Gasification Technologies Council

GASIFICATION

THE WASTE-TO-ENERGY SOLUTION

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INTRODUCTION

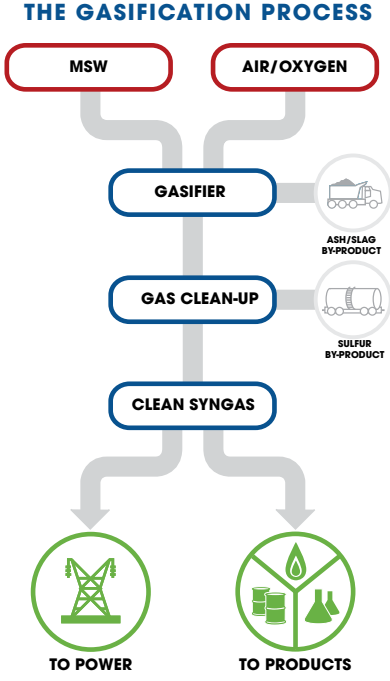
Each year, Americans generate about 250 million tons of Municipal Solid Waste, or MSW—about 4.3 pounds per person per day. This includes "trash" such as kitchen waste, electronics, light bulbs, plastics, used tires and old paint, and yard waste. Despite significant increases in recycling and energy recovery, only about one-third of the total MSW is recovered—leaving the remaining two-thirds to be disposed of in landfills or incinerated. But these traditional methods of waste disposal are becoming less viable.

Many states have banned incineration – or burning – of waste because of the negative environmental impacts. And a number of states, such as New York, New Jersey, Massachusetts, Connecticut and California, are faced with limited landfill space, forcing them to transport their MSW hundreds of miles for disposal in other states. In addition to consuming valuable land, the decomposing MSW generates methane, a greenhouse gas, and the leaching wastes may also pose a threat to surface water and groundwater.

Faced with the million-dollar problem of waste disposal, a growing number of municipalities are turning to **gasification**, a time-tested and environmentally-sound way of converting the energy in MSW into useful products such as electricity, fertilizers, transportation fuels and chemicals. On average, conventional waste-to-energy plants that use mass-burn incineration can convert one ton of MSW to about 550 kilowatt-hours of electricity. With gasification technology, one ton of MSW can be used to produce up to 1,000 kilowatt-hours of electricity, a much more efficient and cleaner way to utilize this source of energy.

WHAT IS GASIFICATION?

Gasification is a unique process that transforms any carbon-based material, such as MSW, into energy without burning it. Instead, gasification converts the materials into a gas by creating a chemical reaction. This reaction combines those carbon-based materials (known as feedstocks) with small amounts of air or oxygen, breaking them down into simple molecules, primarily a mixture of carbon monoxide and hydrogen, and removing pollutants and impurities. What's left is a clean "synthesis gas" (syngas) that can be converted into electricity and valuable products. With gasification, MSW and other types of wastes are no longer useless, but feedstocks for a gasifier. Instead of paying to dispose of and manage the waste for years in a landfill, using it as a feedstock for gasification reduces disposal costs and landfill space, and converts those wastes to electricity and fuels. (http://www.gasification.org/page_1.asp?a=82&b=79&c=85)



FEEDSTOCK

Gasifiers capture the remaining energy "value" from MSW.

OXYGEN/AIR

However, most MSW gasification plants use air. Gasifiers that use oxygen require an air separation unit to provide the gaseous/liquid oxygen; this is usually not cost-effective at the smaller scales used in MSW gasification plants. Air-blown gasifiers use the oxygen in the air for the gasification reactions.

GASIFIER

Before entering the gasifier, the MSW is typically shredded or ground into small particles. Then a controlled amount of air or oxygen (and steam for some gasifiers) is injected into the gasifier. The temperatures in a gasifier for MSW typically range from 1,100 to 1,800 degrees Fahrenheit.

Plasma gasifiers operate at higher temperatures and are discussed later in this brochure. See also http://www.gasification.org/page_1.asp?a=84&b=85.

