WASTE TO BIO: ENERGY, FUELS, GAS & CHEMICALS

Renewable Energy from Waste Technologies Update

Harvey W. Gershman
President
Gershman, Brickner & Bratton, Inc.

Presented at the Waste to BioEnergy Summit
July 10, 2014

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WASTE TO BIO: ENERGY, FUELS, GAS & CHEMICALS

GBB -- Quality – Value – Ethics – Results

- Established in 1980
- Solid Waste Management and Technology Consultants
- Helping Clients Turn Problems into Opportunities

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GBB Waste Technology Services

- Economic, technical, and environmental reviews
- Markets development
- Process planning and design
- Waste characterization and sourcing
- Procurement and negotiation assistance
- Independent feasibility consultant
- Technology due diligence
- Acceptance testing and operations monitoring

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Renewable Energy from Waste

RENEWABLE Energy FROM WASTE CONFERENCE

NOVEMBER 17-20, 2014 SAN JOSE, CALIFORNIA

Food Waste or Fuel Source?

DEPARTMENTS - CRITICAL THINKING

Harvey Gershman
OCTOBER 16, 2013

Share

Hahvee…take out the gahbidge…it stinks!" my mom used to remind me of my household chore growing up in Pawtucket, R.I., in the '60s. We had a 30-gallon can for food waste in the back corner of our lot waiting to be collected by the city and delivered to pig farmers for feed. Neighboring Providence did it a little differently: It had to be bundled in newspapers and set out for collection, eventually to find its way to pig farmers.

HARVEY W. GERSHMAN

Fast-forward to the new millennium. We are serious about increasing recycling even more by going after organics. The U.S. Environmental Protection Agency reports that food waste accounts for approximately 21 percent of landfilled municipal solid waste (MSW), or around 35 million tons per year (TPY). This waste is a resource that can be used to produce biogas, for power production or

www.rewmag.com

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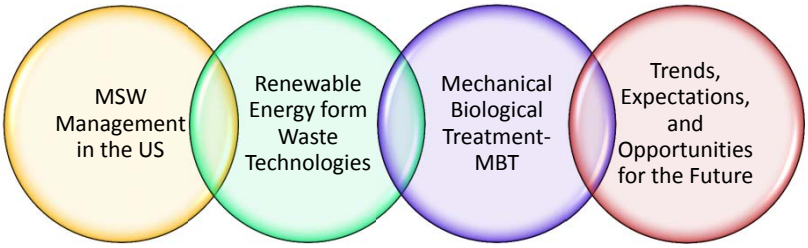
Outline



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SOLID WASTE MANAGEMENT IN THE U.S.

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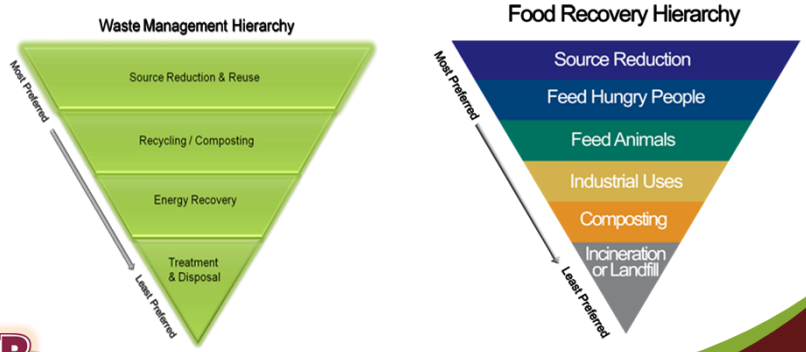
EPA Significant Changes to the Waste Management Policy, 2005
EPA Waste Hierarchies



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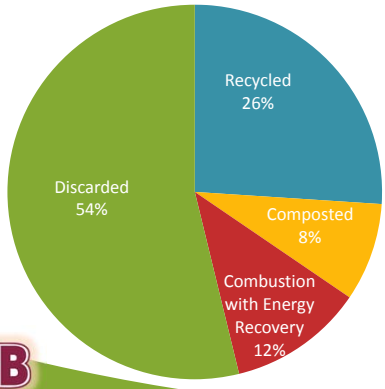
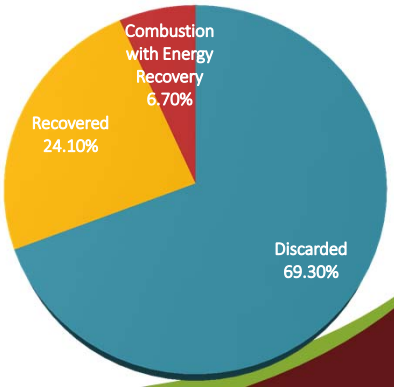
MSW Disposition in the U.S.

