Municipal Utility Food Industry
BioEnergy Projects

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Sacramento Municipal Utility District

8th Annual Forum of the California Biomass Collaborative
Biomass Energy in California: Where Do We Stand?

April 5-6, 2011
UC Davis Conference Center
Overview:

- SMUD
- Drivers
- SMUD’s Renewable Energy Mix
- Biogas Resource Assessments & Opportunities
- Biogas Projects
- Summary
Publicly Owned (Sixth Largest in U.S.)

Service area of 900 square miles, serving 1.4 Million (Sacramento County and parts of Placer)

Over 595,000 Residential, Commercial and Industrial customers

Record peak demand-3,299 MW on July 24, 2006

1st in customer satisfaction survey for the last 9 consecutive years (J.D. Power & Associates Survey)
What Is Driving SMUD’s Biogas Interest?

- **GHG regulations**
  - Reshaping energy supply
  - Prompting biogas development
  - Climate change

- **RPS- & IRP-driven biogas energy additions**
  - Pipeline injection
  - Local biogas development

- **Other Environmental Concerns**
  - Health and Safety Issues
  - Odors & Flies
  - Emissions from disposal practices (NOx, H₂S, etc)

- **Loss of Energy Resources**
  - Electricity and heat
  - Transportation fuels
SMUD’s Renewable Supply Goals

- **Aggressive Renewable Supply Goals**
  - 23.9% (20% RPS, 3.9% Greenergy) by 2010
  - 37% (33% RPS, 4% Greenergy) by 2020
SMUD’s Sustainable Energy Goal

2050 GHG Reduction Goal
(10% of 1990 levels, <350,000 metric tonnes/year)

✓ Assuring reliability of the system;
✓ Minimizing environmental impacts on land, habitat, water quality, and air quality; and
✓ Maintaining a competitive position relative to other California electricity providers.
2050 LOAD CHALLENGES

• Thermal/Carbon emitting - ~10%
• Large hydro - ~15-20%
• Other non-carbon resources - ~70-75%
  – Renewables (37% by 2020)
  – New demand-side/energy efficiency programs
  – Carbon sequestration
  – Other non-carbon generation
  – Purchasing carbon offsets
# Renewable Energy Supply

Sustainable Power Goal, Renewables Portfolio Standard (RPS), and Green Pricing Program (‘Greenergy’)

<table>
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<tr>
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<tbody>
<tr>
<td>RPS</td>
<td>17.5%</td>
<td>18.8%</td>
<td>20%</td>
<td>33%</td>
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<tr>
<td>Greenergy</td>
<td>3.5%</td>
<td>3.5%</td>
<td>3.9%</td>
<td>4%</td>
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<tr>
<td>Totals</td>
<td>21%</td>
<td>22.3%</td>
<td>23.9%</td>
<td>37%</td>
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</table>
SMUD's RENEWABLE ENERGY RESOURCES MIX
SMUD's RENEWABLE ENERGY MIX 2010
(2,600 GWh estimated)

2010 Total GWh ~ 11,000 for all sources
SMUD’s Renewable Energy Supply vs. Goals

SMUD’s Renewable Energy Supply

May 6, 2010

Renewable Energy (GWh)

Year


1.721 2.136 2.266 2.419 2.767 2.769 2.677 2.568 1.858 1.617 1.544 1.333 1.313 1.158 1.153 1.239 1.297 1.301 1.307 1.365 1.352

SMUD SACRAMENTO MUNICIPAL UTILITY DISTRICT
The Power To Do More.”
<table>
<thead>
<tr>
<th>Technology/Fuel Source</th>
<th>Number of facilities *</th>
<th>GWh</th>
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<tbody>
<tr>
<td>Solid Fuel Combustion</td>
<td>4</td>
<td>1,156</td>
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<tr>
<td><strong>Biogas -Landfill gas-to-energy</strong></td>
<td>3</td>
<td>389</td>
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<tr>
<td><strong>Biogas - Wastewater treatment</strong></td>
<td>1</td>
<td>56</td>
</tr>
<tr>
<td><strong>Biogas - Dairy digester</strong></td>
<td>2</td>
<td>2</td>
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<tr>
<td><strong>Totals</strong></td>
<td>10</td>
<td>1,603</td>
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* In and outside of SMUD Region

![Pie chart showing biomass and landfills contributions to biopower]
Multiple Energy Conversion Pathways from Biomass

**Biomass Resources**
- Agricultural Residues (Livestock Manure, Food Wastes, etc.)
- Forestry Residues
- Municipal Solid Waste
- Wastewater

