Solid Waste Forum

Emerging Solid Waste Technology

Presented at the
Carroll County, MD Solid Waste Forum

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By
John G. Carlton, P.E., BCEE
Vice President
Gershman, Brickner & Bratton, Inc.
www.gbbinc.com

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Outline

- Introduction
- Emerging Solid Waste Technologies
- Review of Selected Waste Conversion Technology companies and their projects
- Summary and Trends for Future
- Q&A

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Introduction

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Intro - 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 and focused exclusively to solid waste management
- Owner's representative and feasibility reports for financings
- "Change Agents" to produce better services and facilities

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GBB Recent Waste Conversion Technologies and Renewable Energy

- Reviews addressing economic feasibility, technology effectiveness, environmental issues, and procurements for retrofits or new facilities:
  - County of Maui, HI
  - Orange County, NC
  - Rhode Island Resource Recovery Corporation
  - Marion County, OR
  - City of Annapolis, MD
  - Solid Waste Authority of Palm Beach County, FL
  - City of Allentown, PA
  - New Hanover County, NC
  - Prince William County, VA
  - City of Plano, TX
- Due diligence reviews and business planning for private companies considering purchasing technologies or investing in projects
- Waste characterization and sourcing; processing conceptual design and cost estimating
- Independent feasibility consultant

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Waste Conversion Technologies ...Today and Tomorrow

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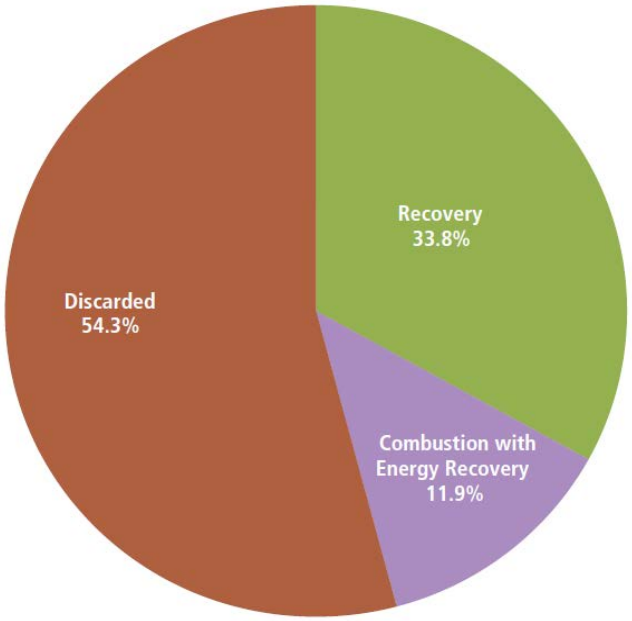
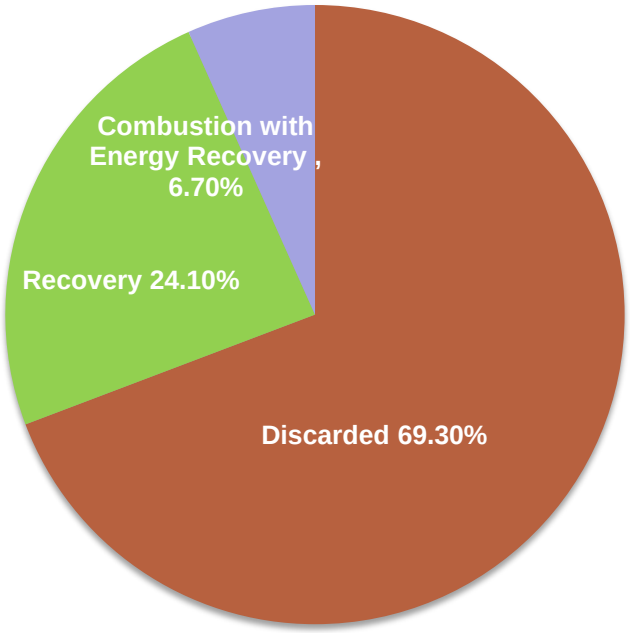
MSW Disposal in America



EPA 2009 Estimate:
243 million tons



Biocycle 2008 Estimate:
389 million tons

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1 Ton of MSW

- Has 11 million BTU's
- Equivalent to:
  - 1 barrel of oil
  - ½ ton of coal
  - 11 Deca-therms of natural gas [a]
- Can make:
  - 5,500 lbs. of steam
  - 400 to 1,000 KWHrs of electricity
  - 80-90 gallons of ethanol

Note: a – 1 "*Deca-therm*" = 10 therms or 1million Btu's

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592 (and counting) Companies Offering Technology and/or Development Services

