

Evaluation of New and Emerging Solid Waste Management Technologies

Prepared for:

**New York City Economic Development Corporation
and
New York City Department of Sanitation**

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1.0 INTRODUCTION

This report presents the results of an evaluation of new and emerging waste management and recycling technologies and approaches (Evaluation). The objective of this Evaluation is to provide information to assist the City of New York (City or NYC) in its ongoing planning efforts regarding the consideration of innovative technologies as part of its waste management system. This report identifies which innovative technologies are available now, i.e., commercially operational processing municipal solid waste (MSW), which are soon-to-be commercially in use for MSW, and which are promising, but in an earlier stage of development. It also compares these technologies to conventional waste-to-energy technology to identify the potential advantages and disadvantages that may exist in pursuing innovative technologies. Conventional waste-to-energy technology was chosen as a point of comparison since such technology is the most widely used technology available today for reducing the quantity of post-recycled waste being landfilled.

For the purposes of the Evaluation, "new and emerging technologies" are defined as technologies (e.g., biological, chemical, mechanical and thermal processes) that are not currently in widespread commercial use in the United States, or that have only recently become commercially operational. Technologies that are commercially operational in other countries, but only recently or not at all in the United States, are defined as "new and emerging" with respect to use in the United States. Proven, commercial solid waste management processes and technologies with widespread use in the United States, such as conventional waste-to-energy, landfilling, and stand-alone material recovery facilities (MRFs), were not considered for this Evaluation. Also, as the New York City Department of Sanitation (DSNY) has already conducted a separate, thorough evaluation of aerobic MSW composting/co-composting, these technologies were not considered in the Evaluation. MRFs and refuse derived fuel (RDF) processes that are required as a prerequisite to new and emerging technologies (e.g., to prepare incoming MSW as feedstock for gasification, anaerobic digestion, waste-to-ethanol systems, etc.) were considered in the Evaluation. Stand-alone RDF technologies were considered, upon demonstration that the RDF technology includes innovative features that offer substantial improvements and advantages over conventional RDF technology. Conventional RDF technology is considered to be a process that mechanically separates out metals and inert, (noncombustible) materials from MSW (e.g., through screening and magnetic separation), and shreds the screened MSW to produce a more homogenous fuel.

The Evaluation started with a wide search to maximize the identification of new and emerging technologies. The search included a review of unsolicited proposals received by the City in the recent past, along with independent research to expand the list of innovative technologies and project sponsors. To further widen the search, a Request for Information (RFI) was issued to gather consistent information from companies offering new and emerging waste management and recycling technologies. The search resulted in the identification of forty-three (43) technologies. Using a methodology developed specifically for the City, these 43 technologies were evaluated through three levels of increasing scrutiny to focus efforts on the most promising technologies.

The results of the Evaluation are presented in the following sections of this report:

- Section 1: Introduction
- Section 2: Search for New and Emerging Technologies
- Section 3: Evaluation Methodology and Criteria
- Section 4: Selection of Technologies to be Evaluated (First-level Screening)
- Section 5: Preliminary Review of Technologies (Second-level Screening)
- Section 6: Comparative, Detailed Evaluation of Technologies
- Section 7: Compilation of Comparative Evaluations
- Section 8: Summary of Findings.

2.0 SEARCH FOR NEW AND EMERGING TECHNOLOGIES

2.1 SUMMARY OF SEARCH PROCESS

The search for new and emerging solid waste management technologies began with a review of the unsolicited proposals received by the City in the recent past. These technologies and the sponsoring companies formed an initial listing of twenty-five (25) new and emerging technologies. This initial list of technologies and companies is provided in Appendix A.

The initial list was expanded following independent research to identify other new and emerging technologies. This research effort consisted of gathering and reviewing information from numerous sources, including: federal, state and local government agencies; professional organizations; cities that have conducted similar evaluations; sources known to be in the forefront of municipal solid waste processing research; internet websites, and other sources. From this independent research, eleven (11) additional companies were identified that offer innovative waste management technologies, for which information had not been recently submitted to the City. These were companies that are well known in the industry, have been recognized in other recent studies, and/or were likely to be able to provide sufficient information to support an initial review of their technology. This supplemental list of technologies and companies is provided in Appendix B.

To further widen the search, a Request for Information (RFI) was prepared. The RFI was designed to gather consistent information from companies offering new and emerging solid waste management technologies. The RFI sought process, performance and product information regarding the new technologies and approaches, along with basic financial data from the companies offering the technologies (i.e., the project sponsors).

The RFI was released by the New York City Economic Development Corporation (NYCEDC) and DSNY on April 21, 2004. The RFI was distributed to the thirty-six (36) companies listed in Appendices A and B. In addition, the RFI was advertised in three publications: Engineering News Record, Waste News, and SWANA E-News (the electronic newsletter of the Solid Waste Association of North America). The RFI was also made available on the NYCEDC and DSNY websites. Based on advertising efforts, sixty-four (64) inquiries were made to a dedicated website set-up for RFI distribution. A listing of the inquiries is provided in Appendix C. A copy of the RFI is provided in Appendix D.

Thirty-four (34) responses to the RFI were received on May 24, 2004. Sixteen (16) of these responses were submitted by companies that had previously submitted information to the City. Six (6) responses were submitted by companies identified through the independent research efforts. Twelve (12) responses were submitted by other companies, as a result of the advertising effort. The quality of the responses varied widely, from short letters issued by project sponsors to detailed responses prepared in conformance with the RFI. Nine (9) companies that had contacted the City in the past year did not submit additional information in response to the RFI, but were included in the Evaluation.

Table 2-1 provides the resulting list of 43 sponsoring companies, categorized by type of technology, that were considered in the Evaluation. The technologies listed in Table 2-1

Table 2-1. Companies Responding to the RFI and/or Submitting Prior Information to the City

Thermal	Digestion	Hydrolysis
BRI Energy Dynecology EBARA Ecosystem Projects Eco Waste Solutions ² Emerald Power/Isabella City Entropic Technologies Corporation ² GEM America Global Energy Solutions Global Environmental Technologies GSB Technologies ² ILS Partners/Pyromex Interstate Waste Technologies Jov Theodore Somesfalean KAME/DePlano ¹ Pan American Resources Peat International/Menlo Int. Rigel Resource Recovery Solena Group ² Startech Environmental Taylor Recycling Facility Thermogenics Zeros Technology Holding ²	<u>Anaerobic:</u> Arrow Ecology and Engineering Canada Composting KAME/DePlano ¹ New Bio Orgaworld Organic Waste Systems VAGRON ² Waste Recovery Systems	Arkenol Fuels Biofine ² Masada Oxynol
		Chemical Processing
		Changing World Technologies
		Mechanical Processing for Fiber Recovery
		Comprehensive Resources WET Systems
		Other
		Freight Pipeline Company (Biomass Densification/RDF)
		Hewitt Communications (Recycling) Pratt Industries/VISY Paper ² (RDF)
		Renewable Energy & Resources (Consulting Proposal)
		Waste and Energy Enterprise Amsterdam (Waste-to-Energy)

(1) KAME/DePlano provides both thermal and digestion processes, and is listed in both categories.

(2) Unsolicited proposal only, no vendor response to formal Request for Information (RFI) received.

include the thirty-four (34) companies that responded to the RFI and the nine (9) companies that previously provided information. Note that KAME/DePlano is listed in two categories (thermal and digestion), resulting in 44 listings.

2.2 DESCRIPTION OF TECHNOLOGY CATEGORIES

The technologies listed in Table 2-1 can be categorized into six broad categories: thermal, digestion, hydrolysis, chemical processing, mechanical processing for fiber recovery, and other. Summary descriptions of these technology categories follow.

2.2.1 Thermal

Thermal technologies encompass a variety of processes that use or produce a significant quantity of heat during the course of treatment. Common descriptors for thermal technologies include gasification, pyrolysis, cracking and plasma. These technologies are similar, in that exothermic or endothermic chemical reactions occur during the processes that change the composition of the organic fraction of the MSW. In general, thermal processes take place in a high-temperature reaction vessel. Air or oxygen may or may not be added to the reactor to influence the composition of the resulting products. The inorganic fraction of MSW may be sorted out prior to treatment or may be treated along with the organic fraction.

Types of products resulting from the processing of the organic fraction of MSW are syngas (i.e., synthesis gas composed of hydrogen gases, carbon monoxide and carbon dioxide), char (a carbon-based solid residue), and organic liquids (e.g., light hydrocarbons). These products represent unoxidized or incompletely oxidized compounds, which in most cases differentiate the innovative thermal technologies from more complete combustion implemented in traditional waste-to-energy projects. If the inorganic fraction of MSW is also processed, additional byproducts such as vitrified silica and mixed metals are produced.

The syngas produced by these thermal processes may be combusted as fuels in efficient, traditional combustors (boilers, reciprocating engines and combustion turbines) to produce energy. Some technologies pre-clean the syngas prior to combustion to remove sulfur compounds, chlorides, heavy metals and other impurities. Syngas cleanup is achieved using standard, commercially available technology. Instead of combustion for energy/electricity production, the synthesis gas may be chemically processed to produce other chemicals, such as methanol. In cases where organic liquids are produced, these may also be used as fuels or as chemical feedstocks for currently unspecified commodity or specialty chemicals.

2.2.2 Digestion (Anaerobic and Aerobic)

Digestion is the reduction of solid organic waste materials through decomposition by microbes, accompanied by the evolution of liquids and gases. The biological process of digestion may be aerobic or anaerobic, depending on whether air (containing oxygen) is introduced into the process.

Anaerobic digestion is a biological process by which microorganisms digest organic material in the absence of oxygen, producing a solid byproduct (digestate) and a gas (biogas). Anaerobic digestion has been used extensively to stabilize sewage sludge, and has been adapted more recently to process the organic fraction of MSW. The biogas produced from anaerobic digestion is primarily methane and carbon dioxide. Biogas is commonly burned in an internal combustion engine to generate electricity. Biogas also has other potential end uses. For example, biogas can be scrubbed of carbon dioxide, hydrogen sulfide and water to obtain usable methane, which can be compressed and used as an alternative fuel in light- and heavy-duty vehicles. Digested material may be used as a soil conditioner, or compost, after a period of aerobic stabilization.

The anaerobic digestion process may be either “wet” or “dry”, depending on the percent solids in the reactor. The process temperature may also be controlled in order to promote the growth of a specific population of microorganisms. Mesophilic anaerobic digestion occurs at temperatures of approximately 35°C (95°F). Thermophilic anaerobic digestion occurs at temperatures of approximately 55°C (131°F).

The wet anaerobic digestion process starts with the organic fraction of MSW, which is mixed with water and pulped. The pulp is fed into a reactor vessel, where optimal heat and moisture conditions are promoted to enhance microbial development and decomposition. The process may be conducted in a single stage or two-stage reactor vessel.

Some of the technologies use a dry anaerobic digestion process, in which no added water is utilized. For dry anaerobic digestion, the incoming shredded organic solid waste is “inoculated” with previously digested material prior to introduction into the reactor vessel. Material in the digester has a retention time of 15 to 17 days, and moves through the digester in a plug flow manner.

In the *aerobic digestion* process, the organic fraction of MSW is metabolized by microorganisms in the presence of oxygen. During the process, temperature and pH increase, carbon dioxide and water are liberated (reducing the mass of material), and pathogens are destroyed. The digested material may be used as a soil amendment or fertilizer (i.e., compost). Unlike anaerobic digestion, no methane gas is produced in the aerobic digestion process.

The aerobic digestion process may be either “wet” or “dry”. Dry aerobic digestion is similar to in-vessel aerobic composting where MSW is put through an enclosed, intensive aerobic digestion phase, screened to remove non-organic material, and then further stabilized in aerated piles. Because DSNY has already conducted a separate, thorough evaluation of aerobic MSW composting, this technology was not considered in the Evaluation. Wet aerobic digestion is considered “new and emerging” and was included in the Evaluation. The wet aerobic digestion process consists of the following steps: pulping the organic fraction of MSW; mixing, heating, aeration and inoculation with microbes; and separating the material into solid and liquid fertilizer products.

2.2.3 Hydrolysis

Hydrolysis is generally a chemical reaction in which water reacts with another substance to form two or more new substances. Specifically with relation to MSW, hydrolysis refers to an acid-catalyzed reaction of the cellulose fraction of the waste (e.g., paper, food waste, yard waste) with water to produce sugars. In most cases, hydrolysis is the first step in a multi-step technology. For example, the additional process steps of fermentation and distillation are proposed by several vendors for conversion of the sugars to ethanol. In one instance, conversion of the sugars derived by hydrolysis to levulinic acid, rather than ethanol, is proposed. Levulinic acid has been identified as a commonly-used chemical feedstock for other chemicals with emerging markets such as tetrahydrofuran (THF), diphenolic acid (DPA) and succinic acid.

Separation of the MSW must take place to first obtain the organic fraction, excluding glass, metal and other inorganic materials. The organic material is shredded and introduced into a reactor vessel where the acid catalyst is added. Complex organic molecules are reduced to simple sugars. Since the acid merely catalyzes the reaction and is not consumed in the process, it is extracted and recycled in the process.

2.2.4 Chemical Processing

Chemical processing generically refers to technologies that utilize one or a combination of various chemical means to convert MSW into usable products. This is a very general process term that can encompass many other more specific processes such as digestion, hydrolysis, gasification and pyrolysis. For purpose of this study, one technology has been categorized as "Chemical Processing", and that technology is based on the chemical process of depolymerization and associated refining processes.

Depolymerization is the permanent breakdown of large molecular compounds into smaller, relatively simple compounds and appears to be "thermal" in nature. However, a number of complex and interrelated processing steps, some similar to petroleum refining, are involved, rather than a single reaction step. In simplified terms, the process is an advanced thermal reforming process that utilizes water as a solvent, converting the organic fraction of MSW into energy products (steam and electricity), oil and specialty chemicals. Following any necessary up-front sorting, the major steps of the depolymerization process are: (1) pulping and slurring the MSW with water; (2) heating the slurried MSW under pressure; (3) quickly lowering, or "flashing" the slurry pressure to release and recover gaseous products (which can be converted to light hydrocarbons or used to generate electricity); (4) reheating the slurry to drive off water and light oils from the solids; and (5) separating the light oils from the water. Further processing of the oils (e.g., distillation, solvent extraction, cracking) can be used to produce higher-value oils. The process also generates carbon solids, which could be activated and used as a filter medium or used as a soil amendment.

2.2.5 Mechanical Processing for Fiber Recovery

Two technologies are categorized as "Mechanical Processing for Fiber Recovery". As the name implies, these technologies mechanically process MSW to recover fiber for use in

paper making. The technology category includes innovative RDF technologies that produce a clean source of secondary fiber.

In general, mechanical processing for fiber recovery starts with steam conditioning of the MSW in an autoclave, followed by mechanical screening to recover recyclables and separate the organic (or biomass) fraction from the inorganic fraction. This up-front processing is innovative compared to conventional RDF, which typically shreds the incoming MSW and uses magnetic separation to recover ferrous metal. The biomass fraction is then pulped with water, to recover long-fiber pulp for paper making, and the sludge generated in the process is anaerobically digested. This fiber recovery process is innovative for MSW. The organic fraction that is not recoverable as a paper pulp substitute is combusted as a conventional RDF.

2.2.6 Other Technologies

Technologies and the sponsoring companies that do not fall into any of the categories described above are placed in the generic category “Other”.

3.0 EVALUATION METHODOLOGY AND CRITERIA

3.1 DEVELOPMENT OF EVALUATION METHODOLOGY

The objective of the Evaluation was to identify, describe and categorize new and emerging technologies based on type of technology, commercial status, and potential applicability to New York City. In developing the Evaluation approach, current and projected City waste management needs and practices were reviewed and considered. Also, potential changes and trends in waste generation and composition as well as environmental, transportation, land-use, and tax laws and regulations were identified and evaluated to determine if such trends may impact new and emerging technologies. In addition, approaches and criteria used by the following cities and public jurisdictions with similar objectives regarding new and emerging technologies were researched and evaluated:

- Toronto, Canada;
- Collier County, Florida;
- Commonwealth of Puerto Rico;
- Santa Barbara County, California; and,
- Seattle, Washington.

This background information, used to develop the Evaluation methodology, is provided in Appendix E.

3.2 EVALUATION METHODOLOGY AND CRITERIA

Based on the study objectives and the background information, a three-step evaluation methodology was developed as follows:

- Step 1: Selection of Technologies to be Evaluated (First-level Screening)
- Step 2: Preliminary Review of Technologies (Second-level Screening)
- Step 3: Comparative, Detailed Evaluation of Technologies

This three-step review process is summarized below.

3.2.1 Step 1: Selection of Technologies to be Evaluated (First-level Screening)

Step 1 of the Evaluation methodology consisted of screening each of the 43 new technologies and approaches identified through the initial search (described in Section 2). This first-level screening sought to answer two questions about each technology:

- Does the technology meet the working definition of "new and emerging" developed for the purpose of this Evaluation?
- Did the sponsor provide sufficient information to evaluate the technology further?

If the answer to these two questions was affirmative, the technology was selected for further review in the Step 2 of the Evaluation. The first-level screening criteria and results are presented in Section 4.

3.2.2 Step 2: Preliminary Review of Technologies (Second-level Screening)

Step 2 of the Evaluation process consisted of a preliminary review of the technologies selected in Step 1. The information provided for each technology was compared to a set of six, second-level screening criteria. These criteria established the minimum requirements the technology had to meet to go on for further, comparative evaluation.

The following six screening criteria were applied:

- **Readiness.** The technology must be at a stage of development to be able to be commercially operational within 10 years.
- **Size.** The technology must be capable of accepting and processing at least 50,000 tons per year (tpy) of waste. This throughput capacity is equivalent to 137 tons per day (tpd), based on 365 days per year.
- **Reliability.** The technology must have operated successfully, processing MSW at a pilot (demonstration) or commercial facility.
- **Environmental Performance.** The technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.
- **Beneficial Use of Waste.** The technology must produce a useful and marketable product (e.g., energy and/or other commercial or potentially commercial products).
- **Residual Waste.** The technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming MSW.

These criteria and the results of the second-level screening are described in Section 5.

3.2.3 Step 3: Detailed, Comparative Evaluation Of Technologies

Those technologies that met the requirements of the second-level screening criteria were further evaluated in Step 3. The third step of the Evaluation process consisted of comparing the relative advantages and disadvantages of the technologies against the final, more detailed evaluation criteria.

The criteria were not weighted with a level of importance nor were the technologies ranked, numerically or otherwise. Rather, the comparative evaluation criteria established a basis for recognizing the strengths and weaknesses of the technologies. These criteria were not meant to exclude any technology, but to evaluate its potential advantages for application in New York City.

The following comparative criteria were applied in Step 3 of the Evaluation:

- **Readiness and Reliability.** Technologies were categorized by status of development to distinguish those that are commercially processing MSW (in the United States or in other countries) from those that are currently in the development stage for MSW.
- **Facility Size and Design Flexibility.** Technologies were categorized by facility size and design flexibility to distinguish those that are accommodating of various waste types and a wide range of throughput capacities from those that have waste composition and/or capacity limitations.
- **Utilization of Existing City Solid Waste Collection System.** Technologies that would require separate collection of source-separated components of MSW (i.e., a new collection system), were distinguished from those that are compatible with the existing collection system.
- **Utility Needs.** Utility needs (e.g., electric, natural gas, fuel oil, water, sewer) were noted and compared.
- **Beneficial Use of Waste.** The extent of beneficial use of waste that may be achieved was noted and compared, including consideration of the strength and volatility of the markets for the products generated.
- **Marketability of Products.** The value of the products, the strength and volatility of existing markets, and the need for market development were considered.
- **Quantity/Quality of Residuals Requiring Landfilling.** The quantity and quality of residue that would be generated was noted and compared.
- **Environmental Impacts.** Environmental impacts were considered, including potential for impacts associated with emissions, noise, odor, traffic and aesthetic concerns.
- **Facility Siting.** The acreage required for development of a facility was noted, along with any technology-specific siting requirements.
- **Public Acceptability.** Factors affecting public acceptability were noted and compared.
- **Estimated Cost.** Cost information was noted and compared, including estimated design and construction cost, annual operation and maintenance cost, and projected tip fee.

- **Opportunities for Economic Growth.** The potential of the technology to provide direct economic benefit and collateral economic growth was considered.
- **Experience and Resources of Project Sponsor.** The experience, capability and resources of the project sponsor (i.e., the company offering the technology) to develop, site, permit, finance, design, build, and operate a project, including the resources to market the product produced, were noted and compared.
- **Willingness to Develop Publicly or Privately Owned Facility.** The willingness of the project sponsor to develop and provide service for operating either a publicly owned or privately owned facility was noted and compared.
- **Risk Profile.** The risk profile for the technologies and the project sponsors was noted and compared.

These Step 3 criteria and the results of the comparative evaluation for individual technologies are described in Section 6.

To place the results of the comparative evaluation into context, conventional waste-to-energy technology was also evaluated using the Step 3 criteria so that any advantages or disadvantages of new and emerging technologies could be compared to this conventional technology. Waste-to-energy was chosen as a point of comparison since it is the most widely used technology available today for reducing the quantity of post-recycled waste being landfilled. Also, project sponsors often describe the advantages of new and emerging technologies in comparison to conventional waste-to-energy systems. The summary results of the comparative evaluation and a comparison with conventional waste-to-energy are presented in Section 7.

4.0 SELECTION OF TECHNOLOGIES TO BE EVALUATED (FIRST-LEVEL SCREENING)

4.1 FIRST-LEVEL SCREENING CRITERIA

Step 1 of the Evaluation was a first-level screening of the 43 technologies and approaches identified through the initial search (described in Section 2), to select those technologies that would be further evaluated. This first-level screening was limited to the following two criteria:

- The technology must meet the working definition of "new and emerging" developed for the purpose of this Evaluation.
- The sponsor must have provided sufficient information to provide for an evaluation of the technology.

For the purposes of the Evaluation, "new and emerging technologies" were defined as technologies that are not currently in widespread commercial use in the United States, or that have only recently become commercially operational. Technologies that are commercially operational in other countries, but only recently or not at all in the United States, were defined as "new and emerging" with respect to use in the United States. Proven, commercial solid waste management processes and technologies with widespread use in the United States, such as conventional waste-to-energy, landfilling, and stand-alone material recovery facilities (MRFs), were not considered for this Evaluation. Also, as the DSNY has already conducted a separate, thorough evaluation of aerobic MSW composting/co-composting, these technologies were not considered in the Evaluation. MRFs and refuse derived fuel (RDF) processes that are required as a prerequisite to new and emerging technologies (e.g., to prepare incoming MSW as feedstock for gasification, anaerobic digestion, waste-to-ethanol systems, etc.) were considered in the Evaluation. Stand-alone RDF technologies were considered, upon demonstration that the RDF technology includes innovative features that offer substantial improvements and advantages over conventional RDF technology. Conventional RDF technology is considered to be a process that mechanically separates out metals and inert (noncombustible) materials from MSW (e.g., through screening and magnetic separation) and shreds the screened MSW to produce a more homogeneous fuel.

The extent of information submitted by project sponsors for review varied widely, from short letters of introduction to detailed, technical responses to the RFI. In some instances, the information provided was insufficient to support a review of the technology beyond first-level screening.

4.2 RESULTS OF FIRST-LEVEL SCREENING

Table 2-1 (provided in Section 2.1) lists the 43 technologies and their sponsoring companies that were identified through the initial search process. Of the 43 technologies originally identified, ten (10) technologies did not meet the first-level screening criteria and were not reviewed beyond Step 1 of the Evaluation process. Table 4-1 lists these ten

**Table 4-1. Technologies not Meeting
First-Level Screening Criteria**

Technologies that are Inconsistent with the Study Definition of "New and Emerging"	Technologies with Insufficient Information Provided for Review
<p><u>Aerobic Digestion</u></p> <p>Real Earth Technologies</p> <p><u>Mechanical Processing</u></p> <p>WET Systems, Inc.</p> <p><u>Other</u></p> <p>Freight Pipeline Company (Biomass Densification/RDF)</p> <p>Hewitt Communications (Recycling)</p> <p>Pratt Industries/VISY Paper (RDF)</p> <p>Renewable Energy & Resources (Consulting Proposal)</p> <p>Waste and Energy Enterprise Amsterdam (Waste-to-Energy)</p>	<p><u>Anaerobic Digestion</u></p> <p>Vagron (Citec International)</p> <p><u>Thermal</u></p> <p>GSB Technologies</p> <p>Solena Group</p>

technologies, identified by sponsoring company and categorized by which first-level criterion was not met.

As listed in Table 4-1, seven technologies were not reviewed beyond first-level screening because they are not considered new and emerging technologies, as defined for the purpose of this study. Three technologies were not reviewed beyond first-level screening because the most recent information available for the technology, as reported by the technology sponsor, was not sufficient to support a detailed evaluation.

The ten technologies that were not reviewed beyond Step 1 of the evaluation process are briefly described below, presented in alphabetical order:

- Freight Pipeline Company.** Freight Pipeline Company proposed a form of RDF technology consisting of mechanical densification of biomass (wood and paper waste), with sale of the biomass logs to power plants as a substitution for coal. The technology is proposed for use at existing transfer stations, where the wood waste and paper waste would be recovered for densification. The remainder, and majority, of the MSW would still require disposal. The information provided in response to the

RFI is limited, and insufficient to support determinations regarding readiness, size and other criteria established for the Evaluation. The proposed densification technology has been researched under sponsorship by the U.S. Department of Energy, including compaction studies and test burn of biomass logs, but not operated to any extent. Further, while the densification process could potentially represent an improvement over conventional RDF technology, such potential has not been substantiated. Therefore, the proposed process, while potentially providing certain advantages for MSW processing, is not considered new and emerging for purpose of this study.

- **GSB Technologies.** GSB Technologies, based in the United States, offers a thermal plasma technology known as Advanced Pyro-Electric Thermal Conversion. Based on an information letter submitted to the City in December 2003, GSB claims that the technology disassociates, rather than incinerates MSW. Reportedly, the technology can effectively manage MSW while producing electricity and steam at lower costs, and reducing air pollutants compared to conventional waste-to-energy. According to information found through internet research, GSB Technologies is currently developing a project in Pakistan. Since GSB Technologies did not respond to the RFI and previously provided only a letter of introduction (with no technical details), insufficient information was available to conduct a detailed review of their plasma thermal technology as part of this study.
- **Hewitt Communications.** Hewitt Communications has offered a theoretical approach to manage the City's waste, which it calls "Urban Gold". The focus of the approach is to process all of the waste in a MRF, where recyclables would be sorted and removed from the waste (i.e., a "dirty" MRF). Non-recyclable materials would then be composted or thermally processed by pyrolysis or gasification. The approach is based on development of an eco-industrial park, which would include manufacturers that would use the recovered recyclables as feedstock. Benefits of the approach, while not substantiated, include claims of avoided costs, avoided pollution and economic development. While the concept of an eco-industrial park is an attractive aspect of the approach offered by Hewitt Communications, and while the approach may have other merits for consideration by the City (perhaps increased recycling), it was not reviewed beyond Step 1 as the information submitted was limited to a high-level conceptual outline, with no technology-specific technical or financial data available for further evaluation.
- **Pratt Industries/VISY Paper.** Pratt Industries/VISY Paper did not respond to the RFI, but previously submitted information to the City. The proposal integrates a new waste processing facility with their existing recycled paper mill on Staten Island, which could improve the economics of transport of recycled paper. The proposal is based on use of the commercially-available Herhof Stabilat technology. Waste paper would be separately collected and delivered to the existing VISY Paper mill for direct processing. MSW (including recyclables other than paper) would be collected and delivered to a new, 370,000 tpy (1,014 tpd) recycling and recovery facility to be integrated with the mill. The waste would be dried, digested, and sorted. Up to 18% of the MSW would be recovered and recycled (aluminum, ferrous, minerals, fines, glass, batteries). The remaining MSW (including paper and plastics) would be

combusted onsite as a fuel to generate steam and electricity for the recycled paper operation. Water recovered from the recycling process would also be collected and used for process needs. Based on information available for review, the Herhof waste processing technology is representative of conventional RDF, in that it recovers MSW components already recycled by established processes (e.g., glass and metals) and uses the majority of the MSW as a fuel (i.e., RDF). The technology is not considered new and emerging for purpose of this study.

- **Real Earth Technologies.** Real Earth Technologies submitted an unsolicited letter and product marketing literature to the City. A copy of the RFI was sent to Real Earth Technologies; however, they did not submit a response. Supplemental information was found on the company website, but information available for review was limited. The technology proposed by Real Earth Technologies is categorized by the company as aerobic digestion. The incoming MSW is sorted, and the glass, metals, and plastics are removed from the incoming waste. The remaining material is aerobically digested in a process system that moves the waste via a series of conveyor-belts and grinders, through a series of passes, mixing and aerating the material as it moves through each pass. The resulting product is used as a soil amendment. The technology was reportedly operated on a pilot scale in the early 1980's, but the extent of testing is not known. Also, it is not clear if the technology has operated or been tested since that time. Based on the limited amount of information available for review from the project sponsor, the technology appears to be representative of conventional MSW composting and is not considered to be new and emerging for purpose of this study.
- **Renewable Energy & Resource Recovery Systems.** Renewable Energy & Resource Recovery Systems has submitted a consulting proposal to develop a solid waste plan for the City, and to lead a team to build and operate numerous biomass recovery and utilization facilities. The technology to be used was not specified. The proposal consists of a three-part study to investigate the technical, economic and environmental feasibility of developing such facilities. Although Renewable Energy & Resource Recovery Systems offers a conceptual plan that may have merit for the City, the information submitted is limited to a conceptual approach for a proposed study and is not technology specific. In this regard, the proposal does not represent a new and emerging technology for purpose of this study.
- **Solena Group.** Solena Group is the sponsor of a patented plasma technology called Plasma Gasification Vitrification. Based on information provided by the Solena Group on their website, their technology is a thermal depolymerization/gasification process that dissociates organic matter and vitrifies inorganic matter. The technology produces synthesis gas containing carbon monoxide and hydrogen gases (syngas), which is combusted in a gas turbine to generate electricity. A byproduct of the process is an inert glassy slag, resulting from vitrification (“fusing”) of the inorganic material. The slag is potentially suitable for use as a construction aggregate. The Solena Group has operated a pilot facility in North Carolina and has reportedly performed testing on various feedstock, including MSW. Solena Group previously contacted the City, but no technical information was provided for review. Also, Solena Group did not respond to the RFI. Therefore, insufficient information

was available to conduct a detailed review of Solena Group's plasma technology as part of this study.

- **VAGRON.** Citec International, based in Vaasa, Finland, is the provider of a wet, single-step anaerobic digestion system. The process involves slurring the organic waste with a large amount of water, and feeding that waste into the digester. This process is in commercial operation in Vagron, the Netherlands. Representatives of the VAGRON digestion system previously contacted the City, but no technical information was provided for review. Also, no response was provided to the RFI. Therefore, insufficient information was available to conduct a detailed review of the VAGRON anaerobic digestion system as part of this study.
- **Waste and Energy Enterprise Amsterdam.** Waste and Energy Enterprise Amsterdam submitted information in response to the RFI. The company offers conventional waste-to-energy, although, their technology is patented and potentially produces a greater amount of energy than the waste-to-energy facilities currently operating in the U.S. Based on information available from the project sponsor, an existing, operational facility in Amsterdam has a net efficiency and plant availability reflective of improved combustion performance. However, the technology is representative of conventional waste-to-energy and does not represent a new and emerging technology for purpose of this study.
- **WET Systems, Inc.** WET Systems, Inc., in partnership with WSI Management, LLC and represented by Prestige Consulting, proposed an RDF process with potentially innovative aspects. The process includes: sterilization and mechanical processing of waste using the patented waste elutriation technology (WET); separation of recyclables from cellulose materials (dryer, trommel, magnetic separation, eddy current separator), with sale of recyclables to secondary markets (glass, plastic, aluminum, steel); and manufacture of fuel cubes from the cellulose material. Discussion is given to the potential for fiber recovery, which is innovative, but fiber recovery appears to not be part of the current design concept. Without fiber recovery, the process offers little innovation beyond existing RDF technologies. The elutriator process vessel may provide improved recovery of recyclables and manufacture of a better waste fuel than existing RDF processes, but performance has not been demonstrated. A prototype facility was constructed in Louisiana in 1990, but operated for only a limited time. Because this technology is representative of conventional RDF, it was not considered to be a new and emerging technology for purpose of this study.

Table 4-2 lists the 33 technologies that met the first-level screening criteria and moved on to Step 2 of the Evaluation.

Table 4-2. New and Emerging Technologies Identified for Second-Level Review

Thermal	Digestion	Hydrolysis
BRI Energy Dynecology EBARA Ecosystem Projects Eco Waste Solutions ² Emerald Power/Isabella City Entropic Technologies Corp. ² GEM America Global Energy Solutions Global Environmental Technologies ILS Partners/Pyromex Interstate Waste Technologies Jov Theodore Somesfalean KAME/DePlano ¹ Pan American Resources Peat International/Menlo Int. Rigel Resource Recovery Startech Environmental Taylor Recycling Facility Thermogenics Zeros Technology Holding ²	<u>Anaerobic:</u> Arrow Ecology and Eng. Canada Composting KAME/DePlano ¹ New Bio Orgaworld Organic Waste Systems Waste Recovery Systems <u>Aerobic:</u> Mining Organics	Arkenol Fuels Biofine ² Masada Oxynol
		Chemical Processing
		Changing World Technologies
		Mechanical Processing for Fiber Recovery
		Comprehensive Resources
		Other
		None

(1) Thermal and digestion processes

(2) Unsolicited proposal only, no vendor response to formal Request for Information (RFI) received

5.0 PRELIMINARY REVIEW OF TECHNOLOGIES (SECOND-LEVEL SCREENING)

5.1 SECOND-LEVEL SCREENING CRITERIA

Of the 43 technologies identified in the initial search, 33 met the first-level screening criteria of Step 1. Step 2 of the Evaluation consisted of a preliminary review of these 33 technologies, comparing them against a set of six, second-level screening criteria. These second-level screening criteria are described below.

- **Readiness.** Readiness is a measure of commercial development of a technology. This criterion was applied to focus the review on technologies that are or could be commercially operational within 10 years. ***Technologies meeting the “Readiness” criterion must be at a stage of development to be able to be commercially operational within 10 years.***
- **Size.** Size is a measure of the annual tonnage the technology can process. This criterion was applied to focus the review on technologies that can process waste at a minimum capacity to be meaningful to the City, considered for this study to be 50,000 tpy (137 tpd). ***Technologies meeting the “Size” criterion must be capable of accepting and processing at least 50,000 tpy (137 tpd) of waste.***
- **Reliability.** Reliability is a measure of the extent of testing performed on the technology and the confidence it will effectively process MSW as designed. This criterion was applied to focus the review on technologies that have been successfully tested, beyond laboratory or bench-scale studies, on MSW or a significant component of MSW (e.g., the organic fraction of MSW, but not just a single component such as tires or plastic). ***Technologies meeting the “Reliability” criterion must have operated successfully, processing MSW at a pilot (demonstration) or commercial facility.***
- **Environmental Performance.** Most emerging solid waste technologies develop with an objective of processing waste in an environmentally preferable manner compared to conventional technologies. While such improved performance may or may not be achieved, any technology used by the City would be required to meet regulatory and permit requirements. This criterion was applied to identify technologies that would be capable of meeting fundamental environmental performance requirements. ***Technologies meeting the “Environmental Performance” criterion must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.***
- **Beneficial Use of Waste.** Most emerging solid waste technologies develop with an objective of beneficially using the waste, by generating energy or otherwise producing useful and commercially marketable products. This criterion was applied to identify technologies that produce a useful or marketable product. ***Technologies meeting the “Beneficial Use of Waste”***

critterion must produce a useful and marketable product; e.g., energy and/or other commercial or potentially commercial product(s).

- **Residual Waste.** Conventional waste-to-energy technology generates ash residue requiring landfill disposal, at rates of 25% to 35% by weight of the incoming MSW. Emerging solid waste technologies are considered for their ability to divert waste from landfill disposal. This criterion considers the amount of residual waste generated by the technology, and was applied to focus the review on technologies that produce comparable or less residual waste than conventional technologies. ***Technologies meeting the “Residual Waste” criterion must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.***

To facilitate the second-level review, a one-page screening worksheet was developed and completed for each of the 33 technologies reviewed in Step 2. This approach provided for consistent application of the screening criteria. The completed worksheets are provided in Appendix F.

5.2 RESULTS OF SECOND-LEVEL SCREENING

Table 4-2 lists the 33 technologies and their sponsoring companies that met the first-level screening criteria and were further reviewed in Step 2. Of these 33 technologies, nineteen (19) did not meet the second-level screening criteria described above and were not reviewed beyond Step 2 of the Evaluation process. Table 5-1 lists these 19 technologies, identified by sponsoring company and categorized by type of technology.

Of the 19 technologies listed in Table 5-1, one (1) was not reviewed beyond second-level screening because it did not meet the residual waste criterion. The other eighteen (18) did not meet the reliability criterion in that they were not commercially operational processing MSW, nor had they demonstrated successful pilot testing of the technology on MSW. Some of the technologies that did not meet the reliability criterion also did not meet other criteria. Of the 19 technologies that did not meet the second-level screening criteria, thirteen (13) were thermal technologies, two (2) were hydrolysis technologies, one (1) was aerobic digestion, one (1) was anaerobic digestion, one (1) was chemical processing and one (1) was mechanical processing for fiber recovery.

Table 5-2 summarizes development status (commercial, pilot, bench-scale, research, indeterminate) of the 33 technologies reviewed in Step 2 of the Evaluation.

**Table 5-1. Technologies Not Meeting
Second-Level Screening Criteria**

Technology	Criterion Not Met
<u>Aerobic Digestion</u> Mining Organics	Reliability
<u>Anaerobic Digestion</u> New Bio	Reliability
<u>Chemical Processing</u> Changing World Technologies	Reliability
<u>Hydrolysis</u> Arkenol Fuels Biofine	Reliability Residual Waste
<u>Mechanical Processing</u> Comprehensive Resources	Reliability, Residual Waste
<u>Thermal</u> BRI Energy Ecosystem Projects Eco Waste Solutions Emerald Power/Isabella City Entropic Technologies Corporation Global Environmental Technologies ILS Partners/Pyromex Jov Theodore Somesfalean KAME/DePlano Group ⁽¹⁾ Peat International/Menlo Int. Startech Environmental Thermogenics Zeros Technology Holding	Reliability Reliability Reliability, Size Reliability Reliability, Readiness Reliability Reliability Reliability Reliability, Readiness Reliability Reliability Reliability, Size Reliability

(1) Includes anaerobic digestion in parallel with gasification.

Table 5-2. Status of Development for Technologies Identified for Preliminary Review

Commercial	Pilot	Not Developed for MSW or Indeterminate
<p><u>Thermal</u> EBARA GEM America Global Energy Solutions Interstate Waste Technologies Rigel Resource Recovery</p> <p><u>Anaerobic Digestion</u> Arrow Ecology and Engineering Canada Composting Orgaworld Organic Waste Systems Waste Recovery Systems</p>	<p><u>Thermal</u> Dynecology Pan American Resources Taylor Recycling Facility</p> <p><u>Hydrolysis</u> Masada Oxydol Biofine</p>	<p><u>Thermal</u> BRI Energy⁽²⁾ Ecosystem Projects⁽³⁾ Eco Waste Solutions⁽¹⁾ Emerald Power/Isabella City⁽²⁾ Entropic Technologies Corp.⁽³⁾ Global Environmental Tech.⁽³⁾ ILS-Partners/Pyromex⁽¹⁾ Jov Theodore Somesfalean⁽²⁾ KAME/DePlano⁽³⁾ Peat International/Menlo Int.⁽²⁾ Startech Environmental⁽²⁾ Thermogenics⁽³⁾ Zeros Technology Holding⁽³⁾</p>
Bench-Scale	Research	<p><u>Anaerobic Digestion</u> KAME/DePlano⁽³⁾ New Bio⁽¹⁾</p> <p><u>Aerobic Digestion</u> Mining Organics</p> <p><u>Hydrolysis</u> Arkenol Fuels⁽¹⁾⁽²⁾</p> <p><u>Chemical Processing</u> Changing World Technologies⁽²⁾</p>
<p><u>Mechanical Processing</u> Comprehensive Resources</p>	<p>None</p>	

(1) Technology is in commercial operation for other waste, but not for MSW.

