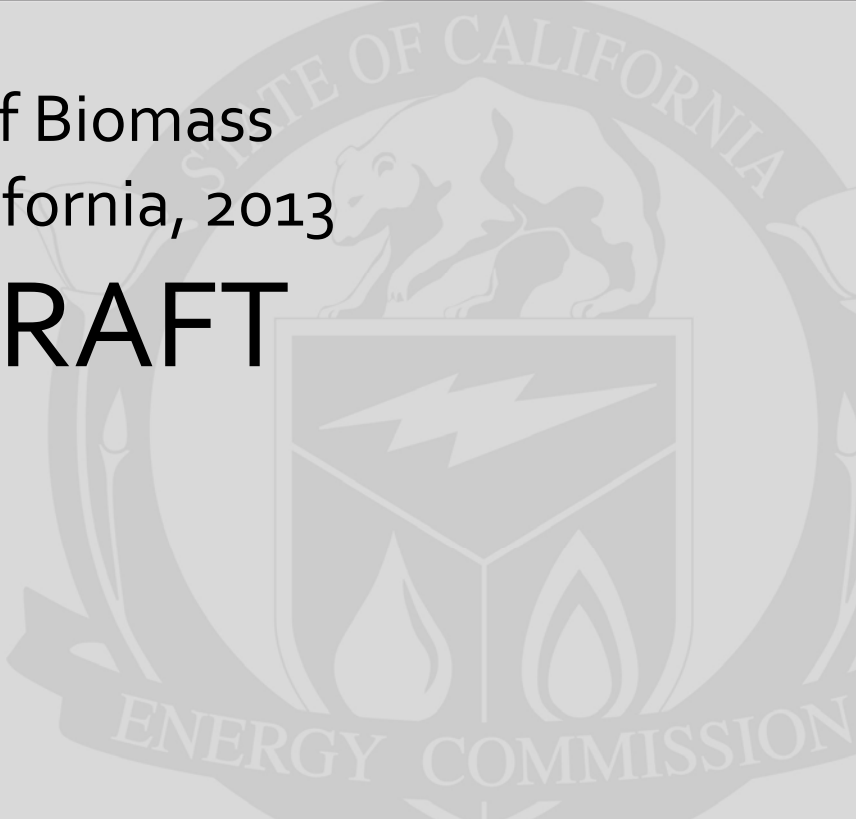


**Public Interest Energy Research (PIER) Program  
INTERIM PROJECT REPORT**

**An Assessment of Biomass  
Resources in California, 2013**

**DRAFT**



Prepared for: California Energy Commission  
Prepared by: California Biomass Collaborative,  
University of California, Davis



**CALIFORNIA**  
**BIOMASS COLLABORATIVE**

MARCH 2015  
CEC-500-11-020

**Prepared by:**

Primary Author(s):

Robert B. Williams  
Bryan M. Jenkins  
Steve Kaffka



California Biomass Collaborative /  
California Renewable Energy Collaborative  
University of California  
One Shields Ave.  
Davis, CA 95616

Contract Number: 500-11-020

**Prepared for:**

**California Energy Commission**

Michael Sokol  
**Contract Manager**

Linda Spiegel  
**Office Manager**  
**Energy Generation Research Office**

Laurie ten Hope  
**Deputy Director**  
**Energy Research and Development Division**

Robert P. Oglesby  
**Executive Director**

**DISCLAIMER**

This report was prepared as the result of work sponsored by the California Energy Commission. It does not necessarily represent the views of the Energy Commission, its employees or the State of California. The Energy Commission, the State of California, its employees, contractors and subcontractors make no warrant, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the uses of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by the California Energy Commission nor has the California Energy Commission passed upon the accuracy or adequacy of the information in this report.

## Preface

The California Energy Commission's 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.

- PIER funding efforts are focused on the following RD&D program areas:
- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

*An Assessment of Biomass Resources in California, 2013 – DRAFT* is the interim report for the California Renewable Energy Collaboratives project (contract number 500-11-020) conducted by the California Biomass Collaborative, University of California. The information from this project contributes to PIER's [insert RD&D program area from bulleted list above] Program.

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

# ABSTRACT

---

## **Biomass Resources in California 2013 Data-Year Assessment**

### **Abstract**

The California biomass assessment has been updated using 2013 year data, the most recent available. Gross and technically available resources are quantified and compiled into statewide and county level inventories. Resource estimates were derived for agricultural (2013 USDA / NASS data) and forestry biomass (2004 CDFFP data), and municipal wastes (primarily 2013 disposal data from CalRecycle). Biomass in the state totals 78 million gross bone dry tons per year (BDT/y). Biomass considered to be available on a technically sustainable basis is estimated to be 35 million BDT/y. Of the gross resource, 25 million tons are from agriculture, 27 million from forest resources, and 26 million tons from municipal wastes, exclusive of waste in place in landfills and biomass in sewage. The current technical potential includes more than 12 million BDT/y in agriculture, 14 million BDT/y in forestry, and 9 million BDT/y in municipal wastes. Dedicated crops are being grown mostly on an experimental basis at present and are not included in the total. Gross electrical generation potential from biomass is currently near 9,900 MWe with more than 2,300 MWe from agriculture, 3,500 MWe from forestry, and 3,900 MWe from municipal wastes including landfill and sewage digester gas. The technical resource generating potential is some 4,600 MWe. Biogas potential from animal manures, landfill gas, anaerobic digestion of food, leaves and grass from the current MSW disposal stream, and from waste water treatment plants is estimated to be about 93 billion cubic feet of methane per year.

**Keywords:** biomass, resource, agriculture, forest, forestry, municipal solid waste, urban, residue, energy, biogas, landfill

Please use the following citation for this report:

Williams, R. B., B. M. Jenkins and S. Kaffka (California Biomass Collaborative). 2015. *An Assessment of Biomass Resources in California, 2013 – DRAFT*. Contractor Report to the California Energy Commission. PIER Contract 500-11-020.

## Table of Contents

Preface.....	iii
Abstract.....	iv
Table of Figures.....	vi
List of Tables.....	vii
Executive Summary.....	viii
1. Introduction.....	1
2. Resource Estimates.....	4
2.1. Agriculture.....	4
2.1.2. Field and Seed Crops.....	9
2.1.3. Vegetable Crops.....	12
2.1.4. Food and Fiber Processing Residues.....	14
2.1.5. Animal Manures.....	17
2.2. Forestry.....	23
2.3. Municipal wastes.....	26
2.3.1. Municipal Solid Wastes.....	26
2.3.2. Biosolids.....	28
2.4. Dedicated Biomass Energy Crops.....	31
2.5. Biomass Resource Summaries.....	31
3. Power and Energy Generation Potentials.....	34
3.1. Energy and Power Capacities.....	34
3.2. Generation Potentials.....	35
3.2.1. Thermal and Biological Conversion Classifications.....	35
3.2.2. Heating Values.....	35
3.2.3. Conversion Efficiency Assumptions and Biogas Production Estimates.....	40
3.2.4. Biogas Technical Potential.....	46
3.3. Power Generation Estimates.....	46
3.3.1. Capacity factors.....	47
4. Summary and Conclusion.....	52
4.1. Comparison to 2008 and 2012 Resource updates.....	53
4.1.1. Other changes in assumptions or methods.....	55
4.2. Data Limitations.....	55
APPENDIX- Comparison of earlier California biomass resource assessments.....	57

## Table of Figures

Figure. ES. 1. Gross and Technical Resource by Category .....	x
Figure 2.3.1. Per-capita and total solid waste disposal in California (1989-2013).....	27
Figure 3.2.3.1. Electricity generation potential from conventional landfill gas in California. ....	42
Figure. 4. 1. Gross and Technical Resource by Category.....	53
Figure. 4. 2. Comparison of Technical Resource, 2013, 2012 vs 2008 Update .....	54

## List of Tables

Table ES.1. Resources and generation potentials from biomass in California, 2013 .....	ix
Table ES.2. Biogas Technical Potential from California Resources .....	x
Table 2.1.1 Acres cultivated in orchard and vineyard, field and seed, and vegetable crops .....	5
Table 2.1.1.1. Residue yield factors for orchard and vineyard crops .....	6
Table 2.1.1.2. Gross orchard and vineyard biomass (BDT/yr), 2013 .....	7
Table 2.1.1.3. Technical orchard and vineyard potential (BDT/yr), 2013 .....	8
Table 2.1.2.1. Residue yield and availability factors for field and seed crops .....	9
Table 2.1.2.2. Gross field and seed crop biomass (BDT/yr), 2013 .....	10
Table 2.1.2.3. Technical field and seed crop biomass (BDT/yr), 2013 .....	11
Table 2.1.3.1. Residue yield and availability factors for vegetable crops .....	12
Table 2.1.3.2. Gross vegetable crop biomass (BDT/yr), 2013 .....	13
Table 2.1.4.1. Computed yield of certain food/fiber processing residues .....	14
Table 2.1.4.2. Gross food and fiber processing residue (BDT/yr), 2013 .....	15
Table 2.1.5.1. Animal populations in California and manure production data .....	17
Table 2.1.5.2. Cattle Populations in California by county, 2013 .....	19
Table 2.1.5.3. Technical availability factors for manure by animal type .....	20
Table 2.1.5.4. Gross animal manures (BDT/yr), 2013 .....	21
Table 2.1.5.5. Technical animal manures (BDT/yr), 2013 .....	22
Table 2.2.1. Gross forest biomass (BDT/yr) .....	24
Table 2.2.2. Technical forest biomass (BDT/yr) .....	25
Table 2.3.1. MSW composition, properties and amount landfilled in 2013 .....	28
Table 2.3.2. Gross biosolids and biomass in MSW (BDT/yr), 2013 .....	29
Table 2.3.3. Technical biosolids and biomass in MSW (BDT/yr), 2013 .....	30
Table 2.5.1. Summary gross biomass resource potential (BDT/yr), 2013 .....	32
Table 2.5.2. Summary technical biomass resource potential (BDT/yr), 2013 .....	33
Table 3.2.1.1. Conversion classifications for gross and technical power potentials. ....	36
Table 3.2.2.1. Higher heating values of orchard and vineyard residues .....	37
Table 3.2.2.2. Higher heating values of field and seed crop residues .....	37
Table 3.2.2.3. Higher heating values of vegetable crop residue .....	38
Table 3.2.2.4. Higher heating values of food processing residue .....	38
Table 3.2.2.5. Higher heating values of animal manures .....	39
Table 3.2.2.6. Higher heating values of forest and dedicated crop biomass .....	39
Table 3.2.2.7. Higher heating values of municipal waste biomass .....	39
Table 3.2.3.1. Biodegradability and overall conversion efficiencies for animal manures .....	41
Table 3.2.3.2. Waste-in-place and landfill gas production and energy potentials .....	44
Table 3.2.3.3. Wastewater Treatment Biogas and Energy Potential .....	45
Table 3.2.4.1. Biogas Technical Potential from California Resources .....	46
Table 3.3.1. Summary gross power generation potentials (MWe) by principal resource category, 2013 .....	48
Table 3.3.2. Summary technical power generation potentials (MWe) by principal resource category, 2013 .....	49
Table 3.3.3. Summary gross energy generation potentials (MWh) by principal resource category, 2013 .....	50
Table 3.3.4. Summary technical energy generation potentials (MWh) by principal resource category, 2013 .....	51
Table 4.1. Summarized gross and technical biomass resources in California, 2013 .....	52
Table 4.2. Biomass Resource by category (million BDT/y) for 2008, 2012 and 2013 updates .....	53
Table 4.3. Electricity generation potential by category for 2008, 2012, and 2013 updates (MW) .....	55

# Executive Summary

---

## Introduction

California has a large and diverse biomass residue-based resource. The full extent to which this resource can be managed for the production of energy and products remains somewhat speculative, however, partly due to uncertainties concerning the gross magnitude of the resource, the quantity that can be used on a sustainable basis, and the costs of producing, acquiring, and converting the large number of diverse biomass feedstocks available. The principal sources of biomass in California are residues from forestry/forest products, agriculture and urban sources (i.e. municipal wastes). All three of these sources provide biomass as residues of other operations and activities. In addition to the primary commodities already produced, agriculture and forestry can also expand or shift into production of biomass commodities for new energy and biobased product development.

Not all of the biomass produced in the state can or should be used for industrial purposes. For example, not all agricultural crop or forest management residue should be harvested where it is needed to maintain soil fertility and tilth or for erosion control. Similarly, terrain limitations, environmental and ecosystem requirements, collection inefficiencies, and a number of other technical and social constraints limit the amount of biomass that can actually be used. For these reasons, amounts that can technically be supplied to utilization activities are substantially less than gross production. Additional economic constraints further limit development.<sup>1</sup> The latter are site specific and require detailed analyses for any proposed project.

