SWANA 2009 Landfill Gas Utilization Excellence Award

Glanbrook Landfill Gas to Energy Facility

This submission is printed on 100% recycled paper
2009 LANDFILL GAS UTILIZATION EXCELLENCE AWARD

NOMINATION FORM

Program/Facility Nominated:
Glanbrook Landfill Gas to Energy Facility

Contact Person Name & Title:
Craig Murdoch – Manager of Waste Disposal

Address:
120 King Street West, 11th Floor, Suite 1170

City, State, Zip/Province, Postal Code:
Hamilton, Ontario L8P 4V2

Phone #: 905-546-2424 x 4490 Fax #: 905-546-4473
Email: Craig.Murdoch@hamilton.ca

Nomination submitted by (if different than information listed above):

Name: ___________________________ Phone #: ___________________________ Email: ___________________________

If selected for an award, how would you like the name of the organization to read on the award (limit of 50 characters)?

City of Hamilton, Waste Management Division

2009 Applications must be submitted to SWANA no later than Friday, April 3, 2009

*** PLEASE NOTE THAT ENTRY REQUIREMENTS HAVE RECENTLY CHANGED***
See the attached Entry & Eligibility Requirements sheet for further information

Application Checklist (Please make sure the following items are included in your submittal packet):

- Completed nomination form with signed release statement (this page)
- 1 original hard-copy application binder
- 1 copy of your award submittal on a CD-ROM
- Executive Summary of your nomination (NO more than 200 words)
- At least 2 pictures of your operation (may be included in nomination text)
- Check (made payable to SWANA) for nomination fee (in U.S. dollars)

Please mail all application packages to:

SWANA
ATTN: Technical Programs Department
1100 Wayne Avenue, Suite 700
Silver Spring, MD 20910

Release Statement: I certify that the information provided in this application is accurate and correct to the best of my knowledge. SWANA reserves the right to publish the enclosed information. Nominations become the property of SWANA. My signature gives SWANA the right to reprint or make available for purchase any portion of this submittal.

Signature: ___________________________ Date: ________________

[Signatures and dates]
Executive Summary

The City of Hamilton, located in southern Ontario, Canada, has successfully constructed and is operating a 3.2 MW (megawatt) Landfill Gas to Energy (LFGTE) Facility at the Glanbrook Landfill site. The $10.3 million LFGTE Facility has been operating since November 2008 with more than 95% availability. The Glanbrook LFGTE Facility presented unique challenges that were addressed with innovative design and construction strategies. It is a Facility with concurrent objectives of odor/noise control, and overcoming leachate mounding while achieving the goal of maximizing gas collection and revenue through the sale of electricity. It is a state of the art facility with innovative controls. It has aggressive operational objectives and a projected payback of 4 years. In addition, the Gas Collection System has an extensive number of horizontal gas collection trenches and relatively few vertical wells. The Glanbrook LFGTE Facility is minimizing impact on the natural environment and atmosphere by directly reducing greenhouse gas emissions and producing green energy using a renewable resource which has an optimistic and sustainable future.

Figure 1 – View from Communications Tower

Figure 2 – Generator #1 Metering Screen Display
# Table of Contents

**Executive Summary** ................................................................................................................................................. 1

**Section 1 - Design and Construction** .......................................................................................................................... 3
  - Glanbrook Landfill History .................................................................................................................................................. 3
  - Location .................................................................................................................................................................................. 3
  - Site Hydrology and Hydrogeology ........................................................................................................................................ 3
  - Project Development ............................................................................................................................................................ 3
  - Innovative Design ................................................................................................................................................................ 4
  - Power Plant .............................................................................................................................................................................. 5
  - Construction .......................................................................................................................................................................... 6
  - Quality Assurance and Quality Control ..................................................................................................................................... 8

**Section 2 - Environmental Controls** .............................................................................................................................. 8
  - Environmental Monitoring ...................................................................................................................................................... 8
  - Overall Impact to Human Health and the Environment ........................................................................................................ 8
  - Compatibility with the Environment ...................................................................................................................................... 9

**Section 3 - Regulatory Compliance** ............................................................................................................................... 10
  - The LFGTE Facility’s Role in the Waste Management System ............................................................................................... 10
  - Environmental Compliance and Facility Inspections ........................................................................................................ 10

**Section 4 - Planning, Operations and Financial Management** ......................................................................................... 12
  - Operation and Maintenance Program ..................................................................................................................................... 12
  - Financial Management ............................................................................................................................................................ 13
  - Future Facility Expansions and New Programs .................................................................................................................... 13
  - Health and Safety Program ..................................................................................................................................................... 14

