New Technologies and Products for Enhancing the Values of Anaerobic Digestion and Biogas Energy Projects

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Presentation Outline

- Current challenges with using organic residuals as feedstock for anaerobic digesters
- New practices and technologies needed for effective utilization of solid organic residuals and improving the performance and economics of anaerobic digestion systems
- UC Davis Biogas Energy Project for research and demonstration of new anaerobic digestion and effluent treatment technologies

Value Proposition of Digester Systems

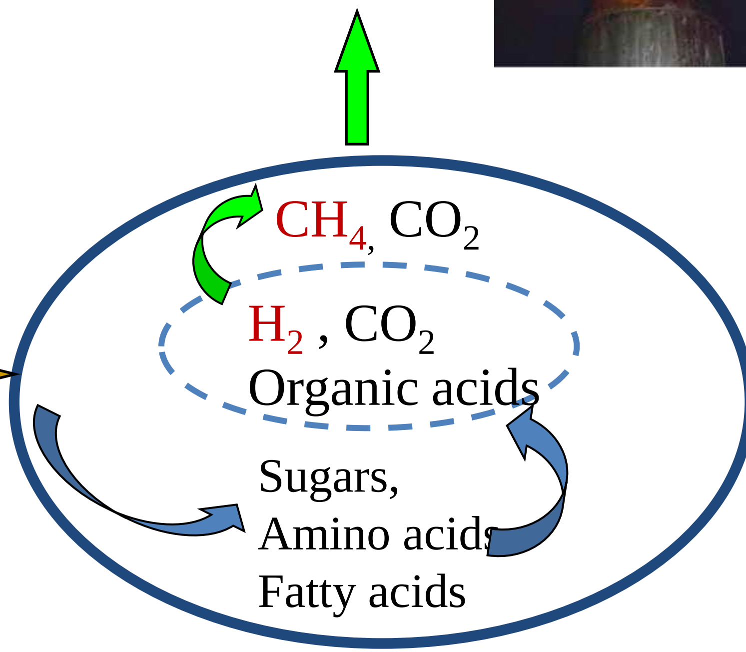
$$$

Biogas
- Electricity and heat
- Natural gas
- Compressed natural gas
- Liquefied natural gas
- Gasoline
- Chemicals

$$$

Feedstock
- Agricultural and Food waste
- Municipal waste

Biogas



$$$

Co-Products from Digester Effluent
- Nutrients
- Fibers
- Water

Anaerobic Digester

$$$

$$$ Carbon Credit
Environmental and Public Health Benefits

Agricultural and Food Waste

Food Processing and Agricultural Residues, Animal Manures,

Food Processing Residuals as Digester Feedstock

- Current Challenges
  - Seasonable production and large quantities in a short time period
  - High moisture content and easy to decompose, causing odor and fly problems
- Future Solutions
  - Effective storage for off season use using ensilage and drying methods
  - Integration with other biomass feedstock supply

Ensilage Silos

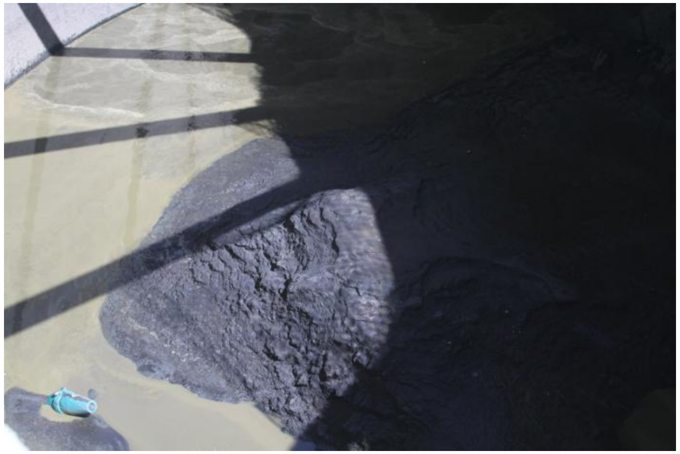
Ensilage Bags

Dairy Manure as Digester Feedstock

Current Challenges

- Low biogas yield compared with other manures and food residuals
- Too much water added into the manure, resulting in low solids (<2% TS) and nutrient contents (<0.1% N), making most digesters and nutrient recovery from digestate not economical
- Sand and grit/soil in the manure, causing sediment in digesters and abrasion problems for equipment

Flushed Dairy Manure



Sand in Digester

Dairy Manure as Digester Feedstock

Future Solutions

- Use scrapers or vacuum truck for manure collection
- Use manure solids and/or other fibers for bedding
- Use lining materials for feedlot and manure storage areas
- Co-digest manure with other organic residuals (cheese and food waste)

