Co-Digestion: The Path to Net-Zero Energy Consumption

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Acknowledgements: Some slides courtesy of…
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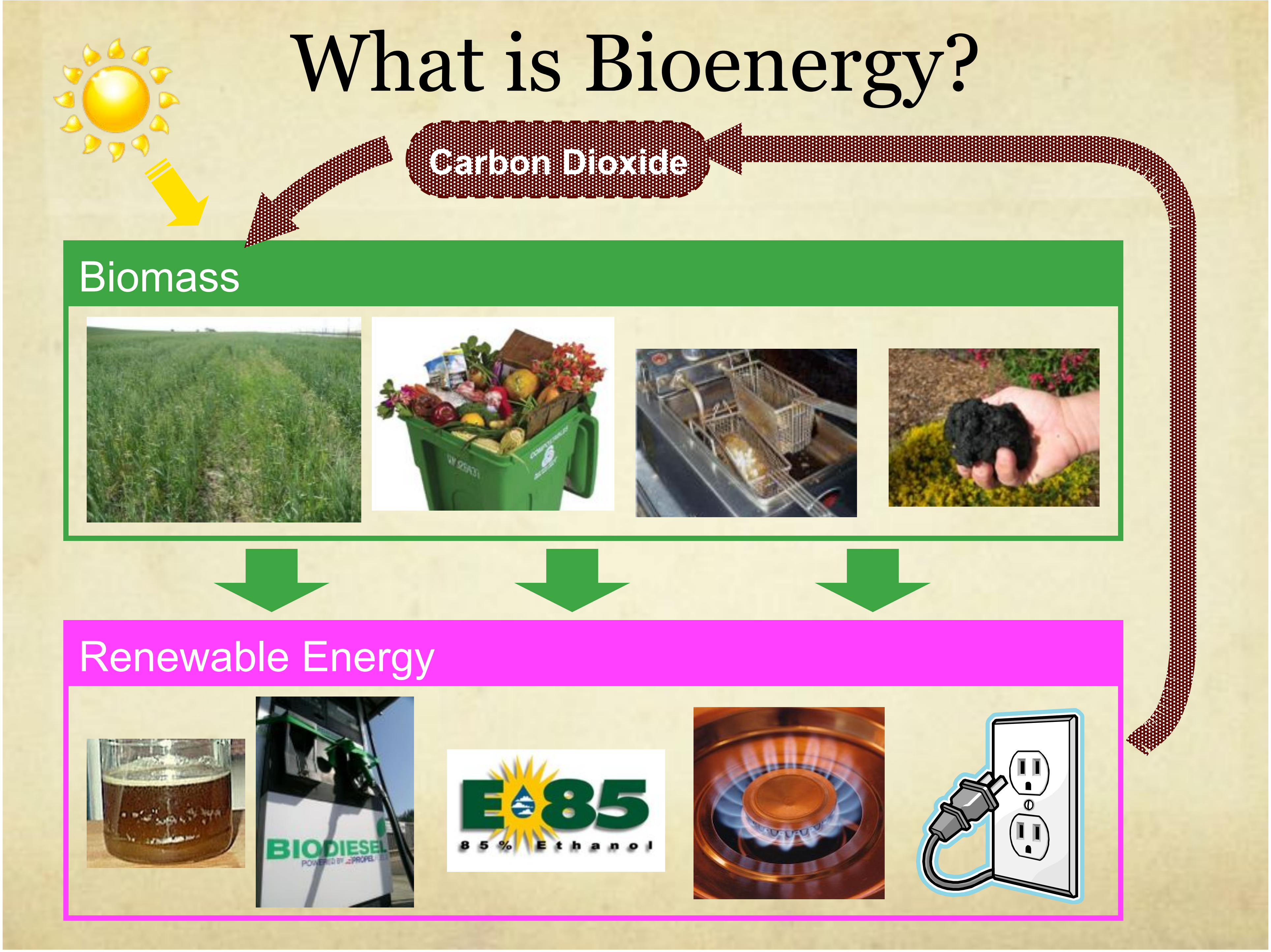
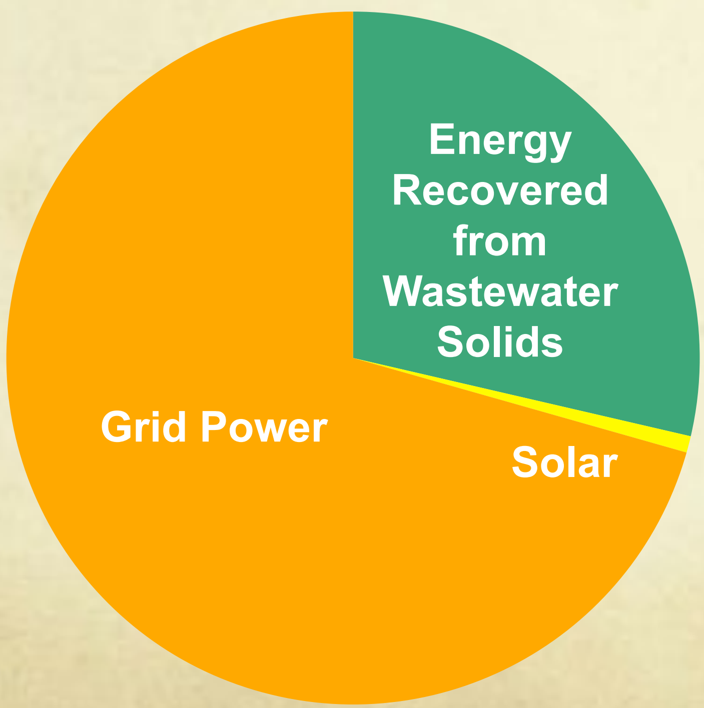
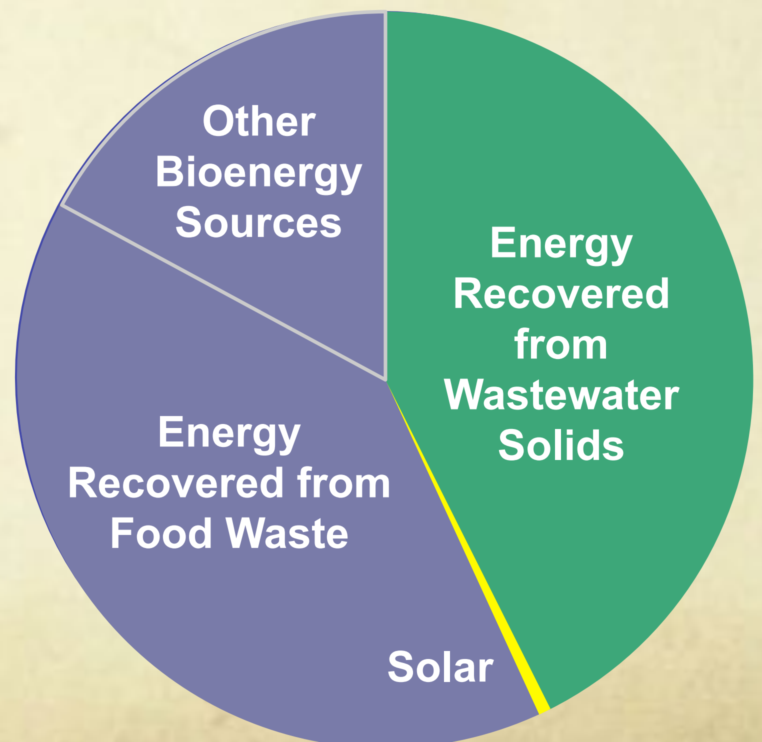

