EXECUTIVE SUMMARY

Solid Waste Conversion/Waste to Energy Technology Options

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MUNICIPALITY OF ANCHORAGE

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1.0 Where Are WTE Facilities Located

Producing and utilizing energy from the combustion of municipal solid waste (MSW), is a concept which has been practiced in Europe since the turn of the last century. Prompted by a concern for groundwater quality and the scarcity of land for landfilling, many European countries and Japan embarked on massive construction programs for waste-to-energy (WTE) programs in the 1960's.

Based on data available from 2018, there are about 2,179 WTE facilities worldwide (Figure 1). Asian countries (Japan, Taiwan, Singapore, and China) have the largest number of WTE facilities, followed by European and North American countries. Many countries that have aggressively pursued WTE face issues with having limited open space for the siting of landfills and large urban populations. For example, Japan currently manages about 70% of its solid waste in WTE facilities.

As of this writing, there are currently 77 WTE plants operating in 25 U.S. states managing about seven percent of the nation's MSW, or about 90,000 tons per day. This is the equivalent of a baseload electrical generation capacity of approximately 2,700 megawatts to meet the power needs of more than two million homes, while servicing the waste disposal needs of more than 35 million people. Three general combustion technologies are utilized in North America for reliable and proven processing of MSW: massburn, RDF (refuse derived fuel), and modular massburn. Massburn is the most commonly implemented combustion technology , followed by RDF, and lastly, modular). Two facilities have a combination of mass burn and one other combustion technology (Honolulu and Tulsa). Recent expansions and additions in the U.S. include one retrofit, three expansions, and two new WTE facilities. Three new WTE facilities have been added in Canada (2015), Palm Beach County, FL (2016), and Pasco County, FL (2020)

Confirmed facility ownership arrangements are about half, divided between public and private entities. WTE facilities are typically operated by private entities, while operation by public entities) has been gaining traction.

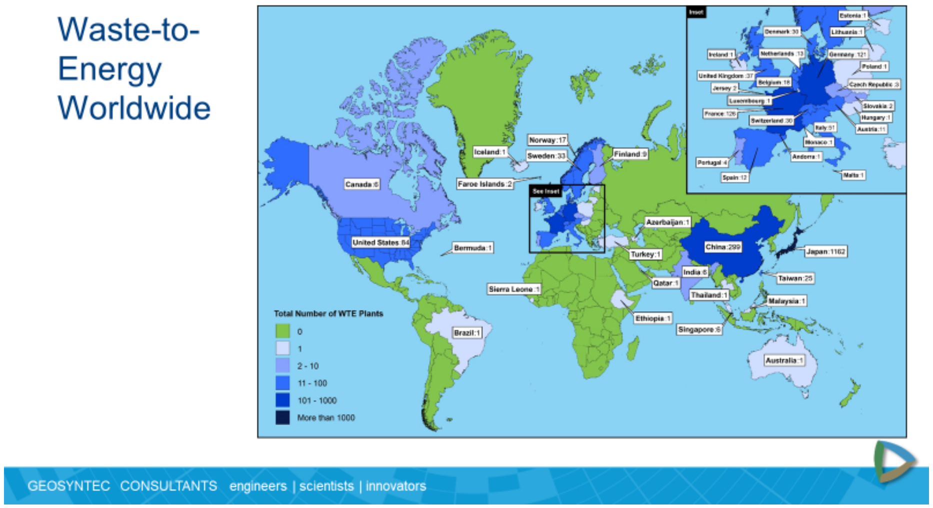


Figure 1: Location of WTE Plants Worldwide

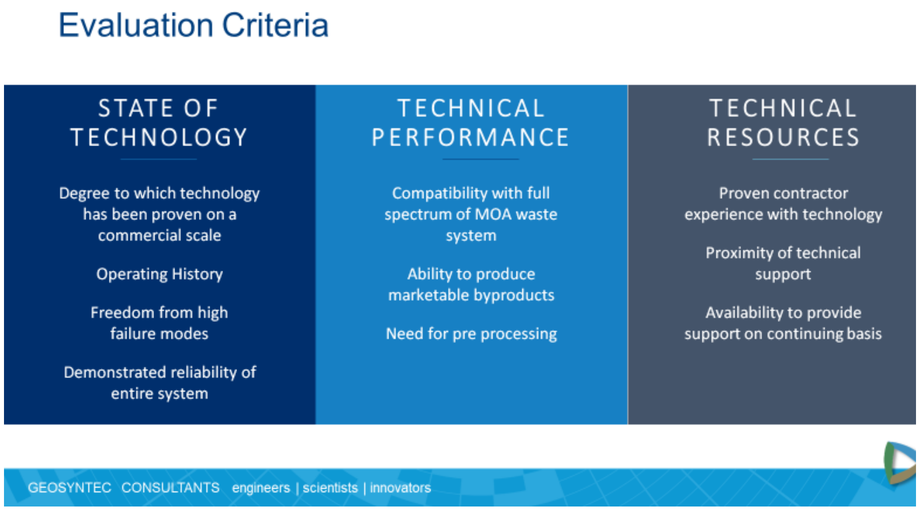
2.0 WTE Selection Criteria

One of the first questions an agency must answer is what technology will be chosen to convert its solid waste into energy. Each agency or developer must identify and evaluate the various WTE technologies that are available and make its own selection based upon the requirements specific to its project. This includes consideration of factors (which will be discussed later) such as: available energy and materials markets; the size of the community's waste flow; capital and operating costs; ownership and financing considerations; and, the level of risk to be assumed by the community or the facility owner.