**Section 5 - Utilization of Equipment/Systems and Technologies** ...................................................................................... 15
  - Generators ................................................................................................................................................................................ 15
  - Transformers and Switchgear ................................................................................................................................................... 15
  - Blowers and Supporting Systems ........................................................................................................................................... 16
  - Control Systems and Technology ........................................................................................................................................ 16
  - Plant Operator Training Program ........................................................................................................................................... 17

**Section 6 - Public Acceptance, Appearance and Aesthetics** ............................................................................................... 17

**Section 7 - Innovation and Creativity** ............................................................................................................................... 18

---

**Supplementary Materials**

- Project Profile
- System Layout
- Electrical Safety Authority Inspection
- Open House Posting
- Open House Map
Section 1 - Design and Construction

Glanbrook Landfill History
The Glanbrook Landfill has been operational since 1980 and is expected to be operational for another 30 years. The Glanbrook Landfill is owned by the City of Hamilton (City) and operated by a contractor. The 529 acre (214 hectare) site has an actual waste footprint of 156 acres (63 hectares), divided into three stages. All three stages are around 52 acres (21 hectares) each. The average depth of the waste deposited from the base of the Glanbrook landfill is 12 feet (4 meters) below the surface grade.

Location
The Glanbrook Landfill is used for the disposal of municipal solid waste that cannot be diverted or composted within the geographical boundary of the City. It is located on Part of Lots 26, 27 and 28, Concession 9 and Part of Lots 26, 27 28 and 29, Concession 10 in Glanbrook, one of the neighborhoods within the City. The site is situated between the Welland River and Buckhorn Creek.

Site Hydrology and Hydrogeology
The geology in the vicinity of the Glanbrook Landfill consists of glaciolacustrine silt and clay overlying sandy silt till and bedrock. The Glanbrook Landfill is situated in a deposit of low permeability clay overlying dolostone bedrock. The clay restricts the potential movement of leachate from the waste under normal hydraulic gradients. Thus, there is a natural tendency for leachate to remain in the waste.

There are two surface watercourses that traverse the property where the site is located. The overall direction of ground water flow is radially away from the Glanbrook Landfill towards the surface watercourses.

Project Development
In late 2003, the Waste Management Division of the City of Hamilton contracted Dillon Consulting Ltd (Dillon) to determine the feasibility of landfill gas recovery at the Glanbrook Landfill. A component of this study was to calculate the amount of gas generated for possible energy generation. Dillon determined that the Glanbrook Landfill could support a Landfill Gas to Energy (LFGTE) project which would have the benefit of reducing landfill odors and greenhouse gases to the atmosphere. The City then formed a partnership with Hamilton Renewable Power Inc. (HRPI) to develop the Glanbrook LFGTE Facility. In 2006, HRPI contracted Toromont Cat Power Systems (Toromont Cat) to undertake a turnkey project to utilize available landfill gas from the Glanbrook Landfill for the purposes of electricity generation and odor control. HRPI is a City' owned corporation that financed the project and collects revenue through the sale of electricity to the power grid to offset the project costs. See Project Profile in the Supplemental Materials.
The Glanbrook LFGTE Facility is expected to operate at an optimal level for at least 20 years (see System Layout in the Supplementary Materials). At the end of the lifespan of the Facility, the City will initiate a closure/decommissioning plan. The plan will dictate how the Facility materials and infrastructure will be dealt with when the site is closed.

Innovative Design

The design phase was completed by Toromont Cat and CRA Contractors Limited (CRACL) in 2008. A typical LFGTE Facility is designed with the primary objective of maximizing revenue. However, the Glanbrook LFGTE Facility had more sophisticated objectives as a number of site-specific concerns needed to be concurrently addressed, adding three new objectives to the design:

- Decrease odors and odor complaints attributed to landfill gas prior to project development;
- Reduce leachate mounding in certain portions of the landfill; and
- Mitigate the noise emissions from the LFGTE Facility due to the close proximity with residents, i.e. ¼ mile (400 metres) and low ambient noise levels.

To maximize the operational flexibility and control odors, a dedicated blower was added to ensure the flare would be able to run independently from the generators, adding extra combustion capacity. In addition, manholes of the leachate collection system were connected to the landfill gas collection system to maximize odor control.

To address leachate mounding concerns, the landfill gas collection system was designed with fifteen (15) vertical extraction wells and twenty eight (28) horizontal gas collection trenches. Horizontal gas collection trenches were placed in areas with higher leachate levels to improve the collection efficiency and allow continued landfilling operations without having to extend vertical wells.

Figure 3 - Blowers
Although the LFGTE Facility was within the noise limits necessary for regulatory compliance in the province of Ontario, due to the low background noise in the rural environment, noise associated with the generators became a concern to the neighboring residents. The following noise mitigation measures were designed and implemented to address noise concerns:

- An elbow was installed in the generators exhausting system diverting the noise away from the closest residents;
- The fan of the radiator system was adjusted to operate at a lower speed, generating less noise; and
- A barrier was installed to minimize noise.

