Evaluating Innovative Technology for Municipal Waste Management

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1.0 Introductions

- **Steven Torres, City Attorney**
  Taunton, Massachusetts
  Representing City Project to Replace Landfill

- **Jim Binder, P.E., Principal**
  Alternative Resources, Inc.;
  Independent Consulting Firm;
  Focus Solid Waste Management, including New and Emerging Technologies;
  Studies for NYC, LA County, CRRA, City/County of Santa Barbara, Taunton
2.0 **Technology Options for Post-Recycled MSW**

- Conventional
  - Transfer
  - Composting/Co-composting
  - Waste-to-Energy
  - Landfill
2.0 Technology Options for Post-Recycled MSW

• New and Emerging Conversion Technologies
  – Thermal
  – Biological
  – Chemical
  – Hydrolysis
  – Other
2.0 Technology Categories

• **Thermal**
  – Use or produce heat to change the composition of MSW
  – Products include synthesis gas, char and organic liquids
  – Descriptors: gasification, pyrolysis, cracking and plasma

• **Digestion (Aerobic and Anaerobic)**
  – Decomposes organic fraction of MSW using microbes
  – Produces biogas and compost
  – Aerobic digestion produces compost

• **Hydrolysis**
  – Chemical reaction in which water (typically with acid) reacts with another substance to form new substances
  – Extracts cellulose from MSW to form products or sugar which is fermented to ethanol
  – Some products include ethanol, levulinic acid

• **Chemical Processing**
  – Example: depolymerization – converts organic fraction into energy, oil, specialty chemicals, carbon solids

• **Mechanical Processing for Fiber Recovery**
  – Recovers fiber from MSW for paper making
2.0 Technology Options for Post-Recycled MSW

• In Addition to Conventional Technologies, Why Consider New and Emerging Conversion Technologies?
  – Environmental benefits, including reduction in greenhouse gas and other emissions
  – Enhanced beneficial use of waste; less waste requiring transfer and landfilling
  – Production of needed “renewable” products with strong, year-round markets
    • Electricity
    • Gas
    • Fuels – CNG, LNG, ethanol, hydrogen
2.0 Technology Options for Post-Recycled MSW

- Examples of New and Emerging Technology Options
  
  **Thermal**
  - Bioengineering Resources, Inc.
  - Ebara Corporation
  - GEM America
  - Geoplasma
  - International Environmental Solutions
  - Interstate Waste Technologies/Thermoselect
  - NTech Environmental
  - Plasco Energy Group
  - Primenergy, LLC
  - Rigel Resources Recovery and Conversion Co./Westinghouse
  - Ze-Gen
  
  **Biological**
  - ArrowBio
  - Canada Composting
  - Organic Waste Systems/DRANCO
  - Orgaworld
  - Waste Recovery Systems, Inc./Valorga
  
  **Chemical**
  - Changing World Technologies
  
  **Hydrolysis**
  - Arkenol/Blue Fire Ethanol
  - Biofine
  - Masada OxyNol
  
  **Other**
  - Herhof GmbH
  - World Waste Technologies
2.0 Technology Options for Post-Recycled MSW

• Examples of Public Initiatives, New and Emerging Technologies
  – NYC
  – LA County
  – City of Los Angeles
  – St. Lucie County, Florida
  – Santa Barbara County, California
  – Connecticut Resources Recovery Authority
  – Delaware Solid Waste Management Authority
  – City of San Diego
## 2.0 NYC Phase 1 Summary of Findings (September 2004)

### Development Status of Innovative Technologies by Category

<table>
<thead>
<tr>
<th>Technology Category</th>
<th>Commercial Use Outside U.S. for MSW</th>
<th>Pilot Testing with MSW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaerobic Digestion</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Thermal Processing</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hydrolysis</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
### 2.0 NYC Phase 1 Summary of Findings

Comparison of Commercially Advanced New and Emerging Technologies (Anaerobic Digestion and Thermal Processing) to Modern Waste-to-Energy

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Advantageous</th>
<th>Comparable</th>
<th>Disadvantageous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Acceptability</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residuals Requiring Disposal</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beneficial Use of Waste</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Cost</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ownership Preferences</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk Allocation</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utility Needs</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Size and Flexibility</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Acreage Required</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Experience of Sponsors</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Readiness and Reliability</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
</tbody>
</table>
2.0 NYC Phase 2: Summary of Economic/ Financial Evaluation (March 2007)

