PPP Canada

PPP Canada

Energy-from-Waste

SECTOR STUDY

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Canada

IMPROVING THE DELIVERY OF PUBLIC INFRASTRUCTURE BY ACHIEVING BETTER VALUE, TIMELINESS AND ACCOUNTABILITY TO TAX PAYERS THROUGH **PUBLIC-PRIVATE PARTNERSHIPS**

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Cover photo courtesy of: Covanta Indianapolis Energy-from-Waste facility.
Mass Burn; in operations.

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Photo Courtesy of: Wheelabrator Lisbon Inc. (Connecticut). Mass Burn; in operations.

Executive Summary

Energy-from-Waste refers to any waste treatment that recovers energy in the form of electricity, heat, syngas, biofuels, and/or steam from a waste source. This study proposes to analyze the drivers for investment in the Energy-from-Waste sector and the potential application of P3s to the sector.

In recent years, Procuring Authorities in Canada have turned their interest to adopting the Public-Private Partnership (P3) model of procurement to Energy-from-Waste projects as a solution to the municipal solid waste problem. Although the Canadian Energy-from-Waste P3 market is still in its infancy, it is growing quickly. The Design-Build-Finance-Operate-Maintain (DBFOM) model is being used to develop the Surrey Organics Biofuels Facility in Surrey, British Columbia. Other jurisdictions, such as Metro Vancouver, are in the development stages of their facilities and in the midst of evaluating the use of the P3 model.

This trend has also been observed internationally. From 2006 to 2010, the global Energy-from-Waste market increased from $4.8 to $7.1 billion, or at a compound annual growth rate of about 8.0%. It is projected that in the period from 2011 to 2021, these global markets will have increased from $8.5 to $27.2 billion, or at a compound annual growth rate of just over 11%.[1]

Over the last few decades, Canadian municipalities have been faced with increasing environmental, economic, and social pressures to address the growing problem of municipal solid waste resulting from the country's increasing population and economic output. Consequently, the issue of managing and disposing of municipal solid waste in an environmentally sound and economically efficient way is a priority for many of Canada's municipalities.

Energy-from-Waste projects are suitable waste diversion strategies for municipalities with populations exceeding 100,000 and can generate the minimum volume of 100,000 tonnes per annum of municipal solid waste needed to make facilities viable. As of 2011, there were 35 municipalities in Canada with populations exceeding 100,000, many of which do not currently host an Energy-from-Waste facility.

P3s will work as a delivery model for new investments in this sector, specifically when the Procuring Authority has secured a site, selected a proven technology, developed a project with capital costs over $75 to $100 million, negotiated a long-term Power Purchase Agreement, appropriately allocated risk and revenue, and guaranteed waste input volumes and composition. Put together, these conditions will facilitate the establishment of a well-structured P3.

PPP Canada has undertaken an in-depth study of the P3 model in the Energy-from-Waste sector. The following conclusions will be discussed in detail throughout this sector study:

1. In order to ensure a successful P3, Procuring Authorities should seek to achieve the following:
   - choose a technology with an integrated solution that will provide the best performance and lowest cost over the life of a facility;
   - achieve the long term objectives and desires of the community;
   - transfer a maximum amount of risk to private partners; and,
   - maximize the long-term predictable performance of the asset.
2. The benefits are anchored by the inclusion of long-term financing, which creates powerful incentives and aligns the interests of the private and public partners with those of the Procuring Authority and lenders, enhances due diligence, and brings a disciplined focus on meeting performance criteria.

[1] SBI Energy (2011) "Thermal and Digestion Waste-to-Energy Technologies Worldwide".

3. Market sounding participants supported the use of DBFOMs in the Energy-from-Waste sector. More specifically, DBFOMs will work in this sector when Procuring Authorities have:
   - selected a site, and attained political and public support for the project;
   - chosen a proven technology that meets the current and future needs of the community;
   - developed a project of sufficient scope with a guaranteed minimum amount of waste;
   - properly allocated risk, including revenue sharing, to the party best able to manage it; and,
   - a well-planned and predictable procurement process.

4. Mass Burn (thermal) and Anaerobic Digestion (non-thermal) are proven technologies often applied in the Canadian and international Energy-from-Waste sector that present lower operating risks than that of other emerging technologies. By choosing these technologies, Procuring Authorities will present to potential financiers technologies with benchmarked, long-term performance and reasonable risk profile, therefore improving the prospects of raising financing, provided that all the other due diligence items are appropriately addressed.

5. The appropriate technology for any given project is dependent on a municipality's waste management objectives and requirements, which include feedstock composition and availability, facility size, outlet market for end-products, emissions and environmental performance objectives, community/public viewpoints, and cost relative to status quo.

6. The risk allocation model for these projects should give consideration to the following key risks: waste stream/feedstock, energy and material markets/revenue, site/site selection, procurement process, political, regulatory and social, and residuals disposal. Historically, Procuring Authorities have assumed the following risks: feedstock composition/volume, procurement process risk, site and site selection, political/regulatory, social, and Power Purchase Agreement price fluctuation. Risks associated with facility construction, performance, operation and maintenance, energy and material markets/revenue, as well as residual disposal, are typically allocated with the private sector.

7. Energy-from-Waste projects offer three potential revenues: electricity/heat off-take; Tipping Fees and end product sales. Electricity/heat off-take revenues are generated under long-term Power Purchase Agreements with local off-takers where Procuring Authorities retain price risk while transferring volume risk to the private partner. Tipping fees, charges levied for acceptance of waste at the site, are generally pre-determined rather than project specific, and, therefore, better managed by the Procuring Authority. Lastly, Procuring Authorities are often unfamiliar with the uses of end products and their markets making it difficult for them to generate revenues, so responsibility for these revenues should be transferred to the private partner.

8. To attract market interest, Energy-from-Waste P3 procurements should draw on established Canadian P3 practices, which include: two-stage processes (a Request for Qualifications and a Request for Proposal) with well delineated timelines; market accepted documentation; fair, open and transparent evaluation processes; the use of independent fairness monitors/advisors; and, two-way communication between bidders and Procuring Authority via Commercially Confidential Meetings. For these projects, P3 Project Agreements should include well-defined output specifications balanced with minimum input volumes and quantities and revenue sharing mechanisms that minimize fuel volume and price risk to the private partner.

1.0 Overview

1.1 PPP Canada

PPP Canada's mandate is to improve the delivery of public infrastructure by achieving better value, timeliness and accountability to taxpayers, through Public-Private Partnerships (P3s). PPP Canada is mandated to deliver more P3s by leveraging incentives, demonstrating success, and providing expertise; and to deliver better P3s by promoting best-practices and capacity-building.

PPP Canada, recognized as the government of Canada's P3 centre of expertise, is taking a lead role in assessing the suitability of P3 projects seeking funding from federal infrastructure programs, in accordance with criteria established by, or pursuant to, Treasury Board authorities. PPP Canada's advisory services are leveraged collaboratively by all levels of government and the private sector.

The increased visibility of P3s as a procurement option for governments is one of the major accomplishments of PPP Canada, and will remain a factor in the Corporation's ability to further develop the P3 market. PPP Canada works closely with provincial, municipal, and territorial governments, as well as Aboriginal Affairs and Northern Development Canada in order to disseminate information about the P3 Canada Fund. Through its successful promotion of P3 best-practices and capacity-building, PPP Canada has positioned itself as an enabler of P3 projects.

1.2 Scope of Study

This study offers guidance on assessing Energy-from-Waste opportunities under P3 delivery models, and focuses primarily on the Design-Build-Finance-Operate-Maintain (DBFOM) model, which PPP Canada promotes as the model that maximizes risk transfer to the private sector. The conclusions formed in this study should be limited to the Energy-from-Waste sector, and not applied to other assets as certain asset classes may have other unique characteristics to consider when evaluating a P3 option.

This study is not intended to promote the Energy-from-Waste sector. Rather, PPP Canada acknowledges the benefits of the three Rs: Reduce, Re-Use and Recycle, but also recognizes their limitations in terms of waste elimination.

In addition, PPP Canada acknowledges the rapid pace of technological change within the Energy-from-Waste sector and prefaces this study by recognizing the difficulty in reaching industry consensus with respect to the various available technologies suitable for P3 implementation.

1.3 Audience

This study is intended for all who are actively considering and developing an Energy-from-Waste infrastructure project through the use of a P3 model. This document may also be of interest to P3 developers (i.e., Design-Build, Operate-Maintain subcontractors, technology providers, lenders, etc.) who are entering the Canadian Energy-from-Waste market.

As the Canadian Energy-from-Waste sector is currently in its development phase, this study assumes that its readers may not be familiar with its intricacies and Canadian-style P3s. Accordingly, it is written with a broad audience in mind. That being said, this study does cover topics that are highly technical nature.

1.4 Format of the Study

This study is structured as follows: Section 2 provides an introduction to the Energy-from-Waste sector and is followed by a discussion on municipal solid waste in Section 3, its market in Section 4, and an explanation of the main Energy-from-Waste technologies in Section 5. Section 6 explores the use of P3 models to deliver past Energy-from-Waste projects. This is followed by a discussion of key project risks and funding model considerations in Sections 7 and 8. Planning and implementation considerations are then explored. Finally, the study summarizes the opportunities for Energy-from-Waste projects through a P3 arrangement.

1.5 Development Methodology and Enquiries

This study was developed in collaboration with Ernst & Young and Golder Associates Ltd. Industry feedback was solicited to review, validate and capture public and private sector issues and concerns when implementing P3 processes. In the event of any enquires specific to the content of this study, the reader should contact PPP Canada directly:

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1.6 Acknowledgements

PPP Canada is grateful for the input and participation of the following municipal participants in developing this report: the Region of Durham, the City of Surrey, the City of Toronto, and Metro Vancouver. PPP Canada would also like to thank the panel of 23 public and private sector participants that provided feedback on the draft version of this study at an outreach workshop held on October 30th, 2013 in Toronto, Ontario. Information about the workshop and a complete list of participant organizations can be found in Appendix 3.

2.0
Introduction

Energy-from-Waste refers to any waste treatment that extracts energy and resources from waste, including energy in the form of electricity, heat, steam, and/or biofuels; and from resources such as ferrous metals (i.e., steel cans, stainless steel, cast iron), non-ferrous metals (i.e., aluminium), glass, paper products, and film plastics.

Canada's Energy-from-Waste infrastructure consists of eight operating facilities (see **Table 1**) capable of handling over one million tonnes per annum of municipal solid waste. British Columbia, Ontario and Quebec have the largest (by capacity) Energy-from-Waste infrastructure built or in development. Facilities currently in development and construction will add nearly 1.0 million tonnes of additional capacity over the next decade.

The Canadian Energy-from-Waste market and its related infrastructure are not as well developed as that of Europe or Asia. This is partially due to the considerable amount of land area that has been made available for landfills in the past, to economic factors, and to the limited policy support received by the industry. There are, however, indications that the Canadian market is undergoing change as governments face growing pressure to reduce the amount of waste going to landfill.

Indeed, facing increasing environmental, economic and social pressures, as well as now limited disposal space, Procuring Authorities across Canada are turning to the idea of developing Energy-from-Waste facilities to reduce the flow of waste to landfill, and place a greater emphasis on energy recovery. Accordingly, Procuring Authorities are pursuing new investments in Energy-from-Waste facilities in many urban centres, including the cities of Edmonton and Surrey, and the Regions of Durham and Peel.

Municipal solid waste is commonly known as trash or garbage consisting of everyday items that are discarded by residents and collected by the municipality. Since 1990, Canada's per capita waste generation has been steadily increasing as a result of the country's economic growth and its by-product: elevated consumption rates and industrial activity. According to Statistics Canada, approximately 33 million tonnes of waste was generated in Canada in 2010 (a decrease of 1 million tonnes or 3% from 2008). It is estimated that 77% of Canada's 33 million tonnes of waste went to landfill.

Households accounted for approximately 14 million tonnes or 42% of all waste generated in Canada, with the remaining 19 million tonnes or 58% generated from the industrial, commercial and institutional; and construction and demolition sectors.[2] Ontario led all provinces in 2010, generating 9.2 million tonnes of waste, followed by Quebec (5.8 million tonnes), Alberta (3.9 million tonnes) and British Columbia (2.7 million tonnes). Accordingly, the provinces with the largest population estimates generated the most waste. It is estimated that an average city of 500,000 people in Canada will generate approximately 516,000 tonnes of municipal solid waste in a year.[3]

Per capita waste disposal figures provide an additional perspective. Canadians generated 729 kg/person of waste (including both residential and non-residential waste) in 2010, a decrease of 6% from 2008.[4] In 2010, Nova Scotia led all provinces with the lowest per capita disposal rate (389 kg/person), British Columbia, New Brunswick and Ontario also disposed of less waste than the national average. Alberta led all provinces with the highest capita rate at 1,052 kg/person.

[2] Statistics Canada (2010) "Waste Management Industry Survey: Business and Government Sectors", http://www5.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=16F0023X&CHROPG=1&lang=eng (Accessed: February 24, 2014).

[3] Statistics Canada (2008). Waste Management Industry Survey.

[4] See note 2.

It will come as no surprise that in 2010, 30% of Canada's existing landfills had already reached or surpassed capacity. It is increasingly difficult to access new land for landfilling, as developers face more vocal public opposition to landfilling and more stringent environmental requirements. Today, a landfill developer must comply with new regulations regarding landfill liners, leachate control systems, landfill gas collection and control systems, and long-term closure requirements, due to environmental risks such as toxins, leachate and greenhouse gases. Furthermore, the methane that is emitted from landfill sites is 20 times more potent as a greenhouse gas than carbon dioxide,[5] thus dramatically increasing the cost of landfilling.

The inability to easily and cost-effectively increase landfill capacity, or to access new land for landfills, forces market mechanisms to react and adjust the supply-demand balance, thus increasing landfilling usage costs. As these costs increase, municipalities are increasingly exploring sustainable alternatives to landfill disposal, all the while supporting a green economy. Canada's growing investment in Energy-from-Waste infrastructure is part of an evolution in waste management from a "logistics and landfill" approach to an integrated waste management solution.

Stakeholders in the municipal solid waste sector have an increasing understanding of the benefits that can be derived from long-term waste planning and are now incorporating Energy-from-Waste as an option for the waste planning process.

Today, over 1,300 Energy-from-Waste facilities worldwide handle approximately 600,000 metric tonnes per day (219,000,000 tonnes/annum) of solid waste.[6] In Europe alone, 440 Energy-from-Waste facilities convert about 69 million tonnes/annum of municipal solid waste, generating 30 terawatt hours of electricity and 55 terawatt hours of heat, supplying the annual needs of over 25 million people with electricity and heat.[7]

Energy-from-Waste facilities have great economic appeal because they generate recoverable energy, recuperate additional recyclables, and create jobs in the short- and long-term, all the while reducing the amount of waste sent to landfill. Accordingly, Canadian municipalities have begun to view solid waste as both an opportunity and a valuable commodity, which can be processed to generate revenue through material recycling and/or reuse, and energy production.

Before discussing the benefits that can be derived from Energy-from-Waste, this study will first provide the reader with an overview of the Canadian market. This will be followed by an examination of the way in which solid waste is managed and diverted, the roles and responsibilities that all levels of government play in solid waste management and the economic activity generated by the solid waste industry, including Energy-from-Waste.

[5] Recycling Council of British Columbia (2012) "Recycling Fact Sheets: Waste Prevention Facts", http://www.rcbc.ca/files/u6/rg_100217_Waste_Prevention_Facts.pdf (Accessed: September 3, 2013).

[6] Rogoff, Marc J. and Francois Sereve (2011) "Waste-to-Energy: Technologies and Project Implementation" 2nd Edition.

[7] *Ibid*.

Photo Courtesy of: Covanta Indianapolis Energy-from-Waste facility. Mass Burn; in operations .

3.0
Canadian Energy-from-Waste Market

3.1 Summary of Projects in Operation or under Development/ Construction in Canada

In Canada, there are a number of Energy-from-Waste facilities in operation or under construction/development. **Table 1** below provides a summary of main facilities by technology.

TABLE 1 Canadian Energy-from-Waste Sector Projects

TECHNOLOGY	FACILITY NAME	LOCATION	ANNUAL WASTE PROCESSED (TONNES)	ENERGY GENERATED	STATUS	DATE COMMISSIONED
Mass Burn	Greater Vancouver Regional District Waste to Energy Facility	Burnaby, BC	280,000	Electricity and Steam	Operational	1988
Mass Burn	Algonquin Power Energy-from-Waste	Brampton, ON	182,500	Steam	Operational	1992
Mass Burn	L'incinérateur de la Ville de Québec	Quebec City, QC	300,000	Steam	Operational	1974
Mass Burn	MRC des Îles-de-la-Madeleine	Havre-aux-Maisons, QC	4,500	None reported	Operational	1995
Mass Burn	Durham York Energy Centre	Durham Region, ON	140,000	Electricity and Steam	Construction	Target Completion Date: Late 2014
Mass Burn	Region of Peel Energy-from-Waste Facility	Peel Region, ON	300,000	Electricity	Procurement Stage	Not Applicable
Gasification Thermochemical	Enerkem Alberta Biofuels	Edmonton, AB	100,000	Bio-fuels, Chemicals	Commissioning/ Operational	June 2014
Plasma Gasification	Plasco Trail Road Facility	Ottawa, ON	49,000	Electricity	Demonstration Facility Operational	Not Applicable
Anaerobic Digestion	Toronto Dufferin Anaerobic Digestion Facility	Toronto, ON	40,000	Biogas	Operational	2002
Anaerobic Digestion	Toronto Disco Anaerobic Digestion Facility	Toronto, ON	90,000	Biogas	Operational	2013
Anaerobic Digestion	City of Surrey Biofuel Processing Facility	Surrey, BC	80,000	Biogas	Procurement Stage	Not Applicable
Anaerobic Digestion	Harvest Power London Facility	London, ON	80,000 - 100,000	Biogas	Operational	2012
TBD	New Waste-to-Energy Capacity to service Metro Vancouver	Metro Vancouver, B.C.	400,000	Electricity	Under Development	Not Applicable

3.2 Companies Involved In the Space

Presently, the Energy-from-Waste market is growing globally, with many waste and resource companies involved in the market space. In Canada, the competitive P3 market space has been demonstrated most recently through the vendor identification and procurement processes undertaken by four Procuring Authorities: the Regions of Durham and York, for the Durham York Energy Centre, and by Metro Vancouver Region for the Metro Vancouver Waste to Energy Facility, the Region of Peel for the Peel Energy Recovery Centre and the City of Surrey for the Surrey Organic Waste Biofuel Processing Facility.

The Request for Qualifications (RFQ) issued by the Regions of Durham and York received nine responses, of which five proponents were pre-qualified to submit a detailed proposal in response to the Request for Proposals (RFP). Metro Vancouver received 22 responses from 19 entities for its RFQ1 – Technology: a process to identify proponents that had the capability to deliver new Energy-from-Waste capacity.[8] The Region of Peel shortlisted four RFQ proponents to respond to its upcoming RFP, while the City of Surrey received 11 responses of which three proponents were pre-qualified to submit a detailed proposal in response to the Request for Proposals (RFP).

TABLE 2 Sample RFQ Respondents (Durham York and Metro Vancouver)

DURHAM YORK ENERGY CENTRE – RFQ SHORT LIST[9]	COMPANY TYPE*
Respondent Team #1	
• Veolia Environmental Services	Operators (Multinational)
• AMEC	Engineering/Construction (Multinational)
• Black & McDonald	Constructors/Operators (Multinational)
Respondent Team #2	
• Covanta Energy Corporation	Technology Provider/Operator (Multinational)
Respondent Team #3	
• WRSI/DESC Joint Venture	Technology Provider/Design/Constructors/Distribution (Multinational)
• Fisia Babcock Environmental GmbH	Engineering/Construction (Multinational)
• Kiewit Industrial Company	Engineering/Construction (Multinational)
• Morgan Stanley Biomass LLC	Financing (Multinational)
• Babcock & Wilcox	Technology/Constructors/Operators (Multinational)
Respondent Team #4	
• Wheelabrator Technologies Inc.	Technology Provider/Operators (Multinational)
Respondent Team #5	
• Urbaser SA	Technology Provider/Design/Financing/Operators (Multinational)
REGION OF PEEL ENERGY RECOVERY CENTRE – RFQ SHORT-LIST[10]	**COMPANY TYPE***
Respondent Team #1	
• Covanta Energy Corporation	Technology Provider/Operator (Multinational)
• Kenaidan Contracting Ltd.	Constructors (Multinational)
• Barton-Malow Canada	Constructors (Multinational)
Respondent Team #2	
• SNC-Lavalin Capital	Financing/Developer (Multinational)
• Babcock & Wilcox Power Generation Group Inc.	Technology/Constructors/Operators (Multinational)
• SNC-Lavalin Inc.	Constructors (Multinational)
• SNC-Lavalin Operations & Maintenance	Operators (Multinational)
Respondent Team #3	
• Suez Environnement North America (SENA Canada Inc.)	Developer/Financing/Constructors/Operators (Multinational)
• Baumgarte Boiler Systems GmbH	Constructors/Operators (Multinational)
• AECOM Canada Ltd.	Permitting/Engineering/Design/Constructors (Multinational)
• Bird Design-Build Construction Inc.	Design/Constructors (Multinational)
• SENA Solid Waste Holdings Inc.	Developer/Financing (Multinational)

[8] New Waste-to-Energy Capacity for Metro Vancouver, www.belcarra.ca/2013_Waste-to-Energy_Capacity_Development_Process.pdf (Accessed: May 2013).

[9] Durham Region (2008) "Durham Region Energy From Waste (EFW) Project: Detailed Business Case and Request for Proposals - Report to: The Joint Works and Finance & Administration Committees", May 21, 2008, http://www.durhamyorkwaste.ca/pdfs/businesscase/efwreport.pdf (Accessed: July 29, 2014)

[10] Region of Peel Energy Recovery Centre, http://www.peelenergyrecovery.ca/project-news-reports/rfqrfp-information/ (Accessed: August 2014)

REGION OF PEEL ENERGY RECOVERY CENTRE – RFQ SHORT-LIST	COMPANY TYPE*
Respondent Team #4	
• Wheelabrator Technologies Inc.	Technology Provider/Operators (Multinational)
• Urbaser S.A.	Technology Provider/Design/Financing/Operators (Multinational)
• Hitachi Zosen Inova, U.S.A. LLC	Technology/Operators (Multinational)
• KBR Inc	Engineering/Constructors (Multinational)
SURREY ORGANIC WASTE BIOFUEL PROCESSING FACILITY - RFQ SHORT-LIST [11]	**COMPANY TYPE***
Respondent Team #1	
• Orgaworld Canada Ltd.	Developer/Technology Provider/Operator (Multinational)
• Shanks Group	Developer/Technology Provider/Operator (Multinational)
• Stantec Consulting Ltd.	Engineering/Design (Multinational)
• Smith Bros. Wilson(BC) Ltd.	General Contactors/Constructors (Regional)
Respondent Team #2	
• Urbaser S.A.	Technology Provider/Design/Financing/Operators (Multinational)
• Knappet Projects Inc.	Contractors/Engineers (Regional)
• Urbaser Environment (Valorga)	Technology Provider/Design/Financing/Operators (Multinational)
Respondent Team #3	
• Plenary Group (Canada) Ltd.	Financing/Developers/Operators (Multinational)
• Harvest Power Canada Ltd.	Developer/Technology Provider/Operator (Multinational)
• CDM Constructors Ltd.	Engineering/Constructors (Multinational)
• CDM Smith	Engineering/Constructors (Multinational)
METRO VANCOUVER WASTE TO ENERGY FACILITY – RFQ1 TECHNOLOGY RESPONDENTS[12]	**COMPANY TYPE***
TM.E. S.P.A. Termomeccanica Ecologia	Constructors (Multinational)
Acciona Infracture Sener	Developer/Constructors /Maintenance (Multinational)
Plenary Group (Canada) Ltd.	Financing/Developers/Operators (Multinational)
Covanta Energy Corporation	Owner/Operator (Multinational)
Wheelabrator Technologies Inc./Urbaser SA	Design/Constructors/Operators (Multinational)
Sentinel Waste International Ltd.	Technology Provider (National)
Chilliwack Bioenergy Group Inc.	Technology Provider (National)
3R Synergie	Technology Provider (National)
Alter NRG Corp.	Technology Provider/Financing (National)
Orgaworld Canada Ltd.	Developer/Operator (Multinational)
Metso Power	Technology Provider (Multinational)
Anergia Inc.	Technology Provider (Multinational)
Aquilini Renewable Energy Ltd.	Financing (National)
Energy Answers International	Financing/Developer/Operator (Multinational)
Lehigh Cement, A Division of Lehigh Hanson Material Ltd.	Constructors (Multinational)
Eurete Enterprises Inc.	Technology Provider (Multinational)
AECOM	Permitting/Engineering/Design/Constructors (Multinational)

* It should be noted that the companies listed may or may not consistently fulfil the same role on all projects on which they participate.

[11] City of Surrey (2014) "Corporate Report: Surrey Organic Waste Biofuel Processing Facility – Update on the Procurement Process", February 24, 2014, http://www.surrey.ca/bylawsandcouncillibrary/CR_2014-R027.pdf (Accessed: July 3, 2014)

[12] Greater Vancouver - Waste to Energy Technology, http://dcnonl.com/cgi-bin/top10.pl?rm=show_top10_project&id=830f9baf55fc494d83584592b4637f71a2b47a20&projectid=9169581&region=western (Accessed: May 14, 2013).

4.0 Municipal Solid Waste Management in Canada

4.1 Waste Stream

Municipal solid waste encompasses any waste, whether or not it is owned, controlled or managed by a municipality, except, (i) hazardous waste, (ii) liquid industrial waste, or (iii) gaseous waste.[13] The three principal categories of generators and wastes that are analyzed in this study are the following: residential/household solid waste; industrial, commercial and institutional solid waste; finally, construction and demolition solid waste.

- **Residential/household solid waste** includes solid waste that is picked up by the municipality (either by municipal staff or through contracting firms), as well as residential solid waste that is taken by the generator to depots, transfer stations and disposal facilities.[14] Typical composition of residential waste in Canada consists of 40% organic materials (includes green waste), 40% recyclable materials, 10% bulky goods, and 10% other materials.[15]
- **Industrial, commercial, and institutional waste** is the waste generated by all non-residential sources in a municipality and is excluded from the residential waste stream. Industrial waste is generated by manufacturing, primary and secondary industries, and is managed off-site from the manufacturing operation. It is then generally picked up under contract by the private sector. Commercial waste is generated by commercial operations such as shopping centres, restaurants, offices, etc. Some commercial waste (e.g., from small street-front stores) may be picked up by the municipal collection system along with residential waste. Institutional waste is generated by institutional facilities such as schools, hospitals, government facilities, seniors' homes, universities, etc. This waste is generally picked up under contract with the private sector.[16] Typically, industrial, commercial, and institutional waste composition in Canada largely consists of paper, plastic and compostable organics such as food and cardboard. Glass, metals, electronics and non-compostable organics such as dairy products, cooking oils and magazines are also included but make up a relatively small proportion of the composition.
- **Construction and demolition solid waste** is generated by construction, renovation and demolition activities. It generally includes materials such as wood, drywall, certain metals, cardboard, doors, windows, wiring, etc. Excluded are materials such as asphalt, concrete, bricks and clean sand or gravel.[17]

Solid waste can be sub-categorized as hazardous or non-hazardous. Hazardous waste materials generally exhibit characteristics such as flammability, corrosiveness or toxicity and require special treatment before disposal or recycling. Approximately 1% of Canadian municipal solid waste is hazardous. Given this volume, hazardous waste management has been excluded from this study.