Vacuum Truck for Manure

Scraped Manure for Digesters

Crop Residues as Digester Feedstock

Current Challenges

- Seasonable production
- High fiber and lignin content, requiring long digestion time
- low nutrient content, requiring nutrient supplement

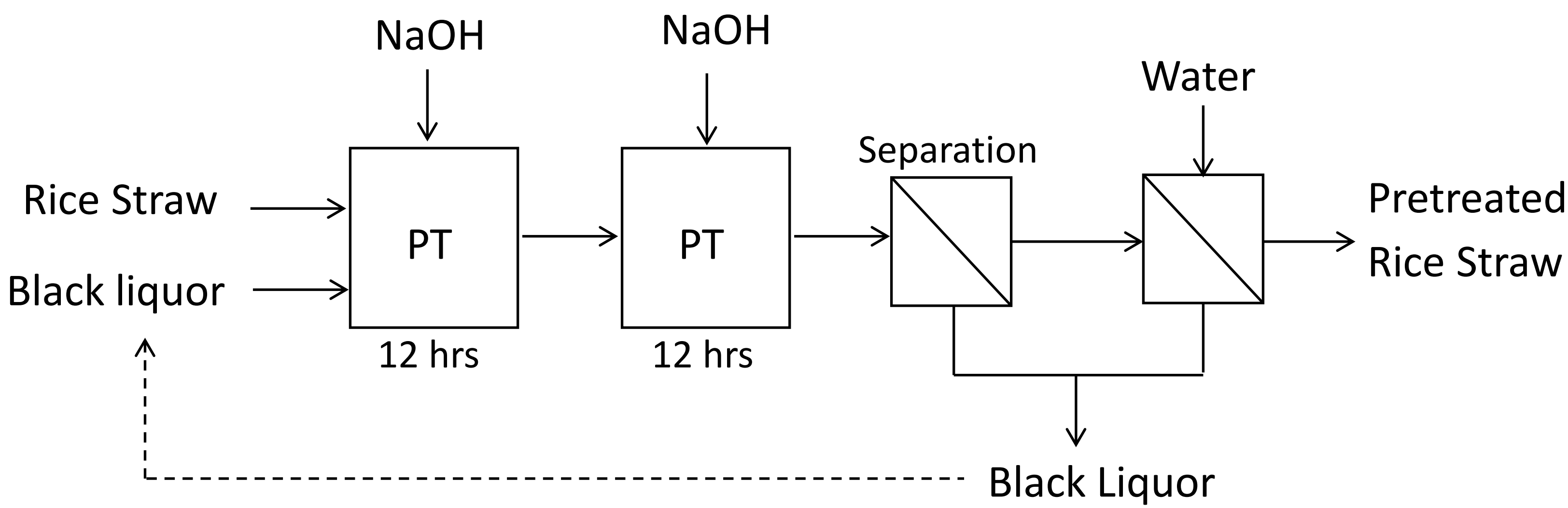
Future Solutions

- Effective pretreatment for increasing the digestibility and biogas yield (heat and alkaline pretreatment)
- Co-digestion with manure and/or food waste

Baled Wheat Straw

Baled Corn Stover

UC Davis New Pretreatment Technology: Two-step Alkaline Pretreatment



Alkaline Pretreatment

Chemicals: Sodium Hydroxide (NaOH), Potassium Hydroxide (KOH), Lime (Ca(OH)2)

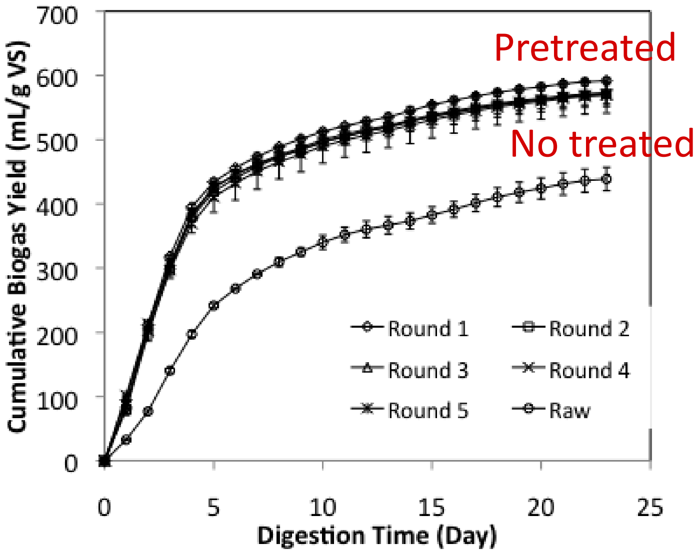
Functions: Solublize the lignin to allow removal;

