generated from WTE), and may create other environmental impacts, such as water pollution.

WTE has proven to be a reliable method for waste processing and disposal. Modern plants are compatible with aggressive recycling programs and have an environmentally acceptable track record.

While new WTE procurements have declined in the United States, the market for this equipment has increased in Europe and in Eastern Asia, with European and Japanese systems suppliers actively marketing their systems, and consistently improving their performance. This technology is well tested and is used more than any other for large waste processing facilities in the United States and overseas. Table 3-2.[14] demonstrates the extent of use of WTE technology throughout the world.

Table 3-2. Use of Waste-to-Energy Facilities Worldwide

Location	Number of Facilities	Amount of MSW Managed by WTE as a % of Total MSW Generated
USA	87	8 to 15% based on MSW reported by EPA and *BioCycle*
Europe	400	varies from country to country
Japan	100	70 to 80%
Other nations (Taiwan, Singapore, China, etc.)	70	varies from country to country

In the State of Florida, there are 11 WTE facilities currently operating, nine mass-burn and two RDF. These facilities process about 18,000 TPD of MSW and generate 513 MW of electricity. Table 3-3 describes those plants.

Table 3-3. Waste-to-Energy Plants in Florida[15]

Facility	City	MSW Capacity	Start Date	Electrical Capacity
Bay County Resource Recovery Center	Panama City	500	1987	10 MW
Hillsborough County Resource Recovery Facility	Tampa	1200	1987	29 MW
Lake County Resource Recovery Facility	Okahumpka	528	1991	14.5 MW
Lee County Resource Recovery Facility	Fort Myers	1836	1994	57 MW
McKay Bay Refuse-to-Energy Facility	Tampa	1000	1985	22.5 MW
Miami-Dade County Resource Recovery Facility	Miami	2592	1979	77 MW
North County Resource Recovery Facility	West Palm Beach	1800	1989	62 MW
Pasco County Resource Recovery Facility	Spring Hill	1050	1991	30 MW
Pinellas County Resource Recovery Facility	St. Petersburg	3000	1983	77 MW
Wheelabrator North Broward, Inc.	Pompano Beach	2250	1991	68 MW
Wheelabrator South Broward, Inc.	Ft. Lauderdale	2250	1991	66 MW

[14] Energy Recovery Council (formerly Integrated Waste Management Services Association) website.

[15] IWSA 2007 Directory, Integrated Waste Services Association (now the Energy Recovery Council; www.energyrecoverycouncil.org).

discussed in Section 4.2. Other gasification technology providers are also mentioned, along with four anaerobic digestion vendors, one plasma arc firm, two pyrolysis providers and a thermal depolymerization firm. While this review is not systematic, it does provide a good summary of the firms and technologies that are most active in the field, and those that localities across the U.S have been most interested in using as they contemplate alternatives to landfilling MSW.

Table 5-1. Technologies/Vendors Mentioned in Recent Procurements

Vendor-designated Technology	Vendor	Total Times Cited
Mass-burn	Covanta Energy Corporation	9
Mass-burn	Wheelabrator Technologies Inc.	8
Gasification	Interstate Waste Technologies/Thermoselect (IWT)	6
Anaerobic Digestion	Valorga S.A.S. (Valorga)/Waste Recovery Systems	5
Anaerobic Digestion	Canada Composting Inc.	4
Anaerobic Digestion	Organic Waste Systems N.V.	4
Gasification	Ebara	4
Anaerobic Digestion	Arrow Ecology Ltd.	3
Anaerobic Digestion	Urbaser	3
Anaerobic Digestion	Waste Recovery Seattle, Inc. (WRSI)	3
Gasification	BRI Energy, LLC	3
Gasification	Primenergy	3
Gasification	Taylor Recycling Facility	3
Gasification	Whitten Group /Entech Renewable Energy System	3
Plasma Gasification	Global Energy Solutions	3
Pyrolysis	International Environmental Solutions	3
Pyrolysis	Pan American Resources	3
Thermal Depolymerization	Changing World Technologies	3

6.0 Environmental Characteristics of Waste Processing Technologies

6.1 Air Quality

6.1.1 Applicable Regulations

Solid waste incinerators, which EPA refers to as Municipal Waste Combustors, are regulated under the federal Clean Air Act, originally passed by Congress in 1963 and updated in 1967, 1970, 1977,1990 and 1995 and 1998. Numerous state and local governments have enacted similar legislation, either implementing federal programs or filling in locally important gaps in federal programs.

Section 111 of the federal Clean Air Act directs EPA to establish pollution control requirements for certain industrial activities which emit significant "criteria air pollutants." These requirements are known as new source performance standards (NSPS) and regulate pollutants. For thermal destruction of solid waste, the NSPS control particulate matter (PM), sulfur dioxide(SO_2), carbon monoxide (CO), nitrogen oxides (NO_x), hydrogen chloride (HCl), dioxins/furans, cadmium, lead, mercury, fugitive ash and opacity. NSPS are detailed in Chapter 40 of the Code of Federal Regulations, Part 60 (40 CFR Part 60), and are intended primarily to establish minimum nationwide requirements for new facilities.

