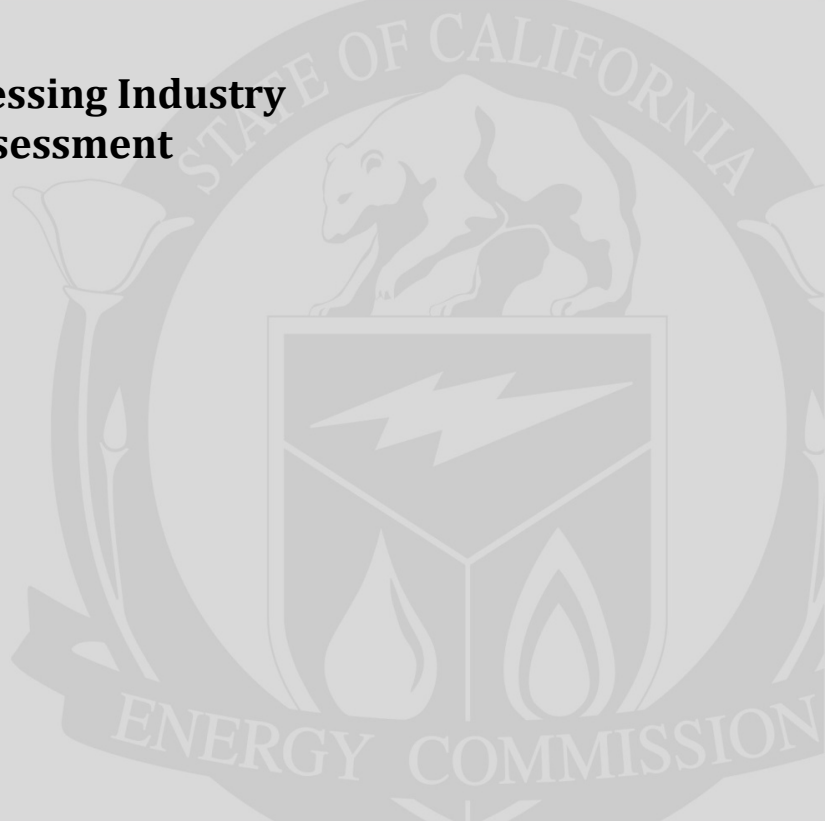


**Public Interest Energy Research (PIER) Program
DRAFT FINAL PROJECT REPORT**

**California Food Processing Industry
Organic Residue Assessment**



Prepared for: California Energy Commission

Prepared by: California Biomass Collaborative, University of California, Davis and
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PREFACE

The California Energy Commission Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

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- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/ Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

California's Food Processing Industry: Residue Assessment is the final report for Task 3.2.1.2 the Biofuels and Biodiversity Report project, contract number 500-08-017. The information from this project contributes to PIER's Renewable Energy Technologies Program.

For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-654-4878.

ABSTRACT

This document analyzes results from an organic residue assessment of the California food processing industry. The objective of the research was to estimate the amount of potential resources available as wastewater and solid residues, and evaluate the amount of energy that these resources might generate. Food processor sectors investigated included: fruit and vegetable canneries, dehydrated and fresh/frozen fruit and vegetable processors, dairy creameries, wineries, meat processors and almond and walnut processors. Where possible, current waste disposal practices and amounts were identified and the potential availability of resources was assessed.

Data were collected from food company personnel, expert interviews, and secondary archival sources. Regression methods using survey data were used to estimate the amount of solids discharged as a function of wastewater, the number of workers and the solids' moisture content for incomplete observations. Potential energy was estimated using generic feedstock properties and basic assumptions for conversion efficiencies.

Results show 26.3 billion gallons of wastewater (equivalent to 175,000 tons of BOD₅) and 3.4 million dry tons of solid residues are produced annually by the industry sectors investigated. Almond hulls and shells account for almost 60 percent of total dry tons of solid residue. This resource represents a technical energy potential of 560 MW of equivalent electricity with 24.5 million MMBtu of recovered heat. Almond hulls represent a significant component of the total energy potential identified in the study. However, much of the residue materials have current economic uses and, at current prices, are not available for energy. These materials include almond hulls, walnut shells, cheese whey, and animal by-products.

Bioenergy generation potential from the use of economically available food industry residues is limited. Food industry managers ought to continue adopting efficiency measures and residue management best practices to achieve cost reductions and improve productivity while complying with environmental standards.

Keywords: biomass, food processor industry, organic residues, energy potential, renewable energy, wastewater, solid residues, industrial boilers.

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Executive Summary

The goal of the California Food Processing Industry Residue Assessment (Assessment) was to compile a county-level inventory of food processing industry residues and to estimate the amount of energy that these residues could generate from California-based biomass resources.

Methods:

A Dun & Bradstreet 2007, Standard Industry Code Food and Beverage Industry Market Place data base was purchased and used to identify the companies that would be included in the survey and secondary data collection process. Data was collected from canneries and dehydrated fruit and vegetable processors, fresh and frozen fruits and vegetables prepared foods manufacturers and dairy creameries. Grape crush pomace, meat processing, almond and walnut hulls and shells were calculated using secondary industry data. Insufficient responses were obtained from breweries, soft drink manufacturers, snacks and bakeries. No data was collected from grain milling and sugar refining enterprises.

Data collection methods included direct communication with food company representatives (who were surveyed online, through email, by phone and/or in person) to gather both liquid and solid residue discharge information for the year 2009. Only companies that employ 25 or more workers were surveyed. Additional data was collected from secondary sources such as Regional Water Quality Control Board offices and wastewater treatment facilities (WWTF) serving food processing companies. Data collection started in March 2010, and was completed in April 2011.

Missing data from returned surveys were estimated using an ordinary least squares regression model using information from complete responses and based on facility size, wastewater discharge amounts, number of workers, etc.

Potential energy was estimated using an Excel-based calculator developed by researchers from the Department of Biological and Agricultural Engineering at UC Davis. This model employs generic feedstock properties and basic assumptions for conversion efficiencies. The energy potential from wastewater flows and solid residues, except nut shells and hulls, were estimated assuming conversion by anaerobic digestion producing biogas, and then used to fuel reciprocating engine generators (for both heat and power). Nut shells and hulls were assumed to be converted via thermal pathways for heat and power.

Results:

Approximately 26.3 billion gallons of wastewater (equivalent to 175,000 tons of BOD₅)¹ and 3.5 million dry tons of solid residues are produced annually by the industry sectors investigated (Table ES-1). Approximately 55 percent of the wastewater is from canneries and fruit and vegetable processing with another 20 percent each from creameries and meat processing (Table ES-1). Almond hulls account for nearly 60 percent of solids residue (dry basis) with almond and walnut shells contributing another 20 percent.

Table ES-1. Summary of Total Food Processing Wastewater Discharged, BOD₅, and Solids Generated Annually in California

Food Processing Sector	WW (MGY)	BOD ₅ (dry tons/ year)	HMS (dry tons/ year)	LMS (dry tons/ year)
Cannery Fruits and Vegetables (F & V)	8,161	55,927	47,240	67,960
Dehydrated F&V	284	2,717	22,600	109,150
Fresh/Frozen F&V	6,290	28,150	25,770	
<i>Subtotal, Fruits and Vegetables</i>	14,735	86,794	95,610	177,110
Meat Processing				
Poultry	3,759	7,700	128,000	
Red Meat	2,000	29,300	187,860	
<i>Subtotal, Meat processing</i>	5,759	37,000	315,860	
Other Food Residues				
Almond Hulls				2,029,730
Almond Shells				495,940
Walnut Shells				199,270
Winery	832	6,760	173,060	
Creamery	4,932	44,060		
<i>Subtotal, Other Residues</i>	5,764	50,820	173,060	2,724,940
Grand Total	26,258	174,614	584,530	2,902,050

Solid residues from fruit and vegetable processing facilities (canneries, dehydrators, fresh and frozen), meat processing, wineries and creameries contribute about 760,000 dry tons solid residue (approximately 20% of total solids) [Figure ES-1).

¹ BOD₅ is the amount (mass) of dissolved oxygen needed by aerobic biological organisms to decompose organic material in (or stabilize) wastewater. Results are usually reported from a 5-day lab test and reported as BOD₅. It is historically an indicator of degree of water pollution and public health risk, but also has value as an indicator of potential biogas production. Tons of BOD₅ do not have any direct relationship to the tons of high and low moisture solids (HMS, LMS).

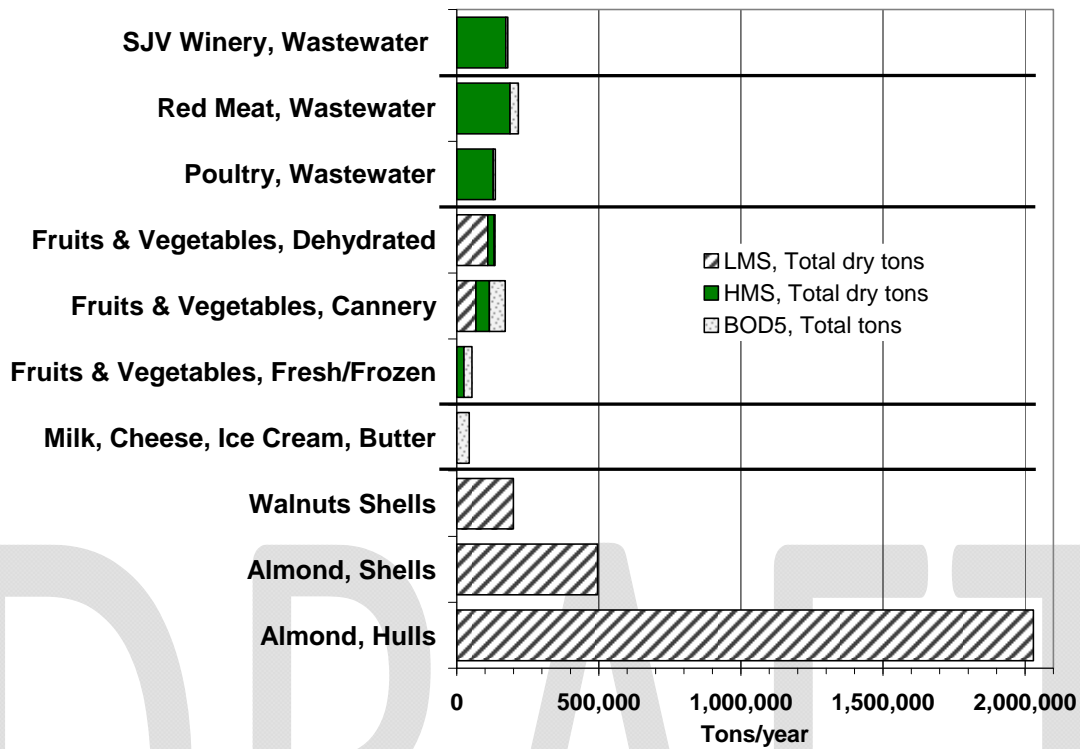


Figure ES-1. Estimated Residue Amounts by Food Processing Sector

Food processing facilities are distributed throughout the state but concentrated in the Central Valley, where most of the agricultural production takes place (Figure ES- 2). Table ES-2 provides county level data for solid residues created by canneries, dehydrators, fresh and frozen fruit and vegetable processors, and almond and walnut processors in California. The figure and table do not include solids data from wine grapes and meat processing because the information was not reported at the county level.

Table ES-2 Food Industry Residues by County

County	BOD tons/yr	HMS tons/yr	LMS tons/yr
Alameda	1,712	400	0
Amador	0	420	0
Butte	1,900	1,050	117,864
Calaveras	0	90	0
Colusa	1,400	3,290	145,642
Contra Costa	11	330	0
Del Norte	0	0	0
El Dorado	0	220	0
Fresno	28,285	49,060	533,636
Glenn	1,683	2,190	87,365
Humboldt	1,139	430	0
Kern	14,977	20,550	559,733
Kings	16,349	6,900	53,522
Lake	0	1,420	3,512
Los Angeles	30,871	4,110	0
Madera	200	22,570	225,582
Marin	0	30	0
Mariposa	0	10	0
Mendocino	0	2,680	0
Merced	10,392	9,920	307,080
Monterey	500	12,320	66,200
Napa	0	12,850	0
Nevada	0	50	0
Orange	1,707	1,500	0
Placer	0	20	855
Riverside	2,004	140	0
Sacramento	14,113	10,530	0
San Benito	300	2,100	1,193
San Bernardino	15	140	0
San Diego	0	30	0
San Joaquin	8,093	37,850	161,161
San Luis Obispo	0	6,170	2,287
San Mateo	0	10	0
Santa Barbara	0	3,680	0
Santa Clara	939	1,880	0
Santa Cruz	0	80	831
Shasta	0	40	0
Siskiyou	0	10	0
Solano	1,147	2,070	10,043
Sonoma	77	10,640	0
Stanislaus	21,816	19,090	414,065
Sutter	100	1,750	26,745
Tehama	0	1,460	28,251
Trinity	0	50	0
Tulare	6,241	6,230	76,537
Ventura	1,901	3,710	2,300
Yolo	2,400	8,250	37,855

Yuba	0	40	7,605
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Figure ES-3 depicts geographical distribution of industry wastewater by county (shown in tons of biological oxygen demand). County level trends are similar to solids residue with the Central Valley reflecting most activity. An exception to this trend is Los Angeles County which has the highest amount of food processor wastewater BOD discharge due to a large number of meat packing, ethnic food preparation facilities and several milk processing creameries.

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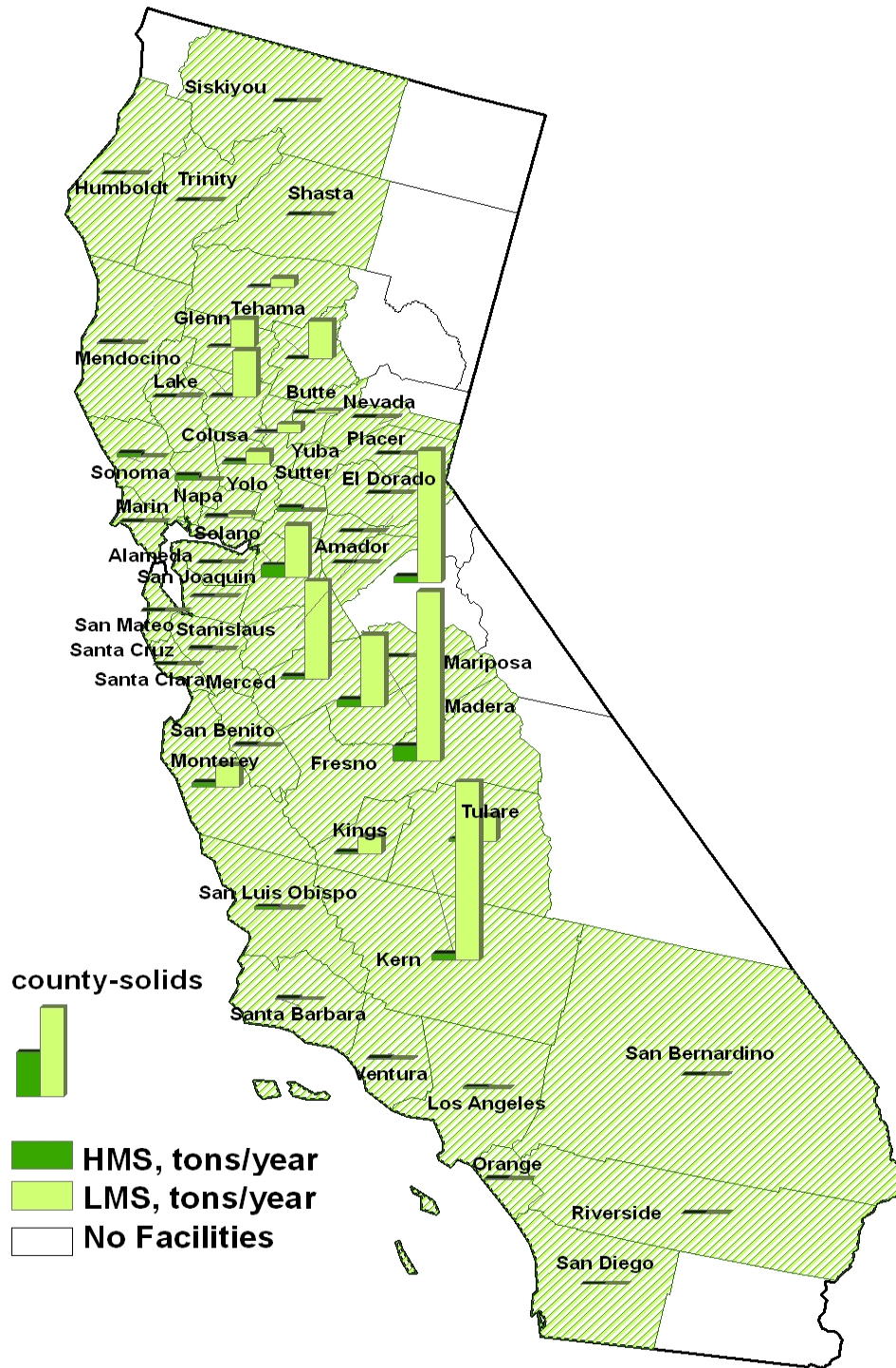


Figure ES-2. Food Industry High (HMS) and Low Moisture Solids (LMS) by County, dry basis

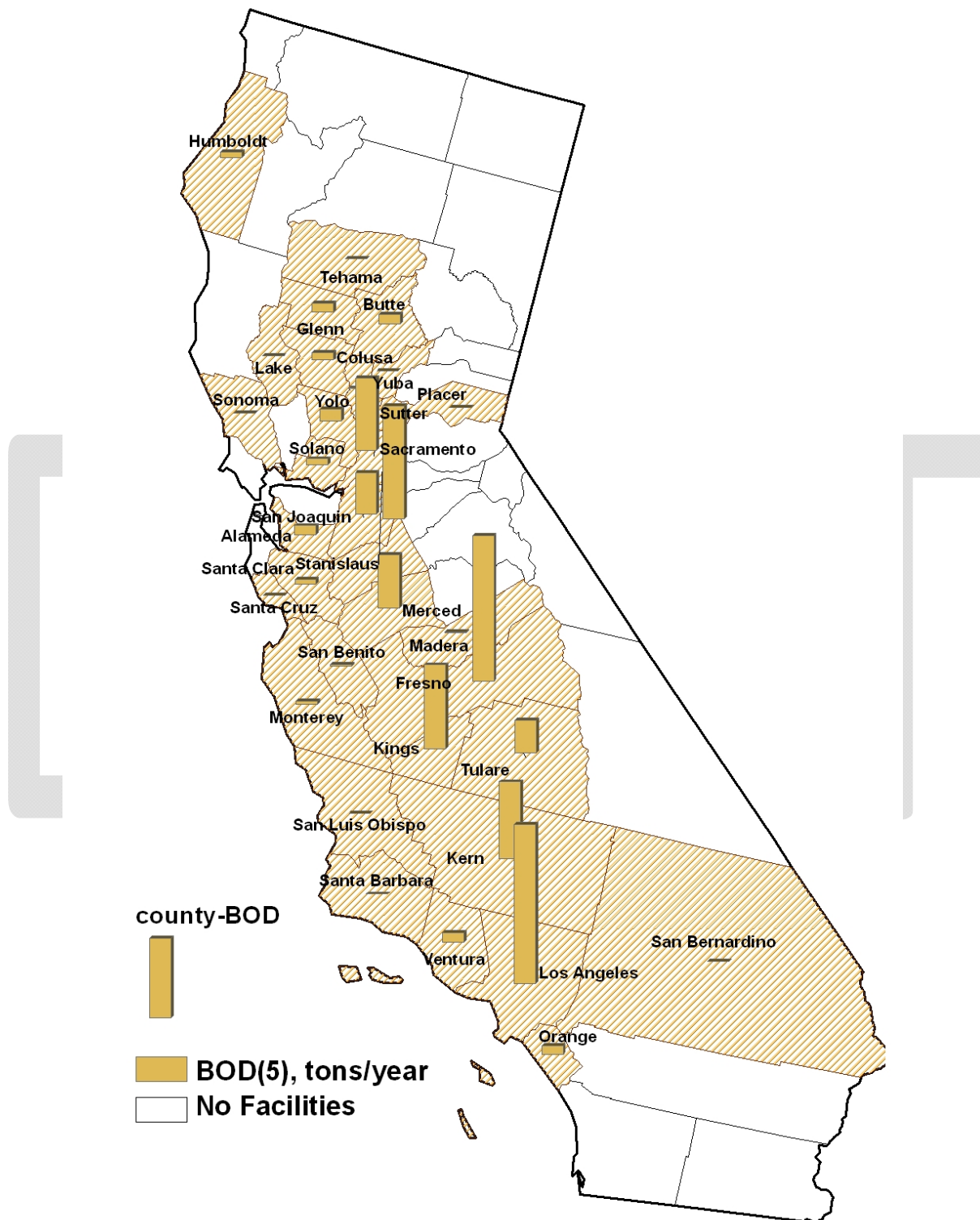


Figure ES-3. Map of Food Processing Wastewater Biological Oxygen Demand, BOD₅

Technical Energy Potential:

Energy potential, which assumes all identified residues are available and converted, is estimated at 557 MW electricity, with 24.5 million MMBtu of recovered heat derived from combined heat and power (CHP) systems (Table ES-3). Energy from fruit and vegetable, creamery, winery, and meat processing liquid and solid residues is estimated at 96 MW of electricity and 3.4 million MMBtu of recoverable heat via conversion of biogas produced by anaerobic digestion.

