

TORONTO STAFF REPORT

August 15, 2003

To: Works Committee

From: Commissioner, Works and Emergency Services
Chief Financial Officer and Treasurer

Subject: New and Emerging Technologies, Policies and Practices
Request for Expression of Interest No. 9155-03-7283

Purpose:

To report on the results of the Request for Expressions of Interest No. 9155-03-7283 for the provision of New and Emerging Technologies for Management of Residual Municipal Solid Waste (the "REOI"). It is provided for informational purposes only and is intended to be considered in conjunction with a companion report carrying recommendations on the workplan and timing for an environmental assessment for New and Emerging Technologies for Management of Residual Municipal Solid Waste and associated procurement process through a Request for Qualification and Request for Proposal.

Financial Implications and Impact Statement:

There are no direct financial implications as a result of this report.

Recommendations:

It is recommended that this report be received for information.

Background:

On April 14, 15 and 16, 2003, City Council had before it Clause 2 of Report No. 3 of the Works Committee that, based on the conclusions of the New and Emerging Technologies, Policies and Practices Advisory Group (the "Advisory Group"), recommended that the Commissioner of Works and Emergency Services be directed to:

1. "issue in May 2003 a "Request for Expressions of Interest" to the marketplace for new and emerging solid waste management technologies;"

2. “issue a subsequent Request for Qualifications to new and emerging solid waste management technology proponents in 2003;” and,
3. “submit a report to the Works Committee no later than January 2004 on the outcome of the Request for Qualifications cited above in Recommendation No. 2., and submit at that time recommendations for the potential issuance of a Request for Proposals for new and emerging technology proposals.”

City Council adopted the Works Committee Report with the following amendments:

1. “the Commissioner of Works and Emergency Services be requested to submit a report to the Works Committee by September 30, 2003, on the results of the Request for Expressions of Interest, the proposed content and requirements of the Request for Qualifications, and the workplan and timeframe for the environmental assessment process;” and,
2. “Councillor Laura Jones be appointed as a Member of the New and Emerging Technologies, Policies and Practices Working Group.”

Comments:

The REOI was issued by the Purchasing and Materials Management Division on June 2, 2003 and closed July 14, 2003. Notification was provided to 190 vendors registered in a vendor database, which staff has been compiling for the past year through vendors contacting the City. As well, the REOI was advertised in various media outlets (See Appendix A for the REOI Media distribution list) and was also advertised on the City’s internet website. This resulted in fifty-one (51) submissions being received. Refer to Appendix B for the respondents that submitted responses to this REOI.

Purpose of REOI

The purpose of the REOI was fourfold:

1. to identify potential vendors of new and emerging technologies as well as proven (operating commercial scale) technologies to manage the City’s residual municipal solid waste;
2. to signal to the marketplace the intention of the City to issue requests for qualifications (RFQL) and proposals (RFP) for such technologies;
3. to solicit information from potential vendors to help define system options and goals; and
4. to provide an opportunity for potential vendors to comment on the RFQL and RFP stages of the procurement process.

The REOI was not a pre-qualification step in the procurement of such technologies.

The scope of the REOI was open to all technologies with the exception of incineration and landfill. This was due to commitments made through an existing contract for the haulage and

disposal of residual solid waste and due to Council’s stipulated policy of achieving 100 percent diversion from landfill by 2010.

General Results of REOI

The following table outlines the summary of REOI submissions received:

General Results Table

| | | | |
|--|----|---------------------|----|
| Total number of submissions | | 51 | |
| Number of vendors submitting who were originally in our vendor database | | 33 | |
| Number of new vendors added to our database | | 16 | |
| Number of duplicate submissions | | 1 | |
| Number of submissions withdrawn (member of Advisory Group) | | 1 | |
| Number of submissions from Local (CDN) firms | | 27 | |
| Number of submissions from USA-based firms | | 14 | |
| Number of submissions from International firms | | 9 | |
| Number of submissions in each technology category and sub-category | | | |
| Biological | 12 | Anaerobic Digestion | 8 |
| | | Aerobic Composting | 3 |
| | | Other | 1 |
| Physical | | 5 | |
| Chemical/Other | | 4 | |
| Thermal | 30 | Gasification | 25 |
| | | Pyrolysis | 5 |
| Number of submissions representing complete systems | | 40 | |
| Number of submissions representing components of complete systems | | 10 | |
| Number of submissions representing unique technology suppliers | | 46 | |
| Number of submissions representing the same technology supplier 4 submissions used Westinghouse Plasma technology | | 4 | |
| Number of submissions that were not relevant to REOI Either did not address the mixed residual solid waste stream or were not waste management technologies | | 3 | |

