Government Relations
1828 L Street NW, Suite 810
Washington, DC
20036-5104 U.S.A.

tel 1.202.785.3756
fax 1.202.429.9417
www.asme.org

Waste-to-Energy and Materials Recovery

EXECUTIVE SUMMARY

ASME MER Division Supports WTE and Materials Recovery- The Materials and Energy Recovery (MER) Division of the American Society of Mechanical Engineers (ASME) supports national policies that encourage the recovery of energy and materials from the processing and controlled combustion of municipal solid waste (MSW), also called Waste to Energy (WTE).

Proven Technology - WTE is a proven, environmentally sound process that provides reliable electricity and steam generation and sustainable disposal of post-recycling MSW. WTE technology is used extensively in Europe and other developed nations such as China, Russia, Japan, Singapore, and Taiwan.

WTE Reduces Greenhouse Gases - New policies to encourage WTE can help reduce the nation's greenhouse gas emissions. In fact, nation-wide use of the WTE technology can become one of the big contributors to America's planned reduction in greenhouse gas emissions.

WTE Reduces Dependence on Fossil Fuel - WTE can also have an impact on reducing fossil fuel usage and increase energy production using renewable sources. MSW is currently comprised of 56% biogenic and 44% non-biogenic materials.[i] Combusting the biogenic fraction of WTE is considered renewable by the DOE.[ii] Currently, there are 86 WTE facilities in the U.S. that process 29 million tons of MSW per year. The nation currently landfills about 248 million tons of waste per year so there is significant potential to increase energy production from WTE. Each ton of MSW combusted has the energy equivalent of one third ton of coal (currently 9.6 million tons per year equivalent) or one barrel of oil (currently 29 million barrels per year equivalent). If all waste were processed in modern WTE facilities, the output from these facilities could satisfy as much as 12 percent of the country's residential electricity consumption.

Additional Environmental Benefits of WTE -

- Complements recycling and reduces landfilling;
- Because WTE facilities tend to be located near populated areas; WTE can reduce truck traffic and associated emissions; and
- Recovers and recycles metals thus reducing mining operations.

WTE Provides Clean Energy – WTE technology has significantly advanced with the implementation of the Clean Air Act[iii], dramatically reducing all emissions. Twenty-four U.S. states classify WTE as a renewable fuel.[iv] The EPA concluded WTE now produces electricity with less environmental impact than almost any other combustion source.

Reliable Electricity – WTE operates continuously and is desirably located in proximity to urban areas where populations have grown substantially in the past decade and where the power is needed the most.

ASME MER Recommendations:

- WTE should be a part of any balanced mix of energy technologies; including any federal Renewable Portfolio Standard.
- WTE has the benefit of reducing greenhouse gas emissions in the U.S.
- The EPA should consider the "life cycle analysis" of waste disposal options
- The EPA should consider applying Maximum Achievable Control Technology (MACT) regulations on all emission sources, as have been applied to WTE facilities.

Introduction

ASME represents 120,000 engineers who are engaged in every aspect of energy generation and utilization. The Materials and Energy Recovery (MER) Division of ASME is dedicated to the recovery of energy and materials from the solids discarded by society and the environmental quality of technologies used in all aspects of waste management.

Municipal solid waste (MSW) is an unavoidable byproduct of human activities. Each day, the average person produces 4.3 pounds of waste.[v] Waste management is a particularly serious issue in the U.S. because we consume an estimated 25 percent of the world's energy and materials and generate twice as much MSW per capita as compared to developed nations in the European Union and Japan. Therefore, there exists a great need for waste reduction and recycling of materials. However, international and U.S. experience has shown that after recycling there remains a large fraction of MSW to be disposed of.

The two proven means for disposal are: 1) burying MSW in landfills; or 2) combusting waste in specially designed chambers at high temperatures, thereby reducing it to one tenth of its original volume. The heat generated by combustion is transferred to steam that can flow through a turbine to generate electricity or be used directly for district heating or other applications. This process is called waste-to-energy (WTE). It converts the energy from combustion of MSW to steam and electricity, and recovers and recycles the metals contained in the MSW. The remaining ash is then either used in landfills for daily cover and landfill roads or cleaned up and used off site for other construction purposes (as is done now in the EU and Japan).

