Biofuel Opportunities for Solid Waste Management Systems

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Gershman, Brickner & Bratton, Inc.
Fairfax, VA USA

November 13, 2013

GBB – Quality – Value – Ethics – Results

- Established in 1980
- Solid Waste Management and Technology Consultants
- Helping Clients Turn Problems into Opportunities
GBB Waste Technology Services

- Economic, technical, and environmental reviews
- Markets development
- Process planning and design
- Waste characterization and sourcing
- Procurement and negotiation assistance
- Independent feasibility consultant
- Technology due diligence
- Acceptance testing and operations monitoring

www.rewmag.com

3rd Annual
Waste Conversion Congress West Coast
3-4 December 2013, San Diego, California
SOLID WASTE MANAGEMENT IN THE U.S.

EPA Significant Changes to the Waste Management Policy, 2005
EPA Waste Hierarchies

Waste Management Hierarchy
- Source Reduction & Reuse
- Recycling / Composting
- Energy Recovery
- Treatment & Disposal

Food Recovery Hierarchy
- Source Reduction
- Feed Hungry People
- Feed Animals
- Industrial Uses
- Composting
- Incineration or Landfill

Gershman, Brickner & Bratton, Inc.
Cost of Collection and Disposal

- Costs and revenues affected by:
  - community size
  - government structure
  - politics
  - facilities used
  - waste supply agreements
  - Revenue sharing back to customer

- Collection
  - Residential solid waste: $10 - $40 USD per month per household
  - Residential recycling: $2 - $4 per month per household

- Commercial waste
  - charged on a per month per box basis, and may include a separate pass-through cost for disposal charges.
  - 2 cubic yard box serviced once per week = $60 - $140 per month
  - 6 cubic yard box serviced once per week = $130 - $280 per month

- WTE tipping fee = $68/ton (2010)
- Landfill tipping fee = $45/ton (2012)

Historical Waste Generation & Management, 1960 - 2011

Disposition of MSW in the U.S.

EPA Estimate: 250 million tons (2011)

Generation and Recovery of Material Types (EPA, 2011)

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight Generated (million tons)</th>
<th>Weight Recovered (million tons)</th>
<th>Recovery as Percent of Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper and paperboard</td>
<td>71.31</td>
<td>44.57</td>
<td>62.5%</td>
</tr>
<tr>
<td>Glass</td>
<td>11.53</td>
<td>3.13</td>
<td>27.1%</td>
</tr>
<tr>
<td>Metals</td>
<td>22.41</td>
<td>7.87</td>
<td>35.1%</td>
</tr>
<tr>
<td>Plastics</td>
<td>31.04</td>
<td>2.55</td>
<td>8.2%</td>
</tr>
<tr>
<td>Rubber and leather</td>
<td>7.78</td>
<td>1.17</td>
<td>15.0%</td>
</tr>
<tr>
<td>Textiles</td>
<td>13.12</td>
<td>1.97</td>
<td>15.0%</td>
</tr>
<tr>
<td>Wood</td>
<td>15.88</td>
<td>2.30</td>
<td>14.5%</td>
</tr>
<tr>
<td>Food</td>
<td>34.76</td>
<td>0.97</td>
<td>2.8%</td>
</tr>
<tr>
<td>Yard trimmings</td>
<td>33.40</td>
<td>19.20</td>
<td>57.5%</td>
</tr>
<tr>
<td>Total other wastes</td>
<td>80.63</td>
<td>21.58</td>
<td>26.8%</td>
</tr>
<tr>
<td>Total MSW</td>
<td>249.86</td>
<td>85.14</td>
<td>34.1%</td>
</tr>
</tbody>
</table>
**Recycling and Material Recovery Facilities**

- In 1970, US relied on local scrap yards and waste paper dealers to receive and prepare materials for recycling
- Now, US also has MRFs:

<table>
<thead>
<tr>
<th>MRF Type</th>
<th>Number of MRFs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year:</td>
</tr>
<tr>
<td></td>
<td>2006</td>
</tr>
<tr>
<td>Single Stream</td>
<td>144</td>
</tr>
<tr>
<td>Dual Stream</td>
<td>227</td>
</tr>
<tr>
<td>Source Separated, Other Programs</td>
<td>127</td>
</tr>
<tr>
<td>All MRFs</td>
<td>437</td>
</tr>
</tbody>
</table>

