REPORT

Facility Energy and Life Cycle Assessment – Technical Study Report

DURHAM YORK
RESIDUAL WASTE EA STUDY

REPORT NO. MA-06-512-30-MA

EXECUTIVE SUMMARY

Durham and York Regions' proposed Project involves the construction of a Facility to thermally process solid waste that remains after Regional diversion efforts. The Proposed Thermal Treatment Facility (the Facility) would be located approximately 2 kilometers (km) south of Highway 401, between Courtice Road and Osborne Road in Clarington, Ontario within the Clarington Energy Business Park.

The Facility has a maximum design capacity of 400,000 tonnes per year (tpy). For the purposes of this Technical Study Report, it has been assumed that the initial design capacity of the Facility would be 140,000 tpy.

Presently there is no energy produced in the Clarington Energy Business Park.

The proposed Facility with an initial design capacity of140,000 tpy would produce electricity and possibly district energy, both heating and cooling, that could be used by businesses developed within the Clarington Energy Business Park.

The direct power outputs from the Facility are summarized as follows.

Table ES-1 Power Production

Scenario	Electrical Power Supplied to the Grid (MW Electrical)	Heat Available for Peak Thermal Loads (MW Thermal)	Total Net Power Production (MW)
Electricity Production Only	13.6	n/a	13.6
Electricity & District Heat Production	11.9	7.4	19.3
Electricity, District Heat & Cooling Production	11.9	7.4	19.3

These power figures are net of the power used to operate the Facility. Compared to straight electricity production, more overall energy is produced and used when district energy is employed in addition to electricity production.

The annual direct energy benefits associated with the Facility are summarized as below.

Table ES-2 Annual Direct Energy Benefits

Scenario	Annual Net Electrical Energy Produced & Saved (MWh)	Annual Quantity of Natural Gas Saved (Million m^3)
Electricity Production Only	107,222	n/a
Electricity & District Heat Production	93,820	5.6
Electricity, District Heat & Cooling Production	96,454	5.0

The benefits to the electricity sector arise because of both electricity supplied to the grid and potential savings in Clarington Energy Business Park electricity consumption resulting from the use of waste heat for district cooling. Natural gas savings result because of the potential use of waste heat for district heating in the Clarington Energy Business Park.

In broad terms, the electricity produced by the Facility, when operating at the initial design capacity of 140,000 tpy, is sufficient to power about 10,000 homes; while the district heating produced could heat the equivalent of 2,200 homes.

Life cycle analysis (LCA) provides a tool for considering the broader effects of the Facility to the environment (both Air and Water). LCA accounts for the direct effects of the Facility itself plus the indirect effects and offsets resulting from the recovery of energy and recyclable materials. The effects of transporting materials to and from the Facility as well as disposal of the solid residues (ash) are also considered along with the landfill methane emissions that would be avoided if the same tonnage of waste had been landfilled in a modern landfill site with 75% methane capture.

The following table illustrates the broader life cycle benefits associated with the Facility.

Table ES-3 Annual Life Cycle

Scenario	Energy Impacts (GJ)	Greenhouse Gas Emission Impacts (tonnes CO_2e)	Acid Gas Emission Impacts (Tonnes of Sulphur Oxides)
Electricity Production Only	(1,113,094)	(16,238)	(189)
Electricity & District Heat Production	(1,205,281)	(27,536)	(340)
Electricity, District & Cooling Production	(1,193,225)	(28,311)	(340)

(1) Negative values represent savings or reductions

Energy impacts expressed in Gigajoules (GJ) are negative for all three scenarios, indicating the overall energy contribution/savings associated with the Facility that result from the recovery of both energy and materials. In broad terms this is equivalent to saving all the energy (heating, cooling, lights, and appliances) consumed in about 8,000 homes.

Greenhouse gas (GHG) emissions, expressed in terms of metric tonnes of CO_2 equivalents (CO_2e) are reduced for all scenarios. For the electricity production only scenario, the indirect reduction in GHGs associated with electrical energy and materials recovery and avoided landfill methane emissions more than offset the direct GHG emissions from the Facility. For the scenarios assuming district energy, the indirect reduction in GHG emissions associated with the recovery of both electricity and heat offset more than the direct GHG emissions from the Facility. Once avoided landfill methane emissions are accounted for, the scenarios that recover waste heat result in greater GHG emission reductions than when only electricity is recovered. This illustrates the benefits of using waste heat rather than natural gas for heating and electricity for cooling purposes.

The Intergovernmental Panel on Climate Change (IPCC) recognizes waste to energy as a technical option for addressing GHG emissions from solid waste disposal, including it as a measure for source reduction (avoidance) of landfill methane. Approximately 10% of Global methane emissions from human-related sources are emitted from landfills and open dumps annually (IPCC Technical Paper I, Technologies, Policies and Measures for Mitigating Climate Change, November 1996).

Although there are air emissions from the Facility itself, there are offsetting reductions in emissions in other areas such as electricity utility power generation. When these various effects are considered together there is a net reduction in emissions to the environment of many common contaminants such as oxides of sulphur that contribute to acid rain.

Although there are no emissions to water from the Facility itself, on a lifecycle basis there are overall reductions in emissions in both dissolved and suspended solids as well as a number of other contaminants. These reductions arise from the energy sector offsets that occur because of the Facility.

This Report focuses on a Facility with an initial design capacity of140,000 tpy, however additional energy and LCA assessments were completed for a Facility with a maximum design capacity of 400,000 tpy (400,000 tpy scenario) to determine potential impacts should maximum capacity be utilized. In general, Facility power outputs and resultant energy benefits increase, thus contributing energy to a great portion of the population. Reduction in GHG emissions also increase for the 400,000 tpy scenario.

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GLOSSARY AND ABBREVIATIONS

** An asterisk (*) beside a defined term indicates that the term is defined in the Environmental Assessment Act.*

'At-Source':	Referring to a waste minimization or management activity occurring at the source of waste generation (e.g. at the household, at the business, etc.).
Air Emissions:	For stationary sources, the release or discharge of a pollutant from a facility or operation into the ambient air either by means of a stack or as a fugitive dust, mist or vapour.
Alternative Methods:	Alternative methods of carrying out the proposed undertaking are different ways of doing the same activity. Alternative methods could include consideration of one or more of the following: alternative technologies; alternative methods of applying specific technologies; alternative sites for a proposed undertaking; alternative design methods; and, alternative methods of operating any facilities associated with a proposed undertaking.
Alternatives:	Both alternative methods and alternatives to a proposed undertaking.
Alternatives To:	Alternatives to the proposed undertaking are functionally different ways of approaching and dealing with a problem or opportunity.
Ash:	The non-combustible fraction that remains after combustion of waste.
Baghouse Residue:	Leftover material that is captured by an air pollution control / filtering device that removes dust and particles from the exhaust gas stream.
Bottom Ash:	The non-airborne ash resulting from burning waste in an incinerator. The material, which falls to the bottom of the combustion grate and is removed mechanically in a Thermal Treatment Facility. .
British Thermal Unit (BTU):	Unit of heat energy equal to the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit at sea level.
By-pass Waste:	Waste that is not suitable for combustion and is removed for disposal prior to combustion.

Calorific Value:	The amount of heat produced by a specific material type when combusted under specific conditions. Calorific Value is usually expressed in Calories or Joules per kilogram (i.e. Cal/Kg or J/Kg).
Coefficient of Performance (COP):	The ratio of the amount of cooling output from a device to the amount of input energy supplied to the device.
Combustion Chamber:	The actual compartment where waste is burned in an incinerator.
Combustion Product:	Substance produced during the burning or oxidation of a material.
Combustion:	1. Burning, or rapid oxidation, accompanied by the release of energy in the form of heat and light. 2. Refers to controlled burning of waste, in which heat chemically alters organic compounds, converting into stable inorganics such as carbon dioxide and water.
Disposal Facilities:	Facilities for disposing of solid waste, including landfills and incinerators, intended for permanent containment or destruction of waste materials.
Disposal:	Final placement or destruction of wastes. Disposal is typically accomplished through use of approved sanitary landfills or incineration with or without energy recovery.
Diversion:	The management of materials by reduction, reuse, recycling, and composting.
Durham:	The Regional Municipality of Durham or its geographic area, as the context requires.
Durham/York Residual Waste Study:	The Durham/York Residual Waste Study is a joint initiative between the Region of Durham and York Region to work together to find a way to manage solid waste remaining after at-source diversion.
Emissions:	Technically, all solid, liquid, or gaseous discharges from a processing facility, but normally referring to Air Emissions (with solids referred to as residue and liquids as effluent).
Energy Content:	See Calorific Value.

Energy Recovery:

The recovery of energy in the form of heat and/or power from the thermal treatment of waste. Generally applied to incineration, pyrolysis, gasification but can also include the combustion of landfill gas and gas produced from anaerobic digestion of organic materials.

Energy-from-Waste (EFW):

The recovery of energy in the form of heat and/or power from the thermal treatment of waste. Generally applied to incineration, pyrolysis, gasification but can also include the combustion of landfill gas and gas produced from anaerobic digestion of organic materials.

Environment*:

The environment is broadly defined under the Environmental Assessment Act as follows:

(a) Air, land or water;

(b) Plant and animal life, including human life;

(c) The social, economic and cultural conditions that influence the life of humans or a community;

(d) Any building, structure, machine or other device or thing made by humans;

(e) Any solid, liquid, gas, odour, heat, sound, vibration or radiation resulting directly or indirectly from human activities; or,

(f) Any part or combination of the foregoing and the interrelationships between any two or more of them.

Environmental Assessment:

Environmental assessment is a study, which assesses the potential environmental effects (positive or negative) of a proposal. Key components of an environmental assessment include consultation with government agencies and the public; consideration and evaluation of alternatives; and, the management of potential environmental effects. Conducting an environmental assessment promotes good environmental planning before decisions are made about proceeding with a proposal.

Environmental Assessment Act:

The *Environmental Assessment Act* (and amendments and regulations thereto) is a provincial statute that sets out a planning and decision-making process to evaluate the potential environmental effects of a proposed undertaking. Proponents wishing to proceed with an undertaking must document their planning and decision-making process and submit the results from their environmental assessment to the Minister for approval.

Environmental Effect: The effect that a proposed undertaking or its alternatives has or could potentially have on the environment, either positive or negative, direct or indirect, short- or long-term.

Ferrous Metals: Metals derived from iron or steel; products made from ferrous metals include appliances, furniture, containers, and packaging like steel drums and barrels. Recycled products include processing tin/steel cans, strapping, and metals from appliances into new products.

Flue Gas: The air coming out of a stack or a chimney after combustion in the burner it is venting. It can include carbon oxides, water vapour, nitrogen oxides, sulfur oxides, particles and other chemical pollutants.

Fly Ash: The airborne ash resulting from burning waste in an incinerator removed by air pollution control systems.

Gigajoule (GJ): A measurement of energy equal to 10,000 Joules. A typical single family household (approx. 2000 sq. ft.) uses approximately 60 to 90 GJ annually for heating (NRCan).

Impact Management Measures: Measures which can lessen potential negative environmental effects or enhance positive environmental effects. These measures could include mitigation, compensation, or community enhancement.

Impact Studies: Studies that predict negative consequences (if any) of a proposed undertaking. Air, Visual, Natural Environmental, Traffic, Hydrogeological, Noise, Health Risk, Land Use and Hydrological Impact Studies are required under the *Environmental Protection Act*.

Incineration: A thermal treatment technology involving destruction of waste by controlled burning at high temperatures with the overall aim of reducing the volume of waste.

Individual Environmental Assessment:	An Individual Environmental Assessment requires the following steps to fully address the requirements of the EAA: Preparation of the Proposed EA Terms of Reference; Submission of the EA Terms of Reference to the Minister of the Environment for Approval; Completion of the EA Study in accordance with approved EA Terms of Reference, and; Submission of the EA Study to the Minister of the Environment for Approval.
Landfills:	Sanitary landfills are outdoor disposal sites for non-hazardous solid wastes. Waste is spread in layers, compacted to the smallest practical volume, and covered by material applied at the end of each operating day.
Leachate Collection System:	A system that gathers leachate and pumps it to the surface for treatment
Liner:	A relatively impermeable barrier designed to keep leachate inside a landfill. Liner materials include plastic and/or dense clay.
Mass Burn Incineration:	The incineration of waste with minimal initial pre-treatment or separation of wastes.
Ministry of the Environment (MOE) Ontario:	The MOE monitors pollution and restoration trends in Ontario and uses that information to develop environmental laws, regulations, standards, policies, programs, and guidelines. The MOE works to provide cleaner air, land, and water for Ontarians.
Mitigation:	Measures taken to reduce adverse impacts on the environment.
Municipal Solid Waste (MSW):	Common garbage or trash generated by industries, businesses, institutions, and homes.
Non-combustible waste:	Waste, which cannot be combusted (burned) even if energy is added. (e.g. stone, glass and metals).
Non-Ferrous Metals:	Nonmagnetic metals such as aluminum, lead, and copper. Products made all or in part from such metals include containers, packaging, appliances, furniture, electronic equipment and aluminum foil.