Thermal conversion of nut shells and hulls could produce another 461 MW of power and 21 million MMBtu of recovered heat (Table ES-3). Nut shells and hulls account for more than 80 percent of energy potential of all food industry residues calculated.

Much of the identified residues would not be available for energy feedstock at current energy prices. Many of these residues are currently committed to profitable and stable end-use markets (for example, essentially all almond hulls, which are the largest component of energy potential at 340 MW, are used in animal feed markets). This study does not evaluate the price range at which almond hulls and other higher value by-products would be diverted to bio refineries instead of current use.

Potential Residue Availability:

Most of the seasonal residues are currently disposed using lowest cost options. Fruits and vegetable residue production occurs mostly from July through October in all agricultural production and processing regions of the state. Large carrot and onion companies in the Central Coast and Southern San Joaquin Valley regions can maintain year round processing facilities by trucking produce from farms in Imperial County and Yuma, Arizona winter production regions.

Table ES-3. Summary of Bioenergy Potential from Food Processing Residuals

Food Processing Sector	BOD ₅ Biogas		Solids Biogas		LMS Thermal		Potential Residue Availability
	Power (MW)	CHP (MMBtu)	Power (MW)	CHP (MMBtu)	Power (MW)	CHP (MMBtu)	
Cannery Fruits and Vegetables (F & V)	7.2	257,480	11.1	394,600			High
Dehydrated F & V	0.4	12,530	12.7	451,460			High
Fresh/Frozen F & V	3.6	129,500	2.5	88,360			High
Winery	0.9	31,080	16.7	592,960			High
Creamery	5.7	202,770					None
Poultry	1.0	35,410	12.3	438,590			None
Red Meat	3.8	134,790	18.1	643,670			None
Almond Hulls & Shells, Combined					427.4	19,545,260	Hulls None; Shells Medium

Almond Hulls, Segregated					340.0		None
Walnut Shells					33.7	1,541,902	High

Total CHP

Power Total (MW)	22.6		73.3		461.1		553.0
Recovered Heat (MMBtu)		803,560		2,609,640		21,087,162	24,315,610

The average sized tomato cannery discharges sufficient residues to produce over 48,000 million Btu (MMBtu, or 480 thousand therms) of biogas resources. The seasonal nature of the fruits and vegetable processing industries, however, does not encourage investment in bioenergy conversion systems. The fruit, vegetable and winegrape segments of the food industry manage liquid and solid residues as cheaply as possible by land discharge/application, or discharge to WWTFs and landfills. These disposal costs for wastewater delivered to WWTFs and to solid waste landfill facilities are expected to increase. An alternative strategy is to develop a value-added enterprise using residues (maximizing profit rather than minimizing costs).

The fruit and vegetable food company managers surveyed acknowledged that there is market interest in their residue streams. Many companies had conducted preliminary studies to calculate the economic returns from bioenergy projects. Wastewater discharged from most of these industries contains biological oxygen demand (BOD) that can be digested to extract methane gas for on-site bioenergy generation. Most concluded that such projects could not recover costs within the three to five year period return on capital that is standard in this industry.

Organic solid residues from the food industry are not wasted. Fruit pits are used in co-generation facilities and for other industrial purposes. Almond hulls, and sometimes shells, are a valuable nutritional component of animal feed, while almond shells are used as animal bedding or as energy feedstock. Dairy creameries have created new businesses from what was once considered a waste by developing products from whey and other creamery by-products. Milk lactose and cheese whey are transformed into high value-added protein-rich nutritional and functional food products. Food corporations are investing in research and development facilities to develop higher value-products from organic residue streams.

Summary of Results:

In the short-term, food companies located in the Central Valley region will continue to dispose most of their "wet waste" through land application practices. However food companies may adopt water conservation practices to reduce wastewater volumes, saving costs from extracting and pumping water while prolonging the use of land discharge permits. As a competitive advantage, the ability to discharge wastewater and

wet solids on land will continue to favor food companies using such practices over those that discharge at a higher cost through WWTFs and landfills.

The adoption of best practices for the management of food industry residues will become important to control costs and to fulfill environmental and sustainability standards. Company executives are exploring technical and behavioral opportunities to reduce waste, reuse recovered materials and recycle value-added residue products. Companies will eventually more aggressively recover materials and recycle value-added residue products, striving for lower resource intensities to find new revenue streams.

Results from the assessment represent a significant portion of the wastewater and wet solid residues generated by California's fruit and vegetable processing facilities. Users of this report have access to data tables to estimate total potential from these and other sources by county. Fruit and vegetable residues and grape pomace are potentially the most available for bioenergy conversion. All other by-products are being utilized.

Further Research

Recommendations for further research include gaining a better understanding of the physical characteristics for the full range of food processor residues (through a combination of literature review and field sampling and analysis) to improve energy estimates. Also, techno-economic modeling combined with geospatial resource and infrastructure data could elucidate locations and opportunities for bioenergy project development (e.g., build on the Biorefinery Siting Model work funded by PIER).

CHAPTER 1: Background

In 2009, the California food product manufacturing industry contributed \$21.9 billion to the State's \$1.9 trillion, Gross Domestic Product (US Department of Commerce, 2011).² The food industry is the State's largest industrial user of electricity, consuming 4,500 Gigawatt hours per year, with a peak demand of 650 megawatt (MW). The food industry is the second largest user of natural gas, behind the petroleum industry, consuming 61 MMBtu, or 610 million therms per year (California Public Utilities Commission, 2008). Direct energy is used for pumping, heating, refrigeration, compression and thermal conversions to clean, cook, and preserve perishable commodities.

1.1 Purpose of the Food Industry Residue Assessment Study

The purpose of this Assessment is to compile a regional inventory of food processing industry residues and to estimate the amount of energy that these resources could generate. This study builds on information developed in earlier PIER supported work (Matteson and Jenkins, 2007, Williams et al., 2008, etc.). The Assessment provides county estimates for liquid and solid residues from the food processing industry, as well as information on amount of wastewater the industry discharges to land or wastewater treatment facilities (WWTFs).

The food industry sectors or processor types that were surveyed include canneries (tomatoes, peaches, pears, olives, and other fruits and vegetables), dehydrated fruit and vegetable processors (raisins, onions, apricots, plums and other) fresh and frozen fruits and vegetables (includes fresh/frozen packaged vegetables and prepared foods), winegrapes, dairy creameries, meat processing and almond and walnut processors. Attempts to collect data from other food processing sectors, such as soft drink manufacturers, bakeries, snacks producers, milling facilities (e.g., rice and other grains), and sugar refineries, were met with little success. No results are reported for these sectors.

Funded by the California Energy Commission Public Interest Energy Research Program (PIER) in response to continued stakeholder and State and Federal agency interest, there is the expectation that these resources can be utilized and contribute to the State's Renewable Portfolio Standard (RPS) or contribute to the Low Carbon Fuel Standard. SBX1-2, signed by Governor Brown on April 13, 2011, increases California's renewable portfolio standard (RPS) target from 20 percent by 2010 to 33 percent by December 31,

² Where food product industry includes NAICS code numbers 311111 through 312140.

2020. Governor Brown has also announced goals to install 20,000 megawatts (MW) of new renewable power by 2020, of which 12,000 MW will be local or distributed generation. The Renewable Energy Equity Act (SB 489, Wolk) signed by the Governor on October 8, 2011, offers to streamline the process to interconnect small distributed generation biomass resources to the California Net Energy Metering Program (leginfo.ca.gov, 2011).³

1.2 Previous Residue Assessments

Earlier PIER funded work surveyed California food and other processing sectors to estimate biomass residue and its energy potential. The study estimated some one million dry tons per year of residue from food processors that support 90 MW of power generation via anaerobic digestion (biogas) and thermal conversion pathways (Matteson and Jenkins (2007).

Regional food industry resource assessments conducted in California include one for the Chino Basin, the Sacramento region, and Humboldt and Marin counties.

The Chino Basin Inventory Report for Agricultural and Food Processing Facilities (part of a larger PIER project) evaluates opportunities to generate biogas from food wastes and selected food processing facilities located in that region (Kitto, 2003). This study identified fourteen food processing facilities with potential to utilize residues for on-site food waste anaerobic digester systems. The study estimated a technical potential to produce methane equivalent to 37 MW of electricity.

A resource assessment for the Sacramento Municipal Utility District (SMUD) territory that looked at food processors and food waste from institutional food service and preparation was conducted by researchers at UC Davis. This study evaluated the potential for biomass to energy utilizing food streams from 45 entities within a 50 mile radius from the City of Sacramento. Fifty-two thousand annual dry tons of residue as well as wastewater streams containing 7,300 tons BOD₅ were identified with an estimated combined electricity generation potential of 4.7 MW (Matteson, et al., 2005).

Studies conducted for the Humboldt Waste Management Authority (HWMA) and the Central Marin Sanitation Agency did not focus on residues from food processors, but instead aggregated information for food waste collection from commercial, industrial and institutional sources. The HWMA study identifies environmental benefits from the establishment of a regional food waste digestion facility; reduced greenhouse gas emissions from landfills and by avoiding long-distance hauling, while displacing grid electricity use (Bohn, 2010). The Central Marin Sanitation Agency study identifies the need to supply 15 tons of food waste per day as the minimum amount to be delivered to the sanitary agency digestion facility to justify investing in equipment to sort, screen and deliver food waste residues (Kennedy/Jenks Consulting, 2010).

³ As of this writing, the Governor has not yet signed the bill.

The East Bay Municipal Utility District's (EBMUD) Resource Recovery Program has established long-term contracts with the Contra Costa Solid Waste Authority to source separate commercial food waste (some may be from food processors but the majority is likely from restaurants, institutional food services and grocery stores), and deliver 25 tons per week of food waste to the district's wastewater treatment plant anaerobic digestion system. EBMUD is working to establish a food waste pre-processing facility on the former Oakland Army Base (adjacent to EBMUD) that would process an additional 200 tons of organic residues per day for anaerobic digestion (Diemer, Dennis, 2010). EBMUD's anaerobic digestion system currently generates 11.5 MW of electricity.

1.3 Food Industry Companies

A Dun & Bradstreet 2007 Standard Industry Code Food and Beverage Industry Market Place database was purchased and used to identify individual companies. A total of 2,950 companies were registered as manufacturers of food and beverage products in California (Standard Industrial Classification (SIC) codes 2011 through 2099). Of these companies, less than 40 employ more than 500 workers, another 300 have from 100 to 499 employees. More than 135,000 people are employed by the industry (Dun & Bradstreet, 2007).

This diverse industry processes crops, livestock, and animal products into fresh and frozen products, canned goods, beer and wine, milk, cheese and other edible products for human and pet consumption.

1.4 Food Industry Organic Residues

Organic residues from the food industry include wastewater and solid residues with variable moisture content. Residue production is seasonal for canneries, wineries and fruit and vegetable processors, peaking midsummer through early fall. Creameries, breweries and meat processing facilities, among others, generally operate year round.

Traditionally, these residual materials have been managed as unwanted excesses with limited value. Creative management solutions that minimize the handling costs by supplying a drop-in feedstock into another enterprise have provided low-cost solutions for both the waste producer and the waste user. More recently, companies are finding that with some investment in capital or technology, these undervalued surplus organic residues can be processed into higher value, or value-added markets. When these enterprises are successful, the revenue generated from the wastes will be greater than the handling costs.

1.5 Residue Management Practices

Food industry company managers attempt to manage these residues as economically as possible many of which find value in secondary markets (e.g., animal feed, bedding, etc.). Liquid residues can be managed in treatment lagoons, through regulated discharges to land, or by delivery to WWTFs (generally through a sewer system). Other regulated options include direct discharge to surface water as well as underground injection. The Porter-Cologne Water Quality Control Act gives regulatory authority to the State Water Resources Control Board and Regional Water Quality Control Boards (California Water Boards) to regulate wastewater discharges from the food industry (California State Water Resources Control Board, 2011). The range of management options and costs available to a particular facility depends on its location.

Residue management can be expensive in terms of worker hours and disposal/discharge fees. It also requires companies to employ skilled workers with expertise to comply with stringent environmental standards and concomitant compliance costs. Treatment processes can be energy and water intensive, and are closely regulated. Food companies will continue to improve residue management practices to comply with regulations, reduce production costs, and to possibly generate revenue from renewable energy or other products.

In the Central Valley, the majority of solid residues from canneries, dehydrated, fresh and frozen fruit and vegetable processing facilities are utilized as animal feed, either directly fed “as is,” or collected by companies to process the residues into animal feed products.

More comprehensive efforts to properly dispose of food industry residues are also available such as the Food Processing By-product

Stanislaus County Food Processing By-Product Reuse Program



The program oversees the orderly disposal of approximately 110,000 wet tons of food industry organic residues annually. Of these, 52,000 tons of by-products are land applied, 44,000 tons are fed directly to cattle, and the remaining 14,000 tons are spread and dried on surfaced pads. (Stanislaus County Food Processing By-products Use Program, 2010).

The dehydration sites are contracted by companies like Agra-Trading, specializing in the collection of agricultural residues to develop value added products. Stone fruit pits are collected and ground as an ingredient for industrial drills, grinders and for fireplace logs or biomass. The kernels in apricot pits are used in high-end cosmetics and pharmaceuticals (<http://www.agra-trading.com/page/stone-fruits.php>).

Survey results show that in 2010, apricot pits sold for \$180 per ton and peach pits sold for \$11/ton.

Reuse Program in Stanislaus County. In 1978, Stanislaus County created this program to facilitate the diversion of food processing residues from landfills to permitted sites. This program created business opportunities to use the residue as direct cattle feed, processed feed products, and soil supplements (or direct land application). Other counties could benefit from similar programs in regions where farmers typically collect residues from food factories to “feed cattle and/or disc into soil” (Stanislaus County, 2010). Please see sidebar for program details.

California’s Regional Water Boards regulate and enforce organic residue land discharge to avoid harm to surface and ground water. They monitor that wastewater and solid residue discharges are applied to fields at reasonable rates to avoid nuisance conditions and salt accumulations. Food companies must submit Waste Discharge reports characterizing the waste streams, as well as develop and implement waste management plans, to avoid contact with surface waters and to ensure no degradation to groundwater (California State Water Resources Control Board, 2011).

1.6 Processing Facility Residue Management Costs

Solid residues such as pomace ⁴ and high moisture solids are hauled to certified disposal locations and facilities. In 2010, disposal costs in the San Joaquin Valley (SJV) ranged from \$7 to \$12 per wet ton for solid waste disposal and \$5 to \$7 per ton of dry pomace (from survey responses). Much of this material is used in composting facilities, animal feed rendering facilities, and discharged on land as soil organic matter.

Food industry facilities located in the Bay Area and the Los Angeles region have fewer residue disposal options. No land discharge permits are issued to food processing facilities in these regions (RWQCB, 2010). Industry wastewater is discharged to municipal WWTFs and solid residues are trucked to landfills, except those collected for rendering companies and animal feed processing facilities.

The urban market is now competing for food processing residue streams. The Sacramento Municipal Utility District (SMUD) is pursuing long-term contracts to secure solid residues in its region. EBMUD is reluctant to share solids collection and wastewater discharge data and private waste management companies in the Inland Empire region in Riverside and San Bernardino Counties do not provide data they have gathered.

If large amounts of food industry residues are diverted to bioenergy production, dairy farms and other animal feed operations will probably be affected the most. Diverting these traditional livestock feeding materials will require replacement of these feeds from other sources and locations possibly increasing the cost of livestock production.

⁴ Pomace is skins, seeds and sometimes stems from grape crushing and tomato processing

1.7 Wastewater Treatment Facility Costs

Food companies that are discharging wastewater to WWTFs continue to pay increasing amounts for disposal and treatment services. The costs are often established on a tier system, charging for capacity and demand flow, wastewater strength or biological oxygen demand (BOD₅), and amount of suspended solids. For the year 2011, a large industrial user in the City of Fresno will pay \$0.542 per hundred cubic feet of effluent flow, \$0.253 per pound of BOD₅ and \$0.287 per pound of total suspended solids (TSS).

For example, a large year round food manufacturing company with 250 workers discharging 120 million gallons per year to Fresno's WWTF with an annual average BOD₅ and TSS of 3000 mg/L and 1100 mg/L respectively, will pay approximately one million dollars a year to the WWTF. These companies may be motivated to adopt emerging technologies that can reduce wastewater discharge.

Not all municipal facilities would welcome a reduction in wastewater discharge, given the expected revenue streams committed to pay for infrastructure development. Many WWTFs are built or expanded to accommodate food processing industry residues by incurring infrastructure debt financing with revenue bonds. Current State Legislation (SBx7-7) targeting 20 percent water use reductions by 2020⁵ may impact municipal district debt financing options.