*Materials Recycling and Processing in the United States (Brevoy, 2012)*

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**U.S. WTE Plants, by Technology**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Operating Plants</th>
<th>Daily Design Capacity (TPD)</th>
<th>Annual Capacity (Million Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Burn (see note)</td>
<td>65</td>
<td>71,354</td>
<td>22.1</td>
</tr>
<tr>
<td>Modular</td>
<td>9</td>
<td>1,342</td>
<td>0.4</td>
</tr>
<tr>
<td>RDF - Processing &amp; Combustion</td>
<td>10</td>
<td>15,428</td>
<td>4.8</td>
</tr>
<tr>
<td>RDF - Processing Only</td>
<td>5</td>
<td>6,075</td>
<td>1.9</td>
</tr>
<tr>
<td>RDF - Combustion Only</td>
<td>5</td>
<td>4,592</td>
<td>1.4</td>
</tr>
<tr>
<td>Total U.S. Plants (2)</td>
<td>94</td>
<td>98,791</td>
<td>30.6</td>
</tr>
<tr>
<td>WTE Facilities</td>
<td>89</td>
<td>92,716</td>
<td>28.7</td>
</tr>
</tbody>
</table>

*Note: A few of these WTE (mass-burning) plants have recently announced closings, typically at end-of-term of initial 20-year debt financings and/or due to other local economic reasons*
In the U.S. - Increased Interest in Advanced WTE and Conversion Technologies

- >590 Technology and/or Project Development Companies Worldwide
- 150 Commercial or Demonstration Facilities with MSW Worldwide

Contributing factors:
- Renewable energy policy
- Funding
- Local governments desire to be greener
- GHG considerations
- Waste diversion from landfills
- Local jobs
- Higher Collection/Disposal Fees
- Transportation costs increase

TECHNOLOGIES AVAILABLE FOR BIOFUELS GENERATION
Landfill Gas

- Landfill gas (LFG) is a by-product of the decomposition of MSW:
  - ~50% methane (CH4)
  - ~50% carbon dioxide (CO2)
  - <1% non-methane organic compounds (NMOCs)
- For every 1 million tons of MSW:
  - ~0.8 MW of electricity
  - ~432,000 cubic feet per day of LFG
- MSW landfills are the third-largest source of human-related methane emissions in the U.S.

State of the U.S. LFG Industry

- LFG is extracted from landfills using a series of wells and a blower/flare system
- Collected gas goes to a central point for treatment and conversion/sale
- As of July 2013, there are 621 operational LFG energy projects in the U.S.
- EPA estimates an additional 450 MSW landfills could turn their gas into energy
  - Enough to power 500,000 homes
Gasification

- Partial combustion in an air-controlled environment
- Product: Syngas for production of electricity, chemicals/fuels (ethanol)
- Feedstocks: biomass, medical waste, demonstration-scale MSW
- Plasma gasification: a plasma arc is used as a heat source

Pyrolysis

- Thermal conversion in the absence of oxygen
- Non-recyclable plastics to oils, fuels
Anaerobic Digestion

Biological degradation of organic material in absence of oxygen

Results are biogas and digestate:

- Biogas is used as fuel for electricity and/or heat production. It can be conditioned to pipeline quality
- Digestate can be used as a soil amendment, animal bedding, or rolled into a composting process

There are 13 AD plants accepting food waste in the U.S., including demonstration, pilot and commercial projects

Renewable Waste Intelligence, March 2013

Companies in U.S. at Work with AD

Companies in U.S. at Work with AD
### Technologies and Risk

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Risks/Liability</th>
<th>Risk Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landfill Gas to Energy</td>
<td>Proven technology; widespread U.S. commercial experience</td>
<td>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>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</td>
<td>Technology under development; not a commercial option at this time</td>
<td>High</td>
</tr>
</tbody>
</table>

Source: GBB, 2013

### Technology Commercialization Examples

<table>
<thead>
<tr>
<th>Location</th>
<th>Technology</th>
<th>Developer</th>
<th>Feedstock</th>
<th>Throughput (TPD)</th>
<th>Energy Products</th>
<th>Cost</th>
<th>Federal Grants/Loan Guarantees</th>
<th>Start Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edmonton, Alberta, CA</td>
<td>Gasification/ Catal.Conv. of Syngas</td>
<td>Enerkem</td>
<td>Non-recycled MSW</td>
<td>300</td>
<td>Methanol; Ethanol</td>
<td>$80M</td>
<td>$23.5M</td>
<td>2014</td>
</tr>
<tr>
<td>Vero Beach, FL</td>
<td>Gasification/ Ferment. of Syngas</td>
<td>INEOS Bio</td>
<td>Yard, vegetative, residential waste</td>
<td>450</td>
<td>Ethanol</td>
<td>$130M</td>
<td>$125M</td>
<td>June 2012</td>
</tr>
<tr>
<td>Storey, NV</td>
<td>Gasification/ Catalytic Conv. of Syngas</td>
<td>Fulcrum Bioenergy</td>
<td>Post-sorted MSW</td>
<td>400</td>
<td>Ethanol; Propanol</td>
<td>$120M</td>
<td>--</td>
<td>2015</td>
</tr>
<tr>
<td>Monterey, CA</td>
<td>Anaerobic Digestion</td>
<td>Zero Waste Energy</td>
<td>SSD (food and yard waste)</td>
<td></td>
<td>Biogas; Electricity</td>
<td>$1.6M</td>
<td>--</td>
<td>Jan 2013</td>
</tr>
<tr>
<td>Sacramento, CA</td>
<td>Anaerobic Digestion</td>
<td>Clean World Partners</td>
<td></td>
<td>15</td>
<td>Biogas; Electricity</td>
<td>$12M</td>
<td>--</td>
<td>2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commercial food waste</td>
<td>100</td>
<td>Biogas; Electricity</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Locations Advancing Technologies