- 31 Aerobic Composting
- 110 Anaerobic Digestion
- 36 Ethanol Fermentation
- 175 Gasification
- 47 Plasma Gasification
- 52 Pyrolysis
- 63 WTE: mass burn, modular, dedicated boilers, and RDF
- 78 Others (agglomeration, autoclave, de-polymerization, thermal cracking, steam reforming, hydrolysis)

Source: Gershman, Brickner & Bratton, Inc., September 2011

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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 and/or guarantor
- Community acceptance
- Other risks and unknowns

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143 Conversion Companies Operating either Commercial or Demonstration facilities with MSW

- 64 Anaerobic Digestion
- 47 Gasification
- 13 Plasma Gasification
- 19 Pyrolysis

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Some U.S. Locations Investigating/Advancing Waste Conversion Technologies

- Ada County, ID
- Baton Rouge, LA
- City of Allentown, PA
- City of Dallas, TX
- City of Glendale, CA
- City of Plano, TX
- City of San Antonio, TX
- City of Taunton, MA
- Columbia, SC
- Fulton, MS
- Prince William County, VA
- Gallatin County, KY
- Lake County, IN
- Los Angeles County, CA
- Mason City, IO
- Salinas Valley, CA
- San Bernardino County, CA
- Santa Barbara County, CA

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Selected Waste Conversion Technology Companies and Projects

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Entec Biogas USA

- Successfully designed, constructed, and commissioned more than 120 full scale biogas projects worldwide
  - Built the first MSW/food waste digesters in Japan and France
  - Currently in final design process for world's largest biogas plant for cow manure in El Paso, Texas
- Specializes in the anaerobic treatment of manure, food residues, municipal sludge, waste water from the food industry, and energy crops.

Malchin, Germany
500,000 MT/yr food waste→ 2 MW

- Offers five different Anaerobic Digester systems
  - Optimized process and highest biogas production yield for each application and project scale
- Options for product treatment include
  - Gas upgrading to natural gas quality and injection into pipeline
  - Solid – liquid separation for the digestate to produce a solid fertilizer for transport and a liquid used for fertilizer
  - Drying and pelletizing of the solid fraction to use as bio-fuel.

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Harvest Power

- Advanced aerobic composting
  - Produces high quality compost
- Anaerobic digestion and gasification
  - For food and yard waste for power and heat
  - Produces biogas with 15-20% higher methane content than comparable single-stage system
- Founded in 2008; $150 million capitalization
- Acquired 100% of Coastal Supply Company, Inc, a Delaware-based soil and mulch manufacturer in September 2011
- Have facilities currently processing over 560,000 TPY of organic waste in PA, BC, and CA
- Facilities in development:
  - London, Ontario (under construction) – 65,000 TPY anaerobic digester to produce 22,000 kWh of energy and 4,000 tons of fertilizer annually
  - Vancouver- partnership with GICON Bioenergie GmbH to construct digestion facility

Fraser Richmond Soil & Fibre Richmond, BC

Harvest Bioenergy Centre London, Ontario

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ALTERNRG

- Plasma gasification technology developed in partnership with Westinghouse Plasma Corp.
- Produces clean syngas from a wide variety of feedstocks, including auto shredder residue, plastics, biomass, wood waste
  - Generates a SYNGAS for power generation or further conversion to ethanol
  - 80% of energy input converted to syngas
  - Plasma torches use 2%-5% of energy input
- 48 ton per day commercial demonstration facility in Madison, PA
- Commercially installed in facilities in Japan, Canada, India, and the U.S.
- Facilities under development 11 countries through partnerships with Coskata, SMSIL, and NRG Energy

