Biofuel Opportunities for Solid Waste Management Systems

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November 13, 2013

GBB – Quality – Value – Ethics – Results

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

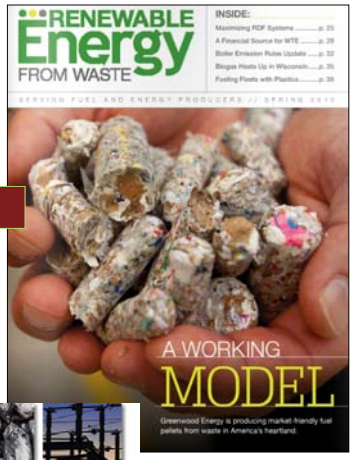
2

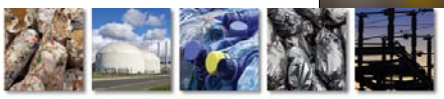
GBB Waste Technology Services

- 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

3

www.rewmag.com





RENEWABLE Energy FROM WASTE CONFERENCE

NOVEMBER 18-20 2013 WEST PALM BEACH, FLORIDA

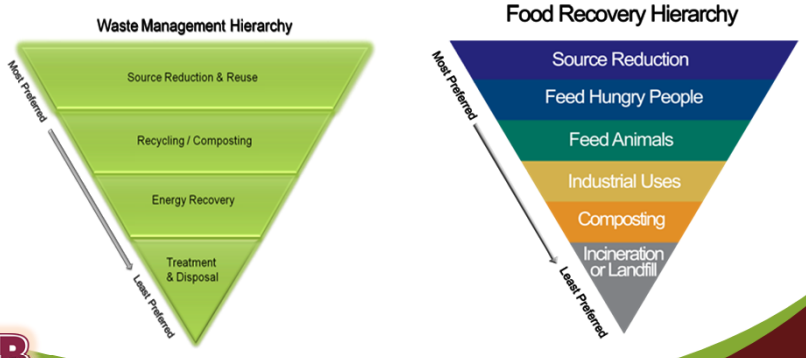
3rd Annual
Waste Conversion Congress West Coast
3-4 December 2013, San Diego, California

4

SOLID WASTE MANAGEMENT IN THE U.S.

5

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

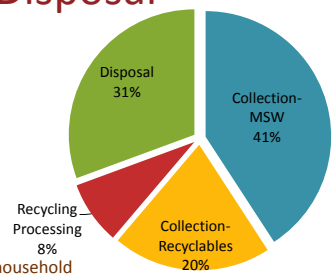


6

Cost of Collection and Disposal

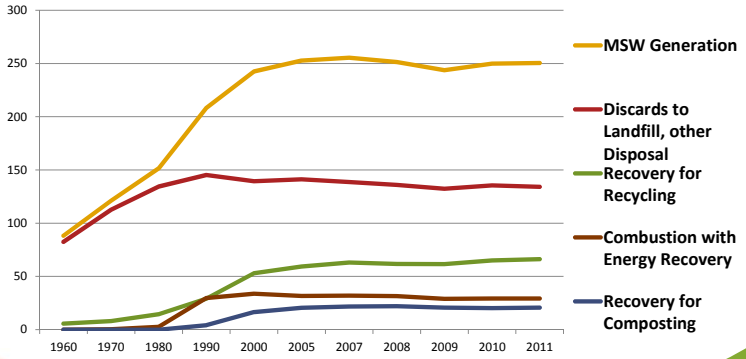
- Costs and revenues affected by:
  - community size
  - government structure
  - politics
  - facilities used
  - waste supply agreements
  - Revenue sharing back to customer
- Collection
  - Residential solid waste : $10 - $40 USD$ per month per household
  - Residential recycling $2 - $4 per month per household
- Commercial waste
  - charged on a per month per box basis, and may include a separate pass-through cost for disposal charges.
  - 2 cubic yard box serviced once per week = $60 - $140 per month
  - 6 cubic yard box serviced once per week = $130 - $280 per month
- WTE tipping fee = $68/ton (2010)

Landfill tipping fee = $45/ton (2012)