In evaluating whether one technology better suits its needs than another, a community may often discover that one or more of their goals established for the project may conflict with others. A technology, for example, may produce the greatest amount of energy for the Municipality of Anchorage's (MOA) waste, albeit at the highest projected capital and operating costs. The selection of a technology, therefore, is not a simple one, but one which can require tradeoffs between one agency's goal with others. Since the risks associated with WTE technology can be substantial, it is critical that MOA attempt to minimize these risks at best it can. The following criteria (Figure 2) can be utilized to assess the relative risk of a WTE technology:

- State of Technology – This addresses the documented track record of the vendor(s) with both pilot and commercial facilities. Some technologies only have been proven in pilot or laboratory operations, or with raw materials other than MSW. Other technologies have only been commercially operated in small facilities and the scale up to larger sized plants may result in unforeseen problems. The operational history of all process steps, from waste receipt through energy conversion to management of material side streams and residuals are considered under the state of the technology. Specific factors assessed include waste types and quantities processed, demonstrated operational reliability, predictable electricity generation.
- Technical Performance - This criterion addresses the ability of the WTE technology to address the full spectrum of the potential needs of the MOA's users and rate payers. Also addressed is whether the proposed process can safely and efficiently process the types of wastes which are generated by the MOA solid waste system users, the need for source separation and/or pre-treatment (removal of items, sorting, and size reduction). The percentage of waste by-passed to the landfill or other waste disposal options is also of importance.
- Technical Resources – This criterion addresses whether vendors are available to bid on the project and can provide continuing local resources. Typically, emerging technologies often will have one project leader. The preferred case would be for the vendor to have a broader pool of resources that can sustain the project in case these project technical leaders move on.

Based on these criteria, there are currently only two widely used and commercially available WTE technologies that should be considered by the MOA – mass-burn and refuse-derived fuel (RDF). It is noted that there are several other "next generation" technologies (e.g., fluidized bed and gasification) that are used in a limited number of WTE facilities in advanced economies, often at relatively small scale.



Evaluation Criteria

STATE OF TECHNOLOGY	TECHNICAL PERFORMANCE	TECHNICAL RESOURCES
Degree to which technology has been proven on a commercial scale Operating History Freedom from high failure modes Demonstrated reliability of entire system	Compatibility with full spectrum of MOA waste system Ability to produce marketable byproducts Need for pre processing	Proven contractor experience with technology Proximity of technical support Availability to provide support on continuing basis

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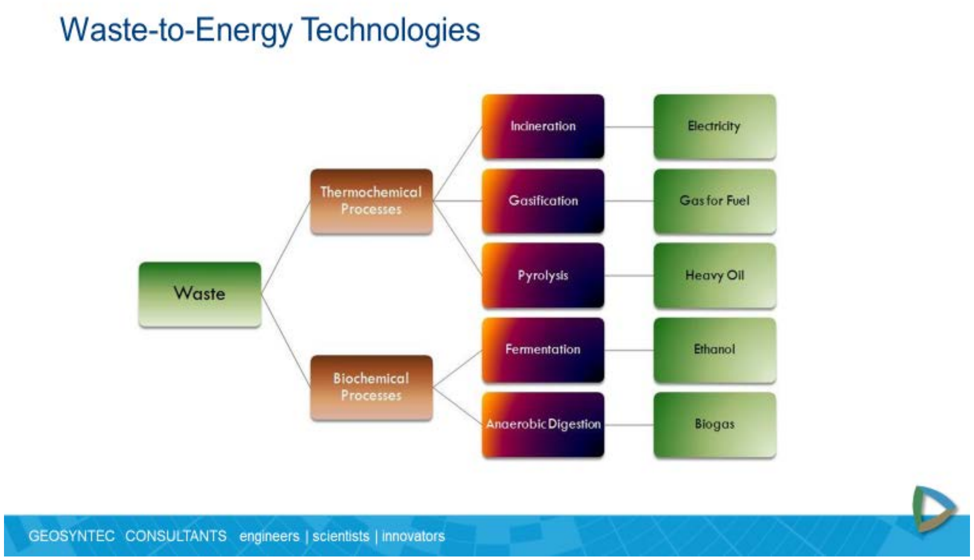
Figure 2: WTE Technology Evaluation Criteria

3.0 Types of WTE Technologies

There is an array of commercially available and emerging WTE technologies, which can convert solid waste into energy, useful products and chemicals, including ethanol and biodiesel. For simplicity, these can be subdivided into thermal, chemical and biological technologies (Figure 3). As will be discussed some of these are commercially proven, while others have been implemented only in university laboratories on a bench scale size, or in pilot plants only working a small fraction of operating capacity.

