18th Annual North American Waste-to-Energy Conference



#### A LEADING PROVIDER OF CLEAN ENERGY SOLUTIONS

Orlando, Florida - May 13, 2010





# **HISTORY OF PDMR DEVELOPMENT**

#### 1997

 PDMR Development Agreement -Hitachi Metals & WPC

#### 2001

 Mihama-Mikata – construction began

#### 1999

- Yoshii one year of MSW testing
- Eco Valley 7 meetings with Residents







#### 2005

- Eco Valley bottom shape remodeled & refractory structure of PFMR changed
- Refractory materials of Afterburner changed

#### 2003

- Eco Valley operational (ASR & MSW)
- Mihama-Mikata operational (MSW & Sludge)

#### 2007

• Eco Valley – temperature control changed during commercial operation

#### 2000

- Yoshii JWRF certification received in September
- Eco Valley construction began
- Mihama-Mikata presentation to government

#### 1998

- WPC Testing Madison PA
- Yoshii Test Plant
   Construction
- Eco Valley environmental assessment

#### 2002

- Plasma Component Manufacturing Agreement – Hitachi Metals & WPC
- Eco Valley commissioning
- Mihama-Mikata commissioning

#### 2004

• Eco Valley – freeboard refractory replaced

#### 2006

- · Plant tours begin
- Eco Valley refractory materials of Afterburner changed
- Mihama-Mikata 3 year guarantee ended





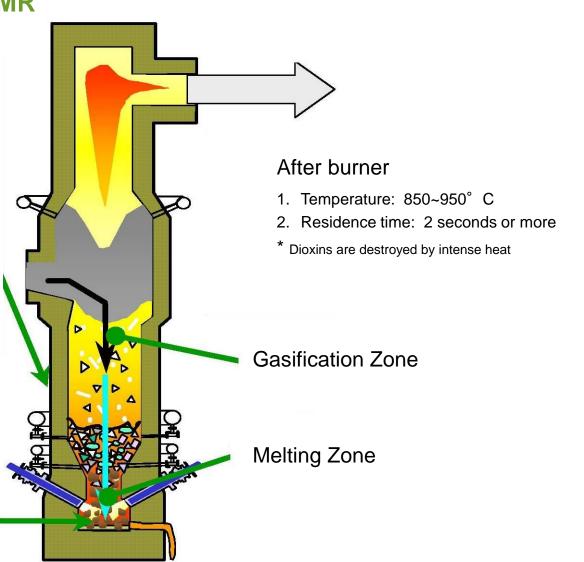
# **ADVANTAGE OF PDMR**

# Gasification/melting zone combined-type shaft furnace

- 1. Simple structure no internal drive unit
- 2. High volume of accumulated heat – MSW can also be treated
- Melting zone 1,550° C or higher – high quality slag and metal are discharged

#### Plasma Torch & Coke Bed

- 1. Output easily adjusted
- 2. Smooth continuous discharge of molten slag and metal







# THE JAPANESE FACILITIES



Hitachi Metals' Eco-Valley Utashinai WTE Facility



Hitachi Metals' Mihama-Mikata WTE Facility



# ECO – VALLEY UTASHINAI WTE FACILITY

- The largest facility is named Eco-Valley and is located in Utashinai, Hokkaido. Built over two years, it was commissioned in 2002 and has been fully operational since 2003
- The Eco-Valley was designed to process MSW and auto shredder residue
- Eco-Valley is operating with 8 Marc-3a Plasma Systems
  - Two operating gasification islands with four torches each

Specifications of the	e Eco-Valley, Utashinai Facility				
Design Capacity	165 metric tons/Day (24 hours) of auto-shredder residue as fuel				
Number of trains	2 trains operating at 82.5 metric tons per 24 hours/train				
Power Generated	7.9MW				
Power Exported	4.3MW				



Inside the Eco Valley, Utashinai Facility

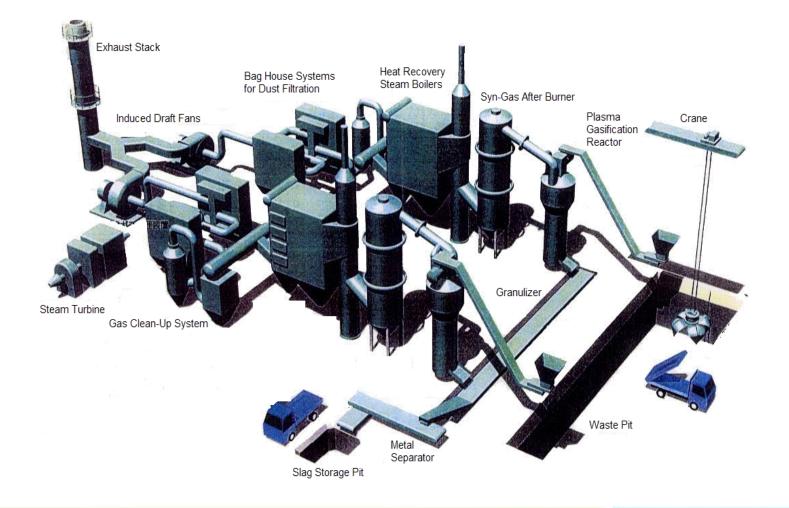
ALTER



Westinghouse Plasma Corporation

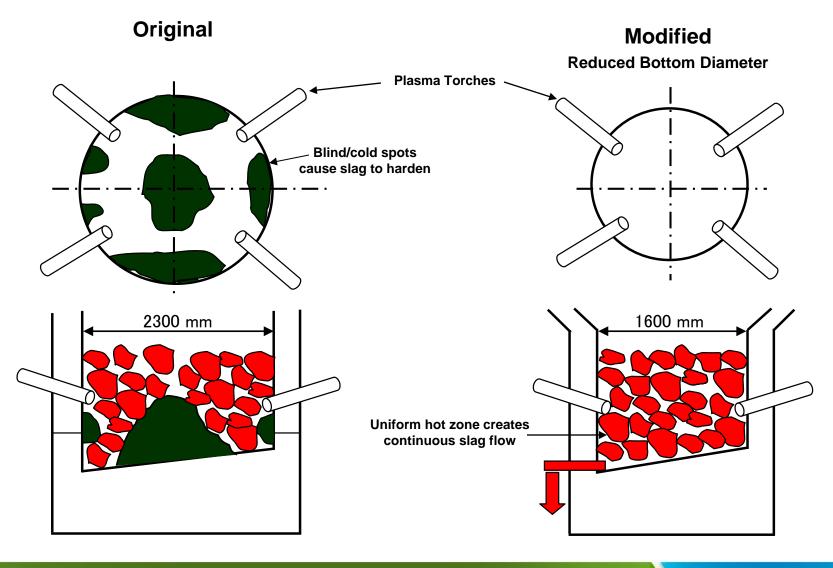
a division of Alter NRG Corp.

# **UTASHINAI PROCESS FLOW DIAGRAM**





### **OPERATIONAL ISSUE #1: BOTTOM DIAMETER TOO LARGE**





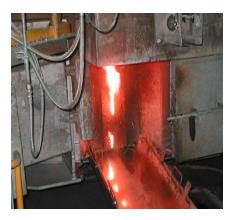
# **OPERATIONAL ISSUE #1: BOTTOM DIAMETER TOO LARGE**



