

Plasma Arc Gasification of Municipal Solid Waste

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What is PLASMA?

- “Fourth State” of matter
- Ionized gas at high temperature capable of conducting electrical current
- Lightning is an example from nature



Commercial Plasma Torch



Plasma torch in operation



Characteristics of Plasma Arc Technology

- Temperatures 4,000°C to over 7,000°C
- Torch power levels from 100kW to 200 MW produce high energy densities (up to 100 MW/m³)
- Torch operates with most gases
 - Air most common
- A pyrolysis and/or gasification process
 - Not an incineration process
- Permits in-situ operation in subterranean boreholes

Plasma arc technology is ideally suited for waste treatment

- Hazardous & toxic compounds broken down to elemental constituents by high temperatures
 - Acid gases readily neutralized
- Organic materials
 - Gasified or melted
 - Converted to fuel gases (H_2 & CO)
 - Acid gases readily neutralized
- Residual materials (inorganics, heavy metals, etc.) immobilized in a rock-like vitrified mass which is highly resistant to leaching

Plasma Arc Technology

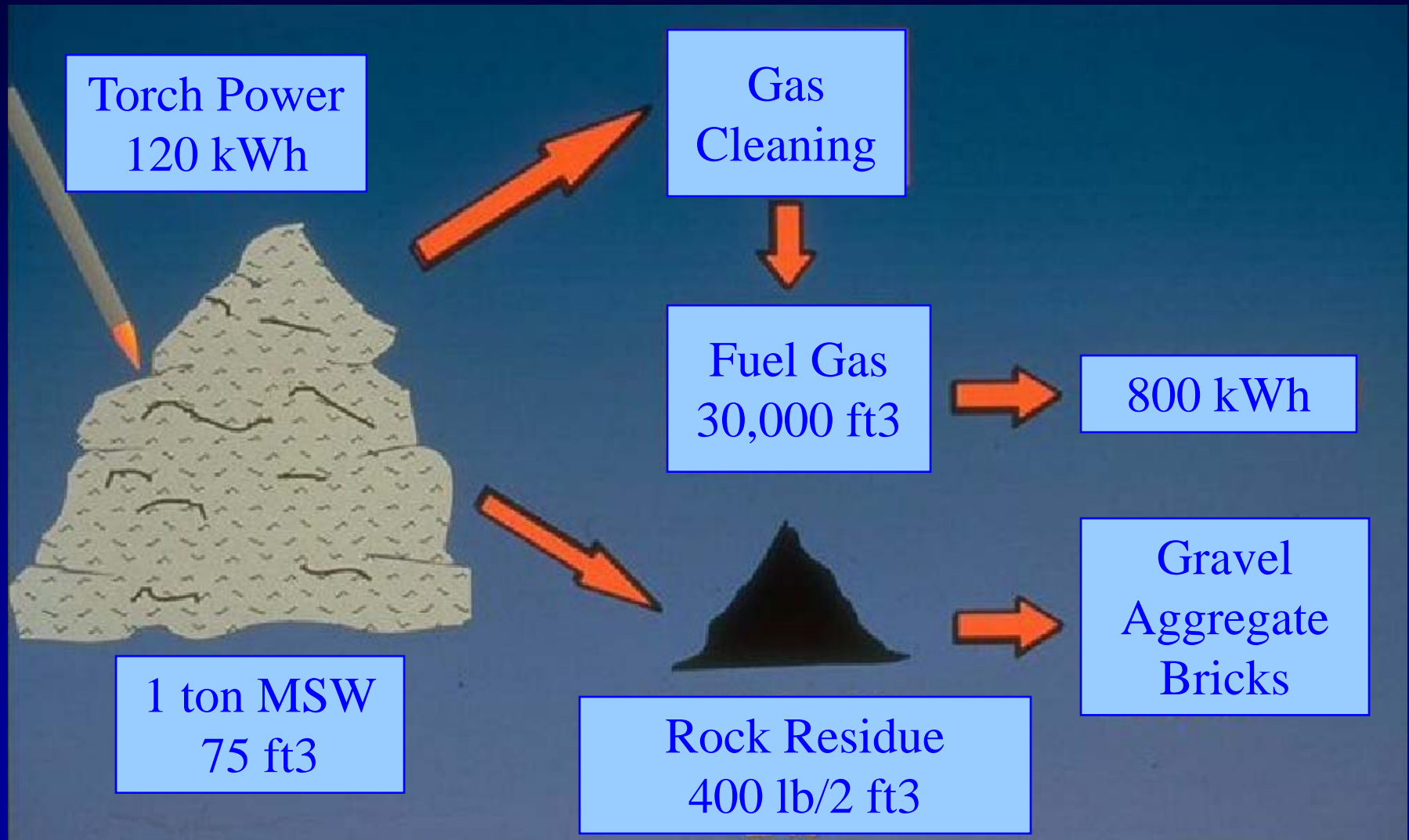
Remediation Facts

- No other remediation technology can achieve the sustained temperature levels ($>7000^{\circ}\text{C}$) or energy densities (up to 100 MW/m^3)
- All known contaminants can be effectively treated or remediated
- Contaminated soil, rock, and landfill deposits can be readily gasified or immobilized in a vitrified rock-like material

GTRI Plasma Research Initiatives

- Asbestos and asbestos-containing materials (ACM) destruction
- Municipal solid waste gasification and energy generation
- Incinerator ash vitrification
- In-situ landfill remediation and reclamation
- In-situ vitrification of contaminated soils
- In-situ soil stabilization

