Waste-to-Energy and Conversion Technologies in the U.S.

Presented at the
2010 Waste Expo Conference

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GBB Overview

- Headquartered in Fairfax, VA
- Established in 1980 as an objective adviser to governments, institutions, and businesses
- 30 years implementing innovative solutions for waste and recycling industry
- Dedicated exclusively to solid waste management; more focused than broad-based firms
- "Change Agents" to produce better services and facilities

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What is Potential of Waste to Energy

- Potential Outputs of 1 Ton of MSW
  - Power - up to 750 kWh of Electricity produced
  - Metals – up to 50 pounds of recovered ferrous & non-ferrous metals
  - Ash – 10% of the original volume

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Agenda

- Looking back
- WTE and conversion technologies
- What is being implemented and where?
- Summary

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Alternative Technologies in the 1970s and early 1980s

- Andco Torrax Gasifier in Niagara, NY
- Black Clawson Hydropulper in Franklin, OH
- CEA Eco-Fuel in Bridgeport, CT
- Columbus, Ohio RDF Burning Power Plant
- Occidental Petroleum, GarbOil in San Diego, CA
- Monsanto Pyrolysis in Baltimore, MD
- Recovery 1 in New Orleans, LA
- Union Carbide Oxygen Pyrolysis in Charleston, WVA
- RDF for Utility Boilers in St. Louis, MO; Milwaukee, WI; Rochester, NY; and Chicago, IL

Why did these projects fail or stop operating?

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Monsanto Pyrolysis Kiln Baltimore, MD (1,000 TPD)

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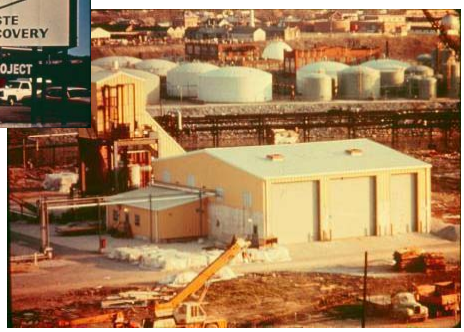
Union Carbide Purox System Charleston, WV (300 TPD)



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NCRR Recovery I Facility New Orleans, LA (750 TPD)

Primary goal was shredding and extensive materials recovery

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RDF Burning in Coal-Fired Utility Boilers

Union Electric Co.
St. Louis, MO

Americology – WEPCO
Milwaukee, WI

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St. Louis facility started with just shredded MSW less ferrous metals as the fuel which became problematic; Milwaukee facility was developed as a complete RDF processing facility w/Americology.

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Today's WTE and Conversion Technologies

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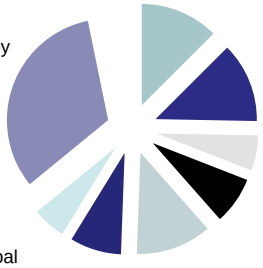
Waste Facts
Source: U.S. EPA 2007

http://www.epa.gov/waste/nonhaz/municipal/pubs/msw07-rpt.pdf

- 254 million tons MSW generated before recycling
- Each person in the U.S. generates approximately 1,686 lbs. per year
  - Estimated 1,752 lbs. per year by 2010
- *What's in our waste?*
  - Recyclables
    - Feasible to recycle 50-70 percent
  - Energy Content of remainder
    - 5,500 BTUs per pound (coal at 9,000 BTUs per pound)



- Food Scraps-12.5%
- Yard Trimmings-12.8%
- Wood-5.6%
- Rubber, Leather & Textiles-7.6%
- Plastics-12.1%
- Metals-8.2%
- Glass-5.3%

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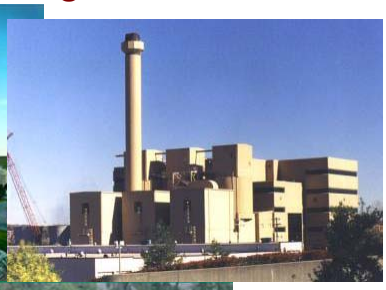
Waste to Energy:
$14 Billion of Productive Assets Servicing the U.S.