Process Category Descriptions

Biological processes refer to processes that use bacteria to decompose organic material. Anaerobic digestion is the bacterial breakdown of organic materials in the absence of oxygen. This biological process produces a gas, sometimes called biogas, principally composed of

methane and carbon dioxide. Aerobic digestion is generally referred to as composting or the breakdown of organic materials in the presence of oxygen.

Physical processes refer to processes that use physical and mechanical separation of material. These processes are generally used in conjunction with a downstream technology. Other physical processes may be used to create refuse-derived fuel (RDF) through compaction and shredding of material.

Chemical processes introduce chemicals to break down material into components of the original state.

Thermal processes such as gasification and pyrolysis degrade organic compounds and melt inorganic materials at high temperatures in low or no oxygen atmospheres, respectively. Products of gasification are a combustible gas, referred to as syngas, and an inert, possibly vitrified, solid residue. The end product of pyrolysis is a mixture of solids (char), liquids (oxygenated oils), and syngas.

Additional information regarding the submissions is included in Appendix C. Information has been extracted from the submissions for a variety of categories including:

- proposed capacities
- data on existing plants
- proposed front-end processing
- estimated diversion potential and products
- comments on proposed screening and evaluation criteria
- comments on how thermal technologies differ from incineration.

Next Steps

A companion report regarding the next steps on the workplan and timing of an environmental assessment for the implementation of New and Emerging Technologies for Management of Residual Municipal Solid Waste and associated procurement process will be on the agenda of the September 4, 2003 Works Committee. The companion report will address the next steps for the issuance of an RFQL and how this process will be integrated with the timing for an environmental assessment.

In order to provide an opportunity for vendors to provide additional information about their respective technologies, we are planning to host a vendor forum in Fall 2003. Opportunities to participate in the forum will only be extended to respondents to the REOI. Additional information will be provided to members of the Committee and interested members of the public at a later date.

Conclusions:

The responses to the REOI have demonstrated the interest of the marketplace in implementing new and emerging technologies to manage the City's residual municipal waste. The industry has

provided useful feedback to help the City in its selection and identification of appropriate systems. As well, the REOI has effectively communicated the City's serious investigation of such technologies and the intention to issue an RFQL and RFP as stated in the REOI document.

City staff with the assistance of the Citizen and Expert Advisory Group will continue to analyze the EOI submissions and obtain addition information to enable the City to implement a system(s), which meets its waste management and environmental goals.

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Commissioner
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Joseph P. Pennachetti
Chief Financial Officer and Treasurer

Appendix A

REOI Distribution List

REOI Distribution list (beyond regular media outlets via Canada NewsWire):

The Conversion Technologies Listserv
Municipal Waste Integration Network (MWIN)
Ontario Waste Management Association
The Composting Council of Canada
US Composting Council
European Compost Network
The Composting Association
International Energy Agency
Environmental Industry Associations
Renewable and Energy Efficiency Organization (Reformed as Future Energy Solutions)
Alternative Energy Institute, Inc.
ASSURRE
Warmer Bulletin
Business News Publishing Company
Environmental Science and Engineering magazine
Biocycle

Distribution list for paid advertisement announcing the REOI:

