



Inc.

Gary C. Young, Ph.D., P.E.

## Some Processes for the Management of Municipal Solid Waste (MSW)

### Thermal Technologies:

Plasma Arc Gasification, 7,200 – 12,600 °F

Conventional Gasification, 1,400 – 2,800 °F

Pyrolysis Gasification, 1,400 – 2,800 °F

Pyrolysis, 1,200 – 2,200 °F

Mass Burn (Incineration), 1,000 – 2,200 °F

Note: Except for Plasma Arc Gasification, these processes have environmental issues for disposing of ash and slag.

### Biological/Chemical Technologies:

Anaerobic digestion (example, landfill gas)

Aerobic Digestion/Composting

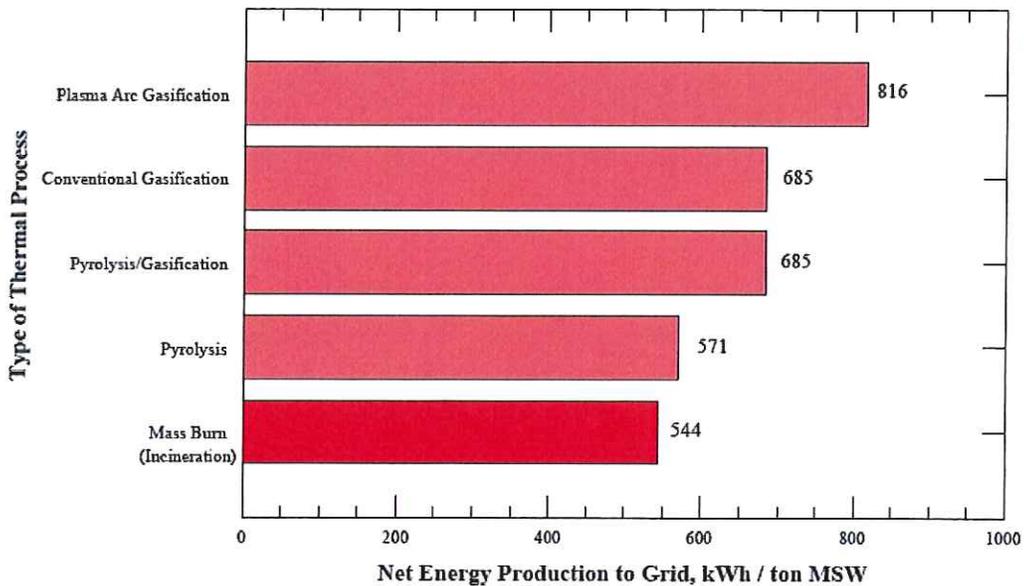
Note: These processes have environmental issues of leachate and biomass/slug disposal.

# Plasma Arc Gasification /Thermal Process



What Are The Comparative Thermal Efficiencies of These Processes?

**Comparison of Various Type of Thermal Processes:  
Net Output of Thermal Processes from Waste [ Municipal Solids Waste (MSW) ] to Energy**



Note: Computations in this table were done (05-30-2007) by Dr. Gary C. Young from information in the reference noted and Energy-from-Waste, copyrighted 2007 Gary C. Young.  
Reference: The Regional Municipality of Halton, Step 1B: EFW Technology Overview, May 30, 2007 Submitted by Genivar, Ramboll, Jacques Whitford, Deloitte & URS, Regional Municipality of Halton, 1151 Bronte Road, Oakville, ON L6M 3L1

Gary C. Young, Ph.D., 05-30-2007  
Via/ThermalProcCompar 05 30 2007.pdf



## What is Plasma Arc Gasification Technology?

- Technologically Advanced and Environmentally Friendly Method of Disposing of Waste by Converting It to Commercially Usable By-products
- Uses an Oxygen-starved Environment
- Uses Extremely High Temperatures  
(7,200 – 12,600 °F)
- Decomposes Waste Material Into Simple Molecules, [Predominantly Carbon monoxide (CO) and Hydrogen (H<sub>2</sub>)] which is called “Syngas”
- By-products are a Combustible Gas (Syngas) and an Inert Vitrified Slag



## Vitrified Slag As A Road Construction Material

One primary requirement of the vitrified slag for use as a road material is to be highly non-leachable. A primary analysis used to show non-leachable characteristics is the Toxicity Characteristic Leaching Procedure (TCLP) as in the risk assessment portion of

EPA's 1999 Report to Congress. TCLP tests conducted on the Vitrified Slag produced from MSW using Plasma Arc Gasification Reactor are shown below:

