Comparison of Environmental Performance Expectations:
Gasification versus Mass-Burn WTE Facilities Currently Under Construction in North America

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By
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Outline
- Introduction
- Facilities Permitted in North America
  - Expansions
  - Greenfield Projects
- Factors Influencing Performance
- Comparison of Permit Limits
- Conclusions
Comparison of Environmental Performance Expectations: Gasification versus Mass-Burn WTE

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

If half of landfilled waste went to WTE → over 9 GW

In 2011, 24.7 GW of announced coal power plant retirements

Source: USEPA, 2010

Conversion Technology Processes and Products

<table>
<thead>
<tr>
<th>Thermal Conversion Technology</th>
<th>Primary Product</th>
<th>Product Conversion</th>
<th>Secondary Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrolysis</td>
<td>Char</td>
<td>Extraction</td>
<td>Chemicals</td>
</tr>
<tr>
<td>Gasification</td>
<td>Tars &amp; Oils</td>
<td>Upgrading</td>
<td>Gasoline</td>
</tr>
<tr>
<td>Combustion</td>
<td>Syngas</td>
<td>Synthesis</td>
<td>Methanol</td>
</tr>
<tr>
<td>Digestion</td>
<td>Heat</td>
<td>Engine</td>
<td>Ammonia</td>
</tr>
<tr>
<td>Fermentation</td>
<td>Heat</td>
<td>Electricity</td>
<td>Methanol</td>
</tr>
</tbody>
</table>

Feedstock: MSW

*may be pre-processed
Challenges to Commercialization

Non-technical Barriers:
- Social Acceptability
  - Perceptions of Pyrolysis & Gasification in society not consistently positive
- Environmental Legislation and Energy Policy
  - Not all fuels produced eligible for renewable incentives
  - Demand for Renewable Energy increasing
- Market fluctuation
  - Feedstock availability (location and consistency of supply)
  - Market value of plastics and end products variable
  - Competition with the price of oil
- Financing of Demonstration Units
  - Projects need to be large enough to be economically feasible
  - Initial set-up stage can be unpredictable if met with public opposition, can exhaust funds

Past and Future Developments

- Hillsborough County, FL
- Lee County, FL
- Olmstead County, MN
- Honolulu, HI
- Energy Answers, Baltimore, MD
- Honolulu, HI
- Renshaw, IL
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Gasification Facilities

<table>
<thead>
<tr>
<th>Developer</th>
<th>Process</th>
<th>APC</th>
</tr>
</thead>
<tbody>
<tr>
<td>INEOS</td>
<td>Feedstock shredded and dried, combined with oxygen in gasifiers. Syngas introduced into a fermentation system and converted to ethanol using bacterial metabolic activity. Off-gases combusted in a boiler, with heat recovery steam generator for power generation</td>
<td>Vent Gas Boiler, Activated Carbon and Lime Injection, Scrubbing of Vent Gas, Desulfurization Unit, Dry Gas Cleaning System</td>
</tr>
<tr>
<td>Geoplasma</td>
<td>Feedstock processed, and gasified in vertical cylindrical vessel heated with plasma torches. Syngas combusted in a multi-stage thermal oxidizer. Heat recovery steam generator for power generation</td>
<td>SCR, Activated Carbon Injection, FGD, ESP, Baghouse</td>
</tr>
<tr>
<td>Enerkem</td>
<td>Feedstock delivered processed, gasified in bubbling fluidized bed reactor in the presence of added water and steam. Syngas treated with cyclones and cooled, then scrubbed. Syngas heated and treated before being converted into methanol and/or chemical feedstocks through catalytic synthesis reactors, then esterification for ethanol pathway</td>
<td>Two-stage Wet Scrubber, Low NOx Burner, Two Cyclones in Series, Baghouse</td>
</tr>
</tbody>
</table>
**INEOS Bio – Vero Beach, FL**

- INEOS Bio and partner New Planet Energy
- Designed to produce 8 million gallons of bioethanol and net 2 MW of electricity from 150,000 tons of MSW and renewable biomass
- Scheduled to begin commercial operation in mid-2012
- $2.5M grant from the State of Florida, $50M grant from DOE, and $75M commitment from USDA. Total project investment will be more than $130M

**Geoplasma - St. Lucie County, FL**

- Geoplasma is a division of the Jacoby Group,
- Designed to produce net 18 MW of electricity from 193,000 tons of MSW and tires annually (600 TPD)
- Cost cited at $130M
- Construction expected to begin in 2012, operation by 2014
- Utilizes a plasma arc gasifier developed by Westinghouse Plasma Corporation, a division of Alter NRG
Enerkem – Edmonton, Alberta

- Partnership with the City of Edmonton, to receive post-recycled waste
- Designed to produce 10 million gallons of methanol from 112,000 tons of RDF annually (300 TPD)
- Plans for additional facility development to produce 9.5 million gallons of bioethanol in future years
- Secured an offtake agreement with Methanex for methanol produced

Mass Burn Facilities

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<thead>
<tr>
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<th>APC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durham/York</td>
<td>Mass Burn Municipal Waste Combustor, with Stoker Grate Steam Boilers, equipped with Covanta's Very Low NOx Combustion Process</td>
<td>SNCR, ESP, Activated Carbon Injection, Ammonia Injection, Dry Recirculation Lime Injection Scrubber, Baghouse</td>
</tr>
<tr>
<td>SWAPBC</td>
<td>Mass Burn Municipal Waste Combustor with reuse of cooling tower water from the existing facility</td>
<td>SCR, ESP, Activated Carbon Injection, Spray Dryer Absorber with Lime Injection, Baghouse</td>
</tr>
</tbody>
</table>
**Durham and York, Ontario**

