To MACT or not to MACT?
Mercury Emissions from Waste-to-Energy and Coal-fired Power Plants

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Chair, Chemical Engineering, Manhattan College

NAWTEC 12, Savannah, Georgia, May 2004
• This is a story of two fuels, one very old, the other relatively new: Coal and MSW.
• Both of these fuels contain mercury:
  • U.S. coal; 0.1-0.2 parts per million
  • U.S. MSW: 1-2 ppm (now: Back in 1988, it was 5-10 ppm)
• When these fuels are combusted, their mercury content volatilizes and forms either mercury vapor (Hgo) or
Generation and Disposition of solid wastes in the U.S. are understated by the EPA/Franklin report

*Kaufman, Goldstein, Millrath (WTERT), Themelis,Biocyte, Jan. 2004*

All numbers are in millions of tons per year:

<table>
<thead>
<tr>
<th></th>
<th>Generated</th>
<th>Recycled</th>
<th>Composted</th>
<th>To WTE</th>
<th>Landfilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPA/ Franklin</td>
<td>229</td>
<td>51</td>
<td>17</td>
<td>30</td>
<td>131</td>
</tr>
<tr>
<td>EEC/BioCycle</td>
<td>369</td>
<td>73</td>
<td>26</td>
<td>29</td>
<td>242</td>
</tr>
<tr>
<td>Chartwell/Beck</td>
<td>545*</td>
<td>146*</td>
<td></td>
<td>29</td>
<td>346*</td>
</tr>
</tbody>
</table>

*Chartwell/ Beck survey includes automobile scrap and industrial wastes disposed in landfills
Is WTE an established technology?

- Number of nations using WTE: 35
- Total Population: 2.6 billion
- Estimated global WTE: 150 mill t/y
- U.S. WTE capacity: 29 million tons
- 15 billion kWh/ year
Should WTE be considered as renewable energy*?

• One ton of MSW fuel in a modern WTE plant generates a net of 500 kWh of electricity
• To generate this much electricity in a coal-fired plant takes about 0.25 tons of coal
• To produce 0.25 tons of coal it is necessary to mine 2 tons of overburden and coal.
• To generate 500 kWh using fuel oil requires one barrel of oil.

*Themelis, WTERT, NYS Commission on Renewable Energy

1 ton of MSW == 0.25 ton coal == 1 barrel of oil
### Biomass fuel contained in US MSW *(EPA, 1997 data)*

<table>
<thead>
<tr>
<th>Biomass combustibles</th>
<th>%</th>
<th>Petrochemical combustibles</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper/board</td>
<td>38.6</td>
<td>Plastics</td>
<td>9.9</td>
</tr>
<tr>
<td>Wood</td>
<td>5.3</td>
<td>Rubber</td>
<td>1.5</td>
</tr>
<tr>
<td>Cotton/wool</td>
<td>1.9</td>
<td>Fabrics</td>
<td>1.9</td>
</tr>
<tr>
<td>Leather</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yard trimmings</td>
<td>12.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food wastes</td>
<td>10.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total biomass</strong></td>
<td>66.8 %</td>
<td><strong>Total petrochemical</strong></td>
<td>14.3 %</td>
</tr>
</tbody>
</table>

*Biomass constitutes 82% of the combustibles in MSW*

**BIOMASS IS RENEWABLE.... SO IS MSW....SAYS DOE**
U.S. DOE: Renewable Energy Installed Capacity: 11 GW
Forest Products: 7.5 GW, MSW: 3 GW, LF Gas: 0.5 GW

Figure 1.1: 1999 Renewable Electricity Generation
(Billion Kilowatthours)

Source: DOE BA Annual Energy Outlook 2001

WTERT, 2004

Figure 1.2: Bioenergy Electricity Generation, 1981 - 1999

WTERT, 2004
### Criteria for Sustainable Development technologies

<table>
<thead>
<tr>
<th>Per ton of MSW to</th>
<th>WTE</th>
<th>Landfill</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-renewable resources:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>-0.25 ton coal</td>
<td>-40 Nm³ CH₄</td>
</tr>
<tr>
<td></td>
<td>or -1 barrel oil</td>
<td></td>
</tr>
<tr>
<td>Minerals &amp; metals</td>
<td>+ 50 lb metal</td>
<td></td>
</tr>
<tr>
<td>Land</td>
<td></td>
<td>+ 1 ft²</td>
</tr>
<tr>
<td><strong>Renewable resources:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air</td>
<td></td>
<td>+ 1.3 t CO₂equ</td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td>+ effluents</td>
</tr>
<tr>
<td>Toxic substances</td>
<td></td>
<td>+ VOC</td>
</tr>
</tbody>
</table>
Additional disadvantages of long-distance trucking of MSW:-

• Need for putrescible waste transfer stations that in many respects are like small temporary landfills

• Diesel truck emissions: WTERT research* has shown that diesel trucks transporting MSW from NYC to PA emit five times more Particulate Matter per ton of MSW, than if the MSW were combusted in NYC.

*Monica DeAngelo, M.S. Thesis, Columbia 2004
So........

....if WTE is environmentally superior to landfills how come 65% of the U.S. MSW is still landfilled ???
“Is it the economy, stupid?”

