EPA United States Environmental Protection Agency

Energy Recovery from the Combustion of Municipal Solid Waste (MSW)

Energy recovery from waste is the conversion of non-recyclable waste materials into usable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolization, anaerobic digestion and landfill gas recovery. This process is often called waste to energy.

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Energy Recovery from Combustion

Energy recovery from the combustion of municipal solid waste is a key part of the non-hazardous waste management hierarchy, which ranks various management strategies from most to least environmentally preferred. Energy recovery ranks below source reduction and recycling/reuse but above treatment and disposal. Confined and controlled burning, known as combustion, can not only decrease the volume of solid waste destined for landfills, but can also recover energy from the waste burning process. This generates a renewable energy source and reduces carbon emissions by offsetting the need for energy from fossil sources and reduces methane generation from landfills.

The Mass Burn Process

At an MSW combustion facility, MSW is unloaded from collection trucks and placed in a trash storage bunker. An overhead crane sorts the waste and then lifts it into a combustion chamber to be burned. The heat released from burning converts water to steam, which is then sent to a turbine generator to produce electricity.

The remaining ash is collected and taken to a landfill where a high-efficiency baghouse filtering system captures particulates. As the gas stream travels through these filters, more than 99 percent of particulate matter is removed. Captured fly ash particles fall into hoppers (funnel-shaped receptacles) and are transported by an enclosed conveyor system to the ash discharger. They are then wetted to prevent dust and mixed with the bottom ash from the grate. The facility transports the ash residue to an enclosed building where it is loaded into covered, leak-proof trucks and taken to a landfill designed to protect against groundwater contamination. Ash residue from the furnace can be processed for removal of recyclable scrap metals.

Combustion Technologies

Common technologies for the combustion of MSW include mass burn facilities, modular systems and refuse derived fuel systems.

Mass Burn Facilities

Mass burn facilities are the most common type of combustion facility in the United States. The waste used to fuel the mass burn facility may or may not be sorted before it enters the combustion chamber. Many advanced municipalities separate the waste on the front end to save recyclable products.

Mass burn units burn MSW in a single combustion chamber under conditions of excess air. In combustion systems, excess air promotes mixing and turbulence to ensure that air can reach all parts of the waste. This is necessary because of the inconsistent nature of solid waste. Most mass-burn facilities burn MSW on a sloping, moving grate that vibrates or otherwise moves to agitate the waste and mix it with air.

Modular Systems

Modular Systems burn unprocessed, mixed MSW. They differ from mass burn facilities in that they are much smaller and are portable. They can be moved from site to site.

Refuse Derived Fuel Systems

Refuse derived fuel systems use mechanical methods to shred incoming MSW, separate out non-combustible materials, and produce a combustible mixture that is suitable as a fuel in a dedicated furnace or as a supplemental fuel in a conventional boiler system.

The History of Energy Recovery from Combustion

The first incinerator in the United States was built in 1885 on Governors Island in New York, NY. By the mid-20th Century hundreds of incinerators were in operation in the United States, but little was known about the environmental impacts of the water discharges and air emissions from these incinerators until the 1960s. When the Clean Air Act (CAA) came into effect in 1970, existing incineration facilities faced new standards that banned the uncontrolled burning of MSW and placed restrictions on particulate emissions. The facilities that did not install the technology needed to meet the CAA requirements closed.

Combustion of MSW grew in the 1980s. By the early 1990s, the United States combusted more than 15 percent of all MSW. The majority of non-hazardous waste incinerators were recovering energy by this time and had installed pollution control equipment. With the newly recognized threats posed by mercury and dioxin emissions, EPA enacted the Maximum Achievable Control Technology (MACT) regulations in the 1990s. As a result, most existing facilities had to be retrofitted with air pollution control systems or shut down

Frequent Questions on Energy Recovery from Combustion

Information on Specific MSW Combustion Facilities

- Use Columbia University's waste map EXIT for state-specific information.
- Search the 2016 Directory of Waste to Energy Plant (PDF) (72 pp, 5.3 MB, About PDF) EXIT for details on all operating facilities.

