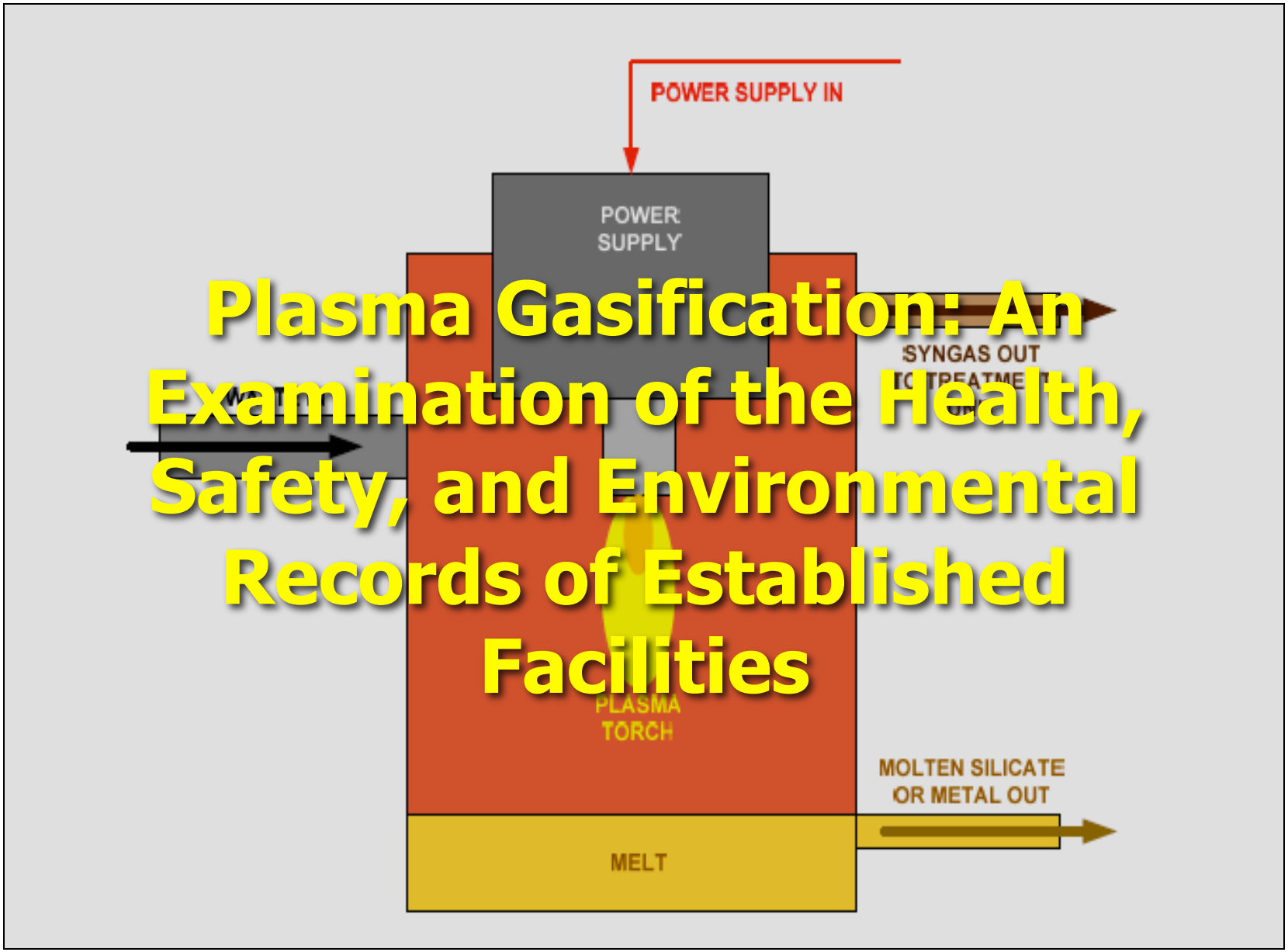
Plasma Gasification: An Examination of the Health, Safety, and Environmental Records of Established Facilities



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DOVETAIL PARTNERS INC.

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Plasma Gasification: An Examination of the Health, Safety, and Environmental Records of Established Facilities

- Background
- Plasma gasification vs. incineration
- The source separation issue
- Plasma gasification – inputs and outputs
  - Input capability
  - Products
  - Emissions and wastes
- Safety of plasma gasification facilities
- Why plasma gasification has not been used until now for processing MSW.
- Summary

This presentation addresses issues linked to the Palisade Plasma Arc Gasification Endeavor

Specifically the focus is on issues related to human health and safety and the environment.