Swell and break the fibers to make them more digestible,

Increasing Biogas Yield of Rice Straw by Alkaline Pretreatment (UCD Research)

Pretreatment conditions:

- Rice Straw at 10% total solid
- 10% NaOH based on straw dry weight
- 25 degree C, 24 hours
- black liquor and water recycling



Biogas Yield Increase:

40-50% compared to non-treated straw

Municipal Solid Waste as Digester Feedstock

Current Challenges

- Contamination by plastics, metals, rocks, etc., requiring separation
- Highly variable in quantity and composition

Municipal Solid Waste as Digester Feedstock

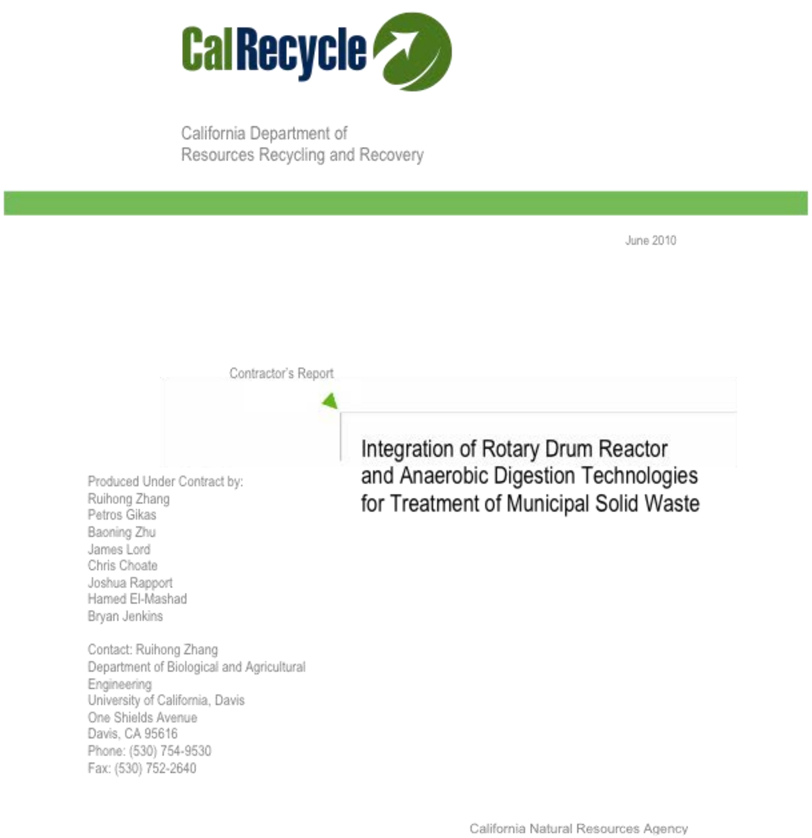
Future Solutions

- Apply effective pretreatment and separation technologies to recover biodegradable organic materials




UC Davis Research on Use of Rotary Drum Reactors as Pretreatment Process for Anaerobic Digesters

- Surveyed six municipal waste treatment plants in US
- Collected design, operational and cost information
- Analyzed the organic materials separated from MSW for solids, nutrient, metals, digestibility and biogas and methane yields
- Designed and tested integrated RDR-Anaerobic Digester system


CalRecycle

California Department of
Resources Recycling and Recovery

June 2010

Contractor's Report

Integration of Rotary Drum Reactor and Anaerobic Digestion Technologies for Treatment of Municipal Solid Waste

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California Natural Resources Agency