Section 112 of the pre-1990 federal Clean Air Act directed EPA to establish standards to reduce emissions of hazardous air pollutants (HAPs). These pollutants include asbestos, benzene, beryllium, inorganic arsenic, mercury, radionuclides, and vinyl chloride. National emission standards for hazardous air pollutants (NESHAPs) are detailed in 40 CFR Part 61 and establish minimum nationwide requirements for existing and new facilities.

The post-1990 NESHAPs require the maximum achievable control technology (MACT) for a particular industrial source category, and are often referred to as "MACT standards." The pre-1990 Clean Air Act prescribed a risk-based chemical-by-chemical approach. The 1990 Clean Air Act Amendments outlined a new approach with two main components. The first component involves establishing technology-based source category standards, and the second component involves addressing any significant remaining risk after the national standards are in place. The NESHAPs promulgated under the 1990 Clean Air Act Amendments can be found in 40 CFR Part 63 and establish nationwide requirements for existing and new facilities.

EPA may implement and enforce the requirements or EPA may delegate such authority to state or local regulatory agencies. Clean Air Act Sections 111 and 112 allow EPA to transfer primary implementation and enforcement authority for most of the federal standards to state, local, or tribal regulatory agencies. In general, EPA does not delegate to state or local agencies the authority to make decisions that are likely to be nationally significant, or alter the stringency of the underlying standard.

The Section 111 and 112 emissions limits applicable to new Municipal Waste Combustors are:

Dioxin/furan (CDD/CDF)	13 nanograms per dry standard cubic meter
Cadmium (Cd)	10 micrograms per dry standard cubic meter
Lead (Pb)	140 micrograms per dry standard cubic meter
Mercury (Hg)	50 micrograms per dry standard cubic meter
Particulate Matter (PM)	20 milligrams per dry standard cubic meter
Hydrogen chloride (HCl)	25 PPM or 95 percent reduction
Sulfur dioxide (SO_2)	30 ppm or 80 percent reduction
Nitrogen Oxides (NO_x)	180 ppm dry volume, and 150 ppm dry volume after first year of operation

A new source review (NSR) permit is required for a new municipal waste combustor and, in addition, depending on its size and emission quantities, it must meet the prevention of significant deterioration (PSD) permit requirements. The PSD review and permitting process will require the following:

- Existing ambient air quality analysis – a detailed analysis of the air quality around the facility site, which may require installing air monitoring equipment to collect data for as long as a year.
- Best Available Control Technology (BACT) analysis – an analysis of all available control technologies for air emissions in a "top down" review.

Analyses include economic, environmental and energy costs for each alternative. The criterion for selection is: best control at acceptable cost.

- Emission dispersion modeling – a detailed analysis, using USEPA-approved models, of the projected impact of the facility emissions on the ambient air quality.

The southeast Florida airshed, Broward, Miami-Dade and Palm Beach Counties, is a non-attainment area for ozone, which imposes additional permitting requirements on the facility. Because of this condition, any new facility (new source) will be required to adhere to the lowest achievable emissions rate (LAER). This will be the lowest emissions rate achieved by a similar source or the lowest rate for a similar source in a state implementation plan (SIP) anywhere in the country. The two pollutants impacted by this are oxides of nitrogen (NOx) and volatile organic compounds (VOC). These analyses will certainly raise the development cost and increase the time required to go through the permit process for a waste conversion facility. Current technology of NOx "Selective Non Catalytic Reduction (SNCR)" can reduce emissions to 100 ppm, below required limits. Other technologies, "Selective Catalytic Reduction (SCR)" can reduce NOx emissions to as low as 15 ppm.[37] Additional reduction in NOx is achieved by urea or ammonia injection into the furnace.

6.1.2 Air Quality Impacts

In the early 1980s, dioxins were discovered in the exhaust of the Hempstead, NY, hydropulpers RDF, WTE facility. This chemical, toxic to animals in even very small quantities, was considered a major pollutant. Other WTE plants were tested, as well as other industries, and were found to be a major dioxin source. In 1995, amendments to the Clean Air Act (CAA) were enacted to control the emissions of dioxins, as well as other toxins, such as mercury, hydrogen chloride and particulate matter.

With the implementation of the CAA requirements in the following years, dioxin emissions from WTE decreased significantly, as shown in Figure 6-1.[38]

[37] Waste to Energy Research and Technology Council (WTERT). 2008. Earth Engineering Center, Columbia University.
[38] Emissions from Large MWC Units at MACT Compliance, USEPA Docket A-9045, VIII.B.11, Office of Air Quality and Standards, 2002.