7

Historical Waste Generation & Management, 1960 - 2011

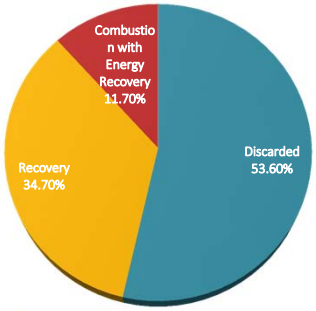


Source: US EPA, Municipal Solid Waste in the United States, 2011 Facts and Figures

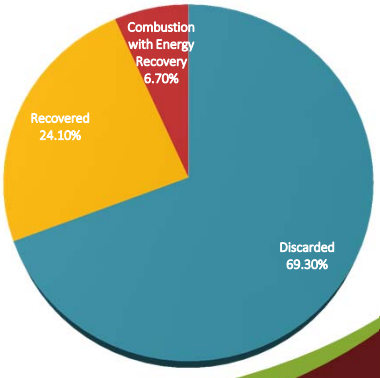
8

Disposition of MSW in the U.S.

EPA Estimate:
250 million tons (2011)



Biocycle Estimate:
389 million tons (2008)



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Generation and Recovery of Material Types (EPA, 2011)

Material	Weight Generated (million tons)	Weight Recovered (million tons)	Recovery as Percent of Generation
Paper and paperboard	71.31	44.57	62.5%
Glass	11.53	3.13	27.1%
Metals	22.41	7.87	35.1%
Plastics	31.04	2.55	8.2%
Rubber and leather	7.78	1.17	15.0%
Textiles	13.12	1.97	15.0%
Wood	15.88	2.30	14.5%
Food	34.76	0.97	2.8%
Yard trimmings	33.40	19.20	57.5%
Total other wastes	80.63	21.58	26.8%
Total MSW	249.86	85.14	34.1%

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Recycling and Material Recovery Facilities

- In 1970, US relied on local scrap yards and waste paper dealers to receive and prepare materials for recycling
- Now, US also has MRFs:

MRF Type	Number of MRFs	
Year:	2006	2012
Single Stream	144	263
Dual Stream	227	228
Source Separated, Other Programs	127	95
All MRFS	437	586

Materials Recycling and Processing in the United States (Berenyi, 2012)

11

U.S. WTE Plants, by Technology

Technology	Operating Plants	Daily Design Capacity (TPD)	Annual Capacity [1] (Million Tons)
Mass Burn (see note)	65	71,354	22.1
Modular	9	1,342	0.4
RDF -Processing & Combustion	10	15,428	4.8
RDF -Processing Only	5	6,075	1.9
RDF -Combustion Only	5	4,592	1.4
Total U.S. Plants [2]	94	98,791	30.6
WTE Facilities	89	92,716	28.7

Note: A few of these WTE (mass-burning) plants have recently announced closings, typically at end-of-term of initial 20-year debt financings and/or due to other local economic reasons

12

In the U.S. - Increased Interest in Advanced WTE and Conversion Technologies

>590 Technology and/or Project Development Companies Worldwide

150 Commercial or Demonstration Facilities with MSW Worldwide

Contributing factors:

- Renewable energy policy
- Funding
- Local governments desire to be greener
- GHG considerations
- Waste diversion from landfills
- Local jobs
- Higher Collection/Disposal Fees
- Transportation costs increase

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TECHNOLOGIES AVAILABLE FOR BIOFUELS GENERATION

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14

Landfill Gas

- Landfill gas (LFG) is a by-product of the decomposition of MSW:
  - ~ 50% methane (CH4)
  - ~ 50% carbon dioxide (CO2)
  - <1% non-methane organic compounds (NMOCs)
- For every 1 million tons of MSW:
  - ~ 0.8 MW of electricity
  - ~ 432,000 cubic feet per day of LFG
- MSW landfills are the third-largest source of human-related methane emissions in the U. S.