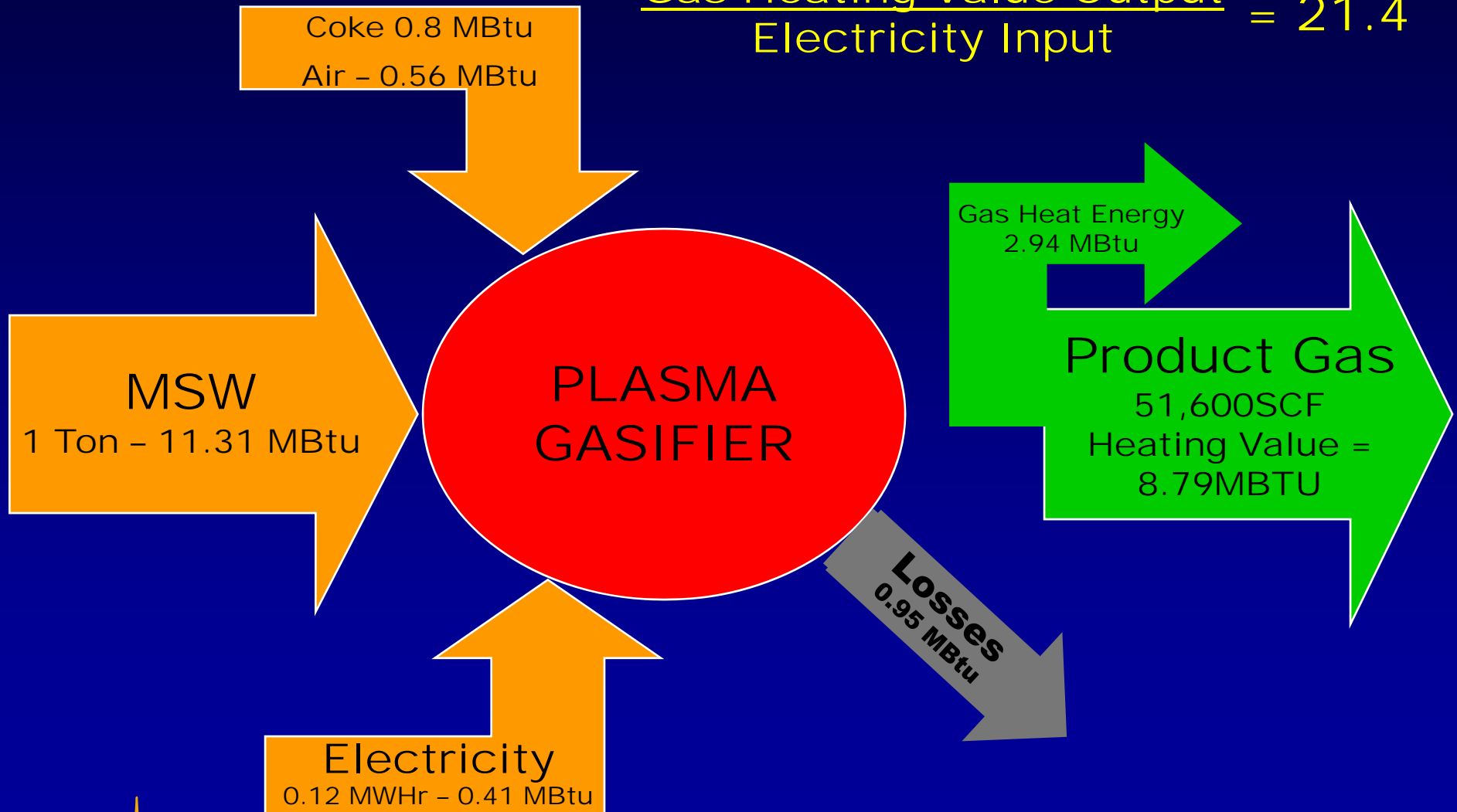
Pyrolysis of MSW



Plasma Gasification of MSW

Notional Heat Balance

$$\frac{\text{Gas Heating Value Output}}{\text{Electricity Input}} = 21.4$$



Municipal Solid Waste (MSW) – to – Electricity Thermal Process Comparisons

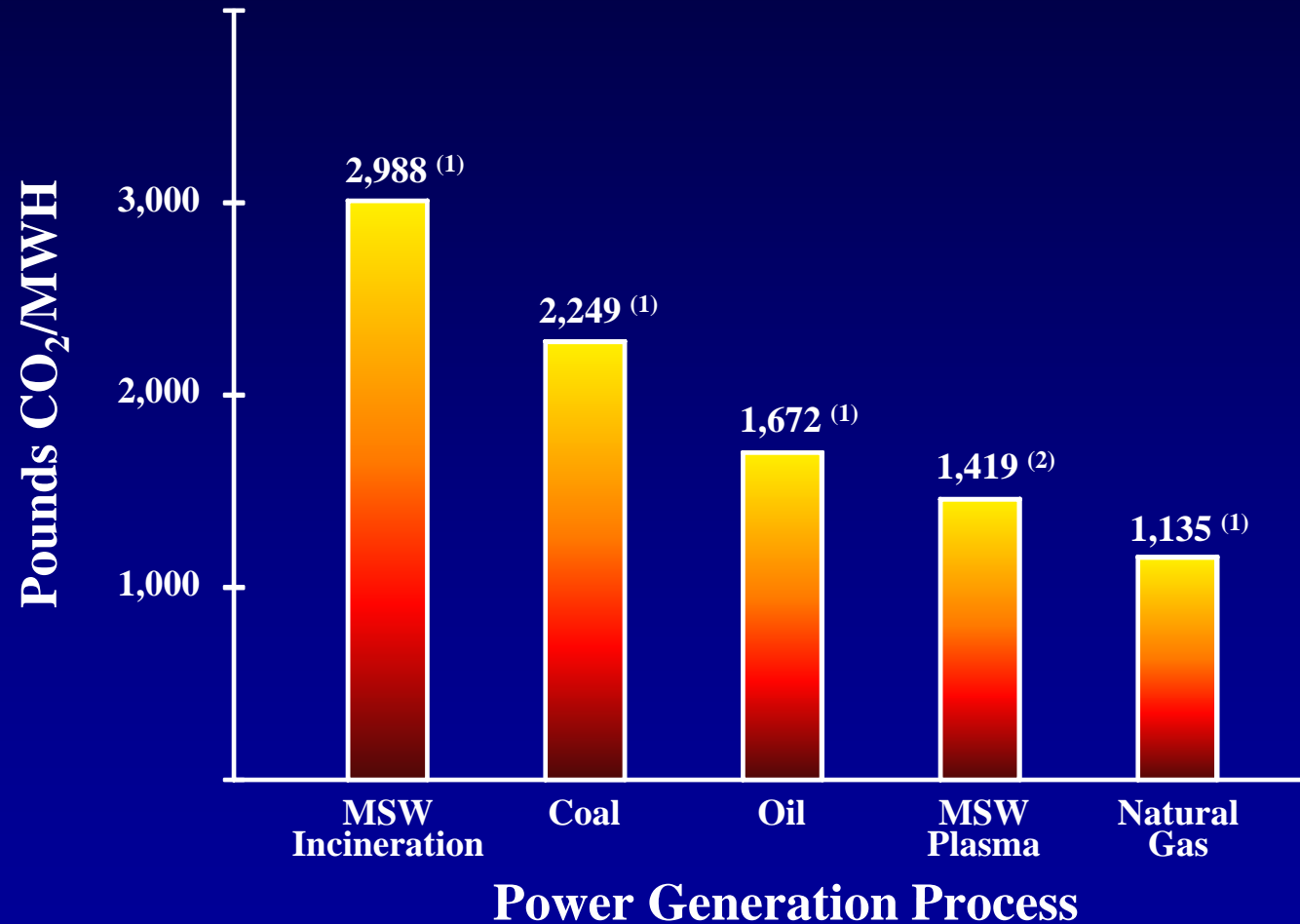
<u>Process</u> ⁽¹⁾	<u>Net Electricity to Grid</u> <u>(kWh/ton MSW)</u> ⁽²⁾	<u>Plasma Advantage</u>
• Plasma Arc Gasification	816	-
• Conventional Gasification	685	20%
- Fixed/Fluidized Bed Technologies		
• Pyrolysis & Gasification	685	20%
- Thermoselect Technology		
• Pyrolysis	571	40%
- Mitsui R21 Technology		
• Incineration	544	50%
- Mass Burn Technology		

(1) 300 – 3,600 TPD of MSW

(2) Steam Turbine Power Generation

