District of Columbia Department of Public Works

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2011 Solid Waste Characterization Study for the District of Columbia

August 2011

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Infrastructure · Water · Environment · Buildings

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Acronyms

APC	Air Pollution Control
CAA	Clean Air Act
DCDPW	District of Columbia Department of Public Works
EGs	Emission Guidelines
EPA	Environmental Protection Agency
FY	Fiscal Year
IWT	Interstate Waste Technologies
LAER	Lowest Achievable Emission Rate
MSW	Municipal Solid Waste
MWC Rule	Municipal Waste Combustor Rule
MWCOG	Metropolitan Washington Council of Governments
NSPS	New Source Performance Standards
NSR	New Source Review
O&M	Operation and Maintenance
RDF	Refuse-derived Fuel
RFEI	Request for Expressions of Interest
RFP	Request for Proposal
RFQ	Request for Qualifications
SOW	Scope of Work
SWMA	Solid Waste Management Administration
TPD	Tons Per Day
TPY	Tons Per Year
USEPA	United States Environmental Protection Agency
WM	Waste Management
WWTP	Waste Water Treatment Plant

Definitions

Anaerobic Digestion	A biological process by which microorganisms digest organic material in the absence of oxygen, producing a solid byproduct (digestate) and a gas (biogas).
Combustion	The process of converting MSW to generate steam or electricity while reducing the volume of MSW that would otherwise need to be landfilled by 70 to 90 percent.
Gasification	The partial thermal degradation of a substance in the presence of oxygen but with insufficient oxygen to oxidize the fuel completely. Products are gas (main combustible components being methane, hydrogen, and carbon monoxide) and a solid residue (consisting of non-combustible material and a small amount of carbon);
Imported Waste	Waste that is brought into the District of Columbia from outside sources (Virginia and Maryland). This may be a result of the District's competitive tipping fees.
Operating Costs	The recurring expenses related to the operation of a facility or business.
Pyrolysis	Pyrolysis is the thermal degradation of a substance in the absence of added oxygen. The end products of this process are potentially useable gas (syngas), char, and organic residue.
Reliable Waste	Waste from haulers that will most likely continue to haul waste to DCDPW facilities. Reliable haulers are the Solid Waste Management Administration, Other District Departments, District of Columbia Public Schools and Public Buildings Contract Hauler (Currently Urban Services), and Waste Management (by nature of its long term transfer station agreement with the District.
Variable Waste	Waste from private haulers that do not have long term agreements with DCDPW or whose agreements are due for renegotiations in the near future. These haulers come to DCDPW transfer stations in part because of the competitive tipping fees.

Executive Summary

The District of Columbia Department of Public Works (DCDPW) is interested in evaluating the most beneficial integrated solid waste management disposition alternatives for the next 25 years. The changes in disposal technologies, population, stakeholder preferences and existing agreements the District has for disposal (expiring in 2014) provide an excellent point to evaluate the options to manage the District's solid waste into the future. Therefore, DCDPW contracted with ARCADIS/Malcolm Pirnie (ARCADIS/Pirnie) to determine the baseline conditions of the current solid waste stream and project future generation. The results of this study may provide a basis for future solid waste management planning.

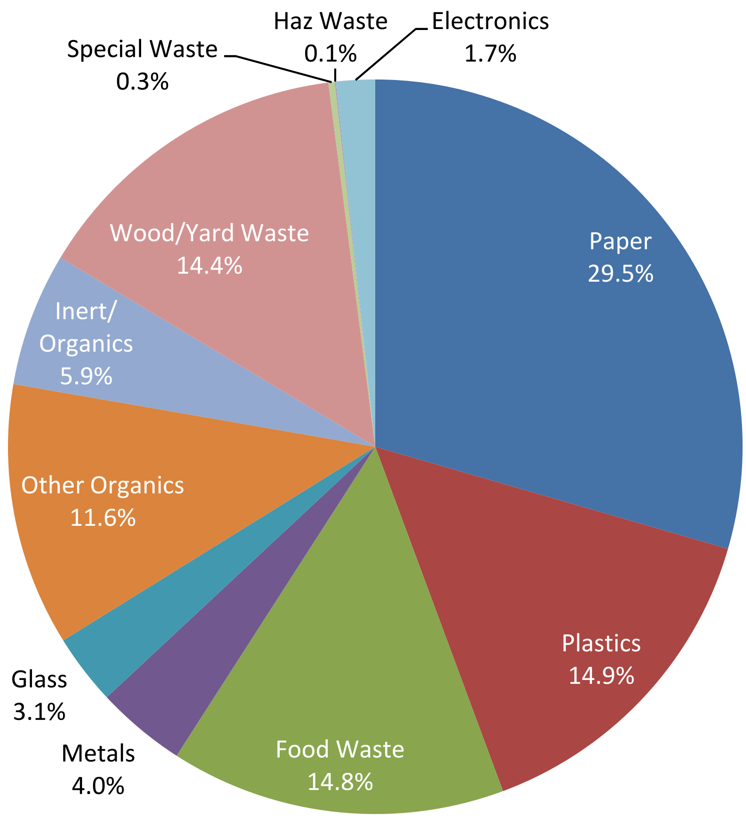
This study:

- Presents the results of a composition analysis of waste delivered to the DCDPW transfer stations.
- Estimates the current and projected residential waste generation rates (lbs/cap/day).
- Projects waste generation projections over a 25 year planning horizon.
- Identifies potential opportunities for improvements of the District's solid waste disposal program.
- Provides an overview of innovative or alternative disposal technologies reported as currently available in the marketplace to DCDPW.

Waste Characterization Results

ARCADIS/Pirnie developed and implemented a waste characterization program to update previous studies on the types and quantities of materials disposed of within the District. The waste characterization program focused on Municipal Solid Waste delivered to DCDPW's Benning Road and Ft. Totten Stations. The total waste composition results are presented in Figure ES-1.

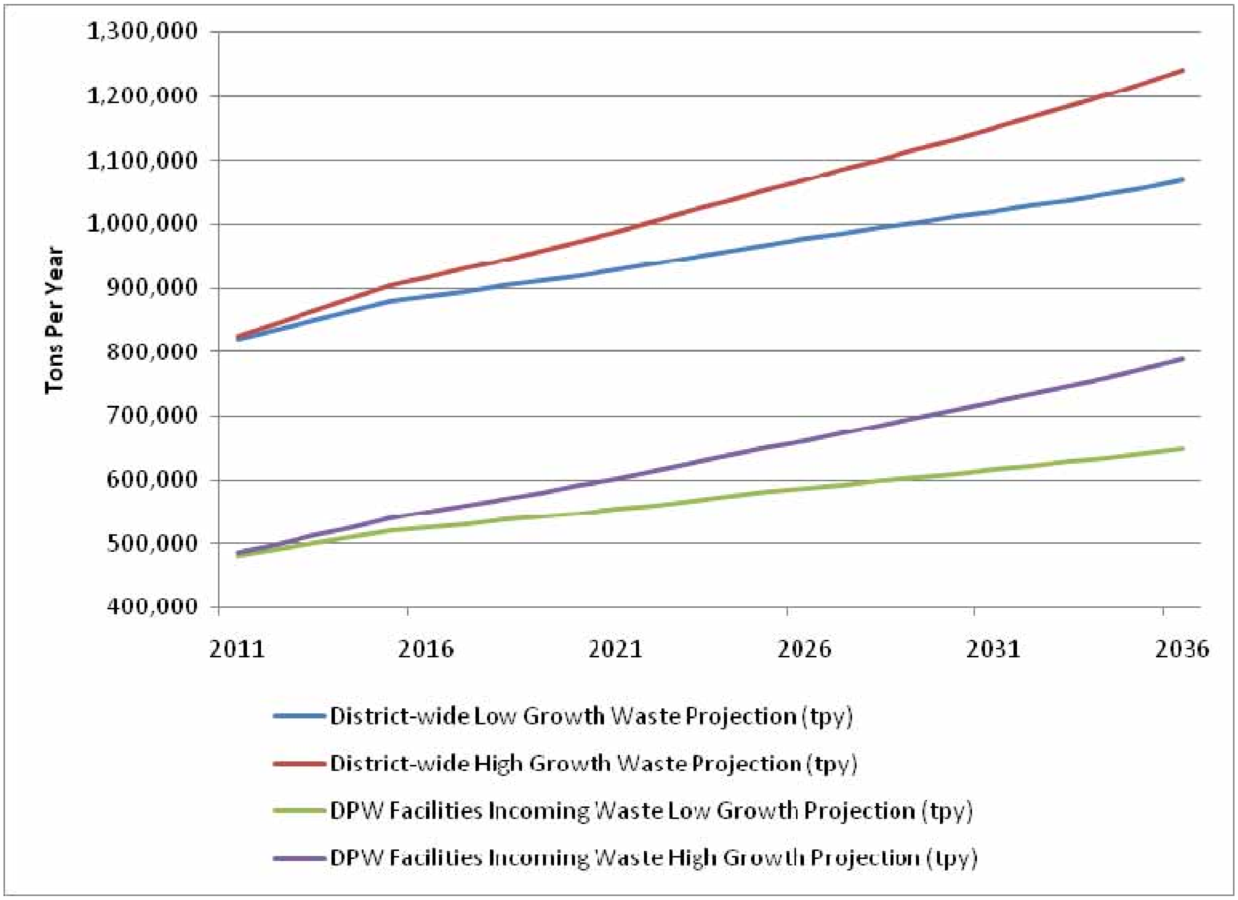
Figure ES-1: Overall Waste Composition Results for DCDPW Facilities



Waste Generation Projections

Waste projections were developed for a planning period through 2036. These projections are based on the per capita waste generation rate (lb/cap/day), as calculated from available data and District population projections from the US Census and the Metropolitan Washington Council of Governments. Figure ES-2 presents the comparison between the waste generation projection estimated for the District and the incoming waste projection for DCDPW facilities.

Figure ES-2: 25-Year Waste Generation Projection



Many haulers utilize the DCDPW transfer stations because of the competitive tipping fees. However, because tipping fees can fluctuate, it is important to identify the percentage of future waste considered most likely continue to be delivered to the DCDPW's facilities.

Based on discussions with DCDPW, reliable haulers include:

- The Solid Waste Management Administration
- Other District government departments
- District of Columbia Public Schools and Public Buildings Contract Hauler (currently Urban Services)
- Waste Management (by nature of its long term transfer station agreement with the District)

The percentage of reliable, or controllable, waste from the above sources has ranged from 53 to 60 of the DPW facilities incoming waste percent since 2008. The projection breakdown is conservatively based on the 53 percent reliable waste proportion from

2010. Figures ES-3 and ES-4 present the reliable and variable waste projections for the District along with waste processed at the private transfer stations.

Figure ES-3: Low Growth Waste Projection by Sector

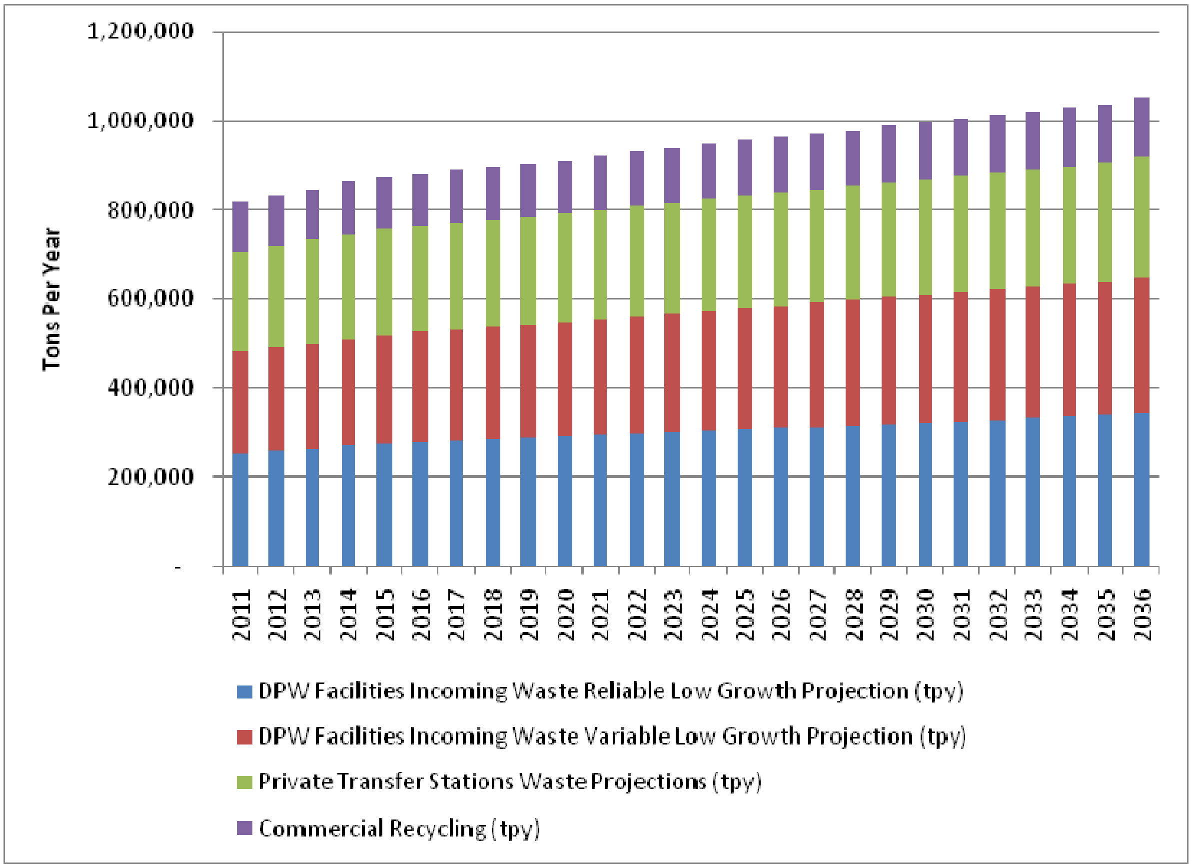
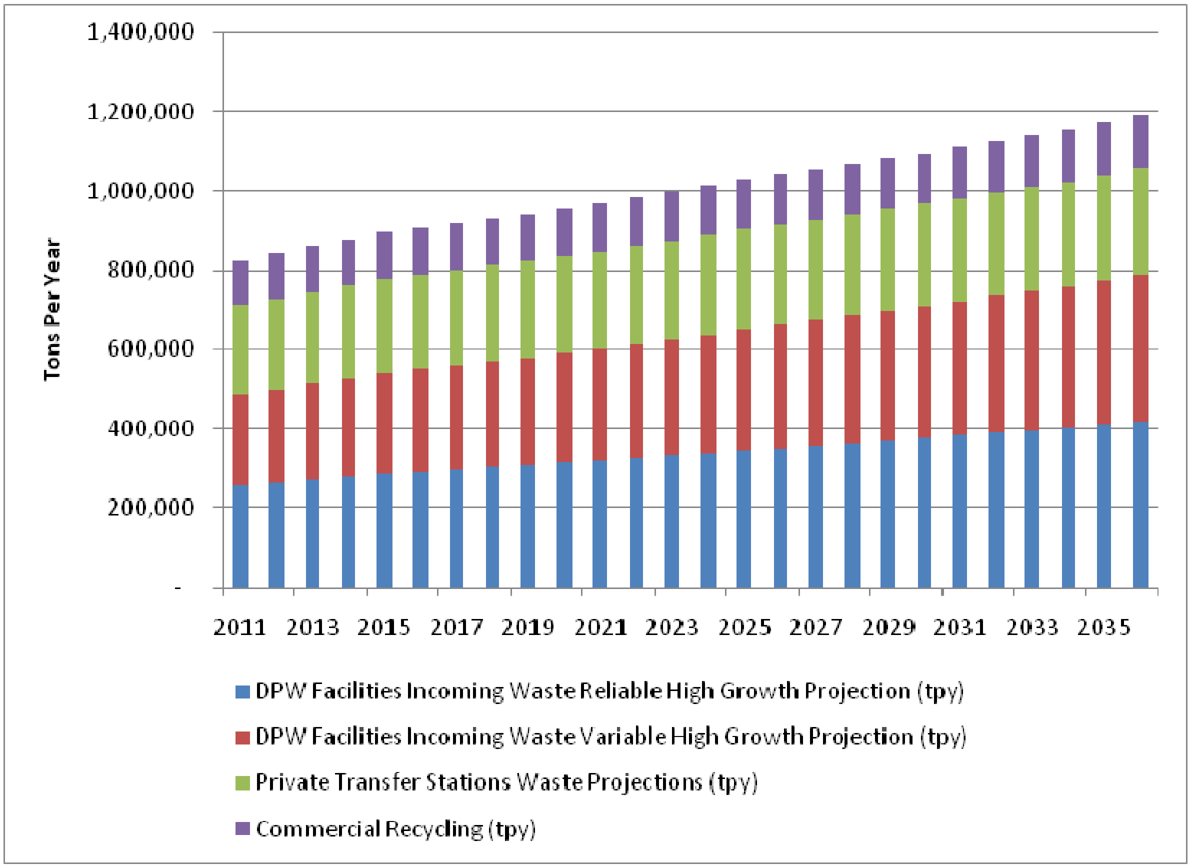


Figure ES-4: High Growth Waste Projection by Sector



For planning purposes, the range of available for processing based on waste projections is presented in Table ES-1.

Table ES-1:
Summary of Waste Projections

	2015 Low Growth Projection (tpy)	2015 High Growth Projection (tpy)	2036 Low Growth Projection (tpy)	2036 High Growth Projection (tpy)
DCDPW Reliable Incoming Waste	276,000	286,000	344,000	418,000
DCDPW Variable Incoming Waste	245,000	254,000	305,000	371,000
Subtotal DCDPW Incoming Waste	**521,000**	**540,000**	**649,000**	**789,000**
Private Transfer Station Waste	237,000	237,000	269,000	269,000
Commercial Recycling	117,000	117,000	133,000	133,000
Total District-wide Waste Generation	**875,000**	**894,000**	**1,051,000**	**1,191,000**

Opportunities for Improvements and Potential Technologies

While the DCDPW's existing waste management processes are cost effective for now, there are many viable environmentally friendly solid waste processing technologies and management approaches available to consider for long-range planning. The most sustainable solutions include source reduction policies and programs (similar to the recently implemented "Bag Law") and improving recycling and composting rates. However, the utilization of MSW as a source of renewable energy has gained more traction in nearby states such as Maryland and Pennsylvania. Therefore, DCDPW may able to capitalize on the District generated MSW as a potential source of renewable energy because energy recovery is consistent with the District's sustainable energy goals.