EPA Estimate:
251 million tons (2012)



Biocycle Estimate:
389 million tons (2008)



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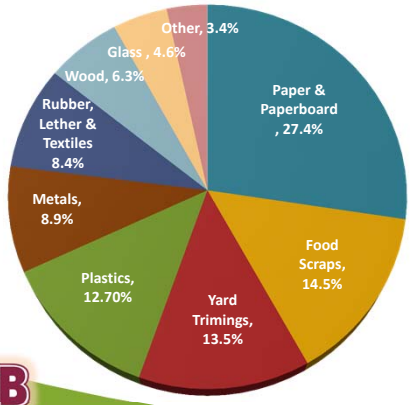
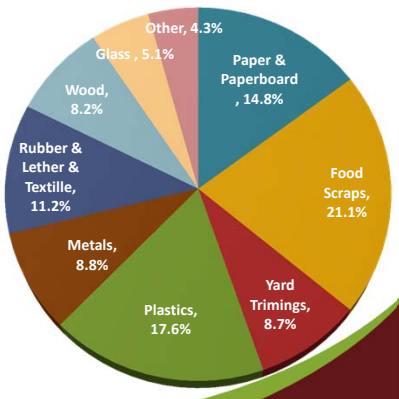
MSW Composition

Total MSW generation, 2012 (by material before recycling)



MSW going to landfills, 2012 (by material after recycling)



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U.S. Waste Management Infrastructure

Technology	Number
Source Separation Collections	9,000
Material Recovery Facilities (MRF)	586
Composting	2,300
Mixed Waste Processing Facilities (MWPF)	51
Mass Burn WTE	65
Modular WTE	9
RDF -Processing &/ or Combustion	20
Anaerobic Digestion	19
Transfer Stations	3,350
Landfills	1,908

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RENEWABLE ENERGY FROM WASTE TECHNOLOGIES

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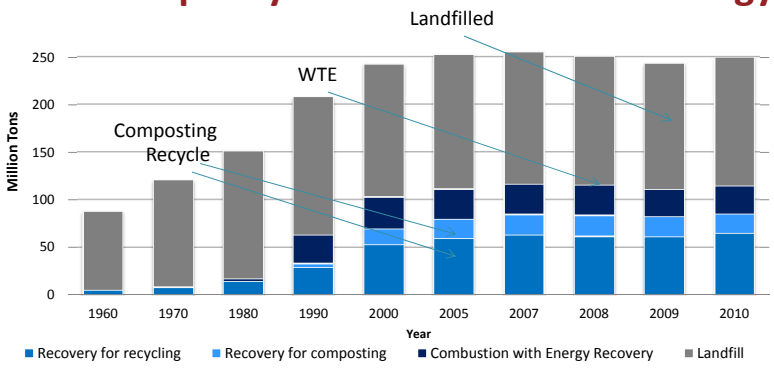
US Capacity to Grow Renewable Energy



The total installed US WTE capacity in 2010 was 2.7 GW, combusting 11.7% of the nation's MSW

Source: USEPA, 2010

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Increased Interest Worldwide in Renewable EfW Technologies

476 Technology/Project Development Companies

- 28 Aerobic Composting
- 106 Anaerobic Digestion
- 30 Ethanol Fermentation
- 117 Gasification
- 30 Plasma Gasification
- 31 Pyrolysis
- 63 WTE: mass burn, modular, dedicated boilers, and RDF
- 69 Others (e.g., thermal cracking, hydrolysis, steam reforming, agglomeration, de-polymerization)

157 Commercial or Demonstration Facilities

- 70 Anaerobic Digestion
- 57 Gasification
- 10 Plasma Gasification
- 12 Pyrolysis

