# Food & Beverage Industry Organic Residue Streams, Distributed Generation and Co-digestion Opportunities

**8th Annual Forum of the California Biomass Collaborative**

**April 6 2011**

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# Session Agenda

- Prab Sethi, California Energy Commission – Opening Remarks.
- Ricardo Amón, California Biomass Collaborative – Fruits & Vegetable Industry Residue Streams and Potential BioEnergy Projects.
- Greg Kester, California Association Of Sanitation Agencies - BioEnergy Generation Challenges and Opportunities in the Wastewater Sector.
- Valentino Tiangco, Sacramento Municipal Utility District – Development of Food and Organic Residue BioEnergy Project.
- Steven Gill, Gills Onions – Lessons Learned from Installed Food Residues to BioEnergy Project.
- Jim Lucas, Southern California Gas Company – Investor Owned Utility Efforts to Develop the BioEnergy Market.
- Jaclyn Marks, California Public Utilities Commission – CPUC Renewable Auction Mechanism
- Rob Neenan, California League of Food Processors - Moderator

# Fruits and Vegetable (F&V) Industry Residue Streams and Potential BioEnergy Projects

## 8th Annual Forum of the California Biomass Collaborative
## April 6 2011

Presented by Ricardo Amón

California Biomass Collaborative

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# Fruits and Vegetable (F&V) Industry Residue Streams and Potential BioEnergy Projects

## Presentation Agenda:

- **Overview:** Food and Beverage Industry Residue Assessment Study
- **Results:** California's F&V Industry Residue Streams
- **Opportunities:** Potential F&V Industry BioEnergy Development

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# Food and Beverage (F&B) Processing Industry Residue Assessment

- **Objective:** Conduct F&B industry organic residue assessment, calculate BioEnergy technical potential
- **Population:** Statewide companies employing 25 or more workers by Line of Business
- **Data Collection Methods:** Personal contact requesting to complete survey instrument, data mining from Regional Water Quality Control Board offices, request for data from Wastewater Treatment Facilities (WWTFs), California Department of Food and Agriculture and US Department of Agriculture

# Lines of Business

| |
|---|
| Bottled, Canned Soft Drinks |
| Canned Fruits & Vegetables, Canned Specialties |
| Cheese, Butter, Fluid Milk, Ice Cream |
| Fruits & Vegetables, Fresh, Frozen, Dehydrated |
| Malt Beverages |
| Meat Plants, Meat products, Poultry, Sausages |
| Snacks, Salted Roasted Nuts |
| Wine |

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# Data Analysis

**Standard Least Square Statistical Models:**

**High Moisture Solids (HMS) Model:**

Model estimates amount of HMS as a function of wastewater, number of workers in relation to wastewater discharge and moisture content of HMS. Model applied to cannery, dehydrated and frozen fruits and vegetables industry data.

$$HM_{pred} = \beta_0 + \beta_{WW}WW + \beta_{WWpWKR}WWpWKR + \beta_{HMSP}HMSP + \beta_{OHS}OHS$$

Where:

*$HM_{pred}$ = is the predicted value of high moisture solids*
*$\beta_0$ = the intercept*
*$\beta_{WW}$ = the coefficient for wastewater quantities*
*WW = the quantity of wastewater*
*$\beta_{WWpWKR}$ = the coefficient for the relationship between amount of wastewater and the number of workers*
*WWpWKR = the amount of wastewater generated per the number of workers*
*$\beta_{HMSP}$ = the coefficient for high moisture solids percentage humidity*
*HMSP = the percentage humidity of high moisture solids*
*$\beta_{OHS}$ = the coefficient for extreme values not typical of the rest of the data*
*OHS = Indicator variable (0,1) for facilities with HM solid residue data exceeding 30,000 tons per year*

# Data Analysis

**Low Moisture Solids (LMS) Model :**

Model estimates amount of LMS as a function of amount of wastewater discharged, number of workers in relation to wastewater discharge, low moisture dry solids ratio between low moisture dry solids in tons divided by total dry solids (including high moisture dry solids) in tons. LMS Model applied to dehydrated fruit and vegetables industry data.

$$LMS_{pred} = \beta_0 + \beta_{WW}WW + \beta_{WWpWKR}WWpWKR + \beta_{LDSR}LDSR + \beta_{olms}OLMS$$

Where:

$LMS_{pred}$ = is the predicted value of low moisture solids

$\beta_0$ = the intercept

$\beta_{WW}$ = the coefficient for wastewater quantities

WW = the quantity of wastewater

$\beta_{WWpWKR}$ = the coefficient for the relationship between amount of wastewater and the number of workers

WWpWKR = the amount of wastewater generated per the number of workers

$\beta_{LDSR}$ = the coefficient for low moisture dry solids ratio in tons divided by total dry solids (including high moisture dry solids) in tons

LDSR = the ratio of low moisture dry solids in tons

$\beta_{OLMS}$ = the coefficient for extreme values not typical of the rest of the data

OLMS = Extreme values not typical of the rest of the data (outliers)

# Cannery, Dehydrated and Fresh/Frozen F&V Industry

- 352 companies produce canned, dehydrated and fresh/frozen fruits and vegetables.
- Of these, 209 companies employ >= 25 workers
- Wastewater data was obtained for 164 (78%) companies, with High and Low Moisture Solids estimated for 79 (48%) of these companies.
- Combined, these companies discharge 15.7 billion gallons of wastewater per year.