This report includes an updated biomass inventory for the state, and sets out gross and technical potentials that can be used as a basis or starting point for more comprehensive and site specific economic analyses.

## Resources and Assumptions

Resources considered for this analysis include biomass from agriculture, forestry, and municipal or urban sources. Dedicated biomass crops (or energy crops) are not assessed. Estimated current gross quantities in bone dry tons per year (BDT/y)<sup>2</sup> were derived from recent crop production, waste disposal, and other data. Estimates for forest based resource in this report is still based on California Department of Forest and Fire Protection (CDFFP) data from 2005.<sup>3</sup> For reporting purposes, all results are aggregated at the state and county levels.

Because of agronomic and ecological requirements, terrain limitations, inefficiencies in biomass collection and handling, and other constraints, not all of the gross biomass resource identified is

---

<sup>1</sup> Gross and technical biomass potentials were estimated without considering costs or market economics.

<sup>2</sup> nominally zero moisture content. 1 BDT = 2,000 lbs = 0.907 metric tons or 0.907 Mg (Megagram = 1,000 kg).

<sup>3</sup> Rosenberg, M., J. Spero, and D. Cromwell, (2005). *Biomass potentials from California forest and shrublands including fuel reduction potentials to lessen wildfire threat; Draft PIER Consultant Report, Contract 500-04-004.* California Department of Forestry and Fire Protection



available for utilization. Estimates are therefore provided of the technical resource potential based on these physical system constraints.

Gross and technical power generation potentials were computed from the resource estimates and assumptions regarding conversion technology, efficiency, capacity factor, and individual material properties such as heating value and biodegradability. Low moisture materials such as wood and some field crop residues were assumed to be converted using thermal technologies, while high moisture materials such as dairy cattle manures, green waste, and food waste were assumed to be converted through anaerobic digestion.

Net efficiency for thermal conversion systems is assumed to be 20% (based on dry matter higher heating value). Net biological conversion efficiencies were based the biodegradability of the biomass in anaerobic digestion or decomposition and the efficiency of the gas conversion to electricity was assumed to be 30%. A capacity factor of 0.85 was applied to all systems. Overall efficiencies in combined heat and power (CHP) operations were not incorporated into this analysis but economic factors, and perhaps policy, will influence such technology selection in the future.

## Results

Total or gross estimated biomass is 78 million bone dry tons (BDT) per year. Technical (recoverable) resource is estimated at 35 million BDT/y (Table ES.1 & Figure ES.1).

Roughly 45% of the gross biomass resource is considered to be technically available for conversion or other uses. The remainder occur in sensitive habitat areas, on steep slopes not suitable for harvesting, are needed to maintain soil tilth and fertility, or unrecoverable by harvesting and recovery equipment.

**Table ES.1. Resources and generation potentials from biomass in California, 2013**

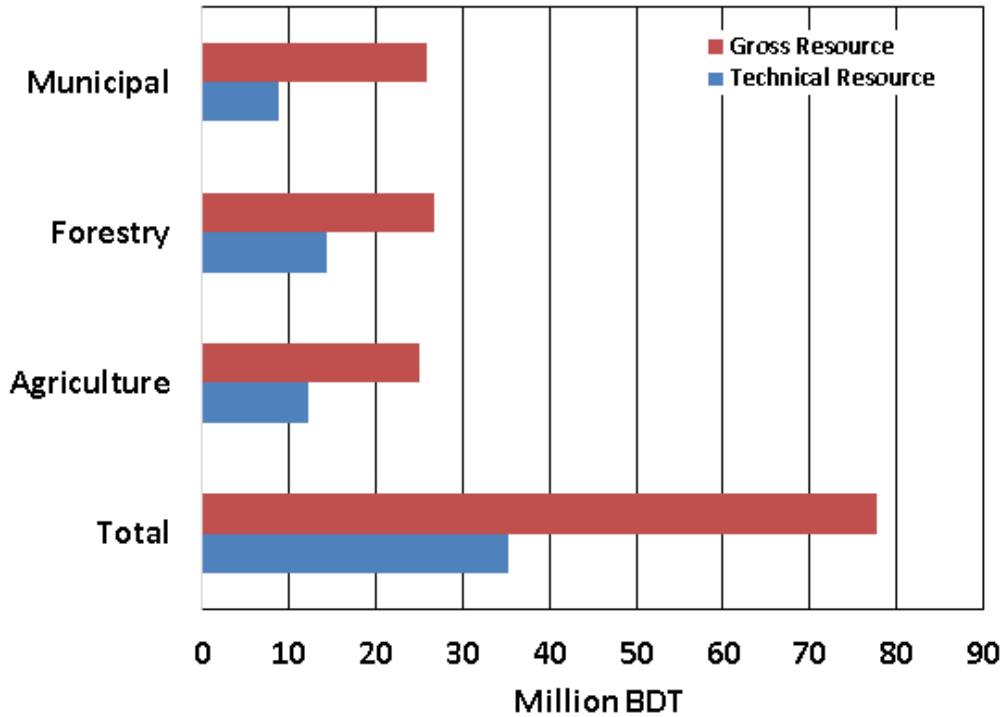
Category	Units	Agriculture	Forestry	Municipal Wastes	Total
Gross Resource	Million BDT/y	25	27	26	<b>78</b>
Technical Resource	Million BDT/y	12.1	14.3	9.0	<b>35</b>
Gross Electrical Capacity	MWe	2360	3580	3957	<b>9,897</b>
Technical Electrical Capacity	MWe	990	1910	1749	<b>4,650</b>
Gross Electrical Energy	TWh	15	27	29	<b>71</b>
Technical Electrical Energy	TWh	7.4	14.2	13	<b>35</b>

The 35 million BDT/y technical biomass resource, coupled with biogas generation from organic wastes already in place in landfills and biogas from existing anaerobic digestion facilities represents more than 4,650 MW and 35 TWh of electrical capacity.

The available resource is roughly equally divided among the primary contributing sectors of agriculture, forestry, and municipal wastes (Table 4.1). This technical resource includes material currently used in existing bioenergy,<sup>4</sup> feed, mulch, compost, bedding and other markets.

<sup>4</sup> Which is roughly 1 GW capacity including solid-fuel biomass, landfill gas-to-energy, and digester gas-to-energy.

Availability for energy purposes depends on economic factors such as recovery and transportation costs, conversion technology and permitting/regulatory costs and competition with other end use markets.



**Figure. ES. 1. Gross and Technical Resource by Category**

Statewide biogas production potential (technical potential) for animal manures, landfill gas based on current waste in place, anaerobic digestion of food, leaves and grass fraction of the current MSW disposal stream and from waste water treatment plants that utilize anaerobic digestion for sludge management is estimated to be about 93 billion cubic feet of methane per year (Table 3.2.4.1).

**Table ES.2. Biogas Technical Potential from California Resources**

Feedstock	Amount Technically Available	Biomethane Potential (billion cubic feet)
Animal Manure	3.4 MM BDT	19.7
Landfill Gas	106 BCF	53
Municipal Solid Waste (food, leaves, grass fraction)	1.2 MM BDT	12.6
Waste Water Treatment Plants	11.8 BCF (gas)	7.7
Total		93

# 1. Introduction

California's agricultural and forestry industries and its large population give the state a large and diverse biomass resource base. The full extent to which this resource can be managed for the production of energy and products remains somewhat speculative, however, partly due to uncertainties concerning the gross magnitude of the resource, the quantity that can be used on a sustainable basis, and the costs of producing, acquiring, and converting the large number of biomass feedstocks available.

The principal forms of biomass produced currently are agricultural and forest residues, wood from forest management and stand improvement operations, and municipal wastes and residues. These materials constitute potential raw material feedstocks for the increased generation of electricity and production of renewable fuels, chemicals, structural composites, and other products. Only small amounts of what can be considered dedicated biomass crops are now in production, but may represent a potential future growth area for agriculture and forestry.

Agricultural biomass includes orchard and vineyard prunings and whole trees and vines removed from production, field and seed crop residues such as cereal grain straws and stovers, vegetable crop residues, animal manures, and residues from food and fiber processing operations. Forestry produces biomass as logging slash and mill residue from timber harvesting and processing, and from forest thinning and understory clearing operations used for stand management and fire hazard reduction. Additional biomass will be generated as forest fuel reduction operations are expanded in order to reduce the considerable wildland fire potential that currently exists. Large amounts of biomass are produced as a component of municipal solid waste (MSW) and additional biomass resides in sewage and other waste waters and in biosolids from waste water treatment.

Concentrations of biomass resources vary throughout the state due to population distribution, climate, land use and geography. Forest resources are largely concentrated in the northern part of the state throughout the Sierra Nevada, Cascade, and Coast mountain ranges but also extend through the southern timber and chaparral ranges. Agricultural biomass is principally located in the Central Valley with more localized concentrations in the Imperial, Coachella, and coastal valleys (Salinas, Santa Maria and Oxnard/Ventura regions) and the Chino basin. Municipal solid waste is concentrated in the urban areas of the state, hence large resources exist in the Los Angeles, Inland Empire, San Diego, San Francisco Bay Area, and Sacramento and Fresno regions. Energy crops will most likely be affiliated with areas currently in agriculture or on nearby marginal lands.

The resources considered include the following:

- Agricultural residue biomass
  - Orchard and vineyard crops
  - Field and seed crops
  - Vegetable crops
  - Food processing residues

- Animal manures
- Forest residues and thinnings
  - Forest thinnings and slash
  - Shrubland treatment biomass (chaparral)
  - Mill residues
- Municipal wastes
  - Biomass fraction of municipal solid waste (MSW)
    - Paper and cardboard
    - Food wastes
    - Green wastes including leaves, grass, prunings, stumps
    - Other organics
  - Biosolids from waste water treatment operations
  - Landfill gas
  - Sewage digester gas

Current quantities in BDT/y are estimated for agricultural, forestry, and municipal solid wastes listed by type for each of the 58 counties in the state. The methodology used to determine these quantities is described below. The report is an update of the 2008 and 2012 editions of the California biomass resource.<sup>5,6</sup> Information and data were gathered from state and federal sources including the California Department of Forestry and Fire Protection (CDFFP), CalRecycle, the California Department of Food and Agriculture (CDFA), the National Agricultural Statistics Service within the USDA (NASS), US EPA and other sources.

Not all of the resource identified can be considered to be available for utilization. Reductions occur due to losses and inefficiencies in collection, processing, transportation, storage, and other handling operations. Agronomic and ecological requirements, terrain limitations, and political and regulatory constraints also impose technical limits on the amount of resource that can be made available for utilization. Technical resource availability is therefore estimated along with gross quantities.

Gross and technical power generation potentials are computed from the resource estimates. Conversion efficiency assumptions depend on the conversion technology considered for each biomass type, and net efficiencies are employed to represent the actual power available exclusive of parasitic demands. Lower moisture materials are assumed to be converted using thermal technologies, while higher moisture materials are assumed to be converted by biological means using anaerobic digestion.

Generating capacity is estimated from annual resource availability, fuel heating value, net conversion efficiency, and facility capacity factor or plant availability. For landfill gas, annual gas production is based on waste in place with assumptions regarding the biodegradability, gas generation rate, and gas composition. Power generation from digester gas is similarly estimated based on the quantity of waste water treated.

---

<sup>5</sup> Williams, R. B., M. Gildart and B. M. Jenkins (2008). An Assessment of Biomass Resources in California, 2007. CEC PIER Contract 500-01-016, California Biomass Collaborative.

<sup>6</sup> Williams, R. B., B. M. Jenkins and S. R. Kaffka (2014). An Assessment of Biomass Resources in California, 2012. CEC PIER Contract 500-11-020, California Biomass Collaborative.

Although this updated assessment deals primarily with the potential power generation from biomass, the inventory data are general and can be used for other assessments of fuels, chemicals, and other bioproducts that come from biomass. Markets for energy and products from biomass will likely continue to develop together. Power generation estimates presented here show potential contributions, recognizing that other markets may compete for the same resource. In many cases the combined development of power and bioproducts, such as through biorefinery concepts, could serve to enhance the overall efficiency of resource utilization and possibly the economic sustainability of the industry.

## 2. Resource Estimates

### 2.1. Agriculture

Principal sources of biomass from agriculture in California are residues of crop and livestock production. These include orchard and vineyard prunings and tree and vine removals; straws and stovers from field and seed crops; leaf, vine, and other plant residuals from vegetable crops; food and fiber processing residues including nut shells, pits, hulls, cotton gin trash, paunch contents, offal, and other residuals from meat processing; and animal manures. Dedicated biomass crop production may provide new agricultural opportunities as renewable energy and bioproduct markets develop.

