Plasma Arc Gasification
of
Municipal Solid Waste

Louis J. Circeo, Ph.D.

Principal Research Scientist

Director, Plasma Applications Research Program

Georgia Tech Research Institute

Electro-Optical Systems Laboratory

What is PLASMA?

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

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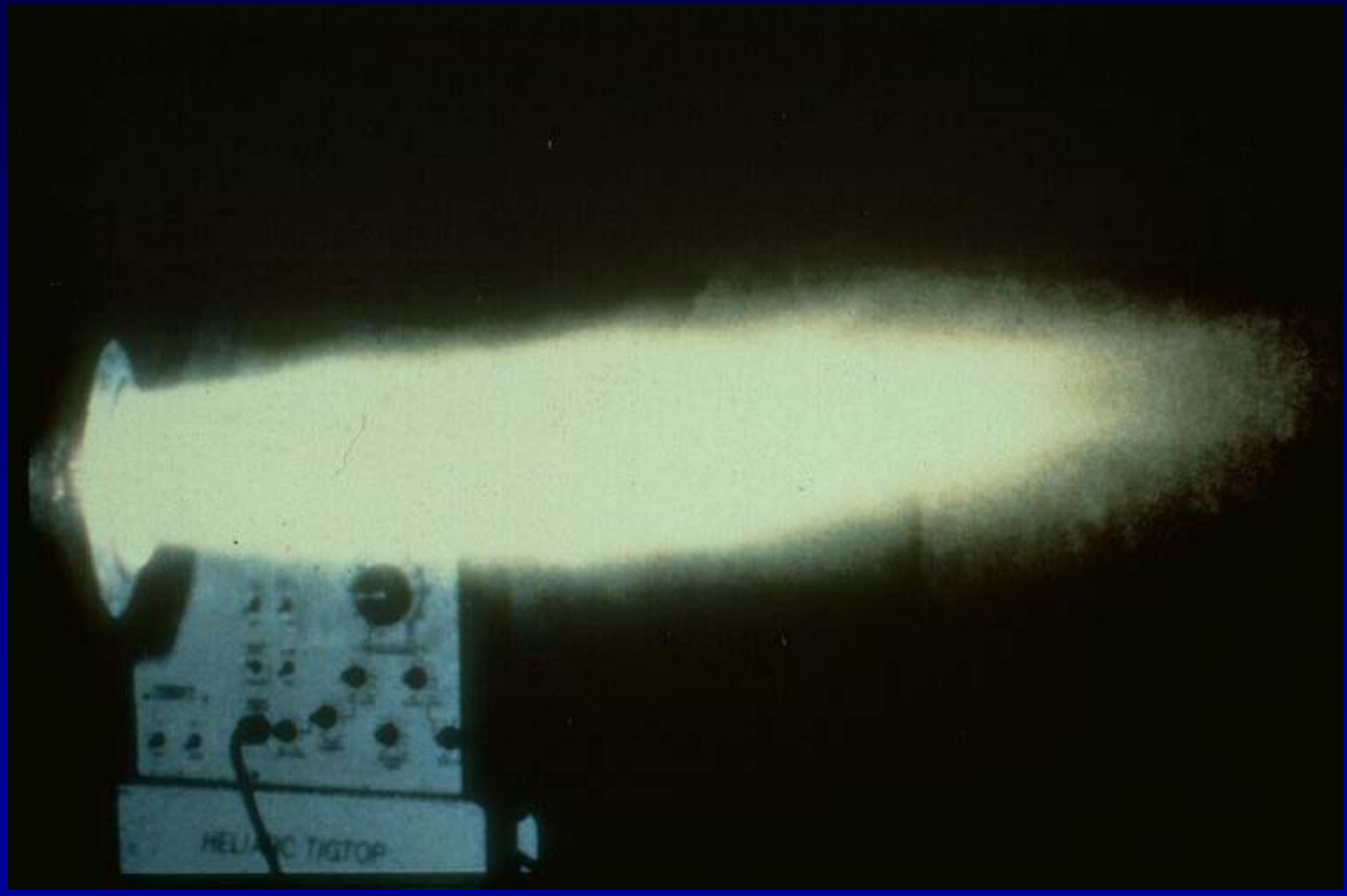
Commercial Plasma Torch

Plasma torch in operation



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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°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

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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

