APWA Sustainability In Public Works Conference 2011

A Renewed Role for Waste-to-Energy in Sustainable Solid Waste Management

Portland, Oregon

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Presenters

**LAND**  
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Learning Objectives

Participants should be able to:

1. Identify opportunities for communities to develop more sustainable solid waste management practices

2. Examine how W-T-E can complement other sustainable solid waste management practices

3. Evaluate and assess benefits of including W-T-E in long-term solid waste management plans
WTE Snapshot

Operating WTE Facilities In North America 80+
Operating WTE Facilities Worldwide 600+
Last New NA WTE operational in 1996
Two New NA WTE permitted in 2010; Three permit application currently pending
Most NA Facilities generate electricity
Most Non-NA Facilities generate process steam or hot water for district heating and cooling
Air Emission are lower than for most fossil fuels
WTE Advantages

- Conserves Landfill Capacity
- Generates Renewable Energy
- Reduces Greenhouse Gases
- Conserves Water Resources
- Increases Recycling
- Provides A Local Waste Management Solution
- Conserves Fossil Fuels
- Provides Rate Stability
LAND

Waste-to-Energy Conserves Landfill Space

- WTE reduces waste volume by more than 90%
- Density of landfilled material is doubled
- Cover material requirements are reduced saving both landfill space and need for borrow pit excavation
Sustainable Waste Management and Energy Generation

Northeast Maryland Waste Disposal Authority

Population: 3.7 million
Households: 1.2 Million

WTE Facilities (3+1)
Sewage Sludge Composting (1)
Landfill Gas to Energy Facilities (3+1)
Solar Energy Projects (1+1)
Commercial Recycling
E-Waste Recycling
Energy Marketing
Waste Volume Reduction
Renewable Energy Production

IN
100 cubic yards of waste (20 tons)

90% volume reduction

OUT
10 cubic yards of inert ash (6 tons)

13,000 KWh
$900 in Revenue
App. One Household for one year
Metals Recovered at WTE Facility

(would otherwise be land filled)
Net Energy Production by Waste Management Strategy

-3,000,000
-2,500,000
-2,000,000
-1,500,000
-1,000,000
-500,000
0
500,000
Local Landfill
Local WTE
Out-Of-State Landfill

Annual Energy Consumption (MBTU)
Baltimore, Maryland Energy Recovery Facility

2,250 tons per day, 60 MW, 25 Years Generating Electricity and Steam
Harford County, Md. WTE Facility, Processes 100,000 tons/year
Provides Steam to Army Base
Montgomery County, Md. Resource Recovery Facility Generating 52 MW Electricity for 16 Years
New WTE Facility in Permitting

Enclosed air pollution control equipment
Source of process water is adjacent WWTP
Combust solid waste and sewage sludge to produce 45 MW
Renewable energy provided to local government
Stable Cost

System Benefit Charge (SBC) paid by homeowners

Businesses pay SBC as well as tipping fees
Compatible with Recycling

Tonnage of Materials Recycled in Montgomery County
(Fiscal Years 1991-2007)

1995
EfW Facility On-Line

Fiscal Year

528,187 tons recycled in FY07

Montgomery County, MD Division of Solid Waste Services 10/17/07
Montgomery County RRF Energy Sales (FY 2010)

Electricity

$21.4 million

Capacity

- Included in Electricity Price

Renewable Energy Credits

$434,000
Renewed Role For Waste-to-Energy In Sustainable Solid Waste Management: Greenhouse Gases & Air
Europe Finds Clean Fuel in Trash; U.S. Sits Back

By ELISABETH ROSENTHAL

HORSHOLM, Denmark—The lawyers and engineers who dwell in an elegant enclave here are at peace with the bulking neighbor just over the back fence: a vast energy plant that burns thousands of tons of household garbage and industrial waste, round the clock.

Known as waste-to-energy plants, have acquired considerable cachet as communities like Horsholm vie to have them built.

