Alter NRG Plasma Gasification: The Next Generation of Waste-To-Energy Solutions

Deep Dive Workshop on Waste-to-Energy
2016 Asia Clean Energy Forum, 7 June 2016

Waste TO Energy
ABOUT US: ALTER NRG

Our Focus and What We Do

• Alter NRG is the marketing entity for Westinghouse Plasma Corporation
• 30+ years of research and development; ~$2 billion invested in technology
• We divert waste that is otherwise landfilled (including Municipal Solid Waste, Hazardous Waste, Industrial Waste, Medical Waste, Mixed Biomass, Construction & Demolition Waste, etc.)
• We make syngas from multiple waste streams
• Provide large and small scale solutions – 25 tpd to 2000 tpd

Our Owner: Sunshine Kaidi

• Sunshine Kaidi wholly owns Alter NRG and Westinghouse Plasma
• Sunshine Kaidi was founded in 1992 and headquartered in Wuhan, China
• Builds, owns and operates a portfolio of waste to energy facilities; holds assets in excess of $6 billion USD
• Generating in excess of 1400 MW to date, and has received permits to build an additional 3000+ MW over the next 5 to 7 year in China alone
Most of the world’s MSW is landfilled
(approximate, million tpy):

- Landfilled: 43%
- Dump: 16%
- Compost: 17%
- Recycled: 9%
- WTE: 9%
- Others: 6%

(Waste generation levels are expected to grow by 69% by 2025.)

- World Bank Study, 2012

(Source: World Bank, 2012)
Global Waste Has Significant Energy Equivalents

**Estimated Municipal Solid Waste**

- **Syngas**: 37 Million Btu/day
- **Liquid Fuels**: 3 Million Bbls/day
- **Electrical**: 178 GW Capacity

*MSW Waste* ~3.6 Million Tonnes/day

**Estimated Waste Biomass**

- **Syngas**: 120 Million Btu/day
- **Liquid Fuels**: 12 Million Bbls/day
- **Electrical**: 685 GW Capacity

*Waste Biomass* ~14 Million Tonnes/day

**Estimated Hazardous Waste**

- **Syngas**: 17 Million Btu/day
- **Liquid Fuels**: 874,000 Bbls/day
- **Electrical**: 43 GW Capacity

*Hazardous Waste* ~1.2 Million Tonnes/day

**Estimated Waste Tires**

- **Syngas**: 520,000 Btu/day
- **Liquid Fuels**: 24,000 Bbls/day
- **Electrical**: 1.4 GW Capacity

*Waste Tires* ~ 28000 Tonnes/day
S.E. Asia Perspective

Challenges:
• Highly populated region of ~620 Million people (excluding China); with highly populated urban cities
• Lack of adequate waste management and recycling
• Waste material consists of high moisture content / wet organics
• Country risk, including political, social, changing renewable policies, difficult to obtain a long-term energy price
• Scarcity of development capital and scarcity of credible project developer/owners

Opportunities:
• Waste volumes are growing and majority of waste is largely landfilled
• Acute energy demand for power generation and economic growth
• Limited availability of land for landfilling vs. human habitation
• International pressure for cleaner waste practices and GHG reduction
SE ASIA/CHINA VERSUS NA/EUROPE

• **Waste:** High moisture content, high organic content in SE Asia waste means low calorific value and lower energy output. NA/EU waste is often RDF – low organic, low glass/metals and high calorific value.

• **Long Term Contracts:** Mostly open markets allow for negotiation of long term waste and energy contracts in NA/EU. Obtaining secure, low risk contracts is much more difficult in China/SE Asia.

• **Revenues:** Revenues are lower in China/SE Asia due to very low tipping fees for waste.

• **Capital Cost:** Low labor and material costs in China/SE Asia mean lower capital costs to build a facility.

• **Political Risk:** Stable governments and policy in NA/EU long term predictable business environment. Less so in many SE Asia countries.