Ontario:	The Province of Ontario, or its geographic area, as the context requires.
Ontario Guideline A-7:	Air emission guidelines developed by the Ministry of the Environment (MOE) to govern combustion and air pollution control requirements for new municipal waste incinerators and gasifiers in the Province of Ontario.
Pollutant:	Generally, any substance introduced into the environment that can adversely affect the usefulness of a resource or the health of humans, animals, or ecosystems.
Pollution:	Generally, the presence of a substance in the environment that because of its chemical composition or quantity can prevent the functioning of natural processes and produce undesirable environmental and health effects
Powdered Activated Carbon (PAC):	Used in air pollution control systems to control mercury and dioxins/furans. PAC has a large surface area, which allows the carbon to adsorb (stick to) and react with contaminants.
Project:	Encompasses the design, construction (including construction financing) and operation of the EFW Facility, and includes, the EA Study, the supply of municipal waste, and the sale of energy.
Proponent*:	A person, agency, group or organization that carries out or proposes to carry out an undertaking or is the owner or person having charge, management or control of an undertaking.
Regions:	Durham and York collectively.
Terms of Reference:	A document prepared by the proponent and submitted to the Ministry of the Environment for approval. The terms of reference sets out the framework for the planning and decision-making process to be followed by the proponent during the preparation of an environmental assessment. In other words, it is the proponent's work plan for what is going to be studied. If approved, the environmental assessment must be prepared according to the terms of reference.
Thermal Treatment:	Use of elevated temperatures to treat wastes (e.g., combustion or gasification).

Waste-to-Energy (WTE) Facility/Municipal-Waste Combustor:	Facility where recovered municipal solid waste is converted into a usable form of energy, usually via combustion.
York:	The Regional Municipality of York or its geographic area, as context requires.

List of Abbreviations

APC	Air Pollution Control
BTU	British Thermal Unit
CEAA	Canadian Environmental Assessment Act
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COP	Coefficient of Performance
EA	Environmental assessment
EA ToR	Environmental Assessment Terms of Reference:
EAA	Environmental Assessment Act
CO_2e	Carbon Dioxide Equivalents
EFW	Energy-from-Waste
EPA	Environmental Protection Act
GHG	Greenhouse Gas
GJ	Gigajoule
HDPE	High Density Polyethylene
HHV	Higher Heating Value
HHW	Household Hazardous Waste
LBP	Lester B. Pearson (Airport)
LCA	Life Cycle Analysis
MSW	Municipal Solid Waste
MTCE	Metric Tonne Carbon Equivalent

OCC	Old Corrugated Cardboard
OEAA	Ontario Environmental Assessment Act
ONP	Old Newspaper
PAC	Powdered Activated Carbon
PM	Particulate Matter
t/yr	Tonnes/year
US EPA	United States Environmental Protection Agency
WTE	Waste-to-Energy
WTEF	Waste to Energy Facility

UNITS OF MEASUREMENT

Area

m^3	cubic metre	
scf	standard cubic feet	35.3 m^3

Mass/Weight

g	gram	
mg	milligrams	1×10^{-3} grams
kg	kilogram	1×10^{3} grams
pg	picogram	1×10^{12} grams
t	metric tonne	1×10^{3} kg
lb	pound	1 lb = 453.592 grams

Power

W	watt	
kW	kilowatt	1×10^{3} W
MW	megawatt	1×10^{6} W

Energy

J joule

MJ megajoule 1×10^6 W

GJ gigajoule 1×10^9 W

Volume

m^3 cubic metre 1 m3 = 1×10^3 L

Rm^3 and DSm^3 dry cubic metre of flue gas corrected to standard conditions (25°C, 101.3 kPa, 11% O2) as defined by MOE APC on Incinerators Policy 01-03-02

Time

h hour

yr year

Elements

Cd Cadmium

Hg Mercury

Pb Lead

Al Aluminum

Compounds

CO Carbon Monoxide

CO_2 Carbon Dioxide

CH_4 Methane

TPM Total Particulate Matter

NO_x Nitrogen Oxides

SO_2 Sulfur Dioxide

Miscellaneous

BTU	British Thermal Unit
°C	temperature in degrees Celsius
n/a	not available
%	percent

REPORT

1.0 INTRODUCTION

Durham and York Regions (the Regions) have partnered to undertake a joint Residual Waste Planning Environmental Assessment (EA) Study. Both municipalities are in need of a solution to manage the residual solid waste that remains after diversion. The Regions are working together to address the social, economic, and environmental concerns through an EA Study process to examine potential long-term residual waste management alternatives.

1.1 The Environmental Assessment Process

The purpose of the undertaking (i.e., what the outcome of this EA Study is intended to do) as described in the approved EA Terms of Reference is:

> *"To process - physically, biologically and/or thermally - the waste that remains after the application of both Regions' at-source waste diversion programs in order to recover resources - both material and energy - and to minimize the amount of material requiring landfill disposal. In proceeding with this undertaking only those approaches that will meet or exceed all regulatory requirements will be considered."*

The EA Study follows a planning approach where environmental constraints or opportunities are considered in the context of the broadly defined environment under the *Environmental Assessment Act* (EAA) (i.e., the natural environment as well as the social, economic and heritage and other "environments" relevant to the undertaking) and potential effects are understood and addressed before development occurs. In accordance with the EA Terms of Reference and EAA, the EA process evaluates: alternatives considering potential effects on the environment; the availability of mitigation measures that address, in whole or in part, the potential effects; and, the comparison of the advantages and disadvantages of the remaining or "net" effects. The result of this process provides the planning rationale and support for a preferred approach and method to implement the undertaking.

The EA document has been prepared and conducted in accordance with the EAA, and in accordance with the Approved Terms of Reference approved by Ontario's Minister of the Environment on March 31, 2006. There are currently no federal environmental assessment process triggers identified and, therefore, this project does not require approval under the *Canadian Environmental Assessment Act* (CEAA).

It is understood and contemplated that environmental management measures recommended as part of the EA process and this Technical Study Report will in many cases be refined, updated, modified and/or superceded as a result of subsequent approval processes.

This EA process essentially consists of three parts taking place in stages including:

- the Development and Approval of an EA Terms of Reference,

- the evaluation of "Alternatives to" the undertaking; and,
- the evaluation of "Alternative methods" of implementing the undertaking.

The Environmental Assessment Report to which this Technical Study Report is appended provides a detailed description of the EA process undertaken as part of the Durham/York Residual Waste EA Study.

1.2 Purpose of the Report

This Report entitled the Facility *Energy and Life Cycle Assessment – Technical Study Report*, has been prepared to identify the potential energy benefits and Life Cycle Analysis (LCA) parameters (GHG emissions, Air emissions, Water emissions) associated with the Proposed Thermal Treatment Facility (the Facility). This Report will form part of the supporting documentation and materials for the "Description of the Undertaking", completed as part of the EA Study. This Report addresses the broader implications of the proposed Facility, in regards to the environmental burden of the Facility at a global or macro-environmental scale.

1.3 Overview of Report Contents

This Report describes the existing energy utilization conditions related to the preferred "Alternative method", the Clarington 01 Site. It then provides an overview of the energy generated by the Facility under three scenarios including:

1. Electricity Production Only
2. Electricity & District Heat Production
3. Electricity, District Heat & Cooling Production

These scenarios are then modeled through the use of a LCA model to determine the net environmental impacts or benefits associated with these energy recovery scenarios.

The key components of the Report are as follows:

- An overview of the previous LCA undertaken during the evaluation of "Alternatives to";
- An explanation of the methodology for the LCA;
- A description of the Facility and Energy Outputs;
- An overview of the inputs to the LCA Model;
- Results of the LCA;
- A summary of Additional Facility and Energy Recovery Scenarios;
- Discussion of the results; and,
- Summary and Conclusion.

The information contained in this Report has been used to complete the EA.

2.0 STUDY METHODOLOGY

The evaluations, documented in this Technical Study Report, were completed for two (2) design capacity scenarios for the Facility. These are: an initial design capacity of 140,000 tonnes per year (tpy); and a maximum design capacity of 400,000 tpy for the Facility.

2.1 Previous Life Cycle Analysis

In the Supplement to Annex E-5 of the *Durham/York Residual Waste Study Alternatives to* report, the environmental life cycle implications associated with the development of a generic Thermal Treatment Facility were modeled and compared to the current residual waste disposal method of a remote landfill. The LCA completed for the Facility was based on typical conditions of modern Thermal Treatment Facilities and an assumed site because Facility (vendor) and site specific information was not available at that time.

Subsequent to the completion of the initial LCA, the planned capacity of the Facility was adjusted to match available waste supply, the Proposed Thermal Treatment Facility Site (the Site) and Covanta Energy (Vendor) was selected as the preferred vendor for development of the Proposed Durham/York Thermal Treatment Facility. Based on Site and Vendor specific information, an updated LCA has been completed and is presented in this Report.

2.2 Methodology for Life Cycle Analysis

The LCA model estimates the environmental implications related to air, water, and energy associated with developing a Thermal Treatment Facility. It includes the assessment of raw material production, manufacture, distribution, use, and disposal, including transportation, involved in operating the Facility.

The LCA model chosen is the Municipal Solid Waste Decision Support Tool (MSW-DST), which utilizes average default data from existing waste management facilities across North America. RTI International developed the MSW-DST in cooperation with the U.S. Environmental Protection Agency (EPA) Office of Research and Development. RTI International offers research and technical solutions to governments and businesses worldwide in the areas of economic and social development, energy, and the environment. The MSW-DST is a peer-reviewed and widely used North American LCA model.

This model is the most extensively used model in North America. It reflects North American conditions and it has undergone extensive stakeholder input and peer review, including a separate review by the U.S. EPA. Other models had been used previously to complete LCA during the evaluation of “Alternatives to” including the IWM model developed by EPIC and the University of Waterloo and the ICF model for GHG emissions developed for Environment Canada. Neither model was capable of providing a full analysis of the LCA impacts for all aspects of the thermal treatment system for Durham/York nor had been subject to the same rigor in regards to peer review.

The MSW-DST model was run by RTI International to determine life cycle implications for three energy recovery scenarios for the Facility at the Site:

1. Electrical energy recovery only;
2. Electrical energy recovery and heat energy recovery for district heating; and,
3. Electrical energy recovery and heat energy recovery for district heating and cooling via absorption chillers.

The first scenario considers only recovery of the electrical energy from the Facility. The Facility would operate on the electrical energy produced and additional electrical energy would be supplied to the local power grid.

The second scenario considers the recovery of both electrical and heat energy. Electrical energy would be produced as in the first scenario and heat output from the Facility would be used for district heating of Clarington Energy Business Park (Business Park), where the Site is located. This heat would offset natural gas that would otherwise be used to heat buildings in the Business Park.

The third scenario considers producing both electrical and heat energy; however heat energy would be used for district heating and district cooling via absorption chilling for the Business Park.

Additional details of the energy utilization for these scenarios are provided in Section 4.1.

3.0 DESCRIPTION OF EXISTING CONDITIONS

The Regions currently dispose of residual waste by remote landfill. The environmental life cycle implications of the management of residual waste by remote landfill were modeled in the previous LCA study presented in the Supplement to Annex E-5 of the *Durham/York Residual Waste Study Alternatives to* report. The LCA was completed based on assuming disposal of residual waste at a modern lined landfill with landfill gas and leachate recovery.

Results of the LCA for the remote landfill were compared with results from the initial LCA of the generic Thermal Treatment Facility (see Section 2.1). Relative energy and environmental implications were compared and, based on these results, it was determined that residual waste management by thermal treatment is better than remote landfill with respect to reduced energy consumption (net energy produced), emissions to air of greenhouse gases (GHGs), acid gases, smog precursors and emissions to water. Note: this previous LCA modeling exercise only considered recovery of electricity from waste by thermal treatment and did not examine the potential benefits of heat recovery.

Information on the LCA for the remote landfill is provided in the *Supplement to Annex E-5 of the Durham/York Residual Waste Study* (July 2007).

The Site is located in the southern portion of the proposed Clarington Energy Business Park. The site for the Business Park is currently mostly used for crop farming; however there are two automobile auction yards and some small industrial buildings located in the Business Park. The land has been zoned Business Park by the Municipality of Clarington and Employment Areas by the Region of Durham, and most of the site is surrounded by a combination of industrially zoned lands, employment areas, waterfront areas, Open Space, and the Darlington Nuclear Generating Station. The vision for the Clarington Energy Business Park identifies industrial uses as the predominant uses in the Park, with some office, research, and commercial (prestige) facilities catering to local businesses. The Park will focus on businesses, research, and other facilities with a focus on new energy and environmental technologies and act as a location where “best practices” in energy and the environment are on display. Presently no energy is produced in the Business Park.

4.0 RESULTS OF ANALYSIS

4.1 Description of Thermal Treatment Facility and Energy Outputs

The Facility will be developed by Covanta Energy Corporation (Vendor), an internationally recognized owner and operator of Thermal Treatment Facility projects. The Facility has an initial design capacity of 140,000 tonnes per year (tpy) (140,000 tpy scenario) of municipal solid waste annually to create usable energy and reduce the amount of waste for disposal. However, with appropriate expansions the Facility maximum design capacity of 400,000 tpy (400,000 tpy scenario) of waste can be processed at the Site if required.

The Facility will meet its own internal energy needs and produce both electricity and heat for export off the Site. The energy output will be a function of the energy content of the incoming waste stream. The Facility will be capable of processing waste with an as received energy content, on a higher heating value (HHV) basis, ranging from 11 MJ/kg to 15 MJ/kg. Waste audit data and energy content calculations indicate that the post diversion waste stream has energy content around the midpoint of this range. This energy content is higher than generally reported for municipal solid waste because of the removal of low energy materials such as food waste by the Regions' aggressive waste diversion program.

The energy output from the Facility, as presented in the Covanta Proposal to the Regions, assuming waste with an energy content of 13 MJ/kg and a Facility sized for the 140,000 tpy scenario is summarized in the following Table (Table 4-1).

Table 4-1 Covanta Proposed Durham/York Thermal Treatment Energy Output

Scenario	Average Electrical Power Supplied to Grid (MW Electrical)	Heat Available for Peak Thermal Loads (MW Thermal)	Annual Electrical Energy Supplied to Grid (MWh Electrical)
Electricity Production Only	13.6	n/a	107,222
Electricity & District Heat Production	11.9	7.4	93,820
Electricity, District Heat & Cooling Production	11.9	7.4	96,454

Three energy recovery scenarios are being considered and include:

1. Electrical energy recovery only;
2. Electrical energy recovery and heat energy recovery for heating; and,
3. Electrical energy recovery and heat energy recovery for heating and cooling.

