Biogas Production Technologies

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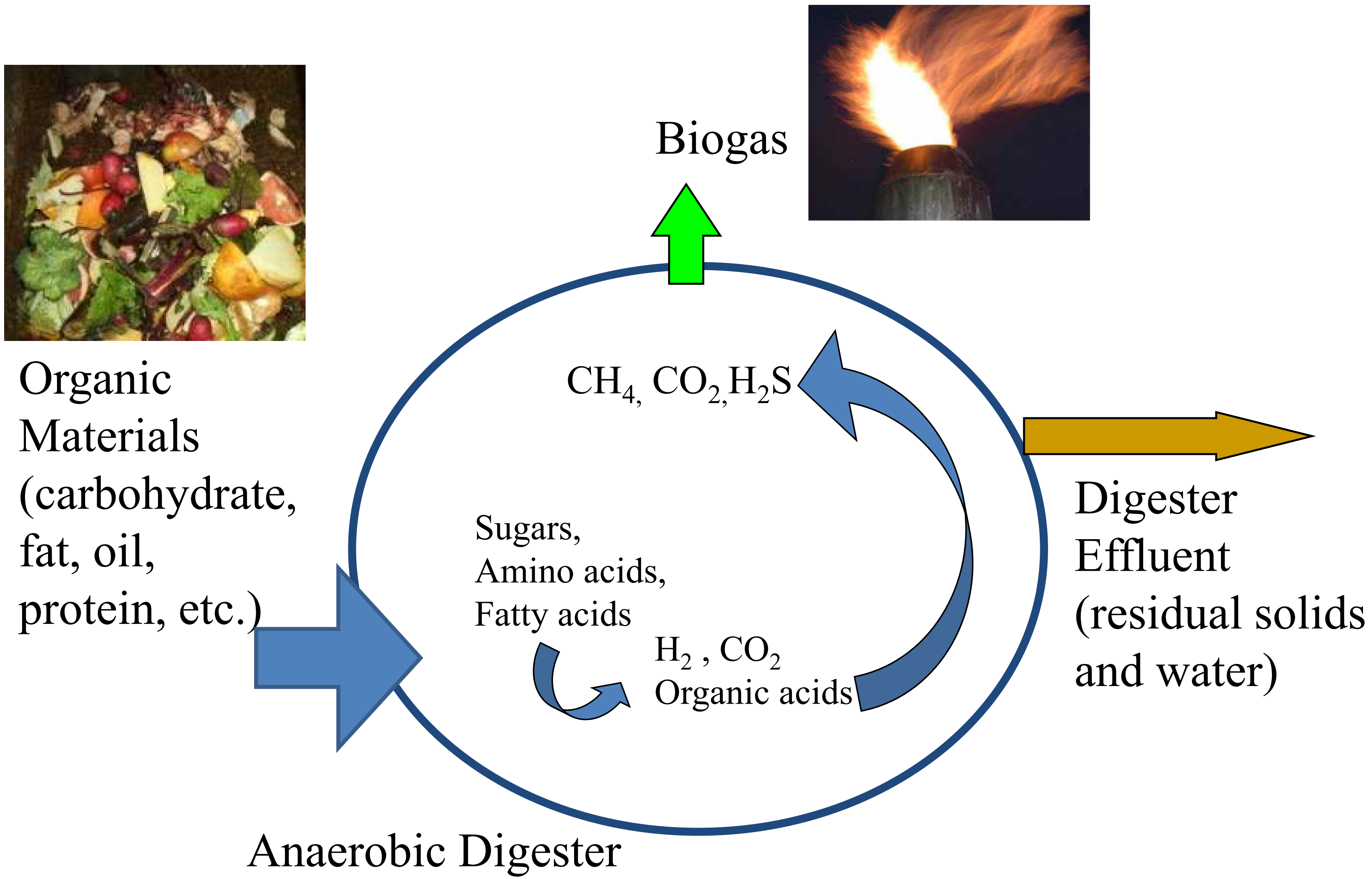
Biogas and Fuel Cell Workshop
National Renewable Energy Laboratory
June 12, 2012

Presentation Outline

- Status of anaerobic digestion technologies and opportunities for further development
- New UC Davis solid waste digestion technologies applied to commercial projects

