Converting Food Leftovers into Energy and Fertilizer Resources

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Food Leftovers:
Food Processing Residues, Food Scraps













Bioenergy From Food Waste

(Energy, Environmental, Public Health and Economic Benefits)

- Produce low carbon fuel for renewable energy
- Divert waste from landfill
- Reduce air and water pollution, greenhouse gas emissions
- Create jobs and economic development





California Renewable Energy Porfolio and Bioenergy Feed-in Tariff

- Renewable energy currently accounts for 20% of total electrical energy supply
- Renewables Portfolio Standards (RPS) requires that all electricity retailers in the state provide 33% of electricity with renewables by the end of 2020.
- SB1122 requires 250 MW of Bioenergy Procurement by Electrical Utilities,
  - 110 MW biogas energy from municipal and food waste sources,
  - 95 MW from dairy waste
  - 45 MW from forest waste

Other California Policy Drivers for Bioenergy Development (McKinney, 2014)

Policy Objectives	Policy Origin	Goals and Milestones
GHG Reduction	AB 32, California Global Warming Solutions Act	Reduce GHG emissions to 1990 levels by 2020 and 80% below 1990 levels by 2050 in California
Petroleum Reduction	California *State Alternative Fuels Plan*	Reduce petroleum fuel use to 15% below 2003 levels by 2020 in California
In-State Biofuels Production	California *Bioenergy Action Plan*	Produce in California 20 percent of biofuels used in state by 2010, 40 percent by 2020, and 75 percent by 2050
Low Carbon Fuel Standard	AB 32	10% reduction in carbon intensity of transportation fuels in California by 2020
RFS2	Energy Policy Act of 2005, Energy Independence and Security Act of 2007	36 billion Gallons of renewable fuel by 2022
Air Quality	Clean Air Act	80 percent reduction in NOx from current levels by 2023
ZEV Mandate	California Executive Order B-16-2012	Accommodate 1 M EVs by 2020 and 1.5 M by 2025 in California

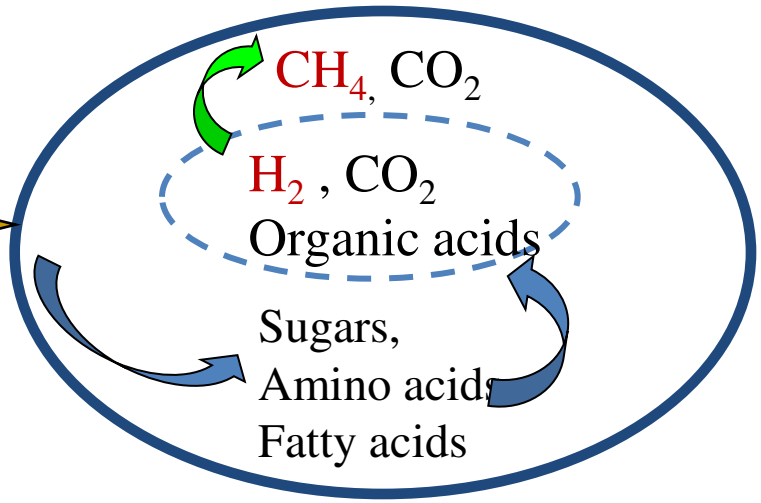
Anaerobic Digestion

Biogas Energy

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



Biogas



Organic Waste

- Food
- Green
- Agricultural



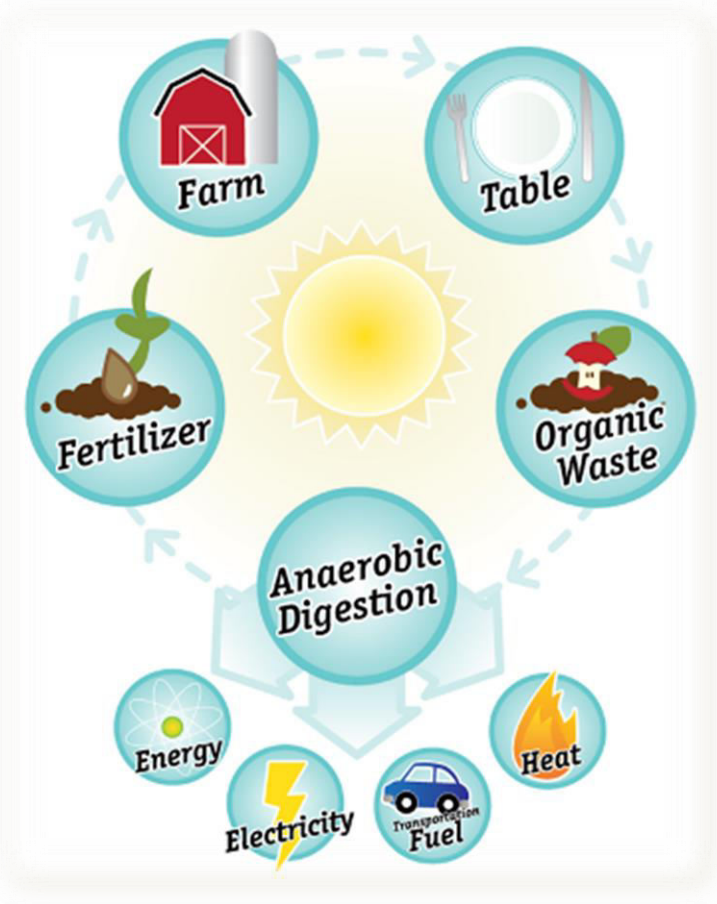
Digester Effluent

- Nutrients
- Fibers
- Water

Anaerobic Digestion

Anaerobic Digestion
Benefits Energy, Environment and Health

- Reduce organic waste – food, green and agricultural – from landfills;
- Produces bioelectricity, heat & renewable Compressed Natural Gas to power homes and vehicles;
- Converts byproducts to valuable organic soil amendments for farming; and
- Captures greenhouse gases & other harmful emissions.