Many food processing companies are bound by long-term contracts to discharge specific amounts of wastewater to their WWTF. The contracts may hamper the ability of some food companies to install on-site anaerobic digestion systems to treat wastewater and capture bioenergy. Other cities are looking for alternative solutions.

Partnering with Wastewater Agencies and Treatment Facilities

There is potential to develop bioenergy resources through partnerships between food industry companies and local municipal agencies. Beyond the technical potential to generate electricity is the potential to leverage mutual resources to achieve common goals.

The City of Modesto encourages food companies to invest in on-site anaerobic digestion wastewater treatment facilities to alleviate infrastructure limits at the local WWTF. Achieving value from residue streams offers multiple environmental benefits beyond the energy generated. Carbon markets will help incentivize these investments as public policy drives to reduce greenhouse gas emissions.



⁵ California Department Of Water Resources Sb X7 - 7 - Water Conservation Program Status
<http://www.water.ca.gov/wateruseefficiency/sb7/docs/SBX77-ProgramStatus-07-12-11.pdf>

Modesto's Wastewater Treatment Capacity Banking and Transfer Program encourage industrial wastewater reductions to free up existing infrastructure capacity, hoping to attract new businesses to the city (City of Modesto, California News Release, January 28, 2009).

Other WWTFs in the SJV region that do not have anaerobic digesters could be encouraged to install bioenergy systems. There are however significant market barriers for WWTFs to invest in biogas conversion to electricity systems including the cost to meet air quality standards in the San Joaquin Valley. Other business models exist to upgrade biogas to transportation fuels and pipeline quality biomethane, and combined heat and power opportunities when available. The SoCalGas Company is investing to develop bioenergy business opportunities with WWTFs (SoCalGas, 2010).

1.8 Energy Efficiency First!

Although not an objective for this report, food industry executives should adopt energy conservation and efficiency measures first, before seriously evaluating the potential for waste-to-energy projects. Food industry companies could account for residue streams and adopt all cost-effective efficiency and resource recovery measures, while reducing energy and water resource demand. The economic potential to generate renewable energy is enhanced by projects that provide combined heat and power capabilities, that satisfy on-site energy demands and that can be integrated with resource efficiency measures.

1.9 Value Added to Organic Food Industry Residues

Fruit and vegetable food company managers surveyed acknowledged that there is market interest in their residue streams. Wastewater discharged from most of these industries contains energy that could be digested to produce biogas for on-site bioenergy generation. Many companies had conducted preliminary feasibility studies for bioenergy projects. Most concluded that such projects could not recover capital costs within three to five years.

Some food processing sectors have relied on technical advancements and by-product innovation to develop products for highly valued markets like the food additive industry. Cheese manufacturers have invested in research and development of functional nutritional food products to eliminate residues while making new products. Milk lactose and cheese whey from most large creameries are transformed into high value-added protein-rich nutritional and functional food products.

The wine industry is investigating value added opportunities from grape pomace. Fruit processing companies may reduce wastewater streams by using new infrared peeling

technologies. Fruit pits are used in co-generation facilities and for other industrial purposes. Almond hulls, and sometimes shells, are a valuable nutritional component of animal feed while almond shells are used as animal bedding or as energy feedstock.

The Jackson Family Winery has invested in Sonomaceuticals, a biotechnology company designed to extract functional products from grape seeds and skins (Novak, 2011). Company research indicates that polyphenolic compounds, and antioxidants, anthocyanins (color pigments), catechins, resveratrol, quercetin, kaempferol and tannins are available for extraction. In addition, grape seeds and skins also contain potentially available proteins, fats, carbohydrates, fiber, sugar, and minerals.

New technologies and best practices will be developed to reduce waste generation and disposal costs. Food industry residue materials will not always be potentially available as a bioenergy feedstock. Food corporations are investing in research and development facilities to develop higher value-products from organic residue streams.

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CHAPTER 2: Methods

2.1 Data Collection Methods

The 2007 Dun & Bradstreet database listed over 2,900 companies in the food processing industry. The number of facilities includes supermarkets that operate bakeries and delicatessens, catering companies, bakeries and hundreds of small cottage food preparation facilities. While the quality of food processing waste differs by line of business, it was assumed *a priori* that employees would be correlated with quantity of residues. The food processing lines of business are highly variable in size and include sectors that are typically large and some that are typically small.

For the purpose of this study, only companies that employed 25 or more workers were considered for residue survey and data collection. This threshold was chosen to reduce the total number of food industry facilities from the sample universe. This threshold captured all large companies, most medium sized and some small companies. By aggregating population by number of workers, it reduced the number of food processing facilities from 2,900 companies down to 1,100 companies, or 38 percent of all the companies. These companies with 25 or more employees accounted for 86 percent of the total food manufacturing industry reported by the D&B 2007, data base.

Data were collected directly from company representatives who agreed to participate through personal contact, and from analyses of public records. Upon consent, a written survey was delivered using Microsoft Word Document and an Internet link to LimeSurvey.com, offering two response options. Please see Appendix A for copy of survey instrument.

Additional data were collected from Regional Water Quality Control Board (RWQCB) offices. RWQCB offices in Sacramento, Fresno and San Luis Obispo were visited to collect land discharge permit data from food companies under their jurisdiction. The RWQCB in Redding provided their data electronically. The Bay Area office is not tracking wastewater discharge in their region's winery industry. All other food companies deliver their wastewater to local WWTFs. Southern California offices had no wastewater land discharge permits from food processing companies under their jurisdictions. RWQCB documents report monthly discharge but sometimes they also report the upper discharge limits. When actual discharge data were available it was gathered, otherwise the upper limit was used, understanding that the upper limits are not always reached.

Observations were also collected from wastewater treatment facilities, sanitary districts, and local government public works agencies serving food processing companies. The following public agencies provided information: Brawley WWTF, City of Bakersfield, City of Fresno, City of Hanford, City of Hayward, City of Lodi, City of Manteca, City of

Newman, City of Stockton, City of Tracy, City of Turlock, City of Visalia, Fairfield-Suisun Sanitary District, Modesto WWTF, Oro Loma Sanitary District, Sacramento Regional Wastewater District, San Jose WWTF, San Leandro WWTF and Selma-Kingsburg-Fowler WWTF.

Collecting data from multiple sources allowed for cross-referencing and accuracy checking, and comparison of wastewater discharge amounts between data collected directly from food companies with the data collected from the WWTFs. In case of discrepancies, data reported by the WWTF was used. Having access to both data sets also allowed for identification of food companies that both deliver to WWTFs as well as discharge on land.

Trade industry representatives were also consulted to gather experiential data from new or pilot systems, particularly equipment manufacturers and vendors of dissolved air flotation systems, peeling equipment, and other residue generation or treatment systems. A few consulting companies also provided support with data collection efforts, expert opinion, and access to industry metrics to calculate solid residue streams. Metrics are used to estimate residue volumes by county for grape pomace, almond hulls and shells, animal rendering materials, and other commodities.

Table 1 summarizes the type of data obtained from each source category and used to assemble observations for eligible companies. The assessment collected data on wastewater in gallons and BOD₅ values in mg/L, and solid residues in wet tons with moisture content value.

Table 1. Data Type by Information Source

Industry	Direct Survey	WWTF	RWQCB	Estimates
Canned F & V	WW, HMS, LMS	WW	WW, HMS	HMS, LMS
Dehydrated F & V	WW, HMS	WW	WW, LMS	LMS
Fresh, Frozen F & V	WW, LMS	WW	WW, HMS	HMS
Winery	-	WW	WW, Pomace	Pomace
Creamery	WW	WW	WW	Whey
Poultry, Red Meat	WW	WW	WW	Rendering
Almonds & Walnuts	-	-	-	Hull, Shells.

Where F & V = fruits and vegetables; WWTF = Wastewater Treatment Facility;

RWQCB = Regional water quality control board; WW = Wastewater;

HMS = High moisture solid, LMS = low moisture solids.

These observations were obtained from companies that responded to the survey instrument, from records housed at Regional Water Quality Control Board offices, and from records provided by wastewater treatment facilities. Other solid residue values from cheese manufacturing, nut hulls and shells, winegrape pomace and animal residues were estimated from industry measurements providing reference data to

calculate byproduct or residue estimation factors. All observations were collected during March 2010, through April 2011.

2.2 Data Reporting

Information is reported in annual gallons of wastewater discharged and total BOD₅ in tons. HMS and LMS residue data are reported on a dry tons per year basis. Energy estimates are reported as annual million standard cubic feet (MMscf) and million Btu (MMBtu) for raw biogas, MMBtu for recovered heat from combined heat and power systems (CHP) and megawatts (MW) for electricity generation capacity.

Information is aggregated by county due to confidentiality agreements with cooperating participants.

2.3 Stratification by Line of Business

Results are organized by line of business or product type. Industry data were used to estimate residue streams from nut processing (for shells and hulls). Wine grape crushing quantities and other data from the wine industry are used to calculate grape pomace volumes, in addition to collecting wastewater data for wineries in the San Joaquin Valley region. Meat slaughtering residues are calculated using USDA's statewide annual slaughtering data (USDA, NASS, 2011a), in addition to wastewater data for meat slaughtering facilities in the Central Valley.⁶

2.4 Ordinary Least Square Statistical Models

Accounting for HMS and LMS in the food processing waste stream is the basis for a calculation of technical energy potential using these resources. Although wastewater data was collected for all observations, HMS and LMS data was not always available for all facilities. To estimate missing or unreported amounts of HMS and LMS, an ordinary least squares model was used to predict HMS and LMS as a function of fruit and vegetables firms' reported total wastewater volume, number of workers and moisture content. The model is programmed using JMP9 software. Industry data was aggregated from survey responses and observations obtained from secondary sources to create a prediction equation to estimate values from collected wastewater data. Resulting high adjusted R Square values provide confidence in estimates of solid residues for those

⁶ Specific assumptions and methods for estimating residue streams are detailed in corresponding sections in Chapter 3 – Results.

surveys that were returned with incomplete solids data. Companies that were significantly different from predicted patterns were identified using indicator variables.

2.4.1 High Moisture Solids (HMS) Model

The HMS model estimates the amount of HMS as a function of wastewater, number of workers and moisture content of HMS. It was derived from data from the cannery, dehydrated and frozen fruits and vegetables industry data (Equation (1)).

$$(1) \quad HMS_{pred} = \beta_0 + \beta_{WW}WW + \beta_{HMSP}HMSP + \beta_{WKR}WKR + \beta_{OHS}OHS$$

Where:

HMS_{pred} = Predicted value of high moisture solids

β_0 = Intercept

β_{WW} = Coefficient for wastewater quantities

WW = Quantity of wastewater

β_{HMSP} = Coefficient for high moisture solids percentage

$HMSP$ = Percentage of high moisture solids

β_{WKR} = Coefficient for number of workers

WKR = Number of workers

β_{OHS} = Coefficient for extreme values not typical of the rest of the data

OHS = Indicator variable (0,1) for facilities with HMS residue data exceeding 25,000 tons per year

2.4.2 Low Moisture Solids (LMS) Model

Model estimates amount of LMS as a function of amount of wastewater discharged and the number of workers. The LMS Model was applied to dehydrated fruit and vegetables industry data (Equation (2)).

$$(2) \quad LMS_{pred} = \beta_0 + \beta_{WW}WW + \beta_{WKR}WKR + \beta_{CBOD}CBOD + \beta_{OLMS}OLMS$$

Where:

LMS_{pred} = Predicted value of low moisture solids

β_0 = Intercept

β_{WW} = Coefficient for wastewater quantities

WW = Quantity of wastewater

β_{WKR} = Coefficient for number of workers

WKR = Number of workers

β_{CBOD} = Coefficient for Calculated BOD (BOD_5 readings + converted COD)

$CBOD$ = Calculated BOD values (BOD_5 values + converted COD values)

β_{OLMS} = Coefficient for extreme values not typical of the rest of the data

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

2.5 Energy Potential Calculations

Energy estimates are based on methods and assumptions from Matteson & Jenkins (2005 & 2007) and Matteson et al. (2005).

Energy potential for wastewater flows and solid residues (high and low moisture), except nut shells and hulls, were estimated assuming conversion by anaerobic digestion producing biogas which then fuels reciprocating engine generators (for both heat and power). Nut shells and hulls were assumed to be converted via thermal pathways for heat and power.

Waste streams are considered high moisture solids (HMS) if the moisture content is 55 percent or higher.

2.5.1 Energy from Most Solid Residues and Wastewater

Anaerobic digestion followed by reciprocating engine generators is assumed for energy estimates from wastewater and all solids except nut shells and hulls.

2.5.1.1 Solid Residues

The annual biogas energy production, E_{annual} (kJ/y), from solid wastes is estimated by Equation (3).

$$E_{\text{annual}} = \Phi_s \times TS \times VS \times B_o \times Y \times M \times CV_m \quad (3)$$

Where,

E_{annual}	Annual biogas energy production from high moisture wastes (kJ/year),
Φ_s	Annual available solid residues (wet tonnes/year),
TS	Total solids content (kg dry matter / wet tonne)
VS	Volatile solids / total solids ratio (fraction)
B_o	Anaerobic biodegradability (fraction)
Y	Biogas yield (m ³ /kg VS destroyed)
M	Methane content of biogas (fraction)
CV_m	Calorific value of methane (kJ/m ³)

For all solid materials assumed converted by anaerobic digestion, the fraction of volatile solids to total solids was assumed to be 0.8. Biodegradability, biogas yield, methane concentration of biogas, and the volumetric heating value of methane at standard conditions were assumed to be 0.67, 0.75 m³ kg⁻¹ VS destroyed, 65%, and 36.3 MJ m⁻³ respectively.

The annual electricity production, EE_{annual} (kWh/y), from biogas produced by digestion of solid residues can then be estimated by Equation (4).

$$EE_{\text{annual}} = \frac{E_{\text{annual}} \times \eta}{3600} \quad (4)$$

Where

η Engine-generator efficiency (fraction)

The engine-generator efficiency was assumed to be 0.3, on higher heating value (HHV) basis.

2.5.1.2 Wastewater

The annual biogas energy production, $E_{w \text{ annual}}$ (kJ/y), from wastewater is estimated by Equation (5).

$$E_{w \text{ annual}} = \Phi_w \times BOD_5 \times Y_{BOD} \times CV_{\text{bi}} \quad (5)$$

Where,

Φ_w Annual wastewater production (m³/year),

BOD_5 5-day biological oxygen demand of wastewater (kg/m³)

Y_{BOD} Methane yield (m³/kg BOD_5)

The methane yield (Y_{BOD}) was assumed to be 0.35 (m³/kg BOD_5)

The annual electricity production, $EE_{w \text{ annual}}$ (kWh/y), from biogas from wastewater was estimated by Equation (6).

$$EE_{w \text{ annual}} = \frac{E_{w \text{ annual}} \times \eta}{3600} \quad (6)$$

2.5.2 Energy from Nut Shells and Hulls

Energy conversion for almond hulls and shells, walnut shells and other LMS was assumed to be by thermochemical means. Annual estimated electricity production, $EE_{t \text{ annual}}$ (kWh/y), from shells and hulls is estimated by Equation (7).

$$EE_{t \text{ annual}} = \frac{\Phi_t \times CV_t \times \eta_t \times 1000}{3600} \quad (7)$$

Where:

Φ_t	Annual available solid residues (dry tonnes/year),
CV_t	Gross (or higher) calorific value of dry biomass methane (MJ/dry tonne)
η_t	Conversion efficiency, dry matter to electricity (fraction)

Gross calorific (or higher heating) value for dry biomass was assumed to be 20,000 MJ/tonne (20 MJ/kg). Efficiency of thermochemical conversion was assumed to be 0.25 (25%), on a higher heating value, dry matter basis.

2.5.3 Power generating potential Estimates

Power generating potential (or generation capacity) was estimated from the appropriate annual electrical energy estimate (e.g., EE_{annual} , $EE_{\text{W annual}}$, etc.) using the generalized Equation (8).

$$P_i = \frac{EE_i}{1000 \times 8760 \times CF} \quad (8)$$

Where:

P_i	Power generation potential (or capacity) for substrate i (MWe)
EE_i	Annual electrical energy production for substrate i (kWh/year)
CF	Annual capacity factor

Annual capacity factor (CF) was assumed to be 0.85.

2.5.4 Heat Recovery from CHP Estimates

There is also potential to co-produce and utilize heat from power generation systems for combined heat and power (CHP) production. Annual heat energy potential, H_i , (kWh/year), was computed from individual substrate electrical energy production using Equation (9).

$$H_i = \frac{EE_i}{\eta_i} (1 - \eta_i) f_h \quad (9)$$

Where,

EE_i	Annual electrical energy production for substrate i (kWh/year)
η_i	Electrical conversion efficiency for substrate/technology i (fraction)
f_h	Fraction of recoverable heat (fraction)

The fraction of recoverable heat (or heat recovery efficiency), f_h , was assumed to be 0.6.

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CHAPTER 3: Results

The Assessment collected wastewater and solid residue observations from the cannery industry, dehydrators, and fresh and frozen fruit and vegetable processors, as well as creameries producing fluid milk, cheese and ice cream, meat slaughtering, poultry and beef processing plants, wineries, almond and walnut processing sectors.

Within the fruit and vegetable processing sectors, some of the survey data and data collected from RWQCB's and WWTFs did not always include HMS or LMS information. Key missing solids data from incomplete observations were completed using ordinary least squares regression techniques, allowing reported data to be expanded for a more complete estimate..

The results of the statistical estimation are presented below in the next section. Subsequent sections of this chapter provide industry characteristics and expected annual residue quantities, and estimated technical energy potential by industry and by county.

3.1 Outcome of High and Low Moisture Solids Estimation

Equation 1 was applied to the observations collected from companies in the cannery, dehydrated, fresh and frozen fruit and vegetable processing industries. From a possible 209 companies with 25 or more workers, the assessment collected 165 observations with wastewater data. It was used to estimate HMS solids for 79 of these observations.

The model accounted data variability with an adjusted R squared value of 0.835 which indicates the model captured a large amount of the available information (Table 2). The Analysis of Variance (ANOVA) had a model F-statistic probability of <0.0001, indicating the model is significantly different than the mean. All of the model parameter estimates were significant, except the intercept.

Equation 2 was used to estimate LMS solids for 13 observations from the dehydrated fruit and vegetable industry (Table 3). The model accounted for data variability with an adjusted R squared value of 0.839. The Analysis of Variance (ANOVA) had a model F-statistic probability of <0.0001, which indicates that the model is significant. All of the model parameter estimates were significant.