15

State of the U.S. LFG Industry

- LFG is extracted from landfills using a series of wells and a blower/flare system
- Collected gas goes to a central point for treatment and conversion/sale
- As of July 2013, there are 621 operational LFG energy projects in the U.S.
- EPA estimates an additional 450 MSW landfills could turn their gas into energy
  - Enough to power 500,000 homes

Maui, HI LFG System

16

Gasification

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

COVANTA CLEERGAS™
Enerkem
Fulcrum BIOENERGY
INEOS Bio
PlascoEnergy GROUP

17

Pyrolysis

- Thermal conversion in the absence of oxygen
- Non-recyclable plastics to oils, fuels

envion
VADXX ENERGY
CLIMAX GLOBAL ENERGY
agilyx
Plastic2Oil

18

Anaerobic Digestion

Biological degradation of organic material in absence of oxygen

Results are biogas and digestate:

- Biogas is used as fuel for electricity and/or heat production. It can be conditioned to pipeline quality
- Digestate can be used as a soil amendment, animal bedding, or rolled into a composting process

There are 13 AD plants accepting food waste in the U.S., including demonstration, pilot and commercial projects

Renewable Waste Intelligence, March 2013

19

Companies in U.S. at Work with AD

Organic Waste Systems

biogas USA entec

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

20

Technologies and Risk

Alternative	Risks/Liability	Risk Summary
Landfill Gas to Energy	Proven technology; widespread U.S. commercial experience	Low
Anaerobic Digestion	Proven technology; limited U.S. commercial experience	Moderate to Low
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
Chemical Decomposition	Technology under development; not a commercial option at this time	High

Source: GBB, 2013

21

Technology Commercialization Examples

Location	Edmonton, Alberta, CA	Vero Beach, FL	Storey, NV	Monterey, CA	Sacramento, CA
Technology	Gasification/ Catal.Conv. of Syngas	Gasification/ Ferment. of Syngas	Gasification/ Catalytic Conv. of Syngas	Anaerobic Digestion	Anaerobic Digestion
Developer	Enerkem	INEOS Bio	Fulcrum Bioenergy	Zero Waste Energy	Clean World Partners
Feedstock	Non-recycled MSW	Yard, vegetative, residential waste	Post-sorted MSW	SSO (food and yard waste)	Commercial food waste
Throughput (TPD)	300	450	400	15	100
Energy Products	Methanol; Ethanol	Ethanol	Ethanol; Propanol	Biogas; Electricity	Biogas; Electricity
Cost	$80M	$130M	$120M	$1.6M	$12M
Federal Grants/Loan Guarantees	$23.5M	$125M	--	--	$1.8M
Start Date	2014	June 2012	2015	Jan 2013	2014

22

Locations Advancing Technologies

- Example of Locations advancing new facilities with thermal technologies:
  - Edmonton, Alberta and Pontotoc, MS – Enerkem
  - City of Los Angeles, CA – Green Conversion Systems
- Anaerobic digestion specific RFPs issued:
  - Humboldt Waste Management Authority, Eureka, CA
  - Montgomery, AL- under construction w/Zero Waste Energy
- 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- w/W2E
  - City of Portland, OR- w/Columbia Biogas
  - Monticello, IN- w/ Waste No Energy LLC
  - City of Charlotte, NC- w/Blue Sphere

23

Locations Advancing LFG to Fuels Projects

- City of Denton, TX uses LFG to fuel a 3 million gal/year biodiesel production facility
- Los Angeles, CA converts LFG into CNG to fuel landfill equipment (Puente Hills LF)
- Orange Co, CA – first commercial LFG-to-LNG facility online Jan. '07 – used in county waste trucks (Frank R. Bowerman LF)
- Central LF, CA plans to convert LFG to CNG to fuel Sonoma County school buses
- Franklin Co, OH uses LFG to produce methanol as a feedstock for biodiesel and a separate CNG plant
- Waste Management, Inc. in CA produces 10-20K gal LNG per day for garbage trucks

24

BIOFUEL USE IN FLEETS

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Pathway from Waste to RNG

** Same infrastructure for RNG as for fossil fuel-CNG

Wastes

All organic wastes contain energy.

Biogas

Anaerobic digestion of wastes at landfills or in digester plants produces energy-rich biogas.