The Globe and Mail
Report on Business (National circ.)
Monday, June 2, 2003

Daily Commercial News
Tuesday, June 3, 2003

Waste News
A weekly industry trade magazine
Published on Mondays
June 9, 2003

Appendix B
List of Firms Responding to the REOI

| | | | |
|----|--|----|--|
| 1 | 1329958 Ontario Inc. | 26 | Interstate Waste Technologies, Inc. |
| 2 | 723230 Ontario Inc., DBA West Corp. Canada | 27 | ISKA GmbH |
| 3 | Ambienteco Group Ltd. | 28 | JDI/Geoplasma, LLC |
| 4 | ArrowBio Canada Inc. | 29 | Kenox Technology Corporation |
| 5 | Brian Brady and Associates Inc. | 30 | Masada Resource Group LLC |
| 6 | Brightstar Environmental | 31 | Mechanical Waste Conversion Corporation |
| 7 | C2 Envirosource Inc. | 32 | Organic Waste Systems N.V. |
| 8 | Changing World Technologies, Inc. | 33 | Pearl Earth Sciences, Corp. |
| 9 | Cinergex Solutions Inc./AESI | 34 | Plasma Environmental Technologies Inc. in Partnership with Kinectrics Inc. |
| 10 | City Clean 2000 Inc. | 35 | PyroGenesis Inc. |
| 11 | Compact Power Limited | 36 | Recovered Energy Inc. |
| 12 | DMS Waste Management Inc. | 37 | Sanderson Watts Associates Limited |
| 13 | Dresden Developments PTY Limited | 38 | Sanderson Watts Associates |
| 14 | Eastern Power Limited | 39 | Scientific Utilization, Inc. |
| 15 | EBARA Corporation, Tokyo, Branch Zurich | 40 | SenreQ International Limited |
| 16 | Enviro-Services and Constructors, Inc. | 41 | Solena Group, Inc. |
| 17 | Enwave District Energy Limited | 42 | Synxx Synfuels Inc. |
| 18 | Gene Syst International Incorporated | 43 | Timberman Recycling Inc. |
| 19 | Global Energy Solutions | 44 | Ronald Mark Stratford |
| 20 | Global Environmental Technologies of Ontario, Inc. | 45 | Wastegen (UK) Ltd. |
| 21 | Global Warning Prevention Technologies Inc. | 46 | Waste Options Atlantic LLC |
| 22 | Greenshift Inc. | 47 | Waste Reduction Technologies Inc. |
| 23 | Greey CTS Inc. | 48 | Withdrawn (Advisory Group Member) |
| 24 | High-Tech Enterprise #130791346 | 49 | Westinghouse Plasma Corporation |
| 25 | International Vapor Power Corp. | 50 | World Waste of America, Inc. |
| | | 51 | Woodland Chemical Systems Inc. |

Appendix C
Summary of Results

Proposed Capacities

Proposed processing capacities ranged from as low as 1,200 tonnes per year to 814,000 tonnes per year. Submissions with lower proposed capacities (<20,000 tonnes per annum (“tpa”)) were of technologies that addressed highly source separated and specific waste streams such as, electronics, packaging and construction waste. Higher proposed capacities were a mix of Biological, Physical, Chemical/Other and Thermal technologies and addressed the entire mixed residual municipal solid waste stream. Not all firms responded with a proposed capacity.

| Proposed Capacity (Upper Range) | <20 (‘000 tpa) | 20-200 (‘000 tpa) | 200-400 (‘000 tpa) | >400 (‘000 tpa) |
|------------------------------------|-------------------|----------------------|-----------------------|--------------------|
| # of Submissions | 2 | 17 | 18 | 10 |

Existing Plants

Firms provided information on existing commercial, demonstration and pilot plants as well as future plant information. Although capacities of up to 814,000 tonnes per year were proposed, the largest capacity for existing plants provided in the submissions was 300,000 tonnes per year. A summary of operating plants is provided below:

| Type | Plants |
|------------------------|---|
| BIOLOGICAL: | |
| Anaerobic Digestion | 5 commercial plants (13.5K to 80K tpa) 3 demonstration plants (3K to 30K tpa) to begin construction in 2003 (150K and 165K tpa) and 2005 (30K tpa) |
| Aerobic Composting | 13 commercial plants (4.5K – 210K tpa) 6 plants to begin construction by 2005 (85K to 220K tpa) |
| PHYSICAL: | |
| Physical | 8 commercial (30K – 300K tpa) 2 pilots one a 900 LB Batch process in construction (200 and 400 tpd); in planning (100 tpd demonstration); in design (500 tpd); potential (2000 tpd) |
| CHEMICAL/OTHER: | |
| Chemical | 2 pilots (capacity not specified) 200 ton/day in start-up and 230K tpa in final bidding stage |
| THERMAL: | |
| Gasification | 20 commercial (8K – 216K tpa) 4 demonstration (3K – 9K tpa) 12 pilot (0.45K – 7.2K tpa) ~10 plants in proposal to pre-construction phases (58tpd to 1500tpd) |

| Type | Plants |
|-----------|--|
| Pyrolysis | 3 commercial (1.5 t/hr – 100 tpa) 3 pilots (70 kg/hr – 50 tpd) A few plants may be in development stages (no specifics provided) |