The U.S. WTE industry has existed for over forty years and its technology has continuously been improved. For example, MSW combustion facilities of all types were once considered a significant source of mercury and dioxin emissions. However, during the 1990's, the WTE industry implemented new EPA regulations on Maximum Achievable Control Technology (MACT) and WTE power plants have reacted by becoming one of the cleanest producers of electricity and heat energy available today.

Currently there are 86 WTE facilities in the U.S. processing 29 million tons of MSW annually and generating 2.7 GW of electricity.[vi] Each ton of MSW combusted has the energy equivalent of one third ton of coal (9.6 million tons per year) or one barrel of oil (29 million barrels per year).[vii] This stands in stark contrast to the European Union; which contains 429 incinerators and has policies in place to reduce carbon dioxide emissions.[vii] WTE has proven itself to be a reliable technology. In 2009, Americans produced about 243 million tons of MSW, or about 4.3 pounds of waste per person per day.[viii] A 2009 study conducted with the support of North Carolina State University determined that WTE contains a lower amount of GHG emissions than methane that is released from landfills.[ix] The United States Conference of Mayors adopted a resolution in 2005 endorsing the U.S. Mayors Climate Protection Agreement, which identifies waste-to-energy as a clean, alternative energy source which can help reduce greenhouse gas emissions.[x]

Unfortunately, there have been some setbacks. For instance, the Supreme Court Carbone ruling on "Flow Control" in 1994 (*C & A Carbone v. Town of Clarkstown, New York*, 511 U.S. 383) forced many major urban areas in the U.S. to opt for long distance transport of their solid wastes to newly built giant landfills; and stopped the growth of this useful energy producing technology in the U.S.[xi] Consequently, since 1995, there have been no new WTE plants built in the U.S. A more recent Supreme Court decision on Flow Control has restored the ability of communities to control the flow of wastes to WTE facilities.

In contrast to what was happening in the U.S., from 1995 through 2011, hundreds of new WTE facilities were built in the European Union, Japan, China, and over 40 other nations where landfilling is regarded as environmentally undesirable and energy- and land-wasteful. Denmark currently has 29 WTE facilities; and has plans underway for 10 more to be built.[xii] The growth of WTE in the European Union is partly due to a directive of the European Community that mandates that wastes containing over 2 percent combustible material shall not be landfilled in order to reduce landfill emissions of methane, the second most important greenhouse gas, and preserve land for future generations.[xiii]

In the U.S., as major urban areas have run out of nearby landfill space, post-recycled MSW is increasingly being transported long distances to other states for burial.[xiv] This has substantially increased the cost to landfill this MSW, and has also increased the associated environmental impacts because of the emissions from transport vehicles to and from the landfills. It has also increased the environmental advantages of WTE versus landfilling. As a result, some WTE facilities have recently expanded their capacity by adding new processing lines to their existing operations. These facilities based their requests for financing and permitting on their successful records of operation and environmental compliance.

The Conventional WTE Process

The conventional WTE combustion process is similar to the stoker burners in many coal- and wood-fired boilers. Waste is continuously fed onto a moving grate in a furnace where high temperatures are maintained. Air is added to the combustion chamber to ensure turbulence and the complete combustion of the organic components to their stable and natural molecular forms of carbon dioxide and water vapor.

The hot combustion gases released during the WTE process are directed through boilers to generate superheated steam that can drive turbine generators that produce electricity. Exhausted steam can also be used efficiently for district heating and for industrial processing if those choices are available.

According to the EPA and Intergovernmental Panel on Climate Change (IPCC) protocols, combusting the biogenic fraction of MSW (about 56 percent of the carbon in MSW) results in a GHG reduction because these waste materials decompose into nearly equal portions of carbon dioxide and methane gas if they are landfilled. Methane is 21 times more potent as a GHG than carbon dioxide.

Energy Benefits of WTE

MSW, depending upon the moisture and energy content of the waste materials, is a good source for both electricity and heat. The thermal treatment of MSW results in the generation of 500-600 kWh of electricity per ton of MSW combusted. European WTE facilities often recover another 600 kWh in the form of steam or hot water that is used for district heating. This additional energy recovery is not generally achieved in the U.S. due to the absence of district heating systems. The corresponding savings in fossil fuel use range from one to two barrels of oil per ton of MSW.

