



MÉXICO-ALEMANIA  
DIÁLOGOS POR UN FUTURO SUSTENTABLE | ENERGÍA DE RESIDUOS

# FORO INTERNACIONAL 2015 VALORIZACIÓN ENERGÉTICA DE RESIDUOS URBANOS

Experiencias y estrategias globales

México, D.F. 7 de octubre del 2015

## Energy Recovery from Municipal Solid Waste in the U.S.

John H. Skinner, Ph.D.  
Environmental Consultant, Washington D.C.

MÉXICO  
GOBIERNO DE LA REPÚBLICA



SENER  
SECRETARÍA DE ENERGÍA

SEMARNAT  
SECRETARÍA DE  
MEDIO AMBIENTE  
Y RECURSOS NATURALES



Embajada  
de la República Federal de Alemania  
Ciudad de México



giz  
Deutsche Gesellschaft  
für Internationale  
Zusammenarbeit (GIZ) GmbH

# **Energy Recovery from Municipal Solid Waste in the U.S.**

**International Forum 2015**

**Mexico City**

**October 7-8, 2015**

**John H. Skinner, Ph.D.  
Environmental Consultant  
Washington, DC**

# Outline

- ◆ **Introduction, Definitions**
- ◆ **Waste-to-Energy**
  - ◆ **Number and Types of Facilities**
  - ◆ **Legal Framework**
  - ◆ **Environmental Standards and Benefits**
  - ◆ **Costs and Revenues**
  - ◆ **Public Perceptions**
  - ◆ **Renewable Energy and Climate Considerations**
- ◆ **Landfill Methane Gas Recovery and Use**
- ◆ **Anaerobic Digestion**
- ◆ **Conversion Technologies (e.g. Gasification)**
- ◆ **Obstacles, Elements for Success and Conclusions**

# Definition

- ◆ **Municipal Solid Waste (MSW)** - solid waste from residential and commercial sources and similar wastes from industrial and institutional sources.



# Energy Potential of MSW

- ◆ **1 Ton of Municipal Solid Waste ( 11 million BTUs, with 30 % moisture)**
- ◆ **Is equivalent to:**
  - ◆ 1 barrel of oil
  - ◆ 1/2 ton of coal
  - ◆ 11 DT natural gas
- ◆ **Can produce:**
  - ◆ 5,500 lbs. of steam
  - ◆ 400 to 600 KWH of electricity
  - ◆ 48 gallons of ethanol

# WTE Definition

- ◆ **Controlled Combustion of Solid Waste in Modern Furnaces with State-of-the-Art Emission Controls**
- ◆ **Energy Recovered in the Form of Electricity and Steam**
- ◆ **Recycling of Ash: Ferrous Metals and Some Non Ferrous Metals and Glass**

# Waste-To-Energy in the U.S.

- ◆ 84 facilities operating in 23 states, \$14 billion in assets
- ◆ Process 30 million tons MSW per year, 13% of waste generated in U.S.
- ◆ Produce 14.5 million MWH of electricity
- ◆ Recover 730,000 tons of ferrous metals
- ◆ Several decades successful experience with this technology

# Palm Beach County, Florida

- ◆ **First new WTE facility in 20 years, began operation in July 2015.**
- ◆ **3,000 ton per day facility, services a county with 1.4 million population**
- ◆ **\$672 million construction cost, Aa bond rating**
- ◆ **\$20 million annual operating contract**
- ◆ **96 MW turbine-generator sells power to Florida electric utility under a long term contract**
- ◆ **DBO by B&W Vølund**

# Palm Beach County, Florida



# Palm Beach County, Florida





# Facility Capacity Expansions



**Olmstead County, MN**



**Hillsborough County, FL**



**Lee County, FL**



**Honolulu, HI**

Source GBB

# Legal Framework in the U.S.

- ◆ **The Federal Government (U.S. EPA):**
  - ◆ Minimum environmental standards for major facilities
- ◆ **State Governments:**
  - ◆ Can establish more stringent or more extensive standards
  - ◆ Issue permits and licenses and enforce Federal and State environmental standards.
- ◆ **Local Governments:**
  - ◆ Provide environmentally sound, safe and economical services (along with the private sector)
  - ◆ Comply with Federal and State standards



# **Environmental Benefits of WTE**

- ◆ **Extensive emission controls required by Federal Clean Air Act**
- ◆ **Produces a clean, reliable, renewable source of energy**
- ◆ **Renewable energy displaces fossil fuels**
- ◆ **Recycling of ferrous and non ferrous metals**
- ◆ **Ash tested and is non-toxic, safe for disposal**
- ◆ **Reduces GHG Emissions on a lifecycle basis**