Front-End Processing

The majority of Expressions of Interest (“EOIs”) proposed front-end processing (removal of metals, glass and in some cases plastic) to various degrees prior to processing. Front-end processing was described as a combination of visual inspections and physical processing through a mixed waste material recovery facility (Mixed-waste MRF). This type of separation was necessary to remove recyclables and material inappropriate for the remainder of the process.

Approximately thirteen (13) Respondents proposed technologies indicating that no front-end processing was necessary. Of these, five (5) were processes that recovered recyclables at the back-end of the system. The remaining eight (8) not requiring a front-end system were Advanced Thermal Gasification Technologies.

Estimated Diversion from Landfill Potential and Products

Diversion potentials in the EOIs ranged from 50 percent to 100 percent. Diversion potential within the biological processes also ranged from 50 percent to 90 percent. However, 90 percent diversion was only achieved where a back-end thermal process was proposed. Otherwise, the highest diversion potential was 75 percent.

Respondents proposing physical and chemical technologies generally did not provide diversion estimates and the two Respondents that did provide diversion estimates (85 percent and 90 percent) did not include information on existing plants to substantiate these claims.

Respondents proposing thermal technologies indicated diversion potentials from 70 percent up to 100 percent. In order to achieve the 100 percent diversion rate, however, it would be necessary to find markets for all by-product residuals remaining after thermal processing. The by-products requiring markets include but are not limited to, vitrified slag, ash residual and concentrated metals. Markets for these products were generally identified in vague terms without substantiating specific proven markets in the Toronto area. Without marketing of the residual materials, process residual is expected to be between 10 and 15 percent.

| Products | By-Products |
|---|--|
| Anaerobic Digestion | |
| recyclables, plastics, biogas, fuel ethanol, furfural, acetic acid, electricity, heat, soil amendments, digestate, SUBBOR peat, possibly co2, yeasts, Refuse Derived Fuel (RDF) | non-recyclables, non digested, non fermented bulky / inerts / minerals / geostabilat stabilized sludge cake, inerts and aggregates biomass fiber residue |

| Products | By-Products |
|--|---|
| Aerobic Composting | |
| Recyclables, stabilat (RDF), odour-stabilized surface mulch or compost/soil conditioner – depending on feedstock, compost | none mentioned |
| Physical | |
| Recyclables, wood chips, ground waste, biomass fuel or soil amendment, cellulose biomass | none mentioned |
| Chemical/Other | |
| fuel gas; methane gas, fuel oil, ethanol fuel, heat (generally used internally), soil amendment, building material – nexis universal panel, recyclables, possibly also CO ₂ , lignin biofuel for gasification | ash-cake residue, hard no-organic residue stream, ash from gasification of lignin |
| Gasification | |
| steam, recyclables (if integrated with up-front separation), electricity, ethanol fuel, syngas, steam, heat, RDF, fuel gas, chemicals, some metals, desalinated water, co ₂ , concrete substitute, granulated polyolefin, mineral, wood, plastic, ethanol, gypsum | ash, slag, char, vitrified ash, vitrified sludge, HCl, sodium bisulfite, sodium nitrite, sulphur, zinc hydroxide, encapsulated slag for construction materials, sand-like aggregate, industrial salts, distilled water, CO ₂ for greenhouses, metal shot , possible recovery of concentrated metals from boiler/filter ash |
| Pyrolysis | |
| Recyclables, energy (for on or off-site use), metals, syncoal | inert ash, chlorine jelly, char, aggregate residue |