The potential waste management approaches were limited to:

- Technologies that are capable of processing MSW on a commercial basis (demonstrated technologies);
- Technologies that are reported to be developing the capability to become commercially viable for processing MSW (emerging technologies); and
- Provide for resource recovery and residuals minimization.

Table ES-2 is a summary of technology types and technology considered as potential technologies.

Table ES-2:
Evaluated Technologies

Technology Type	Technology
Thermal Combustion	■ Mass Burn/Advanced Thermal Recycling ■ Combustion of Refuse-Derived Fuel (RDF)
Thermal Conversion	■ Pyrolysis ■ Gasification ■ Pyrolysis/Gasification
Biological Treatment	■ Anaerobic Digestion ■ Mixed Waste Composting

This study offers an introduction to potential waste processing technology which is intended to provide basic information for planning purposes. The preliminary assessments of the technologies are based on technical, financial, and regulatory criteria that will be addressed through the DCDPW's planning process. Table ES-3 provides a list of the preliminary evaluation criteria utilized in this study.

Table ES-3:
Preliminary Evaluation Criteria

Category	Criteria
Technical	■ Processing capacity: ability to process ≥ 650 tpd. ■ Operating experience: proven operations processing similar mixed MSW waste stream managed by the DCDPW. ■ Operational requirements: capability to process mixed MSW, minimize residual production, and preference for resource recovery. ■ Residuals reuse/recycling: residuals generated and potential for recovery and reuse/recycling. ■ Energy recovery: ability to provide for direct energy production or via residual fuels. ■ Compatibility with existing processes and facilities: (1) ability to be integrated with the DCDPW's transfer stations; (2) ability to be implemented with operations consistent with those of the DCDPW; and/or (3) requirement to be established as a separate facility and operations.
Financial	■ Capital & operating costs: used as a relative measure of the economic requirements for the DPW's waste management system. ■ Risk: risk management issues associated with financial, operating, vendor, and market risks.
Regulatory	■ Permitting ■ Emissions

Based on the evaluations conducted in this study, the key findings for consideration, including preliminary order of magnitude cost estimates and behavioral changes required of customers, are presented in Table ES-4.

Next Steps

The District is committed to promoting and implementing sustainable solutions throughout the government's processes and practices. The DCDPW may be able to identify opportunities to improve their solid waste management by implementing source reduction and/or renewable energy processes.

The DCDPW intends to meet with the other District departments such as the Department of the Environment and Department of Planning to develop streamlined project objectives and goals. Subsequently, vendor interest, qualifications, operating capabilities, warranties, and guarantees are critical for a project's success. These issues can be addressed through the procurement process and the general structure of the contracts established for the project

The DCDPW expects to issue a Request for Expressions of Interest (RFEI) to identify market interest in implementing any of the discussed technologies. An RFEI is a solicitation issued broadly that presents the basic parameters of the improvements and requests interest from the vendor community. Basic parameters include the nature of waste to managed, system processes to be employed, capacities to be managed, acceptable financing arrangements, and the general responsibilities of the vendor and the owner.

Following the evaluation of the RFEI the DCDPW will determine the benefit of issuing a Request for Qualifications (RFQ) and a Request for Proposals (RFP). The RFQ requests specific and detailed qualifications information from interested vendors, which may include vendors who did not respond to the initial RFEI. Qualifications information includes operating experience, financial information, insurance, liabilities, legal information, and ownership data. The RFP is a document that includes detailed facility information (preliminary design, site layouts, design and operating requirements and standards, etc.) to enable vendors to submit comprehensive offers for the project. The RFP process will provide the most meaningful cross-comparison of costs for the DCDPW as proposals will be based on project-specific criteria.

Table ES-4:
Key Findings for Consideration

	Thermal Combustion	Thermal Conversion	Biological Treatment
Technical	▪ Proven experience on a commercial operating basis in U.S. and internationally at required capacities. ▪ Mass burn requires minimal pre-processing. ▪ RDF Combustion requires pre-processing. ▪ Net electric generation typically ranges from 500 to 600 kWh/ton. ▪ Little or no behavioral change required of customers.	▪ An emerging MSW treatment technology. ▪ No known facilities processing required capacity without employing numerous units. ▪ Pre-processing required. ▪ Net electric generation ranges reported from 350 to over 850 net kWh/ton. ▪ Increasing the diversion rates of recyclables (or nonprocessibles) in the waste stream may make the process more efficient.	▪ Limited experience processing mixed MSW. ▪ Reported to be available at or above processing capacity required. ▪ Pre-processing required. ▪ Anaerobic technologies are reported to be capable of generating approximately 100 net kWh/ton. ▪ Mixed waste composting facilities are reported to be capable of generating between 150 and 250 net kWh/ton. ▪ Increasing the diversion levels of recyclables in the waste stream may make the process more efficient.
Regulatory	▪ Public review process can be challenging. ▪ Modern facilities have successfully demonstrated ability to comply with various regulations.	▪ No permitted commercial MSW facilities in U.S. ▪ Reasonable to assume that it is technically capable of operating within U.S. regulatory standards.	▪ Permitting requirements typically provide for the operations to be enclosed in a negative pressure building to control odors and dust.
Financial	▪ Estimated order of magnitude capital costs is approximately $200,000 to $250,000 per ton of installed capacity (or per design ton) ▪ Estimated order of magnitude O&M costs is approximately $40-$80 per ton processed, respectively. ▪ Relatively low risk.	▪ Estimated order of magnitude capital costs is approximately $50,000 to $500,000 per ton of installed capacity (or per design ton) ▪ Estimated order of magnitude O&M costs is approximately $20-$150 per ton processed respectively. ▪ Relatively high risk.	▪ Estimated order of magnitude capital costs is approximately $50,000 to $250,000 per ton of installed capacity (or per design ton). ▪ Estimated order of magnitude O&M costs is approximately $50-$150 per ton processed respectively. ▪ Relatively moderate to high risk.

1. Introduction and Background

This report is prepared in accordance with Task 2 of the Scope of Work (SOW) dated December 3, 2010 for the Solid Waste Composition Study (the Project), Contract Number RQ10-127976-44A-D, submitted by ARCADIS/Malcolm Pirnie (ARCADIS/Pirnie) in response to Solicitation Number DCKT-2011-T-0239 for the District of Columbia Department of Public Works (DCDPW) Solid Waste Management Administration.

1.1. Background

Municipal Solid Waste (MSW) in the District is managed either by the DCDPW or through private collections. Residential waste from buildings with three or fewer dwelling units from within the District is collected by the DCDPW, while private haulers collect the remaining waste. Most of the private haulers have existing agreements with the District and have specific requirements as to where District generated waste is hauled:

- Republic Services (Formerly BFI) and Waste Management (WM) are required to bring waste generated within the District to DCDPW transfer stations (Benning Road and Ft. Totten). The agreements between DCDPW and Republic Services and WM expire October 2012 and December 2022, respectively.
- Urban Services is required to haul waste generated by public buildings within the District to DCDPW facilities. The Urban Services agreement is through 2015.

The majority of the District's MSW is processed through DCDPW's Benning Road or Ft. Totten transfer stations. Private haulers also bring waste into these stations from areas outside the District. In addition, two private transfer stations process MSW and one private transfer station processes construction and demolition waste and recyclables within the District. Disposal is provided by the private sector and through the District's waste supply agreement with Fairfax County (I-95 E/RRF).

The District's current solid waste management disposal agreements for waste and recyclables continue through May 2014. The DCDPW is interested in identifying and contracting for the most beneficial integrated solid waste management disposition alternatives to serve the District for the next 25 years. The results of this study provide a basis for future solid waste management planning.

1.2. Study Objectives

The objectives of this study are to:

- Provide a composition analysis of waste delivered to the DCDPW transfer stations.

- Determine current and projected residential waste generation rates (lbs/cap/day).
- Provide waste generation projections for a 25-year planning horizon.
- Identify potential opportunities for improvements of the District's solid waste disposal program.
- Provide an overview of innovative or alternative disposal technologies reported as currently available in the marketplace to DCDPW.

1.3. General Considerations and Assumptions

Throughout this study ARCADIS/Pirnie used and identified our assumptions and information provided by DCDPW with respect to the conditions which may exist or events which may occur in the future in preparation of this memorandum and the findings contained herein.

The evaluation of waste processing technologies is based on data and information that is available from published sources and vendor information. ARCADIS/Pirnie has applied its knowledge and experience to provide an objective evaluation regarding a technology's merit.

2. Waste Characterization

ARCADIS/Pirnie developed and implemented a waste characterization program to update previous studies on the types and quantities of materials disposed of within the District. The waste characterization program focused on waste disposed at DCDPW's Benning Road and Ft. Totten Stations. The characterization results will provide baseline information for planning and decision-making regarding long term management and disposition strategies.

2.1. Waste Characterization Process

The first step of the waste sorting process identified the number of trucks that would be selected for sampling. The agreed upon protocol was to select trucks by the hauler (for non-DCDPW trucks) and route (for DCDPW trucks). The non-DCDPW trucks to be sampled were brought in by the haulers that delivered a high percentage of the incoming waste to District facilities. Based on Fiscal Year (FY) 2010 data from DCDPW, the approximate percentage of waste attributed to each hauler was calculated, revealing DCDPW brings in approximately 28 percent of the waste, Republic Services brings in 35 percent, WM brings in 17 percent, and the District's public buildings hauler (currently Urban Services) brings in approximately 7 percent. Appendix A identifies all the haulers that contributed waste into the District's transfer stations in FY 2010.

In addition to sampling a proportionate number of trucks from Republic Services, WM, and Urban Services, one truck from each of the District's eight Wards were also sampled. In total, 31 trucks and over 8,800 pounds of MSW were sampled during the sorting effort. Appendix B presents the information on the trucks sampled, any route information provided, and the hauling company.

It is important to note that the scope of the waste characterization study does not include recycling waste hauled into DCDPW transfer stations as DCDPW recently did this (ref study). In addition, because of budget constraints, bulk waste was not visually or physically sorted at either facility.

On March 18, 2011, ARCADIS/Pirnie met with representatives of the District of Columbia Department of Public Works (DCDPW) Solid Waste Management Administration (SWMA) to review the preliminary sampling schedule, health and safety plan, and field working conditions. At that meeting, the on-site sorting schedule was agreed upon as:

- Ft. Totten Transfer Station between March 21, 2011 and March 25, 2011
- Benning Road Transfer Station between March 28, 2011 and April 1, 2011

2.2. Waste Characterization Results

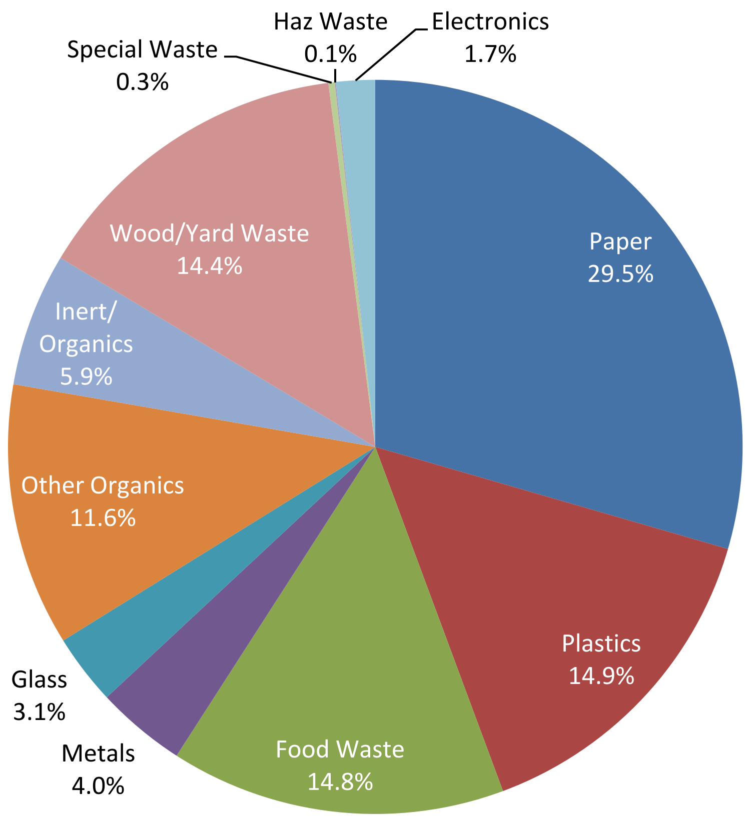
Each sample was sorted, as received, into the following categories and recorded by weight (in pounds):

- Paper
- Plastics
- Food Waste
- Metals
- Glass
- Other Organics (Textiles/Leather, Carpets/Rugs, Rubber, Diapers, Fines)
- Inert/Organic (Asphalt, Concrete/Brick/Rock, Dirt, Roofing Materials, Earthen Materials, Drywall)
- Wood and Yard Waste (Leaves, Grass, Stumps)
- Special Waste (Lead/acid batteries, Dry Cell batteries, Ni/Cd batteries, Tires, Motor Oil)
- Potential Hazardous Waste (Paints, Adhesives, Cleaners, Solvents, Pesticides/ Herbicides, Medical Waste)
- Electronics

2.2.1. Overall Composition Results

The total waste composition results are presented in Figure 2-1.

Figure 2-1: Overall Waste Composition Results for DCDPW Facilities



2.2.2. Composition Results by Transfer Station

Figures 2-2 and 2-3 present the composition results for the Ft. Totten and Benning Road Transfer Stations, respectively.

Figure 2-2: Ft. Totten Composition Results

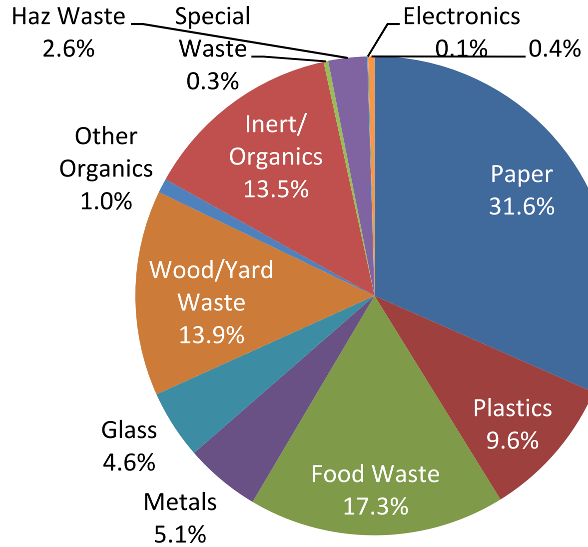
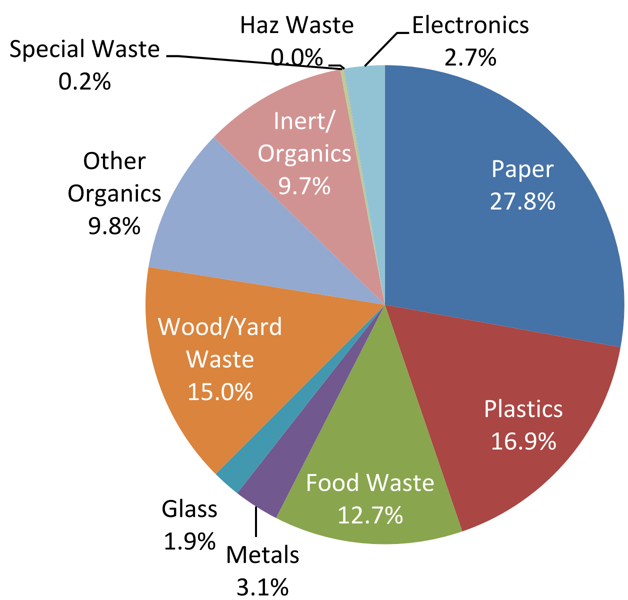


Figure 2-3: Benning Road Composition Results



2.2.3. Composition Results by Hauler

Table 2-1 presents the weighted average percentages of each waste category by hauler.

Table 2-1:
Waste Composition Results by Hauler

	DCDPW	Republic Services	WM	Urban Services	Tenleytown Trash	Total Private Haulers	Total Incoming Waste
Paper	24.4%	31.9%	29.7%	53.9%	32.0%	33.3%	29.5%
Plastics	12.9%	18.4%	10.0%	18.2%	13.0%	16.4%	14.9%
Food Waste	16.4%	10.1%	22.1%	8.5%	28.6%	13.5%	14.8%
Metals	3.2%	2.1%	11.6%	4.2%	7.6%	4.4%	4.0%
Glass	0.3%	1.6%	8.2%	0.1%	2.6%	2.8%	3.1%
Other Organics	13.9%	8.4%	16.4%	14.2%	5.5%	10.1%	11.6%
Inert/ Organics	8.6%	9.5%	0.0%	0.0%	0.4%	6.3%	5.9%
Wood/Yard Waste	18.9%	14.5%	2.1%	0.0%	9.5%	10.7%	14.4%
Special Waste	0.4%	0.3%	0.0%	0.2%	0.4%	0.2%	0.3%
Potentially Hazardous Waste	0.1%	0.0%	0.0%	0.0%	0.3%	0.0%	0.1%
Electronics	1.0%	3.3%	0.0%	0.8%	0.1%	2.2%	1.7%

The differences between the DCDPW and private hauler waste sources may account for the variability in the composition results. For example, because the DCDPW collects primarily residential waste, the percentage of food waste is higher for DCDPW waste than for private haulers. Similarly, because private haulers collect more business waste than DCDPW, their percentage of paper is generally higher. Figures 2-4 and 2-5 present the differences in waste composition for the DCDPW collected waste and the private haulers.