# **Waste-to-Energy Must Meet Federal Air Emission Standards**

- **Standards for Emissions of Metals, Acid Gases, Organics and NO<sub>x</sub>**
- **Standards for Operating Practices and Operator Training**
- **Compliance and Performance Testing**
- **Reporting and Recordkeeping**

# Emission Reductions Achieved Under the Federal Emission Standards

(As reported by U.S. EPA, data from 88 Municipal Waste-to-Energy Combustors)

<b>Pollutant</b>	<b>Uncontrolled Emissions (tons/yr)</b>	<b>Emissions after Application of the Federal Standards (tons/yr)</b>	<b>Percent Reduction</b>
<b>Dioxins and Furans*</b>	<b>4,400</b>	<b>15.0</b>	<b>99+%</b>
<b>Mercury</b>	<b>57</b>	<b>2.3</b>	<b>96%</b>
<b>Cadmium</b>	<b>9.6</b>	<b>0.4</b>	<b>96%</b>
<b>Lead</b>	<b>170</b>	<b>5.5</b>	<b>97%</b>
<b>Particulates</b>	<b>18,600</b>	<b>780</b>	<b>96%</b>
<b>HCl</b>	<b>57,400</b>	<b>3,200</b>	<b>94%</b>
<b>SO<sub>2</sub></b>	<b>38,300</b>	<b>4,600</b>	<b>88%</b>
<b>NO<sub>x</sub></b>	<b>64,900</b>	<b>49,500</b>	<b>24%</b>

\* Dioxin and Furan emissions are in grams per year on a Toxic Equivalent Quantity (TEQ) Basis, all other emissions are in tons/year.

# Ash Management

- ◆ In U.S. bottom ash and fly ash are mixed
- ◆ Collected ash is required to be tested using Federal hazardous waste toxicity test
- ◆ If ash fails toxicity test, it must be disposed of in a regulated hazardous waste landfill
- ◆ If ash passes toxicity test, it can be disposed of in a municipal waste landfill, ash monofill or may be reused
- ◆ Most WTE ash passes the Federal toxicity test, i.e. is not toxic

# WTE Is Renewable Energy

- ◆ **WTE has been defined as Renewable Energy under U.S. Federal legislation and regulations for more than 30 years**
- ◆ **31 States and Territories define WTE as Renewable Energy**
- ◆ **There are Federal Income Tax Credits for the production of electricity from WTE**

# Carbon Offsets in Lee County, Florida

- ◆ **First WTE facility in U.S, to qualify for Carbon Offsets**
- ◆ **In 2010 a new 600 tpd combustion unit was qualified by the Voluntary Carbon Standard to offset greenhouse gas (GHG) emissions.**
- ◆ **GHG reductions came from avoided landfill methane emissions and displacement of electricity produced from fossil fuels.**
- ◆ **Offsets were validated by an independent, accredited verification company**
- ◆ **Lee County's Carbon Credits have been sold carbon exchange markets.**



# Lee County, Florida WTE Facility



# Cost and Revenues

## ◆ Costs

- ◆ Capital cost financed over life of facility (e.g. 25 years)
- ◆ Operating and maintenance costs

## ◆ Revenues

- ◆ Assessment on residences and businesses
- ◆ Energy revenues
- ◆ Recycling revenues
- ◆ Renewable energy and carbon credits
- ◆ Tipping fees



# Public Perception Issues

- ◆ Air emissions
- ◆ Ash toxicity
- ◆ Health effects
- ◆ Costs
- ◆ Compatibility with recycling
- ◆ Land use issues

# **U.S. EPA Conclusions on the Environmental Benefits of WTE**

- ◆ **“Upgrading of the emission control systems to exceed the requirements of the Clean Air Act is an impressive accomplishment.”**
- ◆ **“The performance has been outstanding.”**
- ◆ **“Thus enables us to continue to rely on MSW as a clean reliable, renewable source of energy.”**
- ◆ **“These plants produce electricity with less environmental impact than almost any other source of electricity.”**

Sources: Memoranda from the U.S. EPA Office of Solid Waste, Office of Air Programs and Office of Air Quality Planning and Standards

# **Landfill Gas(LFG)**

## **A Unique Renewable Resource**

- ◆ **LFG is 50 % methane**
- ◆ **Derived from Renewable Resources (Biomass)**
- ◆ **Can be used as boiler fuel, electricity generation, vehicle fuel or fuel cell.**
- ◆ **LFG is designated a renewable fuel under Federal and State laws**
- ◆ **Federal tax incentives provided for energy derived from LFG**