AlterNRG gasifier

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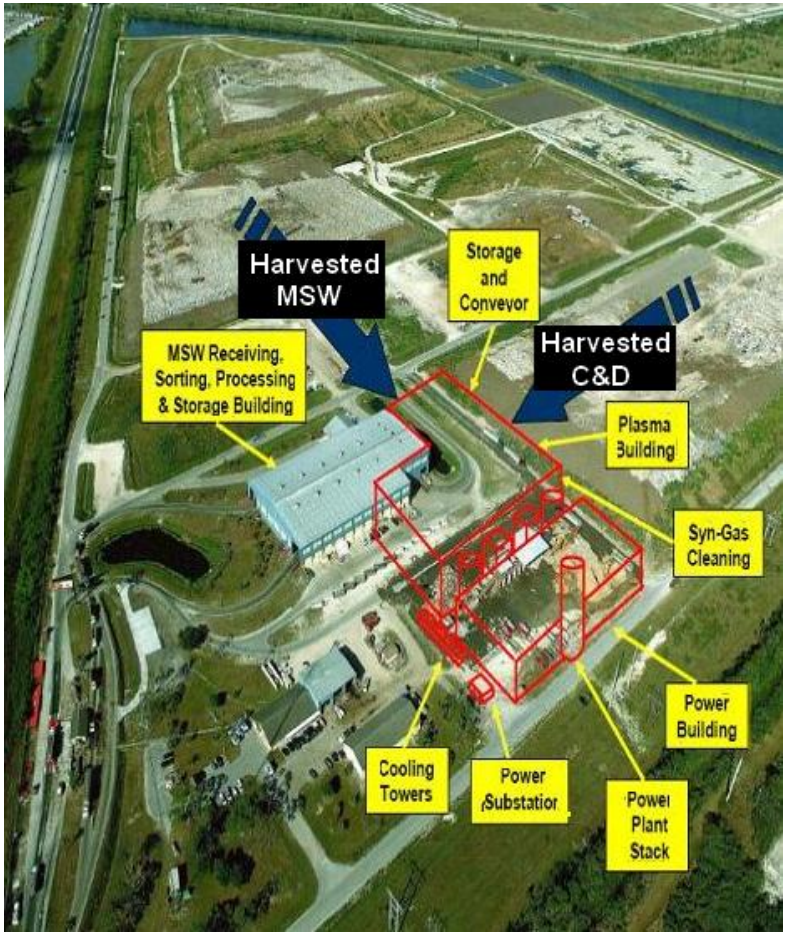
GeoPlasma St. Lucie LLC Renewable Waste-to-Energy Project

- Feedstock (Tons Per Day) : 525 MSW and 75 tires
- Capital cost: $125 million
- 9-acre site at County Landfill
- Energy output type(s): approx. 20 megawatts power and steam offload to Tropicana Products
- Owner: GeoPlasma, Atlanta, GA / Energy Resources Group
- Financing method: Private
- Construction Start: Supposed to be end of the year, 2011, subject to permits and financing
- Florida DEP Air Construction Permit obtained September 2010
- Operations Start: Mid 2013



Source: GeoPlasma-St. Lucie, LLC and Energy Resources Group, May 2010

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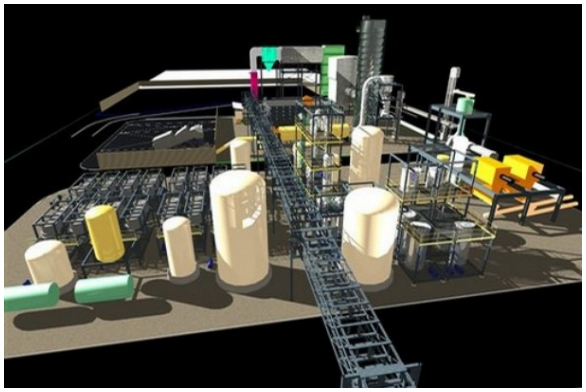
BlueFire Ethanol

- Concentrated Acid Hydrolysis Technology Process converts cellulosic waste materials to ethanol, and other viable alternatives to petroleum derived fuels
- Have demonstrated production of ethanol and other petroleum displacing fuels from post-recycled MSW, rice and wheat straws, wood waste and other agricultural residues



Fulton, MS site prepared for construction, June 2011

- Lancaster, CA – 3.7 million gallon per year facility will use post-sorted MSW from landfills around the Los Angeles area. Anticipated start time is TBD
- Mecca, CA –17 million gallon per year facility will use post-sorted MSW and wood waste from all over southern California. Anticipated start time is TBD
- Fulton, MS – 19 million gallon per year facility will use woody biomass and mill wastes from Cooper Marine & Timberlands. BlueFire has received $88 million in DOE funding and has secured 15-year offtake agreements for products.

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Chinook Energy, LLC

- Developer of energy plants utilizing Chinook Sciences' gasification and metals recycling technologies
- The RODECS ®, Chinook's patented gasification technology
  - World's only Industrial universal gasification system, can process universally any type of waste material without the need for extensive pre-processing
  - Transforms organic based material in waste stream into useful energy (steam, electricity, etc.), and/or useful clean fuel (like Methanol, Ethanol, Synthetic Diesel, Hydrogen, etc.)
  - Currently being used in nine countries in four continents

Two metals recycling and conversion to fuel projects under development in Europe and expect operations to commence at those facilities in 2011.