Figure 2-4: DCDPW Collected Waste Composition Results

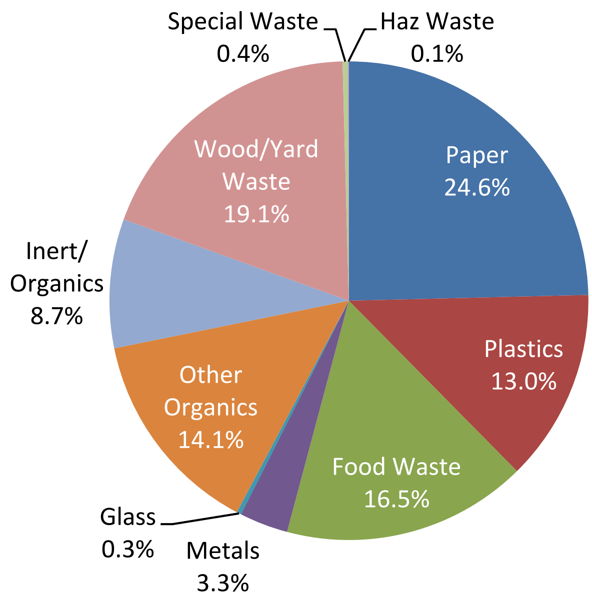
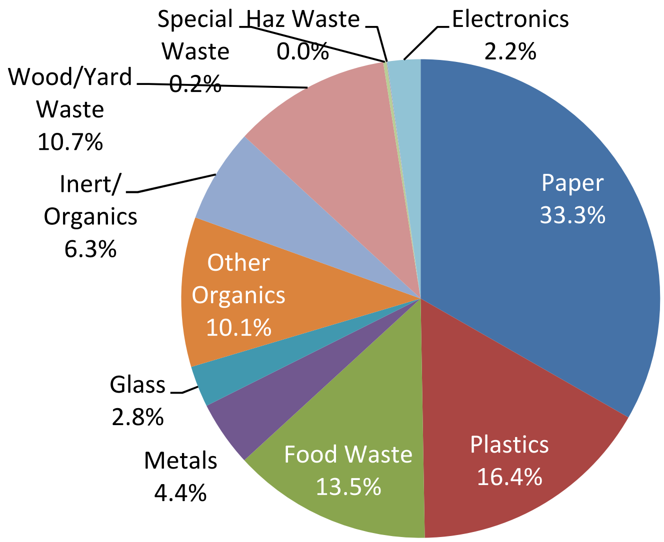
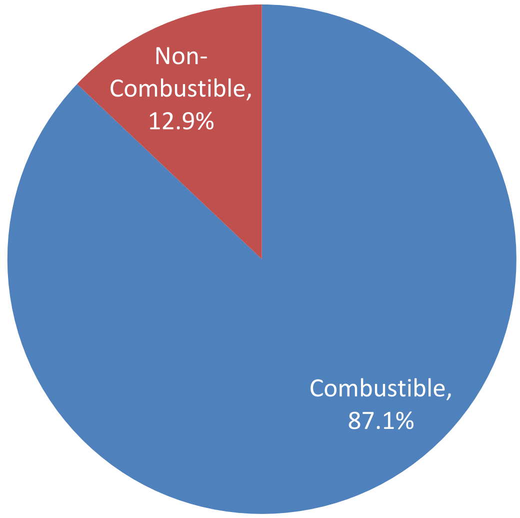


Figure 2-5: Private Haulers Waste Composition Results



Because a potential waste management strategy may include processing waste through a waste-to-energy facility, Figure 2-6 presents the approximate amount of combustible materials in the sorted waste. Paper, plastics, food waste, wood, other organics, yard waste, recyclable plastics, and electronics are considered combustible. Metals, glass, inert/organics, special waste, and potentially hazardous wastes are considered non-combustible.

Figure 2-6: Combustible Waste Percentage

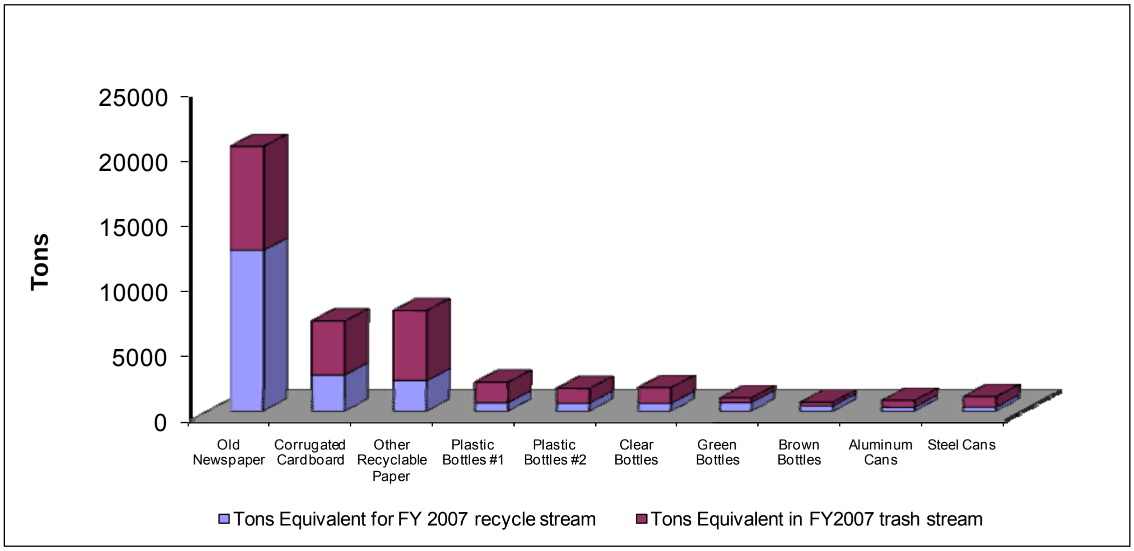


2.2.4. Recycling Waste Stream Composition

The DCDPW performed a hand sort of waste collected by the Solid Waste Management Administration during a three-week period between October and November of 2007[1]. During this sort 56 loads of trash and 33 loads of recycling were sampled by DCDPW staff totaling 16.1 tons. The primary purpose was to identify current and potential recycling streams, and to determine what is being recycled and what is being disposed. The 2007 recycling study determined that approximately 36 percent of the residential waste stream is available for recycling. However, only 18 percent of the total waste was being recycled and approximately 22 percent of the household garbage waste stream was potentially recyclable at that time. For the FY 2007, this translated to 23,800 tons of recyclable materials were lost to the land fill. Figure 2-7 illustrates, by recyclable commodity, the amount recycled, and the amount of recyclable materials remaining in the waste stream.

[1] DCDPW Residential Waste Sort, October – November 2007.

Figure 2-7: Recyclables in 2007 Total Waste Stream[2]



2.2.5. Comparison to Other Studies

The District waste composition study results were compared against similar studies for other metropolitan areas as well as national averages. Table 2-2 shows the waste composition comparison between the District and other areas.

Table 2-2:
Comparison to Other Waste Composition Studies

Material	DCDPW Facilities	2009 EPA Generation Estimates	2009 EPA Disposal Estimates[1]	Pennsylvania Statewide	Southeast PA (Includes Philadelphia)	Georgia Statewide	Atlanta Metro Region	Chicago
Paper	29.5%	28.2%	16.1%	33.3%	34.7%	38.7%	40.0%	13.8%
Food Waste	14.8%	14.1%	20.8%	12.0%	11.3%	12.0%	12.2%	7.1%
Wood/Yard Waste	14.4%	20.2%	16.8%	13.5%	14.8%	7.1%	6.4%	9.5%
Plastics	14.9%	12.3%	17.2%	11.4%	11.1%	15.8%	15.8%	4.8%
Other Organics	11.6%	10.2%	12.8%	10.5%	8.9%	12.0%	11.5%	13.4%
Inert/ Organics	5.9%	1.6%	2.4%	9.3%	8.3%	2.0%	1.5%	21.4%
Metals	4.0%	8.6%	8.5%	5.4%	4.8%	5.4%	5.6%	25.8%
Glass	3.1%	4.8%	5.5%	3.0%	3.7%	3.7%	3.8%	2.5%
Electronics	1.7%	NA	NA	1.5%	1.9%	2.0%	1.8%	0.3%
Special Waste	0.3%	NA	NA	NA	NA	1.0%	0.9%	0.1%
Potential Hazardous Waste	0.1%	NA	NA	0.3%	0.2%	0.4%	0.5%	0.9%

Notes:
1. Post recycling disposal.

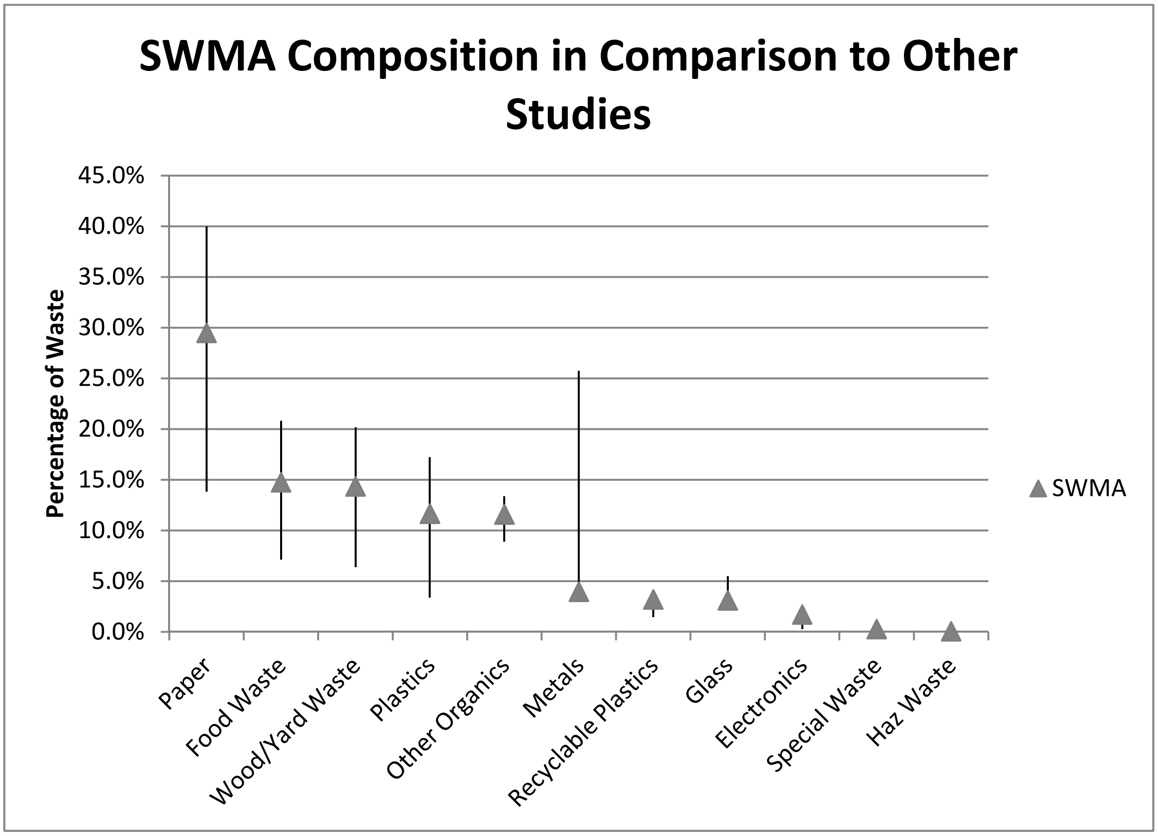
[2] 2007 Residential Waste Sort. DCDPW.

Variations in waste composition percentages among these studies are attributable to differences in:

- Climate and local waste management practices
- Per capita generation rates for some products like newspapers
- Level of commercial and economic activities in communities
- Local and state regulations and practices.

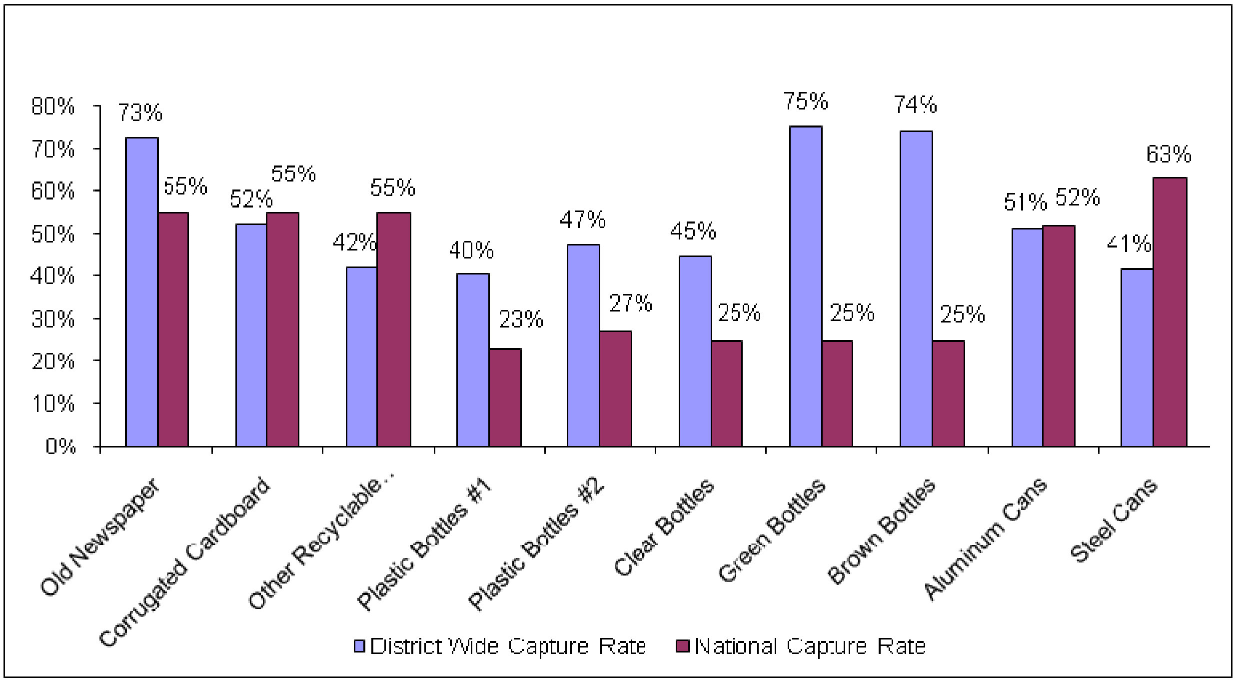
As shown in Figure 2-8, the results of the District's study are predominantly within the range of results from comparable areas.

Figure 2-8: DCDPW Facilities Composition Results in Comparison to Other Studies



The recycling sampling data from FY 2007 also revealed that, in general, the District compares favorability with national average of capture rate for commodities accepted in the residential recycling program. Figure 2-9 compares national capture rates to the Districts capture rates.

Figure 2-9: 2007 District Recycling Rates and National Rates



3. Waste Generation Projections

Waste generation projections were created based on the waste characterization data, population projections, and historical per capita disposal trends. The waste generation projections for the District include waste received at DCDPW facilities, recycling tonnage hauled to other facilities, and waste hauled into a private transfer station within the District.

The waste projections are further broken down into reliable sources (from haulers that are either required or expected to stay with DCDPW facilities) and variable sources (from haulers who have no contractual responsibility to deliver waste to DCDPW).

3.1. Assumptions

Waste projections were developed for a planning period through 2036. The projections are based on the per capita waste generation rate (lb/cap/day), as calculated from available data. Appendix C includes further details on the per capita waste generation calculations,

The waste projections in this study are based on the following data:

- 2010 population within the District from the U.S. Census is 601,723.[3]
- Round 8.0 Cooperative Forecasting: Population and Household Forecasts to 2040 from the Metropolitan Washington Council of Governments (MWCOG), issued in December 2010.
- Tons of waste received at Ft. Totten and Benning Road from 2004-2010.[4]
- One private transfer station within the District processes approximately 250 tons per day (tpd), 6 days a week and another approximately 400 tpd.[5]
- District commercial recycling amounts hauled to a non-DCDPW facility reported to DCDPW for fiscal years 2005-2010 as noted in Table 3-1.

[3] Source: U.S. Census Bureau, Census 2000 State Legislative District Summary File (100-Percent), Table P1, and 2010 Census Redistricting Data (Public Law 94-171) Summary File, Table P1.
[4] Source: DCDPW scale house data
[5] Information based on reported data to DCDPW. Data from the third private transfer station that processes District generated waste is currently unavailable. However, the quantities processed are not expected to be significant enough to effect projections for planning purposes.

Table 3-1:
Reported Commercial Recycling

Year	Commercial Recycling (tpy)
2005	79,588
2006	83,260
2007	68,235
2008	127,783
2009	112,444
2010	110,201

3.2. District-wide Projections

Because per capita rates have historically fluctuated, a simple extrapolation of per capita generation rates is not considered as dependable. Low growth and high growth projections were prepared to provide a range of expected annual generation amounts for future planning efforts. The low growth generation rate of 0.5 percent is based on the per capita waste generation increase between 2005 and 2007 was used. Similarly, the high growth generation rate of 1.2 percent is based on the increase between 2005 and 2010. Based on the above data and assumptions identified in Appendix C, Table 3-2 presents 25-year waste generation projections for the District.