http://www.calrecycle.ca.gov/Publications/D
uments/Organics%5C2010004.pdf

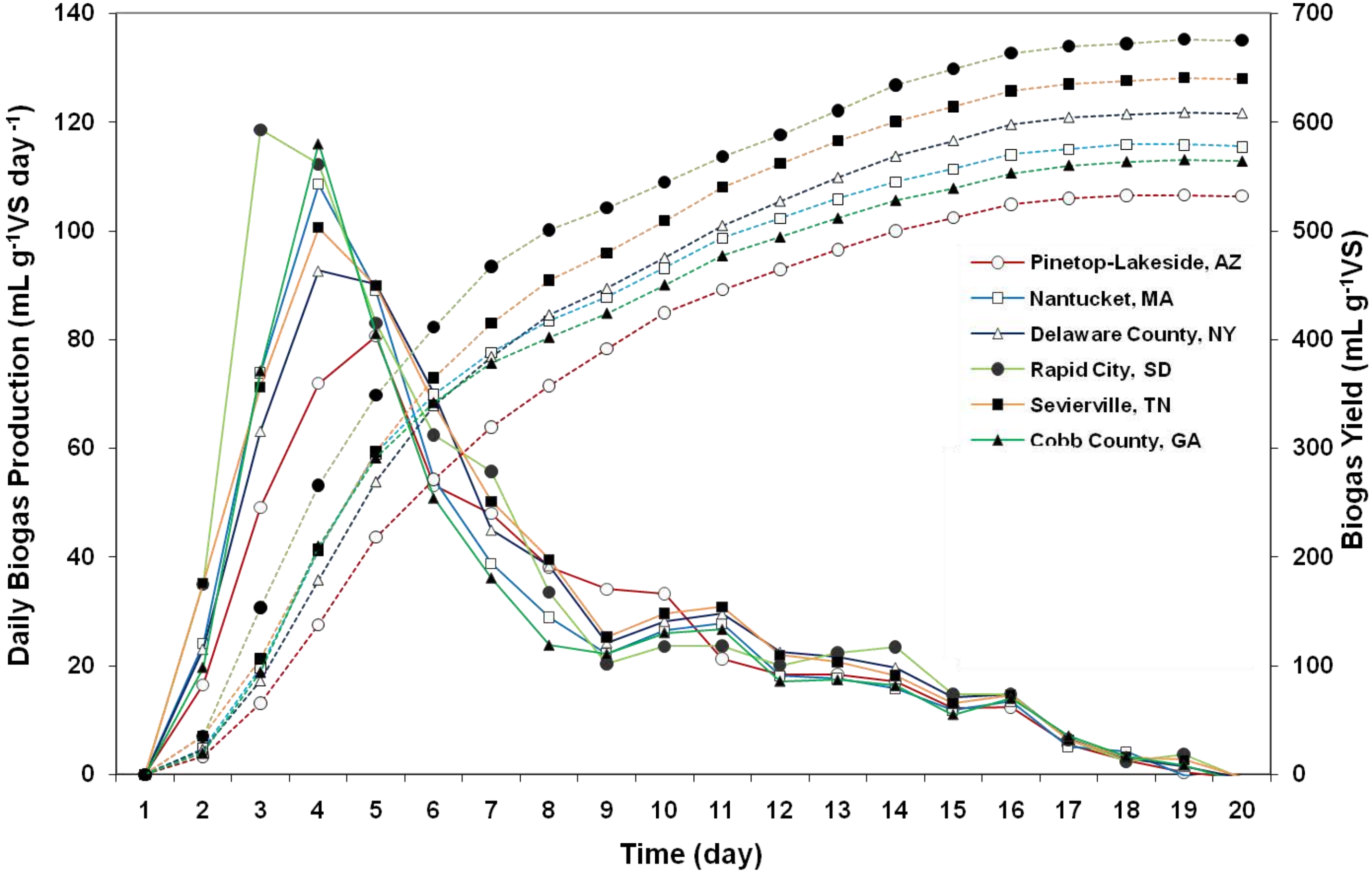
RDR Treated Waste Samples from Six Municipal Waste Treatment Plant