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Source: Gershman, Brickner & Bratton, Inc., June 2014

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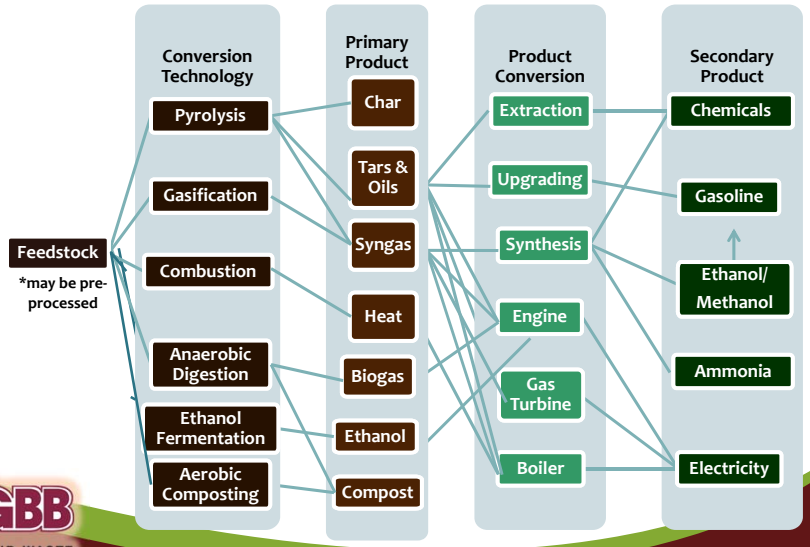
Conversion Technologies and Products



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Energy/Fuel Product Values Are Key

Converting MSW to…	Product	1 ton MSW net yield	Value Per Production Unit	Revenue Per Ton
	Power	500-600 kWh	@ $0.06 / kWh	$30-$36
	Synthetic Crude	1 barrels	@ $80 / barrel	$80.00
	Ethanol	80 gallons	@ $2.50 / gallon	$200.00

++ sale of chemical feedstocks, heat and/or recovered metals

System Capital Costs and O&M Costs impact the NET MSW costs!

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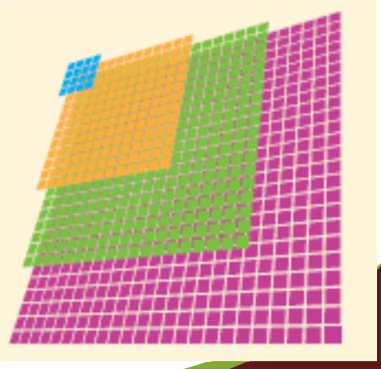
Renewable Energy Technology Land Use

Waste-to-Energy uses less land per megawatt than other renewable energy sources

- WTE facilities require an average of 0.7 acres/MW
- Landfill gas requires 27 acres/MW
- Solar requires 8 acres/MW
- Wind requires 18 acres/MW



Source: Covanta Energy, 2012

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Mass Burn Waste-to-Energy Facilities

North Broward County, FL - Wheelabrator

Alexandria/Arlington, VA - Covanta

Springfield, MA -Covanta

Baltimore, MD - Wheelabrator

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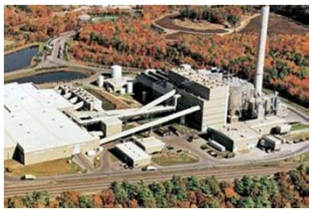
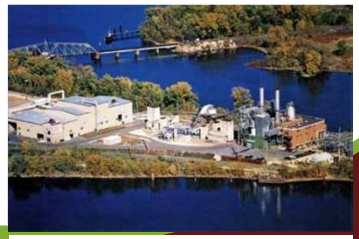
RDF/Dedicated Boiler Facilities



Rochester, MA

Hartford, CT

West Palm Beach, FL



La Crosse, WI

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Locations Advancing Processing/WTE Technologies