Commercial Plasma Waste Processing Facilities

Europe				
Location	**Population**	**Materials Treated**	**Capacity (TPD)**	**Start Date**
Bordeaux, France	1.01 million	Ash from MSW	10	1998
Morcenx, France	4,993	Asbestos	22	2001
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Source: Georgia Tech Research Institute (2009).

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Kakogawa, Japan	268,565	MSW Ash	30	2003
Shimonoseki, Japan	1.5 million	MSW Ash	41	2002
Imizu, Japan	94,313	MSW Ash	12	2002
Maizuru, Japan	89,626	MSW Ash	6	2003
Iizuka, Japan	78,201	Industrial waste	10	2004
Osaka, Japan (Ibaraki Cty)	2.6 million	PCBs	4	2006
Taipei, Taiwan	22.2 million	Medical/ battery waste	4	2005

Source: Georgia Tech Research Institute (2009).

Plasma Gasification is Not New

The use of plasma torches is not new. Westinghouse began building plasma torches for NASA in conjunction with the Apollo Space Program as long ago as the 1960s.

The Use of Plasma Gasification to Large Scale Solid Waste Disposal is New

Plasma gasification of municipal solid waste is a fairly new application that combines well-established sub-systems into one new system.

The subsystems are waste processing and sorting, plasma treatment, gas cleaning, and energy production.

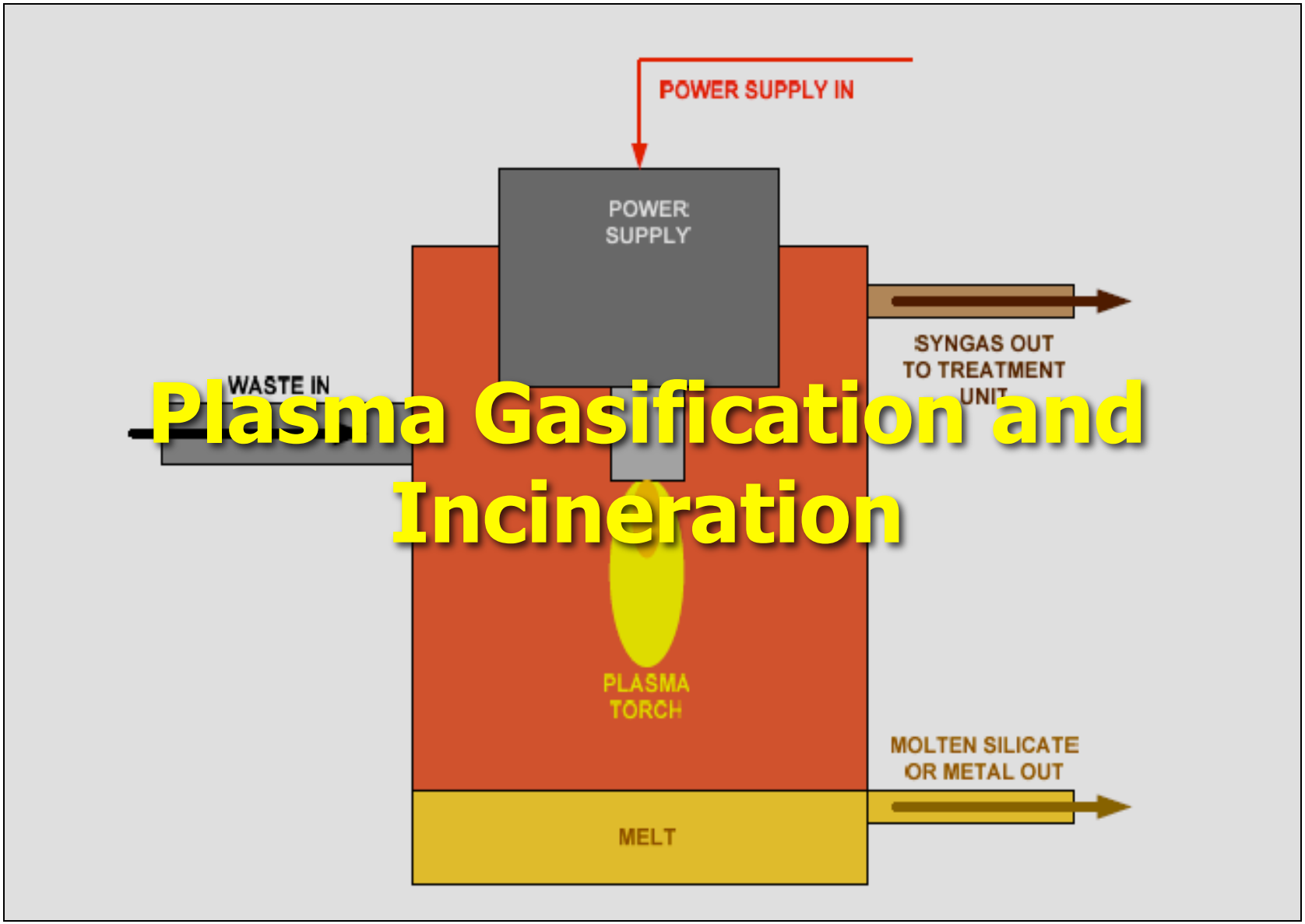
Plasma is simply a high-temperature ionized gas created within a plasma torch that is both thermally and electrically conductive.