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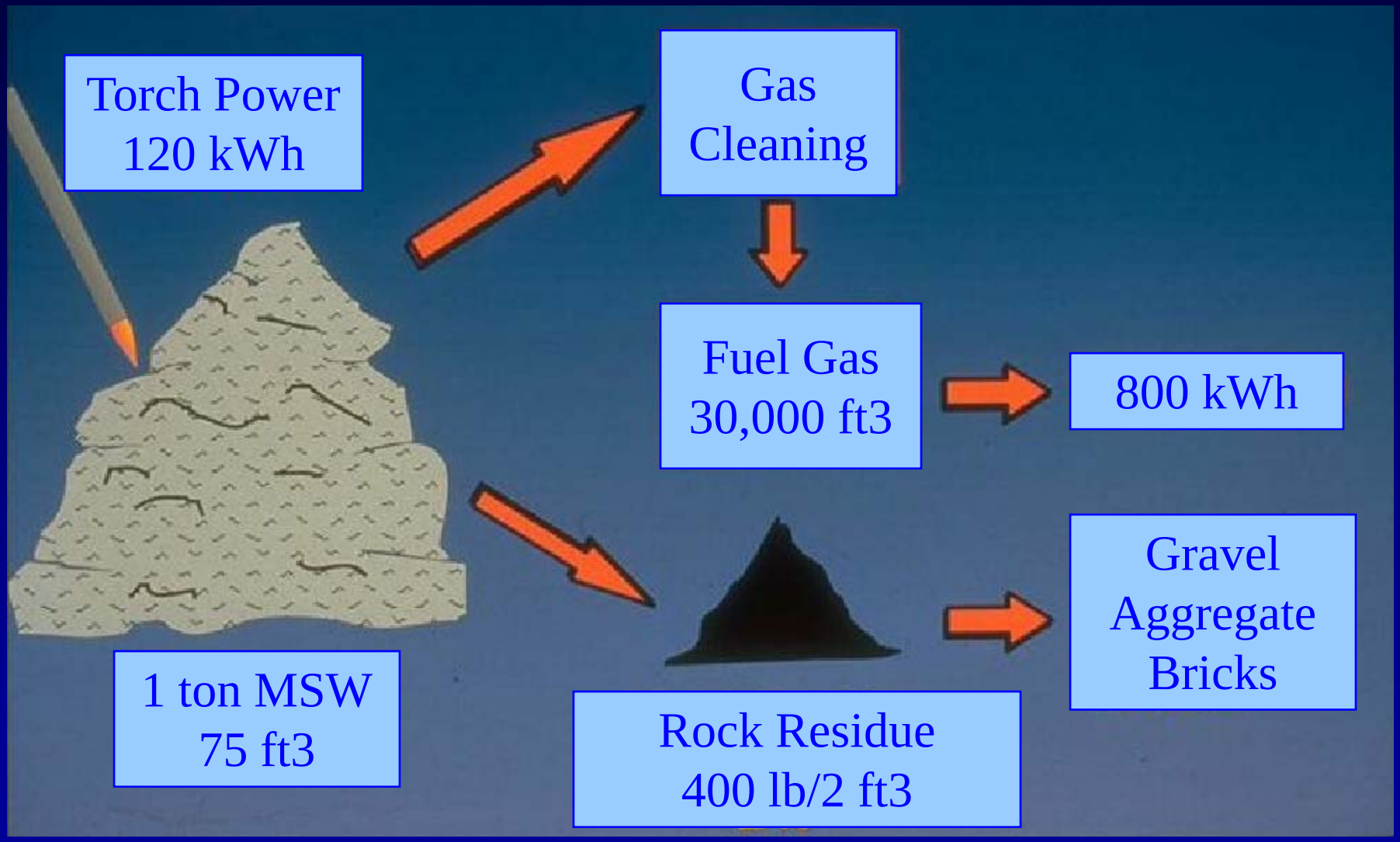