(2) Pilot testing for selected waste types, but no documentation that testing was conducted for MSW (or a significant fraction of MSW).

(3) Insufficient information was provided to determine status of technology for MSW.

The 18 technologies that did not meet the second-level screening criteria and were not reviewed beyond Step 2 of the Evaluation process are briefly described below, presented in alphabetical order:

- **Arkenol Fuels.** Arkenol Fuels offers a patented, concentrated acid hydrolysis (waste-to-ethanol) technology. The conversion technology uses sulfuric acid to break down the cellulose structure of the organic fraction of MSW to its component sugars. Conventional sugar fermentation and thermal conversion methods can then be used to produce a wide range of organic acids, solvents and food additives. Most notably, the sugars can be fermented and distilled to produce ethanol. Approximately 30% residuals are generated in the process. An advantage of the Arkenol technology is that it is able to recover and recycle virtually all of the acid that is not consumed in the reaction. This technology feature enables lower-cost operation and results in almost no wastewater discharge. Arkenol has a commercial facility in Japan, which has been processing wood waste for approximately two years. A one-tpd pilot plant has been operated for the past five years in California; various organic wastes have been processed, but it does not appear that MSW has been piloted. Because Arkenol has not successfully demonstrated the ability to process MSW at a pilot (demonstration) scale, the technology does not meet the reliability criterion.
- **Biofine.** In January 2004, the Institute for the Analysis of Global Security (IAGS) made a presentation to NYCEDC and DSNY advocating use of the Biofine process for conversion of MSW to levulinic acid, and subsequent chemical conversion of the levulinic acid to an alternative fuel methyl-tetrahydrofuran. However, Biofine did not respond to the RFI, and it is unclear upon review of available materials whether Biofine, Inc. is still an incorporated entity. A review of the Department of Energy report produced in conjunction with the piloting of the process in Glen Falls, NY indicated that, when cellulosic material from MSW was the feedstock (e.g., paper, food waste, yard waste), a yield of 31% levulinic acid by weight was produced relative to the weight of the feedstock. The management of the remaining 69% of the post-processed, organic material has not been specified in input provided to date. Therefore, information is not currently available indicating that the residual waste criterion has been met.
- **BRI Energy.** The thermal technology proposed by BRI Energy combines production of synthesis gas with an air-blown gasifier (i.e., gasification) and biocatalytic fermentation of the synthesis gas for production of a high-yield of ethanol (i.e., waste-to-ethanol). In addition, some of the synthesis gas can be diverted from ethanol production to combustion in a gas turbine for electricity production. This technology is unique among the other technologies considered in the Evaluation, because it outlines specifics regarding the conversion of syngas to ethanol. Although a pilot plant, which includes a gasifier and fermentation reactors, has been performance tested under a Department of Energy grant, BRI Energy has not demonstrated that the technology has been operated with MSW as a feedstock. Therefore, the reliability screening criterion was not satisfied.

- **Changing World Technologies.** Changing World Technologies (CWT) owns a unique, patented technology that converts organic waste into marketable, high-quality, clean fuels and specialty chemicals for industrial and commercial use. The Thermal Conversion Process technology is based on the chemical process of depolymerization and associated refining processes, which results in the permanent breakdown of large molecular compounds (e.g., those found in MSW) into smaller, simple compounds (e.g., fuels and chemicals). The process is "thermal" in nature, however, a number of complex and interrelated processing steps, some similar to petroleum refining, are involved, rather than a single reaction step. CWT has an eight-tpd pilot plant/research facility in Philadelphia, which has operated on various feedstock since 1999. Pilot testing has been conducted for agricultural waste, sludge, and selected components of MSW (tires, mixed plastics, electronic waste) but not for unsorted MSW or a significant fraction of MSW. Therefore, the technology does not meet the reliability criterion. Based on pilot testing, the process generates minimal residuals requiring disposal when processing organic agricultural waste. However, residual waste is unknown for mixed MSW processing, and the technology is "indeterminate" for the residual waste criterion.
- **Comprehensive Resources.** Comprehensive Resources, Recovery, & Reuse, Inc. (CR3) offers an innovative RDF process that produces a clean source of secondary fiber for the paper industry. In summary, the process consists of: steam conditioning MSW in an autoclave; mechanical screening to recover recyclables and separate the biomass fraction; wet pulping of the biomass for long-fiber pulp recovery; combustion of the organic fraction that is not recoverable as a paper pulp substitute (e.g., short-fiber pulp); and, anaerobic digestion of the sludge generated from the pulping process. CR3 has operated a 20-tpd demonstration unit of the steam conditioning system in Reno, Nevada, since 1997. Test burns have been conducted for RDF (160 tons). However, only bench-scale research has been conducted for fiber recovery, with integrated lab testing for anaerobic digestion. CR3's first commercial plant is under construction in St. Paul, MN. However, the plant will not include fiber recovery; it will generate RDF. The technology requires more testing for commercialization of fiber recovery; in its current state of development, it does not meet the readiness and reliability criteria. Further, the technology produces 40% residual waste requiring landfill disposal, excluding ash generated from the combustion of the RDF. Up to 7% of the residual waste may potentially be usable for landfill cover material. However, the technology does not appear to meet the residual waste criterion.
- **Ecosystem Projects.** The technology proposed by Ecosystem Projects involves briquetting of MSW and production of synthesis gas using existing, top-feed, gasifier technology. The proposed briquetting technology has been operated with RDF at a scale of approximately 200 tpd, with use of the fuel in conventional solid fueled boilers for electricity production. The proposed gasification technology has been operated with a variety of waste fuel feedstocks that were not briquetted. It is stated that a new gasification facility is going on-line in Italy in the next few months, but it is not clear from the proposal if this facility will involve briquetting of MSW and gasification of the briquettes. Because demonstration of the combination of MSW

briquetting with gasification is not clearly indicated, the reliability criterion was not satisfied.

- **Eco Waste Solutions.** Eco Waste Solutions offers a patented, thermal waste treatment process that is based on the principles of pyrolysis. The process is conceptually similar to combustion, but operated in an oxygen-free environment. Based on the most recent information available from the project sponsor, the technology is in commercial operation. However, it appears to be used for processing medical and hazardous waste and not MSW, and there is no information regarding testing for MSW. Therefore, the technology does not meet the reliability criterion. Also, the technology is modular with unit capacities up to only 25 tpd. It has not been demonstrated that the technology could effectively process 50,000 tpy of MSW, so it does not meet the size criterion. Finally, the information available from the project sponsor is not sufficiently detailed to evaluate products and residuals generated by the process.
- **Emerald Power/Isabella City.** Emerald Power Corporation (EPC), in partnership with Isabella City Carting Corporation (ICCC), submitted a response to the City's RFI. EPC is the exclusive distributor of BioConversion Technology LLC's Pyrolytic Steam Reformer. The "Reformer" gasifies the organic fraction of MSW in an oxygen-free reactor, producing a synthesis gas. The gas can be burned to generate electricity, or through additional processing steps be reformulated into a 98%-methane pipeline-quality gas or fuel-grade ethanol. MSW is pre-processed to extract metals and glass, to recover these materials for sale to secondary markets and to improve the efficiency of the process. Approximately 10% of the original volume of MSW is residual requiring disposal; the amount of residuals by weight was not specified. Based on the most current information available, EPC assumes the residual may be hazardous for lead and mercury. The first commercial unit is currently being manufactured, and will process 15 tpd of sawdust for a user in Canada. The technology has been demonstrated at North Carolina State University on hog manure (July 2003 - April 2004), and a demonstration test is scheduled to take place in Israel to recycle bromine from hazardous waste. The technology has not been tested for MSW, however, discussions are underway between Emerald Power Corporation and ICCC to build a demonstration facility. Because this technology is not yet demonstrated for MSW, it does not meet the reliability criterion.
- **Entropic Technologies Corporation.** An unsolicited report prepared for Entropic Technologies Corporation was submitted to the City by American HomeNet, Inc. The report describes a unique technology involving production of premium synthetic coal from MSW. The MSW is first converted to RDF using conventional technology, and then pyrolyzed (i.e., thermally processed in the absence of oxygen). It is unclear as to whether the pyrolysis step reached the pilot stage with RDF derived from MSW as the raw material. Therefore, it cannot be determined whether the reliability criterion has been satisfied. In addition, it cannot be determined if the readiness criterion can be satisfied since it is unclear if the development of this technology is still active.

- **Global Environmental Technologies.** The technology proposed by Global Environmental Technologies involves the Westinghouse plasma torch technology for production of synthesis gas and the combustion of the synthesis gas in a boiler and steam turbine for production of electricity. While a very general response to the RFI was included in the proposal, the technology development information did not directly provide any example projects that indicated experience with MSW. In most cases, the proposer's responses indicated that additional, specific information would be available upon request. The reliability of the technology for use with MSW, as presented in the proposal by Global Environmental Technologies, is judged to be indeterminate. [Note: The Westinghouse plasma gasification system is offered by another project sponsor (Rigel Resource Recovery), and through that sponsor the plasma technology is further reviewed].
- **ILS Partners/Pyromex.** Innovative Logistics Solutions, Inc., in partnership with the Pyromex Group, offers the patented Pyromex Waste-to-Energy technology. The technology consists of a "gasifier reactor" and can be generally described as ultra-high temperature gasification by induction (non-contact) heating. The gasifier reactor operates at temperatures as high as 3,000°F, processing waste in the absence of oxygen through a series of chemical reactions (i.e., destructive distillation through pyrolysis and hydrolysis - the use of heat to volatilize and separate MSW into chemical components). Pre-processing consists of drying, shredding, and recovery of recyclables. Within the reactor, the organic fraction of MSW is converted to a high-energy "pyrogas" that is combusted to generate electricity. The inorganic fraction is converted to a sand or basalt-like residue with potential reuse applications (landfill cover, building-type materials). The technology is scalable up to 450 tpd, which meets the size criterion. The technology has been commercially operational in Germany for over 2 years, processing sludge from industrial wastewater treatment. Information available does not indicate, however, that any testing has been completed for MSW. Therefore, the technology does not meet the reliability criterion.
- **Jov Theodore Somesfalean.** The technology proposed by Mr. Somesfalean involves gasification to produce synthesis gas and its combustion in a boiler with a steam turbine for production of electricity. A specific gasifier technology is proposed, and is said to have been demonstrated in two sizes: 50 tpd and 75 tpd. The results of the demonstrations are referenced in a U.S. EPA report, which indicate that the fuel used for the demonstrations was tires. No information provided by the project sponsor indicates testing was conducted for MSW. On that basis, the reliability criterion has not been met.
- **KAME/DePlano Group.** The technology proposed by KAME/DePlano Group is intended to process MSW, wood, and agricultural waste. The technology consists of two parallel treatment processes. A portion of the waste would undergo gasification in a pressurized fluid bed gasifier. In a typical fluid bed gasifier, air is used to "fluidize" a bed material (such as sand). MSW is introduced into the bed material, which is maintained at a high temperature. The fluidizing action of the bed provides intense mixing, which facilitates the gasification process. In the KAME/DePlano process, another portion of the waste would be treated in an anaerobic digester.

The anaerobic digestion technology to be used was not specified. No information was provided about the stage of development of the technology, or if pilot-scale or commercial facilities using this technology are operating. Therefore, the readiness criterion is “indeterminate”. The reliability criterion is also “indeterminate”, due to the limited amount of information available from the project sponsor. The respondent also indicated that at this time, he is not able to provide a response to the RFI sections requesting project economics, and business and financial terms. Therefore, this technology was not further evaluated.

- **Mining Organics Management.** Mining Organics Management is the project sponsor for the Enhanced Autothermal Thermophilic Aerobic Digestion (EATAD) Process, and holds the license for the proprietary technology from International BioRecovery Corporation (IBRC) of North Vancouver, Canada. The EATAD technology is an in-vessel technology, designed to process source-separated food waste, agricultural waste, livestock waste and municipal sewage sludge. The incoming waste is processed to manually remove inorganics and contaminants and then macerated and mixed with water (pulped) to form a slurry. The slurry is then pumped to a start-up digester on a batch basis. In the start-up digester, the slurry is mixed, aerated and heated to reach a thermophilic temperature of 55°C to 60°C. When the slurry reaches the desired temperature, it is transferred to the aerobic digester. Aerobic digestion occurs on a batch basis, over a period of 48 to 72 hours (4 to 6 days). During the digestion period, the contents of the digester are intensively mixed and aerated. After the digestion period is completed, the digested material is dewatered, dried and pelletized. The liquid is concentrated by the use of an evaporator tank to create a liquid concentrate. The solid pellets and the liquid concentrate products are marketed as fertilizer to be applied to crops for adding nutrients, enhancing growth, and suppressing disease. The EATAD technology is not yet commercially operational. A 30-tpd demonstration facility has been operating in Vancouver, Canada since 1998. However, the feedstock for this demonstration plant is source-separated food waste, agricultural waste, livestock waste, and municipal sewage sludge. Therefore, the reliability criterion is not met.
- **New Bio.** The technology proposed by New Bio is high-rate anaerobic digestion using a “downflow” bioreactor, with MSW put into the top of the reactor and a sand filter at the bottom of the reactor to retain the biomass. The response to the RFI consisted of a two-page letter and a few pages of product marketing literature. The limited information provided was in the format as requested in the RFI. The response indicated that New Bio was interested in treating only the biodegradable food waste from institutions. New Bio indicated that one Bio Accelerator unit is capable of processing 25,000 pounds per day of food waste (12.5 tpd). The product marketing literature provided is targeted to high-strength food processing wastewater. It is not clear if any pilot scale or commercial scale facilities are operating for the treatment of MSW. Therefore, the reliability criterion is not met. The response indicates that the wastewater along with a small amount of organic waste is to be discharged to the sewer system. The percentage of the incoming waste that is discharged to the sewer system is not provided. Therefore, the residual waste criterion is “indeterminate”.

- **Peat International/Menlo Int.** The technology proposed by PEAT is a specific type of gasifier, characterized as “plasma thermal destruction and recovery” with synthesis gas as the principal product. Two plants have been indicated as processing MSW: a 10 tpd plant in Taiwan and a 1.5 tpd pilot plant in Huntsville, Alabama. However, the company’s definition of MSW does not appear to be consistent with the definition applied in this Evaluation. Specifically, the Taiwan plant processes “municipal solid waste solvents and solutions”, elsewhere characterized as “solvent (laboratory and industrial) and halogenated compound[s]”. The Huntsville plant is reported to have run numerous types of waste, but a detailed listing of tests conducted at the plant give no indication of pilot testing for MSW. On that basis, the reliability criterion was not met.
- **Startech Environmental.** The technology proposed by Startech is a plasma converter, which produces synthesis gas as the principal product. Other recovered products include sulfur, metals and silicates. Approximately 17% of the incoming waste is generated as residuals requiring disposal, consisting primarily of scrubber wastewater containing salts. Two small-scale plants have been built and operated for demonstration purposes. Contracts are reportedly in place to design and construct two, 100,000-tpy (274-tpd) facilities in Poland. This is greater than the size criterion of 50,000 tpy (137 tpd). A seven-tpd plasma converter was delivered to Aberdeen Proving Ground, MD in 1997 for destruction of chemical weapons. A five-tpd plasma converter is available for demonstrations in Bristol, CT. However, it is not clear that MSW has specifically been tested in the plasma converter. On that basis, the reliability criterion was not met.
- **Thermogenics.** The technology proposed by Thermogenics is a small-scale gasification system, intended for installations ranging from 10 tpd to 30 tpd. At this capacity, the technology does not meet the size criterion of being capable of processing 50,000 tpy (137 tpd) of waste. The technology is not in commercial operation. Short-term, small-scale research studies have been conducted for tires and possibly other fuels, but there is no indication that tests have been conducted for MSW. The technology is not sufficiently demonstrated for MSW, and therefore, did not meet the reliability criterion.
- **Zeros Technology Holding.** Zeros is a corporate acronym for "Zero-Emission Energy Recycling Oxidation System", which is a patented, closed thermal oxidation process (i.e., an innovative combustion process). Zeros previously submitted information to the City, but did not respond to the RFI. Review of the technology was based on the information previously provided. The technology is based on oxidation (combustion), but it uses pure oxygen, rather than ambient air, for the oxidation process. The technology is designed to capture and market all products of combustion; no emissions are vented to the atmosphere. No information was available for review on the stage of development for the technology. There were indirect references in product literature to the testing, and perhaps commercial use, of the technology for hazardous waste remediation (i.e., oil contaminated soil). However, no information was available to indicate the technology has been tested with MSW. Based on available information, the technology did not meet the reliability criterion

Table 5-3 lists the 14 technologies that met the second-level screening criteria and moved on to Step 3 of the Evaluation.

Table 5-3. Technologies Meeting Second-Level Screening Criteria and Identified for Detailed Comparative Evaluation

Thermal	Digestion	Hydrolysis
Dynecology EBARA GEM America Global Energy Solutions Interstate Waste Technologies Pan American Resources Rigel Resource Recovery Taylor Recycling Facility	<u>Anaerobic:</u> Arrow Ecology and Engineering Canada Composting Orgaworld Organic Waste Systems Waste Recovery Systems	Masada Oxynol
		Chemical Processing
		<i>None</i>
	<u>Aerobic:</u> <i>None</i>	Mechanical Processing for Fiber Recovery
		<i>None</i>
		Other
		<i>None</i>

6.0 COMPARATIVE (DETAILED) EVALUATION OF TECHNOLOGIES

6.1 COMPARATIVE EVALUATION CRITERIA

Of the 33 technologies that met the first-level screening in Step 1, 14 met the second-level screening in Step 2 and moved on to Step 3 of the Evaluation. Step 3 consisted of a comparative evaluation of the technologies against a final set of criteria to determine their relative advantages and disadvantages. These criteria are described below:

- **Readiness and Reliability.** Readiness and reliability were initially applied as screening criteria in Step 2 to focus comparative review in Step 3 on the technologies that (1) have demonstrated development for MSW, either through commercial operation or successful pilot testing using MSW as a feedstock, and (2) that could become commercially operational in the United States within 10 years. For comparative purposes, technologies were categorized by readiness and reliability generally as follows: (1) technologies that are already in commercial operation (outside of the United States) for MSW; (2) technologies that are not yet operated commercially for MSW, but that are in advanced development and may achieve commercial operation within five years; and, (3) technologies that are less advanced, but could achieve commercial operation for MSW within 10 years. Technologies that are not yet operated commercially for MSW were categorized as "more advanced" or "less advanced" based on the extent and success of pilot testing and consideration of projects currently under development.
- **Facility Size and Design Flexibility.** Size was initially applied as a screening criterion in Step 2 to focus review on technologies that could process a minimum of 50,000 tpy (137 tpd) of MSW. For purpose of comparative evaluation, facility size and design flexibility were further considered including: size of facility, flexibility for expansion, ability to operate successfully with different quantities of waste, and ability to process waste with varying composition.

Technologies were categorized by facility size and design flexibility generally as follows: (1) technologies that are accommodating of various waste types and a wide range of capacities were considered "most flexible"; (2) technologies that are accommodating of waste types and capacities; but require pre-processing of MSW, were considered "somewhat flexible"; and, (3) technologies that have waste composition and/or capacity limitations were considered "least flexible".

- **Utilization of Existing City Solid Waste Collection System.** This criterion was applied to evaluate the ability of the technology to use the City's existing solid waste collection system. Specifically, this criterion considered whether separate collection would be required for source-separated components of MSW. For comparative purposes, the technologies were categorized as: (1) compatible with the existing collection system; or (2) requiring a new collection system (e.g., requiring source separation and separate collection of specific components of MSW).

- **Utility Needs.** Based on the most recent information available, utility needs (e.g., electric, natural gas, fuel oil, water, sewer) of individual technologies were noted and compared.
- **Extent of Beneficial Use of Waste.** Beneficial use of waste was applied as a screening criterion to focus review on those technologies that produce energy or a commercially marketable product. The same criterion was applied in the comparative evaluation process to further consider the extent of beneficial use that may be achieved with a technology; specifically, to consider the amount of energy that is generated and/or the quantity and characteristics of marketable products that are produced. Consistent with New York State policy on the hierarchy for waste management, Environmental Conservation, Title I, Solid and Hazardous Waste Management Policy and Planning (Section 27-0106), those technologies that reuse or recycle greater amounts of the waste material to produce products, and/or those that recover greater amounts of energy from waste, thereby avoiding or reducing landfill disposal, were more favorably considered.
- **Marketability of Products.** Marketability of products is a comparative criterion that is directly related to beneficial use of waste. For comparative purpose, the categorization of technologies based on extent of beneficial use of waste was refined by considering the marketability of the products. Specific consideration was given to the value of the product, the strength and volatility of the existing market, and the need for market development. Those technologies that produce a viable product with a strong and sustainable market were more favorably considered.
- **Quantity/Quality of Residuals Requiring Landfilling.** Quantity of residuals was initially applied as a screening criterion to focus review on technologies that generate less than 35% residue by weight. For purpose of comparative evaluation, quantity and quality of residue was further considered including: quantity of residue generated; hazardous characteristics, if any; existing markets for beneficial use of residue, and potential to develop new markets for beneficial use.
- **Environmental Impacts.** Environmental performance was initially applied as a screening criterion to focus review on technologies that would be capable of meeting environmental permit and regulatory requirements. For purpose of comparative evaluation, environmental impacts were further considered including: potential for environmental impacts associated with emissions, noise and odor, and potential for other impacts such as traffic and aesthetic concerns. Also, the susceptibility of the approach to future environmental and transportation law changes was considered. The technologies were categorized, compared to conventional waste-to-energy technology, as: (1) improved environmental performance; (2) comparable environmental performance; and, (3) reduced environmental performance.

- **Facility Siting.** The acreage required for development of a facility was noted, along with any technology-specific siting requirements. Technologies that require less acreage were more favorably considered.
- **Public Acceptability.** Factors affecting public acceptability were noted and compared. Technologies that can be expected to be more readily accepted by the public were more favorably considered.
- **Estimated Cost.** Cost information was noted and compared, including estimated design and construction cost, annual operation and maintenance cost, and projected tip fee. In addition, the susceptibility of the technologies to future tax law changes was considered.
- **Opportunities for Economic Growth.** The potential of the technology to provide direct economic benefit and collateral economic growth was considered. This criterion considered, for example, the potential for job creation, the need to purchase supporting products and services, and the potential for spin-off industries (e.g., manufacturing facilities that use marketable products).
- **Experience and Resources of Project Sponsor.** The experience, capability and resources of the project sponsor to develop, site, permit, finance, design, build, and operate a project, including the resources to market the product produced, were noted and compared. Specific elements of this criterion included: (1) The project sponsor's legal rights to the technology; (2) the project sponsor's experience in the solid waste industry and with the proposed technology, including experience in project development, design, construction and operation of municipal solid waste processing facility(ies) and the technology; (3) the project sponsor's experience marketing the end product(s); and (4) the financial resources of the project sponsor including capability of financing; ability to secure construction and labor and material payment bonds; capability of securing a letter of credit; investment grade rating, and overall financial resources and financial status.
- **Willingness to Develop Publicly or Privately Owned Facility.** The willingness of the project sponsor to develop and provide service for operating either a publicly owned or privately owned facility was noted and compared.
- **Risk Profile.** The risk profile for the technologies and the project sponsors was noted and compared. Technologies and sponsors that offer less technical, business or other risk that the City would be exposed to and those sponsors willing to provide a company or a parent company guarantee of its obligations received more favorable consideration.

For purpose of completing the comparative evaluations in a consistent and thorough manner, an evaluation worksheet was developed to record information provided by each technology sponsor. The template for the worksheet is provided in Appendix G. The

worksheet was developed to be used as a working tool by the evaluators for purpose of informally compiling information; completed worksheets are not included in this report.

A summary of the comparative evaluations for fourteen new and emerging technologies is provided below, grouped alphabetically by technology type (anaerobic digestion, hydrolysis, and thermal technologies). The comparative evaluations considered the most recent information available for the technologies as reported by the project sponsors, i.e., the information provided in response to the RFI and information previously submitted to the City. The nature of the information submitted varied widely among sponsors, from marketing literature with unsupported claims to detailed technical data regarding process operation. For some of the comparative evaluation criteria, little or no information was provided by any of the technology sponsors. Such lack of information is noted as appropriate.

The results of the comparative evaluations are compiled in Section 7.0, including a series of tables that summarize information and categorize the technologies for the comparative criteria. Section 7.0 also includes a comparison of the innovative technologies to conventional waste-to-energy technology so that any advantages or disadvantages of new and emerging technologies can be compared to this conventional technology. Section 8.0 provides a summary of findings, focusing on technology categories rather than individual technologies.

6.2 ANAEROBIC DIGESTION

6.2.1 Arrow Ecology & Engineering - ArrowBio Process

Arrow Ecology & Engineering Overseas, Ltd. is the project sponsor for the ArrowBio Process technology. The company is headquartered in Israel and is an independent “spin-off” of Arrow Ecology, Ltd., the company that developed the ArrowBio Process.

The ArrowBio Process is a patented, anaerobic digestion process that is intended for unsorted (i.e., mixed) MSW. The technology is unique in that the incoming MSW is deposited into a water bath, which separates component fractions by density. This step facilitates removal of the inorganic fraction of MSW (including recyclables) and prepares the organic fraction for digestion. The organic material is saturated by the water and is reduced to small particles. The organic slurry is pumped to an anaerobic digester. The digester is the Upflow Anaerobic Sludge Blanket (UASB) type. UASB technology is commonly used for industrial wastewater digestion. Hence, the application for MSW essentially renders MSW organic solids into a strong wastewater prior to processing. Biogas is produced as a result of the digestion, which can be combusted to produce electricity. The resulting digested solids are dewatered and aerobically composted to produce a soil amendment. Wastewater generated during the dewatering process is recycled back to the front end of the process.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. The ArrowBio Process has been operating commercially in Tel Aviv, Israel since January 2003. The facility has a design capacity of approximately 77,000 tpy (210 tpd). It is located at a transfer station, and processes unsorted MSW. Prior to this commercial operation, a demonstration plant operated in the mid-1990s for purpose of advancing development of the technology. This demonstration plant, now decommissioned, was designed to process 11 tpd and successfully processed up to three times that design capacity over a 20-month period.

Size and Flexibility. The technology is modular, at approximately 210 tpd per module. There is no technical limit to the number of modules that can be combined, providing flexibility in facility capacity. The technology is able to handle variations in the amount and composition of incoming MSW. The inorganic fraction of MSW is separated from the organic fraction as part of the ArrowBio Process. Only the organic fraction of MSW is processed in the anaerobic digesters.

Use of Existing Solid Waste Collection System. The ArrowBio Process is designed to accept MSW, incorporating and integrating materials separation technology and waste processing technology. Therefore, the technology is compatible with the City's existing solid waste collection system.

Utility Needs. For a one-module, 210-tpd facility, electricity requirements are approximately 50 kWh/ton of waste processed. This power need is met with electricity generated onsite from combustion of biogas. There is reported to be no consumptive water use, since water required for the process is present in the MSW. However, it is unclear whether this applies only to the digestion process, and not the separation process, since the MSW is first processed in a water bath. The digestion process potentially results in the discharge of "a small amount" of wastewater, depending on the moisture content of the MSW and the ability to recycle the recovered water in the process.

Beneficial Use of Waste. Products that result from the ArrowBio Process are recyclables (metal, glass, plastic), biogas (which may be used to generate electricity), and soil amendment. Water is also generated and recycled for process needs. Arrow describes the biogas and recyclables as being the most economically important products. The net electricity production from combustion of the biogas is estimated to be 290 kWh/ton of waste processed. Recyclables are estimated to be 19% of the incoming waste; it is unknown whether this quantity of recyclables is based on MSW collected with an integrated curbside recycling program.

Marketability of Product. The biogas, or electricity produced from biogas, is the most valuable product. For a 210 tpd facility, revenue from sale of electricity is estimated to be approximately \$1 million, and revenue from sale of recyclables and soil amendment is estimated to be approximately \$500,000. Market development would be required for the soil amendment.

Quantity/Quality of Residuals Requiring Landfilling. Based on operating experience at the facility in Israel, the ArrowBio Process produces residuals requiring landfilling at a rate of approximately 10% by weight of the incoming MSW. These residuals consist of nonhazardous grit, stones, non-metallic composite products, and other inorganic components common in MSW. The quantity of residuals could actually be higher than projected, based on the specific composition of New York City waste (including high amounts of bulky waste).

Environmental Impacts. The ArrowBio Process is claimed to have no significant odor potential, since the incoming MSW is immediately deposited into a water bath upon receipt and the digestion process takes place in enclosed tanks. Information was not available regarding air pollutant emissions resulting from combustion of biogas to generate power. Controls are expected to be needed. The process generates “a small amount” of wastewater, characterized as containing BOD, COD, TSS, metals and chloride, and is reportedly suitable for discharge to the sanitary sewer.

Facility Siting. Each 210-tpd module (including front-end processing) requires a land area of approximately 2 acres. Additional land area of 0.5 to 1.0 acre would be required for the long-term storage of secondary materials, in the event of a market downturn.

Public Acceptability. No documented information was available from the project sponsor regarding public acceptability of the technology.

Estimated Cost. Arrow provided a cost estimate of \$10 million for a 210-tpd facility, excluding financing and other soft costs and excluding electric power generators (for exporting power for sale). This cost is approximately equal to \$47,600 per ton of installed daily capacity. Annual operating and maintenance costs were estimated to be approximately \$1.2 million, or approximately \$16 per ton. An estimated tip fee was not provided.

Associated Opportunities for Direct and Collateral Economic Growth. The most recent information available from the project sponsor does not address potential direct or collateral economic benefits associated with the technology.

Experience and Resources of Project Sponsor. Arrow has developed and owns one full-scale project using its patented technology, a 77,000-tpy (210-tpd) facility in Israel. The plant has been operating since mid-January, 2003. Arrow's prior experience includes nine years of research and development, including the development of a pilot-scale facility. No U.S. experience is cited, although Arrow is associated with two U.S. principals (one with U.S. project development and legal experience), and Arrow states that it is “currently engaged in discussions with potential teaming partners having significant local experience and resources.” The company is pursuing two project procurements in California.

Arrow estimates revenues for end products (energy, recyclables, soil conditioner), but it does not offer any detailed discussion of its experience marketing such products or product marketability in the U.S.

Arrow's RFI response did not include specific information on security measures and instruments, but stated that it "routinely" provides contractual assurances to its customers. It also stated, without documentation, that it is "capable of finding the financial resources and financing entities to build its facilities....if that is the City's preferred approach." Company financial information was not available for review.

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. Arrow expressed a preference for design-build-operate implementation (with City ownership and tax-exempt financing) as the most cost-effective approach, but also stated its willingness to consider a variety of financing and project delivery approaches. Its ownership of the facility in Israel may indicate its general willingness to finance and own facilities.

Risk Profile. While not discussing a risk profile in depth, Arrow recognized the need for a "fair and efficient" allocation of risks, and also indicated its interest in a system of incentives and rewards for performance. Arrow generally tied risk to compensation. Regarding risk for waste disposal, Arrow expects a "minimum throughput and tipping fee commitment from the City", but did not specifically indicate a corresponding guarantee on its part (i.e., to accept and process a minimum amount of MSW for a specified tip fee). Regarding business risk, Arrow stated its willingness to assume all product quality and merchantability risks, and offered to consider revenue sharing with the City (with concomitant risk sharing on the part of the City).

6.2.2 Canada Composting - BTA Process

Canada Composting, Inc. is the project sponsor for the BTA Process technology. The company is headquartered in Newmarket, Ontario, Canada. Canada Composting has secured exclusive Canadian and U.S. license rights to the patented BTA Process technology, which was developed in Germany.

The BTA technology is a three-stage anaerobic digestion process (acidification, solids hydrolysis and methanization) that is intended for the organic fraction of MSW. Coupled with a MRF for waste pre-treatment and separation, the incoming waste is sorted to recover ferrous and aluminum recyclables and remove plastics. The sorted MSW is then pulped (using re-circulated process water), and within the pulper, non-digestible (inorganic) material is removed (e.g., plastic, textiles, stone). The pulped organic material is de-gritted in a hydrocyclone to remove sand and other "fines", and then anaerobically digested in the multi-stage reactors identified above. The anaerobic digestion process produces biogas which is 60-65% methane. The biogas has a high heating value and low contaminant levels, and is used to generate electricity using co-generation engines. After digestion, the digestate is dewatered and the solids are aerobically treated for one to three weeks to produce a final, marketable soil compost product.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. The BTA technology is operating commercially in 26 facilities worldwide. The technology has been operating commercially in Europe since the mid-1980s and in Canada since 2000. In addition, 11 more facilities are under development, with two of those presently under construction. Pilot-scale research has been conducted since 1986 on several research topics.

Canada Composting operates the two commercial facilities in Canada (Newmarket, Ontario and Toronto), and has a four-year operating history with the BTA technology. The Newmarket, Ontario facility has been operating since 2000. It is the largest of all BTA processes, with a design capacity of approximately 330 tpd. This facility processes source-separated organics (primarily from commercial and industrial sources). The second facility, in Toronto, has a design capacity of 100 tpd and processes municipal source-separated organics.

Size and Flexibility. The technology is modular in design and scalable to specific needs. Canada Composting reports the minimum economic size for a BTA facility is 40,000 tpy (110 tpd), and states that the maximum “logical” size for a single facility is 200,000 tpy (550 tpd). The technology is able to handle variations of +/- 25% in the quantity of incoming waste. The technology is intended for the organic fraction of MSW. Canada Composting’s two operating facilities accept source-separated organics. However, other commercially operating BTA facilities (in Europe) accept unsorted MSW. The technology would be coupled with a MRF to enable processing of unsorted MSW.

Use of Existing Solid Waste Collection System. This technology is intended for the organic fraction of MSW. Unsorted MSW can be processed with a MRF located upstream of the BTA Process. This combination is compatible with the City’s existing solid waste collection system. However, Canada Composting recommends the City pursue a source-separated organic strategy for enhanced facility operation. This option would require a new collection system.

Utility Needs. The anaerobic digestion of the waste produces biogas, which is used to generate electricity. The most recent information available indicates up to approximately 50% of the electricity generated is used to meet plant electrical requirements. Based on available information, usage is estimated to be 75 kWh/ton of waste processed. The consumptive water use is estimated to be 92 gallons per ton of waste. Wastewater generation is estimated to be 181 gallons per ton of waste.

Beneficial Use of Waste. Products that result from the BTA Process technology are electricity from biogas, recyclables, and compost. For an MSW throughput of 100,000 tpy, the biogas production is estimated to be 10,142 tpy. The electricity production is estimated to be 200 kWh/ton of waste. The soil compost production is estimated to be 26,488 tpy. Aluminum recyclables are estimated to be 761 tpy and ferrous recyclables are estimated to be 599 tpy.

Marketability of Product. The electricity and recyclables (metals) are expected to be readily marketable, although, market prices for recyclables tend to be volatile. Digested solids require further aerobic processing (e.g., windrow composting) to produce a final, marketable compost product. The compost can reportedly be sold in bulk or in bags, depending on market needs, and is typically sold for horticultural uses. Market development for the compost would be required for a project in New York City.

Quantity/Quality of Residuals Requiring Landfilling. Residuals requiring landfilling are described as commingled light fraction (plastics), heavy fraction (inert matter, glass), and grit, suitable for disposal in a landfill. The response indicates that the plastic may be able to be recycled into low-grade plastic products, although there is no indication that this is being done at the existing facilities in Canada. Residuals are estimated to be 18% by weight of incoming material, based on data for Toronto which processes source-separated organic waste. The quantity of residuals could actually be higher than projected, based on the composition of MSW generated in New York City (including, specifically, high amounts of bulky waste).

Environmental Impacts. The BTA Process is conducted in fully enclosed tanks, thereby minimizing odors. Air from the building and process vessels is treated in a biofilter prior to being discharged to the atmosphere. The response indicated that air emissions resulting from the combustion of biogas meet State emissions guidelines, but emissions data was not provided for review. The wastewater generated by the BTA Process technology may require treatment prior to being discharged to the sewer system. Wastewater treated onsite is characterized as containing 250 mg/L TSS, 100 mg/L BOD₅, 20 mg/L TKN, and less than 10 mg/L total phosphorous.

Facility Siting. For a facility with capacity of up to 100,000 tpy (274 tpd) of MSW, the site is estimated to be less than 7 acres in size. The digesters are located outdoors. Buildings typically take up approximately 40,000 square feet of the site. A buffer zone of 1,000 yards from the nearest residence is recommended. Aerobic finishing of the digestate is required. If this is done onsite (in an urban location), in open windrows, an enclosed building with emissions management would be necessary. The building would require an estimated area of 50,000 square feet.

Public Acceptability. The most recent information available from the project sponsor does not address public acceptability of the technology.

Estimated Cost. Canada Composting provided cost estimates for two plant sizes: 50,000 tpy (137 tpd) and 100,000 tpy (274 tpd). Respective capital costs (excluding financing, “soft costs”, and land) were \$23.5 million (\$171,800 per ton of daily installed capacity) and \$32.4 million (\$118,100 per ton of daily installed capacity). Respective annual operating costs were \$4.4 million (\$87 per ton) and \$5.5 million (\$55 per ton). These operating costs exclude the cost of residue disposal; it is uncertain whether costs to cure the compost are included. Tip fees were not estimated in the information provided. The estimated capital and operating costs

were based on experience at the two operating facilities in Canada, and, according to Canada Composting, do not consider different cost structures that might exist for New York City. In addition to tip fees, Canada Composting estimated other revenues at \$2,860,000 for a 100,000 tpy (274 tpd) facility from the sale of electricity, metals and compost (electricity being the most valuable product, at \$1.2 million per year). Carbon credits (a potential source of revenue associated with a reduction in greenhouse gas emissions) were projected to be \$450,000, or 16% of the total non-tip fee revenues.

Associated Opportunities for Direct and Collateral Economic Growth. The response to the RFI does not address potential direct or collateral economic benefits in detail. It does note that a 100,000 tpy (274 tpd) facility would have a permanent operating staff of 22 to 25 people, and would employ short-term construction labor. Recovered products would be sold into local markets, and power to the grid. Canada Composting briefly cited the potential to create new products and markets from the materials (aluminum and ferrous metals, compost).

Experience and Resources of Project Sponsor. Canada Composting holds the license for the BTA Technology. BTA has developed over 20 projects worldwide (in Europe and Asia), and provides technical assistance to Canada Composting. Using the BTA Technology, Canada Composting has developed and operates two commercial facilities in Canada (Toronto, Ontario at 100 tpd and Newmarket, Ontario at 330 tpd). Both are design-build-operate projects, with Canada Composting providing engineering in-house and hiring and training operators, with BTA assistance. Canada Composting owns the Newmarket plant; the Toronto plant is owned publicly. Financing approaches are not discussed.

Annual reports for Canada Composting, a privately held corporation, were not available for review. In response to the RFI, Canada Composting stated that providing security such as bonds and/or letters of credit is a routine part of its business. Its record of doing both a design-build-own-operate and a design-build-operate project suggest Canada Composting's ability to undertake a variety of project delivery approaches.

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. Canada Composting has undertaken projects using both public and private ownership approaches, including Canada Composting-provided construction financing. Canada Composting stated that it would be willing to consider a variety of project delivery approaches (including design-build, with public operation).

Risk Profile. Canada Composting cites the need for put-or-pay waste delivery guarantees from municipalities. It also states that it does provide customary risk mitigation measures such as cost and performance bonds. Canada Composting states that it seeks to reduce risks and costs to municipalities by involving them in projects. For example, a municipality could serve as the markets for facility outputs (such as energy) and, by providing for residuals disposal, could reduce the project's residuals risk, and therefore, the cost to the municipality.

6.2.3 Orgaworld - BIOCEL Dry Anaerobic Digestion

Orgaworld BV is the project sponsor for the BIOCEL Dry Anaerobic Digestion technology. The company is headquartered in Uden, the Netherlands.

