Waste-to-Energy Lessons Learned: A 30-Year Evaluation on Why Projects Succeeded or Failed

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Gershman, Brickner & Bratton, Inc.
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GBB Consulting Services

- 36 years and counting!
- Waste characterization and sourcing
- Economic, technical and environmental reviews
- Procurements
- Due diligence third-party reviews
- Process planning and conceptual designs
- Independent feasibility consultant
History of U.S. Waste Disposition

National Generation & Management 1970-2012

### U.S. MSW Disposition - Current

EPA Estimate: 251 million tons (2013)

- Discarded: 52.80%
- Recovery: 34.30%
- Combustion with Energy Recovery: 12.90%


- Discarded: 63.50%
- Composted: 6.34%
- Recycled: 22.58%
- Combustion with Energy Recovery: 7.58%

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### U.S. Waste Management Infrastructure

<table>
<thead>
<tr>
<th>Technology</th>
<th>US</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>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</td>
<td>21</td>
</tr>
<tr>
<td>WTE</td>
<td>77</td>
</tr>
<tr>
<td>Landfills</td>
<td>1,908</td>
</tr>
<tr>
<td>Landfill Gas Projects (LFG)</td>
<td>636</td>
</tr>
</tbody>
</table>

*Excludes facilities that solely produce RDF
Meanwhile in the EU (1995-2014)

- Landfilling decreased 54%
- Recycling rate increased 166%
- Composting increased 170%
- Waste-to-Energy increased 100%

Source: EUROSTAT, 2016

Drivers in the EU

- Landfill Directive, 1999 - Limited the amount of biodegradable municipal waste going to landfills
- Feed in tariffs
- On average 80 €/t landfilling tax
- 18 EU Countries with landfilling material bans
Mechanical Biological Treatment (MBT)

Source Separated Recyclables

MSW source

Mixed MSW

Source Separated Organics

Mechanical Biological Treatment Plant (MBT)

Mechanical (grinding, screening, recyclables separation, palletizing)

Biological (bio-drying, aerobic composting, anaerobic digestion)

Products:
Recyclables
Compost
Biogas/Electricity
RDF/EF

Over 330 MBT facilities in operation throughout Europe
U.S. Opportunity: Create Circular Economy through Zero Waste to Landfill

Circular Economy

Source: Ellen MacArthur Foundation
Industrial Eco-Parks – Co-locating Resource Recovery Operations

• Build environmental industry
  • Employment
  • Green jobs
  • Redevelopment

• Increase options for diversion
  • Keep resources at home
  • Connect generators with processors and remanufacturers

• Overcomes China’s “Green Fence”

How do you overcome China’s Green Fence?

You build “Green Gates” to convert recyclables to manufacture into consumer products!
Post Source Separation ZWLF Choices

Advanced Conversion Technologies

476 Technology/Project Development Companies

- 28 Aerobic Composting
- 106 Anaerobic Digestion
- 30 Ethanol Fermentation
- 117 Gasification
- 30 Plasma Gasification
- 31 Pyrolysis
- 63 WTE: mass burn, modular, dedicated boilers, and RDF
- 69 Others (e.g., thermal cracking, hydrolysis, steam reforming, agglomeration, de-polymerization)

157 Commercial or Demonstration CT Facilities

- 70 Anaerobic Digestion
- 57 Gasification
- 10 Plasma Gasification
- 12 Pyrolysis

Source: Gershman, Brickner & Bratton, Inc., June 2014
Energy/Fuel Product Values - Key and Cyclical

<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>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>500-650 kWh</td>
<td>@ $0.05 / kWh</td>
<td>$25-$33</td>
</tr>
<tr>
<td>Synthetic Crude</td>
<td>1 barrel</td>
<td>@ $40 / barrel</td>
<td>$40.00</td>
</tr>
<tr>
<td>Ethanol</td>
<td>50 gallons</td>
<td>@ $2.00 / gallon w/o subsidies</td>
<td>$100.00</td>
</tr>
<tr>
<td>Bio-diesel</td>
<td>35</td>
<td>@ $3.57-$4/gallon*</td>
<td>$125-140</td>
</tr>
</tbody>
</table>