Technologies that appear amenable for converting organic and other materials into energy, ethanol, and other products include hydrolysis, gasification, anaerobic digestion, and plasma arc. The following sections briefly describe the technologies.



Waste-to-Energy Technologies

Waste

Thermochemical Processes

Biochemical Processes

Incineration

Gasification

Pyrolysis

Fermentation

Anaerobic Digestion

Electricity

Gas for Fuel

Heavy Oil

Ethanol

Biogas

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Figure 3: Types of WTE Technologies

3.1 Mass Burn WTE Technology

Mass-burn refers to WTE technology that incinerates minimally processed solid waste. An illustration of a typical mass-burn WTE facility is shown in Figure 2 overleaf. Major components of a mass-burn facility include:

- A structure to house the furnace and its appurtenances;
- A tipping floor where the solid waste from collection and transfer vehicles is unloaded;
- A large storage pit that is sized to allow two to three days storage or stockpiling of refuse so that plant operations can continue over weekends and holidays when deliveries will not occur (WTE plants operate on a seven-day per week, twenty-four hour per day basis; storage space is provided to enable this continuous operation);
- A charging system (normally overhead cranes, but could also be a front-end loader and conveyor combination), which mixes the various solid wastes received to develop a somewhat uniform material and then moves it from the storage pit or floor to feed (charge) the furnace;
- One or more furnace systems (sometimes referred to as combustion trains or units) that burn the solid waste to heat the boilers, generating steam to power electricity generating turbines;
- A stoker unit to move the solid waste through the furnaces; the most common stoker designs being:
    - Reciprocating grates: This grate design resembles stairs with moving grate sections which push the solid waste through the furnace;
    - Rocking grates: This grate design has pivoted or rocking grate sections which produce an upward and/or forward motion to move the solid waste through the furnace; or
    - Roller grates: This grate design has a series of rotating steep drums or rollers which agitate and move the solid waste through the furnace;
- Air pollution control subsystems to treat combustion gases; and,
- An ash handling subsystem to manage the fly ash and bottom ash produced from the combustion of solid waste.

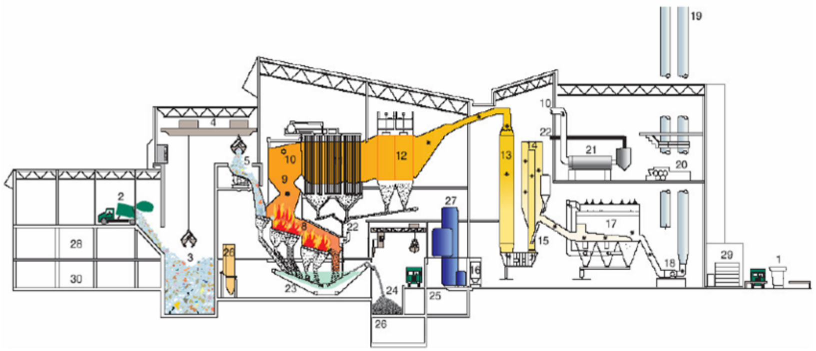

Figure 4: Cross Section of Mass Burn Facility

The only waste pre-processing that occurs as part of the mass-burn WTE operation is the removal of large or unusual objects from the waste stream that would otherwise be a problem or cause damage if fed into the furnace. Examples include very large metal or concrete objects, appliances, telephone poles, or compressed gas cylinders. The operator that charges the furnace is also responsible to visually monitor the nature of the incoming waste so that materials with different moisture contents (e.g., food and plant wastes are relatively wet, while paper and plastics are usually dry) are gradually mixed to achieve a relatively uniform moisture content.

Mass burn incineration produces ash residues amounting to 15 to 30% by weight and 5 to 10% by volume of the incoming solid waste. The amount of ash is dependent of the composition of the waste being incinerated. Generally, recovery of ferrous metals from the ash residue is possible in mass-burn WTE by using magnetic separators (with or without trommels).

In modern waterwall incinerators, proper combustion of the waste is achieved through the introduction of air at two locations in the furnace. One location introduces air underneath the grate system (underfire air), the second location introduces air above the burning waste (overfire air). During the combustion process, flue gases, which are heated to temperatures as high as 1,800 degrees F, move from the furnace through the boiler tube section, where the contained water is heated to form saturated steam and dry steam. The flue gases continue through the economizer section to the air pollution control device, such as an electrostatic precipitator, baghouse, or acid gas scrubber, where the flue gases are cleaned before being released into the atmosphere through a stack.

After the combustion process is completed, the grate system or rotary combustor gradually moves the waste onto the burnout grate where it is discharged into a wet or dry ash handling system that cools the residue and prevents dust from being created. The bottom ash that is produced from the combustion process in the furnace, and the fly ash or other materials produced in the air pollution control device, are transported to landfills by truck or to a temporary onsite ash storage pit for later transport. The bottom and fly ash may be combined or handled separately.