The BIOCEL process is an anaerobic digestion process that is intended for the source-separated fraction of MSW. The incoming waste is processed by grinding (if required). The waste is then placed in the anaerobic digester, where it undergoes dry anaerobic digestion. The material is processed in a batch mode; the retention time within the digester is 21 days. The digested material is further processed by biological drying for a period of seven days. The finished material is used in a variety of compost products.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. The technology has been operating commercially in the Netherlands since 1997. A pilot plant was previously operated for research purposes in the 1990's. Orgaworld operates five waste processing projects in the Netherlands. Two of the five projects use the BIOCEL dry anaerobic digestion technology: the 35,000 tpy (96-tpd) Lelystad plant that processes municipal source-separated organic waste, and the 20,000-tpy (55-tpd) Elsendorp plant that primarily serves the food industry. Orgaworld's other projects are composting facilities.

Size and Flexibility. As noted above, the two existing facilities in the Netherlands have capacities up to 35,000 tpy (96 tpd). A facility with capacity of 120,000 tpy (329 tpd) is in the planning stage. The typical facility size is stated to be 100,000 tpy (274 tpd). The technology can accept mixed MSW, but Orgaworld notes that the composition of mixed MSW can limit market options for the compost product and increase the cost of the project. The response to the RFI notes a profitable advantage to processing food industry waste, commercial waste, catering waste and kitchen waste separately from mixed MSW.

Use of Existing Solid Waste Collection System. The BIOCEL process is intended for the organic portion of unsorted MSW. Processing MSW requires installation of a MRF at the front-end of the BIOCEL process, and marketability of end products may be limited. Therefore, while this technology can accept MSW and is compatible with the City's existing solid waste collection system, product quality could be enhanced with a change that provided for collection of source-separated organic waste.

Utility Needs. The most recent information available from the project sponsor does not include technical details on electricity or natural gas usage. There is no consumptive water use. The technology does not generate any wastewater.

Beneficial Use of Waste. Products that result from the BIOCEL Dry Anaerobic Digestion technology are electricity produced from biogas and soil compost. The gross electricity production is estimated to be 100 kWh/ton of waste input. No quantities are provided for the soil compost. The response indicates that digestion

of “clean” (i.e., source-separated) organic waste feedstock, produces a marketable soil compost. For anaerobic digestion of unsorted MSW, the compost may be less marketable. Orgaworld suggests that in this case, “energy products” may be produced to be co-fired in power stations and cement kilns (i.e., the compost may be burned as fuel).

Marketability of Product. Electricity generated from biogas is expected to be used to meet process needs, with the excess readily sold to the grid. In the Netherlands, compost generated from digesting source-separated organics is marketed as a soil conditioner for agricultural uses; compost generated from mixed MSW may require landfilling or could be co-fired in power plants and cement kilns. No information is available regarding marketing the compost in the U.S., however, market development is expected to be required.

Quantity/Quality of Residuals Requiring Landfilling. The most recent information available from the project sponsor does not address the quantity/quality of residuals requiring landfilling. Compost produced from mixed MSW may require landfilling or incineration, which would increase residual quantities.

Environmental Impacts. Orgaworld indicated that the odorous air from the BIOCEL process would be cleaned in a company-developed biological cleaning system. No specific information was provided regarding control of air pollutant emissions resulting from combustion of biogas to generate power. Such controls are expected to be needed.

Facility Siting. Orgaworld states that a facility with capacity of 100,000 tpy (274 tpd) requires a land area of up to 5 acres. It is unclear whether this area is just for the digestion process, or inclusive of waste receiving and processing and management of digestate from the process.

Public Acceptability. The most recent information available from the project sponsor does not address public acceptability of the technology.

Estimated Cost. Orgaworld did not provide any cost or price information, stating that its technology is “very competitive in the Dutch market under European circumstances (EC-law).”

Associated Opportunities for Direct and Collateral Economic Growth. In response to the RFI, Orgaworld did not address potential direct or collateral economic benefits associated with the technology.

Experience and Resources of Project Sponsor. All intellectual property is owned by Orgaworld. Orgaworld has been developing municipal bio-waste processing projects for at least 10 years, with experience primarily in Europe (the Netherlands). The company has been involved in the development and/or redesign of nine solid waste processing facilities, including two pilot plants and two commercial plants using the proposed technology. The company now operates five MSW processing projects, where food wastes and commercial wastes are composted or digested,

including two facilities that use the BIOCEL dry anaerobic digestion technology. The total installed capacity of Orgaworld's operating projects is 210,000 tpy.

The projects indicate experience with numerous project delivery approaches (although financing was not specifically discussed). Orgaworld's actual role in engineering and construction on the projects is not clear from the information provided. The information provided lists teaming partners for many of the projects, including both governmental agencies and private companies. Its projects include both digestion and composting technologies.

Annual reports for Orgaworld were available only in Dutch, and were not reviewed for purpose of this study. Supplemental information such as financing and security/credit measures was not available for review. The company provided a letter of reference from Commerzbank (Nederland) N.V., which stated that the financial position of the company is strong, and that the bank does maintain a credit facility with Orgaworld (and one of its shareholders, Depa Beheer B.V.).

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. In response to the RFI, Orgaworld did not address financing mechanisms. However, the project information provided included references to numerous project delivery approaches.

Risk Profile. Detailed information was not available for review regarding the Company's risk profile. However, Orgaworld did state in the RFI response that it takes full responsibility for sales of compost and other products.

6.2.4 Organic Waste Systems - DRANCO Dry Anaerobic Digestion

Organic Waste Systems, N.V. (OWS), headquartered in Gent, Belgium, is the project sponsor for the patented DRANCO Dry Anaerobic Digestion technology.

The DRANCO process is an anaerobic digestion process that can be used for source-separated organic waste, the organic fraction of MSW obtained through mechanical separation, and other organic waste streams (including dewatered sludge). The incoming waste is shredded and screened in a rotating sieve and passed across an overbelt magnet. Additional processing occurs to remove inorganics from MSW, including recyclables. The digestion process is one-step, with the complete anaerobic process taking place in the same digester volume. The prepared waste is mixed with previously digested residue to inoculate the material with the anaerobic micro-organisms. This patented, external mixing eliminates the need to mix the substrate in the digester. Steam is injected into the inoculated mixture to increase the temperature to the thermophilic range of 48°C to 55°C, and the heated mixture is pumped into the top of the digester. The material in the anaerobic digester moves from top to bottom by gravity, with an average retention time of about 25 days. No mixing of the material in the digester occurs. On a batch basis, new material is fed into the top of the digester, and digested material is extracted through the bottom. The digested material is dewatered, screened and aerobically finished (composted) to produce a soil compost called Humotex.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. There are currently nine commercial plants operating in Europe (Austria, Belgium, Germany, Italy, Spain, and Switzerland). Two of these plants process mixed MSW and the others process various types of biomass (including waste paper and other, unspecified organic material). The longest-running commercial facility has been operating since 1992. The facilities processing mixed MSW have been in operation since 2002. In addition, six demonstration plants were previously operated, including one in Florida in 1989 processing mixed MSW for an unspecified period. The other demonstration plants processed MSW, manure, and other organic waste.

Size and Flexibility. Existing commercial facilities have capacities ranging from 10,000 tpy to 50,000 tpy (i.e., up to 137 tpd). Information is not available regarding scale-up, however, OWS notes that a 100,000 tpy (274 tpd) facility would improve economics. Regarding waste composition, the digester can be operated with materials ranging from 15% to 40% total solids (i.e., a wide range of moisture content), providing some operating flexibility.

Use of Existing Solid Waste Collection System. This technology is able to process MSW with integrated, front-end mechanical separation. While operations would be enhanced if source-separated organic waste was received and processed, the technology is compatible with the existing collection system.

Utility Needs. The electricity use for the technology is estimated to be 60 kWh/ton of waste, met by biogas production. There is no natural gas use. The consumptive water use reported to be negligible. The quantity of wastewater discharged is 103 gallons per ton of waste.

Beneficial Use of Waste. Products that result from the DRANCO technology are biogas, electricity, recyclables, and the soil compost product Humotex. The technology generates (net) approximately 150 kWh/ton of waste, from a biogas production of 100 m³ to 200 m³ per ton of waste. The Humotex production rate is approximately 664 pounds of product per ton or waste.

Marketability of Product. Electricity is expected to be readily sold to the grid. Information available does not address the marketability of the Humotex. Market development is expected to be required for this compost product, particularly if the facility processes MSW rather than source-separated organic waste.

Quantity/Quality of Residuals Requiring Landfilling. Based on operating experience at the existing European facilities, the DRANCO technology produces residuals requiring landfilling at approximately 9% of incoming waste. This quantity assumes incoming waste consists of source-separated organic waste. The quantity of residuals requiring landfilling is expected to be greater when processing unsorted MSW, particularly for New York City MSW which includes large quantities of bulky waste.

Environmental Impacts. The budgetary quotation for the technology includes “air treatment”; however, no details of what the air treatment entails are provided. Information was not available regarding control of air pollutant emissions resulting from combustion of biogas to generate power. Such controls are expected to be needed. The process generates wastewater. The characteristics of the wastewater are a chemical oxygen demand (COD) of 35,000 mg/L and biological oxygen demand (BOD₅) of 17,500 mg/L.

Facility Siting. Information was not available from the project sponsor regarding minimum acreage required or preferred location for facility siting.

Public Acceptability. The most recent information available from the project sponsor does not address public acceptability of the technology.

Estimated Cost. OWS provided a budgetary quotation for the installation of a 25,000 tpy (68 tpd) facility of approximately \$16.5 million (\$242,600 per ton of daily installed capacity), with annual operating costs of \$2.7 million (\$108 per ton). The quotation was expressed in Euros; costs have been converted to dollars but may not completely or accurately reflect costs that would be experienced in the United States. A tipping fee estimate was not provided.

Associated Opportunities for Direct and Collateral Economic Growth. Information was not available from the project sponsor pertaining to direct or collateral economic benefits.

Experience and Resources of Project Sponsor. OWS was formed in 1988. The company offers two technologies (DRANCO and SORDISEP), and also provides consulting and laboratory testing services. The DRANCO technology is proprietary to OWS. The company’s U.S. subsidiary is OWS, Inc., based in Dayton, Ohio. OWS has built six demonstration facilities using the DRANCO technology (including one in Florida), and references nine commercial plants (the first in 1992). The commercial plants are located in Europe and Asia, and have a total combined installed capacity of approximately 215,000 tpy. It is unclear from the information provided what role OWS played in the development of the referenced projects. The material identifies facilities operation as one of its services, and discusses turnkey installation services. OWS’s annual revenues are approximately \$6.5 million. Project security aspects were not discussed in the materials provided, and its ability to provide such cannot be determined.

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. Information was not available from OWS regarding financing or project delivery approaches.

Risk Profile. OWS did not address risk in the RFI, and information was not available regarding their risk profile for existing facilities.

6.2.5 Waste Recovery Systems - Valorga Process

Waste Recovery Systems, Inc. (WRSI) is the project sponsor for the Valorga anaerobic digestion technology. The company is headquartered in Monarch Beach, California, and is the representative of the technology in North America, the Caribbean, and Central America.

The Valorga Process is an anaerobic digestion process that is intended for the source-separated organic fraction of MSW. The incoming waste is weighed and water (recycled from the process) is added to result in a moisture content of 70%. The material is heated by steam injection and mixed with a small amount of digested material to inoculate it with anaerobic micro-organisms. The material is pumped to the top of the digester, and material is extracted from the bottom of the digester. Mixing of the digester contents is accomplished by injection of pressurized biogas into the bottom of the digester vessel. This method promotes mixing of the digester contents without wear and tear that would occur on a mechanical stirring system. The material moves down through the digester by gravity in a plug flow manner, with an average retention time of 16 to 17 days. The digested material is aerobically treated (composted) to result in a finished compost product.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. The technology has been operating commercially since 1988. Currently, there are thirteen commercial facilities operating in Europe with the Valorga technology, and two more in the planning stages. The information provided for review includes operating information for five Valorga plants in France, Germany, and Spain. Two of the plants are designed for mixed MSW, and three of the plants are designed for the source-separated organic fraction of MSW. The capacities of these five plants range from 38,500 tpy (105 tpd) to 198,000 tpy (542 tpd). The largest Valorga facility has a capacity of approximately 400,000 tpy (1,100 tpd).

Size and Flexibility. The digestion units are modular, and plant sizes may be adjusted as needed. However, the minimum practical commercial size is 100 tpd (one digester). Capacities of at least 1,100 tpd may be accomplished, although this large capacity has not been demonstrated for mixed MSW. The system "enables significant variations to be tolerated in terms of quantity and composition of the waste to be treated." WRSI indicates that the organic portion of the City's mixed MSW may not have enough organic material to operate the digesters on a continuous basis. The response indicates that either additional organic waste (source-separated food waste or sewage sludge) would need to be added to the process, or that excess paper would need to be removed prior to the process (to maintain the proper carbon to nitrogen balance).

Use of Existing Solid Waste Collection System. The technology can accept MSW, with separation of recyclables and other inorganics at the front end of the process. Therefore, the Valorga process is compatible with the City's existing solid waste collection system.

Utility Needs. The most recent information available does not include information on utility requirements, beyond stating there is no consumptive water use. The response to the RFI states that the wastewater would be pretreated and discharged to the sewer system.

Beneficial Use of Waste. The products produced by the Valorga Process are recyclables, electricity, and finished compost. The most recent information available does not specify the amount of electricity produced. The compost production rate is stated to be 854 pounds of compost per ton of waste.

Marketability of Product. Electricity is expected to be readily sold to the grid, and recyclables to secondary materials markets. Compost is reportedly sold for a "variety of commercial uses," which are not specified. The volatility of the markets for recyclables and compost is acknowledged by WRSI.

Quantity/Quality of Residuals Requiring Landfilling. For mixed MSW, the mass balance indicates that 30% of the incoming waste requires landfilling.

Environmental Impacts. The response indicates that the air in the buildings is treated in a biofilter, which is an air pollution control technology that uses microorganisms to treat odorous air. Also, the response states that any odorous air compounds will be combusted when the biogas is combusted to generate electricity. The response states "Based on historical data it is expected that the emissions will easily comply with all applicable regulatory requirements." Information was not available regarding air emissions controls for the combustion of biogas. Information was not available on the quality of wastewater, however, WRSI stated that a pre-treatment system may be required prior to discharge to the sanitary sewer system.

Facility Siting. A Valorga facility that processes approximately 300 tpd requires a facility site size of approximately six acres. The response indicates that, for a specific facility, considerations would need to be made for plant capacity, site storage requirements, compost curing requirements, and the level of vehicular traffic. In regard to buffer zones, the response provides the example of a Valorga facility in Freiburg, Germany, which is sited in a commercial area, immediately adjacent to a Burger King restaurant, an automobile supply store, and a hardware store. The response indicates that the preferred facility location is within the City.

Public Acceptability. The location of the Valorga plant in Freiburg, Germany (i.e., urban area) lends support to WRSI's claim that the Valorga technology has been accepted by the public in Europe.

Estimated Cost. WRSI provided an estimate of \$50 million in capital costs (exclusive of factors such as financing and other soft costs and land acquisition) for a 548 tpd (200,000 tpy) facility, or about \$91,200 per ton of daily installed capacity. The annual cost for operation and maintenance was estimated as \$6.5 million, or approximately \$33 per ton. While not estimating a tip fee, WRSI indicated annual revenues of \$14,875,000 from tip fees, recycled materials sales, compost sales and electric power sales (a breakdown was not provided).

Associated Opportunities for Direct and Collateral Economic Growth. WRSI identified potential direct or collateral economic benefits as job creation. In addition to short-term construction labor (25 – 50 jobs), a 200,000-tpy (548-tpd) facility would have a permanent operating staff of 20 people. Recovered products would be sold to local markets. If biogas were to be processed as a vehicle fuel, WRSI suggests that three to five new jobs would be created to operate a natural gas fueling facility.

Experience and Resources of Project Sponsor. WRSI is the only representative of Valorga International, the developer of the technology for North America, the Caribbean and Central America. WRSI has been associated with Valorga since 1989. Although there are 13 Valorga facilities in Europe, WRSI has not yet completed the development of any U.S. facilities and does not appear to have been involved with the development of the European facilities. WRSI cites extensive experience by its management, but does not provide examples. Based on the most recent information available, WRSI's project development and operations capabilities cannot be assessed.

WRSI is a private corporation, and does not publish its financial statements. However, WRSI did outline a security package that would include bonds provided by its construction contractor and a process guarantee from Valorga International covering both waste quantity/quality processing and end product outputs.

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. In its discussion of ownership and development options, WRSI expresses its willingness to consider a variety of project delivery approaches, and states that it is "prepared to undertake the financing of such projects," through its relationships with investment bankers. WRSI prefers to design, build, own and operate Valorga facilities under terms of a multi-year contract.

Risk Profile. WRSI "is willing to assume full business risk with respect to the sale of recyclable materials, energy from biogas and compost, as well as the disposal of residue from the process."

6.3 HYDROLYSIS

6.3.1 Masada OxyNol - CES OxyNol™ Hydrolysis Process

Masada OxyNol LLC (Masada), located in Birmingham, AL, is the sponsor of the proprietary CES OxyNol Hydrolysis Process.

The basic process steps of the CES OxyNol hydrolysis process include: preparation, acid hydrolysis, acid recovery, fermentation and distillation. Upon collection and delivery to a MRF (onsite or offsite), manual and mechanical separation of the MSW is used to recover certain recyclable materials (i.e., bulky wastes, white goods, plastics, metals). After the recyclable materials are removed, the remaining MSW is shredded to uniform size and dried to reduce the moisture content.

The dried MSW feedstock is reacted with concentrated sulfuric acid, which converts the cellulosic component of the MSW to sugars. In addition to sugars, lignin will be present in the hydrolyzed mixture and the sugars and lignin are subsequently separated by filtration. The energy value of the lignin is recovered in a fluidized bed gasifier. The sugar and acid are then separated in chromatographic columns so that the acid can be recycled for reuse. The sugar stream is next neutralized and finally fermented with yeast to produce ethanol. Sewage sludge is received and blended in a parallel process and the acidified biosolids are dewatered, with recycling of the centrate back into the MSW fed hydrolysis reactors.

The ethanol is concentrated by distillation and denatured with unleaded gasoline to meet the ASTM standard for fuel grade ethanol. Carbon dioxide generated by the fermentation process is collected, conditioned and sold commercially.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. The acid hydrolysis technology for production of ethanol from the organic fraction of MSW has been demonstrated on a pilot scale at Tennessee Valley Authority's (TVA's) Muscle Shoals, AL facility. The TVA pilot-scale demonstration facility operated successfully from 1984 to 1987. At present, there is no commercial facility operating. The first commercial plant for MSW is currently under development in Middletown, NY. That plant has been permitted and is in the final stage of financing.

Size and Flexibility. A "typical" facility size would accommodate 275,000 tpy (753 tpd) of MSW, however, facilities are scaleable due to the modularity of process reactors and separation equipment. Since the design is modular (i.e., multiple reactors, tanks, filters, etc.) operations are flexible. A Masada facility can accept unsorted MSW (except hazardous waste) and receipt of sewage sludge is beneficial as it allows optimization of facility design and performance.

Use of Existing Solid Waste Collection System. Because the technology can accept and process unsorted MSW, it is compatible with the City's existing solid waste collection system.

Utility Needs. Detailed technical data are proprietary and confidential, thus plant utility requirements have not been provided in the response to the RFI. It is noted that a closed loop evaporative system recycles process wastewater.

Beneficial Use of Waste. The facility is described as a "net energy producer", but no quantitative information on gross or net energy production is supplied. Based on Middletown, NY design information supplied in the proponent's response, it is deduced that approximately 272 pounds of ethanol per ton of MSW is produced (9.5 million gallons per year of ethanol for a design capacity of 630 tpd of MSW). Non-hazardous gypsum is a recovered byproduct of the pH adjustment of the sugar stream leaving the acid/sugar separator and is said to be suitable for marketing to a gypsum supplier. The lignin biofuel appears to be combusted in the fluidized bed

gasifier for production of steam to be used in the process. Recyclables are also recovered.

Marketability of Product. Masada states that fuel grade ethanol, which should be a highly marketable product, has been selling for \$1.30 per gallon over the past few years, but that recently the price has risen to \$1.80 per gallon. The prognosis for long term ethanol demand is good, indicating a strong market for this product. Gypsum should have a high probability of ultimate use as a product, however, the materials might have to be sold at a discount price since their rate of production is small compared to industrial suppliers and significant transportation costs may be incurred to transport the materials to an end user or distributor. Marketability of recyclables recovered in the MRF is not discussed, but recyclable markets are traditionally volatile.

Quantity/Quality of Residuals Requiring Landfilling. Less than 10% of the incoming MSW is expected to be residual waste requiring landfill disposal. This amounts to up to 200 lb/ton MSW. This estimate is not specific to New York City MSW composition. Presumably residuals would include unacceptable and nonprocessable waste sorted in the MRF. Ash residue from the gasifier is considered by Masada to be a marketable product.

Environmental Impacts. The potential exists for emissions of odor and dust from the MRF. If the MRF is located at a separate site from the hydrolysis process, as suggested by Masada as an option, increased truck traffic would have an environmental impact. Air pollutant emissions will also be associated with the onsite energy recovery (lignin combustion in the gasifier and fossil fuel combustion in the package boiler which may be needed); air pollution control will be needed, but specific information was not provided. The facility will likely provide a greenhouse gas emissions benefit by creating a renewable fuel (ethanol) and by recovering energy from the solid residue (lignin and sludge solids, both biomass materials). According to Masada, wastewater discharge will have a BOD of 200 mg/l, with use of a closed-loop evaporative system to treat and recycle process wastewater.

Facility Siting. The Middletown, NY, facility, which will have a design capacity of 630 tpd of MSW and approximately 200 tpd (dry) of sludge, will be situated on a 10-acre site. Co-locating near a steam host and a wastewater treatment plant can be economically beneficial.

Public Acceptability. Masada references "overwhelming support from local leadership and environmentalists" for the Middletown facility. Reportedly, permits were obtained and commitments secured for MSW and sludge as the result of more than 200 public meetings conducted by the company.

Estimated Cost. The most recent cost information available was from 1999, which included the following pricing estimates:

- capital cost of a 3,000 tpd MSW facility (with approximately 700 dry tpd sludge processing capacity) - \$300-\$350 million (\$100,000 -\$116,700 per ton of daily installed capacity, exclusive of financing);
- annual operating and maintenance cost of \$100 million (approximately \$91/ton).

These costs resulted in a tip fee range of \$60-\$90 per ton MSW.

Masada noted that capital costs depend upon numerous factors. For example, co-locating with a steam host or utilizing existing MRF capacity could reduce installed costs by up to 20%. As an example, Masada cited that costs for the Middletown project are expected to be less than the estimates given above.

Associated Opportunities for Direct and Collateral Economic Growth. Masada provided information on its Middletown, NY project, for which it estimates 350 union construction jobs and a permanent operating staff of 150. It included, but did not document, a projection of collateral economic benefits of 150-250 “spin off” jobs, with a total economic benefit for the area of \$62-\$68 million. Specific to New York City, it cited the benefit of using the fuel produced in the City’s vehicle fleets, providing an economic benefit.

Experience and Resources of Project Sponsor. Masada holds patents on the key components of the technology process, although the actual individual pieces of equipment used are commercially available. The Middletown, NY project will be Masada’s first full-scale and commercial facility, therefore, a history of completed development and operations is not available. The concepts for the Middletown, NY project were apparently based on the successful performance of the Muscle Shoals, AL demonstration facility, which was developed in association with the TVA and Mississippi State University. Thus, Masada, itself, has experience with the technology, at least at the demonstration level. Masada cites 20 years experience in a variety of other infrastructure projects, but does not provide specific information. The Middletown project is being developed by a team that includes members experienced in the solid waste industry. The facility has apparently been fully permitted, and is soon to be constructed. A private project financing approach, apparently using tax-exempt solid waste financing, was employed, indicating capability to organize a financing.

The financing of the Middletown, NY project indicates Masada’s ability to finance projects. Regarding security, Masada referred to the use of bonds provided by its contractors, rather than instruments such as a project guarantee. The use of letters of credit was not addressed. Because the company declined, at this stage, to provide its proprietary and confidential financial information, comments on the ability of Masada, itself, to directly provide security are not possible.

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. Masada expressed its willingness to consider a variety of project delivery and ownership approaches, including private financing (which was used for the Middletown, NY project).

Risk Profile. Masada stated its willingness to structure an arrangement that would include guaranteed long-term disposal fees for New York City. While Masada was not specific in its discussion of business or contract risks, the company made the statement that its intent would be to structure a project with “no new or unmitigated” risks to the City.

6.4 THERMAL

6.4.1 Dynecology - Gasification with Briquetting of RDF/Coal/Sewage Sludge

Dynecology, Inc. of Harrison, NY is the project sponsor of this gasification technology.

The proposed technology concept is based on forming lump size agglomerates (briquettes) from MSW and dewatered sewage sludge (as filtercake), with coal as a binder. Prior to making the briquettes, the MSW is first processed to RDF quality by conventional methods of sorting and size reduction. The briquettes are then fed to either one of two specific types of British Gas/Lurgi (BGL) gasifiers, which are described as high-pressure, fixed-bed reactors. The briquettes are fed into the top of the reactor vessel and deposited on the top of a "fixed bed" of material, which is maintained in the reactor. Inorganics melt and are removed from the bottom of the reactor as a non-hazardous slag (i.e., vitrified inorganic material). A high quality synthesis gas is produced in the gasification reactor. The syngas is removed from the top of the reactor and can be combusted in a gas turbine to produce electricity. This technology concept is novel among the thermal technologies in that it uses the coal supplement to increase the quality and uniformity of the synthesis gas produced from gasification of the briquettes.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. This technology is not yet commercially operational for MSW. However, extensive, and successful, pilot testing has been performed. Briquetting of RDF, along with sewage sludge and coal, has been demonstrated on a pilot scale by the project sponsor and successfully processed in pilot scale gasifiers in the United States. Gasification of coal/RDF and coal/sewage sludge briquettes has been demonstrated in Germany in a large-scale (700-tpd) reactor. Also, the component technologies proposed have seen extensive commercial operation with other fuels. Based on this extensive testing and commercial use for fuels, the technology is advanced and could potentially be commercial for MSW within five years. Dynecology suggests testing of large quantities of New York City MSW specifically in the large scale demonstration plant in Schwarze Pumpe, Germany to further prove the process.

Size and Flexibility. The technology is modular; gasification units of 800-tpd capacity can be combined to process large quantities of waste. A gasifier processing 800 tpd of briquettes would process 392 tpd RDF derived from 522 tpd of MSW, 128 tpd sludge, and 280 tpd coal. Apparently, economics favor a very large-scale plant size for the gasification and power generation, since a 5,000 tpd MSW throughput is proposed (1.8 million tpy MSW). Briquette fuel is stable and can be stockpiled if gasification equipment is down or to create an inventory such that additional gasifier trains can be put on line when enough backlog warrants.

Use of Existing Solid Waste Collection System. This technology is compatible with the existing New York City solid waste collection system since unprocessed, unsorted MSW is the feedstock. The MSW is then processed at the proponent's facility to remove bulky waste and some recyclables and then further processed into refuse derived fuel, before incorporation into the fuel briquettes.

Utility Needs. Plant utility needs such as electricity, natural gas, water and wastewater are not quantified in the most recent information available. Based on information that is provided, electricity use is deduced to be 460 kWh/ton of waste based on 3.07 MWh/ton produced and 2.61 MWh/ton MSW for power sale (see below under Beneficial Use of Waste). Natural gas would only be used for startup heating of the equipment. The amount of coal needed for production of the briquettes is approximately 1,073 pounds of coal per ton of MSW.

Beneficial Use of Waste. Electricity production of 3.07 MWh/ton of MSW is predicted based on 639 MW for a 5,000 tpd MSW plant. Net export electricity is estimated at 2.61 MWh/ton of MSW based on \$237.9 million dollars per year of annual revenue from power sale at \$0.05/kWh. Based on the RDF (37% on a heat input basis) and sludge cake (11%) components of the briquettes, up to 48% of electricity generated could be considered renewable. The coal component of the briquettes represents 52% of the electric generation and is attributable to fossil, rather than renewable fuel. Additional beneficial use of waste is derived from removal of metal and glass from the MSW prior to its processing into RDF. Residuals from the gasifier and the syngas cleanup system, which may be saleable as products, include sulfur, ammonia and a glassy-slag.

Marketability of Product. Electricity is a highly marketable product. Electricity generated from renewables could be in greater demand than electricity generated from fossil fuels, in the future. Sulfur and ammonia are commodity chemicals that have a high probability of ultimate use as a product, however, the materials might have to be sold at a discount since their rate of production is small compared to industrial suppliers of those chemicals and significant transportation costs may be incurred to transport the materials to an end user or distributor. Information on the marketability of the slag was not provided; market development would likely be required.

Quantity/Quality of Residuals Requiring Landfilling. The slag from the gasifiers and the syngas cleanup process might require landfilling, although this aspect of the technology is not discussed by Dynecology. Quantities of residual are not supplied

in the proposal. However, based on performance of other gasification technologies, the slag quantity is not expected to exceed 35% of the incoming MSW, equivalent to 700 lb/ton MSW. Since coal and sewage sludge, added to the MSW, contain some inorganic material that cannot be converted to syngas, the quantity of slag per ton of MSW is expected to be higher than for the other gasification technologies reviewed.

Environmental Impacts. The MRF, RDF processing, and sludge cake handling all have potential for dust and odor emissions. Also, fugitive dust emissions from coal handling must be considered. Synthesis gas cleanup using the Rectisol process, developed by Lurgi, is proposed to accomplish desulfurization and removal of other compounds, which are undesirable environmentally. The Rectisol process scrubs the syngas with methanol at about minus 90°F, and thus is quite an expensive gas cleanup method. However, it results in extremely clean syngas for feed to the combustion turbines. Although it may be needed, no air pollution control for the combustion turbine system is discussed.

There would likely be a net reduction in greenhouse gas emissions, since the MSW and sewage sludge are renewable fuels. Whether there is a true net reduction depends on whether the fraction of power generated by gasification of the coal component of the briquettes ends up displacing or adding to the existing base of fossil-fuel-generated power. The technology might be advantageous if new laws are passed that restrict greenhouse gas emissions, since it likely provides a reduction in such emissions. Also, if in the future, greenhouse-gas emission reductions become a tradable commodity in the U.S. (tradable “carbon credits”), the technology might be able to generate such saleable carbon credits.

Facility Siting. Dynecology did not provide acreage requirements for the technology. Siting of the MRF/RDF and briquetting facility could be decoupled from the gasification facility, thus briquettes could be produced locally and gasification could take place in a more remote area. However, the information available does not address siting or economics of transportation.

Public Acceptability. The most recent information available from the project sponsor does not address public acceptability of this technology.

Estimated Cost. Dynecology estimated a total project capital cost of \$1.035 billion (or, \$207,000 per ton of daily installed MSW capacity), incorporating MSW, sewage sludge cake and coal processing. Annual operating and maintenance costs were estimated at approximately \$134 million (\$73 per ton of MSW). Tipping fees for both solid waste and sewage sludge were estimated at \$50/ton. The price for power sale used is \$50/MWh. After collection of the tipping fees and power sales, net revenue available for reduction of the “capital charge” was estimated at approximately \$194 million per year (\$107/ton MSW).

Associated Opportunities for Direct and Collateral Economic Growth. The information available from Dynecology does not address potential direct or collateral economic benefits associated with the technology.

Experience and Resources of Project Sponsor. It is unclear from the information available whether Dynecology is a license holder, or whether licenses are required to use what is described as commercially available technology and equipment components. The company did not cite specific experience or capabilities in the development and operation of commercial scale projects, or in the marketing of power (the principal product). Dynecology does not appear to have commercial operating experience in the solid waste industry. While the company appears knowledgeable regarding the technology, it does not have direct experience in developing and operating projects using the technology. The company suggested, as a next step, a demonstration of the system using MSW from New York City. It estimated the cost of such a demonstration at \$3 to \$5 million.

Financial information was not available for Dynecology, nor did they provide information regarding project security measures.

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. Dynecology did not express any project delivery preference, but offered the position that, given the high capital cost of a project for New York City, the most desirable approach is a “public not-for-profit entity” (i.e., some form of public or quasi-public ownership and financing).

Risk Profile. The information available from the project sponsor does not address risk issues.

6.4.2 Ebara Corporation – Fluidized Bed Gasification with Ash Vitrification: “Twin-Rec” Technology

Ebara Corporation is the project sponsor for the Twin-Rec fluid bed gasification technology. The company is headquartered in Tokyo, Japan.

The proposed gasification technology feeds shredded MSW with a particle diameter smaller than 300 mm (12 inches), into a circulating fluidized bed gasifier that uses air as its source of oxygen. Gasification takes place at atmospheric pressure and at relatively low temperatures of 550-630°C (1,022-1,166°F). Ash fines leave the reactor vessel overhead with the synthesis gas and enter a second chamber “ash melting furnace” where addition of secondary air causes additional reaction of carbonaceous compounds and elevation in temperature to 1,300-1,450°C (2,372-2,642°F). The fine particles collect on the walls of the second chamber and become a molten slag. The slag is collected at the bottom of the reactor and then quenched in water to form a vitrified granulate, which may be used as construction aggregate. The synthesis gas produced can be converted to electricity and/or district heat.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. The Twin-Rec technology is a well-developed technology and is in commercial operation for MSW. Currently, there are six Japanese plants (16 process lines) processing MSW. The first Twin-Rec plant was

installed in March 2000 with sewage sludge as the feed. The first Twin-Rec plant fed with MSW was installed in March 2002, with two additional plants installed later in 2002, two plants installed in 2003 and one plant installed in 2004. Due to significant operating experience, this technology is considered highly reliable. Ebara suggests construction of a demonstration plant in the U.S. to overcome the hurdles of technology transfer from Japan to America. Ebara estimates two to three years of operation of the demonstration facility to ensure financing of a full-scale commercial facility.

Size and Flexibility. The Kawaguchi City reference plant, which is the largest of the MSW installations and was installed in November of 2002, has three process lines with a combined capacity of 462 tpd and a rated output of 63 MW. A single process line has a capacity of 154 tpd and a rated output of 21 MW. The smallest unit size is 40 tpd and is fully scalable. The modular design provides flexibility to meet specific capacity needs. Ebara proposes a demonstration plant with a capacity of 40 tpd MSW input (4 MW power output), with an eye toward using this as a stepping stone for development of a 40 MW commercial facility.

Use of Existing Solid Waste Collection System. The technology can accept mixed MSW. It includes bulky waste screening and shredding to meet the maximum particle size of 12 inches. The technology is compatible with the City's existing solid waste system.

Utility Needs. No quantitative information was available for review regarding internal utility needs for a plant or process line. Several general statements are provided: (1) internal power consumption is moderate; (2) supplemental fuel requirements are for startup only; and (3) the facility is self-sustaining.

Beneficial Use of Waste. Net power output for the 40-tpd demonstration plant is predicted to be 455 kWh/ton MSW, which is noted to be lower than for a larger, commercial installation. Given rated power output and MSW input data tabulated in the proposal, the following statistics are available for the existing plants: Kawaguchi reference plant – 623 kWh/ton MSW; Sakata Clean Union – 222 kWh/ton MSW; Ube City – 452 kWh/ton; Chuno Union – 257 kWh/ton; Minami Shinshu Union – 188 kWh/ton MSW; and Nagareyama City – 316 kWh/ton. It is unclear whether the tabulated data represent total power generated at the plants or net power export. Additional byproducts from the demonstration plant are characterized as follows:

- 20 lb of recyclable metals per ton of MSW processed;
- 190 lb of vitrified ash (aggregate) per ton of MSW processed;
- 40 lb of “inert materials” per ton of MSW processed; and
- 50 lb of air pollution control residues per ton of MSW processed.

Marketability of Product. Electricity is a highly marketable product. Recyclable metals should be readily saleable, although, secondary material markets are volatile. The vitrified ash is likely to pass environmental concerns and could potentially be used as a construction aggregate. The vitrified ash has been successfully marketed in Japan, but would require market development in the U.S. The “inert materials”

and air pollution control residues are not characterized well enough to identify them as products available for marketing.

Quantity/Quality of Residuals Requiring Landfilling. Ebara states that 95% of the MSW input is diverted from landfilling. That would indicate 5% residuals requiring disposal. This percentage is consistent with quantity of “inert materials” and air pollution control residues noted above for the demonstration plant under “Beneficial Use of Waste”. For over one year, Ebara's Kawaguchi reference plant has been processing mixed MSW with a landfill diversion rate of greater than 97%. However, the amount of residuals requiring disposal may be greater for New York City waste, particularly due to the large amount of bulky waste present in the City's MSW. Information was not available for review regarding the quality of the residuals requiring disposal.

Environmental Impacts. Odor and dust emissions can be expected from MSW storage and shredding, but controls are not discussed. Ebara proposes conventional air pollution control equipment, similar to waste-to-energy plants. As such, gasifier and electricity production emissions are likely to be less than conventional waste-to-energy, but specific information is not provided. A net reduction in greenhouse gas emissions is to be expected, since MSW is a renewable fuel. As such, if greenhouse-gas reductions become a saleable commodity, carbon credits could be generated. No information on water use was available. Little wastewater discharge can be expected, if any.

Facility Siting. Information was not available regarding siting requirements. Ebara noted that siting of a demonstration facility would be easier than siting of a commercial facility, and as such, could pave the way for public acceptance of the latter.

Public Acceptability. The most recent information available from Ebara does not address public acceptability of the technology.

Estimated Cost. A budgetary investment cost estimation for a 40-tpd demonstration plant is in the range of \$14 to \$21 million (\$350,000 -\$525,000 per ton of daily installed capacity). Cost estimates for operating and maintenance of the technology and estimated tipping fees were not provided.

Associated Opportunities for Direct and Collateral Economic Growth. Ebara cited approximately 15 operating positions at the proposed demonstration facility, plus construction employment. The company stated that large/full-scale facilities (i.e., 3,000 tpd, 80 MW) would create a similar number of jobs as do comparable WTE facilities.

Experience and Resources of Project Sponsor. Ebara, the project sponsor, holds the rights to the proprietary technology. Ebara, which was founded in 1912, referenced 200 waste facilities that employ its fluidized bed technology, 25 of which apply gasification (in Asia and Europe), with 5 additional facilities under construction. Twenty-one gasification/ash melting process lines have been delivered (16 treat

municipal solid waste). The earliest Ebara plant dates from 1978. An additional 60 facilities process industrial waste. Other than providing the technology, it is unclear from the material provided what other roles the company may have played in projects (i.e., development, construction and/or operation). Ebara stated that the proposed demonstration plant would be constructed by a U.S. construction firm and operated by a U.S. waste management company. Its extensive listing of reference projects indicates that Ebara has the requisite capabilities to develop projects. However, it has no U.S. project development or operation experience. The company stated that, as a multi-product line company, it has 18 offices and subsidiaries in the U.S.

The company's role, if any, in marketing the outputs of the facilities cannot be determined from the material provided, although, it expresses confidence in the marketability of outputs (electricity, metals and vitrified glass) which have established U.S. markets.

Although financial information for Ebara was not available for review, the company is a diversified manufacturing company with annual revenues of \$4.7 billion, assets of \$4.8 billion and a 90 year history. Therefore, it can be assumed that Ebara has the financial resources necessary to support projects that it would participate in.

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. Ebara did not discuss ownership and project delivery alternatives specifically, but did state that, for the demonstration project, it would be the "design-build-supplier" of the facility.

Risk Profile. The most recent information available from Ebara does not address risk allocation.

6.4.3 GEM America - GEM Thermal Cracking Technology (Gasification)

GEM America Inc., located in Summit, NJ, and Jamaica Recycling Corporation of Queens, NY, are the project sponsors. GEM America is the American subsidiary of GEM International, the owner and patent holder of the GEM Thermal Cracking Technology, a gasification system.

The GEM Thermal Cracking Technology would accept and process mixed MSW. MSW would first be sorted for recyclables such as metals, glass and cardboard. The remaining waste would be shredded, dried and granulated to become a feedstock for the gasification process. The process would convert the prepared MSW to synthetic gas. The synthetic gas may be sold for use in heating, air conditioning, steam production, or used in reciprocating engines or combustion turbines for powering generators to make electricity.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. A pilot GEM Thermal Cracker has been operated in Romsey, UK since 1998. This pilot reactor is stated to be 1/3 of commercial size. Since the commercial size seems to be 73 tpd in capacity, it is deduced that the pilot unit has a 24 tpd capacity. A second demonstration plant operated with MSW at a landfill site in South Wales, UK, in 2000. The capacity of this demonstration plant was not provided. GEM America anticipates full commercialization of the technology within one year. Four plants, to be sited in various European countries, are in the planning and permitting stages. The capacity of these four plants is not available. One of the four plants will use MSW as its feedstock.