The LFGTE Facility is remotely monitored and controlled. This tool includes the multifunction of Aircard/Wireless/VPN/Landline communications to provide anytime remote monitoring and control of the LFGTE Facility. The operator can remotely perform diagnostic tests, calibration and download data.

The above innovative design measures ensured all project objectives were met while maintaining and maximizing the revenue stream.

**Power Plant**

After careful evaluation of the site, a number of possible locations were identified to build the LFGTE compound. Locating the Power Plant in the southeast corner of the Glanbrook Landfill proved to be the preferred option because it was inside the landfill zoning boundary and it was out of the way from the main gate and therefore would have no construction interference. In addition, the LFGTE Facility was less exposed to public view, was a good site from a storm water drainage perspective, was a good sized area for construction access and was relatively close to the main gate.

The hydrology and hydrogeology for the preferred option was suitable to accommodate the Power Plant.

The Power Plant, located 220 yards (200 meters) east of the Glanbrook Landfill maintenance building, consists of various modules of equipment that convert the landfill gas to electricity:

**Figure 4 – Glanbrook Generator G3520C #1**
Power Module
Two containers, each surrounding a 1.6 MW (megawatt) generator, which burns approximately 1,000 cubic feet per minute (cfm) of landfill gas and generates electricity.

Blower Building
- Pre-engineered building enclosing three blowers (one dedicated to the flare and two redundant blowers for the engines);
- Blowers create a vacuum in the collection system, which draws the gas from the landfill; and
- Landfill gas conditioning equipment, before and after the blower module, cleans the gas before it is combusted by the engines.

Enclosed Flare
- To burn off excess gas generated by the landfill (up to 1,000 cfm capacity) and also burn landfill gas during generator maintenance.

Electrical Module and Appurtenances
- Pre-engineered building housing the motor control center, controls for blowers and flare, landfill gas analyzer and flow meter, and the utility interface panel; and
- Electrical sub-station in an outdoor, non-walk-in enclosure.

Connection to the Power Grid
- Electrical line extended 5 miles (8 kilometers) from the nearest town (Binbrook) into the Glanbrook LFGTE Facility; and
- 100 foot (30 meter) communications tower to provide wireless control to Hydro One (local electricity utility company).

Construction
The construction of the Glanbrook LFGTE facility consisted of two stages. The first stage included installation of the landfill gas collection system and the second stage included the construction of the Power Plant.

The first phase of construction began in May 2007 and included the installation of the horizontal collection trenches, the transmission header piping and condensate traps. The valve chamber installation was completed in December 2007 leaving only restoration activities for Spring 2008. By the end of May 2008, all of the construction work for the gas collection system was completed.

Fifteen (15) vertical extraction wells were installed in August 2007 at the north and east side slopes of the landfill where active landfilling had been completed and the final clay cover is in place. The vertical landfill gas extraction wells were drilled to a maximum depth of 39 feet (12 meters). The vertical extraction wells consist of perforated HDPE pipe connected to the transmission piping system. Each vertical
extraction well has been completed with underground slip joint and an aboveground flexible hose to allow landfill differential settlement, preventing damage to the system.

Twenty-eight (28) horizontal landfill gas collection trenches were constructed. The horizontal collection trenches were constructed using perforated high density polyethylene (HDPE) pipe of 6 and 8 inch (150 mm and 200 mm) diameter. The horizontal collection trenches were backfilled with 2 inch (50 mm) diameter clear stone.

The construction of the landfill gas transmission piping was performed in two stages. The first stage consisted of installation of the header transmission pipe. The second stage consisted of installation of the subheader transmission piping. Solid HDPE pipe was used to construct the gas transmission system. The header transmission pipe, approximately 2,300 yards (2,100 metres) in length, located around the north, south, east and west perimeters of the landfilled portion of the Site were installed first. Subheader piping was installed in the landfill to connect to the header piping, which is connected directly to the vertical extraction wells.

![Figure 5 - Header Transmission Pipe](image1)

![Figure 6 - Fusing HDPE Pipes](image2)

Subheader piping also connects the horizontal collection trench piping to the header piping and the lateral piping was installed in the landfill to connect the extraction wells to the subheader transmission piping. The lateral piping for the collection field was buried directly below the final cover.