What is Bioenergy?
Carbon Dioxide
Biomass
Renewable Energy
BIODIESEL
E85
85% Ethanol

Co-Digestion = Energy Self-Sufficiency?

Current: 30% Power Demand Met by Renewable Energy



Future: 80% to 100% Self Sufficient



Why Codigestion?

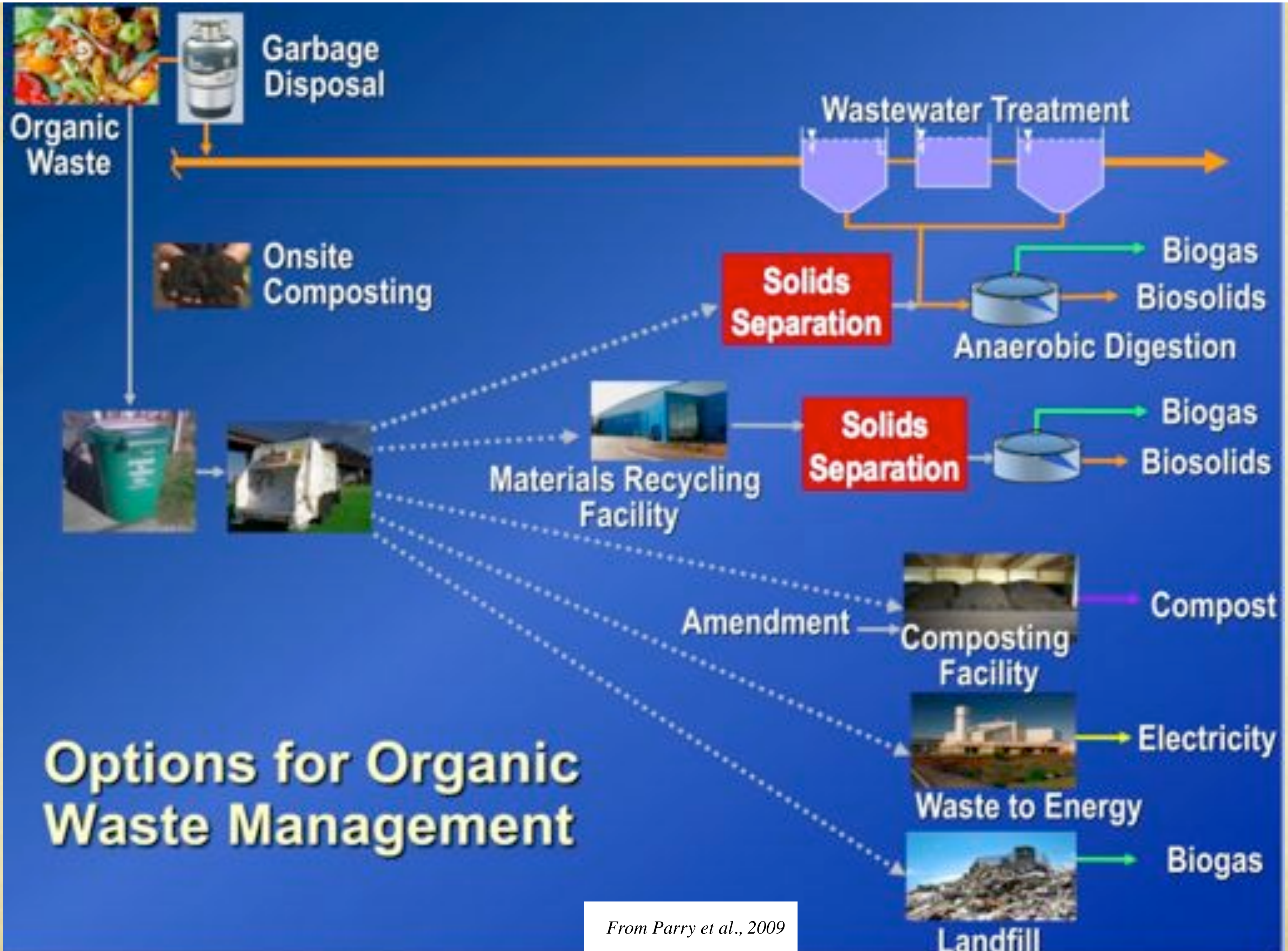
- Increase biogas energy production
- Reduce fossil fuel consumption
- Reduce operating / energy costs
- Minimize carbon footprint
- Increase the plant's value to the community by recycling challenging liquid "wastes"
- Can improve digester performance & biosolids quality
- Be a true Water Resource Recovery Facility (WRRF)

It’s THE NEW HOT TOPIC…

DRIVEN BY…

- Water sector focus on energy consumption
- Renewable energy initiatives
- Energy prices (If it wasn’t for cheap natural gas, the drive would be even greater.)
- States’ focus on diversion of organics from disposal
  - MA 2014 ban on landfill disposal of organics
  - VT ~ 2015 ban on landfill disposal of organics

Organics are becoming a hot commodity!