UC Davis Biogas Energy Project

- Research and demonstration of anaerobic digestion and biogas energy technologies for converting various organic residuals into biogas energy and biobased products
- Public education on waste to energy conversion and resource management



UC Davis Biogas Project Sponsors





















High Solids Anaerobic Digestion Technology Developed at UC Davis

- Thermophilic digestion (three stage)
- Capable of treating a variety of organic solid waste
- Fast digestion rate and short retention time
- High biogas energy output
- Destruction pathogens in waste, producing safe biofertilizers

Lab to Commercial Scale Up for the High Solids Anaerobic Digestion (HSAD) Technology

Microbiology
Biodigester
Engineering

Determine digestibility

Pilot Design

Feedstock Demonstration

Pilot Construction

Pilot Testing

Effluent digester Stability

Economic and Environmental Analyses

Design of commercial plant



2000 2004 2005 2007 2008 2010 2011 2012







Commercialization By CleanWorld

Concept development laboratory testing

0.5-6 Gallons

Process scale-up
Pilot testing

50,000 Gallons

Engineering design
Equipment selection
Construction,
Operation,Monitoring,

>300,000 Gallons

UC Davis Biodigester:
Powering Campus with Food Waste



Jointly developed by CleanWorld and UC Davis

UC Davis Biodigester for Waste to Energy Conversion

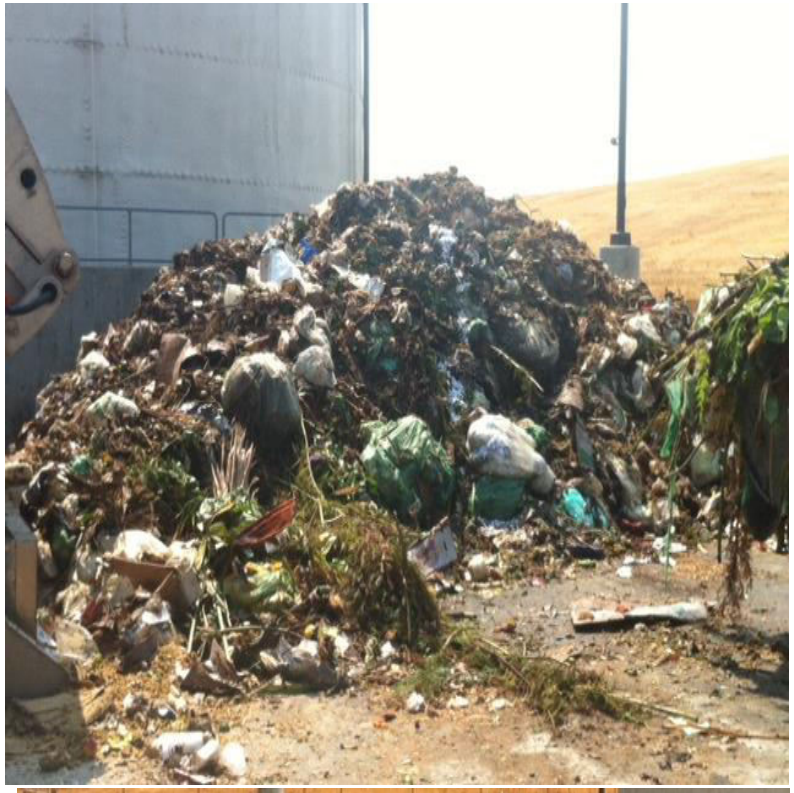
- Designed to treat 50 tons per day organic waste with electrical generation capacity of 690 kW from biogas.
- Additional 235 kW electrical generation capacity provided from landfill gas.
- Anaerobic digestion: a three stage thermophilic anaerobic digestion system with 450,000 gallon digester working volume
- The biogas cleanup: water vapor via chiller, H_2S via iron sponge, siloxanes and volatile organic carbons via carbon filter
- Energy conversion: four Capstone C200 Microturbines (each rated @ 200 kW) for co-generation of electricity and heat and an organic Rankine-cycle (ORC) engine-generator (rated @ 125 kW) for converting waste heat from the microturbines into additional electricity

Renewable Energy Anaerobic Digestion Facility – UC Davis Biodigester



Operation Since January 2014

Digester Feedstock:
Food Waste
Animal Waste









Public Education with UC Davis Biodigester



Providing Bioenergy to West Village A Zero Net Energy Community



Sacramento BioDigester

Project Host Partner: Sacramento County

- Treats 40,000 tons per year of food waste, producing RNG to fuel trucks and buses
- Produces 700,000 diesel gallon equivalents per year of renewable natural gas for area fleets
- Produces valuable soil amendments for area farms





CleanWorld Biodigester System
Sacramento, California



Renewable Natural Gas Production and Fueling Station









Fertilizer and Soil Products from Digestate

- Custom design soil products according to plant needs
  - Nutrients
  - Microbes
  - Pathogen free











Testing Digestate As Organic Fertilizer Products

Testing Variables

- Digestate dilution
- Application rate
- Application schedule

Measurement

- Plant size
- Plant biomass
- Chlorophyll in leaves
- Nutrients uptake
- Soil properties



Application of Digestate Fertilizer Products





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2012-13 SIERRA MAGAZINE

CleanWorld

Alive with possibilities