Slag Buildup on Reactor Bottom Section

#### Slag Close-up Below Torch Tuyeres



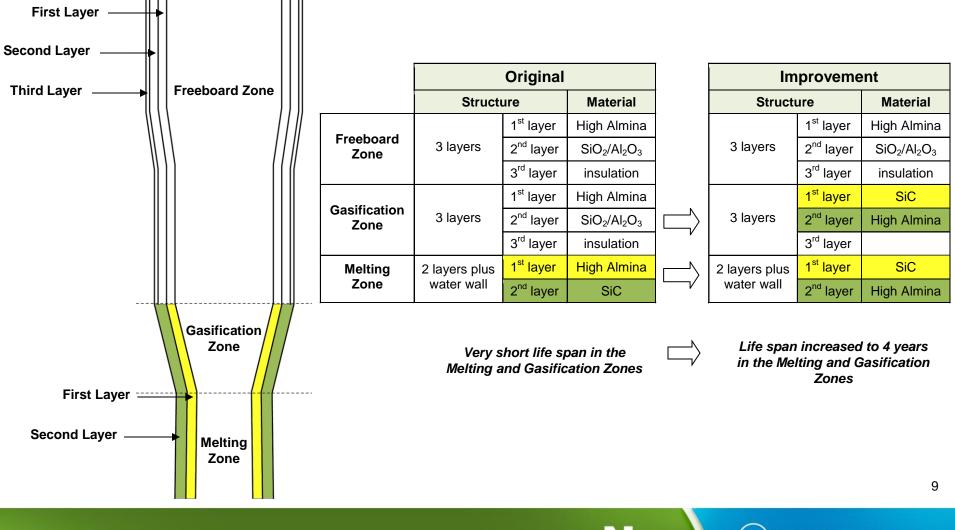


Slag Tapping – smooth flow





# **OPERATIONAL ISSUE #2: INCORRECT REFRACTORY**

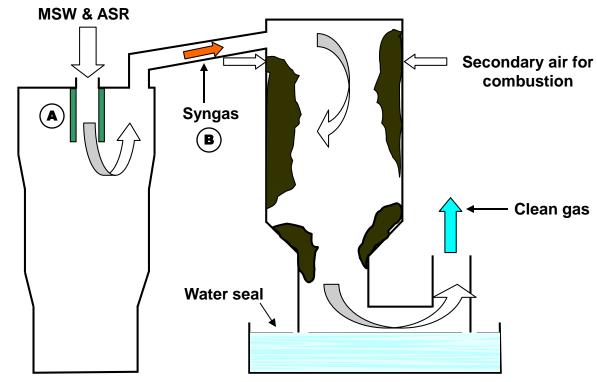




#### **OPERATIONAL ISSUE #3: PARTICULATE CARRY-OVER**

PDMR

After burner



Improv	/ement
Method	Effect
A: feed pipe for prevention of short pass	<ul> <li>ash carry-over was reduced by 50%</li> <li>feed pipe melted</li> </ul>
B: Temperature Control of exiting syngas 1000°C 750~800°C	<ul> <li>not molten but accumulated inside</li> <li>not molten and not accumulated</li> </ul>



## **OPERATIONAL ISSUE #3: PARTICULATE CARRY-OVER**

#### Slag and Ash Accumulation Inside the Afterburner



Before modification – large accumulation



After modification – accumulation reduced





# SUMMARY OF ECO VALLEY EXPERIENCE

- 1. Eco Valley experienced many problems with ASR in the early year of operation, which led to numerous improvements
- 2. Eco Valley has established the PDMR system for use with MSW
- 3. Eco Valley has continued commercial operation with MSW since 2003
- 4. Plant has proven relatively easy to operate
- 5. Plasma torches are proven to be reliable and robust



# **NEXT GENERATION GASIFER DESIGN**

- Alter NRG Corp. purchased Westinghouse Plasma Corporation in 2007
- Alter worked closely with Hitachi Metals to understand operation of Utashinai
- Re-work of the original design through 2008/2009 to incorporate Utashanai experience
- Use of advanced engineering tools to enhance design further
- Strategic partnerships with engineering companies and material supply companies (e.g. refractory)
- Modifications and improvements to pilot plant in Madison WI to further prove new design elements

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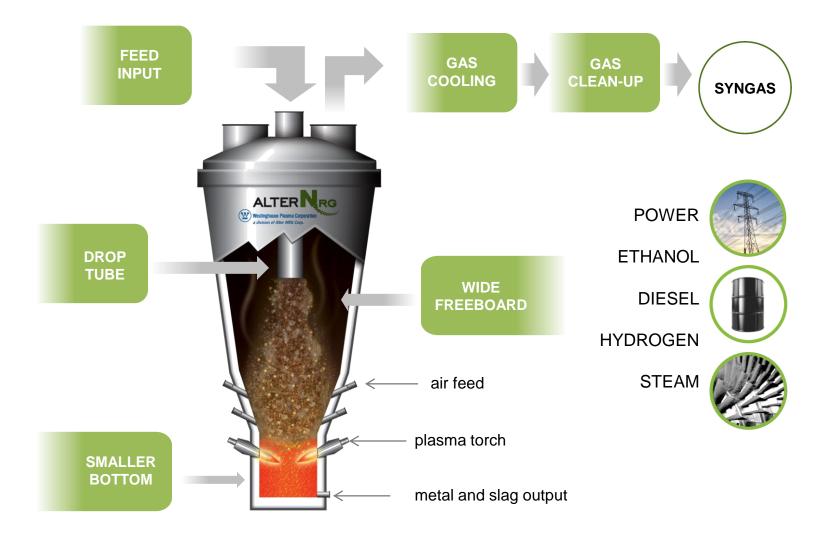


# **UTASHINAI ISSUES ADDRESSED IN NEXT GENERATION DESIGN**

- Issue 1 Bottom diameter sizing
  - Using available thermal modeling tools,
  - Comparison of existing plant data
  - Approximation of steady state heat flux to ensure internal temperature is well above ash melting point
  - Validation/testing in our pilot plant
- Issue 2 Refractory
  - Approximation of slag freezing plane through thermal modeling work (Hatch)
  - Working with Saint Gobain on best suited materials selection → conductive inner layer, similar to Eco-Valley
- Issue 3 Carryover issues
  - Internal partial water quench solidifies molten and sticky particulate
  - CFD work ensures that bulk gas flow is cold enough prior to any changes in direction
  - Drop tube design available for suitable feedstocks, minimizing entrainment of fines



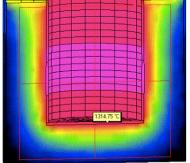
## **ENHANCED GASIFIER DESIGN**

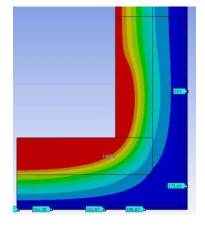




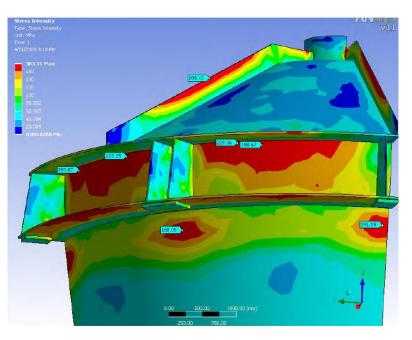
# SOLUTIONS TO PROBLEMS IN CURRENT DESIGN

Issue #1 (Bottom Diameter) & #2 (Refractory): Thermal modeling Work





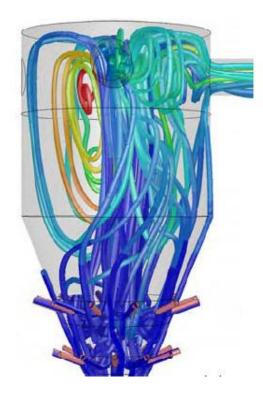
Prediction of slag freezing plane (emulating Eco Valley refractory performance)



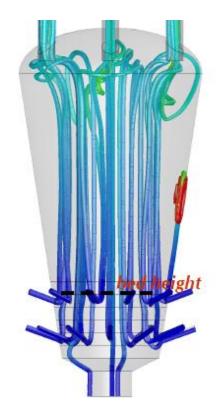
Finite Element Analysis for vessel mechanical integrity



# SOLUTIONS TO PROBLEMS IN CURRENT DESIGN



Issue #3 (Particulate Carryover): CFD Modeling – gas flows, temperatures



Optimization of flow reducing High velocity zones, minimizing carryover



# FURTHER INVESTIGATION OF PROBLEMS



Madison Gasification Facility (WPC)

Oxygen Blown Operation Biomass Fed Particulate Removal Syngas Cleanup Compression

ALTER

RG



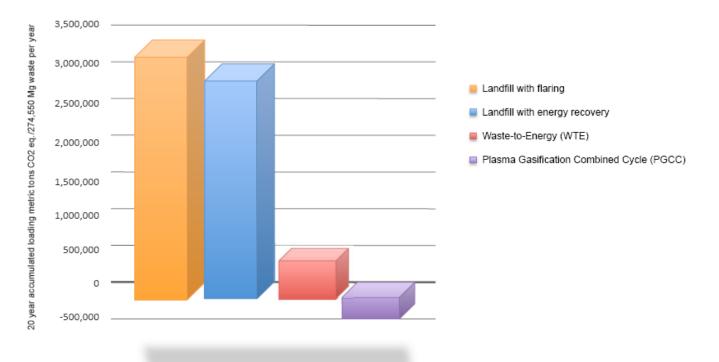
#### **Ethanol Production Facility (Coskata)**

Westinghouse Plasma Corporation

a division of Alter NRG Corp.

# **CO<sub>2</sub> EMISSIONS**

Third party comparison of life cycle CO2 equivalent emissions of landfill, Landfill with flaring, Waste to Energy, and Plasma Gasification Combined Cycle Scientific Certification Systems report, January 2010



Twenty year accumulated GHG loading for four waste disposal options. Results compared on a basis of 274,550 metric tonnes of MSW per year. The zero axis on the chart represents emission level form baseload regional grid emissions in the Northeastern Power Coordinating Council (NPCC) National Energy Reliability Council (NERC) subregion.

The main advantage of PGCC is derived from its ability to operate with combined cycle power island.