- Mass burn WTE expansions completed
  - Hillsborough County, FL - Covanta
  - Lee County, FL - Covanta
  - Olmsted County, MN – Olmsted County
  - Honolulu, HI – Covanta
- Mixed Waste Processing/AD Operating
  - Newby Island (San Jose, CA) – Republic/Zero Waste to Energy
  - Montgomery, AL- Infinitus /Zero Waste Energy
- Mass burn WTE facilities under construction
  - Durham York (Ontario CN) - Covanta
  - Palm Beach County, FL (SWAPBC) – B&W
- Advancing new facilities
  - Allentown, PA – Delta Thermo Energy Inc.
  - Baltimore, MD – Energy Answers
  - City of Cleveland, OH – to be determined
  - County of Hawaii, HI – to be determined
  - City of Houston, TX – to be determined
  - City of Los Angeles, CA – Green Conversion Systems
  - County of Maui, HI - Anaergia
  - Frederick County, MD (NMWDA) - Wheelabrator
  - Iowa City, IA – to be determined
  - Metro Vancouver, CN – to be determined
  - Prince William County, VA – LEEP
  - Puerto Rico – Energy Answers
  - Region of Peel, Ontario, CN – to be determined
  - Prince George's County, MD
  - Wicomico County, MD

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Solid Waste Authority of Palm Beach County, FL

- New Facility - Notice of Award, April 2011
  - 3,000 TPD Mass Burn facility
  - 130 MW renewable power; enough for over 86,000 houses
  - $668 million construction price
  - $20.5 million first year O&M cost
  - To use advanced emissions control system
- Groundbreaking - April 2012
- Expected commercial operation 2015

Source: Babcock & Wilcox; artist's rendering of proposed facility.

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Montgomery, AL - Infinitus

- New high-tech 80,000 square feet "state-of-the-art" Dirty MRF
- Capital cost in excess of $30 million
- First "One Bin for All" in 21st Century in the U.S.
- Main equipment subcontractor, Bulk Handling Systems
  - One-line, 40 ton per hour input for 100,000 tons per year
  - 60 % material recovery guarantee plus other organics separation capabilities
- Commercial operations April 2014; Zero Waste Energy is operator
- AD awaiting new CNG collection fleet decision

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Gasification/Fermentation

- Partial combustion in an air-controlled environment
- With fermentation, includes enzymatic digestion
- Product: Syngas for production of electricity, chemicals/ fuels (ethanol)
- Feedstocks: MSW, biomass, medical waste,
- Plasma gasification: a plasma arc is used as a heat source

COVANTA CLEERGAS™ Enerkem Fiberight Fulcrum BIOENERGY INEOS Bio ALTER NRG IWT INTERSTATE WASTE TECHNOLOGIES SIERRA ENERGY PlascoEnergy GROUP

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Enerkem

- Commercial plant in Edmonton, Alberta- 10 million gal/year, start-up June 2014
  - City MSW Processing Facility with Vecoplan equipment prepares feedstock
- Commercial scale demonstration facility in Westbury, CA (since 2009, 1.3 million gallons/year)
- Pilot plant in Sherbrooke, CA (since 2003)
- Under development: Pontotoc, Mississippi and Varennes, Québec, each 10 million gal/year (MRF construction in 2015)

Edmonton Transfer conveyor between MSW processing and Enerkem Facility

Enerkem Edmonton Facility June 2014

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INEOS Bio

- Gasification followed by biocatalyst fermentation and distillation
- Biomass to Bioethanol operating now; MSW to Bioethanol later in 2014
- Plant:
  - Vero Beach, Indian River County, FL- commercial demonstration facility
    - process ~150,000 TPY of yard, wood and vegetative wastes
    - produce 8 million gal/year ethanol and 6 MW (gross) of electric power

Indian River BioEnergy Center

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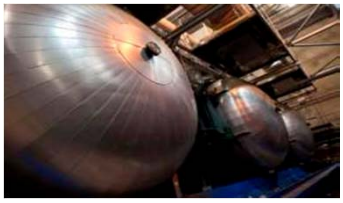
Fiberight

novozymes Rethink Tomorrow



Fiberight High-Solids Pulping

Ethanol Fermentation Feedstock- MSW

- **Plants:**
  - Demonstration plant in Lawrenceville, VA- opened October 2012
  - Blairstown, Iowa- 6 million gal/year, expected to be operational late 2014
  - Has site control for first commercial-scale biofuel plant in Elkridge, MD
  - Recent contract with City of Marion, Iowa; also recently selected as Preferred Contractor by Iowa City, Iowa (Dec. 2013)