Denmark now has 29 such plants, serving 98 municipalities in a country of 5.5 million people, and 10 more are planned or under construction. Across Europe, there are about 400 plants, with Denmark, Germany and the U.K.’s current landfills topped out and pressures to reduce heat-trapping gases grew. Massachusetts and some other states were “actively considering” new waste-to-energized existing plants; said he expects a place where sets off protest.

The Philadelphia Inquirer
Intergovernmental Panel on Climate Change (IPPC) recognizes WtE as a *key mitigation technology*

World Economic Forum: WtE one of 10 technologies likely to make a significant contribution to a future *low carbon energy system*

Reduces GHG emissions to combat global warming by roughly *1 ton CO$_2$ for every ton of waste processed*

- Prevents generation of methane from landfills (second largest greenhouse gas, 25X more potent than CO$_2$)
- Reduces dependence on fossil fuel power and offsets fossil CO2 emissions
- Recycles tons of metal annually, further preventing GHG emissions
GHG Mitigation: The Details

- CO₂ from the combustion of biomass not counted as an emission
- CO₂ from the combustion of plastics counted as an emission

吨CO₂e/吨MSW

- CO₂ from combustion
  - Fossil CO₂ avoided by EfW power
  - Methane avoided by EfW
  - Net GHG factor

EfW Life Cycle Unit Operations
GHG Reductions: A Different Perspective

- **Waste Transportation & Lost Ferrous Recovery**
- **Landfill Methane**
- **Fossil Electrical Generation**

Net GHG Reduction ≈ 1 tons CO$_2$e / ton MSW
Carbon Offsets: Recognizing the Benefits

WTE Projects

- Voluntary Markets:
  636 tpd capital expansion Lee County EfW Facility in Ft. Myers, FL

- International / Kyoto Protocol:
  Huzhou Nantaihu facility in China approved and registered as CDM project – Sept 2010 (AM00025)
2004 *Science* article by Drs. Pacala and Socolow (Princeton University) introduced the concept of the stabilization triangle

7 gigaton of carbon per year (7 GtC/yr) reduction needed by 2054 versus BAU

Subdivided into 7 manageable wedges of 1 GtC/yr each

Seven wedges together would *stabilize* world-wide greenhouse gas *emissions* at today’s emission rate

1. Efficient vehicles
2. Reduced use of vehicles
3. Efficient buildings
4. Efficient baseload coal plants
5. Gas baseload power for coal baseload power
6. Capture CO$_2$ at baseload power plant
7. Capture CO$_2$ at H$_2$ plant
8. Capture CO$_2$ at coal-to-synfuels plant
9. Nuclear power for coal power
10. Wind power for coal
11. PV power for coal power
Why Isn’t Waste Management Listed?

Source: ETC/RWM.
EEA Briefing, “Better management of municipal waste will reduce greenhouse gas emissions.”
Apply the Waste Hierarchy - Globally

1. **Reduce.** Then what can’t be reduced
2. **Reuse.** Then what can’t be reused
3. **Recycle/Compost.** Then what can’t be recycled or composted
4. **Recover.** Using state-of-the-art combustion processes to generate clean, renewable energy, and then
5. **Dispose.** Of that which has no other use and must be landfilled.
**Projecting the Waste “Wedge”**

**Step 1:** Re-allocate global MSW to match hierarchy

- Recycling: 15%
- EfW: 7%
- Landfill: 79%

**Step 2:** Use Improved technology

- Increase EfW Efficiency
- Expand Landfill CH₄ Collection & LFGTE

- Recycling: 18%
- EfW: 36%
- Landfill: 46%
The Results:

“This analysis demonstrates that if the tonnage of MSW is allocated to recycling, waste to energy and landfilling in descending order in lieu of existing ‘business-as-usual’ practices with each option using modern technology and best practices, the system would reduce greenhouse gas emissions by more than 1 Gt C year–1.”

