

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

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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



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# 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



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# 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)



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# Cannery Industry

- 157 companies produce canned fruits and vegetables and canned specialties
- Of these, 71 companies employ  $\geq$  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  $\geq$  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  $\geq$  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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# Cannery, Dehydrated and Fresh/Frozen F&V Industry

- 352 companies produce canned, dehydrated and fresh/frozen fruits and vegetables.
- Of these, 209 companies employ  $\geq$  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**

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



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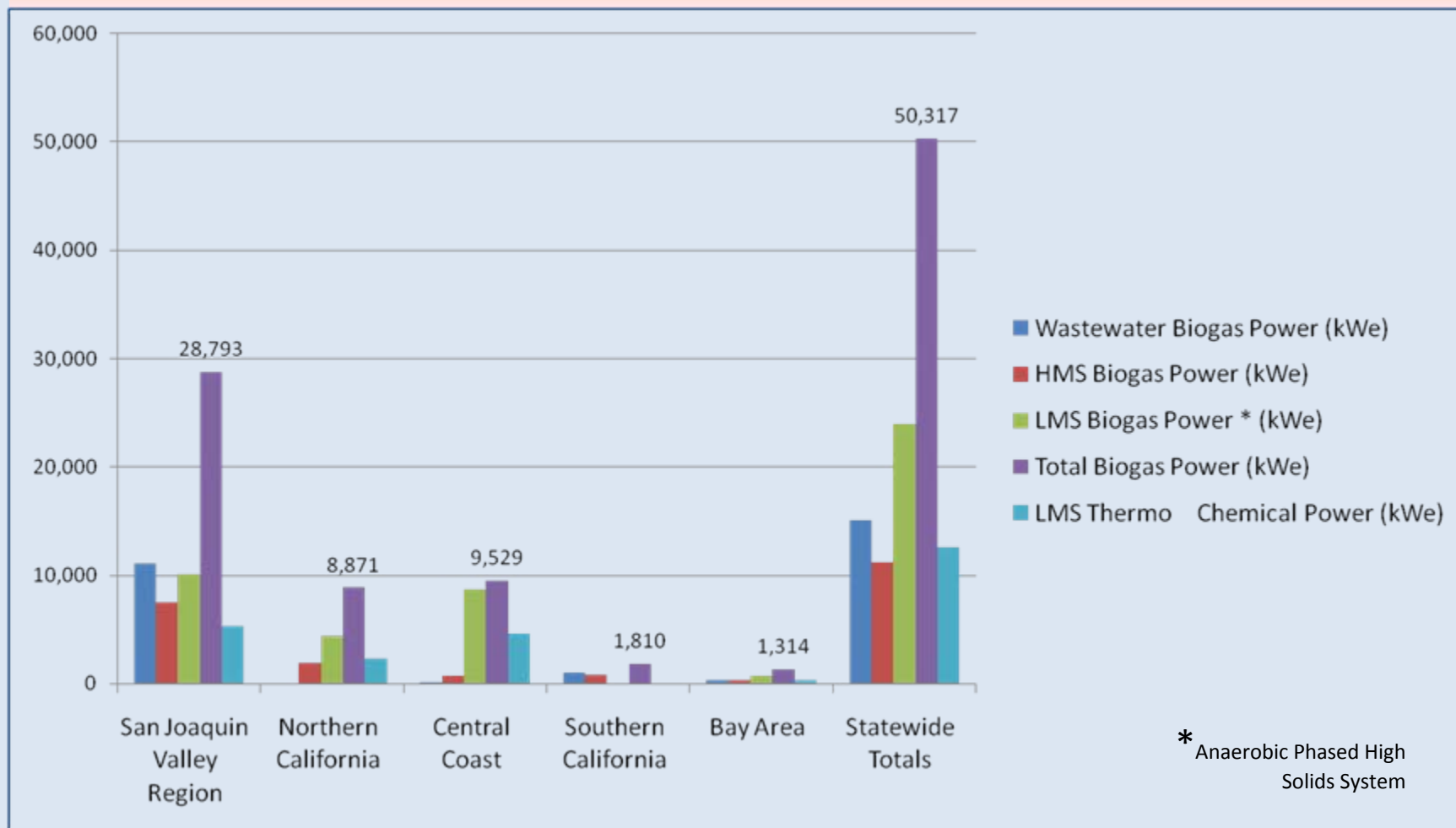
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# Regional BioEnergy Potential

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
<b>Statewide Totals</b>	<b>15,098</b>	<b>11,249</b>	<b>23,969</b>	<b>50,317</b>	<b>12,632</b>