RNG Fuel

Biogas upgrading removes carbon dioxide & impurities to make ***renewable natural gas*** (RNG).

Fuel Stations

RNG goes to on-site fueling stations, or by truck or pipeline to off-site pumps.

Vehicles

RNG works just like regular natural gas to power vehicles.

Source: BioCNG

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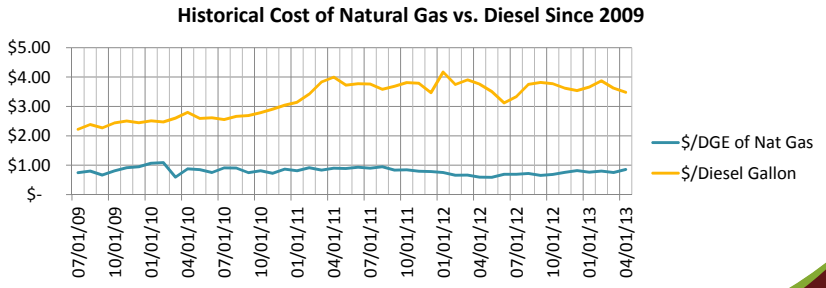
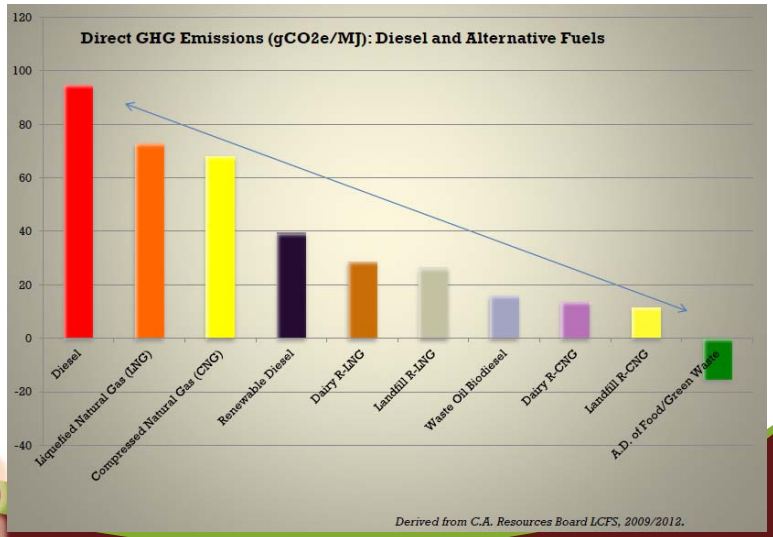
Biofuel (RNG) Benefits

- 85-115% GHG reductions vs. gasoline/diesel
- 50-75% savings over current gas/diesel cost
- Control and distributed source - Fuel cost locked in for 15-20 years



27

Biofuel (RNG) Benefits



28

Selected RNG Projects

Waste Site	State	Vehicles fueled with RNG
Altamont Landfill	CA	300-400 refuse trucks
Fair Oaks Dairy	IN	42 milk delivery trucks
Rodefeld Landfill	WI	25-30 vehicles
Sauk Trail Hills Landfill	MI	RNG leaves site via pipeline
Columbus bio-Energy Digester	OH	25+ vehicles
Janesville Wastewater Plant	WI	40+ vehicles by 2022
St. Landry Parish Landfill	LA	15+ vehicles
Rumpke Landfill	OH	10-15 refuse trucks

Source: "RENEWABLE NATURAL GAS (RNG): The Solution to a Major Transportation Challenge," Energy Vision, New York, September 2012

29

Opinion: Trends for the Future

- Many conversion projects advancing
  - AD development moving quickly
- AD developments coming in 2-3 years; thermal technologies will need 4-6 years to learn what works and all need to clarify their economics
- Continuation of public sector taking "Low Risk" attitude until "proven"
- Demand for more recyclables expected to continue at attractive pricing
- RNG is a fantastic opportunity to coordinate between integrated solid waste management systems and transportation demands

30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Questions and comments?
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31