An Industry Perspective ..... Waste-to-Energy and Alternative Conversion Technologies

Waste-to-Energy Webinar Presented To:
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Intro - GBB Overview

• Headquartered in Fairfax, VA
• Established in 1980 as an objective adviser to governments, institutions, and businesses
• Focus exclusively to solid waste management
• 30+ years implementing innovative solutions for waste and recycling industry
• Owner’s representative and feasibility reports for financings
• “Change Agents” to produce better services and facilities
GBB Waste Technology Services

- Economic, technical and environmental reviews
- Procurements
- Due diligence
- Waste characterization and sourcing
- Process planning and design
- Independent feasibility consultant

Note: Waste-to-Energy uses less land per megawatt than other renewable energy sources

Source: Covanta Energy, 2012
Solid Waste Reduced, But .... Not Going Away Anytime Soon

<table>
<thead>
<tr>
<th></th>
<th>1980</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Waste Generation</td>
<td>3.66 #/Capita/Day</td>
<td>4.43 #/Capita/Day</td>
</tr>
<tr>
<td>Amount Recycled</td>
<td>&lt;10%</td>
<td>34%</td>
</tr>
<tr>
<td>Disposed of in Landfills</td>
<td>89%</td>
<td>54%</td>
</tr>
</tbody>
</table>

Source: USEPA

Capacity to Grow Renewable Energy

The total installed US WTE capacity in 2010 was 2.7 GW, combusting 11.7% of the nation’s MSW

Source: USEPA, 2010
Factors Contributing to Increased Interest in WTE and CT’s

- Federal renewable energy policy and funding
- Local governments desire to be greener and to divert more from landfills
- Local jobs (new construction & operations)
- Increase in disposal fees and transportation costs
- Opportunity for PPEA project’s “promoted by” the private sector

...however, there is no disposal crisis in USA!

U.S. WTE and MRF Plants

<table>
<thead>
<tr>
<th>YEAR</th>
<th>WTE/ RDF</th>
<th>Pyrolysis and Gasification</th>
<th>MRF</th>
<th>Recovered (million tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>71/15</td>
<td>1</td>
<td>565</td>
<td>114.5</td>
</tr>
</tbody>
</table>

Source: Gershman, Brickner & Bratton, Inc., 2011
WTE Plants Operating in Virginia

<table>
<thead>
<tr>
<th>Location</th>
<th>Year of Initial Operation</th>
<th>Technology - Mass Burn or RDF</th>
<th>TPD Design Capacity</th>
<th>Energy Form Sold</th>
<th>Facility Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of Hampton</td>
<td>1980</td>
<td>Mass Burn</td>
<td>2@120 = 240</td>
<td>Steam and Electricity</td>
<td>City</td>
</tr>
<tr>
<td>City of Harrisonburg</td>
<td>1982</td>
<td>Mass Burn</td>
<td>2@100 = 200</td>
<td>Steam and Electricity (2.5 MW)</td>
<td>City</td>
</tr>
<tr>
<td>City of Portsmouth</td>
<td>1988</td>
<td>RDF</td>
<td>2,000</td>
<td>Steam and Electricity</td>
<td>Wheelabrator</td>
</tr>
<tr>
<td>City of Alexandria / Arlington Co.</td>
<td>1988</td>
<td>Mass Burn</td>
<td>3@325 = 975</td>
<td>Electricity (24 MW)</td>
<td>Covanta</td>
</tr>
<tr>
<td>Fairfax Co.</td>
<td>1990</td>
<td>Mass Burn</td>
<td>4@750 = 3,000</td>
<td>Electricity (126 MW)</td>
<td>Covanta</td>
</tr>
</tbody>
</table>

Source: Gershman, Brickner & Bratton, Inc., 2013

WTE Employment

- VIRGINIA (5 facilities; combined capacity of 6,415 TPD, energy sales: 212.5 MW of electricity, and 134,000 lbs/hr of steam)
- Full-time Employees at WTE Plants (based on survey of 63 facilities)
- Total FTE’s (Mean)
  - 2006  58.4
  - 2007  57.6
  - 2008  57.9