In all scenarios, electrical energy recovered through the thermal treatment process would be used to operate the plant and to supply the local 44kV power line into the Wilson Transformer Station, which feeds power to the Clarington area.

In the second scenario, heat energy would also be recovered from the thermal treatment process and would be used for district heating for businesses developed within the proposed Clarington Energy Business Park. Heat from the Facility would be used to offset natural gas that would have otherwise been used to heat buildings in the Business Park.

In the third scenario, the recovered heat energy would be used for district heating, as in the second scenario, as well as district cooling during the summer months. It was assumed that district cooling would be achieved through the use of absorption chillers, which use steam or hot water to drive a phase change in a medium to create a cooling effect. The use of absorption chillers would replace the need for electric chillers and therefore offset some of the electricity requirements for the Business Park.

The heat energy recovered and used from the Facility is dictated by the estimated heating and cooling loads for the Clarington Energy Business Park. The thermal load profile development for the Business Park was based on the light industrial and prestige employment building footprints, developed based on the proposed land use in the *Clarington Energy Business Park Study Report* (March 2005). No industrial process loads were included in the development of the thermal loads because light industrial land use would not likely have a significant load. Buildings were based on RETSCREEN "good insulation" building envelopes. The thermal load profiles were developed based on ASHRAE Psychrometric data for Toronto Lester B. Pearson International Airport and modeled with RETSCREEN software to yield annual heating and cooling load profiles and consumptions. Normal environmental data was obtained from Environment Canada 1971 to 2000 Toronto Lester B. Pearson International Airport weather data.

The potential heating and cooling loads estimated for the Clarington Energy Business Park are summarized as follows:

- Heating load assuming natural gas boilers:
  - Peak heating load 64 MW thermal
  - Annual heating load 225,000 MWh thermal
- Cooling load assuming absorption chillers:
  - Peak cooling load 45 MW thermal
  - Annual cooling load 120,000 MWh thermal

Details of the estimated thermal load profile and potential supply of district energy to this load are provided in **Appendix A**.

The realization of these loads and the resulting benefits of using district energy are dependent upon both the Clarington Energy Business Park being developed and the decision to utilize district energy by the Municipality of Clarington.

In the Request for Proposal (RFP) documents, vendors were required to guarantee their facility's energy outputs assuming the supply of 7.4 MW thermal output for district energy supply. Covanta proposed to supply this energy in the form of approximately 11,000 kg/hr of 260ºC steam at a pressure of about 13 Bar.

European experience has shown that with the extraction of low-grade heat from the back end of a steam turbine, approximately two units of heat, in the form of hot water for district energy can be produced for each unit of electricity produced. With the extraction of this heat, electrical output is reduced to about 80% of what it would have been without any heat recovery. The capital costs for the heat exchangers required to recover this low-grade heat are considerably higher than the capital costs for the approach proposed by Covanta.

Under this European approach, the 140,000 tpy scenario Facility could produce 10.9 MW of electricity plus 21.8 MW of heat for district energy. Nevertheless, in the interest of being conservative, for the 140,000 tpy scenario Facility, the 11.9 MW electrical plus 7.4 MW thermal output from the Facility was assumed.

This output is considerably less than the ultimate peak heating and cooling loads estimated above for the Clarington Energy Business Park. It should therefore be possible for the initial Facility design capacity of 140,000 tpy to supply the required energy during the early stages of development of the Business Park. Future Facility expansions, as discussed in Section 5, would be capable of supplying a larger portion of the needs of the ultimate requirements.

The 7.4 MW thermal output from the Facility was assumed to supply a portion of the estimated Clarington Energy Business Park heating and cooling loads. The heat output used for district heating was assumed to substitute for natural gas boilers with a seasonal efficiency of 80%. The heat output used for district cooling was assumed to substitute for electrical chillers with a Coefficient of Performance (COP) of 6.

The following table (Table 4-2) summarizes the district energy output from the Facility along with the resulting estimated savings in natural gas and electricity. Details of these estimates are provided in **Appendix A**.

Table 4-2 Covanta Proposed Durham/York Thermal Treatment District Energy Output

Scenario	Estimated Annual District Heating Output (MWh Thermal)	Estimated Savings in Natural Gas Consumption (m^3)	Estimated Annual District Cooling Output (MWh Thermal)	Estimated Savings in Electricity Consumption (MWh Electrical)
Electricity & District Heat Production	46,788	5,614,000	n/a	n/a
Electricity, District Heat & Cooling Production	41,900	5,028,000	15,771	2,634

4.2 Inputs to Life Cycle Analysis Model

In order to use the MSW-DST model to accurately reflect the life cycle impacts of the development of the Facility on the Site, vendor and site specific information was input into the model. Details on input information required for the MSW-DST model are provided in this section. Any assumptions that were required are also identified and explained.

4.2.1 Electrical Energy

4.2.1.1 Electrical Energy Grid Split

A custom energy grid following Ontario Power Authority's Integrated Power System Plan (IPSP) was used for the modeling in order to reflect potential future conditions in Ontario. The custom energy grid was developed using the 2015 estimates provided in Exhibit G of the IPSP document. The custom energy grid was adjusted to remove conservation as a component of supply and assumes the eventual replacement of coal-fired power plants with natural gas-fired power plants and renewable energy. The custom energy grid is provided in Table 4-3 below. Given that coal fired power plants presently supply a portion of Ontario's electrical energy needs, this assumed future custom grid yields conservative estimates of the energy offset benefits compared to what would be estimated based on the current power generation mix. For example, the energy offset benefits from the recovery of energy by the Facility would be higher if it were replacing electricity from Coal or Oil fired power plants. We believe that the custom energy grid used in this LCA is a reasonable estimate of future conditions in Ontario for the purpose of this study.

Table 4-3 Custom Energy Grid

Fuel Type	Input (%)
Coal	0
Natural Gas	15
Residual Oil	0
Distillate Oil	0
Nuclear	54
Hydro*	31
Wood	0
Other	0

*Hydro includes renewables (i.e. wind, solar, hydro)

4.2.1.2 Combustion Displacement

Electricity generation (for all three scenarios) and district cooling via absorption chilling (Scenario 3 only) displaces electricity based on the custom energy grid provided. District heating (Scenarios 2 and 3) displaces natural gas.

4.2.2 Waste Quantity and Characterization

4.2.2.1 Waste Generation

The quantity of waste processed is based on the initial Facility size (140,000 tpy), a combined amount from Durham and York Regions. Waste composition estimates were based on post diversion quantities, determined through curbside waste audits and the application of recovery rates for recyclable and compostable materials based on diversion program design (see Annex E-1 from Alternatives to), and are the estimated composition of the waste to be delivered to the Facility. The estimated waste composition provided in Table 4-4 below was developed based on correlating the waste composition estimates derived in the EA Study to the input waste categories used for the MSW-DST.

Table 4-4 Input Waste Composition

Waste Item	Residential Composition (% mass)	Default Heating Value (BTU/lb)	Durham/York Residual Waste Analysis Categories
Yard Trimmings, Leaves	0.8%	2,601	*50% leaf and yard waste*
Yard Trimmings, Branches	3.5%	6,640	*50% leaf and yard waste*
News Print	4.3%	7,541	*Newspaper*
Corrugated Cardboard	1.8%	6,895	*Cardboard*
Magazines	1.7%	5,386	*Magazines/Paperbacks*
Mixed Paper	7.2%	6,799	*Boxboard/rolls, gable top cartons, aseptic containers, other fibres*
HDPE - Translucent	0.2%	18,687	*50% HDPE*
HDPE - Pigmented	0.2%	18,687	*50% HDPE*
PET	0.8%	18,687	*PET*
Plastic - Other #1	0.0%	14,101	*PVC*
Plastic - Other #2	0.6%	14,101	*LDPE & PP*
Plastic - Other #3	1.2%	14,101	*Polystyrene*
Plastic - Other #4	2.5%	14,101	*Film*
Mixed Plastic	6.8%	14,101	*Other plastic*
Ferrous Cans	0.7%	301	*Steel cans*
Ferrous Metal - Other	1.2%	0	*Aerosol cans, paint cans, other metals*
Aluminum Cans	0.3%	0	*Aluminum cans*
Aluminum - Other #1	0.2%	0	*Aluminum foil trays*
Glass - Clear	1.3%	84	*Food & beverage containers*
Glass - Green	1.6%	84	*LCBO glass*
CNNR Other	0.3%	0	*HHW*
Paper - Non-recyclable	11.7%	6,464	*Compostable fibres, sanitary products*
Food Waste	18.1%	1,797	*Food waste, animal waste*
CCCN Other	4.3%	6,799	*Textiles*
Misc.	16.7%	3,669	*Building renovation materials, misc. goods & other material*
Ferrous - Non-recyclable	10.9%	0	*White goods, electronics, bulky goods*
Glass - Non-recyclable	1.0%	0	*Other glass*

Following the thermal treatment process there would be some residual material that would be sent to landfill. Three types of residual are produced as a result of the thermal treatment process. These include bypass waste (removed from the waste stream prior to combustion), bottom ash, and fly ash. The estimated annual quantities of these materials assumed for the LCA are:

- Bypass waste = 2,100 tonnes
- Bottom ash = 29,400 tonnes
- Fly ash = 8,400 tonnes
- Total material to disposal = 39,900 tonnes (28.5%)

Bottom and bypass waste can be sent to a conventional landfill, however Ontario regulations require that fly ash be sent to a secure disposal Facility unless otherwise treated. Covanta proposes to treat the fly ash generated by the Facility through the use of Portland cement which would result in an encapsulated (stabilized) material that may be disposed in conventional landfill. The Information on ash landfills and haul distances is provided in subsequent sections.

Metals are recovered from the bottom ash before it is sent to landfill.

The ferrous recovery rate from the Facility is 80% and the non-ferrous recovery rate is 60%, as quoted by the Vendor. Based on these recovery rates, annual waste amount of 140,000 tonnes, and the waste composition presented above, the annual tonnage of recovered ferrous material is 14,340 tonnes and recovered non-ferrous material is 420 tonnes.

The 14,336 tonnes of recovered ferrous consists of 2,128 tonnes of recovered ferrous representing potentially recyclable materials that ended up in the waste stream plus 12,210 tonnes of recovered ferrous derived from a portion of the bulky waste stream (i.e., mattress shredded with foam and fiber burnt off and ferrous metal springs recovered) and a small amount of electronic waste. The 2,128 tonnes of recovered ferrous is based on waste audit data and the 12,210 tonnes of recovered ferrous is based on reasonable assumptions from the quantity of bulky and electronic waste.

4.2.2.2 Waste Physical Properties

The default heating values for the MSW-DST model are used. Based on the default heating values for the individual materials and waste composition for Durham/York, the energy content of the input waste was estimated as approximately 5,600 BTU/lb. A breakdown of the waste composition and associated heating values is provided in Table 4-4.

The energy outputs from the proposed Covanta Facility are based on processing waste with this energy content.

4.2.3 Transportation Distance and Modes

The distance from the waste generation points to the Facility is approximately 225 km shorter than the distance to the landfill where the post-diversion residual waste would in theory otherwise be disposed. Energy implications from this additional haul distance is applied to the model results for each scenario to take into account the savings achieved by hauling waste to a local facility rather than a remote landfill.

The haul distance from the Facility to the ash landfill is based on a weighted average (i.e., weight of ash for disposal) of distances to conventional and hazardous waste disposal facilities. The resulting averaged haul distance is 300 km.

Waste and ash would be hauled for landfill disposal via transfer trailer.

4.2.4 Combustion

4.2.4.1 General

The net heat rate is an estimate of the amount of heat energy, expressed in Megajoules (MJ) required to produce a kilowatt hour (kWh) of electricity. The Net Plant Heat Rate is estimated at 16.9 MJ/kWh when only electrical energy is being produced (Scenario 1) and 19.3 MJ/kWh when both electric and heat energy is being produced (Scenarios 2 and 3). The Net Plant Heat Rate is estimated based on Vendor data and is the difference between the Gross Plant Heat Rate and Plant Parasitic Load (i.e., energy used to operate the Facility).

For Scenario 1, where only electrical energy is being recovered, the gross electricity production is 868 kWh/tonne and net electricity production is 767 kWh/tonne, as specified by the Vendor. Based on a waste energy content of 13 MJ/kg, the Net Plant Heat Rate is 16.9 MJ/kWh (13,000 MJ/tonne / 767 kWh/tonne).

For Scenarios 2 and 3, where both heat and electrical energy are recovered, the gross electricity production is 773 kWh/tonne and net electricity production is 672 kWh/tonne. Based on a waste energy content of 13 MJ/kg, the Net Plant Heat Rate is 19.3 MJ/kWh. In these Scenarios slightly more input energy is required to produce each kWh of electricity, compared to Scenario 1, as some of the energy is used to produce the heat.

During combustion, ancillary solid waste is created from products that are required for the flue gas cleaning process. These solid wastes include lime, ammonia, and powdered activated carbon, and amounts resulting from the process were specified by the Vendor. These values and other general combustion input parameters to the MSW-DST model are summarized in Table 4-5 below.

Table 4-5 General Combustion Inputs Parameters

Parameter	Units	Input
Plant heat rate (net) - electricity only	MJ/kWh	16.9
Plant heat rate (net) - electricity and heat	MJ/kWh	19.3
WTE Ton Lime per Ton Waste	tonne lime/tonne MSW	0.0091
WTE Ton Ammonia per Ton Waste	tonne ammonia/tonne MSW	0.0005
WTE Ton Powdered Activated Carbon per Ton Waste	tonne PAC/tonne MSW	0.0006

4.2.4.2 Emissions Factors

The Thermal Treatment Facility Stack Emission Limits (Emissions factors) required by Durham and York as set out in the RFP, agreed to with representatives of MOE, and guaranteed by the Vendor are provided in Table 4-6a below.