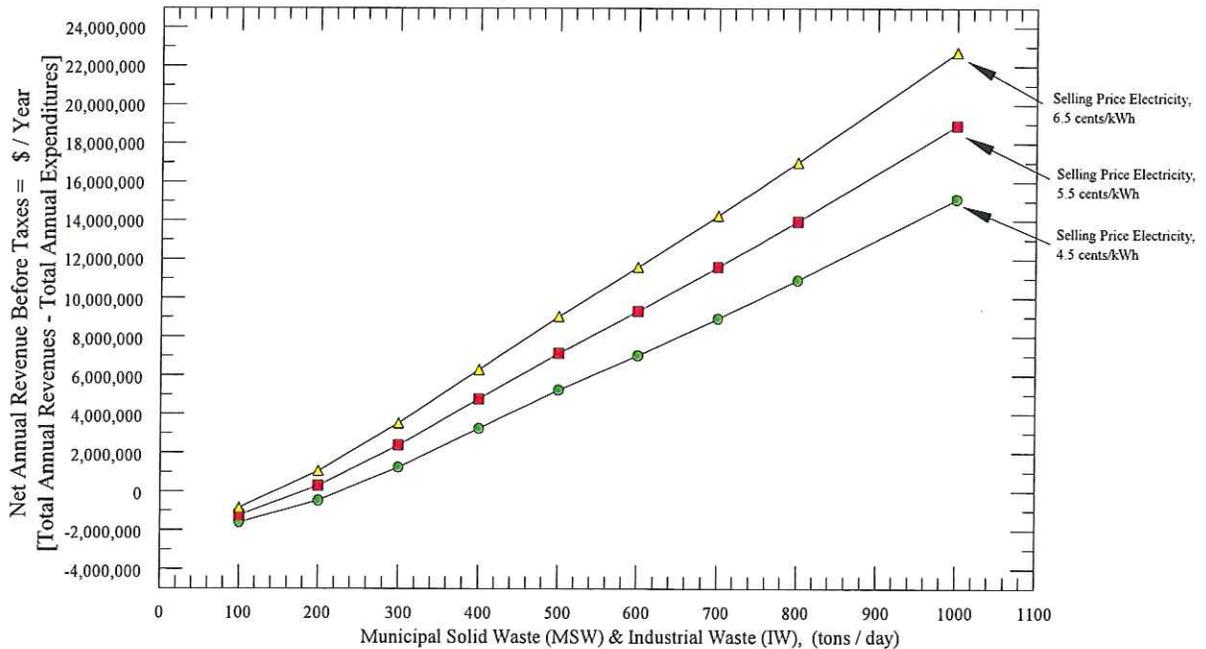
	TCLP	
	Permissible	Measured
Heavy	Concentration	Concentration
Metal	(mg/l)	(mg/l)
_____	_____	_____
Arsenic	5.0	<0.1
Barium	100.0	0.47
Cadmium	1.0	<0.1
Chromium	5.0	<0.1
Lead	5.0	<0.1
Mercury	0.2	<0.1
Selenium	1.0	<0.1
Silver	5.0	<0.1



# Plasma Arc Gasification Facility: Linn County/Cedar Rapids/Marion, Iowa Economy of Scale & Energy Sale Price Influence Upon Net Annual Revenue Before Taxes "Preliminary" Economic Analysis:

Plasma Arc Gasification Facility: Linn County/Cedar Rapids/Marion, Iowa  
Economy of Scale & Energy Sale Price Influence Upon Net Annual Revenue Before Taxes  
"Preliminary" Economic Analysis

Gary C. Young, Ph.D., P.E.  
Cedar Rapids, Iowa 52402  
319-373-5191  
11-13-2007