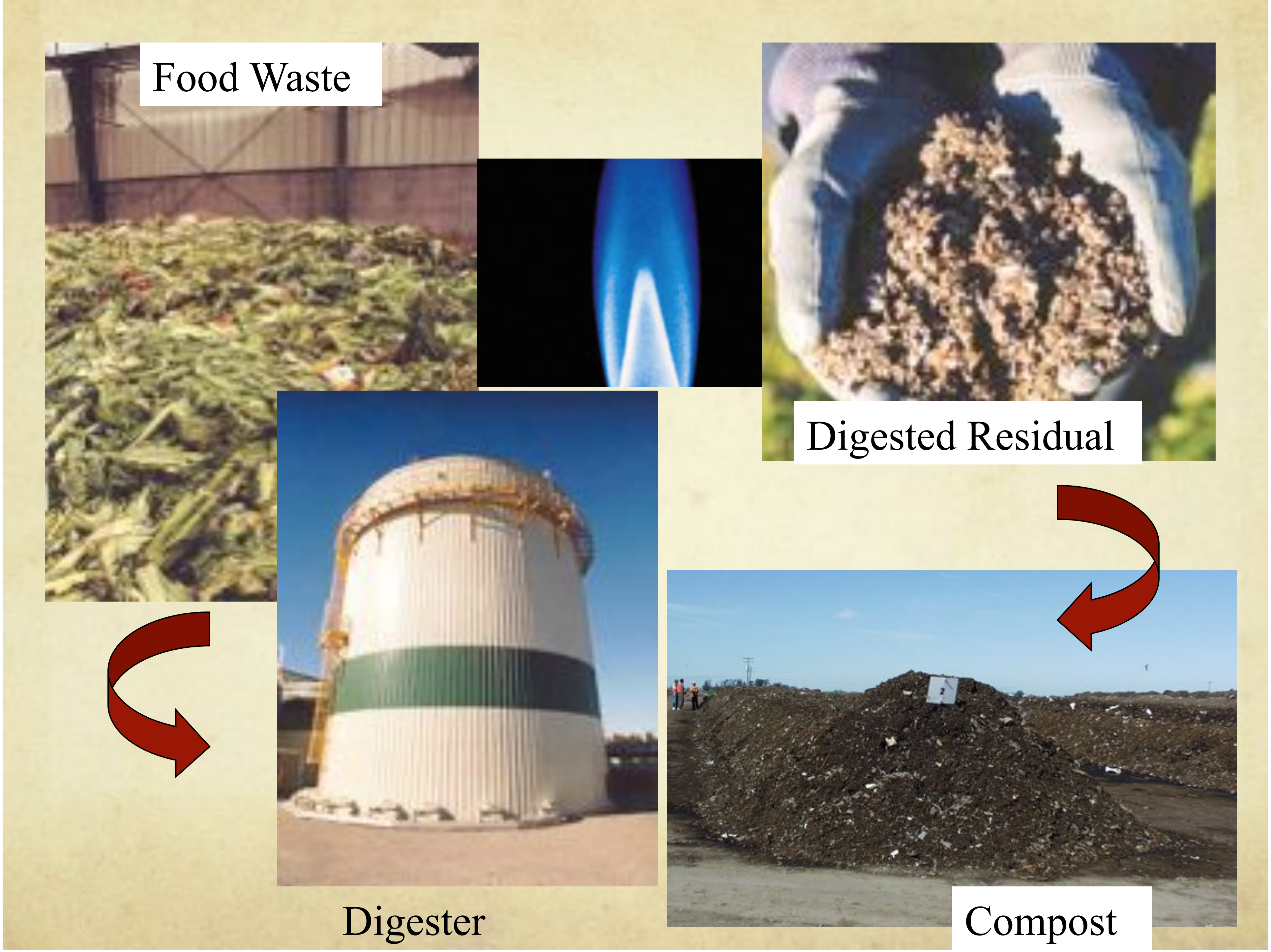
From Parry et al., 2009

Food Waste Is A Key Component to Meeting Landfill Diversion Goals

Photograph from EBMUD Presentation at www.bacwa.org

U.S.

Europe
Canada


Food Waste
Digested Residual
Digester
Compost

WWRFs & Co-Digestion

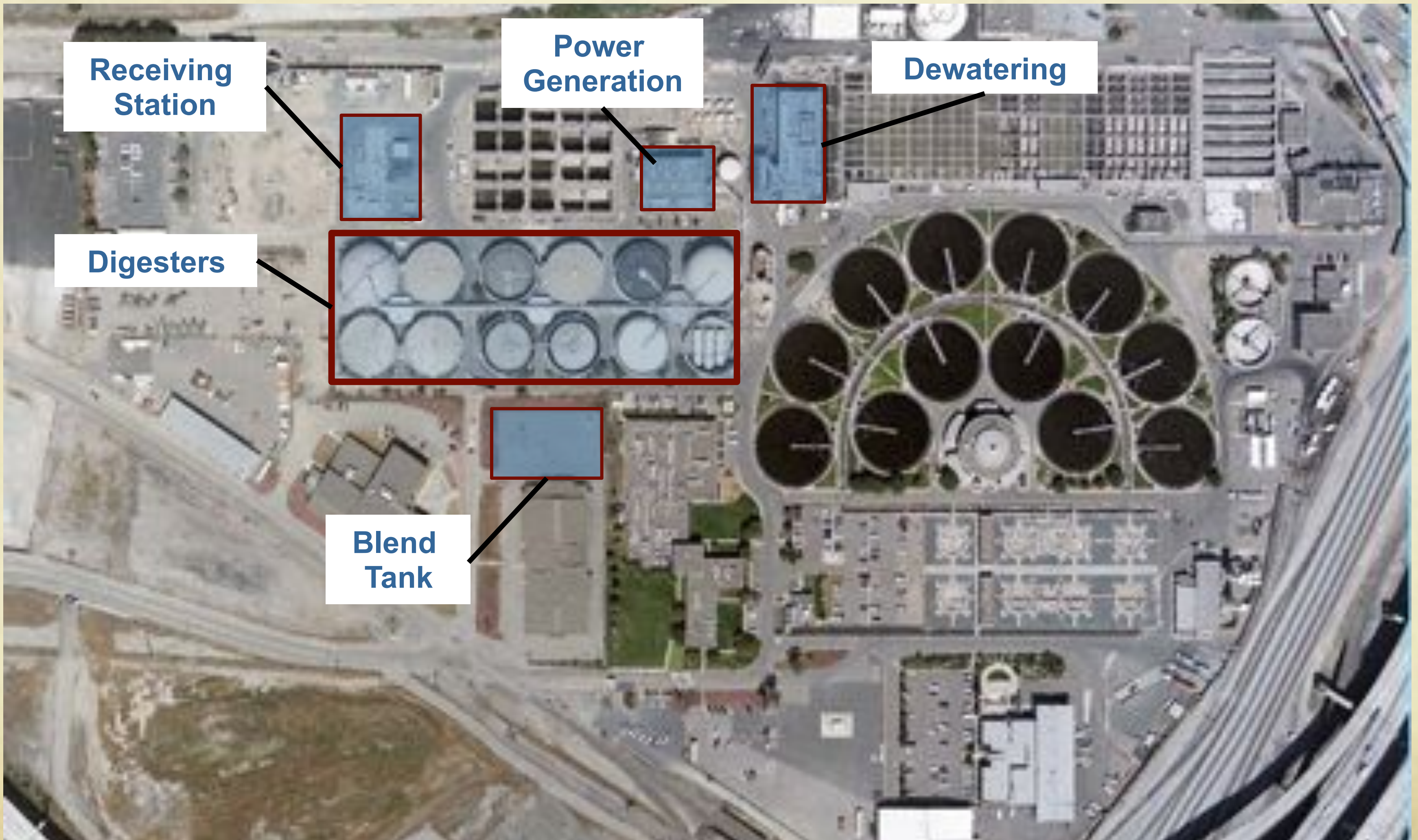
- Pilot studies: Boston (MWRA), Metro Vancouver, Orange County Sanitation District, Dallas Water Utilities, San Francisco Public Utilities Commission, City of Los Angeles
- Whey receiving: Gloversville-Johnstown, NY
- Multiple feedstocks: Des Moines, IA; Essex Juntion, VT
- FOG receiving: Austin Water Utility, City of Tacoma
- Deicing fluid receiving: Philadelphia Southwest Plant,
- Active food waste / FOG / organics receiving: East Bay Municipal Utility District (EBMUD) – NET ENERGY PRODUCTION

