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Gasification the waste-to-energy solution

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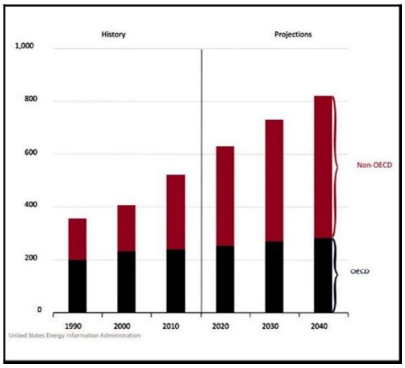
ABSTRACT: *According to the World Bank, the world currently generates about 4 billiontons of all types of waste per year. The world's cities alone generate about 1.5 billion tons of solid waste per year. This volume is expected to increase to 2.4 billion tons by 2025. In lower income countries, waste generation will more than double over the next 25 years. Three-fourths of this waste is disposed of in landfills, with only one fourth being recycled. The United States alone generates 389 million tons of MSW per year, with approximately 63.5% being landfilled (Generation and Disposition of Municipal Solid Waste (MSW) in the United States–A National Survey, 2013 Columbia University).This municipal solid waste (MSW) includes "trash" such as kitchen waste, electronics, light bulbs, plastics, used tires and old paint, and yard waste.*

Key words: *gasifier, syngas and plasma gasification, Increasing energy demand*

Introduction

In the U.S., Japan, and Europe, laws and regulations have significantly increased recycling and reuse of materials reclaimed from MSW. Despite significant increases in recycling and energy recovery in those areas, only about a fourth of the total MSW is recovered—leaving the remaining three-fourths to be disposed of in landfills or incinerated (burned). But these traditional meth-ods of waste disposal are increasingly becoming less viable. In some countries, where there is limited landfill space, or where new laws and regulations either ban disposal of MSW in landfills or require very high landfill disposal fees, the traditional options of landfilling and incineration are becoming less feasible. In addition to consuming valuable land, decomposing MSW generates methane, a greenhouse gas, and the leaching wastes may also pose a threat to surface water and groundwater. Further, some areas have banned incineration of waste because of the negative environmental impacts.



In addition to increasing waste generation, the global demand for energy will increase by 56 percent between 2010 and 2040, with the greatest demand in the developing world (US Energy Information Administration 2013). According to the World Bank, there are currently 1.2 billion people (20% of the world's population) without access to electricity (World Bank-Energy Facts). In India alone, 300 million people lack

any access to power and another 400 million Indians have limited access to power.

THE GASIFICATION SOLUTION

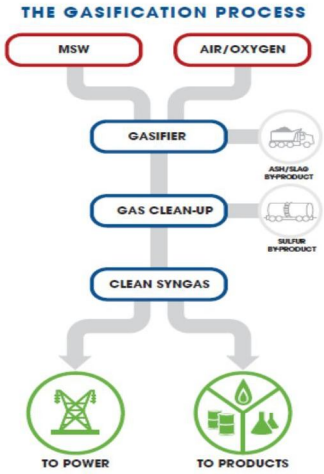
Faced with the costly problem of waste disposal and the need for more energy, a growing number of countries are turning to gasification, a time-tested and environmentally-sound way of converting the energy in MSW into useful products such as electricity, fertilizers, transportation fuels and chemicals. 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. Withgasification 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. Gasification can help the world both manage its waste and produce the energy and products needed to fuel economic growth.

WHAT IS GASIFICATION?

Gasification is a unique process that transforms a carbon-based material, What's produced is a synthesis gas (syngas) that can be converted into electricity and valuable products. With gasification, MSW and wastes are no longer useless, but they become 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 into valuable electricity, fuels, chemicals or fertilizers.

FEEDSTOCK

Gasifiers capture the remaining "value" from a variety of MSW streams such as MSW or biomass, into other forms of energy without actually burn-ing it. Instead, gasification converts the solid and liquid waste materials into a gas through a chemical reaction. This reaction combines those carbon-based materials (known as feedstocks) with small amounts of air or oxygen (but not enough to burn the materials), break-ing them down into simple molecules, primarily a mixture of carbon onoxide and hydrogen.



