WESTINGHOUSE PLASMA GASIFICATION

ENERGY EVOLVED

CLEAN, SUSTAINABLE ENERGY RECOVERY THROUGH PLASMA GASIFICATION
clean renewable energy

Westinghouse Plasma has over 30 years of experience in research, development, testing, design and commercial use of proven plasma torch technology. The Westinghouse Plasma Gasification technology has been in operation globally for over 10 years and has successfully processed multiple feedstocks.

The Westinghouse Plasma Gasification technology has successfully processed municipal solid waste, auto shredder residue, sewage sludge and a variety of caustic hazardous materials. From a demonstration and pilot perspective, the list of feedstocks processed expands to include biomass, river and petrochemical sludges, ash and over 100 other feedstocks. Westinghouse Plasma Gasification technology provide energy solutions that are commercially proven, environmentally friendly, flexible and economical. Westinghouse Plasma provide service and support for engineering, equipment, design integration, start-up support and service parts, from greenfield solutions to meet the needs of new power or liquids production to retrofits of aging coal and oil fired power generation facilities.

Our Vision
To provide the leading technology platform for converting the world’s waste into clean energy for a healthier planet.

Our Mission
As the industry leader, we will forge and dominate an industry segment that transforms current waste management practices. We build shareholder value by enabling our customers to convert waste into clean energy by providing plasma gasification products, services and solutions that are innovative and environmentally friendly.
powering the world
THROUGH CLEAN POWER AND LIQUID ENERGY SOLUTIONS.

Westinghouse Plasma Corp. provides a complete design build solution. Our project scope is designed to minimize execution risk and provide the best possible solutions and service for our customers, including detailed facility engineering to the start-up and commissioning of your facility.

WESTINGHOUSE PLASMA GASIFICATION SOLUTION.

The Westinghouse plasma gasification solution (APGS) using Westinghouse Plasma Gasification technology provides clients with a syngas tailored to meet downstream process needs. Westinghouse works with partnering engineering, procurement and construction firms to provide a fully integrated balance of plant solution.

While Westinghouse supplies the critical components of the gasification system, the balance of plant engineering and design is supplied by engineering firms using equipment proven in applications throughout the world.

Westinghouse Plasma works with clients to design, develop and build the best solutions for waste processing. From providing 3D and simulation modeling, detailed design packages to real world expertise with a world class team, Westinghouse Plasma helps clients move beyond the design stage by providing assistance to project management details. These details include: material take-off, hazardous operation requirements, management & stakeholder communications, and improved process design. How a plant fits, where it fits, and the logistics surrounding the facility are all factors that must be considered in the planning of a plasma gasification facility.

Whether it’s analyzing and developing plans for buildings due to weather, road access, and proximity to other neighboring developments or addressing the environmental impact on the surroundings, Westinghouse Plasma is prepared to work with engineering firms to provide a complete solution.
westinghouse plasma technology is the key enabling technology

Feed Material
Receiving, Storage & Conveying

Industrial Waste
Commercial Waste
Waste Biomass
Household Waste
Medical Waste
Tires
Coal etc.

Plasma Torches
Air or Oxygen
Slag & Recovered Metals

FEED HANDLING
PLASMA GASIFICATION
SYNGAS CLEAN-UP & GAS COOLING

Feed Material Receiving, Storage & Conveying

Industrial Waste
Commercial Waste
Waste Biomass
Household Waste
Medical Waste
Tires
Coal etc.

Gasification is not incineration

WIDE VARIETY OF FEEDSTOCKS
LOW $ COST
FLEXIBLE PROCESS
GASIFIER

▪ Gasification is not incineration
CONVERTS MANY TYPES OF WASTE FEEDSTOCKS INTO A CLEAN SYNGAS, WHICH CAN BE FURTHER CONVERTED INTO ELECTRICITY, ETHANOL, GASOLINE, DIESEL FUEL AND A REPLACEMENT OF FUEL OIL. BETTER ECONOMICS AND ENVIRONMENTAL PERFORMANCE MAKE PLASMA GASIFICATION THE NEXT GENERATION OF WASTE CONVERSION TECHNOLOGY.

UNMATCHED APPLICABILITY TO MARKETABLE COMMODITIES

Gasification creates hydrogen and carbon monoxide: An energy rich gas stream
our technology

PLASMA GASIFICATION OFFERS
FLEXIBLE, EFFICIENT ENERGY RECOVERY.

With over 30 years of research and development, and over 500,000 hours of commercial torch operations, WPC has developed the industry’s leading plasma gasification technology – a highly efficient and reliable solution. Since acquiring WPC in 2007, Alter NRG has expanded on the development of the technology with engineering and operational design improvements. Testing is also ongoing at the Westinghouse Plasma Pilot Facility along with detailed engineering and verification.

The WPC technology is unique in its ability to process heterogeneous feedstock with minimal feed preparation, allowing for the blending of feedstocks such as municipal waste, construction and demolition waste, auto shredder residue, high-ash coal, biomass, liquids and slurries. This flexibility allows companies to optimize operations based on available feedstocks.

The WPC plasma gasification process yields a variety of outputs such as electricity, steam and liquid fuels, while reducing harmful greenhouse gas emissions. WPC plasma gasification is a proven technology that provides a solution for the issues of today by maintaining the balance between energy and the environment.

the plasma gasification process
**THE GASIFIER ISLAND BEHIND THE SYNGAS**

Our plasma gasification island (pictured below) operates at temperatures of 5,500°C (10,000°F), ensuring a complete conversion of the feedstock into syngas. The inorganic materials are released at the base of the gasifier as an inert slag which is cooled and is a benign, non-leachable product that can be sold as construction aggregate.