Overview: EBMUD food waste digestion

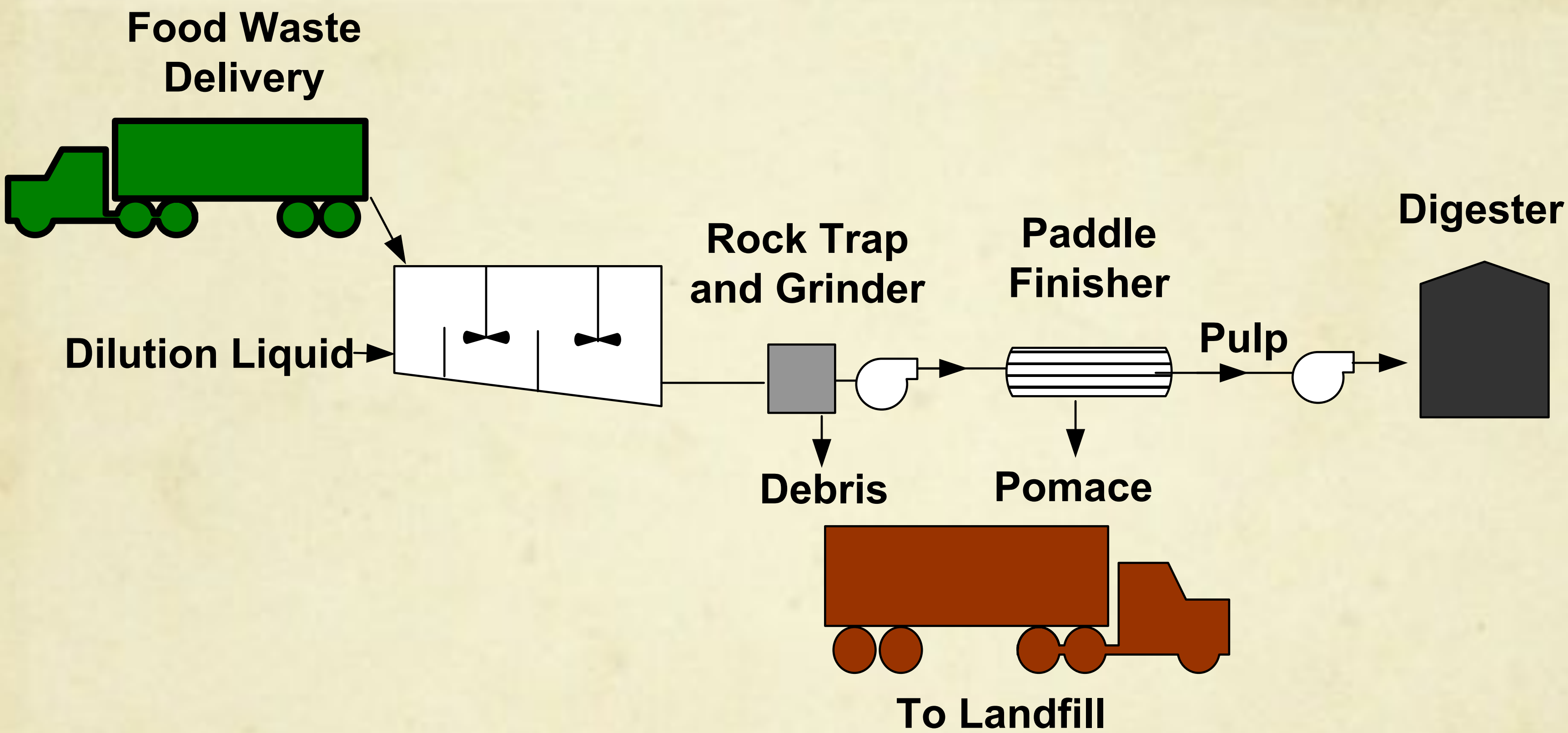
- EBMUD treats wastewater from 7 cities
- Food waste, FOG, and other high-strength wastes are trucked in and co-digested with primary & secondary wastewater solids
- In 2010, at the EBMUD wastewater facility
  - 90% of electricity needs provided from EBMUD biogas
  - Almost $3 million saved in electric power demand
- Winter 2012: EBMUD wastewater facility became a net electricity producer, (new turbine went online).
- EBMUD also has solar & hydropower installations