- Planning level economic analyses indicate that anaerobic digestion and thermal processing technologies, on a commercial scale, are comparable to or less costly than costs for current export practices.
- Projected cost for export practices (2014) = $124/ton
- Projected tipping fee for private ownership and financing (2014):
  - Anaerobic digestion (sale of compost) = $56-$80/ton
  - Anaerobic digestion (compost disposed) = $72-$108/ton
  - Thermal processing = $103-$165/ton
- Projected tipping fee for public ownership and financing (2014):
  - Anaerobic digestion = $43-$65/ton
  - Thermal processing = $76-$129/ton
- Corporate teaming experience in the U.S. continuing to develop for the technology suppliers
# LA County Phase II: Products and Residue (October 2007)

<table>
<thead>
<tr>
<th>Technology Supplier</th>
<th>Residue Generated*</th>
<th>Types of Products Generated</th>
</tr>
</thead>
<tbody>
<tr>
<td>ArrowBio</td>
<td>13%</td>
<td>Recyclables, Biogas, Electricity or Vehicle Fuel, Compost</td>
</tr>
<tr>
<td>CWT</td>
<td>18%</td>
<td>BioDiesel Fuel Oil (light distillate to heavy fuel oil), Fuel Gas, Carbon Fuel</td>
</tr>
<tr>
<td>IES</td>
<td>10%</td>
<td>Fuel Gas, Electricity</td>
</tr>
<tr>
<td>IWT</td>
<td>0%</td>
<td>Syn Gas, Electricity or Fuels, Sulfur, Salts, Zinc Concentrate, Metals &amp; Minerals</td>
</tr>
<tr>
<td>NTech</td>
<td>2%</td>
<td>Recyclables, Oil, Fuel Gas, Electricity</td>
</tr>
</tbody>
</table>

* % by Weight of MSW received for processing and requiring landfilling
### LA County Phase II: Project Concepts by Technology Supplier (October 2007)

<table>
<thead>
<tr>
<th>Technology Supplier</th>
<th>Proposed Facility Size</th>
<th>Site Size</th>
<th>Estimated Tipping Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>ArrowBio</td>
<td>300 TPD 1050 TPD</td>
<td>4 acres 12 acres</td>
<td>$50/ton(1) $50/ton(1)</td>
</tr>
<tr>
<td>CWT</td>
<td>220 TPD 1000 TPD</td>
<td>3 acres 5.8 acres</td>
<td>$60/ton not provided</td>
</tr>
<tr>
<td>IES</td>
<td>125 TPD (prepared) 242 TPD (as received)</td>
<td>1 acre</td>
<td>$56/ton(1), (2)</td>
</tr>
<tr>
<td>IWT</td>
<td>312 TPD 623 TPD 935 TPD</td>
<td>3.5 acres 5 acres 8 acres</td>
<td>$131/ton $70/ton $59/ton</td>
</tr>
<tr>
<td>NTech</td>
<td>413 TPD</td>
<td>3.5 acres</td>
<td>$55/ton(1)</td>
</tr>
</tbody>
</table>

(1) Integrated pricing with MRF, considers use of existing scales, roads and site infrastructure at MRF.
(2) Assumes waste feedstock is preprocessed by MRF to 2” in size, glass, metal removed.
### 2.0 Net Energy Production and Landfill Diversion

#### Net Energy Production

<table>
<thead>
<tr>
<th></th>
<th>Net Electric Output</th>
<th>1,000 TPD 100% Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasification</td>
<td>500 – 800 kWh/Ton</td>
<td>21 – 33 MWe</td>
</tr>
<tr>
<td>Anaerobic Digestion</td>
<td>250 kWh/Ton</td>
<td>10 MWe</td>
</tr>
<tr>
<td>Acid Hydrolysis</td>
<td>31 Gal/Ton</td>
<td>11 Million Gal/Year</td>
</tr>
</tbody>
</table>

#### Landfill Diversion

(By weight)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasification</td>
<td>&gt; 90%</td>
</tr>
<tr>
<td>Anaerobic Digestion</td>
<td>&gt; 75%</td>
</tr>
</tbody>
</table>
## 2.0 Comparison of Air Emissions