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Pyrolysis

- Thermal conversion in the absence of oxygen
- Non-recyclable plastics to oils, fuels
- Plastics-to-Oil Technologies Alliance formed by ACC

Plastic2Oil

VADXX ENERGY

agilyx

RES POLYFLOW

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Anaerobic Digestion

Biological degradation of organic material in absence of oxygen

- Biogas fuel for electricity and/or heat production; can be conditioned to pipeline quality
- Digestate for soil amendment, animal bedding, or rolled into a composting process
- 19 plants operating in the US

Quasar Energy- Cleveland, Ohio

CR&R Eisemann – Perris, CA (under construction)

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Anaerobic Digestion is a HOT topic
Example: Residential Collection of Food Waste

183 communities offer curbside collection of residential food waste

18 states	2.55 million households	726,250 tons in 2012*

* 79% of programs reporting

Source: BioCycle Magazine, March 2013

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Companies in U.S. at Work with AD

Organic Waste Systems

biogas USA entec

WTE Organic Power

EISENMANN

BEKON Energy Technologies GmbH & Co. KG

HARVEST Power of We

CR&R

eci Bio Energy

quasar energy group

ZeroWaste ENERGY, LLC. Recovery and Energy with Zero Waste

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HARVEST Power of We

- US company founded in 2008 in Waltham, MA
- Licensed European AD technologies
- More than 10 composting plants
- Three commercial AD plants
  - Richmond Energy Garden, Canada- 40,000 TPY of food and yard waste
  - London Ontario Energy Garden, Canada- 65,000 TPY of mixed organic waste
  - Energy Garden in Bay Lake, FL- 100,000 TPY of Mixed organic waste

Richmond Energy Garden

London Energy Garden

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quasar energy group

- US company established in 2006 in Cleveland, OH
- Initially European technology, now, more than 98% of the components are purchased in the U.S. and more than 76% of those are from Ohio-based companies
- Integrated Anaerobic Digestion System (iADs) is patent pending technology developed at Ohio State University
- Projects:
  - 8 operating commercial AD projects in the US
  - 3 commercial projects under construction

Cleveland, Ohio- 42,600 TPY of Biosolids, FOG and food waste

Wooster, OH- 20,000 TPY, Pumpable and high solids organic biomass

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ZeroWaste™ ENERGY, LLC. *Recovery and Energy with Zero Waste*

- US company based in Lafayette, CA
- Dry Anaerobic Digestion licensee for:
  - KompoFERM
  - SmartFERM
- Plants:
  - Monterey Regional Waste Management District- 5,000 TPY of food and green waste
  - City of San Jose (start-up November 2013)- 90,000 TPY of commercial food waste
    - Operating at ½ capacity in Jan. 2014 – Scaling up through Spring 2014
  - Operator for Infinitus in Montgomery, AL
  - 3 plants under construction and development

Monterey, CA

San Jose, CA

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Locations Advancing Conversion Technologies

- Advancing new facilities with thermal technologies:
  - Three Rivers Solid Waste Management. Authority - Pontotoc, MS – Enerkem
- Anaerobic digestion specific RFPs issued:
  - Humboldt Waste Management Authority, Eureka, CA
- Anaerobic Digestion plants under development :
  - City of Newport News, VA - quasar
  - Town of Bourne, MA - Harvest Power
  - Town of Brunswick, ME - quasar and Village Green Ventures
  - City of Columbia, SC - W2E
  - City of Portland, OR - Columbia Biogas
  - Monticello, IN- Waste No Energy LLC
  - City of Charlotte, NC - Blue Sphere
  - Perris, CA - CR&R/Eisenmann
  - County of Santa Barbara, CA – Mustang Renewable Power Ventures
  - Prince William County, VA – to be determined

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Mechanical Biological Treatment (MBT)

- Originated in Germany in 1999 (now 36 operating MBTs)
- 330 plants in EU most in: Germany, Austria, Italy, Switzerland and the Netherlands; UK catching up
- Includes:
  - Mechanical sorting of recyclables and organics
  - Food scraps and green waste processed through AD and composting units; mulching too
  - Residuals converted to high BTU refuse-derived fuel (RDF)
- RDF key to MBT diversion results
  - 54% to dedicated boilers, 16% to coal plants, 11% to cement kilns and 19% to others