Table 2. High Moisture Solids (HMS) Model Fit, ANOVA, and Parameter Estimates

Summary of Fit

<i>R Square</i>	0.842
<i>R Square Adj</i>	0.835
<i>Root Mean Square Error</i>	3,797.4
<i>Mean of Response</i>	6,022.4
<i>Observations</i>	87.0

Analysis of Variance

<i>Source</i>	<i>DF</i>	<i>Sum of Squares</i>	<i>Mean Square</i>	<i>F Ratio</i>
<i>Model</i>	4	1,332,715,174	333,178,794	390.5
<i>Error</i>	20	17,062,690	853,134	Prob > F
<i>C. Total</i>	24	1,349,777,864		<.0001

Parameter Estimates

<i>Term</i>	<i>Estimate</i>	<i>Std Error</i>	<i>t Ratio</i>	<i>Prob> t </i>
<i>Intercept</i>	-791.668	785.335	-1.01	0.3164
<i>WW, Wastewater volume</i>	0.00000459	0.00000173	2.65	0.0096
<i>HMSP, High moisture %</i>	46.162	11.478	4.02	0.0001
<i>OHS, Indicator for size</i>	26,118.2	1,890.2	13.82	<.0001
<i>WKR, worker number</i>	6.614	1.916	3.45	0.0009

Table 3. Low Moisture Solids (LMS) Model Fit, ANOVA, and Parameter Estimates

Summary of Fit

<i>R Square</i>	0.865
<i>R Square Adj</i>	0.839
<i>Root Mean Square Error</i>	4,983. 8
<i>Mean of Response</i>	4,764.7
<i>Observations</i>	26.0

Analysis of Variance

<i>Source</i>	<i>DF</i>	<i>Sum of Squares</i>	<i>Mean Square</i>	<i>F Ratio</i>
<i>Model</i>	4	3,477,151,194	869,287,798	47.4
<i>Error</i>	21	384,797,899	18,323,709	<i>Prob > F</i>
<i>C. Total</i>	25	3,861,949,093		<.0001

Parameter Estimates

<i>Term</i>	<i>Estimate</i>	<i>Std Error</i>	<i>t Ratio</i>	<i>Prob> t </i>
<i>Intercept</i>	4,312.8	1,554.7	2.77	0.0114
<i>WW, wastewater volume</i>	0.0003607	0.0000769	4.69	0.0001
<i>OLMS, indicator of extremes</i>	20,709.9	3,967.4	5.22	<.0001
<i>Calculated BOD5</i>	-3.489	1.257	-2.77	0.0113
<i>WKR, worker number</i>	-15.700	6.634	-2.37	0.0277

3.2 Cannery, Dehydrators and Fresh Frozen Fruit and Vegetable Processors

In 2007, there were 355 companies that produced canned, dehydrated, and fresh and frozen fruits and vegetables in California, 209 of which employ 25 or more workers. Data were collected from 164 companies, representing 79 percent of the targeted population. Most of these facilities operate between May and October and are idle otherwise.

Nearly 15 billion gallons of wastewater are discharged annually by these companies. This wastewater contains some 86,800 tons of BOD₅ equivalent and 272,720 dry tons of solid residues.

The wastewater from these three aggregated fruit and vegetable processing industries represents a technical energy potential from anaerobically digested (AD) biogas of 9.5 million therms (950,000 MMBtu). Combined Heat and Power (CHP) energy potential of the biogas is 11 MW of electricity with 4 million therms of recovered heat. The solid residues represent an energy potential from the AD biogas of 22.2 million therms (2,220,000 MMBtu), that can provide potential (CHP) power of 26 MW of electricity with 9.3 million therms from recovered heat.

The disposal and treatment of organic fruit and vegetable residue streams incurs transportation and process energy costs. The lowest cost option is to discharge wastewater and high moisture solids on land, or use them as livestock feeds where they substitute for purpose grown feeds. Residue management and trucking companies provide these services, with many small businesses collecting, disposing and processing industrial organic food residues.

Residues are concentrated along the Highway 99 corridor from San Joaquin County to Stanislaus, Merced, Fresno, Kings and Kern counties. The Central Coast, particularly Monterey and Ventura counties, contribute mostly low moisture solids from vegetable dehydration facilities. These data reflect residues currently utilized to generate 0.6 MW of electricity at Gills Onions in Oxnard, Ventura County.

Details of residue and energy potential estimates for canneries, dehydrators, and fresh and frozen fruits and vegetables processors are in the following three sections.

3.3 Cannery Industry

In the Dun & Bradstreet, 2007 data base, a total of 160 establishments are registered under the Standard Industrial Classification (SIC) system as Canned Specialties (SIC 2032), Canned Fruits, Vegetables, Preserves, Jams, and Jellies (SIC 2033).

Canneries operate during periods of harvest. May to October is the average length of factory operations for the California canning industry (e.g., for tomatoes, peaches, pears, olives and other fruits and vegetables). The volume of liquid and solid residue streams is significant. These residue streams are produced largely six days a week, at least 16 hour days, during four to five continuous months.

3.3.1 Industry Data Collected

Out of 160 total, only 72 canneries employ 25 or more workers. Wastewater data was obtained from survey responses and WWTFs for 51 companies, equivalent to 71 percent of possible observations. Solid residue volumes were estimated for an additional 17 companies using eq. 1 and 2 discussed above in section 3.1. (Tables 2 and 3) When aggregated by the number of employees, these 51 facilities account for 88 percent of the total number of workers in this sector.

Table 4 provides accounting of the number of observations acquired by the assessment compared to total possible observations by county. Though just 71 percent of potential observations were obtained, canneries in the Central Valley, except for Tulare County, are

California's Tomato Processing Industry



2009 Harvested	308,000 Acres
Production	13.3 million Tons
Number of Processors	17

http://www.nass.usda.gov/Statistics_by_State/California/Historical_Data/Tomatoes-P.pdf

The processing of over 13 million tons of tomatoes generates 5.7 billion gallons of wastewater and almost 100 thousand dry tons of solid residues every year. These residues have the technical potential to generate 13 MW of electricity and 463,000 MMBtu of combined heat and power.

Residues are generated between late June and September. An average sized tomato cannery discharges 340 million gallons of wastewater, 12 thousand tons of HMS and almost 5 thousand tons of low moisture solid residues. These residues have the technical potential to generate 0.6 MW of electricity and 20,500 MMBtu of combined heat and power.

Reducing wastewater discharge volumes may become a future priority. Some companies are scheduled to test an emerging technology pilot that uses infrared heat to peel tomato skins. Dr. Zhongli Pan, from the USDA-ARS believes that "peeling tomatoes with infrared heat eliminates lye use, greatly reduces water use, and results in better quality tomatoes". (CA&ES Outlook, Fall/Winter 2009, page 10).

DiNapoli Tomatoes - Factory Tour Video

<http://www.youtube.com/watch?v=32ikIN5Nz3Y>

well represented.

Table 4. Cannery Industry Data Collection Results

County	Potential Sources	Acquired Observations	Missing Observations	Proportion %
Alameda	1	1	0	100
Butte	3	3	0	100
Colusa	2	2	0	100
Humboldt	1	1	0	100
Fresno	9	8	1	89
Glenn	2	2	0	100
Kern	1	1	0	100
Kings	3	3	0	100
Los Angeles	13	4	9	31
Merced	6	6	0	100
Orange	4	3	1	75
Riverside	3	0	3	0
Sacramento	2	2	0	100
San Bernardino	2	0	2	0
San Diego	1	0	1	0
San Joaquin	5	4	1	80
Santa Clara	1	1	0	100
Santa Cruz	1	0	1	0
Solano	1	1	0	100
Stanislaus	7	7	0	100
Tehama	1	1	0	100
Tulare	2	0	2	0
Yolo	1	1	0	100
Totals	72	51	21	71

3.3.2 Residue Amounts and Bioenergy Calculations

Estimated annual residues from canneries include 8.16 billion gallons of wastewater and 115,000 dry tons of solid residues (Table 5). Energy in potential biogas from these residues is more than 1,553,000 MMBtu per year (Table 6).

Table 5. Cannery Industry Residue Quantities and Potential Energy in Biogas

County	Annual Wastewater (WW)				Annual High Moisture Solids (HMS)			Annual Low Moisture Solids (LMS)		
	(MG)	Total BOD ⁷ (ton)	Potential Biogas		Total (dry tons)	Potential Biogas		Total (dry tons)	Potential Biogas	
			Volume (MMscf)	Energy (MMBtu)		Volume (MMscf)	Energy (MMBtu)		Volume (MMscf)	Energy (MMBtu)
Alameda	3.59	10	0.21	140	0	0.00	0	0	0.00	0
Butte	112.25	1,900	32.96	20,880	1,050	13.51	8,560	3,840	49.41	31,300
Colusa	469.29	1,390	23.98	15,190	2,690	34.58	21,900	5,230	67.29	42,620
Humboldt	0.73	5	0.08	50	440	5.71	3,620	0	0.00	0
Fresno	804.59	6,020	104.20	66,000	3,750	48.29	30,590	2,330	29.95	18,970
Glenn	81.72	950	16.52	10,460	1,840	23.66	14,990	950	12.17	7,710
Kern	450.00	840	14.62	9,260	410	5.31	3,370	3,890	50.03	31,690
Kings	984.37	4,560	78.80	49,920	5,990	77.09	48,830	8,940	115.19	72,960
Los Angeles	66.66	790	13.75	8,710	2,090	26.92	17,050	0	0.00	0
Merced	1,276.87	4,290	74.20	47,000	3,360	43.27	27,410	7,710	99.28	62,890
Orange	44.68	260	4.51	2,850	1,230	15.84	10,030	0	0.00	0
Sacramento	554.27	12,640	218.66	138,510	2,490	32.02	20,280	0	0.00	0
San Joaquin	461.81	4,250	73.51	46,560	2,070	26.62	16,860	5,970	76.83	48,670
Santa Clara	27.16	290	5.05	3,200	510	6.60	4,180	0	0.00	0
Solano	395.00	980	16.94	10,730	1,180	15.21	9,630	4,360	56.19	35,590
Stanislaus	2,138.34	14,380	248.83	157,620	12,260	157.89	100,010	11,420	147.10	93,180
Tehama	19.21	2	0.04	20	1,380	17.77	11,260	0	0.00	0
Yolo	270.00	2,370	40.93	25,930	4,500	57.96	36,710	13,320	171.55	108,660
Totals	8,160.54	55,920	967.79	613,030	47,240	608.25	385,280	67,960	874.99	554,240

These summary values are all large numbers, mostly in millions of gallons, standard cubic feet (scf), and Btus. The highly variable quantities and qualities across counties made it difficult to establish rounding protocols without losing useful information. Millions of gallons and scf were rounded to 10⁴. Million Btus (MMBtu) were rounded to 10⁷. Tons of BOD₅ and high and low moisture solids (HMS, LMS) were rounded to 10¹, unless the quantity was less than 10 tons, in which case no rounding was imposed.

Table 6 shows the combined heat and power (CHP) technical energy potential from the estimated biogas production from cannery industry wastewater and solid residue streams by county.

⁷ BOD₅ is the amount of dissolved oxygen needed by aerobic biological organisms to decompose organic material in (or stabilize) wastewater. Test results are usually reported on a 5-day lab test and reported as BOD₅. It is historically an indicator of degree of water pollution and public health risk, but it also has value as an indicator of potential biogas production. Tons of BOD₅ do not have any direct relationship to the tons of high and low moisture solids (HMS, LMS).

Table 6. Cannery Industry Technical Energy Potential by County

County	CHP from Wastewater ⁵		CHP from HMS		CHP from LMS	
	Power (MW)	Recovered Heat (MMBtu)	Power (MW)	Recovered Heat (MMBtu)	Power (MW)	Recovered Heat (MMBtu)
Alameda	0.00	60	0.00	0	0.00	0
Butte	0.25	8,770	0.10	3,590	0.37	13,140
Colusa	0.18	6,380	0.26	9,200	0.50	17,900
Humboldt	0.00	20	0.04	1,520	0.00	0
Fresno	0.78	27,720	0.36	12,850	0.22	7,970
Glenn	0.12	4,390	0.18	6,300	0.09	3,240
Kern	0.11	3,890	0.04	1,410	0.37	13,310
Kings	0.59	20,970	0.58	20,510	0.86	30,640
Los Angeles	0.10	3,660	0.20	7,160	0.00	0
Merced	0.55	19,740	0.32	11,510	0.74	26,410
Orange	0.03	1,200	0.12	4,210	0.00	0
Sacramento	1.64	58,170	0.24	8,520	0.00	0
San Joaquin	0.55	19,560	0.20	7,080	0.57	20,440
Santa Clara	0.04	1,340	0.05	1,760	0.00	0
Solano	0.13	4,510	0.11	4,050	0.42	14,950
Stanislaus	1.86	66,200	1.18	42,010	1.10	39,130
Tehama	0.00	10	0.13	4,730	0.00	0
Yolo	0.31	10,890	0.43	15,420	1.28	45,640
Totals	7.24	257,480	4.54	161,830	6.52	232,770

Within each source of energy combined heat and power (CHP) will generate both electrical power (MW, or megawatt), and recovered heat (million Btu, MMBtu), but the output from the three materials can be additive (Wastewater+HMS+LMS).

When combined, these companies discharged 8.16 billion gallons of wastewater in 2009. The wastewater and organic solid residues have the technical potential to generate 18.3 MW of equivalent electricity with a recoverable heat from the CHP process of 652,000 million btu (MMBtu) using anaerobic digestion conversion (Table 7).

Table 7. Summary values for residual production and power generation from Cannery processing wastes

Cannery Industry Residues	Wastewater – BOD ₅	HMS	LMS	Total
Total Amount (dry tons/year) ^a	55,920 ^a	47,240	67,960	
Potential Power, CHP (MW)	7.24	4.54	6.52	18.30
Potential Heat, CHP (MMBtu)	257,480	161,830	232,770	652,080

^a BOD₅ tons refers to oxygen required, while HMS and LMS tons refer to high and low moisture solids.

It is important to emphasize that the character of these food processing residuals is highly variable. The presentation of the findings and the energy estimations are reported in the smallest industry sector units possible to avoid confusion. The canned fruits and vegetable industries (canneries) are one of three California fruit and vegetable processing industry sectors. The others are dehydrated fruits and vegetables and fresh/frozen fruits and vegetables. Figure 1 displays the potential annual biogas production in the cannery subsector by county and source of energy: Wastewater (BOD), HMS, and LMS. The counties have been sorted in ascending order of wastewater volumes (not presented in the chart). Yolo County has a high proportion of LMS biogas for a mid-level quantity of wastewater. Stanislaus and Sacramento counties are ranked first and fifth, respectively, in total wastewater volume generation, while these same two counties are ranked first and second in biogas potential from wastewater BOD.

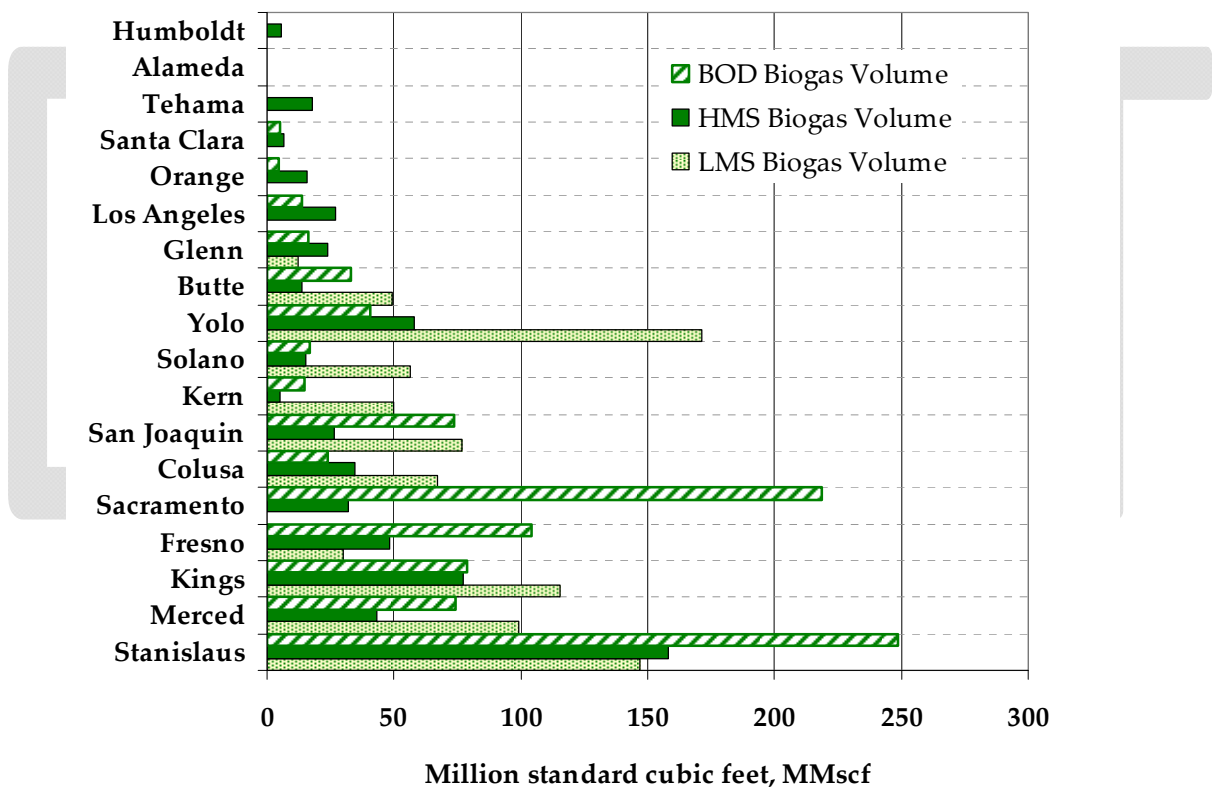


Figure 1. Estimated annual biogas production from canned fruits and vegetable processing by feedstock source of BOD₅, HMS, and LMS, by county

3.4 Dehydrated Fruit and Vegetable Industry

Fruit dehydrators work two to three months per year drying apricots, plums, raisins, and other fruits. The largest onion dehydrator in the state operates year round with supplies arriving from near and far throughout all potential growing windows. Gills

Onions in Oxnard, California is utilizing residue streams to generate electricity using fuel cell technology, creating higher value animal feed products, while reducing BOD₅ wastewater discharge loads.

3.4.1 Industry Data Collected

The D&B 2007, database (Dun & Bradstreet, 2007) identifies 67 companies in the category for Dried and Dehydrated Fruits, Vegetables, and Soup Mixes (SIC 2034). Forty nine of these companies have 25 or more workers. Wastewater data was obtained from survey responses, RWQCB offices and WWTFs for 39 companies, equivalent to 80 percent of possible observations. Solid residue volumes were estimated for 13 additional companies using the HMS and LMS Ordinary Least Squares Regression models (eq. 1 and 2). Model predictions had an adjusted R Square value of 0.84.

These 49 facilities employ 80 percent of the total number of workers in the dried fruit and vegetable sector. Data were obtained for seventy-eight percent of potential observations (Table 8). **Table 8. Dehydrated Fruits & Vegetable Industry Data Collection Results**

County	Potential Sources	Acquired Observations	Missing Observations	Proportion %
Butte	2	2	0	100
Colusa	1	1	0	100
Fresno	17	14	3	82
Glenn	1	1	0	100
Kings	1	0	1	0
Madera	3	3	0	100
Merced	1	1	0	100
Monterey	3	3	0	100
Riverside	1	0	1	0
San Bernardino	1	0	1	0
Santa Clara	1	1	0	100
Santa Cruz	2	2	0	100
Solano	1	0	1	0
Stanislaus	3	1	2	33
Sutter	5	5	0	100
Tehama	2	2	0	100
Tulare	1	1	0	100
Ventura	2	1	1	50
Yolo	1	1	0	100
Totals	49	39	10	80

3.4.2 Residue Amounts and Bioenergy Calculations

Estimated annual residues from dehydrators include 284 million gallons of wastewater and 132,000 dry tons of solid residues (from both HMS and LMS totals in Table 9).