Table 4-6a Proposed Durham York EFW Maximum Stack Emission Limits

Compound	Units	Input
Sulfur dioxide	mg/Rm^3	35
HCl	mg/Rm^3	9
NOx	mg/Rm^3	121
CO	mg/Rm^3	45
TPM	mg/Rm^3	9
Dioxins / Furans (toxic equivalents)	pg/Rm^3	60
Cadmium	mg/Rm^3	0.007
Mercury	mg/Rm^3	0.015
Lead	mg/Rm^3	0.05

Default values from the MSW-DST model were assumed for contaminants not specified by Ontario regulations and not guaranteed by the Vendor, but that are required as inputs to the model. These values are provided in Table 4-6b below.

Table 4-6b MSW-DST Model Default Emission Limits

Compound	Units	Input
Methane	lb emitted/ton MSW	0.003
Ammonia	lb emitted/ton MSW	0
Hydrocarbons	lb emitted/ton MSW	0
As	% removed from flue gas	0.999
B	% removed from flue gas	0.765
Cr	% removed from flue gas	0.993
Cu	% removed from flue gas	0.996
Ni	% removed from flue gas	0.966
Sb	% removed from flue gas	0.967
Se	% removed from flue gas	0.929
Zn	% removed from flue gas	0.997

4.2.5 Heat Load Information

Heat from the plant would be used for district heating (Scenarios 2 and 3) and district cooling (Scenario 3) of the proposed Clarington Business Energy Park. District heating would offset natural gas and district cooling would offset electricity from conventional chillers. The annual heating and cooling requirements for the Business Park that are displaced are as follows:

Displaced Natural Gas Consumption (Heating only) = 5.614 million m^3/yr

Displaced Natural Gas Consumption (Heating and Cooling) = 5.028 million m^3/yr

Displaced Electricity Consumption (Cooling) = 2,634 MWh/yr

The thermal load profile development is discussed in Section 4.1 and details are provided in **Appendix A**.

4.2.6 Landfill Information

In regards to the landfilling of Thermal Treatment Facility residues, default values for ash landfills were used. Landfills are assumed to be lined, U.S. EPA Subtitle D sites.

To determine the uncaptured emissions that would be generated under a landfill scenario (i.e., if the waste thermally processed by the Facility were instead sent to landfill), a lined landfill with 75% landfill gas recovery efficiency and flaring was assumed based on reasonable assumptions reflecting current practice in Ontario.

The same assumptions were used as the Base Case – Remote Landfill Scenario, as documented in the Supplement to Annex E-5 of the *Durham/York Residual Waste Study Alternatives to* report, with the exception of landfill gas recovery. Landfill gas recovery efficiency was increased from 60% to 75% to reflect a more reasonable estimate of current/future gas management and not past gas management for waste already in-place

4.3 Results of Life Cycle Analysis

The MSW-DST model was used to calculate the emissions to air of:

- Greenhouse gases (net carbon dioxide equivalents);
- Acid gases (nitrogen oxides, sulphur oxides, and hydrochloric acid); and,
- Smog precursors (nitrogen oxides and particulate matter).

Although lead was considered, it should be noted that other heavy metals, including mercury and cadmium, as well as dioxins/furans are not standard outputs in the MSW-DST model therefore the emissions of these and other trace contaminants were not presented in the LCA but are considered in other studies including the *Air Quality Impact Assessment Report* and *Human Health and Ecological Risk Assessment Report*.

Although there are no emissions to water from the Facility itself; on a lifecycle basis there are overall reductions in emissions in both dissolved and suspended solids as well as a number of other contaminants. These reductions arise from the energy sector offsets that occur because of the Facility (e.g., reductions in outputs from other generating facilities that result because of the Facility).

The net energy consumption and emissions of these contaminants on an annual and per tonne basis calculated by the MSW-DST model for the three energy recovery scenarios are provided in **Appendix B**. Results, including summary tables of key parameters, are presented in this section.

The net energy consumption and emissions are the sum of the energy consumption and emissions (or reductions from offsets) for the following sources:

- Thermal Treatment Facility – energy consumption and emissions associated with material inputs (i.e., air pollution control system);
- Offset for Electrical /Heating/Cooling Energy – energy offset from the grid/natural gas resulting from the energy produced by the Facility (takes into account the plant parasitic load);
- Ash Transport – transportation of residual ash from Facility to landfill;
- Ash Landfill;
- Recycling Transport – transportation of recyclables from Facility to recycling facility;
- Recycling Offset/Remanufacture – energy consumption and emissions offset by recycling replacing virgin material;
- Landfill Long Haul Burdens – accounts for the haul distance saved by hauling waste to a local facility rather than a remote landfill; and,
- Avoided Landfill – accounts for the avoided methane (uncaptured emissions) that would have resulted if the post-diversion residual waste had been landfilled instead of thermally treated.

A summary of the LCA results for all three energy recovery scenarios are shown in Tables 4-7, 4-8, and 4-9 below. The net energy consumption, greenhouse gas emissions, and other emissions to air are presented; complete tables of results are provided in **Appendix B**.

Table 4-7 Summary of LCA Results (Energy and Air) for Scenario 1 – Electrical Energy Recovery

Parameter	Units	Total	Thermal Treatment Facility	Offset for Electrical Utility	Ash Landfill and Transport	Metals Recycling Offset Including Transport	Landfill Long Haul Burdens
Energy Consumption	GJ/yr	-1,113,094	7,319	-965,204	13,888	-136,958	-32,140
Air Emissions							
Total Particulate Matter	kg/yr	-28,323	8,045	-12,016	965	-22,571	-2,746
Nitrogen Oxides	kg/yr	5,339	85,797	-54,779	7,101	-13,710	-19,070
Sulfur Oxides	kg/yr	-189,059	56,498	-203,423	1,891	-38,612	-5,412
Carbon Monoxide	kg/yr	-51,374	29,654	-22,213	6,293	-46,310	-18,798
Carbon Dioxide Biomass	kg/yr	102,420,647	102,004,603	416,387	186	2	-532
Carbon Dioxide Fossil	kg/yr	8,569,724	25,224,953	-8,725,908	778,353	-6,484,875	-2,222,799
Greenhouse Gas Emissions(1)	tonnes CO_2e	7,692 (2)	25,254	-9,450	781	-6,663	-2,230
Hydrocarbons (non CH4)	kg/yr	-9,702	49,749	-44,327	2,697	-10,147	-7,673
Lead	kg/yr	4	3	0	0	1	0
Ammonia	kg/yr	-265	0	-249	1	-14	-3
Methane	kg/yr	-41,789	1,392	-34,461	125	-8,491	-354
Hydrochloric Acid	kg/yr	6,832	7,617	16	1	-800	-2

(1) Carbon Dioxide from Fossil sources plus Methane (x21)

(2) Landfill emissions of 23,930 tonnes of CO2e are avoided annually hence Total Net Greenhouse Gas Emissions are –16,238 tonnes of CO2e per year.

Table 4-8 Summary of LCA Results (Energy and Air) for Scenario 2 – Electrical and Heat Energy Recovery

Parameter	Units	Total	Thermal Treatment Facility	Utility Offset for Electrical	Offset for Heating	Ash Landfill and Transport	Metals Recycling Offset Including Transport	Landfill Long Haul Burdens
Energy Consumption	GJ/year	-1,205,281	7,319	-843,894	-213,497	13,888	-136,958	-32,140
Air Emissions								
Total Particulate Matter	kg/yr	-27,203	8,045	-10,495	-401	965	-22,571	-2,746
Nitrogen Oxides	kg/yr	-33,381	85,797	-47,695	-45,804	7,101	-13,710	-19,070
Sulfur Oxides	kg/yr	-340,357	56,498	-177,734	-176,988	1,891	-38,612	-5,412
Carbon Monoxide	kg/yr	-72,313	29,654	-19,352	-23,800	6,293	-46,310	-18,798
Carbon Dioxide Biomass	kg/yr	102,422,742	102,004,603	420,997	-2,515	186	2	-532
Carbon Dioxide Fossil	kg/yr	-2,102,279	25,224,953	- 7,120,708	- 12,277,204	778,353	-6,484,875	-2,222,799
Greenhouse Gas Emissions(1)	tonnes CO_2e	-3,606 (2)	25,254	-7,753	-12,994	781	-6,663	-2,230
Hydrocarbons (non CH4)	kg/yr	-51,856	49,749	-38,756	-47,726	2,697	-10,147	-7,673
Lead	kg/yr	4	3	0	0	0	1	0
Ammonia	kg/yr	-504	0	-218	-270	1	-14	-3
Methane	kg/yr	-71,586	1,392	-30,130	-34,128	125	-8,491	-354
Hydrochloric Acid	kg/yr	6,839	7,617	32	-9	1	-800	-2

(1) Carbon Dioxide from Fossil sources plus Methane (x21)

(2) Landfill emissions of 23,930 tonnes of CO_2e are avoided annually hence Total Net Greenhouse Gas Emissions are –27,536 tonnes of CO_2e per year.

Table 4-9 Summary of LCA Results (Energy and Air) for Scenario 3 – Electrical and Heat/Cooling Energy Recovery

Parameter	Units	Total	Thermal Treatment Facility	Utility Offset for Electrical	Offset for Heating	Offset for Cooling	Ash Landfill and Transport	Metals Recycling Offset Including Transport	Landfill Long Haul Burdens
Energy Consumption	GJ/ year	-1,193,225	7,319	-843,894	-191,932	-9,509	13,888	-136,958	-32,140
Air Emissions									
Total Particulate Matter	kg/yr	-27,623	8,045	-10,495	-361	-460	965	-22,571	-2,746
Nitrogen Oxides	kg/yr	-33,658	85,797	-47,695	-41,177	-4,903	7,101	-13,710	-19,070
Sulfur Oxides	kg/yr	-339,585	56,498	-177,734	-159,111	-17,105	1,891	-38,612	-5,412
Carbon Monoxide	kg/yr	-71,104	29,654	-19,352	-21,396	-1,195	6,293	-46,310	-18,798
Carbon Dioxide Biomass	kg/yr	102,422,043	102,004,603	420,997	-2,261	-953	186	2	-532
Carbon Dioxide Fossil	kg/yr	-2,928,156	25,224,953	-7,120,708	-11,037,082	-2,065,998	778,353	-6,484,875	-2,222,799
Greenhouse Gas Emissions(1)	tonnes CO_2e	-4,381 (2)	25,254	-7,753	-11,681	-2,088	781	-6,663	-2,230
Hydrocarbons (non CH4)	kg/yr	-51,190	49,749	-38,756	-42,905	-4,154	2,697	-10,147	-7,673
Lead	kg/yr	4	3	0	0	0	0	1	0
Ammonia	kg/yr	-485	0	-218	-243	-8	1	-14	-3
Methane	kg/yr	-69,194	1,392	-30,130	-30,681	-1,056	125	-8,491	-354
Hydrochloric Acid	kg/yr	6,837	7,617	32	-8	-4	1	-800	-2

(1) Carbon Dioxide Fossil plus Methane (x21)

(2) Landfill emissions of 23,930 tonnes of CO2e are avoided annually hence Total Net Greenhouse Gas Emissions are –28,311 tonnes of CO2e per year.

Results show that for all three scenarios there is net energy production, therefore providing a local source of electrical and heat energy. Approximately 1,113,000 GJ/yr of energy is produced when only electrical energy is recovered, 1,205,000 GJ/yr when, in addition, heat is also recovered for district heating, and 1,193,000 GJ/yr when heat recovery for district cooling is added. The small decrease in total energy benefits between Scenarios 2 and 3 results because of the substitution of heat, used for summer loads such as domestic hot water, for much less efficient absorption cooling.

In addition to potential reductions in net GHG through the WTE process, GHG landfill emissions are also avoided. The Intergovernmental Panel on Climate Change (IPCC) recognizes waste to energy as a technical option for addressing GHG emissions from solid waste disposal, including it as a measure for source reduction (avoidance) of landfill methane. (IPCC Technical Paper I, Technologies, Policies and Measures for Mitigating Climate Change, November 1996). Approximately 10% of Global methane emissions from human-related sources are emitted from landfills and open dumps annually.

Approximately 23,930 tonnes CO_2e of GHG emissions generated from the 140,000 tonnes of waste if it were to be landfilled would be avoided by providing thermal treatment as an alternative to disposal.

Net greenhouse gas (GHG) emissions, expressed in terms of annual metric tonnes of CO_2 equivalents (CO_2e) are reduced for all scenarios. For the electricity production only scenario, the indirect reduction in GHGs associated with electrical energy and materials recovery and avoided landfill methane emissions more than offset the direct GHG emissions from the Facility resulting in net annual GHG emission reductions of 16,238 tonnes CO_2e. For the scenarios assuming district energy, the indirect reduction in GHG emissions associated with the recovery of both electricity and heat offset more than the direct GHG emissions from the Facility. Once avoided landfill methane emissions are accounted for, the scenarios that recover waste heat result in greater GHG emission reductions (27,536 and 28,311 tonnes CO_2e, respectively) than when only electricity is recovered. This illustrates the benefits of using waste heat rather than natural gas for heating and electricity for cooling purposes.

5.0 ADDITIONAL FACILITY AND ENERGY RECOVERY SCENARIOS

The maximum design capacity of the Facility is 400,000 tpy (400,000 tpy scenario) of waste at some point within the 35-year planning period; therefore an energy and life cycle assessment was also completed for the scenario in which the Facility processes 400,000 tpy.