http://www.ebmud.com/our-water/wastewater-treatment/wastewater-energy

Food Waste Digestion at East Bay Municipal Utility District, Oakland, CA



EBMUD Pretreatment Process



** Patented Process*

Photographs from EBMUD Presentation at www.bacwa.org

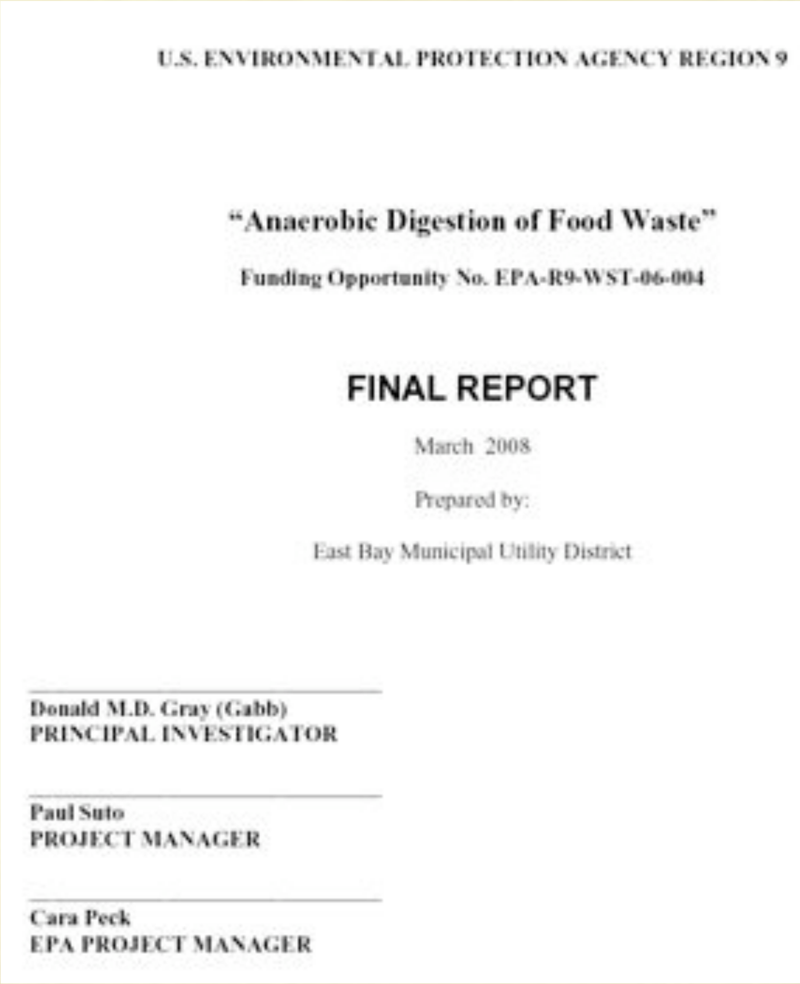
Photographs from EBMUD Presentation at www.bacwa.org

Photograph from EBMUD Odor Control Master Plan, CH2M Hill (2009)

Key for rapid, thorough digestion: consistent pulped waste

EPA-Funded Research on Food Waste Digestion at East Bay MUD

- Evaluation of food waste digestion vs. municipal ww solids digestion
- Bench scale
- Evaluated:
  - Minimum MCRT
  - VS & COD loading
  - VS destruction
  - CH_4 production rates
  - Process Stability
  - Meso & thermo AD operating temperatures



U.S. ENVIRONMENTAL PROTECTION AGENCY REGION 9

"Anaerobic Digestion of Food Waste"

Funding Opportunity No. EPA-R9-WST-06-004

FINAL REPORT

March 2008

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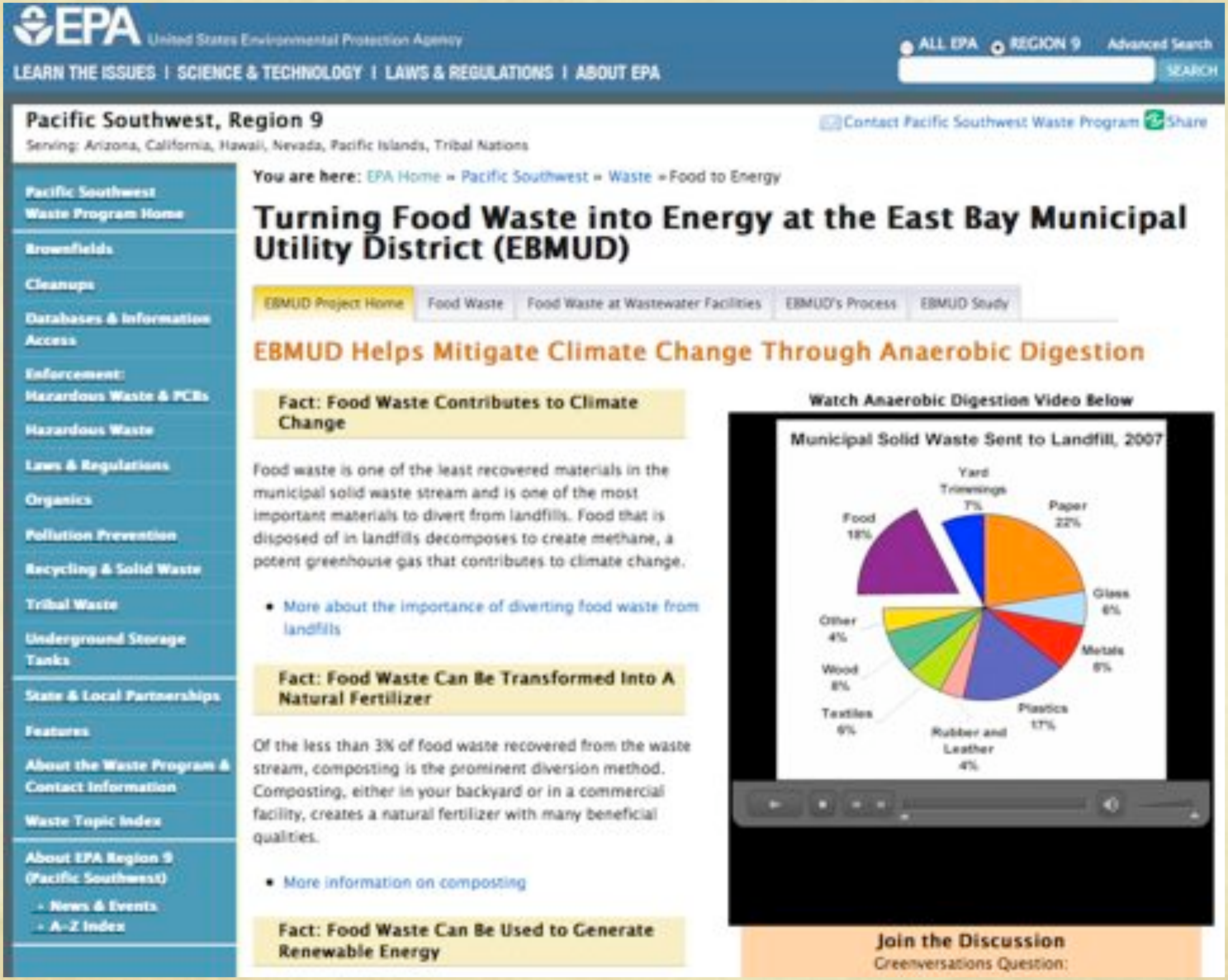


http://www.epa.gov/region9/waste/features/foodtoenergy/index.html

Findings

Compared to wastewater solids, food waste…

- produces as much or more energy / ton of processed material fed into digesters
- Food waste digestion happens at a quicker rate
- VSD = 70 to 80% (compared to ~50 – 60% for wastewater solids)
- Food waste AD produces ~1/2 the residuals (by weight)
- MCRT of 15 days for food waste maximizes CH_4 concentration (65 – 70%), but 10 days is OK too
- In short: food waste is more readily biodegrabable

Table ES-1. Energy Benefit Comparison of Anaerobically Digested Food Waste and Anaerobically Digested Municipal Wastewater Solids.