Characteristics of Organics Recovered from MSW via RDR Process

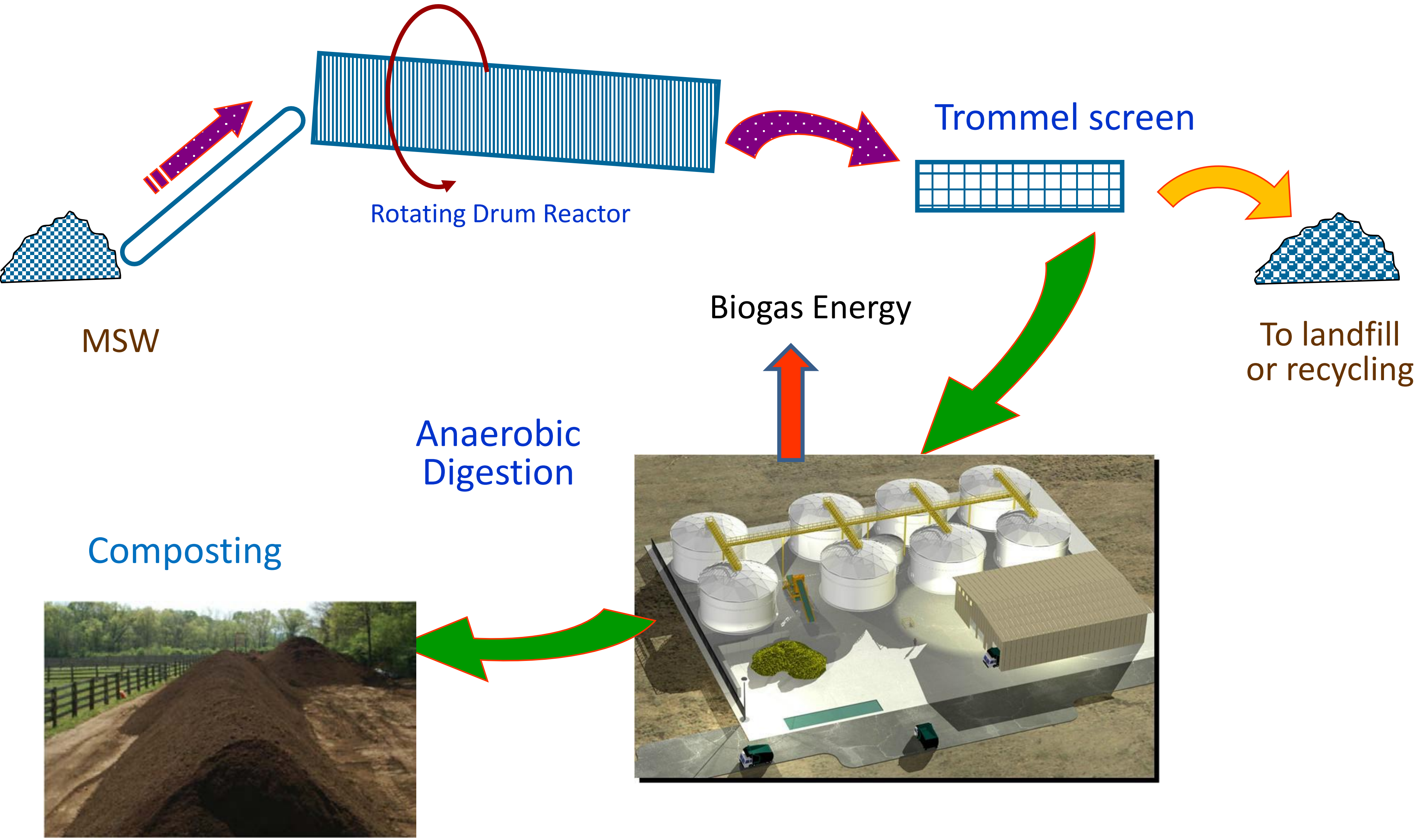
RDR Facility	MC (%)	TS (%)	VS (%)	VS/TS	C (%)	N (%)	C/N
AZ	50.6	49.4	34.8	0.71	35.3	1.44	24.5
MA	44.4	55.6	41.3	0.74	37.6	0.92	40.9
NY	56.1	43.9	32.7	0.75	37.3	1.03	36.5
SD	52.3	47.8	34.8	0.74	37.1	0.88	42.7
TN	52.3	47.7	38.6	0.81	39.5	1.08	36.9
GA	64.8	35.2	27.0	0.77	38.5	1.09	35.4

TS-total solids, MC-moisture content, VS-volatile solids, C-carbon, N-Nitrogen

Daily Biogas Production and Biogas Yield During Batch Thermophilic Digestion



Integrated RDR-Anaerobic Digester System



Solid Waste Digestion Technologies

- Current status
  - Europe has several technologies in commercial use for more established markets.
  - US has the first commercial technologies for emerging markets
- Opportunities
  - Digester technology implementation and integration of digestion with waste preprocessing and composting operations
  - US project and business models

Expectations
for New Digester Technologies

- Capable of handling multiple and variable biomass feedstock of high solids content from different supply sources and at different times
- Can be easily scaled up and down
- Easy to operate and maintain (automation)
- High conversion efficiencies and smaller foot prints
- Affordable cost

UC Davis Biogas Energy Project

n Solids Digester and Biogas Energy Technologies

Digester capacity – 3-5 tons per day,

Digestion temperature – 125-135 F , Digester volume – 50,000 gal

Expected biogas yield –350-583 m^3/day,

Electricity output – 600- 1200 kWh/day

UC Davis Biogas Project Sponsors And Major Partners

State of California Energy Commission

PIER Public Interest Energy Research "Research Powers the Future"

clean world PARTNERS

CalRecycle

ONSITE POWER SYSTEMS INC.