**Processing & Handling**
- Separation
- Processing
- Handling
- Transportation

**Conversion Processes**
- **Thermochemical** (Combustion, Gasification, Pyrolysis)
- **Biochemical** (Anaerobic Digestion, Fermentation, Direct Hydrogen)
- **Physicochemical** (Oil Extraction, Hydrocarbon Extraction)

**Gas Cleaning Upgrading**
- Particles
- Tar, organics
- Sulfur, H₂S
- NOx
- CO₂

**Utilization**

**BioPower:**
- Electricity
- Heat
- CHP & CCHP

**Biofuels:**
- Ethanol
- Biodiesel
- Methanol
- Hydrogen
- Pyrolysis Oil
- Others

**Pipeline Gas**

**SNG**

**Bioproducts & Chemicals**
Biomass-Derived Methane Gas

Landfill Gas From Landfills

Digester Gas From AD of Wastewater Treatment Plants

Biogas From AD Livestock operations

Producer Gas or Syngas From Gasification of Biomass ??
Biogas Resource Assessments
# Biogas Opportunities in the Western US

(Resource Potentials for Pipeline Gas)

| Source: B&V & SMUD 2010, A case of biogas for Pipeline Injection  
(excluding food wastes, FOG, and other organic wastes for co-digestions or stand-alone AD) |

<table>
<thead>
<tr>
<th></th>
<th>California</th>
<th>Other 12 Western States</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>Gross MW*</td>
<td>Gross MW*</td>
<td>Gross MW*</td>
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<tr>
<td>Wastewater Treatment Plants</td>
<td>210</td>
<td>351</td>
<td>561</td>
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<tr>
<td>Landfills</td>
<td>1300</td>
<td>990</td>
<td>2,290</td>
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<tr>
<td>Dairy Manure Digesters</td>
<td>470</td>
<td>566</td>
<td>1,036</td>
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<tr>
<td>TOTAL</td>
<td>1,980</td>
<td>1,907</td>
<td>3,887</td>
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* All analysis assumes a heat rate of 6900 BTU/kWh for conversion of biogas to power
Common Carrier of Gas Pipelines in CA
Food Waste and Liquid Food Processing Waste Assessment

• In 2009, SMUD evaluated the technical potential of food and liquid food processing wastes as feedstock for co-digestion for sources within 50-mile radius of the waste water treatment plant.

IEC Report June 25, 2009
SMUD’s Food & Liquid Wastes Assessment

Technical methane potential = 841,367 MMBtu/yr (841,367,000 CF/yr) 
~ 15 MW (at 92% CF, 6900 Heat rate) for Pipeline Injection

Targeted Generators
- Manufacturers/Processors
- Distributors/Wholesalers
- Hospitals
- Nursing Homes (and related facilities)
- Colleges and Universities
- Correctional Facilities
- Resorts/Conference Facilities
- Supermarkets
- Restaurants (at a later date)
- Refuse Collectors
- Transfer Stations
<table>
<thead>
<tr>
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<th>Food Waste** (MW)</th>
<th>Greases (MW)</th>
<th>Total (MW)</th>
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<tbody>
<tr>
<td>Sacramento*</td>
<td>12</td>
<td>6</td>
<td>18</td>
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<tr>
<td>Dallas</td>
<td>27</td>
<td>14</td>
<td>41</td>
</tr>
<tr>
<td>Phoenix</td>
<td>19</td>
<td>9</td>
<td>28</td>
</tr>
<tr>
<td>Denver</td>
<td>11</td>
<td>5</td>
<td>16</td>
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Source: B&V Report to SMUD, January 2011
* Includes the following counties: Sacramento, Sutter, Solano, Yolo, Placer, San Joaquin, Amador, and El Dorado
** Assumes only high moisture content material suitable for anaerobic digestion
Biogas for Pipeline Injection

Current Contracts:
1. Landfill Gas – Texas (4,500 to 6,0000 MMBTu/day)
2. Biogas from AD of Dairy Wastes/Co-digestion - Colorado (3,000-7,000 MMBtu/day)
3. Another Landfill gas that SMUD’s Board Approved in November 2010

Deployment Projects (Co-Funded by USDOE & CEC)
1. Co-digestion of Food Wastes Sacramento wastewater treatment plant
2. AD of food wastes and other organic wastes in Sacramento
Biogas Projects
SMUD Community Renewable Energy Development Project

- Award from USDOE AARA ($5,000,000), CEC ($500,000)
- 5 projects
  - Sacramento Solar Highways
  - County Wastewater Treatment Plant - Co-Digestion of Fats, Oils & Grease Waste and other liquid wastes
  - New Hope Dairy Anaerobic Digester
  - Warmerdam Dairy Anaerobic Digester
  - Food Wastes Anaerobic Digester in Sacramento
SMUD CRED
Community Renewable Energy Deployment Projects

Food Wastes AD in Sacramento
Solar Highways

New Hope Dairy AD
SMUD Community

Warmerdam Dairy AD
SRCSD Co-Digestion of FOG
SRCSD Co-Digestion of FOG & Liquid Wastes

 Desired Outcome:
 
- Implement full scale co-digestion of fats, oil and grease (FOG) and liquid food processing waste with sewage at the Sacramento Regional Wastewater Treatment facility (estimated power recovery of 1 - 3 MW).