In 2010, Canadian households sent 9.4 million tonnes (67%) of total residential waste generated (14 million tonnes) to landfill, and diverted nearly 4.5 million tonnes (33%) to recycling, organic processing and Energy-from-Waste facilities. Conversely, the industrial, commercial, and institutional; and the construction and demolition sectors sent 15.6 million tonnes (81%) of total waste to landfill, and diverted approximately 3.6 million tonnes (19%). Put together, in 2010, Canadians diverted just over 8 million tonnes of waste from landfill, of which 240,000 tonnes (3%) were treated at one of Canada's eight facilities. Materials typically diverted from landfill include: all paper fibres (40%), glass (5%), organics (27%), construction, renovation and demolition materials (8%) and plastics (4%).

Industrial, commercial and institutional; and, construction and demolition waste streams make up a larger proportion of waste being sent for landfill disposal. This is a result of local governments implementing diversion programs aimed at reducing the quantity of residential waste previously destined for landfill. These programs often include: banning organic waste from landfill and encouraging residents to adopt waste-conscious behaviours.

[13] Ministry of Environment Ontario - Environment Protection Act, Regulation 347

[14] See note 3.

[15] Federation of Canadian Municipalities (2009) "Waste Diversion Success Stories from Canadian Municipalities".

[16] See note 3.

[17] *Ibid*.

4.2 Roles and Responsibilities in the Waste Sector

4.2.1 MUNICIPAL RESPONSIBILITY

In Canada, residential waste collection, diversion (recycling and composting) and disposal operations are the responsibility of municipal governments. These services are provided directly by either public entities in the form of municipalities and waste management boards/commissions, or by private companies under contract to public entities, like municipalities.

Each municipality develops its own waste management program which could include: curbside collection, depot drop-off, pay-as-you-throw, recycling programs and disposal options (e.g., landfill, waste export, etc.), or any combination of these elements provided that the program is in compliance with local and provincial regulations and acts. Municipal solid waste management programs are mainly funded through a municipality's respective tax base.

The municipal waste management structure in Canada varies by municipality, as in some cases governing powers may be distributed in different tiers of municipal governments, with each tier involved in different aspects of waste management. In a two-tier system of local government (i.e., upper and lower tier), some services are delivered by the upper tier municipality, the county or the regional government (e.g., Region of Waterloo, County of Dufferin). Upper tier municipalities often co-ordinate service delivery between lower-tier municipalities in the area (e.g., townships or municipalities within a county or region, such as, the City of Cambridge in the Waterloo Region, or the Town of Hawkesbury in the United Counties of Prescott and Russell), or they provide area-wide services.

In many cases, services are assigned by legislation to upper or lower tiers either exclusively or non-exclusively. Waste management is a good example. Frequently lower tier municipalities are exclusively responsible for collecting garbage, while the upper tier municipality is exclusively responsible for disposal and for broader waste management matters. In other cases, responsibility can be shared by both levels of local government.[18] Examples of such forms of waste service delivery may include but are not limited to:

- A regional government might service an area within which there are a number of local municipalities;
- The upper-tier government might provide all of the waste services;
- Only the lower-tier municipalities might provide waste services;
- Both tiers might provide different services (e.g., one operates a disposal facility, the other tier provides waste collection services);
- Both tiers could provide the same services to different parts of the region (e.g., a lower-tier might run a disposal facility for just their municipality with the regional government running a disposal facility for the remainder of the region);
- Municipalities in one or both tiers could act co-operatively through a separate government agency such as a regional waste commission that both collects waste and runs the disposal facility; or,
- None of the local governments in an area could be doing any waste management, leaving provision of waste services strictly to private sector firms through contractual arrangements.

An example of a two-tier regional structure in Canada is the Region of Durham, where the Region is responsible for collection, composting and processing/disposal of all garbage, blue box recyclables, green bin, yard waste, and bulky items, in all area municipalities (Ajax, Pickering, Clarington, Uxbridge, Brock, Scugog, Whitby, Oshawa, etc.). Exceptions to the above are Oshawa and Whitby who are responsible for their own collection, but not for processing/disposal, garbage, green bin, yard waste, or bulky items within their jurisdictional area.

Waste emanating from the Industrial, commercial and, institutional; and, construction and demolition streams, is typically handled through contracts with private waste management companies. The costs of these waste management services are borne by the private companies in each sector, and not by the municipality. However, it is typical that these waste streams are handled in the same facilities as residential waste.

[18] Province of Ontario (2008) "An Overview of Local Government", http://www.mah.gov.on.ca/Page8391.aspx (Accessed: June 2013).

4.2.2 FEDERAL AND PROVINCIAL RESPONSIBILITIES

Various aspects of waste management and, more specifically, Energy-from-Waste projects, are subject to federal and provincial regulations. Here is an overview of federal and provincial responsibilities in Canada:

- **Federal government** – The federal government is responsible for the regulation of international and interprovincial/territorial movement of waste, as well as the regulation of specific hazardous wastes, toxic substances, and air emissions (including greenhouse gas emissions). The Gas Tax Fund, provided by the federal government to the provinces could be allocated to fund waste management initiatives. In addition, PPP Canada, as a Crown corporation, provides certain infrastructure projects, including solid waste projects,procured as P3 with up to 25% funding applied towards the project's eligible capital costs (e.g., planning, construction, etc.).
- **Provincial/Territorial Governments** – Provincial/territorial governments are responsible for approvals, licensing and monitoring of waste operations, policy/regulatory direction (e.g., diversion targets, landfill bans, etc.), as well as intra-provincial/territorial movement of waste.

During the planning stages of an Energy-from-Waste project, the prospective private sector proponents and Procuring Authority should consult with appropriate provincial and federal departments or regulatory bodies, as required, to confirm applicable regulations and the approval process related to the specific requirements of the proposed project.

4.3 Solid Waste Management Services in Canada

In Canada, solid waste management services can be classified into the following categories:

- Garbage collection and transportation - Activities includes hauling of wastes collected at curb side or depots, and/or material transferring from one facility to another;
- Non-hazardous waste diversion - Activities include curb side/depot recycling programs, material recovery facilities, composting facilities, Energy-from-Waste and other recycling facilities;
- Non-hazardous waste disposal - To landfill sites or Energy-from-Waste facilities; and,
- Hazardous waste disposal - To special purpose hazardous waste treatment centres for safe disposal.

Solid waste management services are traditionally provided by either public bodies (i.e., local governments, waste management boards or commissions) or private firms that enter into contracts (often 5 to 10 year terms) with local governments or businesses to provide waste management services.

4.4 Sustainable Waste Management

Sustainable waste management is quickly being recognised as a key component of the energy and environmental challenges facing administrations around the world, and is an issue that impacts every level of government. At a global level, in excess of 4 billion tonnes of solid waste is generated every year, with increasing levels driven by population growth, urbanization and increases in Gross Domestic Product (GDP) per capita.

The principles of modern sustainable waste management (which are applicable to municipal solid waste) are to maximize environmentally sound waste diversion options, in order to minimize the quantity of municipal solid waste (and associated/compatible waste streams) disposed to landfill. This is accomplished by reducing the quantity of solid waste initially produced, and by diverting waste material to beneficial reuse, recycling, composting or energy production.

Local governments looking to apply the principles of modern sustainable waste management are increasingly making use of Life Cycle Analysis in order to identify the best environmentally friendly and sustainable option. The central aim of Life Cycle Analysis is to reduce overall environmental and economic impacts. This can involve trade-offs between impacts at different stages of the life cycle. Reducing the environmental and/or economic impact of waste at the production stage may lead to greater impacts in the future. For example, a 2010 Statistics Canada report entitled "Waste Management Industry Survey: Business and Government Sectors"[19] found that the largest increase in solid waste expenditures among Procuring Authorities was allocated for maintaining landfills after their closure ($93.2 million, up 60% from $53.4 million in 2008).

Typically, waste remaining after all recycling, re-use, and prevention efforts have been exhausted, often comes with an incremental economic cost as further separation and cleaning is required. Life Cycle Analysis assists policy makers in understanding and contextualizing the environmental and economic benefits and costs when making decisions regarding the appropriate waste disposal solution, including Energy-from-Waste.

4.5 Sustainable Waste Diversion

Solid waste diversion is an important strategy that many provinces and municipalities have adopted in order to reduce the flow of waste to landfill. Solid waste diversion is achieved through several approaches:

- Reducing the amount of solid waste created;
- Re-using the solid waste created;
- Recycling the solid waste that cannot be reutilized; and,
- Energy Recovery.

Though there are different approaches to diversion, it should not be assumed that strategies must be employed in isolation. In fact, there is growing evidence that municipalities are employing multiple diversion strategies, which complement one another. Experiences in Europe substantiate the co-existence of divergence approaches. In 2010, Austria attained 70% recycling (including composting) and 30% incineration, Germany achieved 62% recycling and 38% incineration, while Belgium reached 62% recycling and 37% incineration. This compares to the United Kingdom with 39% recycling and 12% incineration.[20]

Canada's current diversion rate is 24%, which means that 76% (almost 25 million tonnes) of the waste generated in these sectors, is destined to disposal, with the majority of waste going to landfill sites. This is further illustrated below in **Table 3**.

TABLE 3 Quantities of Waste Generated in Canada 2010[21]

COMPONENT	RESIDENTIAL SOURCE		INDUSTRIAL, COMMERCIAL AND INSTITUTIONAL/CONSTRUCTION AND DEMOLITION		TOTALS	
	Tonnes	Percentage	Tonnes	Percentage	Tonnes	Percentage
Diversion	4,505,257	33%	3,557,996	19%	8,063,253	24%
Disposal	9,256,540	67%	15,627,006	81%	24,883,546	76%
Totals	**13,761,797**	**100%**	**19,185,002**	**100%**	**32,946,799**	**100%**

[19] Statistics Canada (2010) "Waste Management Industry Survey: Business and Government Sectors", http://www.statcan.gc.ca/pub/16f0023x/16f0023x2013001-eng.pdf (Accessed: January 2014)

[20] Department of Environment, Food and Rural Affairs (2013) "Energy from Waste: A guide to the debate", DEFRA, United Kingdom.

[21] See note 2.

In Canada, municipalities generally have set ambitious goals for waste diversion from landfill (i.e., beyond 50% diversion), and many are exceeding the Canadian national average of 25% diversion. A number of policy trends have emerged in order to achieve a better diversion rate and, as the public pressure to become 'greener' intensifies, these may become more prevalent. Trends as identified by the Federation of Canadian Municipalities include:

- **Zero Waste Communities** – Municipalities that have made a long-term commitment to reducing waste generated. Examples of such municipalities in Canada include:
  - The City of Edmonton achieves its 60% diversion rate through many activities including:
    - Re-Use Centres;
    - Eco-Stations (household hazardous waste drop-off points);
    - Source-separated recycling by residents, collected by the City;
    - Municipal Composting;
    - E-waste processing;
    - Landfill Gas Recovery;
    - Materials Recovery Facility; and,
    - Greys Paper Recycling Facility (closed-loop recycling by processing waste paper collected from City offices and other sources into recycled paper products for sale back to the City and other clients).
  - The Halifax Regional Municipality adopted a Waste Resource Management Strategy in 1995 to achieve zero waste.
  - The Regional District of Nanaimo adopted a goal of zero waste in 2001 to address its urgent disposal capacity shortfall.
  - Metro Vancouver adopted a zero waste philosophy, and in 2009 the region launched the Zero Waste Challenge, with an interim goal of 70% diversion rate. Several waste reduction initiatives are currently happening in Metro Vancouver and include:[22]
    - Working with municipalities and other groups to develop a model by-law to make sure multi-family and commercial buildings have enough space for recycling;
    - Implementing a ban on organic materials (including food scraps) from waste transfer stations by 2015;
    - Working with municipalities and other groups to develop a model by-law to increase the recycling of construction and demolition materials;
    - Taking the initiative to change behaviours and advocate for changes to the design of products and packaging through the creation of a National Zero Waste Council;
    - Encouraging people to adopt waste-conscious behaviours, through social marketing campaigns such as "Watch Your Waste" and the Christmas "Make Memories, Not Garbage" campaign; and,
    - Developing tools, like Metro Vancouver Recycles, an online directory and APP listing all the places to donate or recycle just about anything.
- **Economic Instruments** – Some municipalities require residents to 'pay-as-you-throw' (e.g., bag tag systems). The Region of Durham sets a collection limit of four (4) garbage bags bi-weekly per household, and any residents wishing to set out additional garbage are required to purchase special bag tags at $1.50 to encourage diversion. Other economic instruments include Tipping Fee surcharges (e.g., taxes) and fines for contaminated loads. For example, Metro Vancouver has indicated that landfill Tipping Fees will increase incrementally each year at regional facilities from $97 per tonne in 2011 to a target rate of $205 per tonne in 2016.[23]
- **Public-Private Partnerships** – The management and operation of Energy-from-Waste facilities tend to fall outside the core responsibilities of municipal activities. P3s give municipalities the opportunity to leverage the economic and environmental benefits that these facilities represent, while transferring significant project risks such as operations, maintenance and lifecycle rehabilitation to the private sector. Several jurisdictions across Canada, including the City of Surrey and the Regions of Durham and York, have adopted a P3 (DBFOM or DBOM) procurement option for the development of their facilities. Other jurisdictions, including Metro Vancouver and the Region of Peel, are also evaluating the P3 model as a DBOM option.

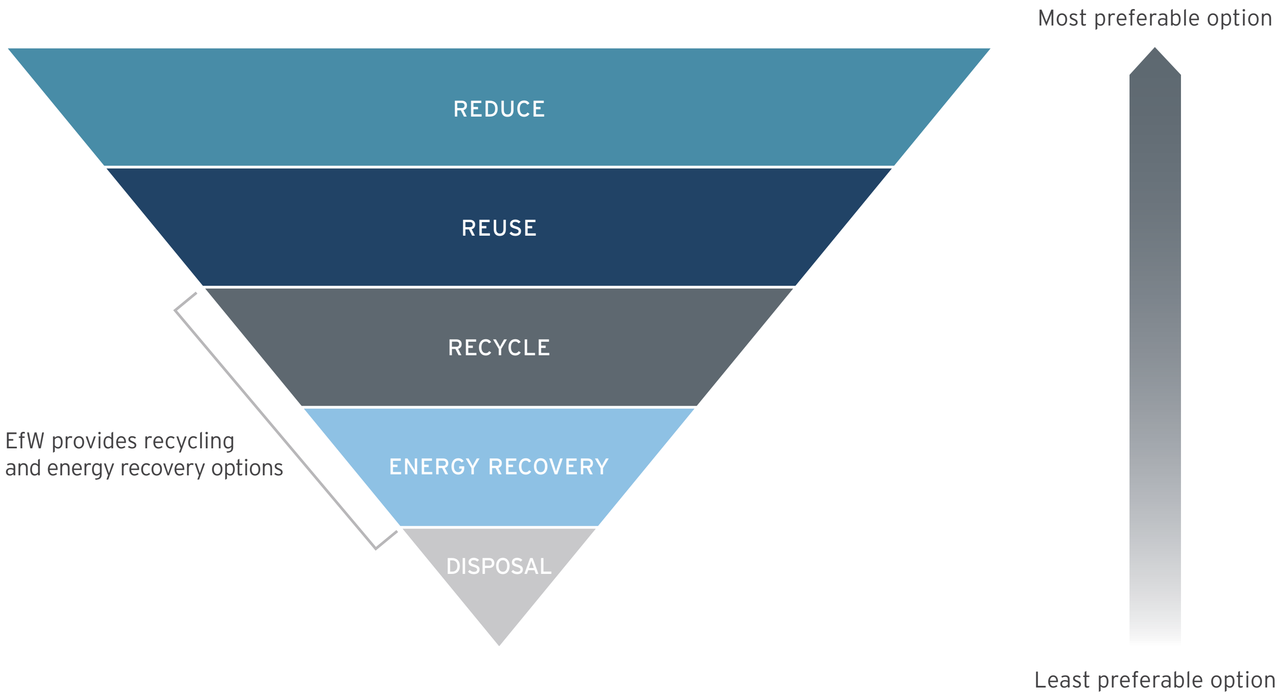
[22] Metro Vancouver (2011) "Zero Waste Challenge", http://www.metrovancouver.org/services/solidwaste/MVandSolidWaste/zwc/Pages/default.aspx (Accessed: June 2013).

[23] Metro Vancouver staff memo to Finance Committee (7 July 2011) "Financial Projections for 2012 to 2016."

- **Green procurement and consumer education** – Municipalities across Canada have implemented by-laws to encourage the industrial, commercial and institutional, and residential sectors to reuse and recycle. Some municipalities have implemented green procurement policies for their own corporate purchasing.[24] Examples include purchasing materials with recycled content, or procuring goods and services that prioritize energy efficiency and have been certified by an environmental performance label.[25]

The practice of diversion supports a green economy, generates economic opportunities, and reduces environmental impacts of waste on land, water, and air. The *Solid Waste Management Hierarchy*, backed by the United States Environmental Protection Agency and the European Union, provides a general framework for waste management policy where the focus is on reduction of waste generation, reuse, and recycling. In Canada, the Solid Waste Hierarchy, seen in **Figure 1**, has been adopted by most jurisdictions, including Metro Vancouver and the City of Toronto, as a foundation for solid waste minimization strategies. The Hierarchy's primary objective is the reduction of solid waste destined for landfill.[26] In other words, to extract the maximum practical benefits from materials and to generate the minimum amount of solid waste.

FIGURE 1 Solid Waste Hierarchy



Once solid waste is created, each material should be managed based on the fundamental principles of sustainability and Life Cycle Analysis. Some recycling activities generate by-products that cannot be reutilized (e.g., used tire processing residue) and not all materials recovered will be recyclable. With respect to materials remaining after reduction, reuse, and recycling, energy recovery should be the preferred disposal option. This energy recovery could be accomplished by Energy-from-Waste facilities, which have the ability to capture inherent resource value, and should be considered in the context of maximizing resource recovery (material or energy resources).

Canada's current diversion statistics are focused on the "recycle" and "disposal" components of the Hierarchy, where the majority of waste management efforts of governments are concentrated. This is not to say that reduction and reuse initiatives do not exist – they are simply difficult to quantify. For example, the Statistics Canada numbers presented do not account for "reduction" and "reuse". The numbers taken into consideration concern the materials that end up in blue boxes, organics programs, and/or disposal facilities.

[24] For additional information on green procurement, refer to Public Works and Government Services Canada website for a Green Procurement Tool Kit

[25] *Ibid*.

[26] Ontario Waste Management Association (2013), "Waste Hierarchy", http://www.owma.org/Issues/WasteHierarchy.aspx (Accessed: June, 25, 2013).

4.6 Energy and Resource Recovery

Energy production is a key source of revenue of Energy-from-Waste facilities. The energy conversion efficiencies of Energy-from-Waste systems vary and are dependent on the operational efficiency, on the system design, and on the specifications of each facility (turbine specifications vs. gas engine), as well as the type of energy produced (e.g., heat, power/electricity, vehicle fuel from biogas, etc.). Additionally, it is possible for Energy-from-Waste systems to be designed as a combined heat and power in order to produce both sources of energy simultaneously.

All Energy-from-Waste facilities are capable of recovering, from the waste stream, certain resource materials that generate revenue, albeit minimal in relation to recoverable energy. These can include dry recyclables captured during pre-processing, metals (ferrous and non-ferrous), ash for use as secondary aggregate, and compost-like-output). Revenue from such materials is dependent on the quality of recovered material (i.e., the degree of contamination), market conditions, and provincial regulations for use of Compost-Like Output. Potential revenue estimates cannot be produced in this study as they fluctuate based on type of incoming feedstock, market demand for material, level of contamination and quality of recyclables, regulatory environment, and geographic location.

4.7 Exporting Municipal Solid Waste to the United States

Given the presence and geographic location of waste management facilities in border regions, some local governments, as well as industrial, commercial and institutional participants, have shipped solid waste across the Canada-US border. Low disposal fees have been significant factor leading to this method of disposal. For example, in Metro Vancouver, the industrial, commercial and institutional sector has the option of contracting waste haulers to dispose of their waste in the regional landfill at an average Tipping Fee (excluding transportation costs) of $108/tonne[27] or contracting a waste hauler to dispose of their waste in neighbouring Washington State for $70.44/tonne.[28] Similarly, the industrial, commercial and institutional sector in the Greater Toronto Area has the option of disposing waste at a City of Toronto landfill for $107/tonne or exporting their waste to nearby states such as New York ($86.30),[29] Virginia ($46.11)[30] and Michigan ($46.82).[31]

According to the most recent data provided by affected state environmental agencies, Canada exported nearly 4 million tonnes of municipal solid waste to the United States in 2004/2005.[32] Most of the shipments came from Southern Ontario, the Greater Toronto Area and Southern British Columbia. States receiving Canadian shipments of solid waste include: Michigan, Washington State, New York and Virginia. In contrast, the United States exported only approximately 12,000 tonnes of municipal solid waste to Canada in the same time period, the majority (11,000) of which was shipped from Maine to New Brunswick.

The exporting of industrial, commercial and institutional waste to the United States has a detrimental fiscal impact to the development of an Energy-from-Waste facility. The inclusion of industrial, commercial and institutional waste aids in building capacity and generating economies of scale, both of which lead to a reduction in per tonne capital costs.

However, this trend is not expected to continue into the foreseeable future due to environmental regulations, landfill capacity, policy/paradigm shifts and potential enactment of waste flow control regulations by local governments.

[27] Metro Vancouver (2014) "Metro Vancouver: 2014 Budget in Brief", http://www.metrovancouver.org/programsandbudget/BudgetDocs/2014DraftBudgetinBrief.pdf (Accessed: February 17, 2014).

[28] Green Power Inc. (2014) "Landfill Tipping Fees in the United States", http://www.cleanenergyprojects.com/Landfill-Tipping-Fees-in-USA-2013.html (Accessed: February 17, 2014).

[29] *Ibid*.

[30] *Ibid*.

[31] *Ibid*.

[32] United States Environmental Protection Agency (2007) "Waste Shipments between the United States and Canada" http://www.epa.gov/nscep/index.html (Accessed: February 24, 2014).

4.8 Economic Development / Job Creation

The solid waste management industry (including both the public and private sectors) in Canada employed nearly 32,000 full-time workers in 2010. Nearly 80% of all full-time workers are employed by the private sector, with the balance being employed by local governments. Full-time employment rose 2% in the public sector and 5% in the private sector between 2008 and 2010. In addition, the number of part-time workers increased by 9% to 3,000 in both sectors.[33]

Energy-from-Waste facilities can also have positive economic implications locally as they will drive employment and job creation during construction and operation stages of a facility. Energy-from-Waste construction projects last approximately three years and result in increased temporary employment over the short- to medium-term. Longer term employment can be created as a direct result of an Energy-from-Waste facility, and typically includes both office based staff (e.g., plant managers, maintenance and operations manager, technical and administrative jobs), and skilled operating staff (e.g., crane operators, tipping hall control, technicians, etc.). The number of new hires during the construction and operation stages can vary significantly based on facility size, technology option and complexity, and pre/post treatment requirements, however, in all cases job creation opportunities exist.

Table 4 below lists the estimated jobs created by Energy-from-Waste projects in Canada and internationally.

TABLE 4 Job Creation in the Energy-from-Waste Sector

PROJECT NAME	LOCATION	FACILITY SIZE	TECHNOLOGY	CAPITAL COST	ESTIMATED JOBS CREATED
Durham York Energy Centre[34]	Region of Durham, ON	140,000 tpy	Mass Burn	$270 million	Construction: • 400 full-time jobs Operation • 40 full-time employees
Enerkem Alberta Biofuels	Edmonton, AB	100,000 dry metric tons/year	Thermochemical Gasification with Catalytic Synthesis	$105 million (approx. standard facility cost)	Construction: • 600 full-time jobs Operation • 40 full-time employees
North Hykeham Energy-from-Waste plant[35]	Lincolnshire, UK	150,000 tpy	Mass Burn	£145 million	Operation • 33 full-time employees
Leeds Energy-from-Waste Plant[36]	Leeds, UK	214,000 tpy	Mass Burn	£460 million	Construction: • 300 full-time jobs Operation • 45 full-time employees
Frederick/Carroll County Renewable Waste-to-Energy Facility[37]	Frederick, Maryland, USA	546,000 tpy* (*based on 1,500 tonne-per-day estimates)	Mass Burn	$527 million	Construction: • 600 full-time jobs Operation • 50 full-time employees
Glasgow Recycling and Renewable Energy Centre[38]	Glasgow, Scotland	200,000 tpy	Gasification	£150 million	Construction: • 250 full-time jobs • 25 apprenticeships

[33] See note 2

[34] Durham York Energy Centre, "Creating Jobs in Durham York", http://www.covantaenergy.com/en/facilities/facility-by-location/durham-york/creating-jobs.aspx (Accessed: March 2013)

[35] The Lincolnite, "Waste-to-energy facility coming in 2013", http://thelincolnite.co.uk/2010/10/city-first-recycling-facility-ready-in-2013/ (Accessed: March 2013).

[36] Resource UK, "Leeds approves plans for two new incinerators", http://www.resource.uk.com/article/Latest/Leeds_approves_plans_two_new_incinerators-2749 (Accessed: March 2013).

[37] Wheelabrator Technologies Inc, "The Frederick/Carroll County Renewable Waste-to-Energy Project", http://www.wheelabratortechnologies.com/plants/project-development/wheelabrator-frederick-county/ (Accessed: March 2013).

[38] Glasgow Recycling and Renewable Energy Centre, "Transforming Waste in Glasgow", http://www.transformingwasteinglasgow.com/ (Accessed: March 2013).

In the United States alone, for example, it is estimated that every dollar of revenue generated by the Energy-from-Waste industry puts a total of 1.77 dollars into the economy through intermediate purchases of goods and services, and payments to employees. In addition to the 5,350 employees directly employed in the US by the industry, this sector creates an additional 8,600 indirect jobs. In other words, another 1.6 jobs are created for every employee hired in the Energy-from-Waste industry.[39]

Energy-from-Waste facilities can also generate indirect economic benefits. A report released by the Solid Waste Association of North America titled "The Economic Development Benefits of Waste-to-Energy Facilities" concluded that: "Over the lifespan of an Energy-from-Waste facility, communities can expect to pay less for municipal solid waste disposal via an Energy-from-Waste facility than at a regional landfill; monies spent on these facilities remain within the communities, while 90% of the monies spent on landfills will be transferred out of the local economy; and these facilities generate significant amounts of base load renewable energy which can be sold to the local power grid."[40]

[39] Berenyi, Eileen (2013) "Nationwide Economic Benefits of the Waste-To-Energy Sector", Governmental Advisory Associates, Inc. http://www.wte.org/userfiles/files/130820%20Berenyi%20Nat'l%20WTE%20Economic%20Benefits.pdf (Accessed: February 18, 2014).

[40] Solid Waste Association of North America "Waste-to-Energy Facilities Provide Significant Economic Benefits, White Paper", http://swana.org/portals/Press_Releases/Economic_Benefits_WTE_WP.pdf (Accessed: February 18, 2014).

5.0
Energy-from-Waste Technologies

5.1 Energy-from-Waste Process

Energy-from-Waste is a generic term referring to processes involved in the recovery of resources from waste streams and/or the conversion of waste streams into an energy source. Energy is generated either directly through combustion, or indirectly through the generation of a fuel source or biogas that can then be combusted for the purposes of energy recovery.