Reference: EFW Technology Overview, The Regional Municipality of Halton, Submitted by Genivar, URS, Ramboll, Jacques Whitford & Deloitte, Ontario, Canada, May 30, 2007

Pounds of CO₂ Emissions per MWH of Electricity Produced



(1) EPA Document: www.epa.gov/cleanenergy/emissions.htm

(2) Complete Conversion of Carbon to CO₂; MSW Material & Heat Balance, Westinghouse Plasma Corp.

Ultimate MSW Disposal System Requirements

- Accept all solid and liquid wastes
 - No preprocessing
 - Can include hazardous/toxic materials, medical wastes, asbestos, tires, etc.
- Closed loop system
 - No direct gaseous emissions to the atmosphere
 - No landfill requirements
- Total waste reclamation
 - Recover fuel value of wastes
 - Produce salable residues (e.g., metals and aggregates)

Commercial Project

Plasma Gasification of MSW in Japan

- Commissioned in 2002 at Mihama-Mikata, Japan by Hitachi Metals, LTD
- Gasifies 24 TPD of MSW & 4 TPD of Wastewater Treatment Plant Sludge
- Produces steam and hot water for local industries



The Plasma Direct Melting Reactor (PDMR) at Mihama-Mikata, Japan converts unprocessed MSW and WWTP Sludge to fuel gas, sand-size aggregate, and mixed metal nodules

Commercial Project

Plasma Gasification of MSW in Japan

- Commissioned in 2002 at Utashinai, Japan by Hitachi Metals, LTD
- Original Design – gasification of 170 TPD of MSW and Automobile Shredder Residue (ASR)
- Current Design – Gasification of approximately 300 TPD of MSW
- Generates up to 7.9 MW of electricity with ~4.3 MW to grid