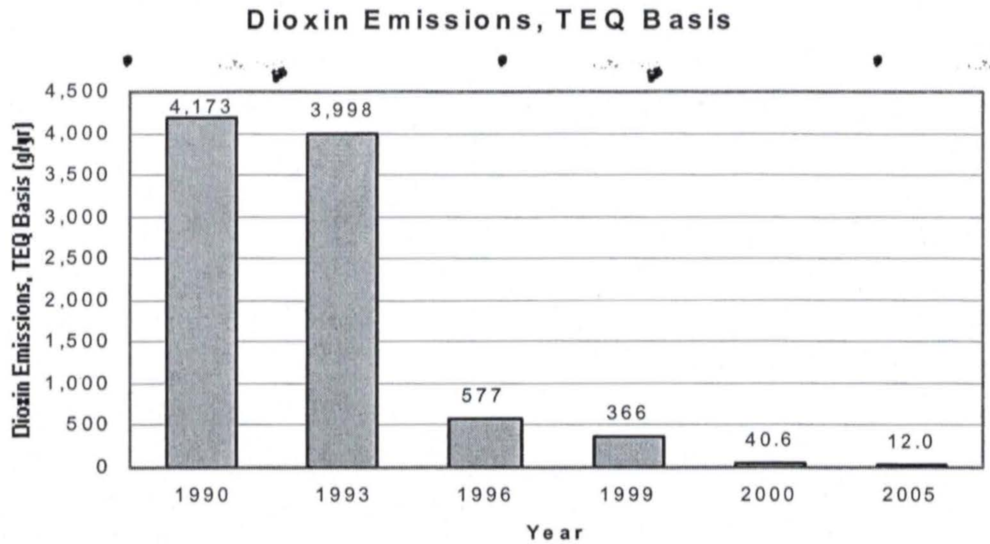

Figure 6-1. Dioxin Emissions from WTE Facilities, 1990 - 2005

While WTE plants had been a major source of dioxins in 1987, as shown in Figure 6-2,[39] they have not been considered significant dioxin sources since 2002. From 1990 to 2005, there was a 99.7% reduction. EPA has stated that "Waste-to-Energy is no longer a major contributor of dioxin emissions."[40]

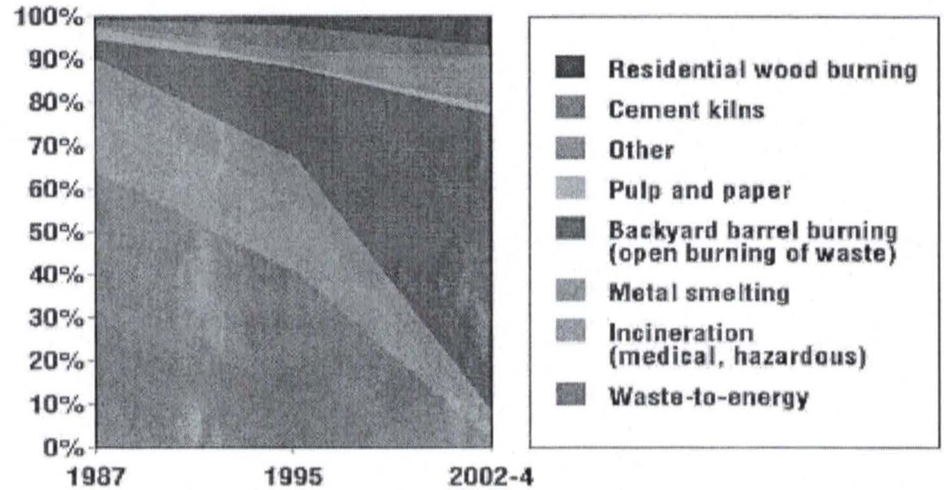

Figure 6-2. Sources of Dioxin Emissions, 1987 - 2002-04

Mercury is another toxin that was found in WTE exhaust, and that was addressed in the CAA amendments. By modifications in the burning process, and the use of

[39] Dioxins from WTE in the USA, J. O'Brien, Comparison of Air Emissions from Waste-to-Energy Facilities to Fossil Fuel Power Plant, SWANA 2005.
[40] Emissions from Large MWC Units at MACT Compliance, USEPA Docket A-9045, VIII.B.11, Office of Air Quality and Standards, 2002.

activated carbon injection in the air pollution control system, dioxins and mercury, as well as hydrocarbons and other constituents, have effectively been removed from the gas stream. The activated carbon removes the contaminants from the emissions by adsorption and other mechanisms. The activated carbon is captured by the APC equipment and would make up part of the fly ash that is captured. Mercury emissions from WTE have been reduced from 1990 levels, as shown in Figure 6-3.[41]

Comparison emissions of mercury in the United States from both WTE and coal fuel-fired electric power plants are shown in Figure 6-4.[42]