*Includes RINS and LCFS (California)
Enerkem Waste-to-Biofuels – Edmonton Alberta, CA

• Refuse derived fuel gasification
• Produces ethanol and chemical intermediates

Edmonton Waste Management Centre:
• Refuse Derived Fuel production facility
• Enerkem Waste-to-Biofuels Facility
• Advanced Energy Research Facility

Source: SWANA Northern Lights 2013, Bud Latta, Processing and Disposal Waste Management Services, City of Edmonton

Example of Industrial Eco-Park

RDF in Cement Kilns

• Huge consumer of fossil fuels
• Closed system: ash in fuels stays in cement
• 107 cement plants in 36 U.S. states
  • Top five companies collectively operate 49.6 percent of U.S. clinker capacity

2016 - Entsorga breaks ground for a MBT facility in Martinsburg, WV to produce fuel for Essroc
WTE Project Cancellations and Closures

WTE Plant Evolution in Past 30 Years

Waste-to-Energy Lessons Learned: A 30-Year Evaluation on Why Projects Succeeded or Failed

<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>15</td>
<td>64</td>
<td>7</td>
<td>86</td>
</tr>
<tr>
<td>2016</td>
<td>13</td>
<td>60</td>
<td>4</td>
<td>77</td>
</tr>
</tbody>
</table>

MWC type: MB = Mass Burn, MOD = Modular excess air, RDF = Refuse-Derived Fuel

References:
Reasons Project Developments Fail

- Technology risk
- Costs too high
- Inadequate waste supply
- Hurts recycling
- No sites
- No financing
- Regulatory push back
- Lack of political will
- No sites

WTE Projects Cancelled in 1980’s

- City of San Diego, CA
- New York, NY (Brooklyn Navy Yard)
- City of Philadelphia, PA (Philadelphia Navy Yard)
- City of Seattle, WA
- Snohomish Co, WI
- Atlantic County, NJ
- Cape May County, NJ
- Middlesex County, NJ
- Passaic County, NJ
1993 Research for Energy Recovery Council Predecessor by GBB

- Monmouth County, NJ: Lost by 2 percent in county-wide referendum.
- City of San Francisco, CA: Referendum in neighboring Town of Brisbane killed project site.
- St. Lawrence County, NY: Facility oversized; “put or pay” requirements; lack of political will.
- Metro (Portland, OR): Siting problems; delays; lost window for tax credits.
- City of Seattle, WA: Citizen opposition and local sitting concerns; need for landfill; put or pay would negatively effect recycling.

Reasons Procurements Fail

- Costs too high
- No site
- Lack of political will
- Technology risk
- Hurts recycling
- Inadequate waste supply
- Regulatory push back
- No financing
WTE/CT Projects Stalled in 2000+

- USVI
- Allentown, PA
- St. Lucie County, FL
- New Hanover County, NC
- City of Baltimore, MD (Fairfield)
- Metro Vancouver, Canada
- Hawaii County, HI
- Glendale, AZ
- Cleveland, OH
- ECUA, FL
- City of Los Angeles, CA
- Marion County, FL
- Frederick County, MD
- Lake County, IN
- Clark County, NV
- Ada County, ID

WTE Facility Closures

- Harford, MD
- Harrisonburg, VA
- Portsmouth, VA
- Nashville, TN
- Wallingford, CT
New WTE/MBT projects

Newest Traditional WTE: Solid Waste Authority of Palm Beach County, FL

- 3,000 TPD Mass Burn facility (1,040,000 TPY)
  - Babcock & Wilcox
  - 130 MW renewable power; enough for over 86,000 houses
  - $668 million construction price
  - $20.5 million first year O&M cost
  - Advanced emissions controls, ferrous and non-ferrous metals recovery

- Notice of Award – April 2011
- Groundbreaking – April 2012
- First Fire – February 2015
- Commercial operation – June 2015
- 12.7% plastics in MSW means over 132,000 TPY recovered as fuel