Commonly used gases are air, nitrogen, carbon dioxide, steam, and argon.

Plasma Gasification is Not Incineration

Incineration is focused on reduction of waste to ash.

Plasma gasification involves *conversion* of waste to synthesis gas and inert slag, with recovery of energy and other products and (sometimes) valuable metals.



Plasma Gasification and Incineration

Differences Between Plasma Gasification and Incineration

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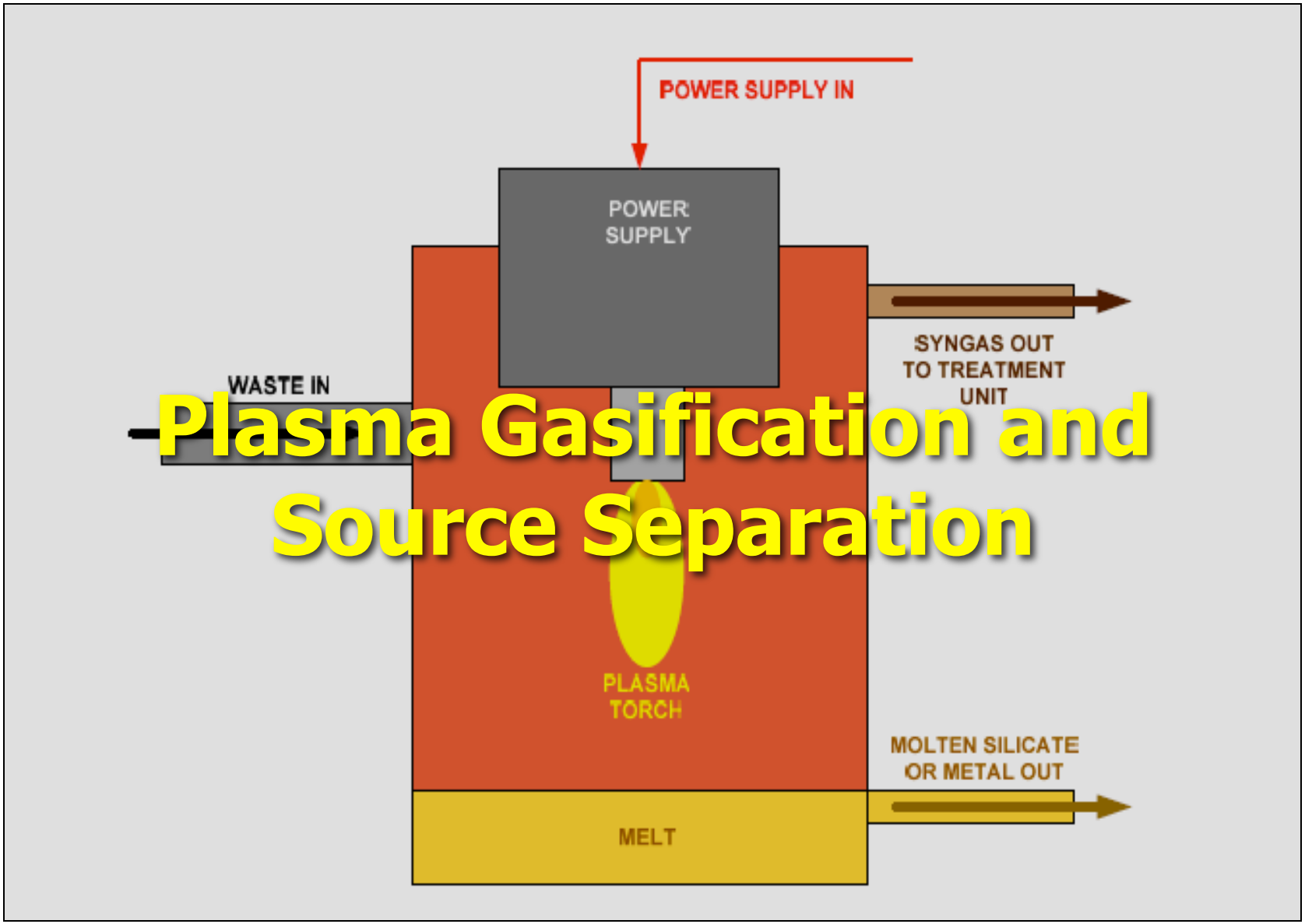
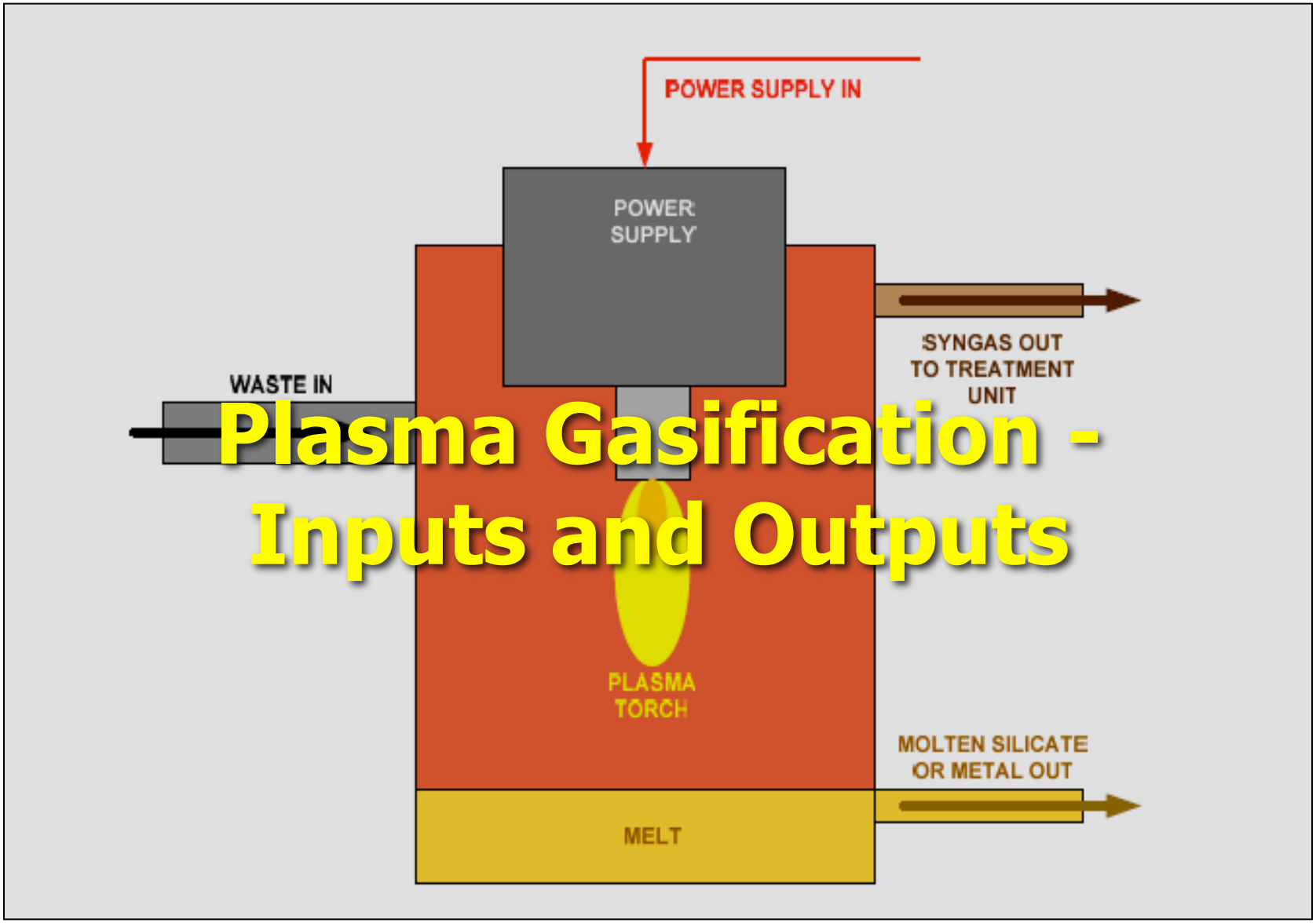
Emissions substantially lower than those resulting from incineration.	Far greater emissions of GHG and other pollutants than with thermal gasification systems.



Plasma Gasification and Source Separation

Source Separation is Recommended Prior to Plasma Gasification

- Although metals and other inorganic materials can be broken down, they have no energy content.
- Sorting MSW to recover recyclable commodities such as paper, metals, and high-value plastics can be a more effective way to recover energy.
- Capturing recyclables can represent a potential revenue stream.
- Wastes with high concentrations of halogen can lead to emissions of difficult-to-capture hydrogen halides and hydrogen sulfide.