• **Permitting:** Permitting often easier in SE Asia/China due to fewer NGOs and simpler permit/license processes.
DEVELOPMENT CHALLENGES WORLDWIDE

• Less than factual media coverage, speculation and misunderstandings about plasma gasification
• NGO pressure – anything short of 100% recycling is bad!
• Changing or uncertain renewable energy policies
  – Unfavourable mandates or lack of incentives
  – Energy from waste not addressed or not considered renewable
  – Incentives come and go with political change
• Risk aversion to newer technologies
ALTER NRG / WESTINGHOUSE PLASMA GASIFICATION TECHNOLOGY
PLASMA GASIFICATION MILESTONES – COMMERCIAL PROVEN

1983
PLASMA FIRED CUPOLA APPLICATION
General Motors; Defiance, Ohio - commissioned in 1987
Demo – 50 tpd

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

1995
INCINERATOR ASH VITRIFICATION
Kiuuura, 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; 200 tpd

2008
WORLD’S LARGEST PLASMA HAZARDOUS WASTE FACILITY
Pune, India – commissioned in 2009

2009
SECOND GENERATION ETHANOL FACILITY

2012
BIOMASS FACILITY
Kaidi, China – operational Q4 2012

2012
DEMONSTRATION FACILITY INTEGRATED WITH EXISTING INCINERATOR
Shanghai, China – operational in Q1, 2014; 30 tpd

2014
ENERGY FROM WASTE FACILITIES, Tees Valley, UK – 2,000tpd MSW to combined cycle power Under construction, commissioning dates: TV1 – 2017 and TV2 - 2018

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ALTER NRG PLASMA GASIFICATION PROCESS – A WASTE REDUCTION TECHNOLOGY

Waste Feedstocks:
Municipal, Hazardous, Industrial, Medical, Mixed Biomass, Construction & Demolition, Coal, Tires, etc.

1000 Tons/day

- Fine & Heavy Particulate Matter Removed
- Coarse Particulate Matter Removed
- Sulphur Removed
- Slag

20 Tons/day
- Sludge to landfill
- Recycled into the Gasifier
- For sale to market

1 Ton/day
- For sale to market
- For sale to market as aggregate

250 Tons/day
- Syngas

50 MW Gross (~41 MW Net to the grid)
- Power
- For sale to market

800-1200 Barrels/day
- Liquid Fuels
- For sale to market

10,420 Btu/day
- Fuel Replacement
- (3.8 MMBtu/year)

IN SUMMARY:

1000 tpd Waste Processed Using Alter NRG Gasifier

250 tpd Slag for Sale To the Market as Aggregate

40 tpd Waste for Disposal
- 20 tpd Particulate Matter + 20 tpd Sludge for Landfill Disposal OR Recycled back into Alter NRG’s Gasifier
CASE STUDY: LARGE SCALE MSW
COST AND REVENUE COMPARISON
## Typical Project Costs

<table>
<thead>
<tr>
<th>Project Costs ($USD)</th>
<th>Duration</th>
<th>G-65 (1000 tpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front-End Engineering</td>
<td>4-6 Months</td>
<td>$2</td>
</tr>
<tr>
<td>Detailed Engineering</td>
<td>2-4 Months</td>
<td>$5</td>
</tr>
<tr>
<td>Equipment and Construction</td>
<td>18-24 Months</td>
<td>$220</td>
</tr>
<tr>
<td>Commissioning</td>
<td>1-2 Months</td>
<td>$18</td>
</tr>
<tr>
<td>Total Estimated Cost</td>
<td></td>
<td>$235</td>
</tr>
</tbody>
</table>
### Typical Capital Cost & Revenues: G-65 Gasification Facility (All costs stated in $Million USD)