Environmental Solutions UK Ltd. - **120,000 metric TPY** of automobile shredder residue processed to generate approximately **30 MW** of renewable electricity, enough to power 21,000 homes

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Enerkem

- Gasification and conversion to syngas, methanol, ethanol
- Feedstocks include municipal solid waste, wood chips, treated wood, sludge, petcoke, spent plastics and wheat straw
- Operates 2 plants in Quebec, Canada
  - Commercial demonstration facility in Westbury, operational since 2009, producing 1.3 million gallons/year
  - Pilot plant in Sherbrooke, operational since 2003, used to test over 25 different solid, slurried, and liquid feedstocks
- Full-scale commercial facilities currently under construction in Edmonton, Alberta and Pontotoc, Mississippi
  - will produce methanol and cellulosic ethanol.

Enerkem's Westbury facility

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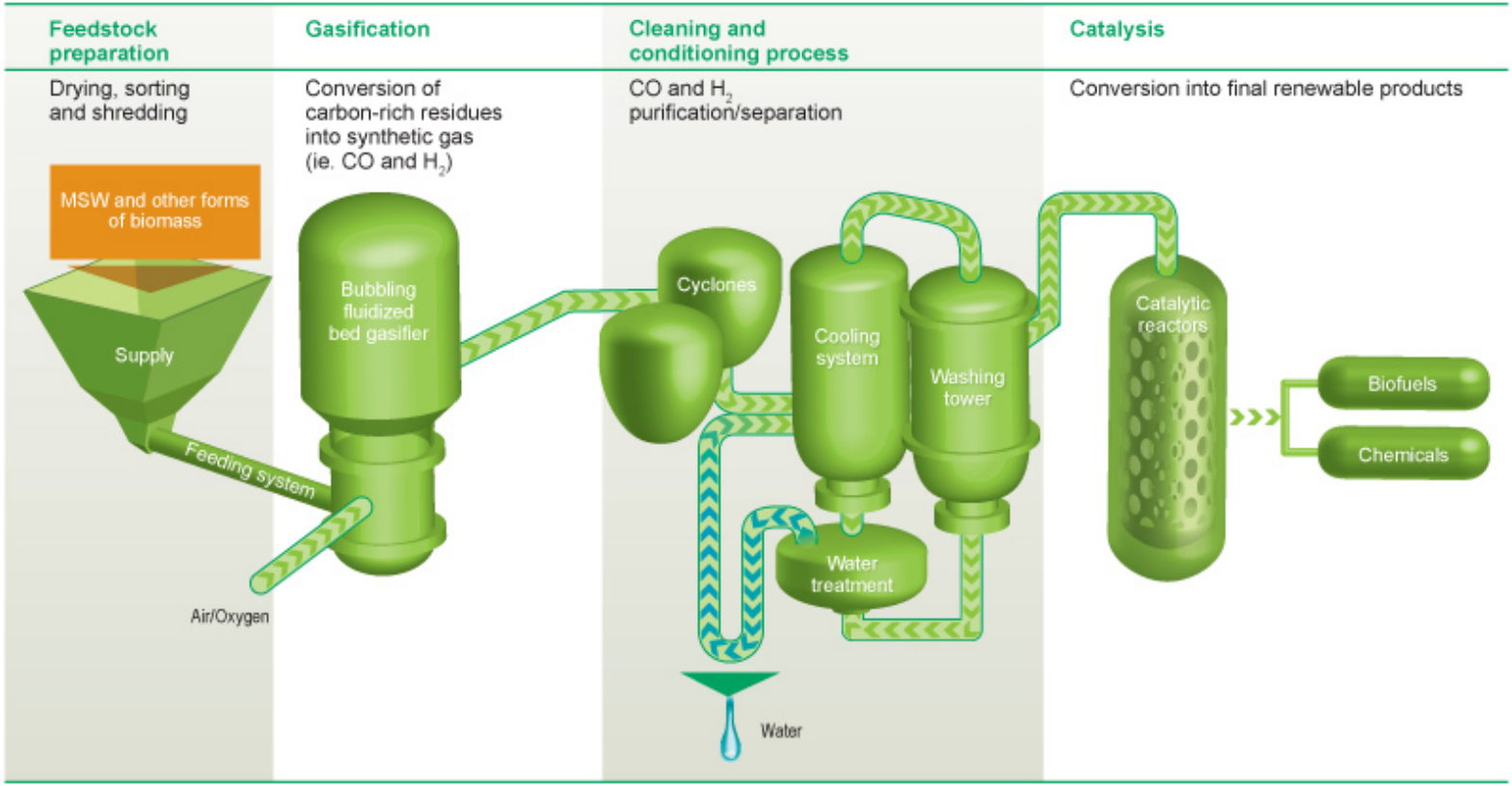
Enerkem Process