 Partners:
 
- Sacramento Regional Sanitation District
- Contractor- TBD
Pilot Study
(Dec 2008-Sept 2009)

- To pump food processing waste and brown grease directly into the digester instead of going through the collection system.
- To increase gas production in the digesters.
- Monitor Biosolids characteristics in the digester, monitor any potential operational issues for a full scale system
- Obtain data on the economic factors to better assess the economic feasibility of a full scale project
- Test and control digester maintained with the same process parameters, only change was adding grease or food processing waste to the test digester
Pilot Study Setup

- Digester 7 (test)
- Digester 5 (control)

Diagram showing the setup with various components like Feedstock Storage Tank, Heat Exchanger, Mixing Pump, and others.
Pilot Study - Conclusions

- Biogas enhancement is feasible at SRWTP
- No adverse effects observed in test digester
- Energy content remained constant
- No issues noted with Siloxane concentration
- Biogas production increased rapidly
- % of TS for FOG varied greatly (<1 to 23%)
- Pre-screening material improves O&M
- Good mixing of material is key
Pilot Study - Results

Strong Community Support

- 2009 recipient of a Sacramento Sustainable Business award, along with other pilot participants
- Many interested processors at the California League of Food Processors Expo in February 2010
- Local Waste Haulers would not need to travel to EBMUD in Oakland, CA
Project Status

- SRCSD PAC approval: Sept 2010
- SRCSD Board approval: mid Jan 2011
- Design: 2011
- Construction: 2012
- $1.5 M grant requirements:
  - functional project by Jan. 2013
New Hope Dairy AD Project

Desired Outcome:

- Implement above ground digester and 500 kW Greenguard™ engine genset for combined heat and power (CHP) application at New Hope Dairy Farm in Galt, California which has over 1200 dairy cows.

Partners:

Williams Engineering Associates

MT-ENERGIE Biogas Technology

CALIFORNIA BIOENERGY
Challenges & Status
New Hope Dairy AD Project

◆ Interconnection Issue
  ◆ Feeder shared with 3 MW PV system
  ◆ Load on Feeder uncertain
    ◆ Data collection and analysis = OK to build
  ◆ PPA pending
  ◆ Financing is being worked out
  ◆ Funding Agreement in negotiations
  ◆ Permit Application – in process
Warmerdam Dairy AD Project

Desired Outcome:

- Implement a complete mix digester and genset that will co-digest other organic wastes and generate an electrical output of 1,000 kW for CHP application which has at Warmerdam Dairy farm in Elk Grove, California.

Partners:

- Van Warmerdam Dairy Farm,
  Innate Energy California LLC
Project Description

Warmerdam Dairy AD Project

- Complete-mix co-digestion anaerobic digester
  - Manure, urban green waste, FOG
- H₂S & water removal from biogas
- 1000 kW CHP GenSet
  - Electricity to SMUD grid
  - Soil amendment
  - BACT emissions, recycle water
- Business model: design, build, own, operate
Project Site

Of the 3 power feeds, ABC, is the preferred connection point (subject to SMUD connection study)
Warmerdam Project

◆ Maximize energy-generation (efficiency)
◆ Minimize emissions; recycle water
◆ Medium-sized (1,000-cow) farm viability
◆ Use proven technologies
◆ Environmental benefits
  ◆ Odor, pathogens, flies, weed seed
  ◆ Climate change (CO₂ & methane avoidance)

Status:
◆ Funding Agreement – Executed
◆ Permit application – in process
Food Wastes AD Project

Desired Outcome:
- Install above ground and complete mix digester that will utilize fruits and vegetables wastes and other food processing wastes that will generate up to 1.5 MW & for pipeline injection

Partners:
- Real Energy, Sacramento Transfer Station (site)

Status: Working on site control
SMUD is working with two local dairies to capture methane from cow manure to generate electricity.
Cal Denier Dairy Digester (North of Galt)

- Dairy Cow Population: 500 milking cows
- Dairy Manure Management: Flushed System, manures held in holding pond
- Digester type: Ambient covered lagoon
- Engine Size: 65 kW baseload engine/generator (genset)
- Start of Operation: July 2008
Tollenaar Dairy Digester (Elk Grove)

