

Plasma Gasification: A Significant Global Waste-to-Energy Opportunity

**Louis Circeo
Luciano Bardari**

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Global Challenges and Opportunities

• Challenges

- **World Bank (2012):** Global generation of Municipal Solid Waste (MSW) will double by 2025.
- **World Bank (2012):** MSW will become a bigger problem than climate change.
- **U.S. Energy Information Agency (2011):** U.S. electricity needs will increase 30% by 2025.

• Opportunities

- **U.S. EPA (2009):** MSW is the only important waste-to-energy (WTE) materials stream for power production.
- **SBI Energy (2011):** MSW could supply 10% of global power.
 - Approaches global nuclear reactor power production
- **Plasma Gasification of MSW:** A unique technology to mitigate the above challenges.
 - Over 30 countries currently involved in plasma gasification projects.

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</u> <u>Advantage</u>
• Plasma Arc Gasification	816	-
• Conventional Gasification - Fixed/Fluidized Bed Technologies	685	20%
• Pyrolysis & Gasification - Thermoselect Technology	685	20%
• Pyrolysis - Mitsui R21 Technology	571	40%
• Incineration - Mass Burn Technology	544	50%

(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

Recent Emission Control Technologies*

- **Electrostatic Precipitator (ESP) System:** Removes fly ash and heavy metals
 - **Fabric Filter (FF) System:**
 - Removes ~94% of particulate matter (PM)
 - Removes heavy metals (lead, cadmium, arsenic, etc.)
 - **Activated Carbon Injection (ACI) System:**
 - Removes ~99.99% of mercury
 - Reduces ~97% of dioxins
 - **Spray Dryer (SD) System:**
 - Lime and water injection to remove acid gases like HCl and SO₂
 - Removes most remaining mercury
 - **Selective Non-Catalytic Reduction (SNCR) System:**
 - Ammonia (NH₃) injection to convert NO_x into nitrogen and water
- * Source: U.S. Environmental Protection Agency (EPA)

Emissions can be made cleaner than natural gas emissions from domestic household gas stoves.

Byproducts

from Municipal Solid Waste and Coal Ash

Molten Stream
Processing
(Product)

Air Cooling
(Gravel)



Water Cooling
(Sand)



Water Cooling
(Metal Nodules)



Spinning Machines
("Plasma Wool")



Saleable Product Uses

Coarse Aggregate (roads,
concrete, asphalt)

Fine Aggregate
(construction products)

Recyclable Metals

Insulation, Agriculture,
Oil Spill Cleanup

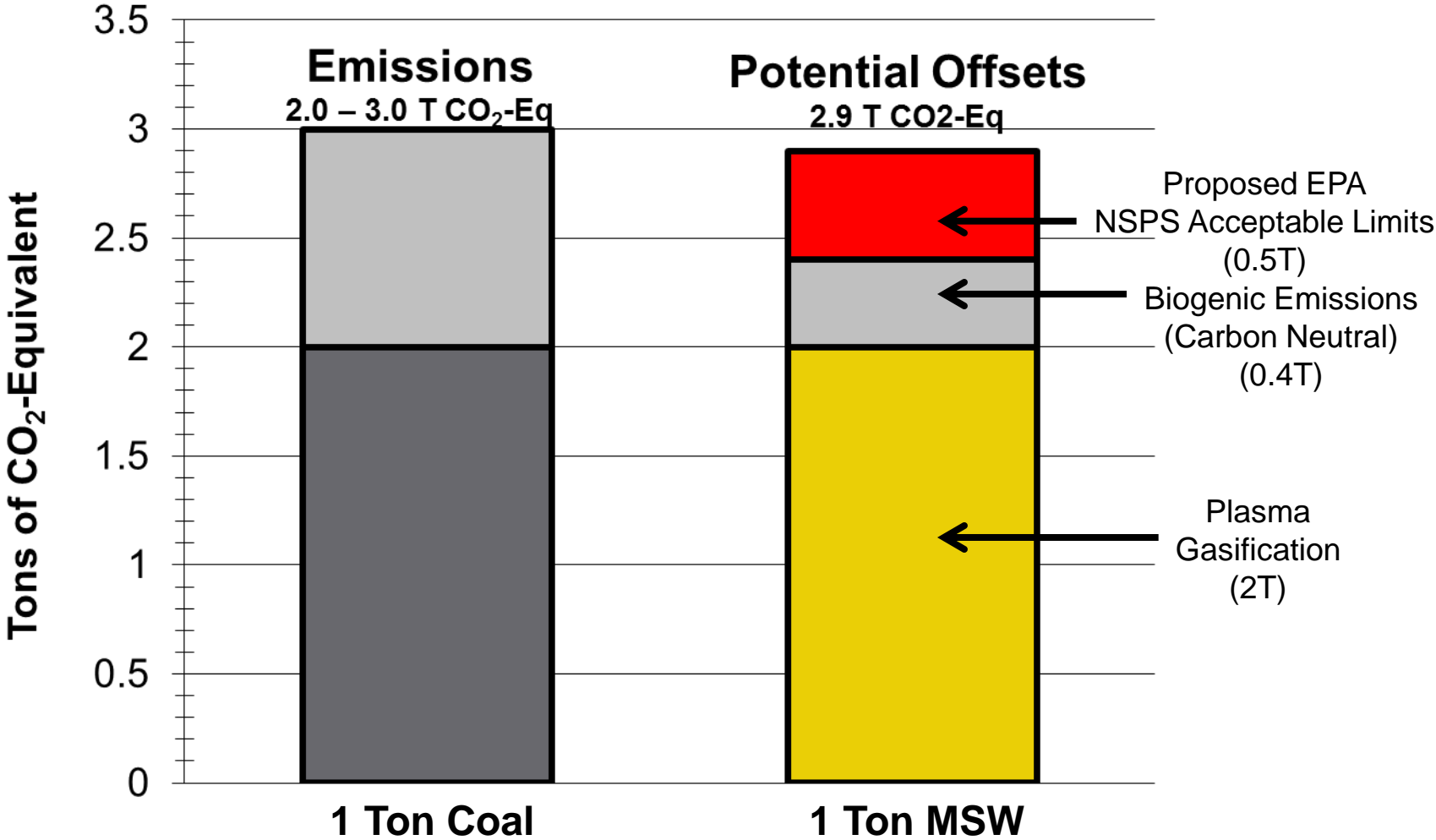
Greenhouse Gas (GHG) Emissions & Potential Offsets