Size and Flexibility. The optimal minimum facility size, to allow sufficient redundancy, is stated to be 66,000 metric tpy (equivalent to 199 tpd), which apparently represents three process lines. GEM America suggests a minimum capacity of 146,000 tpy (400 tpd) for New York City. Modular design of Thermal Cracking units allows for flexibility, and plant sizes up to 3,978 tpd are conceivable by the proponent. Like most gasification technologies, a wide range of waste compositions can be tolerated.

Use of Existing Solid Waste Collection System. GEM America's proposed project makes extensive use of an existing solid waste handling facility owned by Jamaica Recycling Corporation. Preprocessing equipment, skid mounted GEM Thermal Crackers, and ancillary equipment will be located at the existing Queens, NY site without any extensive, outwardly apparent, changes to the facility. This claim, however, is unsupported (e.g., a stack would be required along with interconnection to the grid). The technology can accept and process unsorted MSW, and therefore, is compatible with the City's existing solid waste collection system.

Utility Needs. Facility electric use is estimated at 12 kWh/ton MSW, as received, based on 0.88 MW for 75.32 tph MSW feed. Natural gas use is not shown, and is assumed to be for startup only. Parasitic use of synthesis gas is shown but not quantified. The proponent indicates that there is no water consumption or wastewater generation. However, it seems that water might be used for listed equipment such as cooling towers and gas cleaning systems.

Beneficial Use of Waste. Net export electricity of 175 kWh/ton MSW, as received, can be deduced from 13.18 MW produced at a 75.32 tph MSW feed rate. Net synthesis gas is produced at a rate of 1.7 MMBtu/ton MSW, as received, based on 129.65 MMBtus net at a 75.32 tph MSW feed rate. Recyclables generation rate from the preprocessing step is estimated at 48 pounds per ton of MSW, as received, based on a 75.32 tph MSW feed rate and 50.91 tph feed rate to the GEM Thermal Cracker after preprocessing (assuming that 600 lb/ton MSW is attributable to water driven off in the drying process). Residual from the GEM Thermal Cracker is estimated at 40 lb/ton MSW, as received, and is characterized as suitable for a

construction aggregate. These quantities are based on waste characteristics generally consistent with the composition of New York City waste.

Marketability of Product. Electricity is a highly marketable product. The residual from the process is characterized as inorganics (metal and silica) with a minor amount of char, potentially suitable for use as aggregate. The environmental characteristics of the residual are not discussed, and its apparent heterogeneity may impact its potential for beneficial use. While the product may be saleable, market development would be required.

Quantity/Quality of Residuals Requiring Landfilling. Residual waste generated in the process and requiring landfill disposal amounts to 2% by weight of the total MSW received. It is unclear if this quantity accounts for the large volume of bulky waste present in the City's MSW. Potential for heavy metals in the inorganic residual is recognized with a remedy of neutralization to stabilize the material from leaching.

Environmental Impacts. Emissions to air would be less than with a conventional WTE facility, since the power generating equipment will be combusting synthesis gas which is not a solid fuel. A net reduction in greenhouse gas emissions is to be expected, since MSW is a renewable fuel. As such, if greenhouse-gas reductions become a saleable commodity, valuable carbon credits could be generated. A claim that no stack is needed is not credible, unless the proponents intend to market syngas rather than use the syngas themselves to produce and market electricity. No water use or wastewater discharge is claimed.

Facility Siting. According to GEM America, site requirements for the processing system are minimal. No information is provided on overall acreage required for the 146,000-tpy (400-tpd) minimum facility size suggested by GEM America.

Public Acceptability. The most recent information available from the project sponsor does not address public acceptability of the technology.

Estimated Cost. GEM America estimates a tip fee of \$75 per ton of MSW, based on selling electricity at \$55/MWh. Capital and operating costs were not available for review.

Associated Opportunities for Direct and Collateral Economic Growth. GEM America did not address direct or collateral economic benefits. It did state that operations can be highly automated or rely on manual labor, which would impact staffing requirements.

Experience and Resources of Project Sponsor. GEM America is the U.S. subsidiary of GEM International Ltd., and operates under a 20-year master license with its parent company. GEM America, itself, has no project development or operations experience (in the industry or with the technology). Its affiliate, Jamaica Recycling Corporation, has been operating in the commercial and industrial recycling business since 1972, and operates a recycling facility in Queens. While

GEM America has no direct experience in the development and operation of the technology, GEM UK has installed one solid waste facility in South Wales, and is developing three additional UK facilities and one in Spain. One of the new facilities will process MSW; the others will process various other waste materials. A pilot facility has been operating at Romsey UK since 1998. The second UK plant is expected to be on-line in July 2005. In addition, GEM America has executed a letter of intent for a commercial waste facility in Toronto, Canada.

GEM America did not provide any financial information and did not discuss project security measures in detail. It suggested a New York City/GEM/Jamaica joint venture/profit sharing partnership as a favorable development approach for a City project. It discussed the provision of construction contractor and equipment suppliers' warranties, and stated that a project guarantee could be provided by the company for a guarantee fee of 7.5% of the capital cost of the project.

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. Private ownership and operation is acceptable to the company (as is public ownership). GEM cited the potential to structure a New York City/GEM/Jamaica joint venture/profit sharing arrangement, which is the preferred project development option.

Risk Profile. GEM did not discuss risk in detail. However, it stated that its minimum contract term would be 10 years and implied the need for New York City guarantees regarding waste delivery. It did not discuss process or product marketing risks.

6.4.4 Global Energy Solutions – Thermal Converter Technology (Gasification and Vitrification)

Global Energy Solutions, L.C., located in Sarasota, FL, is the project sponsor for this gasification and vitrification technology.

The technology processes MSW with no pre-sorting or pre-processing. MSW is introduced into the Thermal Converter (i.e., the gasification reactor) through airtight, interlocked doors mounted above the upper chamber of the Thermal Converter. Within the reactor, MSW is subjected to preheated air at 350-450°C (660-840°F). The material then passes through a primary conversion chamber at 1,200-1,350°C (2,200-2,500°F) and a secondary conversion chamber at 1,650-1,700°C (3,000-3,100°F). The secondary chamber contains a bed of molten material, which cleans the gases and vitrifies the residue. The system design is based on Pyro-Thermic Reaction, which is a combination of pyrolysis, gasification and high temperature process. The synthesis gas generated may be combusted in a boiler to produce steam to power a steam turbine and generate electricity.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. Fourteen installations of the Thermal Converter Technology are in operation in Japan, Asia and Europe. Two facilities appear to be fueled exclusively with MSW. Both of these facilities are in Japan, and one has eight

(8) converter units. The other installations process industrial waste, or co-fire industrial waste and MSW. Operating histories and facility capacities are not specified. However, this technology is in commercial operation and has demonstrated that it is permissible in Japan, Asia and Europe.

Size and Flexibility. Modular designs for static (stationary, as opposed to mobile) installations are advertised ranging from 24 tpd to 600 tpd. No specific facility size is proposed for New York City. Due to the modular design and the ability of the process to handle unsorted MSW, it can be considered sufficiently flexible to meet the City's needs.

Use of Existing Solid Waste Collection System. The technology accepts MSW and requires no presorting or preprocessing. Therefore, it is compatible with the City's existing solid waste collection system.

Utility Needs. The most recent information available from the project sponsor does not address utility requirements.

Beneficial Use of Waste. The technology produces synthesis gas, which can be combusted to produce electricity. The quantity of gas and the amount of electricity derived from the syngas per ton of MSW is not available for review. The inert, vitrified residual is stated to be 3% of incoming MSW, equivalent to 60 lb/ton MSW, and is considered by the project sponsor to be of sufficient quality for use as construction aggregate. However, since the MSW is accepted unsorted and with no preprocessing, the quantity of residuals could be higher than stated (i.e., depending on the amount of inorganics, such as metals and glass, which may be present in the MSW).

Marketability of Product. The primary product is synthesis gas, or electricity derived from the synthesis gas. Electricity is a readily marketable product. The residual from the process may be a marketable product, saleable as construction aggregate, based on experience in Japan, Asia and Europe. Market development would be required.

Quantity/Quality of Residuals Requiring Landfilling. The inert residual is characterized as a mixture of metal, silica and char, potentially suitable for use as construction aggregate. If the inert residual is not saleable as a product, it may be landfilling at a rate of 3% of incoming MSW. This quantity may actually be higher, considering the composition of New York City waste.

Environmental Impacts. Odor emissions from MSW handling will occur, but control is not addressed. Air pollutant emissions from the Thermal Converter Technology should be less than traditional WTE, but test data provided are insufficient to confirm this. Emission control methods are needed, but are not described in detail. A net reduction in greenhouse gas emissions is to be expected, since MSW is a renewable fuel. As such, if greenhouse-gas reductions become a saleable commodity, carbon credits could be generated.

Facility Siting. Global Energy Solutions does not address specific facility siting requirements for the technology. However, the proponent does state that the thermal converters are physically smaller than other types of waste handling plants, and that the area required for the converter is "relatively small".

Public Acceptability. The most recent information available from the project sponsor does not address public acceptability of the technology.

Estimated Cost. Global Energy Solutions estimated a tipping fee of approximately \$45 per ton of MSW. However, capital and operating costs were not available for review.

Associated Opportunities for Direct and Collateral Economic Growth. The project proponent did not address direct or collateral economic benefits associated with the technology, except for a reference to an unspecified number of construction and permanent O&M positions.

Experience and Resources of Project Sponsor. Global Energy Solutions owns the Thermal Converter gasification technology. The company cites more than 14 facilities worldwide, using the converter technologies. However, most of the facilities do not process MSW. It did not discuss or cite experience in developing MSW facilities. Global Energy Solutions appears to have limited experience in the solid waste industry, per se, and in the development of large solid waste facilities. It identified a team of advisors and associates that work with the company on project development. Financial information for Global Energy Solutions was not available for review.

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. The project sponsor's preferred approach is Design-Build-Own-Operate (DBOO).

Risk Profile. Global Energy Solutions did not discuss risk and risk profiles in depth. It did state that, under a DBOO approach, it would require guarantees from New York City on the delivery of waste and payment of tipping fees. It also discussed the need for any arrangement with the City to include the ability "to periodically review the terms of the ... agreement ... to determine whether any adjustments should be made to reflect changes due to economic conditions, inflation, tonnage increases/decreases, labor changes, operating costs, increases in costs of fuel, etc."

6.4.5 Interstate Waste Technologies – Thermoselect Gasification Technology

Interstate Waste Technologies, Inc., located in Middleburg, VA, is the project sponsor for the Thermoselect gasification technology.

The Thermoselect process is a closed-loop process based on high temperature gasification with an extended residence time for process gases. For this process, MSW is received in a tipping pit and stored in an enclosed building complete with ventilation equipment designed to remove odors. MSW is moved from the storage area to a press, using overhead cranes,

and then compacted into a plug. The plugs are pushed into a degasification channel that has a jacket heated to 300°C (570°F), where some of the waste is vaporized before entering the high temperature reactor vessel. In the high temperature reactor vessel, waste now in the form of solids and gases is combined with pure oxygen and natural gas, and reaches 1,200°C (2,200°F) in temperature. In this environment a high quality synthesis gas is formed, which leaves the reactor at the top. Inorganic materials leave the bottom of the reactor as molten liquid, which is quickly cooled and separated into metal pellets and a vitrified, sand-like material. The synthesis gas is quenched to a temperature below 70°C (160°F) in less than one second (i.e., "shock quenched"), ensuring no reformation of dioxins and furans, and is then scrubbed to remove sulfur, heavy metals and other impurities. The cleaned synthesis gas is then combusted in dual-fuel engines, fueled primarily with syngas supplemented by a small amount of diesel, to produce electricity and waste heat.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. This gasification technology has reached commercialization. The history of development includes six years of operation of the Fondotoce, Italy, demonstration plant, starting in 1994; operation of the 330 tpd Chiba, Japan, plant since 1999; operation of the 792 tpd Karlsruhe, Germany, plant since 2002; and operation of the 140 tpd Mutsu, Japan, plant since 2003. In the various plants, a nominal throughput of approximately 40,000 tpy (110 tpd) to 264,000 tpy (723 tpd) are processed. The Karlsruhe and Mutsu plants are predominately fueled with MSW. The Chiba plant has demonstrated operation fueled with MSW, but is currently processing industrial waste. Operating history has been gathered on a demonstration scale for six years at Fondotoce, Italy and commercial scale experience has been gathered for over five years. The reliability of this technology has been demonstrated by the established operating history of the reference plants.

Size and Flexibility. Interstate Waste Technologies proposes a facility made up of nine TS-120 modules (estimated 339 tpd per module and 3,051 tpd facility capacity) for an maximum annual throughput of 1.1 million tpy of MSW. The technology is sufficiently flexible due to its modular nature and can take all manner of municipal solid waste, including large bulky items, without any presorting or preprocessing.

Use of Existing Solid Waste Collection System. The technology accepts MSW with no presorting or preprocessing requirements. Therefore, the technology is compatible with the City's existing solid waste collection system.

Utility Needs. Utility requirements for this technology are well defined and tailored to the composition of New York City MSW. Interstate Waste Technologies estimates a parasitic power requirement of 302 kWh/ton MSW (based on 44,891 kW per 148.5 tph MSW). Natural gas is added to the gasification reactor at a rate of 0.0014 MMCF/ton MSW (based on 5,400 Nm³/hr per 148.5 tph MSW). Diesel fuel is consumed by the reciprocating engines at a rate of 2.7 gallons per ton MSW (based on 405 gal/hr per 148.5 tph MSW). Water is consumed by the process at a rate of

560 gallons/ton MSW (based on 2 mgd for 148.5 tph MSW). All wastewater is recycled within the process.

Beneficial Use of Waste. Gross electricity production is estimated at 862 kWh/ton MSW (128,080 kW per 148.5 tph MSW). Net electricity production after subtraction of the parasitic load is 560 kWh/ton MSW (83,188 kW per 148.5 tph MSW). Additional products produced are:

- 17 lb/ton MSW of mixed salts;
- 13 lb/ton MSW of zinc concentrate;
- 64 lb/ton MSW of metal;
- 20 lb/ton MSW of sulfur; and
- 489 lb/ton MSW of aggregate.

Marketability of Product. Interstate Waste Technologies states that all products produced are commercially useful. Electricity is a highly marketable commodity. Regarding the mixed salts, zinc concentrate, metal and sulfur, these are all commercially useful products, however, the materials might have to be sold at a discount since their rate of production is small compared to industrial suppliers and significant transportation costs may be incurred to transport the materials to an end user or distributor. Regarding the aggregate, it is likely to pass environmental concerns since it has done so in Europe, but market development for the product is likely to be required.

Quantity/Quality of Residuals Requiring Landfilling. There are no residuals leaving the plant, as everything produced leaves as a commercially useful product.

Environmental Impacts. Odor and dust from receiving and handling of MSW appears to be effectively mitigated. Air pollutants are emitted from large reciprocating engines/generators and catalytic control is proposed. There are no steady state air emissions from the gasification process and the synthesis gas is cleaned up before introduction as fuel to the engine/generators. As a renewable energy source (MSW as biomass), the technology would give a net reduction in greenhouse gas emissions. If greenhouse gas reductions become a tradable commodity in the U.S., the technology could generate carbon credits. There is water consumption, but all process water is re-used, thus there is zero wastewater discharge. No solid residue is produced requiring disposal, as it is claimed that all materials produced by the facility are marketable.

Facility Siting. Interstate Waste Technologies estimates 20 acres would be required for a 9-module (3,051 tpd) facility.

Public Acceptability. The most recent information available from the project sponsor does not address public acceptability of the technology.

Estimated Cost. Total design and construction cost for a 9-module facility processing over 1.1 million tpy of MSW (3,051 tpd) is \$457 million, which equates to approximately \$149,800 per ton of daily installed capacity for MSW. This cost

estimate includes approximately \$56 million in financing charges. The estimated annual operating cost is \$55.3 million, which results in a unit cost of approximately \$50 per ton of MSW. Interstate Waste Technologies estimates a tip fee for the project ranging from \$42-\$60 per ton of MSW. Projected revenue earned from electricity sales is based on \$65/MWh.

Associated Opportunities for Direct and Collateral Economic Growth.

Interstate Waste Technologies projects a construction force of 350, and a permanent operating labor force of approximately 100. While not providing specific examples, the company estimated that \$4 of collateral economic development and supporting service industries would be created for every \$1 invested in the project (or, over \$1.8 billion in collateral benefit).

Experience and Resources of Project Sponsor. Interstate Waste Technologies, founded in 1990, is the North American licensee for the Thermoselect technology. Interstate Waste Technologies is developing two projects using the Thermoselect technology (Caguas, Puerto Rico and the U.S. Virgin Islands), and is in negotiations to develop a third project (Curacao). Thermoselect (the patent holder) developed the technology between 1985 and 1990, which is now included in eight constructed projects in Europe and Japan, with eleven others in various stages of development in Europe and Japan. The company would develop a project for the City using a team (the IWT "Alliance") composed of Interstate Waste Technologies, Thermoselect (technology and proprietary equipment), HDR (auxiliary systems design and permitting), H.B. Zachry (construction) and Montenay Power (operations). All team members have extensive experience in their respective disciplines.

Experience of the IWT Alliance in the solid waste industry includes:

- Interstate Waste Technologies - project development activity in Puerto Rico and the US Virgin Islands; negotiations underway in Curacao; project selection in Collier County, FL;
- Thermoselect - development of the four reference projects noted, plus numerous others in development or negotiations;
- HDR - various services on over 35 large scale resource recovery projects;
- Zachry - \$1.6 billion in annual construction revenues; and,
- Montenay - operation of eleven waste-to-energy facilities in North America with 11,000 tpd total capacity.

Interstate Waste Technologies is a project development company. While financial information was not provided, the company's project development track record indicates the ability to package the necessary capabilities to develop projects. It appears that individual security instruments would be provided by team members, as appropriate. Thermoselect would provide a corporate guarantee and a letter of credit, HDR and Zachry would provide performance bonds, and Montenay would provide a corporate guarantee and a bond or other instrument if necessary.

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. IWT's preferred project delivery approach is design-build-own-operate (which it has applied on the two projects it has developed), preferably under a 30-year contract to minimize annual debt service requirements. It also expressed interest in other approaches.

Risk Profile. Regarding risk, IWT stated it would expect a New York City guarantee on the delivery of waste and the payment of tipping fees. IWT would guarantee electric power output and sale, as well as production of saleable recycled products. IWT would guarantee that no residuals requiring disposal would be produced.

6.4.6 Pan American Resources - Destructive Distillation Lantz Converter Technology

Pan American Resources, Inc., of Pleasanton, CA, is the sponsor of the Lantz Converter Destructive Distillation Technology.

In Pan American Resources' destructive distillation process, incoming MSW is pre-processed to remove large items and inorganic materials (e.g., ferrous and non-ferrous metals), leaving predominately organic material. The organic material is shredded and dried, then introduced into the Lantz Converter. The dryer may be integrated with the Lantz Converter for optimization of energy use. The Lantz Converter contains a revolving retort (stainless steel cylinder), which is devoid of air and heated externally to a temperature of 1,200 °F. Within the converter, the organic materials first break down into their elemental components, and then recombine to form a volatile gas (converter product gas or CPG) and a solid residue of activated carbon ("char") and inorganic materials (e.g., metal and glass not removed prior to processing). About 85% of the CPG is combusted in a boiler, and the steam produced in the boiler is used with a steam turbine to generate electricity. The remaining 15% of the gas is used to heat the converter.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. There are no currently operating facilities, and there is no history of continuous commercial operation with MSW. However, Lantz Converter demonstration equipment with a capacity of four tpd of dried, shredded waste (prepared from six tpd of MSW) was operated in California from 1962 to 1991. This prototype unit also processed other, unspecified types of waste. Also, a Department of Energy test was conducted for MSW on a 50-tpd Lantz Converter for a period of more than two years. The dates of the test are not provided. In addition, the technology has been operated commercially with various other feedstocks (e.g., to convert woodchips to charcoal).

Size and Flexibility. The technology has a modular design (100 tpd per unit), which affords flexibility. The minimum plant capacity is reported to be 300 tpd, configured with three converters. Pan American Resources notes that a 2,000 tpd facility should be feasible, if land is available for the footprint. Pan American Resources suggests design and installation of a 1,000 tpd facility for New York City, equipped with six, 100-tpd Lantz Converters (1,000 tpd received, 600 tpd processed through

the converters). This represents a unit size scale-up of 2:1 compared to the largest unit to date of 50 tpd size. The MSW must be presorted, shredded and dried prior to introduction into the Converter. Removal of approximately 10% of the total MSW received is assumed to occur up-front in the process. It is assumed by the proponent that another 10% of inorganic material enters the dryer and Lantz Converter as part of the shredded MSW feed.

Use of Existing Solid Waste Collection System. This technology is compatible with the existing New York City solid waste collection system since MSW is the feedstock. The MSW is processed at the proponent's facility to remove some recyclables and inorganics, and then further processed (shredded and dried) before introduction into the Lantz Converter.

Utility Needs. Facility electric use is estimated at 113 kWh/ton, based on 2,350 kW for a 500 tpd facility. Natural gas use is not discussed in the proposal, but its use for startup heating is assumed. Fifteen percent of the converter process gas is used for self-sustaining heating of the retort. The quantity of water use is not discussed, although there will be a Hydrosonic Scrubber, a cooling tower and a steam cycle (which require water consumption). Wastewater is recycled back into the process, resulting in no wastewater discharge.

Beneficial Use of Waste. Gross electric output is predicted to be 427 kWh/ton of MSW received based on 8,896 kW for a 500 tpd plant size. Net electricity exported is estimated at 314 kWh/ton of MSW received, by taking the difference between the gross output (427 kWh/ton) and the parasitic load (113 kWh/ton). The converter product gas production rate is estimated at 10 million Btu (MMBtu) per ton of MSW, based on 208 MMBtu/hr for a 500 tpd facility. Net gas production is stated to be 79% to 85% (different figures are given in different sections of the proposal), since some of the gas is used to heat the retort. The converter process gas differs from synthesis gas and is unique to this technology, in that the CPG is predominately methane with some carbon monoxide and other organic gases, while synthesis gas is primarily hydrogen and carbon monoxide. Additional products expected from the presorting process are:

- 78 lb ferrous metals/ton MSW; and
- 18 lb aluminum/ton MSW.

These quantities are based on waste composition somewhat similar to New York City's MSW, based on a proposal the company prepared for Alameda County, California.

Marketability of Product. Electricity is a highly marketable product. Ferrous metals and aluminum are marketable commodities but prices can be volatile.

Quantity/Quality of Residuals Requiring Landfilling. The rate of residue formation is estimated to be 272 lb/ton MSW (14% by weight), of which about half would be char and half would be inorganics. It is unclear whether this quantity accounts for the specific composition of New York City MSW, particularly

considering the large amount of bulky waste in the City's MSW. The quantity and disposal requirements of residuals from the Hydrosonic Scrubbing system are not addressed. The residue is assumed by the project sponsor to be a benefit to any receiving landfill, as a cover material, and thus no tipping fee would be required. The char, similar to activated carbon, could act as a beneficial material in a landfill in order to immobilize other toxins present in the landfill waste. The ability to use the material as landfill cover with no tipping fee would need to be demonstrated.

Environmental Impacts. There is potential for odor and dust emissions from handling of the MSW, but control is not addressed. Air emissions from the combustion of the converter process gas are to be expected, but they will be less than traditional WTE combustion of solid fuel. A net reduction in greenhouse gas emissions can be expected due to the renewable fuel status of MSW. Accordingly, carbon credits may be generated if a greenhouse gas emissions trading program is implemented in the U.S. Water is conserved through the ability to recover and reuse the water content of the MSW. Generation of wastewater is not discussed. The carbon char residue component is claimed to be non-toxic and claimed to have use as a landfill cover; supporting data was not available for review.

Facility Siting. The RFI response suggested the concept of multiple facilities developed in light industrial zones surrounding the metropolitan area. The project sponsor also noted that proximity to a substation, for sale of electricity, is desired. Acreage requirements were not provided.

Public Acceptability. The most recent information available from the project sponsor does not address public acceptability of the technology.

Estimated Cost. The estimated construction cost for a 1,000-tpd (6 MW) plant (with 600 tpd through the converters) is approximately \$60 million, or \$100,000 per ton of daily installed capacity. Operating costs were estimated to be less than \$20/ton of MSW. An estimated tipping fee was not provided, however, Pan American Resources referred generally to a "tipping fee competitive or lower than local landfill fees...". The company estimated potential annual product sales revenues from a 1,000 tpd plant to be \$9.6 million (electric power at \$50/MWh, ferrous metals at \$20/ton, and aluminum at \$0.42/lb).

Associated Opportunities for Direct and Collateral Economic Growth. Pan American Resources did not discuss direct or collateral economic benefits except for a projection of approximately 30 permanent operating positions and references to potential MSW-related cost savings to New York City (principally reduced transportation and landfill use).

Experience and Resources of Project Sponsor. Pan American Resources originally held a patent for the Lantz Converter, but it expired in 1998. The company states that it has made several patentable improvements and that these improvements will be treated as trade secrets and proprietary information. The company operated an applied research and development facility for MSW until 1991 (four tpd unit in California), and now plans to upgrade equipment and provide new

demonstration capability. Pan American Resources suggested locating its four-tpd pilot unit within New York City as a research and development facility, at a “reactivation” cost of about \$1 million. While the company discussed several reference facilities, including five previous installations and eight years of operating experience, none were primarily for municipal solid waste. Also, they were relatively small in size and do not appear to be recently or currently in operation. The company’s current activities in the industry are unclear. Their role in the various cited projects does not appear to encompass the full range of design, construction and operation. No discussion of product marketing was provided.

Pan American Resources is a publicly-traded company, but financial information was not available for review. Since it has no commercial facilities in operation, it has no recent history with financial guarantees. It stated that it and its general contractor would “provide the necessary construction operations performance bonds,” but did not provide evidence of its ability to do so. It noted that it is exploring the potential for joint venturing with a strategic financial partner.

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. Pan American Resources expressed its preference for private ownership and operation.

Risk Profile. Pan American Resources did not discuss risk and risk profiles in detail. It referred to guaranteed waste stream and tipping fee payment arrangements under long term contracts as integral to its preferred private ownership and operation approach. It did not specifically discuss aspects such as performance guarantees, but noted that it would “not relinquish responsibility to maintain the facility over its lifetime,” and stated that it would be responsible for residue disposal and product marketing.

6.4.7 Rigel Resource Recovery - Westinghouse Plasma Gasification and Tempico Materials Recovery Facility

Rigel Resource Recovery and Conversion Company (Rigel), located in Baltimore, MD, is the project sponsor for the combination of the Westinghouse Plasma Gasification and Tempico Rotoclave technologies with a materials recovery facility (MRF).

Rigel proposes a waste diversion facility (WDF) coupled with a waste conversion facility (WCF). Approximately 10% of the incoming MSW would be passed to the WDF for recovery of recyclables. The remaining MSW, along with the residuals from the WDF, would be processed in the waste conversion facility. The WCF could also accept specialty wastes such as harbor dredge materials, used oil, contaminated soil, and various other types of waste.

The Waste Diversion Facility is based on the Rotoclave system developed and owned by Tempico. “The Rotoclave subjects MSW to high temperature and pressure steam. The combination of mechanical action and vapor-phase processing sterilizes the waste, repulps the fiber content of the waste, materially reduces the volume of the waste stream, and

conditions the product for further mechanical separation and recycling. All of the separation occurs without manual intervention.”

The Waste Conversion Facility is based on the Westinghouse Plasma gasification system and is combined with emissions and waste handling infrastructure engineered by Recovered Energy, Inc. “The plasma gasification process uses high temperature (up to 8,000°F) ionized air, called plasma, to gasify carbon based materials into an energy rich fuel gas with a BTU value about 1/3 that of natural gas.” The fuel gas is cleaned and cooled so that it can be used in a gas turbine, with a small supplement of natural gas, to generate electricity. Inorganic materials leave the plasma reactor as molten liquid and are separated into metals and a glassy slag.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. There are 3 commercial applications of the Westinghouse Plasma gasifier in Japan that process MSW, and a 72-tpd pilot facility in Pennsylvania. The largest Japanese Westinghouse Plasma plant size is 300 tpd. Fifty Rotoclaves are operating commercially, but not with MSW. The Tempico Rotoclave is commercially used for medical waste and has been piloted for MSW. The proponent indicates that a commercial facility incorporating both technologies with a materials recovery facility (MRF) could be developed within four years.

Size and Flexibility. Rigel considers a 1.1 million tpy (3,000 tpd) gasification facility (i.e., the WCF) to be economical, based on six, 500-tpd plasma gasifiers. Rigel is more conservative in its proposal for installation of the Rotoclaves, which are less well proven on MSW, and plans two, 180-tpd units for “initial installation”. Both the gasifiers and the Rotoclaves are modular units and, as such, provide operating flexibility. Size reduction of the MSW prior to introduction into the Rotoclave or gasifier may or may not be required. The facility process flow diagram indicates that size reduction capability will be integral to the plant.

Use of Existing Solid Waste Collection System. This technology is compatible with the existing New York City solid waste collection system since unsorted MSW is the feedstock.

Utility Needs. The facility’s electricity use is not stated in the proposal, however, plasma torch electricity consumption is stated to be 100 kWh/ton MSW. Supplemental natural gas cofired in the combustion turbine with the fuel gas would be used at a rate of 0.0018 MMCF/ton MSW. Plant water consumption is estimated at 230 gal/ton MSW. Wastewater will be generated and treated at the site, although its quality and quantity are undefined.

Beneficial Use of Waste. Gross electricity produced by the facility is estimated at 1,000 kWh/ton MSW. Net export is estimated at 900 kWh/ton MSW after deducting the plasma torch consumption. Plant electricity consumption in addition to the plasma torch is not quantified and has not been deducted in calculation of net electricity production. Of the electricity produced, up to 76% could be considered

renewable, based on the proportion of syngas (on a heat input basis) used to fuel the combustion turbines. The remaining 24% of the electricity would be considered coming from a fossil source, since this quantity represents the natural gas consumption in the combustion turbines (on a heat input basis). The syngas is produced at a rate of 6.3 MMBtu/ton MSW and all syngas goes to the combustion turbine (i.e., none of the gas is used for process requirements). Production of additional byproducts from the gasifier, based on 3,000 tpd MSW and apparently based on the composition of New York City MSW, is estimated at:

- 343 lb glassy slag/ton MSW (based on 42,867 lb/hr); and
- 96 lb metals/ton MSW (based on 12,029 lb/hr).

Rigel also claims to be able to recover paper fiber for repulping, beyond the normal separation of clean, recyclable paper. However, further information is not available.

Marketability of Product. Electricity is an existing commercial product and is expected to be readily sold to the grid. The recovered metal product is also saleable, but the market is volatile. Market development is required for the glassy slag. To that end, addition of a glass manufacturing plant at the facility is proposed to make value added products. Markets for other recyclables such as fiber pulp, plastics and ferrous and non-ferrous metals from the MRF and Rotoclave are not discussed in the proposal.

Quantity/Quality of Residuals Requiring Landfilling. Rigel states that less than 1% of the incoming MSW will end up as residue requiring disposal in a landfill. That would amount to less than 20 lb residuals per ton of MSW. It is unclear whether this estimate is based on the composition of New York City MSW. While the characteristics or origins of the residuals are not discussed, a landfill cost of \$85/ton is estimated for this waste stream.

Environmental Impacts. The proposed facility presents the potential for dust and odor emissions from handling in the WDF. Air pollutant emissions will be generated by combustion of the fuel gas, and supplemental natural gas, in the combustion turbine, but they will be much less than for conventional waste-to-energy. As a renewable energy source (MSW as biomass), the technology would give a net reduction in greenhouse gas emissions. If greenhouse gas emissions trading is implemented in the U.S., this technology has the potential for generating carbon credits.

Facility Siting. According to Rigel, a 3,000 tpd facility would require approximately 35 acres.

Public Acceptability. The most recent information available from the project sponsor does not address public acceptability of the technology.

Estimated Cost. Rigel estimated a total project capital cost of \$800 million, which includes a 350 tpd WDF and a 3,000 tpd WCF, as well as a glass manufacturing plant. This cost is equivalent to approximately \$238,800 per ton of daily installed

capacity. Annual operating costs were estimated at \$58.5 million per year, or \$160/ton MSW. After netting out the sale of power (\$60/MWh), glass products (\$2/ton) and metals (\$5/lb), Rigel estimated a tipping fee in the \$75-\$85/ton MSW range. Operating costs specific to the glass manufacturing operation were not provided.

Associated Opportunities for Direct and Collateral Economic Growth. Rigel cited 300 permanent operating positions, plus construction employment. While not providing specific information, it discussed collateral benefits such as employment at the glass manufacturing operation, the provision of low cost energy locally (and diversity of fuel source), availability of secondary materials to local secondary markets, and the ability to process other, more difficult locally-generated wastes (medical, hazardous, dredging spoils).

Experience and Resources of Project Sponsor. The rights to the proprietary technologies are held by the providers, from whom Rigel would purchase equipment. The company will purchase equipment from Tempico, without license fees, and stated that it is entering into a licensing agreement with Recovered Energy to access the Westinghouse Plasma technology. Rigel has no direct experience with the technology or in project development and operation of solid waste facilities, although its principals have considerable experience in the development of power projects, including projects in New York City. The company has no operating experience in the solid waste industry.

While Rigel, as project sponsor, has no direct experience with the technology, the providers of the two principle components (the Tempico Rotoclave and the Westinghouse Plasma Gasification System) cite numerous installations. The Tempico Rotoclave is commercially used for processing medical waste (50 installations worldwide), and has been pilot tested for MSW. The Westinghouse equipment is currently in use in three MSW processing applications in Japan (worldwide, 100 plasma gasification plants process other types of waste materials). Recovered Energy has partnered with a company that would manage the glass processing operation.

Rigel pointed to significant potential annual revenues from product sales: power, \$80 million; glass, \$8 million; metals, \$1.25 million, although no experience in marketing these products (with the exception of the power experience of its principals) is evident. Rigel did not provide any financial information for review and did not discuss project security measures.

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. Private ownership and operation is acceptable to Rigel. The company cited the potential to apply a not-for-profit ownership/financing approach, which is the preferred project development option. Rigel stated that it has access to financing through Recovered Energy.

Risk Profile. Rigel stated that, while under the not-for-profit approach any direct guarantees provided would be limited, with respect to project development and

operation and product marketing it would assume “all risk.” The company would require a put-or-pay waste delivery/tipping fee payment guarantee from the City for 60%-80% of facility capacity for 10-25 years. However, the company would be open to an arrangement that would enable the City to deliver more waste than the guaranteed amount, under negotiated terms.

6.4.8 Taylor Recycling Facility - Gasification of Biomass after Detailed Upfront Sorting/Separation

Taylor Recycling Facility, LLC, located in Montgomery, NY, is the project sponsor of the specialized recycling methods and biomass gasification process.

The proponent’s proprietary waste management system consists of up-front sorting and separating of the MSW into recyclable product streams including glass, paper, metals, aggregate, and textiles. Additional components considered unsuitable for recycling or introduction into the biomass gasifier will be diverted to landfilling as daily cover material or as bypass material (e.g., latex paints, tires, TVs/CRTs, computers and electronics). The remaining biomass feedstock, which will include wood, food, paper, paperboard boxes and natural textiles, and will also include plastics, will be shredded and then converted to high-value synthesis gas in a biomass gasifier. The cleaned synthesis gas may then be used for generation of steam, heated air or renewable energy in the form of electricity by combustion in boilers, combustion turbines or reciprocating engines.

The evaluation of the technology using the comparative criteria results in the following assessment:

Readiness and Reliability. There are no operating facilities. Taylor is currently completing detailed design for a 300 tpd reference plant (gasifier and reciprocating engines) to be constructed at their existing recycling plant in Montgomery, NY. In the late 1990’s, the biomass gasifier intended for the project was successfully operated at a pilot scale (10 tpd) and integrated with a gas turbine generating system, with refuse derived fuel (RDF) as a feedstock. Taylor has demonstrated expertise in the detailed sorting and recycling of construction and demolition wastes and intends to transfer that expertise to detailed, up-front recycling of MSW.

Size and Flexibility. Taylor proposes a scenario assuming two MRFs with 1,000 tpd MSW feed capacity would serve one 600-tpd gasification facility. Overall processing capacity would be increased by building more facilities. The 1,000-tpd MRFs would be constructed with two 500-600 tpd front-end processing lines. The 600-tpd gasification facility would consist of two, 300-tpd gasifiers. The concept is that the gasification facilities would be located at every other recycling facility (i.e., located on the property of one out of two recycling facilities). Although the design is modular, the small scale of the facilities represents somewhat less operating flexibility than other, larger scale facilities proposed by other project sponsors of gasification technologies. Due to the detailed upfront MRF, the processed MSW fed to the gasifiers will be uniform, perhaps resulting in a more uniform quality of synthesis gas.

Use of Existing Solid Waste Collection system. This technology is compatible with the existing New York City solid waste collection system since MSW is the feedstock. The MSW is sorted at the proponent's facility to remove a significant fraction of recyclables and then further processed (i.e., shredded and dried). The processed MSW is fed to gasifiers at the site or transported to a nearby facility that is equipped with a gasification plant.

Utility Needs. The electric use of a Taylor facility is estimated to be 125 kWh/ton MSW. Natural gas is used for startup and a flare pilot only and is not quantified. The gasifier is a net generator of water, however, if steam is exported from the facility, additional makeup water would be needed. A package wastewater treatment plant is part of the gasification system design. The wastewater process rate is 50 gal/ton MSW, and the treatment plant would use "pH adjustment, charcoal filter, etc." for cleanup to near drinking water standards. Rather than discharge the wastewater, it would reportedly be of sufficient quality for export to other industries for process water.

Beneficial Use of Waste. Gross electricity production is estimated at 483 kWh/ton MSW and net electricity production is 358 kWh/ton MSW. Syngas production is 9.6 MMBtu/ton MSW. Additional materials recovered or products produced by a Taylor facility will include:

- old corrugated cardboard (OCC);
- mixed paper;
- ferrous and non-ferrous metals;
- glass;
- ceramics;
- aggregates;
- reusable mixed textiles;
- PET bottles;
- PVC siding;
- alternative daily cover (ADC); and
- gasifier ashes for cement block manufacture.

Estimated quantities of the additional products are not given.

Marketability of Product. Electricity is the main marketable product, although recovery of useable products from upfront recycling represents almost 25% of the incoming MSW. The proposer demonstrates expertise in finding many specialized markets for recovered products. Gasifier ashes may be of higher quality than residuals from other gasification processes due to the extensive cleanup of the MSW prior to introduction into the gasifier, and therefore possibly more marketable as a construction material. However, it is not clear whether or not the ash is a vitrified product, which is a desirable characteristic. Market development will be required.

Quantity/Quality of Residuals Requiring Landfilling. Residuals and bypass materials may range from 1%-25% of the incoming MSW, depending on the mix of

waste, with the higher end of the range probably more applicable to New York City MSW. This range translates into 20-500 lb/ton MSW. It appears that household hazardous waste would require source-separation or would be separated in the front-end process, and it is assumed that this will be part of the bypass waste shipped off-site for disposal. Residuals in the form of fines from the MSW screening process will require landfilling.

Environmental Impacts. Conventional controls are proposed for containment of odor and dust emissions due to processing of MSW. While air pollutant emissions from combustion of the syngas will likely be less than for conventional WTE, air pollution controls and/or syngas cleanup is not specifically defined. Since the RDF is a renewable fuel, it will result in a net reduction in greenhouse gases through displacement of fossil fuel generated power. Should greenhouse gas trading be adopted in the U.S., carbon credits will likely be generated by the facility.

Facility Siting. The 300 tpd demonstration gasifier is planned to be sited at the existing Taylor recycling facility in Montgomery, NY. No information was provided regarding required acreage.

Public Acceptability. The most recent information available from the project sponsor does not address public acceptability of the technology.