North Broward County, FL



Alexandria/Arlington, VA

Springfield, MA

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Revival of WTE in the U.S.

- Since 2004, WTE and waste conversion have regained significant acceptance due to proven environmental performance
- Higher fossil fuel costs makes MSW landfilling more expensive vs. electricity from waste more valuable
- Many state Utility Commissions now require utilities to generate a portion of their power from renewable sources
- EPA included MSW in Renewable Fuel Standard (RFS) as a fuel source
- The EPA now prefers WTE to landfills and fossil fueled electricity because it has a smaller carbon footprint
- The U.S. EPA has changed its position on WTE with the Resource Conservation Challenge initiated in 2004 by including it as a fourth priority after reduction and recycling

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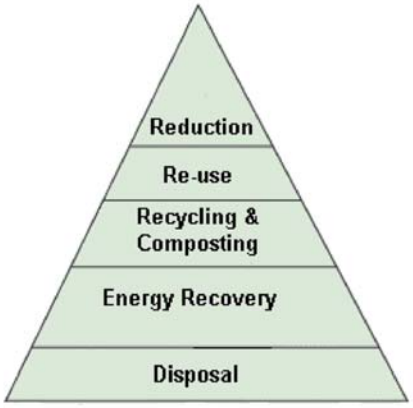
Waste Management Hierarchy



Note: In 2005, EPA designated WTE energy as renewable energy and 35% recycling goal established!

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WTE in the USA

- Energy Recovery Council represents companies and local governments engaged in the waste-to-energy sector
- Base load electric generation capacity of Approx. 2,700 MWs
- Process more than 28 million tons of trash per year

Source: Energy Recovery Council

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U.S. WTE Plants by Technology

Technology	Operating Plants	Daily Design Capacity (TPD)	Annual Capacity (1) (Million Tons)
Mass Burn	64	71,354	22.1
Modular	7	1,342	0.4
RDF - Processing & Combustion	12	15,428	4.8
RDF - Processing Only	2	6,075	1.9
RDF – Coal Combustion	2	4,592	1.4
Total U.S. Plants (2)	87	98,791	30.6
WTE Facilities	83	92,716	28.7

(1) Annual Capacity equals daily tons per day (TPD) of design capacity multiplied by 365 (days/year) multiplied by 85 percent. Eighty-five percent of the design capacity is a typical system guarantee of annual facility throughput.

(2) Total Plants includes RDF Processing facilities that do not generate power on site.

Source: IWSA (now Energy Recovery Council), 2007 Directory

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Air Emissions of Top Three WTE Contenders for WTERT Award in 2006

Emission	WTE-A (mg/Nm³)	WTE-B (mg/Nm³)	WTE-C (mg/Nm³)	Average of 10 Finalists (mg/Nm³)	EU Standard (mg/Nm³)	US EPA Standard (mg/Nm³)
Particulate matter (PM)	0.4	1.8	1	3.1	10	11
Sulphur Dioxide (SO^2)	6.5	7.5	3	2.96	50	63
Nitrogen oxides (NO^x)	80	11	58	112	200	264
Hydrogen chloride (HCl)	3.5	0.5	0.7	8.5	10	29
Carbon Monoxide (CO)	15	7	15	24	50	45
Mercury (Hg)	0.002	0.005	0.002	0.01	0.05	0.06
Total Organic carbon (TOC)	0.5	NA	0.9	1.02	10	n/a
Dioxins (TEQ), ng/m^3	0.002	0.002	0.015	0.02	0.10	0.14

Source: Themelis, N.J. Thermal Treatment Review. Waste Management World, July-August 2007.

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EPA Warm Model Comparison between Recycling Rates with Composting or Waste to Energy

Baseline Description	Alternative	Total GHG Emissions (MTCO2E/day) from:			
		Baseline MSW Generation and Management	Alternative MSW Generation and Management	GHG Emission or Reduction Difference	Barrels of Oil Saved (bbls/day)
Waste landfilled	20% Recycling	110	(310)*	(420)	523
Waste landfilled	50% Recycling	110	(543)	(653)	907
Waste landfilled	50% Recycling and Rest to Composting	110	(597)	(707)	904
Waste landfilled	50% Recycling and Rest to Waste To Energy	110	(661)	(771)	1,047

*Note: numbers in parenthesis are negative showing reductions in CO2 emissions.