There are a number of different Energy-from-Waste processes available to treat solid waste, which vary in terms of complexity, treatment process, and output. Typically, the process comprises of the following steps:

- Waste reception – waste received at an Energy-from-Waste facility is screened to remove contaminants and prepared for treatment;
- Waste treatment – treatment depends on the technology selected, but includes thermal (e.g., Mass Burn and Gasification) and non-thermal treatment (e.g., Anaerobic Digestion);
- Conversion to a usable/transportable type of energy – energy produced is typically in the form of electricity, transport fuel, and/or heat; and,
- Air pollution control system and residual management (e.g., ash, digestate, metal recovery from ash, etc.).[41]

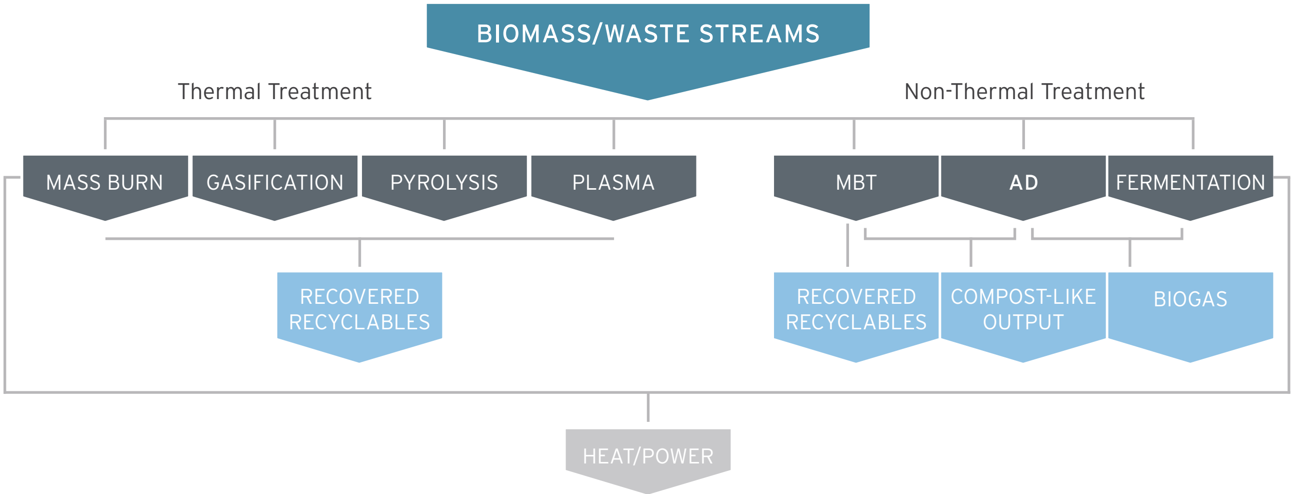
In general, the output products generated by the processes using residual municipal solid waste as feedstock will comprise of one or a combination of the following:

- Recovered recyclables;
- Compost-Like Output;
- Biogas;
- Power/electricity generation;
- Biofuels and chemicals; and/or,
- Ash (bottom and fly).

An Energy-from-Waste process schematic broken down by technology and typical feedstock is provided in **Figure 2**. Note that wet waste is defined as organic refuse or material left over from a manufacturing process, which is characterized by the presence of moisture, whilst dry waste includes all items (e.g., dry recyclables and non-recyclables glass, plastics, metal, wood, etc.).

[41] Department for Environment Food and Rural Affairs. (2013) "Energy from Waste – a Guide to the Debate".

FIGURE 2 Energy-from-Waste Generic Process Chart



5.2 Thermal Technologies

The use of thermal technologies for treatment of municipal solid waste achieves significant volume reduction of the original waste stream, and reduces the demand for available landfill capacity. There are four predominant thermal technologies used to treat municipal solid waste: Mass Burn; Gasification; Plasma Arc Gasification; and Pyrolysis. Other approaches that are less common today include Fluidized Bed Combustion and Refuse-Derived Fuel. While the use and development of these two latter technologies is growing, given their limited application, they will not be given further consideration in this study.

Of the four technologies listed above, Mass Burn and Gasification are the most commonly used thermal technologies. With over 800 facilities currently in operation worldwide, Mass Burn is the most developed and commercially proven thermal technology.

It should be noted that the marketplace for new and emerging thermal technologies is constantly evolving. Emerging technologies such as Gasplasma, Thermal Cracking, and Thermal Oxidation, while still in their development stage (preliminary development, test facilities, or commercial scale proposals) in North America, have yet to be proven on a commercial scale.

5.2.1 MASS BURN

In a Mass Burn facility, waste is fed into a combustion chamber where it is subjected to an oxidizing environment and burned. Plant design can vary between Mass Burn technologies and can have implications on the quantity and type of waste that can be burned, as well as on the heat transfer to the energy recovery system.

Mass Burn technologies can incorporate pre-processing of the residual waste stream to remove remaining recyclables prior to the waste stream being fed into the combustion chamber. Mass Burn thermal treatment facilities can also treat feedstock of varying composition; however, operational efficiencies are typically realized with a dryer feedstock.

Residual outputs of conventional thermal treatment technologies include residues from the burning process (also referred to as Bottom Ash), exhaust gases, and Fly Ash generated as a result of exhaust gas cleaning technologies. The generated Bottom Ash is typically classified as non-hazardous waste and can be disposed of at solid non-hazardous waste landfill sites, though alternative uses for Bottom Ash have been emerging in Europe and include processing for use in cement. Ferrous and non-ferrous metals are also typically recovered from the Bottom Ash prior to disposal through eddy currents and magnets. Recovered metals are sold to secondary processors for re-smelting and/or reuse. Fly Ash is captured by the air pollution control system of the facility and usually requires stabilization prior to disposal. Fly ash is classified as hazardous waste and, therefore, is disposed of at hazardous waste landfill sites. Typical contaminants of concern with conventional thermal treatment technologies include metals, organics (e.g., dioxins and furans), acid gases (e.g., sulphur dioxide), particulate matter, and other substances.

Mass Burn facilities have the capacity to recover energy by feeding the heat generated through a steam-turbine generator creating energy that can be sold as electricity to the grid. Additionally, the steam generated can be used for district heating as demonstrated by the Greater Vancouver Regional District Energy-from-Waste Facility in Burnaby, and the Quebec City Energy-from-Waste Facility (L'incinérateur de la Ville de Québec), which feed their generated steam to neighbouring paper mills. Another example is the Prince Edward Island Energy System Energy-from-Waste facility used in Charlottetown's district heating system, which provides steam heat to the Queen Elizabeth Hospital. Mass Burn systems generally have an energy efficiency between 14% and 27%, which can be optimized to 80% by combining heat recovery with electricity generation.[42]

Mass Burn facilities are modular and, depending on the technology and combustion chamber size, waste processing capabilities can range from 40,000 to 300,000 tonnes per annum per module. Modular facilities can be expanded by adding additional units and ancillary equipment to meet capacity requirements. Typical Mass Burn facilities have a capacity of 100,000 to 1,000,000 tonnes per annum.

Costs associated with a Mass Burn facility are dependent on a number of factors, such as, but not limited to, quality of feedstock, revenue streams and market, geographic location, technology provider, site-specific needs, indirect costs, and financing costs. Therefore cost estimates provided below may not be fully inclusive and should be referenced with caution.

- Capital cost estimates for Mass Burn facilities range from $700 to $1,000 per annual design tonne for a 100,000 tonnes per annum facility, $660 to $960 per annual design tonne for a 150,000 tonnes per annum, and $600 to $900 per annual design tonne for a 200,000 tonnes per annum facility.
- The approximate operating expenditures, excluding financing costs, for Mass Burn facilities ranges from $80 to $130 per tonne of incoming waste.[43]

Further details on Mass Burn facilities can be found in **Annex 1.**

The use of Mass Burn technologies for municipal solid waste treatment is a well-established approach across North America, Europe, and Japan. Over 90% of the approximately 450 Energy-from-Waste facilities in Europe use Mass Burn technology with the largest facility treating approximately 750,000 tonnes per annum. There are 90 operating thermal treatment facilities in North America, the majority of which employ a conventional thermal technology system, mainly Mass Burn.[44] In Canada, there are currently four operational Mass Burn facilities that treat municipal solid waste (greater than 25 tonnes per day).

There are also several Mass Burn facilities currently in the planning or development stages in Canada including: the Durham York Energy Centre (Region of Durham, Ontario) and the Region of Peel Energy Recovery Centre (Region of Peel, Ontario). The Durham York Energy Centre is currently under construction and is expected to commence operations in fall 2014. This facility is permitted to process 140,000 tonnes per annum of residual waste through a Mass Burn system, and will generate up to 20 MW of electricity at full capacity. In June 2013, the Peel Regional Council announced its approval for a 300,000-tonne per year Energy-from-Waste processing facility that could divert as much as 90% of the region's residential waste from landfill when it opens in 2020.

[42] AECOM Canada Ltd. (2009) "Management of Municipal Solid Waste in Metro Vancouver".

[43] Mayor of London (2008) "Costs of Incineration and Non-Incineration Energy-from-Waste Technologies", http://legacy.london.gov.uk/mayor/environment/waste/docs/efwtechnologiesreport.pdf (Accessed, April 2014)

[44] HDR Corporation (2011) "Investigation of Residual Waste Processing System for the City of Kingston", https://www.cityofkingston.ca/documents/10180/27835/Study_IntegratedWasteManagementStudy.pdf/74f16834-524c-4857-ae50-15ff5a9fe9bf, (Accessed: April 2014).

5.2.2 GASIFICATION

Gasification is a process that uses heat, pressure, and steam to chemically and physically change waste to produce gas (syngas) as the main product. The Gasification process is similar to the Pyrolysis process (discussed below), but takes place at higher temperatures and gasifies the fixed carbon content (i.e., converts 70% to 85% of the carbon in the feedstock into syngas). Additionally, Gasification uses small controlled amounts of air (oxygen) to allow partial combustion of the waste, whereas Pyrolysis is undertaken in an oxygen starved reactor. This advanced thermal treatment process occurs within a gasification reactor.

There are a range of reactor designs used in Gasification, including fixed bed reactors (also referred to as the plate system), fluidized bed reactors and entrained-flow reactors. In a Gasification system, oxygen assists with the breakdown of heavy organic compounds by raising the temperature to up to approximately 2,000°C and optimizing the yield of syngas. Fixed and fluidized bed reactors typically operate at relatively lower temperatures and have longer residence times as compared to an entrained-flow reactor, which operates at a very high temperature and pressure, and has a low residence time.

Gasification systems typically require a homogenous feedstock, therefore, a certain amount of front-end mechanical processing of the waste can be required. Drying and/or chopping may also be required to prepare the feedstock for processing.

The syngas generated from gasifiers consists of mainly hydrogen and carbon monoxide, with smaller amounts of nitrogen, methane, carbon dioxide and water. The raw syngas is cleaned to remove impurities prior to end use. The syngas generated can be burned in a gas turbine, boiler or combustion engine to generate electricity and heat.

Other by-products include Bottom Ash, Fly Ash and residue from cleaning the syngas. Ferrous and non-ferrous metals may be recovered from the Bottom Ash. Metals are sent to recyclers, while ash is typically sent to landfills, however, it can potentially be used as secondary aggregate. Slag (i.e., glass) material is also a component of the Bottom Ash and may be derived from inorganic materials. The slag produced is non-hazardous and can be used to make cement, asphalt, and tiles; however, end-use can vary depending on regulatory conditions and market demand. Generally, Gasification systems have a smaller air pollution control system than Mass Burn combustion systems because they produce less flue gas and residue.

Gasification facilities are modular. Each module can range from approximately 40,000 tonnes per annum to 100,000 tonnes per annum.[45] As such, facilities can be expanded depending on the requirement of a municipality.

Although there are no large-scale Gasification facilities that process municipal waste currently in operation in Canada, there are Gasification projects under development, as well as projects currently operating internationally:

- Enerkem, in partnership with City of Edmonton, has completed the construction of the world's first municipal waste-to-biofuels and chemicals facility on the site of the Edmonton Waste Management Centre. At full operation, the facility will convert 100,000 dry metric tonnes per annum of municipal solid waste into 38 million litres of ethanol.
- There are a number of full-scale Gasification facilities in operation in Asia which process municipal waste. In 2010, over 144 of these facilities were in operation throughout the world, though the majority did not use municipal waste as feedstock. Typical feedstock for these gasification facilities includes petroleum products, coal, and petcoke from oil refineries.
- One example of a larger technology provider with operations in Asia and Europe is Thermoselect. This company operates seven Gasification facilities that process up to 170,000 tonnes per annum of waste (industrial and municipal waste) in Japan, and a 225,000 tonnes per annum facility in Germany.

[45] AECOM Canada Ltd. Management of Municipal Solid Waste in Metro Vancouver. June 2009.

Costs associated with a Gasification facility are dependent on a number of factors, such as, but not limited to, quality of feedstock, revenue streams, technology provider, site-specific needs, and indirect and financing costs. Therefore, cost estimates provided herein may not be fully inclusive and should be referenced with caution.

- Capital cost estimates for Gasification facilities range from $760 to $1200 per annual design tonne for a 100,000 tonnes per annum facility, $600 to $1160 per annual design tonne for a 150,000 tonnes per annum, and $600 to $1000 per annual design tonne for a 200,000 tonnes per annum facility.
- The approximate operating expenditures for a Gasification facility, excluding financing costs, ranges from $80 to $140 per tonne.[46]

Further details on Gasification thermal treatment products can be found in **Annex 1.**

5.2.3 PYROLYSIS

Pyrolysis is a form of advanced thermal treatment that reduces the volume of waste feedstock by heat in the absence of oxygen. Residual waste is fed into a Pyrolysis reactor, which is typically maintained at a temperature between 300°C and 850°C. Reactor types can vary by technology vendor; examples of Pyrolysis treatment reactors commonly used include a rotating kiln, a heated tube or a surface contact system. In the reactor, Pyrolysis may occur slowly (i.e., feedstock volatizes over a period of several minutes) or quickly (i.e., feedstock volatizes in seconds) depending on the technology vendor and end product desired.

Pyrolysis technologies require that pre-treatment of incoming waste occur to remove recyclables and non-combustible materials (e.g., grit, stones) and to homogenize the feedstock. Additional drying may be required if the feedstock has a high moisture content. Further, surface contact reactors cannot accommodate large size feedstock and, therefore, may require coupling with size reduction equipment.

Typical by-products from Pyrolysis reactions include solid residue (e.g., bottom ash, char), liquids (i.e., oxygenated oils), and a medium quality gas (syngas). The solid residue consists of both non-combustible material (i.e., metals, glass, silica) and carbon (i.e., char), while the syngas mixture is composed of carbon dioxide, carbon monoxide, hydrogen, methane and volatile organic compounds. The composition of by-products produced from the Pyrolysis process can vary depending on process conditions, such as operating temperature, oxygen level, rate of heat transfer, and residence time in reactor. For example, in slow Pyrolysis the production of char is maximized, whereas fast Pyrolysis produces a comparatively higher volume of syngas.

Syngas generated can be combusted directly in a boiler system to generate steam, or combusted in a gas turbine to create electricity. Additionally, it is possible for the syngas generated to be cleaned and transformed into an organic chemical (e.g., ethanol), or it may be condensed to produce oils, waxes, and tars. When syngas is combusted in a boiler system, an air pollution control system consisting of cyclones, filters, scrubbers, and other ancillary equipment is used to capture volatile metals, dioxins, furans, particulate matter (i.e., hazardous Fly Ash) and other volatile gases.

Pyrolysis facilities are typically modular and can range in size from capacities of 15,000 to 120,000 tonnes per annum. As such, facilities can be expanded depending on the requirement of a municipality.

There are no large-scale Pyrolysis facilities that process municipal waste in operation in North America or Europe. Smaller scale or pilot facilities exist in Europe and the United States. These technologies are new in the marketplace and have not been proven on a larger scale. A number of larger Pyrolysis facilities are presently in operation in Japan. These facilities process 50,000 to 120,000 tonnes of shredded waste and generate electricity.

Costs associated with Pyrolysis facilities are not reliable because this technology option is not widely implemented on a large scale to treat municipal solid waste. However, it assumed that capital and operating expenditures of Pyrolysis would resemble that of a Gasification facility.

Further details on Pyrolysis facilities can be found in **Annex 1.**

[46] Mayor of London. Costs of Incineration and Non-Incineration Energy-from-Waste Technologies. January 2008

5.2.4 PLASMA GASIFICATION

Plasma Gasification is an emerging gasification technology that stems from what may be considered more "traditional" gasification processes. Plasma Gasification uses an electrical arc, or torch gasifier, which passes a high voltage electrical current through low pressure gas/air creating a stream of plasma. The plasma field supplies high heat which can range from 5,000 to 15,000 °C. The extreme heat maintains the gasification reaction by breaking down chemical bonds of waste and converting them into syngas and slag. The syngas generated can be used in steam boilers to generate heat, or, after undergoing a cleaning process, in combustion engines and gas turbines to produce electricity. The remaining slag consists of inorganic wastes that will become vitrified (i.e., inert glass) when exiting the reactor chamber. The slag produced, once cleaned, can be processed into tiles, bricks, gravel or asphalt.

Plasma technologies have been used in a number of industries for over 30 years, with the primary use being to process hazardous wastes and ash from Mass Burn incinerators. Its application to treat municipal waste is relatively new. The largest commercial-scale facility for Plasma Gasification is in Utasjinai, Japan, which uses Westinghouse Plasma Technology to process up to 180 tonnes per day of municipal waste. In Canada, there are no large-scale Plasma Gasification facilities; however, there are two demonstration and pilot plasma projects underway – Alter NRG and Plasco Energy Corp (Plasco).

Alter NRG uses a Plasma Gasification system developed by Westinghouse Plasma Corp. This system employs a plasma torch to create a high heat plasma stream through the interaction between air and an electric arc. Output includes slag, metals, and syngas.

Plasco's commercial scale demonstration facility located in Ottawa, Ontario, began processing post-diversion residential waste from the City of Ottawa in 2008. The demonstration project was initially approved to convert up to 85 tonnes per day consisting of a maximum of 75 tonnes of municipal solid non-hazardous waste and a maximum of 10 tonnes of high carbon waste. At its current scale, the facility is designed to produce approximately 4.2 MW of electricity. The City estimates that the deal will extend the life of Ottawa's existing landfill by at least 28 years, saving the City approximately $250 million in future landfill capital costs. It is estimated that the facility will create 200 construction jobs and 42 permanent positions for facility operation.[47]

Costs associated with a Plasma Gasification facility are dependent on a number of factors, such as, but not limited to, quality of feedstock, revenue streams, technology provider, site-specific needs, indirect and financing costs. Therefore cost estimates provided herein may not be fully inclusive and should be referenced with caution.

- Based on survey of four projects undertaken by Stantec,[48] the reported median capital and operating costs estimates are $1,300/annual design tonne (+/- 44%) and $120/tonne (+/- 55%), respectively.

Further details on Plasma Gasification facilities can be found in **Annex 1.**

5.3 Non-Thermal Technologies

5.3.1 MECHANICAL BIOLOGICAL TREATMENT

In general, Mechanical Biological Treatment facilities use a combination of mechanical separation and biological treatment to process residual waste. When combined with Anaerobic Digestion (discussed in the following sub-section), Mechanical Biological Treatment can be considered an Energy-from-Waste technology.

Mechanical separation is the first stage in a Mechanical Biological Treatment process, irrespective of the biological treatment technology used. This stage consists of a combination of manual and/or automated separation processes (e.g., screening, ballistic separation, optical sorting, magnetic separation, etc.) to extract recyclable materials and to segregate materials suitable for biological treatment. The non-recyclable inorganic fraction of the residual waste stream may be segregated either prior to, or following biological treatment, depending on the chosen design configuration and objectives. The non-recyclable inorganic fraction will require either final disposal (i.e., landfill) or processing (e.g., another Energy-from-Waste solution).

[47] Plasco Energy Group (2012): "Plasco to build 150,000 tonnes per year Waste Conversion Facility in Ottawa" http://www.plascoenergygroup.com/2012/12/plasco-to-build-150000-tonnes-per-year-waste-conversion-facility-in-ottawa/, (Accessed September 18, 2013)

[48] Stantec. (2011). Waste-to-Energy: A Technical Review of Municipal Solid Waste Thermal Treatment Practices.

One of the most significant elements of Mechanical Biological Treatment is the type of biological treatment, which can vary in complexity, process, output and cost. Biological treatment processes in a Mechanical Biological Treatment system can include aerobic composting (no energy production) or an Anaerobic Digestion process.

The scale at which different Mechanical Biological Treatment facilities are built is based on the requirement of the municipality and availability of waste. Mechanical Biological Treatment systems are modular and can therefore be scaled accordingly. The majority of Mechanical Biological Treatment plants have been built at a scale in the range of 20,000 to 100,000 tonnes per annum, though plants with capacities greater than 200,000 tonnes per annum exist. For instance, a facility in Madrid, Spain has an input capacity of 480,000 tonnes per annum.

Mechanical Biological Treatment systems have been processing biodegradable waste fractions for over 20 years. There are no large-scale Mechanical Biological Treatment facilities in Canada, however two facilities in Edmonton and Halifax are using anaerobic composting technologies. Globally there are more than 123 Mechanical Biological Treatment plants in operation, with European countries leading in number of facilities and operational experience.

Costs associated with a Mechanical Biological Treatment facility are dependent on a number of factors, such as, but not limited to, facility size, quality of feedstock, revenue streams, biological step (aerobic or anaerobic), energy generation (if any), technology provider, site-specific needs, indirect costs, and financing. Therefore, cost estimates provided herein may not be fully inclusive and should be referenced with caution.

- Capital cost estimates for a Mechanical Biological Treatment - Anaerobic Digestion facility can range from $320 to $840 per annual design tonne. Operating costs, excluding financing costs, range from approximately $45 to $85 per tonne.

- Capital cost estimates for a Mechanical Biological Treatment Aerobic Composting facility can range from $55 to $450 per annual design tonne. Operating costs, excluding financing costs, range from approximately $40 to $280 per tonne. The high range in capital and operating costs for a Mechanical Biological Treatment Aerobic Composting facility is due to the variability in costs of anaerobic technology used in such a system (i.e. windrow, aerated static pile, in-vessel, etc.).

Further details on Mechanical Biological Treatment Anaerobic Digestion facilities can be found in **Annex 1.**

5.3.2 ANAEROBIC DIGESTION

Anaerobic Digestion is a treatment process that biologically degrades materials in the absence of oxygen. There are a variety of Anaerobic Digestion systems now being used for the treatment of residual organic wastes. The treatment component of these processes varies according to (amongst other things):

- The temperature of operation – mesophilic (circa 37˚C) or thermophilic (57˚C to 70˚C);
- The solids content of the waste in the reactor (i.e., wet versus dry Anaerobic Digestion); and,
- Whether it is a single- or multi-step treatment process.

In all cases, Anaerobic Digestion processes (via biomethanisation) produce a 'biogas' which is rich in methane and can be used to generate energy, either through a generator, or by upgrading the gas to the point when it can be used as a vehicle transport fuel (compressed natural gas), or injected into the gas distribution network. In addition to biogas production, a range of organic materials with a range of potential 'compost' applications can be produced following Anaerobic Digestion treatment. The digestate generated from Anaerobic Digestion undergoes composting and curing via an aerobic process (i.e., windrow, in-vessel) to stabilize the material prior to landfill and/or to produce a 'compost' material. Given the highly variable quality of the compost material produced following Anaerobic Digestion processing and curing, this material is considered a Compost-Like Output rather than a compost product.

As with all systems, however, anaerobic digesters can be developed in all shapes and sizes, comprising of single-stage, multi-stage and batch systems. In single stage digesters, all of these reactions take place simultaneously in a single reactor, whilst in two or multi-stage systems, multiple reactions take place sequentially in at least two separate reactors.

In Wet Anaerobic Digestion Systems, the incoming waste is pulped or slurred to less than 15% Total Solids in water, so that a classic mix reactor may be used. In the case of a residual municipal solid waste feedstock, this process requires the introduction of significant quantities of diluting water and may involve substantial pre-treatment to provide the required consistency for Anaerobic Digestion system process. The process also suffers from precipitation of the heavier fraction of the waste to the bottom of the reactor, inhibiting the mixing process and hence reducing the biogas yield. The process is, however, well suited to materials with a high as-received water and volatile solids content (i.e., organic waste streams), which are far less prone by their nature to the sedimentation and gas yield issues faced by residual municipal solid waste systems.

In Dry Anaerobic Digestion Systems, the fermenting mass has a solid content in the range between 20 and 40%, such that only very dry incoming wastes (more than 50% of Total Solids) require the introduction of any process water. The biggest challenge is in transporting the dry waste, which is undertaken using conveyor belts, screws and powerful pumps, but the rewards are much higher biogas yields due to the higher biomass content, plus a simpler reactor design and cheaper pre-treatment stage. These systems are typically much better suited to residual municipal solid waste feedstock.

With respect to the temperature of operation, mesophilic (digestion takes place optimally at approximately 30 to 38 °C, or at ambient temperatures between 20 and 45 °C, where mesophiles are the primary microorganisms present) and thermophilic (digestion takes place optimally around 49 to 57 °C, or at elevated temperatures up to 70 °C, where thermophiles are the primary microorganisms present) designs return typically the same results, but the operating cost of thermophilic systems and consequences of a fall in reactor temperature are considerably higher. As such, most systems utilized for the treatment of municipal solid waste are mesophilic.

In recent years, the number of Anaerobic Digestion plants commissioned in North America and Europe has increased significantly. There are a number of Anaerobic Digestion facilities in Canada, for example, the Dufferin Organic Processing Facility in Toronto, Ontario. This facility has been in operation since 2002 and processes 40,000 tonnes per annum of household organic waste as feedstock. The City of Surrey is presently developing an Anaerobic Digestion facility capable of processing 80,000 tonnes per annum of household and industrial, commercial and institutional organic waste to produce 12.20 million m^3 to 12.73 million m^3 per year of biofuel.

Early in 2009, Juniper Consultancy undertook a review of Anaerobic Digestion technologies from all over the world, rating the performance of the various processes based on the number and scale of facilities in full operation.[49] From this rating system, there were two suppliers marketing Anaerobic Digestion technologies with a proven rating of "1" (more than one (1) reference site operating for more than two (2) years at a commercial scale), and fourteen suppliers with a rating of "2" (at least one (1) reference facility proven in sustained commercial operation).

Costs associated with an Anaerobic Digestion facility are dependent on a number of variables, such as, but not limited to, quality of incoming feedstock, revenue, energy generation, technology provider, site-specific needs, indirect costs, and financing costs. Therefore, cost estimates provided below may not be fully inclusive and should be referenced with caution.

- Anaerobic Digestion facilities capital cost estimates can range from $490 to $625 per annual design tonne. Operating costs, excluding financing costs, can range from $35 to $55 per tonne.

Further details on Anaerobic Digestion facilities can be found in **Annex 1.**

5.3.3 FERMENTATION PRODUCTION

Fermentation is an anaerobic process whereby yeast or other bacteria are used to generate a liquid biofuel (i.e., ethanol) from waste by breaking down carbohydrates (glucose) found in organic materials into ethanol.

Typical feedstock for fermentation includes wood waste, paper, and pulp. However, in recent years fermentation of municipal or food wastes has emerged, though no large scale facility exists. Pre-treatment of municipal solid waste is required and includes sifting, milling and grinding to reduce particle size. The feedstock then undergoes drying and enzymatic hydrolysis to break complex carbohydrates (i.e., cellulose) into simple sugars. Yeast and bacteria are then added to the feedstock to feed on sugars. This process of yeast/bacterial digestion results in the production of ethanol and carbon dioxide as metabolic waste products.

The ethanol is then distilled and dehydrated, in order to obtain a higher concentration of alcohol, and thus achieve the level of purity required for transport fuel. Residual waste from this process is either sent to landfill or used as cattle feed, depending on its quality.