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## Cannery, Dehydrated and Fresh/Frozen F&V Industry
## Potential Energy from Residue Streams

| Frozen F&V Industry Residues | Wastewater Weight of BOD (Tons/yr) | High Moisture Residue Dry Weight (Tons/yr) | Low Moisture Residue Dry Weight (Tons/yr) |
|---|---|---|---|
| Total Amount | 87,542 | 87,616 | 238,205 |
| Energy Potential: | | | |
| Biogas Technology Power (kW) | 15,098 | 11,251 | 23,971 |
| Thermochemical Technology Power (kW) | 0 | 0 | 12,636 |

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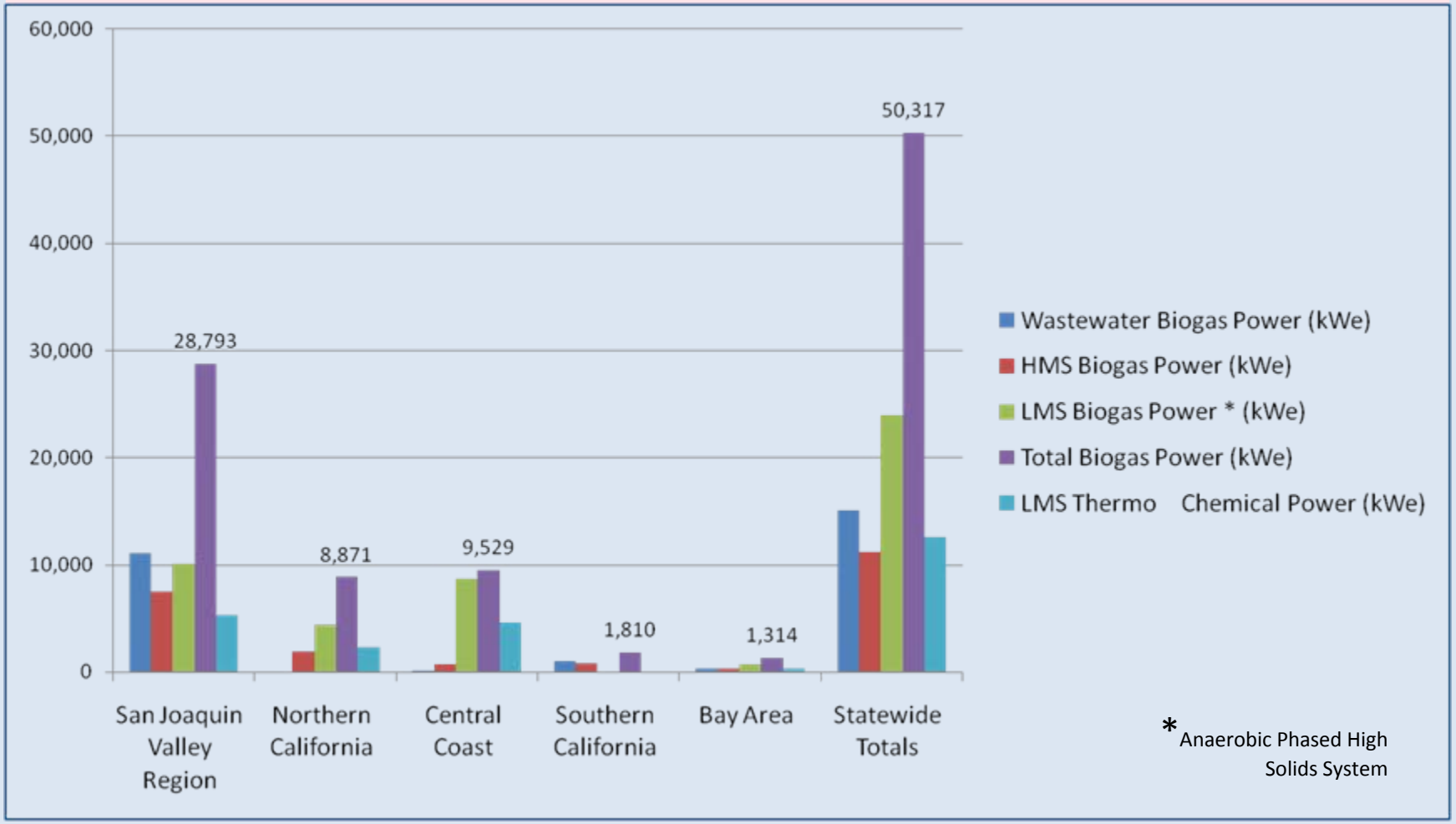
# Regional BioEnergy Potential

| Region | Wastewater Biogas Power (kWe) | HMS Biogas Power (kWe) | LMS Biogas Power * (kWe) | Total Biogas Power (kWe) | LMS Thermo Chemical Power (kWe) |
|---|---|---|---|---|---|
| San Joaquin Valley Region | 11,147 | 7,505 | 10,141 | 28,793 | 5,345 |
| Northern California | | 1,893 | 4,453 | 8,871 | 2,346 |
| Central Coast | 141 | 707 | 8,680 | 9,529 | 4,575 |
| Southern California | 988 | 822 | 0 | 1,810 | 0 |
| Bay Area | 297 | 322 | 695 | 1,314 | 366 |
| **Statewide Totals** | **15,098** | **11,249** | **23,969** | **50,317** | **12,632** |