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Alternative Conversion Technologies

- Biological
  - Aerobic Composting
  - Anaerobic Digestion/ Codigestion
  - Biodiesel
  - Bioethanol
  - Biological Pretreatment
  - Vermicomposting
- Thermal/Chemical
  - Acid Catalysis & Distillation
  - Direct Combustion
  - Gasification/Pyrolysis
  - Microwave Processes
  - Plasma-Arc
  - Thermal Decomposition
- Processing
  - Fiberboard and Construction Composites
  - Refuse Derived Fuels

Source: Gershman, Brickner & Bratton, Inc., April 2010.

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FED Grants Announced

- GBB is tracking over 180 different "Alternative Technology" companies with various solid waste industry offerings
- In December 2009, 19 alternative technologies received a total of $564 million from DOE for Pilot, Demonstration and Commercial Projects

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ArrowBio Facility Hadera, Israel

- 100,000 tons per year of MSW
- 320 TPD on a 6 days per week basis
- Initial separation of recyclables using water slurry
- 23,000 tons of compost product
- 19,000 tons of residue
- Capital cost $70K +/- per daily installed ton

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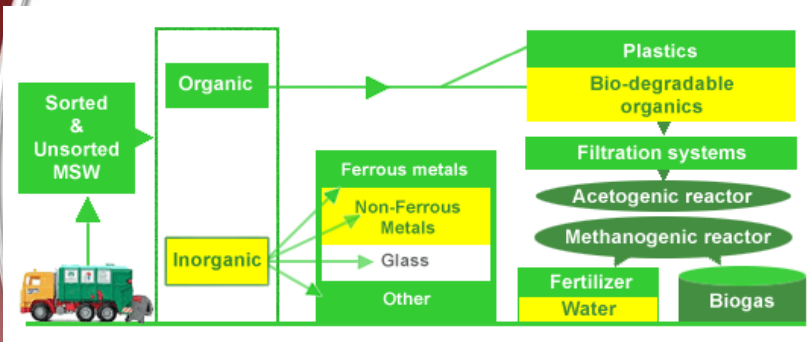
ArrowBio Process Flow



Production facility advancing through startup in Sydney Australia and LA Co. announced in April 2010 that they want to advance an ArrowBio project for a 150 TPD anaerobic digestion process with CR&R Inc.

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Enerkem

- Gasification and conversion to ethanol
- Pilot plant in Westbury, Quebec
- Catalyst conversion system proven and operational
- Feedstock flexibility
- 100,000 TPY demo facility is being build in Edmonton, Alberta (feedstock being prepared by City)

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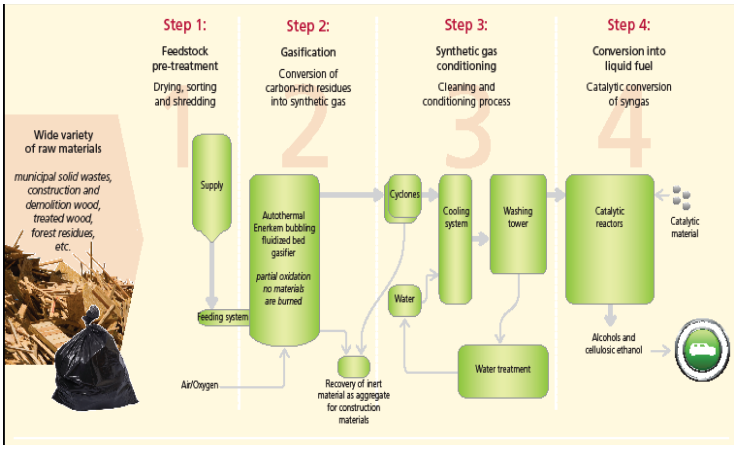
Biofuel from Thermal Gasification Enerkem Technology