The Plasma Direct Melting Reactor (PDMR) at Utashinai, Japan converts unprocessed MSW and ASR to electricity, sand-size aggregate, and mixed metal nodules



*Q*ualifications to Permit, Finance, Construct
Operate and Own the St. Lucie County
Plasma Arc Gasification Facility

Prepared for

St. Lucie County

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GEOPLASMA
LLC

Planned St. Lucie County, FL GEOPLASMA Project

- 3,000 TPD of MSW from County and landfill
- 6 gasifier units @ 500 TPD each
 - Up to 6 plasma torches per cupola
 - Power levels of 1.2 to 2.4 MW per torch
- Energy Production
 - ~160 MW electricity with net of ~120 MW to grid
 - power for ~98,000 households
 - Steam sold to local industries
- Rock-like vitrified residue salable as construction aggregate

Planned GEOPLASMA Project (cont'd)

- County landfill eliminated in about 18 years
- Estimated capital cost approximately \$450 million
 - Similar to cost for WTE incinerator
- Tipping fees of ~\$30/ton will be profitable
 - Average U.S. tipping fees: \$35/ton

TRASH VAPORIZATION

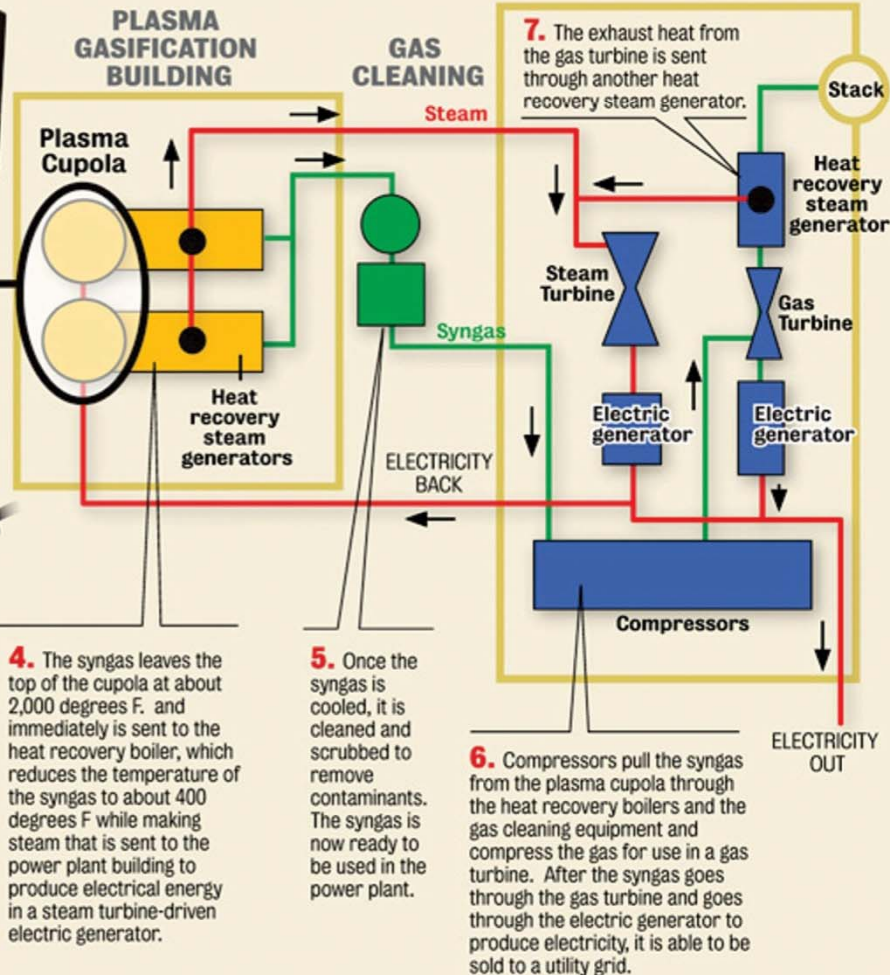
1. Waste is conveyed from the storage area up to the entry into the plasma cupola and enters the cupola via an air lock chamber.

