PLASMA GASIFICATION – INTEGRATED FACILITY SOLUTIONS FOR MULTIPLE WASTE STREAMS

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All dollar figures are Canadian unless otherwise stated.
DEMAND FOR SOLUTIONS…CREATING A DEMAND FOR PLASMA GASIFICATION

• Environmental mandates and regulatory initiatives are driving renewable energy solutions
• Globally, cities around the world cannot expand existing landfills
• Annual waste generation continues to rise globally in newly industrialized countries like China and India
• Global power consumption continues to grow, demand is outstripping supply
• Globally, energy costs are volatile and unpredictable
• Alter NRG Plasma Gasification presents a potential solution:
  • Scalable
  • Economic
  • Flexible
  • Commercially Proven

“WTE helps turn a waste management problem into an energy generating solution…”

U.S. Environmental Protection Agency
ALTER NRG, WORKING WITH TECHNIP, HAS EXPERIENCE AND EXPERTISE TO DELIVER COMPLETE GASIFICATION SOLUTIONS

- A number of global projects utilizing Westinghouse torches
- +20 years experience @ Westinghouse Pilot facility
- 9 years experience @ Japanese MSW/sewage sludge facilities
- 2 years experience @ Indian hazardous waste facilities
- 1 year experience @ co-located Coskata biomass to ethanol facility
- Over $100MM spent in research, development, testing and operational improvements
- Demonstration facilities under construction
  - Biomass: Wuhan Kaidi, Wuhan China
- Recently announced projects:
  - Air Products: Teesside, UK – 950 tpd MSW to power – combined cycle
  - Geoplasma: St. Lucie, Florida – Air permit issued – 600 tpd MSW to power – steam cycle
THE ALTER NRG / WESTINGHOUSE PLASMA SOLUTION EXPERIENCE BASE IS A CULMINATION OF MULTIPLE PROJECTS

- **1987**
  - **PLASMA FIRED CUPOLA APPLICATION**
  - General Motors; Defiance, Ohio - commissioned in 1987

- **1989**
  - **INDUSTRY-LEADING TECHNOLOGY**
  - Plasma technology by others such as Alcan – over 500,000 hours of industrial use

- **1995**
  - **INCINERATOR ASH VITRIFICATION**
  - Kinuura, Japan - commissioned in 1995

- **1999**
  - **PLASMA GASIFICATION OF MUNICIPAL SOLID WASTE (MSW)**
  - Hitachi Metals; Yoshi, Japan - commissioned in 1999

- **2002**
  - **WORLD'S 1ST COMMERCIAL SCALE PLASMA GASIFIER**
  - Mihama Mikata, Japan - operational in 2002

- **2003**
  - **WORLD'S LARGEST PLASMA GASIFIER FOR MUNICIPAL WASTE**
  - Utashinai, Japan - operational in 2003

- **2008**
  - **WORLD'S LARGEST PLASMA HAZARDOUS WASTE FACILITY**
  - Pune, India – commissioned in early 2009

- **2009**
  - **SECOND GENERATION ETHANOL FACILITY**

- **2010**
  - **HAZARDOUS WASTE FACILITY**
  - Nagpur, India – ready for commissioning

  - **Biomass-to-Energy Facility**
  - Wuhan, China – under construction
WHAT IS PLASMA GASIFICATION?

- The facility exports 80% of the energy input to syngas
- Plasma torches use 2% to 5% of the energy input
- Gasification is not incineration
- Gasification creates hydrogen and carbon monoxide: An energy rich gas steam
EVOLUTION OF WESTINGHOUSE PLASMA GASIFICATION UNDER ALTER NRG

Phase 1
Acquisition of WPC
- 2007: Sold plasma torches
- Provided engineering preliminary diagrams

Phase 2
Expanded Product Offering
- Gasifier vessel design
- Expanded scope to gasifier island
  - Quench system
  - Slag system
  - Refractory optimization
- Detailed capital costing

Phase 3
Integrated Product
- Balance of plant integration
  - Steam cycle
  - Combined cycle
  - Syngas clean-up systems
- +/- 10% gasifier design costing
- Full 3D model of entire facility

Phase 4
Improved Efficiency
- Reduced capital (~30%)
  - International sourcing
  - Design optimization
- Reduced operational cost (~30%)
  - Met coke bed replacement
  - Reduced parasitic load
- Facility performance guarantees

Evolution supported by:

- HATCH
- Solar Turbines
- Uhde
- Technip
- Golder Associates
- amec
- RW Beck
- ENSR
- AECOM
- WorleyParsons