#### **TYPICAL HEAT & MATERIAL BALANCE**

#### **Confidential Heat and Material Balance**

#### SALES KIT SIMULATIONS

#### Low Btu (i.e. HHV: 5000 Btu/lb) MSW Gasification - Oxygen Blown (One G65 Gasifier)

Slag:

Metals:

4.4 MW

0.0 MW

ALTER

Total

kg/hr

**Overall Ma** 

rial Balance

RG

<sup>‡</sup> Heat of Vaporization Adjustment for LHV balance

138.05

In

72,977

138.05

Out

72,977

105KS01 - HMB202R00

1-Apr-10

*1105Medium Btu MSW 41 Coke 1 Total excl. coke [Note 7] 41 Total incl. coke 7] 41 Total incl. coke 43 FLUX in Flux Flux Flux Flux Flux Flux Flux Flux	kg/hr 41,667 1,667 41,667 43,334 44,334 44,34444,344 44,344 44,344 44,34444,344 44,344 44,34444,344 44,344 44,34444,344 44,34444,344 44,344 44,34444,344 44,34444,344 44,34444,344 44,34444,344 44,34444,344 44,34444,344 44,34444,344 44,34444,344 44,34444,344 44,34444,344 44,34444,344 44,34444,344 44,34444,344 44,34444,344 44,34444,344 44,44444,444 44,44444,444 44,44444,444 44,44444,444 44,44444,444 44,44444,444 44,44444,444 44,44444,444 44,44444,444 44,44444,444 44,44444,444 44,44444,444 44,44444,444 44,44444,444 44,44444,444 44,44444,44444,444 44,44444,44444,444 44,44444,44444,444 44,44444,44444,44444,444 44,44444,44444,444 44,44444,44444,444 44,44444,444 44,44444,444 44,44444,444 44,44444,44444,444 44,44444,444444,4444 44,44444,44444,44444,44444,44444,44444	r r s basis r r	13.8 M	kJ/kg 10,779 29,834 10,779 11,512 11,512 WW Feedstock WW Feedstock	v	24.28%	7.03% 21.00% 20.46%	99.13% 52.23% 55.23%	H 7.25% 3 0.00% 7.25% 3 6.79% 3	00% 0.0 29% 0.7 84% 0.7	N :74% 0.569	5 0.00% 5 0.93%	cal (MW)	26.9 10.2 1.9 95.1	HHV 26.9 10.2 1.9 100.7 139.7	FAW SYNGAS (Excluding Solids)           Volumetric Flow           Mass Flow           Temperature           Pressure           Composition           CO           CO2           O2           Ar           Hy           CH4           CyH4           CyH4           CyH4           CyH4           CoN           SO2           N2           Hy           CH4           CyH4           CyN5           CO3           SO2           NH5           H>O	MR %           32.156%           25.363%           0.000%           9.109%           1.543%           0.520%           0.520%           0.243%           0.520%           0.520%           0.520%           0.520%           0.533%           0.381%           0.660%           0.060%           0.063%           0.063%           0.005%	kg/hr	Partially Quer 62,716 64,832 850 1011 <u>WR %</u> 0.000% 8.535% 0.437% 0.447% 0.447% 0.447% 0.447% 0.447% 0.447% 0.447% 0.447% 0.447% 0.447% 0.447% 0.447% 0.447% 0.437% 0.447% 0.437% 0.447% 0.447% 0.437% 0.447% 0.437% 0.447% 0.437% 0.447% 0.447% 0.437% 0.437% 0.447% 0.437% 0.437% 0.437% 0.437% 0.437% 0.437% 0.437% 0.437% 0.437% 0.437% 0.437% 0.437% 0.437% 0.437% 0.437% 0.437%0.437% 0.437% 0.437% 0.437%0.437% 0.437% 0.437% 0.437%0.437% 0.437% 0.437%0.437% 0.437% 0.437%0.437% 0.437% 0.437%0.437% 0.437% 0.437%0.437% 0.437% 0.437%0.437% 0.437% 0.437%0.437% 0.437%0.437% 0.437% 0.437%0.437%0.437% 0.437%0.437%0.437% 0.437%0.437%0.437% 0.437%0.437%0.437% 0.437%0.437%0.437%0.437% 0.437%0.437%0.437%0.437% 0.437%0.437%0.437%0.437% 0.437%0.437%0.437%0.437% 0.457%0.45%%0.45%%0.45%%0.45%%0.45%%0.45%%0.45%%0.45%%0.45%%0.45%%0.45%%0.45%%0.45%%0.45%%0.45%%0.45%%%0.45%%%%%%%%%%%%%%%	Nm³/hr           kg/hr           °C           kPa <u>Vol %</u> 24.95           12.51           0.000           7.05           0.83           10.79           0.93           0.37           0.18           0.18
1105Medium Btu MSW     41       Coke     1       Total excl. coke [Note 7]     41       Fotal anci. coke [Note 7]     41       Total excl. coke [Note 7]     41       Total anci. coke [Note 7]     51       Shroud Steam     20       Shroud Air     6       Shroud Air     6       Shroud Air     6       Shroud Air     1       Pressure     1       Temperature     1       Stroud Air <td< th=""><th>1,667 1,667 41,667 41,667 43,334 5,891 kg/hr 43,334 5,891 kg/hr 15,923 kg/hr 15,923 kg/hr 15,923 kg/hr 15,923 kg/hr 136 kPa 25 °C 6,000 kg/hr</th><th>11,630 29,834 11,630 12,330 r r r</th><th>5,000 12,826 5,000 5,301 124.6 M 13.8 M</th><th>29,834 10,779 11,512 WW Feedstock</th><th>4,634 12,826 4,634 4,949 k, LHV V</th><th>1.18% 25.20% 24.28%</th><th>7.03% 21.00% 20.46%</th><th>99.13% 52.23% 55.23%</th><th>0.00% 7.25% 3 6.79% 3</th><th>00% 0.0 29% 0.7 84% 0.7</th><th>00% 0.87° 74% 0.56°</th><th>5 0.00% 5 0.93% 5 0.87% Sensible (MW) Latent (MW) Solids Chemic Syngas Chemi</th><th>cal (MW)</th><th>26.9 10.2 1.9 95.1</th><th>26.9 10.2 1.9 100.7</th><th>Volumetric Flow           Mass Flow           Temperature           Pressure           Composition           CO2           O2           N2           Ar           H3           CH4           C3H6           C3H6           C3H6           C3H7           COS           SC2           N4           C3H6           C3H7           C4H2           C4H2           C4H3           COS           SC2           NH5           HCN</th><th>60,746 1,000 1011 32,159% 32,533% 0,000% 1,003% 0,833% 0,833% 0,833% 0,833% 0,833% 0,833% 0,833% 0,833% 0,833% 0,333% 0,000% 0,000% 0,000%</th><th>kg/hr *C KPa 27.121% 13.615% 0.000% 7.682% 0.0913% 11.749% 1.021% 0.408% 0.204% 0.204% 0.204% 0.204% 0.204% 0.204% 0.204% 0.204% 0.024%</th><th>62,716 64,832 8500 101 101 1030,129% 23,764% 0,000% 0,487% 0,487% 0,487% 0,487% 0,487% 0,487% 0,487% 0,487% 0,337% 0,487% 0,037% 0,037% 0,007% 0,000% 0,007% 0,007%</th><th>Nm³/hr kg/hr *C kPa 24.9; 12.5 0.00 7.00 0.8; 10.7; 0.9; 0.9; 0.3; 0.11 0.11 0.11 0.11 0.2; 0.11</th></td<>	1,667 1,667 41,667 41,667 43,334 5,891 kg/hr 43,334 5,891 kg/hr 15,923 kg/hr 15,923 kg/hr 15,923 kg/hr 15,923 kg/hr 136 kPa 25 °C 6,000 kg/hr	11,630 29,834 11,630 12,330 r r r	5,000 12,826 5,000 5,301 124.6 M 13.8 M	29,834 10,779 11,512 WW Feedstock	4,634 12,826 4,634 4,949 k, LHV V	1.18% 25.20% 24.28%	7.03% 21.00% 20.46%	99.13% 52.23% 55.23%	0.00% 7.25% 3 6.79% 3	00% 0.0 29% 0.7 84% 0.7	00% 0.87° 74% 0.56°	5 0.00% 5 0.93% 5 0.87% Sensible (MW) Latent (MW) Solids Chemic Syngas Chemi	cal (MW)	26.9 10.2 1.9 95.1	26.9 10.2 1.9 100.7	Volumetric Flow           Mass Flow           Temperature           Pressure           Composition           CO2           O2           N2           Ar           H3           CH4           C3H6           C3H6           C3H6           C3H7           COS           SC2           N4           C3H6           C3H7           C4H2           C4H2           C4H3           COS           SC2           NH5           HCN	60,746 1,000 1011 32,159% 32,533% 0,000% 1,003% 0,833% 0,833% 0,833% 0,833% 0,833% 0,833% 0,833% 0,833% 0,833% 0,333% 0,000% 0,000% 0,000%	kg/hr *C KPa 27.121% 13.615% 0.000% 7.682% 0.0913% 11.749% 1.021% 0.408% 0.204% 0.204% 0.204% 0.204% 0.204% 0.204% 0.204% 0.204% 0.024%	62,716 64,832 8500 101 101 1030,129% 23,764% 0,000% 0,487% 0,487% 0,487% 0,487% 0,487% 0,487% 0,487% 0,487% 0,337% 0,487% 0,037% 0,037% 0,007% 0,000% 0,007% 0,007%	Nm³/hr kg/hr *C kPa 24.9; 12.5 0.00 7.00 0.8; 10.7; 0.9; 0.9; 0.3; 0.11 0.11 0.11 0.11 0.2; 0.11