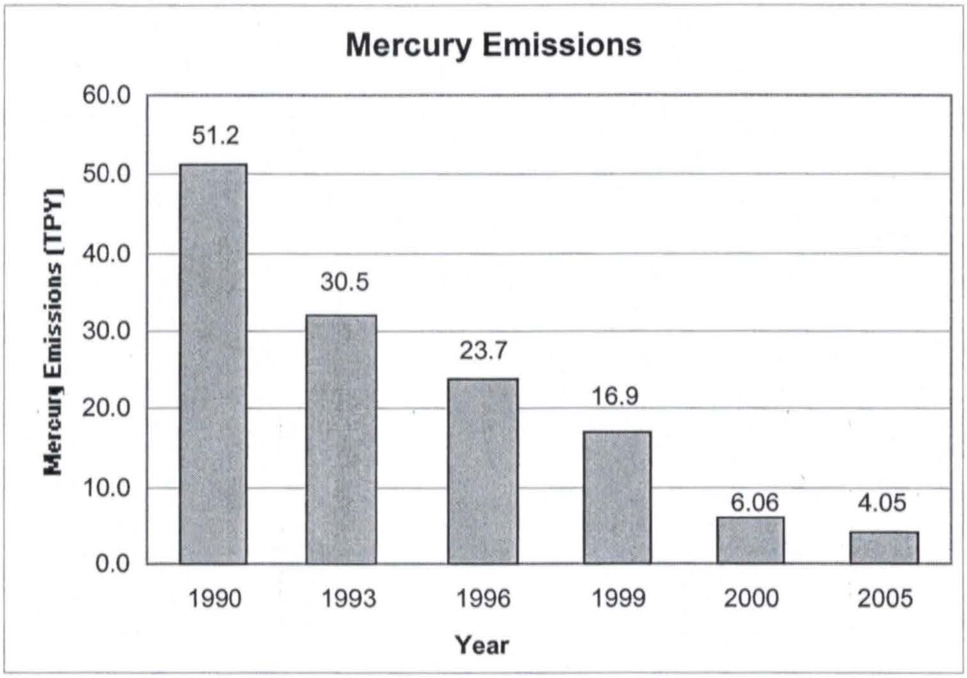

Figure 6-3. Mercury Emission from WTE Facilities, 1990 – 2005

[41] Ibid.

[42] Mercury Emissions from High Temperature Sources, N. Themelis, A. Gregory, ASME Solid Wastes Processing Division Proceedings, May 2002, and the Environmental Working Group, 2006, http://www.ewg.org.

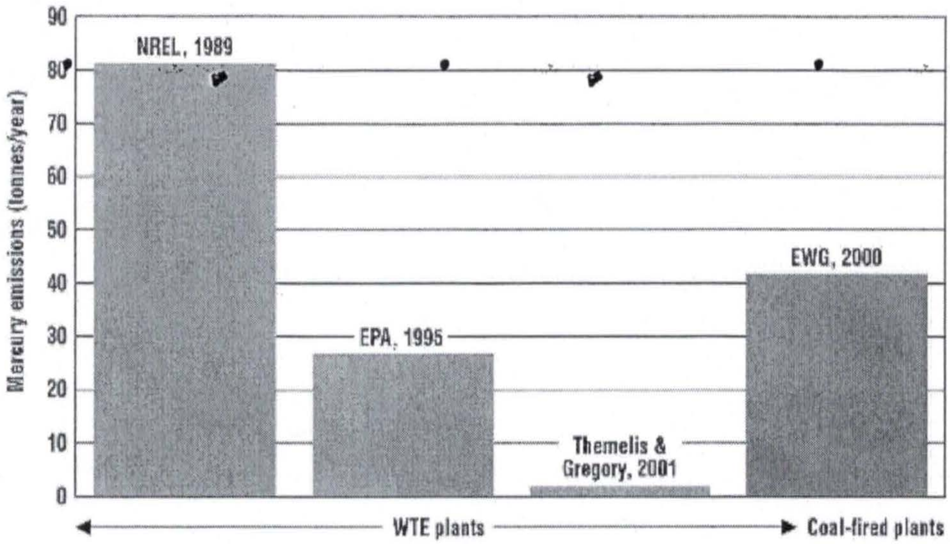

Figure 6-4. Mercury Emission from WTE Facilities and Fossil-Fuel Power Plants

Whether reviewing dioxin data or mercury emissions, it is clear that WTE facilities have made a concerted effort to reduce these emissions to insignificance.

Table 6-1 has the average emissions from 95 WTE plants and compares them to US EPA standards. Dioxins and mercury are lower than 20 percent of the limit. Other pollutants, except Nox, range between 5 and 33 percent of the limits.