As well, as mentioned previously in Section 4.1 of this Report, a higher efficiency of heat recovery can be achieved by extracting a lower grade heat than what was proposed by Covanta. In the interest of being conservative for the 140,000 tpy scenario Facility, only the approach proposed by Covanta was considered. However, for the 400,000 tpy scenario Facility, both heat recovery efficiencies are analyzed.

The majority of the inputs to the LCA model for the 400,000 tpy scenario Facility are the same as with the 140,000 tpy scenario Facility. Input information that changed in the modeling were values proportional to the amount of waste being processed (i.e., quantities of waste, residual material, and recovered metals) and amounts of electrical energy and natural gas saved/displaced. Facility specifications, such as net plant heat rates and emissions factors, were assumed to remain the same.

Processing 400,000 tpy of waste, would result in annual quantities of thermal treatment residuals as follows:

- Bypass waste = 6,000 tonnes
- Bottom ash = 84,000 tonnes
- Fly ash = 24,000 tonnes
- Total material to disposal = 114,000 tonnes (28.5%)

Metals recovery rates remain the same; however, with the increased capacity the annual tonnage of recovered metals would be 40,960 tonnes of ferrous and 1,200 tonnes of non-ferrous.

The natural gas and electricity offsets from district heating and cooling would increase with the increase in Facility capacity. Two scenarios of heat recovery were considered for the 400,000 tpy scenario Facility: extraction of high grade heat as per the Covanta Proposal (low efficiency) and extraction of lower grade heat based on European experience (high efficiency).

European experience shows that approximately two units of heat can be produced for each unit of electricity produced by extracting the lower grade heat. However, with the extraction of this heat, electrical output is reduced to about 80% of what it would have been without any heat recovery. Alternately, based on the Covanta approach of extracting a higher grade heat, the heat output is approximately 60% of the electrical output.

The annual heating and cooling requirements for the Business Park that are displaced for the low efficiency scenario are as follows:

- Displaced Natural Gas Consumption (Heating only) = 13.28 million m^3/yr

- Displaced Natural Gas Consumption (Heating and Cooling) = 12.70 million m^3/yr
- Displaced Electricity Consumption (Cooling) = 7,498 MWh/yr

And for the high efficiency scenario:

- Displaced Natural Gas Consumption (Heating only) = 23.70 million m^3/yr
- Displaced Natural Gas Consumption (Heating and Cooling) = 23.70 million m^3/yr
- Displaced Electricity Consumption (Cooling) = 17,180 MWh/yr

Details of these estimates are provided in **Appendix A.**

A summary of the LCA results for the 400,000 tpy scenario Facility scenarios is provided in Table 5-1. The net energy consumption, GHG emissions, and other emissions to air are presented; complete tables of results are provided in **Appendix B**.

Table 5-1 Summary of LCA Results (Energy and Air) for 400,000 tpy Scenario Facility

Parameter	Units	Electrical Energy Recovery Only Total	Low Efficiency Heat Recovery		High Efficiency Heat Recovery	
			Electrical and Heat Energy Recovery Total	Electrical and Heat/Cooling Energy Recovery Total	Electrical and Heat Energy Recovery Total	Electrical and Heat/Cooling Energy Recovery Total
Energy Consumption	GJ	-3,180,286	-3,339,280	-3,343,706	-3,531,106	-3,593,095
Air Emissions						
Total Particulate Matter	kg	-80,975	-77,574	-78,842	-75,749	-78,751
Nitrogen Oxides	kg	15,419	-72,798	-81,898	-145,959	-177,922
Sulfur Oxides	kg	-540,317	-886,127	-916,047	-1,171,668	-1,283,168
Carbon Monoxide	kg	-146,895	-195,059	-195,935	-234,459	-242,246
Carbon Dioxide Biomass	kg	292,674,327	292,681,545	292,679,098	292,684,661	292,678,446
Carbon Dioxide Fossil	kg	24,483,622	-5,941	-4,584,927	-20,111,880	-33,579,302
Carbon Equivalents	MTCE	6,774	-279	-1,526	-6,052	-9,776
Greenhouse Gas Emissions (including avoided landfill emissions)	tonnes CO_2e	-46,395	-72,323	-76,889	-93,607	-107,219
Hydrocarbons (non CH4)	kg	-27,708	-124,821	-131,584	-204,109	-231,189
Lead	kg	11	11	11	11	9
Ammonia	kg	-757	-1,308	-1,303	-1,757	-1,812
Methane	kg	-119,433	-187,895	-187,280	-244,007	-250,888
Hydrochloric Acid	kg	19,522	19,547	19,537	19,557	19,534

(1) Carbon Dioxide from Fossil sources plus Methane (x21)

Results show that there would be net energy production for all scenarios, therefore providing a local source of electrical and heat energy. At maximum capacity the Facility could potentially produce approximately 3,180,000 GJ/yr of energy when only electrical energy is recovered, 3,513,000 GJ/yr when, in addition, heat is also recovered for district heating at a high efficiency, and 3,593,000 GJ/yr when heat recovery for district cooling is added (also at a high efficiency).

Greenhouse gas (GHG) emissions, expressed in terms of metric tonnes of CO_2 equivalents (CO_2e) are reduced for all scenarios. For the electricity production only scenario, the indirect reduction in GHGs associated with electrical energy and materials recovery and avoided landfill methane emissions more than offset the direct GHG emissions from the Facility resulting in a net reduction of GHG emissions of 46,395 tonnes CO_2e.

Heat energy recovered for district heating offsets natural gas therefore offsetting a large amount of greenhouse gas emissions. The annual GHG emission reductions for the scenario with district heating only is up to 93,607 tonnes CO_2e and is up to 107,219 tonnes CO_2e when district cooling is also incorporated (maximum reductions reported for high efficiency scenario).

An increase in capacity of the Facility would provide the benefit of satisfying a greater portion of the Business Park heating and cooling requirements. Emissions to air increase, however the increases are proportional to the increase in waste, and there is the potential for greater GHG reductions.

6.0 DISCUSSION OF RESULTS

The potential energy benefits and related impacts associated with the development of the Facility, was estimated using a life cycle analysis approach. Results are presented in the previous section.

The LCA for all energy recovery scenarios indicates a significant net energy production. This provides a significant benefit of a local energy source and it offsets the need for an equivalent amount of electricity and natural gas.

Greenhouse gas emissions would be reduced for all scenarios. Greater reductions in overall GHG emissions occur when heat is recovered from the Facility and used for district heating or district heating and cooling as it offsets consumption of natural gas, which, in turn, offsets greenhouse gases.

The energy related benefits associated with the Facility would be maximized if the infrastructure for supplying district energy to the Clarington Energy Business Park was constructed at the same time as the other Facility services are constructed.

7.0 SUMMARY AND CONCLUSION

The purpose of this Report was to assess the potential energy benefits and related LCA impacts to the broader environment associated with the development of the Facility on the Site. A life cycle analysis was conducted to estimate the broader environmental implications related to air emissions, emissions to water, and energy associated with developing the Facility.

Results of the analysis show:

- A benefit of thermal treatment is that it provides a local source of energy. Scenario 3, in which both electrical and heat energy is recovered, and the heat energy provides district heating and cooling, provides the most energy potential;
- Thermal treatment, regardless of the energy recovery scenario (Scenarios 1, 2 and 3), has a net benefit to the environment of reduced LCA emissions of GHGs, acid gases and smog precursors;
- Thermal treatment, regardless of the energy recovery scenario(Scenarios 1, 2 and 3), has a net benefit to the environment of reduced LCA emissions to water for a number of parameters; and,
- Thermal treatment with both electrical and heat energy recovery (Scenarios 2 and 3) results in additional greenhouse gas emission reductions due to the offset of natural gas from district heating.

8.0 CLOSURE

This Report has been prepared by GENIVAR. The assessment represents the conditions at the subject property only at the time of the assessment, and is based on the information referenced and contained in the Report. The conclusions presented herein respecting current conditions, and potential future conditions are at the subject property resulting from the Project, represent the best judgment of the assessor based on current environmental standards. GENIVAR attests that to the best of our knowledge, the information presented in this Report is accurate. The use of this Report for other projects without written permission of Durham Region, York Region and GENIVAR is solely at the user's own risk.

9.0 REFERENCES

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APPENDIX A

Clarington Energy Business Park Heating and Cooling Loads

Appendix A

Energy Efficient Case, Max EFW Heat Output = 62 MW_{th}

400,000 EFW District Heating - Heat only

Month	Clarington Average Thermal Load Heating (MW_{th})	Hours per Month	Clarington Heat Energy Required (MWh_{th})	EFW Heat Power Output (MW_{th})	Hours per Month EFW Operation	EFW Heat Energy Output (MWh_{th})	Nat Gas Displaced with 80% Efficient Boiler M^3 (120 M^3 nat gas/MWh heat)
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Notes	*Input Data*	*Input Data*	*(3)=(1) X (2)*	*Input Data*	*Input Data*	*(6)=(4) X (5)*	*(7)=(6) X 120*
Jan	64.148	744	47,726	62.0	718.4	44,541	5,344,896
Feb	53.695	672	36,083	53.7	646.4	34,708	4,165,014
Mar	37.956	744	28,239	38.0	718.4	27,268	3,272,111
Apr	22.404	720	16,131	22.4	694.4	15,557	1,866,881
May	11.467	744	8,531	11.5	408.0	4,679	561,424
June	2.928	720	2,108	2.9	694.4	2,033	243,984
July	1.970	744	1,466	2.0	718.4	1,415	169,830
Aug	1.970	744	1,466	2.0	718.4	1,415	169,830
Sept	6.659	720	4,794	6.7	694.4	4,624	554,881
Oct	17.620	744	13,109	17.6	461.0	8,123	974,738
Nov	28.820	720	20,750	28.8	694.4	20,013	2,401,513
Dec	46.147	744	34,333	46.1	717.4	33,106	3,972,703
Annual Total		8,760.0	214,738		7,884.0	197,482	23,697,805

Electrical Output To Grid

	EFW Electrical Power Output (MW_e)	Hours per Month EFW Operation	Annual EFW Electricity Output (MWh_e)	Total Net Power Electricity & Heat (MW)
Electricity Production Only	38.9	7,884	306,687.60	38.9
Electricity & District Energy Production	31.1	7,884	245,192.40	93.1

400,000 tpy EFW District Heating - Heat & Cooling

District Heating

120

Month	Clarington Average Thermal Load Heating (MW_{th})	Hours per Month	Clarington Heat Energy Required (MWh_{th})	EFW Heat Power Output (MW_{th})	Hours per Month EFW Operation	EFW Heat Energy Output (MWh_{th})	Nat Gas Displaced with 80% Efficient Boiler M^3 (120 M^3 nat gas/MWh heat)
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Notes	*Input Data*	*Input Data*	*(3)=(1) X (2)*	*Input Data*	*Input Data*	*(6)=(4) X (5)*	*(7)=(6) X 120*
Jan	64.148	744	47,726	62.0	718.4	44,541	5,344,896
Feb	53.695	672	36,083	53.7	646.4	34,708	4,165,014
Mar	37.956	744	28,239	38.0	718.4	27,268	3,272,111
Apr	22.404	720	16,131	22.4	694.4	15,557	1,866,881
May	11.467	744	8,531	11.5	408.0	4,679	561,424
June	2.928	720	2,108	2.9	694.4	2,033	243,984
July	1.970	744	1,466	2.0	718.4	1,415	169,830
Aug	1.970	744	1,466	2.0	718.4	1,415	169,830
Sept	6.659	720	4,794	6.7	694.4	4,624	554,881
Oct	17.620	744	13,109	17.6	461.0	8,123	974,738
Nov	28.820	720	20,750	28.8	694.4	20,013	2,401,513
Dec	46.147	744	34,333	46.1	717.4	33,106	3,972,703
Annual Total		8,760.0	214,738		7,884.0	197,482	23,697,805

District Cooling

0.167

Month	Clarington Average Thermal Load Cooling (MW_{th})	Hours per Month	Clarington Heat Energy Required for District Cooling (MWh_{th})	EFW Heat Power Output (MW_{th})	Hours per Month EFW Operation	EFW Heat Energy Output for District Cooling (MWh_{th})	Electricity Displaced with COP=6 Chiller MWh_e (0.167 MWh_e electrical/MWh_{th} heat)
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Notes	*Input Data*	*Input Data*	*(3)=(1) X (2)*	*Input Data*	*Input Data*	*(6)=(4) X (5)*	*(7)=(6) X 0.167*
Jan	-	744	-	-	718.4	-	-
Feb	-	672	-	-	646.4	-	-
Mar	-	744	-	-	718.4	-	-
Apr	-	720	-	-	694.4	-	-
May	10.2	744	7,623	10.2	408.0	4,180	698
June	31.6	720	22,739	31.6	694.4	21,931	3,662
July	44.8	744	33,352	44.8	718.4	32,204	5,378
Aug	40.6	744	30,175	40.6	718.4	29,137	4,866
Sept	22.2	720	15,984	22.2	694.4	15,416	2,574
Oct	-	744	-	-	461.0	-	-
Nov	-	720	-	-	694.4	-	-
Dec	-	744	-	-	717.4	-	-
Annual Total		8,760.0	109,873		7,884.0	102,868	17,179
Annual Total Heating & Cooling						300,350	

Appendix A

Pro Rated Case, Max EFW Heat Output = 21.1 MW_{th}
400,000 EFW District Heating - Heat only