In Dec. 2009, awarded DOE bio-refinery grant of $50 million for project in Mississippi (Company putting up $90 million)

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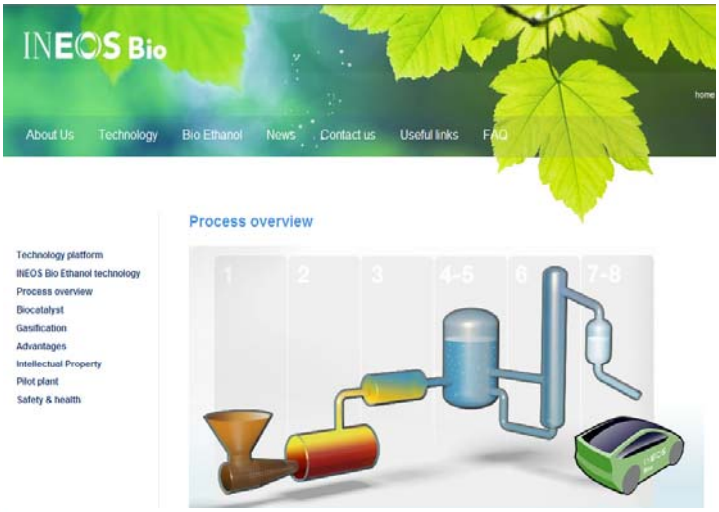
INEOS Bio Waste into Ethanol



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In Dec. 2009, received $50 million DOE grant for project in Vero Beach (Indian River County) – biomass gasification

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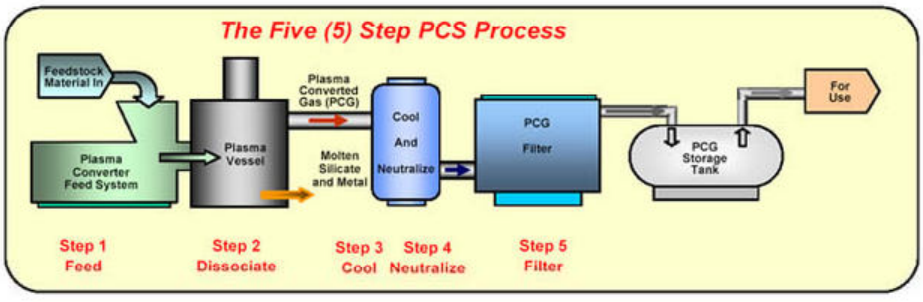
Geoplasma

Jacoby Energy

Plasma Converter System Process



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Generates a SYNGAS that is available for use in power generation. Plasma vessel based on Westinghouse Plasma furnace. Currently permitting a 600 TPD plant in St. Lucie County, FL to generate 22 MW power

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Plasco Energy Group Inc.

- Plasco Energy Group Inc. located in Ottawa, Canada
- Post recycled MSW is shredded for processing in Plasco conversion chamber
- Produces Syngas for electrical generation
- Two operating facilities
  - 100 ton-per-day capacity plant in Ottawa, Canada
  - 5 ton-per-day research and development facility in Castellgali, Spain

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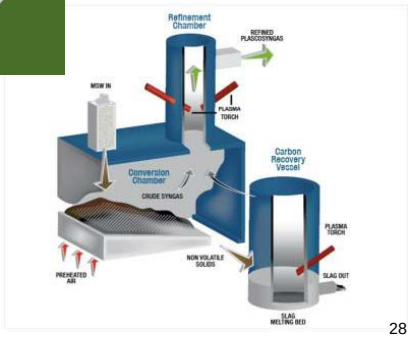
Plasco Energy Group Inc. Conversion System

Note: Plasco Energy recently announced plans to build a plant in China.