Conversion Technology Processes and Products

- **Feedstock**: *may be pre-processed

### Conversion Technology
- Pyrolysis
- Gasification
- Combustion
- Anaerobic Digestion
- Ethanol Fermentation
- Aerobic Composting

### Primary Product
- Char
- Tars & Oils
- Syngas
- Heat
- Biogas
- Ethanol
- Compost

### Product Conversion
- Extraction
- Upgrading
- Synthesis
- Engine
- Gas Turbine
- Boiler
- Electricity

### Secondary Product
- Chemicals
- Gasoline
- Methanol
- Ammonia
- Electricity

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591 (and counting) Companies Offering Technology and/or Development Services Worldwide

- 34 Aerobic Composting
- 109 Anaerobic Digestion
- 37 Ethanol Fermentation
- 169 Gasification
- 45 Plasma Gasification
- 52 Pyrolysis
- 60 WTE: mass burn, modular, dedicated boilers, and RDF
- 81 Others (agglomeration, autoclave, depolymerization, thermal cracking, steam reforming, hydrolysis)

Source: Gershman, Brickner & Bratton, Inc., April 2012
150 Conversion Companies Operating either Commercial or Demonstration Facilities Worldwide

- 67 Anaerobic Digestion
- 48 Gasification
- 19 Plasma Gasification
- 16 Pyrolysis

Source: Gershman, Brickner & Bratton, Inc., April 2012

Durham/ York (Ontario CN) Covanta

- Design, construction and operation by Covanta
- $260 million financed by Durham and York regions
- 140,000 TPY of waste
- 17.5 MW power and steam
- Recovered ferrous (e.g. steel) and non-ferrous (e.g. aluminum etc.) metals for recycling
- Under construction with target operation date late 2014
Solid Waste Authority of Palm Beach County, FL

- Babcock & Wilcox Power Generation Group, Inc. (B&W PGG), and its partner, KBR, Inc. were selected to build the plant
- B&W PGG also to operate and provide maintenance services once the plant is operational
- 3,000 tons per day of MSW capacity — $668 million construction cost
- 325 full-time construction jobs (900 including all part time), 64 permanent, full-time operation jobs.
- Comments from the Florida Sierra Club and Institute for Local Self Reliance were received suggesting approval to be postponed, alternative waste disposal methods to be studied, especially more recycling.
- GBB hired to review and fact check the accuracy of the statements and claims made by Florida Sierra Club and ILSR
- See: http://www.gbbinc.com/WTE-PB.shtml for 60+ paper
- Authority Governing Board approved awarding contract in April 2011

Source: Babcock & Wilcox; artist’s rendering of proposed facility.

Prince William County, VA
Currently Investigating/Advancing Waste Conversion Technologies

- County wants to create the Prince William Renewable Energy Park (PWREP) at their landfill (currently receiving 875 TPD MSW)
- County seeking to host a waste conversion technology demonstration facility on the County’s landfill or composting sites
- Issued RFP to identify qualified technology companies to design, build, finance, own and operate their demonstration
- Looking for technologies with throughput levels between 50 to 200 TPD on a continuous basis
- Eligible technologies include pyrolysis, gasification, anaerobic digestion, plasma torch or other conversion method producing a fuel or energy product, such as electricity, syngas, steam, useable heat and/or other industrial outputs
- Issued RFP June 2012 and received proposals on October 17, 2012
- Currently evaluating proposals from 3 vendors w/GBB assistance
Fauquier Co. VA

- County has extensive integrated solid waste system incl. LF, MRF, multi-Drop Offs, C&D Recycling, etc. (about 300 TPD)
- PPEA Proposer wanted 80% of MSW and right to put any residuals back to Co. LF
- Developer asked for County Tip Fee as their payment (about $45/T)
- Detailed review found County avoided cost for such project only about $10/Ton
- Proposal Died...vendor was not happy with County economic assessment!