*Anaerobic Phased High Solids System

# Regional BioEnergy Potential

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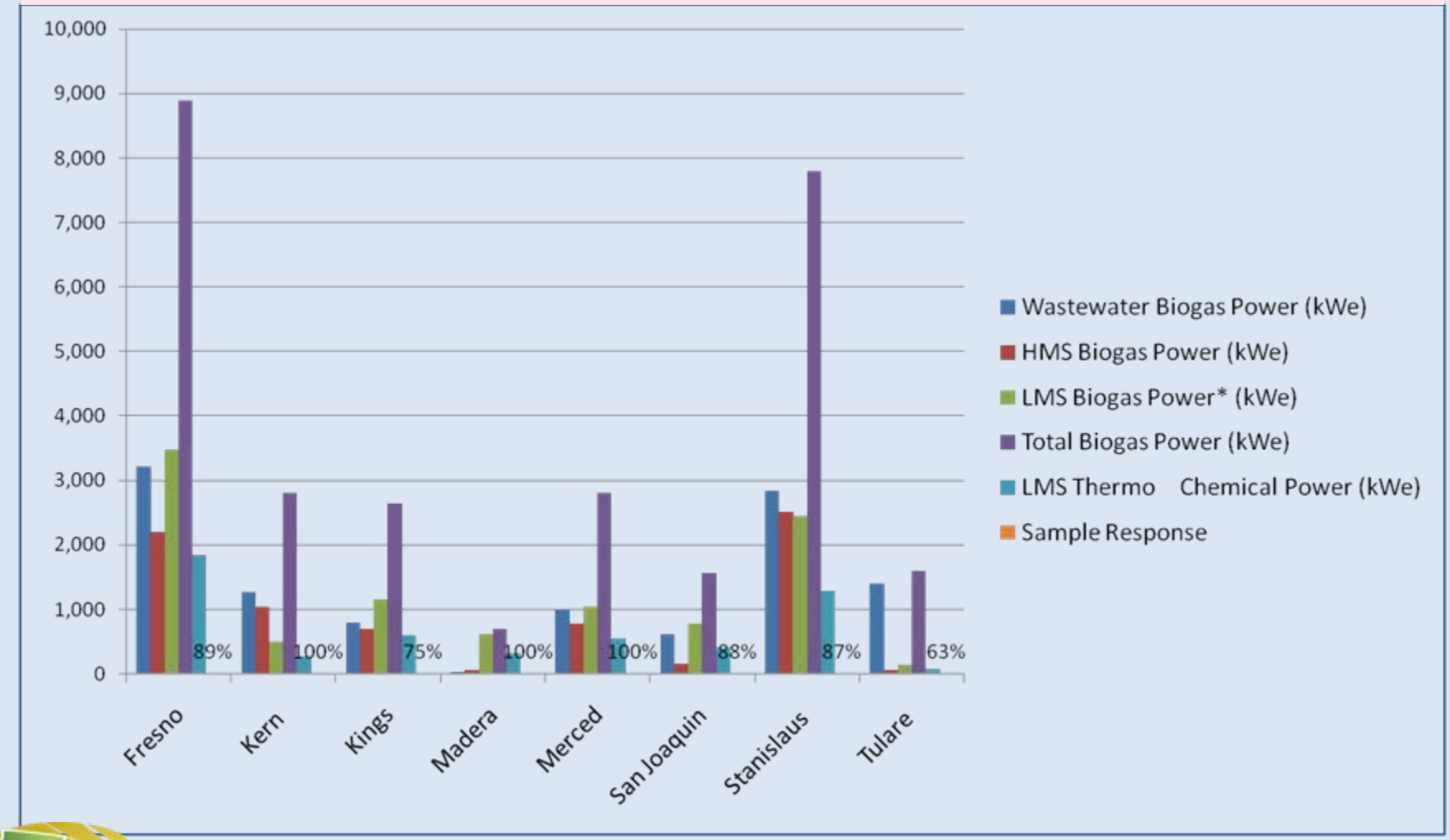
# San Joaquin Valley BioEnergy Potential

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# F&V Industry BioEnergy Project Development Opportunities

- CARB's Cap & Trade rules on-site biomass to energy generation as Carbon Neutral eligible for Carbon Allocations. 35 F&B companies in registry emitting >25k CO2/yr.
- Municipal Districts (East Bay Municipal Utility District) co-digestion of solid food residues with wastewater discharge residues.
- Wastewater Districts (Modesto Sanitary District) Cap & Trade infrastructure program.

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# Acknowledgments


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- Rob Williams, CBC


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# Contact Information

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# Backup Slides

# Cannery Industry

- 157 companies produce canned fruits and vegetables and canned specialties
- Of these, 71 companies employ >= 25 workers
- Wastewater data was obtained for 51 (72%) companies.
- High Moisture Solids estimated for 17 (33%) companies.
- Combined, these companies discharge 8.16 billion gallons of wastewater per year.

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# Dehydrated F&V Industry

- 67 companies produce dehydrated fruits and vegetables.
- Of these, 49 companies employ >= 25 workers
- Wastewater data was obtained for 39 (80%) companies, with Low Moisture Solids estimated for 13 (33%) of these companies.
- Combined, these companies discharge 284 million gallons of wastewater per year.

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# Fresh/Frozen F&V Industry

- 128 companies produce frozen fruits and vegetables.
- Of these, 89 companies employ >= 25 workers
- Wastewater data was obtained for 74 (83%) companies, with High Moisture Solids estimated for 49 (67%) of these companies.
- Combined, these companies discharge 7.25 billion gallons of wastewater per year.