\*Anaerobic Phased High Solids System

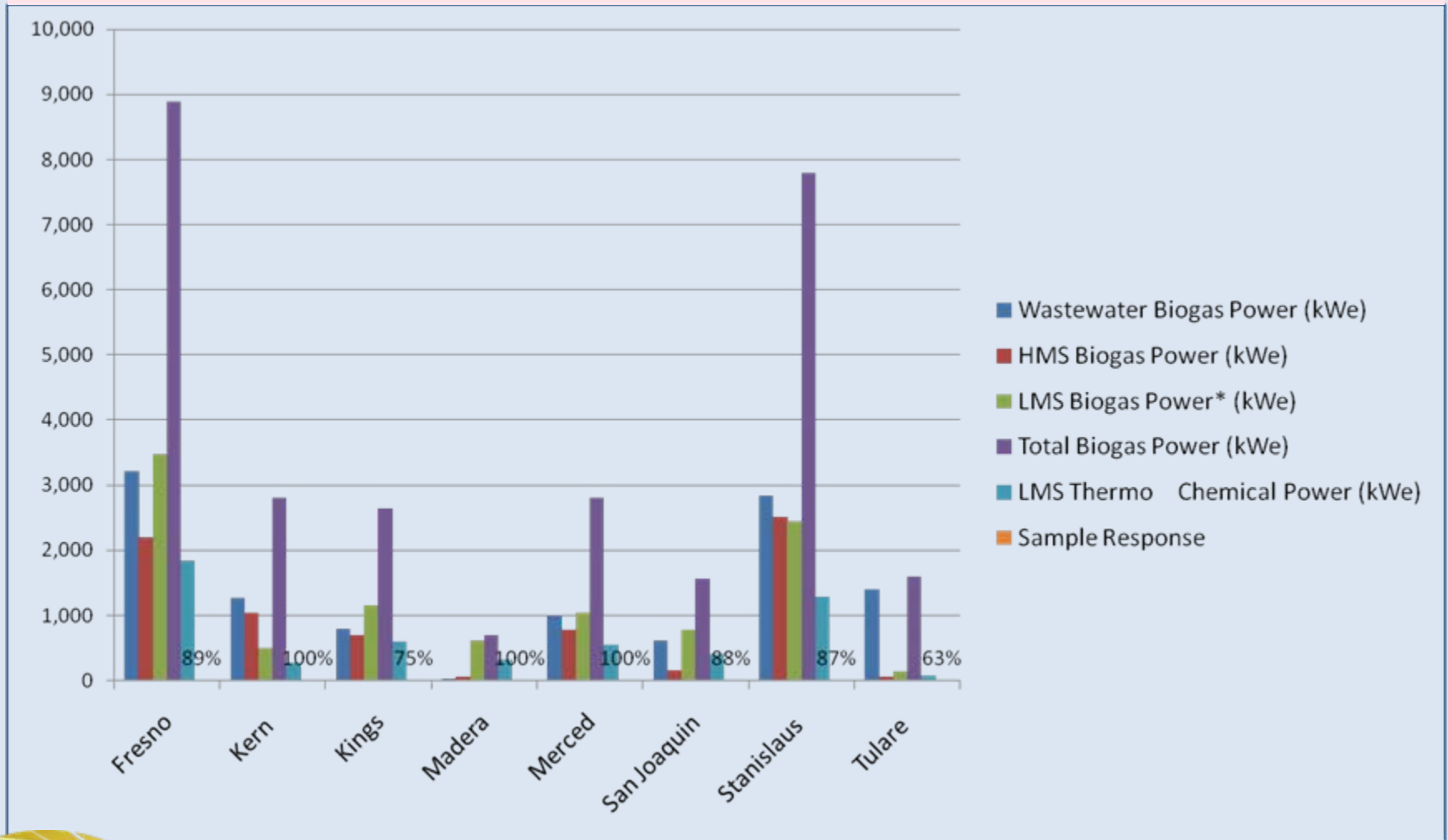
# Regional BioEnergy Potential



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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 CO<sub>2</sub>/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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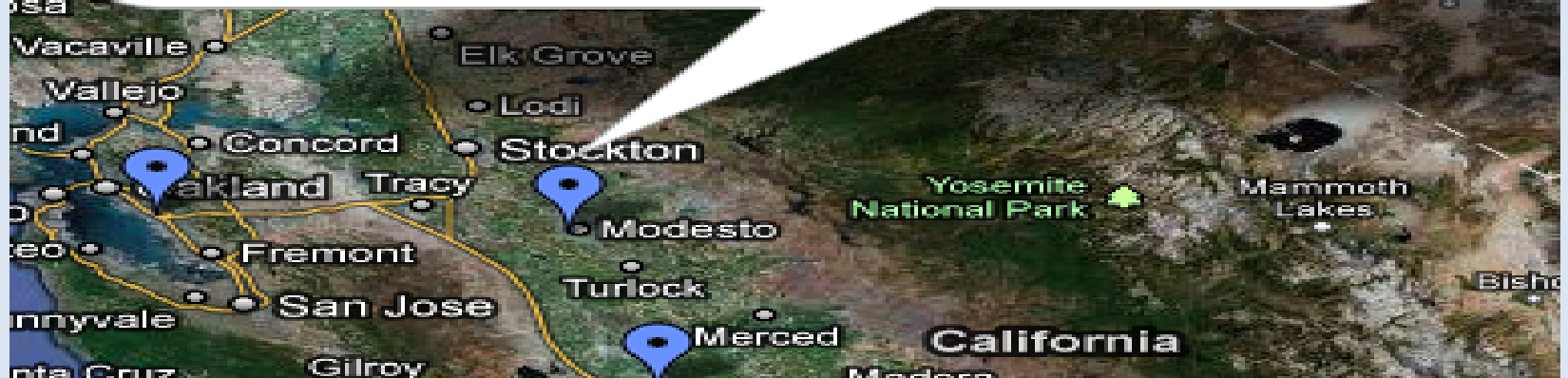
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## City of Modesto: Wastewater Treatment Plant

The City of Modesto offers a Cap & Trade incentive to established industries to reduce wastewater discharge to the wastewater treatment facility. Available WWTF capacity can be used to attract new economic development to the city.

Del Monte Foods and Frito Lay working to develop on-site wastewater anaerobic digestion system: to reduce WWTF discharge, extract methane for boiler feed energy, deliver clean water for agricultural irrigation .

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