Estimated Cost. Taylor proposed expanding one of its operating MRFs to process MSW, by adding a gasifier with reciprocating engines for power generation. Taylor estimates the cost of the expansion at \$23.1 million for a 300 tpd plant, or \$77,000 per ton of daily installed capacity. Annual operating costs of \$2 million (\$18 per ton of MSW) and electric power revenues of \$2 million (growing to \$4 million with the addition of more generating equipment) are expected at the demonstration facility. A tipping fee was not estimated.

Associated Opportunities for Direct and Collateral Economic Growth. Taylor projects a construction workforce of 25 for the gasifier installation, plus an additional 17 to expand its current waste processing facilities, and a permanent operating labor force of 26 over its current levels. Current staffing levels were not specified.

Experience and Resources of Project Sponsor. Taylor operates two waste processing facilities (in New York and Iowa), primarily for construction and demolition (C&D) waste, which it developed over time using its own resources. The NY facility has been operating since 1987, and the Iowa plant started-up in June 2004. The company managed the processing of 550,000 tons of World Trade Center debris. The company does not control the gasification technology and anticipates licensing it from the proprietary owner. Taylor stated that it does not have the financial resources to develop the proposed demonstration project and would seek New York City financial support for its development. The company's experience is primarily in the area of C&D and land-clearing waste processing and materials recovery. It has not developed a project that is aimed primarily at MSW.

Taylor has no direct experience in the development or operation of the gasification/electric power technology, although it has invested over \$1 million of its own funds in the development of the concept. The gasification technology was initially developed in the 1970s by Battelle, and a 10-tpd demonstration plant was tested by Burlington (VT) Electric in the late 1990s. Through operation of its existing facilities, Taylor has experience marketing recovered products (e.g., gypsum, mulch and daily landfill cover)

Taylor is a small, privately-owned business with annual revenues of approximately \$4.5 million. Financial information was not available for review for this study, but Taylor offered future financial disclosure “as needed.” The company stated that it did not, at this time, possess the capability to provide bonds or letters of credit.

Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility. Taylor expressed its willingness to participate in a variety of project delivery approaches, and stated that the project it has proposed would be developed on a design-build-own-operate basis.

Risk Profile. Taylor did not discuss risk and risk profiles in depth. The company did discuss the need for public funding of the proposed project (for up to a 10 year term).

7.0 COMPILATION OF COMPARATIVE EVALUATIONS

7.1 INTRODUCTION

Step 3 consisted of a comparative evaluation of fourteen new and emerging solid waste management technologies (presented in Section 6). In this Section, the comparative evaluations are compiled in a series of tables that present available data and categorize technologies based on the comparative criteria. A comparison to conventional waste-to-energy technology is also provided. A discussion of the compilation of results follows.

7.2 READINESS AND RELIABILITY

Readiness and reliability were established as comparative criteria, to distinguish technologies that are commercially processing MSW (in the U.S. or in other countries) from those technologies that are currently in the development stage. Table 7-1 categorizes the technologies as "Commercial" or "Pilot" for MSW. "Commercial" means a facility is in operation and accepting MSW on a constant basis as an established disposal mechanism. "Pilot" means one or more units were constructed and tested using MSW as a feedstock. Technologies that are only in the pilot (demonstration) stage are further categorized as being more or less advanced. "More Advanced" pilot technologies are expected to be able to achieve commercial status within five (5) years. "Less Advanced" pilot technologies are expected to require up to ten (10) years to achieve commercial status.

All five of the anaerobic digestion technologies and half of the thermal technologies (four of eight) are already in commercial operation for MSW. Anaerobic digestion technologies have a greater number of plants in commercial operation, with capacities generally ranging from 100-500 tpd. These anaerobic digestion technologies are commercially operational in Canada, Europe, the Netherlands, and Israel. The thermal technologies have fewer facilities in commercial operation, but these facilities generally have larger capacities (300-800 tpd). These thermal technologies are commercially operational in Japan, Italy and Germany. The emerging technologies that are in commercial operation overseas and in Canada can be compared to conventional waste-to-energy. Waste-to-energy has been commercial in the United States for several decades and is demonstrated to be a proven and reliable method of waste disposal. Currently, there are close to 100 waste-to-energy facilities in operation in the U.S., processing a combined total of almost 95,000 tpd of MSW. These facilities have rated design capacities ranging from small, modular units (less than 100 tpd) to as much as 3,000 tpd.

Three emerging technologies included in this study are not yet in commercial operation for MSW (in the U.S. or elsewhere), but have advanced past previous development hurdles and could likely achieve commercial status within five years. These technologies are: (1) the Masada CES OxyNol hydrolysis technology, which has received permits for the first commercial facility to be constructed in Middletown, NY, and is in the final stages of project financing; (2) the GEM America gasification technology, which has four projects under development in Europe and is expected to achieve commercial status within one year, and (3) the Dynecology briquetting and gasification technology, which is commercially

**Table 7-1. Comparative Evaluation
Readiness and Reliability**

Commercial for MSW			Pilot for MSW
	No. of Plants ⁽¹⁾	Largest Facility Capacity	More Advanced
Conventional Waste-to-Energy⁽²⁾	98	3,000 tpd	<p>Hydrolysis</p> <p>Masada Oxydol • First commercial plant has been permitted in NY, and is in final stage of financing.</p> <p>Thermal</p> <p>GEM America • Four projects under development; commercialization expected within one year.</p> <p>Dynecology • Technology is commercially operational with other waste types; pilot testing completed for briquette fuel at 700 tpd.</p>
Anaerobic Digestion			
Arrow Ecology and Engineering	1	210 tpd	
Canada Composting	26	330 tpd ⁽³⁾	
Orgaworld	2	96 tpd	
Organic Waste Systems	9	137 tpd	
Waste Recovery Systems	13	542 tpd ⁽⁴⁾	
Thermal			
EBARA	6	432 tpd	
Global Energy Solutions	2	N/A	
Interstate Waste Technologies	2	792 tpd	
Rigel Resource Recovery	3	300 tpd	
Definitions			Less Advanced
<p>Commercial for MSW means a facility is in operation and accepting MSW as an established disposal mechanism (i.e., commercial does not apply to projects under development or facilities that were constructed for the purpose of conducting testing and further developing the technology.</p> <p>Pilot for MSW means one or more units were constructed and tested using MSW as a feedstock. "More Advanced" pilot technologies are expected to be able to achieve commercial status within 5 years. "Less Advanced" pilot technologies are expected to require up to 10 years to achieve commercial status.</p>			<p>Thermal</p> <p>Pan American Resources • No operating facilities (commercial or pilot); piloted for MSW at 6 tpd and at 50 tpd.</p> <p>Taylor Recycling Facility • No operating facilities (commercial or pilot); piloted for MSW at 10 tpd; 300 tpd reference plant in design stage.</p>

(1) In commercial operation and processing MSW.

(2) Integrated Waste Services Association, 2002 Directory of Waste-to-Energy Plants in the U.S.

(3) Capacity shown is the largest of Canada Composting's 2 commercial plants.

The capacity of the licensor's (BTA's) other commercial facilities was not available for the study.

(4) Largest of the 5 Valorga plants identified in the RFI response.

(5) N/A indicates information not available for the study.

operational with other waste types and has successfully completed large-scale testing for briquette fuel in Germany.

Two thermal technologies have demonstrated initial development in the U.S. through pilot testing using MSW as a feedstock, but require further pilot or demonstration testing to overcome development hurdles and achieve commercialization. These companies are Pan American Resources and Taylor Recycling Facility, and are likely to require up to 10 years to achieve commercialization.

7.3 FACILITY SIZE AND DESIGN FLEXIBILITY

Facility size and design flexibility were established as comparative criteria, to identify technologies that are more tolerant of varying waste quantities and composition. Table 7-2 categorizes the technologies as "Most Flexible", "Somewhat Flexible" or "Least Flexible" in consideration of facility size and design flexibility:

- **"Most Flexible"** applies to technologies that are accommodating of various types of waste (including unsorted MSW) and a wide range of capacities. No presorting or preprocessing of MSW is required. Conventional waste-to-energy would be categorized as "Most Flexible" because of the wide range of flexibility in unit capacity and overall facility size, and the great tolerance for varying waste composition with no up-front processing.
- **"Somewhat Flexible"** applies to technologies that are accommodating of various types of waste (including unsorted MSW) and a range of capacities. However, preprocessing for MSW is required, and may include sorting, shredding, granulation, drying, or a combination of these processes.
- **"Least Flexible"** applies to technologies with waste composition or capacity limitations.

All of the innovative technologies are modular, which provides some flexibility for developing a facility that meets customer-specific size requirements. In general, thermal and hydrolysis technologies tend to have larger unit capacities (and correspondingly larger facility capacities) than digestion technologies. The technology sponsors for the digestion technologies tend to promote projects that range in capacity from 300-600 tpd, while the thermal and hydrolysis technology sponsors tend to promote projects that are as much as an order of magnitude larger (3,000 tpd). While all of the technologies offer some flexibility in size, none of the technologies included in this study are operating commercially at a capacity that might be envisioned for New York City (i.e., greater than 1,000 tpd) or that exist for conventional waste-to-energy (up to 3,000 tpd).

The most pronounced distinction between technologies for design flexibility pertain to waste composition. Three thermal technologies are categorized as "Most Flexible", offering the greatest level of tolerance for varying waste composition with no preprocessing. These technologies are sponsored by Global Energy Solutions, Interstate Waste Technologies, and Rigel Resource Recovery. The other thermal technologies and the hydrolysis technology are "Suitably Flexible", because they can accept and process MSW within a

**Table 7-2. Comparative Evaluation
Facility Size and Design Flexibility**

Most Flexible	Somewhat Flexible
<p><i>Conventional Waste-to-Energy</i></p> <p><u>Thermal</u></p> <p>Global Energy Solutions</p> <p>Interstate Waste Technologies</p> <p>Rigel Resource Recovery</p>	<p><u>Hydrolysis</u></p> <p>Masada Oxynol</p> <p><u>Thermal</u></p> <p>Dynecology</p> <p>EBARA</p> <p>GEM America</p> <p>Pan American Resources</p> <p>Taylor Recycling Facility</p>
Least Flexible	
<p><u>Anaerobic Digestion</u></p> <p>Arrow Ecology and Engineering</p> <p>Canada Composting</p> <p>Orgaworld</p> <p>Organic Waste Systems</p> <p>Waste Recovery Systems</p> <ul style="list-style-type: none"> • For all of the anaerobic digestion technologies, mixed MSW can be accepted and sorted, but only the organic fraction is digested. Facility design would require an up-front MRF to recover recyclables and remove non-recyclable inorganics. Compost quality, and marketability, will be negatively impacted when processing mixed MSW as compared to source-separated organic waste. Also, optimal facility sizes are reported to be less than 600 tpd. 	

Most Flexible: Accommodating of various waste types (including mixed MSW) and a wide range of capacities. No presorting or preprocessing of MSW is required.

Somewhat Flexible: Accommodating of various waste types (including mixed MSW) and a range of capacities. However, preprocessing of MSW is required including sorting, shredding, granulation, drying, or a combination of these processes.

Least Flexible: Waste composition and/or capacity limitations, as noted.

large range of capacities. However, these technologies are designed to process only the organic fraction of the waste, and require upfront processing. The digestion technologies are the "Least Flexible". These technologies have smaller facility capacities, and are intended to process only the organic fraction of MSW. While the anaerobic digestion technologies can accept MSW with integrated, up-front processing, compost quality and marketability are expected to be negatively impacted when processing MSW (as compared to source-separated organics).

7.4 UTILIZATION OF EXISTING CITY SOLID WASTE COLLECTION SYSTEM

This criterion was applied to evaluate the ability of the innovative technologies to use the existing City solid waste collection system. The results, compiled in Table 7-3, reveal that all of the technologies are compatible with the existing solid waste collection system. However, four of the anaerobic digestion technologies would benefit (i.e., enjoy enhanced product quality) from processing source-separated organics instead of MSW: Canada Composting; Orgaworld; Organic Waste Systems, and Waste Recovery Systems. Therefore, a new collection system for source-separated organics would be beneficial (although not required) for these four technologies.

7.5 UTILITY NEEDS

Table 7-4 summarizes available information on the utility needs of the individual technologies. Insufficient information was available for the study to categorize the technologies based on utility requirements, or make meaningful comparisons to utility needs of conventional technology.

7.6 BENEFICIAL USE OF WASTE AND MARKETABILITY OF PRODUCTS

Beneficial use of waste and marketability of products were established as evaluation criteria to identify and distinguish the technologies that reuse or recycle the greatest amounts of waste and produce the most viable end products. Table 7-5 summarizes information on the primary and secondary products generated by the technologies, and the relative market strength for those products. In general, thermal and hydrolysis technologies have a stronger market for their primary products (electricity, ethanol) and a weaker market for their secondary products (recyclables, commodity chemicals, slag). In comparison, anaerobic digestion technologies have a weaker market for soil amendment, one of the primary products, but a stronger market for electricity sales (where applicable). However, the market for soil amendment could be improved through further development efforts. Similar to thermal and hydrolysis technologies, the market for recyclables recovered in the digestion processes is generally characterized as weaker (due to historical variability in market prices).

As noted above, the anaerobic digestion technologies produce a soil amendment as the primary product, typically characterized as a compost. Based on the information provided, the amount of soil amendment produced ranges from approximately 500 lb/ton of MSW to more than 800 lb/ton of MSW. In general, the technology sponsors claim a viable market

**Table 7-3. Comparative Evaluation
Utilization of City Solid Waste Collection System**

Fully Compatible with Existing Infrastructure	Compatible with Existing Infrastructure However, New Infrastructure <i>Beneficial</i>
<p><i>Conventional Waste-to-Energy</i></p> <p><u>Anaerobic Digestion</u> Arrow Ecology and Engineering</p> <p><u>Hydrolysis</u> Masada Oxynol</p> <p><u>Thermal</u> Dynecology</p>	<p><u>Anaerobic Digestion</u></p> <p>Canada Composting</p> <p>Orgaworld</p> <p>Organic Waste Systems</p> <p>Waste Recovery Systems</p> <ul style="list-style-type: none"> Assuming the facility includes an up-front, integrated MRF to recover recyclables and remove other inorganics, these technologies can receive and process mixed MSW. However, compost quality could be impacted and may not be marketable as a product. For these anaerobic digestion technologies, performance would be enhanced if new infrastructure were established to provide source-separated organics.
<p>EBARA</p> <p>GEM America</p>	<p align="center"><i>New Infrastructure Required</i></p>
<p>Global Energy Solutions</p> <p>Interstate Waste Technologies</p> <p>Pan American Resources</p> <p>Rigel Resource Recovery</p> <p>Taylor Recycling Facility</p>	<p align="center"><i>None</i></p>

**Table 7-4. Comparative Evaluation
Utility Needs**

Technology	Electricity⁽¹⁾	Fuel⁽²⁾	Water	Wastewater
<i>Conventional Waste-to-Energy</i>	60-75 kwh/ton	variable	variable	can be none
<u>Anaerobic Digestion</u>				
Arrow Ecology and Engineering	50 kwh/ton	N/A	none	N/A
Canada Composting	75 kwh/ton	N/A	92 gal/ton	181 gal/ton
Orgaworld	N/A	N/A	none	none
Organic Waste Systems	60 kwh/ton	none	negligible	103 gal/ton
Waste Recovery Systems	N/A	N/A	none	N/A
<u>Hydrolysis</u>				
Masada Oxydol	N/A	N/A	N/A	N/A
<u>Thermal</u>				
Dynecology	460 kwh/ton	1073 lb/ton ^(c) 490 lb/ton ^(d)	N/A	N/A
EBARA	N/A	N/A	N/A	N/A
GEM America	12 kwh/ton	N/A	none	none
Global Energy Solutions	N/A	N/A	N/A	N/A
Interstate Waste Technologies	302 kwh/ton	0.0014 mmcf/ton ^(a) 2.7 gal/ton ^(b)	560 gal/ton	none
Pan American Resources	113 kwh/ton	N/A	N/A	none
Rigel Resource Recovery	N/A	0.0018 mmcf/ton ^(a)	230 gal/ton	N/A
Taylor Recycling Facility	125 kwh/ton	N/A	none	50 gal/ton

(1) Electricity required for process operation.

(2) Supplemental, auxiliary fuel

(a) natural gas

(b) diesel

(c) coal

(d) sewage sludge cake

(3) N/A indicates information not available for the study.

**Table 7-5. Comparative Evaluation
Beneficial Use of Waste and Marketability of Products**

Technology	Primary Product(s) Generated			Other Marketable Products	
	Product	Quantity (net export)	Market Strength ⁽¹⁾	Products	Market Strength ⁽¹⁾
Conventional Waste-to-Energy	electricity	500-600 kwh/ton	Stronger	ferrous metal	Weaker
Anaerobic Digestion					
Arrow Ecology and Engineering	electricity compost	290 kwh/ton N/A	Stronger Weaker	recyclables	Weaker
Canada Composting	electricity compost	100 kwh/ton 530 lb/ton	Stronger Weaker	recyclables	Weaker
Orgaworld	electricity compost	100 kwh/ton N/A	Stronger Weaker	recyclables	Weaker
Organic Waste Systems	electricity compost	150 kwh/ton 664 lb/ton	Stronger Weaker	recyclables	Weaker
Waste Recovery Systems	electricity compost	N/A 854 lb/ton	Stronger Weaker	recyclables	Weaker
Hydrolysis					
Masada Oxydol	ethanol	272 lb/ton	Stronger	recyclables, gypsum	Weaker
Thermal					
Dynecology	electricity	2607 kwh/ton ⁽²⁾	Stronger	sulfur, ammonia, slag	Weaker
EBARA	electricity	<455 kwh/ton ⁽³⁾	Stronger	metals, ash	Weaker
GEM America	electricity	175 kwh/ton	Stronger	recyclables, residuals	Weaker
Global Energy Solutions	electricity	N/A	Stronger	vitrified residuals	Weaker
Interstate Waste Technologies	electricity	560 kwh/ton ⁽⁴⁾	Stronger	aggregate, other	Weaker
Pan American Resources	electricity	314 kwh/ton	Stronger	recyclables (metals)	Weaker
Rigel Resource Recovery	electricity	900 kwh/ton ⁽⁵⁾	Stronger	metals, glassy slag	Weaker
Taylor Recycling Facility	electricity	358 kwh/ton	Stronger	recyclables, ashes	Weaker

(1) "**Stronger**" market indicates desirable commodity (i.e., established market) and stable price.

"**Weaker**" market indicates market development required, or existing market with variable price.

(2) Net elec. export attributable to MSW energy input is 37% (965 kwh/ton); other energy inputs are sludge and coal.

(3) Gross output; net output not available.

(4) Net elec. export attributable to MSW energy input is 85% (476 kwh/ton); other energy inputs are natl. gas and diesel.

(5) Net elec. export attributable to MSW energy input is 76% (684 kwh/ton); other energy input is natural gas. Plant electricity consumption other than plasma torch consumption is included in net export.

(6) N/A indicates information not available for the study.

for the soil amendment. Such claims, however, are not substantiated, and there are likely to be regulatory impediments and other hurdles to establishing a strong and viable, long-term market for soil amendment. This is particularly true for facilities processing mixed MSW rather than source-separated food waste or other source-separated organic waste. Therefore, the market for soil amendment is characterized as weaker, due primarily to the need to further develop the market (locally and regionally). Further market development could result in a stronger outlook.

Anaerobic digestion and the thermal technologies produce a biogas or synthesis gas (syngas), which is used to generate electricity. Compared to most other products, electricity is characterized as a stronger market. For the thermal technologies, electricity is the primary product of the process. The electricity is used to meet process needs, with excess sold to the grid as a commodity. Digestion technologies have a net electricity generation rate ranging from approximately 100-300 kWh/ton. Thermal technologies have a much higher net electricity generation rate ranging from approximately 200 kWh/ton to over 2 MWh/ton. In comparison, conventional waste-to-energy generates 500-600 kWh/ton of electricity (net). The gross electricity generation rate for the thermal technologies is significantly higher than for the digestion technologies or for conventional waste-to-energy, but the internal electricity needs (i.e., parasitic power requirements) are correspondingly high. Three thermal technologies (Dynecology, Interstate Waste Technologies, and Pan American Resources) routinely use other energy inputs in their process, such as sludge, coal, natural gas and diesel. These additional energy inputs stabilize the process and result in significantly higher electricity rates. The market for electricity is strong, however, many project sponsors claim a sale price that is higher than may be currently achieved.

Masada OxyNol is unique as an emerging technology, in that it generates ethanol as the primary product of the hydrolysis process. The technology generates approximately 272 pounds of ethanol per ton of MSW. Fuel grade ethanol is a highly marketable product, which has risen in value over the past few years. In addition, the prognosis for long term ethanol demand is good. Therefore, ethanol is categorized as a stronger market.

7.7 RESIDUALS REQUIRING DISPOSAL

Based on available information, the emerging technologies included in the comparative evaluation are expected to generate less than 35% residuals by weight. Therefore, the emerging technologies are comparable or preferable to conventional waste-to-energy, which can generate 30% ash residue (or more) by weight.

Table 7-6 categorizes the technologies by amount of residuals generated when processing MSW. Approximately half of the technologies generate less than 10% residuals, with five of the thermal technologies generating 0-5% residuals. These percentages assume the project sponsors would be able to fully market the products as anticipated. Also, the percentage of residuals is not necessarily based on the composition of New York City MSW, and could be higher than state. The possibility of weaker markets (e.g., for soil amendment, recyclables, some commodity chemicals, and slag) could result in higher percentages of residuals requiring landfill disposal. Also, the percentage of residuals is not necessarily based on the composition of New York City MSW, and could be higher than stated.

**Table 7-6. Comparative Evaluation
Residuals Requiring Disposal⁽¹⁾**

Up to 10% Residuals	Up to 25% Residuals	Greater than 25% Residuals
<p><u>Hydrolysis</u> Masada Oxynol (10%)</p> <p><u>Anaerobic Digestion</u> Arrow Ecology and Engineering (10%)</p> <p><u>Thermal</u> EBARA (5%) GEM America (2%) Global Energy Solutions (3%) Interstate Waste Technologies (0%) Rigel Resource Recovery (1%)</p>	<p><u>Anaerobic Digestion</u> Canada Composting (18%)</p> <p><u>Thermal</u> Pan American Resources (14%) Taylor Recycling Facility (1-25%)</p>	<p><i>Conventional Waste-to-Energy</i></p> <p><u>Anaerobic Digestion</u> Waste Recovery Systems (30%)</p>
		<p>Residual Quantity Not Available</p>
		<p><u>Anaerobic Digestion</u> Orgaworld Organic Waste Systems⁽²⁾</p> <p><u>Thermal</u> Dynecology</p>

- (1) Percentages reflect the quantity of residuals generated in relation to the amount of MSW processed. The percentages assume maximum diversion from landfill disposal (i.e., full use of products). If products cannot be marketed as proposed, residuals would increase.
- (2) Organic Waste Systems generates 9% residuals when processing source-separated organics. Information not available for processing mixed MSW, but is likely to be greater than 9%.

7.8 ENVIRONMENTAL IMPACTS

The emerging technologies were evaluated for potential environmental impacts, particularly emissions potential. While the information provided was not sufficiently detailed or verifiable through supporting documentation to provide comparison of technologies to each other by environmental performance, general conclusions can be made in comparison to conventional waste-to-energy (WTE).

All of the innovative technologies would have combustion-related emissions from energy generation. Inherent with the combustion of a gas (i.e., syngas), the emission levels from the innovative technologies of the traditional combustion-related air pollutants would be less than with conventional WTE. Emissions of dioxin and heavy metals (with the possible exception of mercury) would be substantially less with all innovative technologies, and for some technologies, negligible. This is inherent in the processes, which prevent or minimize the formation of dioxins and air emissions of metals. Potential emissions associated with individual technology categories are further discussed below:

- **Anaerobic Digestion.** Generally, the anaerobic digestion technologies entail production of a digester gas (biogas) from MSW, then combustion of the gas to generate power. Typically, these technologies do not emit air pollutants during the process of generating the gas from the MSW. However, when the biogas is combusted in a boiler, turbine, or engine to generate power, this results in the emission of the standard combustion-related air pollutants. These are the same combustion pollutants as are emitted by conventional WTE plants and fossil fuel power plants. In general, the overall emission levels would be less for these thermal technologies than for conventional WTE, since burning a gaseous fuel typically produces lower emissions than burning a solid fuel such as MSW. The anaerobic digestion technologies would have markedly lower emissions of dioxin and heavy metals than conventional WTE. The nature of the digestion process is such that conditions needed for the formation of dioxin are not present. Heavy metals present in the MSW would generally not end up in the biogas that is burned to produce power. The fate of mercury in this regard, however, likely bears further scrutiny.
- **Hydrolysis.** For the one hydrolysis process included in the Step 3, comparative evaluation (Masada), there would be emissions of combustion-related air pollutants resulting from solid residue being processed in a fluid bed gasifier to generate energy. The magnitude of the combustion-related emissions relative to conventional WTE and relative to the other innovative technologies reviewed, is uncertain. The magnitude of the emission of dioxin and heavy metals is uncertain. It is speculated that emissions of heavy metals would likely be substantially less than with conventional WTE, since, with the hydrolysis process, metals present in MSW are likely to end up in the wastewater, rather than in the air emissions stream.

- **Thermal Technologies.** Generally, the thermal technologies entail production of a synthetic gas (syngas) from MSW, then combustion of the gas to generate power. Typically, these technologies do not emit air pollutants during the process of generating the gas from the MSW. However, when the syngas is combusted in a boiler, turbine, or engine to generate power, this results in the emission of the standard combustion-related air pollutants. These are the same combustion pollutants as are emitted by conventional WTE plants and fossil fuel power plants. In general, the overall emission levels would be less for these thermal technologies than for conventional WTE, since burning a gaseous fuel typically produces lower emissions than burning a solid fuel such as MSW. In addition, some technologies pre-clean the gas of some pollutants such as sulfur, prior to the gas being combusted as a fuel. The thermal technologies would have markedly lower emissions of dioxin and heavy metals than conventional WTE. The nature of the gasification processes is such that it inherently discourages the formation of dioxin. Heavy metals present in the MSW would generally not end up in the syngas that is burned to produce power. The fate of mercury in this regard, however, likely bears further scrutiny for many of the thermal processes.

Other conclusions regarding environmental impacts follow:

- **Odor and Dust.** All of the technologies have the potential for odor and dust emissions, since all receive and process MSW. Generally, the potential for odor and dust emissions would be comparable to that of conventional WTE plants, and such emissions are controllable. The hydrolysis process (Masada) may have the potential for greater odor emissions, because it co-processes sludge (sludge processing, however, is optional). One thermal process (Dynecology) may have the potential for greater odor and dust, because it co-processes sludge and coal.
- **Greenhouse Gas Emissions.** All of the innovative technologies reviewed would likely result in a net reduction in emissions of greenhouse gases, as do conventional WTE plants. The thermal processes produce renewable energy that replaces energy that would have been produced using fossil fuels. This yields a net reduction in greenhouse gas emissions. Producing energy from the MSW instead of landfilling the MSW also avoids the emission of greenhouse gases (principally methane) that result from landfilling. Anaerobic digestion of MSW yields both energy and a compost product. This reduces greenhouse gas emissions by producing renewable energy and avoiding landfilling. Hydrolysis processes reduce greenhouse gas emissions by producing a renewable energy fuel (ethanol), renewable thermal energy (steam), and replacing landfilling of the MSW. Based on the information supplied for review at this time, it is not possible to determine if a particular innovative technology would reduce greenhouse gas emissions to a greater or lesser degree than conventional WTE or than any other innovative technology.

- **Water Use.** Generally, the information provided on water use was very limited. The indication is that the thermal processes appear to use somewhat less water than conventional WTE, but there could be exceptions. They also typically recycle process water in most cases. The digestion processes appear to use little to no water, since the inherent water content of MSW is sufficient to meet process needs. Hydrolysis appears to require substantial water for process uses, and seeks to meet that need by using treated effluent from a wastewater plant.
- **Wastewater Discharge.** From the limited information supplied, it appears that the thermal technologies and the digestion technologies would have little to no wastewater discharge. This is similar to conventional WTE plants. No information was available regarding wastewater discharge for the hydrolysis process. Based on a technical review, the hydrolysis process likely has a substantial wastewater discharge.
- **Noise and Traffic.** Noise and traffic impacts were generally not discussed by the technology sponsors, but are expected to be similar to those of conventional WTE plants.
- **Aesthetics.** All of the innovative technologies reviewed would utilize modern, industrial architecture. Some of the thermal and digestion processes, as well as the hydrolysis process, would have a somewhat more industrial appearance (large tanks, etc.) With the exception of anaerobic digestion, all of the innovative processes would require some sort of stack to exhaust combustion emission related to energy generation.

7.9 ESTIMATED COST

The RFI requested information on project economics including capitals cost, annual operating and maintenance costs, annual income from sale of products and tip fees, and potential economic development opportunities. Limited cost information was provided by some of the technology sponsors, while others provided no cost information. Little, and in most cases no, supporting information was provided for projected costs. Information that was provided is compiled in Table 7-7. Tip fees projected by technology sponsors range from approximately \$42 to \$90 per ton, which is generally comparable to conventional waste-to-energy costs, but such tip fees cannot be verified with the limited information provided.

Some, but not all, of the project sponsors addressed the potential opportunities for economic growth associated with development of an innovative waste processing technology. Overall, opportunities appear to be generally applicable to most technologies, rather than technology specific. Opportunities include construction employment and permanent operating positions. Collateral benefits include the provision of low cost energy locally (and diversity of fuel source), delivery of secondary materials to local secondary markets, and in some cases the ability to process other, more difficult locally-generated wastes (medical, hazardous, dredging spoils). One project sponsor (Masada) estimated collateral economic benefit of \$62 to \$68 million dollars, and another (Interstate Waste

**Table 7-7. Comparative Evaluation
Estimated Cost Provided by Technology Sponsor**

Technology	Basis for Cost Estimate (design capacity)	Capital Cost (\$/tpd) ⁽¹⁾	O&M Cost		Tip Fee Estimate (\$/ton)
			million \$/yr	\$/ton	
Conventional Waste-to-Energy	500 tpd	\$150,000	\$8.0	\$44	\$60- \$80
Anaerobic Digestion					
Arrow Ecology and Engineering	211 tpd	\$47,400 ⁽²⁾	\$1.2	\$16	N/A
Canada Composting	274 tpd	\$118,100	\$5.5	\$55	N/A
Orgaworld	N/A	N/A	N/A	N/A	N/A
Organic Waste Systems	68 tpd	\$242,600	\$2.7	\$108	N/A
Waste Recovery Systems	548 tpd	\$91,200	\$6.5	\$33	N/A
Hydrolysis					
Masada Oxynol	3,000 tpd	\$100,000 - \$116,700	\$100	\$91	\$60 - \$90
Thermal					
Dynecology	5,000 tpd	\$207,000	\$134	\$73	\$50
EBARA	40 tpd ⁽³⁾	\$350,000 - \$525,000	N/A	N/A	N/A
GEM America	N/A	N/A	N/A	N/A	\$75
Global Energy Solutions	N/A	N/A	N/A	N/A	\$45
Interstate Waste Technologies	3,051 tpd	\$149,800 ⁽⁶⁾	\$55.3	\$50	\$42 - \$60
Pan American Resources	1,000 tpd	\$100,000	N/A	<\$20	N/A
Rigel Resource Recovery	3,350/1,000 tpd ⁽⁴⁾	\$283,800	\$58.5	\$160	\$75 - \$85
Taylor Recycling Facility	300 tpd ⁽⁵⁾	\$77,000	\$2.0	\$18	N/A

(1) Cost per ton of design capacity. Excludes financing and other soft costs, such as permitting (except as noted).

(2) Excludes costs associated with generating and exporting power.

(3) Budgetary cost estimate for 40 tpd demonstration plant, not for a commercial plant.

(4) Capital costs based on 3350 tpd; O&M costs and projected tip fee based on 1,000 tpd.

(5) Budgetary cost estimate for expansion (gasifier installation) at existing waste processing facility.

(6) N/A indicates information not available for the study

(7) The cost estimates presented are intended as approximations only, to give the City some indication of the orders of magnitude of costs associated with the various technologies. The cost estimates given by the respondents were, by necessity, based upon limited information and broad assumptions. Moreover, in some cases the cost information provided was not explicit, and estimates had to be imputed from the limited information available.

Technologies) suggested \$4 in collateral economic development for every \$1 invested in the project. Supporting information for these estimates was not available.

7.10 EXPERIENCE AND RESOURCES OF PROJECT SPONSORS

The RFI requested information on the experience and resources of each respondent. The purpose of this criterion was to evaluate the sponsors' overall experience in the solid waste industry, specific experience with the proposed technology, and financial resources to develop a project. None of the project sponsors provided financial reports, which were requested in the RFI, or related financial information. Therefore, a meaningful, non-speculative evaluation and comparison of the demonstrated ability (i.e., financial resources) to develop a project cannot be made.

Based on the information that was provided, the technology sponsors have been categorized based on their overall experience in the industry and with the proposed technology. This comparative evaluation is provided in Table 7-8, and includes three categories:

- **Limited Experience.** "Limited Experience" indicates the sponsor has little or no operating experience with the proposed technology, and has not documented (or has no) established corporate experience in the solid waste industry. Five technology sponsors were included in this category, including two that may not currently hold all necessary licenses to offer proprietary technology.
- **Established Experience.** "Established Experience" indicates the sponsor has developed and operates at least one commercial facility that uses the proposed technology, and/or has documented established experience in the solid waste industry. Five technology sponsors were included in this category, including one that does not currently hold the necessary license to offer the proposed technology.
- **Extensive Experience.** "Extensive Experience" indicates the sponsor has developed three or more commercial projects that use the proposed technology, with ten or more years of experience in the solid waste industry. Four technology sponsors were included in this category.

There is no clear distinction, by technology type, of the level of experience of the project sponsors. Both anaerobic digestion and thermal technologies have two sponsors each that are categorized as having "Extensive Experience". Many of the vendors that provide conventional waste-to-energy projects would be categorized as having "Extensive Experience."

**Table 7-8. Comparative Evaluation
Experience and Resources of Project Sponsor**

Limited	Established	Extensive
<p><u>Anaerobic Digestion</u> Waste Recovery Systems</p> <p><u>Thermal</u> Dynecology⁽¹⁾ GEM America Pan American Resources Rigel Resource Recovery⁽²⁾</p>	<p><u>Anaerobic Digestion</u> Arrow Ecology and Engineering Canada Composting</p> <p><u>Hydrolysis</u> Masada Oxynol</p> <p><u>Thermal</u> Global Energy Solutions Taylor Recycling Facility⁽²⁾</p>	<p><i>Conventional Waste-to-Energy</i></p> <p><u>Anaerobic Digestion</u> Orgaworld Organic Waste Systems</p> <p><u>Thermal</u> EBARA Interstate Waste Technologies</p>
<p><i>Limited experience</i> indicates the sponsor has little or no operating experience with the proposed technology, and has not documented established, corporate experience in the solid waste industry.</p>	<p><i>Established experience</i> indicates the sponsor has developed and operates 1 or 2 commercial facilities that use the proposed technology, and/or has documented established experience in the solid waste industry.</p>	<p><i>Extensive experience</i> indicates the sponsor has developed 3 or more commercial projects that use the proposed technology, with ten or more years of experience in the industry.</p>

(1) Unclear from information available if Dynecology holds all necessary licenses.

(2) Licensing rights for Rigel Resource Recovery and Taylor Recycling Facility are pending, or would be obtained for purpose of the project as needed.

7.11 OWNERSHIP PREFERENCES

The willingness of the project sponsors to develop and provide service for either a publicly owned or privately owned facility was established as a comparative evaluation criterion. Conventional waste-to-energy facilities are both privately and publicly owned and operated, with the greater percentage privately owned and operated. For the emerging technologies, only limited information is available regarding ownership preference. In response to the RFI, some project sponsors stated preferences for design-build-operate with public ownership (DBO), or design-build-own-operate (DBOO). The sponsors that preferred public ownership indicated better economics under this project delivery mechanism. Overall, many sponsors expressing a willingness to consider a variety of project delivery and ownership approaches, including private financing. This means that a variety of development approaches could potentially be available to the City, were it to proceed with a new and emerging technology project. Table 7-9 categorizes project sponsors by ownership preferences.

7.12 RISK ALLOCATION

The risk profile for the technologies and sponsors was established as a comparative evaluation criterion, to identify technologies that offer less risk (technical, business or other risk) to the City. Until a project is more specifically developed, however, most project sponsors are willing to discuss risk only generally and informally. This is comparable with conventional waste-to-energy, where risk allocation is highly project specific.

Examples of risk elements include construction cost, schedule, and performance. Risk elements addressed by the project sponsors were generally limited to the company's willingness to accept risk for marketability of products and disposal of residue, and the need for the City to provide a put-or-pay guarantee for waste deliveries. The project sponsors that did address the risk criterion almost uniformly highlighted an industry-standard risk profile: the developer would guarantee project performance; the public would guarantee the delivery of MSW and the payment of tipping fees. Moreover, project sponsors that addressed security aspects recognized the need to provide industry-standard measures such as bonds, letters of credit and corporate guarantees.

Table 7-10 summarizes risk allocation by company for these two issues, based on the limited information that was available for the study.

7.13 OTHER CRITERIA AND COMPARISONS

A brief summary of other criteria, which are not amenable to comparative evaluations based on the limitations of the available information, is provided below.

- **Facility Siting.** Facility siting was established as a comparative criterion to determine acreage and other technology-specific siting requirements, with consideration of the ability of the technology to be sited within the City. Very little information was submitted regarding facility siting. Based on the limited information available, digestion would require up to 7 acres for a facility with capacity to process 100,000 tpy (274 tpd) of MSW. This excludes area for

**Table 7-9. Comparative Evaluation
Ownership Preference**

Willingness to Participate in a Variety of Project Delivery Approaches ⁽¹⁾	Preference for <i>Private</i> Ownership: Design-Build-Own-Operate (DBOO)	Preference for <i>Public</i> Ownership: Design-Build-Operate (DBO)
<p><i>Conventional Waste-to-Energy</i>⁽²⁾</p> <p><u>Anaerobic Digestion</u> Arrow Ecology and Engineering Canada Composting Waste Recovery Systems</p> <p><u>Hydrolysis</u> Masada Oxynol</p> <p><u>Thermal</u> GEM America Rigel Resource Recovery Taylor Recycling Facility</p>	<p><u>Anaerobic Digestion</u> Waste Recovery Systems</p> <p><u>Thermal</u> Global Energy Solutions Interstate Waste Technologies Pan American Resources Taylor Recycling Facility</p>	<p><u>Anaerobic Digestion</u> Arrow Ecology and Engineering</p> <p><u>Thermal</u> Dynecology Rigel Resource Recovery</p> <p align="center">No Preference Stated Regarding Project Delivery Approach</p> <p><u>Anaerobic Digestion</u> Orgaworld Organic Waste Systems</p> <p><u>Thermal</u> EBARA</p>

(1) Some companies are listed twice, i.e., those that expressed a preference but also indicated flexibility.

(2) Conventional waste-to-energy projects have been developed under both public and private ownership.

**Table 7-10. Comparative Evaluation
Risk Allocation⁽¹⁾**

<u>City Risk Element:</u> Company Would Require Put-or-Pay Commitments from City for Waste Deliveries	<u>Company Risk Element:</u> Company Would Accept Risk for End Product Sales	No Position Stated by Company Regarding Risk Allocation
<p><u>Anaerobic Digestion</u></p> <p>Arrow Ecology and Engineering Canada Composting</p> <p><u>Thermal</u></p> <p>GEM America Global Energy Solutions Interstate Waste Technologies Pan American Resources Rigel Resource Recovery</p>	<p><u>Anaerobic Digestion</u></p> <p>Arrow Ecology and Engineering Orgaworld Waste Recovery Systems⁽²⁾</p> <p><u>Thermal</u></p> <p>Interstate Waste Technologies⁽²⁾ Pan American Resources⁽²⁾ Rigel Resource Recovery</p>	<p><u>Anaerobic Digestion</u></p> <p>Organic Waste Systems</p> <p><u>Hydrolysis</u></p> <p>Masada Oxydol</p> <p><u>Thermal</u></p> <p>Dynecology EBARA Taylor Recycling Facility</p>

(1) Information available from Sponsors regarding risk allocation was generic and generally limited to the information included on this table. Other risk elements, such as construction cost, schedule, and performance, were not addressed in the information provided by any of the project sponsors. Absence of a company under a risk category does not mean such risk allocation would not apply.