Table 6-1. Average Emissions of 95 WTE Plants Compared to U.S. EPA Standards[43]

Pollutant	Average Emission	EPA standard[a]	Average Emission % of EPA Standard	Unit
Dioxin/Furan, TEQ basis	0.05	0.26	19.2%	ng/dscm
Particulate Matter	4	24	16.7%	mg/dscm
Sulfur dioxide	6	30	20%	ppmv
Nitrogen Oxides	170	180	94.4%	ppmv
Hydrogen Chloride	10	25	40%	ppmv
Mercury	0.01	0.08	12.5%	mg/dscm
Cadmium	0.001	0.020	5%	mg/dscm
Lead	0.02	0.20	10%	mg/dscm
Carbon Monoxide	33	100	33.3%	ppmv

Significant reductions in the emission of nitrogen oxides (NOx) have been achieved on a test basis in several existing WTE facilities and has been extended to more

[43] Meg Morris and Jack Lauber. Making a Case: The Benefits of Waste to Energy. May 7, 2007.

operating plants. These efforts have been documented in recent technical papers. Covanta Energy and Martin have modified the air flows in the furnace so that the secondary air stream is reduced and the recirculated gas stream is extracted from the roof above the grates and reintroduced through new nozzles located higher in the furnace. The balance of overfire and underfire air and recirculation gas is controlled by modifications to the facility DCS. The results have been significant. When operated in combination with the existing aqueous ammonia-based-SNCR system, NOX emissions were reduced to 50 to 60 ppm with no increase in ammonia slip values[44]. As can be seen in Table 6-1, the U.S. EPA standard is 180 PPM. Table 6-1 shows the average operating NOx emissions of 170 for the 95 facilities. The Covanta/Martin system shows the potential for reductions of 65 percent.

6.2 Greenhouse Gases

The "greenhouse" effect results from sunlight striking the Earth's surface and, when it gets reflected back towards space as infrared radiation (heat), it gets absorbed by gases trapping the heat in the atmosphere. Many chemicals that are present in the Earth's atmosphere act as "greenhouse gases (GHG)." These gases allow sunlight to enter the atmosphere freely, but prevent transmission of the reflected sunlight back to space. Many gases exhibit these "greenhouse" properties. Some of them occur in nature (water vapor, carbon dioxide, methane, and nitrous oxide), while others are exclusively human-made, such as chlorofluorocarbon compounds.

Prior to large-scale industrialization, the level of greenhouse gases in the atmosphere had remained reasonably constant for a long period. Since industrialization, however, the levels of several important greenhouse gases have increased by 25 percent. Carbon dioxide (CO_2) is a key greenhouse gas. During the past 20 years, about three-quarters of human-made carbon dioxide emissions were from burning fossil fuels. CO_2 is used as the standard for measuring GHG by converting to carbon dioxide equivalents (CO2E). For example, the CO2E for CO_2 is 1 and the CO2E for methane is 21, indicating that methane is a potent GHG.

The greenhouse gases that are generated in solid waste processing and disposal that are of concern are: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (NO_2). Each of these gases can be divided into two categories, based on the source of the materials in the waste: (1) biogenic sources and (2) fossil sources. Methane, the principal greenhouse gas emitted from landfills is over 20 times more potent than carbon dioxide, the greenhouse gas resulting from waste combustion/energy generation. CO_2 gas that is emitted from biomass sources can be classified as carbon neutral because biomass growth captures atmospheric CO_2. This establishes a balanced cycle of CO_2 removal due to biomass growth and release through combustion.[45] Solid waste fuels are comprised of a biogenic portion and a petroleum-based portion. The biogenic fraction of the waste can be measured in the gaseous emissions from the stack and be used to determine the percent of emissions that could potentially be counted towards renewable energy credits in a WTE facility, as these are not generated from fossil fuel derived materials. A protocol developed by ASTM is now available, method ASTM D6866.[46] This protocol uses radiocarbon

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[44] New Process for Achieving Very Low NOx, Steve Goff, Covanta, et al, Proceedings of the 17th Annual North American Waste-to-Energy Conference, May 18-20, 2009.

[45] Intergovernmental Panel on Climate Change IPCC, http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_5_Ch5_IOB.pdf.

[46] ASTM International, http://www.astm.org/Standards/D6866.htm.

dating techniques to measure the C^{14} portion of the carbon present in the emissions and compares it to the fossil carbon portion.

A King County, Washington study[47] compares the GHG for five technology options:

1. Mass-burn, waterwall facilities;
2. RDF with dedicated boiler;
3. Advanced thermal recycling (gasification/pyrolysis);
4. Landfilling with landfill gas capture and flaring; and
5. Landfilling with landfill gas combustion, using internal combustion engine.

The study examined the direct emissions from each process and fugitive emissions,[48] but did not include the emissions associated with transportation of waste to the disposal facility. The emission values in the King County report also include those that are avoided by replacing existing electricity generation emissions. The conclusion of the King County study is that the GHG emissions from any of the conversion approaches are double that of landfilling with landfill gas utilization (Option 5), including landfilling without gas utilization (Option 4).