- **GHG Emissions from Coal**

- 2-3 tons CO₂ per ton of coal combusted

- For every ton of MSW processed in a plasma plant, up to 2 tons of CO₂ is reduced from the atmosphere.*
 - Reduced methane emissions from not landfilling the wastes
 - Reduced CO₂ from reduced coal combustion-to-electricity
- The biogenic (carbon neutral) portion of MSW further reduces greenhouse gas emissions (MSW ~60%)
- Proposed EPA New Source Performance Standards (NSPS) permit up to 0.5 tons CO₂ per MWH of power produced

Greenhouse Gas (GHG) Emissions & Potential Offsets



Greenhouse Gas Emission Studies: Conclusions

- “The Plasma Gasification Combined Cycle System provides the lowest greenhouse gas emissions of the evaluated systems for waste disposal.”

(Evaluated systems include: Landfill with Energy Recovery, Traditional Waste to Energy, Natural Gas Combined Cycle)

Source: Scientific Certification Systems, Inc.

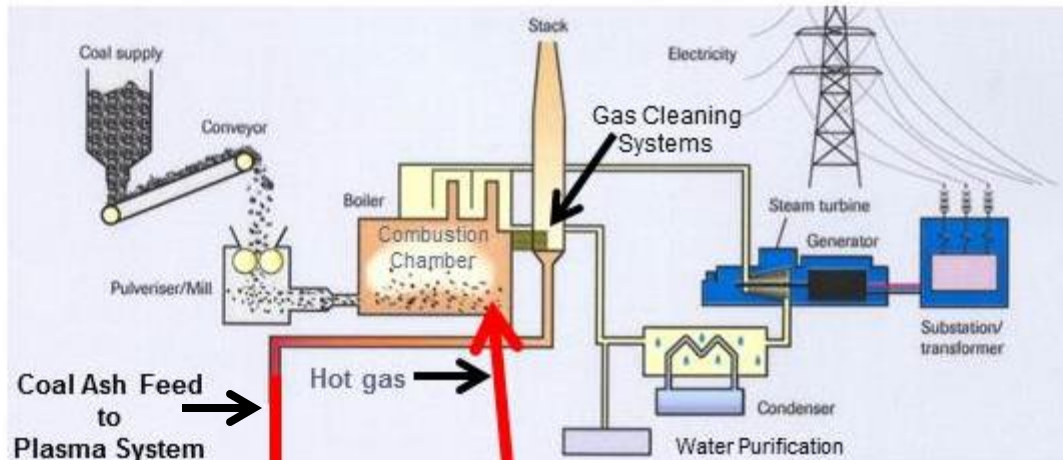
- “Diversion of MSW from solid waste landfills will result in substantial net decreases in greenhouse gas emissions as CO₂ equivalent.”