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Total excl. coke [Note 7] 41 Total incl. coke 43 FLUX in 43 FLUX in 5 FLUX in 5 Stream 2 Stream 2 Stre	41,667 43,334 5,891 kg/hr iestone 0 kg/hr 308 kPa 15,923 kg/hr 92% rmasi 15,923 kg/hr 92% kg/hr 15,923 kg/hr 92% kg/hr 15,923 kg/hr 92% cm 6,000 kg/hr	11,630 12,330 r r r s basis r	5,000 5,301 124.6 M 13.8 M	10,779 11,512 WW Feedstock WW Coke, LHV	4,634 4,949 k, LHV V	25.20% 24.28%	21.00% 20.46%	52.23%	7.25% 3	29% 0.7	74% 0.56%	Sensible (MW) Latent (MW) Solids Chemica Syngas Chemi	cal (MW)	26.9 10.2 1.9 95.1	26.9 10.2 1.9 100.7	Temperature Pressure Composition CO CO CO 2 0 3 N 2 Ar H2 CH4	1,000 101 32,159% 25,363% 0,000% 1,543% 0,038% 0,038% 0,243% 0,387% 0,387% 0,338% 0,309% 0,000% 0,000%	*C KPa 27.121% 13.615% 0.000% 7.682% 0.913% 11.749% 0.204% 0.204% 0.204% 0.204% 0.204% 0.204% 0.214% 0.024% 0.002%	850 101 30.129% 30.129% 8.535% 0.650% 0.487% 0.650% 0.487% 0.367% 0.367% 0.357% 0.357% 0.0471% 0.357% 0.057% 0.057%	°C kPa <u>Vol %</u> 24.9 12.5 0.0 7.0 0.8 10.7 0.9 0.3 0.1 0.1 0.1 0.1 0.2 0.1 0.0
Total acci. coke [Note 7] 41 Total Incl. coke 43 FLUX in 43 FLUX in 5 FLUX Incl. Coke 43 FLUX Incl. Coke 43 Fressure 5 Combined Oxygen Purity 15 Combined Oxygen Purity 15 Shroud Air Stream 9 Fressure 1 Frenperature 1 Pressure 1 Frenperature	41,667 43,334 5,891 kg/hr iestone 0 kg/hr 308 kPa 15,923 kg/hr 92% rmasi 15,923 kg/hr 92% kg/hr 15,923 kg/hr 92% kg/hr 15,923 kg/hr 92% cm 6,000 kg/hr	11,630 12,330 r r r s basis r	5,000 5,301 124.6 M 13.8 M	10,779 11,512 WW Feedstock WW Coke, LHV	4,634 4,949 k, LHV V	25.20% 24.28%	21.00% 20.46%	52.23%	7.25% 3	29% 0.7	74% 0.56%	Sensible (MW) Latent (MW) Solids Chemica Syngas Chemi	cal (MW)	26.9 10.2 1.9 95.1	26.9 10.2 1.9 100.7	Pressure <u>Composition</u> CO CO CO CO CO CO CO CO CO CO	101 <u>₩ %</u> 3.2.165% 2.5.363% 0.000% 1.063% 0.633% 0.633% 0.243% 0.381% 0.361% 0.369% 0.060% 0.000% 0.000% 0.005%	kPa Vol % 27.121% 13.615% 0.000% 7.682% 0.913% 1.021% 0.408% 0.204% 0.204% 0.204% 0.204% 0.204% 0.229% 0.214% 0.024% 0.024% 0.024% 0.024% 0.0214% 0.020% 0.021% 0.020% 0.020% 0.020% 0.020% 0.020% 0.020% 0.020% 0.020% 0.020% 0.020% 0.020% 0.020% 0.020% 0.021% 0.020% 0.021% 0.020% 0.021% 0.001% 0.015% 0.015% 0.015% 0.021% 0.001% 0.015%	101 <u>W1 %</u> 30.129% 23.764% 0.000% 8.535% 0.487% 0.357% 0.487% 0.357% 0.471% 0.228% 0.057% 0.075% 0.075%	kPa Vol % 24.9 12.5 0.0 7.0 0.8 10.7 0.9 0.3 0.1 0.1 0.1 0.1 0.2 0.1 0.0 0.0 0.0 0.0 0.0 0.0 0.0
Total excl. coke [Note 7] 41 Total Incl. coke 43 FLUX in 5 FLUX Marcinal Limes STEAM In Limes STEAM In LP Steam Pressure Temperature 5 Shroud Steam 0 OXIDAT in 0 Oxodant (tota) 15 Combined Oxygen Purity 15 Combined Oxygen Purity 15 Combined Oxygen Purity 15 Shroud Air Stream 9 Shroud Air Stream 9 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 7 Pressure 1 Temperature 1 Pressure 1 Pre	41,667 43,334 5,891 kg/hr iestone 0 kg/hr 308 kPa 15,923 kg/hr 92% rmasi 15,923 kg/hr 92% kg/hr 15,923 kg/hr 92% kg/hr 15,923 kg/hr 92% cm 6,000 kg/hr	11,630 12,330 r r r s basis r	5,000 5,301 124.6 M 13.8 M	10,779 11,512 WW Feedstock WW Coke, LHV	4,634 4,949 k, LHV V	25.20% 24.28%	21.00% 20.46%	52.23%	7.25% 3	29% 0.7	74% 0.56%	Sensible (MW) Latent (MW) Solids Chemica Syngas Chemi	cal (MW)	26.9 10.2 1.9 95.1	26.9 10.2 1.9 100.7	Composition           CO           CO2           O3           N2           Ar           H2           CH4           C3H6           C3H6           C4H6           C3H6           C3H6           C3H6           C3H6           C3H6           C4H70           HCI           H25           COS           SO2           NH70           HCN	MR %           32.156%           25.363%           0.000%           9.109%           1.543%           0.520%           0.520%           0.243%           0.520%           0.520%           0.520%           0.520%           0.533%           0.381%           0.660%           0.060%           0.060%           0.063%           0.063%           0.005%	Val % 27.121% 13.615% 0.000% 7.682% 0.913% 1.021% 0.204% 0.204% 0.204% 0.224% 0.224% 0.224% 0.224% 0.224% 0.024% 0.024% 0.024% 0.016%	Wh %           30.129%           23.764%           0.000%           8.535%           1.446%           0.650%           0.487%           0.357%           0.357%           0.331%           0.227%           0.357%           0.331%           0.289%           0.057%           0.078%	Vol % 24.92 12.5 0.00 7.00 0.83 0.33 0.33 0.33 0.11 0.11 0.11 0.11 0.1
Total excl. coke [Note 7] 41 Total Incl. coke 43 FLUX in 5 FLUX Marcinal Limes STEAM In Limes STEAM In LP Steam Pressure Temperature 5 Shroud Steam 0 OXIDAT in 0 Oxodant (tota) 15 Combined Oxygen Purity 15 Combined Oxygen Purity 15 Combined Oxygen Purity 15 Shroud Air Stream 9 Shroud Air Stream 9 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 7 Pressure 1 Temperature 1 Pressure 1 Pre	41,667 43,334 5,891 kg/hr iestone 0 kg/hr 308 kPa 15,923 kg/hr 92% rmasi 15,923 kg/hr 92% kg/hr 15,923 kg/hr 92% kg/hr 15,923 kg/hr 92% cm 6,000 kg/hr	11,630 12,330 r r r s basis r	5,000 5,301 124.6 M 13.8 M	10,779 11,512 WW Feedstock WW Coke, LHV	4,634 4,949 k, LHV V	25.20% 24.28%	21.00% 20.46%	52.23%	7.25% 3	29% 0.7	74% 0.56%	Sensible (MW) Latent (MW) Solids Chemica Syngas Chemi	cal (MW)	26.9 10.2 1.9 95.1	26.9 10.2 1.9 100.7	CO CO <sub>2</sub> CO <sub>2</sub> N <sub>2</sub> Ar H <sub>3</sub> CH <sub>4</sub> C <sub>2</sub> H <sub>4</sub> C <sub>2</sub> H <sub>4</sub> C <sub>4</sub> H <sub>6</sub> C <sub>4</sub> H <sub>6</sub> C <sub>4</sub> H <sub>6</sub> CAH <sub>10</sub> HCI H <sub>5</sub> S COS SC <sub>2</sub> NH <sub>5</sub> HCN	32.156% 25.363% 0.000% 9.109% 1.543% 0.683% 0.520% 0.243% 0.381% 0.502% 0.363% 0.360% 0.060% 0.006% 0.005%	27.121% 13.815% 0.000% 7.682% 0.913% 11.749% 1.021% 0.408% 0.204% 0.204% 0.204% 0.204% 0.204% 0.229% 0.224% 0.229% 0.214% 0.024% 0.024% 0.024% 0.024%	30.129% 23.764% 0.000% 8.535% 1.446% 0.939% 0.650% 0.487% 0.227% 0.357% 0.471% 0.331% 0.239% 0.331% 0.289% 0.057% 0.0057% 0.007%	24.92 12.51 0.00 7.02 0.83 10.75 0.93 0.33 0.33 0.31 0.18 0.18 0.18 0.22 0.15