Mass burn incineration produces ash resides amounting to 15 to 30% by weight and 5 to 10% by volume of the incoming MSW. The amount of ash is dependent of the composition of the waste being incinerated. Most facilities can produce an ash product that has less than 5% combustible material and 0.2% putrescible matter.

Recovery of ferrous and non-ferrous materials from the ash residue is possible in mass-burn systems. Many facilities have successfully utilized magnetic separators (with or without trommels) to recover ferrous material from the ash. Some systems recover the remaining non-magnetic fraction in the ash, such as aluminum and glass, using various trommels, screens, jigs and fluid separators.

Operations Experience

Mass burning incinerators have been used in Europe and Japan for municipal solid waste disposal for nearly 70 years where their acceptance has been rapid and widespread. With over thousands of facilities in operation worldwide in sizes ranging from 18 to 4,200 tons per day, mass fired incineration is the most thoroughly demonstrated technology in the WTE field at this time.

This technology was introduced into the United States in 1967 at the U.S. Naval Station in Norfolk, Virginia with the construction of a 360 ton per day waterwall plant to produce process energy for the Naval Shipyard. This plant was designed in America and equipped with American equipment. Later plants, which were constructed, were almost entirely designed using state-of-the-art European mass incineration technology.

The introduction of European technology into the United States has not been without difficulties and several of the earlier constructed plants encountered some mechanical problems. These highly reliable and rugged European systems had been designed to burn solid waste that was somewhat different in composition than American wastes. Consequently, systems that had been designed for European conditions required designers to adjust in the grate areas and furnace heat release rates of American plants. In addition, the higher chloride corrosion of the superheaters in American plants meant that designers needed to change the metallurgy of these boiler tubes, as well as limiting the upper stream pressures and temperatures to minimize tube corrosion. Scale-up problems also had to be overcome since many of the European units were designed for the 300 to 500 tons per day range. These problems have been corrected, and most mass-burn systems that have been constructed are still in operation today.

3.2 Refuse Derived Technology

The main difference between mass-burn and RDF technologies is that RDF requires pre-processing of the incoming solid waste to separate some of the non-combustibles and then shredding the remaining material to create a pelletized fuel that can be fired in a dedicated boiler unit. This additional front-end processing effort is performed in order to achieve higher energy efficiencies than mass-fired units. However, experience has shown that the front-end processing of raw solid waste into RDF is expensive and operationally intensive not to mention extremely dangerous, with the shredders and pelletizers requiring significant routine and non-routine maintenance. Although touted as a step forward from mass-burn in the 1980s and 1990s, as a result of these additional challenges, RDF has not become as widespread a technology for WTE as mass-burn. RDF remains a distant second to mass-burn in the number of facilities in operation worldwide. The newer waste conversion technologies, which were discussed in the previous section, have emerged as potential waste processing technologies of the future. Experience to date has been spotty at best with a few plants closing due to technical design challenges that could not overcome even with significant infusions of capital.

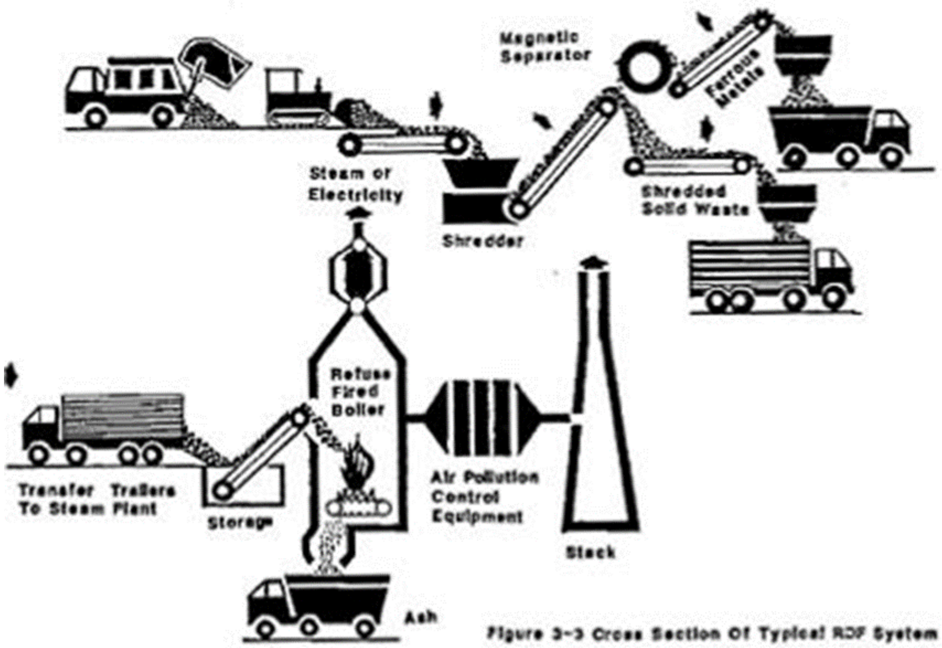

Figure 5: Cross Section of RDF Fuel System

3.3 Emerging Waste Conversion Technologies

Since 2004, several municipalities commissioned reports in order to evaluate new and emerging waste management technologies and approaches. New York City, the City of Los Angeles, Los Angeles County, and King County, WA are among the municipalities that commissioned studies in waste conversion technology. There are many technologies currently being proposed for the treatment and disposal of MSW throughout the world. Most of these involve thermal processing, but some others comprise biological or chemical decomposition of the organic fraction of the waste to produce useful products like compost, chemical feedstocks, or energy products. Technologies include the following: pyrolysis; gasification; anaerobic digestion; mixed waste composting; plasma arc; and, chemical decomposition.