Source: ENSR International Corp./AECOM

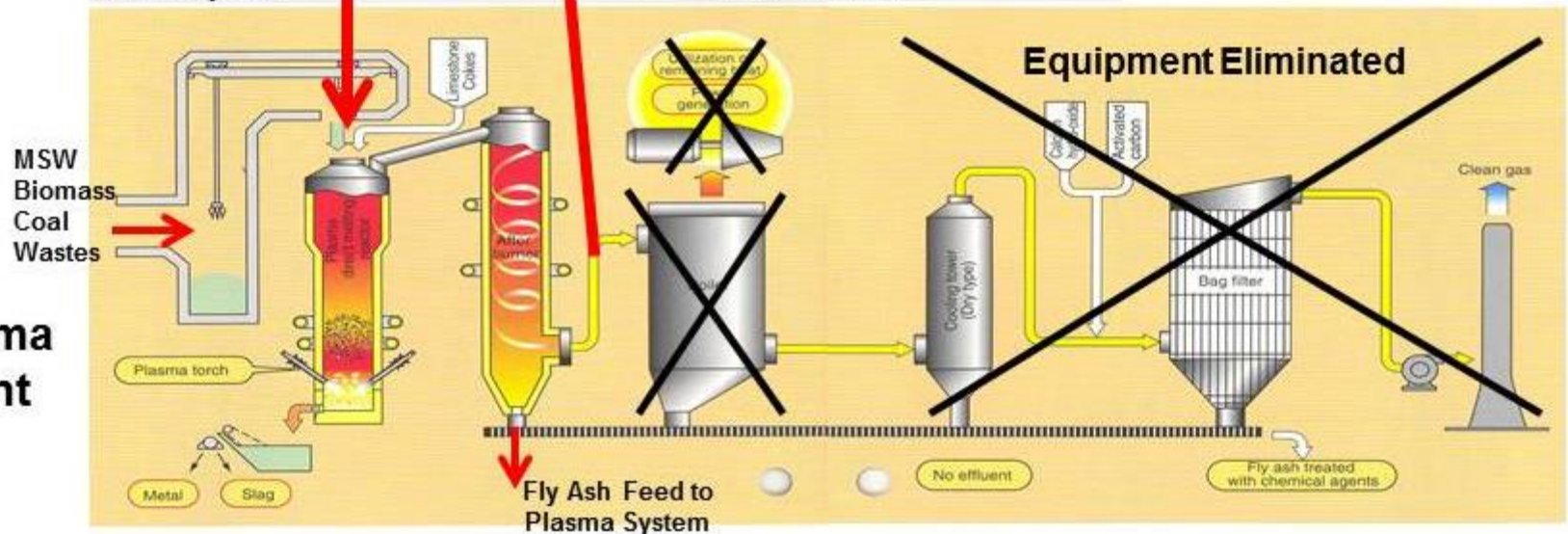
Plasma Augmentation at Coal-Fired Power Plants

Hot Gas/Syngas Delivery Option

Coal Plant



Plasma Plant



Unique Benefits of Collocated Plasma and Fossil Fuel Plants

- Plasma Capital and Operating Costs reduced up to 50%
- Fossil fuels reduced up to 50% of MSW tonnage
- Plasma process offsets reduce GHG emissions
- Coal ash and fly ash sent to plasma plant for conversion into salable byproducts
- Potential: Pollutants meet environmental regulations
 - Recycle all residue materials
 - Gaseous emissions comply with regulations
 - GHG emissions fully or partially offset

Unique Economic Benefits of Plasma/Coal Plant Collocation*

	Plasma (Steam Cycle)	Plasma (Combined Cycle)
MSW Input (Metric TPD)	545	1,000
Total Capital Cost (\$M)	133	231
(Cost with plasma/coal plant collocation)	(66.5)**	----
Power Production (net MW)	21	49
Cost per net installed MW (\$M)	6.3	4.7
(Cost with plasma/coal plant collocation)	(3.2)**	---

*Source: Alter NRG, June 2012 Corporate Presentation

** APAT Concept

Plasma Gasification: State-of-the-Art

- **> 22:** Commercial plasma plants in operation
(4 are WTE plants)
- **> 6:** Demonstration plasma plants completed or under construction
- **> 15:** Companies whose primary business is plasma technology
- **> 30:** Countries involved in plasma gasification projects



Eco-bale Stack in the Naples Region



Eco-bale Stacks in the Naples Region

Eco-Bale Disposal Concept

- About 6 million eco-bales have been produced
 - 1 metric ton each
- Italplasma WTE Concept
 - A 1,000 MT/day plasma system could process 1,000 eco-bales per day.
 - About 45 MW of power could be produced for sale to the electric grid
 - Electricity production sufficient to power about 50,000 households
 - No landfills: Residues → Construction materials