<table>
<thead>
<tr>
<th></th>
<th>Conversion Technology as Compared to Incinerators in Massachusetts*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dioxin</td>
<td>10 to &gt;100 times less</td>
</tr>
<tr>
<td>Mercury</td>
<td>1 to 50 times less</td>
</tr>
<tr>
<td>Nitrogen Oxides</td>
<td>Approximately 10 times less</td>
</tr>
<tr>
<td>(Precursor to Ozone)</td>
<td></td>
</tr>
</tbody>
</table>

* Data from 2006 Solid Waste Master Plan
3.0 Thermal Conversion (Gasification) is not Incineration

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Thermal Conversion</th>
<th>Incineration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Combustion of Solid Waste</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Ash Residual</td>
<td>Little – No Ash</td>
<td>25 – 30%</td>
</tr>
<tr>
<td>3. Potential to capture gases to make fuels</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4. Potential to pre-clean gases prior to combustion</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5. Air Emissions</td>
<td>Reduced</td>
<td>--</td>
</tr>
<tr>
<td>6. Diversion of waste from landfilling</td>
<td>&gt; 90%</td>
<td>70-75%</td>
</tr>
<tr>
<td>7. Marketable products</td>
<td>Electricity, steam, fuels, vitrified aggregate, minerals</td>
<td>Steam, Electricity</td>
</tr>
<tr>
<td>8. Potential to install combined cycle generation to increase energy output</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
4.0 The Promise

- Next generation of technology
- Not perfect, but better than existing alternatives
- Lower emissions
- Reduction in amount waste landfilled
- Enhances recycling and conversion of waste for beneficial use
- Provides source of renewable energy
5.0 Hurdles

• Lack of commercial demonstration in US
• Lack of development/acceptance for certain product markets in US or regulatory hurdles for product use
• Applicability of regulations for environmental permitting is unclear, non-existent, or inadvertently problematic
• Qualification for renewable energy credits for power sale is not consistent
• Need for public education
Example
Illustrations/Schematics of New and Emerging Technologies
IWT – Chiba, Japan
330 TPD
(Operating since 1999)
IWT – Thermoselect Schematic Diagram
GEM America – Pilot Converter, South Wales
40 TPD
(Operated in 2001-2002)
IES – Romoland, CA
50 TPD
(Operating since March 2005)
PROCESS FLOW DIAGRAM

Waste Material

- Municipal Solid Waste
- Medical Waste
- Biosolids
- Tires

Shredder

Thermal Converter

- Syn Gas

Optional Dryer or other process

Thermal Oxidizer

Recyclables

- Carbon Char
- Metal
- Glass

Heat Recovery

Steam Generator

System Stack

- Mist Eliminator
- Induced Draft Fan
- Dust Collector
- Wet Scrubber

Generator

Steam Turbine

Transformer / Switchgear

Substation

Electricity

Transmission
Entech Integrated Process Layout

Generic Layout for illustration purposes only
1. Waste reception and recycling
2. Plastics to Oil Conversion
3. Renewable energy unit
4. Organic drier
5. Air Abatement system / Boiler
Kinetic Streamer
Wastec Facility, York UK
(Operating since January 2005)
Gasifier and Thermal Oxidizer
Entech Facility, Bydgoszcz, Poland
25 TPD – Hospital Waste
(Operating since February 2003)
NTech – Malaysia
67 TPD
Rigel Waste Conversion System: Westinghouse Plasma System
(Operating since 2004, Utashinai, Japan)
ArrowBio – Anaerobic Digestion System
Tel Aviv
110 TPD
(Operating since 2003)
Separation/Processing

ArrowBio, Tel Aviv
Tipping to Process
ArrowBio, Tel Aviv
Primary Flotation
ArrowBio, Tel Aviv
Digestion Tanks
ArrowBio, Tel Aviv
Soil Amendment Results
ArrowBio, Tel Aviv
Reciprocating Engine/Gen Set

ArrowBio, Tel Aviv
ArrowBio – Artist Rendering for Sydney, Australia
300 TPD
ArrowBio
Jacks Gully
Sydney, Australia
May 2007
ArrowBio
Jacks Gully
Sydney, Australia
November 2007
CWT – Process Equipment
Carthage, MO
250 TPD
(Operating since February 2005)
Changing World Technologies – Process Steps
CWT – Oil Products