Biogas energy potential from these combined wastewater and dry solid residues is more than 1,105,000 MMBtu per year (Table 9).

Table 9. Dehydrated Fruits &Vegetable Industry Residue Quantities and Biogas Energy Potential

County	Annual Wastewater (WW)				Annual High Moisture Solids (HMS)			Annual Low Moisture Solids (LMS)		
	(MG)	Total BOD ₅ (ton)	Potential Biogas		Total (dry tons)	Potential Biogas		Total (dry tons)	Potential Biogas	
			Volume (MMscf)	Energy (MMBtu)		Volume (MMscf)	Energy (MMBtu)		Volume (MMscf)	Energy (MMBtu)
Butte	0.64	2	0.03	20	0	0.00	0	3,720	47.85	30,310
Colusa	0.00	0	0.00	0	0	0.00	0	2,070	26.65	16,880
Fresno	142.77	2,070	35.90	22,740	13,620	175.46	111,140	22,010	283.44	179,540
Glenn	0.44	1	0.01	10	0	0.00	0	560	7.21	4,570
Madera	3.34	10	0.11	70	910	11.75	7,440	840	10.85	6,880
Merced	5.75	20	0.41	260	0	0.00	0	1,120	14.38	9,110
Monterey	114.56	550	9.44	5,980	890	11.53	7,300	66,190	852.42	539,950
Santa Clara	0.10	0	0.00	0	830	10.71	6,780	0	0.00	0
Santa Cruz	0.09	0	0.00	0	0	0.00	0	830	10.70	6,780
Stanislaus	3.50	10	0.23	140	560	7.23	4,580	7,500	96.59	61,180
Sutter	1.37	3	0.05	30	1,360	17.54	11,110	1,360	17.56	11,120
Tehama	0.32	1	0.01	10	0	0.00	0	410	5.23	3,310
Tulare	0.03	0	0.00	0	780	10.06	6,380	0	0.00	0
Ventura	10.95	50	0.93	590	3,650	47.01	29,780	2,310	29.75	18,840
Yolo	0.18	0.4	0.01	0	0	0.00	0	230	2.95	1,870
Totals	284.04	2,717	47.13	29,850	22,600	291.29	184,510	109,150	1,405.58	890,340

These summary values are all large numbers, mostly in millions of gallons, standard cubic feet (scf), and Btus. The highly variable quantities and qualities made it difficult to establish rounding protocols without losing useful information. Millions of gallons and scf were rounded to 10⁴. Million btus (MMBtu) were rounded to 10⁷. Tons of BOD₅ and high and low moisture solids (HMS, LMS) were rounded to 10¹, unless the quantity was less than 10 tons, in which case no rounding was imposed.

These residues (wastewater and solids) have the technical potential to generate about 13 MW of equivalent electricity and 460,000 MMBtu of heat energy assuming CHP systems. Monterey and Fresno counties account for 78 percent of this potential (Table 10).

Table 10. Dehydrated Fruits & Vegetable Industry Technical CHP Energy Potential by County

	CHP from BOD ₅		CHP from HMS		CHP from LMS	
	Power	Recovered Heat	Power	Recovered Heat	Power	Recovered Heat
County	(MW)	(MMBtu)	(MW)	(MMBtu)	(MW)	(MMBtu)
Butte	0.00	10	0.00	0	0.36	12,730
Colusa	0.00	0	0.00	0	0.20	7,090
Fresno	0.27	9,550	1.31	46,680	2.12	75,410
Glenn	0.00	0	0.00	0	0.05	1,920
Madera	0.00	30	0.09	3,130	0.08	2,890
Merced	0.00	110	0.00	0	0.11	3,830
Monterey	0.07	2,510	0.09	3,070	6.37	226,780
Santa Clara	0.00	0	0.08	2,850	0.00	0
Santa Cruz	0.00	0	0.00	0	0.08	2,850
Stanislaus	0.00	60	0.05	1,920	0.72	25,700
Sutter	0.00	10	0.13	4,670	0.13	4,670
Tehama	0.00	0	0.00	0	0.04	1,390
Tulare	0.00	0	0.08	2,680	0.00	0
Ventura	0.01	250	0.35	12,510	0.22	7,910
Yolo	0.00	0	0.00	0	0.02	780
Totals	0.35	12,530	2.18	77,510	10.50	373,950

3.5 Fresh and Frozen Fruits and Vegetable Industry

Fresh fruit and vegetable processing facilities transform raw farm products into packaged fruits and vegetables (fresh and frozen), processed food items (enchiladas, pizzas, etc.) sauces, and other value-added products.

This segment of the industry processes crops almost year round. Most large farms complement their California land operations with cropland in Arizona and Northern Mexico, producing for the winter market window. The industry has adopted in-field harvesting practices that lower packing shed residue processing activities.

3.5.1 Industry Data Collected

The D&B 2007 data base, (Dun & Bradstreet, 2007) identifies 128 companies in the categories Frozen Fruits and Vegetables (SIC 2037) and Frozen Specialties (SIC 2038). There are 89 companies that employ 25 or more workers in this sector (with 74 facilities accounting for 79 percent of sector employees). Wastewater data was obtained from survey responses and WWTFs for 74 of these companies, or 83 percent of the total. High Moisture Solids were estimated for 49 of these companies (no LMS were reported). Distribution of actual versus potential observations for the Fresh/Frozen Fruit and Vegetable sector by county appears in Table 11.

Table 11. Fresh and Frozen Fruits & Vegetables Industry Data Collection Results

County	Potential Sources	Acquired Observations	Missing Observations	Proportion %
Alameda	5	5	0	100
Fresno	11	11	0	100
Kern	8	8	0	100
Los Angeles	28	21	7	75
Madera	3	3	0	100
Merced	2	2	0	100
Monterey	3	3	0	100
Orange	4	2	2	50
San Benito	2	2	0	100
San Bernardino	4	1	3	25
San Joaquin	3	3	0	100
Santa Barbara	1	1	0	100
Santa Clara	2	2	0	100
Sonoma	1	0	1	0
Stanislaus	5	5	0	100
Sutter	1	1	0	100
Tulare	6	4	2	67
Totals	89	74	15	83

Over 80 percent of potential observations were obtained. Except for Tulare County, the Central Valley region is well represented by the acquired observations.

3.5.2 Residue Amounts and Bioenergy Calculations

Estimated annual residues from dehydrators include 6.3 billion gallons of wastewater and 25,770 dry tons of solid residues (Table 12). Energy in potential biogas from these combined residues is more than 519,000 MMBtu per year (Table 12).

Estimated annual power and heat from Fresh/Frozen Fruits and Vegetables (combined wastewater and solids) is 6.1 MW and 217,860 MMBtu respectively (Table 13).

Table 12. Fresh and Frozen Fruit and Vegetable Industry Residue Quantities and Biogas Energy Potential

County	Annual Wastewater (WW)				Annual High Moisture Solids (HMS)		
	(MG)	Total BOD ₅ (ton)	Potential Biogas		Total (dry tons)	Potential Biogas	
			Volume (MMscf)	Energy (MMBtu)		Volume (MMscf)	Energy (MMBtu)
Alameda	14.66	90	1.50	950	370	4.80	3,040
Fresno	1,393.06	8,520	147.32	93,320	7,470	96.25	60,970
Kern	3,324.14	14,080	243.56	154,280	7,660	98.63	62,480
Los Angeles	339.54	2,400	41.47	26,270	2,000	25.82	16,350
Madera	29.45	120	2.04	1,290	260	3.41	2,160
Merced	111.45	110	1.84	1,170	1,140	14.63	9,270
Monterey	34.87	30	0.53	330	160	2.09	1,320
Orange	63.98	530	9.25	5,860	270	3.49	2,210
San Benito	126.26	260	4.51	2,860	1,390	17.95	11,370
San Bernardino	22.37	0	0.03	20	140	1.85	1,170
San Joaquin	79.87	10	0.20	130	310	3.98	2,520
Santa Barbara	0.30	0	0.01	10	60	0.76	480
Santa Clara	41.23	260	4.50	2,850	260	3.33	2,110
Stanislaus	554.32	800	13.85	8,770	2,450	31.54	19,980
Sonoma	37.00	20	0.28	180	1,130	14.60	9,250
Sutter	6.50	110	1.93	1,220	270	3.44	2,180
Tulare	111.06	810	14.01	8,880	430	5.49	3,480
Totals	6,290.06	28,150	486.83	308,390	25,770	332.06	210,340

Table 13. Fresh and Frozen Fruits & Vegetable Industry Technical CHP Energy Potential by County

County	CHP from Wastewaters ⁵		CHP from HMS	
	Power (MW)	Recovered Heat (MMBtu)	Power (MW)	Recovered Heat (MMBtu)
Alameda	0.01	400	0.04	1,280
Fresno	1.10	39,190	0.72	25,610
Kern	1.82	64,800	0.74	26,240
Los Angeles	0.31	11,030	0.19	6,870
Madera	0.02	540	0.03	910
Merced	0.01	490	0.11	3,890
Monterey	0.00	140	0.02	560
Orange	0.07	2,460	0.03	930
San Benito	0.03	1,200	0.13	4,780
San Bernardino	0.00	10	0.01	490
San Joaquin	0.00	50	0.03	1,060
Santa Barbara	0.00	0	0.01	200
Santa Clara	0.03	1,200	0.02	890
Stanislaus	0.10	3,680	0.24	8,390
Sonoma	0.00	70	0.11	3,880
Sutter	0.01	510	0.03	920
Tulare	0.10	3,730	0.04	1,460
Totals	3.61	129,500	2.50	88,360

3.6 Wine and Brewery Industry

The California winery and wine grape industry crushed 3.7 million tons of fruit in 2009, (USDA, NASS, 2009a). Although there are more than 2,250 wineries in the state, 35 produce 85 percent of the commercial wine sold in California (Napa Now, 2011).

Both liquid and solid residues are generated from the crushing of wine grapes and production of wine. Wineries discharge wastewater on land using land discharge permits from their Regional Water Quality Districts as well as to aerated holding ponds. A few very large wineries discharge wastewater to local WWTFs.

The pomace (grape skins, seeds and stems) remains after the grape crush. Pomace is a compostable soil amendment and animal feed supplement. Amounts of pomace can be very high leading to disposal and storage constraints.

There are 164 wineries that employ 25 or more workers. Only 48 observations were obtained for a 30 percent data collection rate in this sector. The survey also was unable to collect significant wastewater data from many wineries, with the exception of those in the San Joaquin Valley where wastewater data were obtained for 24 of 29 wineries. These facilities account for 94 percent of all winery workers in the SJV.

3.6.1 Wastewater Amount and Energy Potential from SJV Wineries

The 24 wineries in the San Joaquin Valley region discharge a combined 832 million gallons of wastewater per year. This wastewater represents a potential energy of 740,000 therms of biogas (74,000 MMBtu) and could potentially be converted into 880 kW of electricity (0.88 MW) with 310,800 therms of heat (31.1 MW) from CHP systems (Table 14).

Table 14. San Joaquin Valley Winery Wastewater and Technical Energy Potential Estimates

County	Annual Wastewater (WW)				CHP from BOD ₅	
	(MG)	Total BOD ₅ (ton)	Potential Biogas		Power	Recovered Heat
			Volume (MMscf)	Energy (MMBtu)	(MW)	(MMBtu)
Fresno	132.51	320	5.50	3,480	0.04	1,460
Kern	11.69	120	2.04	1,290	0.02	540
Madera	88.19	1,080	18.67	11,830	0.14	4,970
Merced	125.03	1,930	33.31	21,100	0.25	8,860
San Joaquin	334.30	2,240	38.83	24,600	0.29	10,330
Stanislaus	117.13	990	17.05	10,800	0.13	4,540
Tulare	23.39	80	1.42	900	0.01	380
Totals	832.24	6,760	116.82	74,000	0.88	31,080

3.6.2 State Production of Solid Residues and their Energy Potential

The amount of pomace per ton of fruit (wet basis) crushed varies by district, from 8 to 10 percent in high volume wine districts to 20 percent in the highest quality wine districts (Paul Novak, 2010). For this study, a 10 percent factor is used to estimate the amount of pomace residue from grape crush for all counties and districts except Napa County where a 20 percent rate of pomace residue is used. The moisture content of pomace ranges from 50 to 60 percent (Ingels, 1992; Zhang, 2010). Fifty-five percent moisture content is used to estimate pomace dry matter.

Figure 2 shows the geographical distribution of California's wine growing districts. This numbering system is used to illustrate the location of winegrape pomace produced in respective districts and the estimates to convert this material to energy.

The 3.7 million tons of fruit crushed in 2009 was estimated to produce 385,000 wet tons of pomace or 173,000 dry tons (assuming 55 percent moisture content of raw pomace). This material represents an energy potential of 14.1 million therms of biogas (1.4 million MMBtu) and could potentially be converted into 16.7 MW of electricity with 5.9 million therms of heat (593,000 MMBtu) from CHP systems (Table 15).

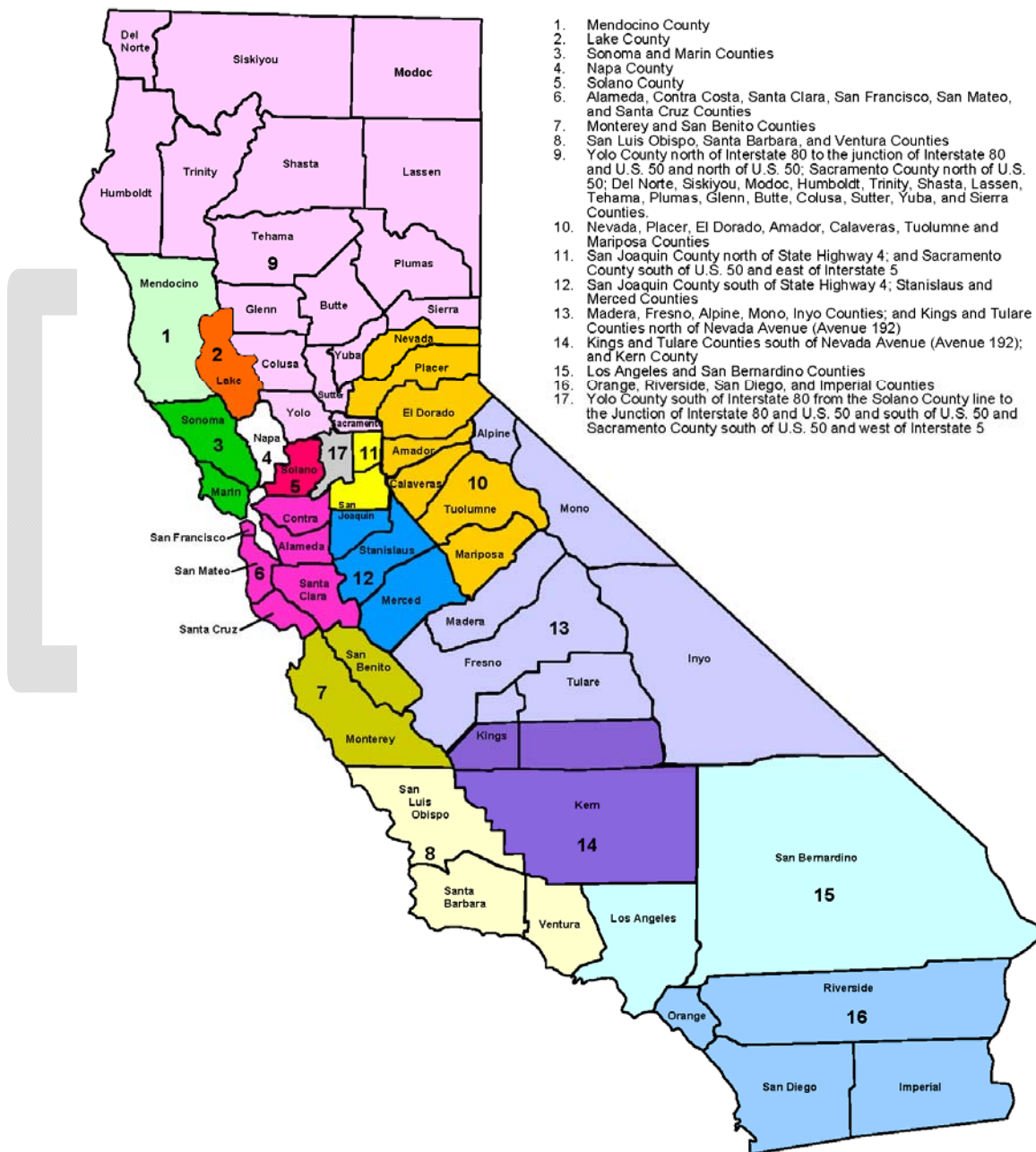


Figure 2. California Wine Growing Districts Source: USDA, NASS, 2011b

Wineries in the San Joaquin Valley account for about 67 percent of the technical energy potential from pomace with Napa and Sonoma Counties (Districts 3 & 4) as well as the Central Coast (Districts 7 and 8) accounting for about 13 percent each (Table 15 & Figure 3).