Biomass from crop residues is estimated from acres planted by crop type and residue yield factors. Gross quantities,  $q_i$ , expressed as bone-dry tons per year (BDT/y), of residual biomass from agricultural operations were estimated from crop-specific acreage data and biomass yield factors according to:

$$q_i = A_i y_i \quad [1]$$

where  $A_i$  = production area for biomass type  $i$  (acres/y)  
 $y_i$  = yield factor for biomass type  $i$  (BDT/acre, dry basis)

Technical resource availability was determined from the gross quantity by modifying equation [1] with a technical availability factor,  $a_i$ :

$$q_{ti} = a_i q_i \quad [2]$$

$a_i$  = technical availability factor for biomass type  $i$  (--)

Acreage data were obtained from the National Agricultural Statistical Service (NASS) databases maintained by USDA for year 2013. Yield data are from the UC Cooperative Extension compilation of Knutson and Miller (1982),<sup>7</sup> converted to dry basis using the reported residue moisture contents. Many of the yield factors date to field studies conducted in the period 1950-1970. Although current residue yields may not be substantially different, there has been no recent attempt to update the values.

There were about 9.4 million acres cultivated in orchard and vineyard, field and seed, and vegetable crops in 2013 (Table 2.1.1.).

---

<sup>7</sup>Knutson, J. and G. E. Miller. 1982. Agricultural residues (biomass) in California...factors affecting utilization. UCCE leaflet 21303, University of California Cooperative Extension, Berkeley, California.

**Table 2.1.1 Acres cultivated in orchard and vineyard, field and seed, and vegetable crops**

<b>County (Acres)</b>	<b>Orchard</b>	<b>Field</b>	<b>Vegetable</b>	<b>Total County</b>
Alameda	3,100	5,700	100	9,000
Alpine	0	200	0	200
Amador	4,200	1,900	0	6,100
Butte	103,500	127,100	0	230,600
Calaveras	1,800	300	0	2,100
Colusa	66,700	221,500	14,100	302,300
Contra Costa	3,200	23,600	2,800	29,600
Del Norte	0	2,600	0	2,600
El Dorado	3,500	200	0	3,700
Fresno	492,100	229,400	203,600	925,000
Glenn	77,500	151,400	100	229,000
Humboldt	0	10,600	0	10,600
Imperial	6,900	392,000	102,000	500,900
Inyo	0	5,000	0	5,000
Kern	390,800	335,400	29,800	756,000
Kings	74,000	400,900	48,900	523,700
Lake	13,700	2,100	0	15,800
Lassen	0	72,700	0	72,700
Los Angeles	500	8,800	100	9,300
Madera	215,700	73,400	4,600	293,800
Marin	200	2,800	900	3,900
Mariposa	100	0	0	100
Mendocino	18,600	0	300	18,900
Merced	130,700	434,800	35,900	601,300
Modoc	0	79,500	7,000	86,500
Mono	0	15,300	300	15,600
Monterey	44,700	15,200	312,200	372,100
Napa	43,900	800	0	44,700
Nevada	400	0	0	400
Orange	100	0	800	900
Placer	1,500	19,500	0	21,100
Plumas	0	10,000	0	10,000
Riverside	40,700	119,600	32,000	192,300
Sacramento	35,500	88,800	3,600	128,000
San Benito	7,400	13,800	26,100	47,300
San Bernardino	4,200	12,200	2,600	19,000
San Diego	37,300	8,200	5,200	50,700
San Francisco	0	0	0	0
San Joaquin	244,900	365,200	49,200	659,300
San Luis Obispo	47,000	17,100	33,300	97,400
San Mateo	300	1,300	1,400	3,000
Santa Barbara	33,800	10,800	76,000	120,600
Santa Clara	3,200	7,100	9,400	19,700
Santa Cruz	3,100	0	14,000	17,100
Shasta	1,300	29,000	300	30,500
Sierra	0	3,600	0	3,600
Siskiyou	0	90,800	10,300	101,200
Solano	18,100	97,400	21,800	137,200
Sonoma	62,700	13,100	500	76,300
Stanislaus	232,900	250,200	29,700	512,800
Sutter	58,500	168,200	8,600	235,300
Tehama	48,100	14,600	200	62,900
Trinity	100	600	0	700
Tulare	359,500	549,700	5,900	915,100
Tuolumne	300	400	0	600
Ventura	41,700	4,500	53,800	100,000
Yolo	51,700	314,700	41,900	408,300
Yuba	25,400	41,400	0	66,800
Sum of Other	39,300	119,700	69,200	228,200
<b>STATE TOTALS</b>	<b>3,095,000</b>	<b>4,985,000</b>	<b>1,258,000</b>	<b>9,337,000</b>

### 2.1.1. Orchard and Vineyard Residues

About three million acres were in orchard and vineyard crops in 2013, with highest concentration in the San Joaquin Valley. Gross residue yield factors for orchard and vineyard crops are listed in Table 2.1.1.1.

The technical availability factor for orchard and vineyard crop residues was assumed to be the same for all types and equal to 0.7 (70% availability). Estimated gross and technical biomass quantities for each crop type by county are listed in Tables 2.1.1.2 and 2.1.1.3, respectively.

**Table 2.1.1.1. Residue yield factors for orchard and vineyard crops.**

Biomass Type	Wet Basis Conversion Factor (tons/acre-y)	Moisture Content (% wet basis)	Dry Basis Conversion Factor (tons/acre-y)
Apples	2.2	35	1.43
Apricots	2.0	35	1.30
Avocados	1.5	35	0.98
Cherries	0.4	35	0.26
Dates	0.6	25	0.45
Figs	2.2	35	1.43
Grapes	2.0	35	1.30
Kiwifruit	2.0	35	1.30
Nectarines	1.6	35	1.04
Olives	1.5	35	0.98
Peaches	2.0	35	1.30
Pears	2.3	35	1.50
Persimmons	1.6	35	1.04
Plums & Prunes	1.5	35	0.98
Pomegranates	1.6	35	1.04
All Citrus	1.0	35	0.65
Almonds	1.3	35	0.85
Pecans	1.6	35	1.04
Pistachios	1.0	35	0.65
Walnuts	1.0	35	0.65
Fruits & Nuts, unspecified	1.6	35	1.05



**Table 2.1.1.2. Gross orchard and vineyard biomass (BDT/yr), 2013**

County Name	Total Orchard & Vine BDT	Apples	Apricots	Avocados	Cherries	Dates	Figs	Grapes	Kiwifruit	Nectarines	Olives	Peaches	Pears	Persimmons	Plums & Prunes	Pomegranates	All Citrus	Almonds	Pecans	Pistachios	Walnuts	Fruit & Nut Unspecified
Alameda	4,000	-	-	-	-	-	-	3,600	-	-	-	-	-	-	-	-	-	-	-	-	-	400
Alpine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amador	5,500	-	-	-	-	-	-	5,300	-	-	-	-	-	-	-	-	-	-	-	-	100	100
Butte	83,100	-	-	-	-	-	790	-	2,490	2,720	-	-	-	-	8,600	-	110	31,690	-	440	28,210	8,050
Calaveras	1,810	-	-	-	-	-	-	1,180	-	130	-	-	-	-	-	-	-	-	-	-	500	-
Colusa	55,300	-	-	-	-	-	-	3,200	-	-	-	-	-	-	820	-	-	39,120	-	-	9,490	2,670
Contra Costa	3,290	-	120	-	130	-	-	2,250	-	30	170	180	-	-	30	-	-	-	-	-	260	120
Del Norte	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
El Dorado	4,470	1,220	-	-	10	-	-	2,760	-	-	60	140	160	-	50	-	-	-	-	-	70	-
Fresno	496,680	900	1,380	-	1,060	-	-	246,760	670	11,860	-	19,490	1,900	1,010	12,430	5,550	25,870	137,080	-	24,640	6,080	-
Glenn	63,290	-	-	-	-	-	-	1,380	-	-	8,660	-	-	-	5,620	-	200	32,360	-	960	14,110	-
Humboldt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Imperial	4,060	-	-	-	-	890	-	-	-	-	-	-	-	-	-	-	3,170	-	-	-	-	-
Inyo	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50
Kern	349,660	-	-	-	1,440	-	-	136,500	-	440	-	1,440	-	-	-	-	35,760	124,220	-	49,400	460	-
Kings	62,730	-	1,210	-	370	-	-	9,590	-	2,040	-	4,260	-	-	2,170	-	-	14,700	-	11,900	9,140	7,350
Lake	16,030	-	-	-	-	-	-	10,730	-	-	-	-	3,120	-	-	-	-	-	-	-	2,150	30
Lassen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Los Angeles	650	-	-	-	-	-	-	650	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Madera	213,100	-	-	-	160	-	6,720	98,280	-	-	600	950	-	-	1,010	-	1,820	83,660	-	18,980	920	-
Marin	230	-	-	-	-	-	-	230	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mariposa	140	-	-	-	-	-	-	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mendocino	24,420	320	-	-	-	-	-	21,840	-	-	-	-	2,000	-	-	-	-	-	-	-	-	260
Merced	117,160	-	490	-	-	-	900	16,710	-	-	-	5,070	-	-	1,370	-	-	83,570	-	3,260	3,550	2,240
Modoc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mono	30	-	-	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monterey	57,130	-	-	230	-	-	-	55,900	-	-	-	-	-	-	-	-	810	-	-	-	-	190
Napa	56,950	-	-	-	-	-	-	56,680	-	-	270	-	-	-	-	-	-	-	-	-	-	-
Nevada	550	-	-	-	-	-	-	550	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orange	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	-	-	-	-	-
Placer	1,260	60	-	-	-	-	-	270	-	-	-	110	20	-	90	-	130	-	-	-	580	-
Plumas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Riverside	34,160	40	20	6,300	10	3,420	-	13,650	-	-	-	190	-	-	-	20	10,070	-	-	-	-	440
Sacramento	45,480	-	-	-	330	-	-	37,700	-	-	-	-	6,790	-	-	-	-	-	-	-	150	510
San Benito	7,960	440	760	-	150	-	-	5,060	-	110	-	-	-	-	-	-	-	-	-	-	1,020	420
San Bernardino	3,340	410	-	200	-	-	-	560	-	-	-	-	-	-	-	-	1,780	-	-	250	-	140
San Diego	32,590	370	-	20,570	-	-	-	1,090	-	-	-	-	-	-	360	-	8,550	-	-	-	-	1,650
San Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Joaquin	230,980	4,960	850	-	5,380	-	-	125,320	-	-	3,750	2,370	380	-	-	-	-	48,000	-	-	39,130	840
San Luis Obispo	56,520	-	-	4,520	-	-	-	47,190	-	-	-	-	-	-	-	-	1,100	-	-	-	1,490	2,220
San Mateo	310	-	-	-	-	-	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	110
Santa Barbara	39,590	-	-	7,260	-	-	-	27,300	-	-	-	-	-	-	-	-	970	-	-	-	-	4,060
Santa Clara	2,990	-	270	-	260	-	-	2,070	-	-	-	-	-	-	-	-	-	-	-	-	120	270
Santa Cruz	4,210	3,050	-	-	-	-	-	850	-	-	-	-	-	-	-	-	-	-	-	-	-	310
Shasta	930	-	-	-	-	-	-	210	-	-	-	-	-	-	-	-	-	-	-	-	720	-
Sierra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Siskiyou	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
Solano	15,670	-	-	-	-	-	-	5,080	-	120	-	-	-	-	710	-	-	2,810	-	-	5,790	1,160
Sonoma	81,530	3,080	-	-	-	-	-	77,740	-	710	-	-	-	-	-	-	-	-	-	-	-	-
Stanislaus	200,460	880	6,460	-	830	-	-	16,120	-	-	-	9,610	-	-	-	-	380	135,200	-	-	24,310	6,670
Sutter	50,360	-	-	-	-	-	200	-	-	770	10,190	-	-	160	16,770	-	-	5,370	-	-	16,900	-
Tehama	38,660	-	-	-	-	-	-	140	-	9,460	-	-	-	-	6,400	-	-	8,700	-	110	13,850	-
Trinity	150	-	-	-	-	-	-	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tulare	307,810	-	1,000	-	660	-	-	80,860	3,190	11,860	11,990	17,560	300	2,530	13,500	4,390	75,540	32,190	890	26,850	23,730	770
Tuolumne	270	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	270
Ventura	33,980	-	-	19,600	-	-	-	-	-	-	-	-	-	-	-	-	13,560	-	-	-	-	820
Yolo	47,740	-	-	-	-	-	-	16,900	-	3,030	-	-	-	-	1,710	-	-	14,960	-	-	9,360	1,780
Yuba	22,120	-	-	-	-	-	-	-	440	-	-	4,800	-	-	8,480	-	-	730	-	-	7,670	-
Sum of Other	40,430	1,700	720	1,300	110	10	1,790	3,420	160	490	2,040	1,460	1,290	400	1,330	18,060	3,070	80	1,520	790	-	690
STATE TOTALS	2,920,000	17,400	13,300	60,000	10,900	4,300	9,400	1,136,100	5,500	26,700	44,400	80,500	16,000	4,500	81,100	28,000	182,900	794,400	2,400	137,600	219,900	44,600