The Power Plant consists of a blower building, an enclosed flare, a generator module and an electrical module. Site works for the Power Plant began in August 2007, with preparation of the sub-grade and site drainage. This stage also included installation of the grounding grid as well as subsurface piping and conduit. Concrete construction followed to complete the foundations and slabs-on-grade, which supported the pre-engineered steel building and the mechanical and electrical
systems. By mid October 2007, the site preparation work had been completed. The mechanical work was completed in November 2007. Following the project construction break from December 2007 to August 2008 due to Hydro One (local electricity utility company) approvals, the installation of electrical works and the remaining systems were completed by October 2008. Commissioning activities were completed through early November 2008 resulting in late November 2008 project completion.

**Quality Assurance and Quality Control**

A quality management plan was prepared and implemented by Toromont Cat and CRACL and included several Quality Assurance/Quality Control (QA/QC) considerations. All of the quality management measures identified were incorporated into the daily construction work. For the construction phase of the project, the QA/QC plan elements included document control and field quality control. As a supplementary component of the QA/QC plan, a Commissioning Plan was also prepared to document the process of converting the project into a fully operable landfill gas collection, flaring, and utilization system.

**Section 2 - Environmental Controls**

**Environmental Monitoring**

Landfill gas, groundwater and leachate monitoring are an important part of ensuring that the Glanbrook Landfill is operating at an optimal and environmentally friendly level. A network of 70 groundwater monitoring wells and 12 landfill gas probes are located in and around the Glanbrook Landfill site and the City places a high priority in monitoring these wells. The monitoring wells are used to obtain water levels and water quality samples in and adjacent to the landfill, while the gas probes are used to measure methane concentrations in the vicinity of the waste footprint. Surface water quality is monitored in Buckhorn Creek and the Welland River adjacent to the landfill.

To reduce the amount of leachate accumulating in the landfill (i.e. mounding), the site was designed with a leachate collection system consisting of perforated pipes surrounding the perimeter of the waste with attached finger drains. These pipes drain and direct leachate to 3 pumping stations in the landfill, which in turn pump the leachate to the sanitary sewer, where the leachate is ultimately treated at the City’s Waste Water Treatment Plant. The pumping station is remotely operated and monitored through Supervisory Control and Data Acquisition (SCADA) system by the Woodward Waste Water Treatment Plant.

**Overall Impact to Human Health and the Environment**

Human health potentially also benefits from the Glanbrook LFGTE Facility. The Glanbrook LFGTE Facility provides effective management of landfill gas emissions,
cleaner air, reduction of greenhouse gas emissions through the destruction of methane either in the flare or in the generators, and the control of potential offsite landfill gas migration.

Odors generated from landfill gas emissions can contribute to unpleasant and pungent odors. These smells can be transmitted off-site to nearby residences and can lower the quality of life for individuals and potentially reduce local property values. However, the Glanbrook LFGTE Facility is a successful long term solution to address the historic odor problems.

Controlling odors at the Glanbrook Landfill was addressed during the planning phase of the construction activities. The company contracted to install the landfill gas collection system (CRACL) worked with the City and implemented an effective odor control plan. The primary activity that causes odor while installing the landfill gas collection system is the installation of horizontal landfill gas collections trenches in previously placed waste. Open excavations were a requirement for the installation of the horizontal landfill gas collection trenches, and CRACL made every effort to minimize the duration of open excavations. When the required piping was in place, CRACL immediately backfilled the open trench before moving to the next section of excavation. This strategy was successful in preventing trenches from being open longer than necessary. CRACL also monitored odors while construction was occurring at various off-property locations. Odor was also suppressed by a portable odour control unit, which was designed to mitigate and neutralize odors on contact. This strategy to control odors resulted in minimal impact to human health, the environment and the community.

Compatibility with the Environment

The Glanbrook LFGTE Facility is wholly compatible with the environment. It reduces the amount of carbon dioxide and methane gas, which are "greenhouse
gases” and contribute to climate change. Not only does the project reduce the amount of greenhouse gases emitted into the atmosphere, it also converts the by-product of landfilling practices into a renewable resource for the generation of electricity. In turn, the electricity can be put back into the grid and sold for an additional source of revenue. Since landfills are the second largest single human source of methane emissions in North America, the project is also improving environmental quality by combusting greenhouse gases produced from the landfill and not allowing them to contribute to global warming.

The Glanbrook LFGTE Facility was designed and built compatible with existing facilities and is a showcase for the City of Hamilton and other communities. It was built within the existing landfill property, optimizing the local land use and resources. The generator containers were painted green and integrated with nearby forested area.

In addition, the following environmental initiatives warrant mentioning:
- The City is currently conducting a feasibility study of recovering the thermal energy from the generators and supplying it to heat a greenhouse facility;
- Condensate is collected and treated at the City’s Waste Water Treatment Plant with no impact to the environment;
- A noise mitigation plan was implemented to minimize noise impacts to the surround environment;
- The Glanbrook LFGTE Facility can be operated remotely through SCADA, saving trips to the site and reducing the carbon footprint; and
- During construction of the LFGTE Facility, two candlestick flares were functioning to burn off the landfill gas as a temporary measure to mitigate odors and reduce greenhouse gases.