A modeling exercise performed by Thorneloe, et al,[49] showed that a WTE plant has a positive impact on the reduction of GHG when analyzed under a life-cycle assessment basis. The results are based on U.S. average waste management practices and energy mix, but show potential reduction for various scenarios comparing landfilling (with and without landfill gas recovery, flaring, and use for energy), recycling and WTE. A scenario recycling 30% of the waste stream and taking the remainder 70% to a WTE facility shows considerable reductions in GHG emissions as compared to recycling 30% and landfilling the rest (with no gas recovery), see Figure 6-5, The results performed for a specific location like Palm Beach County would vary due to the waste management practices, waste characterization and local energy mix.

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[47] Comparative Evaluation of Waste Export and Conversion Technologies Disposal Options, King County, Department of Natural Resources and Parks, Solid Waste Division, R.W. Beck, June 2007 (Draft).

[48] Ibid. Landfill gas capture in all landfills is never total. The report estimated an 80 percent capture and 20 percent fugitive emissions.

[49] Thorneloe SA, Weitz K, Jambeck J. Application of the U.S. Decision Support Tool for Materials and Waste Management. WM Journal, August 2006.

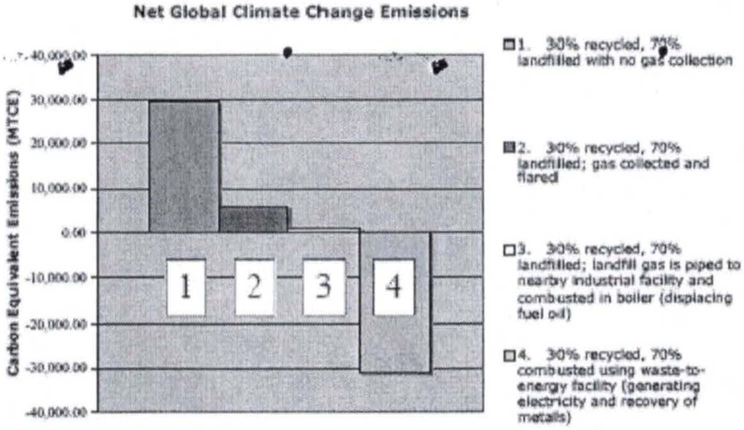

Figure 6-5. Potential GHG Emissions Reductions[50]

The conclusion about net GHG emissions for a similar project in Palm Beach County could be different because of the nature of the credits taken for the electricity-generation emissions displaced by a WTE system. In the case of King County, the electricity replaced is generated by hydro and natural gas. Further, the State of Washington does not recognize either all or part of refuse as a renewable fuel. Florida allows MSW and separated wood waste as a renewable fuel.

According to the Energy Information Administration (EIA), the generating facilities in Florida utilize a variety of fuel including coal, petroleum, natural gas, nuclear, and other fuels. In addition, the national grid, which serves Palm Beach County, also supplies electricity that is generated from a variety of fossil fuels. This makes the displaced emission calculation complicated, but because of the inclusion of coal and petroleum, the displaced emissions for Palm Beach County will be higher than those for King County, WA.

The Waste Reduction Model (WARM) was created by the U.S. EPA to help solid waste planners and organizations estimate greenhouse gas emission reductions from several different waste management practices. WARM calculates GHG emissions for baseline and alternative waste management practices, including source reduction, recycling, combustion, composting, and landfilling. The model calculates emissions in metric tons of carbon equivalent (MTCE) and metric tons of carbon dioxide equivalent (MTCO2E) across a wide range of material types commonly found in municipal solid waste (MSW). In addition, the model calculates energy use for each of the options.

WARM was applied to the waste quantities that are projected in the Plan to be generated in 2015. The quantity of waste used for the models is 3,323,357 tons per year for municipal solid waste, based on the expected growth of 1.77 percent annually from 2010-2015 indicated in the Plan. Current recycling and waste-to-energy practices in place were calculated into the various models, as were composting and yard waste processing activities. WARM requires composition breakdown for the waste streams, which were also taken from a municipal waste

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[50] Source:
http://www.energyrecoverycouncil.org/userfiles/file/Waste%20Not%20Want%20Not.pdf.

composition study for Broward County, Florida. Because the categories in the Plan do not correspond to those in the WARM, some adjustments were made. For example, the Bi-metal Food containers category was added to the Steel Cans category in WARM.

WARM was applied to two scenario-based goals expressed, as follows:

1. Baseline – 100 percent of MSW landfilled with increased transportation costs of transferring waste and landfill gas recovery for energy.
2. Current Activities W/O WTE – Maintain the percent recycling with the remaining MSW landfilled with increased transportation costs of transferring waste and landfill gas recovery for energy.
3. Current Activities – Maintain the percent recycling with current waste-to-energy plant in service and increased transportation costs of transferring waste, as well as landfill gas recovery for energy.
4. Enhanced WTE – Maintain the percent recycling with current waste-to-energy plant in service, with additional diversion to a second waste-to-energy facility, as well as landfill gas recovery for energy.