Plasma Gasification - Inputs and Outputs

Input Capability

Virtually any material can be reduced using plasma gasification:

- Sludge
- Incinerator ash
- Hazardous fly ash
- Car fluff
- Medical wastes
- Pathological wastes
- PCBs
- Ferrous chromium wastes
- Ferro-manganese red. cpd.
- Rubber
- Tires
- Titanium scrap melt
- Niobium recovery products
- Electric arc furnace dust
- Portland cement mfg waste
- Paper/cardboard
- Plastics
- Plastic piping
- Fiberglass insulation
- Asbestos
- Glass
- Ceramics

Virtually any material can be reduced using plasma gasification:

- Asphalt shingles
- Used roadway asphalt
- Oil sands
- Sewage sludge
- Harbor sludge
- Composite materials containing resins.
- Linoleum
- Wood
- Treated wood
- Solvents/paints
- Mixed solid waste
- Steel beams
- Rebar
- Copper piping
- Steel, aluminum, and copper wire
- Concrete
- Stone
- Bricks
- Low-level radioactive waste

Products

Primary Products of Plasma Gasification

- Synthesis gas (a low to medium calorific value gas composed of carbon monoxide and hydrogen).
- A glass-like (vitrified) slag in $1/6^{th}$ to $1/16^{th}$ the volume of the original waste processed (volume depends on proportion of inorganics processed).
- Metals (if present in sufficient volume)
- Sulfur
- Chlorine

Emissions and Wastes

Emissions From Plasma Gasification

The plasma arc process itself produces little waste other than the vitrified slag.

However, when syngas is collected and cleaned for production of energy or industrial feedstocks, pollutants within the gas can escape.

Potential emissions include particulate matter, nitrogen oxide, sulfur dioxide and trioxide, mercury, dioxins and furans, and hydrochloric acid.

Hydrogen halides, hydrogen sulfide, and metals are also sometimes emitted.

Emissions From Plasma Gasification

Emissions are typically well within established limits and standards of even the most developed countries.

EPA Environmental Technology Verification Testing (2000) of InEnTec Plasma Arc Gasification of 10 tpd of Circuit Boards, Richland, Washington

Emissions ($mg/N\text{-}M^3@7\%O_2$)	Measured	USEPA Standard
PM	3.3	20
HCL	6.6	40.6
NOx	74	308
SOx	-	85.7
Hg	0.0002	50
Dioxins/furans* (ng/ $N\text{-}m^3$)**	0.000013	13

* Dioxins and furans are compounds consisting of benzene rings, oxygen, and chlorine that are considered to be toxic or hazardous.

** One *ng/Nm3* is one nanogram per normal cubic meter; Normal means at standard temperature and pressure.

EPA Environmental Technology Verification Testing (2000) of InEnTec Plasma Arc Gasification of 10 tpd of Medical Waste, Richland, Washington

Emissions (mg/N-M^3@7%O_2)	Measured	USEPA Standard
PM	<3.3	20
HCL	2.7	40.6
NOx	162	308
SOx	-	85.7
Hg	0.00067	50
Dioxins/furans* (ng/ N-m^3)**	0.0067	13

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Results of Third-Party Demonstration Source Tests (2008-2009) of Plasco Energy Plasma Arc Gasification of 110 tpd of MSW, Ottawa, Canada

Emissions ($mg/N\text{-}M^3@7\%O_2$)	Measured	EC 2000/76 Standard
PM	12.8	14
HCL	3.1	14
NOx	150	281
SOx	26	70
Hg	0.0002	14
Dioxins/furans* ($ng/N\text{-}m^3$)**	0.009245	0.14

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Results from our analysis [based on independent source test reports, compliance reports from regulatory agencies, and peer-reviewed publications] indicate that pyrolysis and gasification facilities currently operating throughout the world with waste feedstocks meet each of their respective air quality emission limits.

University of California (2009).

With few exceptions, most meet all of the current emission limits mandated in California, the United States, the European Union, and Japan. In the case of toxic air contaminants (dioxins/furans and mercury) every process evaluated met the most stringent emission standards worldwide. Facilities with advanced environmental controls are very likely to meet regulatory requirements in California. . .