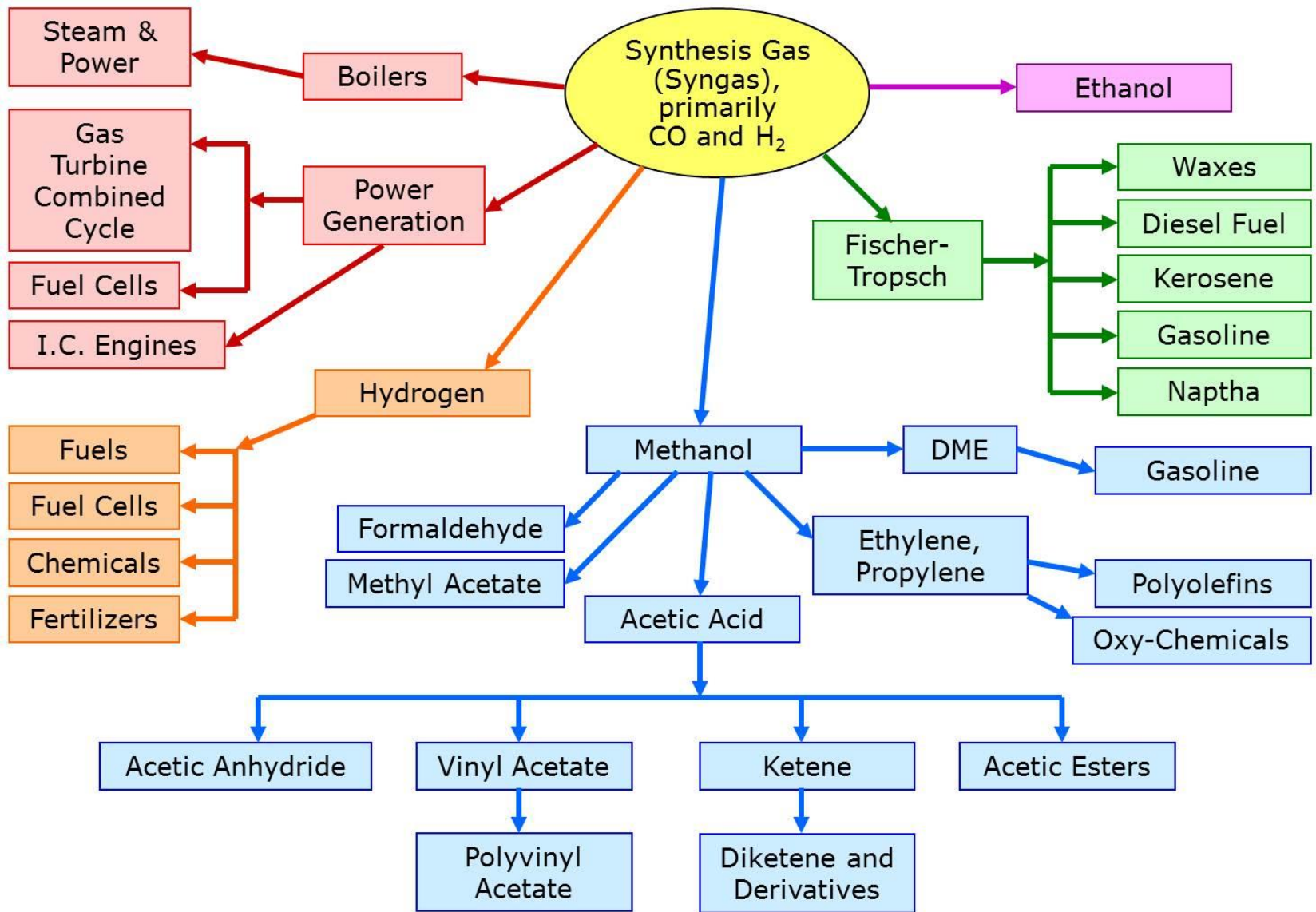
A Significant Global WTE Opportunity

- **Concept:** Convert total annual global generation of MSW to power
 - 2 billion metric tons per year
- **Infrastructure:** Build 6,000 plasma gasification plants, each processing 1,000 metric tons per day.
- **Cost:** Collocation with fossil fuel plant: \$133 Million*
 - About 1/3 the cost of a WTE incinerator
 - Over 50,000 fossil fuel plants worldwide
- **Retrofit existing plant :** \$133-231 Million*
- **New combined cycle plant :** \$231 Million
- **Would approach global nuclear power production**