Section 3 - Regulatory Compliance

The LFGTE Facility’s Role in the Waste Management System

The City has an integrated solid waste management system always strives towards excellence in the Hamilton community. The City provides services of waste disposal, waste transportation, recycling and composting to its residents. The City also provides many educational programs, open houses, and tours regarding the numerous and different working parts that make the City of Hamilton’s Waste Management System function so the community can enjoy the public and environmental benefits they receive. The LFGTE Facility plays an important role on the integrated solid waste management system.

Environmental Compliance and Facility Inspections

Several approvals were required in order to bring the project to commencement and completion:
• The Ontario Ministry of the Environment reviewed and approved the report submitted with project description and set of stamped drawings of the LFGTE Facility. The proposed project was in compliance with Ontario regulations and the Waste Disposal Site Certificate of Approval was amended;

• A report with modeled air and noise emissions associated with the LFGTE Facility was reviewed and approved by the Ontario Ministry of the Environment. The project was in compliance with Ontario regulations and a new Air Certificate of Approval was issued;

• A site plan approval was issued for the LFGTE Facility by the Planning and Development Department of the City of Hamilton. The purpose of the site plan approval process is to provide a review of site, building and landscape features to ensure that an appropriate development solution is achieved, is attractive and functional for its users.

• A Building Permit is required when constructing a building that is greater than 100 square foot (approximately 10 square meters) in gross building area. A Building Permit was issued by the Building Services Division of the City of Hamilton for the LFGTE Facility;

• Hydro One (local electricity utility company) also reviewed and approved the LFGTE Facility to ensure the electricity produced by the project could be delivered without impacting the grid; and

• The Ontario Power Authority reviewed and approved the project under the Standard Offer Program. The project met all requirements and a 20-year contract to sell renewable electricity to the grid was secured.

The City also took the initiative to acquire a new updated Site Certificate of Approval for the Glanbrook Landfill issued by the Ontario Ministry of the Environment, which follows modern landfill operating and environmental requirements. The City was not obligated to attain a new Certificate of Approval, but showed leadership and applied for an updated Certificate of Approval.

The Glanbrook LFGTE Facility collects and destroys most of the landfill gas generated at the Glanbrook Landfill, bringing the Glanbrook Landfill to compliance with Ontario Regulations as it controls off-site odor and potential migration impacts. The Glanbrook Landfill was de-listed from the Canadian national greatest polluters because the greenhouse gas emissions were lowered to a level below the 100,000 tonnes of CO$_2$e threshold.

The facility is operating in compliance with the Certificate of Approval requirement of flaring at a minimum temperature of 1,600 degrees F (871 degrees C). See Figure 9 for a sample of measured flare temperature data.
The Ministry of the Environment inspected the LFGTE Facility and was impressed with the project. The Glanbrook LFGTE Facility also passed the Electrical Safety Authority inspection without restrictions (see Supplemental Materials).

**Section 4 - Planning, Operations and Financial Management**

**Operation and Maintenance Program**

The Glanbrook LFGTE Facility started operations in late November 2008 and both engines have been generating electricity at least 95% of the time after commissioning, which is above the minimum operational goal of 90% availability.

The wellfield is calibrated once a month to ensure consistent minimum landfill gas flow to the engines of 1,000 cfm at a minimum of 50% methane. The flare is operated when one of the engines is down for more than two hours to ensure odor control and greenhouse gas destruction objectives.

An employee from Toromont Cat operates and maintains the Glanbrook LFGTE Facility on a full-time basis. Daily and weekly inspection and maintenance checklists are used to ensure a cost-effective maintenance program. Oil samples are taken from the generators to detect maintenance needs on a regular basis.
Because an “on-peak” incentive pays an additional 3.52 cents per kilowatt-hour for electricity produced from 11 am to 7 pm on business days, Toromont Cat strives to perform most maintenance work that require the generators to shut down outside of the on-peak hours, to maximize the revenue. Major maintenance works are planned and coordinated to be performed all at once to decrease operating downtime and achieve the operating goal of 90% availability.

**Financial Management**

The capital cost actually spent on the Glanbrook 3.2 MW LFGTE Facility was $10.3 million, including $1.3 million spent on a 3-phase electrical connection that needed to be built with lines run from the nearest town located 5 miles (8 kilometers away). The operating and maintenance cost is estimated at $500,000 per year.

