5 Topics for Discussion

1. Background on Dairies, Digesters and CalBio

2. Hub and Scope Model

3. Lagoon Digesters Projects

4. Economics

5. Environmental Impacts
5 Topics for Discussion

(1) Background on California Climate Reductions, Dairy Industry, and CalBio

Helping California reach its greenhouse gas reduction requirements while benefiting the dairy and community
Dairies: One Key to CA’s GHG Reductions

- California is a world leader in climate policy and program development
- CA to reduce GHGs* by 40% by 2030
  - All GHGs by 40% versus 1990 baseline
  - Dairy CH4 by 40% versus 2013 baseline
- Methane is a significant GHG source
  - 9% of total: 100 year GWP*
  - 22.4% of total: 20 year GWP
- Dairies: a primary source of CA CH4
  - 55% of CA methane emissions
  - 26% of CA total from manure lagoon

Source: CARB. *GHG: Greenhouse Gases. GWP: Global Warming Potential
California Dairy Industry

- Dairy is California’s #1 ag product
  - Largest dairy industry in the US. 20% of the nation’s milk
  - $7+ billion per year in farm sales. $98B of economic value.
  - 1.74 million milk cows
  - 1,300 dairies, family owned

- San Joaquin Valley – center of California’s dairying

- Dairy productivity
  - 63 lbs of milk/cow/day; 23,000 lbs/yr
  - 120 pounds of manure/cow/day
  - Over 100 DGEs/cow/year
## California Milk Production

<table>
<thead>
<tr>
<th>County</th>
<th>Milk Production (Pounds)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 Tulare</td>
<td>10,898,199,708</td>
<td>27.4%</td>
</tr>
<tr>
<td>#2 Merced</td>
<td>6,118,632,016</td>
<td>15.4%</td>
</tr>
<tr>
<td>#3 Kings</td>
<td>4,118,692,949</td>
<td>10.3%</td>
</tr>
<tr>
<td>#4 Stanislaus</td>
<td>3,931,744,192</td>
<td>9.9%</td>
</tr>
<tr>
<td>#5 Kern</td>
<td>3,718,554,133</td>
<td>9.3%</td>
</tr>
<tr>
<td>#6 Fresno</td>
<td>2,756,349,010</td>
<td>6.9%</td>
</tr>
<tr>
<td>#7 San Joaquin</td>
<td>2,330,365,468</td>
<td>5.9%</td>
</tr>
<tr>
<td>#8 Madera</td>
<td>1,858,949,176</td>
<td>4.7%</td>
</tr>
<tr>
<td>#9 San Bernardino</td>
<td>978,098,347</td>
<td>2.5%</td>
</tr>
<tr>
<td>#10 Riverside</td>
<td>948,433,111</td>
<td>2.4%</td>
</tr>
<tr>
<td>Other (approximate)</td>
<td>2,141,981,890</td>
<td>5.4%</td>
</tr>
<tr>
<td>Total (approximate)</td>
<td>39,800,000,000</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
About California Bioenergy LLC ("CalBio")

- Founded 2006. Focus on dairy biogas in California.
- Team + partners: dairy, digester, and oil and gas expertise
- Operate 5 projects, developing 40+: 7 clusters
- Supported by grants, lenders & investors
- Work with regulatory & state agencies
- Partner with the dairy farmer
- Goals
  1. Protect global & local environment
  2. Create a new revenue for dairy
  3. Enhance dairy operations
  4. Support the community
# Dairy Digesters are Cost Effective

