Waste Conversion Market Update

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Session - Waste Conversion Market Update

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GBB  Quality – Value – Ethics – Results
Founded 1980

WASTE CONVERSIONS IN THE U.S. – 2017 UPDATE

- MSW Landfills: 64%
- Recycling Facilities: 21%
- Composting Facilities: 6%
- WTE Plants: 9%

Source: “Municipal Solid Waste Management in the U.S.” EREF 2016

U.S. Waste Management Infrastructure

<table>
<thead>
<tr>
<th>Technology</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer Stations</td>
<td>3,350</td>
</tr>
<tr>
<td>Material Recovery Facilities (MRF)</td>
<td>586</td>
</tr>
<tr>
<td>Curbside Recycling Programs</td>
<td>9,000+</td>
</tr>
<tr>
<td>Mixed Waste Processing Facilities &amp; Hybrid MRFs</td>
<td>70*</td>
</tr>
<tr>
<td>Composting</td>
<td>2,300</td>
</tr>
<tr>
<td>Anaerobic Digestion (Stand-alone)</td>
<td>25</td>
</tr>
<tr>
<td>WTE</td>
<td>76</td>
</tr>
<tr>
<td>Landfills</td>
<td>1,908</td>
</tr>
</tbody>
</table>

*Excludes facilities that solely produce RDF
Source: GBB
U.S. Waste Disposition Methodology (2013)

- EREF estimates 347 million tons MSW managed in 2013 using “bottom up” approach
- EPA estimates 254 million tons MSW in 2013 using “material balance” approach
- Approximately 220,000,000 total tons (~600,000 TPD) of MSW disposed at landfills in 2013... diverting this material would provide...
  - Nation-wide investment opportunity of $120 billion
  - 50,000 jobs created across the country

Cost of Collection and Disposal

- 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 per ton
- Landfill tipping fee: $50.60 per ton
- Costs and revenues affected by:
  - Community size
  - Government structure
  - Politics
  - Facilities used
  - Waste supply agreements
  - Revenue sharing back to customer
Landfill prices continue to climb

Organics in the U.S. MSW
Organics Facilities Under Development

Source: GBB 2016

Residential Food Waste Collection

Source: BioCycle Magazine, January 2015
**State Legislative Highlights**

- **Minnesota** – State goal of 75% diversion; Hennepin County, populations greater than 10k must divert food from landfill
- **California** – SRF/RDF does NOT count as diversion; $24M grants to organics; 75% diversion target
- **Oregon** – Metro County voting to require schools/commercial food operations to divert food waste from landfill starting 2019.
- **Vermont** – Universal Recycling Act requires diversion of food waste, yard waste, and wood debris from landfill, continued EPR and e-waste laws
- **New York** – NYC Voluntary residential organics collection rollout, $34 million RFP issued for compost operations in NYC
- **Massachusetts** – ban on disposal of food and yard waste, policies to encourage growth of AD
- **New Jersey** – S-3027: Reduce FW 50% by 2030; S-771: Large FW generator within 25 miles of authorized organics recycling facility must divert material for processing.
- **Rhode Island** - beginning Jan. 1, 2016, required separation of organic waste including food scraps and composting or other beneficial reuse
- **Connecticut** - Ban of commercial food waste from landfills for generators of two or more tons of food waste
- **Florida** – Waste-to-energy is considered recycling
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Energy Transitions

- Shift from Coal to Natural Gas
- Newly installed natural gas infrastructure can benefit existing WTE
- Biogas-electricity (Anaerobic Digestion)
- Big question: Will governments continue to treat RDF/SRF and WTE as “Renewable Energy”?

UK Monthly Coal Consumption

Source: EIA, Carbon Brief

Mass Burn/Dedicated Boilers

- Excess air for complete combustion
  - Starved air with some modular mass burn
- Products: steam, power, hot water, and/or chilled water; also metals, aggregates, and ADC
- Feedstocks
  - MSW
  - Special wastes
  - Biosolids
Waste Conversion Market Update

October 3, 2017

WTE Plant Marketplace in Past 30 Years

- Ash processing for more metals recovery, e.g. Inashco for Lancaster
- Wasatch WTE closed. Mixed waste processing ongoing

<table>
<thead>
<tr>
<th>Year</th>
<th>RDF</th>
<th>MB</th>
<th>MOD</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>12</td>
<td>44</td>
<td>49</td>
<td>105</td>
</tr>
<tr>
<td>1995</td>
<td>41</td>
<td>95</td>
<td>26</td>
<td>162</td>
</tr>
<tr>
<td>2000</td>
<td>26</td>
<td>70</td>
<td>13</td>
<td>102</td>
</tr>
<tr>
<td>2010</td>
<td>25</td>
<td>64</td>
<td>7</td>
<td>96</td>
</tr>
<tr>
<td>2016/2017</td>
<td>13</td>
<td>59</td>
<td>4</td>
<td>76</td>
</tr>
</tbody>
</table>