Waste Management & Research November 2009

Integrated waste management as a climate change stabilization wedge

Brian Stahler, Michael Von Braun
Covanta Energy Corporation, Fairfield, New Jersey, USA

Jeff Stowell
Williams Energy, USA

Katherine Blue
Covanta, Medford, Oregon, USA

Anthropogenic sources of greenhouse gas emissions are known to contribute to global increases in greenhouse gas concentrations and are widely believed to contribute to climate change. A reference carbon dioxide concentration of 355 ppm for 2007 is projected to become a historical high in less than 30 years according to business as usual models. This concentration change is recognized to increase 12 billion tons of carbon per year (12 Tt C year–1). The concept of a stabilization wedge was introduced by Poppa and Swart (Science, 385, 964–972, 2006) to break the 12 Tt C year–1 into manageable 1 Tt C year–1 emissions that would be achievable with current technology. A series of these possible “wedges” were identified, however, an integrated waste syllabus was only carried out for the European Union waste management hierarchy was considered as a wedge. This analysis demonstrates that if the sources of MSW are allocated to recycling, waste to energy and landfilling, in descending order of existing business-as-usual practices with each option using modern technology and best practices, the system would reduce greenhouse gas emissions by more than 1 Gt C year–1. This integrated waste management system reduces CO2 by displacing fossil fuel consumption and avoiding methane emissions from landfills.

Keywords: Climate stabilization wedge, waste to energy, waste management, recycling, greenhouse gas

Introduction

Levels of atmospheric carbon dioxide (CO2) and methane (CH4) were observed at record highs in 2007. Concentrations of 386.1 ppm and 1741 ppb for CO2 and CH4, respectively, were the highest since pre-industrial levels (Keeling et al., 2007). CO2 is the second most important radiative forcing measure (14%) behind CH4 (26%) (IPCC 2001). In doing so, international efforts have been focused on mitigating anthropogenic CO2 emissions, which contribute to 50% of the total CO2 emissions in 2000. 

There is widespread concern that concentrations of greenhouse gases (GHGs) may, at a minimum, be stabilized through a combination of actions, there is a single policy initiative or technology that achieves a larger magnitude of reductions than will be required for climate stabilization. Poppa and Swart (2006) introduced the concept of a stabilization wedge, or a policy effort to stabilize atmospheric CO2. The stabilization wedge can be exemplified in a series of manageable wedges, each driven by a different, economically scalable, technology or policy. Each wedge represents one billion tons of carbon-equivalent per year (12 Tt C year–1) reduction in greenhouse gas emissions by 2020 relative to business as usual (BAU) practices. Several wedges together would stabilize worldwide greenhouse gas emissions at today’s emissions level, roughly 12 Tt C year–1. Additional wedges in subsequent technology would be needed to gradually reduce GHG emissions to a point.
“This analysis demonstrates that if the tonnage of MSW is allocated to recycling, waste to energy and landfilling in descending order in lieu of existing ‘business-as-usual’ practices with each option using modern technology and best practices, the system would reduce greenhouse gas emissions by more than 1 Gt C / yr.” Waste Management & Research November 2009
What if we All did it that way?

The billion tons of greenhouse gases avoided is the equivalent of:

- Closing 1000 large coal-fired power plants
- Building 2 million 1MW wind machines
- Doubling our nuclear power plant capacity
What if the U.S. did it that way?
What if the U.S. did it that way?

Energy Savings - Equivalent Generated Electricity (000 GWh)

- EfW
- Recycle
- Landfill

2004 BAU: 17 GWh
2004 SUS: 291 GWh
2054 BAU: 31 GWh
2054 SUS: 436 GWh

205,000 GWh
317,800 GWh

Operating Scenario
What if the U.S. did it that way?

The greenhouse gas savings is the equivalent of closing ~80 coal-fired power plants.

Energy saved/produced is the equivalent of 10% of our imported oil.
“The performance of the MACT retrofits have been outstanding.”