The results of running the parameters for the four scenarios in WARM are shown in Table 6-2. WARM indicates an emissions savings for 100 percent landfilling of 2015 projected waste of 343,337 metric tons of CO_2, which has been subtracted out to give Scenario 1 a baseline of zero (0). Also, Table 6-2 shows the potential barrels of oil and acres of forest saved in 2015, as well as cars taken off the road for each scenario.

Table 6-2. WARM Emissions Savings and Equivalents for 2015

Waste Management Scenario	Metric Tons of CO_2 in Emissions per Year	Equivalent to Emissions of Barrels of Oil Consumed per Year	Equivalent to Carbon Uptake by Acres of Forest per Year	Equivalent to Cars Taken Off the Road per Year
1 – Baseline –100 percent Landfilled	0	0	0	0
2 – Current Recycling –no WTE facility	-501,299	1,165,812	3,497	91,813
3 – Status Quo – Current Recycling and existing WTE facility	-624,023	1,451,217	4,353	114,290
4 – Enhanced WTE – Current Recycling/WTE plus additional WTE Facility	-791,907	1,841,645	5,524	145,038

The removal of CO_2 may be convertible to carbon credits that have potential to be sold for a source of additional revenue to the SWA. As mentioned above, carbon credits are proposed in the Waxman/Markey Bill based on tax rates and will fluctuate with the market. Recent prices of offsets for the Kyoto program on the European Climate Exchange have been between 10 and 15 Euros per metric ton of CO_2. Given the exchange rate, discount (the 1.25 ton reduction per ton of credit), and likely increase in demand, the initial price of $20 per ton appears conservative. After the first five years, this price will increase by the expected rate of inflation.

Using the price of $20.00 for one ton of CO_2, the projected revenue to the SWA based on passage of Waxman/Markey for Scenario 4 is over $14 million per year.[51]

6.3 Water

Mass-burn and RDF incineration technologies require a water supply and all types of projects have a wastewater discharge. Besides domestic water for workers, potable water is required for the waste heat boilers.

Non-potable water may be used as cooling water for the steam condensers, but the large cooling water supplies necessary for condenser cooling are normally not available, and cooling towers or cooling water ponds are provided as part of the facility. WTE plants also utilize their water discharges from the steam cycle and cooling system in the ash cooling process, which reduces the need for additional water and disposes of any mineral buildup. Water demand can be further reduced in WTE plants by using air cooled condensers to cool their steam system. However, this increases the internal electrical demand reducing net exports to the grid.

If a steam customer is the energy market, the water requirement may be increased significantly from that needed for electricity generation, assuming that the customer generally does not return condensate. Some projects may cogenerate steam and electricity for sale, such as district heating/cooling projects or those with a significant steam user in proximity of the WTE facility site.

Technologies such as gasification and anaerobic digestion will not necessarily use a boiler. They may generate a gas stream for use off-site and not require a condenser cooling water system.

6.4 Residue Disposal

Another consideration is ash disposal. For all but the high-temperature thermal options and the anaerobic digestion system, an ash will be generated. Bottom ash will be discharged from the bottom of the furnace chamber, and fly ash will be collected by the air pollution control system. In accordance with applicable law, waste-to-energy ash must be tested to ensure it is non-hazardous. The test is called the Toxicity Characteristic Leaching Procedure ("TCLP").

Generally, the bottom ash has not been classified as a hazardous material, subject to ash testing and analysis. Fly ash, however when collected separately, will have a higher concentration of heavy metals and may also contain residual organics. As such, it would likely be classified as a hazardous material if it fails toxicity testing, unless it is combined with bottom ash, as is the current U.S. practice. Combined ash routinely passes the TCLP test and is classified as non-hazardous.

Florida regulations require applications for construction permits for WTE facilities must include an ash management plan.[52] The plan must describe measures to control the dispersion of the ash residue and identify sites for disposal. The ash plan must include quantity estimates and estimates of the recycled materials that can be recovered. WTE ash has been used as daily cover for sanitary landfills.

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[51] PJM. Potential Effects of Proposed with Proposed Climate Change Policies on PJM's Energy Market, January 23, 2009.

[52] Florida Statutes, Chapter 62-702 Solid Waste Combustor Ash Management.

If the fly ash is separated, it can be treated with a fixative to prevent the leaching of hazardous constituents, so as to be classified as a non-hazardous material. There are a number of fixatives, such as WES-PHix marketed by the Wheelabrator Corporation. The cost of a fixative must be compared to the options for ash disposal to determine the cost-effective solution for the ash. Part of that analysis would be determining if a market exists for the bottom ash, or for ash that has been treated with a fixative.