Month	Clarington Average Thermal Load Heating (MW_{th})	Hours per Month	Clarington Heat Energy Required (MWh_{th})	EFW Heat Power Output (MW_{th})	Hours per Month EFW Operation	EFW Heat Energy Output (MWh_{th})	Nat Gas Displaced with 80% Efficient Boiler M^3 (120 M^3 nat gas/MWh heat)
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Notes	*Input Data*	*Input Data*	*(3)=(1) X (2)*	*Input Data*	*Input Data*	*(6)=(4) X (5)*	*(7)=(6) X 120*
Jan	64.148	744	47,726	21.1	718.4	15,158	1,818,989
Feb	53.695	672	36,083	21.1	646.4	13,639	1,636,685
Mar	37.956	744	28,239	21.1	718.4	15,158	1,818,989
Apr	22.404	720	16,131	21.1	694.4	14,652	1,758,221
May	11.467	744	8,531	11.5	408.0	4,679	561,424
June	2.928	720	2,108	2.9	694.4	2,033	243,984
July	1.970	744	1,466	2.0	718.4	1,415	169,830
Aug	1.970	744	1,466	2.0	718.4	1,415	169,830
Sept	6.659	720	4,794	6.7	694.4	4,624	554,881
Oct	17.620	744	13,109	17.6	461.0	8,123	974,738
Nov	28.820	720	20,750	21.1	694.4	14,652	1,758,221
Dec	46.147	744	34,333	21.1	717.4	15,137	1,816,457
Annual Total		8,760.0	214,738		7,884.0	110,685	13,282,249

Electrical Output To Grid

	EFW Electrical Power Output (MW_e)	Hours per Month EFW Operation	Annual EFW Electricity Output (MWh_e)	Total Net Power Electricity & Heat (MW)
Electricity Production Only	38.9	7,884	306,687.60	38.9
Electricity & District Energy Production	34.0	7,884	268,056.00	55.1

400,000 tpy EFW District Heating - Heat & Cooling

District Heating 120

Month	Clarington Average Thermal Load Heating (MW_{th})	Hours per Month	Clarington Heat Energy Required (MWh_{th})	EFW Heat Power Output (MW_{th})	Hours per Month EFW Operation	EFW Heat Energy Output (MWh_{th})	Nat Gas Displaced with 80% Efficient Boiler M^3 (120 M^3 nat gas/MWh heat)
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Notes	*Input Data*	*Input Data*	*(3)=(1) X (2)*	*Input Data*	*Input Data*	*(6)=(4) X (5)*	*(7)=(6) X 120*
Jan	64.148	744	47,726	21.1	718.4	15,158	1,818,989
Feb	53.695	672	36,083	21.1	646.4	13,639	1,636,685
Mar	37.956	744	28,239	21.1	718.4	15,158	1,818,989
Apr	22.404	720	16,131	21.1	694.4	14,652	1,758,221
May	11.467	744	8,531	11.5	408.0	4,679	561,424
June	2.928	720	2,108	-	694.4	-	-
July	1.970	744	1,466	-	718.4	-	-
Aug	1.970	744	1,466	-	718.4	-	-
Sept	6.659	720	4,794	6.7	694.4	4,624	554,881
Oct	17.620	744	13,109	17.6	461.0	8,123	974,738
Nov	28.820	720	20,750	21.1	694.4	14,652	1,758,221
Dec	46.147	744	34,333	21.1	717.4	15,137	1,816,457
Annual Total		8,760.0	214,738		7,884.0	105,822	12,698,605

District Cooling 0.167

Month	Clarington Average Thermal Load Cooling (MW_{th})	Hours per Month	Clarington Heat Energy Required for District Cooling (MWh_{th})	EFW Heat Power Output (MW_{th})	Hours per Month EFW Operation	EFW Heat Energy Output for District Cooling (MWh_{th})	Electricity Displaced with COP=6 Chiller MWh_e (0.167 MWh_e electrical/MWh_{th} heat)
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Notes	*Input Data*	*Input Data*	*(3)=(1) X (2)*	*Input Data*	*Input Data*	*(6)=(4) X (5)*	*(7)=(6) X 0.167*
Jan	-	744	-	-	718.4	-	-
Feb	-	672	-	-	646.4	-	-
Mar	-	744	-	-	718.4	-	-
Apr	-	720	-	-	694.4	-	-
May	10.2	744	7,623	-	408.0	-	-
June	31.6	720	22,739	21.1	694.4	14,652	2,447
July	44.8	744	33,352	21.0	718.4	15,086	2,519
Aug	40.6	744	30,175	21.1	718.4	15,158	2,531
Sept	22.2	720	15,984	-	694.4	-	-
Oct	-	744	-	-	461.0	-	-
Nov	-	720	-	-	694.4	-	-
Dec	-	744	-	-	717.4	-	-
Annual Total		8,760.0	109,873		7,884.0	44,896	7,498
Annual Total Heating & Cooling						150,718	

Appendix A

Base Case, Max EFW Heat Output = 7.4 MW_{th}
140,000 tpy EFW District Heating - Heat only

Month	Clarington Average Thermal Load Heating (MW_{th})	Hours per Month	Clarington Heat Energy Required (MWh_{th})	EFW Heat Power Output (MW_{th})	Hours per Month EFW Operation	EFW Heat Energy Output (MWh_{th})	Nat Gas Displaced with 80% Efficient Boiler M^3 (120 M^3 nat gas/MWh heat)
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Notes	*Input Data*	*Input Data*	*(3)=(1) X (2)*	*Input Data*	*Input Data*	*(6)=(4) X (5)*	*(7)=(6) X 120*
Jan	64.148	744	47,726	7.4	718.4	5,316	637,939
Feb	53.695	672	36,083	7.4	646.4	4,783	574,003
Mar	37.956	744	28,239	7.4	718.4	5,316	637,939
Apr	22.404	720	16,131	7.4	694.4	5,139	616,627
May	11.467	744	8,531	7.4	408.0	3,019	362,304
June	2.928	720	2,108	2.9	694.4	2,014	241,651
July	1.970	744	1,466	2.0	718.4	1,437	172,416
Aug	1.970	744	1,466	2.0	718.4	1,437	172,416
Sept	6.659	720	4,794	6.7	694.4	4,652	558,298
Oct	17.620	744	13,109	7.0	461.0	3,227	387,240
Nov	28.820	720	20,750	7.4	694.4	5,139	616,627
Dec	46.147	744	34,333	7.4	717.4	5,309	637,051
Annual Total		8,760.0	214,738		7,884.0	46,788	5,614,512

Electrical Output To Grid

	EFW Electrical Power Output (MW_e)	Hours per Month EFW Operation	Annual EFW Electricity Output (MWh_e)	Total Net Power Electricity & Heat (MW)
Electricity Production Only	13.6	7,884	107,222.40	13.6
Electricity & District Energy Production	11.9	7,884	93,819.60	19.3

Total Net Power (Heat & Electricity

140,000 tpy EFW District Heating - Heat & Cooling

District Heating 120

Month	Clarington Average Thermal Load Heating (MW_{th})	Hours per Month	Clarington Heat Energy Required (MWh_{th})	EFW Heat Power Output (MW_{th})	Hours per Month EFW Operation	EFW Heat Energy Output (MWh_{th})	Nat Gas Displaced with 80% Efficient Boiler M^3 (120 M^3 nat gas/MWh heat)
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Notes	*Input Data*	*Input Data*	*(3)=(1) X (2)*	*Input Data*	*Input Data*	*(6)=(4) X (5)*	*(7)=(6) X 120*
Jan	64.148	744	47,726	7.4	718.4	5,316	637,939
Feb	53.695	672	36,083	7.4	646.4	4,783	574,003
Mar	37.956	744	28,239	7.4	718.4	5,316	637,939
Apr	22.404	720	16,131	7.4	694.4	5,139	616,627
May	11.467	744	8,531	7.4	408.0	3,019	362,304
June	2.928	720	2,108	-	694.4	-	-
July	1.970	744	1,466	-	718.4	-	-
Aug	1.970	744	1,466	-	718.4	-	-
Sept	6.659	720	4,794	6.7	694.4	4,652	558,298
Oct	17.620	744	13,109	7.0	461.0	3,227	387,240
Nov	28.820	720	20,750	7.4	694.4	5,139	616,627
Dec	46.147	744	34,333	7.4	717.4	5,309	637,051
Annual Total		8,760.0	214,738		7,884.0	41,900	5,028,029

District Cooling 0.167

Month	Clarington Average Thermal Load Cooling (MW_{th})	Hours per Month	Clarington Heat Energy Required for District Cooling (MWh_{th})	EFW Heat Power Output (MW_{th})	Hours per Month EFW Operation	EFW Heat Energy Output for District Cooling (MWh_{th})	Electricity Displaced with COP=6 Chiller MWh_e (0.167 MWh_e electrical/MWh_{th} heat)
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Notes	*Input Data*	*Input Data*	*(3)=(1) X (2)*	*Input Data*	*Input Data*	*(6)=(4) X (5)*	*(7)=(6) X 0.167*
Jan	-	744	-	-	718.4	-	-
Feb	-	672	-	-	646.4	-	-
Mar	-	744	-	-	718.4	-	-
Apr	-	720	-	-	694.4	-	-
May	10.2	744	7,623	-	408.0	-	-
June	31.6	720	22,739	7.4	694.4	5,139	858
July	44.8	744	33,352	7.4	718.4	5,316	888
Aug	40.6	744	30,175	7.4	718.4	5,316	888
Sept	22.2	720	15,984	-	694.4	-	-
Oct	-	744	-	-	461.0	-	-
Nov	-	720	-	-	694.4	-	-
Dec	-	744	-	-	717.4	-	-
Annual Total		8,760.0	109,873		7,884.0	15,771	2,634
Annual Total Heating & Coolinc						57,671	

Appendix A - Clarington Energy Business Park Heating and Cooling Loads

Clarington Energy Business Park Peak Thermal Loads

Land Development Criteria	Surface Area		PEAK [1] Thermal Load (MWth) [2,3]	
	m^2	*sf*	***Cooling***	***Heating***
prestige employment	1,275,000	13,716,960	62.5	74.0
light industrial	363,000	3,905,299	17.8	21.1
Total	*1,638,000*	*17,622,259*	*80.3*	*95.0*

Clarington Energy Business Park Annual Thermal Loads and Energy Displacement

Month	Degree Days (5)	Daily Average (5)	AVERAGE Thermal Load [6]	
			Cooling	***Heating***
	(<18C)	*degrees C*	*kWth*	*kWth*
Jan	752.9	-6.3	-	64,148
Feb	662.1	-5.4	-	53,695
Mar	571.6	-0.4	-	37,956
Apr	353.3	6.3	-	22,404
May	171.8	12.9	10,246	11,467
Jun	49.4	17.8	31,592	2,928
Jul	8.9	20.8	44,827	1,970
Aug	17.8	19.9	40,558	1,970
Sep	102.5	15.3	22,200	6,659
Oct	282.6	8.9	-	17,620
Nov	445.5	3.2	-	28,821
Dec	647.4	-2.9	-	46,147
year	*4065.7*	*7.5*		
Annual Total Thermal Load (MWh)			119,565	224,828
Displaced Utilities			electricity	natural gas
Displaced Consumption (m^3/yr)			-	26,987,432
Displaced Consumption (MWhr/yr)			19,927	-
Displaced Equipment			electric chillers	boilers
Efficiency			-	80%
COP			6	-

NOTES

1 Weather Conditions

ASHRAE Toronto	degrees C
99% cooling condition	35
99% heating condition	-20

2

Building	Est'd mix (4)	Cooling	Heating
	%	*W/m^2 at 35C*	*W/m^2 at -20C*
Poor insulation	0%	37	80
Medium Insulation	0%	43	69
Good Insulation	100%	49	58
	composite	*49.0*	*58.0*
	equivalent peak load	*1489.0*	*2163.0*

3 Industrial process loads are not included, but presumed to be minimal.
Reference to Data Processing Centres is important for consideration of significant cooling loads.

4 Building mix selection is estimated.

5 Toronto Pearson Int'l Airport Norms (Environment Canada Website, April 20, 2009) for 1971 to 2000.

6 Retscreen Load and Network Design.

APPENDIX B

Life Cycle Analysis Model Results

WTE with Electrical Energy Recovery - 140,000 tpy

Parameter	Units	Total	WTE Plant	Offset for Electrical Utility	Ash Transport	Ash Landfill	Recyclables Transport	Metals Recycling Offset	Landfill Long Haul Burdens
Energy Consumption	GJ	-1,113,094	7,319	-965,204	10,125	3,763	150	-137,107	-32,140
Air Emissions									
Total Particulate Matter	kg	-28,323	8,045	-12,016	865	100	13	-22,584	-2,746
Nitrogen Oxides	kg	5,339	85,797	-54,779	6,008	1,093	89	-13,799	-19,070
Sulfur Oxides	kg	-189,059	56,498	-203,423	1,705	186	25	-38,637	-5,412
Carbon Monoxide	kg	-51,374	29,654	-22,213	5,922	371	88	-46,397	-18,798
Carbon Dioxide Biomass	kg	102,420,647	102,004,603	416,387	168	18	2	0	-532
Carbon Dioxide Fossil	kg	8,569,724	25,224,953	-8,725,908	700,244	78,110	10,349	-6,495,224	-2,222,799
Carbon Equivalents	MTCE	1,900	6,903	-2,601	192	21	3	-1,948	-670
Greenhouse Gas Emissions(1)	tonnes eCO2	7,692 (2)	25,254	-9,450	703	78	10	-6,674	-2,230
Hydrocarbons (non CH4)	kg	-9,702	49,749	-44,327	2,417	280	36	-10,183	-7,673
Lead	kg	4	3	0	0	0	0	1	0
Ammonia	kg	-265	0	-249	1	0	0	-14	-3
Methane	kg	-41,789	1,392	-34,461	111	14	2	-8,492	-354
Hydrochloric Acid	kg	6,832	7,617	16	1	0	0	-800	-2
Water Emissions									
Dissolved Solids	kg	-256,446	1,367	-254,632	957	105	14	-1,219	-3,038
Suspended Solids	kg	-6,034	54	-5,580	22	4	0	-464	-69
BOD	kg	-254	1	-246	4	1	0	-2	-11
COD	kg	-3,475	20	-3,549	24	554	0	-447	-76
Oil	kg	-3,729	24	-4,457	22	1,107	0	-355	-71
Sulfuric Acid	kg	-35	5	-17	0	0	0	-23	-1
Iron	kg	-1,286	26	-1,191	1	0	0	-121	-2
Ammonia	kg	-200	0	-94	0	3	0	-108	-1
Copper	kg	0	0	0	0	0	0	0	0
Cadmium	kg	-12	0	-12	0	0	0	-1	0
Arsenic	kg	0	0	0	0	0	0	0	0
Mercury	kg	0	0	0	0	0	0	0	0
Phosphate	kg	-12	2	-9	0	0	0	-6	0
Selenium	kg	0	0	0	0	0	0	0	0
Chromium	kg	-12	0	-12	0	0	0	-1	0
Lead	kg	0	0	0	0	0	0	0	0
Zinc	kg	-4	0	-4	0	0	0	0	0

(1) Carbon Dioxide Fossil plus Methane (x21)
(2) Landfill emissions of 23,930 tonnes of eCO_2 are avoided annually hence Total Net Greenhouse Gas Emissions are –16,238 tonnes of eCO_2 per year.