2. The extremely hot (10,000 degrees F) plasma torches at the bottom of the cupola convert the waste into either a fuel gas or a liquid slag.

3 cont. the slag runs out the bottom into a pool of water. The slag is converted into granular pieces that are completely inert and can be used as aggregate (a crushed stone product that is used for constructing foundations, roads, etc.) or shaped into paving bricks or other construction materials.

3. The process is oxygen-deprived (meaning there is no combustion) and it creates a synthetic fuel gas called syngas. The syngas leaves the cupola at the top while...

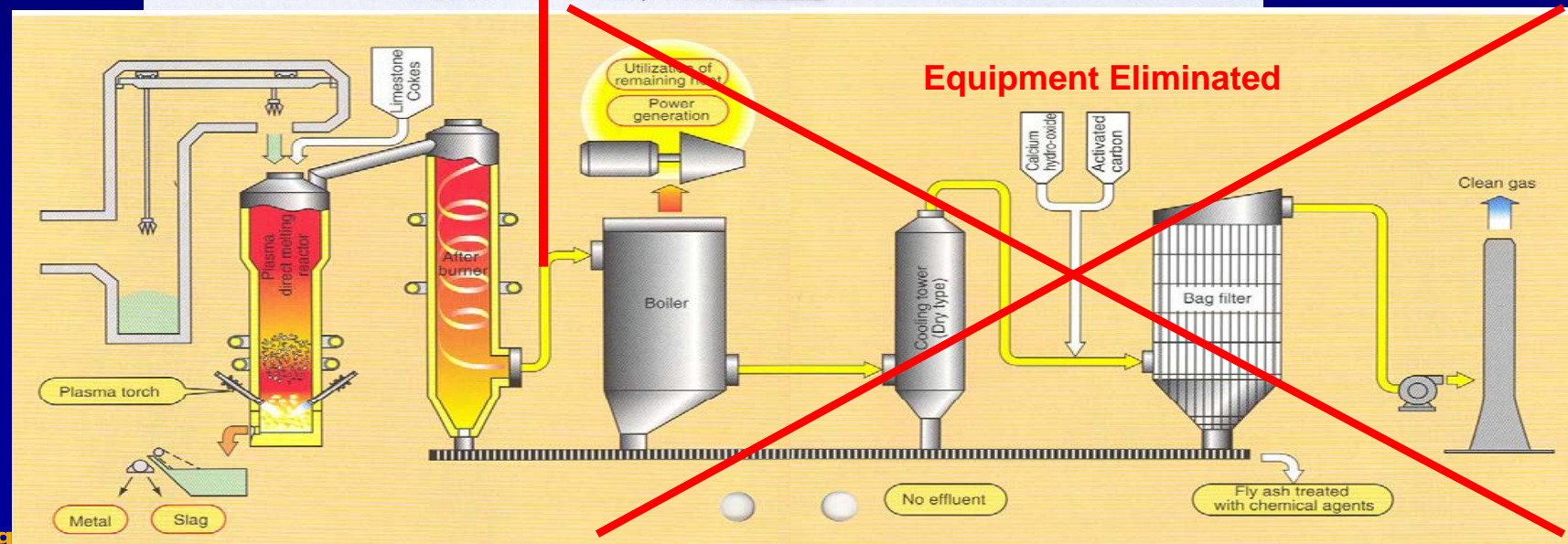
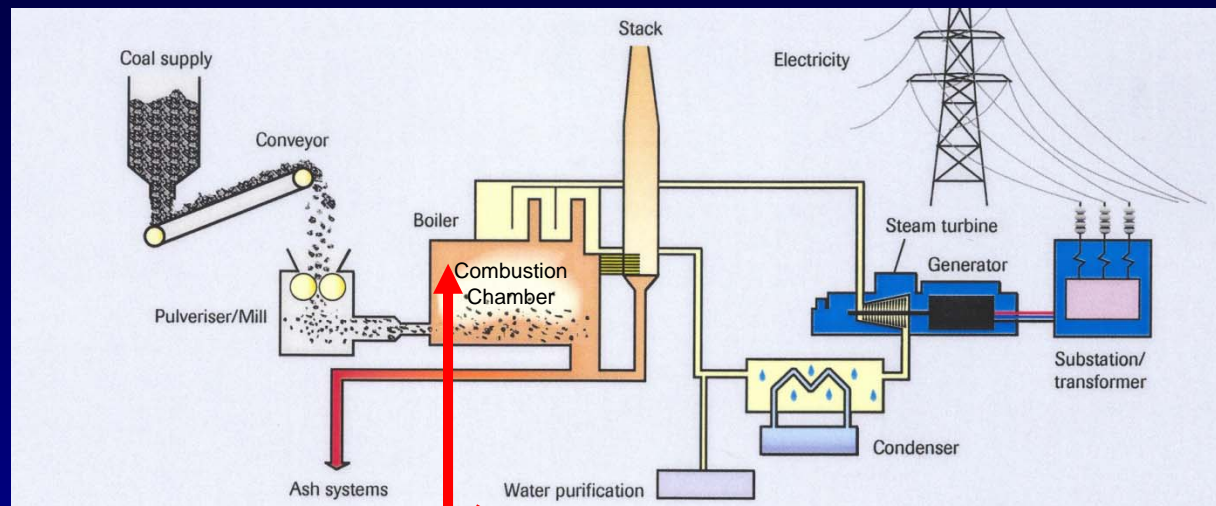
PROPOSED WASTE PLASMA PLANT