Table 3-2:
25-Year Waste Generation Projections

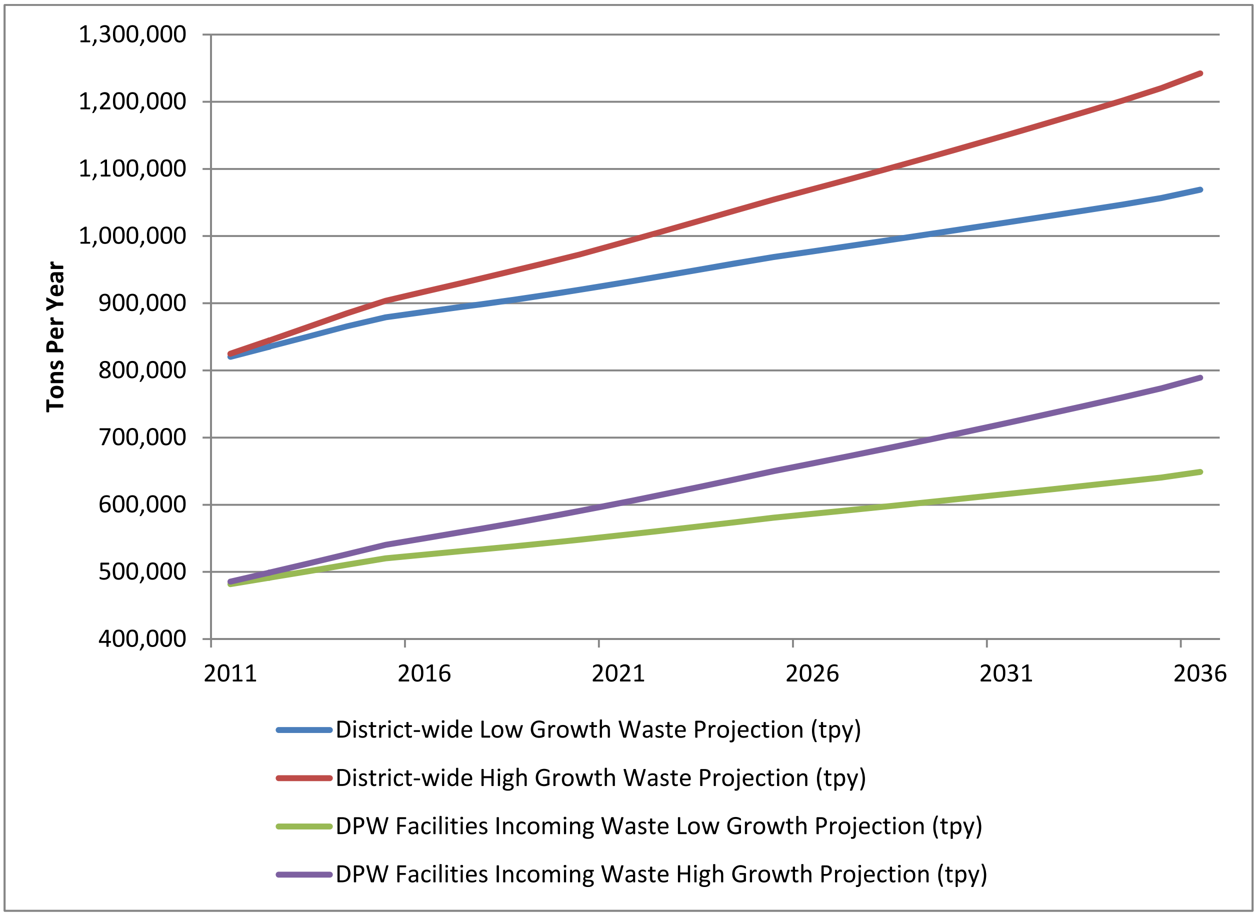
Year	MWCOG Population Change (%)	Population Extrapolation	Low Growth Per Capita Generation Rate (lb/pc/pd)	High Growth Per Capita Generation Rate (lb/pc/pd)	Low Growth Projection (tpy)	High Growth Projection (tpy)
2011	1.50%	610,868	5.33	5.37	820,279	824,770
2012	1.47%	620,013	5.36	5.44	835,336	844,530
2013	1.45%	629,158	5.38	5.50	850,490	864,604
2014	1.43%	638,303	5.41	5.57	865,741	884,996
2015	0.56%	647,448	5.43	5.64	879,080	903,701
2016	0.56%	651,078	5.46	5.71	887,026	916,989
2017	0.55%	654,708	5.48	5.78	895,020	930,471
2018	0.55%	658,338	5.51	5.85	903,063	944,149
2019	0.55%	661,968	5.53	5.92	911,153	958,027
2020	0.72%	665,598	5.56	5.99	919,711	972,524
2021	0.71%	670,375	5.59	6.07	929,487	988,498
2022	0.71%	675,152	5.61	6.14	939,324	1,004,711
2023	0.70%	679,928	5.64	6.22	949,222	1,021,168

Year	MWCOG Population Change (%)	Population Extrapolation	Low Growth Per Capita Generation Rate (lb/pc/pd)	High Growth Per Capita Generation Rate (lb/pc/pd)	Low Growth Projection (tpy)	High Growth Projection (tpy)
2024	0.70%	684,705	5.66	6.29	959,181	1,037,872
2025	0.52%	689,482	5.69	6.37	968,769	1,054,394
2026	0.52%	693,073	5.72	6.45	977,181	1,069,775
2027	0.52%	696,663	5.74	6.53	985,643	1,085,381
2028	0.51%	700,253	5.77	6.61	994,157	1,101,214
2029	0.51%	703,844	5.80	6.69	1,002,723	1,117,280
2030	0.52%	707,434	5.83	6.77	1,011,370	1,133,610
2031	0.52%	711,106	5.85	6.86	1,020,155	1,150,279
2032	0.51%	714,777	5.88	6.94	1,028,994	1,167,194
2033	0.51%	718,449	5.91	7.03	1,037,887	1,184,357
2034	0.51%	722,120	5.94	7.11	1,046,833	1,201,772
2035	0.83%	725,792	5.96	7.20	1,056,682	1,220,291
2036	0.82%	731,789	5.99	7.29	1,069,128	1,242,163

3.3. Waste Projections by Sector

The generation projections presented in Table 3-2 include waste processed at non-DCDPW transfer stations within the District and commercial recycling that is hauled to non-DCDPW facilities. Figure 3-1 presents the comparison between the waste generation projection estimated for the District and the incoming waste projection for DCDPW facilities.

Figure 3-1: 25-Year Waste Generation Projection



Many haulers utilize the DCDPW transfer stations because of the District's competitive tipping fees. However, because tipping fees can fluctuate, it is important to identify the percentage of future waste that will most likely continue to be hauled to the District's facilities.

Based on discussions with DCDPW, reliable haulers include:

- The Solid Waste Management Administration
- Other District government departments
- District of Columbia Public Schools and Public Buildings Contract Hauler Urban Services
- Waste Management (by nature of its long term transfer station agreement with the District)

The percentage of reliable, or controllable, waste from the above sources has ranged from 53 to 60 percent of the DPW Facilities incoming waste since 2008. To be conservative, the projection breakdown is based on the 53 percent reliable waste proportion from 2010. Figures 3-2 and 3-3 present the reliable and variable waste projections for the District along with waste processed at the private transfer stations.

Figure 3-2: Low Growth Waste Projection by Sector

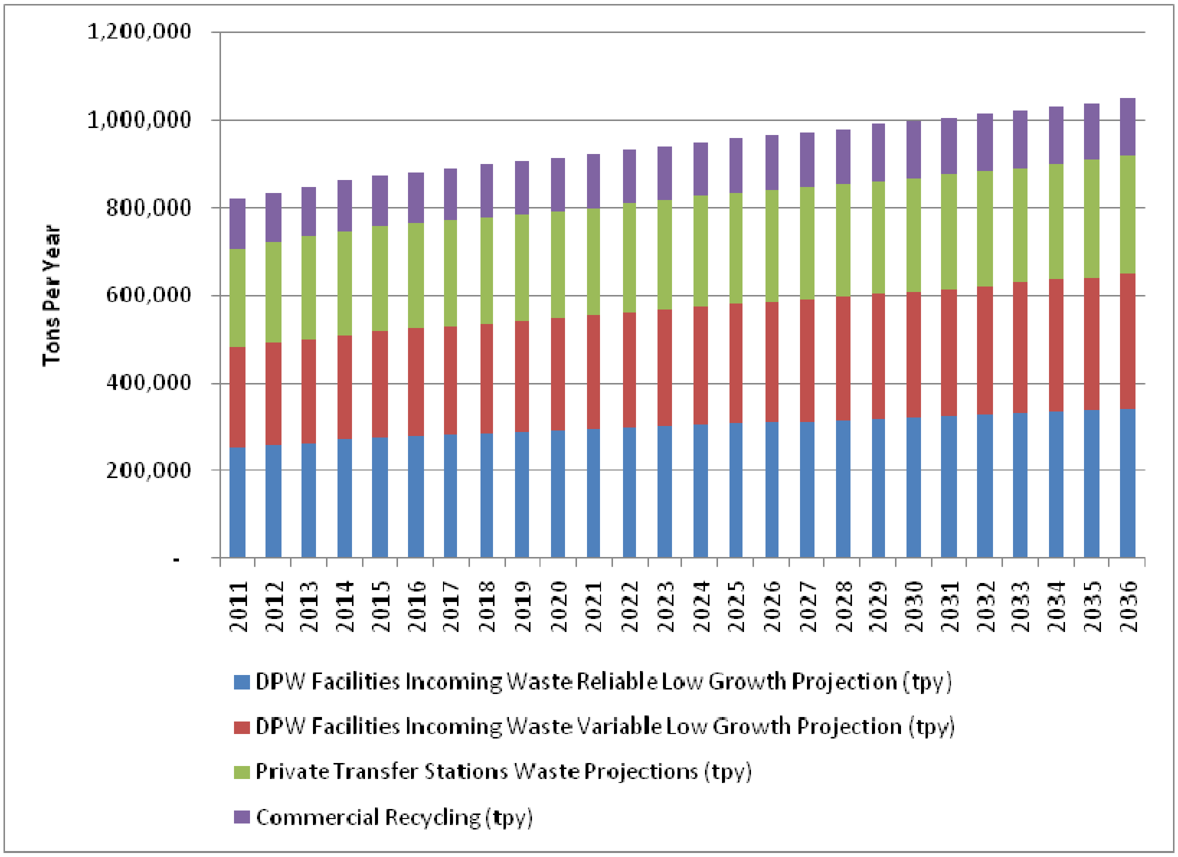
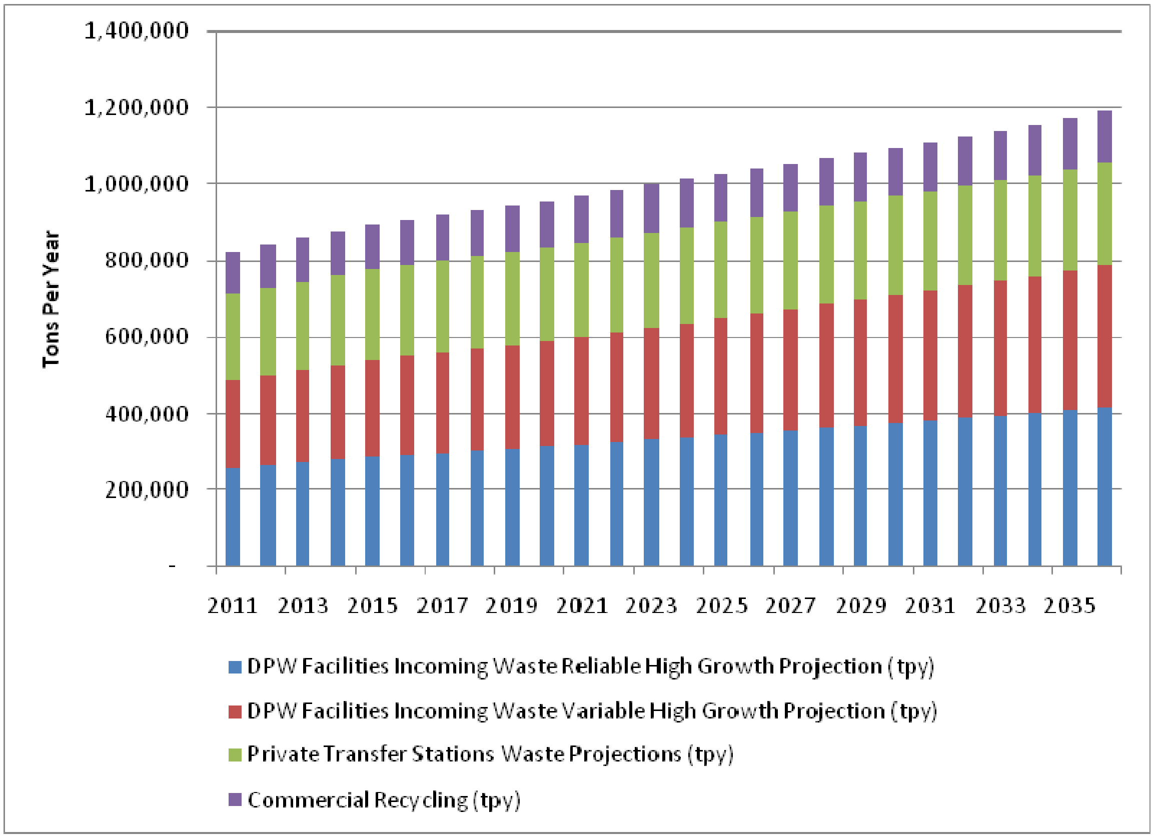


Figure 3-3: High Growth Waste Projection by Sector



3.4. Imported Waste Projections

Some waste hauled by the private sector to DCDPW transfer stations and private transfer stations within the District is generated outside of the District. Inquiries were made with the operators of the private transfer stations and private haulers reported to deliver a significant portion of the waste processed at the Ft. Totten and Benning Road Transfer Stations for an approximate percentage of the waste generated outside of the District.

Based on responses from private haulers received to date, it is estimated that approximately 10 percent of the waste processed at the DCDPW facilities is imported from outside the District. With respect to private transfer stations in the District, one of the private station imports 90 percent of its waste and another one imports 25 percent.[6] Figures 3-4 and 3-5 show the low and high growth scenarios, with respect to imported waste.

[6] Based on information available to DCDPW.

Figure 3-4: Low Growth Imported Waste Projection

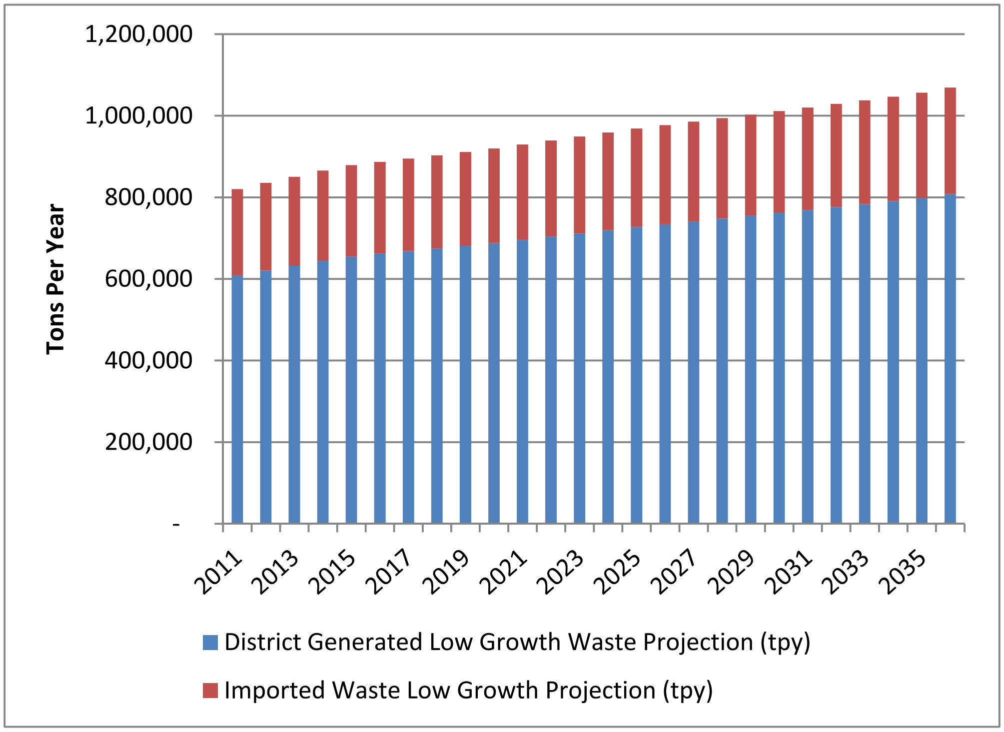
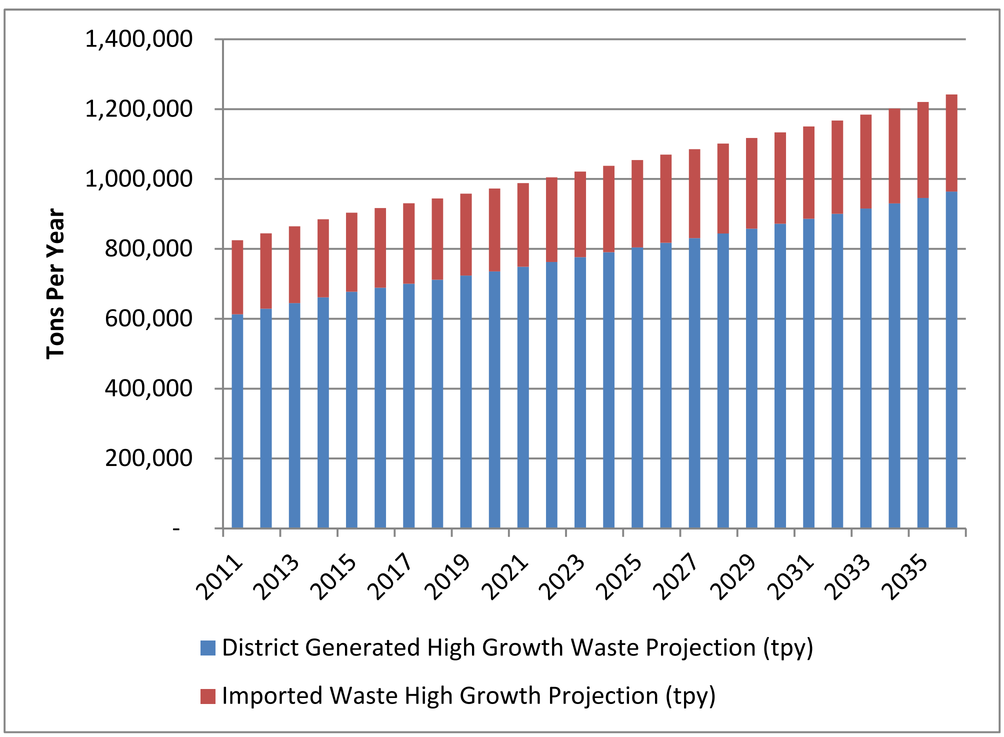


Figure 3-5: High Growth Imported Waste Projection



For planning purposes, the range of available for processing based on waste projections is presented in Table 3-3.

Table 3-3:
Summary of Waste Projections

	2015 Low Growth Projection (tpy)	2015 High Growth Projection (tpy)	2036 Low Growth Projection (tpy)	2036 High Growth Projection (tpy)
DCDPW Reliable Incoming Waste	276,000	286,000	344,000	418,000
DCDPW Variable Incoming Waste	245,000	254,000	305,000	371,000
Subtotal DCDPW Incoming Waste	**521,000**	**540,000**	**649,000**	**789,000**
Private Transfer Station Waste	237,000	237,000	269,000	269,000
Commercial Recycling	117,000	117,000	133,000	133,000
Total District-wide Waste Generation	**875,000**	**894,000**	**1,051,000**	**1,191,000**

4. Opportunities for Improvement

4.1. Solid Waste Management Strategies

While the DCDPW's existing waste management processes are currently cost effective, there are many viable technologies that potentially offer more environmentally friendly and sustainable alternatives. Figure 4-1 depicts the waste management hierarchy as defined by the District, where waste reduction is the most preferred and environmentally sound option.