• True in many states: Since the environmental impact costs are not accounted for, landfilling is cheaper.

• WTE is economic in CT, FL, MD, MA, MI, NH, NJ, NY, OR, PA and in any other states where landfilling fees are over $60 ton.

But: Determined opposition of environmental groups (e.g. in NYC) deters investment on WTEs, thus favoring landfilling….not because of facts but of four perceptions……..
The regrettable result:

Zero new WTE facilities in the U.S. since 1995

..while the rest of the world moves on...

164 new WTE plants abroad since 1995, just by three major WTE technologies

The four perceptions:

**Perception 1**

“When WTE is not available, less trash is generated and more is recycled”

**Reality:** No new WTEs have been built in the U.S. since 1995 but...
… it hasn’t stopped growth in MSW generation!

Municipal solid wastes collected in the U.S.

- EEC/BioCycle, total solids
- EEC/-BioCycle, MSW
- "Biocycle", Dec. 2001
- Franklin/EPA

**Bar Chart**

- **Years**: 1990, 2001
- **Millions of tons**: 0, 100, 200, 300, 400, 500

**Legend**

- "Biocycle", Dec. 2001
- Franklin/EPA
Also: Mandating recycling rates can have strange effects, such as landfilling “recyclables“ in NYC.....

“ ....for lack of markets...90% of the plastics and glass set aside by thoughtful New Yorkers was transported to MRFs and from there to landfills.”

Themelis and Todd (WTERT), Recycling in a Megacity, Journal of Air&Waste Management Assocation.
...or increasing generation rates substantially in California!

Figure 2. Percent changes in California population vs. waste generation, 1989-1999

Themeleis and Kaufman, BioCycle, April 2004
Perception 2: “WTE facilities emit a lot of mercury”

Reality: Not anymore
Perception 3:

“WTE facilities emit a lot of dioxins”

Reality:

• Total dioxin emissions from all U.S. WTEs have been reduced since 1987 by 99% to 12 grams TEQ.
• Major source of dioxins now: Backyard barrel burning (580 grams)
• Under study at Columbia: Dioxins from flaring of landfill gas (P. Ulloa).
Somehow, environmental groups have not paid any attention to landfills....yet the U.S. landfills generate*:

- 39,329 tons ammonia
- 39,213 tons sulfides/ mercaptans
- 742 tons toluene
- 503 tons dichloromethane
- 201 tons tetrachloroethylene
- 112 tons vinyl acetate
- 92 tons acetone
- 64 tons dichloroethane
- 65 tons xylenes
- 63 tons trichloroethylene
- 51 tons vinyl chloride
- 36 tons styrenes
- Smaller tonnages of another ten VOC compounds

*Computed from:

LG constituents as per Tchobanoglous Handbook x (106 million tons of MSW x 62 Nm$^3$/ton minus collected LG as per Berenyi Landfill Yearbook)
Perception 4: New WTEs == Environmental injustice

Yet there are so many examples of WTEs here and abroad that did not represent environmental injustice. Even in places where there has been environmental injustice in the past, it is not necessary to repeat the mistakes of the past.

A properly designed and landscaped WTE can be a boon to a community by:
- closing several “transfer “ stations

- stopping interstate truck emissions

- creating industrial ecoparks where electricity and heat of WTE are used by nearby light industrial facilities and communities,

- creating park land and promenades in areas that now are brownfields and wastelands.
Now: Many transfer stations.....and many long distance trucks

Monica DeAngelo, M.S. Thesis, Columbia 2004
A brownfield
The future?
Two WTEs.

Monica DeAngelo,
M.S. Thesis, Columbia 2004
Brescia, Italy, WTE SITE BEFORE CONSTRUCTION
THE BRESCIA, ITALY, WTE: PRIDE OF BRESCIA
In closing…….

U.S. EPA has assessed WTE as a…..
“…clean, reliable, renewable power…”
“These plants produce…..electricity with less environmental impact than almost any other source of electricity.”
However: Widely distributed EPA reports do not distinguish between WTE and landfilling, but lump them together as “Discards”
One tangible way for EPA to recognize the major investment of companies and communities in the environment...

(average WTE investment: $330/annual ton capacity)

### Table ES-1

<table>
<thead>
<tr>
<th>Table ES-1</th>
<th>GENERATION, MATERIALS RECOVERY, COMPOSTING, AND DISCARDS OF MUNICIPAL WASTE AND ENERGY RECOVERY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Millions of tons</strong></td>
<td><strong>1960</strong></td>
</tr>
<tr>
<td>Generation</td>
<td>88.1</td>
</tr>
<tr>
<td>Recovery for recycling</td>
<td>5.6</td>
</tr>
<tr>
<td>Recovery for composting</td>
<td>Neg.</td>
</tr>
<tr>
<td>Total Materials Recovery</td>
<td>5.6</td>
</tr>
<tr>
<td>Energy Recovery</td>
<td>30.0</td>
</tr>
<tr>
<td>Discards</td>
<td>131.2</td>
</tr>
</tbody>
</table>
Research sponsored by:

Waste-To-Energy Research and Technology Council