Renewable Energy Source

WTE is designated as renewable by the 2005 Energy Policy Act (P.L. 109-58), by the U.S. Department of Energy (DOE), and by twenty-four state governments, as well as the District of Columbia. Excluding hydroelectric power, currently only 3 percent of the U.S. electricity is generated from renewable energy sources. A third of this renewable energy is due to WTE which at this time processes about 8 percent of the U.S. MSW, while nearly 64 percent is landfilled.[xv]).

Environmental Benefits

In addition to its energy benefits, WTE avoids the conversion of greenfields to landfills. The 2,500-acre Freshkills landfill of New York City filled up in about 50 years. Under current regulations (daily cover, etc.), it would have filled in 20-25 years. Although the U.S. is blessed with abundant land, the continuous use of land for landfilling is not sustainable, especially in the metropolitan areas that are experiencing the highest population growth.

Since WTE facilities are a point source of emissions, they are subjected to very stringent environmental regulations. This is not possible for landfills which are dispersed sources extending over hundreds of acres. For example, EPA assumes that 75 percent of the landfill gas (LFG) is captured in landfills that are equipped for such capture. Other studies estimate the actual LFG capture to be much lower since, under current EPA regulations, landfills are not required to capture LFG during the first five years of operation of a cell, the layer of earth where waste is compartmentalized, and stored, within the landfill.

Comparative studies of WTE and landfilling have shown that for each ton of MSW combusted, rather than landfilled, the overall carbon dioxide reduction can be as high as 1.3 tons of CO2 per ton of MSW when both the avoided landfill emissions and the avoided use of fossil fuel are taken into account.[xvi]

WTE processing of MSW has the additional benefit of reducing the transport of MSW to distant landfills and the attendant emissions and fuel consumption. It also reduces interstate truck traffic. According to U.S. Department of Transportation traffic statistics, an average of 7 deaths and over 40 serious injuries occur per year, based on the number of trucks required to transport New Jersey's two million tons per year of excess MSW to landfills in Pennsylvania, Virginia, and Ohio.[xvii]

Diesel fuel consumption of trucking to and from landfills and by equipment used in the burial of MSW in landfills generates air emissions and has other negative environmental impacts. All this energy consumption and diesel exhaust can be avoided by WTE facilities that use MSW as the fuel for generating electricity and steam energy at plants located near urban centers.

Materials Recovery

Another beneficial effect of modern MSW combustion with energy recovery is materials recovery. Using magnetic separators, the U.S. WTE industry recovers and recycles over 770,000 tons of ferrous scrap metal annually from the combustion ash residue.[xviii] At some facilities, non-ferrous metals are also removed through the use of "eddy current separators" that cause these materials to literally jump out of the remaining ash and into a recovery area. Metal processors sort this mixed metal into brass, aluminum, copper and other base metals.[xix] The remaining ash may be used in the construction and maintenance of landfills. [xx]

Existing Obstacles for WTE Technology

The progress of WTE in the U.S. has thus far been stifled by three factors that can be addressed through federal legislation and collective local efforts:

- Inconsistent environmental regulations for various energy sources.

- Failure to consider all environmental factors when local community environmental decisions are made.
- Uneven support by local officials and federal agencies.

Flow Control

Flow control is the authority needed by a municipality to direct the "flow" of its generated solid wastes into a disposal process chosen by the community, e.g., the local WTE facility. Normally, a community must issue bonds for construction of a large WTE facility and employ flow control to have firm waste delivery contracts in place during the term of the bond issue.[xxi]

When the U.S. Supreme Court ruled in the 1994 "Carbone" case that all existing attempts at such control were illegal under the Constitution because they restrained "commerce", they eliminated the ability of a community to finance WTE facilities. However, in the 2007 "United Haulers" decision, the Supreme Court has clarified the ability of local communities to finance long term revenue bond issues and control the flow of waste to these facilities. Moreover, the court recognized that Congress has, in the Resource Conservation and Recovery Act, carved out a vital role for local government in the management of the nation's solid waste.

Implementation of Regulations

Environmental impact statements for any waste management facility (recycling, composting, WTE, waste hauling, and landfilling) should include a life-cycle analysis of all associated environmental and energy impacts that will result from each option. Even recycling, though laudable, has negative, as well as positive, environmental effects. The impacts of the failure to make any community "improvement" should also be weighed in the evaluation of choices.