Anaerobic Digestion



Typical Biogas Composition

Compound	Chem. formula	%
Methane	CH_4	50-70
Carbon dioxide	CO_2	30-49
Nitrogen	N_2, NH_3	0-1
Hydrogen	H_2	0-5
Hydrogen sulfide	H_2S	0.1-0.3
Water	H_2O	Saturated

Energy Content: 500-700 Btu/SCF

Factors Influencing Biogas Composition

- Feedstock composition
  - Methane and carbon dioxide: carbon, oxygen and hydrogen contents
  - Ammonia – nitrogen content
  - Hydrogen sulfide and organic sulfur – sulfur content
  - Siloxanes – municipal solid waste and wastewater
- Anaerobic digestion technologies
  - Wastewater digesters
  - Solid waste digesters

Wastewater Digestion Technologies

- **Current status**
  - Well established for treatment of sewage, animal manure (swine and dairy), and some food processing wastewater
  - Common technologies: covered lagoon, completed mixed digester, plug flow digester, upflow sludge blanket reactor (UASB)
- **Opportunities for new technology development**
  - Creative digester design and integration of unit operations to provide higher energy efficiencies and more capabilities to handle variable influent
  - Co-digestion of different wastes (e.g. food waste with sewage or manure)

Wastewater Digesters

Green GILLS ONIONS
SUSTAINABILITY SUCCESS PROGRAMS

Biogas Energy from Onion Waste

- Biogas powers two 300-kW fuel cells, generating 0.6 MW of electricity.
- Satisfies 95% of Gill's base load requirements

Digester processes 30,000 gal of onion juice per day,
Producing biogas containing 70% methane

Fuel Cells become the most innovative, practical solution to fulfill our needs

• High fuel-to-electricity conversion rate: 47 - 50% efficiency
•Utilizing waste heat from fuel cells will push overall efficiency to 90%

• Elimination of 40,000 gallons diesel fuel to haul onion waste to fields
• AB 32 compliance - reduced GHG Emissions

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

Solid Organic Residuals:

Food Processing and Agricultural Residues, Animal Manures, Municipal Solid Waste,