Total excl. coke [Note 7] 41 Total Incl. coke 43 FLUX in 5 FLUX Marcinal Limes STEAM In Limes STEAM In LP Steam Pressure Temperature 5 Shroud Steam 0 OXIDAT in 0 Oxodant (tota) 15 Combined Oxygen Purity 15 Combined Oxygen Purity 15 Combined Oxygen Purity 15 Shroud Air Stream 9 Shroud Air Stream 9 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 7 Pressure 1 Temperature 1 Pressure 1 Pre	41,667 43,334 5,891 kg/hr iestone 0 kg/hr 308 kPa 15,923 kg/hr 92% rmasi 15,923 kg/hr 92% kg/hr 15,923 kg/hr 92% kg/hr 15,923 kg/hr 92% cm 6,000 kg/hr	11,630 12,330 r r r s basis r	5,000 5,301 124.6 M 13.8 M	10,779 11,512 WW Feedstock WW Coke, LHV	4,634 4,949 k, LHV V	25.20% 24.28%	21.00% 20.46%	52.23%	7.25% 3	29% 0.7	74% 0.56%	Sensible (MW) Latent (MW) Solids Chemica Syngas Chemi	cal (MW)	26.9 10.2 1.9 95.1	26.9 10.2 1.9 100.7	CO <sub>2</sub> O <sub>2</sub> N <sub>2</sub> Ar H <sub>3</sub> C <sub>3</sub> H <sub>4</sub> C <sub>3</sub> H <sub>4</sub> C <sub>3</sub> H <sub>6</sub> C <sub>4</sub> H <sub>10</sub> H <sub>10</sub>	25.363% 0.000% 9.109% 1.543% 0.683% 0.520% 0.381% 0.352% 0.309% 0.000% 0.000% 0.000% 0.003% 0.005%	13.615% 0.000% 7.682% 0.913% 11.749% 1.021% 0.408% 0.204% 0.204% 0.204% 0.229% 0.224% 0.224% 0.224% 0.024% 0.024% 0.024% 0.024% 0.024%	23.764% 0.000% 8.535% 0.650% 0.487% 0.227% 0.357% 0.357% 0.331% 0.289% 0.057% 0.0057% 0.000%	12.51 0.00 7.05 0.83 10.77 0.93 0.33 0.18 0.18 0.18 0.21 0.15 0.02
Total excl. coke [Note 7] 41 Total Incl. coke 43 FLUX in 5 FLUX Marcial Limes STEAM In Limes STEAM In 1 LP Steam Pressure Temperature 5 Shroud Steam 0 COUDANT in 0 Condiant (tota) 15 Combined Oxygen Purity 15 Combined Oxygen Purity 15 Combined Oxygen Purity 15 Shroud Air Stream 9 3 mol% purity 15 Shroud Air Stream 9 35 mol% purity 15 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 6 Shroud Air 7 Pressure 1 Temperature 1 Pressure 1 Temperature 1 Pressure 1 Temperature 1 Pressure 1 Temperature 1 Purit Controls / Gasifier 1 Radio 1 Purit Controls / Gasifier 1 Electric Energy Use 1 Shroud Air 7 Shroud Oxygen 9 Marce 1 Purit Controls / Gasifier 1 Electric Energy Use 1 Controls / Gasifier 1 Electric Energy Use 1 Controls / Gasifier 1 Electric Energy Use 1 Controls / Casifier 1 Electric Energy Use 1 Controls / Casifier 1 Control Control / Casifier 1 Control Control / Casifier 1 Control Control / Casifier 1 Control Cont	41,667 43,334 5,891 kg/hr iestone 0 kg/hr 308 kPa 15,923 kg/hr 92% rmasi 15,923 kg/hr 92% kg/hr 15,923 kg/hr 92% kg/hr 15,923 kg/hr 92% cm 6,000 kg/hr	11,630 12,330 r r r s basis r	5,000 5,301 124.6 M 13.8 M	10,779 11,512 WW Feedstock WW Coke, LHV	4,634 4,949 k, LHV V	25.20% 24.28%	21.00% 20.46%	52.23%	7.25% 3	29% 0.7	74% 0.56%	Sensible (MW) Latent (MW) Solids Chemica Syngas Chemi	cal (MW)	26.9 10.2 1.9 95.1	26.9 10.2 1.9 100.7	0, N2 Ar H5 CH4 C3H6 C4H4 C3H6 C4H6 C4H6 C4H6 C0S SO2 SO2 SO3 SO3 SO3 SO3 SO4 HC0 HC0 HC0 HC0 HC0 HC0 HC0 HC0	0.000% 9.109% 1.543% 0.693% 0.693% 0.243% 0.381% 0.353% 0.353% 0.360% 0.060% 0.060% 0.003% 0.005%	0.000% 7.682% 0.913% 1.749% 0.204% 0.204% 0.204% 0.204% 0.229% 0.214% 0.024% 0.024% 0.024% 0.024% 0.024%	0.000% 8.535% 0.939% 0.650% 0.487% 0.227% 0.357% 0.471% 0.331% 0.289% 0.057% 0.000% 0.007%	0.00 7.05 0.83 10.75 0.93 0.37 0.18 0.18 0.18 0.21 0.15 0.22
Total Incl. coke     43       Flux Marrial     Limes       Flux Marrial     Limes       STEAM In     E       Desarra     Temperature       Shroud Steam     OxiDANT In       Oxidant (total)     15       Combined Oxyaen Purty     Oxyaen Steam (b)       Oxidant (total)     15       Combined Oxyaen Purty     Oxyaen Steam (b)       Oxyaen Steam (b)     15       Freesure     Temperature       Temperature     6       Shroud Air     6       Shroud Air     6       Pressure     1       Temperature     1       Pressure     1       Temperature     1       Pressure     1       Temperature     1       Pressure     1       Temperature     1       Pussure     1       Temperature     1       Temperature     1       Pussure     1       Temperature     1	5,891 kg/hr estone 0 kg/hr 308 kPa 150 °C 0 kg/hr 15,923 kg/hr 92% mast 15,923 kg/hr 15,923 kg/hr 15,923 kg/hr 15,923 kg/hr 15,923 kg/hr	r r r r s basis r r	5,301 124.6 M 13.8 M	11,512 MW Feedstock MW Coke, LHV	4,949 k, LHV V	24.28%	20.46%	55.23%	6.79% 3	84% 0.7		Sensible (MW) Latent (MW) Solids Chemica Syngas Chemi	cal (MW)	26.9 10.2 1.9 95.1	26.9 10.2 1.9 100.7	Ny Ar Hy CH4 CH4 C3H9 C3H9 C4H9 C4H9 C4H9 C4H9 C0S SO2 NH5 HCN	9.109% 1.543% 1.003% 0.693% 0.520% 0.243% 0.381% 0.353% 0.309% 0.060% 0.000% 0.0083% 0.003%	7.682% 0.913% 11.749% 1.021% 0.408% 0.204% 0.204% 0.204% 0.229% 0.214% 0.024% 0.024% 0.024% 0.024%	8.535% 1.446% 0.939% 0.650% 0.487% 0.227% 0.357% 0.471% 0.331% 0.289% 0.057% 0.005% 0.000%	7.05 0.85 10.75 0.93 0.37 0.18 0.18 0.18 0.21 0.15 0.02
FLUX in         5           FLix         5           Flix         Limet           STEAM in         Limet           LP Steam         Pressure           Pressure         Condiant (ota)           OxIDANT in         OxOidant (ota)           Oxigen Stream @ 93 mol% purity         15           Ark Stream         Shroud Air           Shroud Air         6           Shroud Air         6           Shroud Air         6           Shroud Air         15           Pressure         1           Temperature         1           Puestorter         1           Temperature         1           Temperature         1           <	5,891 kg/hr estone 0 kg/hr 308 kPa 15.923 kg/hr 15,923 kg/hr - kg/hr 136 kPa 25 *C 6,000 kg/hr	r r s basis r r	124.6 M 13.8 M	MW Feedstock MW Coke, LHV	k, LHV V			Ì				Sensible (MW) Latent (MW) Solids Chemica Syngas Chemi	cal (MW)	26.9 10.2 1.9 95.1	26.9 10.2 1.9 100.7	Ar H <sub>2</sub> CH4 C <sub>2</sub> H4 C <sub>2</sub> H4 C <sub>2</sub> H4 C <sub>4</sub> H10 H <sub>5</sub> COS SO <sub>2</sub> SO <sub>2</sub> NH5 HCN	1.543% 1.003% 0.520% 0.243% 0.381% 0.381% 0.353% 0.309% 0.060% 0.060% 0.0083% 0.003%	0.913% 11.749% 1.021% 0.408% 0.204% 0.204% 0.229% 0.214% 0.024% 0.024% 0.024% 0.024% 0.024%	1.446% 0.939% 0.650% 0.227% 0.357% 0.471% 0.331% 0.289% 0.057% 0.000% 0.007%	0.85 10.75 0.95 0.37 0.18 0.18 0.21 0.18 0.21 0.15 0.02
Flux Flux Material Linet STAM In Linet STAM In Linet STAM In Linet STAM In LP Steam Pressure Temperature Shroud Steam Oxidant (total) Combined Oxygen Purity Art Stream (§ 33 mo1% purity Art Stream (§ 33 mo1% purity Art Stream Shroud Air Stream (§ 33 mo1% purity Art Stream Shroud Air Stream (§ 33 mo1% purity Art Stream Shroud Air Shroud Oxygen (§ 33 mo1% purity Art Stream Shroud Air Shroud Oxygen (§ 33 mo1% purity Art Stream Shroud Air Shroud Oxygen (§ 33 mo1% purity Art Stream Pressure Temperature Pressure Temperature Interpretature Pressure 1 Puestant Cont Air Oxoch Air Shroud Oxygen (§ 33 mo1% purity 1 Pressure 1 Temperature Pressure 1 Temperature Pressure 1 Temperature Interpretature	0 kg/hr 308 kPa 150 °C 0 kg/hr 92% mass 15,923 kg/hr 92% mass 15,923 kg/hr - kg/hr 136 kPa 25 °C 6,000 kg/hr	r r s basis r r	13.8 M	WW Coke, LHV	v			ALT	ERN			Latent (MW) Solids Chemica Syngas Chemi	cal (MW)	26.9 10.2 1.9 95.1	26.9 10.2 1.9 100.7	H <sub>2</sub> CH <sub>4</sub> C <sub>2</sub> H <sub>9</sub> C <sub>2</sub> H <sub>9</sub> C <sub>4</sub> H <sub>9</sub> C <sub>4</sub> H <sub>9</sub> HCI H <sub>5</sub> COS SC <sub>2</sub> NH <sub>5</sub> HCN	1.003% 0.693% 0.224% 0.381% 0.352% 0.353% 0.309% 0.060% 0.000% 0.003%	11.749% 1.021% 0.408% 0.204% 0.204% 0.224% 0.229% 0.214% 0.024% 0.024% 0.000% 0.116%	0.939% 0.650% 0.487% 0.227% 0.357% 0.471% 0.331% 0.289% 0.057% 0.057% 0.000%	10.75 0.93 0.37 0.18 0.18 0.21 0.18 0.21 0.15 0.02