Since this technology is emerging and unproven using large municipal solid waste feedstock, no costing or vendor supply information can be provided at this stage.

5.4 Summary of Energy-from-Waste Technologies

Based on the above technology review, there are number of Energy-from-Waste processes available to the waste industry. The type of technology selected is dependent on a municipality's waste management requirements that include feedstock composition and availability, facility size, outlet market for products (e.g., power-grid connection), cost relative to status quo.

The tables below provide a high-level overview of factors for the consideration of Energy-from-Waste technology options. Capital and operating cost information for Pyrolysis and Plasma Gasification technologies range widely due to the limited number of facilities in operation in North America and the lack of reliable data available.

[49] Juniper for Renewables East, "Commercial Assessment – Anaerobic Digestion Technology for Biomass Projects,") 2009.

TABLE 5 Technology Summary – Capital and Operating Considerations

	THERMAL TECHNOLOGIES				NON-THERMAL TECHNOLOGIES		
	Mass Burn	Gasification	Pyrolysis	Plasma Gasification	Mechanical Biological Treatment	Anaerobic Digestion	Fermentation Production
Capital Costs	$600 to $1000 / annual design tonne	$600 to $1200 / annual design tonne	$150 to $1000 / annual design tonne – data is not reliable	$730 to $1872 / annual design tonne	$320 to $840 / annual design tonne	$490 to $630 / annual design tonne	No Data Available
Operating Costs	$80 to $130 / tonne	$80 to $140 / tonne	$50 to $110 / tonne – data is not reliable	$50 to $190 / tonne	$40 to $490 / tonne	$30 to $60 / tonne	No Data Available

TABLE 6 Technology Summary - Performance Specifications

	THERMAL TECHNOLOGIES				NON-THERMAL TECHNOLOGIES		
	Mass Burn	Gasification	Pyrolysis	Plasma Gasification	Mechanical Biological Treatment	Anaerobic Digestion	Fermentation Production
Scalability	Modular	Modular	Modular	Modular	Modular	Modular	No Data Available
Reliability	Established Technology	Emerging Technology	Emerging Technology	Emerging Technology	Established Technology	Established Technology	Emerging Technology
Feedstock Sensitivity	Non-sensitive	Sensitive	Highly sensitive	Sensitive	Typically for organic waste streams	Typically for organic waste streams	Typically for wood waste, paper and pulp
Residue (% of original feedstock by volume)	Bottom Ash: 20%-30% APC Residue (includes Fly Ash): 2% - 6%	Bottom Ash: 20% APC Residue (includes Fly Ash): 1% -5%	No reliable data	Bottom Ash: 1%-10% APC Residue (includes Fly Ash): 1% - 10%	Compost-Like Output : variable Contaminated or Unrecoverable: ~30%	Compost-Like Output : variable Contaminated or Unrecoverable: variable	No Data Available
Energy Recovery	Heat Electricity Combined Heat and Power	Heat Electricity Hydrogen Gas Liquid Fuel Combined Heat and Power	Heat Electricity Hydrogen Gas Liquid Fuel Combined Heat and Power	Heat Electricity Hydrogen Gas Liquid Fuel Combined Heat and Power	Biogas Combined Heat and Power	Biogas Combined Heat and Power	Biogas
Noted Technical Risk(s)	Feedstock Security	Feedstock Security; Feedstock Composition; Technology Reliability; Technology Supplier	Feedstock Security; Feedstock Composition; Technology Reliability; Technology Supplier; Performance Guarantees	Feedstock Security; Feedstock Composition; Technology Reliability; Technology Supplier;	Feedstock Security; Feedstock Composition; Compost-Like Output Management	Feedstock Security; Feedstock Composition;	No Data Available

In Canada and internationally, Mass Burn and Anaerobic Digestion are the most common and reliable form of Energy-from-Waste technologies in operation, however, this may change with emerging technologies becoming more established. According to a recent study, from 2006 to 2010, approximately 95% of the global Energy-from-Waste market was accounted for by only two technologies: Mass Burn and Anaerobic Digestion. Pyrolysis, Plasma Gasification, and Gasification are expected to gain relative market share, and together are projected to comprise over 30% of the total Energy-from-Waste market by 2015.[50]

Capital cost requirements and operating costs for Mass Burn and Anaerobic Digestion facilities tend to be smaller in comparison to other Energy-from-Waste technologies. Mass Burn, Mechanical Biological Treatment and Anaerobic Digestion facilities tend to be more scalable, providing greater efficiencies and economies of scale with larger facilities. Mass Burn facilities require less source separation than comparable technologies and allow for more flexible feedstock options. With respect to the biological treatment processes reviewed (i.e., Mechanical Biological Treatment Anaerobic Digestion,, Anaerobic Digestion, and fermentation), Mechanical Biological Treatment Anaerobic Digestion, and Anaerobic Digestion are both well-established technologies typically suited for waste streams with higher organic content. Mature technologies such as Mass Burn and Anaerobic Digestion are proven and often applied in the Canadian Energy-from-Waste sector, and present lower operating risks than that of other emerging Energy-from-Waste technologies. Given time, and further success in the sector, emerging Energy-from-Waste technologies such as Gasification and Pyrolysis may demonstrate a proven track record, scalability, and reliability.

Photo Courtesy of: Enerkam Alberta Biofuels. Gasification Thermochemical; in operations.

[50] SBI Energy (2011) "Thermal and Digestion Waste-to-Energy Technologies Worldwide", http://www.sbireports.com/Thermal-Digestion-Waste-2847741/, (Accessed: September 3, 2013).

6.0 Relevant Project Delivery Models

6.1 Introduction

For public infrastructure projects, Procuring Authorities can usually choose from a range of delivery options. Depending on project requirements and characteristics, Procuring Authorities can choose from amongst the following options: traditional approaches such as Design-Bid-Build (DBB), P3 models such as Design-Build-Operate-Maintain (DBOM), Design-Build-Finance-Maintain (DBFM), Design-Build-Finance-Operate-Maintain (DBFOM), and, even privatization models. This section investigates relevant project delivery models for procuring Energy-from-Waste projects.

Traditional project delivery models, often referred to as DBB models, involve the Procuring Authority first entering into a contract for the design of the project and then a separate contract, usually with a different entity, for the construction of the project. Often the responsibility to maintain and/or operate the project remains with the Procuring Authority. In traditional delivery models, the risk transfer from the public sector to the private sector is minimal.

Procuring Authorities in Canada and internationally (as evidenced in **Table 7**) do not usually procure Energy-from-Waste projects using the traditional DBB approach. Procuring Authorities choose to depart from the traditional delivery approach for the following reasons: the technical, environmental and operating complexities involved in operating and maintaining a facility; lack of internal operating expertise; and, risk management. Accordingly, the DBB approach will not be discussed in any further detail.

P3 models are a long-term performance-based approach for procuring public infrastructure where the private sector assumes a major share of the responsibility in terms of risk and financing for the delivery and the performance of the infrastructure, from design and structural planning, to long-term maintenance. Accordingly, there are different P3 models reflecting different degrees of private sector responsibility and risk transfer, including: DBFM, DBOM, or DBFOM. In part, risk transfer and improved performance are achieved by integrating different combinations of activities: design, build, operations, and, maintenance of the asset. The addition of private finance adds discipline, further aligning incentives and anchoring risk transfer, making it a critical element of many P3s.

Due to the tight integration and overlap between operations and maintenance (O&M), there is generally no practical ability to separate O&M from each other as is done, for example, in hospital DBFMs. As can be seen in **Table 7**, the DBFOM and DBOM models have emerged as the predominant delivery approaches in the Canadian Energy-from-Waste market. The following sections will compare and delineate the advantages and disadvantages of the DBFOM and DBOM models.

TABLE 7 Selected Listing of Recent DBFOM and DBOM Energy-from-Waste Projects

PROJECT	REGION	TOTAL VALUE (USD)[51]	STAGE	MODEL
Surrey Organic Biofuels Facility	Canada	$78.6M	In Procurement	DBFOM
Buckinghamshire Energy-from-Waste Plant PFI	United Kingdom	$356.0M	Under Construction	DBFOM
Cornwall Energy-from-Waste Plant	United Kingdom	$363.4M	Under Construction	DBFOM
Essex MBT Plant	United Kingdom	$255.4M	Under Construction	DBFOM
Oxfordshire Waste Facility	United Kingdom	$329.6M	Under Construction	DBFOM
South Tyne & Wear Waste PFI	United Kingdom	$456.1M	Under Construction	DBFOM
Suffolk Waste Plant	United Kingdom	$348.1M	Under Construction	DBFOM
Barnsley Doncaster and Rotherham Residual Waste PFI Facility	United Kingdom	$356.0M	Under Construction	DBFOM
Poznan Energy-from-Waste Plant	Poland	$334.2M	Under Construction	DBFOM
Lancashire PFI Waste	United Kingdom	$776.8M	Operational	DBFOM
Cumbria Waste Plant	United Kingdom	$124.0M	Operational	DBFOM
Greater Manchester Waste	United Kingdom	$1,092.6M	Operational	DBFOM
Western Riverside Waste Authority Belvedere Energy-from-Waste	United Kingdom	$1,128.8M	Operational	DBFOM
Cambridgeshire Waste Mechanical Biological Treatment Facility	United Kingdom	$137.0M	Operational	DBFOM
Durham York Energy-from-Waste Facility	Canada	$270M	Under Construction	DBOM
Northumberland Waste Plant	United Kingdom	$196M	Under Construction	DBOM
Dagenham Anaerobic Digestion Plant P3	United Kingdom	$29.9M	Operational	DBOM
Grosseto Integrated Waste Treatment Plant P3	Italy	$48M	Operational	DBOM
Instalación 3 Waste Treatment Plant	Spain	$150.2M	Operational	DBOM
West Berkshire Integrated Waste PFI	United Kingdom	$56M	Operational	DBOM

6.2 Rating of Models against High-Level Objectives

Table 8 on the next page rates the suitability of the DBFOM and DBOM models against some common objectives, including construction cost and scheduling risk, operating performance risk and innovation.

The DBOM and DBFOM models give bidders the opportunity to provide innovation in terms of designing, constructing, operating and maintaining the constructed asset. Innovation may also be environmental, in terms of residuals management and air quality control, as well as organizational and involve business processes, contractual relations and management systems. Innovation is a key feature of these models, in part because the Procuring Authority only specifies the outputs rather than inputs when soliciting for bids. In other words, Procuring Authorities specify what is required but not how the asset is to be delivered. Driven by private capital-at-risk over the entirety of the agreement, bidders to a DBFOM project, will be further incentivized to offer innovation in order to maintain a balance between initial project capital outlay and life-cycle cost.

The models as contemplated in the table reflect common application of the models either on Energy-from-Waste sector projects, or on projects in other sectors in Canada.

[51] Infrastructure Journal, "Report Generator – EfW Sector Projects" www.ijonline.com, (Accessed: February 25, 2014)

TABLE 8 Rating of DBFOM and DBOM Models against Typical High-Level Objectives

OBJECTIVE	DBOM	DBFOM
Suitable market of service providers	✓	✓
Potential for innovation	✓	✓
Consideration of life-cycle in design		✓
Transfer of construction cost risk	✓	✓
Transfer of construction schedule risk	✓	✓
Transfer of life-cycle cost risk		✓
Transfer of operating performance risk	✓	✓
Quality of long term security		✓

Based on **Table 8**, the DBFOM model best meets the above high-level objectives of Procuring Authorities. As a result, the DBFOM model forms the preferred P3 spectrum in this sector. Driven by private capital-at-risk during the construction and operating periods, the DBFOM model offers the greatest potential for innovation, the highest level of risk transfer and the greatest potential to capitalize on private sector know-how and expertise.

6.3 The P3 Model - Design-Build-Finance-Operate-Maintain (DBFOM)

The DBFOM project delivery integrates the design, construction and operation life of a project whereby the private sector will be responsible for designing, building, financing, operating, and maintaining the asset for a period of 20 to 30 years. The private sector will be responsible for securing short term financing to cover the funding requirements during the construction period. The private partner is also required to provide long-term debt and equity financing for a portion of construction costs. The DBFOM approach is often used on projects for which there are significant operational responsibilities and risks that can be transferred, including the provision of services to the public. The presence of significant short-term and long-term financing anchors and enables considerable risk transfer to the private sector in the DBFOM.

6.3.1 PAYMENT MECHANISM

The DBFOM payment structure is a performance-based approach. Typically, there are no payments to the private partner until the project has reached Substantial Completion, is fully constructed and available for use. In some cases, milestone payments will be made during construction once a portion of the asset is complete and/or is available for service. Typically, milestone and Substantial Completion payments, when combined, cover from 25% to 50% of the capital costs of the asset. During the operating period, the Procuring Authority will provide an Annual Service Payment, which in part repays long-term financing over the life of the P3 contract. Part of the Annual Service Payment is index linked for the duration of the operating period and pays for the operating and maintenance costs. This mechanism informs the Procuring Authority (at project award) of the Annual Service Payments that must be made over the life of the project. The Annual Service Payment is usually subject to deductions if the private partner does not make the asset available for service or does not fully meet performance criteria.

6.3.2 SECURITY

In a DBFOM, security is provided through the private financing to the extent that the financed amount is high enough to secure the risk transfer.[52] With private financing, the private partner has "skin in the game". If there is a project default, on the part of the private partner, the equity partner can lose their investment in the project and lenders could take a loss on their loan. This provides a high level of motivation to ensure that the private partner meets the required performance under the contract. Additional security through bonding or letters of credit, and guarantees from the parent company, where applicable, may be necessary. Private sector lenders will require additional due diligence for security requirements.

6.3.3 BENEFITS OF A DBFOM

The DBFOM model achieves the maximum transfer of risk to the private sector. DBFOMs provide extended life-cycle benefits including transfer of design, construction, financing costs, and maintenance and operation costs for the term of the contract. Substantial Completion payments create strong incentives to complete construction on time and in accordance with specifications, in order to receive payment and repay lenders. The presence of equity creates a cushion if risk events materialize over the life of the project, and create strong incentives to find operational and life-cycle savings to increase project returns. Also, as Annual Service Payments are performance-based, deductions will impact equity returns. This will motivate the private partner to ensure that the asset performs over the term of the agreement and to create overall project efficiencies.

The use of long-term finance in a DBFOM puts private sector debt and equity capital at risk over the length of the contract term; this ensures that the private partner has very strong incentives to ensure the long-term quality of the infrastructure and O&M services. The combination of gradual repayment of capital and performance based payment is the most robust form of performance security. It is very difficult for the private partner to walk away from its contractual obligations since it must continue to perform in order to repay its debt and equity investors.

The DBFOM delivery model aligns the interests of the Procuring Authorities and the private lenders in that they are both incentivized to ensure that the private sector partner is able to deliver the services required by the Procuring Authority. To help achieve that, lenders typically hire a Lender's Technical Advisor to help identify, understand and mitigate project risk through an additional layer of due diligence on the project. Some of the services that are offered by a Lender Technical Advisor include:

- Review of a consortium's experience, capability and financial viability;
- Commercial and contractual review;
- Technology validation;
- Asset delivery assessment;
- Security package assessment;
- Permitting and regulatory approvals requirements and approach;
- Capital cost, cash flow, and schedule analysis;
- Life-cycle replacement approach and pricing analysis;
- Payment mechanism analysis;
- Construction phase monitoring;
- Operational phase monitoring; and,
- Secondary market due diligence.

A DBFOM aligns with many of PPP Canada's reasons to invest in and support a project: capture of private sector expertise, use of performance specifications, placing private capital at risk, cost certainty, and consideration of life-cycle costs in the selection of infrastructure solutions.

[52] PPP Canada. (January 2013) "Water/Wastewater Sector Study", http://www.p3canada.ca/en/about-p3s/p3-resource-library/p3-water-wastewater-sector-study/.

6.3.4 POTENTIAL DRAWBACKS OF DBFOM

While a DBFOM is perhaps the ultimate form of P3 in terms of risk transfer and harnessing private sector expertise, it does suffer from one key problem from the standpoint of the Procuring Authority - the cost of private financing. On any given project, a municipality will be able to secure capital financing at lower cost than the DBFOM contractor. The additional cost of contractor financing must be set-off against the benefits of the DBFOM approach, for a P3 project to offer more Value for Money than the traditional procurement approach. This issue is typically addressed by the Procuring Authority contributing capital during construction to reduce the amount of private financing needed.

The DBFOM option may be more challenging from a procurement perspective than a DBOM as a result of the time lag between commercial and financial close caused by the Environmental Assessment (screening) process. Typically, banks can hold long term financing rates for up to six months, but the timeline for the Environmental Assessment (screening) can be approximately 20 months and in some cases several years. As an example, the Durham / York Environmental Assessment took 6 years to complete and get approval. This situation presents the biggest challenge from a financing perspective under a DBFOM.

Various options to handle this situation exist and include: undertaking significant project scoping at the outset of the project (e.g., conduct waste stream analysis to determine the size of the facility, define the technology, identify the site and review all permitting requirements, etc.) to initiate the Environmental Assessment process; at the RFP stage require proponents to prepare upfront drawings as well as an emissions report; and, compress the RFP evaluation period to two months in order to provide proponents with a 5 month bid validity period (period between submission of proposals and financial close), plus 1 month of contingency.

Additionally, the complexity of a DBFOM, which includes private financing solutions, operations and maintenance, often comes at a cost. These costs are incurred primarily as a result of the increased amount of due diligence and overhead required for private sector consortia to thoroughly understand the project's requirements, degree of risk transfer, and other incremental complexities of the DBFOM model. For project sizes below $50 million the incremental cost of private financing can make the project uneconomical as compared with other delivery options.

6.4 Design-Build-Operate-Maintain (DBOM)

In cases where the costs of accessing private financing are too high or where private financing may not be available, jurisdictions may want to consider a DBOM, as opposed to attempting a more traditional delivery approach. This could be the case for smaller projects, projects with capital costs below $100 million, where it will be difficult to attract long-term financing at competitive rates or to overcome the fixed upfront costs of project financing. The DBOM builds on the Design-Build format by integrating the operations and maintenance of the constructed asset into the contract. The contractor is responsible for designing, building, operating, maintaining and rehabilitating the asset over a 20 to 30 year concession period.

The private sector will be responsible to secure short-term financing to cover the funding requirements during the construction period. The short-term financing is made possible by the Substantial Completion payment that the Procuring Authority will make at end of construction or Substantial Completion.

6.4.1 PAYMENT MECHANISM

A DBOM can be paid as two separate contracts: a contract in which capital is paid for through milestone payments or Substantial Completion payments; and a separate operations and maintenance contract paid over the term of the operating period.

Over the operations and maintenance contract period, the Procuring Authority will make periodic payments to the private sector partner (operator). These payments are pre-determined by the private sector partner at bid submission, and are designed to cover the operating, maintenance and life-cycle costs. These payments will typically contain clauses for non-performance deductions. Rehabilitation payments may also be made in regular intervals, or in an irregular fashion to match the contractor's actual timing of costs. Rehabilitation costs for a greenfield project are the responsibility of the private sector.

6.4.2 SECURITY

Security for DBOM construction and capital costs features short-term financing placed by the contractor and added security from bonding and letters of credit. The long-term operations and maintenance portion of the contract are typically secured by performance bonds and parent guarantees, and in some cases by secured letters of credit. The private partner provides security against routine performance of the contractor. The levels of these securities may not be equivalent to the capital at risk in a DBFOM and do not provide the same liquidity.

6.4.3 POTENTIAL BENEFITS OF THE DBOM

The advantage of using the DBOM approach is that it combines responsibility for design, construction, operations and maintenance under a single consortium. This allows all of the private partners to take advantage of a number of efficiencies. The project's design can be customized to the construction equipment and materials. In addition, the consortium will establish a long-term operation, maintenance and rehabilitation program up front to minimize cost and maximize efficiency. The consortium's intimate knowledge of the project design and the materials at an early stage allows it to develop an OM&R plan that anticipates and addresses expenditures and project needs as they arise, thus mitigating the risk that problems will go undetected and deteriorate into much more costly problems.

6.4.4 POTENTIAL DRAWBACKS WITH THE DBOM

A primary concern with DBOM relates to the quality of the long-term security. The DBOM security level is lesser than that of the DBFOM model. The private partner would not be risking private capital (debt and/or equity) during the concession period. Instead, the Procuring Authority would have to depend on more limited and less liquid forms of performance-based securities such as letters of credit, parent company guarantees and performance bonds, all of which provide less security to the Procuring Authority than a DBFOM model, which ties the private partner to its long-term equity investment and debt obligations.

In the event that the private partner does not perform, and escalating remedies do not cause the contractor to self-correct, the Procuring Authority will likely have to sue the contractor or a parent company of the contractor for damages incurred in self-performing the work, especially if the non-performance is related to rehabilitation. Overall, the quality of the long-term risk transfer in a DBOM ultimately relies on aforementioned performance-based securities, the value of which can only be judged subjectively and only at the time of contract award. Given that a DBOM could have a term of 20 to 30 years, the value of a company's promise could erode significantly depending on intervening events.

In a DBOM, there is no lender's oversight and, therefore, the private partner could be less incentivized to perform maintenance and life-cycle replacements in the later stages of an operations and maintenance contract. This may result in higher hand back risks, leaving the Procuring Authority with a facility that requires additional capital investment or rehabilitation. In a DBFOM, a portion of the capital Annual Service Payment, which pays back the debt financing and equity distributions, provides a potential source of funding in the event that the private partner does not undertake sufficient upkeep of the facility.

In addition, the equity investment provides incentive for consortium team members to work closely together. The DBOM model does not require private sector partners to provide any equity investment in the project, which may result in a team comprised of a loosely partnered DB contractor and O&M contractor without the added level of discipline and project management often found in DBFOM projects. In addition, equity provides a cushion should a risk event materialize. In a DBOM, consortia members cannot draw on bonds, parent guarantees, even letters of credit, in order to source funds to deal with the impacts of risk events. Thus, there is greater probability of default.

6.5 Conclusions

Both the DBFOM and DBOM models have been used in Canada and internationally. The choice of delivery model is dependent on the Procuring Authority's appetite for risk, technology, financing availability, as well as the availability and interest of private sector partners, among other considerations.

The DBFOM model is best able to meet the objectives of Procuring Authorities, and transfers the greatest amount of risk and responsibilities to the private sector, as performance targets are tied to long-term financing, bringing with it additional due diligence. As will be discussed in the subsequent sections, market sounding participants indicated that the DBFOM delivery model has been successfully applied to large-scale Energy-from-Waste projects. The DBFOM should be pursued for those projects that can reach a scale sufficiently large to attract private finance and overcome fixed upfront costs, e.g. projects with capital costs greater than $75 to $100 million.

The DBOM model has also been used in this sector. It is recommended that its use be limited to projects with capital costs lower than $75 million, where market capacity for long-term debt is limited and where Procuring Authorities are recommending the use of advanced/emerging Energy-from-Waste technologies.

Photo Courtesy of: Wheelabrator Baltimore, LP. Mass Burn facility; in operations.

7.0 Key Energy-from-Waste Sector Project Risks

7.1 Introduction

The main principle underlying all P3 arrangements is the ability to transfer risks to the party that is best suited to manage such risks, resulting in effective partnerships between the public and private sector. Once the need to proceed with a facility as a P3 has been identified, Procuring Authorities should dedicate sufficient time and resources to carefully identifying and examining all project risks, and developing appropriate mitigation strategies to limit their exposure to those risks. This is especially true in Canada as facilities are relatively new and the market lacks the experience required to fully understand the impact of the project risks. In most P3 Project Agreements, risks are identified, assessed, quantified and allocated with the agreement of all relevant and affected parties.

7.2 Risk Identification and Allocation

Table 9 below provides a high-level allocation of the most common risks considered for Energy-from-Waste projects. As presented below, "Retained Risks" means that the responsibility of managing the risk resides with the Procuring Authority, while "Transferred Risks" means that the responsibility of managing such risk is transferred from the Procuring Authority to the private partner. Depending on the delivery model selected, the allocations below may vary.

TABLE 9 Energy-from-Waste Risk Allocation under DBFOM and DBOM

RISK CATEGORY	TYPICALLY RISK ALLOCATION
Political/Regulatory and Social Risks	
Approvals and permitting	Retained
Environmental Assessments	Retained
Public acceptance	Retained
Development transparency	Retained
Utility company fees	Retained
Site Risks*	
Geotechnical	Retained
Contamination	Retained
Greenfield vs. brownfield considerations	Retained
Procurement Risks	
Scope changes	Retained
Termination of contract	Retained
Contract ambiguities	Retained
Delivery of performance standards	Retained
Financing Risks	
Availability of financing	Transferred under DBFOM, Retained under a DBOM
Changes to inflation or interest rates	Shared
Deterioration of financial situation of partners	Transferred

RISK CATEGORY	TYPICALLY RISK ALLOCATION
Construction Risks	
Construction design risks	Transferred
Construction delays	Transferred
Failure to build to design	Transferred
Resource availability	Transferred
Construction contractor default	Transferred
Scope changes by owner	Retained
Technology Obsolescence Risks	
Technology selection and performance	Retained
Advances and upgrades	Transferred
Operations and Maintenance Risks	
Unanticipated operating costs	Transferred
Labour relations	Transferred
Quality	Transferred
Preventative maintenance	Transferred
Unscheduled maintenance	Transferred
Feedstock Risks	
Waste input volumes	Retained
Waste composition	Shared
Residuals Management Risks	
Disposal risks	Transferred
Fly Ash	Transferred
Revenue Risks	
Marketability of outputs	Transferred
Quality of outputs	Transferred
Market volatility	Transferred
Price risk	Transferred
Completion Risks	
Commissioning delays	Transferred
Ambiguities in handover agreement	Retained

*Assuming the municipality provides the site. Based on the market sounding, the private sector has a preference for municipal lands due to the lengthy Environmental Assessment, permitting and approvals processes.

As illustrated in **Table 9** above, both models transfer significant risk to the private sector partner. More importantly, the quality of the risk transferred under DBFOM models is greater to that under a DBOM model in that the private sector partner has more incentive to mitigate all transferred risks. In particular under a DBFOM, the private sector partner will pay close attention to its O&M activities and ensure that they are adhering to all provisions set out in the Project Agreement. Under a DBFOM, if the private sector partner underperforms, they risk losing the entire Annual Service Payment and will have to answer to, not only the Procuring Authorities, but also the project's long-term lenders.

7.3 Key Energy-From-Waste Risks

Many of the decisions Procuring Authorities make along the path of implementing Energy-from-Waste projects require an understanding of risks that are specific to this sector, including: waste stream/feedstock; energy and material markets/revenue; site/site selection; procurement process; political, regulatory and social issues; and, residuals disposal.

7.3.1 WASTE STREAM / FEEDSTOCK RISK

Waste stream/feedstock risk refers to the composition of the waste stream as it impacts the facility's inputs and outputs. Waste composition is expected to change over the course of the operating life of a facility. Changes to legislation, waste diversion strategies, packaging, and demographics, along with numerous other factors, can drastically impact the composition, quality and volume of waste inputs, creating additional risks for output quality and revenue opportunities.

Changes in waste stream composition over the operating life of a facility may severely impact its economic feasibility and revenue opportunities. The changes in the composition may result in a reduction in waste stream below the facility's capacity, which in turn may impact the energy outputs produced by the facility.

Any risks associated with providing a supply of solid waste to a facility are generally assumed by the Procuring Authority. The Procuring Authority will typically guarantee a reference solid waste composition that the bidders will assume in developing their design and operating strategies. In the event that the reference composition changes, the Procuring Authority will assume the responsibilities and additional costs resulting from this change, often through Tipping Fee increases.