Source: SWANA 2017

Newest Facility: Solid Waste Authority of Palm Beach County, FL

- Groundbreaking – April 2012
- Commercial operation – June 2015
- First new facility in US in 20 years!
- SWANA Excellence Award, WTE - 2017
- 3,000 tons per day Mass Burn facility (1,040,000 tons per year)
  - Babcock & Wilcox
  - $672 million construction price
  - Advanced emissions controls, ferrous and non-ferrous metals recovery

<table>
<thead>
<tr>
<th>Waste Processed</th>
<th>Boiler Utilization</th>
<th>Gross Electric Generation (kWh/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>976,621</td>
<td>88.0%</td>
<td>581.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Emission Limit</th>
<th>Performance Emission (% of Limit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM (filterable)</td>
<td>12 mg/dscm</td>
<td>2.3 (19.2%)</td>
</tr>
<tr>
<td>HCl</td>
<td>20 ppm</td>
<td>1.5 (7.5%)</td>
</tr>
<tr>
<td>CO</td>
<td>100 ppm</td>
<td>18.7 (18.7%)</td>
</tr>
<tr>
<td>NOx</td>
<td>50 ppm</td>
<td>30.8 (61.6%)</td>
</tr>
<tr>
<td>SO2</td>
<td>50 ppm</td>
<td>20.9 (41.8%)</td>
</tr>
</tbody>
</table>

Source: SWANA 2017
Anaerobic Digestion/Composting

- Biological decomposition of the organic material in absence of oxygen
- >20 commercial plants that take source separated organics
- Feedstock: Commercial food waste, residential SSO, co-digestion at WWTP and farms
- Two main type: high solids AD and low solids AD

CR&R – Perris, CA
Anaerobic Digestion
- $100 million facility
  - 84,000 TPY operating;
  - 335,000 TPY planned capacity
  - High solids anaerobic digestion system
  - Feedstock: residential food scraps and yard waste, and commercial food waste
  - Generating CNG to fuel truck fleet

Blue Sphere – Charlotte, NC
Anaerobic Digestion
- $27 million facility
  - Operational in Q4 2016
  - 156,000 TPY capacity
  - Food waste and animal waste
  - Generating electricity and soil amendment

Source: GBB
Gasification

- Partial combustion in an air-controlled environment
- Product: Syngas for production of electricity, chemicals/fuels (ethanol)
- Feedstocks
  - Engineered fuel from MSW
  - Biomass
  - Agricultural waste

Enerkem Process

Feedstock preparation
- Sorting, shredding, moistening (if required) and feeding

Gasification
- Conversion of raw waste into syngas

Cleaning and conditioning process
- Primary syngas purification

Catalytic synthesis and product purification
- Conversion of chemical-grade syngas into final renewable products

* Municipal solid waste
Project Status - Edmonton Waste-to-Biofuels Facility, Alberta, Canada

### Financing
- Privately financed by capital and ownership investments
- Waste Management of Canada
- EB Investments
- Alberta Innovates
- City of Edmonton

### Owner/operator
- Public-Private Partnership: Enerkem Alberta Biofuels LP
- Builds, owns, and operates Waste-to-Biofuel facility
- City of Edmonton and Alberta Innovates own/operate co-located facilities

### Waste Stream
- City of Edmonton provides 110,000 tons MSW annually
- 25 year contract
- Pre-processed in RDF facility
- Tip fee $45/Ton

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**Formerly Plasco Energy Group; new owner**

- 2011: contracted with City of Ottawa to build & operate 110,000 ton per year MSW plant
- Had commercial-scale demonstration, 94 ton per day plant in Ottawa
- Gasification followed by plasma torches to refine the syngas product

- Now focused on selling technology to municipalities with existing MSW facilities
Plastic to Oil Technologies

- Thermal conversion in the absence of oxygen
- Non-recyclable plastics to oils, fuels
- Plastics-to-Oil Technologies Alliance formed by ACC

Source: RES Polyflow
Montgomery, AL – Infinitus

• High-tech 80,000 square feet “state-of-the-art” Mixed Waste Processing Facility
• $35 Million capital cost
• First “One Bin for All” in 21st Century in the U.S.
• Bulk Handling Systems Process
  – One-line, 40 ton per hour input for 100,000 tons per year
  – 60% material recovery guarantee (including organics)
• Commercial operations began April 2014
• Closed October 2015
• Heading to Bankruptcy; City of Montgomery, AL offering to purchase for ~$625,000

Source: GBB 2014

Berkeley County, WV MBT Facility

• Uses High Efficiency Mechanical Biological Treatment (HEBioT) process
  – Front end sorting of MSW to remove high value recyclables
  – Remaining material is processed by mixed waste composting to create Solid Recovered Fuel (SRF)
• SRF marketed to cement kilns valued at ~$30/ton
  – EPA approved alternative to coal to reduce emissions
• Under Construction -- Commercially operable April 2018
Hampden, Maine - Anaerobic Digestion/Enzymatic Hydrolysis Plant