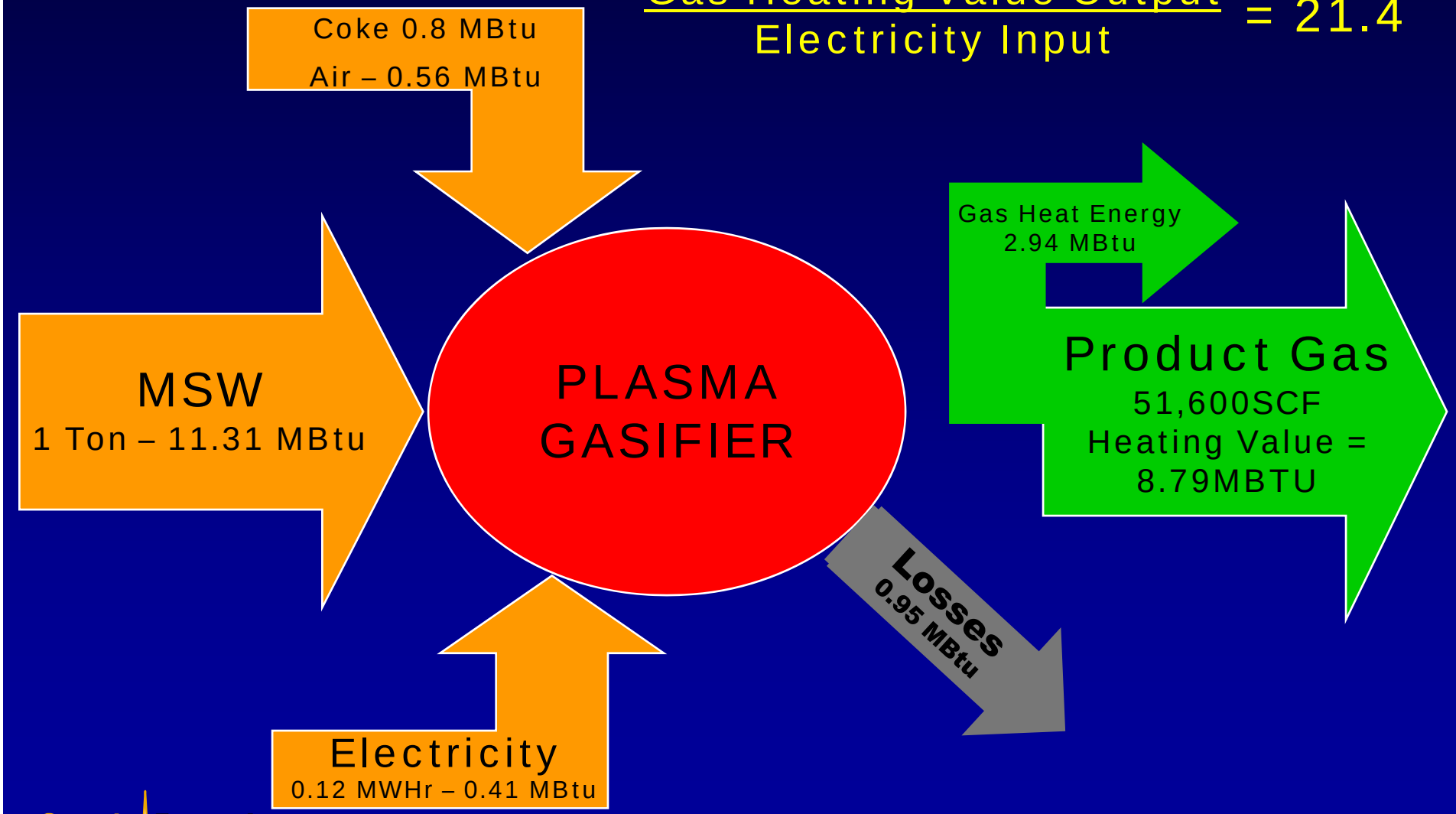
Pyrolysis of MSW