Westinghouse Plasma Corporation
a division of Alter NRG Corp.
GASIFIER VESSEL DEVELOPMENT

Pre-Generation 1

- Feed Stock
- Gasification Area
- Plasma Torch
- Continuous Flow of Slag
- Cupola Well Melting Area >1500°C

Generation 2

- Alter Nrg Plasma Gasifier
- Syngas Outlet
- Waste Inlet
- Air Feed
- Plasma Torch
- Metal and Slag Output

Generation 3/4

- Freeboard Zone
- Gasification Zone
- Removable Bottom

Technip

ALTER NRG

Westinghouse Plasma Corporation
a division of Alter NRG Corp.
OPTIMIZATION OF GASIFIER DESIGN

CFD Modeling - Gas flows, Temperatures

Optimization of flow reducing High velocity zones, minimizing carryover
INCREASING REFRACTORY PERFORMANCE AND IMPROVING VESSEL INTEGRITY

Refactory Thermal Modeling Work

Finite Element Analysis for Vessel Mechanical Integrity

Prediction of slag freezing plane
REPLACE FOSSIL FUEL FOUNDRY COKE BED MATERIAL

- Foundry coke possesses good attributes as bed material
- However:
  - A fossil fuel with negative perceptions
  - Expensive
  - Not readily available globally
- These shortcomings have been addressed
- Initial Step: pilot plant evaluation on multiple runs. Results were very positive both operationally and economically
- Applied for a provisional patent
- Next Step: Commercial implementation
IMPROVE TORCH PERFORMANCE

Torch Development Goals

- Reduced operating costs
- Use other gas compositions aside from air
- 10% improved power efficiencies
- Up to 50% increase torch power output
CAPITAL AND OPERATING COST REDUCTION

Focus of generation 4 technical development is improved design resulting in:

- Reduced Operating Cost
  - Alternative bed material in some cases only 30% of the cost of a metallurgical coke bed
- Reduced Capital Cost
  - Reduced by up to 30% for the Alter NRG scope from original cost estimates
- Improved Efficiency
  - Example—Torch developments for improved performance
  - Optimize overall torch power usage
- Improved Operability
ALTER NRG EXPERTISE IS GASIFICATION

We have strategic partners who will integrate our technology into a turnkey, balance of plant solution.
& BALANCE OF PLANT DESIGN
TECHNIP: BUSINESS SEGMENTS

SUBSEA
▶ Design, manufacture and supply of deepwater flexible and rigid pipelines, umbilicals, and riser systems
▶ Subsea construction and pipeline installation services
▶ Five state-of-the-art flexible pipe and umbilical manufacturing plants
▶ Five spoolbases for reeled pipeline assembly
▶ A constantly evolving fleet strategically deployed in the world's major offshore markets

OFFSHORE
▶ Engineering and fabrication of fixed platforms for shallow waters (TPG 500, Unideck®)
▶ Engineering and fabrication of floating platforms for deep waters (Spar, semi-submersible platforms, FPSO)
▶ Leadership in floatover technology
▶ Two construction yards

ONSHORE
EPC Execution of:
▶ Gas Treatment and Processing
▶ Gas Liquefaction (LNG)
▶ Gas-To Liquid (GTL)
▶ Refining, hydrogen and sulphur units
▶ Onshore pipelines
▶ Petrochemicals (ethylene, aromatics, olefins, polymers, fertilizers)
▶ Renewables: Biofuels, Waste to Energy, Solar, Geothermal
▶ Metals and Mining

2009 Revenues: $ 9 billion, Backlog : $ 10.5 billion
TECHNIP’S LEADERSHIP IN HYDROGEN/SYNGAS

World No.1

- Customized solutions
- Single-source responsibility
- State-of-the-Art designs
- Large reference base
- Exclusive world wide alliance with APCI in Hydrogen
TECHNIP’S ROLE: BALANCE OF PLANT DESIGN

Collaboration agreement in place with Alter NRG to be their Preferred EPC partner for North America, Middle East, Europe

- Technip brings expertise in Syngas handling, cleaning & emissions abatement
  - Integrate the gasification island with the syngas clean-up and balance of plant
- Design gas clean up section (removal of metals, ammonia, sulfur, mercury, HCN etc.)
  - Design Power Island, Utilities and Offsites
  - Provide overall Project Management, Detailed Engineering, Procurement, Construction solutions, Start-up and Commissioning services
KEY CONSIDERATIONS IN DESIGN OF WASTE TO ENERGY UNITS