**Table 2.1.1.3. Technical orchard and vineyard potential (BDT/yr), 2013**

County Name	Total Orchard & Vine BDT	Apples	Apricots	Avocados	Cherries	Dates	Figs	Grapes	Kiwifruit	Nectarines	Olives	Peaches	Pears	Persimmons	Plums & Prunes	Pomegranates	All Citrus	Almonds	Pecans	Pistachios	Walnuts	Fruit and Nut Unspecified	
Alameda	2,800	-	-	-	-	-	-	2,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	300
Alpine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amador	3,900	-	-	-	-	-	-	3,700	-	-	-	-	-	-	-	-	-	-	-	-	-	100	100
Butte	58,100	-	-	-	-	-	-	-	600	-	1,700	1,900	-	-	6,000	-	100	22,200	-	300	19,700	-	5,600
Calaveras	1,300	-	-	-	-	-	-	800	-	-	100	-	-	-	-	-	-	-	-	-	-	400	-
Colusa	38,700	-	-	-	-	-	-	2,200	-	-	-	-	-	-	600	-	-	27,400	-	-	-	6,600	1,900
Contra Costa	2,300	-	100	-	100	-	-	1,600	-	-	100	100	-	-	-	-	-	-	-	-	-	200	100
Del Norte	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
El Dorado	3,000	900	-	-	-	-	-	1,900	-	-	-	100	100	-	-	-	-	-	-	-	-	-	-
Fresno	347,600	600	1,000	-	700	-	-	172,700	500	8,300	-	13,600	1,300	700	8,700	3,900	18,100	96,000	-	17,200	4,300	-	-
Glenn	44,400	-	-	-	-	-	-	1,000	-	-	6,100	-	-	-	3,900	-	100	22,700	-	700	9,900	-	-
Humboldt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Imperial	2,800	-	-	-	-	600	-	-	-	-	-	-	-	-	-	-	2,200	-	-	-	-	-	-
Inyo	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40
Kern	244,760	-	-	-	1,010	-	-	95,550	-	310	-	1,010	-	-	-	-	25,030	86,950	-	34,580	320	-	-
Kings	43,920	-	850	-	260	-	-	6,710	-	1,430	-	2,980	-	-	1,520	-	-	10,290	-	8,330	6,400	5,150	-
Lake	11,220	-	-	-	-	-	-	7,510	-	-	-	-	2,180	-	-	-	-	-	-	-	1,510	-	20
Lassen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Los Angeles	460	-	-	-	-	-	-	460	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Madera	149,170	-	-	-	110	-	4,700	68,800	-	-	420	670	-	-	710	-	1,270	58,560	-	13,290	640	-	-
Marin	160	-	-	-	-	-	-	160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mariposa	100	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mendocino	17,090	220	-	-	-	-	-	15,290	-	-	-	-	1,400	-	-	-	-	-	-	-	-	-	180
Merced	82,020	-	340	-	-	-	630	11,700	-	-	-	3,550	-	-	960	-	-	58,500	-	2,280	2,490	1,570	-
Modoc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mono	20	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monterey	39,990	-	-	160	-	-	-	39,130	-	-	-	-	-	-	-	-	570	-	-	-	-	-	130
Napa	39,870	-	-	-	-	-	-	39,680	-	-	190	-	-	-	-	-	-	-	-	-	-	-	-
Nevada	390	-	-	-	-	-	-	390	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orange	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	-	-	-	-	-	-
Placer	880	40	-	-	-	-	-	190	-	-	-	80	10	-	60	-	90	-	-	-	410	-	-
Plumas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Riverside	23,910	30	10	4,410	10	2,390	-	9,560	-	-	-	130	-	-	-	10	7,050	-	-	-	-	-	310
Sacramento	31,840	-	-	-	230	-	-	26,390	-	-	-	-	4,750	-	-	-	-	-	-	-	110	-	360
San Benito	5,570	310	530	-	110	-	-	3,540	-	-	80	-	-	-	-	-	-	-	-	-	710	-	290
San Bernardino	2,350	290	-	140	-	-	-	390	-	-	-	-	-	-	-	-	1,250	-	-	180	-	-	100
San Diego	22,820	260	-	14,400	-	-	-	760	-	-	-	-	-	250	-	-	5,990	-	-	-	-	-	1,160
San Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Joaquin	161,700	3,470	600	-	3,770	-	-	87,720	3,470	-	2,630	1,660	270	-	-	-	-	33,600	-	-	27,390	-	590
San Luis Obispo	39,550	-	-	3,160	-	-	-	33,030	-	-	-	-	-	-	-	-	770	-	-	-	1,040	-	1,550
San Mateo	220	-	-	-	-	-	-	140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	80
Santa Barbara	27,710	-	-	5,080	-	-	-	19,110	-	-	-	-	-	-	-	-	680	-	-	-	-	-	2,840
Santa Clara	2,090	-	190	-	180	-	-	1,450	-	-	-	-	-	-	-	-	-	-	-	-	80	-	190
Santa Cruz	2,960	2,140	-	-	-	-	-	600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	220
Shasta	650	-	-	-	-	-	-	150	-	-	-	-	-	-	-	-	-	-	-	-	500	-	-
Sierra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Siskiyou	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
Solano	10,970	-	-	-	-	-	-	3,560	-	-	80	-	-	-	500	-	-	1,970	-	-	4,050	-	810
Sonoma	57,080	2,160	-	-	-	-	-	54,420	-	-	500	-	-	-	-	-	-	-	-	-	-	-	-
Stanislaus	140,330	620	4,520	-	580	-	-	11,280	-	-	-	6,730	-	-	-	-	270	94,640	-	-	17,020	-	4,670
Sutter	35,250	-	-	-	-	-	-	-	140	-	540	7,130	-	110	11,740	-	-	3,760	-	-	11,830	-	-
Tehama	27,070	-	-	-	-	-	-	100	-	-	6,620	-	-	-	4,480	-	-	6,090	-	80	9,700	-	-
Trinity	110	-	-	-	-	-	-	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tulare	215,450	-	700	-	460	-	-	56,600	2,230	8,300	8,390	12,290	210	1,770	9,450	3,070	52,880	22,530	620	18,800	16,610	-	540
Tuolumne	190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	190
Ventura	23,780	-	-	13,720	-	-	-	-	-	-	-	-	-	-	-	-	9,490	-	-	-	-	-	570
Yolo	33,420	-	-	-	-	-	-	11,830	-	-	2,120	-	-	-	1,200	-	-	10,470	-	-	6,550	-	1,250
Yuba	15,490	-	-	-	-	-	-	-	310	-	-	3,360	-	-	5,940	-	-	510	-	-	5,370	-	-
Sum of Other	28,280	1,190	500	910	80	10	1,250	2,390	110	340	1,430	1,020	900	280	930	12,640	2,150	60	1,060	550	-	-	480
STATE TOTALS	2,044,000	12,200	9,300	42,000	7,600	3,000	6,600	795,200	3,900	18,700	31,000	56,300	11,100	3,100	56,700	19,600	128,000	556,200	1,700	96,300	153,900	-	31,300

## 2.1.2. Field and Seed Crops

California has about five million acres in field and seed crops. Gross quantities (BDT/y) of residual biomass from field and seed crops were estimated in the same manner as for orchard and vineyard crops. Residue yield and availability factors for crops considered are listed in Table 2.1.2.1.

**Table 2.1.2.1. Residue yield and availability factors for field and seed crops**

Biomass Type	Wet Basis (tons/acre-y)	Moisture (% wet basis)	Dry Basis (tons/acre-y)	Availability (-)
Corn	4.7	14	4.04	0.5
Sorghum	2.2	14	1.92	0.5
Wheat	1.9	14	1.63	0.5
Barley	1.3	14	1.12	0.5
Oats	1.2	14	1.03	0.5
Rice	3.5	14	3.01	0.5
Safflower	0.9	14	0.73	0.5
Sunflower	0.9	14	0.73	0.5
Cotton	1.5	14	1.29	0.5
Beans	1.0	14	0.86	0.5
Lima Beans	1.0	14	0.86	0.5
Cowpeas & Southern Peas	1.0	14	0.86	0.5
Potatoes	1.2	0	1.20	0.05
Sweetpotatoes	1.2	0	1.20	0.05
Sugar Beets	2.4	14	2.06	0.05
Unspecified Field & Seed	1.0	14	0.86	0.5
Alfalfa Seed	1.0	14	0.86	0.5
Bermuda Grass Seed	1.0	14	0.86	0.5

Silage and hay crops were assumed to yield no harvestable residue biomass. For crops producing straw and stover residues, half of the gross residue production was considered to be available after accounting for harvesting and handling losses and the need to leave organic material in the field. Field studies conducted on rice straw, for example, show that typical harvest yields are about two-thirds of total straw yields.<sup>8</sup> Accounting for additional losses suggests a technical availability of about half the total residue biomass. For crops generating higher moisture leaf and vine residues, only 5% was considered to be available. In most cases such residues would be incorporated into the soil. Estimated gross and technical biomass quantities for each crop type by county are listed in Tables 2.1.2.2 and 2.1.2.3.

<sup>8</sup> Jenkins, B.M., R. Bakker-Dhaliwal, M.D. Summers, L.G. Bernheim, H. Lee, W. Huisman and L. Yan. 2000. Equipment performance, costs, and constraints in the commercial harvesting of rice straw for industrial applications. ASAE Paper No. 006035, ASAE, St. Joseph, MI 49085-9659.