Figure 4-1: District of Columbia Waste Management Hierarchy

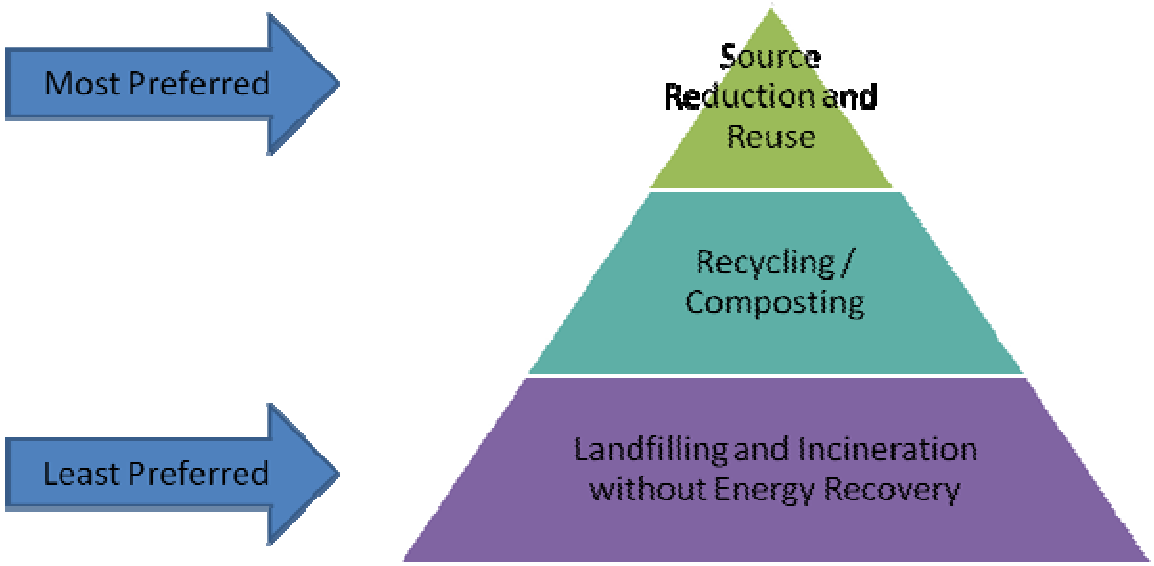
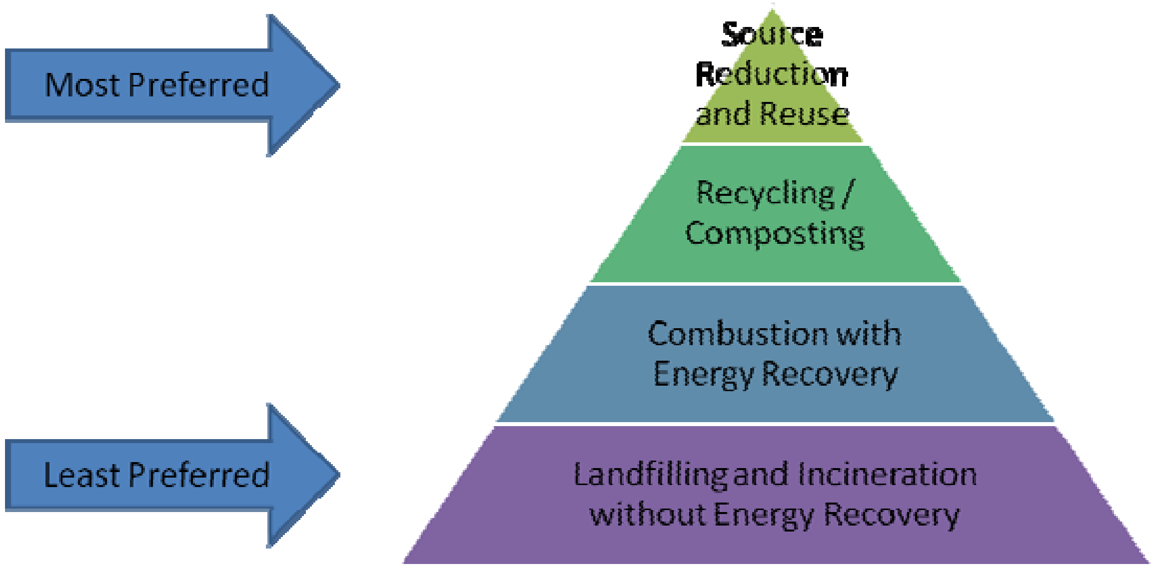


Figure 4-2 depicts the waste management hierarchy as defined by EPA, which includes combustion as an energy recovery option.

Figure 4-2: Waste Management Hierarchy[7]



4.2. Source Reduction

The best way to reduce costs and improve sustainability is to reduce the amount of waste generated within the District. Source reduction refers to any change in design, policy, or use of materials or products which reduces their amount or toxicity in MSW. The District has recently had success in implementing a source reduction strategy aimed at consumers through the "Bag Law," which is intended to reduce the amount of bags that enter the MSW stream and as a source of pollution for the Anacostia River. Similarly, policies may be implemented which encourage businesses to utilize less packaging.

Some communities have implemented a "Pay-As-You-Throw" program, in which a customer's fee is directly proportional to the amount of waste they contribute into the municipal solid waste stream.

4.3. Recycling/Composting

Another environmentally friendly approach to increase the efficiency of solid waste management is to increase the recycling rate within the District. The 2007 residential recycling waste sort indicated that increasing paper and metal recycling offers the greatest opportunities for the District to increase the recycling diversion rate for the residential waste stream. To achieve a higher capture rate it was recommended that DCDPW should create more messaging that focuses on increasing the amount of cardboard, other paper and metal food and beverage containers. It was also suggested that

[7] Solid Waste Management Hierarchy. US EPA. http://www.epa.gov/epawaste/nonhaz/municipal/hierarchy.htm. Accessed on June 28, 2011.

the economic viability of creating additional recycling streams for yard waste and the textiles should be analyzed. Subsequently, DCDPW sent targeted communications regarding recycling to certain residents. However, because of budget constraints, further endeavors were limited.

Based on the results of the 2011 composition study, approximately 10 percent of the current MSW stream is recyclable plastics, glass, and metals that is not recycled. While capturing all the recyclables in the MSW is unlikely, further efforts to improve recycling rates may be successful. One option may be to provide larger or more recycling bins. Another option is to conduct more targeted communications to encourage recycling. While, the District's "Green DC" website has helpful tips on how residents can improve their household recycling, the DCDPW can take advantage of popular social media outlets to interactively promote recycling.

The DCDPW can also utilize similar communication strategies to improve composting rates within the District. Approximately 40 percent of the current MSW being processed at the DCDPW facilities is food waste, wood, yard waste, and organics. Organics can be processed by alternative technologies including anaerobic digestion and mixed waste composting, as discussed in the following sections.

4.4. Combustion and Energy Recovery Options

If the results of the waste characterization study are extrapolated to the entire District, approximately 87 percent of the District generated waste or 700,000 tpy is combustible. Through the existing disposal agreement with Fairfax County, a majority of the waste generated in the District is ultimately utilized as feed stock at an energy recovery plant. However, the estimated volume of reliable waste generated within the District and managed by DCDPW is generally sufficient to sustain an energy recovery option locally.

The utilization of MSW as a source of renewable energy has gained more traction in nearby states such as Maryland and Pennsylvania. Therefore, DCDPW may able to capitalize on the District generated MSW as a potential source of renewable energy because energy recovery is consistent with the District's sustainable energy goals.

As the District and the DCDPW are committed to advancing projects that provide affordable renewable energy sources and improving the level of sustainability of their solid waste management programs, the following sections also provide a brief introduction into the thermal combustion and conversion processes potentially available to the District.

5. Preliminary Criteria

This study provides a macro-level evaluation of technical, financial, and regulatory aspects related to potential waste processing technologies. Information considered in this study is compiled from research and industry reports, trade journal publications, technical papers, and information from vendors, as well as from ARCADIS/ Pirnie's experience. Preliminary evaluation criteria were established to assess how well a technology may satisfy DCDPW's needs. These criteria were developed considering technical, financial, and regulatory requirements that are typically associated with MSW management programs.

5.1. Technical

Technical criteria include processing capacity, operating experience, operational requirements, residuals reuse/recycling energy recovery, and compatibility with existing waste management processes. These criteria address DCDPW's goal of providing the most beneficial and integrated solid waste management services for effective long-term operations.

5.1.1. Processing Capacity

Any implemented technology should be able to process the waste generation projections for the DCDPW's Reliable Waste. However, it would also be advantageous if the processing capacity of the technology could be easily increased to accommodate additional waste generated in the District. For planning purposes, the range of available for processing based on waste projections should be between approximately 650 tpd to 1,400 tpd in 2015 and 800 tpd to 2,000 tpd in 2036.

5.1.2. Operational Experience

The waste processing technology should have a record of proven operations, preferably in the U.S. However, technologies successfully operating at capacities near the expected requirement for the DCDPW may be viable options for further study.

5.1.3. Operational Requirements

The waste processing technology must be capable of processing mixed MSW. In addition, technology that provides for resource recovery (e.g., energy and/or materials) is preferred and minimization of residuals is essential.

5.1.4. Residuals Reuse/Recycling

In accordance with the District and DCDPW's sustainability goals, it is preferred that residuals can be practically reused or recycled.

5.1.5. Energy Recovery

Energy recovery in the form of net positive electric production is preferred from a technology. The sale of electricity is expected to be supported by available markets that provide a stable revenue source for the project. Energy recovery is consistent with the District's sustainable energy goals and provides a dependable revenue source that positively impacts project economics.

5.1.6. Compatibility with Existing Processes and Behavioral Considerations

Technologies should be evaluated for their compatibility with the existing solid waste management processes at the Ft. Totten and Benning Road Transfer Stations and existing collection processes, in terms of waste processing capability and nature of operations. In addition, any behavioral changes required of customers at the point of collection will be considered..

It is anticipated that all the potential technologies will require a significant public outreach and education effort to gain the political approval to move forward with improvements.

5.2. Regulatory Requirements

Regulatory criteria are centered on the ability of the technology to meet regulatory and environmental standards.

5.2.1. Permitting

This criterion refers to the likelihood that the technology and associated components will be permitted by the appropriate federal, state, and local regulatory bodies. Complexity of the permitting process is also a consideration in this criterion as well as feasibility of continued compliance with current and anticipated future regulations.

5.2.2. Emissions

The emissions criterion considers the nature and type of process emissions that are regulated, including gases, liquids, and solids. A technology's ability to eliminate, reduce, or control emissions is also considered.

5.3. Financial

Financial criteria measure the financial and economic risks. These criteria include:

5.3.1. Capital and Operating Cost

The capital and operating cost is a relative measure of economic requirements that at this stage is appropriate for use in comparative analyses. A technology's capital and operating costs are the basis for establishing the economic breakeven point of the system's operations. Detailed economic analyses (including breakeven analyses) are not a part of this study.

5.3.2. Risk

Risk factors influencing the selection of a technology include:

- Financing risk – the ability to attract public financing at competitive terms.
- Operational risk – risk to the DCDPW and District in the event of technology failure.
- Vendor risk – the vendor community's willingness to accept risk of performance and provide guarantees to protect DCDPW in the event of vendor default, thereby reducing risks to DCDPW.
- Market risk – the ability to attract private haulers to maximize available capacity while maintaining a rate structure that meets financial obligations.

6. Potential Technologies

The section provides an evaluation of waste processing technologies for the potential to provide the level of service necessary to meet DCDPW’s projected waste management responsibilities. This section is based on data and information that is available from published sources and vendor information. ARCADIS/Pirnie applied its knowledge and experience to provide an objective evaluation regarding a technology’s merit.

Accordingly, the section’s focus is limited to the primary technological aspects of a waste processing system (e.g., the treatment method). This study does not include direct discussions with vendors nor does it evaluate detailed aspects of potential processing systems and associated components. Rather, this section is intended to provide a broad view of the technology options, including preliminary order of magnitude cost estimates, that may be considered by the DCDPW in addressing its future waste processing requirements. Subsequent activities should be undertaken by the DCDPW with respect to technologies evaluated in this study to address the full range of technical, financial and regulatory issues associated with implementing the waste management approach that best meets the DCDPW’s needs.

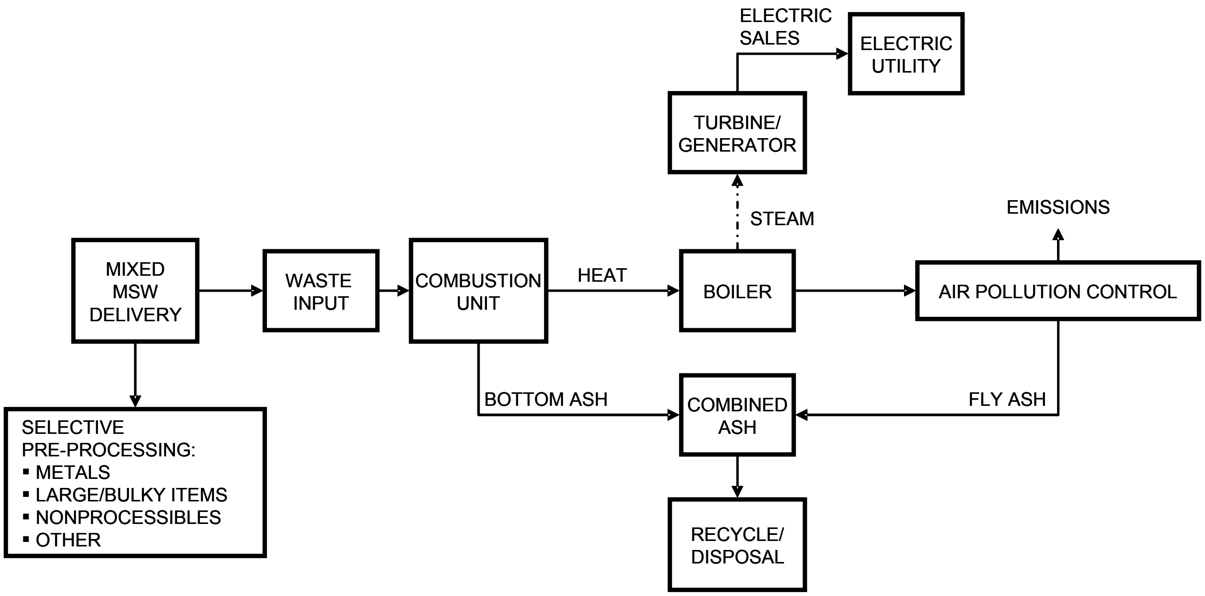
6.1. Combustion Technologies

Combustion thermal treatment technologies include modern conventional mass burn or combustion of refuse-derived fuel (RDF), both of which directly burn or combust MSW. Combustion converts MSW to generate steam or electricity and reduces the volume of MSW that would otherwise need to be landfilled by 70 to 90 percent.

6.1.1. Mass Burn

Mass burn systems have a proven operating record using units of varying capacities and configurations up to and exceeding the capacities DCDPW is expected to process. Mass burn provides for residual minimization and generates useful byproducts that include (a) heat for steam generation, energy recovery, and electric sales; (b) ash residue that is potentially reusable; and (c) recovered ferrous and non-ferrous metals. Mass burn systems require sophisticated air pollution control (APC) equipment and to operate within regulatory compliance standards. Figure 6-1 illustrates a typical process for the mass burn systems.

Figure 6-1: Mass Burn System



Physical separation may be used to complement mass burn systems. Potential benefits from the removal of large objects and metals prior to combustion include improved combustion and energy recovery from mass burn systems. Lower operations and maintenance (O&M) costs and higher system reliability and depending on the level of physical separation, lower air emissions, may be realized as well. However, pre-processing will increase operational requirements (e.g., increases in staff, equipment, and O&M of the pre-processing system). In addition, should the removed materials not be marketable (if intended), additional system costs will be incurred.

6.1.1.1. Technical Evaluation

Processing Capacity

Mass burn systems have a long history of use and have progressed steadily in terms of technical maturity in response to evolving needs for increased efficiencies and regulatory control. Combustion units range in size from 50 tpd to over 1,000 tpd with facility daily throughput capacities ranging from several hundred to thousands of tons, depending on the number and arrangement of units.

Operational Experience

Modern plants are state-of-the art and have an extensive record of successful commercial operations: the USEPA reports 87 facilities in the U.S. and over 600 facilities worldwide. These plants have been operating on a commercial basis in the U.S. since early 1970s (e.g., Saugus, MA) and for over 40 years in Europe.

Palm Beach, FL

Although mass burn is not necessarily a new technology there have been advances and improvements in efficiencies. As of April 2011 Palm Beach County has a signed contract with Babcock & Wilcock to design and construct a new, 3,000 tpd state-of-the-art waste-to-energy power plant. The design will include three 1,000 tpd mass burn boilers capable of generating up to 95 gross MW of electricity, grates, ash systems, metals recovery systems, emissions control equipment – including a dry flue gas desulfurization unit, baghouse, carbon injection and selective catalytic reduction system – duct work and other components. The project scope includes the installation of a metals recovery system to maximize the recovery and recycling of aluminum, steel and other metals. The new plant will be located on 24 acres and cost approximately $660 million.

Some of the innovative technologies and expected environmental impacts of this project include the following:

- Reduced Air Emissions
  - Selective Catalytic Reduction for control of Nitrogen Oxides (NOx) at less than 50 ppmv (24-hour) and 45 ppmv (12-month rolling) at 7% O dry basis, which is approximately one-third of the existing EPA New Source Performance Standards (NSPS).
  - Reduced Carbon Monoxide (CO) at less than 50 ppmv (4-hour) at 7% O dry basis, which is less than half of the existing EPA NSPS.
  - Reduced Mercury (Hg) to less than 10 mg/dscm at 7% O dry basis, which is approximately one third of the existing EPA NSPS.
- Higher Resource Recovery Rates to existing plants in Fairfax, Alexandria, and Montgomery County.
  - Electricity – Net 575 kWh per ton with 4,600 Btu per pound waste
  - Ferrous Metals – 90%
  - Non-Ferrous Metals – 85%
- Waste Receiving and Storage Operating Efficiencies
  - Digital refuse pit receiving and inventory management system
  - Fully automated multiple refuse pit crane operation during non-peak delivery periods
  - Automated hot spot/fire refuse pit monitoring system

Puerto Rico

Puerto Rico has plans to also construct an Interstate Waste Technologies facility to process up to 450,000 tons per year. It will be privately financed, built, owned, and operated by Caribe Waste Technologies (CWT). The facility will occupy 18 acres of land and cost about $450 million.

Operational Requirements

Modern facilities use oxygen available in combustion air at temperatures approaching 2,500°F. Mass burn plants accept mixed MSW and require little pre-processing (minimally limited to the removal of hazardous wastes and oversized objects). It is recognized that upfront physical separation may provide benefits such as improved combustion, reduced emissions, increased metals recovery, and improved energy recovery. However, large scale physical separation of MSW has been attempted with mixed results as operations have been challenged by operational difficulties, quality of separated materials (i.e., ability to meet market requirements), market conditions, and operating costs. One inherent risk in large scale physical separation is the potential for additional disposal costs should the separated materials not be accepted by markets.

Residuals Reuse/Recycling

Combustion byproducts from mass burn include heat and ash residue. Ash residue is generally managed as combined fly ash and bottom ash. Combined ash, which consistently meets regulatory standards for non-hazardous waste, may be recycled; however it is typically landfilled. Several combustion projects have ash recycling programs. Metals are typically removed post-combustion from the ash. As the ash reuse market develops and chemical testing continues to demonstrate the non-hazardous nature of the ash, it may be possible to manage fly ash and bottom ash separately as reusable materials, an opportunity to further increase the marketability of the combustion system's solid residues.