Summary of Technologies

Table 1 provides a very general comparative overview of these technologies. Throughout this section, we use the terms conversion technologies and alternative technologies interchangeably to describe technologies that are being considered for MSW processing and conversion to energy and other products.

Table 1: General Overview of Conversion Technologies

Technology	Amenable Feedstock	Feedstock Requirements	Emissions/ Residues
Acid or Enzyme Hydrolysis	Cellulosic material	Cellulosic feedstock	Wastewater, CO_2
Gasification	Biomass, MSW	Drier feedstock, high carbon	Ammonia, NO_x, tars, oil
Anaerobic Digestion	Manure, Biosolids	Wet material, High nitrogen	Wastewater, CH_4, CO_2, H_2S
Plasma Arc	MSW	High carbon, high hydrogen content	Slag, scrubber water

Hydrolysis is a chemical decomposition process that uses water to split chemical bonds of substances. There are two types of hydrolysis, acid and enzymatic. Feedstock that may be appropriate for acid or enzymatic hydrolysis typically is plant-based materials containing cellulose. These include forest material and sawmill residue, agricultural residue, urban waste, and wastepaper.

Ethanol facilities could be co-located at Material Recovery Facilities (MRFs) where existing materials are already collected, and the existing solid waste transportation infrastructure could be utilized. Ethanol facilities co-located at MRFs could take advantage of the existing solid waste collection and transportation infrastructure. Figure 6 includes a typical hydrolysis process.

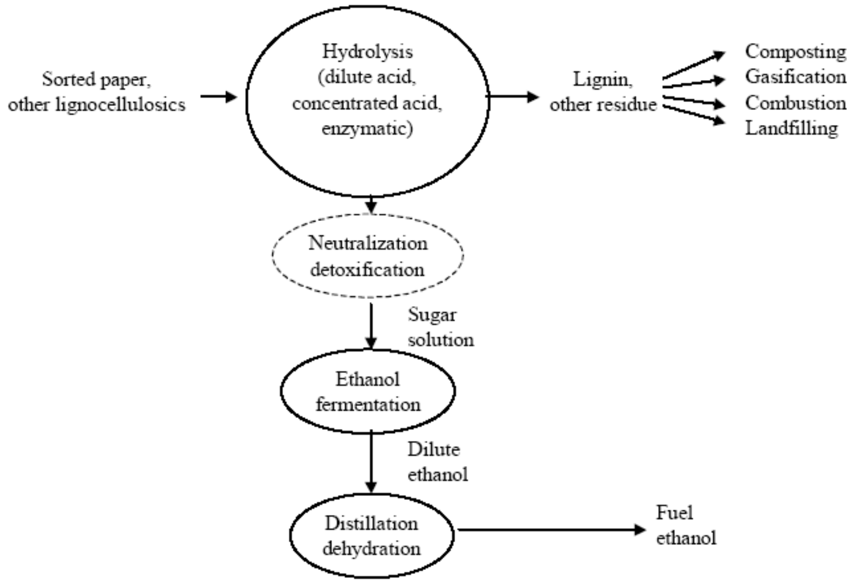

Figure 6: Hydrolysis Process

Gasification

Gasification is a process that uses heat, pressure, and steam to convert materials directly into a gas composed primarily of carbon monoxide and hydrogen. Gasification technologies differ in many aspects but rely on four key engineering factors:

- Gasification reactor atmosphere (level of oxygen or air content);
- Reactor design;
- Internal and external heating; and,
- Operating temperature.

Typical raw materials used in gasification are coal, petroleum-based materials, and organic materials. The feedstock is prepared and fed, in either dry or slurried form, into a sealed reactor chamber called a gasifier. The feedstock is subjected to high heat, pressure, and either an oxygen-rich or oxygen-starved environment within the gasifier. Most commercial gasification technologies do not use oxygen. All require an energy source to generate heat and begin processing.

There are three primary products from gasification:

- Hydrocarbon gases (also called syngas);
- Hydrocarbon liquids (oils); and,
- Char (carbon black and ash).

Syngas is primarily carbon monoxide and hydrogen (more than 85 percent by volume) and smaller quantities of carbon dioxide and methane. Syngas can be used as a fuel to generate electricity or steam, or as a basic chemical building block for a multitude of uses. When mixed with air, syngas can be used in gasoline or diesel engines with few modifications to the engine.