- Mechanically separates MSW for processing into various bio-fuels
  - Front end separation of recyclables
  - Anaerobic digestion of soluble organics produces biogas
  - Enzymatic hydrolysis of cellulose organics produces high value sugars
  - Lignin, non-recyclable plastics → engineered fuel
- Design capacity: 600 tons per day
- Will serve residential and commercial waste stream from 83 communities
  - $72 per ton tipping fee
- Construction started Spring 2017
- Operational Spring 2018

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Energy/Fuel Product Values Versus Capex

<table>
<thead>
<tr>
<th>Product</th>
<th>Yield from 1 Ton MSW</th>
<th>Value Per Production Unit</th>
<th>Revenue Per Input Ton</th>
<th>Capital Investment for 1,000 tpd facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>500-650 kWh</td>
<td>@ $0.05 / kWh</td>
<td>$25-$33</td>
<td>$300 - 400 million</td>
</tr>
<tr>
<td>Engineered Fuel</td>
<td>8 - 16 MMBTU</td>
<td>@ $1.50 / MMBTU</td>
<td>$12 - 24</td>
<td>$50 – 100 million</td>
</tr>
<tr>
<td>Ethanol (w subsidies)</td>
<td>50 gallons</td>
<td>@ $4.00 / gallon</td>
<td>$200</td>
<td>$300 - 400 million</td>
</tr>
</tbody>
</table>
State of WTE in Europe

- 400+ WTE plants across Europe processing over 100 million tons
- 27% of waste in EU processed via WTE
- UK plans to phase out coal by 2025; additional WTE projects in planning stage

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of WTE plants</th>
<th>Tons processed (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>11</td>
<td>2.76</td>
</tr>
<tr>
<td>Belgium</td>
<td>18</td>
<td>3.75</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>3</td>
<td>0.73</td>
</tr>
<tr>
<td>Denmark</td>
<td>26</td>
<td>4.35</td>
</tr>
<tr>
<td>Finland</td>
<td>9</td>
<td>1.3</td>
</tr>
<tr>
<td>France</td>
<td>126</td>
<td>16.2</td>
</tr>
<tr>
<td>Germany</td>
<td>99</td>
<td>27.56</td>
</tr>
<tr>
<td>Italy</td>
<td>40</td>
<td>6.72</td>
</tr>
<tr>
<td>Netherlands</td>
<td>12</td>
<td>8.35</td>
</tr>
<tr>
<td>Portugal</td>
<td>4</td>
<td>1.26</td>
</tr>
<tr>
<td>Sweden</td>
<td>33</td>
<td>6.2</td>
</tr>
<tr>
<td>Switzerland</td>
<td>30</td>
<td>4.29</td>
</tr>
<tr>
<td>Spain</td>
<td>12</td>
<td>2.76</td>
</tr>
<tr>
<td>UK</td>
<td>37</td>
<td>9.35</td>
</tr>
</tbody>
</table>

Many WTE Developments in Asia

- Vietnam opens first WTE plant – 7.5 MW (Hitachi Zosen)
- India: RFP for 100 WTE facilities to be proposed
  - Currently 287 MW of WTE installed
  - Singapore approved $470 million loan for WTE
  - 3,600 tons per day, 120 MW
- Israel opens first RDF plant in Recycling Park
- Malaysia, Philippines, Indonesia, many others expressing interest
Developments in China

- Subsidizing Anaerobic Digestion for farmers
- Asian Development bank investing $100 million in Chinese WTE projects
- Rapid pace of development
- Rising middle class
- China has had enough of our waste, must now also address their own
  - National Sword
  - NIMBY!

- Chinese investors to acquire German firm EIW Energy from Waste
  - Local private equity group, G2F Infrastructure, has reached an agreement in principle to acquire German waste-to-energy firm EIW Energy from Waste (formerly ELN Energy from Waste) in a deal reportedly valued at €700 million.
Circular Economy

- U.S.: boundless landfill capacity at reasonable prices
- Continued lowering of energy revenues unless subsidies/grants
- Food waste and organics interest significant – anaerobic digestion and composting expanding
- Collections changes for efficiency: technology in containers, trucks, and back office; franchising; and bio-CNG and clean diesel fuels
- Resource Parks added to integrated waste systems for domestic circular economy
- ‘Environmentalists’ and ‘Zero Waste’ advocates promoting policy and recycling only alternatives
- International: WTE growing fast, especially in China; China also developing its domestic supply of recyclables will hurt recycling markets in U.S.

Waste is very recyclable and it is also very renewable!
A lot less waste to landfills is better!
"If it is not recyclable, not organic, what is it... it's fuel!"
Thank you!

Harvey Gershman
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