Flux Flux Material Linet STAM In Linet STAM In Linet STAM In Linet STAM In LP Steam Pressure Temperature Shroud Steam Oxidant (total) Combined Oxygen Purity Art Stream (§ 33 mo1% purity Art Stream (§ 33 mo1% purity Art Stream Shroud Air Stream (§ 33 mo1% purity Art Stream Shroud Air Stream (§ 33 mo1% purity Art Stream Shroud Air Shroud Oxygen (§ 33 mo1% purity Art Stream Shroud Air Shroud Oxygen (§ 33 mo1% purity Art Stream Shroud Air Shroud Oxygen (§ 33 mo1% purity Art Stream Pressure Temperature Pressure Temperature Interpretature Pressure 1 Puestant Cont Air Oxoch Air Shroud Oxygen (§ 33 mo1% purity 1 Pressure 1 Temperature Pressure 1 Temperature Pressure 1 Temperature Interpretature	0 kg/hr 308 kPa 150 °C 0 kg/hr 92% mass 15,923 kg/hr 92% mass 15,923 kg/hr - kg/hr 136 kPa 25 °C 6,000 kg/hr	r r s basis r r	13.8 M	WW Coke, LHV	v	ion		ALT	ERN		5	Latent (MW) Solids Chemica Syngas Chemi	cal (MW)	26.9 10.2 1.9 95.1	26.9 10.2 1.9 100.7	C244, C244, C346, C446, HCI HCS COS SC2, NH5, HCN	0.693% 0.520% 0.243% 0.381% 0.502% 0.353% 0.309% 0.060% 0.000% 0.000% 0.083%	1.021% 0.408% 0.204% 0.204% 0.229% 0.214% 0.022% 0.024% 0.000% 0.116%	0.650% 0.487% 0.227% 0.357% 0.471% 0.331% 0.289% 0.057% 0.000% 0.0078%	0.93 0.37 0.18 0.18 0.21 0.15 0.21
Flux Flux Material Linet STAM In Linet STAM In Linet STAM In Linet STAM In LP Steam Pressure Temperature Shroud Steam Oxidant (total) Combined Oxygen Purity Art Stream (§ 33 mo1% purity Art Stream (§ 33 mo1% purity Art Stream Shroud Air Stream (§ 33 mo1% purity Art Stream Shroud Air Stream (§ 33 mo1% purity Art Stream Shroud Air Shroud Oxygen (§ 33 mo1% purity Art Stream Shroud Air Shroud Oxygen (§ 33 mo1% purity Art Stream Shroud Air Shroud Oxygen (§ 33 mo1% purity Art Stream Pressure Temperature Pressure Temperature Interpretature Pressure 1 Puestant Cont Air Oxoch Air Shroud Oxygen (§ 33 mo1% purity 1 Pressure 1 Temperature Pressure 1 Temperature Pressure 1 Temperature Interpretature	0 kg/hr 308 kPa 150 °C 0 kg/hr 92% mass 15,923 kg/hr 92% mass 15,923 kg/hr - kg/hr 136 kPa 25 °C 6,000 kg/hr	r r s basis r r	13.8 M	WW Coke, LHV	v	ion		ALT	ERN			Latent (MW) Solids Chemica Syngas Chemi	cal (MW)	26.9 10.2 1.9 95.1	26.9 10.2 1.9 100.7	C244, C244, C346, C446, HCI HCS COS SC2, NH5, HCN	0.520% 0.243% 0.381% 0.502% 0.353% 0.309% 0.060% 0.000% 0.000% 0.083% 0.005%	0.408% 0.204% 0.204% 0.229% 0.214% 0.024% 0.000% 0.116%	0.487% 0.227% 0.357% 0.471% 0.331% 0.289% 0.057% 0.000% 0.078%	0.37 0.18 0.18 0.18 0.21 0.19 0.02
Flux Marrial         Limes           STEAM in	0 kg/hr 308 kPa 150 °C 0 kg/hr 92% mass 15,923 kg/hr 92% mass 15,923 kg/hr - kg/hr 136 kPa 25 °C 6,000 kg/hr	r r s basis r r				ion		ALT	ERN		5	Latent (MW) Solids Chemica Syngas Chemi	cal (MW)	10.2 1.9 95.1	10.2 1.9 100.7	C2H4 C3H6 C4H6 HC HC C3H6 C4H6 C0S C0S C0S S02 NH5 HCN	0.243% 0.381% 0.502% 0.353% 0.309% 0.060% 0.000% 0.083% 0.005%	0.204% 0.204% 0.229% 0.214% 0.024% 0.024% 0.000% 0.116%	0.227% 0.357% 0.471% 0.331% 0.289% 0.057% 0.000% 0.000%	0.18 0.18 0.21 0.19 0.19
STEAM in       LP Steam       Pressure       Temperature       Shroud Steam       OXIDANT in       Oxidant (tota)       15       Combined Oxygen Purity       Oxygen Steam @ 93 mol% purity       Temperature       Shroud Air       Shroud Air       Shroud Air       Shroud Air       Pressure       Temperature       Plasma Torch Air       Plasma Torch Air       Puse of Torch Air       Puse of Torch North Cenergy       Type of Torch / Gasifier       Redrift Cransfered	0 kg/hr 308 kPa 150 °C 0 kg/hr 15,923 kg/hr 92% mass 15,923 kg/hr - kg/hr 136 kPa 25 °C 6,000 kg/hr	r s basis r	-2.9 <u>M</u>	WW Limestone	e Calcinati			ALT	ERN	-	5	Solids Chemica Syngas Chemi		1.9 95.1	1.9 100.7	C <sub>3</sub> H <sub>0</sub> C <sub>4</sub> H <sub>10</sub> HCI H <sub>2</sub> S COS SO <sub>2</sub> SO <sub>2</sub> NH <sub>3</sub> HCN	0.381% 0.502% 0.353% 0.309% 0.060% 0.060% 0.000% 0.083% 0.005%	0.204% 0.204% 0.229% 0.214% 0.024% 0.000% 0.116%	0.357% 0.471% 0.331% 0.289% 0.057% 0.000% 0.000%	0.18 0.18 0.21 0.19 0.02
LP Steam Pressure Temperature Shroud Steam OxiDaNT in Oxidant (total) Coxyen Steam @ 93 mot% purity Ar Stream Pressure Temperature Shroud Air Shroud Air Shroud Air Pressure Temperature Plasma Torch Air Pressure 1 Plasma Torch Air Pressure 1 PLASMA TORCH Energy Type of Torch No. of Torches / Gasifier Electric Energy Use Temperature	308 kPa 150 °C 0 kg/hr 92% mass 15,923 kg/hr 92% mass 15,923 kg/hr - kg/hr 136 kPa 25 °C 6,000 kg/hr	r s basis r						ALT	ERN	-	5	Syngas Chemi		95.1	100.7	C <sub>4</sub> H <sub>10</sub> HCI H <sub>2</sub> S COS SO <sub>2</sub> NH <sub>3</sub> HCN	0.502% 0.353% 0.309% 0.060% 0.000% 0.083% 0.005%	0.204% 0.229% 0.214% 0.024% 0.000% 0.116%	0.471% 0.331% 0.289% 0.057% 0.000% 0.078%	0.18 0.21 0.19 0.02
Pressure Temperature Shroud Steam OXIDANT in OXidant (tota) Condiant (tota) Co	308 kPa 150 °C 0 kg/hr 92% mass 15,923 kg/hr 92% mass 15,923 kg/hr - kg/hr 136 kPa 25 °C 6,000 kg/hr	r s basis r				1		ALT	ERN	-			nical (MVV)			HCI H <sub>2</sub> S COS SO <sub>2</sub> NH <sub>3</sub> HCN	0.353% 0.309% 0.060% 0.000% 0.083% 0.005%	0.229% 0.214% 0.024% 0.000% 0.116%	0.331% 0.289% 0.057% 0.000% 0.078%	0.21
Temperature         Shroud Steam           OXIDANT In         Conkined Oxygen Purity           Conkined Oxygen Purity         Ar Stream           Ar Stream         93 mol% purity           Ar Stream         Shroud Oxygen Q 93 mol% purity           Pressure         Temperature           Shroud Oxygen Q 93 mol% purity         1           Pressure         Temperature           Pleasma Torch Air         Pressure           Temperature         1           Pustor Torch Air         Pressure           Type of Torch         Nor of Torches / Gasifier           Nor of Torche / Gasifier         Marc           Thermal Energy Transferred         1	150 °C 0 kg/hr 92% mass 15,923 kg/hr 92% mass 15,923 kg/hr - kg/hr 136 kPa 25 °C 6,000 kg/hr	r s basis r				1		ALT	ERN	-		Total (MVV)		134.2	139.7	H <sub>2</sub> S COS SO <sub>2</sub> NH <sub>3</sub> HCN	0.309% 0.060% 0.000% 0.083% 0.005%	0.214% 0.024% 0.000% 0.116%	0.289% 0.057% 0.000% 0.078%	0.19
Shroud Steam           OXIDANT In           Oxidant (tota)           Combined Oxygen Purity           Oxygen Steam @ 93 mol% purity           Air Stream @           Temperature           Shroud Air           Shroud Air           Shroud Air           Shroud Air           Plessure           Temperature           Plasma Torch Air           Pressure           Temperature           PLASMA TORCH Energy           Type of Torch           No. of Torches / Gasifier           Electric Energy Use           Themal Energy Transferred	0 kg/hr 15,923 kg/hr 92% mass 15,923 kg/hr - kg/hr 136 kPa 25 °C 6,000 kg/hr	r s basis r				1		ALT	ERN	-		I				COS SO <sub>2</sub> NH <sub>3</sub> HCN	0.060% 0.000% 0.083% 0.005%	0.024% 0.000% 0.116%	0.057% 0.000% 0.078%	0.02