Energy Recovery

The heated combustion gases are exhausted to a boiler for heat recovery and electrical generation, with the off-gases treated (cleaned) at atmospheric pressures and subsequently released to the environment. Modern plants are reported to generate between 500 and 600 kWh/ton (net of in-house usage). Mass and volume reductions of 70 percent to 90 percent, respectively, are typically achieved.

Compatibility with Existing Processes and Behavioral Considerations

It is likely that mass burn combustion is compatible with existing DCDPW solid waste management operations and behavioral changes of the customer at the point of collection are not required to successfully implement this option. The public outreach and education effort is expected to focus on gaining acceptance for the improvements, identifying environmental and cost benefits, and allaying environmental fears.

6.1.1.2. Regulatory Requirements

Permitting

Regulatory programs for mass burn facilities are established. As modern facilities have successfully demonstrated the ability to comply with the various federal and state environmental regulations to which they are subject, it is anticipated that future combustion facilities will be able to similarly comply. One challenge associated with permitting is expected to be public review process, which involves receiving input from the public and other interested stakeholders.

Additionally, the New Source Review (NSR) program may require NSR permits as well. Under the NSR program, new or modified facilities in locations that do not meet national ambient air quality standards (i.e., non-attainment areas) may be subject to Lowest Achievable Emission Rate (or LAER), which may require emission credits. Specifics regarding regulatory permitting requirements for new and modified major sources should be more fully evaluated during implementation of any improvements.

As for combustion facilities, regulatory considerations for physical separation systems are established. Permitting requirements typically call for the operations to be enclosed in a negative pressure building to control odors and dust, much like material recycling facilities (MRF), MSW transfer stations and other waste handling operations. The permitting process would include siting, design, and public review.

Emissions

Existing, modified, and new municipal waste combustion facilities must comply with the emission standards established under the Municipal Waste Combustor Rule (MWC Rule). As part of the Clean Air Act's (CAA) five-year review, on December 6, 2005, the USEPA proposed new Emission Guidelines (EGs) for large combustors as well as new NSPS.

6.1.1.3. Financial

Capital and Operating Cost

Combustion thermal technologies are proven, commercially-viable processes that have been in operation for more than 40 years. Accordingly, it is likely that more favorable (as compared to other technologies without a demonstrated operating history) financing terms are achievable and, as an owner, the DCDPW should be able to secure vendor/operator guarantees as part of the service agreement. The estimated order of magnitude capital and O&M costs for a facility, is approximately $200,000 to $250,000 per ton of installed capacity (or per design ton) and approximately $40 to $80 per ton processed respectively. These estimated costs do not represent an estimate of a market tipping fee nor do they include costs associated with pre-processing.

Risk

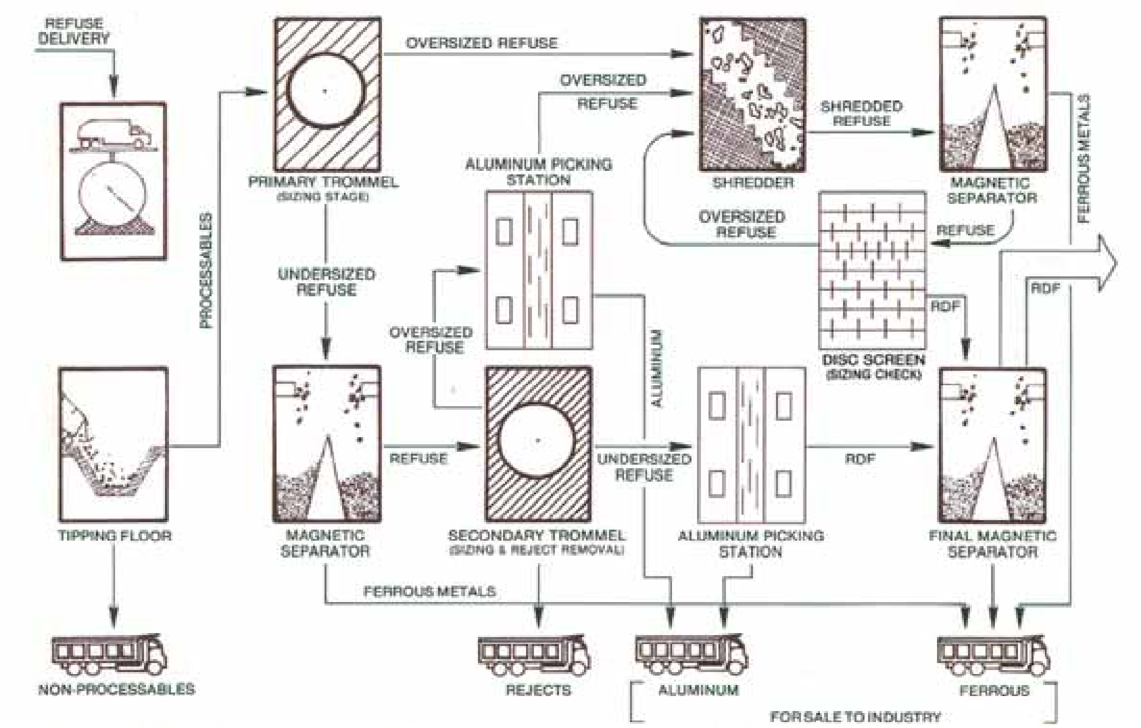
Because mass burn is a proven technology with long histories of operation at similar capacities to the requirements of the DCDPW in the US and internationally, the risks associated with it are relatively low when compared to the other technologies. There are several vendors who would be interested in participating in a mass burn project who are experienced with designing facilities that meet regulatory criteria. In addition, financing is expected to be easier to obtain for a proven technology than emerging technologies. To mitigate operational risk, many mass burn facilities utilize multiple units which creates operational redundancy.

One risk associated with developing a mass burn facility for the District is the market risk. There are several plants in Maryland and Virginia with a combined processing capacity of approximately 4,000 tpd within 30 miles of the District, 8,400 tpd within 75 miles, and at least two new facilities in progress with a combined capacity of approximately 5,500 tpd. Further market studies should be completed to assess the market viability of a new facility in the region.

6.1.2. Combustion of RDF

Resource Derived Fuel (RDF) technologies include mechanical steps to extensively separate, sort and/or size waste materials to produce the waste feedstock (e.g., homogenous, densified, etc.) required for the subsequent combustion processing system. MSW is processed in a “front end” system to produce a more homogenous and easily burned fuel. RDF is shredded MSW with ferrous metals removed. Additional processing can be applied to the incoming waste stream to remove other non-combustible materials such as glass and aluminum. Additional screening and shredding stages can be placed in the processing line to further enhance the RDF. RDF is fed directly to a combustion system. Figure 6-2 illustrates a typical RDF process.

Figure 6-2: RDF Process



6.1.2.1. Technical Evaluation

Processing Capacity

RDF facilities are capable of providing the required processing capacities (reported up to 2,000 tpd).

Operational Experience

Similar to mass burn, RDF has a long history. There are currently 15 operating RDF facilities in the U.S.

Baltimore, MD

Energy Answers, specializing in processed RDF is developing a new 800 tpd facility. This project is still in the early planning stages. However, it is expected to generate up to 120 MW of power and cost approximately $1 billion.

Operational Requirements

Combustion of RDF accepts mixed MSW, with pre-processing to prepare the combustible portion (the RDF). Pre-processing systems are operationally complicated and can be labor and O&M intensive. Additionally, the cost of pre-processing may not be offset by the sales of recovered materials (recyclables) should market availability or dependability not be consistent.

Residuals Reuse/Recycling

Residuals (byproducts) include RDF, nonprocessibles, and recyclables. Byproducts are process-dependent. Combustion of RDF may result in better quality of separated materials; thus increasing recyclables.

Energy Recovery

Combustion of RDF is similar to mass burn except that due to increased homogeneity of the fuel, the combustion system and the boiler are of simpler design, somewhat mimicking fossil fuel combustion boiler system. Environmental performance of the combustion system is also considered somewhat superior to mass burn (however the overall environmental benefit of mass burn as compared to RDF is subject to debate). The energy efficiency is higher than mass burn system; however, pre-processing energy use can erode this advantage on an overall basis.

Compatibility with Existing Processes and Behavioral Considerations

Combustion of RDF is feasible, but will require additional facilities to accommodate the up-front waste processing required when compared to a mass burn facility. Significant behavioral changes of the customer at the point of collection are not required to successfully implement this option. However, improving the recycling rate may improve the efficiency of the RDF combustion because it increases the percentage of non-recyclables (with a higher caloric value for combustion) in the feed stock and reduces the cost of pre-processing. The public outreach and education effort is expected to focus on gaining acceptance for the improvements, identifying environmental and cost benefits, allaying environmental fears, and a recycling campaign.

6.1.2.2. Regulatory Requirements

An RDF combustion facility will be subject to the same permitting requirements as a mass burn facility. However, combustion of RDF may result in lower air emissions than a mass burn facility.

6.1.2.3. Financial

Capital and Operating Cost

Physical separation, at least for RDF, is labor intensive and requires intensive O&M programs. A project's economic stability is dependent on the ability to produce recyclable materials of sufficient quality for available markets. Market availability and stability is also an issue that can have negative financial impacts. While the pre-processing system may be capable of providing the desired waste feedstock for a given system, substantial risk is associated with material recycling as failure of this aspect results in additional processing or disposal costs. Reported order of magnitude capital costs for RDF physical processing may range from $200,000 to $250,000 per ton of installed capacity with per ton O&M costs ranging from $40 to $80 per ton processed.

Risk

The risks associated with a RDF facility are relatively low because it is a proven technology and are similar to those identified for a mass burn facility in Section 6.1.1.3. Further market studies should be completed to determine whether another solid waste combustion facility is a viable option in the region.

6.2. Conversion Technologies

Conversion technologies thermally convert waste feedstock into potentially usable byproducts, typically gas, solids and/or liquids in the absence of or with minimal oxygen. Thermal conversion technologies include pyrolysis, gasification, and plasma arc. Plasma arc technologies are not further evaluated in this study because they are energy consumptive processes and are expensive to operate. The process' thermal efficiency (e.g., potential for net energy production) is reportedly attractive in continuous feed systems (data on net electric generation was not discovered to support an evaluation of this capability); however project economics are largely dependent on the systems revenues to offset operational costs. In many cases, energy recovery has not been implemented due to unfavorable economics. As most facilities of this type have been implemented on limited and small scale, the capability for net-electric generation on a commercial basis is not well understood.

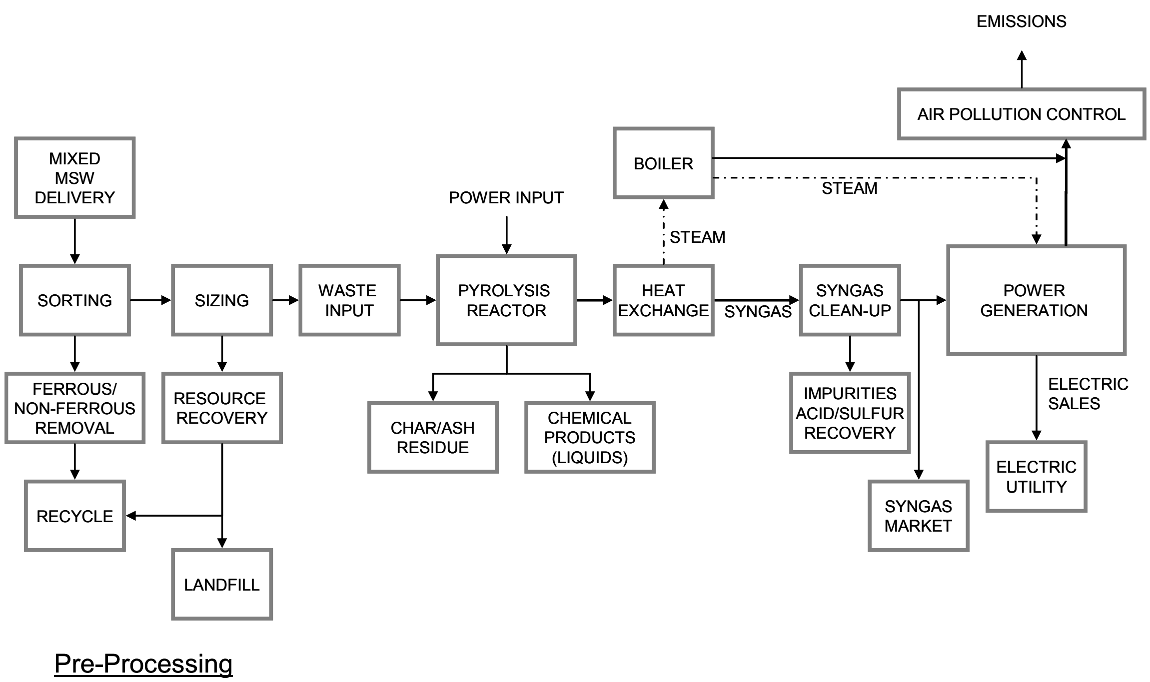
Conversion technologies generally require upfront waste feedstock preparation to separate and remove non-convertible fractions, including metals, glass, and other inorganic materials. Marketability and market dependability are major concerns when considering mixed MSW pre-processing, as failures of the marketability (related to material quality) and market dependability (related to significant fluctuations in demand and prices) could require additional processing and/or disposal costs, negatively impacting system tipping fees.

Pyrolysis and Gasification have been most successfully used to process organic waste streams to produce gases and liquids that, depending on the feedstock, have significant reuse potential. For example, waste (other than MSW) feedstock with highly homogenous organic content, like tires, which are generally unstable at elevated temperatures, have been successfully demonstrated to produce usable and marketable syngas (synthetic gas comprised principally of hydrogen, carbon monoxide, and carbon dioxide). Thermal conversion processes generally require feedstock that meet narrow specifications for organic content, moisture, size, and uniformity.

6.2.1. Pyrolysis

Pyrolysis is an endothermic process that requires a source of heat to initiate the thermal reactions. Pyrolysis systems typically use drums, kiln structures, or tubes which are externally heated in a closed system (in the absence of oxygen). This process is similar to that of the generation of coke from coal or charcoal from wood. It generates a gas, char, and inorganic residue. Pyrolysis systems operate at a range of temperatures (750°F to 1,650°F), depending on the feedstock and the desired byproducts. At higher temperatures syngas is produced and is potentially reusable as a combustion fuel or as a heat source for the pyrolytic process. At lower temperatures, liquids or oils (typically light hydrocarbons) are more readily produced. Figure 6-3 illustrates the typical process for pyrolysis treatment systems.

Figure 6-3: Pyrolysis Treatment



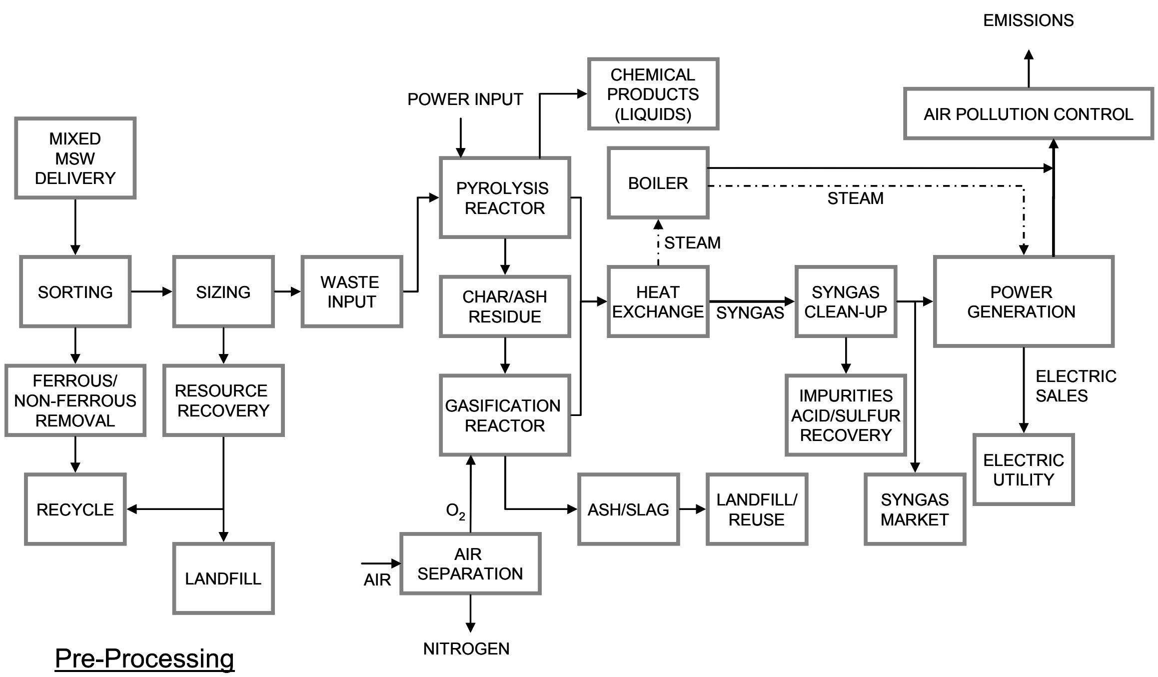
6.2.2. Gasification

Pyrolysis can be supplemented by gasification to further process and recover energy from the pyrolysis residues. Gasification includes the partial oxygenation of carbon-based feedstocks to generate syngas. The gasification process has been used for industrial purposes for over 100 years. Gasification is similar to pyrolysis, except that small amounts of oxygen, air, or steam are added to promote gasification, forming carbon monoxide, hydrogen, and methane. Gasifier systems are horizontally or vertically oriented and of the fixed bed, fluidized bed, or entrained air reactor design.

6.2.3. Pyrolysis/Gasification

Pyrolysis/gasification includes pyrolysis as the initial step with the char or solid residue discharged to a gasification reactor. The liquid residue from the gasification process is typically discharged to a water bath and quenched to form a glassy, slag material. The off-gas can be used as a heat source to be processed through a boiler for steam generation and electricity production or as a fuel or syngas. If sulphur is present in the off-gas, it can be recovered as well; however, the potential marketability of recovered sulphur is not certain. The Sulphur Institute reports that U.S. sulphur production, coming mostly from the petroleum industry is increasingly surpassing market demands. Consistent with worldwide markets, this trend is expected to continue as clean air regulations require greater reductions in sulphur emissions. Figure 6-4 illustrates the typical process for pyrolysis/gasification treatment systems.