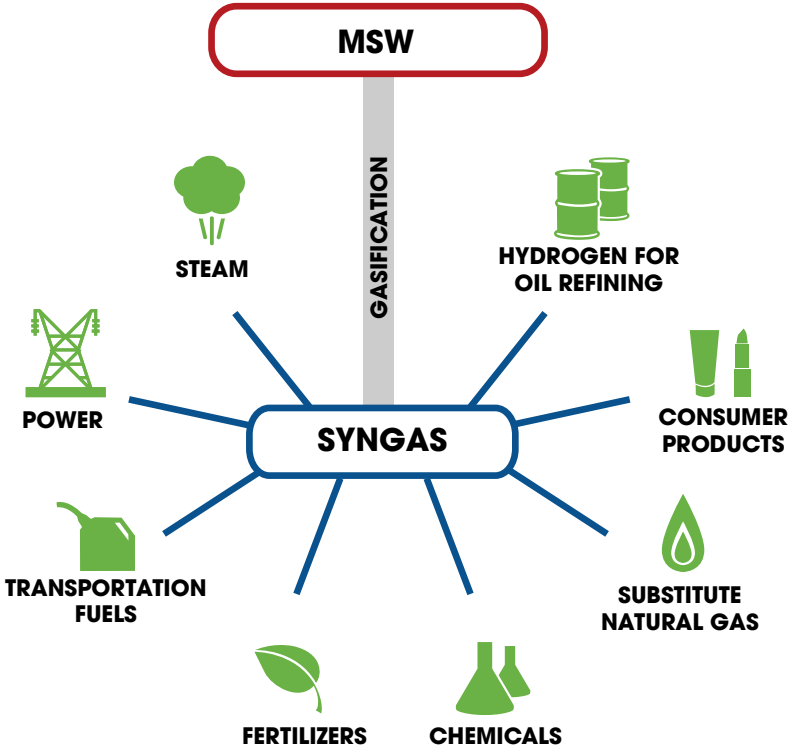
SYNGAS CLEANUP

Some downstream processes require that the syngas be cleaned of trace levels of impurities. Trace minerals, particulates, sulfur, mercury and unconverted carbon can be removed to very low levels using processes common to the chemical and refining industries. More than 95% of the mercury can be removed from syngas using commercially-available activated carbon beds.

CLEAN SYNGAS

The clean syngas can then be sent to a boiler, internal combustion engine or gas turbine to produce power or further converted into chemicals, fertilizers and transportation fuels. (http://www.gasification.org/page_1.asp?a=25&b=1&c=85)

GASIFICATION PRODUCTS



Gasification has been used worldwide on a commercial scale for more than 75 years by the chemical, refining and fertilizer industries, and for more than 35 years by the electric power industry. It is currently playing an important role in meeting energy needs in the U.S. and around the world. In new settings it is being adopted in smaller-scale applications to solve the problem of waste disposal and extract valuable energy from waste.

Gasification Can Recover Valuable Energy from Waste

Gasification can convert MSW that is normally incinerated into a clean, useful syngas

- This clean syngas can then be used to produce energy and valuable products, such as chemicals, transportation fuels, fertilizers, and electricity
- In the gasification process, MSW is not a fuel, but a **feedstock** for a high temperature chemical conversion process. There's no burning.
- Gasification does not compete with recycling; in fact, it enhances it. Metals and glass must be segregated from the waste stream prior to being sent into the gasification process. In addition, many plastics cannot be recycled and would otherwise end up in a landfill. Such plastics make excellent high energy feedstocks for gasification, thereby reducing the amount of those unrecyclable materials that would end up in a landfill.
- There are significant environmental benefits of MSW gasification, including reducing the need for landfill space, decreasing methane emissions from the decomposition of organic materials in the landfill, and reducing the risk of groundwater contamination from landfills.

*Gasification is **Not** Incineration*

The gasification process represents *significant* advances over incineration. In order to understand the advantages of gasification when compared to incineration, it's important to understand the differences between the two processes:

Incineration literally means to render to ash. Incineration uses MSW as a fuel, burning it with high volumes of air to form carbon dioxide and heat. In a waste-to-energy plant that uses incineration, these hot gases are used to make steam, which is then used to generate electricity.

Gasification converts MSW to a usable synthesis gas, or syngas. It is the production of this syngas which makes gasification so different from incineration. In the gasification process, the MSW is **not a fuel**, but a **feedstock** for a high temperature chemical conversion process. Instead of making just heat and electricity, as is done in a waste-to-energy plant using incineration, the syngas produced by gasification can be turned into higher value commercial products such as transportation fuels, chemicals, fertilizers, and substitute natural gas.

In addition, one of the concerns with incineration of MSW is the formation and reformation of toxic dioxins and furans, especially from PVC-containing plastics. These toxins end up in exhaust streams by three pathways:

- By decomposition, as smaller parts of larger molecules;
- By "re-forming" when smaller molecules combine together; and/or
- By simply passing through the incinerator without change.