WTE with Electrical Energy and Heat Energy Recovery - 140,000 tpy

Parameter	Units	Total	WTE Plant	Utility Offset for Electrical	Offset for Heating	Ash Transport	Ash Landfill	Metals Recycling Transport	Metals Recycling Offset	Avoided Landfill Long Haul Burdens
Energy Consumption	GJ	-1,205,281	7,319	-843,894	-213,497	10,125	3,763	150	-137,107	-32,140
Air Emissions										
Total Particulate Matter	kg	-27,203	8,045	-10,495	-401	865	100	13	-22,584	-2,746
Nitrogen Oxides	kg	-33,381	85,797	-47,695	-45,804	6,008	1,093	89	-13,799	-19,070
Sulfur Oxides	kg	-340,357	56,498	-177,734	-176,988	1,705	186	25	-38,637	-5,412
Carbon Monoxide	kg	-72,313	29,654	-19,352	-23,800	5,922	371	88	-46,397	-18,798
Carbon Dioxide Biomass	kg	102,422,742	102,004,603	420,997	-2,515	168	18	2	0	-532
Carbon Dioxide Fossil	kg	-2,102,279	25,224,953	-7,120,708	-12,277,204	700,244	78,110	10,349	-6,495,224	-2,222,799
Carbon Equivalents	MTCE	-1,204	6,903	-2,135	-3,570	192	21	3	-1,948	-670
Greenhouse Gas Emissions(1)	tonnes eCO2	-3,606 (2)	25,254	-7,753	-12,994	703	78	10	-6,674	-2,230
Hydrocarbons (non CH4)	kg	-51,856	49,749	-38,756	-47,726	2,417	280	36	-10,183	-7,673
Lead	kg	4	3	0	0	0	0	0	1	0
Ammonia	kg	-504	0	-218	-270	1	0	0	-14	-3
Methane	kg	-71,586	1,392	-30,130	-34,128	111	14	2	-8,492	-354
Hydrochloric Acid	kg	6,839	7,617	32	-9	1	0	0	-800	-2
Water Emissions										
Dissolved Solids	kg	-501,691	1,367	-222,629	-277,247	957	105	14	-1,219	-3,038
Suspended Solids	kg	-10,308	54	-4,879	-4,976	22	4	0	-464	-69
BOD	kg	-490	1	-215	-268	4	1	0	-2	-11
COD	kg	-6,891	20	-3,103	-3,862	24	554	0	-447	-76
Oil	kg	-8,019	24	-3,897	-4,850	22	1,107	0	-355	-71
Sulfuric Acid	kg	-35	5	-15	-2	0	0	0	-23	-1
Iron	kg	-1,143	26	-1,041	-7	1	0	0	-121	-2
Ammonia	kg	-193	0	-82	-5	0	3	0	-108	-1
Copper	kg	0	0	0	0	0	0	0	0	0
Cadmium	kg	-24	0	-10	-13	0	0	0	-1	0
Arsenic	kg	0	0	0	0	0	0	0	0	0
Mercury	kg	0	0	0	0	0	0	0	0	0
Phosphate	kg	-12	2	-7	-1	0	0	0	-6	0
Selenium	kg	0	0	0	0	0	0	0	0	0
Chromium	kg	-24	0	-10	-13	0	0	0	-1	0
Lead	kg	0	0	0	0	0	0	0	0	0
Zinc	kg	-8	0	-3	-4	0	0	0	0	0

(1) Carbon Dioxide Fossil plus Methane (x21)
(2) Landfill emissions of 23,930 tonnes of eCO_2 are avoided annually hence Total Net Greenhouse Gas Emissions are –26,536 tonnes of eCO_2 per year.

WTE with Electrical Energy and Heat/Cooling Energy Recovery - 140,000 tpy

Parameter	Units	Total	WTE Plant	Utility Offset for Electrical	Offset for Heating	Offset for Cooling	Ash Transport	Ash Landfill	Metals Recycling Transport	Metals Recycling Offset	Avoided Landfill Long Haul Burdens
Energy Consumption	GJ	-1,193,225	7,319	-843,894	-191,932	-9,509	10,125	3,763	150	-137,107	-32,140
Air Emissions											
Total Particulate Matter	kg	-27,623	8,045	-10,495	-361	-460	865	100	13	-22,584	-2,746
Nitrogen Oxides	kg	-33,658	85,797	-47,695	-41,177	-4,903	6,008	1,093	89	-13,799	-19,070
Sulfur Oxides	kg	-339,585	56,498	-177,734	-159,111	-17,105	1,705	186	25	-38,637	-5,412
Carbon Monoxide	kg	-71,104	29,654	-19,352	-21,396	-1,195	5,922	371	88	-46,397	-18,798
Carbon Dioxide Biomass	kg	102,422,043	102,004,603	420,997	-2,261	-953	168	18	2	0	-532
Carbon Dioxide Fossil	kg	-2,928,156	25,224,953	-7,120,708	-11,037,082	-2,065,998	700,244	78,110	10,349	-6,495,224	-2,222,799
Carbon Equivalents	MTCE	-1,415	6,903	-2,135	-3,209	-571	192	21	3	-1,948	-670
Greenhouse Gas Emissions[1]	tonnes eCO2	-4,381 [2]	25,254	-7,753	-11,681	-2,088	703	78	10	-6,674	-2,230
Hydrocarbons (non CH4)	kg	-51,190	49,749	-38,756	-42,905	-4,154	2,417	280	36	-10,183	-7,673
Lead	kg	4	3	0	0	0	0	0	0	1	0
Ammonia	kg	-485	0	-218	-243	-8	1	0	0	-14	-3
Methane	kg	-69,194	1,392	-30,130	-30,681	-1,056	111	14	2	-8,492	-354
Hydrochloric Acid	kg	6,837	7,617	32	-8	-4	1	0	0	-800	-2
Water Emissions											
Dissolved Solids	kg	-481,850	1,367	-222,629	-249,243	-8,164	957	105	14	-1,219	-3,038
Suspended Solids	kg	-10,087	54	-4,879	-4,473	-282	22	4	0	-464	-69
BOD	kg	-477	1	-215	-241	-14	4	1	0	-2	-11
COD	kg	-6,638	20	-3,103	-3,472	-137	24	554	0	-447	-76
Oil	kg	-7,684	24	-3,897	-4,360	-155	22	1,107	0	-355	-71
Sulfuric Acid	kg	-54	5	-15	-2	-19	0	0	0	-23	-1
Iron	kg	-1,162	26	-1,041	-6	-19	1	0	0	-121	-2
Ammonia	kg	-195	0	-82	-5	-2	0	3	0	-108	-1
Copper	kg	0	0	0	0	0	0	0	0	0	0
Cadmium	kg	-23	0	-10	-11	0	0	0	0	-1	0
Arsenic	kg	0	0	0	0	0	0	0	0	0	0
Mercury	kg	0	0	0	0	0	0	0	0	0	0
Phosphate	kg	-22	2	-7	-1	-9	0	0	0	-6	0
Selenium	kg	0	0	0	0	0	0	0	0	0	0
Chromium	kg	-23	0	-10	-11	0	0	0	0	-1	0
Lead	kg	0	0	0	0	0	0	0	0	0	0
Zinc	kg	-8	0	-3	-4	0	0	0	0	0	0

(1) Carbon Dioxide Fossil plus Methane (x21)
(2) Landfill emissions of 23,930 tonnes of eCO_2 are avoided annually hence Total Net Greenhouse Gas Emissions are –28,311 tonnes of eCO_2 per year.

WTE with Electrical Energy Recovery - 400,000 tpy

Parameter	Units	Total	WTE Plant	Offset for Electrical Utility	Ash Transport	Ash Landfill	Metals Recycling Transport	Metals Recycling Offset	Avoided Landfill Long Haul Burdens
Energy Consumption	GJ	-3,180,286	20,916	-2,758,138	28,895	11,661	428	-392,127	-91,921
Air Emissions									
Total Particulate Matter	kg	-80,975	23,240	-34,588	2,469	311	37	-64,590	-7,854
Nitrogen Oxides	kg	15,419	249,689	-161,052	17,145	3,388	254	-39,464	-54,540
Sulfur Oxides	kg	-540,317	164,236	-584,085	4,865	576	72	-110,503	-15,478
Carbon Monoxide	kg	-146,895	86,308	-65,042	16,901	1,148	250	-132,696	-53,764
Carbon Dioxide Biomass	kg	292,674,327	292,780,125	-104,818	479	57	7	0	-1,523
Carbon Dioxide Fossil	kg	24,483,622	83,643,534	-36,496,365	1,998,382	242,018	29,598	-18,576,339	-6,357,205
Carbon Equivalents	MTCE	6,774	25,171	-11,594	603	73	8	-5,570	-1,918
Greenhouse Gas Emissions[1]	tonnes eCO2	21,976 [2]	83,727	-38,564	2,005	243	30	-19,086	-6,378
Hydrocarbons (non CH4)	kg	-27,708	142,160	-126,668	6,898	866	102	-29,123	-21,944
Lead	kg	11	8	0	0	0	0	4	0
Ammonia	kg	-757	1	-713	3	0	0	-39	-10
Methane	kg	-119,433	3,976	-98,476	318	43	5	-24,288	-1,011
Hydrochloric Acid	kg	19,522	22,176	-363	2	0	0	-2,287	-6
		0							
Water Emissions		0							
Dissolved Solids	kg	-732,802	3,905	-727,629	2,731	326	40	-3,488	-8,688
Suspended Solids	kg	-17,242	153	-15,946	62	13	1	-1,328	-197
BOD	kg	-725	4	-704	10	2	0	-5	-32
COD	kg	-9,798	57	-10,142	68	1,715	1	-1,279	-217
Oil	kg	-10,391	69	-12,737	64	3,430	1	-1,016	-202
Sulfuric Acid	kg	-101	14	-49	1	0	0	-65	-2
Iron	kg	-3,676	75	-3,404	1	1	0	-345	-5
Ammonia	kg	-570	0	-268	1	8	0	-308	-3
Copper	kg	0	0	0	0	0	0	0	0
Cadmium	kg	-35	0	-33	0	0	0	-2	0
Arsenic	kg	0	0	0	0	0	0	0	0
Mercury	kg	0	0	0	0	0	0	0	0
Phosphate	kg	-35	7	-24	0	0	0	-17	-1
Selenium	kg	0	0	0	0	0	0	0	0
Chromium	kg	-35	0	-33	0	0	0	-2	0
Lead	kg	0	0	0	0	0	0	0	0
Zinc	kg	-12	0	-11	0	0	0	-1	0

(1) Carbon Dioxide Fossil plus Methane (x21)
(2) Landfill emissions of 68,371 tonnes of eCO_2 are avoided annually hence Total Net Greenhouse Gas Emissions are –46,395 tonnes of eCO_2 per year.