The revenue from the Glanbrook LFGTE Facility is based on actual kilowatt-hours of electricity produced and sold to the grid. HRPI receives 11 cents per kilowatt-hour plus 3.52 cents per kilowatt-hour for electricity produced on peak hours (11 am to 7 pm on business days). Electricity is sold to the Province of Ontario under a 20-year contract as part of the Standard Offer Program for renewable energy projects. It is estimated the Glanbrook 3.2 MW LFGTE Facility will produce a net electricity output of 26,000 MWh per year, which can power approximately 2,100 homes.

Considering the project costs and revenue stream, the project payback was estimated to be approximately 4 years within the 20-year contract.

**Future Facility Expansions and New Programs**

As a result of an extensive waste screening program that occurs at the City’s transfer stations, all waste delivered to the Glanbrook Landfill has been screened and deemed to be acceptable for disposal. Glanbrook Landfill only accepts municipal non-hazardous waste, of which organic waste make up a significant portion, ensuring sustained landfill gas production. Landfill gas production models show that gas production will remain around 1,500 cfm for at least 20 years. The installation of a third engine is not currently anticipated at this point as the gas flow has not yet proven to consistently sustain more than 1,000 cfm with 50% methane. However, in the future, as the project matures and available surplus gas is verified, there is physical room to expand the LFGTE Facility as its set up is modular in nature.

The generators also have the flexibility to be retrofitted to supply heat to a future greenhouse. The City is currently conducting a feasibility study of recovering the thermal energy from the generators and supplying it to heat a greenhouse facility. It was estimated that 7.5 millions of BTU per hour of heat is available to be captured and delivered to an adjacent greenhouse via heat exchangers and a buried glycol pipeline. Under local historic climate conditions and with modern commercial greenhouse construction standards, this represents heating capacity for about 2
acres (1 hectare) of greenhouses. The future construction of greenhouses will increase the effectiveness of the LFGTE Facility to reduce greenhouse gases.

**Health and Safety Program**

The project was completed in accordance with the Ontario Health and Safety Act and applicable Regulations under the Act with no recorded accidents.

Health and Safety was taken into consideration at all stages of the construction phase. Toromont Cat/CRACL submitted the City's “Contractor Safety Checklist/Pre-Construction Meeting Form”. Toromont Cat/CRACL also prepared and implemented a Health & Safety Policy and Procedure Manual as well as the Glanbrook LFGTE Specific Health and Safety Plan.

All personnel conducting work at the Glanbrook LFGTE Facility were required to have completed the appropriate health and safety training as applicable to their assigned job tasks and duties. In addition to this, an initial site-specific training session or briefing was conducted by the Project Manager/Site Supervisor during the initial training session. Employees were instructed on the following topics: personnel responsibilities, content and implementation of the HASP (Health and Safety Plan), site hazards and controls, site specific hazardous procedures (e.g. Drilling, etc), training requirements, PPE (Personal Protective Equipment) requirements, emergency information, including local emergency response team phone numbers, route to nearest hospital, accident reporting procedures, emergency response procedures and location of safety equipment.

City Waste Management staff also underwent thorough regular health and safety training. City staff are trained in traffic control and awareness of equipment and vehicles. Also, staff attended First Aid and CPR training. Monthly health and safety meetings are also conducted. The City's waste management facilities are regularly audited by the Waste Management Division’s Joint Health and Safety Committee to ensure that we are operating in compliance of the City’s and Governmental safety requirements.

Health and Safety was a top priority during the construction activities. Construction personnel followed the policies and procedures in place and as a result no reported injuries were recorded during the construction activities.

Health and Safety continues to be a top priority during the operation and maintenance activities. Toromont Cat implemented a Health and Safety Program and City's staff conducts Health and Safety inspections at the LFGTE Facility at least once a month, and to date no injuries or violations have been reported.
Section 5 - Utilization of Equipment/Systems and Technologies

Generators
Caterpillar 1.6MW G3520C generators were selected to meet the performance objectives of the City of Hamilton. The Caterpillar 1.6 MW G3520C generators offer the benefits of high efficiency and low air emissions. The Glanbrook LFGTE Facility has 3.2 MW of capacity and an average net production of 3.0 MW. Figures 10 and 11 show the Caterpillar G3520C generators being delivered and installed.

![Figure 10 - Engines Being Delivered](image1)
![Figure 11 - Engines Placed on Concrete Pad](image2)

Key performance data for the Caterpillar G3520C generators are outlined below:
- Low energy fuel (1:43 methane : carbon dioxide ratio);
- Low fuel pressure engines (1.5 - 5.0 Psig);
- Fuel consumption: 456 BTU/scf;
- Combustion: low emission;
- No low-BTU fuel problems;
- Gas flow and pressure: 584 scfm of landfill gas at 45% methane, 1.5 Psig; and
- Heat value of engines: 9,650 BTU/kWh (LHV) or 10,611 BTU/kWh (HHV).