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>1990 Emissions (tpy)</th>
<th>2005 Emissions (tpy)</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDD/CDF, TEQ basis*</td>
<td>4400</td>
<td>15</td>
<td>99+%</td>
</tr>
<tr>
<td>Mercury</td>
<td>57</td>
<td>2.3</td>
<td>96%</td>
</tr>
<tr>
<td>Cadmium</td>
<td>9.6</td>
<td>0.4</td>
<td>96%</td>
</tr>
<tr>
<td>Lead</td>
<td>170</td>
<td>5.5</td>
<td>97%</td>
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<tr>
<td>Particulate Matter</td>
<td>18,600</td>
<td>780</td>
<td>96%</td>
</tr>
<tr>
<td>HCl</td>
<td>57,400</td>
<td>3,200</td>
<td>94%</td>
</tr>
<tr>
<td>SO₂</td>
<td>38,300</td>
<td>4,600</td>
<td>88%</td>
</tr>
<tr>
<td>NOₓ</td>
<td>64,900</td>
<td>49,500</td>
<td>24%</td>
</tr>
</tbody>
</table>
EPA Study: Life Cycle Emissions from Energy

EfW is far below business as usual practice (landfills) in every category—CO₂, SO₂, NOₓ and PM.

- **CO₂**—EfW better than landfills, coal, oil, and on par with natural gas.

- **SO₂**—EfW better than landfills, coal and oil.

- **NOₓ**—EfW better than landfills, coal and on par with oil and natural gas.

- **PM**—EfW better than landfills, coal and oil.

Is It Better To Burn or Bury Waste for Clean Electricity Generation?, P. Ozge Kaplan, Joseph DeCarolis, and Susan Thorneloe Environ. Sci. Technol. 2009, 43 (6), 1711-1717
WATER

It takes a lot of water to generate electricity!
WATER

It take a lot of water to generate electricity!

A fossil fuel thermoelectric power generation facility will consume between 3,750 to 7,500 G/MWh of electricity generated
How do technologies compare?

<table>
<thead>
<tr>
<th>Power Generation Technology</th>
<th>Efficiency (G/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroelectric</td>
<td>69</td>
</tr>
<tr>
<td>Geothermal</td>
<td>444</td>
</tr>
<tr>
<td>Solar thermal</td>
<td>785</td>
</tr>
<tr>
<td>Fossil fuel thermoelectric</td>
<td>3750</td>
</tr>
<tr>
<td>Nuclear</td>
<td>8190</td>
</tr>
</tbody>
</table>
Major Water Uses

- Cooling
- Air Pollution Control
- Boiler Makeup
- Auxiliary Systems
- Washdown and Dust Control
- Ash Quench and Conditioning
## Waste-to-Energy

<table>
<thead>
<tr>
<th>Power Generation Technology</th>
<th>Efficiency (G/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palm Beach Renewable Energy Facility No. 1</td>
<td>1,215</td>
</tr>
</tbody>
</table>
| Palm Beach Renewable Energy Facility No. 2 | 210  
   Excluding Water Reused From PBRREF No. 1  
   85 |
Water Uses – PBREF No. 1

- Cooling
- Air Pollution
- Boiler Makeup
- Auxiliary Systems
- Washdown/Dust
- Ash Handling
Water Saving Design

- Air Cooled Condenser
- Reuse of Cooling Blowdown from PBREF No. 1
- Reuse of Process Water
- Rainwater Harvesting
- Native Landscaping Plants
Water Uses – PBREF No. 2

- Cooling
- Air Pollution
- Ash Handling
- Washdown/Dust
- Boiler Makeup
- Auxiliary Systems
Water Usage Reduced 82%
Water Sources – PBREF No. 1

- **Ground Water**: 1000 gpm
- **Potable Water**: 136 gpm
Water Sources – PBREF No. 2

- Groundwater: 70 gpm
- PBREF No. 1: 146 gpm
- Rainwater: 21 gpm
- Potable: 1.5 gpm

The Water Division of ARCADIS
Air Cooled Condenser
Rainwater Cistern

Two Million Gallon Capacity Cistern
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