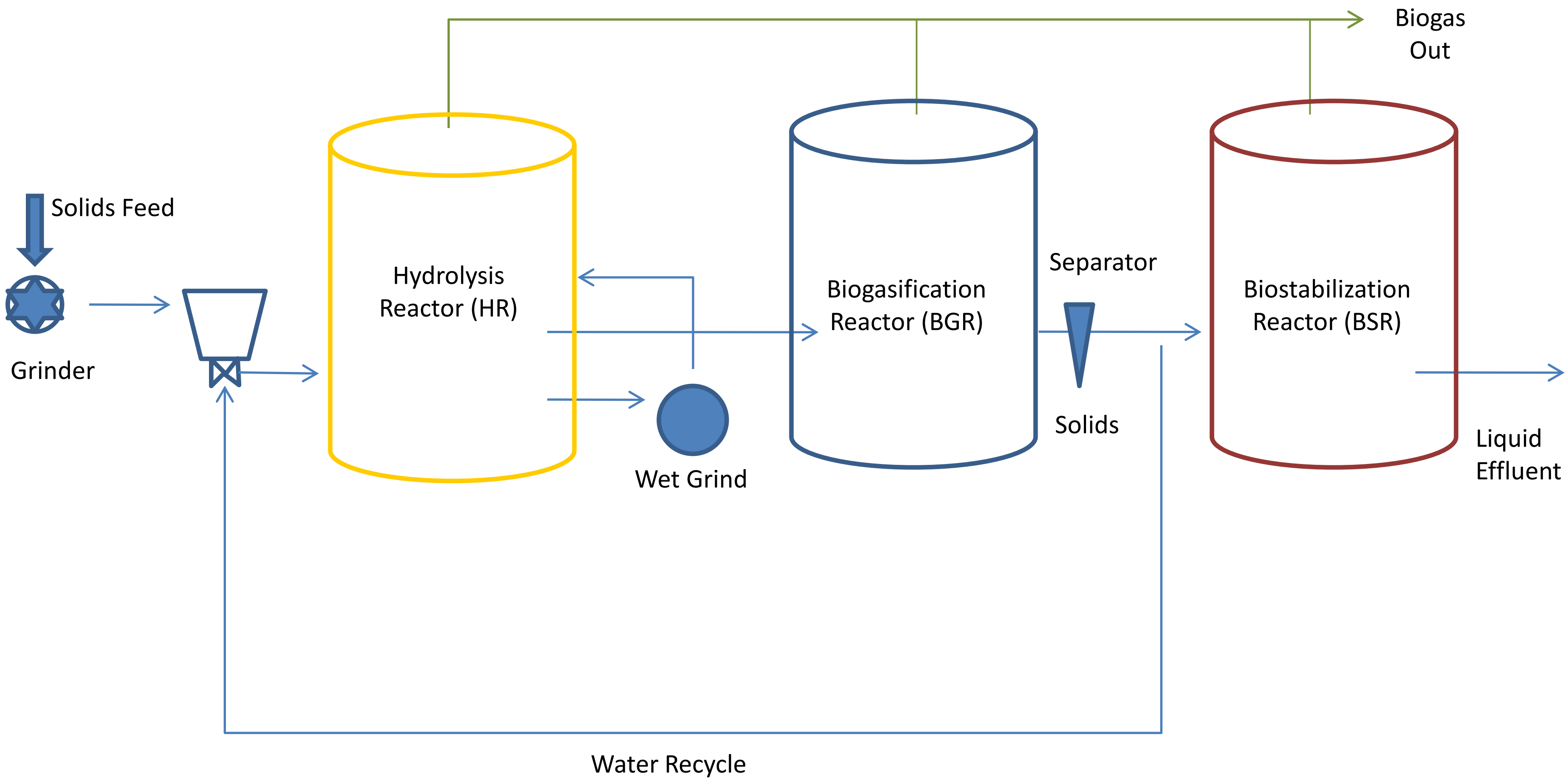
A Real Problem with Solid Waste

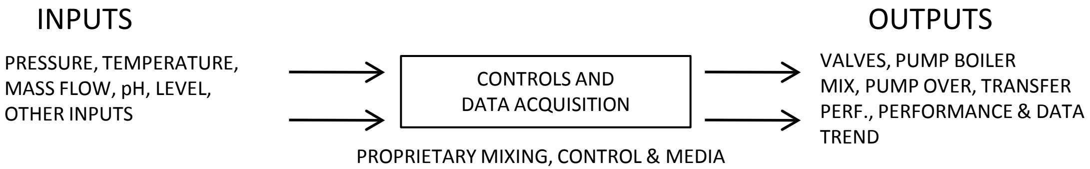
- Millions of tons of organic waste dumped in landfills every year result in harmful greenhouse gas (GHG) emissions
- Mandates require businesses producing high volumes of organic waste to seek more sustainable waste disposal solutions
- Businesses have committed to sustainability and are now scrambling to follow through
  - Wal-Mart: Zero waste by 2014; all suppliers must report waste and greenhouse gases http://walmartstores.com/sustainability/9292.aspx
  - Campbell: new sustainability policy http://www.campbellsoupcompany.com/csr/planet.asp
- Anaerobic digestion (AD) of organic solid waste has not been successfully implemented in the US to date in commercial scale

UC Davis Technology
High Rate Digester (HRD)

- Three stage anaerobic digestion
- Allows for high system stability regardless of fluctuations in loading and waste composition
- Provides even gas production and rapid waste digestion
- Well suited for treating highly degradable solids waste streams, such as:
  - Municipal food waste
  - Food processing waste
  - Animal manure
  - Crop residues

HRD: High Rate Digester





UC Davis Biogas Project

Anaerobic Digester Demonstration System

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

Clean World Partners Built the First Commercial Digesters for Food and Paper Waste at American River Packaging, Sacramento