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# Energy Potential Calculations

Based on the amounts and characteristics of solid waste and wastewater streams, annual energy generation could be estimated for each stream:

**Energy From Wastewater and From High Moisture Wastes:**

**A.** The annual energy production ($E_{annual}$) from high moisture wastes is estimated as follows:

$$E_{annual} = \phi_{hm} \times TS \times VS \times Bo \times Y \times M \times CV_m$$

Where:

$E_{annual}$ = annual energy production from high moisture wastes (kJ/year),
$\Phi_{hm}$ = annual production of high moisture wastes (ton/year),
TS = Total solid contents (kg/ton),
VS = Volatile solids/total solids ratio (fraction),
Bo = anaerobic biodegradability (fraction),
Y = biogas yield ($m^3$/kg VS destroyed),
M = methane content (fraction),
$CV_m$ = the caloric value of methane ($kJ/m^3$),
If the ratio of volatile solids/the total solids is not given by a food processor, a value of 0.8 could be assumed. The biodegradability, biogas yield, methane concentration of biogas, and the volumetric heating value of methane at standard conditions could be assumed to be 0.67, 0.7 $m^3$ $kg^{-1}$ VS destroyed, 65%, and 36.3 MJ $m^{-3}$ respectively.

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# Energy Potential Calculations

**Energy From Wastewater and From High Moisture Wastes:**

**B.** The annual electricity production ($EE_{annual}$) from high moisture solid residues is estimated as follows:

$$EE_{annual} = \frac{E_{annual}\eta}{3600}$$

Where:

$EE_{annual}$ = annual electricity production (kWh/year),
$\eta$ = generator efficiency (fraction).
An engine-generator efficiency of 30%-35% could be assumed.

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# Energy Potential Calculations

**Energy From Wastewater and From High Moisture Wastes:**

**C.** For estimating the annual energy production from the anaerobic digestion of wastewater, the following equation is used:

$$\mathrm{Ew}_{\mathrm{annual}} = \phi_w \times \mathrm{BOD} \times 0.35 \times CV_m$$

Where:

$Ew_{annual}$= annual energy production from wastewater (kJ/year),

$\phi_w$ = annual wastewater production ($m^3$/year),

BOD = concentration of biological oxygen demand, kg/$m^3$,

0.35 = a conversion factor: theoretical methane produced per kg BOD ($m^3$/kg)

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# Energy Potential Calculations

**Energy From Wastewater and From High Moisture Wastes**

**D.** For estimating the annual electricity production ($Ewe_{annual}$) from the anaerobic digestion of wastewater, the following equation is used:

$$Ewe_{annual} = \frac{Ew_{annual} \times \eta}{3600}$$

Where:

$Ew_{annual}$= annual electricity production from wastewater (kWh/year),

$\eta$ = generator efficiency (fraction)

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# Energy Potential Calculations

**Energy From Low Moisture Wastes:**

For low moisture wastes, thermochemical conversion technologies is applied to produce energy.

**A.** The following equation is used to estimate the annual energy production from low moisture wastes:

$$Et_{annual} = \phi_{lm} \times CV_{lm}$$

Where:

$Et_{annual}$ = annual energy production from thermochemical conversion (MJ/year),

$\Phi_{lm}$ = annual production of low moisture waste stream (ton/year),

$CV_{lm}$ = heating value of low moisture waste (MJ/ton)

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# Energy Potential Calculations

**Energy From Low Moisture Wastes:**

**B.** For estimating the annual electricity production from low moisture waste via thermochemical technologies ($EEtwe_{annual}$), the following equation is used:

$$EEt_{annual} = \frac{Et_{annual} \times \eta_t \times 1000}{3600}$$

Where:

$EEt_{annual}$= annual electricity production from low moisture waste (kWh/year),
The efficiency of thermo-chemical technologies is assumed to be 25%.

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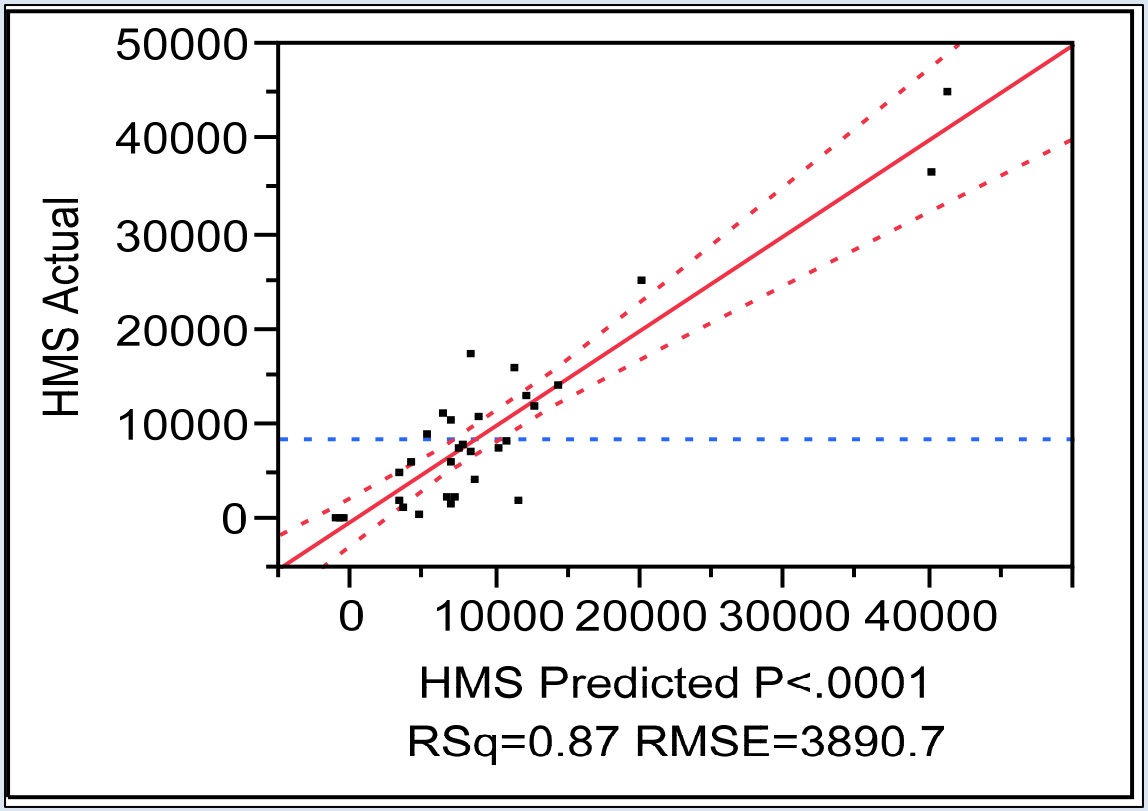
# Cannery Industry Residue Streams BioEnergy Potential