Incineration does not allow control of these processes, and all clean-up occurs *after* combustion. One of the important advantages of gasification is that the syngas can be cleaned of contaminants **prior** to its use, eliminating many of the types of after-the-fact (post-combustion) emission control systems required by incineration plants. The clean syngas can be used in reciprocating engines or turbines to generate electricity or further processed to produce hydrogen, substitute natural gas, chemicals, fertilizers or transportation fuels, such as ethanol. (http://www.gasification.org/page_1.asp?a=87&b=85)

Gasification is significantly different from and cleaner than incineration:

- In the high temperature environment in gasification, larger molecules such as plastics, are completely broken down into the components of syngas, which can be cleaned and processed before any further use;
- Dioxins and furans need sufficient oxygen to form or re-form, and the oxygen-deficient atmosphere in a gasifier does not provide the environment needed for dioxins and furans to form or reform;
- Dioxins need fine metal particulates in the exhaust to reform; syngas from gasification is typically cleaned of particulates *before* being used;
- In gasification facilities that use the syngas to produce downstream products like fuels, chemicals and fertilizers, the syngas is quickly quenched, so that there is not sufficient residence time in the temperature range where dioxins or furans could re-form; and
- When the syngas is primarily used as a fuel for making heat, it can be cleaned as necessary *before* combustion; this cannot occur in incineration.

The ash produced from gasification is different from what is produced from an incinerator. While incinerator ash is considered safe for use as alternative daily cover on landfills, there are concerns with its use in commercial products. In high-temperature gasification, the ash actually flows from the gasifier in a molten form, where it is quench-cooled, forming a glassy, non-leachable slag that can be used for making cement, roofing shingles, as an asphalt filler or for sandblasting. Some gasifiers are designed to recover melted metals in a separate stream, taking advantage of the ability of gasification technology to enhance recycling.

GASIFICATION ENHANCES RECYCLING RATES

Gasification does not compete with recycling. In fact, it enhances recycling programs. Materials can and should be recycled and conservation should be encouraged. However, many materials, such as metals and glass, must be removed from the MSW stream before it is fed into the gasifier. Pre-processing systems are added up-front to accomplish the extraction of metals, glass and inorganic materials, resulting in the increased recycling and utilization of materials. In addition, a wide range of plastics cannot be recycled or cannot be recycled any further, and would otherwise end up in a landfill. Such plastics are an excellent, high energy feedstock for gasification.

Gasification's' Environmental Benefits

- Reduces the need for landfill space
- Decreases methane emissions from decomposition of MSW in landfills
- Reduces risk of surface water and groundwater contamination from landfills
- Extracts useable energy from waste that can be used to produce high value products
- Enhances existing recycling programs
- Reduces use of virgin materials needed to produce these high value products
- Reduces transportation costs for waste that no longer needs to be shipped hundreds of miles for disposal
- Reduces use of fossil fuels

PLASMA GASIFICATION

In an effort to reduce both the economic and environmental costs of managing MSW (which can include construction and demolition wastes), a number of cities are working with a specialized form of gasification called plasma gasification. In addition, various industries that generate hazardous wastes as part of their manufacturing processes (such as the chemical and refining industries) are examining plasma gasification as a cost-effective means of safely converting those waste streams to other forms of energy.

Plasma is an ionized gas that is formed when an electrical discharge passes through a gas. The resultant flash from lightning is an example of plasma found in nature. Plasma torches and arcs convert electrical energy into intense thermal (heat) energy. Plasma torches and arcs can generate temperatures up to 10,000 degrees Fahrenheit. When used in a gasification plant, plasma torches and arcs generate this intense heat, which initiates and supplements the gasification reactions, and can even increase the rate of those reactions, making gasification more efficient. This extreme heat maintains the gasification reactions, which break apart the chemical bonds of the feedstock and convert them to a synthesis gas (syngas). The syngas consists primarily of carbon monoxide and hydrogen—the basic building blocks for chemicals, fertilizers, substitute natural gas, and liquid transportation fuels. The syngas can also be sent to gas turbines or reciprocating engines to produce electricity, or combusted to produce steam for a steam turbine-generator.

Because the feedstocks reacting within the gasifier are converted into their basic elements, even hazardous waste becomes a useful syngas. Inorganic materials in the feedstock are melted and fused into a glassy-like slag, which is nonhazardous and can be used in a variety of applications, such as roadbed construction and roofing materials. (http://www.gasification.org/page_1.asp?a=84&b=85)

COMMERCIAL USE

Plasma technologies have been used for over 30 years in a variety of industries, including the chemical and metals industries. Historically, the primary use of this technology has been to safely decompose and destroy hazardous wastes, as well as to melt ash from mass-burn incinerators into a safe, non-leachable slag. Use of the technology as part of the waste-to-energy industry is much newer.

There are currently plasma gasification plants operating in Japan, Canada and India. For example, a facility in Utashinai, Japan has been in commercial operation since 2001, gasifying MSW and auto shredder waste to produce electricity. There are a number of proposed plasma gasification plants in the United States.

For more information about gasification and list of GTC members that are active in waste gasification see www.gasification.org.

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