www.cleanworldpartners.com


Clean World Partners Project

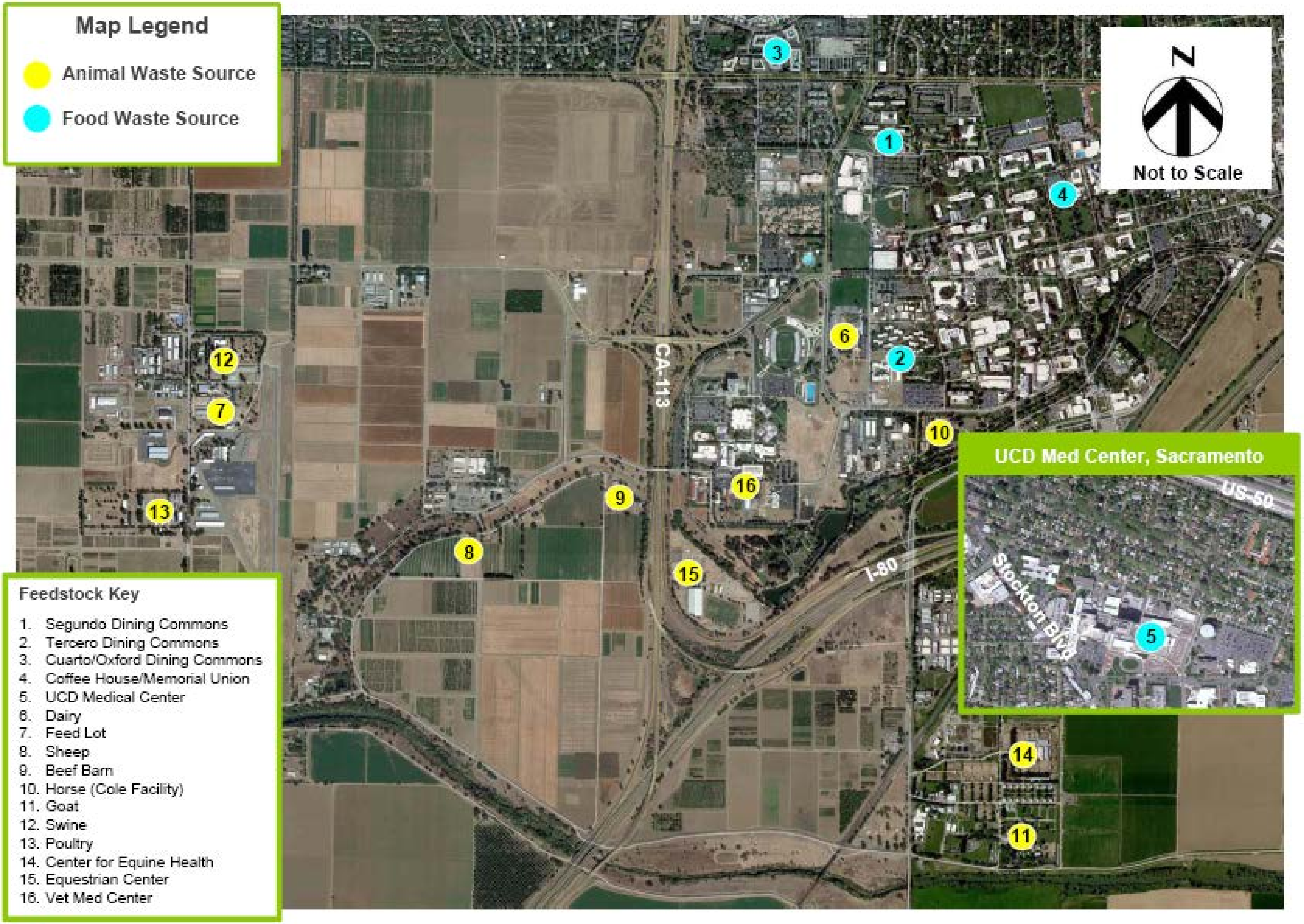
American River Packaging (ARP): Packaging manufacturer with corrugated waste

- 8 tons per day (0.5 cardboard and 7.5 tons food waste)
- System size 10 tpd (accounting for paper absorption)
- Producing 1300 kWh per day of electricity with micro-turbines for use on site
- Food waste coming from local food processors
- System continuously operating since March 16, 2012