Transformers and Switchgear
The transformer provides power to the outdoor metal enclosed 4160 Volt main secondary switchgear via 1200 A busway. The main secondary switchgear consists of a transformer main secondary breaker (52-M), utility metering compartment, generator #1 breaker (52-G1), generator #2 Breaker (52-G2), station service fused switch, ground fault protection PTs; bus synchronizing PTs and generator PTs.

The transformer main secondary breaker (52-M) is a 1200 A, electrically operated, draw out air circuit breaker, c/w shunt trip coil. The generator breakers (52-G1 and 52-G2) are 1200 A, electrically operated, draw out air circuit breakers, c/w shunt trip and UV trip coils.
**Blowers and Supporting Systems**

Inside the Blower Building, two 1,000 cfm blowers were installed to draw LFG from the Glanbrook Landfill. One blower operates at any given time to supply LFG to the generators, while the remaining blower only operates on a prime and standby basis. This allows for blower maintenance to be performed without interrupting LFG collection and electricity generation. The blowers are automatically controlled, monitored and protected by a plant control panel. The landfill gas system is comprised of a landfill gas condenser, to either of the two blowers which are configured in parallel. Then the pressurized and heated gas discharged from the blower flows through an aftercooler, which reduces the gas temperature. The pressurized and cooled gas is supplied to the 2 reciprocating engines. The Power Plant has the flexibility to have none of the engines, one or both of the engines operating when a blower is running.

**Control Systems and Technology**

The generators are controlled with an Allen Bradley Panelview Plus 1250 with a display and software programmable computer which drives 23 input/output logic cards. The generators are protected by GE Management 489 Relay. The blowers are controlled with an Allen Bradley Panelview 1250 Plus Touch Screen Display, with software programmable which drives 17 logic input/output cards to control systems. The flare has an Automatic Direct display with software programmable and drives 6 logic control cards.

All systems are integrated together via Monaco relays and send data to a single base station. The base station (computer Intel Core Duo 2.33 GHz) is equipped with Lenovo desktop SCADA System and monitored with a 24’ Samsung Syncmaster monitor. This large monitor displays all Control information Plus Cat ET Monitoring of over 100 parameters of information.

SCADA system is capable of remote Monitoring & Control of the Facility anywhere in the world using a personal computer to display more than 100 parameters, diagnostic codes, event codes, engine configuration and performance data.

The operator is equipped with the latest Lenovo T61 ThinkPad loaded with the latest in communication technology. This tool includes the multifunction of Aircard / Wireless / VPN / Landline communications to provide anytime remote monitoring and control of the LFGTE Facility. The operator can remotely perform diagnostic tests, calibration and download data.

![Figure 12 – Control Room](image)
Plant Operator Training Program
Toromont Cat has a comprehensive training program and employs qualified power plant operators. The Glanbrook LFGTE Facility full-time operator has over three decades of experience with Caterpillar equipment. Key training that he has received since 1977 includes Factory Training on Gas and Large Bore Engines & Generation, TSSA–Gas Fitters License, SWANA Landfill Gas & Field Maintenance Training, Gas License, and Class A Automotive with Diesel Endorsement.

As part of the training program, senior operators provide hands-on training and mentorship to junior operators forming a pool of operators that is available to cover absences and minimize downtime.

Section 6 - Public Acceptance, Appearance and Aesthetics
The City’s goal for the Glanbrook LFGTE Facility is to provide a facility that is environmentally friendly, is able to reduce greenhouse gases, controls odors and to highlight to the community the sound integrated solid waste management practices of the City.

The City has dedicated solid waste management community outreach programs. Open houses were offered to the general public on August 9, 2007 and June 21, 2008 providing residents with an opportunity to tour the Glanbrook Landfill and learn about the LFGTE Facility (see Supplementary Materials). In addition, the City held an information session during the design phase of the LFGTE Facility to educate the community on how the facility was being incorporated into the waste management system. Another media event is planned as a ribbon cutting ceremony on May 22, 2009.
The Glanbrook Landfill Coordinating Committee, comprised of local residents and the Ward Councilor, toured the LFGTE facility a number of times and has been updated on the progress of the facility design, construction and operation.

The facility is kept clean and designed to be harmonious visually with the other landfill equipment and the immediate environment. The gas facility is green to incorporate the environmental theme and to be integrated with surrounding forested area.

The City recognized that in order for the community to positively accept the project, the site needed to be visually appealing. In 2007, the City initiated a program to improve the visual effect of the buffer area between surrounding properties and the property line. The City planted approximately 75 trees in 2007 and 200 trees in 2008 in areas identified as priority or gap by City Staff and with input received from local residents. Along with the cultivation of the trees, a watering and maintenance plan was developed to ensure a higher survival rate of the newly planted trees. In addition, as part of the extensive tree planting program, 20 large size trees were planted at residences along a perimeter road to improve green buffer for the new hydro line.