Plasma Gasification of MSW

Notional Heat Balance

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



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

Process [1]	Net Electricity to Grid (kWh/ton MSW) [2]	Plasma Advantage
• 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

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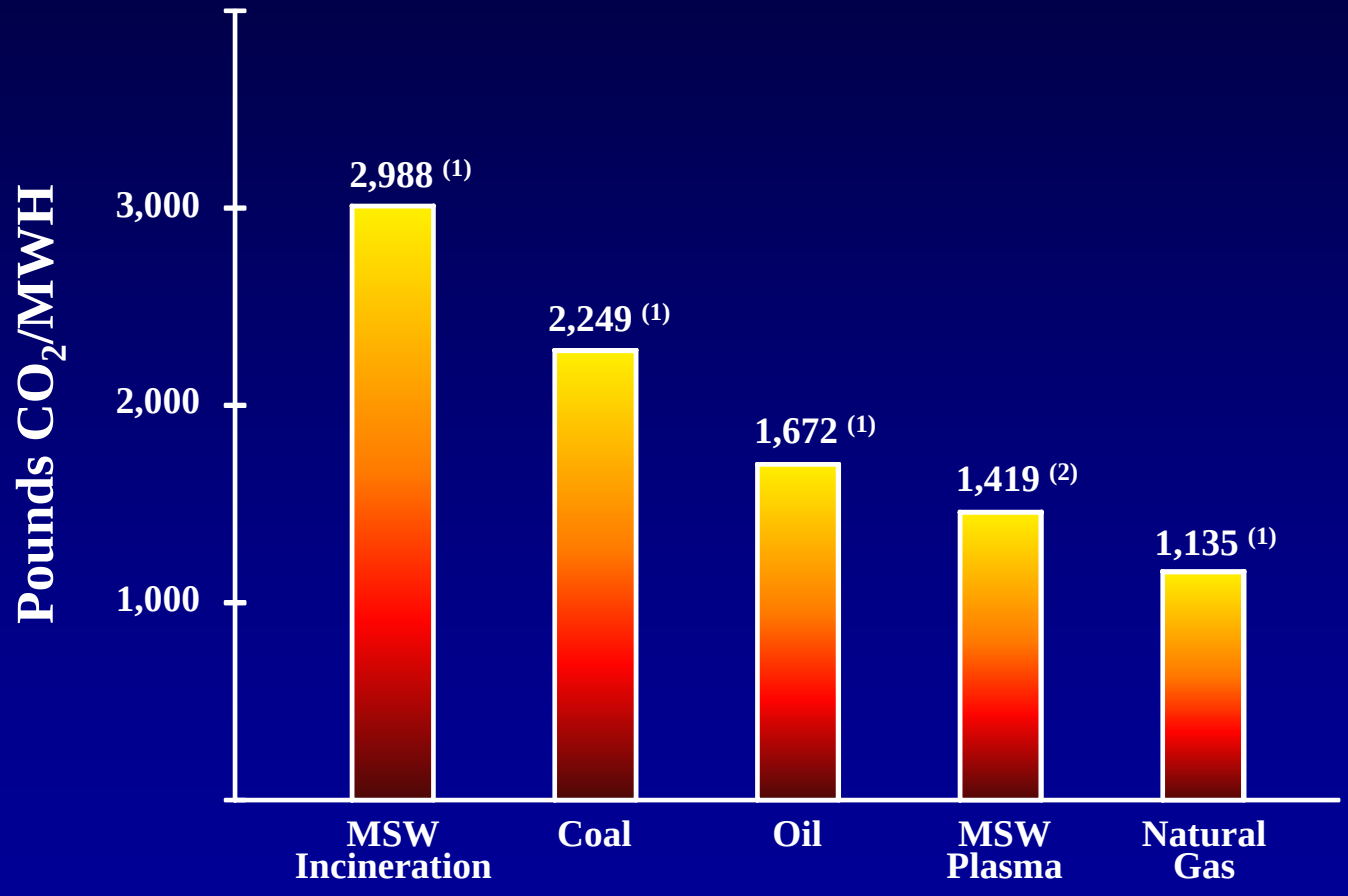
Pounds of CO_2 Emissions per MWH of Electricity Produced



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

(2) Complete Conversion of Carbon to CO_2; MSW Material & Heat Balance, Westinghouse Plasma Corp.

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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

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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

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

Prepared for

St. Lucie County

Prepared by

Geoplasma™, LLC
171 17th Street, NW, Suite 1550
Atlanta, Georgia 30363
T. 678. 538. 4321

GEOPLASMA LLC

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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