| Cannery Industry Residues | Wastewater Weight of BOD (Tons/yr) | High Moisture Residue Dry Weight (Tons/yr) | Low Moisture Residue Dry Weight (Tons/yr) |
|---|---|---|---|
| Total Amount | 53,016 | 56,282 | 67,141 |
| Energy Potential: | | | |
| Biogas Technology Power (kW) | 9,144 | 7,227 | 8,621 |
| Thermochemical Technology Power (kW) | 0 | 0 | 4,545 |

# Cannery Industry Standard Least Square Model
# High Moisture Solids Actual by Predicted Plot

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# Canning Industry Potential BioEnergy
# County Data

| County Data | Wastewater (Gal/Yr) | Total WW Weight Of BOD (Tons/Yr) | Potential WW Biogas Power (Kwe) | High Moisture Waste Dry Weight (Tons/Yr) | HMS Biogas Power (Kwe) | Low Moisture Waste Dry Weight (Tons/Yr) | LMS Biogas Power (Kwe) | LMS Thermo Chemical Power (Kwe) | Survey Response Rate |
|---|---|---|---|---|---|---|---|---|---|
| Alameda | 3,594,885 | 12 | 2 | 0 | 0 | 0 | 0 | 0 | 100.00% |
| Butte | 112,254,799 | 1587 | 274 | 1980 | 254 | 3836 | 493 | 260 | 100.00% |
| Colusa | 469,293,782 | 1396 | 241 | 2685 | 345 | 4750 | 610 | 322 | 100.00% |
| Humboldt | 730,000 | 5 | 1 | 661 | 85 | 0 | 0 | 0 | 100.00% |
| Fresno | 804,590,471 | 7453 | 1286 | 6096 | 783 | 2444 | 314 | 165 | 89.00% |
| Glenn | 81,719,625 | 818 | 141 | 1838 | 236 | 945 | 121 | 64 | 100.00% |
| Kern | 450,000,000 | 845 | 146 | 413 | 53 | 3885 | 499 | 263 | 100.00% |
| Kings | 984,367,227 | 4596 | 793 | 5465 | 702 | 8944 | 1148 | 605 | 100.00% |
| Los Angeles | 66,658,125 | 548 | 95 | 2574 | 330 | 0 | 0 | 0 | 31.00% |
| Merced | 1,276,871,910 | 5392 | 930 | 4925 | 632 | 7008 | 900 | 474 | 100.00% |
| Orange | 44,676,000 | 280 | 48 | 1384 | 178 | 0 | 0 | 0 | 75.00% |
| Sacramento | 554,269,000 | 8460 | 1459 | 1434 | 184 | 0 | 0 | 0 | 100.00% |
| San Joaquin | 461,810,782 | 3386 | 584 | 940 | 121 | 6064 | 779 | 410 | 80.00% |
| Santa Clara | 27,156,000 | 292 | 50 | 690 | 89 | 0 | 0 | 0 | 100.00% |
| Solano | 395,000,000 | 979 | 169 | 1181 | 152 | 4363 | 560 | 295 | 100.00% |
| Stanislaus | 2,138,343,730 | 14597 | 2518 | 18137 | 2329 | 11583 | 1487 | 784 | 100.00% |
| Tehama | 19,208,630 | 2 | 0 | 1380 | 177 | 0 | 0 | 0 | 100.00% |
| Yolo | 270,000,000 | 2366 | 408 | 4500 | 578 | 13320 | 1710 | 902 | 100.00% |
| **Totals** | **8,160,544,966** | **53,016** | **9,144** | **56,282** | **7,227** | **67,141** | **8,621** | **4,545** | |