Lenders and bidders will demand that the Procuring Authority guarantee at least a minimum tonnage of their waste stream through a long-term put or pay contract, governmental collection of solid waste (i.e., franchising), Tipping Fee regime changes, or through a local by-law/ordinance to regulate waste flow.

7.3.2 ENERGY AND MATERIALS MARKETS / REVENUE RISK

Outputs from an Energy-from-Waste facility, such as energy in the form of electricity or heat, or compost materials, may be sold to generate additional revenues and offset operating costs. This risk deals with the uncertainty surrounding the markets available for Energy-from-Waste facilities' outputs.

The sale of Energy-from-Waste outputs is subject to market price risks that have a direct impact on the economics of the facility operation. In many Canadian jurisdictions, the regulatory environment supports long-term Power Purchase Agreements and price security for energy sales. Despite this, there are still risks associated with the energy market and the sale of Energy-from-Waste outputs. For example, in the event that the electric grid in the jurisdiction in which the facility operates reaches its full capacity and does not require any additional base load, power authorities may become reluctant to enter into new Power Purchase Agreement.

While energy revenues and markets can be predictable, the undefined market for residual materials, such as fertilizer and Compost B grade outputs (resulting from Mechanical Biological Treatment – Anaerobic Digestion processes) can lead to revenue uncertainty and additional risks. For example, currently in Canada there is no market for Compost B which may not only impact revenue generation of the facility, but may also result in increased operational costs required to pay for hauling and disposing of the outputs.

Risks associated with energy and material markets are often assumed by the Procuring Authority. The Procuring Authority typically subsidizes lost revenues through increased Tipping Fees. This risk could be mitigated by securing long-term Power Purchase Agreement contracts.

7.3.3 SITE AND SITE SELECTION

Site and site selection risks refer to risks associated with the site and the activities carried out during the facility site selection process. It includes risks related to access to land, site servicing, land/site requirements, existing geotechnical conditions, contamination and the environmental condition of the site. Risks specifically related to these projects include site condition, subsurface conditions, location, proximity to a landfill, impact on natural environment, and efficient use of public resources.

Main challenges to be considered when selecting a site are technical (location and size), environmental (approvals and permits, air quality, noise etc.) and social (land uses, permitting considerations, land ownership, cultural resources). Any of these challenges, if not planned for accordingly, could result in costly delays to the procurement process or even project cancelation. Traditionally, the Procuring Authority retains the risks associated with the site and site selection.

7.3.4 PROCUREMENT PROCESS RISKS

Procurement Risk refers to challenges that may arise during the procurement process. They include, but are not limited to, the following:

- Lack of planning and pre-assessment analysis of the project;
- Ambiguous RFQ and RFP tender documentation;
- Unproven procurement model in the Energy-from-Waste sector;
- Unanticipated changes to scope by the Procuring Authority;
- Lack of competition due to unqualified consortia;
- Unfamiliar Project Agreement to the market;
- Risk sharing not in line with Energy-from-Waste standards;
- Technology selection;
- Poor definition of payment mechanism; and,
- Financial capability of the proponent.

The impact of the procurement challenges, if they occur, will be a delay in the procurement process or even project cancelation. The impact varies and depends on which event occurs. Some events will impact the early stages of the procurement while others will delay commercial and financial close.

The Procuring Authority retains the procurement risk because they have control over the process. It is important for the Procuring Authority to put in place a procurement approach that is open and transparent yet protects all confidential information that makes the process fair and competitive. Procuring Authorities are encouraged to retain an independent consulting team with an excellent track record in Energy-from-Waste implementation. This team, consisting of technical, financial, legal, procurement, environmental and health and safety advisors, should be hired at the outset of the project to complement the Procuring Authority's internal project team in order to help design and customize the procurement process in such a way that addresses all the challenges that may result in a costly and unsuccessful procurement.

7.3.5 POLITICAL, REGULATORY AND PUBLIC ACCEPTANCE

These risks relate to, among other factors, the legal, political, and regulatory framework, government policy, taxation, nationalization, expropriation, and approvals that may expedite, delay or terminate the project. For these projects, this category involves risks related to Environmental Assessment approvals, municipal approvals, utility company fees, building permits, and environmental regulations. Social risks such as public acceptance and development transparency are important considerations in the development of the project.

The impact of these risks on the project can vary widely from a simple delay in the procurement to project cancelation. Many participants to the market sounding interviews noted that Environmental Assessment approvals, site approvals, and other permits can lead to lengthy timelines for the planning and development process of a facility. General public buy-in was also raised to be a major factor to the success of an Energy-from-Waste project impacting social risks.

These risks are best managed by the Procuring Authority and can be mitigated, although not fully, by gathering support for the project from political leaders at all levels of governments. The Procuring Authority is encouraged to develop a plan on how to gain public support and formulate a strategy early on for the public consultation process. The importance of the public consultation process cannot be overstated for the success of an Energy-from-Waste facility.

7.3.6 RESIDUAL DISPOSAL RISKS

Residual disposal risks are related to the environmental and economic risks associated to the disposal of residuals including Fly Ash and other air pollution control residues, which are classified as hazardous waste and, therefore, require stabilization and treatment prior to disposal at a hazardous landfill site.

This is a risk that is best managed by the operator of a facility and in the case of a P3 arrangement this would be the private sector partner.

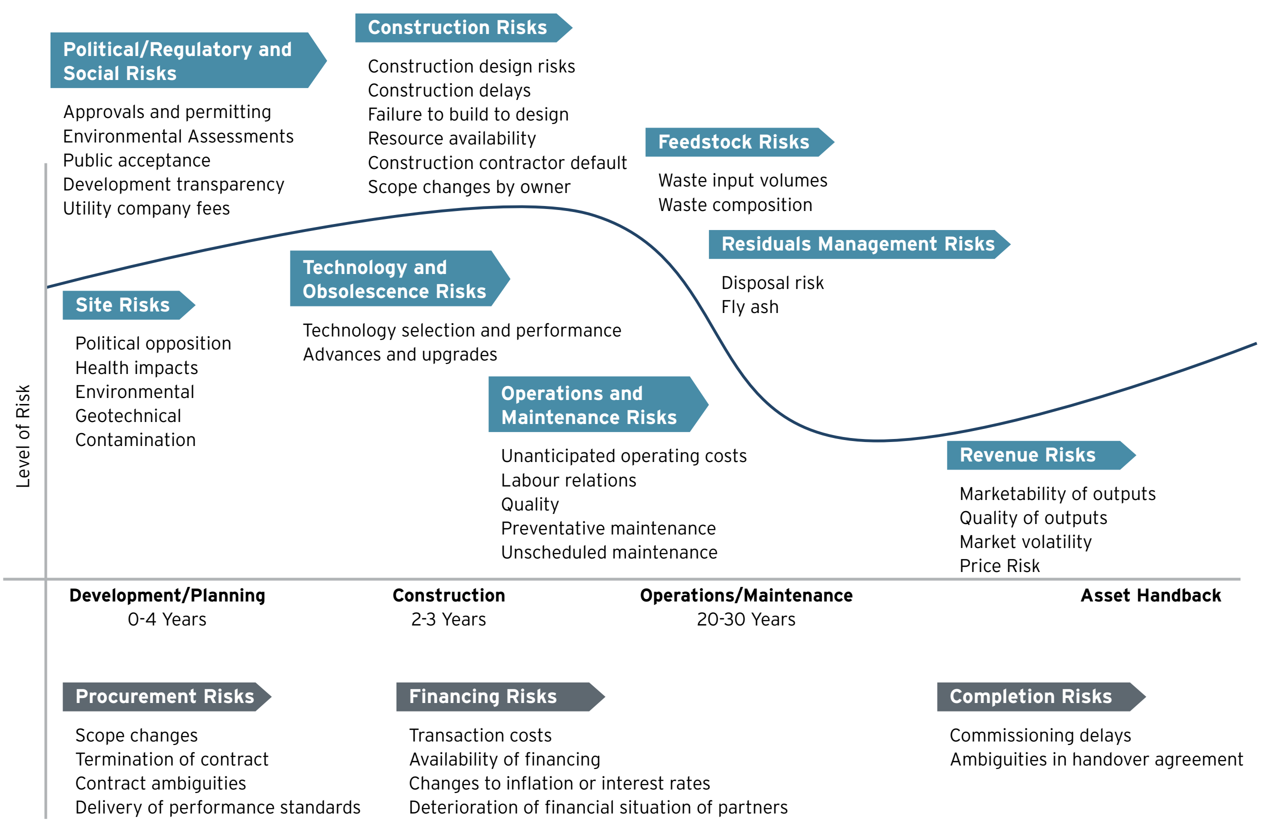
Fly Ash relates to fine particles that rise after waste combustion in a Mass Burn facility. Particle filtration systems, for example electrostatic precipitators and filter bags, are deployed to capture the Fly Ash before escaping into the atmosphere. Fly Ash can contain a number of hazardous chemicals, such as dioxins and furans. In order to comply with emissions regulations, the facility operators must manage and invest in proven, reliable and compliant equipment and processes for treatment and proper disposal of such ashes.

As an example, in 2012 Fly Ash from the Burnaby incinerator in British Columbia was found to be exceeding guidelines for hazardous materials.[53] The operator of the facility may potentially incur up to $50 per tonne in additional costs to ship the hazardous Fly Ash to a landfill in Alberta that is approved to handle hazardous materials.

7.4 Timing of Risk Exposure

While the timing of individual risks is difficult to determine, generally, risk categories are associated with phases of the project life-cycle. Procurement risks may arise in the procurement phase of the project, construction risks could develop in the construction phase of the project, while revenue, demand, operational and maintenance risks may occur in the operating life-cycle of the asset. Political/regulatory, financing, technology, and completion risks may occur at any time over the project life-cycle. **Figure 3** below provides a high level example of probable risk timing and risk levels throughout the project life-cycle.

FIGURE 3 Energy-from-Waste Project Life-Cycle Risk Profile



[53] The Globe and Mail (December 5, 2012).
http://www.theglobeandmail.com/news/british-columbia/costs-adding-up-as-incinerator-ash-being-shipped-to-alberta/article5989220/

8.0 Financing Energy-from-Waste Projects

8.1 Introduction

Securing private financing is often times the most critical component of any infrastructure project. This can typically be one of the greatest challenges for Energy-from-Waste projects, particularly if the Procuring Authority has selected a newer technology.

The sources available to finance the construction, operation and maintenance of the facilities vary depending on factors including the technology, delivery model and revenue model of the project. A DBFOM facility procured using a P3 arrangement with a 30 year operations and maintenance term is typically funded with a combination of public and private sources during the various stages of the project.

Lenders typically expect that the private partner will have a long-term waste contract with the Procuring Authority. The supply contract is the primary source of income for the private partner. Furthermore, lenders will expect to see a project supported by a Power Purchase Agreement. Combined, these revenue streams make the project bankable for lenders.

8.2 Uses of Financing

During the construction period, a portion of the project costs, including capital costs and interest accrued during the construction period, are typically financed with a short-term bank facility. The facility is borrowed by the private sector partner and secured by a Substantial Completion Payment paid at the end of construction by the Procuring Authority to the private sector partner. The payment size varies depending on the size of the project, but ranges from 40% to 60% of the project costs.

Another portion of the construction costs is financed using long-term financing solution, often a bond that pays for construction costs and is amortized over the life of the operating contract. In other words, the private partner will repay the long-term bond over the 30 years contract. The long-term debt portion also varies in size and ranges from 40% to 60% of project costs. Typically, under the DBFOM delivery model, both the short- and long-term debt portions typically range between 70% and 90% of the project costs. The remaining portion, 10% to 30%, is financed by private equity.

During the operations and maintenance term, costs are also supported by a combination of Tipping Fees, revenues from recycled materials, and revenues from sale of energy through a Power Purchase Agreement or heat off-take arrangements. The following section provides a detailed description of each source of financing.

8.2.1 BANK FINANCE

In the P3 context, bank financing is simply a bank loan secured by the contract between the Procuring Authority and the preferred proponent. In recent P3 transactions, due to the impact of the financial crisis on the banks' risk tolerance, bank financing has generally been available to finance the construction period of the project ranging between three and five years backed by a Substantial Completion Payment made at the end of construction by the Procuring Authority. The bank financing amount has generally been equal to the Substantial Completion Payment, which can range between 40% and 60% of the total project's capital costs. Current market conditions suggest that private sector financing is limited by technical risks involved in this sector. Sources of bank financing include loans from Canadian and international commercial banks.

Market sounding participants noted that emerging technologies are more difficult to finance than those that are tested and mature in the market. Market capacity from Canadian banks suggests that size of borrowing may range from $75 million to $300 million for large scale Energy-from-Waste projects. Availability of bank financing is subject to the risk appetite of lenders and the relationship between the lender and the borrowing party.

8.2.2 BOND FINANCE (LONG-TERM DEBT)

The majority of third-party financing for P3 projects consists of long-term debt finance, which typically varies from 40% to as much as 60% of the total financing requirement, depending on the perceived risks of the project.[54] Long-term debt for P3 projects is issued mostly by private placement of bonds, with few public offerings. Investors for long-term debt financing include, but are not limited to Canadian and international banks, pension funds and insurance companies. The tenor for long-term bonds can be up to 30 years, corresponding to the length of the operating contract or P3 concession period. Prior to 2008, long-term bank financing was available through European banks for P3 projects.

8.2.3 EQUITY (PRIVATE CAPITAL)

The preferred proponent will contribute their equity into the project to fund the remaining portion of the capital costs. Equity is the most costly source of financing as equity holders require the highest return on investment. Based on industry guidance and precedent projects, equity returns can range from 12% to 16% for Energy-from-Waste P3 projects.

Equity is necessary to ensure that the private partner's financing is fully committed to the project and thus cannot be withdrawn or cancelled half-way through the construction or concession phase. In addition, it ensures that the private partner has a long-term interest in the project derived from earning their return over the full life of the Project Agreement (i.e., not skewed towards the early years of the Project Agreement).

Table 10 illustrates the use of debt and equity in recent Energy-from-Waste projects that have been procured using the Design-Build-Finance-Operate-Maintain delivery approach. These projects are typically financed using a blend of debt and equity. Due to the technical nature and complexity of Energy-for-Waste facilities (i.e., technology, waste composition, facility size), debt providers typically require a higher level of equity in relation to other social infrastructure projects, such as hospitals, roads and water/wastewater. In some cases, the private sector has secured financing through their current strategic stakeholders.

TABLE 10 Use of Debt and Equity in Energy-from-Waste Projects

PROJECT	REGION	TOTAL VALUE (USD)	TOTAL DEBT (USD)	TOTAL EQUITY (USD)	DEBT/ EQUITY
Buckinghamshire Energy-from-Waste Plant PFI	United Kingdom	$356.0M	$291.5M	$64.5M	82:18
Cambridgeshire Waste Facility	United Kingdom	$137.0M	$121.0M	$16.0M	88:12
Cornwall Energy-from-Waste Plant	United Kingdom	$363.4M	$281.7M	$81.6M	78:22
Cumbria Waste Plant	United Kingdom	$124.0M	$91.6M	$32.4M	74:26
Essex MBT Plant	United Kingdom	$255.4M	$220.7M	$34.7M	86:14
Greater Manchester Waste	United Kingdom	$1,092.6M	$857.3M	$238.3M	72:28
Lancashire PFI Waste	United Kingdom	$776.8M	$672.8M	$104.0M	87:13
Norfolk Waste PFI – Contract B	United Kingdom	$321.6M	$258.3M	$63.3M	80:20
Oxfordshire Waste Facility*	United Kingdom	$329.6M	$0M	$329.6M	0:100
Poznan Energy-from-Waste Plant	Poland	$334.2M	$271.9M	$62.3M	81:19
South Tyne & Wear Waste PFI	United Kingdom	$456.1M	$317.6M	$138.5M	70:30
Suffolk Waste Plant**	United Kingdom	$348.1M	$0M	$348.1M	0:100
Western Riverside Waste Authority Belvedere Energy-from-Waste	United Kingdom	$1,128.8M	$920.9M	$207.9M	82:18
Barnsley Doncaster and Rotherham Residual Waste PFI Facility	United Kingdom	$356.0M	$291.5M	$64.5M	82:18

* The private partner (Viridor) is investing the entire $329.6US (£205 million) to finance a project that did not receive any PFI credits from the UK government.[55]
**The private partner (SITA UK) is financing the project on balance sheet - a strategy understood to have been chosen by the firm in order to maximise its chances of landing a bid and building its presence in the UK waste sector. Its original bid featured a bank solution with Royal Bank Investments acting as equity provider.[56]

[54] European P3 Expertise Centre (2011) "The Guide to Guidance: How to Prepare, Procure and Deliver P3 Projects".

[55] Infrastructure Journal Online (March 2011) "Viridor closes Oxfordshire waste PPP" IJ Online, http://www.ijonline.com/Articles/68206 (Accessed: April 2, 2014).

[56] Infrastructure Journal Online (October 2010) "UK waste deal reaches FC", IJ Online, http://www.ijonline.com/Articles/64915 (Accessed: April 2, 2014).

8.3 Energy-from-Waste Revenue Opportunities

8.3.1 TIPPING FEES

Procuring Authorities and operators customarily use Tipping Fees as a main source of revenue from Energy-from-Waste facilities to offset the facility operating costs. Tipping Fees (also known as Gate Fees) are financial charges levied on each tonne of waste accepted at a site for treatment, and are used to off-set the facility costs. Tipping Fees for similar waste management options vary substantially both within and across provinces in Canada and internationally.

In Canada, Tipping Fees range from $108/tonne[57] in Metro Vancouver to $112/tonne[58] in the Region of Peel; meanwhile in the United States, fees range from $53/tonne in Florida to $85/tonne in New Jersey; in Europe, Tipping Fees for facilities in the United Kingdom vary between $80 and $150/tonne; in Denmark and Germany they vary between $100 and $150 tonne.[59]

Table 11 below provides a summary of Tipping Fees for a number of facilities based on a market survey in the United Kingdom. It should be noted that even though Tipping Fees typically reflect capital and operating costs of a facility, they are also significantly impacted by constantly changing market and regulatory conditions, and therefore estimates provided herein should be referenced with caution.

TABLE 11 Tipping Fees for Residual Waste Management Treatment Technologies in the UK[60]

TECHNOLOGY	GATE FEE RANGE (CDN $)
Incineration with Energy Recovery[61]	$80 to $160 per tonne
Mechanical Biological Treatment	$101 to $130 per tonne
Anaerobic Digestion	$54 to $93 per tonne
Fermentation Production	N/A

Factors used to determine Tipping Fees for waste facilities are complex and range from facility capacity, contract specifications (e.g. profit margin), technology used, age of a facility, and revenue sharing from the sale of recovered materials and/or energy. Tipping Fees are typically collected by the owner of the waste processing or disposal facility. For example, Tipping Fees charged at Algonquin Energy-from-Waste Facility in Peel Region are collected by Algonquin Power, the owner and operator of the facility.

8.3.2 ENERGY AND MATERIALS MARKET

The sale of energy (e.g., electricity, heat, steam, etc.) represents the second most important revenue stream for an Energy-from-Waste facility. These facilities generate revenue through sale of energy produced and materials recovered. Revenues from the production of energy and materials recovered vary significantly because they are dependent on the quality of recovered material (i.e., degree of contamination) and the type of energy generated, market conditions and outlets, and provincial regulations.

Revenues from electricity generation are often received through contracts or partnerships with local utility providers. The proposed Durham York Energy Centre Energy-from-Waste facility plans to partner with the Ontario Power Authority, which will purchase generated electricity at 8 cents per kilowatt-hour. Similarly, revenues from heat or steam generation can be negotiated under similar terms. Lastly, the sales of other outputs and residues, such as secondary aggregates made from Bottom Ash, are not expected to off-set costs, as markets for such as materials are not well developed in Canada.

[57] Algonquin Power Energy From Waste (2011) - Waste Supply Agreement Proposal, http://www.peelregion.ca/council/agendas/pdf/rc-20111027/communication-pw-b2.pdf (Accessed: March 1, 2014).

[58] Metro Vancouver (2013) "Greater Vancouver Regional District Zero Waste Committee: Meeting Agenda", http://www.metrovancouver.org/boards/Zero%20Waste%20Committee/Zero_Waste_Committee-October_3_2013-Agenda.pdf (Accessed: March 1, 2014).

[59] Inter-American Development Bank (2013) "Guidebook: For the Application of Waste to Energy Technologies in Latin America and the Caribbean".

[60] WRAP UK (2011). "Comparing the Cost of an Alternative Waste Treatment Option – Gate Fee Report."

[61] Includes all forms of thermal treatment in UK (e.g., Mass Burn, Gasification, etc.).

8.3.3 ENERGY OFF-TAKE AGREEMENTS

Each province across Canada has its own energy market, subject to different legislation and requirements. Energy-from-Waste proponents within each project must understand the local market and stakeholders within their respective provinces. Energy off-take counter parties across Canada are as follows:

TABLE 12 Energy Off-Take Counter Parties across Canada

PROVINCE	ENERGY OFF-TAKE COUNTER PARTY
British Columbia	BC Hydro
Alberta	Utility Buyers*
Saskatchewan	SaskPower
Manitoba	Manitoba Hydro
Ontario	Ontario Power Authority
Quebec	Hydro Quebec
Newfoundland	Newfoundland Power
New Brunswick	New Brunswick Power
Nova Scotia	Nova Scotia Power
Prince Edward Island	Maritime Electric
Northwest Territories	NWT Power Corporation
Yukon	Yukon Energy Corporation

* Alberta's liberal energy market allows electricity producers and consumers to select a utility counter party. As such an Energy-from-Waste facility would need to negotiate an electricity off-take rate with a specific utility, or respond to a call for renewable electricity.

Recently developed projects show that there is no uniform system for procuring an energy off-take agreement. The route to developing a Power Purchase Agreement for Energy-from-Waste produced electricity is through negotiations with the local counter party.

Market sounding participants indicated that the Procuring Authority may be better placed to lead Power Purchase Agreement negotiations. Given the unique nature of each province's electricity landscape and each Energy-from-Waste project, a Procuring Authority considering a project should, at a minimum, take into account the following when deciding how to approach Power Purchase Agreement negotiations:

- Contracting party: Often the energy off-take counter party prefers to negotiate with the party that will be signing the contract whether it is the private sector or the Procuring Authority, albeit with a range of advisors present to guide and advise;
- Relationships: Determining which relationships exist among the municipality, the technical provider, financial advisor, etc. and the Power Purchase Agreement counter party. The strongest should be leveraged to open and sustain negotiations;
- Experience: Ensure that the party with the greatest Power Purchase Agreement negotiations experience is at the negotiating table; and,
- Contract term: Ensure that the Power Procuring Agreement contract aligns with the concession period and includes a floor price.

Given the negotiation process and unique energy marketplaces within each province, rates for energy have been reported to range between 8 cents/kWh and 14 cents/kWh across all jurisdictions.

Another challenge to consider for those planning this type of project is the province's requirement/appetite for additional load generation. The desire for additional load electricity varies between provinces and the latest market trends should be sought very early in the initial project planning. The absence of an open Power Purchase Agreement market across all jurisdictions could provide significant economic challenges to a proposed project. Drawing from lessons learned in other markets, Procuring Authorities have begun to consider acting as the energy off-take counter party, using the electricity to meet their own base load needs.

In the UK market, the combination of rising energy prices and liberalized market structures have provided opportunities for Procuring Authorities to provide energy and related services to their communities. Examples include the Coventry City Council's development of a heating network from an existing Energy-from-Waste facility to heat its municipal offices and other social infrastructure, and the Greater Manchester Regional Council's securing Ineos Chlor as an anchor tenant for both electricity and heat off-take, negating the need for a Power Purchase Agreement with traditional utility.

8.3.4 HEAT OFF-TAKE

The ability to transfer heat in addition to/instead of electricity provides significant revenue generation flexibility to Energy-from-Waste projects. Heat from an Energy-from-Waste facility is typically transferred via piped-steam to nearby heat-load centres. Steam for sole-recipient or district-heating can typically only be transferred over 2 km before the steam's thermal properties degrade to a non-viable level. Due to this constraint, projects seeking to produce steam are typically located close to their intended heat counter party.

Heat off-take contracts are developed through negotiations with local heat counter parties. Steam off-take terms vary considerably for both steam value and contract structure. When developing a financial model for an Energy-from-Waste project, the market value of a steam off-take contract should be included to illustrate the credit, revenue and operational risks for the heat-counter party.

8.3.5 BIOFUELS OFF-TAKE

Biofuels are a mandated commodity within Canada and the United States. Off-take agreements may be easier to obtain because of the demand commanded by the transportation fuels sector. Within Canada, the market demands a minimum of 2 million litres of renewable fuel be purchased by petroleum blenders. In the United States, the market demand is approximately 22.7 million litres. The off-take customer is also not limited by geography in the case of biofuels because the product can be stored and transported.

8.4 Energy-From-Waste Funding Conclusions

Energy-from-Waste projects are funded using a combination of the aforementioned solutions. Funding sources available for these projects vary depending on factors including, but not limited, to technology, ownership, economics, and experience. Procuring Authorities are encouraged to consider the following:

- Financiers tend to provide more favourable financing terms for Energy-from-Waste projects that feature mature and proven technologies, such as Mass Burn or Mechanical Biological Treatment. The availability of energy and materials markets impacts the economics of a project. Procuring Authorities are encouraged to conduct a thorough analysis of these markets to understand the benefits that the potential sale of outputs may incur for the Procuring Authority and private sector partners.
- Energy-from-Waste projects are more complex than many other P3 infrastructure projects, and many lenders have limited Canadian experience with this asset class. This unfamiliarity will likely increase financing cost and/or time to financial close.
- Lenders that are not familiar with or do not have experience in this sector may have a lower risk appetite than those with sector experience. Procuring Authorities and bidders are encouraged to seek out lenders with strong knowledge in this sector.
- When developing these projects, Procuring Authorities should consider the potential reduction in annual operating costs due to the realization of energy and materials revenues. In the case of the Durham York Energy-from-Waste facility, the budgeted annual electricity and materials revenues reduce the gross annual operating costs by approximately 60%.[62]
- To provide a rough estimate of potential revenues generated by these facilities, using the Durham York Energy-from-Waste facility as an example, the budgeted electricity revenues make up 58% of the gross annual operating costs and 12.6% of the total capital costs, while budgeted materials revenues make up 2% of gross annual operating costs and 0.4% of total capital costs (this is subject to negotiation).

[62] York Region Environmental Services Committee (January 19, 2011) "Energy from Waste Towards Sustainable Waste Management – Presentation to Environmental Services Committee."

- Changes in the regulatory environment could lead to unpredictable revenues or deficits. To ensure that the Procuring Authorities and private sector partners are aware of potential revenue risks, they may consider conducting extensive sensitivity analyzes on revenue projections to determine risk appetite and risk transfer conditions.
- Under a DBOM delivery model, Substantial Completion Payment is made by the Procuring Authority at construction completion to pay for 100% of the project costs. While, under a DBFOM model, a portion of the project costs may be covered by a Substantial Completion Payment, however, the majority of the project costs are funded by long-term borrowing that is typically amortized over the length of the contract and repaid through a portion of the Annual Service Payment.
- The P3 delivery model has a greater impact on the financial structure of an Energy-from-Waste facility than funding sources. When undertaking a project as a P3, the Procuring Authorities need to consider the availability of long-term financing. If long-term financing is unavailable under a DBFOM delivery model, the Procuring Authority may consider alternative delivery models to accommodate the capital requirements of the project.

Given the negotiation process and unique energy marketplaces within each province, rates for energy have been reported to range between 8 cents/kWh and 14 cents/kWh across all jurisdictions.