1. How much waste does America combust for energy recovery?

Currently, there are 86 facilities in the United States that recover energy from the combustion of municipal solid waste. These facilities exist in 25 states, mainly in the Northeast. Although no new facilities have opened in America since 1995, some expanded to handle additional waste and create more energy. There 86 facilities have the capacity to produce 2,720 megawatts of power per year by processing more than 28 million tons of waste.

A typical waste to energy plant generates about 550 kilowatt hours (kWh) of energy per ton of waste. At an average price of four cents per kWh, revenues per ton of solid waste are often 20 to 30 dollars. For more information, read *Is It Better to Burn or Bury Waste for Clean Energy?* EXIT

2. Why are MSW combustion facilities not more common in the United States?

According to the Advancing Sustainable Materials Management: Facts and Figures Report, America combusted over 33 million tons of MSW with energy recovery in 2014.

MSW combustion accounts for a small portion of American waste management for multiple reasons. Generally speaking, regions of the world where populations are dense and land is limited (e.g. many European countries, Japan), have greater adoption of combustion with energy recovery due to space constraints. As the United States encompasses a large amount of land, space limitations have not been as important a factor in the adoption of combustion with energy recovery. Landfilling in the United States is often considered a more viable option, especially in the short term, due to the low economic cost of building an MSW landfill verses an MSW combustion facility.

Another factor in the slow growth rate of MSW combustion in the United States is public opposition to the facilities. These facilities have not always had air emission control equipment, thus gaining a reputation as high polluting. In addition, many communities do not want the increased traffic from trucks or to be adjacent to any facility handling municipal waste.

Additionally, the upfront money needed to build an MSW combustion facility can be significant and economic benefits may take several years to be fully realized. A new plant typically requires at least 100 million dollars to finance the construction; larger plants may require double to triple that amount. MSW Combustion facilities typically collect a tipping fee from the independent contractors that drop the waste off on a daily basis to recover costs. The facilities also receive income from utilities after the electricity generated from the waste is sold to the grid. A possible third stream of revenue for the facilities comes from the sale of both ferrous (iron) and non-ferrous scrap metal collected from the post-combusted ash stream.

3. What is the ash generated by combustion and what happens to it?

The amount of ash generated ranges from 15-25 percent (by weight) and from 5-15 percent (by volume) of the MSW processed. Generally, MSW combustion residues consist of two types of material: fly ash and bottom ash. Fly ash refers to the fine particles that are removed from the flue gas and includes residues from other air pollution control devices, such as scrubbers. Fly ash typically amounts to 10-20 percent by weight of the total ash. The rest of the MSW combustion ash is called bottom ash (80-90 percent by weight). The main chemical components of bottom ash are silica (sand and quartz), calcium, iron oxide, and aluminum oxide. Bottom ash usually has a moisture content of 22-62 percent by dry weight. The chemical composition of the ash varies depending on the original MSW feedstock and the combustion process. The ash that remains from the MSW combustion process is sent to landfills. Visit EPA's Landfill Methane Outreach Program for additional information on how facilities recover energy from landfills.

4. Which regulations apply to energy recovery from waste?

Energy recovery from waste is important in the development of sustainable energy policies. EPA continues to develop regulations that encourage energy recovery from hazardous materials or materials that might otherwise be disposed of as solid waste.

Identification of Non-Hazardous Materials that are Solid Waste

The 2011 non-hazardous secondary material (NHSM) final rule under RCRA identifies which non-hazardous secondary materials are, or are not, solid wastes when burned in combustion units. This determines which Clean Air Act emission standards a combustion unit is required to meet.

Gasification

Gasification is a process that converts any material containing carbon—such as coal, petroleum or biomass—into synthesis gas (syngas) composed of hydrogen and carbon monoxide. The syngas can then be burned to produce electricity or further processed to produce vehicle fuel. As part of EPA's effort to promote flexible, innovative ways to convert waste to energy, EPA finalized an exclusion to RCRA's regulation for oil-bearing hazardous waste generated at a petroleum refinery in January 2008. This exclusion ensures that the gasification of these materials will have the same regulatory status (i.e., excluded) as other oil-bearing hazardous waste reinserted into the petroleum refining process.

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