Proposed Screening and Evaluation Criteria

The REOI document provided Respondents with the opportunity to comment on proposed screening and evaluation criteria that may be utilized at the RFQL or RFP stages of the project. We received feedback on our screening and evaluation criteria and other aspects of the industry that will be useful in scoping out an RFQL and RFP and that will assist Staff and the Citizen and Expert Advisory Group in the identification of further research required for effective identification and selection of a preferred technology(ies). A list of the major comments is provided in the table below:

| RFQL/RFP Screening Criteria Comments |
|--|
| <p>General</p> <ul style="list-style-type: none"> Set timelines for screening and evaluation criteria - "must-have" and "need-to-have" by specified time to allow vendors time to manage detailed data submissions by the many participating entities. |

| RFQL/RFP Screening Criteria Comments |
|---|
| <p>Limiting Scope of RFQL</p> <ul style="list-style-type: none">• The City should select 3 to 4 vendors to submit at the RFQL/RFP stages. Tenders are expensive to prepare. The more open the process the more likely the offers will be of lesser quality as the risk of winning is smaller;• An economic business case model should be developed for RFQL stage which proponents can use to determine whether proposed technology will meet City's minimum requirements; and,• Request financial information at the RFQL stage to reduce the list of prospective proponents to those capable of meeting financial requirements. |
| <p>Feedstock</p> <ul style="list-style-type: none">• Consider including sewage sludge in evaluation; and• Add "or other waste" to feedstock. |
| <p>Technology Evaluation</p> <ul style="list-style-type: none">• Proposed technologies should be capable of 100 percent recovery of materials; and should produce zero waste;• Evaluate proven nature of individual components;• Evaluation should be based on minimum price per tonne of Municipal Solid Waste (MSW) throughput, adjusted for the types of MSW accepted;• Add ranking on toxicity of products relative to feed; prevention versus the control of pollution; how extreme the operating conditions are; simplicity; 4R's hierarchy;• Consider extending the operating period of existing plants to greater than 1 yr. to allow as much time as possible for data collection; and,• Evaluation criteria generally exclude technologies that are not currently operating commercially in several communities and are not consistent with the intent of the request. Consideration should be given to the proven nature of each component and not the final package. |
| <p>Environmental Performance</p> <ul style="list-style-type: none">• Provide comprehensive list of regulations and approvals required;• Add list of Canadian environmental approvals to list of requirements;• Environmental performance should consider current conditions and potential improvements; and,• Include standards set for measuring lifecycle inventory. |
| <p>Public Acceptability</p> <ul style="list-style-type: none">• For public acceptability consider all benefits to City, including jobs; and,• Concerned about highly qualitative nature of public acceptability. The vendor has no ability to address this in the proposal. Public acceptability should be determined by City Council after all respondents have been fairly evaluated and recommendations made on the preferred vendor to achieve City's objectives. |

| RFQL/RFP Screening Criteria Comments |
|--|
| <p>Plant Scale</p> <ul style="list-style-type: none">• Limit of 200K tpa maximum too restrictive due to economies of scale;• Throughput figures should be approximate to allow variation in energy content which governs throughput;• Should be looking for pilot reference plants of greater than 1 tpd because the scale-up risk from 1 tpd is too great;• Must have a plant with minimum design of ~ 500 kg/hr or 10 tpd with an operating period of at least 2 years and demonstrating the ability to operate at up to 75 percent of design consistently; and,• Require a minimum feedstock of no less than 100K tpa and a maximum of no more than 400K tpa. |
| <p>Third Party Assessment</p> <ul style="list-style-type: none">• Consider waiving the requirement for the third party assessments if: 1) the technology provider has operating facilities that have demonstrated their ability to comply with each of the evaluation criteria, and 2) the operating facilities are monitored by government regulatory agencies;• Possible problems with requirement of third party verification and Freedom of Information and Privacy Protection Act. Typically highly confidential information. |
| <p>Financial Requirements Comments</p> <ul style="list-style-type: none">• Indicate whether all or 1 member of a consortium needs to satisfy the requirements - e.g. 1 incorporated in ON, 1 demonstrate financial strength, consortium demonstrate insurability;• Request that parent company be allowed to satisfy the financial and insurance requirements;• Add "Signing officer of each company...must sign RFQL...or provide a letter acknowledging participation in the submission;"• Project financing would be gained through equity and tax-free private revenue bonds backed by risk mitigation package which would include protection against technology under performance and market risks;• Waive requirement that company is incorporated in Ontario and instead stipulate that if must be incorporated in Ontario if awarded contract;• Limit degree of confidential information required for evaluation and execute confidentiality agreements for that which is;• Modify the bonding requirements according to ownership and operational approach. If City-owned, contract and therefore bonding requirements likely would be based on construction cost of plant and be of limited duration. If vendor owned, contract will likely be based on cost per tonne and be of longer duration. Therefore bonding requirements of 20 percent Letter of Credit or 40 percent Bond may be impractical;• Developers proposing design, build, own and operate projects will object to disclosure of capital and operating cost. |

With respect to the current screening and evaluation criteria, it was noted that approximately half of the vendors would not pass the initial criteria indicating the requirement for a plant to be running with 1 tonne per day for at least one full year using a feedstock of MSW.