- Catalysis produces methanol, which can be sold as-is, converted to ethanol, or used as a chemical building block for the production of secondary chemicals, such as acrylic acid, n-Propanol, and n-Butanol

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Enerkem Facilities

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Pontotoc, Mississippi

- **Feedstock :** Sorted MSW and wood residues
  - 660 TPD to 330 TPD RDF for feedstock
- **Total Capacity :** 10 M gallons/year
- **Products:** syngas, methanol, ethanol
- **Start date:** 2012, Currently in permitting cycle
- In partnership with Three Rivers Solid Waste Management Authority
- Will help recycle and convert 60% of the waste crossing the area's landfill gate
- Awarded $50M funding from U.S. DOE Bio-Refinery Assistance Program, total $130 million in financial support from the U.S. Department of Agriculture and DOE

Edmonton, Alberta

- **Feedstock :** Sorted MSW
  - 660 TPD to 330 TPD RDF for feedstock
- **Total Capacity :** 10 M gallons/year
- **Products:** syngas, methanol, ethanol
- **Start date:** 2012
- **Approval:** Environmental permit granted
- Secured offtake agreement for sale of methanol produced with Methanex in September 2011

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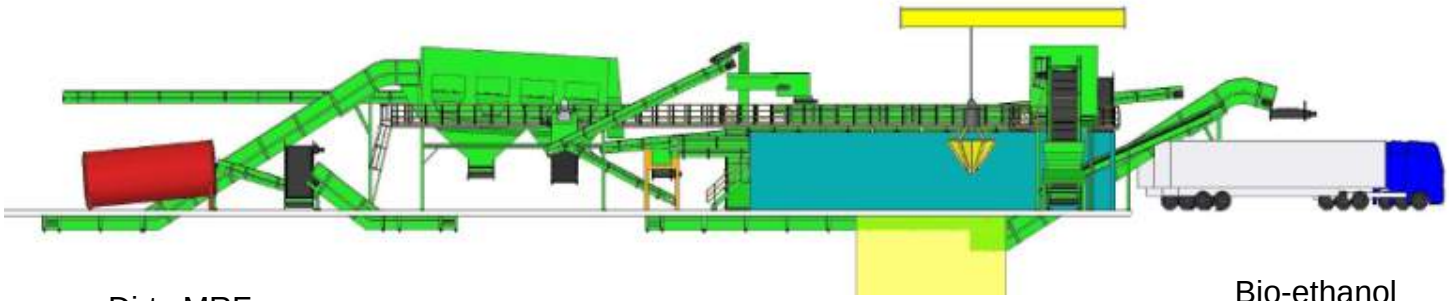
Fiberight

- Targeted Fuel Extraction (TFE) process cost effectively transforms MSW:
  - Dirty MRF separates, cleans and processes organic and hydrocarbon fractions
  - Converts organic fraction into cellulosic biofuel through hydrolysis, fermentation, and anaerobic digestion
  - Converts hydrocarbon fraction into plant energy and electricity
  - Utilizes byproducts for beneficial sale or energy production
- Cellulosic pulp can produce **90 gallons of ethanol per ton**
- End-to-end process operates on a 100% MSW input, robust system has been tested at scale



Dirty MRF

Hydrolysis, Fermentation, Distillation

Bio-ethanol

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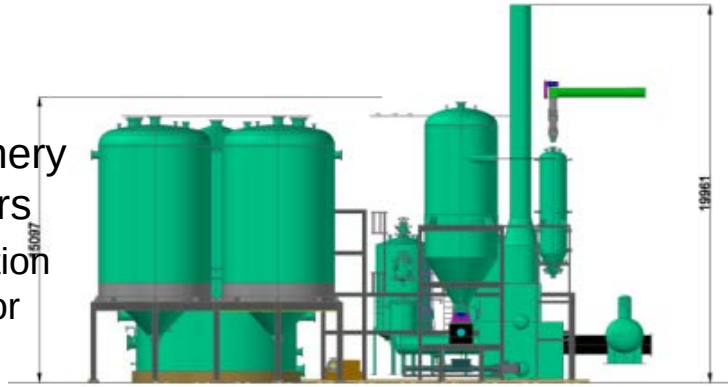
Fiberight (cont'd)

- Attained high yield conversion factors in 2009 at Lawrenceville, VA pilot plant
  - Developed robust enzyme catalysts and enzyme recycle process in partnership with Novozymes
- Commenced production at Blairstown, Iowa plant, converted from corn ethanol plant into cellulosic ethanol plant in May 2010
  - Plant will be scaled to full commercial production capacity of 6 million gallons in 2012 with first production in 2011.
- Has site control for first commercial-scale biofuel plant in Elkridge, MD
- In 20-year partnership with TMO Renewables, UK, to build fifteen bio-refinery plants across the US in the next five years
  - Utilizing Fiberight digestion and fractionation process to produce "clean fiber" stream for TMO's bacterial fermentation process to produce ethanol