- Example of Locations advancing new facilities with thermal technologies:
  - Edmonton, Alberta and Pontotoc, MS – Enerkem
  - City of Los Angeles, CA – Green Conversion Systems

- Anaerobic digestion specific RFPs issued:
  - Humboldt Waste Management Authority, Eureka, CA
  - Montgomery, AL - under construction w/Zero Waste Energy

- Anaerobic Digestion plants under development:
  - City of Newport News, VA - quasar
  - Town of Bourne, MA - Harvest Power
  - Town of Brunswick, ME - quasar and Village Green Ventures
  - City of Columbia, SC - w/W2E
  - City of Portland, OR - w/Columbia Biogas
  - Monticello, IN - w/ Waste No Energy LLC
  - City of Charlotte, NC - w/Blue Sphere

Locations Advancing LFG to Fuels Projects

- City of Denton, TX uses LFG to fuel a 3 million gal/year biodiesel production facility
- Los Angeles, CA converts LFG into CNG to fuel landfill equipment (Puente Hills LF)
- Orange Co, CA – first commercial LFG-to-LNG facility online Jan. ‘07 – used in county waste trucks (Frank R. Bowerman LF)
- Central LF, CA plans to convert LFG to CNG to fuel Sonoma County school buses
- Franklin Co, OH uses LFG to produce methanol as a feedstock for biodiesel and a separate CNG plant
- Waste Management, Inc. in CA produces 10-20K gal LNG per day for garbage trucks
BIOFUEL USE IN FLEETS

Pathway from Waste to RNG

** Same infrastructure for RNG as for fossil fuel-CNG

- **Wastes**: All organic wastes contain energy.
- **Biogas**: Anaerobic digestion of wastes at landfills or in digester plants produces energy-rich biogas.
- **RNG Fuel**: Biogas upgrading removes carbon dioxide & impurities to make renewable natural gas (RNG).
- **Fuel Stations**: RNG goes to on-site fueling stations, or by truck or pipeline to off-site pumps.
- **Vehicles**: RNG works just like regular natural gas to power vehicles.

Source: BioCNG
Biofuel (RNG) Benefits

- 85-115% GHG reductions vs. gasoline/diesel
- 50-75% savings over current gas/diesel cost
- Control and distributed source - Fuel cost locked in for 15-20 years

**Historical Cost of Natural Gas vs. Diesel Since 2009**

- $/DGE of Nat Gas
- $/Diesel Gallon

**Direct GHG Emissions (gCO2e/MJ): Diesel and Alternative Fuels**

Derived from CA, Resource Data ACT, 2009-2012.
Selected RNG Projects

<table>
<thead>
<tr>
<th>Waste Site</th>
<th>State</th>
<th>Vehicles fueled with RNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altamont Landfill</td>
<td>CA</td>
<td>300-400 refuse trucks</td>
</tr>
<tr>
<td>Fair Oaks Dairy</td>
<td>IN</td>
<td>42 milk delivery trucks</td>
</tr>
<tr>
<td>Rodefeld Landfill</td>
<td>WI</td>
<td>25-30 vehicles</td>
</tr>
<tr>
<td>Sauk Trail Hills Landfill</td>
<td>MI</td>
<td>RNG leaves site via pipeline</td>
</tr>
<tr>
<td>Columbus bio-Energy Digester</td>
<td>OH</td>
<td>25+ vehicles</td>
</tr>
<tr>
<td>Janesville Wastewater Plant</td>
<td>WI</td>
<td>40+ vehicles by 2022</td>
</tr>
<tr>
<td>St. Landry Parish Landfill</td>
<td>LA</td>
<td>15+ vehicles</td>
</tr>
<tr>
<td>Rumpke Landfill</td>
<td>OH</td>
<td>10-15 refuse trucks</td>
</tr>
</tbody>
</table>


Opinion: Trends for the Future

• Many conversion projects advancing
  • AD development moving quickly
• AD developments coming in 2-3 years; thermal technologies will need 4-6 years to learn what works and all need to clarify their economics
• Continuation of public sector taking “Low Risk” attitude until “proven”
• Demand for more recyclables expected to continue at attractive pricing
• RNG is a fantastic opportunity to coordinate between integrated solid waste management systems and transportation demands
Questions and comments?

Thank you!

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