9.0 Market of Service Providers and Industry Players

9.1 Market Sounding Objective

A market sounding was undertaken to gain a better understanding of the of the Canadian Energy-from-Waste sector, based on the perspective of key industry players such as Procuring Authorities, Energy-from-Waste technology providers, operators, project financiers, and utility companies.

The following aspects of this sector and related projects were discussed:

- The current state of the Canadian Energy-from-Waste sector;
- Key drivers and barriers to Energy-from-Waste projects;
- Project delivery models; and,
- Approvals and permitting considerations.

9.2 Key P3 Observations of Industry Players

All market sounding participants expressed a number of concerns with a range of elements within this sector in Canada.

9.2.1 PROJECT DELIVERY MODELS AND THE COMPLEX PROCUREMENT PROCESS

All technical, utility and financial participants expressed how the complex nature of a traditional Energy-from-Waste procurement process could increase risk, lengthen development timelines, and add costs. Of the municipalities interviewed, the DBOM model was the most commonly applied procurement delivery model, with the Procuring Authority retaining ownership of the facility and providing guarantees for a portion of input waste streams. Technology providers and operators provided similar views on the DBOM delivery model. Technology providers and operators experienced in DBFOM arrangements noted that Procuring Authority guarantees for input waste streams would be necessary in negotiating an agreement and securing performance.

DBFOM arrangements were cited as adding costs to the procurement process, but also providing structure and helping to reduce a Procuring Authority's unknowns surrounding project requirements and technology. On the other hand, interviews with financiers indicated their preference for the DBFOM delivery model. Financiers specifically noted that DBFOM procurement process anchors the risk transfer process through private financing, and the additional oversight provided by lenders and other private sector partners.

Market sounding participants suggested the need for detailed procurement documents, with defined timelines, requirements, project variables, and well defined output specifications. Respondents noted that procurement documents need to be informative and allow for innovation (i.e., design, construction, residuals management), yet concise enough to prevent lengthy response and award timelines. They also added that the evaluation criteria should be influenced by technical components and developed by external technical and financial advisors. Many jurisdictions have proposed multi-phased RFQ processes to narrow down technology, facility size, and site considerations.

Lenders noted that in a majority of instances they would not fund un-proven technologies, but that unproven/newer technologies could be procured through the DBOM model. They added however that such procurement processes need to have the ability to screen-in serious players, in order to bring these technologies to market. Moreover, according to lenders, unproven/newer technologies have different risk and return profiles for funding, and Procuring Authorities need to do their due diligence at the project business case stage, and conduct an in-depth analysis to select a particular form of technology.

Respondents also drew attention to the need for municipal guidance on project requirements, such as site location, technology types, and facility sizes at the project business case stage. Several participants cited the City of Surrey as an exemplary case of a Procuring Authority undertaking due diligence (i.e., waste composition, site selection, waste flows) on Anaerobic Digestion technology, to identify and signal to the market unique project specific risks.

Developers recommended a $75 to $100 million minimum threshold for DBFOM Energy-from-Waste projects, particularly to attract competitive funding.

9.2.2 APPROVALS, AGREEMENTS, AND PERMITTING CONSIDERATIONS

Of the numerous approvals, agreements and permits involved in an Energy-from-Waste project, market sounding participants were most concerned with permitting for sites, Environmental Assessments, and Power Purchasing Agreements. Environmental Assessments were noted to be lengthy and complex for these projects as they touch upon a number of environmental areas including: emissions to air, land and water; residue management; consumption of natural resources; potential noise, odour and visual impacts; and land and siting requirements. Municipal guidance or ownership of the Environmental Assessment or site permitting requirements during the project development/pre-procurement stages may alleviate concerns surrounding the procurement and financing processes.

Power Purchasing Agreements are usually negotiated on a bilateral basis between the utility and the private sector. Negotiations can yield varying prices across jurisdictions, depending on timing and negotiating parties, often resulting in inconsistent and uncertain revenue opportunities for the private sector. Market sounding participant concerns over agreements emphasized the incongruent energy policies that exist, specifically, the fact that different regulations and policies across jurisdictions create difficulties in assigning benchmarks for comparable negotiation rates and strategies.

Each stakeholder participating in market sounding discussions noted unique concerns and motivations for negotiating Power Purchasing Agreements in the Canadian Energy-from-Waste sector. Technology providers suggested that in seeking negotiations with utility companies, municipal support or presence could offer better rates. Procuring Authorities were deemed as being well equipped to negotiate Power Purchasing Agreements, as it was noted that partnering with a government organization can provide a more "stable" agreement and more favourable price.

Participants representing utility companies were most concerned with the negotiation and establishment of Power Purchasing Agreements. Energy-from-Waste contracts are tailored to individual projects. Power Purchasing Agreement terms typically last between 15 and 35+ years, and negotiations should be undertaken once environmental permits are in place and the Environmental Assessment underway. Typically, utility companies do not hold meaningful negotiations until there is an indication of the assessment being completed.

Participants stated that Power Purchasing Agreement negotiations should start at the latest point possible in the project development process. Utility companies also added a caveat for facility operators or those benefiting from the sale of electricity outputs, as they often have misconceptions on the revenue opportunities provided by Power Purchasing Agreements. Public and private sector participants must manage their expectations and balance potential Power Purchasing Agreement revenues with Tipping Fees and other revenue opportunities.

Depending on permitting, negotiating parties, site location and financing, the Power Purchasing Agreement negotiation process can take anywhere from one day to seven years. The contract signee is the lead party, with utilities agreeing that they will not negotiate with any other parties from the consortium as this can draw the negotiations in different/unwanted directions. Often, Power Purchasing Agreements introduce penalties if electricity production falls below a certain level, or if there is a failure to obtain final permits or provincial government targets/objectives.

9.2.3 TECHNOLOGY COMPATIBILITY

A Procuring Authority's technology bias or preference may lead to the consideration of inappropriate technology solutions and potential problems in the procurement process. Additional technology concerns are related to the bankability of new technology and reliability of new and untested technologies. Participants voiced concerns that overly optimistic technology providers may downplay commercialization and scale-up risks, to the detriment of the entire Energy-from-Waste sector.

Participants also noted that significant challenges exist when scaling-up unproven equipment, including transfer of design theory to reality, comprehension of waste complexity, understanding of the capital required to complete a project, and/or sufficiency of logistical and operating experience. Participants suggested that inappropriate technology choices tended to be driven by inexperienced Procuring Authorities. To minimize risks associated with technology selection, Procuring Authorities may wish to seek input from sector experts, and consider mature technologies, such as Mass Burn, with a track record or predictable performance.

9.2.4 SITE SELECTION

During the market sounding exercise it was noted that technology providers and private lenders prefer to have the site identified prior to commencement of the procurement process and that the Procuring Authority manage this risk (ideally) by obtaining planning permission in principle for the site prior to initiating the procurement process. For example, the site for the Durham York Waste-to-Energy facility was selected during the Environment Assessment process to eliminate any uncertainties that may arise from the site selection during the procurement process.

It was noted that the private sector would be better served if the Procuring Authority took on permitting and Environmental Assessment approval risk, since lenders do not appreciate having to absorb this "unquantifiable risk". Participants similarly acknowledged that Procuring Authorities would be best served to select a site, followed by technology, but that this is not always possible based on regional constraints, whereby getting an agreeable site from constituents is a major hurdle to overcome. Procuring Authorities also need to collaborate with the private sector to establish an optimal technology for a given site.

In light of public opposition, Procuring Authorities are typically required to place Energy-from-Waste facilities far from the local population. The consequence is that plants are then unable to fully harness the energy that they are capable of producing, as heat cannot be transported long distances. There are major opportunities to use even more Energy-from Waste in the form of heat, if linking of heat customers to Energy-from-Waste plants is encouraged.

Participants also noted that the choice of site has a critical impact on the marketability and viability of an Energy-from-Waste facility, including the choice of technology and outputs. Participants suggested that Procuring Authorities should consider proximity to the following when selecting a site: electricity connection lines/grid, industrial steam customers; landfills (for ash disposal); water; access roads; and other utilities.

9.3 Key Sector Observations

9.3.1 UPFRONT CAPITAL COSTS

Some market sounding participants noted that current upfront costs for developing an Energy-from-Waste facility exceed those of a landfill site. These participants suggested that high upfront capital costs could discourage public authorities from pursuing Energy-from-Waste facilities or options, leading to the use of landfills for lower front-end costs to align budgets. On the other hand, some public sector market sounding participants suggested that high closing costs of a landfill site were greater than the upfront costs for projects. These participants also suggested revenues earned from energy and commodity sales during operations could be used to offset operating costs.

All market sounding participants discussing capital costs agreed that an uneven playing field exists for landfill sites when compared to an Energy-from-Waste facility, driven by materially different environmental requirements between new Energy-from-Waste facilities and legacy landfill sites. Landfill sites currently provide a less expensive destination for municipal waste, with a few market sounding participants suggesting that these sites exclude externality costs and impacts. The inability to develop new landfill sites has resulted in waste being transferred between regions seeking the least costly solution to waste disposal, and adversely impacting the effectiveness of Energy-from-Waste.

Despite such wide-ranging economic viewpoints, it was clear that Procuring Authorities would need to consider all costs over a long-term time horizon to properly understand the overall project cost differences between Energy-from-Waste and landfill options. Both options must also incorporate potential revenue opportunities to offset project costs. The landfill option is subject to additional revenues through Tipping Fees, provided it is owned by the Procuring Authority, while facilities may recoup costs through the sale of energy and other outputs produced. Currently, Energy-from-Waste capital costs are typically higher than those for landfilling.

9.3.2 PROJECT SCALE REQUIREMENTS

Canada's geographic expansiveness may challenge the plans of smaller communities seeking to integrate Energy-from-Waste infrastructure into their overall waste management solution. It was suggested that smaller communities consider pooling resources with neighbouring communities, possibly employing a 'hub and spoke' model for collection and processing. The hub and spoke model in this sector relates to the provision of appropriately sized of the infrastructure in a specific region relative to available waste flows.

Market sounding conversations indicated that a thermal reduction of a facility would only be economical with waste flows of 100,000 tonnes per annum or greater. Communities with less than 100,000 tonnes per annum capacity requirements would be advised to instil a regional approach in which communities combine waste streams and undertake as much economically viable waste stream upgrades as possible at a local level as waste input supply for a centralized facility.

The hub and spoke model also requires Procuring Authorities to consider the transportation costs and environmental impact of additional transfers and haulage. An example of the hub and spoke model can be seen in the Durham-York Energy-from-Waste facility, where 70% of waste is provided from the Durham region and 30% of waste is sourced from the York region.

9.3.3 SOCIAL LICENSE TO OPERATE

A strong trend and concern from all market sounding participants was the need for Energy-from-Waste projects to obtain the social license to operate (i.e., general public buy-in). In jurisdictions where Energy-from-Waste is less well known, the public often has outmoded pre-conceptions about the industry, based on emissions in the past, and the perception that Mass Burn/incineration is an "old" technology. Mass Burn/incineration is a technically mature and reliable means of treating residual waste and new plants are built both in Canada and abroad.

The majority of participants recommended that commencing the public consultation process early is a key to a project's success. The public consultation process should also continue throughout the development of the project, with clear demonstration each time that feedback gathered from previous consultation sessions has been considered in the project plan. Proactive communications with clear messaging regarding site, technology, odour and transportation impact on human health, etc. are seen as important approaches to inform the wide array of project stakeholders. It is critical for Procuring Authorities to consult as early as possible with potential technology providers, as well as technical and environmental advisors to obtain information on each technology and their human health impacts.

9.3.4 SOLID POLITICAL SUPPORT

As these projects are often a key component in developing integrated waste management solutions for Procuring Authorities, market sounding participants noted the need for a strong political champion in support of these projects. Respondents expressed that a project would require a political champion to promote the procurement process and related projects. Procurement process support was noted as an important factor, given the length of development time and permitting required. This could be supported by providing information and guidance to council on the procurement steps.

Helping Procuring Authorities understand the changes to their local waste landscape, project risks, and benefits is vital to project success. The changes to the local waste landscape could vary significantly from project to project, however there is a shift in residual waste management from a logistical exercise of collection and haulage to landfill, to an operational and market-based skill set. Market sounding participants noted this could present challenges to the project and wider political support without proactively managing both the skills transfer and messaging surrounding this process.

It was also noted that private sector participants who have undertaken prior Energy-from-Waste project developments have strong public relations skills and understand the concerns of local residents and stakeholders. Project developers are often very eager to work with Procuring Authorities to provide communications and public messaging for the project.

9.3.5 EMISSIONS

Some market sounding participants specifically cited public concerns on air emissions as a barrier to Energy-from-Waste project development. These concerns are often linked with Mass Burn or grate technology, and the fear of an adverse impact on air quality in the host community. Public concerns surrounding air emissions can originate at the outset of project development, with press coverage or other, often unplanned, news releases. Project opponents will regularly champion air emission risks to derail project development, often building on a population's inexperience with the technology.

Market sounding participants suggested mitigation strategies such as public consultation with host and neighbouring communities, and transparency surrounding project developments. Consistent messaging was also noted from market sounding participants as an important factor to reinforce public engagement. From a technical perspective, designing a facility to exceed current or likely future emission standards can contribute towards earning the social license to operate.

9.3.6 AVAILABILITY OF FEEDSTOCK

Energy-from-Waste projects are supplied waste feedstock from municipal waste streams, with Procuring Authorities providing waste tonnage guarantees. Of all the project development activities, feedstock forecasting is one of the most important, providing a base for facility sizing calculations and the required level of future Procuring Authority waste-flow guarantees. Some market sounding participants noted concerns regarding the long-term availability of waste streams, as increased recycling efforts and pressures to minimize waste gradually reduce waste availability. It was also noted that waste composition could change over the life of a long-term operating contract.

Participants expressed concern that an overly prescriptive operating contract, or a strong reliance on one revenue source may render a facility ill-equipped to adapt to changing waste compositions and the associated changes in waste calorific value. Participants expressed a view that the private sector should have the option to contract or process merchant waste from industrial, commercial and institutional or construction and demolition sources to make up for any feedstock shortfalls.

In projects with a private financing component, lenders typically require that unsecured third party waste is no greater than 15% to 20%. Participants noted that in some jurisdictions, provincial environmental ministries may specifically prohibit certain waste flows to a facility. In the case of Durham-York Energy Centre, the Ontario Ministry of the Environment specifically included a provision in the Environmental Assessment and Certificate of Approval preventing the facility from accepting any waste that would not be controlled by the municipality.

9.3.7 INDUSTRIAL, COMMERCIAL AND INSTITUTIONAL WASTE

Procuring Authorities seemed eager to find a solution allowing them to integrate industrial, commercial and institutional waste, which has typically remained outside municipal control. In certain markets, flow control legislation has been enacted to address this issue, for example, the Halifax Regional Municipality passed by-law S-600 prohibiting the movement of municipal solid waste (including industrial commercial and institutional waste) generated within the boundaries of the Halifax Regional Municipality to be exported outside its jurisdiction. Moreover, municipalities in Nova Scotia have been given full authority to enforce requirements for all municipal solid waste, irrespective of the generating source. Participants noted that in Ontario, one of the largest Energy-from-Waste markets in Canada, the *Municipal Act* does not afford municipalities the same level of control. Instead, Ontario municipalities are only able to control residential waste. Conversely, waste diversion for industrial, commercial and institutional waste is regulated through the *Environmental Protection Act* under the Ministry of the Environment.

The private sector operators discussing industrial, commercial, and institutional waste; and construction and demolition waste in the market sounding process did not provide a consensus view on how to guarantee additional streams of non-municipally sourced waste, or how it could be captured by a facility. Some participants noted that industrial commercial and institutional waste could be sourced through short-to-medium term supply contracts with national/regional waste supply contractors, landfill tariffs/taxes, and legislation such as those imposed in the Halifax Regional Municipality.

Private sector operators suggested industrial commercial and institutional waste could be included as a potential source of Energy-from-Waste input feedstock, should municipal waste stream volume and composition change over time. Some developers noted, from a commercial standpoint, that they would be willing to retain the risk of sourcing up to 20% of a facility's feedstock requirement from the industrial commercial and institutional waste sectors. In some European countries without landfills, developers have been responsible for sourcing up to 40 to 50%.

9.3.8 JURISDICTIONAL APPROACH TO ENERGY POLICY

Each province has a unique energy market that requires Procuring Authorities to understand their local market and associated stakeholders/counter parties. Augmenting the process challenges presented by market diversity within Canada is a need for base load electricity on a macro-market level. Each province has a different base load need, which some market sounding participants felt drove an inconsistent policy approach to Energy-from-Waste.

9.3.9 COMMODITY MARKET

These facilities can prioritize the production of recycled products and other commodities, while decreasing the quantities of electricity or heat being generated. Facility operators expressed a concern over the lack of a Canadian market for Energy-from-Waste recycling products, excluding electricity and steam. The perceived market weakness typically forces reliance on electricity and to a lesser extent heat output, which may limit project development options, and suffer long term consequences based on waste flows and output quality.

Operators can include innovations for source separation of the incoming waste streams, to generate as much value as possible from recycled products. A focus on recyclable or saleable outputs can adversely impact Tipping Fees, which many Procuring Authorities are seeking to minimize, due to a reliance on volatile sources of revenue.

9.4 Market Sounding Conclusions

Market sounding participants supported developing projects under DBOM or DBFOM procurement mechanisms. Many cited the benefits of the DBFOM procurement process, including the anchoring the risk transfer process through private financing, and additional oversight provided by lenders and other private sector partners.

In considering the approvals, agreements and permits involved in an Energy-from-Waste project, market sounding participants were most concerned with permitting for sites, Environmental Assessments, and Power Purchase Agreements. The lengthy Environmental Assessment process was noted to be a risk in securing financing and meeting project timelines. Procuring Authority involvement in the Environmental Assessment process and Power Purchasing Agreement negotiations was highlighted as a positive influence in the development of these projects. Procuring Authorities can mitigate these risks by developing detailed waste composition studies, a draft Power Purchasing Agreement, defining technology, and conducting public consultations throughout the project development and RFQ stage.

The overwhelming majority of market sounding participants view this sector in Canada with cautious optimism. This perspective is in light of rising environmental awareness, associated environmental regulations, increased landfilling costs, and new landfill site development, as principal drivers behind Energy-from-Waste's increased profile and future project pipeline.

10.0 Project Planning and Procurement Considerations

10.1 Introduction

This section presents an overview of some of the key factors to be taken into consideration when planning and procuring an Energy-from-Waste project. Many of these factors, such as public consultations and Environmental Assessments, will be present regardless of the delivery model that is pursued, whereas others will be specific to the model. This is the case for financing, hand back, and procurement considerations.

10.2 Public Consultation

As noted by market sounding participants, public perception and acceptance of this type of project are vital to the sector's growth and success. Public opinion and concerns seem to focus on public costs, health and safety, and other impacts on local communities caused by Energy-from-Waste processes and technologies. Market sounding participants have attributed these public concerns to a lack of public awareness of this sector, public misconceptions about incineration technologies and benefits, and a lack of public education/access to information on Energy-from-Waste in general.

Public consultation is an important tool in garnering community feedback and acceptance for Energy-from-Waste projects. In the planning process for the Durham-York Energy-from-Waste facility, public consultations were held during the initial discussions for the project, and also after significant project milestones such as selection of a preferred site, technology selection, Environmental Assessment submission, and commencement of facility construction. This process demonstrated to the public that the Region was taking the necessary measures to incorporate and address the public's concerns throughout the planning and development phases of the project in order to maintain public support.

The overarching goal for public consultation is to support Energy-from-Waste project planning activities by informing, engaging and obtaining feedback from all stakeholders. It is important to develop and implement multi-faceted consultation programs that will integrate different and relevant stakeholder groups, such as First Nations communities, lower-tier municipalities, and the general public by:

- Identifying stakeholders at the outset of the process;
- Implementing a combination of traditional (e.g., open houses, workshops, etc.) and digital engagement (e.g., social medial, websites, etc.) methods;
- Documenting suggestions, issues and concerns; and,
- Adjusting the planning framework to respond to stakeholder input, and mitigating any potential impacts.

Additionally, the proponents of the project should be visible, accessible and accountable to the public they serve.

As highlighted through the Durham-York Energy-from-Waste project, public consultation and engagement programs should be developed early in the project decision-making process to ensure that public inputs and concerns are addressed early on. Early consultations can be successful, particularly during the project siting stages.

Metro Vancouver has included an independent third party review panel. These panels are often used to bridge dialogue between the Procuring Authority and community groups concerned with social, environmental, and economic aspects of the project. If these panels receive explicit charters and specific timeframes from the Procuring Authority, they can be very useful and help avoid significant implementation delays.

10.3 Site Selection

When a project is procured under a P3 model, special considerations must be given to the site selection process at an early stage, as the site is often required to be approved by local government and relevant provincial ministries, as well as supported by the public. When considering a site for a plant, a number of criteria should be taken into account to identify and evaluate potential constraints of a proposed site. Key criteria that should be considered include, but are not limited to, the following:

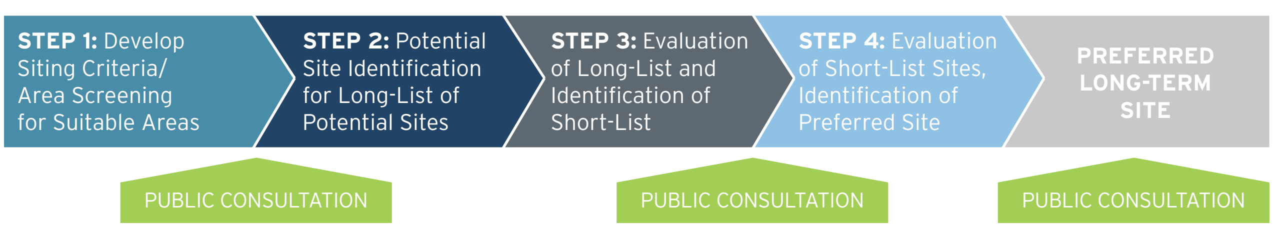
- Compatibility with planning framework (i.e., a site should be compatible with existing policy, regulatory, and land-use designation);
- Existing site conditions (e.g., geotechnical, engineering works, contamination, environmental, and logistics, etc.);
- Technical considerations (e.g., site drainage, foundation suitability, size and shape of the site, accessibility/road access, location to current and future solid waste collection area, energy sales market, and needed utilities such as electricity and water, etc.);
- Environmental/Health impacts (e.g., water quality, air quality/emissions, ecology, odour, dust, noise and other nuisances, etc.);
- Social impacts (e.g., surrounding land uses, permitting considerations, land ownership, natural conservation/heritage or archaeological impacts); and,
- Proximity to energy end-users (i.e., effective heat/energy transfer to communities immediately adjacent to the facility).

Additionally, it is necessary to have a property that is large enough to allow for building structures, as well as being able to provide a minimum buffer from waste processing to site boundaries to prevent odour problems. The amount of buffer space necessary is dependent on the type of technology chosen, and local regulatory requirements.

From a private sector perspective, site considerations such as ownership of land and Environmental Assessments drastically increase the risk profile of the project. Financiers noted during the market sounding interviews that private sector ownership of a site draws additional risk and financing considerations for planning, contamination, permitting, and timing. As noted by other respondents, Environmental Assessments and other permitting and approval requirements are often time-consuming and introduce uncertainties to project timelines. Utility companies prefer sites and facilities that are closer to the load transmission site. These sites are not always available or are too expensive to convert for use. For RFQ/RFP development, it is important to note that private sector bidders and lenders are more likely to bid on projects involving single site, publicly-owned lands with the necessary approvals already in place.

Figure 4 provides high-level illustration of the site selection path.

FIGURE 4 Site Selection Path



10.4 Technology Selection

Prior to selecting an Energy-from-Waste technology, the Procuring Authority will need to examine and analyze many factors including, but not limited to the following:

- Feasibility and affordability of the technology;
- Reliability of the technology and the experience of the technology supplier based on past examples in other jurisdictions;
- Availability of relevant energy and materials market to the technology;
- Ability to achieve desired levels of revenue;
- Likelihood of political/social approvals;
- Likelihood/ease of Environmental Assessment/regulatory approvals; and,
- Acceptable levels of technical risk by the Procuring Authority.

Some Procuring Authorities may contemplate starting the procurement process and go to market without selecting a preferred technology. From a P3 perspective, this would allow the private sector enough flexibility to determine the best solution and most suitable option for the Procuring Authority. However, it would also drastically increase the risk profile of the project and may have an impact on the ability of the project to: (i) attract qualified and competent bidders; and (ii) obtain financing from private lenders and equity holders.

Through the market sounding interviews, it was noted that the private sector prefers that the Procuring Authority clearly prescribe a 'preferred' technology solution or technology requirements. The Procuring Authority should also note that the technical expertise required for technology selection and requirements planning is often not available locally and may require input from external parties.

10.5 Environment Assessment / Permitting Process

Environmental permit approvals generally relate to the planning of projects and regulates the release of emissions to the atmosphere, discharge of contaminants to ground and surface water, management of potable water supplies, and the storage, transport, processing, and disposal of waste. In addition, public consultation and participation in the decision-making process is ensured through prescribed processes that provide an opportunity for public review and comment.

In considering the development of an Energy-from-Waste facility, an understanding of the current regulatory environment, including governing legislation and pending regulatory changes, is important as it can vary by province and location of site selected. Additionally, the environmental permit process can add cost and time to a project.

In some jurisdictions, it is common practice to complete the Environmental Assessment process before commencing the planning and procurement processes. For the Durham York Energy Centre, the Procuring Authority completed the process and approvals before moving forward with subsequent phases of the project. During the market sounding interviews it was noted that other jurisdictions, notably California, have developed an environmental approval 'review' which allows a municipality to undertake 75% to 80% of requirements needed for a full environmental approval prior to commercial close, thus substantially reducing the gap between commercial and financial close.

Market sounding participants noted that the Environmental Assessment process can take from 18 to 24 months in Canada, which is consistent with international averages. In some instances, the process can take several years. In order for Procuring Authorities to proceed through the process expeditiously, it is critical to define a site, technology and facility size. Financial close is often subject to the outcomes of the Environmental Assessment. The timing gaps associated with environmental assessments and site permitting can often impact the availability of financing, credit spreads, upward movements in their capital, and operating costs estimates, together with increasing the risks related to completion of the project. In addition, financiers noted that long-term financing rates are typically held for a maximum of up to six months. Environmental Assessment process beyond this would require refreshing overall financing.

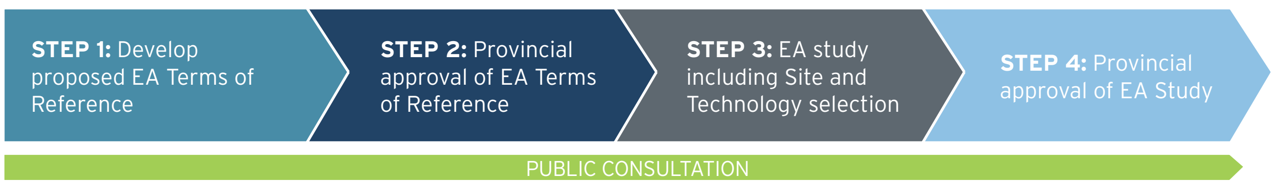
To mitigate this risk, Procuring Authorities can choose to stagger technical and financial RFP submissions. Proposals are separated into Technical and Financial Submissions, whereby the Technical Submission is provided to the Procuring Authority up to 60 days or more in advance of the Financial Submission. The Technical evaluation (i.e., design review) is a much more time and resource intensive process than the financial evaluation (i.e., scoring the price). In addition, part of the technical submission could be used to start the Environmental Assessment process, so that the process can take place in parallel to the proposed evaluation.