Figure 6-4: Pyrolysis/Gasification Treatment



6.2.4. Technical Evaluation

Processing Capacity

Based on available information, there are no known commercial applications demonstrating the ability to provide the throughput capacity of 650 tpd established for this study without employing numerous units. Thermoselect reports that its pyrolysis/gasification unit in Karlsruhe, Germany was capable of processing over 650 tpd, however this facility was closed in 2004. The next largest facility processes approximately 555 tpd in Kurashiki, Japan. [8]

Operational Experience

Literature indicates limited applications of pyrolysis or pyrolysis/gasification systems to MSW. One such process developed by Thermoselect, uses processed (size reduced to 20 inches or smaller) MSW, which is pushed in a degassing channel by a press (in "waste plugs") into a high temperature gasifier. Pyrolysis occurs within the degassing channel starting at 570^{o}F and increasing to over 1,100^{o}F. The pyrolysis step creates syngas (CO and H2). Char (the solid residue from pyrolysis) is discharged to the high temperature (2,200^{o}F) gasification section creating more syngas, which is then cooled and cleaned by wet scrubbing.

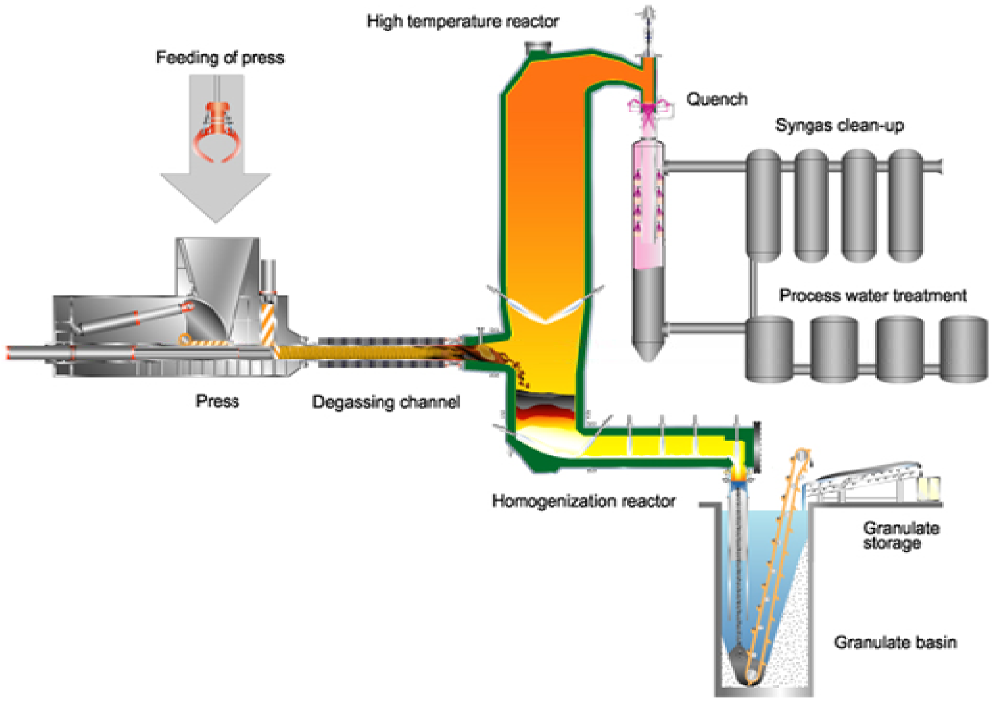
With respect to MSW, gasification was attempted in the early 1980s; however, these early attempts failed due to operational difficulties associated with the heterogeneous nature of MSW.

Taunton, MA

The City of Tauton, MA needed to replace a landfill and selected Interstate Waste Technologies (IWT) to head up construction and operation of a solid waste treatment facility to convert MSW into ethanol. This treatment facility system is developed by Thermoselect and uses pyrolysis/gasification technology to consume MSW and produce a valuable energy resource. The facility is proposed to sit on a 36-acre and process 1,770 tons of MSW per day, producing 34 million gallons of ethanol per year. The expected cost of this facility is approximately $650 million.[9] This project is still in the planning stages and a start-up date is not readily available. The Thermoselect process to be utilized at the Taunton facility is depicted in Figure 6-5.

[8] Interstate Waste Technologies. 2008. An Overview of the History and Capabilities of the Thermoselect Technology. http://www.swananys.org/pdf/Thermoselect.pdf
[9] Taunton Daily Gazette. Ted's Take: Taunton dependent on ethanol approval. Ted Gay. Apr 02, 2010

Figure 6-5: Taunton Pyrolysis/Gasification Process



Lake County, IN

Lake County, Indiana has also decided to implement a 2,000 tpd waste-to-energy facility where MSW is converted to ethanol. The technology chosen by Lake County was developed by INESO Bio and unlike the Thermoselect technology, it has a biological component. First the waste is dried using heat created by the process. Next, similar to the Thermoselect process, organic material is gasified with oxygen at high temperatures under controlled conditions to produce synthesis gas. The valuable gas is recovered, cleaned, and enters a fermenter. The cool, clean syngas is introduced to patented bacteria, which selectively convert it to ethanol. According to the INESO Bio literature, the bacteria biocatalyst is far more effective than all known conventional catalysis for syngas conversions to fuels. After the bacteria have converted the carbon monoxide and hydrogen to ethanol, the water is removed and returned to the fermenter. Finally the ethanol is further processed to produced anhydrous ethanol (>99.7 percent) which can be used in many applications. Construction is expected to begin late summer 2011.

The plant in Lake County is planned to sit on 240 acres of land. It is expected to produce 160 million gallons of ethanol per year when running a full capacity, or about 90 gallons per ton of waste. The amount of waste going to landfills is expected to be reduced by 80 percent to 90 percent, with the diverted material being recycled. Literature indicates that the estimated cost for construction is about $256 million.

Operational Requirements

For MSW applications, the initial challenge is the heterogeneity of MSW and associated pre-processing requirements. For energy efficiency purposes, it is important to not only render the MSW feedstock to a homogenous organic feedstock, it is also important to remove inorganic materials (e.g., glass and grit) as the inorganic fraction consumes energy in the process. Moreover, the need to remove the char or solid residuals after cooling may interrupt the pyrolytic process and negatively impact potential operational efficiencies.

MSW gasification applications require significant pre-processing to remove inorganic materials and often include shredding, screening, air classifiers, drying and ferrous and non-ferrous metals removal. It is reported that these systems require 10-20 percent moisture in the feedstock; a requirement that may necessitate drying.

Residuals Reuse/Recycling

The solid gasification residue, slag, is formed at a high temperature (3,600^{o}F) with help of natural gas supplementary firing with oxygen. All waste products (slag and the scrubbing residuals) are potentially reusable materials, depending on the availability of markets. Information regarding markets and potential revenues from recovered resources is not available at this time.

Energy Recovery

Thermal conversion technologies produce significant quantities of heat and are largely similar in that endothermic or exothermic chemical reactions take place in highly controlled, oxygen deficient processes. Thermal conversion technologies are reported to be capable of generating from 350 to over 850 net kWh/ton, depending on the systems and ancillary equipment used.[10]

Compatibility with Existing Processes and Behavioral Considerations

Thermal conversion processes may be of limited compatibility with existing facilities and operations, primarily due to the mixed MSW pre-processing requirements. A separate thermal conversion facility may not feasible at the size required at this time. In addition, pre-processing is required to process the District's mixed MSW waste stream, which may be implemented adjacent to the existing Benning Road Transfer Station or at a separate location.

Behavioral changes of the customer at the point of collection will help to successfully implement this option. Improving the recycling rate will improve the efficiency of the conversion process by reducing the amount of inorganic material (glass, metal, and

[10] Mechanical-Biological-Treatment: A Guide for Decision Makers. Juniper Consultancy Services Ltd, March 2005, Version 1.1.

plastics) in the feedstock. The public outreach and education effort is expected to focus on gaining acceptance for the improvements, identifying environmental and cost benefits, allaying environmental fears, and a recycling campaign.

6.2.5. Regulatory Requirements

Permitting

In addition to permitting requirements similar to mass burn and RDF facilities, permits would be required for the pre-processing facilities. The permitting process would include siting, design, and public review. The pre-processing facility would also need to be housed in a negative pressure enclosure to control odors and dust.

Emissions

Regulatory considerations for pyrolysis and gasification facilities that process MSW address airborne emissions, odor, noise, and dust emissions, as well as residuals management. While there are no known MSW thermal conversion facilities permitted in the U.S., the Virginia Department of Environmental Quality reports that the Plasma Energy Pyrolysis System hazardous waste processing facility in Lorton, Virginia operates within its specified permit limits.[11] The nature of air emissions from thermal conversion processes is assumed to be similar to those of combustion systems and may have improved emissions depending on the level of pre-processing and operating temperatures. At this level of analysis, it is reasonable to assume that thermal conversion processes are technically capable of operating within U.S. regulatory standards. A thermal conversion facility would likely be required to operate at regulatory standards required for combustion facilities. The improved marketability of the solids residue may reduce the potential environmental impact.

6.2.6. Financial

Capital and Operating Cost

Attempts to process MSW on pyrolysis/gasification technologies have been limited and on a small scale. The lack of proven operations negatively affects the ability to attract competitive public financing rates and increases the risk of additional disposal cost for pre-processed materials. Reported order of magnitude capital and O&M costs may range from $50,000 to $500,000 per ton of installed capacity and $20 to $150 per ton processed, respectively.[12] These estimated costs do not represent an estimate of a market tipping fee, as they do not include project costs such as the cost of capital, debt coverage

[11] City of Honolulu. Review of Plasma Arc Gasification and Vitrification Technology for Waste Disposal. January 2003. R. W. Beck, Inc.
[12] City of Los Angeles. Summary Report: Evaluation of Alternative Solid Waste Processing Technologies. September 2005. URS Corporation.

reserves, and other system costs not specifically related to the operation of the treatment technology.

Risk

Because not many plants operate at a commercial scale, the risks associated with using pyrolysis/gasification technologies for the treatment of waste are considered to be higher than for more established technologies. The lack of proven operations can negatively affect the ability to attract competitive rates via public financing and increases the financial risk to the owner. Further, substantial risk is associated with the ability to provide materials that meet market quality specifications, as well as market availability and stability. Should pre-processed materials not be marketable, additional processing or disposal costs will incur.

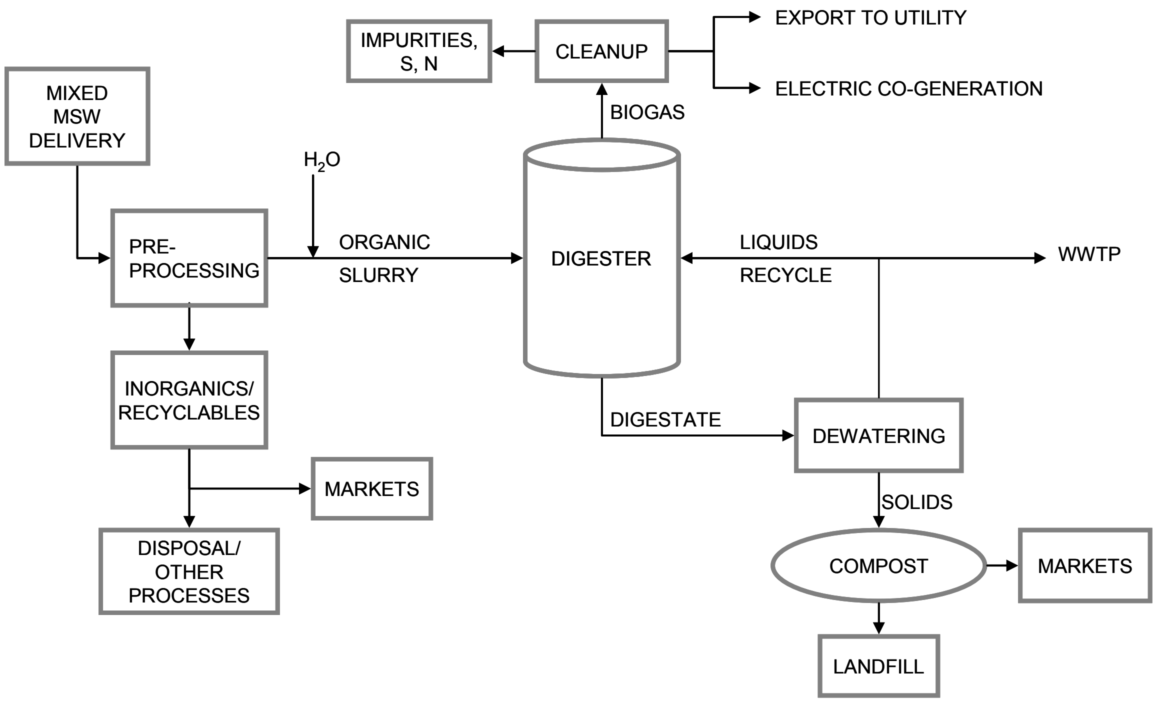
6.3. Biological/Chemical Treatment

Biological/chemical waste treatment technologies are generally low temperature (several hundred degrees Fahrenheit or less) operations that require a biodegradable feedstock. Many can accept high moisture content materials. For the purposes of this study, biological/chemical processes were limited to anaerobic digestion and mixed waste composting. Byproducts of biological/chemical technologies typically include compost, chemicals, and gases.

6.3.1. Anaerobic Digestion

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 of MSW is used commercially in Canada and Europe, mostly using source separated organic wastes. For this process to be efficient with mixed MSW, pre-processing is required to remove non-biodegradable materials. The feedstock is often shredded and pulped to improve removal of inorganic materials and grit. The resulting organic feedstock (or slurry) is processed in one or more digestion units. Figure 6-6 illustrates a typical process for anaerobic digestion system.

Figure 6-6: Anaerobic Digestion



There are several anaerobic digestion technologies currently on the market. An abbreviated description of different anaerobic digestion system designs is presented below.

Wet vs. Dry Systems

The difference between a “dry” and “wet” anaerobic digestion system is the solids content of the feed to the digester. In a wet system, the feed to the digester is an organic rich suspension with approximatley 5-6 percent solids. In order to produce the suspension, water must be added to the organic waste as part of the processing step. The design of the digester employed in wet systems is very similiar to digesters used for the stabilization of solids in municipal WWTPs. Given the nature of solid waste, it is typically necessary to remove heavy fractions such as grit and sediment prior to the digester, since this material can cause rapid wear of mechanical systems and sedimentation in the digester. Light fractions and flotables may also have to be removed to prevent the formation of a scum layer or film on the liquid surface inside the digester. Another frequent characteristic of wet systems is foaming, which can be controlled via chemical addition and consistent organic loading to the reactor.

Dry systems operate at a solids content of 20-40 percent solids, which reduces the amount of upstream processing required. The waste is typically screened to remove large objects greater than 40 or 50 millimeter (mm). The dry organic waste is then blended with a high recycle flow of digestate, in order to inocculate the incoming organic waste with anaerobic bacteria. Since the solids content in the reactors is high, there are few problems with heavy or light fractions separating from the bulk waste stream. Dry systems can handle non-digestible or abrasive material such as rock, glass, plastics and other inerts found in solid waste – this material simply passes through the reactor unaltered. The primary challenges associated with dry systems are designing the reactor and conveyance systems to handle abrasive and high viscosity material. Robust feed pumps and reactor design are required. While dewatering of the digestate is frequently required, dry systems require considerably less water compared to wet systems.

Single-Stage vs. Multi-Stage Systems

In a single-stage system, all biochemical operations (hydrolysis, acidogenenis, acetogenesis, and fermentation) occur in a single reactor. Single-stage systems are less costly to build and simpler to operate than multi-stage systems, but must operate at lower loading rates. Multi-stage systems use two (2) or more reactors to separate fermentation from the other biochemical processes. This allows for higher processing rates and biogas yields. The additional biogas generated from multi-stage systems rarely justifies the added capital and operating expense of multiple reactors. As such, single-stage anaerobic digestion systems are most commonly employed.

Operating Temperature (Mesophilic vs. Thermophilic)

Because anaerobic bacteria grow slowly under ambient condition, anaerobic digestion technologies operate at warmer temperatures to increase reaction rates. Anaerobic digestion processes that operate at a temperature typically between 86-95°C (possibly up to 104°C depending on design) are known as mesophilic. The advantage of operating at mesophilic conditions is that microbial populations are more diverse and stable, making them more resiliant to changing influent conditions. By comparison, a thermophilic anaerobic digestion process operates within a range of 120-150°C. Operating at this temperature range allows for higher reaction rates and biogas yields. Thermophilic systems may be less stable than mesophilic reactors, especially in wet anaerobic digestion system designs, which are more prone to foaming at this temperature.

6.3.1.1. Technical Evaluation

Processing Capacity

Anaerobic technologies have been used in a number of waste applications, including animal wastes, agricultural wastes, food wastes, and in limited applications mixed MSW. Commercial applications are exclusive of the U.S., with most reported solid waste applications in Canada and Europe processing over 700 tpd.

Operational Experience

Anaerobic digestion systems are available from a number of vendors whose technologies have been developed over recent decades. Table 6-1 summarizes, by technology vendor, the types of systems available, operating parameters, throughput capacities of existing systems, and general descriptions. Of the technologies listed below, all but Entec is considered potentially feasible as Entec has limited experience processing mixed solid waste. The other technology vendors report experience processing mixed solid waste.

