Waste Conversion Technologies
Life Cycle Assessment

WTERT Fall Meeting
October 8, 2004

Keith Weitz, RTI International

Background

- California Integrated Waste Management Board is required to prepare a report on waste conversion technologies
  - Life cycle assessment
  - Market impact assessment
- RTI worked with the National Renewable Energy Laboratory to complete the life cycle portion
- Companion study by the University of California to conduct a comprehensive technical evaluation of alternative conversion technologies
What is Life Cycle Assessment?

- “Cradle-to-grave" systems analysis
- Upstream and downstream
- Multi-media / Multi-pollutant
- ISO 14040 provides guidelines for conducting an LCA and LCA typically includes:
  - Inventory Analysis
  - Impact Assessment
  - Interpretation

Overall Approach

- Defined conversion technologies based on existing systems for:
  - Acid hydrolysis (Masada)
  - Gasification (Brightstar Environmental)
  - Catalytic Cracking (Plastics Energy, LLC)
- Developed material and energy balances
- Developed life cycle inventory models
- Analyzed alternative scenarios for the Los Angeles and San Francisco Regions
Defined Conversion Technologies

Gasifier/Reformer → Cyclone → Gas Scrubber → Water Cooler/Treatment

Centrifuge → Mix Tank → Gas Cooler → De-Emulsifier

Waste Heat Recovery → Engine/Generator Set → Air Pollution Control

Gasification – Brightstar Environmental Technology

Material and Energy Balance

Feedstock (Processed MSW) → Conversion Technology

Energy → Products
Materials → Energy
Air Emissions → Water Pollution
Solid Waste

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Material and Energy Balance

- Developed by the National Renewable Energy Laboratory using a commercial model called ASPEN Plus
- Used publicly available information
  - Patent applications
  - Responses to UC questionnaire
- Communicated with technology vendors
- Employed conservative assumptions
  - Contaminate removal efficiency
  - Air pollution control

Life Cycle Inventory

- Started with materials and energy balances
- Used RTI’s solid waste model to capture remaining processes:
  - Collection
  - Transfer station
  - Materials separation/recycling
  - Composting
  - Combustion
  - Landfill
- Data gaps filled with data from a commercial life cycle database – Ecobalance DEAM/TEAM:
  - Chemicals and fuels
Life Cycle Boundaries

Collection Materials Separation Conversion Technology (e.g., acid hydrolysis)

Land Disposal

Energy and Materials

Emissions

Material and Energy Balance

Emissions Energy Products (gypsum) Residues (filtercake)

Scenarios Analyzed

- Landfill
  - Gas vent (worst case)
  - Gas collection and flare (average case)
  - Gas collection and energy recovery (best case)
- Waste-to-Energy
- Composting
- Recycling
  - 35 percent separation efficiency
  - 55 percent separation efficiency
  - 75 percent separation efficiency
- Conversion technology
Conversion Technology Scenario

2003 (Base Year)
- Three 500 tpd acid hydrolysis facilities (1,500 tpd total).
- Four 500 tpd gasification facilities (2,000 tpd total).
- One 50 tpd catalytic cracking facility (50 tpd total).

Years 2004 to 2010
- One additional 500 tpd gasification plant 2005.
- Two additional 500 tpd acid hydrolysis plants in 2007.
- One additional 500 tpd gasification plant built in 2010.

tpd = tons per day

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<th>2003</th>
<th>2005</th>
<th>2007</th>
<th>2010</th>
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<tr>
<td><strong>Tonnage Capacity (San Francisco Region)</strong></td>
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<tr>
<td>Acid Hydrolysis</td>
<td>493,500</td>
<td>493,500</td>
<td>822,500</td>
<td>822,500</td>
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<tr>
<td>Gasification</td>
<td>658,000</td>
<td>822,500</td>
<td>822,500</td>
<td>987,000</td>
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<td>Catalytic Cracking</td>
<td>16,450</td>
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<td>16,450</td>
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<td><strong>Total</strong></td>
<td>1,167,950</td>
<td>1,332,450</td>
<td>1,661,450</td>
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<th>2003</th>
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<tr>
<td><strong>Required Incoming Tonnage (San Francisco Region)</strong></td>
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<tr>
<td>Acid Hydrolysis</td>
<td>641,780</td>
<td>643,525</td>
<td>1,072,542</td>
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<td>Gasification</td>
<td>754,643</td>
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<td>943,093</td>
<td>1,131,712</td>
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<td>Catalytic Cracking</td>
<td>1,078,636</td>
<td>1,118,529</td>
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<td><strong>Total</strong></td>
<td>1,396,423</td>
<td>1,586,618</td>
<td>2,015,635</td>
<td>2,204,254</td>
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Findings

Finding #1: The amount of energy produced by the conversion technology scenario is larger than the alternative management scenarios studied and creates large life cycle benefits.

2010 San Francisco Results: Net Energy (MBTU)
Findings

- Finding #2: For criteria air pollutants, the conversion technology scenario is better than the alternative management scenarios.

2010 San Francisco Results: Net NOx Emissions (lb)
Findings

- Finding #3: From a climate change perspective, the conversion technology scenario is generally better than the alternative management scenarios.
Findings

- Finding #4: Insufficient data were available to assess the potential for the conversion technology scenario to produce emissions of dioxins, furans, and other HAPs.
- Finding #5: The environmental benefits of the conversion technology scenario are highly dependent upon their ability to achieve high conversion efficiencies and materials recycling rates.
- Finding #6: Conversion technologies would decrease the amount of waste disposed of in landfills.
- Finding #7: No conversion technology facilities exist in the United States for MSW; therefore, there is a higher level of uncertainty regarding their environmental performance than existing waste management practices.
Uncertainties and Limitations

- Conversion technologies studied don’t exist in the U.S. for MSW
- Didn’t focus on optimal siting/co-location aspects
- Uncertainty in how the feedstock will be delivered to the conversion facilities
- Considered MSW only, no other types of waste
- National averages used for most processes.
- LCA is not a risk assessment.
  - No spatial differentiation
  - Net total emissions, not concentrations or rates of release

Future Research Needs

- Update results with data from actual facilities in California and the U.S.
- Analyze regions with a wider variation in waste composition.
- Analyze other feasible conversion technologies.
- Analyze optimal conversion technology facility configurations.
- Analyze small modular conversion technology facilities.
Thank You

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