(2) Waste Recovery Systems and Pan American Resources also expressed a willingness to accept risk for residual disposal. Interstate Waste Technologies would guarantee no residue generated requiring disposal.

aerobically treating the digested solids (and storing such solids during poor market periods), which could easily increase land requirements to 10 acres or more. Therefore, digestion technologies may require more acreage than a comparably-sized waste-to-energy facility, which would require less than 10 acres for a 275 tpd facility. Thermal and hydrolysis technologies are expected to require comparable land areas as waste-to-energy.

- **Public Acceptability.** Information was not available from project sponsors regarding public acceptability of their projects. In general, any of the innovative technologies are likely to be more acceptable to the public than traditional waste-to-energy, because none involve the combustion of MSW (although some involve the combustion of biogas or syngas generated from the MSW). Also, two thermal technologies, sponsored by GEM America and Taylor Recycling Facility, are proposing projects at existing sites (i.e., modifications to existing waste management facilities). Since these projects do not require new site acquisition, public acceptance might be more readily achieved. This said, current reality is that nationwide, any solid waste processing, whether innovative or not, facility remains controversial and its siting a matter of public scrutiny.

8.0 SUMMARY OF FINDINGS

8.1 INTRODUCTION

The objective of the Evaluation was to identify, describe and evaluate new and emerging technologies based on type of technology, status of development, and potential applicability for New York City. The Evaluation considered 43 technologies. These technologies were categorized as follows:

- **Thermal.** Thermal technologies are those that use or produce a significant quantity of heat during the course of processing MSW. Common descriptors for thermal technologies include gasification, pyrolysis, cracking and plasma. These technologies are similar, in that exothermic or endothermic chemical reactions occur during the processes that change the composition of the MSW. Types of products resulting from thermal processing include syngas (i.e., synthesis gas composed of hydrogen gases, carbon monoxide and carbon dioxide), which is combusted to produce electricity; char, which is a carbon-based solid residue; and organic liquids (e.g., light hydrocarbons).
- **Digestion (Aerobic and Anaerobic).** Digestion is the reduction of the organic fraction of MSW through decomposition by microbes, accompanied by the evolution of liquids and gases. The biological process of digestion may be aerobic or anaerobic, depending on whether air is introduced into the process. Anaerobic digestion produces a biogas, which is primarily methane and carbon dioxide, and a compost. Biogas can be combusted to generate electricity. Aerobic digestion produces a compost that may be used as a soil amendment or fertilizer; aerobic digestion does not produce a biogas.
- **Hydrolysis.** Hydrolysis is generally a chemical reaction in which water reacts with another substance to form two or more new substances. Specifically with relation to MSW, hydrolysis refers to an acid-catalyzed reaction of the cellulose fraction of the waste (e.g., paper, food waste, yard waste) with water to produce sugars. Additional process steps are used to convert the sugars to ethanol or other products such as levulinic acid, a commonly used chemical feedstock for producing specialty chemicals.
- **Chemical Processing.** Chemical processing is a general term for technologies that utilize one or a combination of various chemical processes. For the purpose of the study, one technology was included in this category. That technology is based on the chemical process of depolymerization, which is the permanent breakdown of large molecular compounds into smaller, relatively simple compounds. The process converts the organic fraction of MSW into energy products (steam and electricity), oil, specialty chemicals and carbon solids.
- **Mechanical Processing for Fiber Recovery.** Technologies included in this category mechanically process MSW to recover fiber for use in paper making.

This technology category includes innovative refuse-derived fuel technologies that produce a clean source of secondary fiber.

The technologies were advanced through three levels of scrutiny from preliminary review to more detailed, comparative review of the more developed technologies. Fourteen of the 43 technologies initially identified advanced to the most detailed level of comparative review, as summarized in Sections 4, 5 and 6 of this report.

The findings of the Evaluation are summarized in this Section by technology category. The findings are based on: (1) information available in the literature and unsolicited information provided to the City by potential project sponsors, and (2) a review of the most recent information available from an expanded number of potential sponsors based on direct inquiry from and specific to New York City. The summary of findings describes the status of development for each technology category and presents a comparison of the innovative technology categories to conventional waste-to-energy, since it is the most common method used today for reducing the quantity of post-recycled waste being landfilled.

8.2 STATUS OF DEVELOPMENT

As part of the Evaluation, the technologies were categorized by their development status (i.e., are they in commercial use, being tested at a demonstration or pilot facility, or in the process of ongoing, developmental research). The results are summarized in Table 8-1.

Anaerobic digestion is currently in commercial operation (for MSW) outside of the United States (e.g., Canada, Israel, the Netherlands, Italy, Germany, and other European countries). Anaerobic digestion has not been commercially applied within the United States. Therefore, technology transfer to the United States would need to be addressed in considering commercial application in this country (e.g., MSW composition, waste management practices, end-product markets and regulatory requirements).

Thermal processing (i.e., gasification) is currently in commercial operation (for MSW) outside of the United States (e.g., Japan, Germany, and Italy). Several types of gasification technologies are in commercial operation, including fluid bed gasification, high temperature gasification, plasma gasification and gasification/vitrification. These gasification technologies have not been commercially applied within the United States. Again, technology transfer to the United States would need to be addressed in considering commercial application in this country.

Hydrolysis is not yet in commercial operation for MSW. However, one company (Masada Oxynol) is advancing the technology to commercial application, with pilot testing completed in the U.S. and a facility under development in Middletown, New York.

Aerobic digestion is not yet in commercial operation for MSW. However, a 30-tpd demonstration plant is in operation in Vancouver, Canada, processing source-separated food waste and other source-separated organic waste. Additional research and testing is required to advance to pilot-testing for mixed MSW.

Table 8-1. Development Status of Innovative Technologies by Category

Technology Category	Commercial Use Outside U.S. for MSW	Pilot Testing with MSW	Additional Research and Testing Required for MSW	Desirable for Monitoring
Anaerobic Digestion	✓	✓		
Thermal Processing	✓	✓		
Hydrolysis		✓		
Aerobic Digestion			✓	
Chemical Processing			✓	✓
Mechanical Processing				✓

Chemical processing (specifically, depolymerization represented by Changing World Technology's Thermal Conversion Process) requires research and testing to advance to the pilot stage for MSW. An eight-tpd pilot plant in Philadelphia is available to conduct this research and testing. Also, the first full-scale facility by Changing World Technologies (Carthage, Missouri), which will manage turkey processing waste, is expected to be commercially operational shortly.

Mechanical processing for fiber recovery bears monitoring. It is the least developed of all the innovative technology categories, with only bench-scale testing completed for the fiber recovery process.

Based on success demonstrated outside of the United States by several companies, anaerobic digestion and thermal processing (gasification) technologies could be considered for commercial application in the United States, including serving New York City, with suitable project definition and risk sharing between the public and the private sponsor. Should the potential risk be greater than a project sponsor is willing to assume, then a pilot project for anaerobic digestion or gasification technologies could be established first, before commercial application. The results of such a pilot project could be used to establish the basis for commercial application, including project definition and risk sharing.

Although anaerobic digestion and thermal processing technologies have enjoyed success outside of the United States, as a first step for future consideration by the City, a focused, detailed review of these technologies is recommended to supplement and verify information presented by project sponsors during this study. Also, such a detailed review should address the potential impact of technology transfer issues such as City waste composition and waste management practices, product markets, regulatory requirements and related environmental issues.

Hydrolysis could also be considered for a pilot project. The City could monitor the development of the commercial hydrolysis project in Middletown, NY and could consider sending waste to this facility (for pilot testing) when it becomes operational.

The development of aerobic digestion projects should be monitored.

Chemical processing and mechanical processing technologies should be assessed again; e.g., in five years, to monitor their progress.

8.3 COMPARISON TO CONVENTIONAL WASTE-TO-ENERGY TECHNOLOGY

Table 8-2 compares in summary fashion the more developed technology categories (i.e., anaerobic digestion, hydrolysis and thermal processing) to conventional waste-to-energy technology. Conventional waste-to-energy was chosen as a point of comparison since it is the most widely used technology available today for reducing the quantity of post-recycled waste being landfilled. The comparisons are made for the criteria considered in the study. (A comparison for the other technology categories, chemical and mechanical processing, could not be made since these technologies have not processed MSW at any stage and information is not available to allow an informative comparison.) Detailed evaluations and comparisons can be found in Sections 6 and 7 of this report.

Although thermal processing and anaerobic digestion technologies are being commercially applied outside the United States, innovative technologies have limited operating experience when compared to conventional waste-to-energy technology. This is to be expected for an innovative technology. Waste-to-energy has been commercial in the United States for several decades and is demonstrated to be a proven and reliable method of solid waste disposal. Currently, there are close to 100 waste-to-energy facilities in operation in the U.S. processing a combined total of almost 95,000 tpd of MSW. These waste-to-energy facilities have a wide range of rated design capacities, with the largest being approximately 3,000 tpd. Of the innovative technologies, hydrolysis and thermal processing are expected to be comparable regarding facility size and flexibility, however, the largest facility currently in operation and processing MSW is an 800-tpd gasification facility. Anaerobic digestion technologies generally have lower design capacities. Also, in general, and as would be expected, the overall experience of the project sponsors that offer the innovative technologies is not as extensive and as well developed as the companies offering conventional waste-to-energy technology. It should be noted, however, that several companies in the conventional waste-to-energy business have entered the innovative technology industry.

Nevertheless, the innovative technologies offer certain advantages in comparison to conventional waste-to-energy. Most notably, the emission levels from innovative technologies are expected to be less than with conventional waste-to-energy. The thermal technologies (gasification) and anaerobic digestion produce and combust a synthesis gas or biogas, rather than a solid fuel (MSW). Inherent with the combustion of a gas (compared to combustion of a solid, like MSW), emissions would potentially be lower, particularly for dioxins and heavy metals. Overall, the innovative technologies are also potentially advantageous because they may produce less residuals requiring disposal. However, market development would be required for the end-products of the innovative processes. Lack of successful market development would increase the disposal rate. Because the innovative technologies have potentially lower emissions than conventional waste-to-

Table 8-2. Comparison of Advanced Innovative Technology Categories to Conventional Waste-to-Energy Technology

Criteria	Anaerobic Digestion	Hydrolysis	Thermal Processing
Readiness and Reliability	D	D	D
Facility Size and Design Flexibility	D	C	C
Utilization of Existing Infrastructure	C	C	C
Utility Needs	C	D	C
Extent of Beneficial Use of Waste	C	A	A
Residuals Requiring Disposal	A	A	A
Environmental Impacts (Emissions)	A	C-A ⁽¹⁾	A
Siting Requirements (Acreage Required)	D	C	C
Public Acceptability	A	A	A
Cost	C	C	C
Experience of Project Sponsors	C-D ⁽²⁾	D	C-D ⁽²⁾
Ownership Preferences	C	C	C
Risk Allocation	C	C	C
<p><u>Legend</u></p> <p>A - Potentially advantageous in comparison to conventional waste-to-energy D - Potentially disadvantageous in comparison to conventional waste-to-energy C - Comparable to conventional waste-to-energy</p> <p><u>Notes</u></p> <p>(1) Comparable based on limited information available; potentially advantageous due to reduced air emissions of heavy metals. (2) Depends on the specific project sponsor.</p>			

energy and potentially fewer residuals requiring disposal, the innovative technologies may also enjoy greater public acceptability.

Limited cost information was available for this study. Based on the information that was available for review, the innovative technologies are potentially comparable to conventional waste-to-energy, with tip fees projected by project sponsors ranging from \$42 to \$90 per ton of MSW. Further, the project sponsors expressed a willingness to consider a variety of project delivery and ownership approaches, including private financing. Also, project sponsors that addressed risk allocation almost uniformly highlighted an industry-standard risk profile: the developer would guarantee project performance, and the public entity would guarantee the delivery of MSW and the payment of tipping fees.

References

- (1) Request for Qualifications No. 9155-04-7021 for Development and Operation of a Small-Scale Research Facility for Processing Residual Municipal Solid Waste, Works and Engineers Department, Solid Waste Management Services Division, City of Toronto, January 2004.
- (2) Telephone communication, 4/20/04, between D. Austin (ARI) and Lawson Oates (Project Manager, innovative technologies initiative), City of Toronto.
- (2A) Telephone communication, 5/6/04, between D. Austin (ARI) and Lawson Oates (Project Manager, innovative technologies initiative), City of Toronto.
- (3) Request for Proposals for Municipal Solid Waste (MSW) Processing and Gasification Facility, RFP #02-3316, Solid Waste Department, Collier County, Florida, November 2001.
- (4) Telephone communication, 4/19/04, between D. Austin (ARI) and Kevin Dugan, Collier County Solid Waste Department.
- (5) Request for Qualifications for Proposers for the Development of a Resource Recovery Facility for Northwest Puerto Rico, Solid Waste Management Authority, Puerto Rico, May 1998.
- (6) Request for Proposals to Design, Build and Operate a Resource Recovery Facility for Northwest Puerto Rico, Solid Waste Management Authority, Puerto Rico, April 15, 1999.
- (7) Alternatives to Disposal, Final Report, Santa Barbara County Multi-Jurisdictional Solid Waste Task Group, September 22, 2003.
- (8) Telephone communication, 4/20/04, between D. Austin (ARI) and John McInnes, Santa Barbara County, California.
- (9) Anaerobic Digestion of Source Separated Food Study, Final Technical Memorandum No. 1, Digestion Technology Assessment, Seattle Public Utilities C02-029, September 2002.
- (10) Telephone communication, 4/20/04, between K. Luvisi (ARI) and Gabriella Uhlar-Heffner, Seattle Public Utilities.
- (11) Request for Proposals to Transport and Dispose of Containerized Waste from One or More Marine Transfer Stations, City of New York, Department of Sanitation, December 22, 2003.
- (12) Request for Proposals to Receive, Transfer, Transport and Dispose of Department of Sanitation Managed Waste from Brooklyn Formerly Delivered to the Greenpoint

- Marine Transfer Station, City of New York, Department of Sanitation, December 22, 2003.
- (13) Request for Proposals to Receive, Transfer, Transport and Dispose of Department of Sanitation Municipal Waste from the Bronx, City of New York, Department of Sanitation, December 22, 2003.
- (14) Request for Proposals to Receive, Transfer, Transport and Dispose of Department of Sanitation Municipal Waste from Queens Formerly Delivered to the Greenpoint Marine Transfer Station, City of New York, Department of Sanitation, December 22, 2003.
- (15) Wisconsin Statewide Waste Characterization Study, Cascadia Consulting Group, May 2003.
- (16) 2002 Oregon Solid Waste Characterization and Composition, State of Oregon Department of Environmental Quality, April 2004.
- (17) Statewide Waste Composition Study, Pennsylvania Department of Environmental Protection, April 2003.
- (18) Results from the 2000 Census: Population Growth and Race/Hispanic Composition, NYC DCP #01-11, New York City Department of City Planning, Summer 2001

APPENDIX A

SUMMARY LIST OF UNSOLICITED PROPOSALS

**Summary of Unsolicited Proposals (Innovative Waste Technologies)
Received by New York City Economic Development Corporation**

Company Information (1)	Technology Description (2)
<p>Arrow Ecology Limited Tel: 972-4-841-2599 Fax: 972-4-841-2586 http://www.arrowecology.com/ Dan Elias, Representative Elias Group 411 Theodore Fremd Avenue Rye, NY 10580 Tel: 914-925-0000 Fax: 914-925-9344 delias@eliasgroup.com http://www.eliasgroup.com/</p>	<ul style="list-style-type: none"> • MRF/Anaerobic Digestion • Patented ArrowBio process sorts, cleans and separates recyclables, and processes the organic fraction (hydro-crusher to prepare waste, acidogenic bioreactor, methanogenic fermentation reactor) into fertilizer, water and biogas. The MRF process produces inert waste requiring disposal. • Lab and field testing conducted at prototype plant (10 tpd) in Hadera, Israel (1999) • ArrowBio plant in operation since December 2002 in Tel-Aviv (220 tpd; biogas used to generate parasitic power)
<p>Bioengineering Resources for Renewable Energy (BRI) William Bruce, President Tel: 908-608-0491 wfbruce@bellsouth.net http://www.brienergy.com/</p>	<ul style="list-style-type: none"> • Gasification/Anaerobic Fermentation • Contact information listed by City, but no information provided for review • No mailing address available
<p>Biofine, Inc. Stephen Fitzpatrick, Ph.D. 300 Bear Hill Road Waltham, MA 02154 Tel: 617-684-8331 Fax: 781-684-8335 Anne Korin, Representative 6101 Executive Boulevard, Suite 380 Rockville, MD 20852 Tel: 415-867-2677 anne@iags.org</p>	<ul style="list-style-type: none"> • Hydrolysis: Organic Waste to Levulinic Acid • Biofine patented two-stage reactor system (dilute mineral acid hydrolysis) • 1 tpd demonstration plant in South Glens Falls, NY • 300 tpd facility under construction in Caserta, Italy (Le Calorie)
<p>Changing World Technologies Brian Appel, Chairman and CEO 460 Hempstead Ave West Hempstead, NY 11552 Tel: 516-486-0100 Fax: 516-486-0460 cwt@changingworldtech.com http://www.changingworldtech.com/</p>	<ul style="list-style-type: none"> • Thermo-Depolymerization • Thermal process that converts organic materials into fuel-gas, light organic liquid, and solid products that can be used as fuel, fertilizer or adsorbent carbon • 7 tpd pilot plant in Philadelphia, PA • 200 tpd commercial plant in Carthage, MO
<p>Comprehensive Resources, Recovery and Reuse, Inc. (CR3) 1755 E. Plumb Ln. Suite 265A Reno, NV 89502 Tel: 775-852-2039 Fax: 775-852-2038 Dr. Jack Milgrom, Representative Walden Research, Inc. Tel: 610-644-1666 Fax: 201-457-1699 jmilg@aol.com</p>	<ul style="list-style-type: none"> • Steam Autoclave combined with numerous other operations (MRF, pulp laundering or pelletizing, wastewater treatment (anaerobic digestion), and biogas combustion) • Pilot plant in Reno, NV • Developing commercial plant in St. Paul, MN and soon in Bangor, ME

<p>Dynecology Incorporated Environmental Energy Systems Helmut Schulz, Chairman and CEO 611 Harrison Avenue Harrison, NY 10528 Tel: 914-967-8674 Fax: 914-967-8530</p>	<ul style="list-style-type: none"> • MRF/RDF/gasification • Proprietary Simplex waste conversion process: waste is processed to recover recyclables and produce RDF; RDF is mixed with lime and coal fines to create fuel briquettes; briquettes are feedstock for Integrated Gasification Combined Cycle (IGCC) power plant • High-pressure, slagging gasification process • Technology demonstrated in 1982 by U.S. Bureau of Mines
<p>Eco Waste USA Lowell Feuer, President Tel: 917-674-8106 lhfeuer@msn.com Eco Waste Solutions, Inc. Lucy Casacia, President 5195 Harvester Road, Unit 6 Burlington, Ontario Canada L7L 6E9 Tel: 905-634-7022 Fax: 905-634-0831 http://www.ecosolutions.com/</p>	<ul style="list-style-type: none"> • Pyrolysis • Eco Waste Oxidizer - patented, two-stage batch pyrolysis process • Company specializes in small waste oxidizers with capacities up to 25 tpd
<p>Emerald Power Corporation Robert J. Mahony, Managing Partner Jonathan Schreiber, Managing Partner 7 Stonegate Lane Rye NY 10580-1847 Tel: 917-596-8859 Fax: 718-884-4527 jschreiber@emeraldpower.com</p>	<ul style="list-style-type: none"> • Waste (biomass) to Ethanol • Gasification/Catalytic Technology (patent-pending) • Lab-scale gasification module in Durham, NC
<p>Entropic Technologies Corporation 4660 South Hagadorn Road East Lansing, Michigan 48823 Kenneth S. Hannan, Representative American HomeNet, Inc. 4165 Abbott Street North Andover, MA 01845 Tel: 978-974-9271 Fax: 978-686-0486 kshsr@aol.com</p>	<ul style="list-style-type: none"> • RDF/Pyrolysis • Patented Entropic Waste Thermolysis Process converts organic waste (RDF) to synthetic coal by processing it through a specially designed twin screw mixer where temperature and pressure induced by intense mixing in an oxygen free environment converts the waste into a coal-like material
<p>GEM America, Inc. (Graveson Energy Management) Gerald R. Kondritzer 139 East 63rd Street, #4D New York, NY 10021 http://www.gem-ltd.co.uk/ Douglas Weltz, Managing Director 26 Laurel Avenue Summit, NJ 07901 Tel: 201-457-1903 Fax: 908-608-0156 dweltz@earthlink.net</p>	<ul style="list-style-type: none"> • Gasification (Thermal Cracking) • Patented process that converts processed waste (sorted, shredded, dried) to synthetic gas • Pilot plant operational in South Wales

<p>GSB Technologies Michael J. Katz, Senior Vice President 3966 Carman Drive Lake Oswego, OR 97035 Tel: 201-394-8774 Fax: 503-699-7320 mikejkatz@aol.com</p>	<ul style="list-style-type: none"> • Gasification (Plasma Technology) • No technical information available
<p>International Bio-Recovery Corporation (Technology Licensor) Thomas Buchanan, Representative Mining Organics Management LLC (Project Managers) 1890 Palmer Avenue, Suite 203 Larchmont, NY 10538 Tel: 914-834-2631 Fax: 914-834-3896 tbuchanan@ecapglobal.com</p>	<ul style="list-style-type: none"> • Aerobic Digestion • Patented, Enhanced Autogenous Thermal Aerobic Digestion (ATAD): blending/screening to remove nonorganics, in-vessel digestion (additional removal of nonorganics), product finishing (drying/pelletizing), end product distribution (plant biostimulant) • Operating facility in Vancouver, B.C. for over 5 years; project under development in NJ • Proposed for source-separated food waste (solid and liquid)
<p>International Joint Venture KAME Ecosquare S.A. (Switzerland) A.D.D. Green Power S.p.A. (Italy) http://www.ecosquare.com/ c/o Marco De Plano, Representative De Plano Group One Madison Avenue New York, NY 10010 Tel: 212-213-2224 Fax: 212-889-8337 mdeplano@deplano.com</p>	<ul style="list-style-type: none"> • Gasification • Integrated Gasification Combined Cycle (IGCC) • Integration of pressurized fluidized bed gasification and anaerobic digestion with moving bed gasification • Same Joint Venture stakes claim to the Biofine Levulinic Acid Plant in Caserta, Italy (Le Calorie) • Ecosquare is an international waste brokerage firm
<p>Interstate Waste Technologies Frank Campbell, President 17 Mystic Lane Chester County Commons Malvern, PA 19355 Tel: 610-644-1665 Fax: 610-644-1733 http://www.interstatewastetechnologies.com/ Tonio Burgos, Representative tburgos@tonioburgos.com</p>	<ul style="list-style-type: none"> • Gasification • Thermoselect Gasification Technology • Uses high temperature to break down and transform waste into clean synthesis gas to make electricity and other commercially useful products (construction aggregate, metal alloy) • Commercially demonstrated outside of the U.S.
<p>Orgaworld Henk Kaskens, Managing Director Loopkantstraat 45 Post-office box 96 5400 AB UDEN Netherlands Tel: 0413-24 33 25 Fax: 0413-24 33 15 h.kaskens@orgaworld.nl http://www.orgaworld.nl/</p>	<ul style="list-style-type: none"> • Biostabilization • Biostabilization process for stabilization and weight/volume reduction followed by landfilling, incineration, composting or anaerobic digestion • Manages MSW, organic waste from MSW, yard waste, organic industrial/ commercial waste • Five plants in operation in the Netherlands
<p>Pan American Resources, Inc Mr. John Toman, Chairman, CEO, President 4222 Bevilacqua Ct. Pleasanton, CA 94566 Tel: 925-846-2657 Fax: 925-846-2657 partoman@earthlink.net</p>	<ul style="list-style-type: none"> • Destructive Distillation • Uses Lantz converter (airfree, heated externally) for thermal transformation. Converts dried, shredded, organic material into a volatile product gas, which is used to produce steam and electricity, and activated char or carbon, which is used as a filter or as cover in a landfill.

<p>Peat International, Inc. 555 Skokie Blvd - Suite 350 Northbrook, IL 60062 Tel: 847-559-8567 Fax: 847-291-3704 http://www.peat.com/ Duke Eric d'Antin, Representative 342 East 67 Street New York, NY 10021 Tel: 212-249-6076</p>	<ul style="list-style-type: none"> • Gasification (Thermal Plasma Technology) • Patented Plasma Thermal Destruction and Recovery (PTDR) process converts waste into synthetic gas and other useful products (e.g., silicate slag) • 2 tpd R&D facility in Huntsville, AL (1992) • US Army installation in Lorton, VA • 10 tpd facility in Kaohsiung Taiwan
<p>Pratt Industries/VISY Paper Helmut Konecsny, CEO 1800-C Sarasota Business Parkway Conyers, GA 30013 Tel: 770-918-5678 Fax: 770-388-5252 http://www.prattindustries.com/ Technology: Herhof Environmental Technologies</p>	<ul style="list-style-type: none"> • Stabilization/RDF/Waste-to-Energy • Two-stage operation consisting of 7-day heat treatment to dry waste (kills pathogens, facilitates sorting) followed by mechanized sorting. Materials are recovered for recycling, including water for reuse, and a refuse derived fuel (RDF) is produced (called Stabilat); RDF is combusted (at VISY paper mill)
<p>RealEarth Technologies Richard Jewett, Vice President 21318 San Miguel Street Woodland Hills, CA 91364 Tel: 818-703-6550 Fax: 801-409-3787 rjewett@realearthtech.com http://www.realearthtech.com/</p>	<ul style="list-style-type: none"> • Aerobic Digestion • In-vessel, 6-stage system converts organic waste into soil amendment • 150 tpd demonstration facility in Madisonville, KY from 1981-1984 • According to website, technology has been dormant since 1984
<p>Solena Group 1900 K Street NW, Suite 626 Washington, DC 20006 Tel: 202-682-2405 Fax: 202-682-1843 yvidal@solenagroup.com http://www.solenagroup.com/</p>	<ul style="list-style-type: none"> • Plasma Gasification • Contact information listed by City, but no information provided for review
<p>Startech Environmental Corporation Joe Klimek, CEO/President 15 Old Danbury Road Wilton, CT 06897 Tel: 203-762-2499 Fax: 203-761-0839 starmail@startech.net http://www.startech.net/</p>	<ul style="list-style-type: none"> • Plasma Conversion • Contact information listed by City, but no information provided for review
<p>Terra Environmental Solutions in joint venture with Global Environmental Technologies Dr. Tim Wood Montauk Highway Southampton, NY 19968 Tel: 631-965-2281 Fax: 631-283-5127 terracorp@optonline.net</p>	<ul style="list-style-type: none"> • Plasma Gasification • No technical information available
<p>VAGRON Mechanical Biological Pretreatment Plant Thijs Oorthuys P.O. Box 14 NL-3730 AA De Bilt Netherlands thijs.oorthuys@grontmij.nl</p>	<ul style="list-style-type: none"> • Anaerobic Digestion • Contact information listed by City, but no information provided for review

<p>Westinghouse Plasma, Recovered Energy, Inc., Tempico (Technology Partners) Carl D. Liggio Jr., Ph.D. 3801 Canterbury Road Baltimore, MD 21218 Tel: 410-961-4141 cliggio@aol.com</p>	<ul style="list-style-type: none"> • Autoclave/ Plasma Gasification • Tempico Rotoclave (rotary autoclave) combined with Recovered Energy Plasma Gasification System (Westinghouse Plasma Gasification Technology) • Westinghouse Plasma Gasification Technology is reported to be commercial with a 5+ year track record
<p>Zeros Technology Holding, LLC 25 Highland Park Village Suite 100-701 Dallas, TX 75205-2785 Teal: 214-528-4805 http://www.zerosinc.com/ Bonnie H. Weinstein, Marketing Rep 1825 Eye Street, N.W., Suite 400 Washington, DC 20006 Tel: 202-293-4752 Fax: 202-530-0179 bhwlaw@aol.com</p>	<ul style="list-style-type: none"> • Thermal Oxidation • Closed system uses pure oxygen rather than ambient air for the oxidation (combustion) process; recirculates flue gas; produces electricity; recovers carbon dioxide; generates zero emissions; generates ash

Notes

- (1) Companies are arranged in alphabetical order.
- (2) Technology descriptions provided in this table are based on a preliminary review of information submitted to the City and provided to ARI, and are provided as an initial overview of the technology. Insufficient information is available from the unsolicited proposals to provide consistent technology descriptions for each company, particularly regarding demonstration of the technology through pilot projects or commercially operational facilities. Information submitted through the RFI process will be used to provide more complete technology descriptions.

APPENDIX B

**SUPPLEMENTAL LIST OF VENDORS IDENTIFIED
THROUGH INDEPENDENT RESEARCH**

**Identification of Additional Vendors
(Innovative Waste Technologies)
Identified During ARI Research**

Arkenol, Inc. *(Hydrolysis/Fermentation/Distillation)*
 Arnold Klan, President
 31 Musick
 Irvine, CA 92618
 Tel: 949-588-3767
 Fax: 949-588-3972
<http://www.arkenol.com/>

Brightstar Environmental *(Pyrolysis/Gasification)*
 7700 San Felipe
 Suite 480
 Houston, TX 77063-1613
 Tel: 713-781-5353
 Fax: 713-781-5303
<http://www.brightstarencvironmental.com/>

Canada Composting, Inc. *(Anaerobic Digestion)*
 390 Davis Drive, Suite 301
 Newmarket, Ontario
 L3Y 7T8
 Tel: 905-830-1160
 Fax: 905-830-0416
<http://www.canadacomposting.com>

Down Stream Systems *(Gasification)*
 Robert D. McChesney
 #1807 7550 Folsom Auburn Rd.
 Folsom, CA 95630-6631
 Tel: 916-989-8180
 Fax: 916-989-8753
<http://www.downstreamsystems.com>

Eco Electric Power Company *(Gasification)*
 (EEPC)
 6010 West Cheyenne
 #15 Suite 947
 Las Vegas, NV 89108
 Tel: 702-645-2124
 Fax: 702-658-8918
<http://www.eepci.com/> (inactive) or
<http://www.ecopower-gas.com> (inactive)

Genahol, Inc. *(Hydrolysis/Fermentation/Distillation)*
 Donald Bogner
 P.O. Box 228
 Wooster, OH 44691
 Tel: 330-264-7474
 Fax: 330-264-7535
<http://www.genaholincorporated.com>

Masada Resource Group LLC *(Hydrolysis/Fermentation/Distillation)*
 2170 Highland Avenue, Suite 200
 Birmingham, AL 35205
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APPENDIX C
INQUIRIES FOR THE RFI

Inquiries for the RFI

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APPENDIX D
REQUEST FOR INFORMATION

APPENDIX E

DEVELOPMENT OF THE EVALUATION APPROACH

APPENDIX E DEVELOPMENT OF THE EVALUATION APPROACH

INTRODUCTION

In developing the Evaluation methodology and criteria, approaches and criteria previously used by the City and by other cities and public jurisdictions with similar objectives as New York City were researched and evaluated. Also, potential changes and trends in waste generation and composition and in environmental, transportation, land-use, and tax laws and regulations were identified and evaluated to determine if such trends may impact new and emerging technologies. The results of this background work are summarized in this Appendix.

REVIEW OF APPROACH AND CRITERIA USED BY OTHERS

Several other cities and public jurisdictions have previously or are currently considering innovative technologies as a means to manage municipal solid waste. Several recent programs undertaken by public entities to evaluate alternative technologies include:

- Toronto, Canada;
- Collier County, Florida;
- Commonwealth of Puerto Rico;
- Santa Barbara County, California; and,
- Seattle, Washington.

The programs undertaken by these public entities were reviewed and considered in the development of an evaluation approach for New York City. These programs are described below.

Toronto, Canada

One of the most recent procurement efforts for emerging technology is for the City of Toronto, Canada. Toronto is currently in the midst of an ongoing procurement to develop a small scale research facility utilizing new and emerging technology, with the capacity to process 5,000 to 20,000 tpy of Toronto's residual (i.e., post recycled) waste. Technologies were limited to physical processes, biological processes, chemical processes and advanced thermal processes, including pyrolysis, fixed-bed gasification, fluidized bed gasification, high temperature gasification and plasma gasification, where a synthesis gas is produced and the synthesis gas is treated prior to thermal oxidation. The small-scale research facility will be operated and tested for three to five years. If the project is successful, a larger facility capable of handling up to 40% of Toronto's waste may be developed. Toronto's overall goal is to divert 100% of its waste from landfill disposal by 2010.

Toronto issued a Request for Information in 2003, followed by a formal Request for Qualifications (RFQL)⁽¹⁾ in January 2004. Thirteen (13) companies responded to Toronto's RFQL^{(2) (2A)}. Of the 13 companies, four were found to have satisfied the mandatory information requirements and screening criteria. Of the four, two presented fluidized bed

gasification processes, one a plasma gasification process, and one an aerobic composting process. Toronto is not yet proceeding with further procurement for a small-scale research facility. It is anticipated that future action for innovative technologies, such as a formal Request for Proposals, will be handled as part of an environmental assessment that will be prepared over the next year.

Although Toronto has engaged in a formal procurement (not a study) to develop a research facility for new and emerging technologies, the approach and evaluation criteria used by Toronto provide valuable insight for New York City's study. Mandatory criteria (in the RFQL) which must be met for a company/technology to be considered qualified to receive an RFP include providing evidence that:

- the technology reference facility has a design capacity of not less than 1 tpd and has processed not less than 200 tons of municipal solid waste in the previous 12 months;
- the respondent has completed the design, construction, and commissioning of one or more manufacturing or processing facilities involving electrical and mechanical systems with a total design and construction phase cost, excluding land purchase, of not less than \$7 million;
- the respondent has a bonding capacity of not less than \$7 million; and
- the respondent has direct operating control of one or more operating reference facilities. The operating reference facility must be for the purpose of solid waste management such as waste transfer, processing and/or final disposal. In addition the operating reference facility must have managed 10,000 tons of material similar to municipal solid waste in the previous 12 months.

Proposed requirements for the RFP (not yet finalized) include such items as:

- mandatory requirements for a bid bond;
- an agreement to provide performance and labor and materials payment bonds for design and construction of the research facility in the amount of 50% of the design and construction costs;
- an agreement to provide a letter of credit for the operation of the research facility in the amount of 50% of one operating year's fees;
- an agreement to provide a letter of credit to compensate the city for the costs of remediating the facility, including removal of municipal solid waste, products and emissions, in the event of a default by the contractor; and
- agreement to provide unrestricted access to the facility and to provide operating data from the facility.

Collier County, Florida

In November 2001, Collier County, Florida, issued a Request for Proposals for companies to design, permit, finance, construct, start up, test, operate and manage a municipal solid waste processing and gasification facility⁽³⁾. The facility was to have a minimum processing capacity of 75,000 tpy (approximately 200 tpd), with an option for a facility capable of processing 150,000 tpy (approximately 400 tpd). The facility was designated for county waste only and was to be located on a site provided by the county. It was not meant to displace existing recycling programs. The proposer was to be responsible for marketing products, including electricity, and for disposing of any residue. Incineration of solid waste or any product of the solid waste was not permitted. The facility was to be capable of recovering materials to the maximum extent possible to assist the county in achieving a State-mandated recycling goal of 30% and the county's ultimate goal of "zero waste" disposal.

Gasification was the only innovative technology requested in this formal procurement process. The RFP established minimum evaluation criteria that had to be met by all proposers. Those proposers that met the minimum criteria were then ranked through a comparative evaluation, using a point-assigned set of comparative evaluation criteria.

Although this was a formal procurement and not a study, the criteria used provide insight into the county's approach regarding acceptance of an innovative technology. The minimum evaluation criteria included the requirements that:

- the proposer demonstrate that it had successfully completed a facility similar in scope and scale to the proposed facility and that the proposer's technology and project approach can be used to construct the facility to the county's satisfaction;
- the gasification technology proposed must have been successfully implemented by the proposer at a minimum of one gasification facility that was (at the time of the proposal) currently commercially operating, or would be in commercial operation within six months of proposer selection;
- the gasification technology must have been implemented by the proposer in at least one gasification facility with a modular unit size of 50 tpd to 350 tpd;
- the proposer or the operator team member must have demonstrated experience operating one or more waste-to-energy facilities for a minimum period of two years;
- the proposer must have a net worth of at least \$20 million; and,
- the proposer must have a current ratio (current assets/current liabilities) greater than 1:1.

The comparative evaluation criteria included qualifications, experience and financial capacity, technical approach and compliance with technical requirements and contract

principles, willingness to guarantee performance and the extent of deviation or exceptions from the risk allocation taken to the terms and conditions of the proposed contract principles, and price.

Based on a discussion with county officials in April 2004⁽⁴⁾, it is understood that proposals from two companies met the minimum evaluation criteria: Brightstar Environmental and Interstate Waste Technologies. A comparative evaluation then found that Brightstar could provide a system of the size specified by the county at a competitive price, but that the technology had technical problems. Interstate Waste Technologies could not provide a facility as small as that specified by the county (200 tpd to 400 tpd) at a price the county considered a competitive price (understood to be \$40-\$45 per ton). As a result, the county took no action on either proposal.

Commonwealth of Puerto Rico

The Commonwealth of Puerto Rico undertook a procurement for an 1,800 tpd resource recovery facility to process post recycled, municipal solid waste and convert the waste to energy and/or other viable products. It was a two step procurement process: an RFQ⁽⁵⁾ to short list technologies and companies, followed by an RFP⁽⁶⁾ to the qualified companies. Both conventional technologies and new and emerging technologies were considered. The procurement was initiated in 1998 and was concluded in 2000.

Technologies that were represented in the response to the RFQ included mass burn and RDF waste-to-energy technologies, the Thermoselect gasification technology and a plasma gasification technology. All technologies/companies, with the exception of the plasma gasification process, met minimum qualification criteria and were found to be qualified to receive an RFP. Companies responding to the RFP presented mass burn and RDF waste-to-energy technologies and the Thermoselect gasification technology. Upon review of proposals in accordance with comparative evaluation criteria, including proposer qualifications, technical approach, environmental impacts, price and conformance to contract terms, a mass burn technology was selected.

Although the Puerto Rico experience was a procurement rather than a study, the minimum evaluation criteria used at the RFQ stage, and the comparative evaluation criteria used during proposal evaluation provide insight for New York City's study. The minimum evaluation criteria for the RFQ included the requirements that:

- the proposed technology must have been demonstrated at a minimum at one facility of similar size or with a minimum unit size of 100 tpd and shall have been in operation, for at least two years, processing municipal solid waste;
- the respondent must have successfully developed, designed and constructed and put in operation at least one, resource recovery facility with similar technology;
- the respondent must have at least two years of relevant experience in the operation and maintenance of a resource recovery facility with similar technology;

- the respondent must be capable of providing a construction performance bond and a labor and materials payment bond of a size equal to the estimated cost of construction;
- the respondent not be involved in any bankruptcy proceeding, has participated in a financing of a similar type and size and has a positive net income for at least two of the last three years; and,
- the respondent has a satisfactory environmental compliance record.

Santa Barbara County, California

Santa Barbara County, California, completed a study of “waste conversion” technologies to identify and evaluate the feasibility of conversion technologies to provide an alternative to disposal by landfill of post-recycled municipal solid waste⁽⁷⁾. In general, the county study considered gasification, hydrolysis and anaerobic digestion technologies. The specific definition of waste conversion technologies was “The processing, through non-combustion thermal means, chemical means, or biological means, of mixed municipal solid waste from which recyclable materials have been substantially diverted and/or removed to produce electricity, alternative fuels, chemicals, or other products that meet quality standards for use in the marketplace, with a minimum amount of residuals remaining after processing.”

A study group formed in June 2002 and completed a report of their work in September 2003. The study recommended that the county consider the development of a waste conversion facility as part of its long-term solid waste management plan. Furthermore, it established a short-list of waste conversion technologies and companies for consideration, including gasification, hydrolysis, anaerobic digestion, refuse derived fuel and fiber extraction.