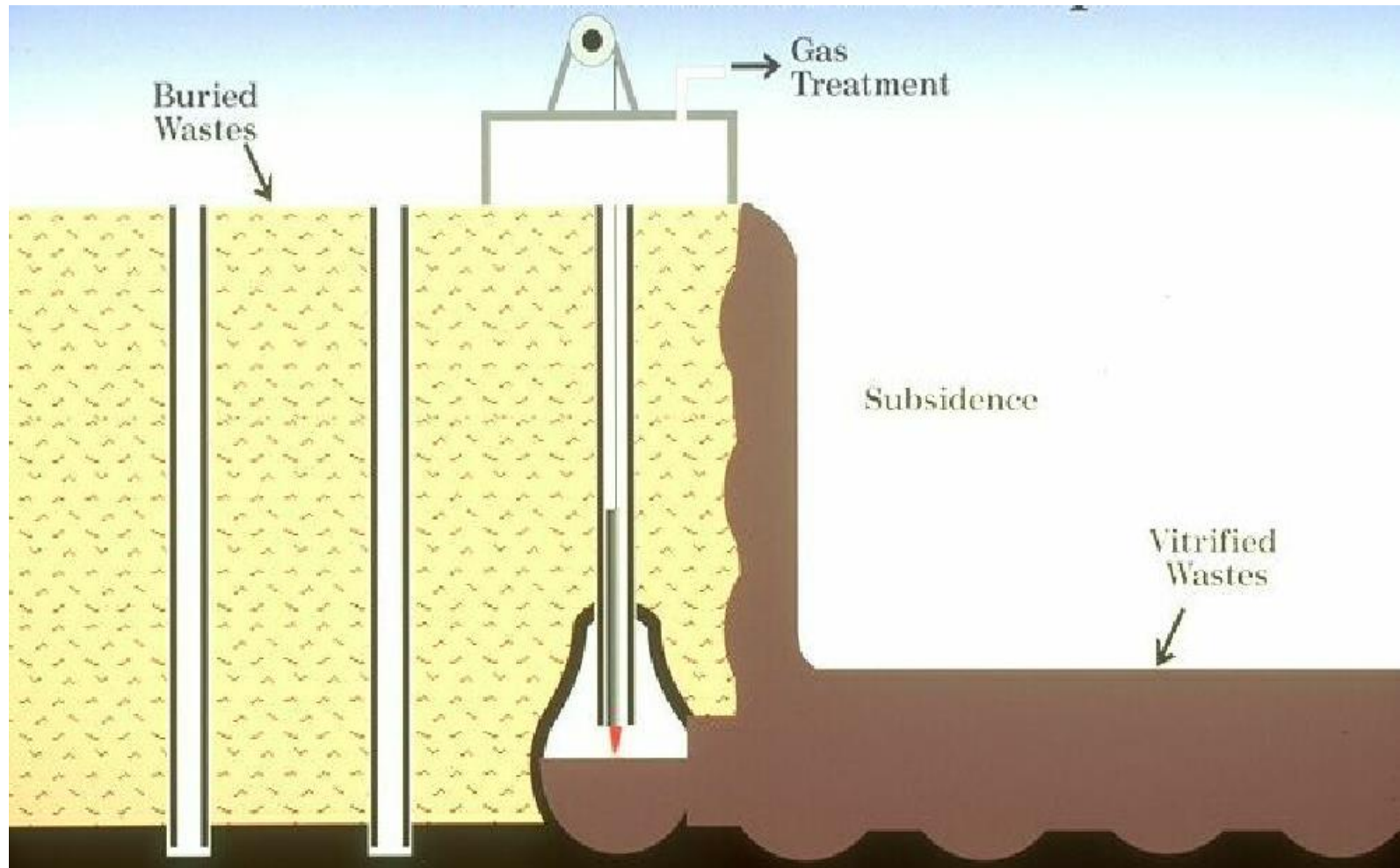
Summary

- Plasma gasification of MSW offers many unique opportunities unequalled by any other existing, emerging, or contemplated thermal WTE technology.
- It should be possible to reduce or eliminate the need for Carbon Capture and Sequestration (CCS) systems using plasma gasification GHG offsets.
- Full development of plasma gasification technology has the potential to significantly mitigate the challenges of global MSW generation, power requirements, and climate change.
- In 2008, the Director of the International Atomic Energy Agency (IAEA) advocated that a new global energy organization be established for energy systems development, commercialization and worldwide technology transfer.

Gasification – Potential Output Products



Landfill Remediation Concept





Potential In-Situ Landfill Remediation Equipment (based on an older DOE technology)