OUDANT in         Oxidant (total)         15           Combined Oxygen Purity         15         Ar Stream           Ar Stream         93 mol% purity         15           Ar Stream         Stroud Ar Stream         5           Shroud Air         6         Shroud Air           Pressure         1         1           Temperature         1         1           Plasma Torch Air         1         1           Plasma Torch Air         1         1           Pussure         1         1           Pussure         1         1           Temperature         1         1           Plasma Torch Air         1         1           Pussure         1         1           Tumperature         1         1           Plasma Torch Air         1         1           Not of Torches / Gasifier         Narc         1           Not of Torches / Gasifier         1         1           Themail Energy Transfered         1         1	15,923 kg/hr 92% mass 15,923 kg/hr - kg/hr 136 kPa 25 °C 6,000 kg/hr	r s basis r				1		ALT	ERN	80		I				SO <sub>2</sub> NH <sub>3</sub> HCN	0.000% 0.083% 0.005%	0.000% 0.116%	0.000% 0.078%	
Oxidant (total)     15       Combined Oxygen Purity     15       Combined Oxygen B) 83 mot% purity     15       Air Stream     Pressure       Temperature     6       Shroud Akir     6       Shroud Akir     6       Shroud Akir     11       Pressure     11       Temperature     11       Pressure     11       Temperature     11       Pressure     11       Temperature     11       Pressure     11       Temperature     11       Pressure     11       Pressure     11       Temperature     11       Pressure     11       Temperature     12       Public Attribution     Marc       No. of Torches / Gasifier     Marc       Electric Energy Use     15       Temmal Energy Transferred     14	92% mass 15,923 kg/hr - kg/hr 136 kPa 25 °C 6,000 kg/hr	s basis r r				١		ALT		PC		I				NH3 HCN	0.083% 0.005%	0.116%	0.078%	0.00
Combined Oxygen Purky Oxygen Stream @ 93 mot% purky Ar Stream Pressure Temperature Stroud Air Stroud Oxygen @ 93 mot% purky Pressure Temperature Plasma Torch Air Pressure Temperature Plasma Torch Air Pressure 1 PLASMA TORCH Energy Type of Torch No. of Torches / Gasifier Electric Energy Use Temenal Energy Transferred	92% mass 15,923 kg/hr - kg/hr 136 kPa 25 °C 6,000 kg/hr	s basis r r				٦		ALT	ERN	PO		I				HCN	0.005%			
Oxygen Stream @ 93 mol% purity Ar Stream Pressure Temperature Shroud Air 6 Shroud Oxygen @ 93 mol% purity 1 Temperature Plasma Torch Air Pressure Temperature Plasma Torch Ar Pressure 1 Temperature PLASMA TORCH Energy Type of Torch No. of Torchs / Gasifier Electric Energy Tansferred	15,923 kg/hr - kg/hr 136 kPa 25 °C 6,000 kg/hr	r n				T		ALT	ERN	PO								0.005%		0.10
AF Stream Pressure Temperature Temperature Shroud Air Shroud Air Pressure Pasma Torch Air Pressure Pasma Torch Air Pressure 1 Temperature 1 PLASMA TORCH Energy Type of Torch No. of Torches / Gasifier Electric Energy Use Temmal Energy Transferred	- kg/hr 136 kPa 25 °C 6,000 kg/hr	r.							ERN	PO										0.00
Pressure Temperature Shroud Air GShroud Oxygen @ 93 mol% purity Pressure Temperature Plasma Torch Air Pressure 1 Temperature PLASMA TRCH Energy Type of Torch No. of Torchs / Gasifier Electric Energy Transferred	136 kPa 25 °C 6,000 kg/hr	rić						ALT	ERN	PO							27.676%	36.292%	32.235%	41.45
Temperature 6 Shroud Air 6 Shroud Air 7 Shroud Air 7 Pressure 7 Plasma Torch Air 7 Pressure 1 Temperature 1 PLASMA TORCH Energy 7 PLASMA TORCH Energy 7 PLectric Energy Transferred 7	25 °C 6,000 kg/hr						1	ALT	<b>-R</b>	PO						Total	100.000%	100.000%	100.000%	100.00
Shroud Air         6           Shroud Oxygen @ 93 mol% purity         1           Pressure         1           Temperature         1           Plessma Torch Air         1           Pressure         1           PLASMA TORCH Energy         1           Type of Torch         Marc           No. of Torches / Gasifier         Marc           Recht: Energy Use         Tensered	6,000 kg/hr									INCO.						H <sub>2</sub> /CO	0.43			
Shroud Oxygen @ 93 mol% purity         1           Pressure         1           Temperature         1           Plasma Torch Air         Pressure           Temperature         1           Temperature         1           Type of Torch         No. of Torches / Gasifier           Electric Energy Transferred         Marce								~		Manuel						CARRY-OVER SOLIDS				
Pressure Temperature Plasma Torch Air Pressure Temperature 1 Temperature	1,260 kg/hr					- 10	(	W) Westing	ouse Plasma Cor	ration						Solids [Note 3]	1,754			
Temperature Plasma Torch Air Plasma Torch Air Penssure 1 Temperature PLASMA TORCH Energy T No. of Torchs / Gasifier Electric Energy Use Themai Energy Transferred	· · · · · · · · · · · · · · · · · · ·					- 10		A Galanti	A ANY NONC CAN							Carbon Chemical Energy	1.9			
Plasma Torch Air Pressure 1 Tamperature 1 PLASMA TORCH Energy Type of Torch No. of Torches / Gasifier Electric Energy Use Tansferred	136 kPa					- 10										ENERGY DENSITY	HHV	LHV		
Pressure 1 Temperature PLASMA TORCH Energy Type of Torch Marc No. of Torches / Gasifier Electric Energy Use Thermal Energy Transferred	25 °C					- 10										kJ/kg <sup>†</sup>	8,382	7,917		
Temperature PLASMA TORCH Energy Type of Torch No. of Torches / Gasifier Electric Energy Use Thermal Energy Transferred	570 kg/hr					- 10										kcal/Nm <sup>3†</sup>	2,360	2,229		
PLASMA TORCH Energy Type of Torch No. of Torches / Gasifier Electric Energy Use Thermal Energy Transferred	1,136 kPa															Btu/scf <sup>†</sup>	251	237		
Type of Torch Marc No. of Torches / Gasifier Electric Energy Use Thermal Energy Transferred	25 °C															MJ/Nm <sup>3†</sup>	9.9	9.3		
No. of Torches / Gasifier Electric Energy Use Thermal Energy Transferred																Syngas Chemical Energy (MW)	100.7	95.1		
Electric Energy Use Thermal Energy Transferred																<sup>†</sup> dry basis				
Thermal Energy Transferred	6															SLAG & METAL OUT	-			
	2.31 MW												Heat Loss:	3.3 MV	V	Slag & Metals Stream	10,477			
	1.96 MW															Pressure	101			
Simulation Indicators																Temp	1,650	°C		
	69%						1000									Overall Energy Balance on LHV Ba				
	12.74		0.0 M	WW Steam							<b>7</b>						In	Out		
	1,278 °C		_													Feedstock	135.52			
	17.4% of flo															Torch	2.31			
	4.0% of fee		0.0 M	WW Oxidant			+				4					Oxidant Streams	0.00			
	1.6% of inp	put energy								-						Steam	0.00	0.00	ŧ	
	0.90			WWe Plasma T												Feedstock Moisture/Steam		6.40	+	
Tuyere Tip Temperature	871 °C		2.0 M	WWt Plasma Te	Torch				-		-					Chemical		96.97		
care va d'arc																Sensible		26.94		
Others																Heat Loss		3.35		
Quench Water [Note 5]			0.0 M	WW Shroud Air	ir/Oxygen	6										Slag		4.39		
	4,086 kg/hr	r:					-									Metals		0.00		
Notes:	4,086 kg/hr	r	_													Solubility Adjustment	0.22			