U.S. WTE facilities have complied with very stringent EPA regulations, known as Maximum Achievable Control Technology (MACT), at an estimated cost of over one billion dollars. [xxii] Air quality regulations for all forms of combustion processes should have consistent health-based emissions limits for all facilities.

Disposal of solid waste from major urban areas in landfills frequently involves long haul trucking resulting in diesel exhaust pollution and the need for multiple waste transfer stations. Additionally, the landfilling process also results in diesel exhaust emissions and the long term generation of gaseous pollutants from the decomposition of trash in a landfill.

Public decision makers should carefully consider all environmental factors before adopting a solution to an environmental problem such as disposal of MSW. In addition, the public should be educated to know the benefits and burdens associated with each potential solution before making a final decision.

Recommended Actions

The U.S. Environmental Protection Agency (EPA) needs to fulfill its obligation to the public by advocating for the best solutions to environmental problems, including the disposal of MSW. Sound science should be the basis for decision-making. EPA must lead by educating the public as to the pros and cons that go with any solution and, thus, help overcome misconceptions about proven technological solutions.

In recent years, the EPA has taken a more active role in educating the public, by distinguishing in its annual reports between tonnages of MSW going to WTE and to landfilling, instead of lumping them

together as "disposal". Also, some EPA regions have taken a pro-active role in educating the public in the benefits of WTE. For example, EPA Region 2 organized a one-day seminar in Puerto Rico at which they educated the general public on the benefits of WTE vs. landfilling, especially for an island where land is very scarce and precious. EPA has also re-instituted the hierarchy of integrated solid waste management, which places waste-to-energy above landfill disposal. We applaud these efforts undertaken by the EPA and feel that now is the time to build upon them.

It is given that no one wants a new public facility of any sort near their homes, whether it is an airport, highway, water treatment plant or a waste disposal facility. We believe that it is paramount that environmental regulators coordinate with local officials to hold public hearings where new facilities and technologies and the "do-nothing" consequences can be discussed. Additionally, we encourage the EPA to actively promote WTE as a mutually beneficial endeavor for both local communities and the nation.

The following actions are recommended by the ASME MER to advance the use of WTE technology in the U.S.:

- Congress should re-examine and reconsider the level of regulatory limits required for new sources of energy. Regulations have worked well for waste-to-energy facilities and they are equally able to control emissions from all other sources of combustion based energy production.

- Congress, in an effort to expand WTE, should consider enacting legislation that would make renewable energy credits available for WTE under the definitions of green or renewable energy.

- Congress should direct EPA to study and post notice regarding the effects of the "whole picture" for all available waste management options.

The ASME MER believes that these policy recommendations, if fully adopted, could successfully take advantage of an opportunity to develop a renewable energy source at a critical time for our nation. The country will also be well served by recovery of reusable materials, reduced truck traffic and highway congestion, and less dependence on landfill for solid waste disposal.

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This position statement represents the views of the Materials and Energy Recovery Division and Energy Committee of ASME's Technical Communities of Knowledge and Community and is not necessarily a position of ASME as a whole.

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[i] LaRiviere, Marie, April 2007, Energy Information Administration (EIA), Trends in Municipal Solid Waste (MSW) Composition, Department of Energy

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[iii] USEPA, Dec. 1995, Preamble: Proposed Rules and Notice, Federal Register, Pg. 65413.

[iv] "Europe Finds Clean Energy in Trash, but U.S. Lags" http://www.nytimes.com/2010/04/13/science/earth/13trash.html

[v] Non-Hazardous Waste http://www.epa.gov/epawaste/basic-solid.htm

[vi] Energy Recovery from Waste http://www.epa.gov/epawaste/nonhaz/municipal/wte/index.htm

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[x] http://www.energyrecoverycouncil.org/userfiles/file/ERC_2010_Directory.pdf
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[xv] 2004 BioCycle/Columbia national survey; www.wtert.org/sofos/SOG2006.pdf
[xvi] Comparative Impacts of Local Waste to Energy vs. Long Distance Disposal of Municipal Waste, Extended Abstract # 08
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[xviii] C. Wiles and P. Shephard, April 1999 USDOE, 126 Pg. Booklet #BK-570-25841 "Beneficial Use and Recycling of Municipal Combustion Residues – A Comprehensive Resource Document" by the National Renewable Energy Laboratory.
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