U.S. DEPARTMENT OF ENERGY

Campbell's CREATING Possibilities

Recology WASTE ZERO

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OTTO CONSTRUCTION

FMB FRANK M. BOOTH DESIGN BUILD CO.


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BIOGAS ENERGY PROJECT
THIS PILOT PROJECT WAS MADE POSSIBLE THROUGH THE CONTRIBUTIONS OF
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Pilot Testing with Food Processing Residuals from Campbell Soup

Food Waste (Average):
Moisture – 80%
Total Solids – 20%
Volatile Solids – 19%

APS-Digester Performance

- Digester testing with 200 tons of food processing residuals from June 2008 to April, 2009
- Digester Performance Summary:
  - Solids reduction in food waste:

    89.5% for total solids, 90% for volatile solids
  - Biogas production: average 4,600 ft^3/ton (wet)
  - Methane production: average 2760 ft^3/ton (wet) (7 ft^3/lb VS)
  - Energy content in biogas: 27 therm/ton (wet)
  - Biogas composition: 55-60% methane, 2-5% hydrogen
  - Digester pH: 5-7 for hydrolysis reactor and 7-8 for biogasification reactor.

Pilot Testing for UC Davis Renewable Energy Anaerobic Digestion (READ) Project

Food Waste

Dairy Manure

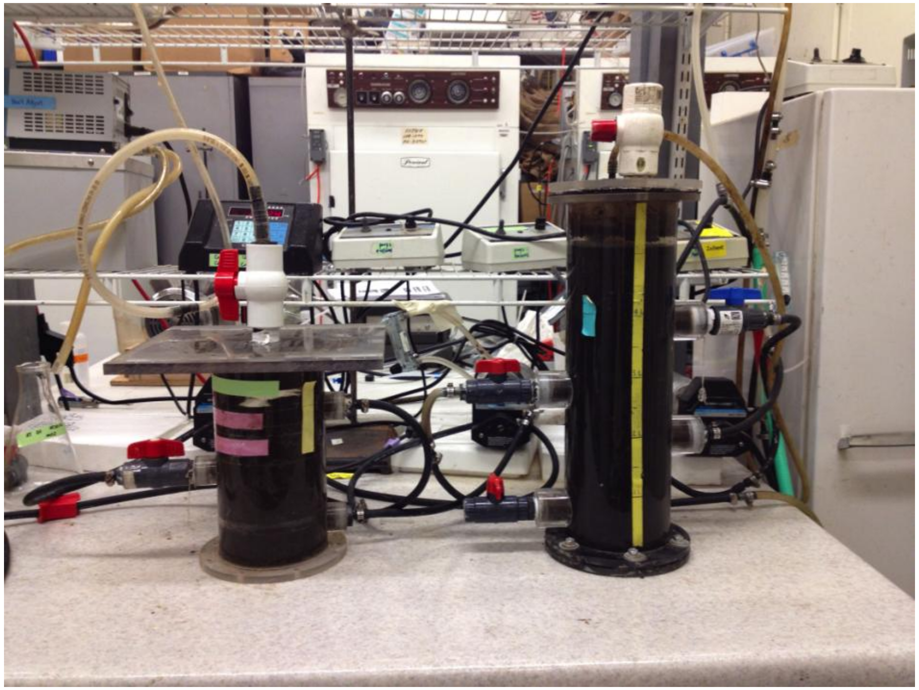
APS Digester Performance

- Digester testing with UC Davis food waste and dairy manure from 5/15 to 7/20, 2012.
  - 65 tons : 39 tons of dairy manure and 26 tons of food waste
  - Dairy manure: 16-55% total solids (32% ave.)