As in the case of ethanol conversion facilities, gasification facilities could be co-located at MRFs to take advantage of the current solid waste transportation infrastructure. In addition, co-location at MRFs would ensure that recyclable materials would be removed beforehand and only residuals would be sent to a gasifier. If a gasification facility is co-located at a landfill that accepts MRF residuals, the gasification facility could utilize landfill gas in the gasification process or could work in tandem with a landfill gas-to-electricity project. Figure 7 shows a typical gasification system.

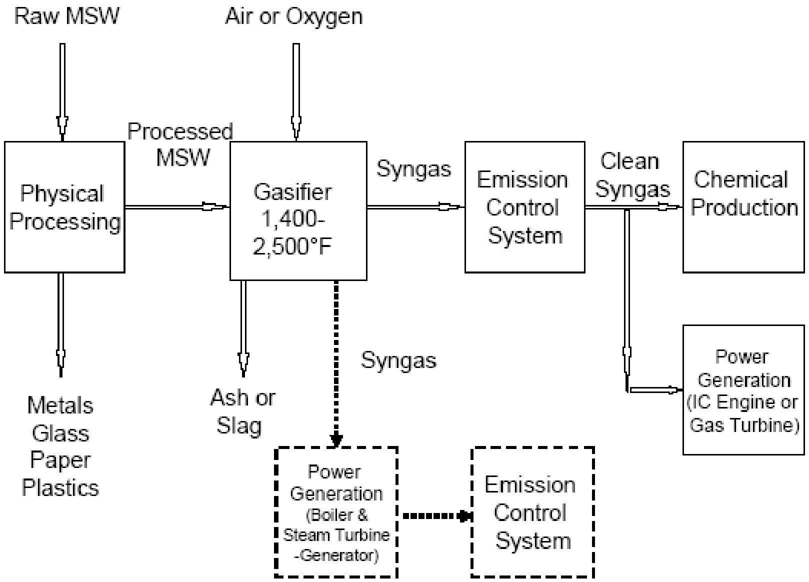

Figure 7: Gasification System

Seven plants with this technology are currently operating in Japan, with at least two of them firing MSW. The largest of these plants in Kurashibi has a reported boiler size of 185 tpd, with three units of this size. Another gasifier marketed for MSW is built by EnTech of Devon, England. They have constructed approximately 20 of these facilities, which are in operation on MSW in Europe and Asia. Most of them are relatively small (less than 10 tons per day), with none designed for more than 70 tons per day throughput.

Anaerobic Digestion

Anaerobic digestion is the bacterial breakdown of organic materials in the absence of oxygen. This biological process produces a gas, sometimes called biogas, principally composed of methane and carbon dioxide. This gas is produced from feedstock such as biosolids, livestock manure, and wet organic materials.

The anaerobic digestion process occurs in three steps:

- Decomposition of plant or animal matter by bacteria into molecules such as sugar;
- Conversion of decomposed matter to organic acids; and,
- Organic acid conversion to methane gas.

Anaerobic processes can occur naturally or in a controlled environment such as a biogas plant. In controlled environments, organic materials such as biosolids and other relatively wet organic materials, along with various types of bacteria, are put in an airtight container called a digester where the process occurs. Depending on the waste feedstock and the system design, biogas is typically 55 to 75 percent pure methane. A typical anaerobic digestion process system is shown in Figure 8.

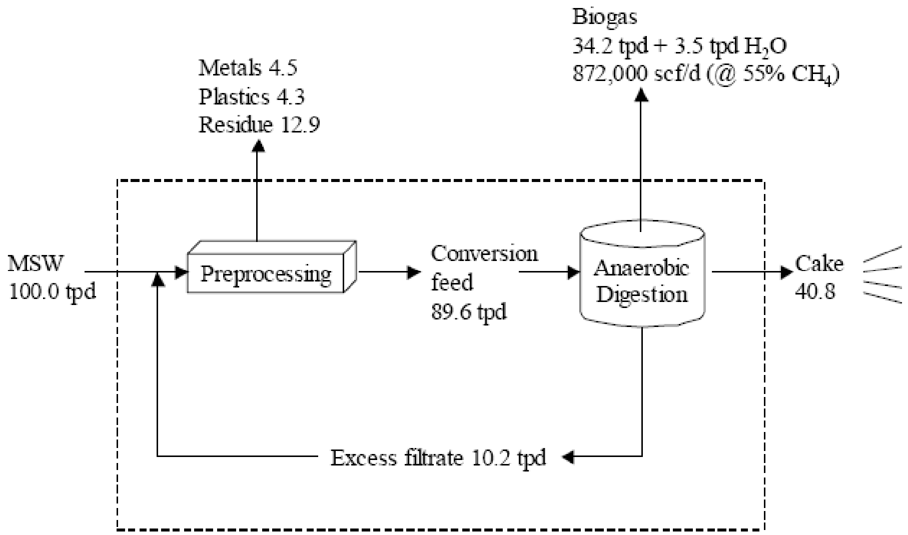

Figure 8: Typical MSW Anaerobic Digestion Process System

ArrowBio of Haifa, Israel, is a vendor offering to construct anaerobic digestion facilities to process MSW in the U.S. They have responded to procurements in Los Angeles and New York. They operate a 100-TPD, full-scale MSW demonstration process line in Tel Aviv and have a 270-TPD, commercial scale plant for MSW operating in Australia.