<table>
<thead>
<tr>
<th>Program</th>
<th>Cost Per Ton$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organics and recycling loans</td>
<td>$4</td>
</tr>
<tr>
<td>Forest health</td>
<td>4</td>
</tr>
<tr>
<td><strong>Dairy digester research and development program</strong></td>
<td><strong>8</strong></td>
</tr>
<tr>
<td>Organics composting/digestion grants</td>
<td>9</td>
</tr>
<tr>
<td>Forest legacy</td>
<td>10</td>
</tr>
<tr>
<td>Recycling manufacturing</td>
<td>15</td>
</tr>
<tr>
<td>Delta and coastal wetlands restoration</td>
<td>30</td>
</tr>
<tr>
<td>State water and efficiency and enhancement program</td>
<td>33</td>
</tr>
<tr>
<td>Clean vehicle rebates</td>
<td>46</td>
</tr>
<tr>
<td>Sustainable agricultural lands conservation</td>
<td>59</td>
</tr>
<tr>
<td>Mountain meadow ecosystems restoration</td>
<td>113</td>
</tr>
<tr>
<td>Urban and community forestry</td>
<td>116</td>
</tr>
<tr>
<td>Water-energy grant program</td>
<td>141</td>
</tr>
<tr>
<td>Affordable housing and sustainable communities</td>
<td>191</td>
</tr>
<tr>
<td>Single-family solar photovoltaics$^b$</td>
<td>209</td>
</tr>
<tr>
<td>Transit and intercity rail capital</td>
<td>259</td>
</tr>
<tr>
<td>Single-family energy efficiency and solar water heating$^b$</td>
<td>282</td>
</tr>
<tr>
<td>Large multifamily energy efficiency and renewables$^b$</td>
<td>343</td>
</tr>
<tr>
<td>Enhanced fleet modernization program “plus-up”</td>
<td>414</td>
</tr>
<tr>
<td>Truck and bus voucher incentives</td>
<td>452</td>
</tr>
<tr>
<td>Incentives for public fleets pilot project for DACs</td>
<td>725</td>
</tr>
<tr>
<td><strong>Overall Average</strong></td>
<td><strong>$57</strong></td>
</tr>
</tbody>
</table>

*Based on 100 yr GWP
CA Digesters: from DairyCares.com

California Dairy Digester Development

Kern County (11)

Kings & Tulare Counties (48)

Merced, Madera & Fresno Counties (12)

Learn more at DairyCares.com/dairy-digesters

1. Bidart- Old River
2. Bidart- Stockdale
3. Blakes Landing Farms/Straus Family Creamery
4. Castelanelli Brothers Dairy
5. Cottonwood Dairy/ Joseph Gallo Farms
6. Denier Dairy*
7. Fiscalini Farms
8. Giacomini Dairy
9. Hilarides Dairy
10. New Hope Dairy*
11. Open Sky Ranch
12. Pacific Rim Dairy
13. Piedey Biogas
14. Van Steyn Dairy
15. Van Warmerdam Dairy
16. Verwey Dairy- Hanford
17. Verwey Dairy- Madera
18. GJ'TeVeilde Ranch
19. Carlos Echeverria & Sons
20. Lakeview Dairy
21. West Star Dairy
22. Van Beek Dairy
23. Wreden Ranch
24. Trilogy Dairy
25. Cloverdale Dairy
26. T & W Farms
27. K & M Visser
28. Maple Dairy
29. S & S Dairy
30. Rancho Terezita Dairy
31. Piedey Dairy
32. Legacy Ranch
33. Moonlight Dairy
34. Robert Vander Eyk Dairy
35. Circle A Dairy
36. Bos Farms
37. Hamstra Dairy
38. Hollanda Farms
39. 4K Dairy
40. Ackerman Dairy
41. Aukeman Farms
42. Belonawe Dairy
43. BV Dairy
44. Cornerstone Dairy
45. De Groot Dairy (North)
46. De Groot Dairy (South)
47. Decade Centralized Dairy
48. DJ South Dairy
49. Double J Dairy
50. Double L Dairy
51. Dykstra Dairy
52. 5H Dairy
53. FM Jerseys Dairy
54. Hoogendam Dairy
55. Horizon Jersey Dairy
56. Jacobus De Groot #2 Dairy
57. Little Rock Centralized Dairy
58. Lone Oak #1 Dairy
59. Double D Dairy
60. Meirinho Dairy
61. Mellema Dairy
62. Milky Way Dairy
63. Mineral King Dairy
64. Rancho Sierra Vista Dairy
65. Red Rock Dairy
66. River Ranch Dairy
67. Riverbend Dairy
68. Riverview Dairy
69. Rob Van Grouw Dairy
70. Rocking Horse Dairy
71. Rockshar Dairy
72. Sousa & Sousa Dairy
73. Udder Dairy
74. Valadao Dairy
75. Vander Poel Dairy
76. Vander Woude Dairy
77. Vista Verde Dairy
78. Western Sky Dairy
79. El Monte Dairy
80. Scheenstra Dairy
81. Antonio Brasil Dairy