Thermal Technologies Differing from Incineration

Respondents proposing thermal technologies were asked to differentiate their technologies from incineration. A summary of these comments is presented below.

| |
|--|
| <p>Differentiate from Incineration</p> |
| <p>Gasification Definition – US EPA</p> <p>Gasification system means an enclosed thermal device and associated gas cleaning system or systems that does not meet the definition of an incinerator or industrial furnace, and that: (1) Limits oxygen concentrations in the enclosed thermal device to prevent the full oxidization of thermally disassociated gaseous compounds; (2) utilizes a gas cleanup system or systems designed to remove contaminants from the partially oxidized gas that do not contribute to its fuel value; (3) slags inorganic feed materials at temperatures above 2000; deg. F; (4) produces a synthesis gas; and (5) is equipped with monitoring devices that ensure the quality of the synthesis gas produced by the gasification system.</p> |
| <p>Operating Temperatures</p> <ul style="list-style-type: none">• Gasification works at temperatures of 5000-8000^F with an exit temperature of 2300^F. An incinerator works with temperature in the 1600^F range. (Recovered Energy);• Gasification maximum process temperature of 2000^C compared to 1000^C for incineration (Interstate Waste – US EPA definition);• Pyrolysis operates at temperatures of 300-500^C higher than incineration and requires no fossil fuels for combustion (Plasma Environmental);• Temperature is 1,000 to 1,200^C or greater, up to 8,000^C; incineration is a maximum of 1,000 to 1,200^C (International Vapour);• Thermo reduction operates at lower temperature (1200^F versus 2000^F) (WestCorp);• Gasification reactor temperature of 600^C not 900^C (Ebara); |
| <p>Gas produced</p> <ul style="list-style-type: none">• Syngas is produced, which can be marketed for green energy or for the chemical industry;• Gas can be cleaned and used – distilled and refined to methanol/ethanol, hydrogen feedstock, or used in manner similar to natural gas (20-25 percent of heating value);• Gas resulting from incinerators must be cleaned and discharged to the environment;• Gasification/Pyrolysis Syngas is comprised of “CO and H2” OR “CO and H2 and CH4” OR “CO, H2, N2 and H2O”. Incineration gas is comprised of H2O and CO2 and particulates, oxides of chlorine, nitrogen, sulphur, and possibly traces of furans and dioxins;• Synthesis gas produced by process contains 20-40 percent H2, 20-35 percent CO and no oxygen; Incineration gases contain no H2, minimal levels of CO and about 10 percent O2. |