Plasma Arc

Plasma arc technology is a non-incineration thermal process that uses extremely high temperatures in an oxygen-starved environment to completely decompose waste into very simple molecules. Plasma arc technology has been used for many years for boutique metals processing. The heat source is a plasma arc torch, a device that produces a very high temperature plasma gas. A plasma gas is the hottest, sustainable heat source available, with temperatures ranging from 2,700 to 12,000 degrees F. A plasma arc system is designed specifically for the type, size and quantity of waste material to be processed. The very high temperature profile of the plasma gas provides an optimal processing zone with the reactor vessel through which all input material is forced to pass. The reactor vessel operates at atmospheric pressure.

The feedstock can be almost completely gasified, while non-combustible material, including glass and metal, is reduced to an inert slag. The product gas typically has a heating value approximately 1/4 to 1/3 the heating value of natural gas (natural gas has a value of approximately 1,040 Btu/standard cubic foot); therefore, it may be used as an efficient fuel source for industrial processes, including the generation of electricity, and the production of methanol and ethanol. The slag can be used in the construction industry or for road paving. All other byproducts, such as scrubber water and cyclone catch material, can be recycled into the process for reprocessing to alleviate disposal requirements. A typical plasma gasification system is shown in Figure 9.

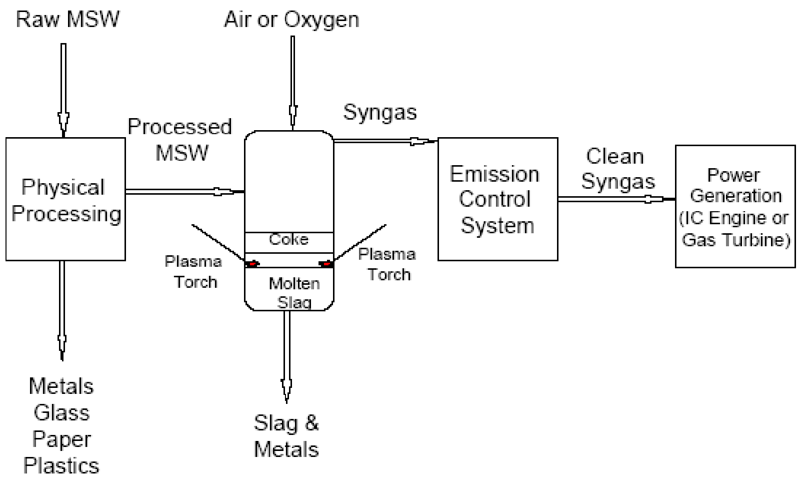

Figure 9: Typical Plasma Gasification System

There are no commercial-scale plasma arc facilities processing MSW in the U.S., although several companies are marketing some form of this technology and proposing facilities. There are three small plasma arc facilities processing MSW and/or auto-shredder residue in Japan reportedly using the Westinghouse plasma reactor. Few, if any of the plasma arc pilot facilities have been able to generate a fuel gas, and air emissions have been found to be no better than conventional incineration systems.

Two Canadian firms offer advanced gasification. Enerkem, headquartered in Montreal, Quebec, had an operating pilot gasification facility in Sherbrooke, Quebec, and built a commercial facility in Edmonton, Alberta, which processes 100,000 tpy which produce ethanol from the gas using a thermal/chemical process. The Plasco Energy Group, which had a 5 tpd research facility in Spain and operated a 400 tpd plant in Ottawa, Ontario. Both facilities have since closed due to mechanical issues.

Microwaves

Microwaves can be used as the external heat source for chemical decomposition or depolymerization. Microwave systems have been built to decompose some special wastes, particularly tires. Goodyear obtained a patent to “de-vulcanize” tires and built a facility in Lincoln, NE, to process in-plant scrap in the late 1970s. Several small units have been operated on tires. The application of microwaves to drying and decomposition of various wastes, including medical waste and nuclear waste, is proven, but its application to municipal solid waste has not been proven.

4.0 Evaluation

In assessing the applicability of waste processing technologies for the MOA, one must consider the overall track record of each, including the operational/commercial experience of the technology, the size and scale of the successful facilities, their environmental performance and impacts, their overall economics, their reliability over time, and the availability of financially strong companies to offer them under full service arrangements.