Staggering the technical and financial submissions allows the Project Team to complete the technical evaluation while the Proponents refine their cost estimates. In recent Canadian P3 transactions, staggered submissions have been used successfully in combination with credit spread benchmarking. Credit spread benchmarking allows Proponents to refresh the credit spreads used in their Financial Submissions at a specified point in time to reflect changes in the financial markets. The credit spread benchmarking mechanism is typically proposed by the Proponent during the Procurement Phase for Procuring Authority approval.

Municipal guidance, ownership of the Environmental Assessment, or site permitting requirements may also reduce concerns surrounding the procurement and financing processes.

Figure 5 below illustrates at a high-level the Environmental Assessment process.

FIGURE 5 Environmental Assessment Process



10.6 Energy-From-Waste Outputs

Depending on the technology selected, a facility can produce a range of outputs, typically electricity, heat, liquid transportation fuels, and/or recycled materials. The Procuring Authority should consider the marketability of the outputs when selecting the technology. This will mitigate procurement and operational risks, resulting in a more efficient and competitive process.

In the planning and development of a project, the Procuring Authority needs to determine the range/types of outputs for a proposed facility. The output specifications can be incorporated into procurement materials (including RFQ and RFP). Output specifications will be tied to input characteristics such as waste composition and quantity. As suggested by all market sounding participants, a feedstock guarantee (a minimum guarantee, in terms of payment mechanics) from the Procuring Authority is often necessary for a facility operation contract.

10.7 Waste Availability / Facility Sizing

Waste feedstock composition and its availability are key parameters used when defining and determining which technology option would be most suitable for a project. Understanding the waste feedstock will help select the right technology at the plant design stage. For instance, the larger Mass Burn technologies are less sensitive to variations in feedstock, but some of the smaller scale processes such as Gasification and Pyrolysis, are more sensitive to fuel change, generally requiring pre-treatment to homogenize the feedstock. Pre-treatment may consist of the following on-site mechanical waste preparation techniques: (i) splitting open refuse bags; (ii) shredding waste into smaller particle sizes; and (iii) removing bulky waste through a semi-or automated system.

The scale of a facility is determined based on the requirements of Procuring Authorities. Feedstock security is also the main determining factor for the size of any facility, as Procuring Authorities often provide minimum feedstock volume guarantees for private sector partners. A waste flow analysis during the initial planning stages needs to convey to private and public sector funders that sufficient feedstock is available over the life of the facility and permit it to run at capacity. Many private sector participants in an Energy-from-Waste facility will require a Procuring Authority to guarantee feedstock availability over the life of a contract.

In some instances, Procuring Authorities can be bound by put-or-pay contracts whereby a Procuring Authority purchases a service guaranteeing a specific annual tonnage of waste for processing, or pay the equivalent cost, even if treatment services are not needed. Alternative provisions can be in place where a treatment facility takes a supplier's waste (i.e., municipality waste) or pay a penalty. Such agreements are frequently employed by proponents of waste facilities as collateral for financing of large Energy-from-Waste undertakings.

10.8 Waste Flow Control

Depending on the size of a municipality or region, a waste flow system may be required. Waste flow control relates to measures taken by a municipality or regional district to ensure all municipal solid waste generated from the sectors regulated under its authority is controlled via their waste processing facilities as the volume and consistency of waste that a facility will be handling is critical to its development.

A municipality developing a facility under a P3 model should undertake robust waste flow analysis and modelling as part of the pre-investment stage activities. Ensuring feedstock availability over the life of a facility and understanding compositional value of the waste will drive facility-capacity sizing decisions and shape the entire business case. Additionally, Procuring Authorities would need to consider any potential changes to their present activities that might impact the quantity or composition of the waste they require to ensure the facility runs near capacity.

Instituting waste flow management systems can be challenging as certain waste industry market opponents view waste flow control as a means of unfairly eliminating alternative private disposal options and competition.

10.9 Financing New Technologies

Energy-from-Waste technologies are often new, with no long-term reliability benchmarks of operating history. The bankability and reliability of selected technology, and subsequent compatibility with the waste streams is a significant risk and barrier for financiers. New technology, as with many new technologies, can be regarded as 'not bankable' by some funders if there is insufficient scale-up and operating data, case studies and lessons learned to provide sufficient comfort. As a consequence, non-bankable technologies struggle to attract debt finance and are unable to access lower costs of capital often required to make these projects economically viable. Accordingly, the DBFOM model may not be economically feasible for newer technologies. Instead, Procuring Authorities seeking to develop a facility with such technology may opt to use the DBOM model.

Front end technologies (sorting) are considered bankable, as they have proven track-records, with predictable service requirements. Gasification technologies have often been balance sheet funded.

Experience has shown that technology scale-up will uncover unanticipated challenges and obstacles. Real life events and unforeseen circumstances challenge technology development timelines and often require strong innovation skills from technology developers. Technology developers are best advised to comprehensively document successes and failures, to provide a technology development "story", and to achieve gradual scale up.

Funding new technologies can be a challenge in the current financial environment, where many technology concepts are competing for a limited pool of technology-orientated risk capital. Many potential sources of development capital exist, however, traditional funding principals were developed to finance a business, rather than a technology, and as such very few non-industry funders are truly focused on technology development. For example, traditional venture capital funds seek to deploy high-risk capital, which is congruent with early stage technology development. However, typical venture capital funds require an exit within three years while typical technology development can take up to ten years.

10.10 Energy Market / Power Purchasing Agreement Considerations

During the early planning stages, the Procuring Authority should give consideration and initiate the process of obtaining a Power Purchase Agreement for the proposed facility. Securing a Power Purchasing Agreement would guarantee the revenue stream to the facility, therefore, reducing the operating costs of the facility. When planning for the Power Purchasing Agreement negotiation process, the Procuring Authority must keep in mind that utility companies will negotiate the terms of the agreement with the party that will be responsible for operating the facility.

Power Procuring Authorities are based on bilateral negotiations and the resulting guaranteed rates could vary from one facility to another even if in the same jurisdiction. Power Procuring Agreement terms should align with the length of the concession period and may last for a duration in excess of 35 years. Negotiations should be undertaken once environmental permits have been obtained. Usually there are no serious negotiations until there is advanced indication of the Environmental Assessment being completed, however, the Procuring Authority is encouraged to seek out information from the utility company in their jurisdiction to familiarize themselves with the requirements of the procedure.

During the market sounding interviews, utility companies also noted those facility operators, or those benefiting from the sale of electricity outputs, as often having misconceptions on the revenue opportunities provided by Power Purchasing Agreements. Public and private sector participants must manage their expectations and balance potential Power Purchasing Agreement revenues with Tipping Fees and other revenue opportunities.

10.11 Procurement Consideration

Energy-from-Waste procurement under a P3 arrangement can be a complex and a lengthy process; however, it provides a comprehensive framework and encompasses all aspects of the procurement, typically for the 20 to 30 year term of the project. P3s require specialized procurement (i.e., project governance, document development) and post-contract administration knowledge to be retained by Procuring Authorities to facilitate the management of the process. This element is of additional importance when considering Energy-from-Waste project procurement, due to the lack of precedent projects and the overall complex nature of Energy-from-Waste projects (when compared to other infrastructure classes). The Procuring Authority should consider the impact of regulatory compliance, site selection, public consultation, and Power Purchasing Agreement negotiations on the complexity and length of the procurement.

10.12 Hand Back / End of Plant Life Considerations

Energy-from-Waste facilities are typically built with a minimum planned life span. This is often associated with the length of the concession period or the period for return on investment. Nevertheless, the minimum planned life span is not necessarily tied to the physical lifetime of the facility. In fact, several facilities have the potential to operate for longer periods of time due to additional lifecycle investments.

For example, the Metro Vancouver Waste-to-Energy Facility, operating as Covanta Burnaby Renewable Energy, began commercial operation in March 1988. Life-cycle investments including, a $7 million upgrade in 2006 to increase the amount of heat recovered from the waste increased the quantity of electricity produced. In addition, a $4.2 million upgrade in 2013 to the air-cooled condensers is being completed to further increase the quantity of electricity being produced. Hand back / End of Plant Life investments such as these are a combination of life-cycle planning exercises conducted by the Procuring Authority and private partner throughout the concession period. Depending on the project structure, the private partner may be obligated to incur all necessary life-cycle costs to ensure the asset is handed back to the Procuring Authority as per the hand back specifications outlined in the Project Agreement.

11.0 Summary of Opportunities and Impediments for Energy-from-Waste P3 Models

11.1 The P3 Opportunity

In 2008, Canadians generated over 34 million tonnes of waste, 75% of which was predominately disposed of in landfills. Limitations on the availability of new landfill area, higher costs of disposal, and increasing public awareness of environmental sustainability have prompted an opportunity for diversion alternatives in the management of over 25 million tonnes of waste per annum. The Federation of Canadian Municipalities has suggested that municipalities across Canada are reaching 50% and beyond in their waste diversion efforts and garnering significant environmental, economic, and social recognition within their communities. Interest and investment in waste diversion programs and investment in this sector are on the rise.

Stakeholders in the waste sector have an increasing understanding of the benefits that can be derived from long-term waste planning and are now incorporating Energy-from-Waste as an option for the waste planning process. These projects are large capital undertakings, often supported by the public and private sectors. The design, construction, finance, operation and maintenance of these facilities require significant financial and technical support, often leading to opportunities for the public and private sector to collaborate through P3 arrangements.

There is an opportunity to apply the P3 model in this sector. These facilities require large capital outlays and require technological expertise that may be outside the scope of municipal responsibilities. As demonstrated through the market sounding and existing Energy-from-Waste projects, P3 models allow the private sector to bring operational and technical expertise to support the design, build, finance, operations and maintenance of these projects. The P3 model, specifically the DBFOM model, also allows for the greatest transfer of significant risks and responsibilities from the public to private sector. The choice of P3 delivery model is dependent on the Procuring Authority's appetite for risk, technology selection, financing accessibility and the availability and interest of private sector partners, among other considerations.

In Canada, there are currently five Energy-from-Waste projects in operation and/or under development that have been procured under a P3 model. These include, the Durham York Energy Centre, Metro Vancouver Waste-to-Energy Facility, the Surrey Biofuels Facility, the Region of Peel Energy-from-Waste Project, and the New Waste to Energy Capacity to Service Metro Vancouver Project.

11.2 Potential Impediments

Below are some potential impediments to the procurement of a project as a P3 model. Impediments could vary with the scope, timing, technology, jurisdiction, delivery model and Procuring Authority of each project.

11.2.1 PUBLIC AWARENESS

While the application of P3 procurement frameworks for these projects is an emerging trend in Canada, only a few projects are in development or currently operating. The addition of private sector partners in municipal, provincial and federal infrastructure projects could lead to public opposition. The opposition may be attributed to misconceptions surrounding the roles and responsibilities of the respective public and private sector partners. Educating the public on the structure, responsibilities and benefits of a P3 procurement methodology can mitigate public opposition and increase public awareness of P3 procurement of Energy-from-Waste projects.

11.2.2 PROJECT SIZE

During market sounding interviews, participants suggested that a project size of at least 100,000 tonnes per annum would achieve economies of scale, as well as financial and operational efficiency. If a project is smaller than 100,000 tonnes per annum it may be an impediment to P3 procurement. Financiers interviewed in the market sounding exercise suggested that the optimal project size is dependent on the complexity of the work and opportunity cost associated with the project. Projects with capital cost requirements greater than

$100 million are typical for a debt lender. Smaller projects may not meet the minimum requirements to obtain private sector financing. In such cases, Procuring Authorities can lean on the DBOM model. A project should be suitably sized in order to attract qualified bidders and ensure a competitive process.

11.2.3 FINANCING NEW TECHNOLOGIES

Many technologies are new to market, with limited benchmarking or long-term performance metrics. Financiers associate higher risks and costs to new technologies. Procuring Authorities may face difficulties in appropriating the necessary capital for large-scale projects. Selecting technologies with predictable performance or selecting partners with specialized expertise could alleviate financier concerns surrounding this sector projects.

11.2.4 AVAILABILITY OF ENERGY AND MATERIAL MARKETS

The challenging process for obtaining a Power Purchase Agreement in many Canadian jurisdictions, coupled with the limited availability of the energy and materials market (i.e. sale of Compost-Like Output Class B) may have an impact on realizing potential revenues, hence altering the profitability of a project. Procuring Authorities may face challenges in attracting potential bidders without providing guarantees to secure potential revenues. Under a DBOM and DBFOM delivery model, revenue related risks such as marketability of outputs, market volatility and price risk are all transferred to the private sector partner. The limited availability of energy and materials markets may impede the P3 procurement of a project, as private sector partners may have a low risk tolerance for potential revenue shortfalls.

11.3 Overall Conclusions

The following are considerations and conclusions for the procurement of an Energy-from-Waste project as a P3 arrangement:

1) There is an increased interest and investment in projects, driven by municipal waste diversion targets and limited landfilling opportunities. P3 procurement methods are applicable to Energy-from-Waste projects. In Canada two Energy-from-Waste projects, the Region of Durham Energy Centre and the Greater Vancouver Regional District Energy-from-Waste, have been procured as a P3 arrangement under a DBOM delivery model. Projects under development or in procurement, such as the Surrey Organics Biofuels Project, are considering other delivery options such as DBFOM.
2) Sources of funding available for these facilities vary depending on the technology and delivery model selected to procure the project. Traditionally, waste projects have been funded through municipal programs. Procuring Authorities are increasingly considering procuring these projects under P3 arrangements, and as such, the DBFOM model may help leverage private sector financing.
3) Selecting proven technologies minimizes the perceived risks surrounding the projects. Procuring Authorities may select a private sector partner with experience in this sector to provide input on technology selection.
4) Developing a project takes a considerable amount of time. The P3 procurement of a project involves site approvals, Environmental Assessments, permits and necessary public acceptance to move forward. Procuring Authorities should consider beginning assessments, permitting and public awareness programs in advance of the P3 procurement process to minimize delays in project development.
5) Canada's geographic expanse may pose a challenge to smaller communities seeking to deploy Energy-from-Waste infrastructure into their overall waste management solution. Smaller communities should consider pooling resources with neighbouring communities to ensure that capacity requirements are met.
6) Public perception and acceptance of these projects are vital to the sector's growth and success. The overarching goal for public consultation is to support the project planning activities by informing, engaging and obtaining feedback from all stakeholders. It is important to develop and implement a multi-faceted consultation program that is inclusive of various stakeholder groups, as applicable, such as First Nations communities, lower-tier municipalities, and the general public.
7) In considering the development of a facility, an understanding of the current regulatory environment, including governing legislation and pending regulatory changes is important, as it can vary by province and location of site selected. Additionally, the environmental permit process can add cost and time to a project. Involving environmental regulators in the RFQ and RFP phases of a P3 project may be valuable in the P3 procurement of a project. Municipal guidance or ownership of the Environmental Assessment or site permitting requirements may also reduce concerns surrounding the procurement and financing processes.

Photo Courtesy of: Covanta. Durham York Energy Centre. Mass Burn facility; expected to be operational by end of 2014.

ANNEX 1

Summary of Energy-from-Waste Technologies

1.0 Risk Ratings

The following table provides an explanation of the risk ratings used in the Energy-from-Waste technology summary tables that follow.

CRITERIA	PROBABILITY RANGE		DESCRIPTION
Low	5%	15%	There is 5-15% chance of the risk materializing during the construction and/or concession period. The private partner should be able avoid this risk from occurring through application of standard practices and due diligence.
Medium	15%	35%	There is 15-35% chance of the risk materializing during the construction and/or concession period. This risk occurs from time to time on similar Energy-from-Waste projects. These risks are generally more complex and challenging to mitigate and have a greater financial impact on the Project.
High	35%	50%	There is a 35-50% chance that the risk will transpire during the construction and/or concession period. This risk is relatively common and has materialized on many similar Energy-from-Waste projects. These risks can severely impact the bankability of an Energy-from-Waste Project under the DBFOM model.

2.0 Mass Burn Facility Summary Table

TECHNOLOGY	MASS BURN
Economic Dimension	
Capital Cost Estimate	$600 to $1000/annual design tonne
Operating Cost Estimate	$80 to $130/ tonne
Technical Dimension	
Scalability	Mass Burn facilities are typically modular, and waste processing capabilities can range on a requirement basis.
Reliability	Mass Burn facilities are well established on a commercial scale worldwide, with many operating facilities across North America, Europe and Asia. Fewer complexes than other WTE approaches. Scheduled and unscheduled downtime reported as <10%.
Feedstock	Mass Burn facilities can treat feedstock of varying composition; however, operational efficiencies are typically realized with a dryer feedstock.
Residue	Bottom Ash: 20-30% of the original waste feedstock by weight, potential use as aggregate, classified as non-hazardous. Air Pollution Control (APC) Residue (includes Fly Ash): 2 to 6% of the original waste feedstock requiring stabilization and disposal, classified as hazardous. Potential use as aggregate for concrete products once stabilized.
Energy Recovery	Energy recovery possible, however, energy recovery efficiencies dependent on production mechanism and energy conversion technology. Energy outputs include: • Heat only • Electricity through a steam turbine generator • Combined Heat and Power

TECHNOLOGY	MASS BURN
Technical Dimension	
Revenue	Revenue possible through Tipping Fees, energy production, and material recovery from waste streams. Recovered materials and outlets can include: • Bottom Ash sold as secondary aggregate • Metals sold for re-smelting and recycling
Technical Risks	Feedstock Security - High Risk Feedstock Composition - Low Risk Technology Reliability - Low Risk Technology Supplier - Low Risk Fly Ash Residue Management - Low Risk Market Outlet for Recyclables and Energy Recovery - Low Risk Performance Guarantees - Low Risk Note: Technical risks associated with Mass Burn are qualitative and based on available data at the time.
Select Examples of Operating Facilities in Canada[63,64]	
Greater Vancouver Regional District Energy-from-Waste Facility (Burnaby, BC)	Location: Burnaby, BC Capacity: 285,000 tonnes of waste per annum Energy Recovery and Outlet: approximately 600 tonnes of steam is sold to a paper recycling facility per day, and 20 MW of electricity is sold to BC Hydro enough to power 15,000 homes Bottom Ash is used as aggregate or landfill cover, whilst Fly Ash is treated and disposed at a landfill site
Algonquin Power, Peel Energy-from-Waste Facility (Brampton, ON)	Location: Brampton, ON Capacity: 147,700 tonnes of waste per annum Energy Recovery and Outlet: The facility processes 500 tonnes of MSW waste per day and produces a maximum of 15 megawatts of electrical energy. Steam is provided to an adjacent paper mill and the paper mill returns the condensed steam to the facility as condensate. The utilization of Bottom Ash in paving material is actively pursued, while Fly Ash presently disposed of in a hazardous landfill.
L'incinérateur de la Ville de Québec (Quebec City, Quebec)	Location: Limoilou, QC Capacity: 312,000 tonnes of waste per annum Energy Recovery and Outlet: heat generated is used to dry sludge, whilst steam is produced is sold to a paper pulp company. An estimated 810,000 tonnes of steam is generated per annum Bottom Ash is disposed at landfill site, whilst Fly Ash is treated through a chemical extraction process and disposed at landfill
PEI Energy Systems Energy-from-Waste Facility (Prince Edward Island)	Location: Charlottetown, PEI Capacity: Approximately 26,000 tonnes of waste per annum Energy Recovery and Outlet: an estimated 57,000 tonnes of steam is generated which is sold to Charlottetown's district heating system Bottom Ash is disposed at non-hazardous landfill site, while fly is disposed at a hazardous landfill site

[63] Stantec. (2011). Waste-to-Energy: A Technical Review of Municipal Solid Waste Thermal Treatment Practices.

[64] Environment Canada. MSW Treatment in Canada 2006. https://www.ec.gc.ca/gdd-mw/default.asp?lang=En&n=D54033E4-1&offset=5&toc=hide [Date accessed March 2013]

3.0 Gasification Facility Summary Table

TECHNOLOGY	GASIFICATION
Economic Dimension	
Capital Cost Estimate	$600 to $1200/annual design tonne
Operating Cost Estimate	$80 to $140/tonne
Technical Dimension	
Scalability	Gasification facilities are modular. Each module can range from approximately 40,000 to 100,000 tonnes per annum.
Reliability	There are no large scale Gasification facilities that process municipal waste currently in operation in Canada. At least seven plants in operation in Japan at a large scale with over two years of operating experience and a number under construction in Europe. Scheduled and unscheduled downtime reported as approximately 20%. However other reports indicate potential for up to 45% downtime.
Feedstock	Sensitive to input feedstock characteristics, particularly moisture content. Gasification systems typically require a homogenous feedstock; therefore, a significant amount of front-end processing of the waste may be required. Traditionally Gasification is used for other waste streams (e.g. biomass, coal, plastics, etc.).
Residue	Bottom Ash/Slag: Approximately 20% potential use as aggregate, classified as non-hazardous. APC Residue (includes Fly Ash): Approximately 1 to 5% of the original waste feedstock requiring stabilization prior to disposal, classified as hazardous. Potential use as aggregate for concrete products once stabilized.
Energy Recovery	Energy recovery possible, however, energy efficiencies dependent on production mechanism and energy conversion technology. Energy outputs can include: • Heat only • Electricity through a steam turbine generator, gas engine, or combine cycle gas engine • Hydrogen gas recovery system to generate vehicle fuel or electricity • Catalytic reactions to generate liquid fuel or chemicals • Combined Heat and Power
Revenue	Revenue possible through Tipping Fees, energy production, and material recovery from waste streams. Recovered materials and outlets can include: • Front end material recycling (glass, metals) sold for re-smelting, glass processor or used as secondary raw material • Slag and ash sold as secondary aggregate • Metals sold for re-smelting and recycling • Condensate processed and sold as liquid fuel or for chemical applications
Technical Risks	Feedstock Security - High Risk Feedstock Composition - Medium Risk Technology Reliability - Medium Risk Technology Supplier - Medium Risk Fly Ash Residue Management - Low Risk Market Outlet for Recyclables and Energy Recovery - Low Risk Performance Guarantees - Low Risk Note: technical risks associated with gasification are qualitative and based on available data at the time.

TECHNOLOGY	GASIFICATION
Select Examples of Operating Facilities in Canada and Internationally	
Enerkem, Edmonton Waste-to-Biofuel Facility (Edmonton, AB)	There is only one facility in operation in Canada. In June 2014, the City of Edmonton and Enerkem announced the launch of the world's first commercial advanced biorefinery to exclusively use municipal solid waste to produce advanced biofuels and chemicals. This is a joint project between the City of Edmonton and Enerkem Inc. to process 100,000 tonnes per annum of waste into 38 million litres of methanol per year. Biomethanol production will begin progressively during the start-up. A module converting the biomethanol into advanced ethanol will be added by the end of 2015. The project will help the City of Edmonton increase its residential waste diversion rate to 90%, and is expected to generate net economic spending in the local area of nearly CDN $ 65 million annually. Enerkem signed a 25 year agreement with the City of Edmonton to build and operate this facility.
Thermoselect, Karlsruhe, Germany	There are a number of Gasification facilities operating commercially in Japan, which utilize municipal waste as feedstock. Such facilities in Japan have been driven by the regulatory environment, which favours high temperature treatment of Bottom Ash.[65] A 225,000 tpy Gasification facility in Karlsruhe, Germany operated for several years prior to closure in 2004 due to a series of environmental and economic problems.

[65] Stantec. (2011). "Waste-to-Energy: A Technical Review of Municipal Solid Waste Thermal Treatment Practices".

4.0 Pyrolysis Facility Summary Table

TECHNOLOGY	PYROLYSIS
Economic Dimension	
Capital Cost Estimate	$161 to $926/annual design tonne – data is not as reliable
Operating Cost Estimate	$50 to $105/annual design tonne – data is not as reliable
Technical Dimension	
Scalability	Pyrolysis facilities are modular.
Reliability	There are no known operational plants delivering energy from municipal waste using Pyrolysis in North America or Europe. A number of larger Pyrolysis facilities are presently in operation in Japan, though without energy recovery.
Feedstock	Highly sensitive to feedstock physical and chemical characteristics, particularly moisture content. Pyrolysis systems typically require a homogenous feedstock; therefore, a significant amount of front-end processing of the waste may be required. Traditionally Pyrolysis is used for other waste streams (e.g. biomass, plastics, tires etc.).
Residue	No reliable data available, however quantities of residue similar to that of Gasification.= Bottom Ash/Char: Approximately 20% of the original waste feedstock, potential use as aggregate, classified as non-hazardous. APC Residue (includes Fly Ash): 1 to 5% of the original waste feedstock requiring stabilization prior to disposal, classified as hazardous.
Energy Recovery	Energy recovery possible, however, energy efficiencies dependent on production mechanism and energy conversion technology. Energy outputs can include: • Heat only • Electricity through a steam turbine generator, gas engine, or combine cycle gas engine • Hydrogen gas recovery system to generate vehicle fuel or electricity • Catalytic reactions to generate liquid fuels or chemicals • Combined Heat and Power
Revenue	Revenue possible through Tipping Fees, energy production, and material recovery from waste streams. Recovered materials and outlets can include: • Front end material recycling (glass, metals) sold for re-smelting, glass processor or used as secondary raw material • Char and ash sold as secondary aggregate • Metals sold for re-smelting and recycling • Pyrolysis oil processed and sold for chemical application
Technical Risks	Feedstock Security - High Risk Feedstock Composition - High Risk Technology Reliability - High Risk Technology Supplier – High Risk Fly Ash Residue Management - Low Risk Market Outlet for Recyclables and Energy Recovery - Low Risk Performance Guarantees - Medium Risk Note: Technical risks associated with Pyrolysis are qualitative and based on available data at the time.
Select Examples of Operating Facilities	
Select Examples of Operating Facilities in Canada	Presently there are no Pyrolysis facilities that process municipal waste in Canada.
Select Examples of Operating Facilities in Internationally	Japan: six commercial facilities using Mitsui technology process 50,000 to 120,000 tonnes per annum of municipal solid waste producing between 1.5 and 8.7 MW.[66]

[66] See note 60.