Table 6-1:
Anaerobic Digestion Vendors

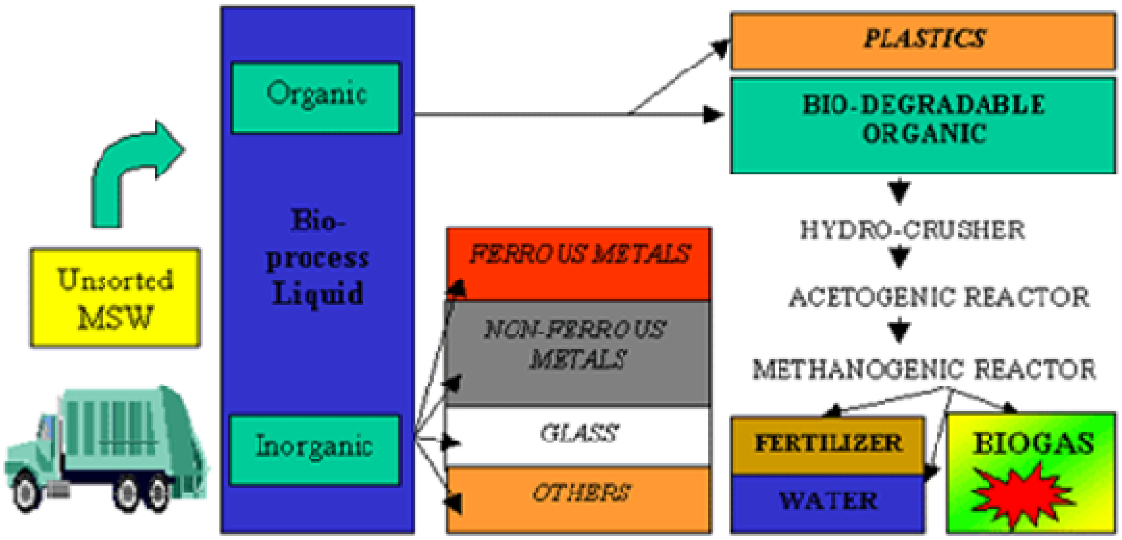
Technology Vendor / Type	No. of Projects and Experience	Stages	Total Solids Low <20% High >20%	Mesophilic/ Thermophilic (95˚C)	(130˚C)	Throughput Capacity (tons/year)	Description	Facility Location
Wassa (wet)	10+, including the OMRIN and VAGRON facilities in the Netherlands	Single	Low	X	X	3,000 -230,000	General term for a wet AD process used for solid waste, because it was first applied in Wassa, Finland in 1989. Complete mix digester with pre-chamber and inoculation loop. Pulping and fractionization of incoming organic fraction is critical.	Many locations in Europe. Largest system is in Groningen, Netherlands
bta (wet)	36 facilities - various scopes of work and equipment supply. Many solid waste applications	Single or Multiple	Low	X	X	1,000 -150,000	The bta process is consistent with the Wassa process. bta supplies specialized equipment including waste pulper, grit removal, and digester mixing (gas lances) systems. Pulper may act as hydrolysis reactor, especially in smaller systems.	Many locations including Germany, Austria, Denmark, Belgium, Korea, Canada, and Italy
Entec (wet)	5 facilities - various waste processing applications, but mostly non-solid waste	Single	Low	X		40,000 – 150,000	Similar to the Wassa process, except digester mixing is provided using the BIMA-System (Biogas Induced Mixing Arrangement), which requires less mixing than other systems.	Primarily Germany. One possible municipal waste application in India (operational 2002-2004)
Valorga (dry)	21 facilities, organic waste, separation of recalcitrant fraction required	Single	High	X	X	10,000 - 270,000	Vertical reactor, modified plug flow, mixing accomplished using compressed biogas. Feed stocks >80% moisture content do not perform well.	Facilities in Europe and Asia, including France, Spain, Portugal, Italy, Germany, Belgium, Switzerland, and Netherlands

Technology Vendor / Type	No. of Projects and Experience	Stages	Total Solids Low <20% High >20%	Mesophilic/ Thermophilic (95˚C)	(130˚C)	Throughput Capacity (tons/year)	Description	Facility Location
Kompogas (dry)	50 digesters worldwide, mostly smaller size.	Single	High		X	1,000 -110,000	Horizontal plug flow reactor, mixed with internal rotors to degas and homogenize the waste, prefab in standard sizes. Moisture content must be maintained at 72-77%, process water and/or digestate must be mixed with incoming waste.	Many locations in Europe and Japan
Arrow Ecology	2 facilities, mixed municipal solid waste and source separated biowaste	Multiple	Low		X	100,000	Vertical reactor, multi-stage. Claimed production of high quality compost.	Israel (demonstration facility) and Australia
Dranco (dry)	20 facilities, mixed municipal solid waste and source separated biowaste	Single	High		X	3,000 -120,000	Vertical plug flow reactor, top-down flow, no mixing, HRT of 15-30 days mixed with the influent at a ratio of 6:1. Source separated household and industrial waste preferred. Mix waste can be treated.	Belgium, Japan, Spain, Germany, Korea, Italy, Switzerland, Austria, France. Two large units in Brecht, Belgium

Hatera Israel Facility

The Arrow Ecology company based in Israel has developed a MSW system based on hydromechnical sorting and anaerobic digestion. One of the advantages of this system is there is no need for pretreatment. It is based on the principle that different materials either float or sink in water. It can sort a mixed waste input into different recycle fractions for resale and recycling, and produce biogas as depicted in Figure 6-7.

Figure 6-7: Arrow Ecology System



The biogas is typically 70 to 80 percent methane and can be used to meet the power requirement of the plant. Currently there is a small plant near Tel Aviv, Israel and a commercial scale 250 tpd plant in Sydney, Australia completed in 2008. In addition to the facilities in Australia and Israel, there is a plant being developed in Scotland to be designed for 275 tpd and ArrowEcology is being considered for a project in Southern California.

San Jose, CA

Another example of anaerobic digestion used in MSW can be found in San Jose California, where a company called ZeroWaste has utilizes "dry" fermentation in their process. The dry fermentation method differs in that pre-processing is not required, digesters are biologically self-heated, plants require a smaller footprint than traditional systems, and the digestate emerging at the end of the process contains the lowest moisture content of any available system. Once completed, the facility in San Jose will process over 740 tpd of organic waste. The facility is expected to start up in July, 2012.

Operational Requirements

All commercial anaerobic digestion technologies require some amount of processing and conditioning of the organic waste. This may include simple screening to remove large particles, blending and washing to create a consistent organic suspension, separation of heavy and light fractions, and/or particule size reduction to make the waste more amenable to digestion. Generally, metals and plastics need to be removed from the processing waste stream.

Residuals Reuse/Recycling

One key advantage of anaerobic disgestion is the production of a methane-rich biogas, which can be used to generate renewable electricity or treated to "pipeline quality" and solids to natural gas distributors. Biogas production rates varies depending on the organic content and digestibility of the waste, but are typically in the range of 100 to 120 normal cubic meter (Nm^3) per ton of waste processed.

The other byproducts of anaerobic disgestion are partially stabilized organic solids ("digestate"), which can be further stabilized to produce compost, can be incinerated, or simply landfilled. The compost byproduct is produced from the dewatered solids left from the anaerobic digestion process, which typically requires aerobic treatment for several weeks. Dewatering effluent can be recycled to the digester or discharged to a wastewater treatment plant.

Compost products may be marketable if the material can meet market quality standards. If these materials are not marketable, additional costs for disposal will incur.

Energy Recovery

The biogas produced by anaerobic disgestion consists mainly of methane (typically around 55 to 60 percent) and carbon dioxide. The biogas can be utilized as a fuel to generate electric and heat power. Biogas leaving the digester has a high mositure content and may have trace contaminants, such as hydrosulfide and siloxane. Mositure and contaminants may have to be removed before the biogas can be used. Biogas can be used to generate electricity using engines or microturbines. Biogas can also be treated to increase the methane content to concentrations over 90 percent, potentially meeting natural gas quality standards. Such "pipeline quality" gas can be metered into the natural gas distribution system. Anaerobic technologies are reported to be capable of generating approximately 100 net kWh/ton.[13]

Compatibility with Existing Processes and Behavioral Considerations

Anaerobic digestion may be of limited compatibility with existing facilities and operations, primarily due to the mixed MSW pre-processing requirements. A separate thermal conversion facility may not feasible at the size required at this time. In addition, pre-processing is required to process the District's mixed MSW waste stream, which may be implemented adjacent to the existing Benning Road Transfer Station or at a separate location.

Behavioral changes of the customer at the point of collection will help to successfully implement this option. Improving the recycling rate will improve the efficiency of the

[13] Mechanical-Biological-Treatment: A Guide for Decision Makers. Juniper Consultancy Services Ltd, March 2005, Version 1.1.

anaerobic digestion process by reducing the amount of metals and plastics in the feedstock. The public outreach and education effort is expected to focus on gaining acceptance for the improvements, identifying environmental and cost benefits, allaying environmental fears, and a recycling campaign.

6.3.1.2. Regulatory Requirements

Permitting

Permitting requirements typically provide for the operations to be enclosed in a negative pressure building to control odors and dust, much like MRFs, MSW transfer stations and other waste handling operations. The permitting process would include siting, design, and public review, which is more challenging to obtain for an unproven system. Additional permitting requirements apply to energy recovery applications (e.g., methane gas combustion) and chemical storage and handling.

Emissions

Emissions from anaerobic digestions are inherently lower than those of MSW combustion or thermal conversion since biogas production and combustion is cleaner (conversion temperature is well below 200°F, and biogas combustion is similar to combusting natural gas). As a result, biological conversion of MSW is not expected to have significant air emissions concerns.

6.3.1.3. Financial

Capital and Operating Cost

Reported order of magnitude implementation costs in terms of capital and O&M costs are from $50,000 to $250,000 per ton of installed capacity and $50 to $150 per ton processed, respectively.[14] These estimated costs do not represent an estimate of a market tipping fee, as they do not include project costs such as the cost of capital, debt coverage reserves, and other system costs not specifically related to the operation of the treatment technology.

Risk

Investing in anaerobic digestion technologies can be risky because suitability of unsorted MSW can vary. Aggressive pre-processing of waste may inadvertently lead to cross contamination of the separated waste, which could raise quality and marketability concerns with the residuals. Should pre-processed materials not be marketable (e.g., do not consistently meet market quality standards and/or markets are not stable or available), additional processing or disposal costs will incur. The lack of proven MSW operations

[14] Mechanical-Biological-Treatment: A Guide for Decision Makers. Juniper Consultancy Services Ltd, March 2005, Version 1.1.

with similar capacities to the Districts may negatively affects the ability to attract competitive rates via public financing.

6.3.2. Mixed Waste Composting

Composting is the decomposition of waste using microscopic organism to breakdown organic matter. Both aerobic and anaerobic bacteria are capable of digesting organic matter. The first requires oxygen or air to function and later functions without oxygen. Each produce different by-products: anaerobic composting produces combustible biogas such as carbon dioxide and methane, where aerobic composting does not. Composting is most effective utilizing yard trimmings, agricultural wastes, and sewage sludge. There are a number of challenges unique to MSW. Five major factors influence MSW composting effectiveness: 1) moisture, 2) oxygen, or air, 3) temperature, 4) chemical balance of carbon and nitrogen and, 5) particle size. The first three factors can be automated. The last two are determined by the incoming waste and can be controlled by: collection, contamination separation, sizing and mixing.

6.3.2.1. Technical Evaluation

Processing Capacity

Aerobic and anaerobic composting can be easily scaled to meet waste stream requirements. In 2009, there were 12 functioning mixed waste composting facilities in the U.S. with capacities ranging from 15 to 350 tpd.

Operational Experience

There are several hundred mixed waste composting plants in Europe, utilizing both aerobic and anaerobic processes. The track record of large plants, designed to handle 200 tpd or more is limited. Such large scale plants were built in Portland, OR, Baltimore, MD, Miami, FL, Cobb County, GA, Sevier County, TN, Sumter County, FL, and Pembroke Pines, FL, all of which were unsuccessful for technical reasons such as odor control issues or funding difficulties. This may be due to lower than expected quality of the compost products, which reduced revenues and the projects overall financial viability.

The current trend in composting is to segregate bio-wastes in order to produce compost and/ or biogas. This has lead to thousands of successful small scale (less than 10 tpd) facilities, primarily composting yard waste and sewage sludge.

Gore Membrane System

There are generally two choices with composting. Open composting, which has odor and environment control issues, or indoor facilities which can incur large capital and operations costs. A compromise between open composting and complex, closed facilities, while meeting permitting requirements, is to use membrane textiles. It is reported that membrane textiles are scalable to nearly any size, starting with plants that operate around 20 tpd.

The addition of the membrane cover to open composting allows moisture, temperature, and aeration to be controlled in an outdoor setting. This saves the owner capital and operation costs. One such membrane technology is produced by GORE®. At the Marburg, Germany composting plant, the addition of membrane textile technology allowed for greater facility throughput by decreasing decomposition time from 24 weeks to 8 weeks.[15]

Operational Requirements

Segregating bio-wastes for higher quality compost adds complexity to composting facilities.

Residuals Reuse/Recycling

Mixed waste composting leads to several residual and recyclable products. Ferrous metals, nonferrous metals, and various grades of plastic separated from the waste stream in front end processing can be recycled or landfilled. Glass may be recovered as well; however it can also be pulverized and become part of the compost product. The compost itself has low economic value and competes with peat moss as a soil conditioner.

Energy Recovery

If an anaerobic process is used to compost the mixed waste, methane biogas is created and can be used to generate renewable electricity. Mixed waste composting facilities are reported to be capable of generating between 150 and 250 net kWh/ton.[16]

Compatibility with Existing Processes and Behavioral Considerations

Mixed waste composting may be compatible existing processes. However, further studies are required to identify whether the Benning Road Transfer Station will be adequate.

Behavioral changes of the customer at the point of collection will help to successfully implement this option. Improving the recycling rate will improve the efficiency of the composting process by reducing the amount of inorganic material (glass, metal, and plastics) in the feedstock. In addition, creating a source separated organic waste stream would significantly improve the efficiency and quality of a composting program, but the required behavioral changes by customers may not be feasible. The public outreach and education effort is expected to focus on gaining acceptance for the improvements, identifying environmental and cost benefits, allaying environmental fears, and a recycling campaign.

[15] http://www.gore.com/MungoBlobs/912/762/swt_food_yard.pdf
[16] Mechanical-Biological-Treatment: A Guide for Decision Makers. Juniper Consultancy Services Ltd, March 2005, Version 1.1.

6.3.2.2. Regulatory Requirements

Permitting

Permitting requirements typically provide for operations to be enclosed to control odor and dust, similar to MSW waste transfer stations. Other requirements include facility design, operating plans, description of incoming materials, monitoring plans, potential environmental releases, landfills to be used, and potential markets for the compost.

Emissions

Composting could have significant air emissions, which are controlled by composting either in-vessel or inside a negative pressure-controlled building.

6.3.2.3. Financial

Capital and Operating Cost

Reported order of magnitude implementation costs in terms of capital and O&M costs on a per ton of installed capacity are similar to those for anaerobic digestion and range from $50,000 - $250,000 and $50 – $150, respectively[17]. These estimated costs do not represent an estimate of a market tipping fee, as they do not include project costs such as the cost of capital, debt coverage reserves, and other system costs not specifically related to the operation of the treatment technology.

Risk

Because there are no large scale operations, with similar capacities to DCDPW's and the failure of some facilities, composting has a higher risk rating that proven technologies. However, if the resulting compost is adequate for regional markets, the market risk for it may be less than some innovative technologies.

6.4. Summary of Findings

Based on the evaluations conducted in this study, the key findings for consideration are presented in Table 6-2.

[17] Mechanical-Biological-Treatment: A Guide for Decision Makers. Juniper Consultancy Services Ltd, March 2005, Version 1.1.

Table 6-2:
Key Findings for Consideration

	Thermal Combustion	Thermal Conversion	Biological Treatment
Technical	▪ Proven experience on a commercial operating basis in U.S. and internationally at required capacities. ▪ Mass burn requires minimal pre-processing. ▪ RDF Combustion requires pre-processing. ▪ Net electric generation typically ranges from 500 to 600 kWh/ton. ▪ Little or no behavioral change required of customers.	▪ An emerging MSW treatment technology. ▪ No known facilities processing required capacity without employing numerous units. ▪ Pre-processing required. ▪ Net electric generation ranges reported from 350 to over 850 net kWh/ton. ▪ Increasing the diversion rates of recyclables (or nonprocessibles) in the waste stream may make the process more efficient.	▪ Limited experience processing mixed MSW. ▪ Reported to be available at or above processing capacity required. ▪ Pre-processing required. ▪ Anaerobic technologies are reported to be capable of generating approximately 100 net kWh/ton. ▪ Mixed waste composting facilities are reported to be capable of generating between 150 and 250 net kWh/ton. ▪ Increasing the diversion levels of recyclables in the waste stream may make the process more efficient.
Regulatory	▪ Public review process can be challenging. ▪ Modern facilities have successfully demonstrated ability to comply with various regulations.	▪ No permitted commercial MSW facilities in U.S. ▪ Reasonable to assume that it is technically capable of operating within U.S. regulatory standards.	▪ Permitting requirements typically provide for the operations to be enclosed in a negative pressure building to control odors and dust.
Financial	▪ Estimated order of magnitude capital costs is approximately $200,000 to $250,000 per ton of installed capacity (or per design ton) ▪ Estimated order of magnitude O&M costs is approximately $40-$80 per ton processed, respectively. ▪ Relatively low risk.	▪ Estimated order of magnitude capital costs is approximately $50,000 to $500,000 per ton of installed capacity (or per design ton) ▪ Estimated order of magnitude O&M costs is approximately $20-$150 per ton processed respectively. ▪ Relatively high risk.	▪ Estimated order of magnitude capital costs is approximately $50,000 to $250,000 per ton of installed capacity (or per design ton). ▪ Estimated order of magnitude O&M costs is approximately $50-$150 per ton processed respectively. ▪ Relatively moderate to high risk.

7. Next Steps

The District is committed to promoting and implementing sustainable solutions throughout the government's processes and practices. The DCDPW may be able to identify opportunities to improve their solid waste management by implementing source reduction and/or renewable energy processes.

The DCDPW intends to meet with the other District departments like the Department of the Environment and Department of Planning to develop streamlined project objectives and goals. Subsequently, vendor interest, qualifications, operating capabilities, warranties, and guarantees are critical for a project's success. These issues can be addressed through the procurement process and the general structure of the contracts established for the project

The DCDPW expects to issue a Request for Expressions of Interest (RFEI) to identify market interest in implementing any of the discussed technologies. An RFEI is a solicitation issued broadly that presents the basic parameters of the improvements and requests interest from the vendor community. Basic parameters include the nature of waste to managed, system processes to be employed, capacities to be managed, acceptable financing arrangements, and the general responsibilities of the vendor and the owner. The RFEI requires the submittal of general information on the vendor and provides opportunity for vendors to make suggestions for the improvements. The RFEI is an important step as it not only gauges vendor interest, availability, and capabilities, but also allows for refinement of the procurement approach used in the subsequent procurement stages.

Following the evaluation of the RFEI, it the DCDPW will determine the benefit of issuing a Request for Qualifications (RFQ). The RFQ requests specific and detailed qualifications information from interested vendors, which may include vendors who did not respond to the initial RFEI. Qualifications information includes operating experience, financial information, insurance, liabilities, legal information, and ownership data.

Following the RFQ process, a Request for Proposals (RFP) may be issued. The RFP is a document that includes detailed facility information (preliminary design, site layouts, design and operating requirements and standards, etc.) to enable vendors to submit comprehensive offers for the project. The RFP process will provide the most meaningful cross-comparison of costs for the District as proposals will be based on project-specific criteria. The RFP should present a standard on which all vendors must submit a bid. Optional approaches may either be defined in the RFP or vendors may be given the option to propose alternative approaches.