Fiberight High-Solids Pulping



TMO Blairstown, Iowa Layout

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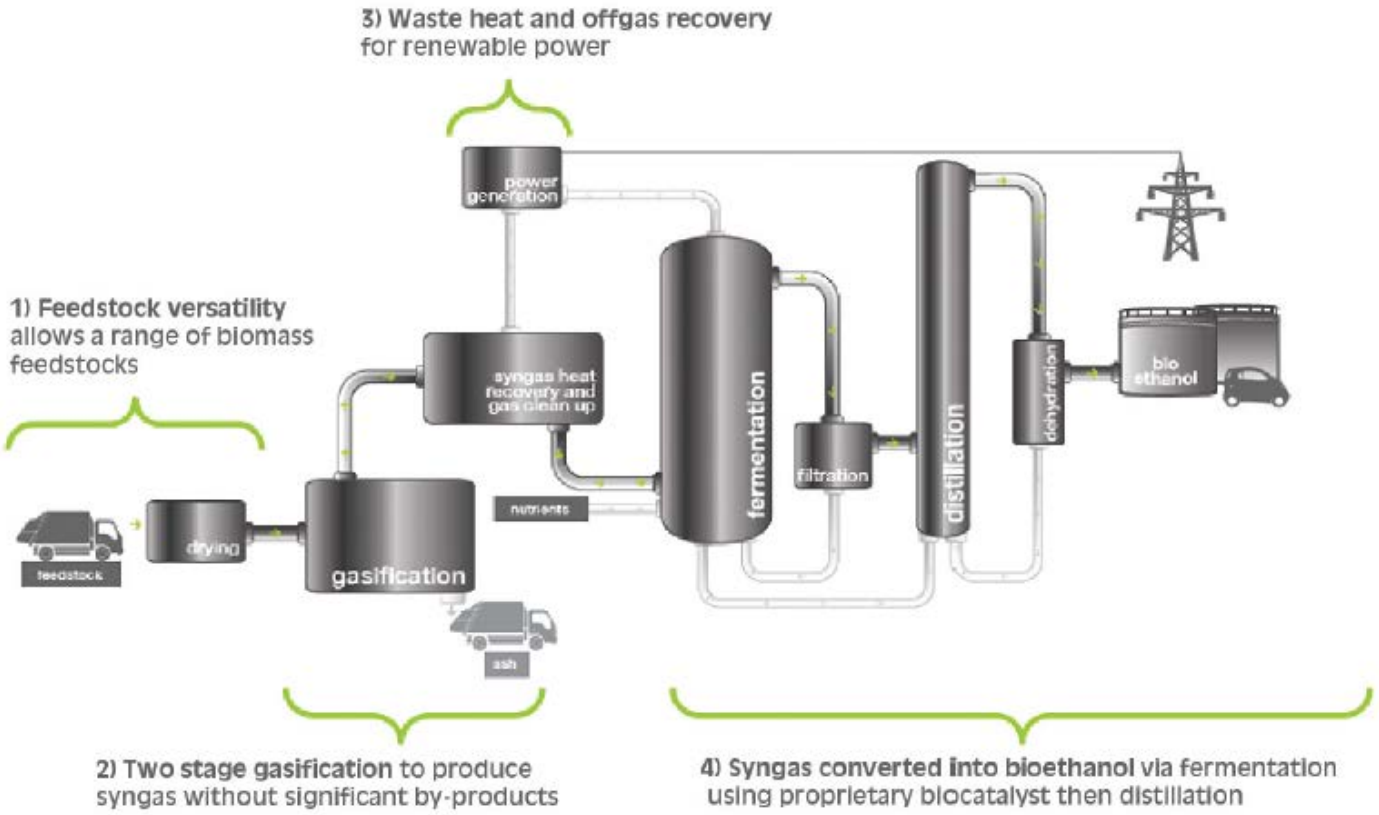
INEOS Bio



Feed Handling → Gasification → Fermentation → Ethanol Purification

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INEOS New Planet Bio Energy Indian River County, FL