WTE with Electrical Energy and Heat Energy Recovery - 400,000 tpy low efficiency

Parameter	Units	Total	WTE Plant	Utility Offset for Electrical	Offset for Heating	Ash Transport	Ash Landfill	Metals Recycling Transport	Metals Recycling Offset	Avoided Landfill Long Haul Burdens
Energy Consumption	GJ	-3,339,280	20,916	-2,411,487	-505,707	28,958	11,661	428	-392,127	-91,921
Air Emissions										
Total Particulate Matter	kg	-77,574	23,240	-30,241	-951	2,474	311	37	-64,590	-7,854
Nitrogen Oxides	kg	-72,798	249,689	-140,811	-108,495	17,182	3,388	254	-39,464	-54,540
Sulfur Oxides	kg	-886,127	164,236	-510,676	-419,230	4,876	576	72	-110,503	-15,478
Carbon Monoxide	kg	-195,059	86,308	-56,868	-56,375	16,937	1,148	250	-132,696	-53,764
Carbon Dioxide Biomass	kg	292,681,545	292,780,125	-91,644	-5,957	480	57	7	0	-1,523
Carbon Dioxide Fossil	kg	-5,941	83,643,534	-31,909,390	-29,080,852	2,002,696	242,018	29,598	-18,576,339	-6,357,205
Carbon Equivalents	MTCE	-279	25,171	-10,136	-8,456	549	73	8	-5,570	-1,918
Greenhouse Gas Emissions(1)	tonnes eCO2	-3,952 (2)	83,727	-33,717	-30,778	2,009	243	30	-19,086	-6,378
Hydrocarbons (non CH4)	kg	-124,821	142,160	-110,748	-113,047	6,913	866	102	-29,123	-21,944
Lead	kg	11	8	0	0	0	0	0	4	0
Ammonia	kg	-1,308	1	-623	-640	3	0	0	-39	-10
Methane	kg	-187,895	3,976	-86,099	-80,839	319	43	5	-24,288	-1,011
Hydrochloric Acid	kg	19,547	22,176	-318	-21	2	0	0	-2,287	-6
		0								
Water Emissions		0								
Dissolved Solids	kg	-1,298,058	3,905	-636,178	-656,712	2,737	326	40	-3,488	-8,688
Suspended Solids	kg	-27,023	153	-13,942	-11,786	62	13	1	-1,328	-197
BOD	kg	-1,270	4	-615	-634	10	2	0	-5	-32
COD	kg	-17,670	57	-8,868	-9,148	68	1,715	1	-1,279	-217
Oil	kg	-20,278	69	-11,136	-11,488	64	3,430	1	-1,016	-202
Sulfuric Acid	kg	-100	14	-43	-4	1	0	0	-65	-2
Iron	kg	-3,264	75	-2,976	-16	1	1	0	-345	-5
Ammonia	kg	-549	0	-235	-13	1	8	0	-308	-3
Copper	kg	0	0	0	0	0	0	0	0	0
Cadmium	kg	-61	0	-29	-30	0	0	0	-2	0
Arsenic	kg	0	0	0	0	0	0	0	0	0
Mercury	kg	0	0	0	0	0	0	0	0	0
Phosphate	kg	-35	7	-21	-2	0	0	0	-17	-1
Selenium	kg	0	0	0	0	0	0	0	0	0
Chromium	kg	-61	0	-29	-30	0	0	0	-2	0
Lead	kg	0	0	0	0	0	0	0	0	0
Zinc	kg	-21	0	-10	-10	0	0	0	-1	0

(1) Carbon Dioxide Fossil plus Methane (x21)
(2) Landfill emissions of 68,371 tonnes of eCO_2 are avoided annually hence Total Net Greenhouse Gas Emissions are –72,323 tonnes of eCO_2 per year.

WTE with Electrical Energy and Heat/Cooling Energy Recovery - 400,000 tpy low efficiency

Parameter	Units	Total	WTE Plant	Utility Offset for Electrical	Offset for Heating	Offset for Cooling	Ash Transport	Ash Landfill	Metals Recycling Transport	Metals Recycling Offset	Avoided Landfill Long Haul Burdens
Energy Consumption	GJ	-3,343,706	20,916	-2,411,487	-483,064	-27,070	28,958	11,661	428	-392,127	-91,921
Air Emissions											
Total Particulate Matter	kg	-78,842	23,240	-30,241	-908	-1,311	2,474	311	37	-64,590	-7,854
Nitrogen Oxides	kg	-81,898	249,689	-140,811	-103,637	-13,958	17,182	3,388	254	-39,464	-54,540
Sulfur Oxides	kg	-916,047	164,236	-510,676	-400,459	-48,691	4,876	576	72	-110,503	-15,478
Carbon Monoxide	kg	-195,935	86,308	-56,868	-53,850	-3,401	16,937	1,148	250	-132,696	-53,764
Carbon Dioxide Biomass	kg	292,679,098	292,780,125	-91,644	-5,690	-2,714	480	57	7	0	-1,523
Carbon Dioxide Fossil	kg	-4,584,927	83,643,534	-31,909,390	-27,778,724	-5,881,114	2,002,696	242,018	29,598	-18,576,339	-6,357,205
Carbon Equivalents	MTCE	-1,526	25,171	-10,136	-8,077	-1,626	549	73	8	-5,570	-1,918
Greenhouse Gas Emissions(1)	tonnes eCO2	-8,518 (2)	83,727	-33,717	-29,400	-5,944	2,009	243	30	-19,086	-6,378
Hydrocarbons (non CH4)	kg	-131,584	142,160	-110,748	-107,985	-11,825	6,913	866	102	-29,123	-21,944
Lead	kg	11	8	0	0	-1	0	0	0	4	0
Ammonia	kg	-1,303	1	-623	-612	-24	3	0	0	-39	-10
Methane	kg	-187,280	3,976	-86,099	-77,220	-3,005	319	43	5	-24,288	-1,011
Hydrochloric Acid	kg	19,537	22,176	-318	-20	-10	2	0	0	-2,287	-6
Water Emissions											
Dissolved Solids	kg	-1,291,893	3,905	-636,178	-627,307	-23,241	2,737	326	40	-3,488	-8,688
Suspended Solids	kg	-27,297	153	-13,942	-11,258	-802	62	13	1	-1,328	-197
BOD	kg	-1,281	4	-615	-606	-39	10	2	0	-5	-32
COD	kg	-17,651	57	-8,868	-8,738	-391	68	1,715	1	-1,279	-217
Oil	kg	-20,205	69	-11,136	-10,973	-442	64	3,430	1	-1,016	-202
Sulfuric Acid	kg	-153	14	-43	-4	-54	1	0	0	-65	-2
Iron	kg	-3,319	75	-2,976	-15	-55	1	1	0	-345	-5
Ammonia	kg	-555	0	-235	-12	-7	1	8	0	-308	-3
Copper	kg	0	0	0	0	0	0	0	0	0	0
Cadmium	kg	-61	0	-29	-28	-1	0	0	0	-2	0
Arsenic	kg	0	0	0	0	0	0	0	0	0	0
Mercury	kg	0	0	0	0	0	0	0	0	0	0
Phosphate	kg	-62	7	-21	-2	-27	0	0	0	-17	-1
Selenium	kg	0	0	0	0	0	0	0	0	0	0
Chromium	kg	-61	0	-29	-28	-1	0	0	0	-2	0
Lead	kg	0	0	0	0	0	0	0	0	0	0
Zinc	kg	-21	0	-10	-10	0	0	0	0	-1	0

(1) Carbon Dioxide Fossil plus Methane (x21)
(2) Landfill emissions of 68,371 tonnes of eCO_2 are avoided annually hence Total Net Greenhouse Gas Emissions are –76,889 tonnes of eCO_2 per year.

WTE with Electrical Energy and Heat Energy Recovery - 400,000 tpy high efficiency

Parameter	Units	Total	WTE Plant	Utility Offset for Electrical	Offset for Heating	Ash Transport	Ash Landfill	Metals Recycling Transport	Metals Recycling Offset	Avoided Landfill Long Haul Burdens
Energy Consumption	GJ	-3,531,106	20,916	-2,206,510	-902,510	28,958	11,661	428	-392,127	-91,921
				0						
Air Emissions				0						
Total Particulate Matter	kg	-75,749	23,240	-27,671	-1,697	2,474	311	37	-64,590	-7,854
Nitrogen Oxides	kg	-145,959	249,689	-128,842	-193,625	17,182	3,388	254	-39,464	-54,540
Sulfur Oxides	kg	-1,171,668	164,236	-467,268	-748,178	4,876	576	72	-110,503	-15,478
Carbon Monoxide	kg	-234,459	86,308	-52,034	-100,609	16,937	1,148	250	-132,696	-53,764
Carbon Dioxide Biomass	kg	292,684,661	292,780,125	-83,854	-10,630	480	57	7	0	-1,523
Carbon Dioxide Fossil	kg	-20,111,880	83,643,534	-29,197,092	-51,899,090	2,002,696	242,018	29,598	-18,576,339	-6,357,205
Carbon Equivalents	MTCE	-6,052	25,171	-9,275	-15,091	549	73	8	-5,570	-1,918
Greenhouse Gas Emissions[1]	tonnes eCO2	-25,236 [2]	83,727	-30,851	-54,929	2,009	243	30	-19,086	-6,378
Hydrocarbons (non CH4)	kg	-204,109	142,160	-101,334	-201,750	6,913	866	102	-29,123	-21,944
Lead	kg	11	8	0	0	0	0	0	4	0
Ammonia	kg	-1,757	1	-570	-1,143	3	0	0	-39	-10
Methane	kg	-244,007	3,976	-78,781	-144,270	319	43	5	-24,288	-1,011
Hydrochloric Acid	kg	19,557	22,176	-291	-37	2	0	0	-2,287	-6
Water Emissions										
Dissolved Solids	kg	-1,759,271	3,905	-582,103	-1,172,001	2,737	326	40	-3,488	-8,688
Suspended Solids	kg	-35,085	153	-12,757	-21,033	62	13	1	-1,328	-197
BOD	kg	-1,715	4	-563	-1,131	10	2	0	-5	-32
COD	kg	-24,094	57	-8,114	-16,325	68	1,715	1	-1,279	-217
Oil	kg	-28,345	69	-10,190	-20,501	64	3,430	1	-1,016	-202
Sulfuric Acid	kg	-100	14	-39	-8	1	0	0	-65	-2
Iron	kg	-3,023	75	-2,723	-28	1	1	0	-345	-5
Ammonia	kg	-539	0	-215	-22	1	8	0	-308	-3
Copper	kg	0	0	0	0	0	0	0	0	0
Cadmium	kg	-82	0	-26	-53	0	0	0	-2	0
Arsenic	kg	0	0	0	0	0	0	0	0	0
Mercury	kg	0	0	0	0	0	0	0	0	0
Phosphate	kg	-35	7	-20	-4	0	0	0	-17	-1
Selenium	kg	0	0	0	0	0	0	0	0	0
Chromium	kg	-82	0	-26	-53	0	0	0	-2	0
Lead	kg	0	0	0	0	0	0	0	0	0
Zinc	kg	-28	0	-9	-18	0	0	0	-1	0

(1) Carbon Dioxide Fossil plus Methane (x21)
(2) Landfill emissions of 68,371 tonnes of eCO_2 are avoided annually hence Total Net Greenhouse Gas Emissions are –93,607 tonnes of eCO_2 per year.

WTE with Electrical Energy and Heat/Cooling Energy Recovery - 400,000 tpy high efficiency

Parameter	Units	Total	WTE Plant	Utility Offset for Electrical	Offset for Heating	Offset for Cooling	Ash Transport	Ash Landfill	Metals Recycling Transport	Metals Recycling Offset	Avoided Landfill Long Haul Burdens
Energy Consumption	GJ	-3,593,095	20,916	-2,206,510	-902,510	-61,989	28,958	11,661	428	-392,127	-91,921
				0							
Air Emissions				0							
Total Particulate Matter	kg	-78,751	23,240	-27,671	-1,697	-3,002	2,474	311	37	-64,590	-7,854
Nitrogen Oxides	kg	-177,922	249,689	-128,842	-193,625	-31,964	17,182	3,388	254	-39,464	-54,540
Sulfur Oxides	kg	-1,283,168	164,236	-467,268	-748,178	-111,500	4,876	576	72	-110,503	-15,478
Carbon Monoxide	kg	-242,246	86,308	-52,034	-100,609	-7,787	16,937	1,148	250	-132,696	-53,764
Carbon Dioxide Biomass	kg	292,678,446	292,780,125	-83,854	-10,630	-6,215	480	57	7	0	-1,523
Carbon Dioxide Fossil	kg	-33,579,302	83,643,534	-29,197,092	-51,899,090	-13,467,421	2,002,696	242,018	29,598	-18,576,339	-6,357,205
Carbon Equivalents	MTCE	-9,776	25,171	-9,275	-15,091	-3,724	549	73	8	-5,570	-1,918
Greenhouse Gas Emissions[1]	tonnes eCO2	-38,848 [2]	83,727	-30,851	-54,929	-13,612	2,009	243	30	-19,086	-6,378
Hydrocarbons (non CH4)	kg	-231,189	142,160	-101,334	-201,750	-27,079	6,913	866	102	-29,123	-21,944
Lead	kg	9	8	0	0	-2	0	0	0	4	0
Ammonia	kg	-1,812	1	-570	-1,143	-54	3	0	0	-39	-10
Methane	kg	-250,888	3,976	-78,781	-144,270	-6,881	319	43	5	-24,288	-1,011
Hydrochloric Acid	kg	19,534	22,176	-291	-37	-23	2	0	0	-2,287	-6
Water Emissions											
Dissolved Solids	kg	-1,812,491	3,905	-582,103	-1,172,001	-53,220	2,737	326	40	-3,488	-8,688
Suspended Solids	kg	-36,922	153	-12,757	-21,033	-1,837	62	13	1	-1,328	-197
BOD	kg	-1,805	4	-563	-1,131	-90	10	2	0	-5	-32
COD	kg	-24,989	57	-8,114	-16,325	-895	68	1,715	1	-1,279	-217
Oil	kg	-29,356	69	-10,190	-20,501	-1,011	64	3,430	1	-1,016	-202
Sulfuric Acid	kg	-223	14	-39	-8	-124	1	0	0	-65	-2
Iron	kg	-3,150	75	-2,723	-28	-127	1	1	0	-345	-5
Ammonia	kg	-554	0	-215	-22	-15	1	8	0	-308	-3
Copper	kg	0	0	0	0	0	0	0	0	0	0
Cadmium	kg	-84	0	-26	-53	-2	0	0	0	-2	0
Arsenic	kg	0	0	0	0	0	0	0	0	0	0
Mercury	kg	0	0	0	0	0	0	0	0	0	0
Phosphate	kg	-97	7	-20	-4	-62	0	0	0	-17	-1
Selenium	kg	0	0	0	0	0	0	0	0	0	0
Chromium	kg	-84	0	-26	-53	-2	0	0	0	-2	0
Lead	kg	0	0	0	0	0	0	0	0	0	0
Zinc	kg	-29	0	-9	-18	-1	0	0	0	-1	0

(1) Carbon Dioxide Fossil plus Methane (x21)
(2) Landfill emissions of 68,371 tonnes of eCO_2 are avoided annually hence Total Net Greenhouse Gas Emissions are –107,219 tonnes of eCO_2 per year.