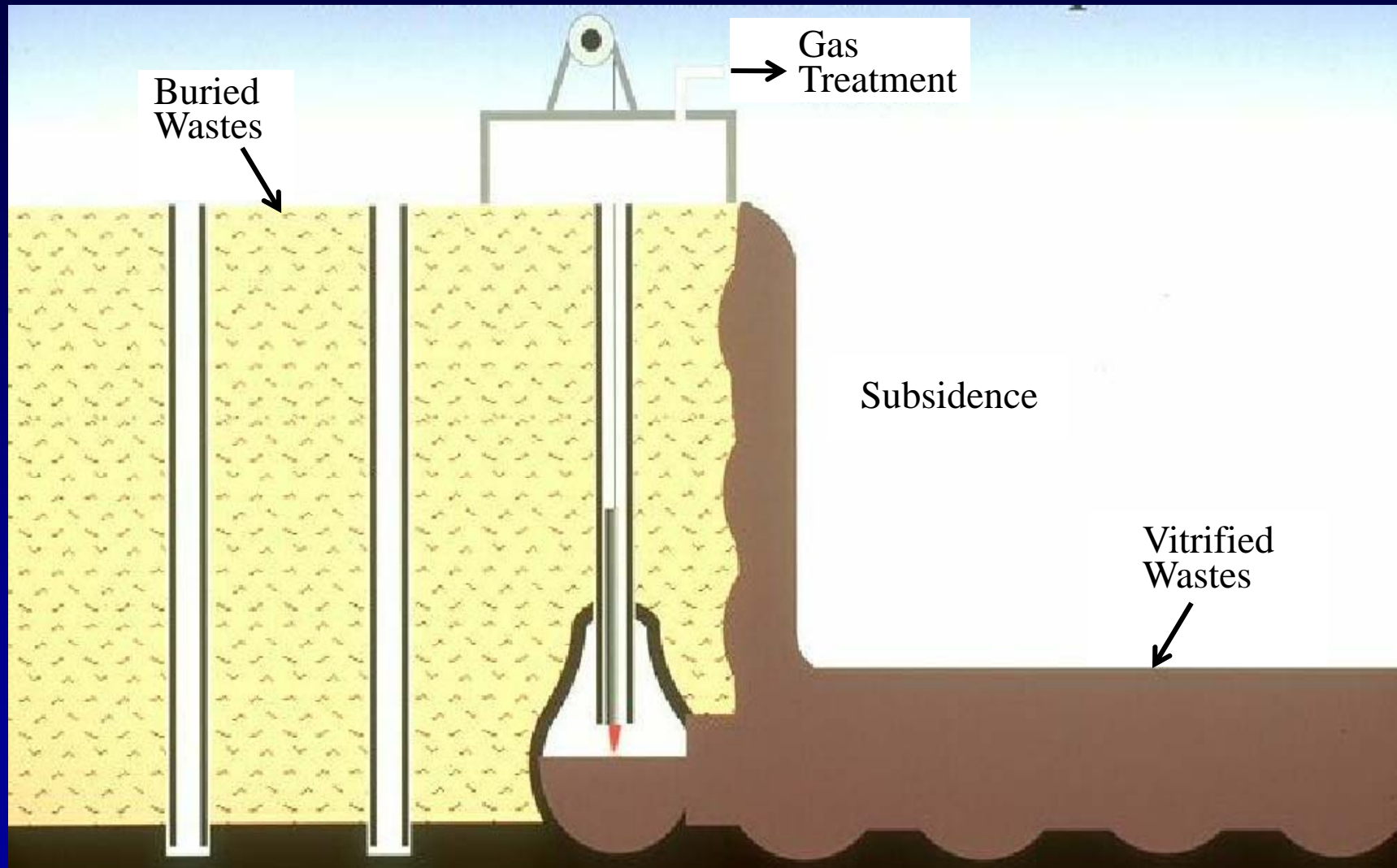
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Plasma Processing of MSW at Fossil Fuel Power Plants