Parameter	Unit	Food Waste 15-day MCRT AVG (Range)	Food Waste 10-day MCRT AVG (Range)	Municipal Wastewater Solids 15-day MCRT AVG (Range) [5]
Methane Production Rate	ft^3/dry ton applied[1]	13,300 (9,800 – 17,000)	9,500 (6,600 – 14,400)	10,000 (7,500 – 12,600)
	ft^3/wet ton delivered[2]	3,300 (2,500 – 4,300)	2,400 (1,700 – 3,600)	NA[6]
	m^3/ dry metric ton applied[1]	420 (300 – 530)	300 (200 – 450)	310 (230 – 390)
	m^3/wet metric ton delivered[2]	100 (75 – 135)	75 (50 – 110)	NA[6]
	ft^3 per day/ 1,000 ft^3 digester volume	2,300 (1,100 – 3,200)	2,600 (1,800 – 3,800)	750 (550 – 930)
Electricity Production Rate[3]	kWh/dry ton applied[1]	990 (730 – 1,300)	710 (490 – 1,080)	750 (560 – 940)
	kWh/wet ton delivered[2]	250 (190 – 320)	180 (130 – 270)	NA[6]
	kWh/dry metric ton applied[1]	1,100 (800 – 1,400)	780 (540 – 1,190)	830 (620 – 1,040)
	kWh/wet metric ton delivered[2]	280 (200 - 350)	200 (140 - 300)	NA[6]
	kWh per year/ 1,000 ft^3 digester volume	43,700 (21,300 – 62,100)	57,000 (43,000 – 73,700)	14,600 (10,700 – 18,000)
Household Energy Equivalent Rate[4]	households/year/ 100 tons/day	1,100 (800 – 1,400)	800 (550 –1,200)	NA[6]
	households/year/ 100 metric tons/day	1,200 (880 – 1,500)	880 (600 – 1,300)	NA[6]
	households per year/ 1,000 ft^3 digester volume	7.3 (3.6 – 10.3)	8.4 (5.8 – 12.3)	2.4 (1.8 – 3)

Notes:

1. Dry ton applied refers to food waste solids applied to the digesters after processing a wet ton delivered load.
2. Wet ton delivered refers to food waste tonnage (including water) delivered by the hauler prior to processing.
3. Calculated based on 1 ft^3 CH_4 = 1,000 BTUs and 13,400 BTUs = 1 kWh.
4. Calculated based on 2001 EIA residential energy survey for CA where average household energy use is 6,000 kWh annually.
5. Based on data from previous EBMUD bench-scale pilot study. Digesters were fed thickened waste activated sludge and screened primary sludge.
6. Data is not typical of municipal wastewater solids loading to digesters.
7. For annual data, 100 tons/day food waste assumes processing at 5 days per week, 52 weeks per year.
8. For annual data, it is assumed municipal wastewater solids loading occurs 5 days per week, 52 weeks per year.
9. A typical food waste load delivered weighs approximately 20 tons, and has a 20% TS content.
10. Approximately 10% of the delivered food waste as total solids (TS) mass is discharged in reject stream.
11. Data range presented is from stable digester operating periods for both mesophilic and thermophilic digesters.
12. AVG– Average. NA–Not Applicable.

Food Waste vs. Wastewater Solids Comparison		
Parameter	**Food Waste Pulp**	**Wastewater Solids**
Volatile Solids in Feed (%)	85–90	70–80
Volatile Solids Loading (lbs/ft3-day)	0.60 +	0.20 max
COD Loading (lbs/ft3–day)	1.25 +	0.06–0.30
Total Solid Fed (%)	10 +	4
Volatile Solids Reduction (%)	80	56
Hydraulic Detention Time (days)	10	15
Methane Gas Produced (meter^3/ton)	367	120
Gas Produced (liters/liter of digested volume)	58	17
Biosolids Produced (lbs/lbs fed)	0.28	0.55

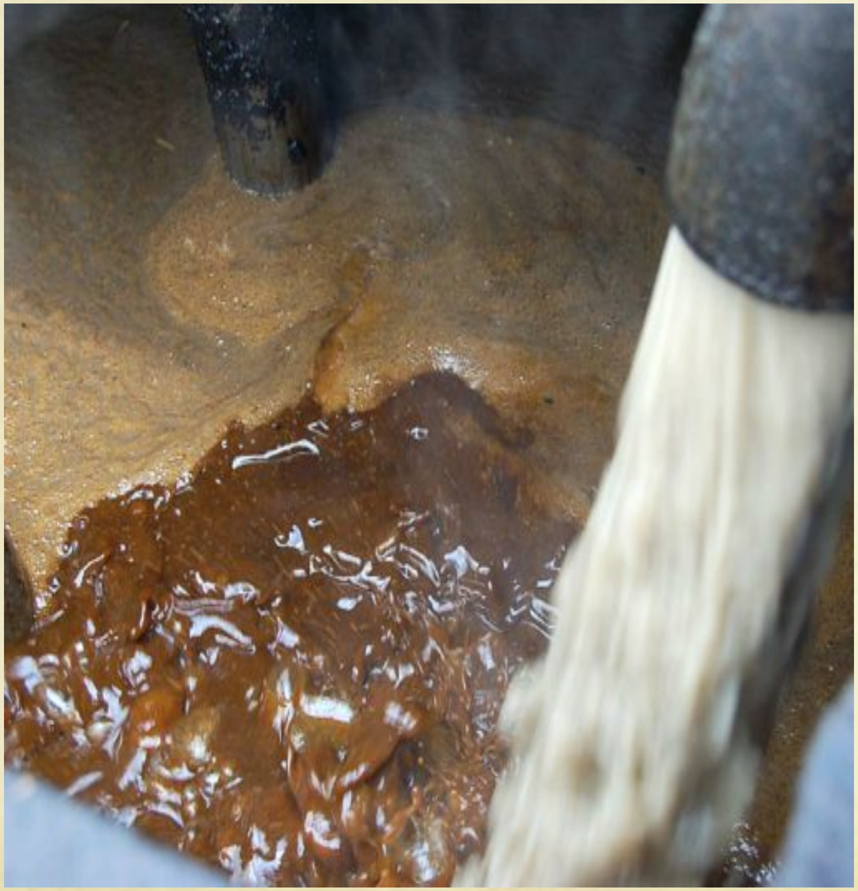
2010 EBMUD Net Renewable Power Production

144,818 MWh	Hydropower generated
640 MWh	Solar power generated
36,900 MWh	Biogas power generated
182,358 MWh	Total renewable energy produced by EBMUD
81,500 MWh	Power purchased from the grid by EBMUD
100,858 MWh	Net renewable energy produced by EBMUD

The Problem with FOG – Fats, Oil, and Grease


THIS SIDE UP
DO NOT REUSE
Canola Oil

What is Brown Grease?