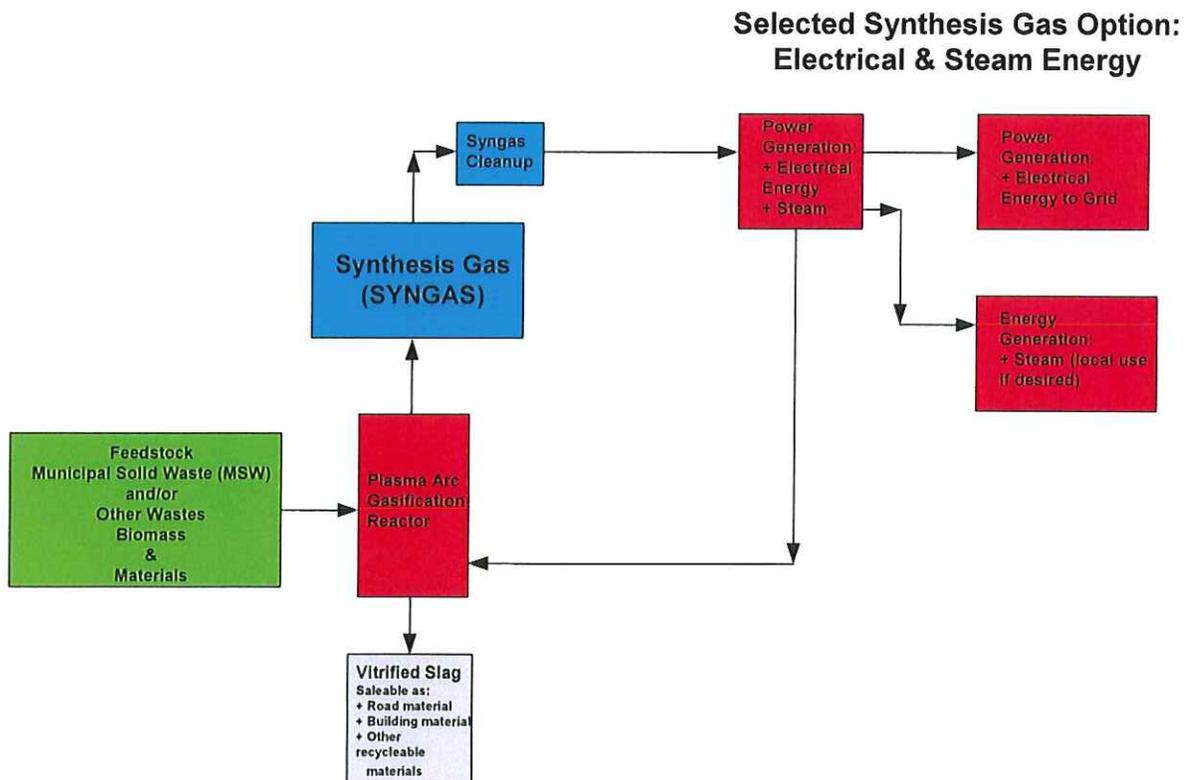


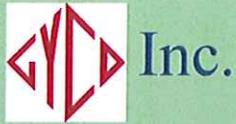
Opinion:	Parameters:
Capacity	Capital Investment
100 tpd	\$38,676,000
200 tpd	\$58,622,000
500 tpd	\$101,584,000
700 tpd	\$124,309,000
1,000 tpd	\$154,000,000
	Tipping fee, \$35/ton
	Green tags, 2.0 cents/kwh
	Vitrified slag, \$15/ton
	State tax credit, 1.5 cents/kWh up to 20MW
	Capital at 6.00% interest and 20-years
	O&M considered

**"PRELIMINARY"**  
LinnCRMarionPlasFac 11 13 2007.pdw  
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# Block Flow Diagram (BFD) of Plasma Arc Gasification Process For Management of Wastes Such As Municipal Solid Waste (MSW)

## Energy-from-Waste





## Process By Which Plasma Arc Gasification Technology Generates Revenue From Destruction Of Municipal Solid Waste (MSW) and Generates Revenue From By-products

Municipal Solid Waste (MSW)

+

Heat

Breaks Chemical Bonds

Of Hydrocarbons In MSW

=

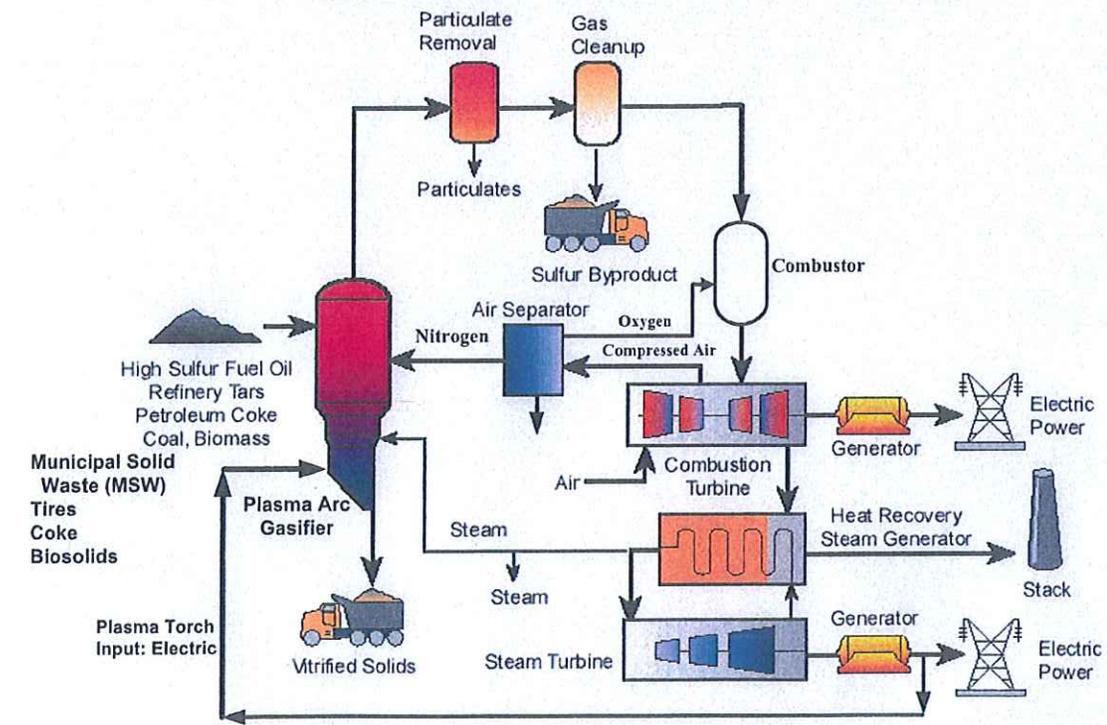
Carbon monoxide (CO) & Hydrogen (H<sub>2</sub>)