<table>
<thead>
<tr>
<th>Project Costs</th>
<th>North America</th>
<th>Europe</th>
<th>Asia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment and Materials</td>
<td>$105</td>
<td>$110</td>
<td>$80</td>
</tr>
<tr>
<td>Installation Cost</td>
<td>$75</td>
<td>$80</td>
<td>$35</td>
</tr>
<tr>
<td>Owner Costs and Contingency</td>
<td>$55</td>
<td>$60</td>
<td>$35</td>
</tr>
<tr>
<td>Total Project Capital Cost</td>
<td>$235</td>
<td>$250</td>
<td>$150</td>
</tr>
<tr>
<td>Typical Annual Revenues</td>
<td>$50</td>
<td>$75</td>
<td>$30</td>
</tr>
<tr>
<td>Annual Variable Costs</td>
<td>$10</td>
<td>$10</td>
<td>$8</td>
</tr>
<tr>
<td>Annual Fixed Costs</td>
<td>$10</td>
<td>$12</td>
<td>$9</td>
</tr>
<tr>
<td>Net Power Generation</td>
<td>25 MW</td>
<td>30 MW</td>
<td>15-20 MW</td>
</tr>
</tbody>
</table>

Assumptions: 1000 tpd; MSW to Power Steam Cycle; Equity financing of 100%; 25 year project life
SMALLER SCALE APPLICATIONS
HAZARDOUS AND INDUSTRIAL WASTE SOLUTIONS
Commercial operations:
• In India (since 2008).
• In China (since 2013).

Flexible operations:
• Processed over 600+ hazardous waste streams since 2008.
• Syngas can be utilized for steam, power or process fuel.

Turnkey modular facility:
• Can be co-located with industrial facility
• Compact facility footprint: ~2,000 m²
• Reduces project time lines
• Approximately $25-35m USD solution depending on location

Environmentally sustainable:
• Slag has commercial uses (construction aggregate, rock wool insulation, etc.)
• WPC’s high temperature gasification process does not create furans or dioxins.
THE WRAP UP

• Alter NRG provides a turnkey waste-to-energy solution
• Alter NRG will finance, build, own and operate the complete facility though Sunshine Kaidi (principal owner)
• Provide investment opportunities for project/equity partners if needed
  o Provide total project guarantees and warranties for the entire facility through its EPC and strategic partners
  o Is modular, cost effective that reduces project time lines and increases economic returns
• Can handle multiple waste streams, where inorganic materials are transformed to an inert non-leaching vitrified slag product that can be sold for beneficial use
• The high temperature process does not create furans or dioxins and is environmentally superior
THANK YOU
SUPPLEMENTAL SLIDES

Converting the World's waste into clean energy
In 2008, Sunshine Kaidi received approvals for biomass power projects in 266 municipalities and counties in China, where the feedstock will be agricultural and forest waste. Currently, Sunshine Kaidi has 37 projects in commercial operation and 34 projects under construction.

Sunshine Kaidi has signed twelve investment agreements for wind power projects throughout China. These projects include operating facilities in Pinglu, Fuxin, and Yanchi, all of which have 49 MW (each) of installed power capacity. Currently, Sunshine Kaidi has eight wind power projects under construction.

Sunshine Kaidi has 16 more hydropower projects proposed within Yunnan Providence, China along the Jingping River Valley, Chitong River Valley and Sanjia River Valley.

Biomass Power Plants

Fujian, China – 12 MW
Anhui (Ningguo), China – 12 MW
Anhui (Wangjiang), China – 30 MW
Hubei, China - 30MW

Hydro Power Plants

Yunnan, China – 315 MW
Nanbuhe, China – 5 MW
Bajiu, China – 22 MW

Wind Power Plants

Pinglu, China – 49 MW

Sunshine Kaidi has 16 more hydropower projects proposed within Yunnan Providence, China along the Jingping River Valley, Chitong River Valley and Sanjia River Valley.
By the end of 2014, Sunshine Kaidi had successfully implemented more than 200 turnkey power projects as an EPC contractor – both domestically and internationally.
TEES VALLEY, UK: ADVANCED GASIFICATION ENERGY-FROM-WASTE PLANTS

Overview:
- **2,000 tpd** of Municipal Solid Waste
- **100MW** (gross) electrical base load production via combined cycle
- World’s first combined cycle Energy from Waste facility