The Westinghouse Plasma gasification process is highly efficient. The overall energy recovered from the feedstocks processed by the WPC gasifier is approximately 80%. This recovered energy is a clean syngas that can be used to generate power, liquid fuels or other energy products. Of the total energy needed to run the gasification process, only 2-5% of that energy is used to power the plasma torches.

Given our equipment’s modular, scalable design, we can quickly install a plasma gasification system anywhere, for total project costs ranging from $30 to $300 million, making plasma technology accessible around the world.

**THE PLASMA GASIFICATION ISLAND**

<table>
<thead>
<tr>
<th>TORCH MODEL</th>
<th>POWER OUTPUT (KW)</th>
<th>VESSEL MODEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARC 3</td>
<td>80-300</td>
<td>P 5, W 15</td>
</tr>
<tr>
<td>MARC 11</td>
<td>350-800</td>
<td>G 65</td>
</tr>
<tr>
<td>MARC 11H</td>
<td>860-2,400</td>
<td>G 65</td>
</tr>
<tr>
<td>MARC 4.5</td>
<td>280-530</td>
<td>G 65</td>
</tr>
</tbody>
</table>
TOP OR SIDE FEED PORT
2 SYNGAS OUTLETS
SUPPORT RING
INTERNAL FEED PIPE
ACCESS DOOR
12 TERTIARY OXIDANT TUYERES
12 SECONDARY OXIDANT TUYERES
FLANGE FOR BOTTOM REMOVAL
4 PRIMARY OXIDANT TUYERES
4 PRIMARY TORCH TUYERES
STEAM RAISING WATER JACKET
2 SLAG OUTLETS

GASIFIER MODELS

<table>
<thead>
<tr>
<th>GASIFIER MODEL</th>
<th>APPROXIMATE CAPACITY (TONNES/DAY)</th>
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<tbody>
<tr>
<td></td>
<td>Feedstock</td>
</tr>
<tr>
<td>G 65</td>
<td>Waste</td>
</tr>
<tr>
<td></td>
<td>Biomass</td>
</tr>
<tr>
<td>W 15</td>
<td>Waste</td>
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<td>Biomass</td>
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<td></td>
<td>Hazardous Waste</td>
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Westinghouse Plasma Gasification has Significant Commercial Advantages

THE WESTINGHOUSE PLASMA TECHNOLOGY PROCESSES HAVE SIGNIFICANT BENEFITS WHICH HAVE ATTRACTED WORLD-LEADING INNOVATORS AS OUR CUSTOMERS.

Diverse Gasification Portfolio

Standard platforms

P 5
• Replaces up to 50,000 bbls/yr of fossil fuel
• 30 to 100 tpd of Waste
• Produces up to 5 MW electrical

W 15
• Replaces up to 150,000 bbls/yr of fossil fuel
• 100 to 290 tpd of Waste
• Produces up to 15 MW electrical

G 65
• Replaces up to 650,000 bbls/yr of fossil fuel
• 450 to 1000 tpd of Waste
• Produces up to 50 MW electrical

ENGINEERING SERVICES
• Feasibility Study
• Design Basis Memorandum (DBM)
• Process Design Package (PDP)

SCOPE OF SUPPLY
• Feed System
• Plasma gasification reactor
• Plasma torch systems
• Slag solidification system
• Initial syngas cooling & cleaning
• Syngas Cleaning Systems

We offer a range of standard products for many feedstocks and various types of projects.

Minimal feedstock preparation
• Typically a pre-sorting of recyclables and a one stage shredding of the material

Handles a wide range of feed compositions
• High moisture content
• High inert content
• Blend any number of solid or liquid feedstock’s
• Ability to blend feedstocks reduces project feedstock risk and significantly increases project economics

High reliability
• Operates in rugged industrial applications
• Over 500,000 hours and 20 years of industrial use of the plasma torches

Low emissions and waste by-products
• Syngas, after cleanup, burns clean like natural gas
• Vitrified slag is inert/non-leaching and is being used as a construction aggregate
• Low greenhouse gas footprint when compared to alternative methods of creating power
The syngas clean-up process removes unwanted chemicals from the syngas, preventing harm to human health, the environment and the facility’s equipment. Syngas clean-up options are based upon feedstock and syngas application (ie: electricity or liquids). Based on the plasma gasification facility’s inputs and end products, the engineering, procurement and construction for the facility will design the optimal syngas clean-up system based on the specific application and configuration. One example for syngas clean-up used in a power generation process: upon exit from the gasification reactor, the syngas is rapidly cooled and particulate matter is removed by mixing with process water in a venturi scrubber and spray tower. Further removal of particulates occurs in a wet electrostatic precipitator. The temperature of the syngas is decreased and the pressure is increased to condense any moisture from the syngas. Removed process water is treated on-site to be reused within the facility. Any mercury present is removed as the syngas passes through activated carbon beds with sulfur being removed by a hydrolysis reaction and conversion to crystals. Following this process the syngas is used to generate power.
RECOVERY OF INORGANIC PRODUCTS

Inorganic and saleable products can be recovered from the plasma gasification process. Ferrous iron and fine aggregate are recovered from the molten material exiting the plasma gasification reactor, in addition to crystalline sulfur produced through syngas clean-up. The separation of mixed metals occurs when the molten material from the reactor is discharged into a quench bath. This results in metal modules which are then separated from the aggregate. The remaining slag material, consisting of a wide range of elements, primarily silica, can be used in numerous construction applications and products. All materials recovered add commercial value to the plasma gasification process.

FROM LOW VALUE FEEDSTOCKS

TO HIGH QUALITY PRODUCTS

By-product: Inert, Benign Vitrified Slag
Aggregate for use in Construction
Rockwool Insulation produced from Glass Slag