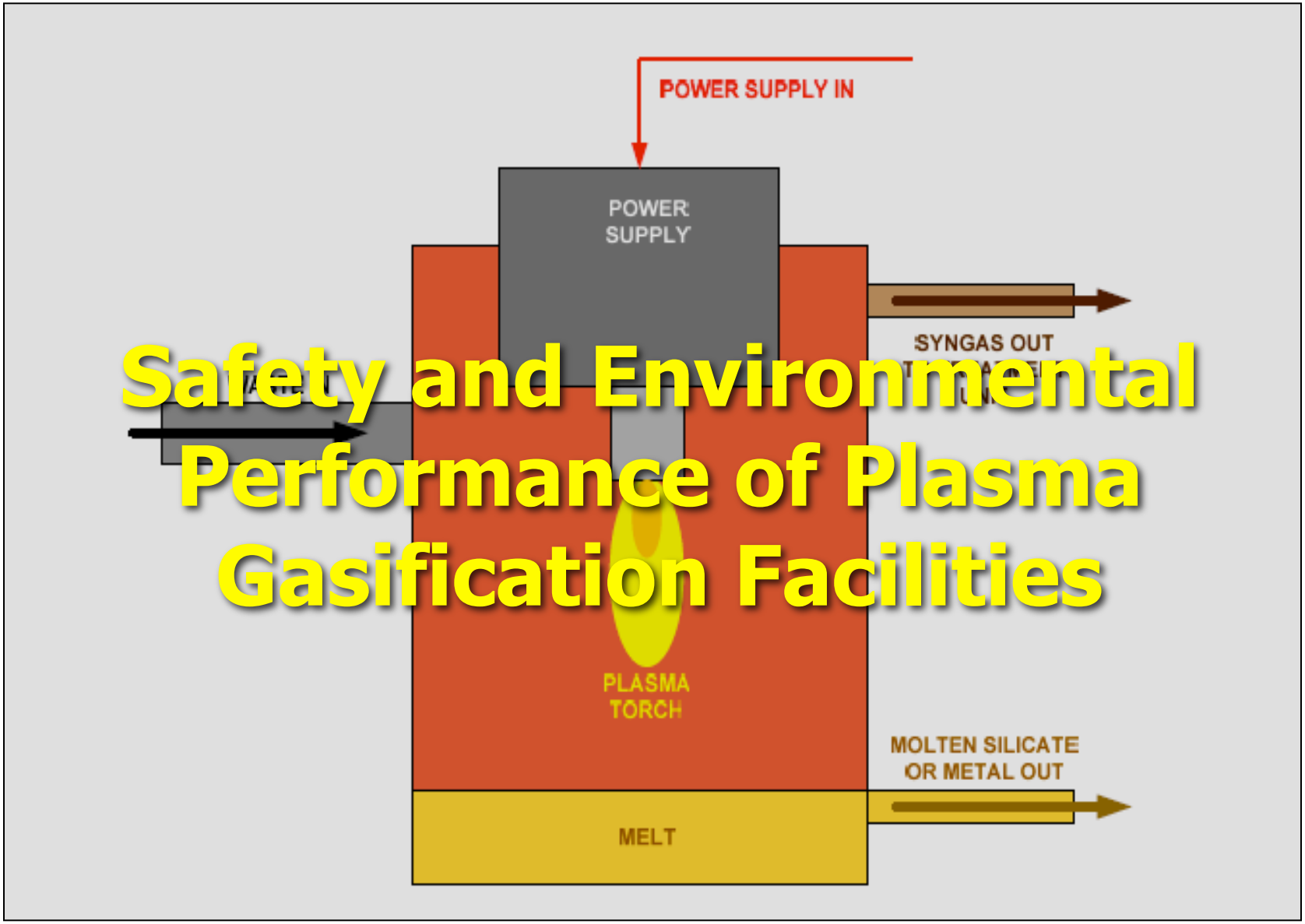
University of California (2009).

How Emissions From Plasma Gasification Compare to Those From Landfilling

Even sealed landfill systems tend to leak eventually, posing risks to ground and surface water.

Substantial quantities of methane also emanate from landfilled trash.

Safety and Environmental Performance of Plasma Gasification Facilities



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The only two plasma arc plants commercially treating mixed solid waste (MSW) in the world are those operating in

Utashinai and Mihama-Mikata, Japan.

There are a number of years of experience in Japan and in France of using plasma arc technology to treat ash from mixed solid waste incineration. No reports of operating problems for any of these plants were found.

Similarly, no reports of environmental or health/safety problems were found for plants treating materials including asbestos, tannery waste, aluminum dross, catalytic converters, medical wastes, and munitions.

One plant apparently did have emissions problems; a pilot facility operated by the Allied Technologies Group in Richland, Washington, designed for treatment of hazardous wastes, was reported to have exceeded emissions limits on several occasions.