What Have We Learned?
Economics

- Waste-to- Fuels appear to have more favorable economics than Waste-Energy
  - Cheap Natural Gas
  - Expiration of Electricity Related Tax Credits
- Landfill Competition
  - Cheap and Plentiful
- Economics of fully Integrated Waste System is most important

Finance

- Private Debt
  - Use of % of In-house Financing
  - Venture Capital, but higher returns needed
- Public Debt
  - Until technology is proven, unlikely to see public debt issued for “innovative technologies”
- “Strong enough to fail”- extra reserve funds needed to deal with scalability issues
Regulatory Framework

• Needed!
  – Define the role and the purpose of the conversion technology
  – Does it qualify for landfill diversion, recycling or as a renewable energy?
• Understand the Local, State and Federal Framework
• Situation likely to get worse as some “financial incentives” expire

Future Trends

• Continued interest in alternative energy and innovative conversion technologies
• Some projects will advance; slow and steady
• 3-5 years for the new technologies to prove technical and economic feasibility
• Continuation of public sector taking “Low Risk” attitude until “proven”
• More mixed waste processing systems to remove recyclable materials
Project Building Blocks...”Go List”

- High Alternative Disposal Costs
- Adequate Waste Supply
- Energy and Materials Market(s)
- Site for Facility - Good transportation logistics, site can be permitted, and accepted by neighbors (or have no neighbors!)
- Landfill for process ash and by-pass waste
- Contractor with resources and proven technology or willingness to take technology risk if innovative tech
- Access to Capital (for Construction and Guarantees)
- Financeability (incl. Performance Bonds/Insurance)
- Compatibility with Higher Levels of Recycling
- Political Will of the Governing Body – Key Element!!
Enerkem

- Gasification followed by catalytic conversion to bio-fuels and chemicals
- Feedstock: MSW, wood chips, treated wood, sludge, petcoke, spent plastics and wheat straw
- Preprocessing: drying, sorting and shredding
- Facilities:
  - Commercial scale demonstration facility in Westbury, CA (since 2009, 1.3 million gallons/year)
  - Ongoing projects on full-scale commercial facilities:
    - Edmonton, Alberta - 10 mill gallons per year under construction, start-up fall 2012, commercial operations 2013
    - Pontotoc, Mississippi (USA) - 10 million gallons per year are under development (about 200,000 TPY of MSW)

Fulcrum BioEnergy

- Gasification followed by alcohol synthesis; InEnTec technology partner
- Feedstock: MSW
- Product: ethanol
- Preprocessing required

- Sierra BioFuels - First commercial scale plant under construction in City of McCarran, NV
  - 10.5 million gallons ethanol per year
  - Have local and state regulatory permits
  - Have feedstock contracted through Waste Connections and WM
  - Have off take agreement for full output of plant
  - Estimate completion in 2nd half of 2013
  - Received USDA $105 million loan guarantee in August 2012
• Gasification followed by biocatalyst fermentation and distillation
• Feedstock: MSW
• Preprocessing- drying of the feedstock
• Product: Bioethanol

**Plants:**
- Fayetteville, AR- pilot plant
- Vero Beach, Indian River County, FL - under construction
  - process 150,000 TPY MSW
  - produce 8 million gallons of fuel-grade ethanol and 6 MW (gross) of electric power
  - start-up and commissioning began in summer 2012
- Lake County (IN) Solid Waste Management District- under development

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**Plascoe Energy Group**

• Headquartered in Ottawa, Canada
• Gasification followed by plasma torches to refine the syngas product
• Preprocessing- separation of inert materials
• Plants:
  - Commercial-scale demonstrational, 94 TPD- Train Road, Ottawa, CA
  - R&D, 5TPD, Castellgali, Spain
• Recently contracted to build 375 TPD facility in Ottawa Canada
Gasification Technologies