Several states, including Florida, permit the "beneficial use" of ash produced at WTE plants in certain applications subject to the ash passing the TCLP and possibly subject to other restrictions, depending on the state. These applications may include daily landfill cover, landfill shaping and grading material, landfill gas venting layers and certain construction and road fill applications. Some states, such as California and Maryland, allow ash that is beneficially used to be included in recycling diversion formulas. A substantial number of the WTE facilities in the U.S. report the beneficial use of ash resulting from the waste combustion process. In 2004, it was reported that in a survey of U.S. waste-to-energy plants, 30 facilities responded that ash from their operation was being beneficially used in some manner. Most of this ash, over 2.5 million tons, was reported as being used as alternative daily landfill cover.[53] Florida regulations allow for recycling ash residue to be processed into products. The processor of the ash bears the responsibility to demonstrate to the Department of Environmental Protection that the product will not endanger human health or the environment.

It should be noted that communities with aggressive, comprehensive recycling programs and programs focused on removing toxics from the municipal solid waste stream, such as those to divert used electronics ("e-waste"), household hazardous waste ("HHW"), mercury thermometers, fluorescent light fixtures, batteries, various metals and white goods, and the like, could be expected to have a post-diversion municipal solid waste stream for combustion containing less toxic materials and thus the ash from combustion to have a lower potential to exhibit hazardous characteristics upon TCLP testing.

The solids residual from high temperature systems, such as plasma-arc or pyrolysis, may have a better opportunity for end-use applications and marketing. These glassy-type granules generally have very low leachability and, therefore, may be classified as non-hazardous and used in construction materials, or as a fill.

The organic substrate after the digestion process may also be beneficially processed and recovered as a compost-like soil conditioner. The residue then remaining from anaerobic digestion is nothing more than stones, glass or similar items, which is normally directed to a solid waste landfill. Otherwise, the residue quantity and characteristics is different and greater in quantity.

7.0 Waste Processing Technologies for Palm Beach County

In assessing the applicability of waste processing technologies for Palm Beach County, one must consider the overall track record of each, including the operational/commercial experience of the technology, the size and scale of the successful facilities, their environmental performance and impacts, their overall

[53] JVL Kiser, The 2004 IWSA Directory of Waste-to-Energy Plants (June 2004).

economics, their reliability over time, and the availability of financially strong companies to offer them under full service arrangements. Table A-2 in the Appendix is a matrix summarizing the overall performance of the technologies reviewed in this paper. The first four columns address the technology, whether it has been employed commercially at the scale required for handling Palm Beach County's MSW stream (at 3,000 tons MSW per day), and its expected reliability. The next column evaluates its environmental acceptability. The fifth and sixth columns address project economics, and the last two columns deal with an assessment of the overall risk and liability issues inherent in selecting that technology at this time. A discussion of several of the comparative factors that have gone into the evaluation of technology applicable to Palm Beach County follows.

Experience: The mass-burn/waterwall technology has been used for MSW treatment and disposal for over a hundred years. Modular systems and RDF facilities have been used for decades. Anaerobic treatment of MSW is a relatively new application, but it has a long history of application to liquid and sludge wastes. There is little, if any, operating history with MSW for the other listed processes.

Size: The only technologies that has been applied to large MSW feed rates, over 2,000 TPD, are mass-burn/waterwall and RDF/dedicated boiler. None of the other technologies have been successfully built in these relatively large sizes. Many of these facilities are built in modules and, for larger capacities, a number of modules can be installed. For instance, Thermoselect has a 400 TPD module, so a 3,000 TPD facility would require the procurement of 7-8 modules. Likewise, International Environmental Solutions (pyrolysis) and ArrowBio (anaerobic digestion) would also need to provide a large number of modules to achieve the required throughput.

Reliability: Systems that have a long history of successful operation will necessarily have a demonstrable reliability. Such systems include mass-burn, both modular and waterwall and RDF systems. Pyrolysis and gasification systems have limited MSW operating history on which to rely and, although they may have fewer moving parts and appear to be simpler in operation than other systems, they do not have sufficient experience to draw conclusions for reliability of operation. The anaerobic digester system has many constituent unit processes in an operating line, and has the potential for reliability issues.

Environmental/Air: Mass-burn, RDF, pyrolysis/gasification and plasma arc systems utilize similar air pollution control systems and equipment. Pyrolysis and "starved-air" gasification technologies use less air than other thermal systems, and will have less flue gas generation; however, the characteristics of the air emissions from these systems are similar to mass-burn and RDF systems. The mass-burn and RDF facilities meet the stringent air emissions requirements that were promulgated a decade ago, and that are constantly being upgraded and strengthened. The processes that do not burn an off-gas as part of their process line generate a syngas for downstream use. The syngas, after cleanup, is projected to burn cleaner and have lower emissions than incineration emissions. Several gasification/pyrolysis systems show the gas generated driving a gas turbine, which could be part of a combined cycle system. This would increase efficiency; however, turbine manufacturers are reluctant to guarantee performance on units fueled by syngas from MSW.

Environmental/Water: The anaerobic digestion system will generate a water surplus, but the other systems will require a water supply. Non-potable cooling water is necessary for steam condenser cooling when generating electric power and for other equipment cooling requirements, such as air compressor cooling. Potable water is