Source: Mechanical Biological Treatment of Municipal Solid Waste. UK Department for Environment Food & Rural Affairs (DEFRA). February 2013

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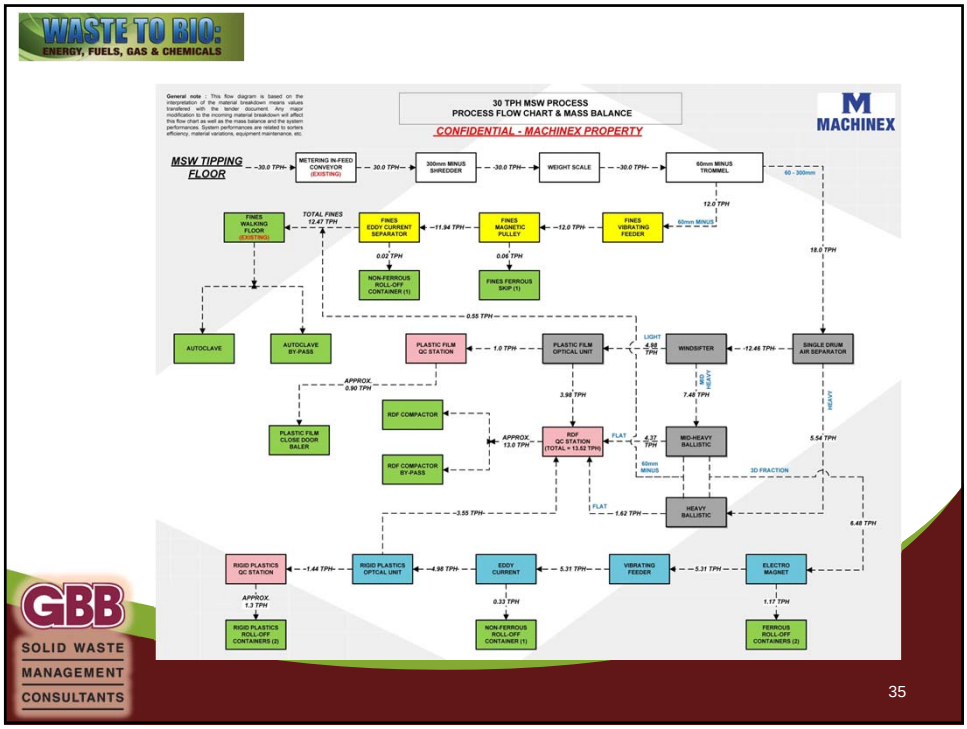
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30 TPH MSW PROCESS
PROCESS FLOW CHART & MASS BALANCE
CONFIDENTIAL - MACHINEX PROPERTY
MACHINEX
MSW TIPPING FLOOR
METERING IN-FEED CONVEYOR (EXISTING)
300mm MINUS SHREDDER
WEIGHT SCALE
60mm MINUS TROMMEL
FINES WALKING FLOOR (EXISTING)
FINES EDDY CURRENT SEPARATOR
FINES MAGNETIC PULLEY
FINES VIBRATING FEEDER
NON-FERROUS ROLL-OFF CONTAINER (1)
FINES FERROUS SKIP (1)
AUTOCLAVE
AUTOCLAVE BY-PASS
PLASTIC FILM QC STATION
PLASTIC FILM OPTICAL UNIT
WINDSIFTER
SINGLE DRUM AIR SEPARATOR
PLASTIC FILM CLOSE DOOR BALER
RDF COMPACTOR
RDF COMPACTOR BY-PASS
RDF QC STATION (TOTAL = 13.52 TPH)
MID-HEAVY BALLISTIC
HEAVY BALLISTIC
RIGID PLASTICS QC STATION
RIGID PLASTICS OPTICAL UNIT
EDDY CURRENT
VIBRATING FEEDER
ELECTRO MAGNET
RIGID PLASTICS ROLL-OFF CONTAINERS (2)
NON-FERROUS ROLL-OFF CONTAINER (1)
FERROUS ROLL-OFF CONTAINERS (2)
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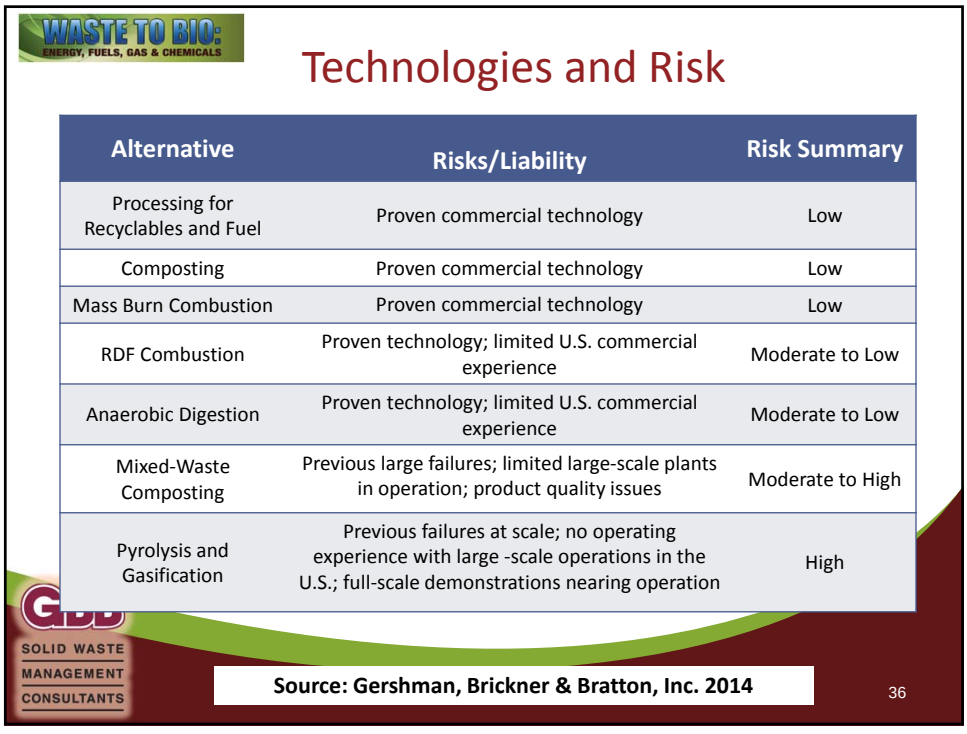
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ENERGY, FUELS, GAS & CHEMICALS
Technologies and Risk
Alternative
Risks/Liability
Risk Summary
Processing for Recyclables and Fuel
Proven commercial technology
Low
Composting
Proven commercial technology
Low
Mass Burn Combustion
Proven commercial technology
Low
RDF Combustion
Proven technology; limited U.S. commercial experience
Moderate to Low
Anaerobic Digestion
Proven technology; limited U.S. commercial experience
Moderate to Low
Mixed-Waste Composting