*Temporarily Offline

Updated March 2019
5 Topics for Discussion

(2) Hub and Spoke Model

- A digester is at the dairy
- H2S is removed locally
- The dairy biogas is moved through a gathering line
- At a central location the biogas is upgraded to nearly pure methane
- The methane is injected into the pipeline
From Independent to Hub & Spoke

Hub & Spoke Model

High pressure gas pipeline to utility interconnection

Hub
Gas Cleaning & Conditioning
Gas Pressurizing

Dairy 1
Low pressure PVC gathering line

Dairy 2

Dairy 3

Dairy 4

Dairy 5

Dairy 6

Dairy 7

Dairy 8

Dairy 9

Dairy 10
Kern Cluster: 15 dairies, 14 planned digesters
(3) How a Lagoon Digester Project Works

- In California manure is flushed with water into a lagoon system, where ambient temperature bacteria breakdown the manure releasing methane.

- The project integrates a covered lagoon digester into the flush manure management system.

- The covered lagoon captures the biogas composed of CH4, CO2, H2S and other gases.
How a digester works to produce biogas

Cows → Lagoon System → Biogas → Field
Digester in Construction
1. Manure water is flushed
2. It goes over a separator and sand lane.
3. Flows into a Covered Lagoon - Digester
3a. The Lagoon Digester is Double-Lined
3b. The Lagoon Digester Has Baffle Walls
3c. The Lagoon Cover is Strong & Expands
4. H2S Removal

- **H₂S**
  - High, dangerous concentrations: 2000 to 5000 PPM
  - Risk to people. Corrosive to equipment
  - So vital to remove in pre-treatment
  - Gives dairies rotten egg smell, greatly reduced after cleanup

- **Removal systems**
  - Air injection under the cover
  - Iron sponge
4. H2S Gas Equipment
5. Gathering Line Connects the Dairies (in red)
6. Upgrading to CNG, Air Liquide System

- SoCalGas has high standards for quality of gas to be accepted
  - Greater than 97% methane at very high pressures
  - Nearly non-existent levels of H$_2$S, H$_2$O, and CO$_2$
  - If requirements are not met, gas is rejected and vented into the atmosphere

- A very precise membrane that only allows CH$_4$ to flow
(4) Economics

The value comes from the generation of “credits” from California’s program and the U.S. EPA program.
Fuel (CNG) versus Electricity

**Fuel (R-CNG)**
1. **Price:** $50-$95/MMBTU
   - CA’s Low Carbon Fuel Standard
   - US EPA’s RPS RINs (D-3)
   - Plus natural gas value
2. **Bank history – risk adverse**
   - Market based volatile pricing
3. **Significant environ. benefits:**
   - NOx-pollution reductions

**Electricity (options changing)**
1. **Price:** $24/MMBTU or higher
   - Was electricity + GHG credits
   - Increasing with LCFS value
   - Potential future eRIN
2. **Bank financeable with PPAs**
   - Bank financing issues with LCFS
3. **NOx emissions:**
   - Impact changing
California Bioenergy LLC: California Dairy Digester Biogas to CNG GREET 2.0, LCFS FP: CNG056, CI: -276.24
(5) Other Environmental Benefits

- A lagoon digester collects the fugitive biogas
  - The methane is used as vehicle fuel.
- Natural gas trucks are significantly cleaner than diesel trucks
Dairy Biomethane for Fuel Reduces NOx

NOx Reduction when Dairy Biogas is Diverted from On-Site Electric Generation to Diesel Truck Fuel Substitute

* Heavy-duty diesel engine at 0.2 g/bhp-hr NOx. Heavy-duty “NZ” NG engine at 0.02 g/bhp-hr Nox. Electric gen. at 0.15 g/bhp-hr BACT
San Joaquin Valley Air Quality Improvements

- One digester at a dairy of approximately 3000 cows reduces NOx emissions equivalent to taking 89 cars off the road. The displacement of diesel by CNG trucking fleets further reduces NOx by the equivalent of 5,971 cars.

- A cluster of digesters (of approximately 24,000 cows) reduces NOx emissions equivalent to taking 40,837 cars off the road.
CalBio Contact Information

Neil Black (President)
nblack@calbioenergy.com

Any Questions?
Please contact us via email or
at 559-667-9560

California Bioenergy
324 S. Santa Fe St., Suite B
Visalia, CA 93292

www.calbioenergy.com