Update on both phases:
- TV1 (1,000 tpd) – completed construction and commissioning; in startup and will be fully operational in 2016
- TV2 (1,000 tpd) – currently under construction; commissioning late 2016

WPC Gasifier and Auxiliary Modules installed at TV1
TEES VALLEY, UK: TV1 - 2015

Administrative & Control Rooms
Feedstock Reception
Coke & Flux Silos
Feedstock Conveyors
WPC Gasifier & Auxiliary Modules
Gas Turbines
Syngas Cleanup Train
Syngas cleaned and compressed to FT specification

Syngas cleaned and compressed to FT specification
THE OPERATION OF THE TEES VALLEY PROJECT DEMONSTRATES:

1. Industrial / Commercial scale volumes of syngas from waste:
   • 2,000 tpd of feedstock will produce ~7 Million MMBtu/year of syngas
   • 100 MW (gross) electrical, base load production of energy
   • Equivalent production of 1,600 – 2,000 Bbls/day of liquid fuels

2. The ability to consistently produce syngas at the required specification:
   • To ensure reliability, the syngas must consistently meet the fuel specification of the gas turbine
   • Gas turbine syngas specification is similar to liquids conversion technology syngas specification

3. The ability to create negative to low cost syngas from feedstock's
   • Tipping fee revenues reduce the operating cost of making clean syngas
KEMI, FINLAND: BIOMASS TO BIOFUELS FACILITY

Overview:

- The facility will produce **200,000** metric tons/year of biofuels from waste biomass; **75%** biodiesel and **25%** bio-gasoline
- Established permitting, engineering and design; construction will start in **2017** and planned commercial operations in **2019**
- Will utilize Alter NRG’s plasma gasification system and Rentech’s Fischer-Tropsch (FT) liquids processes (both owned by Kaidi)

Benefits:

- An investment of EUR 1 billion, with a tax revenue of over EUR 200 million
- Will create 4,000 man-years of construction work; over 150 permanent positions once operational
- Be part of the EU's Renewable Energy Directive - 20% of energy consumption from renewable sources by 2020
- Be part of Finland’s goal to reach a target of 40% biofuels usage by 2030
SHANGHAI, CHINA: HAZARDOUS WASTE FACILITY

Overview:
- **30** tpd of medical waste and incinerator ash.
- Co-located with Shanghai Chengtou hazardous waste facility.
- Facility was commissioned in **Q1, 2014**
- WPC offers this plant globally as a turnkey solution.
- **Successfully completed 150+ day continuous operation.**

Benefits:
- Vitrifies hazardous incinerator ash.
- Inorganic materials are transformed into non-leaching marketable slag.
- Creates steam that is utilized in a steam turbine.
Overview:

• **150 tpd** of mixed wood biomass.
• Creates diesel and naptha using catalytic Fischer-Tropsch (FT) process.
• Facility was commissioned in **Q4 2012**.
• **Successfully completed 2+ years in operation.**

Update:

• Development of **(3) 2000 tpd** commercial facility in progress.
• Wuhan Kaidi uses both proprietary cobalt and Rentech’s iron slurry FT technology.
PUNE, INDIA: COMMERCIAL HAZARDOUS WASTE FACILITY

Overview:

• Designed to process 72 tpd of hazardous waste
• Routinely processes 40-60 different waste streams on weekly basis.
• Over 600 different waste streams processed since plant start-up
• Syngas is used to create electricity which is exported to the grid.
• Facility was commissioned in 2008.
• Successfully completed 7+ years in operation.
MIHAMA-MIKATA, JAPAN: ENERGY FROM WASTE

• Hitachi Metals 2nd project with Westinghouse Plasma Corp.

• Serves the two cities of Mihama and Mikata, Japan

• WPC Plasma gasification of 20 tpd of MSW and 4 tpd of waste water sludge.

• Oldest operating facility; Commissioned in 2002.

• Syngas is combusted; resulting heat is used to dry sewage sludge prior to gasification.

• Successfully completed 13+ years in operation.