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Thermoselect SA - Pyrolysis

- Swiss pyrolysis/gasification technology
- Offered in U.S. by Interstate Waste Technologies, the North American licensee
- Seven facilities with this technology in Japan (with variety of fuels)
- Actively marketing system in U.S.
- Through Caribe Waste Technologies, Inc. (CWT), in final negotiations for a 450,000 tons-per-year facility in Caguas, Puerto Rico

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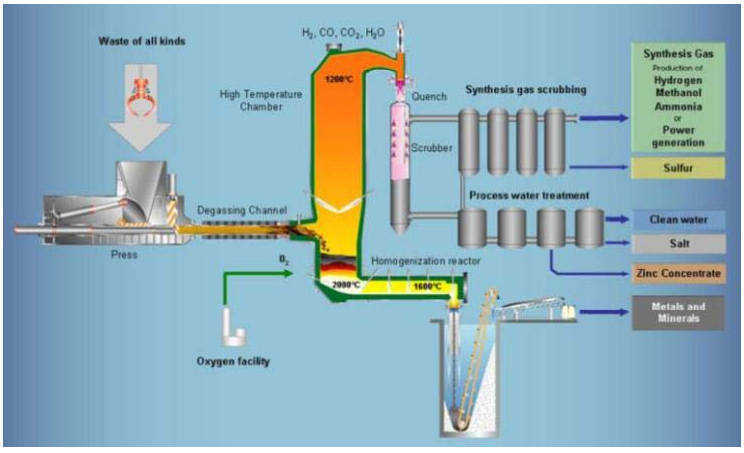
Thermoselect Process Flow



There is no waste preparation or RDF production required.

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Bouldin Corp. "WastAway" Process

- Process MSW into RDF; then steam heated and hydrolyzed to make RDF into a "Fluff" product
- Multi-year demonstration operation in McMinnville, TN (two - 2 TPH lines)
- New 2-line commercial plant in Aruba; operational since July 2009
- Selected by developer for two 200-TPD plants on USVI (Fluff into fuel pellets for firing in fluidized bed boilers)

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International Environmental Solutions

- Currently, there are no full-scale pyrolysis systems in commercial operation on MSW in the United States.
- A pilot demonstration system has been operating in southern California for two years, built and operated by International Environmental Solutions of Romoland, CA

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Issues to consider in Technology Development

- Performance history and size
- Scaling uncertainties
- Environmental impacts
- Siting and permitting needs
- Cost uncertainties and their $ coverage
- Product market uncertainties
- Process guarantees
- Financial resources of developer/guarantor
- Community acceptance (work with community; don't surprise them!)
- Other risks and unknowns

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Technologies and Risk

Source: GBB, April 2010

Alternative	Risks/Liability	Risk Summary
Mass Burn/WaterWall	Proven commercial technology	Very Low
Mass Burn/Modular	Proven commercial technology	Low
RDF/ Dedicated Boiler	Proven commercial technology	Low
RDF/Fluid Bed	Proven technology; limited U.S commercial experience	Moderate
Pyrolysis	Previous failures at scale, uncertain commercial potential; no operating experience with large scale operations	High
Gasification	Limited operating experience at only small scale; subject to scale-up issues	High
Anaerobic Digestion	Limited operating experience at small scale; subject to scale-up issues	High
Mixed-Waste Composting	Previous large failures; No large-scale commercially viable plants in operation; subject to scale-up issues	Moderate to high
Chemical Decomposition	Technology under development; not a commercial option at this time	High

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Recent Planning and Procurement Activities with Waste Processing Technologies in the U.S

- Locations with Planning/Procurements:
  - New York, NY; City of Los Angeles, CA; Los Angeles County, CA; St. Lucie County, FL; Hawaii County, HI; Frederick and Carroll Counties, MD (NMWDA); Harford County, MD (NMWDA); City of Sacramento, CA; Tallahassee, FL; Broward County, FL; Palm Beach County, FL; Taunton, MA; Santa Barbara, CA; San Bernardino County, CA
  - 80 different companies responded

