North American Perspective on Integrated Solid Waste Management

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Introductions
History of the MSW management in the US
Management Practices
Technology Review
On-going projects
Opinion & Trends
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
History of the MSW Management in the US

- Recognized value in recovery of materials and energy from waste
- Waste reduction and product stewardship efforts
- Reduce the environmental impact of products
- Implementation of integrated waste management related policy with recycling goals
  - No significant disposal taxes nor bans
- Public and financial support for better waste management
Policy History

- The first U.S. federal solid waste management law: Solid Waste Disposal Act (SWDA) of 1965
- First Earth Day April in 1970
- The Resource Conservation and Recovery Act (RCRA) of 1976
- Amendments to RCRA in 1984 through 1998 policy shift from landfilling toward waste reduction, and recovery of materials and energy

EPA Significant Changes to the Waste Management Policy, 2005

EPA Waste Hierarchies
Historical Generation & Management of MSW 1970 - 2010


Management Practices

What are we doing today with our waste?
Disposition of MSW in the U.S.


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: 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</td>
<td>127</td>
</tr>
<tr>
<td>Programs</td>
<td></td>
</tr>
<tr>
<td>All MRFs</td>
<td>437</td>
</tr>
</tbody>
</table>

Materials Recycling and Processing in the United States (Berenyi, 2012)
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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>

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 data)
Landfill Pricing (Tip Fees) for MSW by Region and Year (in $ per ton)


Technology review
Existing and emerging technologies
WTE Evolution in the US

- 150 WTE projects in development in the U.S. in the late 1990s
- 2 US Supreme Court cases and the 1990 Clear Air Act Amendment affected the WTE development
- Today, there are 85 WTE plants operating in 23 states, handling approximately 12% of MSW

WTE Plants in the US

<table>
<thead>
<tr>
<th>Technology</th>
<th>Number of Facilities</th>
<th>Average Tons Per Day</th>
<th>Total Tons Per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Facilities</td>
<td>85</td>
<td>975</td>
<td>82,893</td>
</tr>
<tr>
<td>Mass Burn</td>
<td>65</td>
<td>1,023</td>
<td>64,452</td>
</tr>
<tr>
<td>RDF</td>
<td>15</td>
<td>1,128</td>
<td>16,926</td>
</tr>
<tr>
<td>Modular</td>
<td>7</td>
<td>216</td>
<td>1,515</td>
</tr>
</tbody>
</table>

Facilities and Tons Processed by Technology Type (BERENYI, 2012)
Technology and Project Developers – 579 and Counting

- 34 Aerobic Composting
- 100 Anaerobic Digestion
- 30 Ethanol Fermentation
- 174 Gasification
- 49 Plasma Gasification
- 69 Pyrolysis
- 59 WTE: mass burn, modular, dedicated boilers, and RDF
- 64 Others (agglomeration, autoclave, de-polymerization, thermal cracking, steam reforming, hydrolysis)

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

Gasification Technology Offerors
Technologies Processing Mixed Non-recyclable Plastics

Technologies Processing Organic Waste
Technology Commercialization Examples

<table>
<thead>
<tr>
<th>Location</th>
<th>Edmonton, Alberta, CA</th>
<th>Vero Beach, FL</th>
<th>Storey, NV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>Gasification/Catal.Conv. of Syngas</td>
<td>Gasification/Ferment. of Syngas</td>
<td>Gasification/Catalytic Conv. of Syngas</td>
</tr>
<tr>
<td>Developer</td>
<td>Enerkem</td>
<td>INEOS Bio</td>
<td>Fulcrum Bioenergy</td>
</tr>
<tr>
<td>Feedstock</td>
<td>Non-recycled MSW</td>
<td>Yard, vegetative, resid. waste</td>
<td>Post-sorted MSW</td>
</tr>
<tr>
<td>Throughput (TPD)</td>
<td>300</td>
<td>450</td>
<td>400</td>
</tr>
<tr>
<td>Energy Products</td>
<td>Methanol; Ethanol</td>
<td>Ethanol</td>
<td>Ethanol; Propanol</td>
</tr>
<tr>
<td>Cost</td>
<td>$80M</td>
<td>$130M</td>
<td>$120M</td>
</tr>
<tr>
<td>Federal Grants/Loan Guarantees</td>
<td>$23.5M</td>
<td>$125M</td>
<td>--</td>
</tr>
<tr>
<td>Start Date</td>
<td>2014</td>
<td>June 2012</td>
<td>2015</td>
</tr>
</tbody>
</table>

Locations Advancing “Proven” Technologies

- Example of Mass burn WTE expansions completed
  - Hillsborough County, FL – Covanta
  - Lee County, FL – Covanta
  - Olmsted County, MN – Olmsted County
  - Honolulu, HI – Covanta
- Example of Locations advancing new facilities with ‘proven’ technologies:
  - Baltimore, MD – Energy Answers
  - Frederick County, MD (NMWDA) - Wheelabrator
  - Durham York (Ontario CN) - Covanta
  - City of Los Angeles, CA – Green Conversion Systems
  - Palm Beach County, FL (SWAPBC) – B&W
  - Puerto Rico – Energy Answers
  - Metro Vancouver, Canada – To be determined
Featured on ongoing projects in North America

- City of Cleveland - Cleveland Recycling and Energy Generation Center Project
- City of Houston - One Bin for all
- Prince William County - Demonstration plant of an emerging MSW WTE conversion technology
- County of Maui - Integrated Waste Conversion and Energy Project
- Metro Vancouver - Establishment of New WTE capacity

Opinion: Trends for the Future

- Many conversion projects advancing
- Will need 4-6 years to learn what works and their economics
- Continuation of public sector taking “Low Risk” attitude until “proven”
- Demand for more recyclables expected to continue at attractive pricing
- More mixed waste processing systems [again]
  - Many conversion technologies require MSW pre-processing... for feedstock sizing and inerts removal
  - Electric utilities may become a player for RDF
- ‘Environmentalists’ and ‘Zero Waste’ proponents will continue to fight WTE and Waste Conversion Technologies calling them all “incineration”
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!

Questions and comments?

Thank you!!

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