| |
|--|
| <p>Differentiate from Incineration</p> |
| <p>Oxygen and Air Requirements</p> <ul style="list-style-type: none">• Gasification/Pyrolysis operates in oxygen starved environment called pyrolysis or partial oxidation in reducing environment in which there is a deficiency of oxygen ordinarily required for complete combustion. Incineration operates in open system in presence of atmospheric gases. Gasification is a closed system without air;• 30 percent of stoichiometric (quantitative relationship between reactants and products in a chemical reaction) air requirements for gasification/pyrolysis and 140 percent to 200 percent for incineration;• quantity of oxygen used in process is approximately 50 percent of the stoichiometric requirement compared to 200 percent for incineration. |
| <p>Residuals</p> <ul style="list-style-type: none">• Gasification produces a low-volume vitrified slag, which passes leachability tests, is not considered hazardous and may be used in the construction industry. Incineration produces ash (25 percent and possible up to 50 percent), which must be treated as waste (generally hazardous) that requires landfilling at a secure site or has limited and controversial use in concrete. |
| <p>Clean-up and Environmental Controls</p> <ul style="list-style-type: none">• Since gasification/pyrolysis systems do not use excess air, there is less volume of emissions to treat; Incineration generally requires a large plant with expensive pollution control equipment due to higher volume of gases;• Gasification/Pyrolysis does not favor the production of dioxins: high temperature effectively destroys Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans (PCDD and PCDF OR Dioxins and Furans) compounds or precursors in the feed; lack of oxygen in reducing environment precludes formation of free chlorine from HCl, through limiting chlorination of dioxin precursors in syngas; use of rapid water quench at exit of gasifier serves to freeze the thermodynamic equilibrium of the gas, thereby negating the temperature conditions for the reformation of dioxins and furans; Higher energy recovery limited by limiting temperature envelope to keep away from dioxin formation zone;• Incinerators - Conditions favouring formation of dioxins present in incinerators: large amount of excess air, high dust loading, slow gas cooling in energy recovery boiler (850 to 400 °C) through dioxin synthesis zone (250 – 650 °C). Incinerators generate huge volumes of flue gas containing fully oxidized components requiring major investment in gas cleaning equipment;• Because of high temperatures in gasification systems all tars, furans, dioxins, char, PAHs are destroyed. |
| <p>Pre-Treatment of Waste</p> <ul style="list-style-type: none">• Sorting not required for gasification/pyrolysis and required for incineration;• Gasification/Pyrolysis may operate with any organic waste, while incineration has limitations – moisture can develop cold spots in incineration. |

Respondents, Categories, Sub-Categories and Proposed Capacities

| Sub No | Respondent | Primary Category | Sub-category* | Proposed Capacity ('000 tpa) |
|---|---|-------------------------------|--|------------------------------|
| Anaerobic Digestion/Fermentation | | | | |
| 4 | ArrowBio Canada Inc. | Physical / Biological | Anaerobic Digestion | 420 |
| 7 | C ₂ Envirosource Inc | Biological | Anaerobic Digestion and Fermentation | 4.5-75 |
| 14 | Eastern Power Limited | Biological | Anaerobic Digestion | 420 |
| 18 | GeneSyst International Inc. | Biological | Acid Hydrolysis, Fermentation and Distillation | 30-300 |
| 27 | ISKA GmbH | Physical / Biological | Percolation – Separation, Aerobic and Anaerobic Biological Degradation, Dewatering | 75 |
| 32 | Organic Waste Systems N.V. | Biological | Anaerobic Digestion | 200 |
| 37 | Sanderson Watts Associates Limited | Physical / Biological | Steam Autoclave and Anaerobic Digestion | 80 |
| 38 | Sanderson Watts Associates | Physical / Biological | Steam Autoclave and Anaerobic Digestion | 80 |
| Aerobic Composting | | | | |
| 12 | DMS Waste Management Inc. | Biological / Physical | Biothermal Drying / Semi-Composting | 200 |
| 44 | Ronald Mark Stratford – Antrim Industries Canada | Biological | In-vessel Aerobic Composting | 1.4 organics |
| 46 | Waste Options Atlantic LLC | Physical / Biological | In-vessel Aerobic Composting | 3-30 |
| Other | | | | |
| 22 | Green Shift Inc. | Biological | Biodegradable Bags and Ventillated Carts | Not applicable |
| Physical | | | | |
| 5 | Brian Brady and Associates Inc. | Physical | Delamination and Separation | 1.2-9.6 |
| 16 | Enviro-Services and Constructors Inc. d/b/a RRT Design and Construction | Physical | Pre-sorting - Automated and Manual | 433+ |
| 43 | Timberman Recycling Inc. | Physical | Grind and Screen | 300 |
| 47 | Waste Reduction Technologies Inc. | Physical / Thermal | Steam-assisted Pressure Pulverization | 54 |
| 50 | World Waste of America Inc. | Thermal but actually Physical | Steam Classification and Sorting | 135-542 |