5.0 Plasma Gasification Facility Summary Table

<table>
<tr><th>TECHNOLOGY</th><th>PLASMA GASIFICATION</th></tr>
<tr><td colspan="2">Economic Dimension</td></tr>
<tr><td>**Capital Cost Estimate**</td><td>$1300/annual design tonne (+/- 44%)</td></tr>
<tr><td>**Operating Cost Estimate**</td><td>$120/tonne (+/- 55%)</td></tr>
<tr><td colspan="2">Technical Dimension</td></tr>
<tr><td>**Scalability**</td><td>Plasma Gasification facilities are modular.</td></tr>
<tr><td>**Reliability**</td><td>There are no large scale Plasma Gasification facilities that process municipal waste currently in operation in Canada (there is a demonstration facility in Ottawa, ON). There are only two plants in Japan with 2 or more years of operations. Complex Operation, scheduled and unscheduled downtime, unknown. Limited data available to establish reliability at large scale.</td></tr>
<tr><td>**Feedstock**</td><td>Sensitive to feedstock physical and chemical characteristics. Plasma Gasification systems typically require a homogenous feedstock; therefore, a significant amount of front-end processing of the waste may be required.</td></tr>
<tr><td>**Residue**</td><td>Approximately >1 to 10%, consisting of mainly slag (non-hazardous, can be used as aggregate) and APC residue (hazardous, treatment required, and can be used as aggregate or disposed).</td></tr>
<tr><td>**Energy Recovery**</td><td>Energy recovery possible, however, energy efficiencies dependent on production mechanism and energy conversion technology. Energy outputs can include:
• Heat only
• Electricity through a steam turbine generator, gas engine, or combine cycle gas engine
• Hydrogen gas recovery system to generate vehicle fuel or electricity
• Catalytic reactions to generate liquid fuels or chemicals
• Combined Heat and Power</td></tr>
<tr><td>**Revenue**</td><td>Revenue possible through Tipping Fees, energy production (above), and material recovery from waste streams. Recovered materials and outlets can include:
• Front end material recycling (glass, metals) sold for re-smelting, glass processor or used as secondary raw material
• Slag and ash sold as secondary aggregate
• Metals sold for re-smelting and recycling
• Condensate processed and sold as liquid fuel or for chemical applications</td></tr>
<tr><td>**Technical Risks**</td><td>Feedstock Security – High Risk
Feedstock Composition – High Risk
Technology Reliability – High Risk
Technology Supplier – Medium Risk
Fly Ash Residue Management – Low Risk
Market Outlet for Recyclables and Energy Recovery – Low Risk
Performance Guarantees – High Risk
Note: Technical risks associated with Plasma Gasification are qualitative and based on best available data at the time.</td></tr>
<tr><td colspan="2">Select Examples of Operating Facilities</td></tr>
<tr><td>**Select Examples of Operating Facilities in Canada**</td><td>There is one Plasma Gasification facility in Canada:
• Plasco Facility (Ottawa, Ontario): a demonstration facility located in Ottawa, began processing post-diversion up to 75 tonnes per day residential municipal waste from the City of Ottawa. In 2011, the Plasco facility was issued a permanent approval from the Ministry of the Environment for commercial operations at the existing scale.</td></tr>
</table>

6.0 Mechanical Biological Treatment-Anaerobic Digestion Summary Table

TECHNOLOGY	MECHANICAL BIOLOGICAL TREATMENT-ANAEROBIC DIGESTION
Economic Dimension	
Capital Cost Estimate	MBT–AD: $320 to $840/annual design tonne
Operating Cost Estimate	$45 to $85/tonne
Technical Dimension	
Scalability	MBT-AD facilities can be scaled to various sizes and are modular.
Reliability	Technology is well established and reliable. There are number of large scale commercial MBT facilities in Europe, and AD facilities in Canada.
Feedstock	MBT facilities typically accepts residual wastes, and though biological systems can be sensitive to changes in input feedstock, and are typically well suited for feedstock from the organic waste stream.
Residue	CLO: variable, dependent on incoming waste. Potential market available depending on local jurisdiction regulations and market conditions. Rejects (e.g., contaminated materials or unrecoverable materials during mechanical sorting, digestate, etc.): variable, dependent on composition of incoming waste. For residential residual waste it is estimated that 30% by weight is disposed at landfill.
Energy Recovery	Energy recovery possible, however, energy recovery efficiencies dependent on production mechanism and energy conversion technology. Biogas generated in MBT-AD systems can be utilized in a number of ways, these include: • Upgrade methane content to 90 to 96% for use as a vehicle fuel • Utilize biogas in a fuel cell to generate power directly and heat • Use biogas to fire steam turbo-generators or as fuel in a gas engine to generate electricity and power • Combine heat and power
Revenue	Revenue possible through Tipping Fees, energy production (above), and material recovery from waste streams. Recovered materials and outlets can include: • Front end material recycling (glass, metals, plastics, textiles, paper) re-used as secondary raw materials, or re-processed at recycling facilities • CLO used a compost to improve certain low quality soils, or for landfill cap restoration
Technical Risks	Feedstock Security – High Risk Feedstock Composition – Medium Risk Technology Reliability – Low Risk Technology Supplier – Low Risk CLO Management – Medium Risk Market Outlet for Recyclables and Energy Recovery – Low Risk Performance Guarantees – Low Risk Note: Technical risks associated with MBT-AD are qualitative and based on available data at the time.
Select Examples of Operating Facilities	
Select Examples of Operating Facilities in Canada	There are no large scale MBT facilities with AD in Canada, however two MBT facility using aerobic composting technologies are in the Cities of Edmonton and Halifax: • Otter Lake Facility (Halifax): front end mechanical processing followed by biological stabilization unit (aerobic composting). Facility is in operation since 1999; and • Edmonton Integrated Waste Management Facility (Edmonton): front end mechanical treatment following by aerobic composting. Facility operation since 2002 and processes 200,000 tonnes per annum of residential waste and 25,000 tonnes per annum of bio-solids.

7.0 Anaerobic Digestion Facility Summary Table

TECHNOLOGY	ANAEROBIC DIGESTION (AD)
Economic Dimension	
Capital Cost Estimate	$490 to $625/annual design tonne
Operating Cost Estimate	$35 to $55/tonne
Technical Dimension	
Scalability	AD facilities can be scaled to various sizes and are modular.
Reliability	Technology is well established and reliable. There are number of large scale commercial AD facilities in Canada and Europe.
Feedstock	AD systems can be sensitive to changes in input feedstock, and are typically well suited for feedstock from the organic waste stream.
Residue	CLO: variable, dependent on incoming waste. Potential market available depending on local jurisdiction regulations and market conditions. Rejects (e.g. contaminated materials or unrecoverable materials during waste preparation): variable, dependent on composition of incoming waste.
Energy Recovery	Energy recovery possible, however, energy recovery efficiencies dependent on production mechanism and energy conversion technology. Biogas generated in AD systems can be utilized in a number of ways, these include: • Upgrade methane content to 90 to 96% for use as a vehicle fuel • Utilize biogas in a fuel cell to generate power directly and heat • Use biogas to fire steam turbo-generators or as fuel in a gas engine to generate electricity and power • Combine heat and power
TECHNOLOGY	ANAEROBIC DIGESTION (AD)
Technical Dimension	
Revenue	Revenue possible through Tipping Fees, energy production (above), and material recovery from waste streams. Recovered materials and outlets can include: • Front end material recycling (glass, metals, plastics, textiles, paper) re-used as secondary raw materials, or re-processed at recycling facilities • CLO used a compost to improve certain low quality soils, or for landfill cap restoration
Technical Risks	Feedstock Security – High Risk Feedstock Composition – High Risk Technology Reliability – Low Risk Technology Supplier – Low Risk CLO Management – Low Risk Market Outlet for Recyclables and Energy Recovery – Low Risk Performance Guarantees – Low Risk Note: Technical risks associated with AD are qualitative and based on available data at the time.
Select Examples of Operating Facilities	
Select Examples of Operating Facilities in Canada	There are a number of AD facilities in Canada, for example, the Dufferin Organic Processing Facility in Toronto, Ontario. This facility has been in operation since 2002 and processes 40,000 tonnes per annum of household organic waste as feedstock.

APPENDIX 1

Glossary of Key Terms

The definitions contained herein are generally sector-understood or derived from PPP Canada publications.

TERM	DEFINITION
Anaerobic Digestion	Anaerobic Digestion is a treatment process that biologically degrades materials in the absence of oxygen.
Bottom Ash	Bottom Ash is the mineral material left after the combustion of the waste. Bottom Ash is a heterogeneous mixture of slag, metals, ceramics, glass, unburned organic matter and other non-combustible inorganic materials, and consists mainly of silicates, oxides and carbonates. Typically, Bottom Ash makes up approximately 20 – 25% by weight or 5 to 10% by volume of the original waste.
Compost-Like Output	The Ontario compost guideline establishes three categories for finished compost (AA, A and B): • *Category AA* – Ontario's current compost standard, which is the highest quality compost product, and the strictest standard in Canada. Category AA compost is not classified as 'waste,' and hence exempt from the ministry's requirement for use and transport. • *Category A* – Category A would be the same as AA in almost all regards, except it would allow slightly elevated levels of zinc and copper in the finished compost and would allow bio-solids (maximum 25% of total feedstock) that meet the feedstock metal standards to be used as feedstock. Category A compost is not classified as 'waste,' and hence exempt from the ministry's requirement for use and transport. • *Category B* – Category B would allow higher levels of metal in the finished compost than Category A, and would also allow bio-solids that meet the feedstock metal standards to be used as feedstock. The use of bio-solids must meet the same metal standards for feedstock as Compost A. Category B compost is still classified as 'waste,' however may be put to beneficial use through a variety of regulated uses, such as on agricultural land or as soil conditioner.
Commercially Confidential Meetings	Commercially Confidential Meetings between the Procuring Authority and individual Proponents (along with their respective advisors) to discuss matters such as the Project Agreement and Proponents' suggested amendments thereto; design issues; and RFP submission requirements. CCMs are an opportunity for productive, meaningful, non-attributable dialogue between responsible department or agency and proponents with the goal of receiving quality final proposals.
Construction & Demolition Waste	Construction and Demolition includes wastes generated by construction, renovation and demolition activities. It generally includes materials such as wood, drywall, certain metals, cardboard, doors, windows, wiring, etc. It excludes materials from land-clearing on areas not previously developed, as well as materials such as asphalt, concrete, bricks and cleans sand or gravel.
Design-Build-Finance- Operate-Maintain (DBFOM)	Typically considered for large projects involving new construction on a vacant site (Greenfield or Brownfield). The private sector is generally responsible for design, construction, long-term financing, operations and maintenance. The project is paid for through a combination of Substantial Completion and annual service payments over a fixed period, usually 25 to 30 years.
Design-Build-Operate-Maintain (DBOM)	Typically considered for smaller projects involving new construction on a vacant site (Greenfield or Brownfield). The private sector is generally responsible for design, construction, operations and maintenance. Risk transfer is not anchored by private financing.
Energy-from-Waste	Energy-from-Waste is generic term referring to processes involved in the conversion of wastes (typically municipal solid waste) into an energy source. Energy generation is either direct through combustion, or indirect through the generation of a fuel source or biogas that can then be combusted for the purposes of energy recovery.
Energy Recovery	The conversion of non-recyclable waste materials into usable heat, electricity, or fuel through a variety of processes, including Combustion, Gasification, Pyrolyzation and Anaerobic Digestion. Energy Recovery from waste is part of the Non-Hazardous Waste Management Hierarchy.
External Advisors	External team members engaged by the Procuring Authorities to provide specialty advice and guidance to the Procuring Authorities through the P3, from P3 Definition to Close Out.

Fairness Advisor/ Monitor	The Fairness Advisor is an independent monitor who oversees, and advises on the entire procurement process to ensure that the process is not only fair, but that it is seen to be fair, in recognition of the public-interest nature of the undertaking. The Fairness Advisor may be a professional lawyer, engineer, or an accountant.
Feedstock	A composition of residential solid waste, industrial, commercial and institutional (IC&I) waste and construction and demolition (C&D) waste; this includes organics waste.
Fermentation Production	Fermentation is an anaerobic process whereby yeast or other bacteria are used to generate a liquid biofuel (i.e., ethanol) from waste by breaking down carbohydrates (glucose) in organic materials into ethanol.
Finance /Financing	Private financing can take two forms: A) The private sector partner arranges the construction financing until Substantial Completion. During construction, the public sector partner can make milestone payments or a lump sum payment at Substantial Completion. B) In order to transfer additional financial risk to the partner, a long term private financing approach is used. Under this scenario, the private sector provides a percentage of financing during the construction phase that could be carried over through the end of the concession period. Securing private financing during the concession period anchors the risks transferred during the operational period.
Fly Ash	Fly Ash relates to fine particles that rise after waste combustion in a Mass Burn facility. Particle filtration systems, for example electrostatic precipitators and filter bags, are deployed to capture the Fly Ash before escaping into the atmosphere. Fly Ash is classified as hazardous waste and, therefore, is disposed of at hazardous waste landfill sites.
Gasification Process	Gasification is a process that uses heat, pressure and steam to chemically and physically change waste to produce gas (syngas) as the main product. The Gasification process is similar to the Pyrolysis process, but Gasification takes place at higher temperatures and gasifies the fixed carbon content (i.e., converts 70% to 85% of the carbon in the feedstock into syngas). Additionally, Gasification uses small controlled amounts of air (oxygen) to allow partial combustion of the waste, whereas pyrolysis is undertaken in an oxygen starved reactor. Gasification systems typically require a homogenous feedstock; therefore, a significant amount of front-end processing of the waste may be required.
Greenfield	A project that lacks constraints imposed by prior work, with no need to remodel or demolish an existing structure.
Hand Back	The P3 contract states the condition in which the asset must be in at the end of the concession period. These conditions must be laid out in detail with definable metrics illustrating not only specific values, but also the processes by which these values will be assessed. Typically, asset audits will begin several years before the end of the concession period to allow the Private Partner the opportunity to remedy any hand back requirements that are not met.
Industrial, Commercial and Institutional Waste	IC&I waste is the waste generated by all non-residential sources in a municipality, and is excluded from the residential waste stream. This includes: Industrial waste, which is generated by manufacturing, primary and secondary industries, and is managed off-site from the manufacturing operation, and is generally picked up under contract by the private sector. Commercial waste is generated by commercial operations such as shopping centres, restaurants, offices, etc. Some commercial waste (from small street-front stores, etc.) may be picked up by the municipal collection system along with residential waste. Institutional waste is generated by institutional facilities such as schools, hospitals, government facilities, seniors' homes, universities, etc. This waste is generally picked up under contract with the private sector
Innovation	In P3 projects, innovation is an element brought into the project by the private sector, which was not originally conceived by the public sector and provides either tangible or intangible value. Innovation can take the form of new technologies, more efficient designs, better construction and operational methods, improved aesthetic appeal, etc. Innovation is evaluated retrospectively and does not appear on initial analysis or VfM because it typically is not anticipated. However, an RFP should include a method for assessing innovations in the event they are included in the bidders' proposals.
Life-Cycle Costs	The whole life cost of delivering an infrastructure asset including design, construction, operational, maintenance, recurring or one time major maintenance costs and residual value at the end of ownership or useful life. Major maintenance costs are defined as the cost of major renovation or replacement of major components of an infrastructure asset and are included as part of life-cycle costs.

Market Sounding	A process by which the public sector gathers intelligence from potential bidders and other market players regarding various aspects of the investment. The process is used to test/confirm assumptions, identify areas of concern for the private sector, and assess the market's potential level of interest in the investment. The market sounding also informs the market of the potential investment and provides market players with an overview of the investment, including the potential procurement process and the commercial structure. Typically, the market-sounding document includes a project profile, a potential procurement process and the high-level commercial structure.
Mass Burn	Mass Burn technologies are used for solid waste treatment and are well-established approach across North America, Europe and Japan. Waste is fed into a combustion chamber where the waste is subjected to an oxidizing environment and burned. Plant design can vary between Mass Burn technologies and can have implications with respect to the quantity and type of waste that can be burned, as well as the heat transfer to the energy recovery system. Mass Burn technologies can incorporate pre-processing of the residual waste stream to remove remaining recyclables prior to the waste stream being fed into the combustion chamber. Mass Burn thermal treatment facilities can also treat feedstock of varying composition; however operational efficiencies are typically realized with a dryer feedstock.
Mechanical Biological Treatment	MBT uses a combination of mechanical separation and biological treatment to process residual waste. Mechanical separation is the first stage in a MBT process, irrespective of the biological treatment technology used. This stage consists of a combination of manual and/or automated separation processes (e.g. screening, ballistic separation, optical sorting, magnetic separation, etc.) to extract recyclable materials and to segregate materials suitable for biological treatment. The non-recyclable inorganic fraction of the residual waste stream may be segregated either prior to, or following biological treatment, depending on the chosen design configuration and objectives. The non-recyclable inorganic faction will require either final disposal (i.e. landfill) or processing (e.g. Energy-from-Waste). One of the most significant elements of MBT is the type of biological treatment, which can vary in complexity, process, output and cost. Biological treatment processes of an MBT system can include aerobic composting (no energy production) or an Anaerobic Digestion process.
Output Specifications	Performance-based specifications and requirements that articulate the public sector's performance expectations of the private sector and form the basis upon which bidders develop their proposals. Reliance on performance based measures leaves bidders with the responsibility for determining how to best meet the requirements, thus allowing for innovative and creative approaches. Output specifications are set out by the asset owner.
Plasma Gasification Technology	Plasma Gasification is an emerging Gasification technology that stems from what may be considered more "traditional" gasification. Plasma Gasification uses an electrical arc or torch gasifier that passes a high voltage electrical current through low pressure gas/air creating a stream of plasma. The plasma field supplies high heat which can range from 5,000 to 15,000 °C. The extreme heat maintains the Gasification reaction by breaking down chemical bonds of waste and converting them into syngas and slag. The syngas generated can be used in steam boilers to generate heat, and combustion engines and gas turbines after cleaning to produce electricity. The slag produced, once cleaned, can be processed into tiles, bricks, gravel or asphalt.
Power Purchase Agreement	A contract between two parties, one who generates electricity (the seller / Procuring Authority) and one who is looking to purchase electricity (the buyer / Local Power Authority). The agreements defines all of the commercial terms for the sale of electricity between the two parties, including when the project will begin commercial operation, schedule for delivery of electricity, penalties for under delivery, payment terms, and termination. A PPA is the principal agreement that defines the revenue and credit quality of a generating project and is thus a key instrument of project finance.
Preferred Proponent	The single highest ranking Proponent selected at the end of the RFP evaluation process for negotiation to reach Commercial Close and Financial Close.
Project Agreement	The contract governing the relationship between the Procuring Authority and the Project. The Project Agreement clearly outlines the risk sharing mechanism, including the roles and responsibilities of both the public and the private parties. The Project Agreement contains key schedules that outline contractual obligations such as: design and schedule, output specifications, payment mechanism/ penalties for non-performance, performance security requirements, lender's direct agreement, commissioning and testing, hand back requirements, dispute resolution and termination payments.
Project Company/ Private Partner/ Consortium/ Special Purpose Vehicle	In the context of a P3, these terms are used to refer to the commercial entity established to fulfil the private sector's obligations under the Project Agreement. This entity, which could take many forms, including that of a corporation or a partnership, will have no pre-existing assets or liabilities and will typically be owned by equity providers of the winning consortium. Lenders, designers, constructors and operational and maintenance contractors are all contractually related to this entity.

Project Finance	The financing of long-term infrastructure, industrial projects and public services based upon a nonrecourse or limited recourse financial structure where project debt and equity used to finance the project are paid back from the cash flow generated by the project. It is a common form of financing in P3s because it allows for the formation of project consortia consisting of companies with various financial capacities. The nature of this financial structure requires thorough due diligence and comprehensive risk analysis, together with a risk allocation process that limits risk for all parties involved and allows for high leverage.
Procuring Authority	Procuring Authorities identifying the sponsor of the project. Typically the owner of the asset.
Proponent	A bidder in a procurement process.
Public-Private Partnership	A long-term contractual relationship between a public authority and the private sector that involves: the provision of capital assets and associated services to meet a defined output specification (i.e., define what is required rather than how it is to be done); the integration of multiple project phases (e.g., design, build, finance, operate and maintain); the transfer of risk to the private sector anchored with private sector capital at risk; and the performance-based payment mechanism.
P3 Business Case	The P3 business case will identify and assess a range of procurement models using both qualitative and quantitative analysis. The intent of a P3 business case is to identify, assess and make a recommendation on the appropriate procurement model that best achieves project objects and Value for Money for taxpayers. The business case will start with a project rationale and then proceed to a plan for the execution of the project, including strategic alignment, transaction structure, procurement process, and project governance.
Pyrolysis	Pyrolysis is a form of advanced thermal treatment that reduces the volume of waste feedstock by heat in the absence of oxygen. Residual waste is fed into a Pyrolysis reactor, which is typically maintained at a temperature between 300°C and 850°C. In the reactor, pyrolysis may occur slowly (i.e. feedstock volatizes over a period of several minutes) or quickly (i.e. feedstock volatizes in seconds) depending on the technology vendor and end product desired. Pyrolysis technologies require that pre-treatment of incoming waste occur to remove recyclables and non-combustible materials (e.g. grit, stones) and to homogenize the feedstock. Typical by-products from pyrolysis reactions include solid residue (i.e. Bottom Ash, char), liquids (i.e. oxygenated oils), and a medium quality gas (syngas).
Qualitative Assessment	A qualitative assessment considers non-financial factors such as degree of confidence in good whole-of-life performance, social benefits, aesthetic design, functionality, and political risk. Consideration must also be given to organizational and operational impacts and whether the project is suitable for private sector management.
Quantitative Assessment	A quantitative assessment considers financial factors such as size and timing of cash flows, payments through the life-cycle, project risks and the Value for Money for each delivery model.
Request for Proposals	The RFP process is the final stage of P3 procurement and occurs after the RFQ process. The RFP process results in the selection of the preferred proponent who will enter into a Project Agreement with the public sector. The RFP document clearly describes the public sector's requirements, the procurement process, the evaluation criteria and methodology, and security requirements (e.g., letters of credit, surety, etc.). The RFP for a P3 will include the Project Agreement and key schedules, including the output specifications, payment mechanism and hand back requirements.
Request for Qualifications	The RFQ process in P3 procurement is meant to produce a short-list of qualified bidders for the RFP process through an assessment of interested parties' experience and qualifications as they relate to the project being procured (e.g. project management experience, infrastructure design and construction experience, etc.). The RFQ document articulates clear criteria against which bidders are evaluated and pre-qualified. The RFQ may limit bidder participation to a few pre-qualified participants which increases a potential bidder's motivation to participate in the procurement process because it increases a bidder's chance of winning. A typical RFQ in the Canadian P3 market short lists the three most qualified bidders. The RFQ process also optimizes the procuring authority's resource allocation in the RFP process as more than three bidders necessitate additional effort for a fair, open and transparent evaluation, and less than three bidders may result in an erosion of competitive tension during the procurement process.
Residential (Household) Waste	Includes solid waste from residential sources (households), and includes waste that is picked up by the municipality (either using its own staff or through contracting firms), or residential waste that is taken by the generator to depots, transfer stations and disposal facilities.

Revenue /Project Revenue	In the context of P3s, there are generally two types of revenue: external project revenues where the private sector is allowed to charge user fees (e.g. toll road concession); and availability based revenues where there are availability-based payment by the Procuring authority. Expected project revenues are an important consideration for project viability as they must be sufficient to cover all project costs (capital, operational and life-cycle maintenance) as well as generate acceptable returns for investors.
Revenue Risk	In the context of P3s, revenue risk refers to the third party risk associated with demand or production output of an asset and its impact on revenues. If revenue risk is transferred to the private sector and the asset does not generate revenue or generates less revenue than expected in a given time, the private sector is contractually responsible and will be responsible to absorb or mitigate revenue shortfalls.
Risk Transfer	Risk exists in all projects, irrespective of the procurement approach. In a P3, risks are allocated to the party that can best manage them, thereby reducing financial uncertainty for the public sector.
Slag	Slag (i.e., glass) material is a component of the Bottom Ash and can be formed from the inorganic materials. The slag produced is non-hazardous and can be used to make cement, asphalt, and tiles.
Solid Waste	Solid waste is commonly known as trash or garbage consisting of everyday items that are discarded by residents and collected by the municipality. Solid waste encompasses any waste, whether or not it is owned, controlled or managed by a municipality, except, (i) hazardous waste, (ii) liquid industrial waste, or (iii) gaseous waste.
Substantial Completion	A level or state of completion defined in the Project Agreement that is generally characterized by completion of the construction of the asset including all equipment installations, the issuance of any applicable occupancy permits, and the assets readiness to commence operating.
Substantial Completion Payment	A one-time payment by the Procuring Authority to the Project Company at the time of Substantial Completion of a project's construction. A Substantial Completion payment reduces a project's long term private financing requirement and associated private financing costs. Substantial Completion payments will generally be set as percentage of the project's construction costs, and must be incorporated into a P3 project's financial structure with consideration for long-term risk transfer and liquidity.
Syngas	A gas mixture synthesized from waste materials that contains carbon monoxide and hydrogen (but may contain smaller amounts of other gases).
Tipping Fees	Charges for the unloading or dumping of waste at a recycling facility, composting facility, landfill, or transfer facility.
Traditional Procurement	The status quo approach to procurement for the Procuring Authority. While different authorities may have different default approaches, the most common approach to procurement is the Design-Bid-Build approach. In this method, the Procuring Authority enters into separate, sequential contracts: one for the design and specification of the asset; and another for its construction. As such, the Procuring Authority retains the majority of the risks associated with the project, such as design flaws, cost over-runs, and delays in construction. During operations, the performance of the asset is the responsibility of the Procuring Authority or any third party operator hired to carry out operations.
Value for Money	Value for Money (VfM) is the comparison between the total project costs (capital base costs, financing costs, retained risks and ancillary costs), at the same point in time, for a traditionally procured project (known as the public sector comparator or PSC) and delivery of the same project using the P3 model (known as the shadow bid). The incremental difference between the public sector comparator and the shadow bid is referred to as the VfM. There is said to be a positive VfM for procuring a project using a P3 approach when the Shadow Bid is less than the public sector comparator.

APPENDIX 2
Glossary of Acronyms

AD	Anaerobic Digestion
AMO	Association of Procuring Authorities in Ontario
APC	Air Pollution Control
C&D	Construction and Demolition
CCME	Canadian Council of the Ministers of the Environment
CHP	Combined Heat and Power
CLO	Compost-Like-Output
DB	Design-Build
DBB	Design-Bid-Build
DBF	Design-Build-Finance
DBFM	Design-Build-Finance-Maintain
DBFOM	Design-Build-Finance-Operate-Maintain
DBO	Design-Build-Operate
DBOM	Design-Build-Operate-Maintain
EA	Environmental Assessment
EfW	Energy-from-Waste
FCM	Federation of Canadian Municipalities
GDP	Gross Domestic Product
IC&I	Industrial, Commercial and Institutional
LC	Letter of Credit
LTA	Lenders' Technical Advisor
MBT	Mechanical Biological Treatment
MSW	Municipal Solid Waste
OECD	Organization for Economic Co-operation and Development
O&M	Operate and Maintain
OM&R	Operations, Maintenance and Rehabilitation
PPA	Power Purchasing Agreement
P3	Public-Private Partnership
RFEI	Request for Expression of Interest
RFP	Request for Proposal
RFQ	Request for Qualifications
SCP	Substantial Completion Payment
SPV	Special Purpose Vehicle
SWANA	Solid Waste Association of North America
SWM	Solid Waste Management
TPA	Tonnes Per Annum
TPY	Tonnes Per Year
TS	Total Solids
VFM	Value for Money
WEC	World Energy Council

APPENDIX 3

Energy-from-Waste Market Outreach Workshop

Methodology

A workshop was held by PPP Canada Inc. on October 30, 2013 in Toronto, ON and facilitated by Morrison Hershfield. A select number of public and private sector stakeholders from the Energy-from-Waste sector were invited to participate in the interactive session.

Workshop Objective

The workshop had the intended objective to validate information presented in PPP Canada's Energy-from-Waste Sector Study by offering a forum for constructive feedback and discussion based on participant experiences in the Energy-from-Waste sector.

LISTING OF PARTICIPANT ORGANIZATIONS

#	ORGANIZATION	MARKET CATEGORY
1	PPP Canada Inc.	Public Sector
2	Covanta Energy	Technology
3	Enerkem	Technology
4	Veolia Environmental Services	Technology
5	Wheelabrator Technologies	Technology
6	Plasco Energy Group	Technology
7	Impact BioEnergy	Technology
8	Urbaser S.A.	Developer/Financier
9	Plenary Group	Developer/Financier
10	Forum Equity Partners	Financier
11	Scotia Bank	Financier
12	CIBC World Markets	Financier
13	HDR Inc.	Engineering
14	AECOM	Engineering
15	Ramboll Group	Consulting Engineer
16	Kenaidan Contracting Ltd.	Constructor
17	PCL Constructors Inc.	Constructor
18	Ontario Power Authority	Public Sector
19	Regional Municipality of Durham	Public Sector
20	Canadian Energy-from-Waste Coalition	Advocacy Group
21	Morrison Hershfield Limited	Facilitator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