1. All values are illustrative in nature and are provided for discussion purpose only.

2. Heat balance is provided on lower heating value (LHV) basis.

3. Quantity of carry-over solids is affected by feedstock particle size distribution, which will be evaluated during detailed engineering.

4. Energy balance computed by VMG on a heat of formation basis. LHV balance provided for display purposes only.

5. Gas will undergo a partial water quench to 850 °C.

6. Indicative heat and material balance, to be confirmed via pilot testing of actual feedstock.

Feedstock feedrate is based on the average particle size of 125 m and bulk density of 250 kg/m<sup>3</sup>.
 Actual feedrate will be determined during the Pre-FEED and/or detailed engineering based on the actual particle size distribution and bulk density of the feedstock.





- Incorporated learnings from Utashinai operating issues into design
- Enhanced design tools (flow analysis, refractory, etc.)
- Utashinai gasifier running extremely well after modifications
- New design incorporates modifications resulting from operating problems experienced at Utashinai



## MIHAMA-MIKATA VITRIFIED SLAG

Slag from the Mihama-Mikata facility has been put through a number of leachate tests including the Japanese JLT-46, NEN-7341 and the American TCLP analysis. These tests were conducted by two independent laboratories Shimadzu Techno-Research Inc. and ALS Laboratory Group. The results show that the Mihama-Mikata slag components are below the test detection limits and the slag is considered non-leaching. Below is a chart showing some of the results from the JLT-46 tests

MIHAMA-MIKATA SLAG JLT-46 TEST RESULTS									
Heavy Metal	Unit	Method Detection Limit	Average Measured Value of Slag	JLT-46 Limit					
Arsenic	mg/L	0.001	<0.001	0.01					
Cadmium	mg/L	0.001	<0.001	0.01					
Chromium VI	mg/L	0.005	<0.005	0.05					
Lead	mg/L	0.001	<0.001	0.01					
Mercury	mg/L	0.0001	<0.0001	0.005					
Selenium	mg/L	0.001	<0.001	0.01					

Notes: mg/L = parts per million (PPM)

JLT-46 performed by Shimadzu Techno Research, Inc., Kyoto Japan on Mihama-Mikata slag samples received from Kamokon







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# **COMPARISON OF TECHNOLOGIES**

	Plasma Gasification	Pyrolysis	Incineration
Temperature	2,000-2,500 <sup>0</sup> F (gasification zone)	750-1400 <sup>°</sup> F	Up to 2,192 <sup>0</sup> F
By-product	Inert, non-hazardous glassy slag	Carbon char, silicon, metals and glass	Hazardous Fly Ash and Incinerator Bottom Ash
Feedstock Preparation	Pre-processing is minimal with shredding	Pre- processing is necessary in most cases as MSW is too heterogeneous	Sorting
Feedstock	Carbon material Coke is added to aid the reactions	Any carbon-based material	MSW, Medical Waste, Sewage Sludge
Syngas Composition	Carbon Monoxide and Hydrogen	Methane, Carbon Monoxide, and Hydrogen	Not produced
Typical Size (commercially)	Up to 250tpd (750-1000tpd in development)	Up to 300tpd	Up to 3,000tpd
Typical Uses	Melting incinerator ash, destroying hazardous and medical waste, processing municipal solid waste	Make charcoal from wood, process tires and produce carbon black, steel and fuel, created activated carbon	Waste disposal and to generate power & heating



# ENERGY RECOVERY FROM WASTE – PLASMA GASIFICATION IS CLEAN

ENSR validated Alter NRG's anticipated emissions levels for a 750tpd MSW integrated gasification combined cycle (IGCC) facility which concluded that emissions for NOx, PM, SO<sub>2</sub>, HCI, CO, Hg and PCDD/PCDF would all be lower that EPA regulated standards and lower than six recently approved incineration facilities in the USA
 ENSR AECOM

#### Comparison of Resource Recovery Incinerator Permitted Emissions Limits to Anticipated Alter NRG IGCC WTE Emissions Levels (US EPA Units)

Pollutant	units	Recently Permitted Incineration Facilities in USA (200-800 tpd MSW)	Canada - CCME	US EPA New Source Performance Standards	US EPA Section 111(d) Emissions Guidelines	Alter NRG MSW IGCC WTE (750 tpd MSW)
NOx	(ppm∨d)	110-205	293.32	150	205	36.66
PM	(mg/dscm)	16-27	28.08	20 - 24	25 - 27	4.21
S02	(ppm∨d)	26-29	136.94	30	29 - 31	1.05
HCI	(ppm∨d)	25-29	69.4	25	29 - 31	6.48
со	(ppm∨d)	100	68.66	100	100	19.27
Hg	(µg/dscm)	28-80	Tier 3 Metals	50 - 80	80	<1.4
PCDD/PCDF	(ng/dscm)	13-30	0	13 - 30	30 - 60	0