| Sub No | Respondent | Primary Category | Sub-category* | Proposed Capacity ('000 tpa) |
|----------------|---|------------------------|--|------------------------------|
| Chemical/Other | | | | |
| 8 | Changing World Technologies Inc. | Thermochemical | Depolymerizing and Reforming | 66-330 |
| 13 | Dresden Developments PTY Ltd. | Physical / Chemical | Mechanical Treatment and Chemical Binding | 50 |
| 29 | Kenox Technology Corporation | Thermal / Biological | Wet Air Oxidation and Anaerobic Digestion | 30 |
| 30 | Masada Resource Group | Chemical | Acid Hydrolysis, Fermentation and Distillation | 275+ |
| Gasification | | | | |
| 3 | AmbientEco Group Ltd. | Thermal | Combustion / Gasification (close coupled) | 75-250 |
| 6 | Brightstar Environmental LLC | Thermal | Pyrolysis, Gasification / Steam Reforming | 136-272 |
| 9 | Cinergex Solutions Inc. / AESI | Thermal | Pyrolysis H2 Reforming and Catalytic Conversion | 68? |
| 10 | City Clean 2000 Inc. | Biological and Thermal | Aerobic Composting and Gasification | 420 |
| 11 | Compact Power Limited | Thermal | Pyrolysis, Gasification, Thermal Oxidation (close coupled) | 420-450 |
| 15 | Ebara Corporation, Tokyo, Branch Zurich | Thermal | 1. Gasification (close coupled) and Ash Melting; 2. Gasification | 100-400 |
| 17 | Enwave District Energy Ltd. | Thermal | Gasification | 100-350 |
| 19 | Global Energy Solutions | Thermal | Pyrolysis / Gasification and Vitrification | 6.5-163 |
| 20 | Global Environmental Technologies of Ontario Inc. | Thermal | Plasma Gasification and Vitrification | 542-814 |
| 21 | Global Warming Prevention Technologies Inc. | Thermal | Gasification (close coupled) | 85 |
| 23 | Greey CTS Inc. | Thermal | Pyrolysis / Gasification (close coupled) | 180 |
| 24 | Hi-Tech Enterprise #130791346 | Thermal | Plasma Arc Gasification | 325 |
| 26 | Interstate Waste Technologies Inc. | Thermal | Gasification with Ash Melting and Vitrification | 420 |
| 28 | JDI /Geoplasma LLC | Thermal | Plasma Gasification (close coupled) | 362 |
| 33 | Pearl Earth Sciences Inc. | Thermal | Plasma Gasification | 1.5-600 |
| 34 | Plasma Environmental Technologies Inc. in partnership with Kinetrics Inc. | Thermal | Plasma Gasification - Pyrolysis | 30 + |

| Sub No | Respondent | Primary Category | Sub-category* | Proposed Capacity ('000 tpa) |
|-----------|---|-------------------------------|---|--|
| 35 | PyroGenesis Inc. | Thermal | Gasification and Vitrification | 50 tpd demonstration, 400 |
| 36 | Recovered Energy Inc. | Thermal | Plasma Gasification and Vitrification | 542-814 |
| 39 | Scientific Utilization Inc. | Thermal | Gasification | 408 |
| 40 | SenreQ International Limited | Thermal | Gasification | Multiples of 8.1 |
| 41 | Solena Group Inc. | Thermal | Plasma Gasification and Vitrification | 200 – 400 |
| 42 | Synxx Energy Solutions Inc. | Physical / Thermal / Chemical | Gasification and Encapsulation | Range of scales: small to 416 |
| 49 | Westinghouse Plasma Corporation | Thermal | Plasma Gasification and vitrification | Not provided |
| 51 | Woodland Chemical Systems Inc. | Thermal | Gasification and Chemical refining (distillation) | 28-36 |
| Pyrolysis | | | | |
| 1 | 1329958 Ontario Inc. | Thermal | Flash Pyrolysis / Thermal Cracking | 50-400 |
| 2 | West Corp - 723230 Ontario Inc. | Thermal | Thermal Reduction / Pyrolysis | Not provided |
| 25 | International Vapour Power Corp. | Thermal | Plasma Pyrolysis | Not provided |
| 31 | Mechanical Waste Conversion Corporation | Thermal | Pyrolysis | 217 |
| 45 | Wastegen UK Ltd. | Thermal | Pyrolysis (close coupled) | 450; suggest plants of 250K tpa with recyclables + rejects |

NOTES:

* Where term "close coupled" is bracketed, this is the preliminary interpretation of City staff and will be confirmed

Sub No = submission number (refer to Appendix B)

Where Respondents indicated proposed tonnages in tonnes per day, numbers were multiplied by 300 (25 working days per month by 12 months) to determine annual tonnages

“tpa” – tonnes per annum