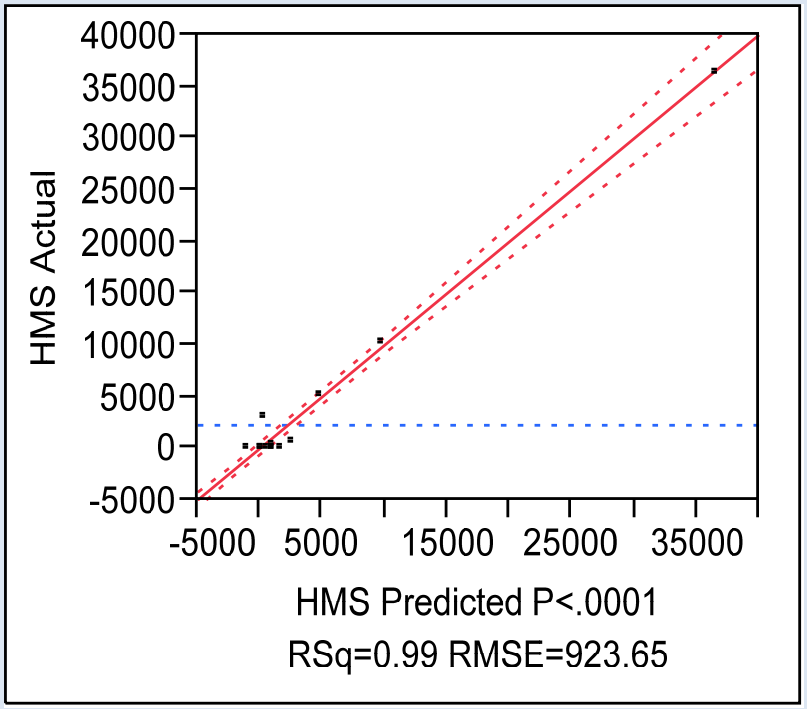
No response was obtained from Kings (1), Riverside (1), San Benito (1) San Bernardino (1), and Tulare (1) counties

# Dehydrated F&V Industry Residue Streams BioEnergy Potential

| Dehydrated F&V Industry Residues | Wastewater Weight of BOD (Tons/yr) | High Moisture Residue Dry Weight (Tons/yr) | Low Moisture Residue Dry Weight (Tons/yr) |
|---|---|---|---|
| Total Amount | 3,087 | 10,856 | 171,064 |
| Energy Potential: | | | |
| Biogas Technology Power (kW) | 532 | 1,394 | 15,350 |
| Thermochemical Technology Power (kW) | 0 | 0 | 8,091 |

# Dehydrated F&V Industry Standard Least Square Model

## High and Low Moisture Solids Actual by Predicted Plot

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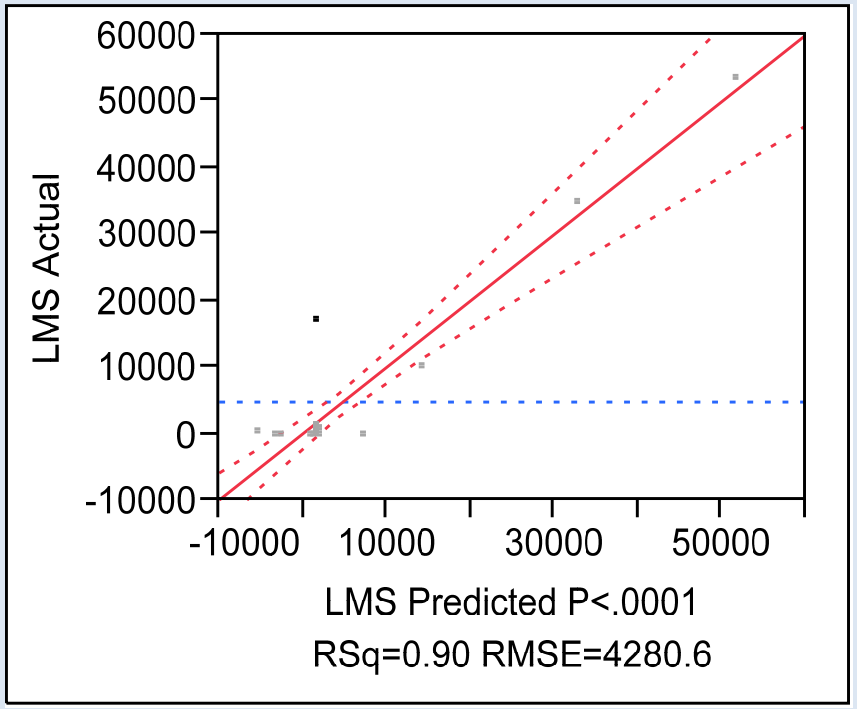


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# Dehydrated F&V Industry Potential BioEnergy County Data