**Table 2.1.2.2 Gross field and seed crop biomass (BDT/yr), 2013**

County Name	Total Field and Seed	Corn Silage	Corn	Sorghum	Wheat	Barley	Oats	Rice	Safflower	Sunflower	Cotton	Beans	Lima Beans	Peas	Potatoes	Sweet potatoes	Sugar Beets	Unspecified Fid & Sd.	Alfalfa Seed	Grass Seed	Hay (alfalfa, grain, tame, grn chp)	combined Seed	combined Rye (new)	Silage (Other)
Alameda	950	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	950	-	-	-	-	-	-
Alpine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amador	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200	-	-	-	-	-	-
Butte	333,950	-	-	-	7,960	-	-	310,900	330	-	-	810	-	-	-	-	-	12,200	-	-	-	1,750	-	-
Calaveras	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Colusa	557,690	-	30,320	-	34,000	-	-	476,000	1,210	-	-	3,940	-	-	-	-	-	-	-	-	-	12,220	-	-
Contra Costa	54,580	-	45,270	-	6,700	-	-	-	-	-	-	340	-	-	-	-	-	2,270	-	-	-	-	-	-
Del Norte	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
El Dorado	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fresno	227,020	-	45,270	-	78,760	4,090	-	-	-	-	80,760	8,030	-	-	-	-	-	-	8,940	-	-	1,170	-	-
Glenn	359,500	-	71,140	-	14,300	740	-	262,900	-	-	1,610	1,090	-	-	-	-	-	-	-	-	-	7,720	-	-
Humboldt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Imperial	237,160	-	34,640	-	89,050	-	-	-	-	-	4,420	-	-	-	3,110	-	52,430	-	25,800	26,490	-	1,220	-	-
Inyo	190	-	-	-	-	-	-	-	-	-	-	-	-	-	190	-	-	-	-	-	-	-	-	-
Kern	140,140	-	-	-	57,190	4,980	-	-	-	-	59,730	1,550	-	-	15,360	-	-	-	-	-	-	1,330	-	-
Kings	283,820	-	12,730	-	75,000	-	-	-	-	-	133,520	790	-	-	-	-	-	53,320	-	-	-	8,460	-	-
Lake	1,800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,800	-	-	-	-	-	-
Lassen	9,810	-	-	-	4,540	-	-	5,100	-	-	-	-	-	-	-	-	-	-	170	-	-	-	-	-
Los Angeles	530	-	530	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Madera	13,340	-	3,800	-	7,350	-	-	-	-	-	2,190	-	-	-	-	-	-	-	-	-	-	-	-	-
Marin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mariposa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mendocino	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Merced	209,350	-	87,310	-	34,150	2,370	-	10,200	-	-	45,920	-	910	-	-	20,760	-	1,580	-	-	-	6,150	-	-
Modoc	21,400	-	-	-	13,610	2,520	70	-	-	-	-	-	-	130	5,070	-	-	-	-	-	-	-	-	-
Mono	170	-	-	-	-	-	-	-	-	-	-	-	-	-	170	-	-	-	-	-	-	-	-	-
Monterey	14,680	-	-	-	470	7,990	-	-	-	-	-	2,440	-	1,400	-	-	-	1,720	-	-	-	660	-	-
Napa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nevada	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orange	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Placer	50,170	-	-	-	1,310	-	-	47,900	-	-	-	-	-	-	-	-	-	960	-	-	-	-	-	-
Plumas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Riverside	57,070	-	8,490	-	16,500	-	2,480	-	-	-	19,350	930	-	-	8,090	-	-	1,230	-	-	-	-	-	-
Sacramento	161,970	-	113,580	-	11,360	-	-	25,200	1,730	-	-	-	-	-	-	-	-	2,740	-	-	-	4,440	2,920	-
San Benito	780	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	160	-	-	-	620	-	-
San Bernardino	20	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Diego	3,260	-	460	-	-	-	-	-	-	-	-	130	-	-	330	-	-	2,340	-	-	-	-	-	-
San Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Joaquin	348,950	-	244,420	-	43,140	-	-	13,600	3,330	-	-	9,710	340	-	3,840	-	-	29,840	-	-	-	730	-	-
San Luis Obispo	7,820	-	-	-	-	4,080	-	-	-	-	-	-	-	240	-	-	-	3,500	-	-	-	-	-	-
San Mateo	760	-	-	-	-	-	210	-	-	-	-	380	-	170	-	-	-	-	-	-	-	-	-	-
Santa Barbara	4,210	-	-	-	-	-	-	-	-	-	-	2,950	-	-	-	-	-	680	-	-	-	580	-	-
Santa Clara	6,930	-	5,020	-	-	-	-	-	-	-	-	960	-	-	-	-	-	510	-	-	-	440	-	-
Santa Cruz	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shasta	17,200	-	-	-	-	-	-	17,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sierra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Siskiyou	51,180	-	-	-	26,940	3,860	170	-	-	-	-	-	-	-	3,480	-	-	12,340	-	-	-	-	4,390	-
Solano	95,060	-	49,720	-	30,620	-	-	-	-	-	-	1,820	-	-	-	-	-	1,260	-	-	-	8,890	-	-
Sonoma	670	-	-	-	-	-	670	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stanislaus	23,180	-	-	-	4,740	-	-	3,600	-	-	-	5,110	6,070	-	-	1,370	-	1,910	-	-	-	380	-	-
Sutter	442,920	-	49,720	-	16,310	-	-	362,900	1,120	340	-	740	-	-	-	-	-	-	-	-	-	11,790	-	-
Tehama	12,340	-	7,110	-	5,080	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	150	-	-
Trinity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tulare	146,010	-	38,290	-	36,440	7,230	-	-	-	-	24,300	7,030	-	-	-	-	-	32,160	-	-	-	560	-	-
Tuolumne	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ventura	4,230	-	1,440	-	-	-	-	-	-	-	-	50	2,740	-	-	-	-	-	-	-	-	-	-	-
Yolo	390,670	-	78,410	-	54,410	-	-	115,600	5,710	-	-	-	-	-	-	-	-	105,780	-	-	-	30,760	-	-
Yuba	118,000	-	-	-	-	-	-	118,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other- not located	90,450	-	29,640	10,260	7,830	2,010	220	13,300	1,360	-	2,730	5,580	610	60	870	870	-	7,820	650	-	-	6,310	330	-
STATE TOTALS	4,500,000	-	957,330	10,260	677,760	39,870	3,820	1,782,400	17,540	340	374,530	54,380	10,670	2,000	40,510	23,000	52,430	277,270	35,560	26,490	-	106,330	7,640	-

**Table 2.1.2.3 Technical field and seed crop biomass (BDT/yr), 2013**

County Name	Total Field and Seed	Com Silage	Corn	Sorghum	Wheat	Barley	Oats	Rice	Safflower	Sunflower	Cotton	Beans	Lima Beans	Peas	Potatoes	Sweet potatoes	Sugar Beets	Unspecified Fld & Sd.	Alfalfa Seed	Grass Seed	Hay (alfalfa, grain, tame, gm chp)	combined Seed	combined Rye (new)	Silage (Other)
Alameda	480	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	480	-	-	-	-	-	-
Alpine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amador	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-
Butte	165,830	-	-	-	3,980	-	-	155,450	170	-	-	40	-	-	-	-	-	6,100	-	-	-	90	-	-
Calaveras	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Colusa	271,580	-	15,160	-	17,000	-	-	238,000	610	-	-	200	-	-	-	-	-	-	-	-	-	610	-	-
Contra Costa	27,150	-	22,640	-	3,350	-	-	-	-	-	-	20	-	-	-	-	-	1,140	-	-	-	-	-	-
Del Norte	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
El Dorado	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fresno	109,380	-	22,640	-	39,380	2,050	-	-	-	-	40,380	400	-	-	-	-	-	-	4,470	-	-	60	-	-
Glenn	175,790	-	35,570	-	7,150	370	-	131,450	-	-	810	50	-	-	-	-	-	-	-	-	-	390	-	-
Humboldt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Imperial	93,050	-	17,320	-	44,530	-	-	-	-	-	2,210	-	-	-	160	-	2,620	-	12,900	13,250	-	60	-	-
Inyo	10	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-
Kern	61,880	-	-	-	28,600	2,490	-	-	-	-	29,870	80	-	-	770	-	-	-	-	-	-	70	-	-
Kings	137,750	-	6,370	-	37,500	-	-	-	-	-	66,760	40	-	-	-	-	-	26,660	-	-	-	420	-	-
Lake	900	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	900	-	-	-	-	-	-
Lassen	4,910	-	-	-	2,270	-	-	2,550	-	-	-	-	-	-	-	-	-	-	90	-	-	-	-	-
Los Angeles	270	-	270	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Madera	6,680	-	1,900	-	3,680	-	-	-	-	-	1,100	-	-	-	-	-	-	-	-	-	-	-	-	-
Marin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mariposa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mendocino	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Merced	92,180	-	43,660	-	17,080	1,190	-	5,100	-	-	22,960	-	50	-	-	1,040	-	790	-	-	-	310	-	-
Modoc	8,370	-	-	-	6,810	1,260	40	-	-	-	-	-	-	10	250	-	-	-	-	-	-	-	-	-
Mono	10	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-
Monterey	5,320	-	-	-	240	4,000	-	-	-	-	-	120	-	70	-	-	-	860	-	-	-	30	-	-
Napa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nevada	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orange	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Placer	25,090	-	-	-	660	-	-	23,950	-	-	-	-	-	-	-	-	-	480	-	-	-	-	-	-
Plumas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Riverside	24,490	-	4,250	-	8,250	-	1,240	-	-	-	9,680	50	-	-	400	-	-	620	-	-	-	-	-	-
Sacramento	77,680	-	56,790	-	5,680	-	-	12,600	870	-	-	-	-	-	-	-	-	1,370	-	-	-	220	150	-
San Benito	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	80	-	-	-	30	-	-
San Bernardino	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Diego	1,430	-	230	-	-	-	-	-	-	-	-	10	-	-	20	-	-	1,170	-	-	-	-	-	-
San Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Joaquin	167,910	-	122,210	-	21,570	-	-	6,800	1,670	-	-	490	20	-	190	-	-	14,920	-	-	-	40	-	-
San Luis Obispo	3,800	-	-	-	-	2,040	-	-	-	-	-	-	-	10	-	-	-	1,750	-	-	-	-	-	-
San Mateo	140	-	-	-	-	-	110	-	-	-	-	20	-	10	-	-	-	-	-	-	-	-	-	-
Santa Barbara	520	-	-	-	-	-	-	-	-	-	-	150	-	-	-	-	-	340	-	-	-	30	-	-
Santa Clara	2,840	-	2,510	-	-	-	-	-	-	-	-	50	-	-	-	-	-	260	-	-	-	20	-	-
Santa Cruz	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shasta	8,600	-	-	-	-	-	-	8,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sierra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Siskiyou	22,050	-	-	-	13,470	1,930	90	-	-	-	-	-	-	-	170	-	-	6,170	-	-	-	-	220	-
Solano	42,710	-	24,860	-	15,310	-	-	-	1,380	-	-	90	-	-	-	-	-	630	-	-	-	440	-	-
Sonoma	340	-	-	-	-	-	340	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stanislaus	5,780	-	-	-	2,370	-	-	1,800	-	-	-	260	300	-	-	70	-	960	-	-	-	20	-	-
Sutter	215,830	-	24,860	-	8,160	-	-	181,450	560	170	-	40	-	-	-	-	-	-	-	-	-	590	-	-
Tehama	6,110	-	3,560	-	2,540	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
Trinity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tulare	69,600	-	19,150	-	18,220	3,620	-	-	-	-	12,150	350	-	-	-	-	-	16,080	-	-	-	30	-	-
Tuolumne	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ventura	860	-	720	-	-	-	-	-	-	-	-	-	140	-	-	-	-	-	-	-	-	-	-	-
Yolo	181,510	-	39,210	-	27,210	-	-	57,800	2,860	-	-	-	-	-	-	-	-	52,890	-	-	-	1,540	-	-
Yuba	59,000	-	-	-	-	-	-	59,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other- not located	38,660	-	14,820	5,130	3,920	1,010	110	6,650	680	-	1,370	280	30	-	40	40	-	3,910	330	-	-	320	20	-
STATE TOTALS	2,116,000	-	478,665	5,130	338,880	19,935	1,910	891,200	8,770	170	187,265	2,719	534	100	2,026	1,150	2,622	138,635	17,780	13,245	-	5,317	382	-

### 2.1.3. Vegetable Crops

Vegetable crops are planted on about 1.26 million acres in California. Gross quantities (BD) and residual vegetable crop biomass were estimated in similar manner as for the other crop types. Residue yield factors for vegetable crops are listed in Table 2.1.3.1. Technical yield factors (availability) were set at zero (the availability factor was 0.05 in earlier editions of the resource report).

**Table 2.1.3.1. Residue yield and availability factors for vegetable crops.**

Biomass Type	Wet Basis Conversion Factor (tons/acre-y)	Moisture Content (% wet basis)	Dry Basis Conversion Factor (tons/acre-y)	Availability (-)
Artichokes	1.7	0	1.70	0.0
Asparagus	2.2	0	2.20	0.0
Green Lima Beans	1.0	14	0.86	0.0
Berries	1.3	0	1.30	0.0
Snap Beans	1.0	14	0.86	0.0
Broccoli	1.0	14	0.86	0.0
Cabbage	1.0	14	0.86	0.0
Cantaloupe Melons	1.2	0	1.20	0.0
Carrots	1.0	14	0.86	0.0
Cauliflower	1.0	14	0.86	0.0
Celery	1.0	14	0.86	0.0
Cucumbers	1.7	0	1.70	0.0
Garlic	1.0	14	0.86	0.0
Combined Melons	1.2	0	1.20	0.0
Lettuce and Romaine	1.0	0	1.00	0.0
Dry Onions	1.0	14	0.86	0.0
Green Onions	1.0	14	0.86	0.0
Hot Peppers	1.0	14	0.86	0.0
Sweet Peppers	1.0	14	0.86	0.0
Spices & herbs	1.1	0	1.10	0.0
Spinach	1.0	14	0.86	0.0
Squash	1.2	0	1.20	0.0
Sweet Corn	4.7	14	4.04	0.0
Tomatoes	1.3	0	1.30	0.0
Unspecified vegetables	1.4	14	1.20	0.0

Estimated gross biomass quantities for each vegetable crop type by county are listed in Table 2.1.3.2. We assume that vegetable crop residues are incorporated in the soil or used for animal feed, and consequently, there is zero technical biomass potential.