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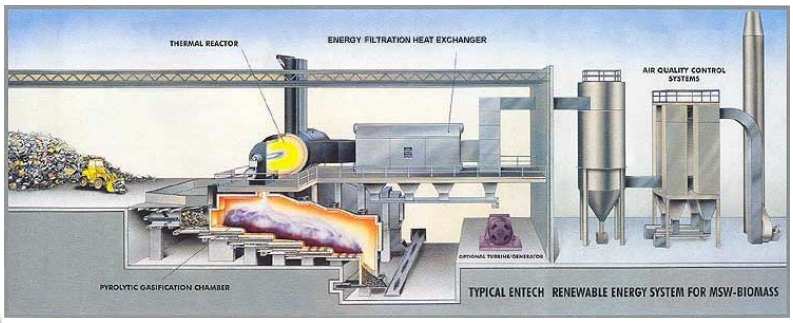
Entech Typical Arrangement Advanced Conversion Technology



Final negotiations in progress for a contract agreement with the County of LA for facility to be located on Rainbow Disposal, Nichols Street materials recovery facility in Huntington Beach, CA.

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RDF Facilities in the United States

Facility	Location	Thruput (TPD)	1st Year of Operation	Operating Entity
Ames Municipal Electric Utility	Ames, IA	175	1975	Ames Municipal Electric System
Elk River Resource Recovery Facility	Elk River, MN	1,300	1989	Resource Recovery Technologies (RRT)
French Island Station	La Crosse, WI	502	1987	Xcel Energy
Greater Detroit Resource Recovery Facility	Detroit, MI	2,832	1991	Michigan Waste Energy, Inc. (Covanta)
Honolulu Resource Recovery Venture – HPOWER	Honolulu, HI	1,851	1990	Covanta Honolulu Resource Recovery Venture
Maine Energy Recovery Company	Biddeford, ME	600	1987	KTI Operations (Casella)
Miami-Dade County Resource Recovery Facility	Miami, FL	2,592	1979	Montenay Power Corporation; acquired recently by Covanta
Mid-Connecticut Resource Recovery Facility	Hartford, CT	2,000	1987	Covanta Mid-Conn, Inc.
Newport Resource Recovery Facility	Newport, MN	1,360	1988	Resource Recovery Technologies (RRT)
North County Resource Recovery	West Palm Beach, FL	1,800	1989	Babcock & Wilcox
Penobscot Energy Recovery Corp.	Orrington, ME	1,500	1988	ESOCO Orrington LLC
SEMASS Resource Recovery Facility	West Wareham, MA	2,700	1989	Covanta SEMASS, L.P.
Southeastern Public Service Authority (SPSA)	Portsmouth, VA	2,000	1982	SPSA; being sold to Wheelabrator

Source: Energy Recovery Council (www.energyrecoverycouncil.org)

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Future of RDF…Reasons for Increased Demand

- Most, but not all, conversion technologies require MSW pre-processing
- Electric utilities required to have 20 percent of demand met through renewable energy and efficiency measures by 2020
- Electric utilities that burn coal could be retrofitted for RDF
  - 10 percent of the coal used equates to 225 millions tons RDF per year

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Summary Points

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The Road to Discovery and Implementation

- Proper solid waste management planning
- Enlightened elected officials and purchasing agents (armed w/realistic data)
- Staff resources
- Public education
- Incremental decision-making as part of plan
- Project management & operations capability a must!

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Summary Points

- Make sure significant recycling is supported; can't assume that project replaces recycling
- A public/private ownership structure will help assure feedstock control and revenue sources
- Know the feedstock preparation requirements and characteristics
- Be aware of competition for the same material
- Know the local disposal market and options for local communities
- Need to prove conversion technologies; some risk must be assumed by someone
- Know the current political climate of the community
- Be aware of the Not In My Backyard (NIMBY) groups

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Germany…An Example of Zero Waste

- In 1993, placed restrictions on landfilling
  - MSW pre-treatment requirement by May 2005
  - "Treated" MSW allowed in landfills but needed to be essentially inert
  - Inert residues processed for recycling
  - Thermal treatment required with combined heat and power (CHP)
- In 2006, results were:
  - 68% recycling/composting
  - 32% WTE
  - 0.7% landfilling
- Landfill disposal tax $

Source: Dr.-Ing. Helmut Schurer, Former Deputy Director General for Waste Management, German Federal Ministry for the Environment

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