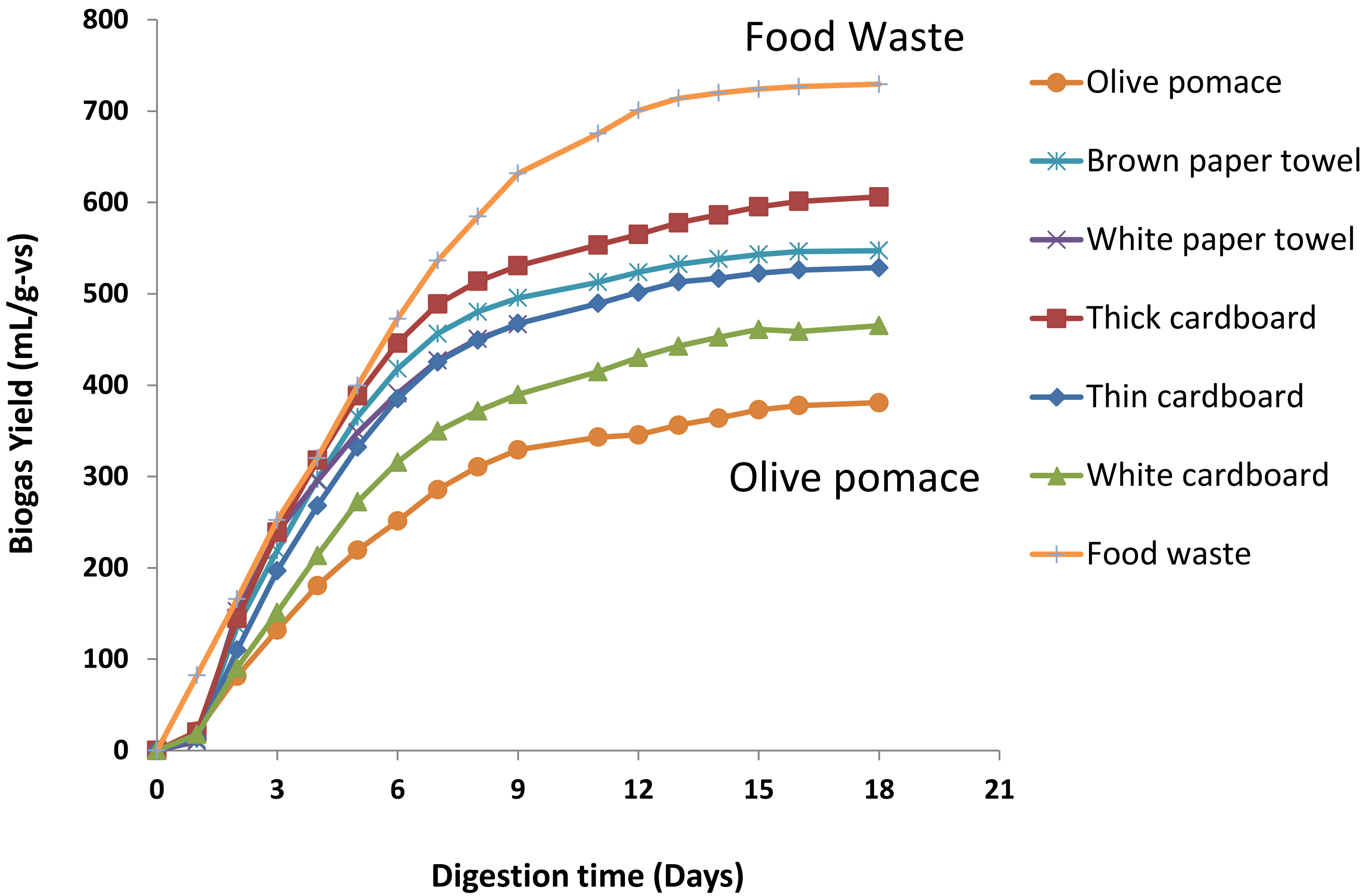
UC Davis Renewable Energy Anaerobic Digestion (READ) Project