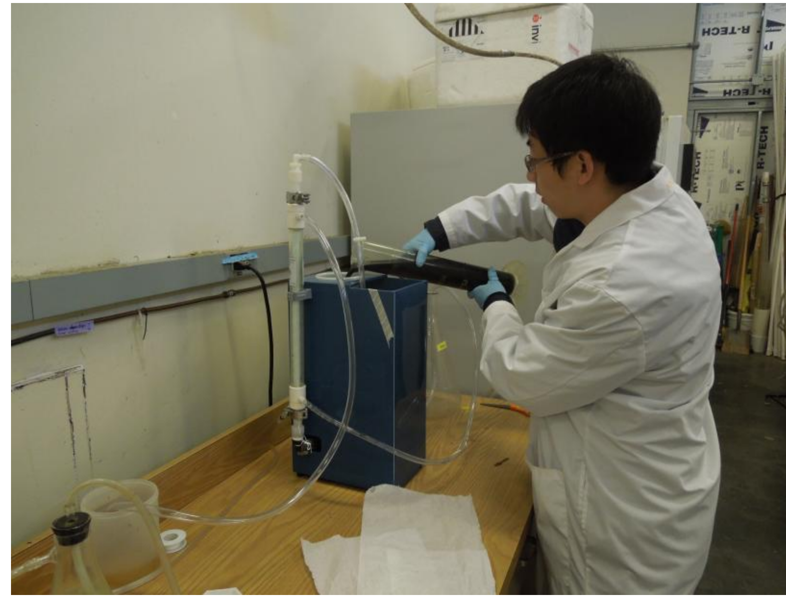
    10-24% volatile solids (16% ave.)
  - Food Waste: 10-34% totals solids (25% ave.), 9-32% volatile solids (24% ave.)
  - Biogas yield: 0.61 L/gVS (ave.) or 9.82 SCF/lbVS
  - Methane content of biogas: 62% (ave.)

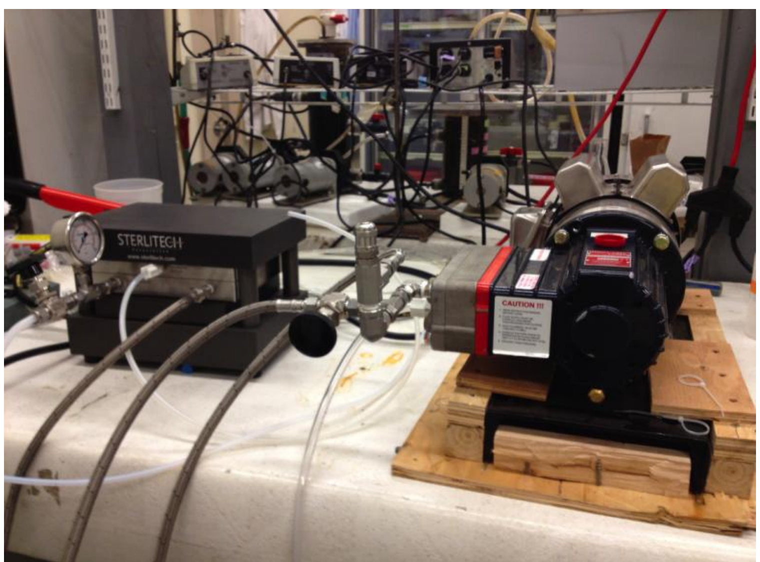
Digester Effluent Treatment for Fiber, Nutrient and Water Recovery

- Solid and Liquid Separation
  - Reduce solids content in liquid effluent and recover fibers for compost
- Aerobic Treatment
  - Reduce organic and solids content, and partially oxide ammonia into nitrate
- Filtration and Membrane Separation
  - Microfiltration to separate suspended solids from liquid
  - Reverse Osmosis for separating nutrients from water