(CO & H<sub>2</sub>) mixture is called “Syngas”

[Which Can Be Converted Into Electricity in a Power Plant]

# Simplified Process Flow Drawing of Plasma Arc Gasification Process For Management of Wastes Such As Municipal Solid Waste (MSW)

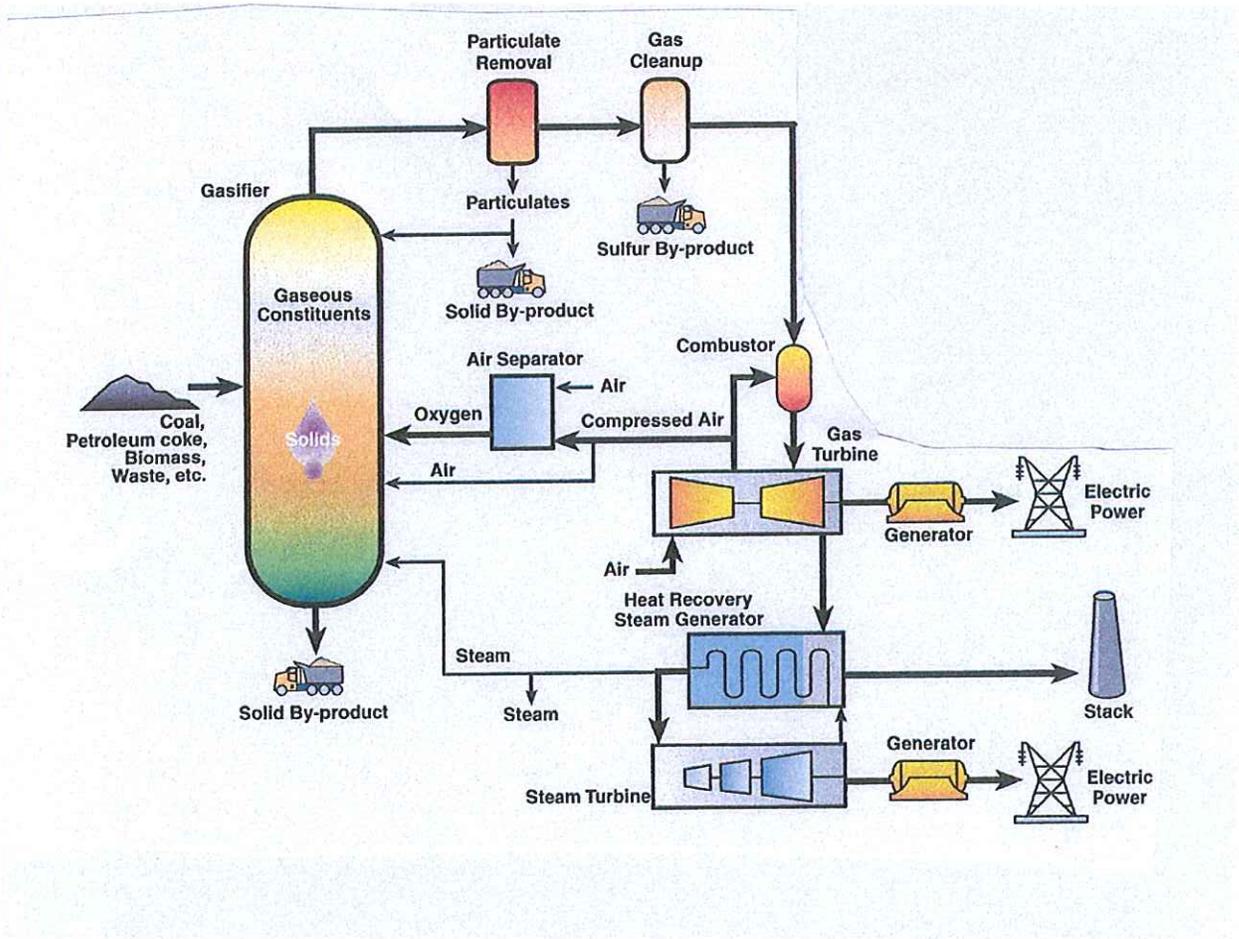
Plasma Arc Gasification Process Combined Cycle Power Generation [ Integrated Gasification Combined Cycle, (IGCC) ]