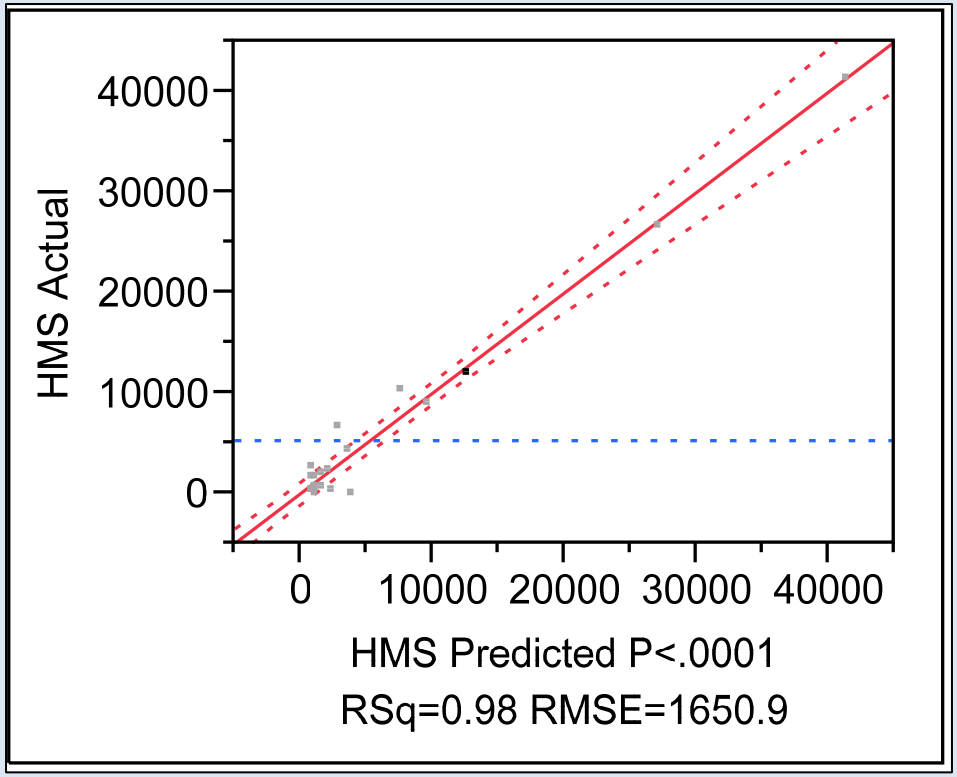
| County Data | Wastewater (Gal/Yr) | Total WW Weight Of BOD (Tons/Yr) | Potential WW Biogas Power (Kwe) | High Moisture Waste Dry Weight (Tons/Yr) | HMS Biogas Power (Kwe) | Low Moisture Waste Dry Weight (Tons/Yr) | LMS Biogas Power (Kwe) | LMS Thermo Chemical Power (Kwe) | Survey Response Rate |
|---|---|---|---|---|---|---|---|---|---|
| Butte | 644,777 | 1 | 0 | 0 | 0 | 1,176 | 106 | 56 | 100.00% |
| Colusa | | | 0 | 0 | 0 | 16,900 | 1,085 | 572 | 100.00% |
| Fresno | 142,773,554 | 2,524 | 435 | 6,662 | 855 | 35,233 | 3,167 | 1,669 | 85.00% |
| Glenn | 440,000 | 1 | 0 | 0 | 0 | 800 | 72 | 38 | 100.00% |
| Madera | 3,344,314 | 5 | 1 | 227 | 29 | 6,769 | 608 | 321 | 100.00% |
| Merced | 5,746,559 | 24 | 4 | 0 | 0 | 1,188 | 143 | 76 | 100.00% |
| Monterey | 114,562,970 | 462 | 80 | 239 | 31 | 89,680 | 8,406 | 4,431 | 100.00% |
| Santa Clara | 99,090 | 0 | 0 | 0 | 0 | 1,506 | 135 | 71 | 100.00% |
| Santa Cruz | 88,924 | 0 | 0 | 0 | 0 | 1,510 | 97 | 51 | 100.00% |
| Stanislaus | 3,500,000 | 13 | 2 | 77 | 10 | 10,000 | 963 | 508 | 33.00% |
| Sutter | 1,275,600 | 2 | 0 | 0 | 0 | 1,948 | 175 | 92 | 100.00% |
| Tehama | 320,000 | 1 | 0 | 0 | 0 | 580 | 52 | 27 | 100.00% |
| Tulare | 31,306 | 0 | 0 | 0 | 0 | 1,476 | 133 | 70 | 100.00% |
| Ventura | 10,950,000 | 54 | 9 | 3,650 | 469 | 1,971 | 177 | 93 | 50.00% |
| Yolo | 180,000 | 0 | 0 | 0 | 0 | 327 | 29 | 15 | 100.00% |
| Totals | 283,957,094 | 3,087 | 532 | 10,856 | 1,394 | 171,064 | 15,350 | 8,091 | |

No response was obtained from Kings (1), Riverside (1), San Bernardino (1), and Tulare (1) counties

# Fresh/Frozen F&V Industry Potential Energy from Residue Streams

| Frozen F&V Industry Residues | Wastewater Weight of BOD (Tons/yr) | High Moisture Residue Dry Weight (Tons/yr) | Low Moisture Residue Dry Weight (Tons/yr) |
|---|---|---|---|
| Total Amount | 31,439 | 20,478 | 0 |
| Energy Potential: | | | |
| Biogas Technology Power (kW) | 5,422 | 2,630 | 0 |
| Thermochemical Technology Power (kW) | 0 | 0 | 0 |

# Frozen F&V Industry Standard Least Square Model
# High Moisture Solids Actual by Predicted Plot




| | |
|---|---|
| R Square Adj. | 0.971134 |

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# Frozen F&V Industry Potential BioEnergy
# County Data

| County Data | Wastewater (Gal/Yr) | Total WW Weight Of BOD (Tons/Yr) | Potential WW Biogas Power (Kwe) | High Moisture Waste Dry Weight (Tons/Yr) | HMS Biogas Power (Kwe) | Survey Response Rate |
|---|---|---|---|---|---|---|
| Alameda | 14,659,860 | 83 | 14 | 372 | 48 | 100.00% |
| Fresno | 1,393,058,461 | 8,684 | 1,498 | 4,327 | 556 | 100.00% |
| Kern | 3,324,137,900 | 6,533 | 1,127 | 7,659 | 983 | 100.00% |
| Los Angeles | 339,544,315 | 4,498 | 776 | 2,005 | 257 | 66.00% |
| Madera | 29,445,721 | 145 | 25 | 265 | 34 | 100.00% |
| Merced | 111,450,000 | 310 | 54 | 1,136 | 146 | 100.00% |
| Monterey | 34,874,658 | 40 | 7 | 162 | 21 | 100.00% |
| Orange | 63,984,500 | 402 | 69 | 298 | 38 | 50.00% |
| San Benito | 126,261,930 | 262 | 45 | 1,394 | 179 | 100.00% |
| San Bernardino | 22,374,500 | 2 | 0 | 144 | 18 | 25.00% |
| San Joaquin | 79,865,808 | 190 | 33 | 340 | 44 | 100.00% |
| Santa Barbara | 297,360 | 0 | 0 | 65 | 8 | 100.00% |
| Santa Clara | 41,230,719 | 359 | 62 | 258 | 33 | 100.00% |
| Stanislaus | 554,324,283 | 1,827 | 315 | 1,319 | 169 | 100.00% |
| Sutter | 6,500,000 | 3 | 0 | 267 | 34 | 100.00% |
| Tulare | 1,110,594,400 | 8,100 | 1,397 | 469 | 60 | 66.00% |
| **Totals** | **7,252,604,415** | **31,439** | **5,422** | **20,478** | **2,630** | |