**Section 7 - Innovation and Creativity**

The Glanbrook LFGTE Facility is innovative and creative for a number of reasons. The project was self-developed by the City and HRPI and will provide direct environmental and financial benefits to both City and HRPI while partnering with Toromont Cat (private partnership).

The operational and environmental concerns of odor/noise control, leachate migration control and greenhouse gases reduction were achieved while maintaining the financial benefits of the project.

The gas collection system is connected to the leachate system to maximize the gas collection efficiency and further decrease odors. The Glanbrook LFGTE Facility has a large number (28) of horizontal gas collection trenches, which were installed in areas of the landfill with higher leachate levels to ensure full coverage of gas collection and allow continued landfilling operations without having to extend vertical wells.

The Caterpillar G3520C generators are very efficient and meet the most stringent low emission guidelines and regulations. The LFGTE Facility is remotely monitored and controlled with the latest in communication technology. The operator can remotely perform diagnostic tests, calibration and download data.
Another unique aspect of this gas utilization project is that the flare on site can be operated at the same time as the engines, or when the engines are shut down for maintenance, adding extra capacity to control odors and reduce greenhouse gases.

During construction of the LFGTE Facility, two candlestick flares were functioning to burn off the landfill gas as a temporary measure to mitigate odors and reduce greenhouse gases.

The Glanbrook landfill was retrofitted with the gas collection system while at the same time operating regularly. The odor control plan implemented during construction activities used efficient strategies while minimizing the length of excavations in waste and using portable odor control units.

The Glanbrook Gas to Energy Project is a “renewable” and “green energy” project and is aiding in preserving the earth's atmosphere and slowing global climate change while providing electricity to approximately 2,100 residences.
Supplemental Materials
GLANBROOK LANDFILL GAS TO ENERGY PROJECT
HAMILTON, ONTARIO

Owner: Hamilton Renewable Power Inc.
Duration: Fall of 2006 to Fall of 2008

Hamilton Renewable Power Inc. (HRPI) contracted Toromont Cat Power Systems to undertake a turnkey project to utilize available landfill gas from the Glanbrook Waste Management Site in the City of Hamilton for the purposes of electricity generation and odour control.

The scope of work generally included geotechnical investigation, landfill gas collection system design, plant foundation design, plant structural design, fuel gas conditioning system design, electrical systems design and utility interconnection design. Furthermore, Toromont was responsible to oversee and undertake all on site construction activities and mentor the plant commissioning process.

The project involved the installation of horizontal collection trenches and vertical extraction wells, landfill gas transmission piping, condensate management facilities, flare system and a generation facility complete with two Caterpillar G3520C 1.6 MW reciprocating gas generator sets, heat rejection radiators, fuel gas trains, ventilation systems and controls. The landfill gas collection field consists of 15 vertical extraction wells, 28 horizontal trenches and approximately 8500m of LFG collection piping. The landfill and collection field is manually controlled and monitored to allow LFG pressure and quality to be optimized.

A 6m x 10m pre-engineered structural steel and metal clad blower building contains the landfill gas blowers and gas conditioning equipment. An electrical module contains the motor control centre, control panels, metering cabinet and utility interface panel. Electricity generation is provided at 4160V and stepped up to the utility distribution voltage of 27.6kV. Excess landfill gas not consumed by the generator sets can be delivered to the enclosed flare. The plant is fully automated and remotely operated.
Requested Inspection Outcome Summary Report

K-LINE MAINTENANCE & CONSTRUCTION
LIMITED
12731 HIGHWAY 48
STOUFFVILLE ON L4A 7X5

ISSUE DATE: October 23, 2008
PRINT DATE: October 24, 2008
CUSTOMER ID: 4825
FAX NUMBER: 905640-8887

Notification: 12524084
Cust Order #: 11303

Site:
GLANBROOK LANDFILL
3665 enter
1500 HALDBROOK RD, gate code
GLANBROOK TWP ON

Status: Passed
Code: Service
GLANBROOK LANDFILL FREE OPEN HOUSE!

Saturday, June 21, 10am-3pm

Meet at Glanbrook Arena (4300 Binbrook Road West)

Ever wonder where your garbage goes?

See why it’s important to reduce your waste to one container a week.

Board an 1840s replica HSR trolley for a complete tour of Hamilton’s Glanbrook Landfill.

You’ll learn what a ‘tipping face’ is, how leaf and yard waste is composted, and how we’re using generators to convert methane gas into electricity.

We’ll have cool displays and really BIG machines on hand so bring your whole family!

Hamilton Public Works