Pilot facility in Fayetteville, AR

- Facility to be constructed in Vero Beach, Indian River County, FL as a joint venture with NPE Florida
- Will process150,000 tons annually of waste materials from landfills to produce **8 million gallons of fuel-grade ethanol and 6 megawatts (gross) of electric power**
- **80-100 gallons of ethanol produced per dry ton of waste**
- Received and closed on DOE grant and $75M in USDA backed private financing, Total project investment will be more than $130M
- Project ground breaking was Feb. 2011; construction to be complete w/operations in April 2012
- Will create an estimated 380 direct and indirect jobs (including 175 construction jobs) over the next two years, and 50 full time jobs once the BioEnergy Center becomes operational

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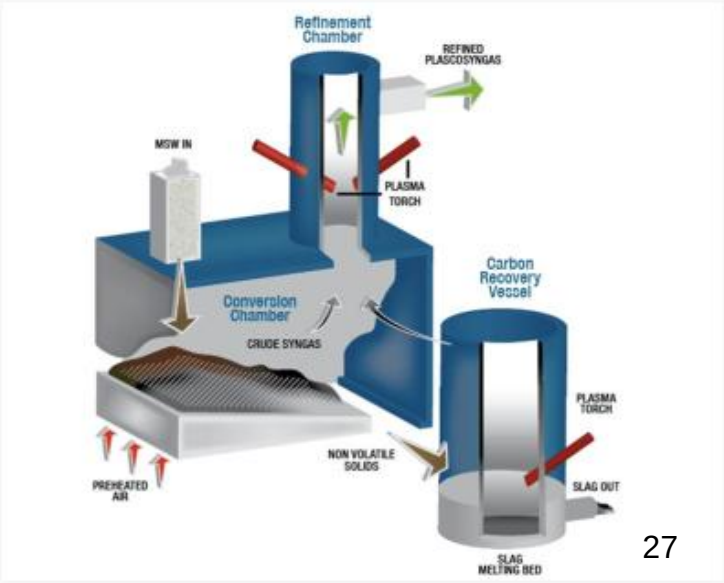
PlascoEnergy GROUP

- Shreds/processes MSW for introduction into conversion chamber
- Produces syngas (for electrical generation), recyclable slag, water, and recovered metals through gasification
- Uses plasma torches to refine the syngas produced
  - Limited use of torches = reduced electricity demand
- 94 ton-per-day capacity, 4MW commercial-scale Train Road facility in Ottawa, Canada
  - Partnership since 2006 with the City of Ottawa, facility has a small footprint (3 acres) and was built on existing landfill space
- Selected by the Salinas Valley Solid Waste Authority (CA) as a viable technology for planned Resource Management Park, Environmental Impact Study currently underway
- Shortlisted in Santa Barbara, CA

Plasco Trail Road



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Taylor Biomass Energy LLC
Town of Montgomery, NY

- Expands the Taylor Sorting and Separating Process to accept mixed solid waste, in addition to wood waste, and waste from construction and demolition debris (“C&D”) as inputs
- Converts the organic biomass portion of mixed solid waste to electric power, through gasification; 20 MW power
- Location: 95-acre site in Montgomery, Orange County, NY
- Plans to expand from 307 TPD of C&D waste and 100 TPD of wood waste to 450 TPD of C&D waste, 100 TPD of wood waste, and 500 TPD of MSW
- Construction started in January 2011, completion expected by early 2012
- $145 million construction cost - financed by $100 million in U.S. DOE grants, $20 million in private investment, and tax credits

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Thermoselect SA - Pyrolysis

Chiba, Japan facility

- Applied gasification technology to MSW beginning in 1985
- Combined four proven technologies - compaction, pyrolysis, gasification and gas cleaning
- No waste preparation or RDF production required
- Can process a variety of feedstocks
  - Between 3,500 and 8,000 Btu/lb (HHV)
- Actively marketing system in U.S. - Qualified for a project with Los Angeles County, CA and Puerto Rico
- Has operated successfully in nine facilities, the first beginning in 1992 as a 110 tpd Demonstration Facility in Fondotoce, Italy
- Offered in U.S. by Interstate Waste Technologies, the North American licensee

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City of Taunton, MA
Solid Waste Management Facility

- Awarded through public procurement for non-mass burn incineration technologies
- Design capacity: 1,770 tons per day
- Guaranteed availability: 85.6% or 552,750 tpy
- Construction cost: estimate: $420 million
- Annual Operating costs: $55 million
- Estimated Start-up date: Late 2013
- Output (current): Gasification process with Syngas to methanol and then into Gasoline
- Est. of Net Service Fee: Approximately $50 per ton
- Owner is IWT Taunton Renewable Energy LLC.
- Financing: debt and equity; to apply for loan under DOE Loan Guarantee Program
- **Notified that this technical process (the 4th considered) is now within the MA ban on MSW combustion.**