No response was obtained from Sonoma (1) County

# Regional BioEnergy Potential

| San Joaquin Valley Region | Wastewater Biogas Power (kWe) | HMS Biogas Power (kWe) | LMS Biogas Power* (kWe) | Total Biogas Power (kWe) | LMS Thermo Chemical Power (kWe) | Sample Response |
|---|---|---|---|---|---|---|
| **Fresno** | 3,218 | 2,194 | 3,481 | 8,893 | 1,834 | 89% |
| **Kern** | 1,273 | 1,036 | 499 | 2,808 | 263 | 100% |
| **Kings** | 793 | 702 | 1,148 | 2,643 | 605 | 75% |
| **Madera** | 26 | 63 | 608 | 697 | 321 | 100% |
| **Merced** | 988 | 778 | 1,043 | 2,809 | 550 | 100% |
| **San Joaquin** | 617 | 164 | 779 | 1,560 | 410 | 88% |
| **Stanislaus** | 2,835 | 2,508 | 2,450 | 7,793 | 1,292 | 87% |
| **Tulare** | 1,397 | 60 | 133 | 1,590 | 70 | 63% |
| **Totals** | **11,147** | **7,505** | **10,141** | **28,793** | **5,345** | |

*Anaerobic Phased High Solids System

# Regional BioEnergy Potential

| Northern California | Wastewater Biogas Power (kWe) | HMS Biogas Power (kWe) | LMS Biogas Power* (kWe) | Total Biogas Power (kWe) | LMS Thermo Chemical Power (kWe) | Sample Response |
|---|---|---|---|---|---|---|
| **Butte** | 274 | 254 | 598 | 1,126 | 315 | 100% |
| **Colusa** | 241 | 345 | 1,695 | 2,281 | 893 | 100% |
| **Glenn** | 141 | 236 | 193 | 570 | 102 | 100% |
| **Humboldt** | 1 | 85 | 0 | 86 | 0 | 100% |
| **Sacramento** | 1,459 | 184 | 0 | 1,643 | 0 | 100% |
| **Sutter** | 1 | 34 | 175 | 210 | 92 | 100% |
| **Tehama** | 0 | 177 | 52 | 229 | 27 | 100% |
| **Yolo** | 408 | 578 | 1,740 | 2,726 | 917 | 100% |
| **Totals** | **2,525** | **1,893** | **4,453** | **8,871** | **2,346** | |

*Anaerobic Phased High Solids System

# Regional BioEnergy Potential

| Central Coast | Wastewater Biogas Power (kWe) | HMS Biogas Power (kWe) | LMS Biogas Power* (kWe) | Total Biogas Power (kWe) | LMS Thermo Chemical Power (kWe) | Sample Response |
|---|---|---|---|---|---|---|
| **Monterey** | 87 | 51 | 8,406 | 8,544 | 4,431 | 100% |
| **San Benito** | 45 | 179 | 0 | 224 | 0 | 100% |
| **Santa Barbara** | 0 | 8 | 0 | 8 | 0 | 100% |
| **Santa Cruz** | 0 | 0 | 97 | 97 | 51 | 67% |
| **Ventura** | 9 | 469 | 177 | 655 | 93 | 50% |
| **Totals** | **141** | **707** | **8,680** | **9,528** | **4,575** | |

*Anaerobic Phased High Solids System

# Regional BioEnergy Potential

| Southern California | Wastewater Biogas Power (kWe) | HMS Biogas Power (kWe) | LMS Biogas Power * (kWe) | Total Biogas Power (kWe) | LMS Thermo Chemical Power (kWe) | Sample Response |
|---|---|---|---|---|---|---|
| **Los Angeles** | 870 | 588 | 0 | 1,458 | 0 | 61% |
| **Orange** | 118 | 216 | 0 | 334 | 0 | 63% |
| **San Bernardino** | 0 | 18 | 0 | 18 | 0 | 14% |
| **Totals** | **988** | **822** | **0** | **1,810** | **0** | |

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# Regional BioEnergy Potential

| Bay Area | Wastewater Biogas Power (kWe) | HMS Biogas Power (kWe) | LMS Biogas Power* (kWe) | Total Biogas Power (kWe) | LMS Thermo Chemical Power (kWe) | Sample Response |
|---|---|---|---|---|---|---|
| **Alameda** | 16 | 48 | 0 | 64 | 0 | 100% |
| **Santa Clara** | 112 | 122 | 135 | 369 | 71 | 100% |
| **Solano** | 169 | 152 | 560 | 881 | 295 | 100% |
| **Totals** | **297** | **322** | **695** | **1,314** | **366** | |

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