- Dairy Cow Population: 1000 milking cow
  Farmers grows portion of the feeds

- Dairy Manure Management: Flushed System

- Digester type: Complete mix, concrete, covered lagoon & heated digester

- Engine Size: 212 kW, Guascor engine engine/generator

- Start of Operation: April 2009
SMUD R&D: Gas & NOx Cleanup

Objective: Demonstrate an integrated emission control process for sulfur (H₂S) removal for the biogas and NOx removal system on the engine exhaust at Tollenaar Dairy Farm

Partners: SMUD (prime), Cha Corporation, Applied Filter Technology, Gerling Applied Engineering

Funded by CARB – ICAT (Integrated Clean Air Technology Program & SMUD)
SMUD R&D: Gas & NOx Cleanup

CHA’s NOx Removal System next to engine at the Tollenaar dairy farm

AFT’s H₂S Removal System
NOx Removal System

• Fixed carbon bed to capture NOx from cooled engine exhaust
• Remove NOx from carbon using microwave energy applied to carbon bed
• Microwave reactor to destroy low volume, high concentration NOx
• Goal is NOx in exhaust below 5 ppm when biogas is less than 50 ppm H₂S
Field Demonstration of Microwave Technology for NOx Removal

- NOx removal system has been installed and operated at Tollenaar Holsteins Dairy Farm in Elk Grove, CA
- Various NOx adsorbents were tested
- NOx emission is monitored during engine operation
NOx Removal System and Engine
NOx Adsorption Unit
Microwave NOx Destruction Unit
PLC Box and NOx Removal Unit
Two Demisters and Condensed Water Collection System
Two 3-inch Adsorbers
Test Results

3-inch Column NOx Adsorption Test

Outlet NOx Conc, ppm vs. Adsorption Time, min

- Fresh MgO GAC
- 1st Reg MgO GAC
- 2nd Reg MgO
Test Results

NOx Concentration of Adsorber Outlet Gas for 212-kW Engine Running on Biogas

Average NOx Concentration for 24 hours = 3.3 ppm
Average NOx Concentration for 42 hours = 5.2 ppm
SMUD R&D: Biogas-fueled Low Emission Engines Generator Demonstration

Homogeneous Charge Compression Ignition (HCCI)

The HCCI Combustion Process

- Homogeneous mixture formed early in cycle
- Mixture compressed to high temperature and pressure
- Fuel/air chemistry results in ignition near top dead center
- Very rapid combustion event follows ignition

Objectives: System NOx emission of approximately 5 ppm (0.07 lb/MW-hr)

Efficiencies = > 35% (electrical only), > 60% (CHP)

Funding: CEC (RESCO & EPAG Programs) & Pending DOE Award

Partners: Makel Engineering (Prime), SMUD, UC Berkeley

Hosts: Cal Denier & Tollenaar Dairy Farms
Enhanced Biomethane Production using Wastewater Digester

Desired Outcome:
- Develop, demonstrate & deploy an innovative approach of enhancing biogas using magnesium silicates (additive technology)

Partners:
- Eurisko Scientific, Technikon, SMUD, Argonne National Lab, SRCSD, Cha Corp, Williams Engineering
- CEC –AB 118 Funded project
Eurisko Scientific – Argonne NL Technology
SMUD – SRCSD

Existing Systems

Additive Technology

**Methane: Biogenic methane**

- Methane production from biomass, waste, and coal

Graph showing the increase in methane production with and without Argonne treatment. The graph indicates a 5X increase in methane production with Argonne treatment compared to without treatment.
TDA’s SulfaTrap™ Biogas Applications with Fuel Cell Energy, Inc and SMUD

- SulfaTrap™ sorbent are evaluated in two DOE Programs for cleaning anaerobic digester gas from food processing and wastewater treatment facilities
- SulfaTrap™-R8 sorbent achieves a very high sulfur capacity and can simultaneously remove sulfur and siloxanes without any need for refrigeration
  - Multi-contaminant removal (mercaptans, disulfides and siloxanes)
- Recent USDOE Grant Award - scheduled to remove sulfur to protect Solid Oxide Fuel Cells at ppb levels based on Combined Heat and Power Systems

- **Hosts**: Cal Denier & Tollenaar Dairy Farms and/or WWTP in SMUD Region
Summary

- GHG/RPS goals/regulation driving SMUD to more biogas
- Transmission constraints driving SMUD to local solutions
- Local renewables for SMUD means biomass (and biogas) and solar
- Continue RD&D innovations (e.g., NOx solutions) and better define strategic values
- It takes time and $$ to build AD and other renewable energy projects
Thank You

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