**Table 2.1.3.2. Gross vegetable crop biomass (BDT/yr), 2013**

County Name	Total Vegetable	Artichokes	Asparagus	Green Lima Beans	combined Berries	Broccoli	Cabbage	combined Melons	Carrots	Cauliflower	Celery	Cucumbers	combined Garlic	combined Lettuce	Dry Onions	Hot Peppers	Sweet Peppers	Spices & Herbs	Spinach	Squash	Sweet Corn	Tomatoes & Eggplant	combined unspecified vegetables
Alameda	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
Alpine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amador	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butte	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calaveras	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Colusa	18,310	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18,070	240
Contra Costa	3,550	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	-	3,120	390
Del Norte	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
El Dorado	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fresno	239,230	-	5,150	-	-	3,720	-	30,350	-	-	-	-	16,600	17,870	16,680	-	950	-	-	840	-	145,740	1,330
Glenn	170	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	170
Humboldt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Imperial	96,780	-	-	-	-	13,670	1,380	9,520	11,780	3,360	-	-	-	45,330	7,650	-	-	-	4,090	-	-	-	-
Inyo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kern	32,710	-	-	-	830	-	-	3,340	-	-	-	-	2,370	-	6,590	-	2,280	-	-	-	-	17,300	-
Kings	62,020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43,420	18,600
Lake	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40
Lassen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Los Angeles	80	-	-	-	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	-
Madera	5,980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,980	-
Marin	1,090	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,090
Mariposa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mendocino	410	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	410
Merced	45,660	-	-	-	130	-	-	6,110	-	-	-	-	-	-	-	-	-	-	-	-	-	33,740	5,680
Modoc	8,040	-	-	-	-	-	-	-	-	-	-	-	-	-	870	-	-	-	-	-	-	-	7,170
Mono	220	-	-	-	-	-	-	-	-	-	-	-	220	-	-	-	-	-	-	-	-	-	-
Monterey	313,220	8,840	4,750	-	15,260	56,360	7,620	-	2,740	18,040	11,670	-	1,120	116,540	1,630	-	1,140	2,950	10,610	360	-	960	52,630
Napa	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
Nevada	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orange	1,070	-	-	-	1,040	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	20	-
Placer	50	-	-	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plumas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Riverside	33,160	990	-	-	770	1,890	80	4,920	2,710	970	530	-	-	5,190	120	-	4,020	1,160	1,170	460	-	900	7,280
Sacramento	4,520	-	-	-	130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	390	-	2,300	1,700
San Benito	26,840	-	-	-	-	770	160	-	-	-	400	-	-	8,960	830	-	1,580	-	3,600	-	-	2,870	7,670
San Bernardino	2,540	-	-	-	260	-	1,550	-	-	-	-	10	-	-	-	-	-	40	-	150	-	10	520
San Diego	6,480	-	-	-	840	-	-	110	-	-	-	350	-	80	-	-	170	530	-	780	-	2,430	1,190
San Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Joaquin	67,980	-	13,070	-	1,700	-	-	2,640	-	-	-	3,640	-	-	1,870	-	710	-	-	4,320	-	37,040	2,990
San Luis Obispo	33,840	-	-	-	4,310	9,290	2,430	-	-	1,270	510	-	-	3,970	-	-	680	-	-	240	-	-	11,140
San Mateo	1,710	100	-	-	-	-	-	-	-	-	-	-	110	-	-	-	-	-	-	210	-	-	1,290
Santa Barbara	74,840	-	-	-	9,500	23,560	920	-	-	6,750	3,540	-	-	13,900	-	-	370	-	1,160	860	-	-	14,280
Santa Clara	9,620	-	-	-	100	110	200	-	-	-	260	-	220	2,450	30	410	1,350	-	740	490	-	2,030	1,230
Santa Cruz	16,820	-	-	-	8,870	-	-	-	-	-	-	-	-	3,230	-	-	-	-	-	-	-	-	4,720
Shasta	290	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	290	-	-	-	-	-
Sierra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Siskiyou	11,650	-	-	-	-	-	-	-	-	-	-	-	-	-	1,570	-	-	-	-	-	-	-	8,740
Solano	27,140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,340	-	-	-	13,520	13,620
Sonoma	650	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	650
Stanislaus	36,610	-	-	-	-	2,300	-	3,890	-	-	-	-	-	-	-	-	-	-	-	630	-	25,130	4,660
Sutter	11,140	-	-	-	-	-	-	650	-	-	-	-	-	-	-	-	-	-	-	-	-	10,490	-
Tehama	180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	180
Trinity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tulare	6,880	-	-	-	1,730	900	-	-	-	-	-	280	-	-	-	-	-	-	-	-	-	-	3,970
Tuolumne	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20
Ventura	58,390	-	-	-	23,900	340	3,330	-	280	-	9,720	90	-	2,420	170	-	2,930	5,050	1,190	220	-	730	8,020
Yolo	53,780	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	44,980	8,800
Yuba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other- not located	65,720	90	800	-	1,530	1,040	1,700	1,260	33,470	290	1,790	630	270	3,310	1,170	1,810	310	3,580	1,380	820	-	860	9,610
STATE TOTALS	1,380,000	10,020	23,770	-	70,980	113,950	19,370	62,800	50,980	30,680	28,420	5,000	20,910	223,250	39,180	2,220	16,490	14,940	23,940	10,810	-	411,690	200,160

### 2.1.4. Food and Fiber Processing Residues

Food and fiber processing operations in the state produce a variety of biomass feedstocks including nut shells, fruit pits, hulls, cotton gin trash, meat processing residues, grape and tomato pomace, cheese whey, beverage wastes, and waste water streams containing sugars and other degradable solids. Total solids in this category exceed 4.5 million BDT/y in the state. This is a large increase over the 1.5 million BDT/y for this category in the 2007/8 resource report. Reasons for this increase include; larger almond and walnut production, addition of the almond hull category (2.5 million BDT/y), improved (higher) gross yield factors for shells, rice hulls, cotton gin trash, and winery pomace, and inclusion of extensive new data for fresh and frozen fruit vegetable processors and canneries from Amón et al. (2012).<sup>9</sup> Stone fruit and olive pits were omitted from this update due to low quality or lack of data.

Gross quantities of almond shell & hull, walnut shell, winery pomace, rice hull and cotton gin waste were obtained by applying dry yield factors (Table 2.1.4.1) to food/fibre production amounts from 2013 NASS California crop report.<sup>10</sup>

**Table 2.1.4.1. Computed yield of certain food/fiber processing residues**

Biomass Type	Dry Yield	Units
Almond Shell	0.6	(lbs. per lb. of nut meat)
Almond Hull	2.52	"
Walnut Shell	0.45	"
Winery (pomace)	0.045	(lbs. per lb. grape crush)
Rice Hull	0.18	(lb per lb. rough rice)
Cotton Gin Waste	0.83	(Trash:Lint Ratio)

Technical residue availability for all food and fiber residues was assumed to be 80%. Losses in handling should be reduced compared to other agricultural sources due to the fewer number of operations required prior to conversion. Though we assume high technical availability for food/fibre processing residue, much of the material is consumed in existing feed and energy markets. Estimated gross and technical biomass quantities for each food/fibre processing residue type by county are listed in Tables 2.1.4.2 and 2.1.4.3.

<sup>9</sup> Amón, R., M. Jenner, R. B. Williams, H. El-Mashad and S. R. Kaffka (2012). California Food Processing Industry Residue Assessment, University of California. Contractor report to the California Energy Commission. **CEC 500-2013-100**.

<sup>10</sup> USDA (2014). California Agricultural Statistics, 2013 Crop Year, NASS, California Field Office.

[http://www.nass.usda.gov/Statistics\\_by\\_State/California/Publications/California\\_Ag\\_Statistics/index.asp](http://www.nass.usda.gov/Statistics_by_State/California/Publications/California_Ag_Statistics/index.asp)



**Table 2.1.4.2. Gross food and fiber processing residue (BDT/yr), 2013**

County Name	Total Food Processing	Almond Shell	Almond Hull	Walnut Shell	Cannery Residue	Dehyd. fruit&veg.	Fresh/froz fruit&veg	Winery	Rice Hull	Cotton Gin Waste	Meat Processing
Alameda	370	-	-	-	-	-	370	-	-	-	-
Alpine	-	-	-	-	-	-	-	-	-	-	-
Amador	100	-	-	100	-	-	-	-	-	-	-
Butte	191,260	15,270	64,130	28,460	4,890	3,720	-	-	74,790	-	-
Calaveras	510	-	-	510	-	-	-	-	-	-	-
Colusa	266,840	25,530	107,230	9,570	7,920	2,070	-	-	114,520	-	-
Contra Costa	260	-	-	260	-	-	-	-	-	-	-
Del Norte	-	-	-	-	-	-	-	-	-	-	-
El Dorado	70	-	-	70	-	-	-	-	-	-	-
Fresno	755,020	124,080	521,140	6,130	6,080	35,630	7,470	13,830	-	40,660	-
Glenn	171,960	17,370	72,950	14,230	2,790	560	-	-	63,250	810	-
Humboldt	440	-	-	-	440	-	-	-	-	-	-
Imperial	2,230	-	-	-	-	-	-	-	-	2,230	-
Inyo	-	-	-	-	-	-	-	-	-	-	-
Kern	660,940	118,020	495,680	470	4,300	-	7,660	4,740	-	30,070	-
Kings	157,830	9,210	38,680	9,220	14,930	-	-	18,570	-	67,220	-
Lake	3,900	-	-	2,160	-	-	-	1,740	-	-	-
Lassen	1,240	-	-	-	-	-	-	-	1,240	-	-
Los Angeles	4,090	-	-	-	2,090	-	2,000	-	-	-	-
Madera	335,330	61,050	256,410	930	-	1,750	260	13,830	-	1,100	-
Marin	3,830	-	-	-	-	-	-	3,830	-	-	-
Mariposa	-	-	-	-	-	-	-	-	-	-	-
Mendocino	2,790	-	-	-	-	-	-	2,790	-	-	-
Merced	364,240	60,420	253,760	3,580	11,070	1,120	1,140	7,580	2,450	23,120	-
Modoc	-	-	-	-	-	-	-	-	-	-	-
Mono	-	-	-	-	-	-	-	-	-	-	-
Monterey	74,410	-	-	-	-	67,080	160	7,170	-	-	-
Napa	7,900	-	-	-	-	-	-	7,900	-	-	-
Nevada	-	-	-	-	-	-	-	-	-	-	-
Orange	1,500	-	-	-	1,230	-	270	-	-	-	-
Placer	12,090	-	-	580	-	-	-	-	11,510	-	-
Plumas	-	-	-	-	-	-	-	-	-	-	-
Riverside	9,740	-	-	-	-	-	-	-	-	9,740	-
Sacramento	16,080	-	-	160	2,490	-	-	7,380	6,050	-	-
San Benito	9,590	-	-	1,030	-	-	1,390	7,170	-	-	-
San Bernardino	140	-	-	-	-	-	140	-	-	-	-
San Diego	-	-	-	-	-	-	-	-	-	-	-
San Francisco	-	-	-	-	-	-	-	-	-	-	-
San Joaquin	216,800	27,450	115,290	39,470	8,040	-	310	22,960	3,280	-	-
San Luis Obispo	4,700	-	-	1,500	-	-	-	3,200	-	-	-
San Mateo	-	-	-	-	-	-	-	-	-	-	-
Santa Barbara	3,260	-	-	-	-	-	60	3,200	-	-	-
Santa Clara	1,720	-	-	120	510	830	260	-	-	-	-
Santa Cruz	830	-	-	-	-	830	-	-	-	-	-
Shasta	4,860	-	-	730	-	-	-	-	4,130	-	-
Sierra	-	-	-	-	-	-	-	-	-	-	-
Siskiyou	-	-	-	-	-	-	-	-	-	-	-
Solano	21,730	1,790	7,510	5,840	5,540	-	-	1,050	-	-	-
Sonoma	8,800	-	-	-	-	-	1,130	7,670	-	-	-
Stanislaus	475,550	78,540	329,870	24,520	23,680	8,060	2,450	7,580	850	-	-
Sutter	118,260	2,100	8,820	17,050	-	2,720	270	-	87,300	-	-
Tehama	35,260	3,750	15,750	13,970	1,380	410	-	-	-	-	-
Trinity	-	-	-	-	-	-	-	-	-	-	-
Tulare	132,550	14,730	61,870	23,930	-	780	430	18,570	-	12,240	-
Tuolumne	-	-	-	-	-	-	-	-	-	-	-
Ventura	9,160	-	-	-	-	5,960	-	3,200	-	-	-
Yolo	89,870	5,430	22,810	9,440	17,820	230	-	6,330	27,810	-	-
Yuba	38,530	460	1,940	7,740	-	-	-	-	28,390	-	-
Other- not located	323,960	-	-	-	-	-	-	4,900	3,200	-	315,860
STATE TOTALS	4,541,000	565,200	2,373,840	221,770	115,200	131,750	25,770	175,190	428,770	187,190	315,860