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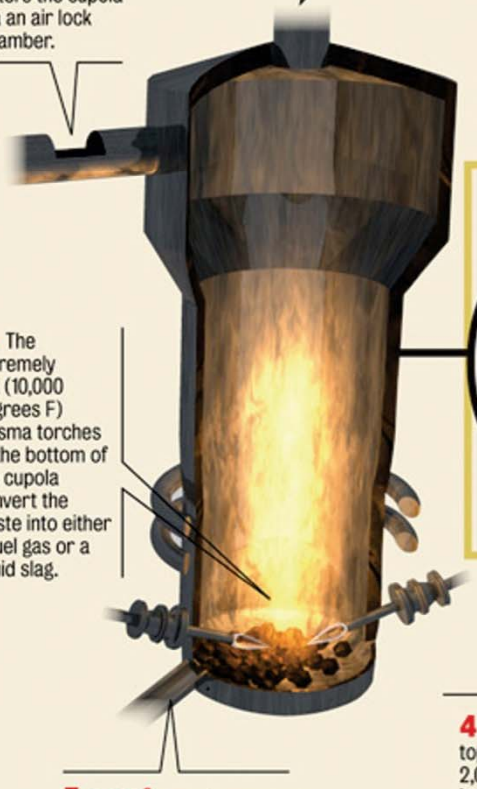
Planned GEOPLASMA Project (cont'd)

- 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.

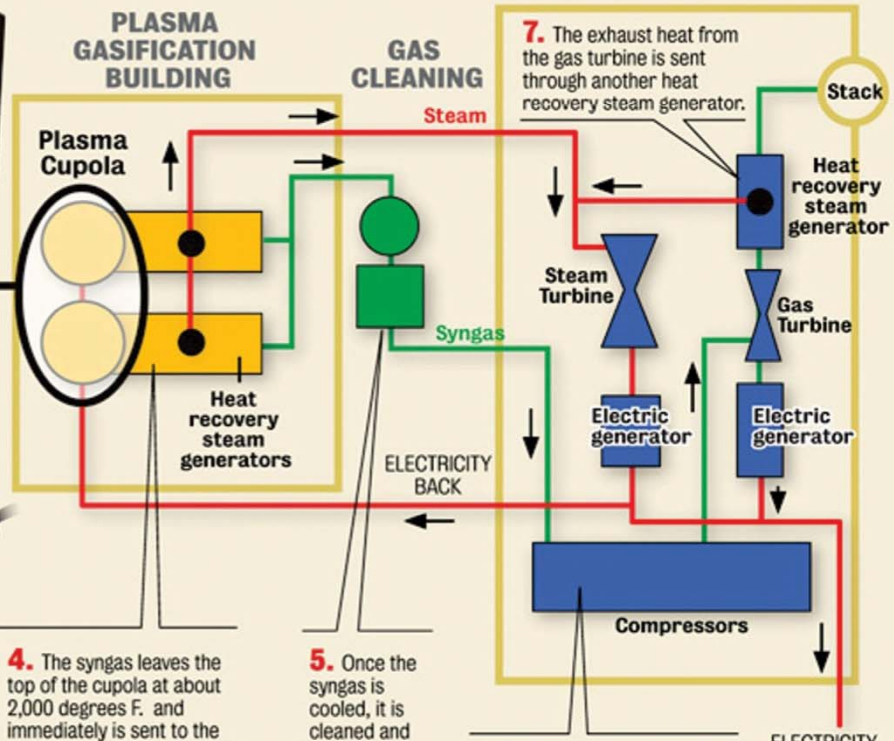
3. The process is oxygen-deprived (meaning there is no combustion) and it creates a synthetic fuel gas called syngas. The syngas leaves the cupola at the top while...



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.

PROPOSED WASTE PLASMA PLANT



4. The syngas leaves the top of the cupola at about 2,000 degrees F. and immediately is sent to the heat recovery boiler, which reduces the temperature of the syngas to about 400 degrees F while making steam that is sent to the power plant building to produce electrical energy in a steam turbine-driven electric generator.

5. Once the syngas is cooled, it is cleaned and scrubbed to remove contaminants. The syngas is now ready to be used in the power plant.

6. Compressors pull the syngas from the plasma cupola through the heat recovery boilers and the gas cleaning equipment and compress the gas for use in a gas turbine. After the syngas goes through the gas turbine and goes through the electric generator to produce electricity, it is able to be sold to a utility grid.