- Fats, Oils, and Grease (FOG) that have come into contact with graywater
- High free fatty acid (FFA) Content: 50-100%
- Found in restaurant grease traps and interceptors

FOG Control Ordinances

Installed AGRD

Typical grease trap

- Most require installation of some kind of grease trap with basic BMPs
- More cutting edge:
  - Restaurants must install/upgrade to Automatic Grease Recovery Devices (AGRDs) within 3 years
  - AGRDs ensure daily recovery, dewatered grease, easy collection
  - AGRDs must be serviced & inspected every 90 days
  - All recovered FOG must be beneficially reused

THE SOLUTION:
LAWPCA digesters have ~15% excess capacity

Benefits of Codigestion to a Municipality

- All types of organic waste can be treated in one plant
- Efficient recovery of biogas, a renewable energy source
- Closed system with a minimum of smell/odor
- Energy can be recovered as electrical power, combined heat & power, compressed biogas (CBG) upgraded to vehicle fuel
- Revenue from tip fees (SF Bay agencies $0.03-$0.15/gallon)

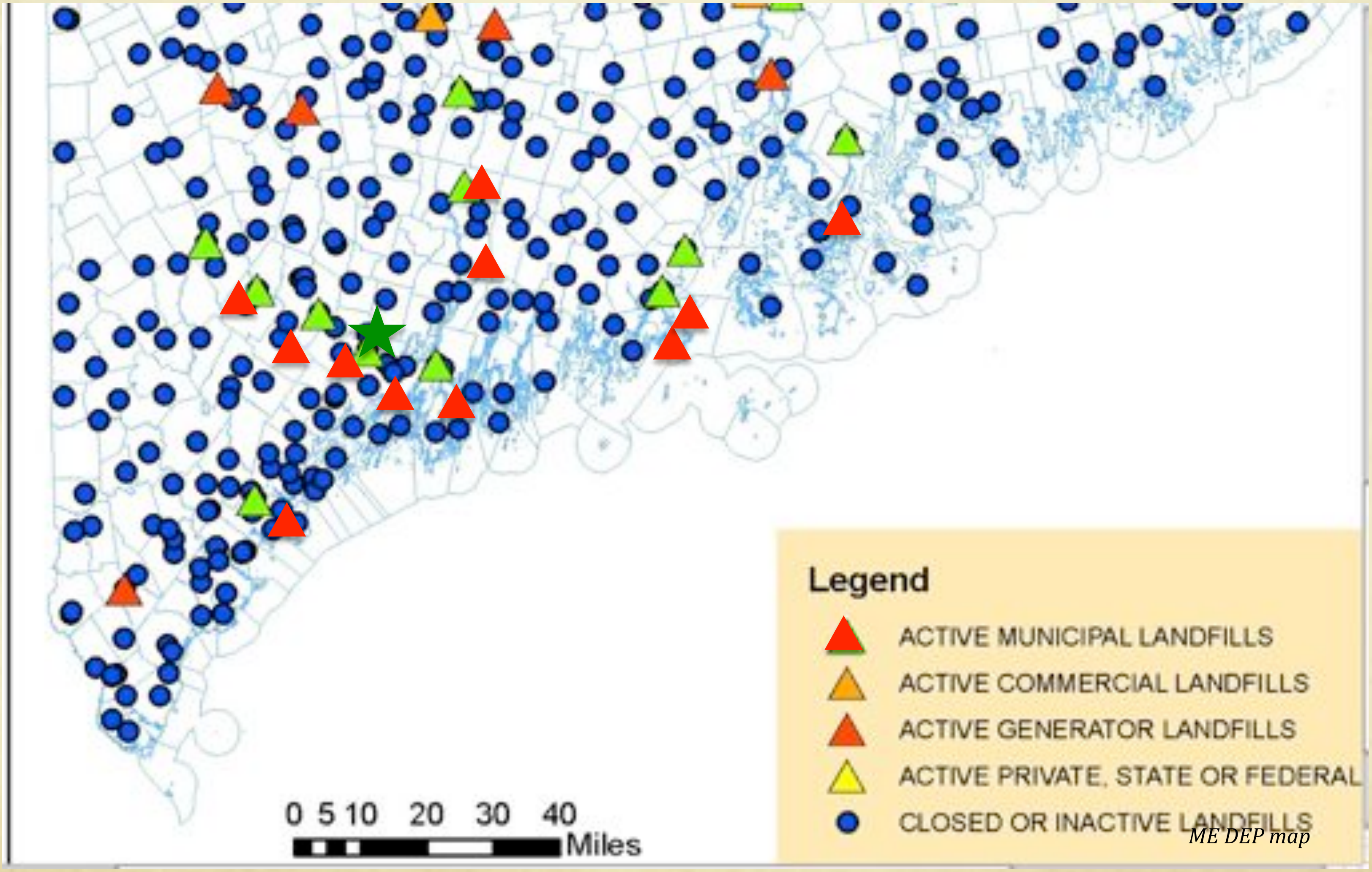
Codigestion Impacts on a WRRF

- Challenges:
  - Preprocessing: off-site? Pumpable? Truckable?
  - Control of incoming wastes/need to establish permit program
  - Pretreatment of wastes to remove debris and protect equipment
  - Ensuring sufficient digester capacity
  - Potential for process upsets – need to provide uniform feed
  - Effect on biosolids and/or organics end use
  - Unknown effect on nutrient content in sidestream
  - Odor potential at receiving area and during maintenance
  - **Public outreach**