**Table 2.1.4.3. Technical food and fiber processing residue (BDT/yr), 2013**

County Name	Total Food Processing	Almond Shell	Almond Hull	Walnut Shell	Cannery Residue	Dehyd. fruit&veg.	Fresh/froz fruit&veg	Winery	Rice Hull	Cotton Gin Waste	Meat Processing
Alameda	300	-	-	-	-	-	300	-	-	-	-
Alpine	-	-	-	-	-	-	-	-	-	-	-
Amador	80	-	-	80	-	-	-	-	-	-	-
Butte	153,010	12,220	51,300	22,770	3,910	2,980	-	-	59,830	-	-
Calaveras	410	-	-	410	-	-	-	-	-	-	-
Colusa	213,480	20,420	85,780	7,660	6,340	1,660	-	-	91,620	-	-
Contra Costa	210	-	-	210	-	-	-	-	-	-	-
Del Norte	-	-	-	-	-	-	-	-	-	-	-
El Dorado	60	-	-	60	-	-	-	-	-	-	-
Fresno	604,000	99,260	416,910	4,900	4,860	28,500	5,980	11,060	-	32,530	-
Glenn	137,570	13,900	58,360	11,380	2,230	450	-	-	50,600	650	-
Humboldt	350	-	-	-	350	-	-	-	-	-	-
Imperial	1,780	-	-	-	-	-	-	-	-	1,780	-
Inyo	-	-	-	-	-	-	-	-	-	-	-
Kern	528,760	94,420	396,540	380	3,440	-	6,130	3,790	-	24,060	-
Kings	126,270	7,370	30,940	7,380	11,940	-	-	14,860	-	53,780	-
Lake	3,120	-	-	1,730	-	-	-	1,390	-	-	-
Lassen	990	-	-	-	-	-	-	-	990	-	-
Los Angeles	3,270	-	-	-	1,670	-	1,600	-	-	-	-
Madera	268,260	48,840	205,130	740	-	1,400	210	11,060	-	880	-
Marin	3,060	-	-	-	-	-	-	3,060	-	-	-
Mariposa	-	-	-	-	-	-	-	-	-	-	-
Mendocino	2,230	-	-	-	-	-	-	2,230	-	-	-
Merced	291,400	48,340	203,010	2,860	8,860	900	910	6,060	1,960	18,500	-
Modoc	-	-	-	-	-	-	-	-	-	-	-
Mono	-	-	-	-	-	-	-	-	-	-	-
Monterey	59,530	-	-	-	-	53,660	130	5,740	-	-	-
Napa	6,320	-	-	-	-	-	-	6,320	-	-	-
Nevada	-	-	-	-	-	-	-	-	-	-	-
Orange	1,200	-	-	-	980	-	220	-	-	-	-
Placer	9,670	-	-	460	-	-	-	-	9,210	-	-
Plumas	-	-	-	-	-	-	-	-	-	-	-
Riverside	7,790	-	-	-	-	-	-	-	-	7,790	-
Sacramento	12,860	-	-	130	1,990	-	-	5,900	4,840	-	-
San Benito	7,670	-	-	820	-	-	1,110	5,740	-	-	-
San Bernardino	110	-	-	-	-	-	110	-	-	-	-
San Diego	-	-	-	-	-	-	-	-	-	-	-
San Francisco	-	-	-	-	-	-	-	-	-	-	-
San Joaquin	173,440	21,960	92,230	31,580	6,430	-	250	18,370	2,620	-	-
San Luis Obispo	3,760	-	-	1,200	-	-	-	2,560	-	-	-
San Mateo	-	-	-	-	-	-	-	-	-	-	-
Santa Barbara	2,610	-	-	-	-	-	50	2,560	-	-	-
Santa Clara	1,380	-	-	100	410	660	210	-	-	-	-
Santa Cruz	660	-	-	-	-	660	-	-	-	-	-
Shasta	3,880	-	-	580	-	-	-	-	3,300	-	-
Sierra	-	-	-	-	-	-	-	-	-	-	-
Siskiyou	-	-	-	-	-	-	-	-	-	-	-
Solano	17,380	1,430	6,010	4,670	4,430	-	-	840	-	-	-
Sonoma	7,040	-	-	-	-	-	900	6,140	-	-	-
Stanislaus	380,440	62,830	263,900	19,620	18,940	6,450	1,960	6,060	680	-	-
Sutter	94,620	1,680	7,060	13,640	-	2,180	220	-	69,840	-	-
Tehama	28,210	3,000	12,600	11,180	1,100	330	-	-	-	-	-
Trinity	-	-	-	-	-	-	-	-	-	-	-
Tulare	106,030	11,780	49,500	19,140	-	620	340	14,860	-	9,790	-
Tuolumne	-	-	-	-	-	-	-	-	-	-	-
Ventura	7,330	-	-	-	-	4,770	-	2,560	-	-	-
Yolo	71,890	4,340	18,250	7,550	14,260	180	-	5,060	22,250	-	-
Yuba	30,820	370	1,550	6,190	-	-	-	-	22,710	-	-
Other- not located	259,170	-	-	-	-	-	-	3,920	2,560	-	252,690
STATE TOTALS	3,632,000	452,160	1,899,070	177,420	92,140	105,400	20,630	140,140	343,010	149,760	252,690

### 2.1.5. Animal Manures

The agricultural animal population in the state is nearly 66 million including 60 million poultry (broiler and layer chickens and turkeys) [Table 2.1.5.1]. Total cattle population about 5.3 million, with 1.77 million milking cows (lactating and dry combined), 610,000 beef cows, and 2.9 million other cows (replacements and heifers) [Table 2.1.5.2]. Sheep, lambs, horses and “other” animal types were excluded from this edition of the resource report due to low numbers or lack of data.

Total manure production from animals is nearly 11.7 million BDT/y, with 10.9 million BDT/y from cattle (6 million BDT/y from milking cows in dairies). Poultry contributes about 700,000 BDT/y or about 6% of agricultural animal manure.

**Table 2.1.5.1. Animal populations in California and manure production data.**

Animal type	Number in California Inventory	Total Wet Manure (lb/animal-day)	Moisture Content (% wb)	Total Solids (TS)			Volatile Solids (VS)	
				(lb/animal-day)	(lb/animal-year)	Statewide (BDT/y)	(lb/animal-day)	(lb/animal-year)
Dairy Cows - Lactating & Dry	1,774,108	140	87	18.7	6,807	6,038,398	15.83	5,778
Beef Cows	610,000	125	88	15.0	5,475	1,669,875	13.00	4,745
Other Cattle (cow replacements & heifers)	2,951,892	50	88	6.0	2,190	3,232,322	5.00	1,825
Swine -growing/finishing	91,000	10	91	1.0	365	16,608	0.85	310
Poultry (Layer Chickens)	17,960,000	0.20	75	0.05	17.9	160,607	0.04	13.1
Poultry (Broiler Chickens)	37,473,714	0.22	74	0.06	21.3	398,939	0.04	16.0
Poultry (Turkeys)	4,897,616	0.58	74	0.15	54.9	134,408	0.12	43.9
<b>Total</b>	<b>65,758,330</b>					<b>11,650,000</b>		

Manure production was estimated from animal populations and animal-specific production rates. Average animal sizes, daily wet manure production rates, moisture contents, and volatile solids production rates are from standard values published by ASAE<sup>11</sup> as listed in Table 2.1.5.1.

Gross biomass is calculated as total solids derived from the daily wet manure production and moisture content (wet basis). Manure production for “other cattle” are based on growing cow replacements and heifers.

The dairy cow manure gross estimate is significantly larger than that in the 2007/8 resource report (6 vs. 3.9 million BDT/y) for approximately the same number of cows. This is mainly due to a ~67% increase in manure solids production in the latest ASAE Manure Production Characteristics standard (both in specific production and assumed animal size).

The dairy cow inventory is composed of mature cows which include those actively producing milk (lactating) and those that have stopped producing (dry cows) for a two month period leading up to birthing their next calf. Calving intervals are normally one year so this dry period is about 15% of the year (or it can be assumed that 15% of a dairy herd is dry at any time, while 85% of the cows are

<sup>11</sup> ASAE D384.2 MAR2005 (R2010), Manure Production Characteristics. American Society of Agricultural and Biological Engineers, St. Joseph, Michigan.

lactating). Feed ration and manure production is much higher for lactating cows compared to dry cows (dry weight manure production varies from 20 to 11 lbs./day for lactating and dry cows respectively (ASAE D384.2)). The manure production value for dairy cows shown in Table 2.1.5.1 (18.7 lbs./animal-day) is therefore a weighted average of lactating and dry cows in a typical herd (85:15 lactating: dry).

**Table 2.1.5.2. Cattle Populations in California by county, 2013**

County	Milk Cow (mature)	Beef Cow	Other Cattle	Total Cattle
Alameda	0	9,000	7,400	16,400
Alpine	0	200	100	300
Amador	0	8,800	5,600	14,400
Butte	350	7,700	6,050	14,100
Calaveras	0	7,900	6,100	14,000
Colusa	0	8,700	5,900	14,600
Contra Costa	0	9,900	12,600	22,500
Del Norte	2,697	800	11,003	14,500
El Dorado	0	3,500	4,500	8,000
Fresno	114,700	15,800	264,500	395,000
Glenn	17,000	13,000	32,000	62,000
Humboldt	13,000	14,700	28,300	56,000
Imperial	4,717	3,000	362,283	370,000
Inyo	0	9,600	4,300	13,900
Kern	169,938	32,000	138,062	340,000
Kings	179,408	5,500	230,092	415,000
Lake	0	2,200	1,100	3,300
Lassen	0	24,000	16,500	40,500
Los Angeles	0	1,000	5,200	6,200
Madera	74,000	13,400	87,600	175,000
Marin	7,874	9,700	22,426	40,000
Mariposa	0	0	24,000	24,000
Mendocino	800	8,800	7,600	17,200
Merced	267,000	26,000	257,000	550,000
Modoc	0	31,000	20,000	51,000
Mono	0	3,500	1,200	4,700
Monterey	600	20,000	37,400	58,000
Napa	0	0	9,600	9,600
Nevada	0	2,700	2,000	4,700
Orange	0	100	200	300
Placer	300	0	12,400	12,700
Plumas	0	0	16,800	16,800
Riverside	40,000	1,900	34,100	76,000
Sacramento	14,815	13,300	26,885	55,000
San Benito	0	12,000	25,500	37,500
San Bernardino	54,984	3,800	91,216	150,000
San Diego	1,889	3,700	9,611	15,200
San Francisco	0	0	0	0
San Joaquin	98,000	18,300	123,700	240,000
San Luis Obispo	0	31,000	26,000	57,000
San Mateo	0	1,300	800	2,100
Santa Barbara	0	15,200	27,800	43,000
Santa Clara	5,000	7,600	2,300	14,900
Santa Cruz	0	400	3,700	4,100
Shasta	0	14,300	20,200	34,500
Sierra	0	2,100	7,200	9,300
Siskiyou	693	29,500	22,807	53,000
Solano	3,000	18,200	31,800	53,000
Sonoma	27,000	11,700	55,300	94,000
Stanislaus	183,901	27,000	184,099	395,000
Sutter	500	3,700	2,300	6,500
Tehama	3,428	24,500	32,072	60,000
Trinity	0	3,000	1,500	4,500
Tulare	484,845	25,500	559,655	1,070,000
Tuolumne	0	4,900	3,400	8,300
Ventura	0	3,400	2,000	5,400
Yolo	1,000	0	13,500	14,500
Yuba	2,669	5,200	4,631	12,500
Sum of Other	0	36,000	0	36,000
<b>STATE TOTALS</b>	<b>1,774,108</b>	<b>610,000</b>	<b>2,951,892</b>	<b>5,336,000</b>

Technical availability factors for manure from each type of animal are listed in Table 2.1.5.3. The estimates are conservative and largely based on whether the animals are produced under confinement, with greater availability from confined animal operations. Beef cattle are produced both in confined animal feeding operations (CAFO) and on the range. Manure from range animals is not likely to be collected. Much of the manure from milking cows and swine is produced under confined conditions and current manure handling systems make much of this available for use.<sup>12</sup> Poultry are also largely produced in confinement although much of the manure now is composted. Estimated gross and technical biomass quantities for manure by animal type and by county are listed in Tables 2.1.5.4 and 2.1.5.5.

**Table 2.1.5.3. Technical availability factors for manure by animal type.**

Biomass Type	(--)
Beef Cow Manure	0.2
Milk Cow Manure	0.5
Other Cattle Manure	0.2
Swine	0.2
Poultry Layer Chickens	0.5
Poultry Broiler Chickens	0.5
Poultry Turkeys	0.5

<sup>12</sup> As mentioned, the technical recovery factors presented here for manure from CAFO animals are conservative. Technical recovery here represents a conservative (low) estimate of manure that could be gathered for energy purposes, i.e., use in an anaerobic digester. The remaining manure mass is assumed to be not easily collectible or suitable for conversion. In reality, manure at CAFOs is not “stockpiled” in the long term and must be periodically removed and spread on fields, composted or otherwise distributed elsewhere.