Table 15. Wine Grape Crush Data By District, with Pomace Residue, and Energy Technical Potential Estimates

UDSA Wine Growing Districts	Counties	Total Crush (tons/yr)	Wet Pomace (tons) ¹	Annual HMS			CHP from HMS	
				Total (dry tons) ²	Potential Biogas		Power	Recovered Heat
					Volume (MMscf)	Energy (MMbtu)		
1	Mendocino	59,617	5,962	2,680	34.55	21,890	0.26	9,190
2	Lake	31,623	3,162	1,420	18.33	11,610	0.14	4,880
3	Marin, Sonoma	212,675	21,268	9,570	123.26	78,070	0.92	32,790
4	Napa	142,752	28,550	12,850	165.46	104,810	1.24	44,020
5	Solano, <i>Sacramento</i> *	19,272	1,927	870	11.17	7,070	0.08	2,970
6	Alameda, Contra Costa, San Mateo, Santa Clara, Santa Cruz	26,925	2,693	1,210	15.60	9,880	0.12	4,150
7	Monterey, San Benito	264,848	26,485	11,920	153.49	97,230	1.15	40,840
8	San Luis Obispo, Santa Barbara, Ventura	216,936	21,694	9,760	125.73	79,640	0.94	33,450
9	Butte, Colusa, Glenn, Humboldt, <i>Sacramento</i> *, Shasta, Siskiyou, Sutter, Tehama, Trinity, <i>Yolo</i> *, Yuba	60,142	6,014	2,710	34.86	22,080	0.26	9,270
10	Amador, Calaveras, El Dorado, Mariposa, Nevada, Placer, Tuolumne	18,192	1,819	820	10.54	6,680	0.08	2,800
11	<i>Sacramento</i> *, <i>San Joaquin</i> *	770,101	77,010	34,650	446.31	282,710	3.34	118,740
12	Merced, <i>San Joaquin</i> *, Stanislaus	316,063	31,606	14,220	183.17	116,030	1.37	48,730
13	Fresno, <i>Kings</i> *, Madera, <i>Tulare</i> *	1,074,821	107,482	48,370	622.91	394,570	4.66	165,720
14	Kern, <i>Kings</i> *	347,297	34,730	15,630	201.28	127,490	1.51	53,550
15	San Bernardino, Los Angeles	1,078	108	50	0.62	400	0.00	170
16	Orange, Riverside, San Diego	3,841	384	170	2.23	1,410	0.02	590
17	Solano, <i>San Joaquin</i> *	136,847	13,685	6,160	79.31	50,240	0.59	21,100
Totals		3,703,030	384,578	173,060	2,228.82	1,411,810	16.68	592,960

1) based on 10% by weight

2) based on 55% moisture

* ***Bold, italic counties*** indicate partial counties in multiple districts

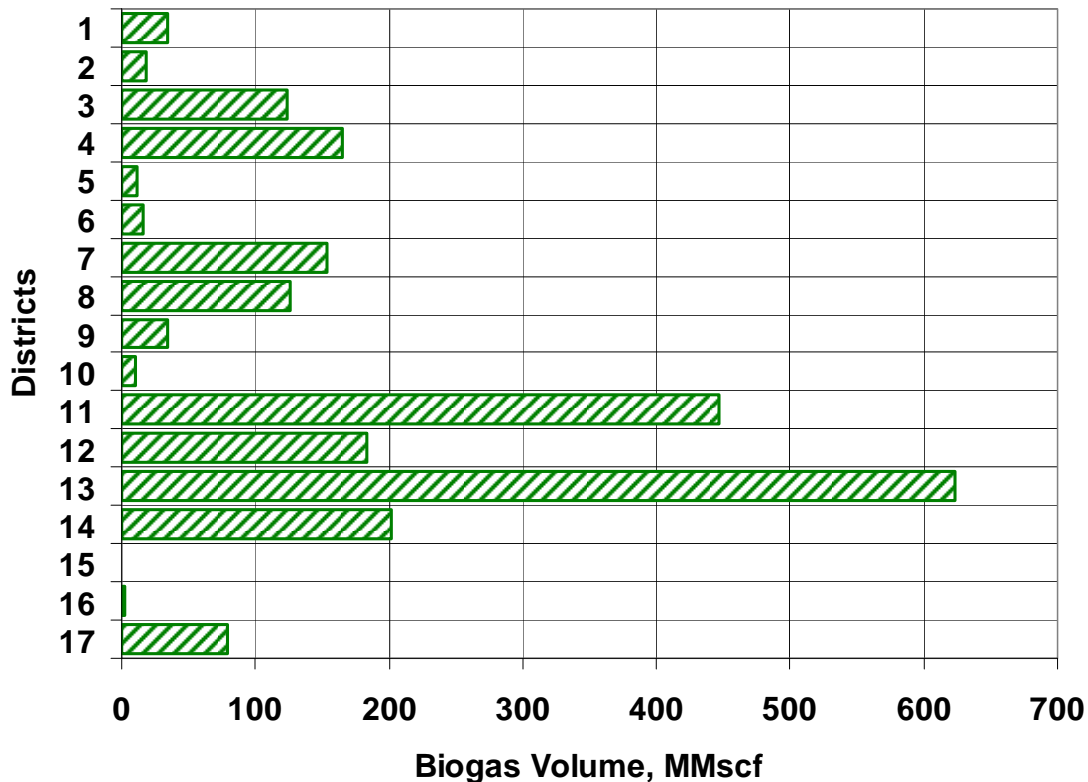


Figure 3. Winegrape Pomace Biogas Potential, Million Standard Cubic Feet (MMscf)

3.6.3 Breweries

Additional data was collected from breweries but the number of observations was too low to reliably estimate industry residues. The largest beer manufacturing facilities in the state, Anheuser-Busch InBev in Fairfield and Los Angeles, MillerCoors in Irwindale and the Sierra Nevada Brewing Company have already installed anaerobic digesters (AD) to pre-treat wastewater discharged to local sewer systems, reducing costs and producing biogas to feed boilers. These companies regard these investments as a component of their sustainability policies and practices. Appendix B provides a list of food companies, including breweries that produce energy from process residues.

3.7 Dairy Creamery Industry

There are over 1,700 dairy farms in California, housing over 1.7 million cows. The San Joaquin Valley is home to the majority of the state's dairy cows. California dairies supplied almost 40 billion pounds of raw milk in 2009 to creameries that process raw material into value added fluid milk, cheese, butter, ice cream, whey protein and other dairy products (CDFA, 2009). Values in Table 16 are used to estimate cheese whey production.

Table 16. Milk Production and Dairy Product Production, 2009

Dairy Product	Annual California Production
Total Statewide Milk Production	39.5 Billion Pounds
Cheese	2.06 Billion Pounds
Ice Cream	520.3 Million Gallons
Yogurt	620 Million Pounds
Cottage Cheese	89.8 Million Pounds
Nonfat Dry Milk	832.3 Million Pounds

Source: (California Department of Food and Agriculture (CDFA), 2009, Directory)

The D&B database for California lists 88 companies involved in milk processing and dairy products including 32 fluid milk companies (SIC 2026), 38 natural, processed, and imitation cheese companies (SIC 2022), and 18 involved in ice cream and frozen desserts (SIC 2024) (Dun & Bradstreet, 2007).

Survey responses indicate that most creameries are installing dissolved air flotation systems and pre-treatment aerated lagoons. Some have their own wastewater treatment facilities. Creameries are also modifying wastewater pH levels before discharging onto land. Most creameries that discharge to municipal WWTFs must pretreat the wastewater to reduce solids content. Current practices creamery wastewater solids separation includes dissolved air flotation systems, ceramic membranes, cavitation air flotation systems, and moving bed bioreactors. Creamery managers commented that the adoption of pre-treatment wastewater technologies is driven to comply with environmental standards and achieve residue recovery opportunities.

Some of the creameries that responded to the survey are using aerated lagoons to treat wastewater. The biosolids that are produced are periodically collected during lagoon maintenance every three to four years. These materials are dewatered and used as soil amendments. Companies that dredge ponds reported the extraction of “industrial biosolid” residues. Due to lack of residue specific quality data, the biosolids / sludge was not used to estimate energy potential.

Depending on location, creameries have more than one option to discharge wastewater and solid residues. Some creameries within the Central Valley are able to discharge onto land, but are required to meet Regional Water Quality Control Board disposal standards. Survey responses indicate that creamery managers still consider methane recovery for energy not to be cost effective but the need to pre-treat wastewater may be a future driver to install AD systems.

National creamery corporations have developed profitable methods to capture and sell milk by-products as higher value commodities. Surveyed large cheese companies reported no solid residue streams, but rather reported volumes produced of whey protein concentrate, lactose and other ingredients used in value added products.

Milk by-products have become an important source of revenue for large dairy processing companies. As far back as 2001, cheese makers were quoted as saying, "cheese to break even, whey for profit" (Cryan, 2001 & 2011). To date, the US creamery industry has integrated the extraction of lactose and whey for further processing, transforming these materials into value added products. Creameries have invested in research and development of functional nutritional food products with great success.

A total of 77 creamery facilities were identified that employ 25 or more workers (Dun and Bradstreet, 2007). Fifty-five observations were obtained for a statewide response of 71 percent. These 55 facilities employ 87 percent of the total number of workers employed by target companies.

3.7.1 Wastewater Amounts and Energy Potential

Annual estimated wastewater amounts are 2.03, 2.19 and 0.71 billion gallons for fluid milk, cheese, and ice cream/butter processors respectively. Potential CHP capacity from industry wastewater is 5.7 MW and 200,000 MMBtu of heat (Tables 17, 18 and 19).

Most of this wastewater is discharged to WWTFs, where much of the energy potential is lost through the aerobic treatment applied at most WWTFs. Employing onsite AD to pretreat wastewater prior to discharge to sewer systems is one way to exploit the energy potential of the resource. The economic motivation for onsite AD for wastewater pretreatment is often due to reduced discharge fees charged by WWTFs for lower strength (or pretreated) wastewater.

Table 17. Fluid Milk Wastewater Discharge and Potential Energy

County	Annual Wastewater (WW)				CHP from BOD ₅	
	(MG)	Total BOD ₅ (ton)	Potential Biogas		Power (MW)	Recovered Heat (MMBtu)
			Volume (MMscf)	Energy (MMBtu)		
Alameda	156.89	1,490	25.86	16,380	0.19	6,880
Fresno	443.60	1,740	30.10	19,070	0.23	8,010
Humboldt	70.00	1,140	19.71	12,480	0.15	5,240
Los Angeles	439.48	6,040	104.50	66,190	0.78	27,800
Merced	254.40	2,490	43.06	27,280	0.32	11,460
Orange	88.13	840	14.55	9,220	0.11	3,870
Riverside	88.52	2,000	34.67	21,960	0.26	9,220
Solano	38.25	150	2.54	1,610	0.02	680
Sonoma	32.79	80	1.34	850	0.01	360
Stanislaus	14.39	50	0.81	510	0.01	220
Tulare	389.57	1,140	19.69	12,470	0.15	5,240
Ventura	17.50	70	1.14	720	0.01	300
Totals	2,033.52	17,230	297.97	188,740	2.24	79,280

Table 18. Cheese Manufacturing Wastewater Discharge and Potential Energy

County	Annual Wastewater (WW)				CHP from BOD ₅	
	(MG)	Total BOD ₅ (ton)	Potential Biogas		Power	Recovered Heat
			Volume (MMscf)	Energy (MMBtu)	(MW)	(MMBtu)
Del Norte	6.00	0	0.00	0	0.00	0
Glenn	54.33	670	11.51	7,290	0.09	3,060
Kings	995.27	11,410	197.36	125,010	1.48	52,510
Los Angeles	109.50	980	16.92	10,720	0.13	4,500
Merced	89.16	650	11.17	7,080	0.08	2,970
San Joaquin	275.00	3,290	56.97	36,090	0.43	15,160
Stanislaus	336.59	1,910	33.09	20,960	0.25	8,800
Tulare	324.35	1,860	32.26	20,440	0.24	8,580
Totals	2,190.20	20,770	359.28	227,590	2.70	95,580

Table 19. Ice Cream and Butter Wastewater Discharge and Potential Energy

County	Annual Wastewater (WW)				CHP from BOD ₅	
	(MG)	Total BOD ₅ (ton)	Potential Biogas		Power	Recovered Heat
			Volume (MMscf)	Energy (MMBtu)	(MW)	(MMBtu)
Contra Costa	2.00	10	0.19	120	0.00	50
Kern	5.47	80	1.34	850	0.01	360
Los Angeles	15.48	380	6.66	4,220	0.05	1,770
Merced	160.14	730	12.65	8,010	0.09	3,360
Orange	6.36	70	1.14	720	0.01	300
Sacramento	16.71	1,510	26.17	16,580	0.20	6,960
Stanislaus	453.91	2,720	47.09	29,830	0.35	12,530
Tulare	48.27	560	9.71	6,150	0.07	2,580
Totals	708.34	6,060	104.95	66,480	0.78	27,910

3.7.2 Energy Technical Potential from Solid Residue Sources

Producing 2 billion pounds of cheese in 2009, (CDFA, 2009) California cheese manufacturers would have created 1 billion pounds of solid whey or the equivalent to 500,000 tons. For every two pounds of cheese produced, about one pound of whey solids is left over (Roger Cryan, 2011). Most of the cheese manufacturers have developed whey processing businesses so much of this material is currently not available for energy.

3.8 Meat Processing Industry

California's meat processing industry includes more than 400 companies that slaughter, process and distribute meat products from cattle, swine, poultry, sheep and other livestock sources. These companies include meat packing plants, meat product producers, sausage and other prepared meat products, fresh and frozen packaged fish products, and poultry slaughtering processors. There are also sixteen rendering companies categorized as Animal and Marine Fats and Oils, (Dun & Bradstreet, 2007).

Most animal slaughtering in California occurs in a few very large facilities. The 2011 US Department of Agriculture Meat, Poultry and Egg Product Inspection Directory indicates there are eight poultry slaughtering facilities between Turlock and Fresno in the San Joaquin Valley. Specialty poultry processing also takes place in the Petaluma region. The USDA directory also includes 19 beef slaughtering facilities concentrated in Selma, Los Banos, Madera, Hanford, Fresno and Brawley. The rest of the beef slaughtering takes place at small facilities for specialty ethnic markets (USDA, FSIS. 2011).

Some of the large slaughtering facilities are vertically integrated corporations that also own the feed lots that finish poultry, cows, lambs and swine before slaughtering at adjacent processing facilities. They also manufacture their own branded products as well as deliver wholesale cuts to urban-based meat product companies. The large majority of registered companies are small processors that purchase already cut meats to finish and pack specialty products.

National Beef Company Plant Productivity Improvements



In 2007, National Beef in Brawley, California, received a California Energy Commission Industrial Energy System Assessment (ESA). The ESA identified conservation measures, efficiency improvements and bioenergy opportunities. In addition to steam system efficiency measures, the report recommended to utilize biogas generated at the on-site anaerobic digester lagoon to feed boilers instead of flaring.

SoCalGas has supported National Beef by granting \$450,000 for the biogas boiler conversion. The completed project is achieving one million therms of natural gas displacement, and 5,864 tons equivalent CO₂ reduction per year. (SoCalGas, 2011).

On-site biogas generation for boiler feed to supplant natural gas consumption has great potential among food processing factories in California. The project economics depends on the price of natural gas, among other things, but utility efficiency rebates can reduce total costs.

Projects may generate CO₂ credit allocations under the California Green House Gas Reduction program.

SoCalGas Efficiency Financial Incentives:

The incentives can be as high as \$1 million per project and \$2 million per premise, per year. Please visit:
<http://www.socalgas.com/innovation/energy-resource-center/energy-efficiency.shtml>

There are five companies that employ more than 500 workers; another 33 companies have from 100 to 499 employees (Dun & Bradstreet, 2007). The assessment did not gather sufficient observations to provide an estimate of the amount of residue materials and numbers of livestock involved in these facilities.

Meat processing companies generally pre-treat their wastewater effluents using dissolved air flotation (DAF) systems and other solid separation technologies. These companies generate large quantities of wastewater that contains blood, fat, solids and dirt (from feathers or hides), which need to be removed before secondary (biological) treatment. The DAF systems typically reduce suspended solids from 2,000 mg/l down to 200 mg/l, with the reduction of fats and oils in the range of 95 percent (USDA, GIPSA, 2007). This wastewater with primarily dissolved organic content is then discharged to local wastewater treatment facilities, or, in some cases, is distributed on land if permits allow.

Meat and poultry companies in California dispose of hides, skin, feathers, blood, fats, oils and other animal materials through contracts with renderers or specialty processors to convert these residuals into value-added products. High value materials like cow hides are exported and industrial tallow is produced from separated melted fat for industrial purposes and some biodiesel fuel production. Other products like proteins for pet food and bone and meat meal fertilizers are also produced.

3.8.1 Poultry Industry

In 2006, California processed over 250 million broiler chickens with an average weight of 5.5 pounds (California Poultry Federation, 2011), for a total of 687,500 tons. Turkey facilities processed 15.8 million broilers with average weight of 33 pounds (California Poultry Federation, 2011), for a total of 260,700 tons.

Slaughtering facilities deliver poultry broilers to meat processing facilities for further cutting and processing. The largest poultry processors distribute meat to canneries for soup ingredients, large supermarket chains, and small and medium sized facilities that further process branded products. In addition to residues delivered for rendering purposes, other organic residues are collected through dissolved air flotation and other wastewater pre-treatment processes. Organic sediments (sludge) are also dredged from facultative ponds. These residues are generally composted and applied to land. The sludge applied at local farms is monitored by the Regional Water Quality Control Board offices or the County Environmental Health Departments.

Survey responses reveal that most of the animal residues produced at poultry facilities are sold or processed at a centralized company owned rendering facility. At the time of high energy prices during the California energy crisis in 2001, this company retrofitted boilers to run on animal fat residues (Energy Commission, Agricultural Peak Load Reduction Program, 2004). From conversations with company managers, it was learned

that prices offered for rendering materials make the use of “yellow grease” to power industrial boilers uneconomical.

Of 33 chicken and turkey facilities included in the Dun & Bradstreet database (Dun and Bradstreet, 2007), 24 employ 25 or more workers. Twelve observations were obtained for a statewide response of 50 percent. Combined, these twelve facilities employ 80 percent of the total number of workers in the group of target companies.

Survey responses from poultry processing companies reported no organic solid residue streams, except for the extraction of “industrial biosolids” residue from onsite wastewater pretreatment. This sludge was not used to calculate technical energy potential. These facilities have on site wastewater treatment to process water before discharge to municipal WWTFs. Some also operate by-product processing facilities to collect feathers or render animal fat, grease and oils.

3.7.1.1 Technical Energy Potential from Wastewater Sources

The 12 observations from poultry slaughtering, packing, and processing facilities amount to the discharge of 3.8 billion gallons of wastewater. Low BOD₅ loads provide a technical CHP energy potential of about 1 MW of electricity and 354,000 therms (or 35.4 MMBtu, Table 20).

Table 20. Poultry Industry Technical Energy Potential from Wastewater Residues

County	Annual Wastewater (WW)				CHP from BOD ₅	
	(MG)	Total BOD ₅ (ton)	Potential Biogas		Power (MW)	Recovered Heat (MMBtu)
			Volume (MMscf)	Energy (MMBtu)		
Fresno	1,233.70	1,440	24.85	15,740	0.19	6,610
Los Angeles	21.64	580	9.96	6,310	0.07	2,650
Merced	1,540.00	2,030	35.13	22,250	0.26	9,350
Stanislaus	599.16	1,780	30.71	19,450	0.23	8,170
Tulare	364.37	1,870	32.43	20,540	0.24	8,630
Totals	3,758.87	7,700	133.08	84,290	0.99	35,410

Although collected observations only represent 57 percent of companies that hire 25 or more workers, in Stanislaus County, these companies employ 77 percent of the workers. Collected observations from Tulare County represent 94 percent of workers.

3.7.1.2 Technical Energy Potential from Solid Residue Sources

Practically all of the solid residues from poultry processing is rendered to create value-added non-human consumption products. California’s chicken processors produce annually 123,750 tons of rendering by-products while turkey processing facilities generate 59,961 tons of rendering by-products. None the less, their energy potential is estimated below.

Meat dress weight ratios are used to estimate animal by-product residues from poultry slaughtering facilities. The maximum yield of edible or ‘dressed’ product from poultry

species ranges from a high of 77 percent for turkey broilers to a low of 58 percent for ducks. Chicken broilers' dressed percentage averages 70 percent (Food and Agriculture Organization, 1996).

Approximately 128,000 dry tons annually of poultry solid residues are estimated (Table 21). Potential combined heat and power from these materials (if not sent to rendering) is estimated to be 12.3 MW and 4.4 million therms (439,000 MMBtu).