7. The exhaust heat from the gas turbine is sent through another heat recovery steam generator.

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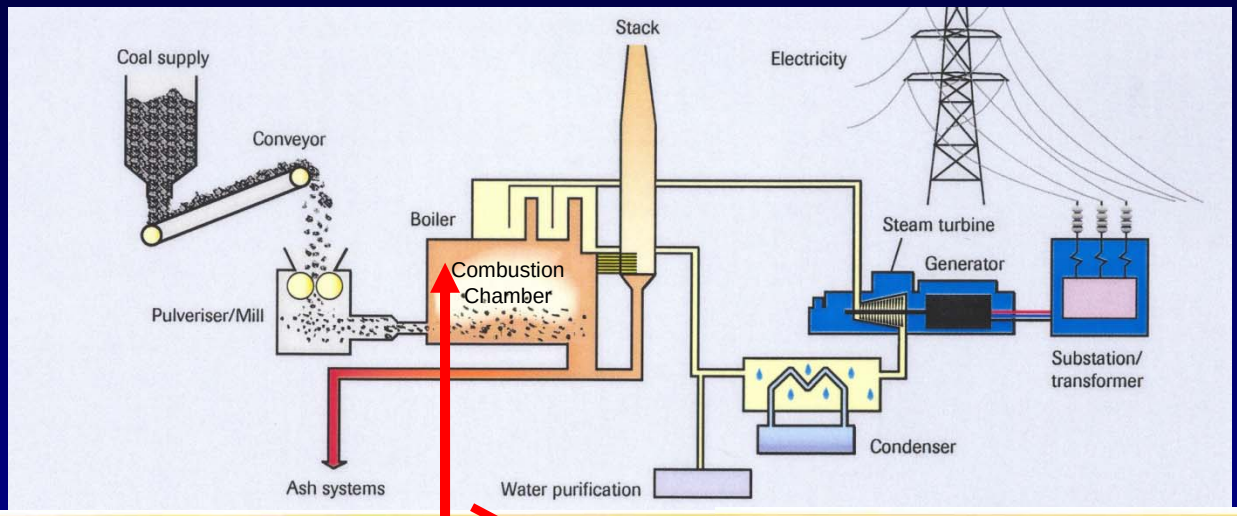
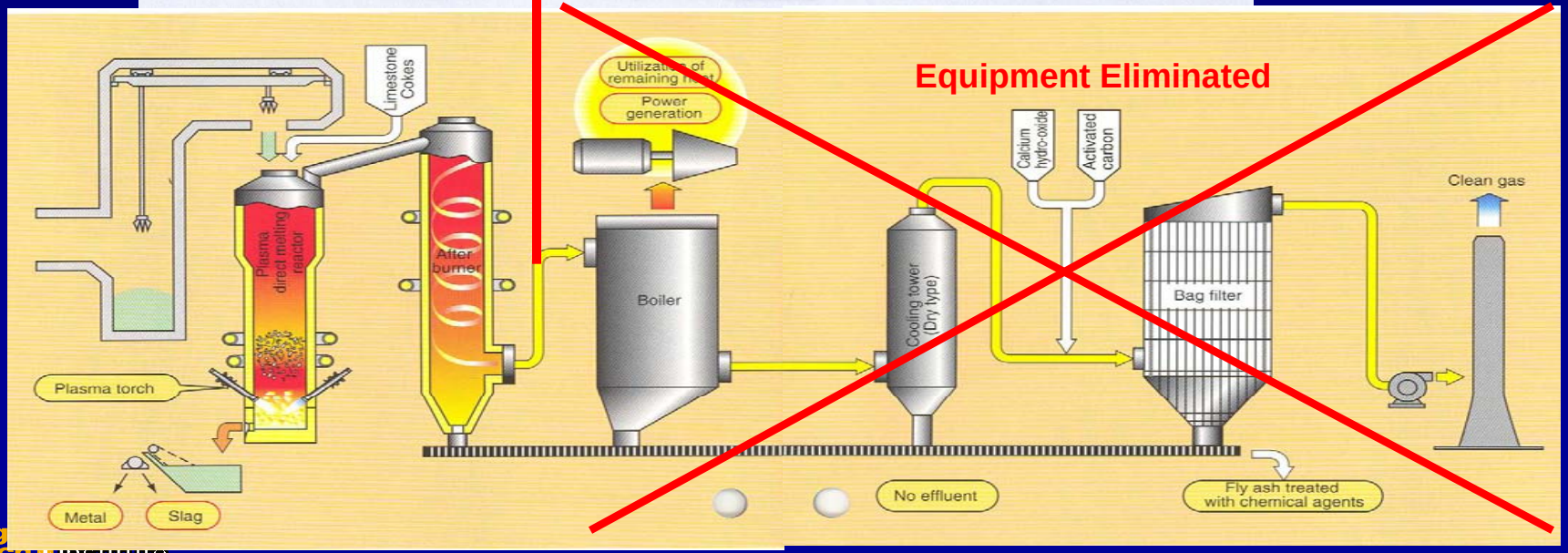
Plasma Processing of MSW at Fossil Fuel Power Plants





