Biomethane from Dairy Waste

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Biomethane is Renewable Natural Gas

- Made From Biogas
- Can be Used for Transportation, Heat, Cooling, and Power Generation
- Upgrading is Proven Technology
- Added Costs for Storage and Distribution
- Has Environmental, Social Benefits
- Becoming More Cost Competitive as Natural Gas Prices Rise
Uses of Biogas

- Combust to Generate Electricity and Heat (most common energy use)
- Combust for Heat Alone
- Upgrade to Biomethane
- Flare--No Energy Benefit
- Release to Atmosphere--Methane is a Potent Greenhouse Gas

Five Cows Can Fuel One Car
Biomethane is Made by Upgrading Biogas

- Remove
  - Hydrogen Sulfide $\text{H}_2\text{S}$
  - Water Vapor $\text{H}_2\text{O}$
  - Carbon Dioxide $\text{CO}_2$
- Various Technologies Available
- Problem is Cost Effectiveness and Reliability at Small Scale of Dairy

Environmental Effects

- Reduces Greenhouse Gas Emissions
- Reduces Odors
- If Digester Heated, Controls Pathogens and Weed Seeds
- Improves Water Quality, Lowers BOD
- Some VOC Reduction
- Combustion Generates NOx, Biomethane Easier to Control than Biogas
Societal Benefits

- Energy Security
  - Diversity of Energy Supply
  - Reduce Dependence on Imported Oil and Natural Gas
- Rural Development

Aspects of Biomethane Project

- Identify Source of Biogas
- Identify Buyer of Biomethane
- Build Biomethane Upgrade Plant
- Store Biomethane
- Transport it to Buyer
How Much Biomethane in California?

- Gross Methane Potential is
  - 125 Billion ft³/Year
- Technical Methane Potential is
  - 23 Billion ft³/Year
- Technical Methane Potential from Dairy Waste is
  - 14 Billion ft³/Year
  - Enough to Fuel 250,000 Cars

Storage and Distribution

- Dairy Produces More than It Can Use
- Non-Farm Vehicles will not Come to Farm to Refuel
- Need to Move Biomethane to Off Farm Buyer
- Significant Barriers to Using Pipeline Grid
  - Institutional Barriers
  - Most Dairies not on Grid
- Alternatives are Trucks and Private Pipelines
- Storage May be Required
Public Policy Issues

- Policy Supports Ethanol, Biodiesel and Renewable Electricity
- Little Support for Biomethane
- Electricity Market Structure Limits Financial Opportunities for Dairy Generators
- Barriers to Accessing Gas Pipeline Grid
- No Financial or Regulatory Incentive to Control Greenhouse Gas Emissions

What Does it Cost?

- Costs of Anaerobic Digestion
- Costs of Upgrading to Biomethane
- Costs of Storage and Transportation
Estimated Cost of Anaerobic Digestion to Produce Biogas

- For a 1,500 Cow Dairy
- Biogas is ~60% Methane
- Estimated Costs per 1,000 ft$^3$ Biomethane
- Capital Cost ~$3.10
- Operating Cost ~$0.60

Estimated Cost of Upgrading Biogas to Biomethane

- 1,500 Cow Dairy is Small Plant
- Operating Costs Exceed Capital Costs
- Estimates Much Less Firm than for Anaerobic Digestion, Costs per 1,000 ft$^3$ Biomethane
- Capital Cost ~$3.10
- Operating Cost ~$5.00
Estimated Combined Cost for 1,000 cu ft$^3$ Biomethane

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<th>Make Biogas</th>
<th>Upgrade to Biom.</th>
<th>Est. Tot Cost</th>
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Costs of Natural Gas

- Prices are Volatile, Currently at Levels Very High Historically
- Wellhead Price Oct 2005 $10.97
- City-Gate Price Oct 2005 $12.18
- Commercial Price Oct 2005 $14.61

Source: USDOE, Energy Information Administration, Natural Gas Monthly December 2005
Natural Gas Price Trend

Estimated Costs to Distribute Biomethane

- Storage Needed if Trucking Involved
- Fueling Station Needed at Distribution
- Dedicated Pipelines Cost $100,000-$250,000 per mile
- Trucking Probably Higher
- Distribution May Add $3.00/1,000 ft³
Financial Issues

- Biomethane Competitive at Current (High) Commercial Price of Natural Gas
- Commercial Price Includes Transportation
- Costs of Distribution Make Biomethane Higher Than Natural Gas
- Biomethane Access to Pipeline Would Bring Distribution Cost Down
- As Natural Gas Prices Rise, Biomethane More Competitive
- Volatility of Gas Prices Produces Project Risk

Kyoto is the Big Opportunity

The Greenhouse Effect: the Kyoto protocol

Emissions in 1990, in millions of equivalent tonnes and reduction commitments by 2012

-7% 6.049
-8% 4.208
0% 3.040
-6% 1.213
+6% 612
Augmentation 423

USA* European Union (15 members) Russia Japan Canada Australia*

* Pulled out of protocol or won't ratify

Negotiations will begin in 2005 on the second commitment period after 2012
Value if Kyoto in Place

- Value of Carbon Trade in Europe
  Currently about $25/ton of CO$_2$E
- Avoiding 1,000 ft$^3$ of Methane Emissions
  Avoids about 1/2 ton CO$_2$E Emissions
- At $25/ton, Value of Avoided GGE is
  $12.00/1,000$ ft$^3$
- Plus Substitution Value

Biomethane Versus Electricity

- Currently Electricity More Cost Effective if Dairy Load Meets On-Farm Demand
- Hard to Sell Electricity Exports Due to Market Structure
- Decision Depends on Market Structure, Comparative Prices, Need for Energy Independence, Government Incentives
21 Biomethane Plants in Sweden

Biomethane in Sweden

- Plants Produce High Quality Renewable Natural Gas
- Fuel for 2,300 Vehicles, Mostly Buses
- Different Economics than U.S.
  - Cheap Electricity from Hydro and Nuclear
  - Expensive Gasoline, No Fossil Fuel
  - High Tax on Greenhouse Gas Emissions
- Lesson: Production Must be Matched to Consumption and Distributed to Buyer
Key Success Factors

- Find a Buyer for the Biomethane
- Locate Feedstock for the Digester
- Set Up Transportation to Get the Biomethane to the Buyer
- Financial Model that Works, Public Support Needed Initially
- Robust Reliable Technology
- If No Grid, Must Have Proximity

Opportunity: Industrial User

- Many Central Valley Industrial Natural Gas Customers are Near Large Concentration of Dairies
- Gas Could Move Through Private Pipeline
- Possibly Biogas Would Suffice
Opportunity: LNG Substitute

- California’s Liquefied Natural Gas is Trucked in From Out of State
- Biomethane Plant Could Provide LBM Locally and Save Truck Mileage

Modesto, Tulare, Hanford, Visalia as CBM Transit Hubs
Tulare

- 165,000 Cows
- =30,000 Cars
- 3 mi Circles

Opportunity: Transit Hub

- Central Valley is Non-Attainment Area
- At Least 4 Central Valley Cities Have
  - Many Dairies in Close Proximity
  - Existing CNG Fueling Stations
- Locally Produced Compressed Biomethane Could Replace/Augment CNG
- To Make Projects Work Need
  - More CNG Vehicles
  - Expanded Fueling Station
  - Transport of Biomethane to Fueling Station
Biomethane Report

- Full Report Can Be Found on Sustainable Conservation or Western United Dairymen Websites
- www.westernuniteddairymen.com/USDA%20Grant/USDAgrantfinalreport.htm