Previous large failures; limited large-scale plants in operation; product quality issues
Moderate to High
Pyrolysis and Gasification
Previous failures at scale; no operating experience with large -scale operations in the U.S.; full-scale demonstrations nearing operation
High
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Source: Gershman, Brickner & Bratton, Inc. 2014
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TRENDS, EXPECTATIONS, AND OPPORTUNITIES FOR THE FUTURE
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Opinion of Trends for Future
More mixed waste processing (MBT is gaining interest)
Added recycling side-benefit
Most conversion technologies require pre-processing for feedstock preparation
Electric utilities may become a player for RDF
CNG from AD projects and municipal fleet use (City of Montgomery, Al project)
"One-bin" approaches key to watch
'Environmentalists' and 'Zero Waste' proponents continue to fight WTE and Waste Conversion Technologies calling them all "incineration"
Less waste to manage is an excellent policy to embrace!
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Legislation and Regulations

- *Will more states ban food scraps from disposal?*
- *Will U.S. landfill disposal ever be as expensive as in EU and UK?*
- Permitting needs to be streamlined/rational
- Several states stepping up recycling/diversion goals and Producer Responsibility (EPR)
- EPA needs to help lead the way with RFS and EF rules
- ***Waste is very recyclable and it is also very renewable!***

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Questions and comments?

Thank you!

Harvey Gershman
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