Available wastes in LAWPCA region

1. **Fats, Oils, Grease (FOG)**
2. **2. Airplane De-icing Fluids (Glycols)**
3. **Other Glycol Sources**
4. **Pioneer Plastics / Pionite**
5. **Waste Oils**
6. **Machine Coolant (Halogens)**
7. **Glycerin**
8. **Landfill and Transfer Station Leachate**
9. **Dairy Waste (whey, washwater)**
10. **Brewery Waste**
11. **Organic Portion of Municipal Solid Waste (mostly consumer food waste)**
12. **Food Processing Wastes**
13. **Beverage Bottlers**
14. **Slaughterhouse Wastes**

Landfill leachate



Estimating Financial Benefits (1)

The following only include tipping fees. Additional factors to consider include, but are not limited to:

- Additional revenues or cost offsets from increased biogas production.
- Costs of infrastructure needed to accept, store, and meter in the outside wastes.
- Costs to process the additional solids, including dewatering, polymer, labor, etc.
- Costs to manage the additional biogas, including cleaning, storage, and combustion.
- Feed rate of LAWPCA solids – 58,000 gals/day

Estimating Financial Benefits (2)

Scenario 1. Accept only fats, oils, & grease (FOG) from a variety of transporters:

- **a.** 3,000 gallons/day @ $.06 / gallon = ~$66,000 / year (This pricing matches the lowest-priced current competition, Anson-Madison Sanitary District)
- **b.** 3,000 gallons/day @ $.14 / gallons = ~$155,000 (This pricing matches South Berwick, ME)

Estimating Financial Benefits (3)

Scenario 2. Accept other specialty wastes

- They generate higher tipping fees
- Likely available (subject to review for contamination and feasibility):
- ~$100,000 / year:
  - *Food processing waste* (B & M Baked Beans): 1,100 gallons / day @ $.14 / gallon = ~$56,000 / year.
  - *Pioneer Plastics / Pionite glycols, etc.*: 1,100 gallons / day * $.14 / gallon = ~$40,000 / year

Co-substrates:

- Restaurant food waste
- Pharmaceutical industry ethanol & methanol (2/3 used for nit/denit)
- Grease
- Airport de-icing fluid

Pretreated:

- Sieve-hammermill
- Ground to 2 mm
- Stored at 60º C

Biogas used for heating digesters, drying solids, and in vehicles

Example

Bern

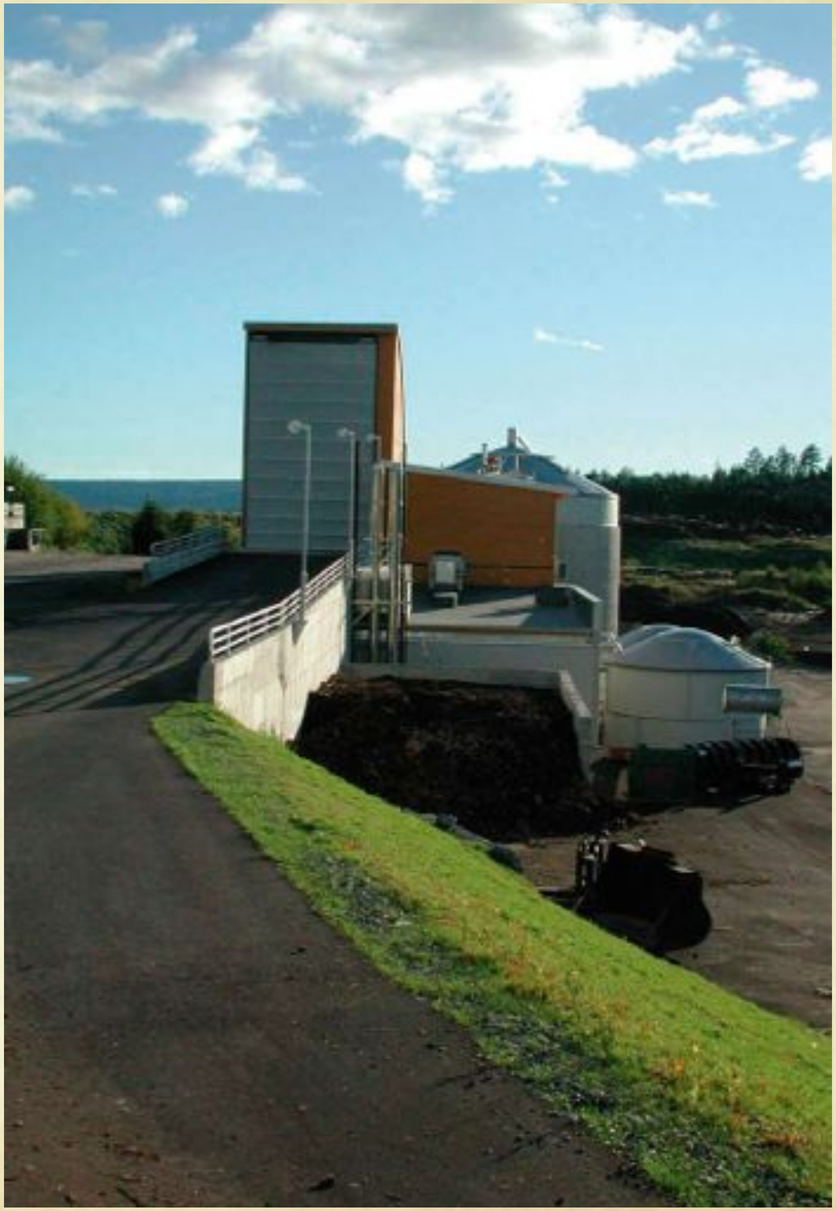
From *biogasmax 2006/2010 the synthesis.*
See www.biogasmax.eu

Toronto, Canada

- **Input/material to be treated:**
- Source – separated household waste
- Operating on demonstration scale since 2006
- Processes 25,000 metric tons/ year
- Operational issues with organic waste only digesters (ammonia inhibition)

Plant at Lillehammer

- Source – separated household waste and food waste from industrial sector.
- Capacity: 14,000 t/a
- For every 1000 kg input, there is approx. 380 kg reject and 150 kg of digestate. The plant makes about 300 kWh of electricity per 1000 kg of post-reject waste.
- Biogas converted to electrical power; THP steam and digester heat.
- In operation since 2001



Conclusions

- LAWPCA built digesters for solids reduction.
- Taking in outside wastes is optional; not banking on it.
- There is competition for wastes – lots of potential digester & composting projects.
- Generators not interested in long-term contracts
- Muncipal AD has benefit of existing infrastructure for managing solids & side stream.
- Phased implementation to taking outside wastes helps operators adjust.

Thank you. Questions?

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