UC Davis: Moving towards zero waste

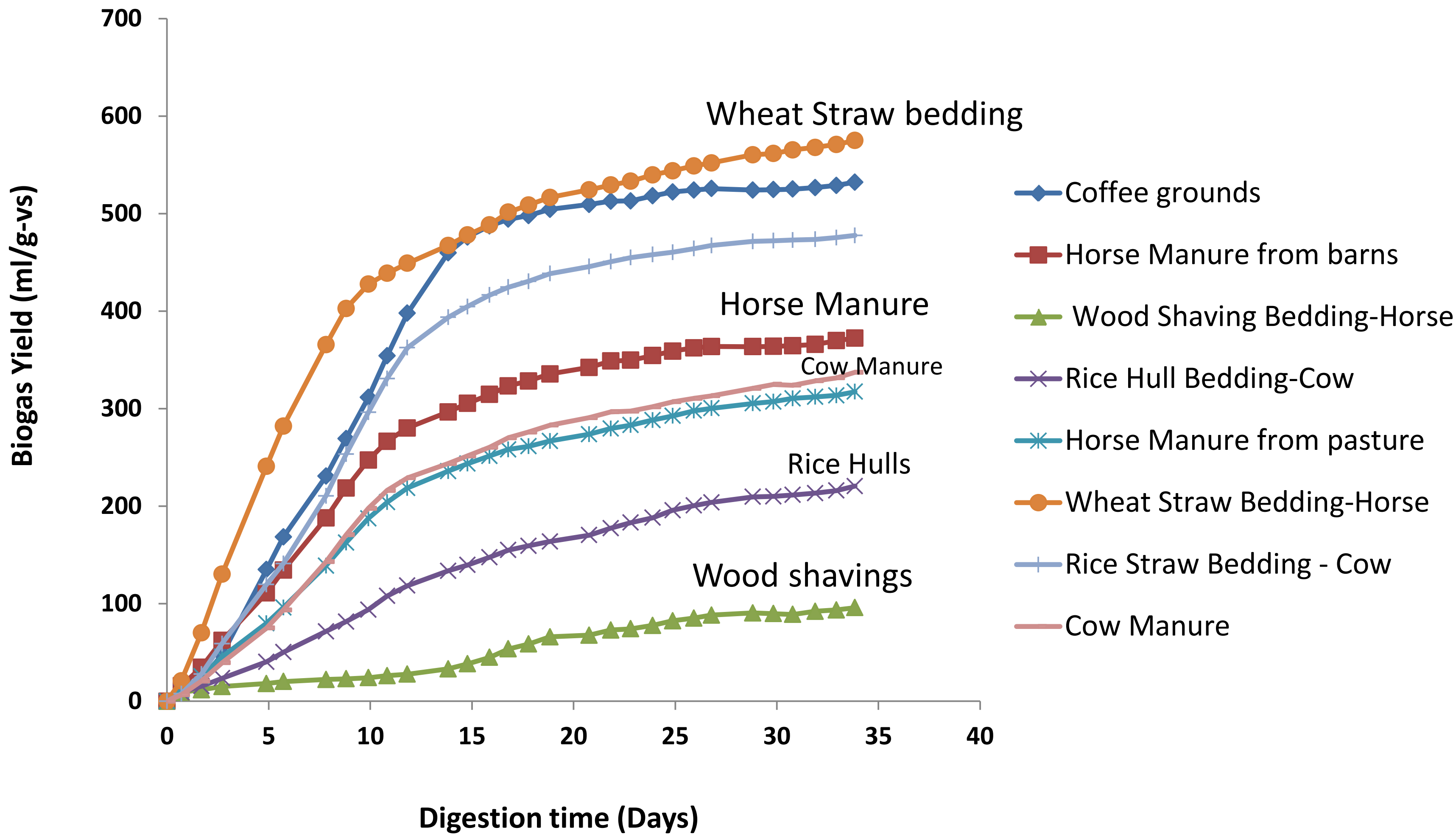
- Phase I - 25 tons per day manures from campus and food waste from campus dining facilities
- Phase II – 35 to 50 tpd separated organics from MSW
- Allow other surrounding communities to use digester system
- Combining landfill collection and digester gas streams
- Producing electricity to feed its net zero community
- Sophisticated preprocessing system
- Opening December 2012


Map Legend
Animal Waste Source
Food Waste Source
N
Not to Scale
CA-113
I-80
UCD Med Center, Sacramento
US-50
Stockton Blvd
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Feedstock Key
1. Segundo Dining Commons
2. Tercero Dining Commons
3. Cuarto/Oxford Dining Commons
4. Coffee House/Memorial Union
5. UCD Medical Center
6. Dairy
7. Feed Lot
8. Sheep
9. Beef Barn
10. Horse (Cole Facility)
11. Goat
12. Swine
13. Poultry
14. Center for Equine Health
15. Equestrian Center
16. Vet Med Center