Table 2 is a matrix summarizing the overall performance of the technologies reviewed in this white paper. Several columns address the technology, whether it has been employed commercially at the scale required for handling MOA's MSW (1,000 to 1,200 tpd) and its expected reliability. Based on the need to minimize risk and operational costs, **Geosyntec considers mass-burn WTE technology to be the preferred and only option for further consideration by the MOA for this project.**

Table 2: Comparison Among Technologies

Description of Criteria	TECHNOLOGY			Comments
	Massburn	RDF	Waste Conversion	
State of Technology				
Degree to which system has been proven on a commercial scale	Commercially proven over the past 50 years	Commercially proven over the past 25 years at numerous plants	Few facilities have long term proven operating experience	Identify status of technology: Bench Scale, Pilot, Demonstration (0-3 years), or Commercially Proven (+3 years)
Operating History	Yes, well proven >80 plants and over 1,000+ plants worldwide	5 RDF processing and WTE plants in U.S.	Several facilities in Japan and Canada	How many operational plants and years of successful operation have been shown?
Freedom from high risk failure modes	Yes, mature industry addressing high risks with design codes and operational procedures	High potential for shredder explosions has been experienced	A few very key projects have failed after major developer investment to correct major design and operational issues	Are there identified design problem areas with mitigation measures implemented to prevent high risk situations?
Demonstrated reliability of entire system	Yes, >92-96% plant availability, many facilities have life spans exceeding 20-30 years	Yes, high reliability (87%) has been demonstrated	Uncertain reliability at the current time at the size range anticipated by the MOA	What is the capacity and throughput and the historical annual plant availability?
Technical Performance				
Compatibility with the full spectrum of MOA waste stream	Yes, for the typical MSW waste stream, limited percentage of tires, HHW, treated lumber, mercury containing devices, limited percentage of tires, some co-combustion of biosolids	Yes, except non-processible materials removed prior to combustion	Requires significant pre-processing of the waste stream with current technology	Is the process compatible with the full spectrum of MOA potential needs (residential, commercial, HHW, C&D, medical wastes, E-waste, special wastes
Ability to produce marketable byproducts	Yes, gross electricity (>600 kwh per ton, hot water, steam, ferrous and non-ferrous metals, aggregates for landfill cover	Yes, electricity, hot water, steam, ferrous and non-ferrous metals, aggregates for landfill cover	Unknown due to the lack of commercially proven facilities	Does the technology produce a viable commodity that can be sold to a large local or regional market? What type of marketable by-products are produced?
Need for pre-processing	No, other than removal of a small percentage of bulky items (<1%) of waste delivered	Yes, the RDF process extracts metals, glass, and inert materials to create an RDF fuel for combustion	Requires significant pre-process to an engineered fuel for further processing	Does the process require source separation, sorting, or sizing
Technical Resources				
Proven contractor experience with technology	Yes	Yes	Uncertain	Are there vendors who have direct and applicable experience in the receipt, storage, handling, and processing of MSW
Proximity of technical support	U.S. based vendors	U.S. based vendors	Uncertain, vendors based in Europe or Asia	Do vendors have local resources to provide on-going technical support for the process, or will the support be based in the U.S. or offshore?
Availability to provide support on continuing basis	U.S. based vendors with significant pool of experienced professionals	U.S. based vendors with significant pool of experienced professionals	Uncertain, vendors based in Europe or Asia	Is there a key project leader without whom the project may fail, or does a broader industry team if a project leader becomes unavailable?

5.0 References

1. American Society of Mechanical Engineers, Integrated Waste Services Association, Municipal Waste Management Association, and Solid Waste Association of North America, America's Own Energy Source (1995).
2. CDM Smith, King County WTE Study, Task 2 – WTE Existing Conditions Memorandum (2017).
3. Confederation of European Waste-to-Energy Plants, Municipal Waste Treatment (2015).
4. Gershman, Brickner & Bratton (GBB), Meeting the Future: Evaluating the Potential of Waste Processing Technologies to Contribute to the Solid Waste Authority's System (2009).
5. Lacoste, Elisabeth and Philippe Chalmin, 2006 World Waste Survey: Turning Waste Into a Resource: Veolia Environmental Services (2006).
6. Manders, Jan., Developments on Waste to Energy Across Europe, Presentation to WTERT, October 8, 2010.
7. Municipality of Anchorage, Anchorage Energy Landscape and Opportunities Analysis (2017).
8. Rogoff, Marc Jay. and Francois Screve, Waste-to-Energy Technologies and Project Implementation, 3rd Edition. Elsevier (2019).
9. Rogoff, Marc Jay, Waste-to-Energy Trends, MSW Management, February (2019).
10. Rogoff, Marc Jay, Waste-to-Energy Implementation Concepts, MSW Management, February (2018).
11. Standaert, Michael, As China Pushes Waste-to-Energy Incinerators, Protests Are Mounting, Yale Environment 360, hhttps://e360.yale.edu/features/as-china-pushes-waste-to-energy-incinerators-protests-are-mounting (2017).
12. Tetra Tech, Integrated Solid Waste Master Plan, Municipality of Anchorage, Alaska, September 2018.
13. Themelis, Nickolas and Zhixiao Zhang. WTe in China, Waste Management World. (August 2010).
14. World Bank. What A Waste – A Global Review of Solid Waste Management (2015). United Nations-Habitat: Solid Waste Management in the World's Cities. United Nations Human Settlement Programme (2009)