• Determine the mix of feedstock to be used and their specifications
  • e.g. MSW, Tires, CDW, ASR, Biomass, etc

• Establish emission limits to be met

• Establish optimal plant configuration for the site
  • Gasifier design
  • Gas clean up- establish sequence of unit operations
  • Select steam/power generation equipment

• Determine sparing philosophy based on plant availability requirements
PLASMA GASIFICATION & BALANCE OF PLANT CONFIGURATION OPTIONS

Various plant configurations can be considered as follows:

• Gasifier configurations
  • Air blown gasifier
  • Oxygen blown gasifier

• Balance of plant configurations
  • Pre-combustion syngas clean up
  • Post-combustion flue gas clean up
  • Boiler + STG for power production
  • Gas Turbine - simple cycle or combined cycle for power production
  • Liquid fuels or chemicals production
## ADVANTAGES/DISADVANTAGES - OPTIONS OF PLANT CONFIGURATION

<table>
<thead>
<tr>
<th>Air Blown</th>
<th>Oxygen blown</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Oxygen plant</td>
<td>Syngas suitable for boiler/steam turbine cycle and combined cycle power generation system</td>
</tr>
<tr>
<td>Good for direct firing in a boiler with post combustion clean up</td>
<td>Higher MW per ton of MSW</td>
</tr>
<tr>
<td>Higher volume of syngas due to presence of N2</td>
<td>Lower volume of syngas, smaller equipment</td>
</tr>
</tbody>
</table>
PRE-COMBUSTION GAS CLEAN-UP + COMBINED CYCLE POWER PLANT - TYPICAL
A CASE STUDY ON TARGET EMISSIONS- PLASMA GASIFICATION OF MSW/TIRES TO PRODUCE POWER

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>Emission Limits, 7% v (dry) O₂, 24 MW Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOX</td>
<td>150 ppmvd,</td>
</tr>
<tr>
<td>CO</td>
<td>50 ppmvd</td>
</tr>
<tr>
<td>SO2</td>
<td>30 ppmvd</td>
</tr>
<tr>
<td>VOC</td>
<td>N/A</td>
</tr>
<tr>
<td>HCl</td>
<td>25 ppmvd or 95% reduction</td>
</tr>
<tr>
<td>PM/PM10</td>
<td>20 mg/dscm</td>
</tr>
<tr>
<td>Pb</td>
<td>140 microg/dscm</td>
</tr>
<tr>
<td>Hg</td>
<td>50 microg/dscm</td>
</tr>
<tr>
<td>Cd</td>
<td>10 microg/dscm</td>
</tr>
<tr>
<td>Dioxins/Furans</td>
<td>13 microg/dscm</td>
</tr>
<tr>
<td>VE</td>
<td>10%- 6 minute average</td>
</tr>
<tr>
<td>NH3 slip</td>
<td>2 ppmvd</td>
</tr>
</tbody>
</table>

Note: Units can be designed to site specific regulatory limit.

Case study results shown in the table.
BREAKDOWN OF TOTAL INSTALLED COST - CASE STUDY

- Basis of estimate:
  - 185TPD Hazardous/Industrial waste - combination of multiple feed streams
  - >10MW power generation- combined cycle,
  - Oxygen blown gasifier
  - ROI > 25% as result of high value feed
  - Should not be directly scaled

<table>
<thead>
<tr>
<th>Plant Section</th>
<th>% of TIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste handling/storage/buildings</td>
<td>Excluded</td>
</tr>
<tr>
<td>Gasification island + Oxygen unit</td>
<td>32 %</td>
</tr>
<tr>
<td>Syngas clean up</td>
<td>28 %</td>
</tr>
<tr>
<td>Power generation</td>
<td>40 %</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$ 100-120 million</td>
</tr>
</tbody>
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SUMMARY

• Alter NRG’s Plasma Gasification creates Hydrogen and Carbon Monoxide: an energy rich gas stream “building block”

• Alter NRG’s Plasma Gasification is commercially proven, economically viable technology. It is environmentally sustainable; reducing carbon footprint & emissions

• Alter NRG’s Plasma Gasification system can handle multiple complex waste streams with the flexibility of producing a range of energy solutions

• Technip’s expertise in EPC work for syngas handling/conditioning and power generation enables complete waste-to-energy solutions to be offered to clients

• The collaboration agreement between Alter NRG and Technip USA have the following benefits:
  • Technip USA is providing the optimal design for the balance of plant
  • Technip USA is the preferred EPCM for the complete balance of plant
  • Alter NRG and Technip jointly provide industry standard performance guarantees on a project by project basis