Based on discussions with county officials in April 2004⁽⁸⁾, it was found that the county is currently going through the process of getting acceptance from the member cities in the county on the recommended plan for developing a full-scale municipal solid waste conversion facility. If such acceptance is obtained, then the county will develop an RFP for such a facility. The county is considering a full-scale facility to substantially reduce or eliminate disposal at their landfill, which currently has 15 years of projected remaining capacity. They do not believe that they have time to do a small-scale demonstration facility as a first step in this process, but must proceed, at this time, with a full-scale facility.

The study used a screening process to identify technologies that were then studied in detail and ranked, using more definitive criteria. The screening criteria included requirements that the conversion technology:

- be capable of processing mixed solid waste that is disposed in county landfills (100,000-400,000 tpy);
- be capable of operating for a minimum of 20 years;

- be compatible with local solid waste management systems, including existing recycling programs;
- divert a majority of the processed waste from the county landfill;
- be competitive with the costs of siting, developing and operating a new landfill; and,
- produce end products that have probable, identifiable or existing markets.

Upon selecting several companies from the screening process, representing gasification, hydrolysis, anaerobic digestion, refuse-derived fuel and fiber extraction, a comparative, numeric evaluation and ranking of technologies was completed. The comparative evaluation criteria included:

- fiscal viability;
- demonstrated ability to operate in similar conditions as in Santa Barbara County (i.e., tons and types of waste processed, with minimal intervention and downtime);
- existence of markets for energy and secondary products;
- product marketing experience;
- visual impacts of technology;
- design and operational capabilities relative to emissions, odor, noise, litter, dust, and worker health and safety issues, and their relationship to applicable laws and regulations;
- ability to permit based on compatibility of technology components/functions with current or proposed California regulatory/permitting structure;
- quantity and characteristics of residual waste;
- flexibility of system relative to scaling, i.e., increasing/decreasing throughput;
- process stability and reliability;
- utility requirements (electricity and water);
- project air emissions profile.

Seattle, Washington

The city of Seattle, Washington, recently concluded a study evaluating anaerobic digestion⁽⁹⁾, as a potential technology for processing food waste and soiled paper. Seattle determined that it would be necessary to recycle the residential and commercial food waste currently landfilled in order to achieve its long-term recycling goal of 60%. The study found that the technology was suitable for that purpose and commercially available.

Based on discussions with city officials in April 2004⁽¹⁰⁾, it was found that pursuit of an anaerobic digestion system may be considered in the longer term, but is not presently being implemented because of “high” costs (\$55 to \$65 per ton) when compared to management of food waste through conventional composting. Seattle is implementing a program to collect commercial food waste and compost this waste at an existing, modified, conventional compost facility. This program is expected to be operational within a year. The program to collect residential food waste is presently on hold.

In evaluating anaerobic digestion, Seattle used four criteria to compare the relative strengths of various digestion technologies, including:

- the number of reliably, continuously operating facilities;
- the history of reliability and continuous operation;
- the installation of facilities in North America; and,
- the suitability of the technology to the specific circumstances in Seattle, including the total amount of waste generated, the amount of organic waste, climate and facility siting requirements.

Six anaerobic digestion processes were selected to be evaluated in detail. There were no minimum evaluation criteria, but an approach taken where the highest ranked technologies were chosen for detailed study based on the comparative evaluation criteria noted above.

WASTE GENERATION FACTORS AND TRENDS

The quantity and composition of municipal solid waste, now and in the future, is directly relevant in the evaluation of new and emerging technologies for management of such waste. Waste generation factors and trends, as described below, were considered in the development and application of the evaluation methodology.

Waste Quantities

Table 1 summarizes waste generation in New York City over the period 1998 through 2003. The data show that waste generation in the City has remained relatively constant in recent years. Recycling rates have been variable, reflecting the City's efforts to promote recycling (1998-2001) followed by reductions in recycling programs due to budget cuts (2003).

Recycling rates for 2004 are expected to return to the level demonstrated in 2002. Changes in recycling rates have had a corresponding impact on disposal rates.

Table 1. New York City Waste Generation Data

Fiscal Year	Disposed (Tons)	Recycled (Tons)	Total (Tons)
1998	3,815,921	570,448	4,386,369
1999	3,690,078	641,146	4,331,224
2000	3,708,318	719,455	4,427,773
2001	3,516,609	730,719	4,247,328
2002	3,348,138	727,952	4,076,090
2003	3,799,200	427,904	4,227,105

Source: City of New York Department of Sanitation, Request for Proposals to Transport and Dispose of Containerized Waste from One or More Marine Transfer Stations, December 22, 2003, Table 4-4

In comparison to New York City's waste generation data, national trends documented by USEPA show an overall increase in MSW generation (USEPA, *Municipal Solid Waste in the United States: 2001 Facts and Figures*). According to USEPA, source reduction has steadily increased, and per-capita generation rates have decreased slightly over the past decade. Population increases, however, have resulted in an overall increase in MSW generation. National data also show a trend of increased recycling. In 1990, approximately 16.2% of MSW generated was recovered by recycling or composting. In 2001, the recovery rate had increased to 29.7%.

Waste Composition

Composition of the City's waste was determined in 1990, and included in the City's 1992 Solid Waste Management Plan. A comparison of the City's data (1990) to USEPA, national waste composition data (1990 and 2001) is provided in Table 2.

Data summarized in Table 2 show that the composition of New York City waste, particularly residential waste, is not materially different from national averages (particularly considering the likely distribution of "other" materials into USEPA designations). The most prominent exception is a significantly lower percentage of yard waste in New York City, which is reflective of the City's urban setting.

Summary of Waste Generation and Composition Trends

USEPA's report *Municipal Solid Waste in the United States: 2001 Facts and Figures* is widely recognized as a reliable source of waste generation and composition data. The report is based on data collected since 1960, and is updated regularly. The historical and comprehensive data provided by USEPA is useful for establishing trends. In addition, many states and governmental organizations have conducted focused waste characterization studies as a local or regional planning tool. Several of the most recent State-led studies (Wisconsin⁽¹⁵⁾, Oregon⁽¹⁶⁾ and Pennsylvania⁽¹⁷⁾) were reviewed to gather

supplemental and corroborating information for identifying waste generation and composition trends.

**Table 2. New York City and National Waste-Composition Data
(Percent of Total Generation)**

Material	New York City Data (1990) (a)		USEPA Data (b)	
	Residential	Institutional	1990	2001
Paper	31.3	52.9	35.4	35.7
Glass	5.0	2.5	6.4	5.5
Metals	4.8	4.0	8.1	7.9
Plastics	8.9	10.5	8.3	11.1
Textiles, Rubber, Leather	4.7	2.1	5.6	7.1
Wood	--	--	6.0	5.7
Yard Trimmings (c)	6.3	4.4	17.1	12.2
Food Scraps	12.7	10.1	10.1	11.4
Misc. Inorganics	2.9	2.9	1.4	1.5
Other (d)	23.4	8.4	1.6	1.8

(a) Source: 1992 Solid Waste Management Plan, Appendix 1.2, Waste Stream Data; composition data not currently available for commercial waste

(b) Source: USEPA, Municipal Solid Waste in the United States: 2001 Final Report

(c) For New York City data, "yard trimmings" includes wood waste (lumber)

(d) For New York City data, "other" includes bulky items, miscellaneous organics, and fines (likely distributed under wood, metals, and perhaps glass and rubber in USEPA data). For USEPA data, "other" is more limited and includes electrolytes in batteries and fluff pulp and waste materials in disposable diapers.

Waste quantities requiring disposal are impacted by population trends, per-capita waste generation rates (including source reduction efforts), and recovery rates for recycling and composting. National data show decreasing per-capita waste generation rates, increasing source reduction efforts, and increasing recovery of waste for recycling and composting. Despite these documented efforts to reduce waste quantities, waste generation is increasing nationally due to population increases. There have been some annual occurrences of decreases in national waste generation, reflective of short-term economic factors. Historically, though, waste generation rates have increased. Looking ahead, waste generation (nationally) is likely to continue to follow the historical, increasing trend with population increases. In comparison, New York City waste generation rates have remained relatively stable in recent years, with disposal rates fluctuating in response to changes in the City's recycling programs and recycling rates. This may be due to slower population growth in the City compared to the Nation as a whole. From 1990 to 2000, population in New York City increased by 9.4%, compared to a national increase of 13.2%⁽¹⁸⁾. Future waste generation rates in the City could be expected to follow population growth, but current data do not show a trend of increasing waste quantities.

More applicable to new and innovative technologies than the general, national trend of increasing waste quantities are identifiable trends in waste composition. Over the past decade, national waste composition data has shown a significant decrease in the amount of yard waste and an increase in plastics (see Table 2). The decrease in yard waste is attributed to state and local regulations banning or discouraging disposal of yard waste, while promoting mulching and composting of this component of the waste stream. Since New York City has substantially less yard waste than national averages, this national trend is not transferable locally. On the contrary, the national trend which shows an increase in the amount of plastic waste is likely to be reflected in New York City's waste stream. Plastic waste quantities have increased as plastics replace glass in certain packaging and become increasingly prevalent in durable goods. In general, changes in waste composition can be expected to continue to occur over time, nationally and in New York City. As a result, waste management technologies or approaches with the flexibility to accept different wastes or wastes with varying composition would be advantageous.

Consumer electronics, accounted for in USEPA data as plastics, metals and glass, are a growing segment of waste. A State-led waste composition study conducted in Oregon⁽¹⁶⁾ documents an increase in the disposal of computer monitors, computer equipment, and other electronic devices, although this portion of the waste stream is noted as being highly variable due to frequent "stockpiling" of electronics by consumers. The Oregon study and a similar study conducted recently in Wisconsin⁽¹⁵⁾ also document the presence of other problematic materials in the waste stream, such as mercury-containing items. While these components of the waste stream may be most effectively managed through source separation and recycling initiatives, innovative technologies or approaches that address such problematic wastes would provide an additional means of management.

TRENDS AND CHANGES IN LAW

Trends and changes in the law – environmental, transportation, land use, and tax laws – could affect the prospects for implementation of innovative technologies for solid waste management. Such trends were identified and considered in the development and application of the evaluation methodology.

Environmental Law

In terms of environmental law, the general trend over the past several decades has been towards ever increasing stringency in environmental protection. This ratcheting-down trend can be expected to continue. New laws to further abate air pollutant emissions are virtually certain, as well as new laws to curtail pollutant discharges to surface waters. A continuing general trend towards increased stringency in environmental law would encourage the use of innovative technologies that have lower air emissions and/or reduced water use or wastewater discharge.

Some innovative waste-management technologies turn solid waste into a useful product, such as ethanol, diesel oil, construction aggregate, or a commodity chemical. For two decades now, there has been a measured trend towards states (including New York State) granting "Beneficial Use Determinations" for such technologies. When a Beneficial Use Determination is granted, this means that the solid waste delivered to such a facility is no

longer regulated as solid waste; rather, regulators view the facility as a product manufacturing plant. Innovative technologies that convert solid waste into a useful product qualifying for a Beneficial Use Determination would likely gain siting acceptance by the public more readily than a traditional waste-management technology. For example, an unusual degree of public acceptance did manifest with an actual, innovative technology project under development in Orange County, New York, following the issuance by New York DEC of a Beneficial Use Determination for that facility. The innovative technology in that case involved the conversion of municipal solid waste to ethanol.

In the past, there had been a trend towards increased stringency in environmental laws governing the landfilling of solid waste itself, as well as the solid residues resulting from waste combustion. That trend towards increased stringency does not appear to be continuing at present. If anything, there are indications that regulators may become more receptive to allowing beneficial use of the solid residue resulting from the combustion or other processing of municipal solid waste. The State of Minnesota recently passed comprehensive new regulations that allow Beneficial Use Determinations for waste combustion ash. Should a trend in this regard emerge nationally, this could result in the residue from solid waste combustion no longer being regulated as a solid waste itself. Conventional waste-to-energy could gain the advantage some innovative technologies have, associated with marketing the residue as a useful product. In turn, this could significantly improve the economics of traditional waste-to-energy technology.

There is a continuing trend towards stricter regulations for control of emissions from truck diesel engines. Should the cost for compliance significantly increase transportation costs in the future, then this would tend to discourage long-distance trucking of solid waste for disposal, and encourage local waste management within the City or at least within the metropolitan region. In this event, based on the experience in Orange County, New York, it may be easier to gain public acceptance for siting an innovative waste-management technology in the metropolitan region than a traditional technology.

The global warming issue, in particular, may provide an impetus for increased interest in innovative technologies for solid waste management. It is reasonable to project a trend in environmental law towards curtailing greenhouse gas emissions, in light of mounting concerns over global warming domestically and continuing political pressure from Europe for the U.S. to act. New York State is already addressing the issue. Governor Pataki commissioned a task force in 2001 to identify specific actions for achieving major reductions in greenhouse gas emissions. In 2003, the Governor co-developed a "cap and trade" program to reduce greenhouse gas emissions from power plants. Among many available means to reduce greenhouse gas emissions, two are particularly relevant here: using renewable fuels instead of fossil fuels to generate electric and steam energy, and reducing dependence on municipal waste landfills, significant generators of the greenhouse gas, methane. Similar to conventional waste-to-energy technology, most innovative technologies for solid waste management would afford one or both of these means for reducing greenhouse gas emissions. Already, many states, including New York, provide financial and/or tax incentives to develop renewable energy projects. To summarize, future laws to control greenhouse gases could create new regulatory incentives to use technologies for solid waste management that reduce greenhouse gases. In addition,

renewable-energy subsidies and tax credits could improve the economic viability of those technologies.

Transportation Law

Regarding transportation law, current federal law promotes free flow of commerce across state lines. Because solid waste is considered “commerce” under current transportation law, this makes it difficult for waste importing states to limit waste imports. Various legislative initiatives have been mounted over the years in Congress aimed at changing the transportation law to allow greater state control of waste imports. In fact, new such proposals are before Congress at this time. To date, however, all such initiatives have failed; Congress has been consistently reluctant to weaken the interstate commerce rules. While purely speculative, should transportation law change at some point in the future to allow states to control waste imports, this would tend to force in-State disposal of the City’s solid waste. In that event, it would become necessary to site new waste-management facilities within the State of New York. Again, based on the experience in Orange County, New York, gaining public acceptance for in-State siting may be more successful by proposing innovative waste-management technologies rather than traditional technologies.

“Flow control” refers to the ability of local government (e.g., city, county, an authority) to mandate that solid waste collected within the jurisdiction be delivered to a specified disposal facility. Through flow control, local government can promote the economic viability of a solid waste facility by assuring an adequate supply of waste. Thus, the ability to impose flow control would enhance the prospects for local development of solid waste facilities, whether using innovative or traditional technologies. The courts, however, have imposed significant limits on the types of flow control considered legal. The fundamental court decision in this regard was the “Carbone decision” in 1994, in which the Supreme Court held that a local flow control ordinance that directed waste to a *private* disposal facility violated the free Commerce Clause. More recently (2001), however, the issue was re-opened by the 2nd Circuit Court in the case of United Haulers versus the Oneida-Herkimer Solid Waste Management Authority. The Court upheld a flow control ordinance that does not discriminate between in-state and out-of-state interests, and directs waste to a *publicly* owned disposal facility (as opposed to privately owned). The case was remanded back to the District Court to determine whether the ordinance places an unreasonable burden on the free flow of commerce. The significance is that this may open the door for flow control by localities, at least with respect to publicly owned disposal facilities. This, in turn, could facilitate local development of disposal facilities if publicly owned. A preference for public ownership of disposal facilities could favor traditional technologies over innovative ones since traditional technologies will be considered “less risky”.

Land Use Laws

With respect to trends in land use laws, there are no apparent changes in the offing at the State and local levels that could affect the siting of waste management facilities, other than new City siting rules for transfer stations. Nationally, however, there has been a trend towards assessing whether siting such facilities could impart disparate impacts to minority and low-income communities (“Environmental Justice”). More generally, there has been a

policy trend of providing compensation to communities willing to accept a solid waste management facility; i.e., a “host community fee.” Because New York City generally lacks the ability to directly compensate in this fashion, it may be more feasible politically to site a waste management facility in a community outside of the City, where host community compensation can be more readily provided. This would be true whether a waste management facility uses innovative technology or traditional technology.

Tax Law

Regarding trends in tax laws, there are potential considerations for waste management projects that use innovative technologies. Innovative technology projects have inherently higher technology risks and accordingly, are more likely to be privately owned than publicly owned. Under current tax laws, any given privately-owned project, when seeking favorable, tax-exempt financing, must compete with other infrastructure projects for an allocation under a fixed total cap on bonding. There is proposed legislation before Congress that would exempt privately-owned *solid waste* projects from the cap. Should this become law, it could make it easier for privately-owned solid waste projects to obtain tax-exempt financing. This is noteworthy for innovative technology projects in particular, given that such projects are more likely to be privately owned, at least for the near term.

As noted above, there has been a trend towards giving favorable tax treatment to renewable energy projects. Many of the innovative technologies for solid waste management are renewable energy technologies, and would qualify for such favorable tax treatment. This would increase the economic viability of those innovative technologies.

A tax law issue of potential interest to the City, but not directly relevant to consideration of innovative technologies, concerns an opinion issued by the Department of Taxation and Finance to impose a sales tax on the collection of solid waste from transfer stations (see attached opinion). Proposed legislation would override the Opinion and make clear that collection from transfer stations was not subject to a sales tax.

APPENDIX F
PRELIMINARY SCREENING WORKSHEETS

THERMAL TECHNOLOGIES

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Gasification with Fermentation to Produce Ethanol

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: BRI Energy – Bioengineering Resources for Renewable Energy

Contact Name: William F. Bruce, President Phone: (407) 210-3839

Address: 301 East Pine Street Fax: (386) 409-7188

City, State, Zip: Orlando, FL 32801 E-Mail: wfbruce@bellsouth.net

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Pilot scale performance testing has been conducted. Operation of first plant envisioned for 2007.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Economics projected for a 100,000 TPY facility. Modular design with 150 TPD gasifiers (>50,000 TPD each gasifier).	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Pilot plant has been performance tested under a DOE grant. Unable to determine scale of pilot plant or if MSW has specifically been tested in the process.	NO
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Primary product is ethanol, with additional fuel gas available to produce energy.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	17,300 tons of solid waste residue to landfill per 100,000 tons solid waste feedstock results in 17% residual waste requiring disposal.	YES
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Gasification with Briquetting of RDF, Combustion Turbine and Optional Methanol Mfg.

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: Dynecology, Inc.

Contact Name: Dr. Helmut Schulz, Chairman and CEO Phone: _____

Address: 611 Harrison Ave. Fax: _____

City, State, Zip: Harrison, NY 10528 E-Mail: _____

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years..	Briquetting has been demonstrated on a pilot scale by Dynecology. Proposed gasifier technologies have been demonstrated for several fuels, including coal/RDF and coal/sewage sludge briquets. It is general knowledge that combustion turbines can run on synthesis gas if it is of sufficient quality.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Plant economics run at 5,000 TPD (1.8 million TPY) with multiple gasifier/turbine trains or modules.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Briquetting of MSW/sewage sludge/coal combination has been demonstrated on a pilot scale by Dynecology. Pilot testing of RDF/coal and sewage sludge/coal briquettes has been successfully tested in two gasifier designs in Europe.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Primary product is electricity from the combustion of the synthesis gas. Optional methanol production is indicated in a diagram but not discussed in detail.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Insufficient information provided to allow evaluation.	INDETERMINATE
Does the proposed technology meet the requirements of the screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Gasification – Fluidized Bed with Ash Vitrification

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: Ebara Corporation

Contact Name: Hiroshi Tanaka

Phone: ++81-3-5783-8537

Address: 1-6-27 Konan Minato-ku

Fax: ++81-3-5461-6011

City, State, Zip: Tokyo, 108-8480 Japan

E-Mail: tanaka.hiroshi@ebara.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	21 TwinRec (Option 1) process lines have been installed commercially with 16 processing MSW. Two pilot ICFG (Option 2) pilot plants have been constructed. One has operated on biomass since early 2003. The other is designed for RDF and MSW and was scheduled to go on line April 2004.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	The Asahi Clean Center in Kawaguchi features three TwinRec lines for a total capacity of 18 TPH (>150,000 TPY).	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	TwinRec (Option 1) technology meets reliability criteria. ICFG (Option 2) technology had not yet been operated with MSW at the time of writing of the proposal.	TwinRec YES ICFG NO
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	Air pollution controls necessary to meet environmental permit and regulatory controls will be implemented as needed. Syngas cleanup is incorporated into the process.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Synthesis gas for combustion and production of electricity is produced. Additional products include vitrified ash (glass) and metals.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	More than 95% of the waste input can be recycled and recovered.	YES
Does the proposed technology meet the requirements of the screening criteria?		TwinRec YES ICFG NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Gasification preceded by Briquetting
 Technology: _____
 Category: Thermal

Project Sponsor Contact Information

Company Name: Ecosystem Projects, LLC
 Contact Name: Stephan J. Henriquez, President Phone: (518) 472-1526
 Address: 122 South Swan Street Fax: (518) 472-1544
 City, State, Zip: Albany, NY 12210 E-Mail: shenriquez@ecosystemprojects.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Briquetting and gasification technologies have been proven independently. A facility in Italy, apparently using briquetting and gasification together is scheduled to go on line in the next few months (unclear if this is commercial or pilot scale).	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Multiple briquetting facilities sited in NYC at 200 to 400 TPD, scaleable to 1,000 TPD. Gasification facility sited in NY State of undetermined size.	INDETERMINATE
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	It is unclear as to whether a pilot scale operation using both the MSW briquetting technology and the gasification technology has been operated. The proponent is proposing a pilot scale operation for such demonstration on NYC MSW.	INDETERMINATE
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Synthesis gas for combustion and production of electricity is the sole product.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Ash is 12-15% of the weight of briquettes loaded into the gasifier and may be used as landfill cover. Briquets have most metals and inorganic material removed by in the briquetting process.	YES
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Waste Oxidizer

Technology Category: Thermal (Pyrolysis)

Project Sponsor Contact Information

Company Name: Eco Waste Solutions, Inc.

Contact Name: Mr. Steve Meldrum, CEO, or Mr. Lowell Feuer Phone: 905-634-7022

Address: 5195 Harvester Road, Unit 6 Fax: 905-634-0831

City, State, Zip: Burlington, Ontario Canada L7L 6E9 E-Mail: info@ecosolutions.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Commercially available at a small scale. Uncertain if commercial for MSW or stage of development for large-scale applications.	INDETERMINATE
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Unit capacity up to 25 tpd (9,125 tpy). Modular, but uncertain if sufficient units could be effectively coupled to achieve 50,000 tpy or more.	NO
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Technology is commercial, but at a small scale and uncertain whether MSW has been processed.	INDETERMINATE
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	Information not provided. Reasonably assumed to be at least comparable to conventional waste-to-energy. Likely to be capable of meeting permit and regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Energy recovery option and post-combustion recycling of metals and glass. No information provided on energy recovery from the system.	INDETERMINATE
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Generates ash residue. Reportedly achieves 90% waste reduction. Uncertain if this percentage is by weight or volume.	INDETERMINATE
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: **Gasification - Bioconversion Technology LLC (BCT) Pyrolytic Steam Reformer**

Technology Category: **Thermal**

Project Sponsor Contact Information

Company Name: **Emerald Power Corporation and Isabella City Carting Corporation**

Contact Name: **Robert Mahony or Jonathan Schreiber** Phone: **212-627-0380**

Address: **75 Ninth Avenue Suite 3G** Fax: **212-647-9433**

City, State, Zip: **New York, NY 10011** E-Mail: **rmahony@emeraldpower.com**

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Demonstrations completed on hog manure, and scheduled to take place on hazardous waste. Discussions underway to test with MSW. First commercial unit is being manufactured, and will generate electricity from sawdust. Could be commercially available for MSW within 10 years.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	First commercial unit is only 15 tpd (5,475 tpy). Although not demonstrated, typical installation is expected to be 1-4 modular units of 250 tpd each.	INDETERMINATE
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	The only successful demonstration test was a prototype reformer (size unspecified) that processed hog manure for a 9 month period. This same reformer will now be used to test hazardous waste in Israel. No tests for MSW.	NO
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No combustion of waste, although, process emissions from burning gas to heat reactor chamber and to generate electricity. Technology is expected to be capable of meeting permit and regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Technology produces synthesized gas (carbon monoxide, carbon dioxide, methane, hydrogen). The gas can be burned to generate electricity or reformulated into pipeline-quality methane or fuel-grade ethanol.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Residue is reported to be 10% by volume, which is comparable to conventional waste-to-energy systems. Note, however, that the sponsor assumes the residue will be hazardous.	YES
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

**NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}**

Proposed Technology: Pyrolysis – Production of Synthetic Coal

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: Entropic Technologies Corporation c/o American HomeNet, Inc.

Contact Name: Kenneth S. Hannan Phone: (978) 974-9271

Address: 416 Abbot Street Fax: (978) 686-0486

City, State, Zip: North Andover, MA 01845 E-Mail: kshsr@aol.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Materials on file are undated and it is unclear if development of this technology is currently active. At the time the report was written, a commercial scale facility for recycling of industrial scrap, including tires was underway.	INDETERMINATE
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Financial projections are provided for 1,600 and 2,400 TPD projects (>500,000 TPY).	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Plant produces low-grade RDF from MSW using conventional, proven processes. It is unclear whether or not the R&D efforts with MSW for the pyrolytic process (which converts the RDF to a premium synthetic coal) reached the pilot stage.	INDETERMINATE
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	Neither syncoal product nor production operations present significant environmental impact.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Premium grade synthetic coal is produced.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	18.5% of incoming MSW represents rejects to landfill from the RDF process.	YES
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Gasification – Thermal Cracking Technology

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: GEM America, Inc.

Contact Name: Douglas E. Weltz, Managing Director Phone: (908) 608-0491

Address: 26 Laurel Avenue Fax: (908) 608-0156

City, State, Zip: Summit, NJ 07901-3437 E-Mail: dweltz@earthlink.net

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	GEM UK (European operations) has designed and installed one MSW site. Four additional plants are in the design and permitting phase in Europe.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Ideal minimum size is 66,000 metric tonnes per year (greater than 70,000 TPY).	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Reportedly, GEM UK has designed and installed a MSW facility in South Wales.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	The South Wales facility has been licensed. Three of the four facilities in the final planning stages in Europe have received environmental “conditional C and A’s” based on agency review of actual test results.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Synthesis gas is the primary marketable product.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Residual mineral solids are the only by-product of the operation (8% to 10% by weight).	YES
Does the proposed technology meet the requirements of the screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Gasification, Pyrolysis and High Temperature Process (Thermal Converter)

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: Global Energy Solutions

Contact Name: Edmund R. Danzig, President Phone: (941) 355-8876

Address: 1748 Independence Blvd., Bldg. A Fax: (941) 351-7287

City, State, Zip: Sarasota, FL 34234 E-Mail: GlobalES@teamges.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	There are more than 20 Thermal Converter installations in Japan, Korea and Europe. Based on a review of Figure 1, it appears that at least three process "domestic" waste, assumed to be MSW.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Figure 8 shows various models of Thermal Converters ranging in size from 24 TPD to 600 TPD (8,760 to 219,000 TPY). Presumably multiple units may be installed.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Numerous units are operating commercially with various unsorted industrial and domestic wastes.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	Meets or does better than European and US air emissions standards.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Synthesis gas for combustion in a boiler and generation of electricity using a steam turbine.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Claims only 3% residual which is useable as aggregate for roadbeds and building materials.	YES
Does the proposed technology meet the requirements of the screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Gasification – Plasma Torch

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: Global Environmental Technologies, Inc.

Contact Name: Mr. Dario Cantano Phone: (631) 965-2281

Address: 35 Montuak Highway Fax: (631) 283-5127

City, State, Zip: Southampton, NY 11968 E-Mail: dcantano@get-recycled.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	"The technology has been proven with daily use over the last 15 years in commercial and industrial use."	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Minimum plant supply tonnage is 5,000 TPD, however, the proposed project is anticipated to handle 10,000 TPD.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Plasma technology has been used for gasification, reportedly with municipal solid waste. However, no reference projects or pilot plant information was provided.	INDETERMINATE
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	"The proposed project is a very low emissions facility. Supporting laboratory data is available, verifying all claims of environmental impact which are well below any and all Federal and State mandates."	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Synthesis gas is the primary product and the plant proposal includes boilers and steam turbines to generate electricity from the syngas combustion.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	"Any and all by-products produced as a result of the processing of waste are completely without contaminants and are re-useable in many commercial and industrial applications."	YES
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: **Ultra-high Temperature Gasification (Destructive Distillation)**

Technology Category: **Thermal**

Project Sponsor Contact Information

Company Name: **Innovative Logistics Solutions (ILS-Partners/Pyromex)**

Contact Name: **John S. Sloan, VP Marketing and Sales** Phone: **760-568-9369**

Address: **1 Como Circle** Fax: **775-213-0554**

City, State, Zip: **Palm Desert, CA 92211** E-Mail: **j.sloan@ils-partners.com**

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	The technology has achieved commercial operation in Europe for industrial sludge applications. The technology has not been tested for MSW. It is uncertain, but possible, that commercial operation for MSW could be achieved within 10 yrs.	INDETERMINATE
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	The technology is reported to be efficient at 10 tpd and greater. Units are scalable up to approximately 450 tpd (i.e., greater than 50,000 tpy).	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	The technology has been operational for over 2 years in Germany, but that facility processes industrial sludge. No indication of any commercial applications, or even pilot testing, of the technology for MSW.	NO
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	Data provided shows emissions are below environmental standards and regulations, worldwide. Technology is expected to be capable of meeting permit and regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Organic material is converted to a pyrogas, which is combusted to produce electricity. Inorganic material is converted to a residue (sand or basalt-like), reported to have reuse applications.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Residue is reported to be 5% by volume, and has reuse applications.	YES
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Gasification

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: Interstate Waste Technologies

Contact Name: Francis C. Campbell, President Phone: (540) 687-3177

Address: Two West Washington St.; PO Box 1280 Fax: (540) 687-3179

City, State, Zip: Middleburg, VA 20118 E-Mail: _____

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET? (YES OR NO)
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Commercial scale plants are currently in operation in Europe and Japan.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	At least two plants have been operating exceeding 100,000 TPY capacity for several years.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Commercial scale plants in Europe and Japan have operated successfully for more than one year.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	Existing plants meet strict European and Japanese environmental standards which are at assumed to be at least as stringent as U.S. local, state and federal standards.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Highest value product is energy from the combustion of synthesis gas with reciprocating engines. Additional products are materials such as grit, refineable metals, elemental sulfur, industrial salts, and zinc concentrate.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Proponent states that <u>all</u> materials leaving the plant are saleable products.	YES
Does the proposed technology meet the requirements of all six screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Gasification and Pyrolysis

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: Jov Theodore Somesfalean

Contact Name: Jov Theodore Somesfalean, Developer Phone: (212) 595-2511

Address: 170 West End Avenue Fax: (212) 580-8698

City, State, Zip: New York, NY 10023 E-Mail: JOVTS@aol.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	A 50 to 75 TPD "pilot" plant was constructed and operated in Redwood City, Washington and operated for three years. A pilot plant of this scale could be considered commercial size.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	The Redwood City pilot plant, at 50 TPD had this capability (greater than 18,000 TPY). The optimum plant size is stated to be 750 TPD.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	In Section 6 of the proposal, a letter reports that the Redwood City pilot plant demonstrated a 50 TPD and a 75 TPD gasifier. However, the referenced EPA report indicates the fuel was tires.	NO
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	The proponent reports that emissions from the Redwood City plant were tested and met California EPA standards. Emission results are summarized in the proposal, but contain some factual or typographical errors.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Products are synthesis gas and char. Synthesis gas has been demonstrated to produce electricity in a steam turbine (i.e., burned successfully in a boiler).	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Char and residue represents 25% by weight and 10% by volume of the incoming waste.	YES
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
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Proposed Technology: **Destructive Distillation**

Technology Category: **Thermal**

Project Sponsor Contact Information

Company Name: **Pan American Resources, Inc.**

Contact Name: **John Toman, CEO/President** Phone: **(925) 846-2657**

Address: **4222 Bevilacqua Ct.** Fax: **(925) 846-2657**

City, State, Zip: **Pleasanton, CA 94566** E-Mail: partoman1@earthlink.net

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	The Lantz Converter has achieved or is very close to commercial availability based on equipment previously sold for waste management projects.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	700 TPD facility proposed (>250,000 TPY)	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	A Lantz Converter with dryer rated at 6 TPD of municipal solid waste has been operated for demonstration and research from 1962 to 1991.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements. Note that the fate of the hydrosonic scrubber blowdown is not indicated on the system flow chart.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Synthesis gas is produced and is used to fuel a steam generating boiler. The boiler steam is used to produce electricity. The char material that contains some inorganics is said to be suitable for improved landfill management.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Char represents 31% of shredded waste produced after sorting large items out and removing metals.	YES
Does the proposed technology meet the requirements of the screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

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Proposed Technology: Gasification – “Plasma Thermal Destruction and Recovery”

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: PEAT International, Inc.

Contact Name: Daniel Ripes, Corp. Communications Manager Phone: (847) 559-8567

Address: 555 Skokie Blvd., Suite 350 Fax: (847) 291-3704

City, State, Zip: Northbrook, IL 60062 E-Mail: _____

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Commercial for other waste, but not MSW. A 10 TPD plant in Taiwan started trial operations in December 2003, processing liquid waste (solvents and PCBs) for industrial client.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Facility size may be from 1.5 TPD to 480 TPD (greater than 175,000 TPY).	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	The 10 TPD Taiwan plant is in trial operation, processing liquid industrial waste. A 3 to 5 TPD facility is under construction in Taiwan and is “designed to handle municipal solid waste from sewage sludge, to medical wastes to incinerator ash.” Huntsville pilot facility has tested various waste, but no pilot testing for MSW.	NO
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	EPA type risk assessment performed and construction permit obtained for a Plasma system fueled with medical waste in San Diego, CA.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Synthesis gas, glassy silicate slag and metal alloy materials are produced.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Amount of residual waste is not explicitly stated, however, since above noted products (syngas, silicate slag and metal alloy) represent almost all of what results from the mass input, meets criterion.	YES
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

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Proposed Technology: Westinghouse Plasma Gasification combined with MRF (Tempico)

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: Rigel Resource Recovery and Conversion Company

Contact Name: Carl Donald Liggio, Jr., Ph.D. Phone: 410-961-4141

Address: 3801 Canterbury Road Fax: 410-366-2743

City, State, Zip: Baltimore, MD 21218 E-Mail: cliggio@aol.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Based on RFI response, a commercial facility could be developed within 4 years.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Proposed size: 350 tpd waste diversion facility (WDF) and 3000 tpd gasification waste conversion facility (WCF)	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	There are 3 small commercial applications of the Westinghouse plasma gasifier in Japan, and a 3 tph pilot facility in PA. The Tempico rotoclave (for waste handling/recycling) is commercially used for medical waste and has been piloted for MSW.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	Gas is scrubbed prior to and after combustion, reportedly resulting in emissions less than EPA standards. Likely to meet permit and regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	The Tempico rotoclave would recover recyclables (metals, plastic, paper as pulp). The gasification technology produces a syngas, which is burned to produce electricity, and vitrified glass for remanufacture.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Minimal residual waste, assuming molten glass can be manufactured into finished products.	YES
Does the proposed technology meet the requirements of the screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

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Proposed Technology: Plasma Converter

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: Startech Environmental Corp.

Contact Name: Joseph S. Klimek, President and CEO Phone: (203) 762-2499

Address: 15 Old Danbury Road Fax: (203) 761-0839

City, State, Zip: Wilton, CT 06897 E-Mail: _____

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Two small scale, commercial plants have been built and operated for demonstration purposes. Two contracts are in place to design and construct commercial scale facilities in Poland.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Proposed facility size for NYC ranges from 300 to 2,000 TPD. Polish facilities will be 300 TPD each (over 100,000 TPY).	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	7 TPD plasma converter was delivered to Aberdeen Proving Ground, MD in 1997 for destruction of chemical weapons. 5 TPD converter is available for demonstrations in Bristol, CT, however, it is not clear that MSW has been tested.	INDETERMINATE
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Technology produces saleable products including clean synthesis gas, recovered sulfur and valuable metals and silicates.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Only residual requiring disposal is scrubber wastewater containing salts at 12,766 kg/75,758 kg waste or 17%.	YES
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

**NYDS and NYCEDC
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Proposed Technology: Biomass Gasification with Upfront Sorting/Separation

Technology Category: Thermal (Gasification)

Project Sponsor Contact Information

Company Name: Taylor Recycling Facility, LLC

Contact Name: James J. Taylor, Jr., Chairman Phone: 845-457-4021

Address: 350 Neelytown Road Fax: 845-456-4003

City, State, Zip: Montgomery, NY 12459 E-Mail: jim@taylor-recycling.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	The company is currently completing detailed design for a 300 tpd reference plant (gasifier) to be constructed at their existing recycling plant in Montgomery, NY. Technology is expected to be commercially available for MSW within 10 yrs.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Currently designing for a 300 tpd reference plant.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Tested RDF and other biomass fuels with a 10 tpd pilot-scale gasifier. Demonstration facility included integrated gas turbine generating system.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	Claims of improved environmental performance compared to conventional waste-to-energy. Likely to be capable of meeting environmental permit and regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Process recovers recyclables and produces a synthesis gas. Synthesis gas can be used to generate steam, heated air, renewable energy.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Limited information is provided on residual waste. However, similar to other gasification systems, residual waste is expected to be less than 35% by weight.	YES
Does the proposed technology meet the requirements of the screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

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Proposed Technology: Gasification

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: Thermogenics, Inc.

Contact Name: Leland T. Taylor, President Phone: 505-761-5633

Address: 7100 F 2nd Street NW Fax: 505-341-0424

City, State, Zip: Albuquerque, NM 87107 E-Mail: linvent@aol.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	USDOE report provided by Thermogenics concludes that long-term gasifier operation is required, along with work on other technical issues. Based on info provided, uncertain if commercial operation achievable within 10 yrs.	INDETERMINATE
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Focus is small-scale (10-30 tpd). Cover letters cites use at the source - i.e., in office buildings. Multiple units might achieve larger scale, but uncertain.	INDETERMINATE
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Technology is not in commercial operation. Short-term, small-scale research studies have been conducted for tires and perhaps other fuels; no indication of tests for MSW.	NO
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	Similar to other gasification systems, the technology is expected to produce less emissions than conventional waste-to-energy. Likely to be capable of meeting permit and regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Technology produces syngas, which is used to produce electricity.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	No information provided.	INDETERMINATE
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

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Proposed Technology: **Zero-Emission Energy Recycling Oxidation System (ZEROS)**

Technology Category: **Thermal (Thermal Oxidation Process)**

Project Sponsor Contact Information

Company Name: **Zeros, Inc.**

Contact Name: _____ Phone: **214-528-4805**

Address: **25 Highland Park Village Suite 100-701** Fax: _____

City, State, Zip: **Dallas, TX 75205-2785** E-Mail: _____

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	No information provided on the stage of development achieved for the technology.	INDETERMINATE
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Literature provided says that a full-size, modular system is sized at 250,000 lb/day (125 tpd).	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	No information provided on pilot or commercial scale operations of the technology. Indirect references are made to the testing, and perhaps commercial use, of the technology for hazardous waste remediation (oil-contaminated soil).	INDETERMINATE
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	If the technology is shown to perform as proposed, emissions are eliminated offering improved environmental performance.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Technology produces energy (steam, electricity) and high-grade carbon dioxide suitable for industrial uses.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Residuals include ash and brine. Sufficient information is not provided on the production of residual waste. The quantity of residuals depends on the characteristics of the waste processed.	INDETERMINATE
Does the proposed technology meet the requirements of the screening criteria?		INDETERMINATE

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

DIGESTION TECHNOLOGIES

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Proposed Technology: Arrow Bio Process

Technology Category: Anaerobic Digestion

Project Sponsor Contact Information

Company Name: Arrow Ecology & Engineering Overseas, Ltd.