Feedstocks can include wood waste (sawdust and bark), crops, agricultural waste (corn stalks), wastewater treatment plant biosolids, MSW, animal wastes (stall wastes) and blends of the various feedstocks. Generally, the feedstock requires some pre-processing to remove the inorganic materials (such as metals and glass) that cannot be gasified. In addition, the MSW is typically shredded or ground into very small particles as well as dried before being fed into the gasifier.

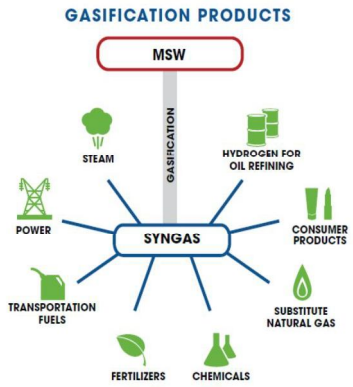
GASIFIER

The feedstock is fed into the gasifier along with a controlled amount of air or oxygen (and steam for some gasifiers). The temperatures in a gasifier for MSW typically range from 1,100 to 1,800ºF (600-1,000ºC). Plasma gasifiers operate at higher temperatures and are discussed later in this brochure.

SYNGAS CLEANUP

Many downstream processes require that the syngas be cleaned of trace levels of impurities. Trace minerals, particulates, sulfur compounds, mercury and unconverted carbon can be removed to very low levels using processes com-mon 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



- **Gasification Can Recover Valuable Energy from Waste**
- In the gasification process, MSW is not a fuel, but a **feedstock** for a high chemical conversion process. There's no burning.

The clean syngas can then be sent to a boiler, internal combustion engine or gas turbine to generate electricity or further converted into chemicals, fertilizers transportation fuels, or substitutes natural gas.

WHAT IS GASIFICATION USED FOR?

Gasification has been used worldwide on a commercial scale for making"town gas" from coal for heating, lighting and cooking for over 200 years. It has been used for more than 80 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 around the world, using a wide range of feedstocks that include coal, petroleum coke, and biomass. Gasification is now being adapted for smaller-scale applications to solve the problem of waste disposal and to extract valuable energy from waste.

- Gasification can convert MSW that would typically be 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.

Gasification does not compete with recycling; in fact, it enhances

- **it.** Metals, glass, and other materials that cannot be gasified are typically segregated from the waste stream prior to being sent into the gasification process. In addition, many plastics in MSW cannot be recycled and would otherwise end up in a landfill. Those plastics make excellent high energy feedstocks for gasification, thereby reducing the

amount of those unrecyclable materials that would otherwise 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 surface water and 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 intermediate product, 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 producing 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 even substitute natural gas. Incineration cannot achieve this.

Combustion versus Gasification

$C + O_2 \rightarrow CO_2$ $C + ½\ O_2 \rightarrow CO$

$C + CO_2 \rightarrow 2CO$ $C + H_2O \rightarrow CO + H_2$

A flame is present Syngas is produced

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 incinerator 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 in 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.

Gasification is significantly different from and cleaner than incineration:

- In the high temperature environment in gasification, larger molecules such as plastics, are broken down into the valuable

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 quench-cooled, 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 with incineration.
- 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

TYPES OF WASTE GASIFICATION

There are many types of gasifiers for waste gasification. These gasifiers vary in size and the type of MSW that they can gasify. Some gasifiers are designed to gasify construction and demolition debris, others are for MSW. Many gasifi-ers require some type of pre-processing of the MSW to remove the inorganic materials (such as metals and glass) that cannot be gasified. Some gasifiers require the shredding, drying and sizing of the feedstock before it is fed into the gasifier.

A number of companies are developing smaller, compact gasifiers designed to be used by cities and towns or on military bases.

PLASMA GASIFICATION

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 10,000ºF (5,500ºC). 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 incinera-tors into a safe, non-leachable slag.

CONCLUSION

As the world's population increases, so does the demand for energy and products, and so will the amount of waste generated. This waste represents both a threat to the environment and human health, but also a potential source of energy. Gasification can help address and solve these problems.

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