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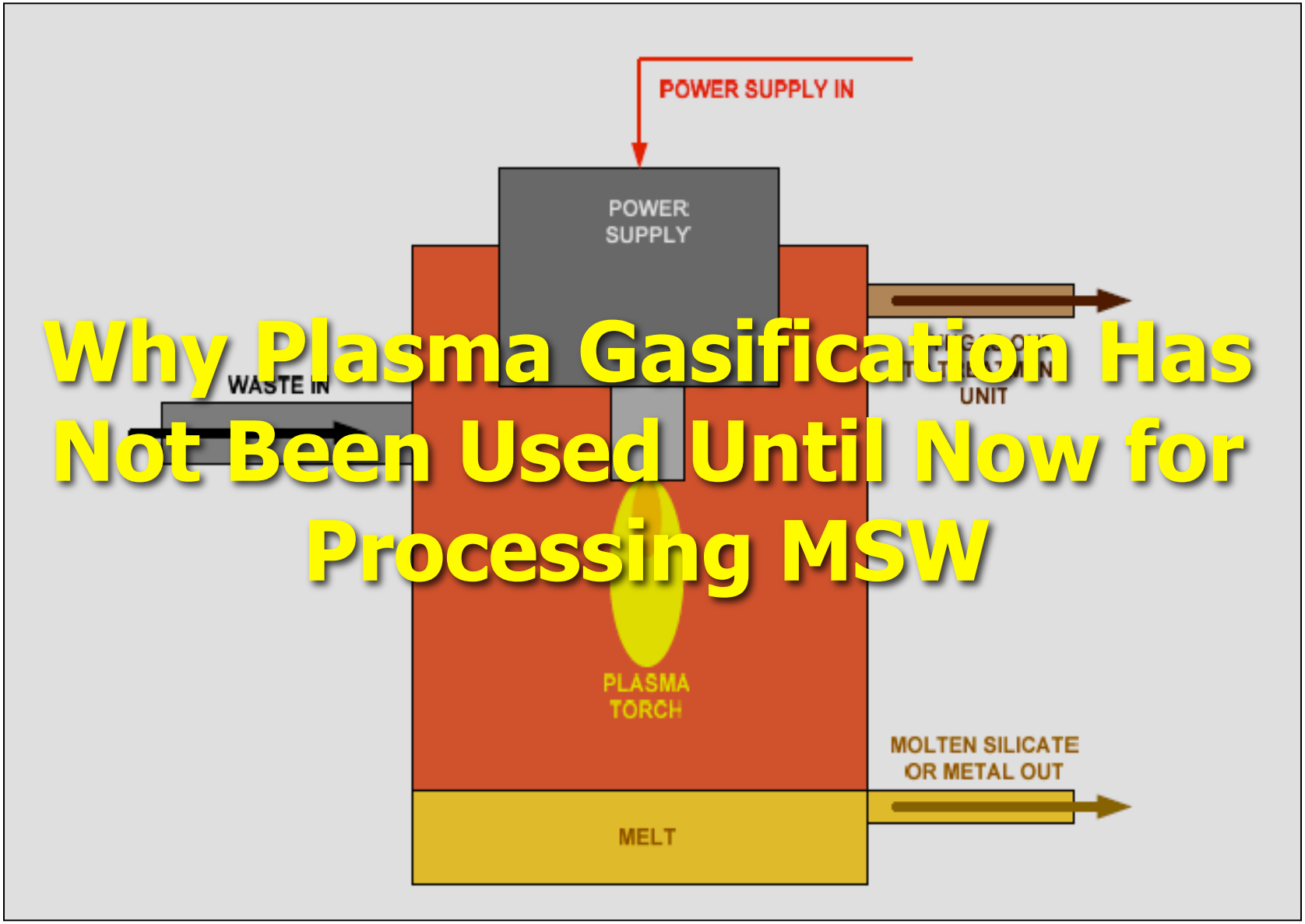
The only reported environmental problem occurred in 2007 when one or more specially coated bags used to absorb dioxins from flue gases failed; in that instance dioxin limits reportedly marginally exceeded emissions limits (but would not have exceeded US, EU, or Canadian standards).