Aerobic Reactors

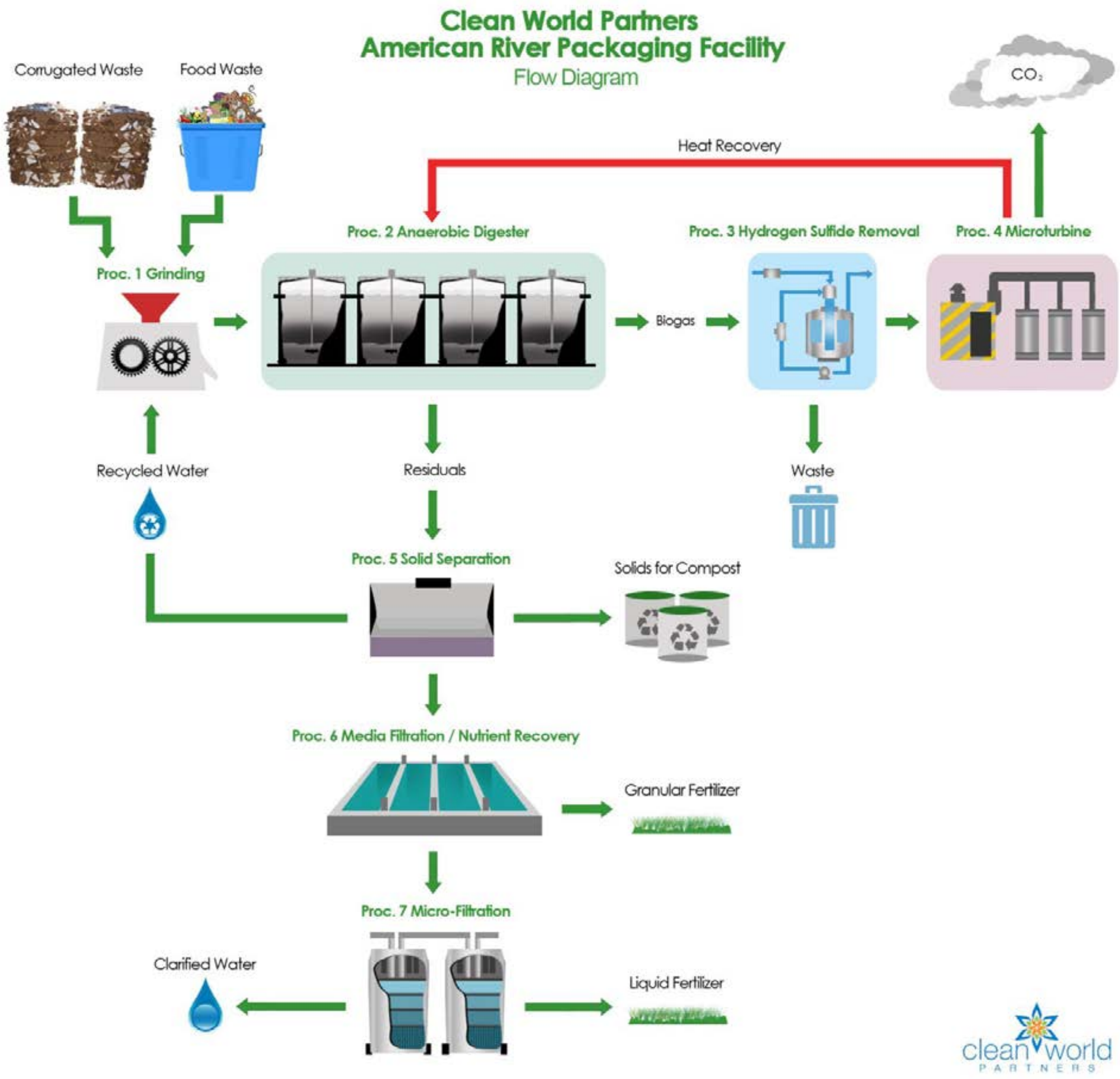




Membrane Separation Testing Unit

Digester Effluent before and After Filtration

Clean World Partners Waste Recycling Center



UC Davis and CleanWorld Renewable Energy Anaerobic Digestion (READ) Project

UC Davis: Moving towards zero waste

- Phase I - 25 tons per day souce separated organics , including animal manures and bedding, food waste, papers, etc.
- Phase II – 35 to 50 tpd separated organics from MSW
- Allow other surrounding communities to use digester system
- Producing electricity to feed its net zero West Village community

Potential Biomethane Production

- Total Daily Production: 108,595 SCF/day
  - 59,520 SCF/day from source separated organics
  - 49,075 SCF/day from MSW
- Total Electricity Generation: 16,516 kWh/day (assuming 50% efficiency for fuel cells)
  - 9,275 kWh/day from source separated organics
  - 7,241 kWh/day from MSW

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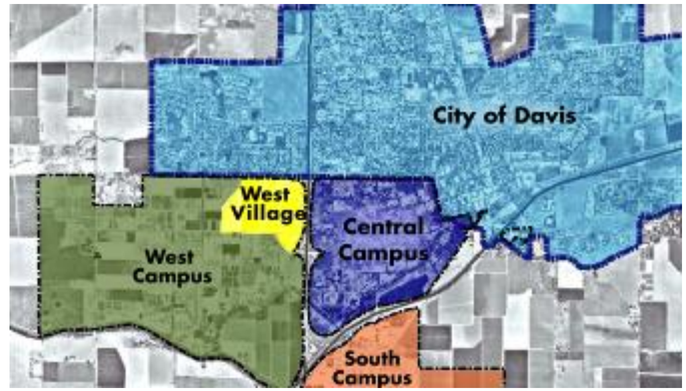

WEST VILLAGE

A Zero Net Energy Community

ENERGY INITIATIVE

PROGRAM

Incorporate energy efficient building design and technologies to decrease community energy consumption.

REDUCE

PRODUCE

Convert locally-available renewable resources from sun and food waste into energy to power the community.

Successful Technology Development and Commercialization

- Research innovation and technology development
- Public and private investment and partnership
- Competent and effective technical, management, and business development teams
- Favorable policy and market environment