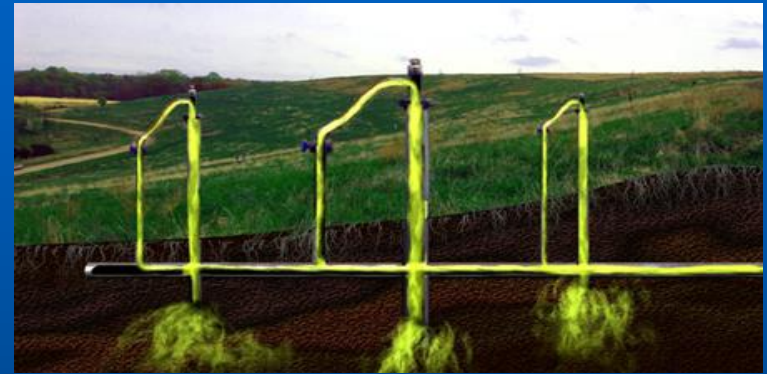
# **Energy from Landfill Gas(LFG) in the U.S.**

- ◆ **Over 645 landfills produce energy from LFG**
- ◆ **73% produce electricity from engine-generators powered by LFG**
- ◆ **27% use LFG as a fuel in boilers and furnaces.**
- ◆ **An additional 400-500 landfills flare the gas**
- ◆ **New LFG uses include:**
  - ◆ **Producing Compressed Natural Gas (CNG) for vehicle fuel**
  - ◆ **Upgrading the LFG for injection into Natural Gas Pipelines**

# LFG Extraction System



**LFG Wellhead**



**Wells and Collection System**



**Blower, Flare and Treatment System**

# Engines Powered by LFG



**Reciprocating  
Engines**

**Gas Turbines**





# Anaerobic Digestion (AD)

- ◆ AD is the decomposition of biodegradable organic wastes in the absence of oxygen
- ◆ AD produces a high methane content Biogas which can be used as a fuel
- ◆ Digestate (solid fraction) can be composted to produce a soil conditioner
- ◆ Can be applied to food, vegetative and contaminated paper wastes (44% of MSW remaining after recycling programs)

# AD-Technological Issues

- ◆ Organic fraction of MSW has a moisture content of 50% to 75%
- ◆ AD of organic MSW requires High Solids Anaerobic Digesters, usually batch fed
- ◆ Source separation or contaminant removal and size reduction may be necessary
- ◆ Organic MSW may be combined with food or beverage processing wastes
- ◆ There are 25 stand-alone, AD facilities processing MSW food and vegetative wastes in the U.S.



# Anaerobic Digestion

## Monterey Regional Waste Management District



4,500 tons per year of food and vegetative waste are converted to 800,000 KWH of electricity and 4,100 tons of compost. Zero Waste Energy Inc.

# Anaerobic Digestion City of San José, CA



270,000 tons per year of commercial food waste and vegetative waste are converted to 13 million KWH of electricity and 30,000 tons of compost. Zero Waste Energy Inc.

# Conversion Technologies

- ◆ **New technologies that convert solid waste into industrial bio-chemicals and fuels**
- ◆ **Gasification, Pyrolysis, Plasma Arc, Hydrolysis,**
- ◆ **Potential for higher value fuels or chemicals**
- ◆ **Most in pilot stage, very few commercial operations**
- ◆ **Several larger scale projects coming into operation in the next few years**



# Edmonton, Alberta Canada



Enerkem Alberta Biofuels

Gasification to Produce Methanol and Ethanol

140,000 tons a year of MSW to produce 10 million gallons of ethanol a year.

# Vero Beach, Indian River County FL



Ineos New Planet Bioenergy Center.

Gasification to Produce Ethanol

- Designed to produce 8 million gallons a year of ethanol from 300 TPD of biomass.
- Currently operating on vegetative waste, MSW in the future.

# Obstacles to Energy Recovery from MSW

- ◆ Lower cost, abundant landfill capacity
- ◆ Low natural gas prices
- ◆ High capital cost
- ◆ Public perception: misconception of environmental impacts
- ◆ Regulatory obstacles
- ◆ Siting difficulties (NIMBY)

# Elements of Successful Programs

- ◆ **Good business plan**
- ◆ **Contracts for waste supply, energy and recycling sales**
- ◆ **Good record of past performance of technology**
- ◆ **Good public participation and education**
- ◆ **Risk sharing: government, owner and operator**
- ◆ **Availability of revenue bond financing**
- ◆ **Landfill restrictions**
- ◆ **Availability of renewable energy and carbon credits**
- ◆ **Political leadership**

# Conclusions

- ◆ **There is significant evidence in the U.S. that demonstrates that Energy Recovery Facilities can provide environmentally sound, cost effective and reliable management of MSW and can provide a significant source of renewable energy.**