Landfill remediation concept



Commercial Plasma Waste Processing Facilities (Asia)

Location	Waste	Capacity (TPD)	Start Date
Mihama-Mikata, JP	MSW/WWTP Sludge	28	2002
Utashinai, JP	MSW/ASR	300	2002
Kinuura, JP	MSW Ash	50	1995
Kakogawa, JP	MSW Ash	30	2003
Shimonoseki, JP	MSW Ash	41	2002
Imizu, JP	MSW Ash	12	2002
Maizuru, JP	MSW Ash	6	2003
Iizuka, JP	Industrial	10	2004
Osaka, JP	PCBs	4	2006
Taipei, TW	Medical & Batteries	4	2005

Commercial Plasma Waste Processing Facilities (Europe & North America)

Location	Waste	Capacity (TPD)	Start Date
Bordeaux, FR	MSW ash	10	1998
Morcenx, FR	Asbestos	22	2001
Bergen, NO	Tannery	15	2001
Landskrona, SW	Fly ash	200	1983
Jonquiere, Canada	Aluminum dross	50	1991
Ottawa, Canada	MSW	85	2007 (demonstration)
Anniston, AL	Catalytic converters	24	1985
Honolulu, HI	Medical	1	2001
Hawthorne, NV	Munitions	10	2006
Alpoca, WV	Ammunition	10	2003
U.S. Navy	Shipboard	7	2004
U.S. Army	Chemical Agents	10	2004

Summary and Conclusions

- Plasma processing of MSW has unique treatment capabilities unequaled by existing technologies
- It may be more cost-effective to take MSW to a plasma facility for energy production than to dump it in a landfill
- Plasma processing of MSW in the U.S. could:
 - Significantly reduce the MSW disposal problem
 - Significantly alleviate the energy crisis
 - Reduce the need for landfills

Summary and Conclusions – cont'd

- Plasma processing of MSW has the potential to supply ~5% of U.S. electricity needs
 - Equivalent to ~25 nuclear power plants
- Can create more renewable energy than the projected energy from solar, wind, landfill gas and geothermal energies combined
- When fully developed, it may become cost-effective to mine existing landfills for energy production