Technologies Processing Mixed Non-recyclable Plastics
### Summary of Technologies and Risks/Liabilities

**Source:** Gershman, Brickner & Bratton, Inc. August 2012

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Risks/Liability</th>
<th>Risk Summary</th>
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<tbody>
<tr>
<td>Mass Burn/WaterWall</td>
<td>Proven commercial technology</td>
<td>Very Low</td>
</tr>
<tr>
<td>Mass Burn/Modular</td>
<td>Proven commercial technology</td>
<td>Low</td>
</tr>
<tr>
<td>RDF/ Dedicated Boiler</td>
<td>Proven commercial technology</td>
<td>Low</td>
</tr>
<tr>
<td>RDF/Fluid Bed</td>
<td>Proven technology; limited U.S. commercial experience</td>
<td>Moderate to Low</td>
</tr>
<tr>
<td>Anaerobic Digestion</td>
<td>Proven technology; limited U.S. commercial experience</td>
<td>Moderate to Low</td>
</tr>
<tr>
<td>Mixed-Waste Composting</td>
<td>Previous large failures; No large-scale commercially viable plants in operation; subject to scale-up issues</td>
<td>Moderate to high</td>
</tr>
<tr>
<td>Pyrolysis</td>
<td>Previous failures at scale; uncertain commercial potential; no operating experience with large scale operations</td>
<td>High</td>
</tr>
<tr>
<td>Gasification</td>
<td>Limited operating experience at only small scale; subject to scale-up issues</td>
<td>High</td>
</tr>
<tr>
<td>Chemical Decomposition/ Depolymerization</td>
<td>Technology under development; not a commercial option at this time</td>
<td><strong>High</strong></td>
</tr>
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WM’s Organic Growth Group (Investments in Alternative Conversion Technologies)

- Terrabon
- Renmatix
- Genomatica
- Fulcrum Bioenergy (1)
- Enerkem (1)
- Agilyx
- Agnion
- InEntec

(1) Nearest to Fuels Commercialization

Big News September 2012!

- Terrabon filed Chapter 7 Bankruptcy
- Was to have 2012 financing round – WM expected lead…but backed out!
- Founded in 1995 - but no engineering package yet for commercial scale
  - Goal – 70 gallons “green gasoline” / ton MSW
  - In 2009, Terrabon believed its 200+ tpd plant could produce 5.5 million GPY of renewable gasoline for approx. $1.75 to $2.00 per gallon.
  - Now -1000 tpd(dry) [e.g.1400 tpd @30% H2O]

Projected: $4.00 - $5.33 / Gallon as Capital Cost & $0.67 / Gallon Operating Cost
Other Hard Times Firms
Geoplasma (Plasma Arc)

- In early 2006 began courting St. Lucie Co. FL in 2006 w/3,000 tpd project for $220 million
- Selected by Co. and Development Agreement Executed in April 2007
- Facility Downsized to 600 tpd at price of $120 million
- Got State Permit 2010 but never got financing (tonnages down, bad economy)
- County terminated the agreement April 17, 2012

Other Hard Times Firms
R3 Environmental

- Developed the “SMART MRF” concept for >80% landfill diversion w/ 1/3 materials recovery from MSW and C&D plus 2/3 biomass fuel
- Facility concept included major mechanical separation, optical sorting and robotics
- In 2010, selected in New Hanover Co. NC (Wilmington area) for 200,000+ tpy project for $20 million and about $35/ton tipping fee
- Contract Signed w/ County October 4, 2010.
- Ultimately, could not get financing and forfeited $380,000 bond to County in March 2011
A Realistic & Ultimate Goal:

Fully Integrated and Efficient Waste Management System with Significant Diversion (Recycling) and WTE-WCT
...in a 50-50 partnership!
...for more jobs, better environment, and energy independence!

Thank you!!

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