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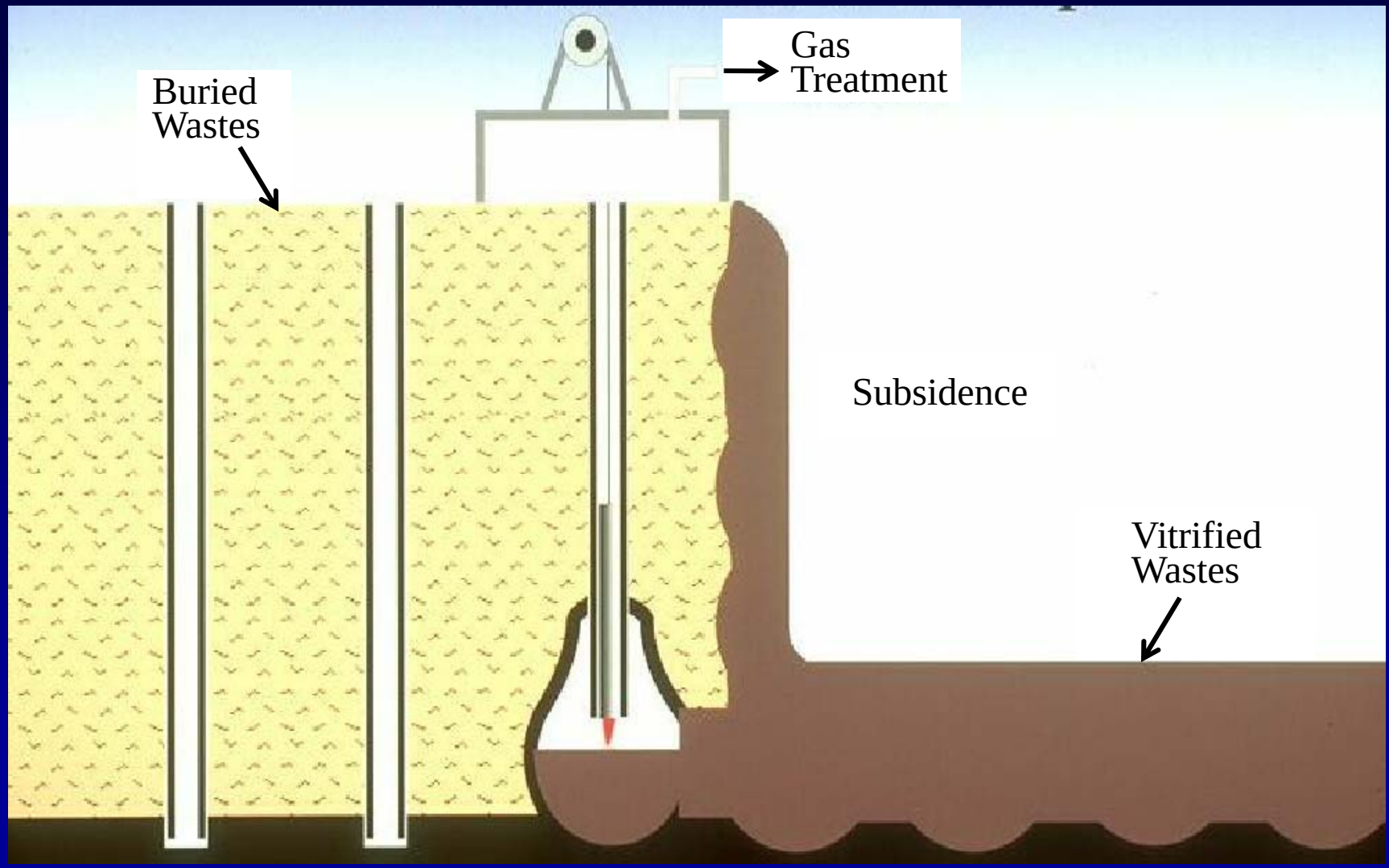
Landfill remediation concept



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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