Table 21. Technical Energy Potential from Poultry Solid Residues

Species	Recoverable Meat (%) ¹	Animals Slaughtered in California ² (million)	Annual High Moisture Solids (HMS)			CHP from HMS	
			Total (dry tons)	Potential Biogas		Power (MW)	Recovered Heat (MMBtu)
				Volume (MMscf)	Energy (MMBtu)		
Chicken Broilers	70	250.0	92,810	1,195.32	757,150	8.94	318,000
Turkey Broilers	77	15.8	35,190	453.27	287,110	3.39	120,590
Totals		265.8	128,000	1,648.59	1,044,260	12.33	438,590

References:

- (1) Management of Waste from Animal Product Processing, Agriculture and Consumer Protection, Food and Agriculture Organization, 1996. <http://www.fao.org/wairdocs/LEAD/X6114E/x6114e04.htm>.
- (2) California Poultry Federation, 2006 production year. http://www.cpfif.org/index.php?option=com_content&task=view&id=163&Itemid=125.

Assumptions:

Total slaughter weight = (250 million chicken broilers x 5.5 pounds/broiler)/2000 pounds/ ton, or 687,500 tons of live weight. Multiplying by 30% average residual (not meat or hides) = 206,250 tons wet. At 45% dry matter, 92,813 dry tons are available. (USDA meat inspector, 2011).

Total slaughter weight = (15.8 million turkeys x 33 pounds/head) / 2000 pounds/ton, or 260,700 tons of live weight. Multiplying by 30% average residual (not meat) = 78,210 tons wet. At 45% dry matter, 35,195 dry tons are available. (USDA meat inspector, 2011).

3.7.2 Cattle and Hog Processing Industry

In 2009, California beef slaughtering facilities processed 1.6 million head of commercial cattle, 2.6 million hogs and 314,000 head of sheep and lamb (USDA, NASS. 2011a). From slaughtering facilities, meat is delivered to meat packing plants for further cutting and processing. Some vertically integrated companies both slaughter and process meat. The majority of companies in the meat industry are small and medium sized facilities that purchase meat cuts from slaughter and meat packing plants for further value-added processing and distribution of their own products.

California was once the top cattle feeding state (Andersen, et. al., 2002). Andersen comments that the number of feedlots in California has decreased because of increased regulatory costs and the closure of beef processing facilities. He reports that the decline in slaughter capacity in California has forced California-grown cattle to be slaughtered

at facilities in Washington, Utah and Colorado, with associated loss of residues, increased transportation fuel costs and emissions and lost energy potential.

There were 76 meat packing plants in California as of 2007. Twenty-six of these companies employed 25 or more workers (Dun and Bradstreet, 2007). Wastewater data was obtained for 15 of these companies from WWTFs. Although these 15 companies represent only 58 percent of the meat packing facilities, they employ 72 percent of the total workers. There are approximately 3,800 workers employed by the 26 largest meat packing plants.

There are 318 other meat product processors categorized as Meats, Meat Products and Sausage, other Prepared Meats, Frozen and Packaged Fish and Animal Marine Fats and Oil (Dun & Bradstreet, 2007). Of these, 89 companies employ 25 or more workers. Data were only obtained from 30 of these facilities (a 34 percent response rate). Estimates of residues and energy potential from this sector are less reliable than others in this report.

Because wastewater observations were obtained through public records, the analysis was unable to determine the BOD₅ value of the raw wastewater before pretreatment and discharge to WWTFs or land. Thus residues collected through screening, flotation and other technology practices to reduce solids in the wastewater stream are not available.

3.7.2.1 Technical Energy Potential from Wastewater Sources

The 45 observations from meat packing and processing facilities discharged 2 billion gallons of wastewater in 2009, representing a technical energy potential of 3.7 MW of equivalent electricity and 134,800 MMBtu of recoverable heat (Table 22).

Table 22. Meat Wastewater Residues and Technical Energy Potential

County	Annual Wastewater (WW)				CHP from BOD ₅	
	(MG)	Total BOD ₅ (ton)	Potential Biogas		Power (MW)	Recovered Heat (MMBtu)
			Volume (MMscf)	Energy (MMBtu)		
Alameda	29.80	120	2.02	1,280	0.02	540
Fresno	743.16	8,510	147.21	93,250	1.10	39,160
Glenn	1.68	20	0.30	190	0.00	80
Kings	84.63	340	5.89	3,730	0.04	1,570
Los Angeles	998.72	19,690	340.65	215,780	2.55	90,630
Merced	14.14	100	1.65	1,040	0.01	440
San Bernardino	5.37	20	0.26	170	0.00	70
Santa Clara	8.87	340	5.87	3,720	0.04	1,560
Solano	0.11	0	0.01	0	0.00	0
Stanislaus	113.51	160	2.75	1,740	0.02	730
Tulare	0.36	0	0.03	20	0.00	10
Totals	2,000.35	29,300	506.64	320,920	3.78	134,790

3.7.2.2 Energy Technical Potential from Solid Residue Sources

Meat dress weight ratios were used to calculate the technical potential to collect animal by-product residues from meat slaughtering facilities. Beef slaughtering (fats, bones and hides) generates on average 40 percent non-human consumption animal residues, while the ratio is 30 percent for hogs and 50 percent for lambs (USDA meat inspector, 2011; Food and Agriculture Organization, 1996).

Meat processors produce an estimated annual 188,000 dry tons of rendering by-products (43,450 dry tons from hog processing) (Table 23). Though most of these residues are sold for value added by-products as hides, tallow, pet foods and other products they represent potential CHP energy of 18 MW of electricity and 646,700 MMBtu of recoverable heat.

Table 23. Technical Energy Potential from Animal Solid Residues

Species ¹	Percent Animal Weight for Human Consumption ²	Number of Animals Slaughtered in California, 2009 ³	Annual High Moisture Solids (HMS)			CHP from HMS	
			Total (dry tons)	Potential Biogas		Power (MW)	Recovered Heat (MMBtu)
				Volume (MMscf)	Energy (MMBtu)		
Cattle	60	1,649,500	144,410	1,859.83	1,178,080	13.91	494,790
Hogs	70	2,649,100	43,450	559.61	354,480	4.18	148,880
Totals			187,860	2,419.44	1,532,560	18.09	643,670

References

- (1) Sheep numbers were relatively small not estimated at this time.
- (2) Management of Waste from Animal Product Processing, Agriculture and Consumer Protection, Food and Agriculture Organization, 1996.
<http://www.fao.org/wairdocs/LEAD/X6114E/x6114e04.htm>.
- (3) USDA, Agricultural Statistics Service, QuickStats <http://quickstats.nass.usda.gov/>,

Assumptions

Total slaughter weight = (1,649,500 head of cattle x 1297 pounds/head) / 2000 pounds/ ton, or 1,069,701 tons of live weight. Multiplying by 30% average residual (40% less 10% hide weight, or 30%) = 320,910 tons wet. At 45% dry matter, 144,410 dry tons are available (USDA meat inspector, 2011).

Total slaughter weight = (2,649,100 hogs x 243 pounds/head) / 2000 pounds/ton, or 321,686 tons of live weight. Multiplying by 30% average residual (not meat) = 96,560 tons wet. At 45% dry matter, 43,452 dry tons are available (USDA meat inspector, 2011).

3.9 Almond and Walnut Industry

The California almond industry produced some 800,000 tons of almonds harvested between August and December of in 2009 (California Almond Board, 2010 Almanac). Kern, Fresno, Stanislaus, Merced and Madera counties produce 77.4% of the state's almond crop. Hulls and shells are available from hullers and processors from Kern to Tehama counties in the Central Valley. An additional 432,334 tons of walnuts were also produced in 2009 (USDA, NASS, 2009b).

The production of nut crops is dominated by almond production in the San Joaquin Valley (Figure 4). Walnut production is more evenly distributed across both the Sacramento and San Joaquin Valleys, but the total production of walnut shells is much lower than the production of almond shells and hulls.

There is a large infrastructure of small and medium sized facilities and a few large handlers that process these crops. Processed nuts are distributed directly to market or to companies that utilize already clean nut kernels for manufacturing confectionary products.

Almond hulls are valued by dairyman for their feed value. In 2010, dairy operators paid \$120 to \$160 per dry ton of hulls delivered. The price fluctuates according to the corn, wheat and barley spot market prices. Almond shells sold for \$15 to \$25 per ton in 2010. Essentially all almonds hulls generated are sold for animal feed purposes (Gene Beach, 2010).

Shells can be burned at biomass power plants for energy, manufactured into fire place logs, used as glue filler for laminate board, or used as raw material for other wood board production. Dairy farms use shells for animal bedding (Best Agrimarketing, 2011).

Walnut hulls are not collected or have much value because most hulls drop on orchard floors from harvesting practices and are not suitable as animal feed. Walnut shells are used as industrial abrasives and for biomass conversion to electricity.

The California Almond Board indicates that the almond processing industry discharges marginal amounts of wastewater from a few, large processing facilities blanching specialty almond products. This practice is not considered a significant contributor of wastewater (California Almond Board staff, 2010).

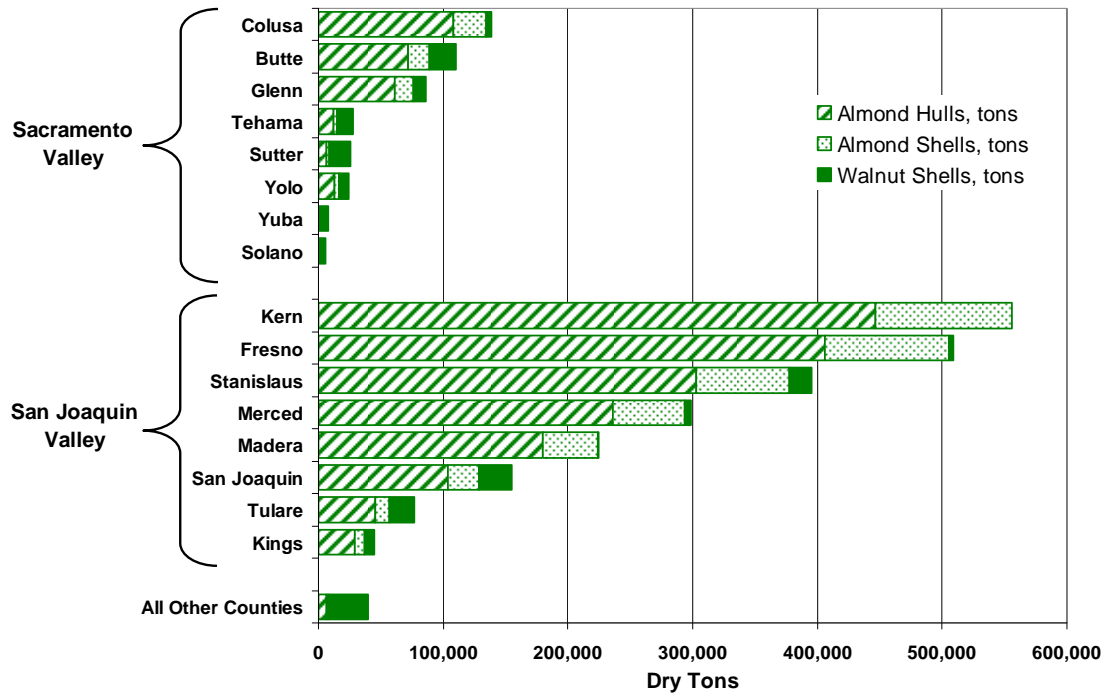


Figure 4. Distribution of the production of almond hulls and shells and walnut shells by county and Central Valley production area

3.9.1 Almond Hulls

Approximately 86 percent of almonds are grown in the San Joaquin Valley and most of the balance grown in the Sacramento Valley [California Almond Board 2009].

The total state almond hull production is about 2 million dry tons, with a technical potential of 343 MW and 157 million therms of co-product heat, assuming thermal conversion (Table 24).⁸

⁸ California Almond Board and the Almond Hullers and Processors Association, use a ratio of 2.8 pound of hulls per pound of kernel to calculate the total amount of hulls produced. Almond hull's moisture content is usually 10% under field air-dry conditions (California Agriculture, March 1965).

Table 24. Almond Production, Hulls to Energy Conversion

County	Production, million lbs. ¹	Amount hulls in million lbs ²	Hulls (wet tons) ³	Annual Low Moisture Solids (LMS)		CHP from LMS	
				Total (dry tons)	Potential Thermal	Power (MW)	Recovered Heat (MMBtu)
					Energy (MMBtu)		
San Joaquin Valley							
Kern	354.3	992.04	496,020	446,420	7,677,080	75.54	3,454,680
Fresno	322.2	902.16	451,080	405,970	6,981,520	68.70	3,141,690
Stanislaus	240.6	673.68	336,840	303,160	5,213,390	51.30	2,346,030
Merced	187.3	524.44	262,220	236,000	4,058,470	39.93	1,826,310
Madera	142.7	399.56	199,780	179,800	3,092,070	30.43	1,391,430
San Joaquin	82.1	229.88	114,940	103,450	1,778,970	17.50	800,540
Tulare	36.2	101.36	50,680	45,610	784,390	7.72	352,980
Kings	23.4	65.52	32,760	29,480	507,040	4.99	228,170
Subtotal	1,388.8	3,888.6	1,944,320	1,749,890	30,092,930	296.1	13,541,830
Sacramento Valley							
Colusa	86.0	240.80	120,400	108,360	1,863,470	18.34	838,560
Butte	56.9	159.32	79,660	71,690	1,232,930	12.13	554,820
Glenn	48.6	136.08	68,040	61,240	1,053,080	10.36	473,890
Yolo	10.4	29.12	14,560	13,100	225,350	2.22	101,410
Tehama	9.7	27.16	13,580	12,220	210,180	2.07	94,580
Sutter	5.3	14.84	7,420	6,680	114,840	1.13	51,680
All other	5.2	14.56	7,280	6,550	112,680	1.11	50,700
Subtotal	222.1	621.88	310,940	279,840	4,812,530	47.36	2,165,640
Totals	1,610.9	4,510.5	2,255,260	2,029,730	34,905,460	343.47	15,707,470

Notes

(1) California Almond Board (CAB), 2009 Almond Almanac, pg. 31

(2) 2.8 pound hulls per pound kernel, CALIFORNIA AGRICULTURE, MARCH, 1965, pg. 13.

<http://ucce.ucdavis.edu/files/repositoryfiles/ca1903p12-59109.pdf>

(3) 10% moisture under air-dry conditions, Almond Hullers & Processors Association, California Almond Board

3.9.2 Almond Shells

The San Joaquin Valley also accounts for 86 percent of the total technical energy potential from almond shells.

Sources, including the California Almond Board and the Almond Hullers and Processors Association, use a ratio of 0.67 pounds of shell per pound of kernel. At 8% moisture (Gene Beach, 2010), the total amount of almond shells equal 496,000 dry tons,

with a technical energy potential of 84 MW and 38 million therms (3.8 MMBtu) of co-product heat assuming thermal conversion (Table 25).

Table 25. Almond Production, Shells to Energy Conversion

County	Production, million lbs. ¹	Shells (wet tons) ²	Annual Low Moisture Solids (LMS)		CHP from LMS	
			Total (dry tons)	Potential Thermal	Power (MW)	Recovered Heat (MMBtu)
				Energy (MMBtu)		
San Joaquin Valley						
Kern	354.3	118,691	109,430	1,881,920	18.52	846,860
Fresno	322.2	107,937	99,520	1,711,420	16.84	770,140
Stanislaus	240.6	80,601	74,310	1,277,980	12.58	575,090
Merced	187.3	62,746	57,850	994,870	9.79	447,690
Madera	142.7	47,805	44,080	757,970	7.46	341,090
San Joaquin	82.1	27,504	25,360	436,090	4.29	196,240
Tulare	36.2	12,127	11,180	192,280	1.89	86,530
Kings	23.4	7,839	7,230	124,290	1.22	55,930
Subtotal	1,388.8	465,248	428,960	7,376,820	72.6	3,319,570
Sacramento Valley						
Colusa	86.0	28,810	25,930	445,900	4.39	200,660
Butte	56.9	19,062	17,160	295,030	2.90	132,760
Glenn	48.6	16,281	14,650	251,990	2.48	113,390
Yolo	10.4	3,484	3,140	53,920	0.53	24,270
Tehama	9.7	3,250	2,930	50,300	0.49	22,640
Sutter	5.3	1,776	1,600	27,490	0.27	12,370
All other	5.2	1,742	1,570	26,960	0.27	12,130
Subtotal	222.1	74,404	66,980	1,151,590	11.33	518,220
Totals	1,610.9	539,652	495,940	8,528,410	83.9	3,837,790

Notes:

(1) California Almond Board (CAB), 2009 Almond Almanac, pg. 31

(2) 7.8% moisture content. New and renewable energy technologies for sustainable development, 2004.

Assumes 0.67 of a pound per pound kernel. Almond Hullers & Processors Association, California Almond Board

3.9.3 Walnut Shells

A ratio of 0.50 pounds of shells (at 8% moisture) per pound of kernels was assumed (Thompson, 2011, and Kader, 2011). The total amount of walnut shells produced statewide in 2009 is estimated at slightly more than 199,000 dry tons, with a technical energy potential of almost 34 MW and 1,542,000 MMBtu recovered heat assuming thermal conversion CHP (Table 26).

Table 26. Walnut Production, Shells to Energy Conversion

County	Production, (tons) ¹ .	Shells (tons) ²	Annual Low Moisture Solids (LMS)		CHP from LMS	
			Total (dry tons) ³	Potential Thermal	Power (MW)	Recovered Heat (MMBtu)
				Energy (MMBtu)		
Butte	46,656	23,328	21,510	369,880	3.64	166,450
Colusa	8,716	4,358	4,020	69,100	0.68	31,090
Fresno	8,282	4,141	3,820	65,660	0.65	29,540
Glenn	21,718	10,859	10,010	172,180	1.69	77,480
Kings	17,125	8,562	7,890	135,760	1.34	61,090
Lake	7,618	3,809	3,510	60,390	0.59	27,180
Madera	1,967	983	910	15,590	0.15	7,020
Merced	9,586	4,793	4,420	76,000	0.75	34,200
Placer	1,855	927	860	14,700	0.14	6,620
San Benito	2,588	1,294	1,190	20,520	0.20	9,230
San Joaquin	57,273	28,636	26,400	454,050	4.47	204,320
San Luis Obispo	4,962	2,481	2,290	39,340	0.39	17,700
Solano	12,240	6,120	5,640	97,040	0.95	43,670
Stanislaus	38,287	19,144	17,650	303,540	2.99	136,590
Sutter	36,977	18,488	17,050	293,150	2.88	131,920
Tehama	27,605	13,802	12,730	218,850	2.15	98,480
Tulare	42,854	21,427	19,760	339,740	3.34	152,880
Yolo	17,613	8,807	8,120	139,630	1.37	62,840
Yuba	51,914	25,957	23,880	410,481	4.03	184,742
Totals	432,334	216,165	199,270	3,426,391	33.7	1,541,902

Notes and assumptions:

(1) @ 1.9 tons per acre, where 227,000 bearing acres in 2009, produced 432,334 in-shell tons. USDA, NASS. 2009b. California Walnut Acreage Report and Walnut/Raisin/Prune Report, State Summary – 2009 Crop Year.

(2) @ 0.50 ton of shells per ton of kernel. Expert opinion from Jim Thompson and Adel Kader, UC Davis, 2011.

(3) @ 8% moisture. Expert opinion from Jim Thompson and Adel Kader, UC Davis, 2011.