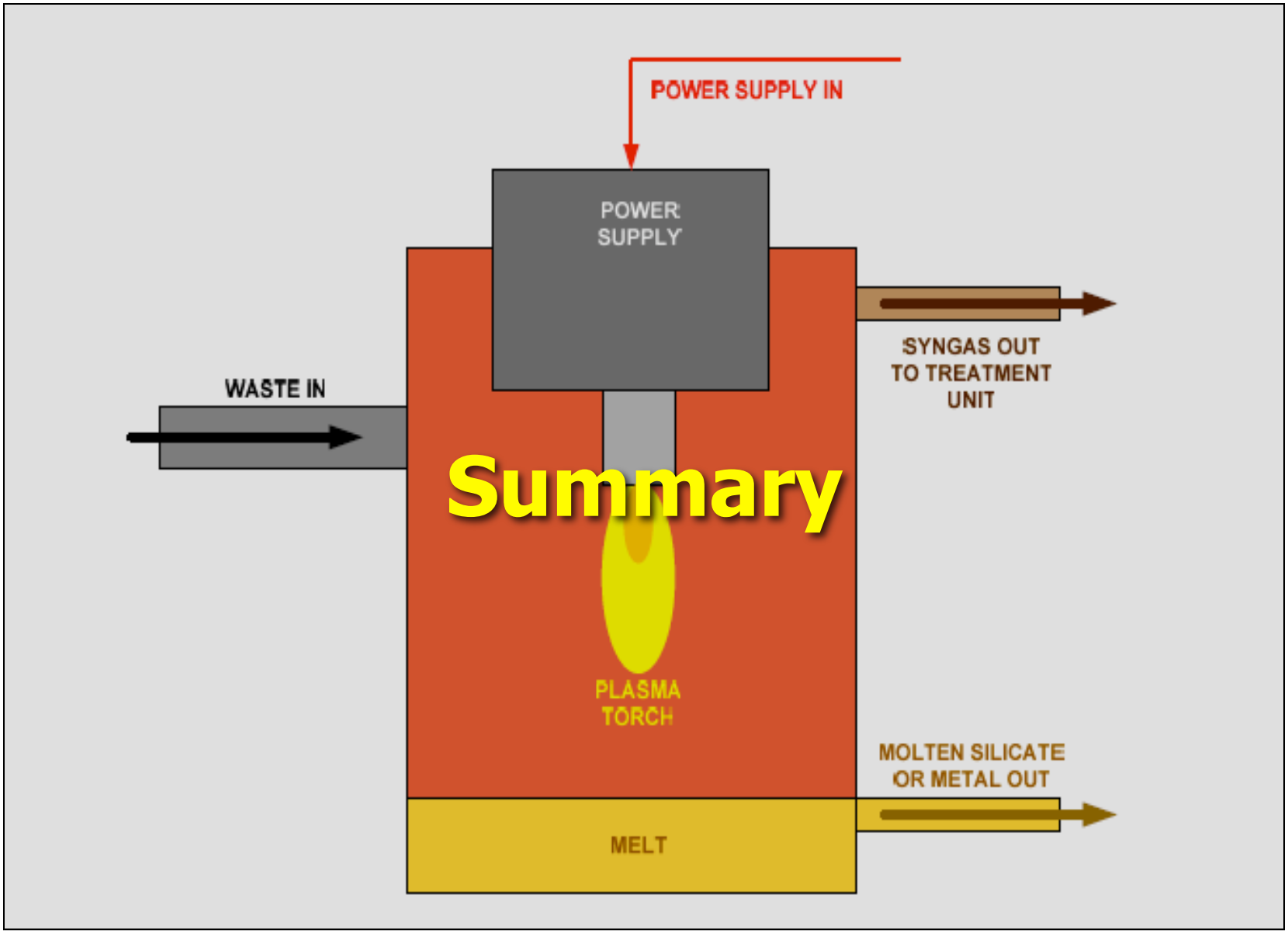
Karlsruhe, Germany
Fontodoce, Italy
Kanagawa, Japan



Why Plasma Gasification Has Not Been Used Until Now for Processing MSW

It is very clear that heath/safety and environmental concerns are not preventing acceptance of plasma gasification for large-scale treating of MSW. Instead, it is economic concerns that are most greatly inhibiting acceptance.

Some clarity regarding plasma arc potential for processing MSW may soon come to the North American scene. The much studied and often maligned Plasco pilot plant in Ottawa, Canada is on the verge of giving way to two large commercial scale facilities. A March 8 report indicates that contracts were signed on that date to build commercial-scale plasma arc MSW processing facilities in Ottawa and Red Deer, Alberta.


POWER SUPPLY IN
POWER SUPPLY
SYNGAS OUT TO TREATMENT UNIT
WASTE IN
Summary
PLASMA TORCH
MOLTEN SILICATE OR METAL OUT
MELT

Summary

- The plasma gasification process is distinctly different than incineration, resulting in fewer emissions, a smaller proportion of solid residue following processing, a residue (slag) that is inert and a potential raw material for value-added products, and a synthesis gas that can be used to generate heat or power, or as a feedstock for production of industrial chemicals or liquid fuels.
- Source separation prior to plasma arc processing is highly desirable from economic and environmental perspectives.

Summary

- Virtually any material can be decomposed in a plasma arc system. However, to achieve a favorable energy balance the volume of inorganics in the waste stream should be minimized.
- The main solid product of plasma gasification is a glass-like (vitrified) inert slag that amounts to 1/12th to 1/6th the volume of the original waste stream.

Summary

- Processing of large volumes of metals is prohibitive from an energy balance standpoint.
- There are no documented cases of health/safety incidents or issues in or related to plasma gasification plants.
- Despite occasional claims to the contrary, there *are* emissions from plasma gasification when gases are used in energy generation; with few exceptions, such emissions have been well within established limits.