"PRELIMINARY"

Gary C. Young, Ph.D., P.E.  
GYCO, Inc., 03-22-2007

# Simplified Process Flow Drawing of Integrated Gasification Combined Cycle (IGCC) for Coal Gasification Facility





## Emission Levels for Integrated Gasification Combined Cycle (IGCC) for Coal Gasification Facility

<u>Criteria</u>	<u>Demonstrated</u>	<u>Coal Based</u>
<u>Pollutant</u>	<u>IGCC</u>	<u>Federal New Source Performance</u>
	<u>Emission Level</u>	<u>Standards (NSPS)</u>
SO <sub>2</sub>	<0.15 lb/10 <sup>6</sup> Btu or 1.35 lb/MWh	1.2 lb/10 <sup>6</sup> Btu
NO <sub>x</sub>	<0.1 lb/10 <sup>6</sup> Btu or 0.9 lb/MWh or 15 ppm	1.6 lb/MWh
PM10	<0.015 lb/10 <sup>6</sup> Btu or 0.14 lb/MWh	0.03 lb/10 <sup>6</sup> Btu

Note: PM10 is particulate matter  $\leq 10 \mu\text{m}$  in diameter.

## Criteria Pollutant Emissions from a State-of-the-Art IGCC Facility

Criteria Pollutant Emissions from a State-of-the-Art IGCC Plant are well-below Current Emissions Standards for Coal-fired Power Plant.

Plasma Arc Gasification technology for the Management of MSW is Similar to Gasification technology for the Management of Coal.

Proven Coal Gasification technology generated the technology for Plasma Arc Gasification for MSW.

## **SUMMARY: PLASMA ARC GASIFICATION TECHNOLOGY**

- Plasma Arc Gasifiers/System is proven Technology by Westinghouse Plasma Corporation to Gasify Municipal Solid Waste (MSW) to Syngas (CO & H<sub>2</sub>)

[Proven technology in General Motors Motors foundry plant in Defiance, Ohio since 1987]

[300 TPD of MSW Facility Commissioned in 2002 at Utashinai, Japan by Hitachi Metals, Ltd.

- Remaining Process Technology proven by Coal Gasification Power Plants since 1994.



## Active Projects In The United States:

Operating Commercial-Scale IGCC Plants Fed  
With Coal/Petroleum Coke – Steady-State  
Operational/Environmental Performance

Tampa Electric Polk Power Station, (Polk County,  
Florida, USA), (Operation Status 1996- Present)

Wabash River Generating Station, (West Terre  
Haute, Indiana, USA), (Operation Status 1995-  
Present)

NUON/Demkolec, (Buggenum, The Netherlands),  
(Operation Status 1994-Present)

ELCOGAS, (Puertollano, Spain), (Operation  
Status 1998-Present)



## SOME LITERATURE CITED:

Young, Gary C., “Zapping MSW with Plasma Arc,” Pollution Engineering, November 2006

Young, Gary C., “How Trash Can Power Ethanol Plants,” Public Utilities Fortnightly, p. 72, February 2007

Young, Gary C., “From Waste Solids to Fuel,” Pollution Engineering, February 2008

Dr. Lou J. Circeo, Engineering & Environmental Applications of Plasma Arc Technology, Technological Forum, Kirkwood Training and Outreach Services Center, Marion, Iowa, November 22, 2005

National Energy Technology Laboratory (NETL), “Major Environmental Aspects of Gasification-Based Power Generation Technologies, Final Report,” December 2002

Summary Report: Evaluation of Alternative Solids Waste Processing Technologies, Prepared for City of Los Angeles, Department of Public Works, Bureau of Sanitation, Los Angeles, CA and Prepared by URS Corporation, Los Angeles, CA, September 2005