Air Emissions of Contenders for WTERT Award in 2006*

<table>
<thead>
<tr>
<th>Emission</th>
<th>WTE-A (mg/Nm³)</th>
<th>WTE-B (mg/Nm³)</th>
<th>WTE-C (mg/Nm³)</th>
<th>Average of 10 Finalists (mg/Nm³)</th>
<th>EU Standard (mg/Nm³)</th>
<th>US EPA Standard (mg/Nm³)</th>
<th>Maximum Concentration in Palm Beach WTE (mg/Nm³)</th>
<th>Palm Beach WTE Test Results (mg/Nm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate matter (PM)</td>
<td>0.4</td>
<td>1.8</td>
<td>1</td>
<td>3.1</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>0.6-2.5</td>
</tr>
<tr>
<td>Sulphur Dioxide (SO₂)</td>
<td>6.5</td>
<td>7.5</td>
<td>3</td>
<td>2.96</td>
<td>50</td>
<td>63</td>
<td>62.82</td>
<td>29-58</td>
</tr>
<tr>
<td>Nitrogen oxides (NOₓ)</td>
<td>80</td>
<td>11</td>
<td>58</td>
<td>112</td>
<td>200</td>
<td>264</td>
<td>94</td>
<td>61-63</td>
</tr>
<tr>
<td>Hydrogen chloride (HCl)</td>
<td>3.5</td>
<td>0.5</td>
<td>0.7</td>
<td>8.5</td>
<td>10</td>
<td>29</td>
<td>30.67</td>
<td>2.3-4.1</td>
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<tr>
<td>Carbon Monoxide (CO)</td>
<td>15</td>
<td>7</td>
<td>15</td>
<td>24</td>
<td>50</td>
<td>45</td>
<td>114.5</td>
<td>19-27.5</td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>0.002</td>
<td>0.005</td>
<td>0.002</td>
<td>0.01</td>
<td>0.05</td>
<td>0.06</td>
<td>0.025</td>
<td>0.0006</td>
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<tr>
<td>Total Organic carbon (TOC)</td>
<td>0.5</td>
<td>NA</td>
<td>0.9</td>
<td>1.02</td>
<td>10</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Dioxins (TEQ)</td>
<td>0.002</td>
<td>0.002</td>
<td>0.015</td>
<td>0.02</td>
<td>0.10</td>
<td>0.14</td>
<td>0.001</td>
<td>0.0002-0.0004</td>
</tr>
</tbody>
</table>

New WTE/MBT projects

- Hartford, CT (MIRA)  
  - In procurement
- Housatonic Resource Recovery Authority, CT  
  - In procurement
- Berkeley County, WV  
  - Ansorga
- City of Hood River/The Dalles, OR  
  - In procurement
- Hampton, ME  
  - Fiberight
- Lake County, OR  
  - Red Rock Biofuels
- Metro Portland, OR  
  - In procurement
- Lebanon, TN  
  - PHG
- Prince William County, VA  
  - In procurement

Municipal AD Projects Under Development

City of Portland, OR - Columbia Biogas  
- Prince Georges County, MD – TBD
- County of Santa Barbara, CA – Mustang Renewable  
- Prince William County, VA – Freestate Farm  
- City of Perris, CA – CR&R  
- Town of Brunswick, ME  
- Johnson, Rhode Island - Blue Sphere
- City of Charlotte, NC - Blue Sphere  
- City of Columbia, SC - W2E
Project Building Blocks

- Regulatory impetus and incentives
- Limited or high disposal costs
- Waste Supply
- Markets
- Site with good logistics that can be permitted
- Landfill for residues
- Contractor with resources and proven technology
- Capital
- Ability to pay service fees
- Finance
- Compatibility with High Level of Recycling
- Political Will

Pre-Develop Project Building Blocks

- Include a site
- Address recycling as part of future solution
  - In certain states, organics too
- Show understanding of cost implications and how it will be funded
- Offer waste supply strategy and commitment
- Include service agreement showing risk posture
- Involve internal decision-makers and stakeholders
- Have internal team with resources and advisors
Trends

- Significant focus on AD projects, especially in California
  - Wastewater treatment plants with excess AD capacity interested in adding food waste
- Several conversion technologies to watch carefully, including “One-Bin”
- Mixed waste processing key to Zero Waste To Landfill
- Increased public sector involvement needed and willing to pay more for increasing diversion
- ‘Zero Waste’ proponents fight non-recycling only alternatives

Questions, Answers, and Thank you!!

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