- Certificate of Approval in June of 2011 from Ontario Minister of the Environment
- 480 TPD (2 x 240) mass burn WTE facility in Clarington, Durham
- Covanta Energy Limited selected to design, construct, and operate the facility, located in Ontario’s Clarington Business Park
- Net 14 MW of electricity from 156,800 tons per year of MSW
- Financing for the facility provided by Durham and York, total cost of $260M
- Construction began in fall of 2011, projected commercial operation in 2014

**Palm Beach County, FL**

- Solid Waste Authority of Palm Beach County, permitted by Florida DEP for the Renewable Energy Facility No.2
- In April 2011 selected Babcock & Wilcox Power Generation Group to design, construct, and operate the facility
- Located adjacent to the SWAPBC Renewable Energy Facility No.1
- 95 MW gross of electricity generated from 3,000 tons per day of MSW (3 x 1,000)
- Under construction, projected to begin commercial operation in spring of 2015
- Capital costs cited at $668M, first year O&M cost of $20.5M
Expectation of Performance

Four primary factors differentiating expectations of overall performance and emission production between facilities currently permitted:

- **Technological Process**
- **Facility Size**
- **Feedstock Utilized**
- **Primary Products**

These facilities show wide variation of combination of these four differentiating factors:

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<th>Enerkem</th>
<th>Palm Beach</th>
<th>Durham/York</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>Plasma Gasification</td>
<td>Gasification, Fermentation</td>
<td>Gasification, Catalytic Synthesis</td>
<td>Mass Burn (R&amp;W)</td>
<td>Mass Burn (Covanta)</td>
</tr>
<tr>
<td>Feedstock</td>
<td>RDF</td>
<td>RDF (biomass)</td>
<td>RDF</td>
<td>MSW</td>
<td>MSW</td>
</tr>
<tr>
<td>TPD Feedstock</td>
<td>600</td>
<td>300</td>
<td>300</td>
<td>3000</td>
<td>480</td>
</tr>
<tr>
<td>Product Outputs</td>
<td>Net 18 MW</td>
<td>7.9 M gal/yr ethanol, Net 2 MW</td>
<td>9.5 M gal/yr ethanol</td>
<td>Gross 95 MW</td>
<td>Net 14 MW, steam</td>
</tr>
</tbody>
</table>
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Onondaga County Resource Recovery Facility

- Operating as Covanta Onondaga, L.P. since 1995
- Processes 990 tons per day of MSW (3 x 330)
- Generates 39.5 MW
- 14-year average of 631 kWh/ton of MSW processed
- Waterwall furnaces with Martin® reverse-reciprocating grates
- APC:
  - SNCR
  - ESP
  - Ammonia Injection
  - Semi-dry Flue Gas Scrubbers injecting Lime and Activated Carbon
  - ESP

<table>
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<tr>
<th>g/ton of feedstock processed</th>
<th>Geoplasma</th>
<th>Ineos Bio</th>
<th>Enerkem</th>
<th>Palm Beach</th>
<th>Durham/York</th>
<th>OCRRA</th>
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<tbody>
<tr>
<td>SO2</td>
<td>117.2</td>
<td>812.29</td>
<td>101.88</td>
<td>272.16</td>
<td>260.19</td>
<td>534.42</td>
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<tr>
<td>NOx</td>
<td>206.26</td>
<td>901.11</td>
<td>608.36</td>
<td>407.14</td>
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<td>1913.34</td>
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<td>PM2.5</td>
<td>7.9</td>
<td>127.76</td>
<td></td>
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<tr>
<td>PM/PM10</td>
<td>236.76</td>
<td>136.74</td>
<td>192.96</td>
<td>51.17</td>
<td>66.91</td>
<td>104.25</td>
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<tr>
<td>CO</td>
<td>201.37</td>
<td>457.31</td>
<td>797.32</td>
<td>495.32</td>
<td>297.36</td>
<td>265.2</td>
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<tr>
<td>HCl</td>
<td>136.31</td>
<td></td>
<td>129.55</td>
<td>66.91</td>
<td></td>
<td></td>
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<tr>
<td>VOC</td>
<td>159.72</td>
<td>712.78</td>
<td>502.76</td>
<td>54.43</td>
<td>245.32</td>
<td></td>
</tr>
</tbody>
</table>

Air Permit Limits
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OCRRA 2011 and Long-Term Stack Test Results

CONCLUSIONS

Commercial Operation Yields Information and Support

- Emissions
- Economics
- Public Understanding
- Political Acceptance
FUTURE ACTIVITY

- Community evaluations of conversion technologies

- Ada County, ID
- Baton Rouge, LA
- City of Allentown, PA
- City of Dallas, TX
- City of Glendale, CA
- City of Plano, TX
- City of San Antonio, TX
- City of Taunton, MA
- Columbia, SC
- Fulton, MS
- Gallatin County, KY
- Lake County, IN
- Los Angeles County, CA
- Mason City, IA
- Maui County, HI
- New York, NY
- Prince William County, VA
- Salinas Valley, CA
- San Bernardino County, CA
- Santa Barbara County, CA

- Several have concluded with the initiation of procurements
- As facilities currently under construction begin to come online, more procurements to come
- Time frames may be short, so be prepared!

Thank you!!

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REFERENCES