IWT
INTERSTATE WASTE TECHNOLOGIES

Source: Multiple sources including Interstate Waste Technologies, May 2010

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San Jose, CA

new contract to boost recycling

San Jose signs new contract to boost recycling

- The City of San Jose selected Zero Waste Energy Development for a 15 year contract to process all of the City's commercial organics under a new city-wide, collection system
- Technology: dry fermentation anaerobic digestion
- Objective to bring the commercial recycling rate to 80 percent by 2014 from current level of 22 percent
- Will be processing over 270,000 tons per year of waste that would otherwise be disposed in a landfill
- High quality compost and biogas will be produced
- Site development has started with operations planned to begin in in July, 2012

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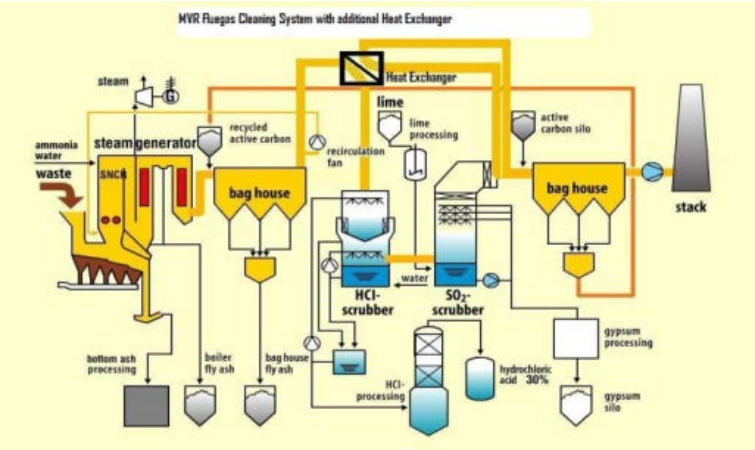
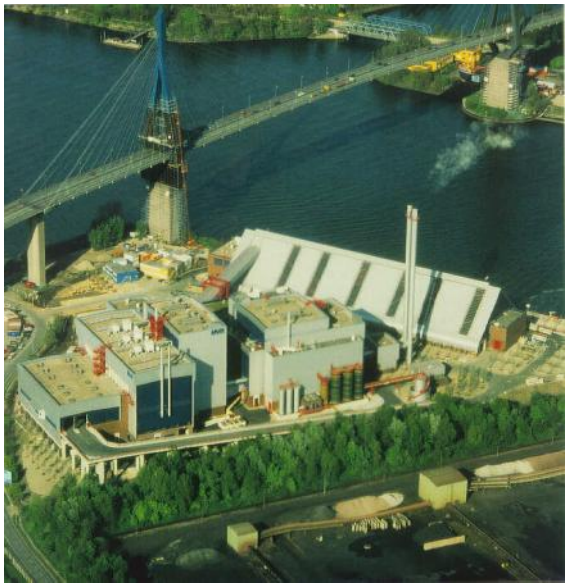
City of Los Angeles, CA – Green Conversion Systems

- 1,100 TPD post-recycled residential waste
- “Advanced Thermal Recycling”
- MRF recycling @ 29%
- Conversion Technology by Fisia Babcock Environment GmbH (formerly Steinmueller)
- Reference facility: Hamburg, Germany
- Air emissions to be well below permit limits and real time air emission readings to be public
- Emphasis on aesthetics
- Ash processed for aggregates
- Landfill diversion rate @ **99%**





Source: http://www.ecoling.ch/englisch/refmva_eng1.htm

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Summary Points

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Technologies and Risk

Source: Gershman, Brickner & Bratton, Inc. September 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	Moderate
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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Opinion: Trends for the Future

- Many conversion projects advancing
- Will need 4-6 years to learn what works and their economics
- Continuation of public sector taking “Low Risk” attitude until “proven”
- Demand for more recyclables expected to continue at attractive pricing
- More mixed waste processing systems [again]
  - Many conversion technologies require MSW pre-processing... for feedstock sizing and inerts removal
  - Electric utilities may become a player for RDF
- ‘Environmentalists’ and ‘Zero Waste’ proponents will continue to fight WTE and Waste Conversion Technologies calling them all “incineration”

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A Realistic & Ultimate Goal:

Fully Integrated and Efficient Waste Management System with Significant Diversion (Recycling) and WTE-WCT

…in a 50-50 partnership!

…for more jobs, better environment, and energy independence!

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Thank you!

John Carlton

jcarlton@gbbinc.com

908-319-5992 cell
703-573-5800 office
800-573-5801 office
703-698-1306 fax

www.gbbinc.com

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