UC Davis Campus Biomass Feedstock Biogas Yield



UC Davis Campus Biomass Feedstock Biogas Yield



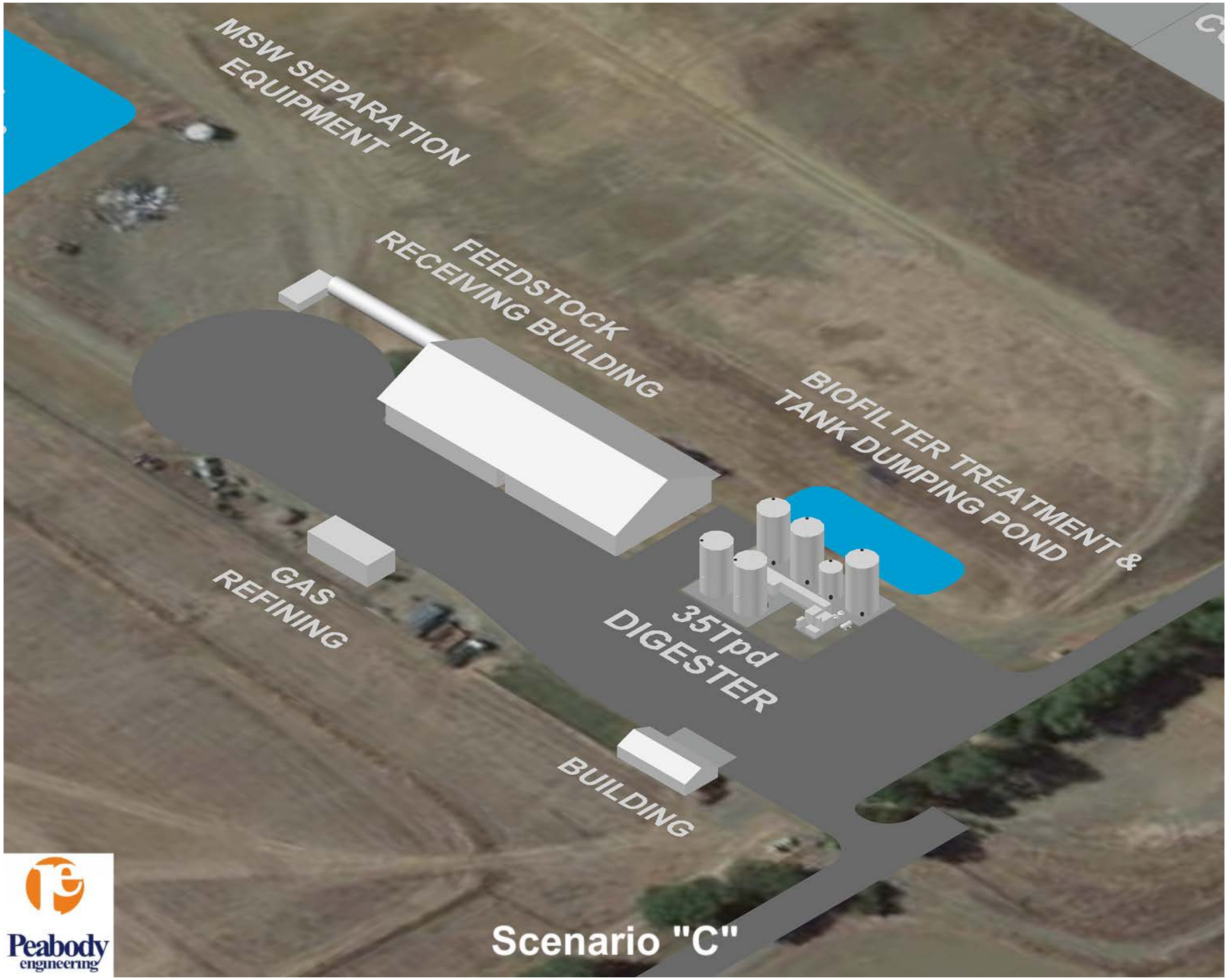
Potential Biomethane Production

- 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

Food Waste
from Dining Commons

Dairy Manure

UC Davis READ Project



Successful Technology Development and Commercialization

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