Chapter 4: Discussion and Conclusions

The concept of a residual infers a byproduct of production that has limited or no economic value. The value of these food processing residuals is generally highly variable. The assessment shows there is technical potential to convert food industry residues to energy, but most of these biomass resources are not readily available for energy conversion. Most food processing residuals from cheese manufacturing, animal processing, and almond hulls command high prices as value added by-products. Seasonal residues from the fruit and vegetable processing industries are the most potentially available biomass for bioenergy conversion. These materials are available during a short season when significant amounts of wet and dry residues are generated. Most of these residues make an important contribution by providing non-forage and non-grain crop dairy ration substitutes for animal feed. Animal feed remains the highest value use for most of these residues.

Table 27 provides a summary of the annual wastewater, BOD₅, and solids produced by each sector.⁹ These values do not account for some material with existing byproduct markets, such as whey solids.

Table 27. Summary of Total Food Processing Wastewater Discharged, BOD, and Solids Generated Annually in California

Food Processing Sector	WW MGY	BOD (dry tons/ year)	HMS (dry tons/ year)	LMS (dry tons/ year)
Cannery Fruits and Vegetables (F & V)	8,161	55,927	47,240	67,960
Dehydrated F&V	284	2,717	22,600	109,150
Fresh/Frozen F&V	6,290	28,150	25,770	
<i>Subtotal, Fruits and Vegetables</i>	14,735	86,794	95,610	177,110
Meat Processing				
Poultry	3,759	7,700	128,000	
Red Meat	2,000	29,300	187,860	
<i>Subtotal, Meat processing</i>	5,759	37,000	315,860	
Other Food Residues				
Almond Hulls				2,029,730
Almond Shells				495,940
Walnut				199,270
Winery	832	6,760	173,060	
Creamery	4,932	44,060		
<i>Subtotal, Other Residues</i>	5,764	50,820	173,060	2,724,940
Grand Total	26,258	174,614	584,530	2,902,050

⁹ The BOD₅ ‘tons’ are not solids, but refer to the amount (mass) of dissolved oxygen required to stabilize wastewater by aerobic microbes. It is an indication of wastewater “strength” or level of organic pollution that also correlates to potential methane production.

The design of this current assessment was strongly influenced by the earlier work of Matteson and Jenkins (2005). Changes in treatment and processing technologies, and also the overall understanding of evaluating these residues across industry sectors on the basis of human health, environmental quality, food and feed markets, and energy potential, since that initial study, made direct comparisons to that earlier work difficult.

This study did not evaluate the economic potential from siting bioenergy projects at seasonal or year-round facilities. To date these investments have not been found to be economical according to industry managers. Cheese whey and animal by-products already have profitable markets, and are unlikely to be diverted for energy generation.

4.1 Bioenergy Generation Potential

Although seasonal residues are disposed of by using lowest cost options, particularly land discharge practices, this material could be redirected to local anaerobic digesters instead of disposal sites. Some companies are investigating the feasibility of building bioenergy projects, as well as entertaining offers from residue prospectors looking for long-term feedstock contracts. The food industry could be a catalyst to the development of private public initiatives to convert seasonal food industry residue streams to bioenergy.

The development of bioenergy projects in the food industry will be driven by the need to comply with evolving environmental standards. Many facilities that historically have used land discharge methods to dispose residues now comply with higher water, soil and air quality standards. Food processors that discharge to municipal wastewater treatment facilities (WWTF) have had to reduce discharged organic loads to comply with new standards and/or to reduce costs. Companies in urban areas have few alternatives but to dispose of residues at landfills and are required to find alternatives. Corporate sustainability goals are also a driver for these businesses to invest in bioenergy and other renewable energy systems, as well as reduce the water and energy intensity of consumption.

Food processing companies are investing in technologies that allow for residue recovery and treatment, including membranes and dissolved air flotation systems. Relatively few food and beverage companies have invested to date in anaerobic digesters (AD) or thermal conversion systems.

Based on the quantities reported in Table 27, and the assumptions described in this report, total CHP power available from the California food processing industry is estimated at 557 MW with 24.5 million MMBtu (Table 28). Significantly, most of the power estimates come from thermal conversion of nut residues, and most of these are used for animal feed (almond hulls). Some shells are used currently for power

production. There are other residues that are beginning to be developed in energy projects (e.g., Appendix B). And there are some residues that are currently being used in more profitable, non-energy markets.

Table 28. Summary of Bioenergy Potential from Food Processing Residuals

Food Processing Sector	BOD ₅ Biogas		Solids Biogas		LMS Thermal		Potential Residue Availability
	Power (MW)	CHP (MMBtu)	Power (MW)	CHP (MMBtu)	Power (MW)	CHP (MMBtu)	
Cannery Fruits and Vegetables (F & V)	7.2	257,480	11.1	394,600			High
Dehydrated F & V	0.4	12,530	12.7	451,460			High
Fresh/Frozen F & V	3.6	129,500	2.5	88,360			High
Winery	0.9	31,080	16.7	592,960			High
Creamery	5.7	202,770					None
Poultry	1.0	35,410	12.3	438,590			None
Red Meat	3.8	134,790	18.1	643,670			None
Almond Hulls & Shells, Combined					427.4	19,545,260	Hulls None; Shells Medium
<i>Almond Hulls, Segregated</i>					340.0		<i>Medium</i>
Walnut Shells					33.7	1,541,902	High
Total CHP							
Power Total (MW)	22.6		73.3		461.1		553.0
Recovered Heat (MMBtu)		803,560		2,609,640		21,087,162	24,315,610

F & V = Fruits and Vegetables

4.2 Barriers

Air quality regulations, especially those for oxides of nitrogen (NO_x) emissions in the SJV, currently limit the scope of cost-effective technology options to utilize biogas for onsite electricity generation. Most of the bioenergy projects currently installed at food processing facilities in California are using their biogas to feed boilers, displacing natural gas use and creating the potential for carbon credit allocations under a future California greenhouse gas emission reduction program.

The seasonal nature of the biomass available from fruit and vegetable processing facilities further limits the economic potential of on-site bioenergy projects. Because many of the year-round food industry residues are already committed to higher value products, there are only limited amounts of available year-round residues from food

industry facilities. The prospect to enable the use of both seasonal and year-round residues at centralized locations may be limited to a few counties in the San Joaquin Valley region. Kern, Fresno, Merced, and Stanislaus counties accumulate the largest amount of organic residues from food processing facilities.

4.3 Feedstock Limitations

It is very unlikely that animal by-product residues would be diverted for energy conversion purposes because they currently have market value. The same can be said about almond hulls, given the high premium price paid as animal feed. Essentially, all almond hulls produced are committed to animal feed.

This assessment did not account for the amount of almond and walnut shells being used to power existing biomass to electricity facilities. Anecdotal comments revealed interest among cement companies to use almond shells to fuel cement kilns. This interest may increase when the California greenhouse gas emission regulations go into effect.

4.4 Value Added Innovations

Large cheese manufacturers now utilize whey in value-added byproducts and whey is no longer considered a residue stream. It should be expected that medium and small-sized cheese producers will develop their cheese whey into value added products as well.

This could be a model for other food processor sectors to develop value added materials from residue streams. As these developments take place and the value of energy remains low, fewer residues would be available for energy conversion.

Technological change may also have a direct impact on wastewater effluent in tomato and fruit canning facilities. The use of infrared heat technology to peel tomatoes and peaches is being advanced at the University of California Davis and the USDA Albany Laboratory, and has shown a technical potential to reduce wastewater discharge loads by almost fifty percent (CA&ES Outlook, Fall/Winter 2009). The wine industry is researching value added opportunities for winegrape pomace.

Additional incentives will be needed to overcome investment barriers at seasonal food processing facilities. Food industry executives recognize that anaerobic digesters (AD) could be an integral component of food manufacturing facilities, to treat wastewater streams, to reduce, reuse and recycle water and other solid materials. AD systems can generate thermal heat and power to supplement natural gas used on industrial boilers. Doing so may earn carbon credit allocations under future greenhouse gas regulations. Most of the food companies that have installed bioenergy recovery systems are using the biogas to fuel industrial boilers.

Food companies will continue to search for value-added opportunities. Fruit and vegetable processors as well as wineries have the challenge to change the business model from a cost-minimizing strategy for mitigating waste to a profit maximizing strategy from value-added products. The addition of complementary processes like anaerobic digestion may enhance their ability to do so. Food companies located in the Central Valley region will continue to dispose most of their "wet waste" through land application practices. However food companies may adopt water conservation practices to reduce wastewater volumes, saving costs from extracting and pumping water while prolonging the use of land discharge permits. As a competitive economic advantage, the ability to discharge wastewater and wet solids on land will continue to favor these food companies over others that discharge at a higher cost through WWTFs and landfills.

4.5 Industry Needs

Industry managers speak of the need for policy clarity in order to determine the cost of complying with the upcoming California greenhouse gas emissions reduction regulations. They recognize that a new regulatory cost structure will be added to their business, adding to the challenge of remaining globally competitive while continuing to operate food facilities in California.

4.6 Recommendations for Future Research

The calculations for estimating energy potential were based on a single factor for methane production from solid residues, another for methane from wastewater BOD₅ and a third for thermal conversion of relatively dry nut shells and hulls. There is likely variation in methane producing properties from food processing residues. There is also probably a variation among nut shells and hulls with respect to properties for thermal conversion. To fine tune the energy estimates in this report, further research is recommended that involves an in-depth literature review and collecting and characterizing a range of food processor residues for biomethane potential and other characteristics that affect methane production, i.e., micronutrients, metals content, volatile solids, total solids, and C:N ratio, and for those properties affecting thermal conversion, i.e., ultimate analysis, heating value, ash content and ash properties.

Building from these results, further research is needed to understand the dynamics by which bioenergy projects could be an economic development component of the SJV's agricultural, food processing and urban landscape. There are compelling reasons why this region could be a prime location for bioenergy economic development. The organic residue from seasonal fruit and vegetable processing is potentially available for higher value options. Other agricultural residues are available from seasonal orchard and vineyard wood removal practices, to year-round animal manures from dairies, poultry and confined animal facilities.

A systematic analysis could illustrate the theoretical potential to locate distributed generation bioenergy conversion facilities. The food industry residue assessment could be added to the California Biorefinery Siting Model (CBSM), produced for PIER by the California Biomass Collaborative (Parker, et. al., 2010). Based on this analysis, the CBSM could be used to minimize transportation distances or to estimate other optimization objectives related to the use of food processing industry resources. This analysis could also identify both policy and economic conditions under which more bioenergy development could be achievable in the San Joaquin Valley region.

Additional research efforts should identify the technical, economic and environmental potential benefits from integrating the use of anaerobic digesters and other renewable energy technologies at seasonal food processing industrial facilities. Develop modeling tools to identify best use opportunities to treat wastewater and other organic residues that contribute cash flow and produce ancillary benefits to industrial plant productivity.

Development of decision tools (models) to estimate the costs and benefits of complying with California 's new and evolving greenhouse gas regulations would help industry managers make sound long-term investments and help the food processing industry remain economically viable.

This study did not evaluate the price range at which almond hulls and other higher value by-products would be diverted as biomass for bioenergy generation, on-site or at aggregated bio-refinery facilities. Future projects may develop economic models to calculate market price signals for energy resources, accounting for the potential economic and environmental impact to the animal feed supply chain.

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List of Acronyms

AD	Aanaerobic digesters or anaerobic digestion
BOD5	Biochemical Oxygen Demand (5 day)
Btu	British thermal unit
CBSM	California Biorefinery Sitting Model
CHP	Combined heat and power
D&B	Dunn and Bradstreet or D&B database
DAF	Dissolved air flotation
EBMUD	Bay Municipal Utility District
GIPSA	Grain Inspection Packers and Stockyards Administration, USDA
HHV	Higher heating value
HMS	High moisture solids
HWMA	Humboldt Waste Management Authority
kW	Kilowatts: 1,000 watts
L	Liter
LMS	Low moisture solids
MGY	Million gallons per year
mg	Milligram
MMBtu	Million Btu
MMscf	Million standard cubic feet
MUD	Municipal Utilities District
MW	Megawatt: 1,000,000 watts, or 1,000 kilowatts
NAICS	North American Industry Classification System
PIER	Public Interest Energy Research
Pomace	Pomace is skins, seeds and stems from grape crushing and tomato processing
RPS	Renewable portfolio standard
RWQCB	Regional Water Quality Control Board
scf	Standard cubic feet
SIC	Standard Industrial Classification
SJV	San Joaquin Valley
SMUD	Sacramento Municipal Utilities District
therm	A heat unit: 100,000 Btu, or 0.1 MMBtu
tonne	Metric ton or 1000 kg (approximately 1.1 US short tons)
TS	Total solids
TSS	Total suspended solids
VS	Volatile solids
UC	University of California
WWTF	Wastewater treatment facilities

Appendix A

Data Collection Instrument

FOOD INDUSTRY RESIDUE ASSESSMENT STUDY

The California Biomass Collaborative (CBC) at the University of California, Davis is conducting an assessment of food processing industry residues in California. The survey results will be used to estimate the technical potential for energy (including biofuels) and other bio-based products from these residue streams. Your company was selected at random from a list of industrial food processing companies.

The information you provide will be held confidential and reported without identifying specific respondents. Only aggregated results will be reported.

Contact Information: Ricardo Amón, California Biomass Collaborative, University of California Davis; 530-752-2636
ramon@ucdavis.edu

Would you like us to send to you a report with the data you provide and the potential energy represented by the residue streams?

Yes:

No:

1. COMPANY INFORMATION SECTION:

Company Name:

Name of respondent:

Job Title:

Address:

City: County:

Phone Number:

Email Address:

- 1a. What is produced at this facility:** (i.e., Fruits and Vegetables; Dairy; Meat Cannery; Bakery and Snacks; Flower and Rice Milling; Winery; other Beverages; other products.)?

- 1b. What is the typical annual amount of product produced at this facility** (range in tons per year, by product)?

1.c. Length of production season (days/year):

1.d. When does production season start (mm/dd)?

1.e. When does production season end (mm/dd)?

2. WASTEWATER SECTION:

2.a. How much wastewater is produced?

Annual amount (range in gallons):

2.b. Average daily amount and range in gallons per day:

2.c. Average and range of total solids (TS) concentration (mg/L or %):

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2.d. Average and range of: (please answer at least one of the following)

Volatile Solids concentration (mg/L or % or % TS):
Biological Oxygen Demand (BOD) value (mg/L or %):
Chemical Oxygen Demand (COD) value (mg/L or %):

2.e. Is there any wastewater treatment on site? If yes, please describe.

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2.f. How is the wastewater utilized and/or disposed, at what cost?

Method (Yes/No)	Cost/unit
Discharged to sanitary sewer system	
Evaporation ponds	
Used as irrigation water	
Other	

3. SOLID RESIDUE SECTION:

3.a. What types of organic solid residue are produced at this facility?

3.b. Annual amount and range of organic solid residue produced in tons or other available unit: By type:

3.c. Average daily amount and range of organic solid residue produced in tons or other available unit: By type:

3.d. Organic solid residue moisture content (%): By type:

3.e. How is the organic solid residue managed?

Is there an onsite use for the solid residue? What is it? How much of the residue is utilized onsite?

3.f. For residues not managed onsite, how are residues managed or disposed:

What percentage of the organic solid residue is utilized for value-added purposes? i.e., animal feed, compost, land application, other uses.

3.g. What is the cost to dispose of the organic solid residue (\$/ton):

3.h. Is there revenue from selling the organic solid residue (\$/ton):

FINALSECTION:

Has the company considered the use of residue streams for on-site energy production?

If yes, what did the company decide to do?

THANK YOU FOR COMPLETING THE SURVEY.

Appendix B

Bioenergy Systems at Food Processing Facilities

DRAFT

Company Name	City	County	Conversion Technology	Energy Generation	Environmental Drivers	Links
Anheuser-Busch, Inc.	Fairfield	Solano	Anaerobic digester (AD)	83,247 Therms/yr. Methane gas used as boiler heat, producing 15% of fuel needs	Wastewater pre-treatment to meet WWTF standards, Corporate Sustainability goals	http://www.ab-inbev.com/pdf/ABI_CSR10_Mech07.pdf
Anheuser-Busch, Inc.	Los Angeles	Los Angeles	AD	1.4 million Therms/yr. Methane gas used as boiler heat	Wastewater pre-treatment to meet WWTF standards, Corporate Sustainability goals	http://www.ab-inbev.com/pdf/ABI_CSR10_Mech07.pdf
Miller Brewing	Irwindale	Los Angeles	AD	WWTF biogas feed to boilers. 1.6 million Therms/yr.	Wastewater pre-treatment to meet WWTF standards. Company sustainability goals	http://www.greatbeergreatresponsibility.com/Gbgr/sdr2010/index.html , Go to page 15
Sierra Nevada Brewing	Chico	Butte	AD + Fuel Cells	Four 300 kW Fuel Cell Energy units using natural gas. Experimenting with biogas to hydrogen fuel cell system to produce electricity.	Wastewater pre-treatment to meet WWTF standards. Company sustainability goals	http://www.sierranevada.com/environment/solar.html
Anderson Valley Brewing	Boonville	Mendocino	AD followed by 3 consecutive aerobic treatment lagoons	Waste stream is used to generate a small amount of methane which is used to heat water.	Company sustainability goals	-

Company Name	City	County	Conversion Technology	Energy Generation	Environmental Drivers	Links
Gills Onions	Oxnard	Ventura	High-rate upflow anaerobic sludge blanket reactor (UASB) supplied by Biothane from Camden, N.J.	600kW fuel cell. Solid residue disposal costs, land application soil and water quality permit compliance.	Company sustainability goals	http://www.gillsonions.com/waste-to-energy
Valley Fig Growers	Fresno	Fresno	AD, 1,800,000 gallon digester. Effectively reduced BOD by 90 % and SS by 60%.	Methane produced was once used to fuel 70 kW micro turbine generator that failed. Replaced turbine due to failures with a 100 hp boiler.	Reduce high BOD load to comply with fresno WWTF costs and standards	
Sun Maid Growers	Kingsburg	Fresno	AD using raisin waste	Biogas to feed 60% of 300 hp boiler energy demand	Solid waste disposal limitations	
Musco Olives	Tracy,	San Joaquin	Thermal conversion of olive pits.	Producing Syn gas to feed boiler. steam engine wastewater salinity evaporation system	Wastewater salt load compliance with Water Board land discharge permit	http://www.cstgreen.com/video3.html
Hillmar Cheese	Hillmar	Merced	AD wastewater treatment facility	Biogas to feed boilers.		-
National Beef	Brawley	Imperial	AD	1 million therms biogas to feed boilers	Capture previously flared biogas from AD lagoon.	

Company Name	City	County	Conversion Technology	Energy Generation	Environmental Drivers	Links
E & J Gallo Winery	Fresno	Fresno	AD wastewater treatment	46,666 Therms/year	Wastewater compliance with Water Board land discharge permit	
Dixon Ridge Farms	Dixon	Solano	Gasifier BioMax 50.	50 kW generator, using walnut shells	Company sustainability goals	http://www.dixonridgefarms.com/farmingandprocessing/sustainability.html