Contact Name: Mr. Yair Zadik, Business Manager Phone: +972-505-424239

Address: Histadruth Avenue Fax: +972-04-8412586

City, State, Zip: Haifa, 31250 Israel E-Mail: yair@arrowecology.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	A pilot scale plant operated for five years, and is now decommissioned. A commercial plant has been operating in Tel Aviv, Israel since 2003.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	The size of one "module" is 77,000 tpy.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	The pilot scale plant operated at a capacity of 10 to 30 tpy during its last year of operation.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	The products that result from this process are biogas, which is used to generate electricity; soil conditioner; and recyclables such as glass, plastic, and metal.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	The response to the RFI states that approximately 10% of the incoming waste remains as a residual.	YES
Does the proposed technology meet the requirements of the screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

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Proposed Technology: **BTA Process Technology – Anaerobic Digestion**

Technology Category: **Anaerobic Digestion**

Project Sponsor Contact Information

Company Name: **Canada Composting, Inc.**

Contact Name: **Mr. Kevin Matthews, President and CEO** Phone: **(905) 830-1160**

Address: **390 Davis Drive, Suite 301** Fax: **(905) 830-0416**

City, State, Zip: **Newmarket, Ontario, L3Y 7T8 Canada** E-Mail: **ccikevin@attglobal.net**

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Canada Composting, Inc. has been operating a commercial facility in Newmarket, Ontario since 2000.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	The capacity of the Newmarket facility is 120,000 metric tons of source-separated organic waste.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	The commercial facility has been operating since 2000.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	The products that result from this process are biogas which is used to generate electricity and organic residue which is used as a soil amendment.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	A mass balance prepared using City of Toronto data estimates that 18% of the incoming waste will require disposal.	YES
Does the proposed technology meet the requirements of the screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

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Proposed Technology: Gasification and Anaerobic Digestion

Technology Category: Thermal Process and Anaerobic Digestion

Project Sponsor Contact Information

Company Name: KAME/DePlano Group

Contact Name: Anthony DiNapoli Phone: (978) 470-2424

Address: c/o DePlano Group One Madison Avenue Fax: (978) 478-2452

City, State, Zip: New York, NY 10100 E-Mail: bdiusa@attglobal.net

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	No specific information is provided for the time frame for demonstration or commercial operation.	UNDETERMINED
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	The RFI response states that the facility size is envisioned to have a capacity of 450 tpd for gasification plus up to 180 tpd for anaerobic digestion. This capacity is above 50,000 tpy.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	No specific information is provided about existing operating facilities.	UNDETERMINED
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	The products that result from this process are: electricity, silica, cinderblocks and bricks, and carbon black.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	The RFI response states that the process results in "non-significant or almost zero" waste.	YES
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

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Proposed Technology: **New Bio High Rate Anaerobic Process** **for processing of food waste only**

Technology Category: **Anaerobic Digestion**

Project Sponsor Contact Information

Company Name: **New Bio**

Contact Name: **Jim Last, Sales Manager** Phone: **(952) 476-6194**

Address: **P.O. Box 771** Fax: **(952) 476-8622**

City, State, Zip: **Hopkins, MN 55343** E-Mail: **jl@newbio.com**

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	The company has been in business for six years and has three installations presently operating.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	The response to the RFI indicates that one 36-ft. diameter size BioAccelerator unit can treat about 25,000 lb/day of food waste. This value is approximately 4,500 tpy	NO
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	The marketing materials included in the submittal are all related to the treatment of high-strength food waste organic wastewater, not MSW. No information is provided related to this criterion.	UNDETERMINED
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	The product that results from this process is biogas, which can be used to generate electricity.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	This technology is intended to process food waste only. The response to the RFI indicates that the food waste input to the reactor must be 95% biodegradable. Paper and plastic and other non-biodegradable materials must be removed from the waste stream Wastewater and waste biomass from the reactor are proposed to be discharged to the sewer system.	UNDETERMINED
Does the proposed technology meet the requirements of the screening criteria?		NO

(1) Information provided by companies in response to Request for Information or as otherwise noted.

(2) Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

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Proposed Technology: **BIOCEL Dry Anaerobic Digestion**

Technology Category: **Anaerobic Digestion**

Project Sponsor Contact Information

Company Name: **Orgaworld**

Contact Name: **Ir. H.J.M. Kaskens, General Manager** Phone: **+31(0)41 33 33 500**

Address: **Loopkantstraat 39, P.O. Box 96** Fax: **+31(0)41 33 33 509**

City, State, Zip: **5400 AB UDEN Netherlands** E-Mail: **info@orgaworld.com**

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	This technology has been operating commercially since 1997.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Existing operations are smaller than 50,000 tpy. The response to the RFI indicates that an existing plant is expecting a permit for expansion to 88,000 tpy, and a new planned facility is to be permitted for a capacity of 75,000 tpy.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Commercial facilities with larger capacity than 1 tpy have been operating since 1997.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	For source-separated organic waste: a soil compost is produced. For municipal solid waste, the product is intended to be co-fired in power plants.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	No information provided. The response to the RFI indicated that additional information would be provided upon request.	UNDETERMINED
Does the proposed technology meet the requirements of the screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: **DRANCO Process – Dry Anaerobic Digestion**

Technology Category: **Anaerobic Digestion**

Project Sponsor Contact Information

Company Name: **Organic Waste Systems OWS nv**

Contact Name: **Luc De Baere** Phone: **32/9/233.02.04**

Address: **Dok Noord 4** Fax: **32/9/233.28.25**

City, State, Zip: **B-9000 Gent Belgium** E-Mail: **luc.de.Baere@ows.be**

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	This technology is being operated commercially in Europe.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	One of the existing commercial scale facilities has a capacity of 50,000 tpy.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	The largest operating commercial facility has been operating since 1992.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	The products that result from this process are biogas and soil amendment.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	The response to the RFI includes a mass balance which shows 1000 tons of "rejects" being produced for 25,000 tons of incoming waste. This is a percentage of 4%.	YES
Does the proposed technology meet the requirements of the screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Valorga Process

Technology Category: Anaerobic Digestion

Project Sponsor Contact Information

Company Name: Waste Recovery Systems

Contact Name: Steven A. Morris Phone: (949) 290-6996

Address: 33655 Marlinspike Drive Fax: (949) 388-8834

City, State, Zip: Monarch Beach, CA 92629-4428 E-Mail: samwrsi@aol.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	The technology is operating commercially in Europe.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	The largest operating facility is 1100 tpd. This capacity is larger than 50,000 tpy.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	The technology is operating commercially in Europe.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	The products produced by this technology are biogas, which is used to generate electricity, and soil amendment.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	The response to the RFI includes a mass balance which indicates that approximately 30% of the incoming waste is disposed in a landfill.	YES
Does the proposed technology meet the requirements of the screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: **Enhanced Autothermal Thermophilic Aerobic Digestion (EATAD) Process**

Technology Category: **Aerobic Digestion**

Project Sponsor Contact Information

Company Name: **Mining Organics Management**

Contact Name: **William Gildea or John Tucker** Phone: **(617) 624-0111**

Address: **7A Commercial Wharf West** Fax: **(617) 624-0333**

City, State, Zip: **Boston, MA 02110** E-Mail: **Not Provided**

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	One 30-tpd demonstration facility is being operated in Vancouver, Canada.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	The existing facility has a capacity of 30 tpd. This is smaller than 50,000 tpy; however, there is no reason that the technology cannot be scaled up to a larger capacity of 50,000 tpy.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	The Vancouver facility has been operating since 1998, but it processes source-separated food waste and other source-separated organics (e.g., agricultural waste), not MSW.	NO
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	The aerobic digestion process converts the organic waste into "single cell protein", which has value as an amendment to cropland. The products produced by this technology are solid product pellets and liquid concentrate supplement.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	The response to the RFI includes a mass balance, which indicates that 16.1% of the incoming waste is disposed in a landfill. This is for source-separated organic waste and would likely be higher for MSW.	INDETERMINATE
Does the proposed technology meet the requirements of the screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

HYDROLYSIS TECHNOLOGIES

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: **Concentrated Acid Hydrolysis (Waste-to-Ethanol)**

Technology Category: **Hydrolysis**

Project Sponsor Contact Information

Company Name: **Arkenol Fuels, Inc.**

Contact Name: **Arnold R. Klann, President** Phone: **949-588-3767 X310**

Address: **31 Musick** Fax: **949-588-3972**

City, State, Zip: **Irvine, CA 92618** E-Mail: **ARKlann@arkenol.com**

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Commercial facility in Japan (wood waste, 2 yrs operating) and 5 years of pilot operations in CA (various feedstock) promote readiness for commercial application in USA within 10 years.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Capable of processing >50,000 tpy (140 tpd). Cost effective at 260 tpd and higher. Projects promoted for 500-2000 tpd.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Commercial facility in Izumi, Japan - operational for past 2 years, but processes only wood waste. A pilot plant (1 tpd) has been operated for past 5 years in CA on various feedstocks; no documentation that MSW has been piloted.	NO
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	Process designed as "zero discharge" by recovering and recycling reagents. Fugitive emissions possible from waste handling, but manageable. Likely to meet permit and regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Technology produces ethanol, a marketable commodity. Other end products can also be produced.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Approximately 30% residuals from processing MSW potential for reduction in residuals with further processing.	YES
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Acid Hydrolysis and Condensation Reactions to Produce Levulinic Acid

Technology Category: Hydrolysis

Project Sponsor Contact Information

Company Name: Biofine, Inc. / BioMetics, Inc.

Contact Name: Dr. Stephen Fitzpatrick Phone: (781) 684-8331

Address: 300 Bear Hill Road Fax: (781) 684-8335

City, State, Zip: Waltham, MA 02451 E-Mail: _____

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Commercial scale plant has been built in Italy, however, feedstock is paper sludge. Pilot demonstration has been made on MSW-derived fiber.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Italian plant sized for up to 300 TPD (>100,000 TPY).	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Pilot demonstration at Glen Falls, NY, operated at up to 2 TPD while fed with MSW-derived fiber.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	No information indicating that the facility could not be permitted and meet regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Levulinic acid is produced. This substance has promise as a commodity feedstock chemical for tetrahydrofuran, delta amino levulinic acid, aceto acrylic acid, and ethyl levulate.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	The pilot demonstration at Glen Falls yielded 0.31 lb of levulinic acid per lb of cellulose feed. The management of the remaining 69% of the material has not been specified in input provided to date, therefore, information is not presently available indicating that this criterion has been met.	NO
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: **CES OxyNol Hydrolysis Process**

Technology Category: **Hydrolysis**

Project Sponsor Contact Information

Company Name: **Masada Oxynol**

Contact Name: **Alice W. Durkee, Vice President**

Phone: **205-968-0078**

Address: **1400 Urban Park Drive, Suite 125**

Fax: **205-968-0079**

City, State, Zip: **Birmingham, AL 35242**

E-Mail: **masadaoffice@aol.com**

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Demonstrated on pilot scale at Tennessee Valley Authority's Muscle Shoals, AL facility (1984-1987). First commercial plant is in advanced development stages (Middletown, NY).	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	"Typical" facility is designed to process 275,000 tpy. Capacities of 3,000 tpd and greater are feasible.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Successful pilot testing completed for MSW over a three year period.	YES
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	Middletown, NY facility has received necessary permits.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Technology produces ethanol, a useful and marketable product.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Residue generation rate is projected to be less than 10% by weight of incoming MSW.	YES
Does the proposed technology meet the requirements of the screening criteria?		YES

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

CHEMICAL PROCESSING TECHNOLOGY

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Thermal Conversion Process

Technology Category: Thermal

Project Sponsor Contact Information

Company Name: Changing World Technologies (CWT)

Contact Name: Brain Appel, Chairman, CEO

Phone: 516-486-0100

Address: 460 Hempstead Ave

Fax: 516-486-0460

City, State, Zip: West Hempstead, NY 11552

E-Mail: cwt@changingworldtech.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Nearing commercial operation of 250 tpd facility in MO to serve the food processing industry (turkey processing waste). Additional development required to process MSW, but likely achievable within 10 years.	YES
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Technology can process greater than 50,000 tpy.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	8 tpd pilot facility plus bench reactors in operation in PA since 1999; pilot testing at facility for agricultural waste, sludge and components of MSW (tires, mixed plastics, computers) but not for heterogeneous MSW.	NO
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	Closed, pressurized system with no combustion; no process discharge to atmosphere. Emissions from boilers are manageable and odors can be controlled. Likely to meet permit and regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Recovers metals and glass for sale to secondary material markets. Produces gas, oil and carbon solids from the organic fraction of the waste.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Minimal residual is produced for agricultural organic waste and tested components of MSW. Unknown, however, for processing mixed MSW.	INDETERMINATE
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

MECHANICAL PROCESSING FOR FIBER RECOVERY

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: **Innovative Refuse Derived Fuel**

Technology Category: **Other (Steam Conditioning, Wet Pulping Process, integrated Anaerobic Digestion)**

Project Sponsor Contact Information

Company Name: **Comprehensive Resources, Recovery and Reuse (CR3)**

Contact Name: **Joseph Anderson, President** Phone: **775-852-2039**

Address: **1755 E. Plumb Lane Suite 265A** Fax: **775-852-2038**

City, State, Zip: **Reno, NV 89502** E-Mail: _____

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	First commercial plant (250 tpd) is under construction in St. Paul, MN. Plant does not include fiber recovery; generates RDF. Technology requires more testing for commercialization of fiber recovery (i.e., the innovative part of this technology).	INDETERMINATE
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	First commercial plant is designed for 250 tpd (i.e., greater than 50,000 tpy). Studies have demonstrated feasibility at 500-5000 tpd.	YES
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Pilot (20 tpd) demonstration unit of the steam conditioning system in Reno, NV since 1997. Test burn for RDF (160 tons). Only bench scale research for fiber recovery integrated with lab testing of anaerobic digestion.	NO
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	In general, the processes used in the proposed approach (i.e., steam conditioning in an autoclave, wet pulping, mechanical screening, and anaerobic digestion) are capable of meeting environmental permit and regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	The technology recovers: recycled products for sale to secondary markets (plastic, glass, aluminum, steel); long-fiber pulp for papermaking or RDF; short-fiber pulp for RDF; and biogas. A percentage of inorganics can be used as landfill cover material.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	The technology produces 40% residual waste requiring landfill disposal. Up to 7% of the residual waste may be useable as landfill cover. However, 40% residual excludes ash from burning fuel cubes.	NO
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

NYDS and NYCEDC
Evaluation of New and Emerging
Waste Management Technologies and Approaches
Screening Evaluation Worksheet ^{(1) (2)}

Proposed Technology: Waste Elutriation Technology (WET System)

Technology Category: Other (RDF: Sterilization, Recovery of Recyclables, Fuel Cubes)

Project Sponsor Contact Information

Company Name: WET Systems, Inc.

Contact Name: Sherwood J. DeAmbrose, CEO Phone: 813-754-1152

Address: P.O. Box 3749 Fax: 813-849-0870

City, State, Zip: Plant City, FL 33563 E-Mail: woody@wetsystemsinc.com

SCREENING CRITERIA	INFORMATION PROVIDED	CRITERIA MET?
<u>READINESS</u> Technology must be at a stage of development to be able to be commercially operational within ten (10) years.	Response to RFI ways full commercial operation could be achieved in up to 18 months. This is unlikely, since no pilot or commercial facility is in operation and no tests have been performed on the fuel cubes.	INDETERMINATE
<u>SIZE</u> Technology must be capable of accepting and processing at least 50,000 tpy of waste.	Insufficient information to show technology can operate at 50,000 tpy. However, reported to be economical at 1200 tpd and greater.	INDETERMINATE
<u>RELIABILITY</u> Technology must have operated successfully processing MSW at a pilot (demonstration) or commercial scale (i.e., more than bench scale).	Prototype facility was constructed in 1990 in Louisiana, but with limited operations. No pilot or commercial facilities are in operation. No tests on the fuel cubes. No indication that testing has been done for fiber recovery.	NO
<u>ENVIRONMENTAL PERFORMANCE</u> Technology must be capable of meeting environmental permit and regulatory requirements in New York City and New York State.	Described as a "zero discharge" process with odor control and recapture of water. Combustion of fuel cubes would produce emissions; no data available. Technology reasonable assumed to be capable of meeting permit and regulatory requirements.	YES
<u>BENEFICIAL USE OF WASTE</u> Technology must produce a useful and marketable product, such as energy and/or other commercial or potentially commercial product(s).	Technology recovers recyclables (aluminum, steel, plastic and glass) and manufactures fuel cubes.	YES
<u>RESIDUAL WASTE</u> Technology must not produce residual waste requiring disposal in excess of 35% by weight of incoming waste.	Residual requiring disposal is 16% of waste fed into elutriator. Removal of materials occurs ahead of elutriator, but quantity is not specified. Ash from burning fuel cubes not addressed.	INDETERMINATE
Does the proposed technology meet the requirements of the screening criteria?		NO

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

⁽²⁾ Technologies that meet the requirements of all six (6) screening criteria will undergo a more detailed comparative evaluation.

APPENDIX G

**WORKSHEET TEMPLATE FOR
COMPARATIVE EVALUATIONS**

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Technical Evaluation Worksheet ⁽¹⁾**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____
 Address: _____ Fax: _____
 City, State, Zip: _____ E-Mail: _____

Technical Criteria	Information Provided
<u>READINESS / IMPLEMENTATION SCHEDULE</u>	
Description of the readiness level of the technology (i.e., R&D stage; pilot scale stage; commercial stage; other)	
Estimate of the number of years necessary to develop a commercial project for the technology	
Description of hurdles that need to be overcome in order to commercially develop the technology	
Ability of the technology to be permitted under existing City and State regulations	
Need for the appropriate agency to seek interpretation as to which City and State regulations apply	
Summary of Readiness:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Technical Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Technical Criteria	Information Provided
<u>FACILITY SIZE / DESIGN FLEXIBILITY</u>	
Description of the optimal size of the facility and unit size.	
Does the facility design have flexibility for expansion (i.e., modular unit design)?	
<ul style="list-style-type: none"> • Does the facility design have the capability to operate successfully with different quantities of waste? • To what degree? • Description of the range of quantities of waste for the optimal size facility. 	
<ul style="list-style-type: none"> • Does the facility design have the capability to operate successfully with varying waste composition? • What types of waste? • Description of the range of varying waste composition for the optimal size facility. 	
Summary of Size and Flexibility:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Technical Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Technical Criteria	Information Provided
<u>RELIABILITY</u>	
Number of operating facilities	
Location(s) of operating facilities	
Size(s) of operating facilities in tons per day	
Waste processed (tons per year)	
Number of years that this technology has been operating at commercial, pilot, R&D status	
Summary of Reliability:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Technical Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Technical Criteria	Information Provided
<u>USE OF EXISTING INFRASTRUCTURE</u>	
Description of the ability of the technology to use the existing City Solid Waste infrastructure	
Waste Collection	
Waste Separation	
Waste Processing	
Waste Transfer	
Waste Transportation	
Summary of Use of Existing Infrastructure:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Technical Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Technical Criteria	Information Provided
<u>UTILITY NEEDS</u>	
Estimate of the facility's electric use. <ul style="list-style-type: none"> • Total electric use (KWH) for optimal facility size. • Electric Use per ton (KWH per ton) for optimal facility size 	
Estimate of the facility's natural gas use. <ul style="list-style-type: none"> • Total natural gas use (MMCF) for optimal facility size. • Natural Gas Use (MMCF) per ton for optimal facility size 	
Estimate the facility's consumptive water use. <ul style="list-style-type: none"> • Total consumptive water use (million gallons per day) for optimal facility size. • Water Use per ton (million gallons per ton) for optimal facility size 	
Estimate the facility's wastewater generation (i.e., quantity discharged to sewer). <ul style="list-style-type: none"> • Total wastewater discharged (million gallons per day) for optimal facility size. • Wastewater discharged per ton (million gallons per ton of MSW processed) for optimal facility size 	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Technical Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

<u>UTILITY NEEDS, continued</u>	
Describe characteristics of wastewater discharge.	
Summary of Utility Needs:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Technical Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Technical Criteria	Information Provided
<u>EXTENT OF BENEFICIAL USE OF WASTE</u>	
Total energy produced for optimal facility size • Electricity (KWH per ton) • Gas (KWH per ton)	
Net (less consumptive facility use) Energy Production for optimal facility size (KWH per ton of MSW)	
Net (less consumptive facility use) Gas Production for optimal facility size (MMCF per ton of MSW)	
Product Production (pounds per ton of MSW) for optimal facility size Description of the Product	
Summary of Extent of Beneficial Use of Waste: 	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Technical Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Technical Criteria	Information Provided
<u>MARKETABILITY OF PRODUCT</u>	
Description of product. Is it an existing commercial product? Must the market be developed?	
Description of potential value of product (\$ per unit; e.g., \$ per KWH of energy or \$ per pound of product)	
Description of history of market; sustainability of market.	
Description of volatility of market.	
Summary of Marketability of Product:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Technical Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Technical Criteria	Information Provided
<u>QUANTITY / QUALITY OF RESIDUALS REQUIRING LANDFILLING</u>	
Estimate of the residual that remains at the completion of the process and requires marketing or landfilling (pounds of residual per ton MSW).	
Does the facility produce hazardous or non-hazardous residuals?	
Can the residuals produced by the facility be marketed to existing, commercial markets?	
Description of potential new markets for the residuals produced by the facility.	
Summary of Marketability of Product: 	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Environmental Evaluation Worksheet ⁽¹⁾**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Environmental Criteria	Information Provided
<u>ENVIRONMENTAL IMPACTS</u>	
Does the technology generate or result in emissions of air pollutants? If yes, identify type and quantity. What control is proposed?	
Does the technology generate or result in the emission of greenhouse gases? If yes, describe type and quantity. What control is proposed?	
Does the technology result in emission of dioxin? If yes, describe type and quantity. What control is proposed?	
Does the technology result in emission of heavy metals? If yes, describe type and quantity. What control is proposed?	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Environmental Evaluation Worksheet ⁽¹⁾, continued

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Environmental Criteria	Information Provided
<u>ENVIRONMENTAL IMPACTS</u>, continued	
What is the consumptive water use of the facility (million gallons per ton of MSW)?	
What measures are taken to reuse wastewater in the plant?	
Does the potential for noise emissions exist? What mitigation is proposed?	
Describe the potential for odor emissions and impact from the facility. What mitigation is proposed?	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Environmental Evaluation Worksheet ⁽¹⁾, continued

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Environmental Criteria	Information Provided
<u>ENVIRONMENTAL IMPACTS</u>, continued	
Describe the potential for traffic impact from the facility. What mitigation is proposed?	
Describe the potential aesthetic impact of the facility.	
Summary of Environmental Impacts: 	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Environmental Evaluation Worksheet ⁽¹⁾, continued

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Environmental Criteria	Information Provided
<u>WORKER HEALTH AND SAFETY</u>	
Has the respondent stated that the design and operational capabilities of the facility meet worker health and safety laws and regulations? Describe.	
Summary of Worker Health and Safety: 	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Environmental Evaluation Worksheet ⁽¹⁾, continued

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Environmental Criteria	Information Provided
<u>FACILITY SITING</u>	
Site Size for Optimal Facility (acres)	
Is the proposed facility to be sited in New York City?	
If no, is the proposed facility to be sited in New York State?	
If the facility is to be sited in New York State: estimation of the distance from the proposed site to New York City.	
Summary of Facility Siting:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Environmental Evaluation Worksheet ⁽¹⁾, continued

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Environmental Criteria	Information Provided
<u>PUBLIC ACCEPTABILITY</u>	
Description of the potential for public acceptability of the technology.	
Summary of Public Acceptability:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Environmental Evaluation Worksheet ⁽¹⁾, continued

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Environmental Criteria	Information Provided
<u>POTENTIAL IMPACT OF FUTURE ENVIRONMENTAL, TRANSPORTATION, AND TAX LAW CHANGES</u>	
Description of the susceptibility of the technology to changes in environmental law.	
Description of the susceptibility of the technology to changes in transportation law.	
Description of the susceptibility of the technology to changes in tax law.	
Summary of Potential Impact of Future Changes in Law:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Financial Evaluation Worksheet ⁽¹⁾**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Financial Criteria	Information Provided
<u>ESTIMATED COST</u>	
What is the estimated design and construction cost? <ul style="list-style-type: none"> • Total Design and Construction Cost for optimal size facility (\$) • Cost in \$ per ton of MSW 	
What is the estimated annual operation and maintenance cost? <ul style="list-style-type: none"> • Total Annual Operation and Maintenance Cost for optimal size facility (\$) • Cost in \$ per ton of MSW 	
What is the estimated tip fee for the optimal size facility? <ul style="list-style-type: none"> • Estimated Tip Fee in \$ per ton of MSW 	
Summary of Estimated Cost:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Financial Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Financial Criteria	Information Provided
<u>ASSOCIATED OPPORTUNITIES FOR DIRECT AND COLLATERAL ECONOMIC GROWTH</u>	
Description of the potential direct economic benefit of the facility (e.g., jobs created, goods and services purchased to construct, operate, and maintain the facility).	
Description of the collateral economic benefit of the facility. (e.g., potential for spin-off industries to produce or enhance the value of final product)	
Summary of Associated Opportunities for Direct and Collateral Economic Growth:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Project Sponsor Evaluation Worksheet ⁽¹⁾**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Project Sponsor Criteria	Information Provided
<u>CAPABILITIES OF PROJECT SPONSOR</u>	
Does the project sponsor have the licensing or other legal rights to the technology?	
Does the project sponsor have the capability and resources to accomplish the following?	
Project development	
Project siting	
Project permitting	
Project financing	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Project Sponsor Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Project Sponsor Criteria	Information Provided
<u>CAPABILITIES OF PROJECT SPONSOR, continued</u>	
Project design	
Project construction	
Project operation	
Marketing of the product produced	
Summary of Capabilities of Project Sponsor:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Project Sponsor Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Project Sponsor Criteria	Information Provided
<u>EXPERIENCE OF PROJECT SPONSOR IN SOLID WASTE INDUSTRY</u>	
Has the project sponsor designed a municipal solid waste processing facility? • Number and description of facilities: • Years of experience:	
Has the project sponsor constructed a municipal solid waste processing facility? • Number and description of facilities: • Years of experience:	
Has the project sponsor operated a municipal solid waste facility? • Number and description of facilities: • Years of experience:	
Has the project sponsor marketed a product produced from such a facility? • Number and description of products: • Years of experience:	
Summary of Experience of Project Sponsor in Solid Waste Industry:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Project Sponsor Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Project Sponsor Criteria	Information Provided
<u>EXPERIENCE OF PROJECT SPONSOR WITH PROPOSED TECHNOLOGY</u>	
Has the project sponsor designed a municipal solid waste processing facility that utilizes the proposed technology? <ul style="list-style-type: none"> • Number and description of facilities. • Years of experience: 	
Has the project sponsor constructed a municipal solid waste processing facility that utilizes the proposed technology? <ul style="list-style-type: none"> • Number and description of facilities. • Years of experience: 	
Has the project sponsor operated a municipal solid waste facility that utilizes the proposed technology? <ul style="list-style-type: none"> • Number and description of facilities. • Years of experience: 	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Project Sponsor Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Project Sponsor Criteria	Information Provided
<u>EXPERIENCE OF PROJECT SPONSOR WITH PROPOSED TECHNOLOGY,</u> continued	
Has the project sponsor marketed a product produced from such a facility? • Number and description of products. • Years of experience:	
Summary of Experience of Project Sponsor with Proposed Technology:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Project Sponsor Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Project Sponsor Criteria	Information Provided
<u>FINANCIAL RESOURCES OF PROJECT SPONSOR</u>	
Is the project sponsor willing and capable of financing the proposed work?	
Is the project sponsor capable of securing construction and labor and material payment bonds?	
Is the project sponsor capable of securing a letter of credit?	
Does the project sponsor have an investment grade rating? If yes, what is the investment grade rating?	
Other indications of financial strength (describe):	
Summary of Financial Resources of Project Sponsor:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Project Sponsor Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Project Sponsor Criteria	Information Provided
<u>WILLINGNESS TO DEVELOP PUBLICLY OR PRIVATELY OWNED FACILITY</u>	
Is the project sponsor willing to develop and provide service for either a publicly owned or privately owned facility?	
Summary of Willingness of Project Sponsor to Develop Publicly Owned or Privately Owned Facility:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Project Sponsor Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Project Sponsor Criteria	Information Provided
<u>RISK PROFILE</u>	
Description of the level of risk related to waste disposal to which the City may be exposed.	
Description of the level of business risk to which the City may be exposed.	
Description of the level of other contract risk to which the City may be exposed.	
Summary of Risk Profile:	
Waste Disposal:	
Business Risk:	
Other Contract Risks:	

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

**Evaluation of New and Emerging
Waste Management Technologies and Approaches
New York City Department of Sanitation and
New York City Economic Development Corporation
Project Sponsor Evaluation Worksheet ⁽¹⁾, continued**

Proposed Technology: _____

Technology Category: _____

Project Sponsor Contact Information:

Name: _____ Telephone: _____

Address: _____ Fax: _____

City, State, Zip: _____ E-Mail: _____

Other Comments

ARI Evaluator: _____

Date of Evaluation: _____

⁽¹⁾ Information provided by companies in response to Request for Information or as otherwise noted.

APPENDIX H

PHASE II SCOPE OF SERVICES

EVALUATION OF NEW AND EMERGING SOLID WASTE MANAGEMENT TECHNOLOGIES

PHASE 2 - FOCUSED RESEARCH FOR ADVANCED TECHNOLOGIES

A. SCOPE OF SERVICES

In September 2004, a Consultant completed an evaluation of new and emerging solid waste management technologies for the New York City Department of Sanitation and the New York City Economic Development Corporation. The evaluation included 43 technologies, categorized by type of technology: thermal, digestion (aerobic and anaerobic), hydrolysis, chemical processing, and mechanical processing for fiber recovery.

As a result of the study, the technology categories of anaerobic digestion and thermal processing were determined to have developed the furthest, with both types of technologies currently in commercial operation for municipal solid waste (MSW) outside of the United States. The other technology categories included in the evaluation are at various stages of development, but have not achieved commercial operation for MSW.

The next step in the evaluation process (Phase 2) consists of focused verification and validation of anaerobic digestion and thermal technologies, to address technical, environmental, cost, and technology transfer issues. At the City's discretion, other technology categories could be included in the focused research if recent developments have further advanced these technologies. The objective of the focused research is to provide assurance that the advanced technology categories can reasonably meet potential expectations for City application, thereby warranting development of an implementation plan for development of one or more demonstration facilities for New York City.

The Phase 2 Scope of Services is structured to provide for focused validation and verification of advanced technology categories through direct interaction with technology sponsors and independent due diligence to check sponsor claims. To ensure the most current and detailed information is provided for review and evaluation, information will be obtained through a two-step process that begins with a letter request for supplemental information tailored to each technology sponsor, followed by one-on-one meetings with technology sponsors. Site visits to reference facilities could also be conducted, but are not currently included in the scope of services. Independent due diligence will consist of independent verification of data presented by the sponsors; checking sponsor calculations for mass and energy balances and emission estimates; reviewing records of performance, product quality and sales; and communicating directly (by telephone or email) with those that operate, regulate, and are served by reference facilities. Work will be documented throughout the process, and will be presented in a report at the completion of the focused research and evaluation.

The Scope of Services includes the following Tasks:

- Task 1: Obtain Supplemental Information
- Task 2: Review and Preliminary Evaluation of Supplemental Information
- Task 3: Meetings with Technology Sponsors
- Task 4: Detailed Evaluation of Advanced Technologies
- Task 5: Final Report of Findings

Task 1: Obtain Supplemental Information

Under Task 1, the Consultant will prepare and issue letter requests to those sponsors of the more advanced technologies, i.e., those that have achieved commercial operation for MSW or have successfully demonstrated operation, to the City's satisfaction, at a pilot level for MSW. The requests will include questions common to all technology categories and all sponsors, but will also include specific, tailored questions to individual sponsors based on information previously submitted as part of the Evaluation Report (September 2004).

Up to nine (9) technology sponsors will be included in the focused research. To select these nine, the Consultant will send a letter to twelve (12) sponsors of technologies, providing the opportunity to demonstrate that their technology has achieved commercial operation for MSW or successfully demonstrated operation, to the City's satisfaction, at a pilot level for MSW. Responses will be reviewed to determine which of the sponsors have demonstrated to the City's satisfaction that they meet this criterion, and are interested in participating. A determination will then be made of which nine of the twelve technologies will be able to provide the most comprehensive, beneficial information for purpose of the focused research. As necessary, the Consultant will attend meetings in New York City with the sponsors and evaluate information presented regarding the status of the technology, providing an opportunity to ensure that full consideration has been given to be included in the focused research (one day for meetings is included in the fee estimate). A decision will then be made to identify those technologies that will be included in the verification and validation process.

Deliverables under Task 1 will consist of:

- Letter providing technology sponsors the opportunity to demonstrate commercial or successful pilot operation for MSW.
- Supplemental, detailed information requests for nine (9) technology sponsors.

Each of these deliverables will be provided to the City in draft form for review. City comments will be incorporated, and a final version will be issued.

Task 2: Review and Preliminary Evaluation of Supplemental Information

The Consultant will review information received in response to the supplemental, detailed information requests. Beginning with our preliminary review of information under this Task

2, and continuing through meetings with technology sponsors (Task 3) and detailed evaluations of technologies (Task 4), our review and evaluation will focus on four areas of interest for the verification and validation process: technical, environmental, cost, and technology transfer issues. As described in more detail under Task 4, the Consultant's review and evaluation will be performed by a team consisting of engineers, environmental specialists, and economic analysts. The Consultant will also include specialty consultants on the review team, as needed, to supplement our expertise. For example, specialty consultants offering technical services related to technologies, such as expertise offered through universities and research facilities, may be added to the team. A decision will be made with the City to include specialty consultants, with the Consultant providing coordination and management for any such subconsultants.

Our initial review of supplemental information provided by technology sponsors will consider completeness of information provided. As necessary, the Consultant will communicate with the technology sponsors to verify and validate information provided, and to obtain additional information required for our review. Under this Task 2, we will also initiate our own independent evaluation of the technologies, which will continue through and be completed under Task 4.

Following our initial review and preliminary evaluation of supplemental information submitted by technology sponsors, we will summarize our findings in a memorandum. The primary purpose of the memorandum will be to identify data gaps specific to the technologies and to highlight information requiring further clarification. Our findings will be used as a basis of formulating additional, written questions to the technology sponsors and establishing discussion topics for meetings to be conducted under Task 3. The memorandum will be provided to the City in draft and final form. During preparation of the memorandum, the Consultant will meet with the City to review the preliminary findings and to coordinate for meetings with technology sponsors.

Task 3: Meetings with Technology Sponsors

Upon completing a review and preliminary evaluation of supplemental information, working meetings will be held with the technology sponsors. The purpose of the meetings will be to further clarify information, address data gaps, and engage in discussions necessary for completing an evaluation of the technologies. Each technology sponsor will be given the opportunity to meet individually with the City and the Consultant, to present their technology and answer questions. At these meetings, each sponsor will be asked to present information on the reference facilities for their technology.

It is proposed that the meetings with technology sponsors be held at the Consultant's offices, in order to cost-effectively include a larger number of the Consultant participants in the meetings (i.e., the engineers, and environmental and economic specialists that are involved in the verification and validation process). As outlined in Task 1, the Consultant assumes that nine technology sponsors will be included in the verification and validation process. To provide sufficient opportunity for each sponsor to present their technology, we suggest meeting with two sponsors a day over a one-week period. Depending on the

ability to successfully schedule sponsors, it maybe necessary to conduct meetings over a two-week period.

The Consultant will prepare for the meetings by issuing a tailored list of questions to each technology sponsor, highlighting issues to be discussed at the meeting. We will request written responses in advance of the meeting, and will review those responses in preparation for the meeting. The Consultant will assist the City in coordinating the meetings, by scheduling meeting times with each individual sponsor.

After all meetings with the technology sponsors have been completed, the Consultant will prepare a set of meeting notes. The meeting notes will document information that was clarified by the technology sponsors or otherwise provided to address data gaps.

The following deliverables will be issued under Task 3, in draft and final form:

- Written questions for nine (9) technology sponsors, for purpose of discussion at individual meetings.
- Meeting notes documenting information that was clarified or provided to address data gaps.

Task 4: Detailed Evaluation of Advanced Technologies

Work completed under Tasks 1 through 3 will provide an interactive, progressive approach to obtain and evaluate the most current, detailed information available for the technologies included in the focused research. As mentioned in Task 2, our review and evaluation will focus on four areas of interest: technical, environmental, cost, and technology transfer issues. The Consultant's review and evaluation will be performed by a team consisting of engineers, environmental specialists, economic analysts, and, if needed, specialty consultants to supplement the Consultant's expertise.

The Consultant's evaluation will begin with an initial review of supplemental information provided by technology sponsors (Task 2), and will continue through our review of information gathered during working meetings with sponsors and through contact with parties at reference facilities (owners, operators, public entities served, and regulatory agencies) (Task 3). Our detailed evaluation, however, will be conducted under this Task 4, after completing the progressive process of obtaining and verifying information from the technology sponsors.

An overview of primary issues to be addressed through the Consultant's evaluation process is provided below.

Technical Evaluation

The Consultant will request, review and evaluate supplemental technical information, including independent validation of certain technical elements. Some of the more

important technical elements that will be evaluated and independently validated include:

- Process schematics and major system components: to be reviewed to determine if the process is complete and fully described (e.g., including up-front processing, management of end products, and ancillary systems such as water treatment and wastewater management).
- Mass and energy balances: to be reviewed and confirmed through independent calculations.
- Facility site layout and equipment general arrangement: to be reviewed and evaluated for access and efficient operation, including consideration of site size requirements.
- Operating data: data such as waste throughput, operating hours, annual availability, quantity and characteristics of products, sales of products, and quantity and characteristics of residuals requiring disposal, will be tabulated and evaluated, compared to expected performance.

Environmental Evaluation

The Consultant will request copies of environmental permits issued for operation of each facility, and will review environmental limitations contained in those permits. The Consultant will also request documentation of facility performance (i.e., compliance with permit limits), including stack test results, continuous emission monitoring data, and other analytical data associated with the process. Sponsors will be asked to provide any notices of noncompliance, or similar regulatory actions or compliance-related correspondence, for the Consultant's review. The environmental performance of the facility will be compared to the facility's permit limits as well as to comparable limits promulgated by the United States Environmental Protection Agency and New York State and City regulatory agencies.

Other environmental issues that will be addressed will include potential for odor and dust, noise and traffic impacts, water use, and wastewater discharge. If any permit limitations or conditions are imposed for these parameters, the permit conditions will be reviewed and performance will be compared to those conditions. In addition, questions will be asked during calls or emails to reference facilities regarding odor, dust, noise and traffic impacts. Technical information will be requested and tabulated regarding the quantity of water used in the process, the amount of wastewater discharged, and the quality of wastewater.

Cost Analysis

During Phase 1 of the City's evaluation of new and emerging technologies, only limited information was provided by technology sponsors regarding project economics. In some cases, tip fees were projected by technology sponsors, but supporting information, if any, was not sufficient to allow for verification of such tip

fees. During this Phase 2 evaluation, technology sponsors will be requested to provide more detailed information on project economics for reference facilities, including capital costs, annual operating and maintenance costs, annual income from sale of products and tip fees. Supporting documentation will be requested for project economics, along with disclosure of assumptions used to develop cost estimates for a proposed facility in New York City.

The Consultant will review and evaluate the economic information provided by technology sponsors. We will identify the cost elements that could have the greatest impact on project economics (e.g., capital cost, operating costs, market volatility for end products, financing costs) and will assess the potential variability of such costs as well as the impact such variability could have on the projected tip fees. Overall, the objective of the Consultant's cost analysis will be to summarize and compare project economics as estimated by the technology sponsors, and to provide an independent assessment of the reasonableness of these economics.

Technology Transfer Issues

Anaerobic digestion and thermal technologies have achieved commercial operation in Japan, Europe and Canada. Technology transfer to the United States will be considered, focusing on MSW composition, waste collection practices, end-product markets and regulatory requirements. The Consultant will request information from technology sponsors regarding these issues at operating facilities overseas, as well as for a future facility in New York City.

Upon completing the evaluation, The Consultant will provide the City a written summary of the evaluation process and findings. The Consultant will issue the written summary to the City, and will subsequently meet with the City to discuss the findings. City comments on the evaluation will be addressed, and a revised version of the text will be incorporated into the draft report completed under Task 5.

Task 5: Final Report of Findings

Following the completion of Tasks 1 through 4, the Consultant will prepare a report summarizing the work that was completed and presenting findings regarding new and emerging solid waste management technologies. The Consultant will issue a draft report for City review and comment, followed by a revised draft and final report.