**Table 2.1.5.4. Gross animal manures (BDT/yr), 2013**

County Name	Total Animal Manure	Total Cattle Manure	Beef Cow Manure	Milk Cow Manure	Other Cattle Manure	Swine	Poultry Layer Chickens	Poultry Broiler Chickens	Poultry Turkeys
Alameda	32,700	32,700	24,600	-	8,100	-	-	-	-
Alpine	700	700	500	-	100	-	-	-	-
Amador	30,200	30,200	24,100	-	6,100	-	-	-	-
Butte	28,900	28,900	21,100	1,200	6,600	-	-	-	-
Calaveras	28,300	28,300	21,600	-	6,700	-	-	-	-
Colusa	30,300	30,300	23,800	-	6,500	-	-	-	-
Contra Costa	40,900	40,900	27,100	-	13,800	-	-	-	-
Del Norte	23,400	23,400	2,200	9,200	12,000	-	-	-	-
El Dorado	14,500	14,500	9,600	-	4,900	-	-	-	-
Fresno	877,100	723,300	43,300	390,400	289,600	-	-	125,600	28,200
Glenn	128,500	128,500	35,600	57,900	35,000	-	-	-	-
Humboldt	115,500	115,500	40,200	44,200	31,000	-	-	-	-
Imperial	421,000	421,000	8,200	16,100	396,700	-	-	-	-
Inyo	31,000	31,000	26,300	-	4,700	-	-	-	-
Kern	817,200	817,200	87,600	578,400	151,200	-	-	-	-
Kings	887,800	877,600	15,100	610,600	252,000	-	-	-	10,200
Lake	7,200	7,200	6,000	-	1,200	-	-	-	-
Lassen	83,800	83,800	65,700	-	18,100	-	-	-	-
Los Angeles	8,400	8,400	2,700	-	5,700	-	-	-	-
Madera	399,300	384,500	36,700	251,900	95,900	-	-	5,000	9,800
Marin	77,900	77,900	26,600	26,800	24,600	-	-	-	-
Mariposa	26,300	26,300	-	-	26,300	-	-	-	-
Mendocino	35,100	35,100	24,100	2,700	8,300	-	-	-	-
Merced	1,321,900	1,261,400	71,200	908,800	281,400	-	27,600	-	32,900
Modoc	106,800	106,800	84,900	-	21,900	-	-	-	-
Mono	10,900	10,900	9,600	-	1,300	-	-	-	-
Monterey	97,700	97,700	54,800	2,000	41,000	-	-	-	-
Napa	10,500	10,500	-	-	10,500	-	-	-	-
Nevada	9,600	9,600	7,400	-	2,200	-	-	-	-
Orange	500	500	300	-	200	-	-	-	-
Placer	14,600	14,600	-	1,000	13,600	-	-	-	-
Plumas	18,400	18,400	-	-	18,400	-	-	-	-
Riverside	196,200	178,700	5,200	136,100	37,300	-	17,500	-	-
Sacramento	122,900	116,300	36,400	50,400	29,400	-	-	6,600	-
San Benito	60,800	60,800	32,900	-	27,900	-	-	-	-
San Bernardino	333,000	297,400	10,400	187,100	99,900	-	32,600	3,000	-
San Diego	48,600	27,100	10,100	6,400	10,500	-	18,300	3,200	-
San Francisco	-	-	-	-	-	-	-	-	-
San Joaquin	540,400	519,100	50,100	333,600	135,500	-	16,500	4,800	-
San Luis Obispo	113,300	113,300	84,900	-	28,500	-	-	-	-
San Mateo	4,400	4,400	3,600	-	900	-	-	-	-
Santa Barbara	72,100	72,100	41,600	-	30,400	-	-	-	-
Santa Clara	40,800	40,300	20,800	17,000	2,500	-	-	500	-
Santa Cruz	5,100	5,100	1,100	-	4,100	-	-	-	-
Shasta	61,300	61,300	39,100	-	22,100	-	-	-	-
Sierra	13,600	13,600	5,700	-	7,900	-	-	-	-
Siskiyou	108,100	108,100	80,800	2,400	25,000	-	-	-	-
Solano	94,900	94,900	49,800	10,200	34,800	-	-	-	-
Sonoma	194,100	184,500	32,000	91,900	60,600	-	9,600	-	-
Stanislaus	1,027,600	901,400	73,900	625,900	201,600	-	17,200	87,600	21,400
Sutter	14,300	14,300	10,100	1,700	2,500	-	-	-	-
Tehama	113,900	113,900	67,100	11,700	35,100	-	-	-	-
Trinity	9,900	9,900	8,200	-	1,600	-	-	-	-
Tulare	2,363,000	2,332,900	69,800	1,650,200	612,800	-	-	24,700	5,400
Tuolumne	31,800	17,100	13,400	-	3,700	-	-	-	14,700
Ventura	11,500	11,500	9,300	-	2,200	-	-	-	-
Yolo	18,200	18,200	-	3,400	14,800	-	-	-	-
Yuba	28,400	28,400	14,200	9,100	5,100	-	-	-	-
Other- not located	286,700	98,600	98,600	-	-	16,600	21,500	138,000	12,000
STATE TOTALS	11,650,000	10,940,000	1,670,000	6,040,000	3,230,000	17,000	161,000	399,000	135,000

**Table 2.1.5.5. Technical animal manures (BDT/yr), 2013**

County Name	Total Animal Manure	Total Cattle Manure	Beef Cow Manure	Milk Cow Manure	Other Cattle Manure	Swine	Poultry Layer Chickens	Poultry Broiler Chickens	Poultry Turkeys
Alameda	6,500	6,500	4,900	-	1,600	-	-	-	-
Alpine	100	100	100	-	-	-	-	-	-
Amador	6,000	6,000	4,800	-	1,200	-	-	-	-
Butte	6,100	6,100	4,200	600	1,300	-	-	-	-
Calaveras	5,600	5,600	4,300	-	1,300	-	-	-	-
Colusa	6,100	6,100	4,800	-	1,300	-	-	-	-
Contra Costa	8,200	8,200	5,400	-	2,800	-	-	-	-
Del Norte	7,400	7,400	400	4,600	2,400	-	-	-	-
El Dorado	2,900	2,900	1,900	-	1,000	-	-	-	-
Fresno	338,700	261,800	8,700	195,200	57,900	-	-	62,800	14,100
Glenn	43,100	43,100	7,100	29,000	7,000	-	-	-	-
Humboldt	36,300	36,300	8,000	22,100	6,200	-	-	-	-
Imperial	89,000	89,000	1,600	8,100	79,300	-	-	-	-
Inyo	6,200	6,200	5,300	-	900	-	-	-	-
Kern	336,900	336,900	17,500	289,200	30,200	-	-	-	-
Kings	363,800	358,700	3,000	305,300	50,400	-	-	-	5,100
Lake	1,400	1,400	1,200	-	200	-	-	-	-
Lassen	16,700	16,700	13,100	-	3,600	-	-	-	-
Los Angeles	1,600	1,600	500	-	1,100	-	-	-	-
Madera	159,900	152,500	7,300	126,000	19,200	-	-	2,500	4,900
Marin	23,600	23,600	5,300	13,400	4,900	-	-	-	-
Mariposa	5,300	5,300	-	-	5,300	-	-	-	-
Mendocino	7,900	7,900	4,800	1,400	1,700	-	-	-	-
Merced	555,200	524,900	14,200	454,400	56,300	-	13,800	-	16,500
Modoc	21,400	21,400	17,000	-	4,400	-	-	-	-
Mono	2,200	2,200	1,900	-	300	-	-	-	-
Monterey	20,200	20,200	11,000	1,000	8,200	-	-	-	-
Napa	2,100	2,100	-	-	2,100	-	-	-	-
Nevada	1,900	1,900	1,500	-	400	-	-	-	-
Orange	100	100	100	-	-	-	-	-	-
Placer	3,200	3,200	-	500	2,700	-	-	-	-
Plumas	3,700	3,700	-	-	3,700	-	-	-	-
Riverside	85,400	76,600	1,000	68,100	7,500	-	8,800	-	-
Sacramento	41,700	38,400	7,300	25,200	5,900	-	-	3,300	-
San Benito	12,200	12,200	6,600	-	5,600	-	-	-	-
San Bernardino	133,500	115,700	2,100	93,600	20,000	-	16,300	1,500	-
San Diego	18,100	7,300	2,000	3,200	2,100	-	9,200	1,600	-
San Francisco	-	-	-	-	-	-	-	-	-
San Joaquin	214,600	203,900	10,000	166,800	27,100	-	8,300	2,400	-
San Luis Obispo	22,700	22,700	17,000	-	5,700	-	-	-	-
San Mateo	900	900	700	-	200	-	-	-	-
Santa Barbara	14,400	14,400	8,300	-	6,100	-	-	-	-
Santa Clara	13,500	13,200	4,200	8,500	500	-	-	300	-
Santa Cruz	1,000	1,000	200	-	800	-	-	-	-
Shasta	12,200	12,200	7,800	-	4,400	-	-	-	-
Sierra	2,700	2,700	1,100	-	1,600	-	-	-	-
Siskiyou	22,400	22,400	16,200	1,200	5,000	-	-	-	-
Solano	22,100	22,100	10,000	5,100	7,000	-	-	-	-
Sonoma	69,300	64,500	6,400	46,000	12,100	-	4,800	-	-
Stanislaus	431,200	368,100	14,800	313,000	40,300	-	8,600	43,800	10,700
Sutter	3,400	3,400	2,000	900	500	-	-	-	-
Tehama	26,300	26,300	13,400	5,900	7,000	-	-	-	-
Trinity	1,900	1,900	1,600	-	300	-	-	-	-
Tulare	976,800	961,700	14,000	825,100	122,600	-	-	12,400	2,700
Tuolumne	10,800	3,400	2,700	-	700	-	-	-	7,400
Ventura	2,300	2,300	1,900	-	400	-	-	-	-
Yolo	4,700	4,700	-	1,700	3,000	-	-	-	-
Yuba	8,400	8,400	2,800	4,600	1,000	-	-	-	-
Other- not located	108,800	19,700	19,700	-	-	3,300	10,800	69,000	6,000
STATE TOTALS	4,351,000	4,000,000	334,000	3,020,000	646,000	3,400	80,500	199,500	67,500



## 2.2 Forestry

This is the same forest biomass resource data that has been used since the 2005 CBC resource assessment. It was developed by the California Department of Forestry and Fire Protection (CDFFP) and is reported without modification. CDFFP is updating forest biomass resource data which will be included in the next edition of this report if available.

The four main categories of forestry biomass are logging slash, mill residues, biomass from forest thinning and stand improvement operations, and chaparral. Estimates of logging slash, thinnings, and chaparral were developed by the. Mill residues were computed by factoring timber harvest data. Logging slash, mill residues, and forest thinnings are already in commercial use as fuel for power generation. Harvesting of chaparral has not been conducted on a large scale in California so far. Gross and technical forest biomass is listed by county in Tables 2.2.1 and 2.2.2 respectively.

- *Logging slash* comprises branches, tops, and other materials removed from trees during timber harvest. Slash excludes the tree stem or “bole,” defined as from a one-foot stump to a four inch diameter top. Because the volume of slash is directly proportional to logging activity, slash has declined considerably in the state in recent years. Slash left on the ground after harvest can be a substantial source of surface fuels which can carry wildfire. Production of slash is estimated at nearly 8 million BDT/y.
- *Forest thinnings* include non-merchantable components extracted during harvest activities and include understory brush, small diameter tree boles, and other material transported to the mill that cannot produce sawlogs. Thinning also material derived from silvicultural treatments designed to reduce crowding and enhance overall forest health and fire resistance. Thinning may or may not produce merchantable saw logs (close to half of which may end up as mill waste). The issue of mechanically thinning forests has been and remains controversial, but thinning is likely to increase, particularly in wildland-urban interface areas, due to new federal legislation<sup>13</sup> and increasing public concerns over the risk from wildfire. Estimates of the technical availability exclude forest reserves, stream management zones, coastal protection zones, coastal sage scrub habitats, national forest lands with slopes steeper than 35%, and private and other public forest lands with slopes steeper than 30%. There are an estimated 7.7 million BDT/y of potential thinnings.
- *Sawmill residues* are a byproduct of the milling of sawlogs that consist generally of softwood tree boles with a diameter at breast height (dbh) of about ten inches. Sawmill and other forest products manufacturing operations generate a variety of wood residues including bark, sawdust, planer shavings, and trim ends. Resource quantities follow logging activity although imports and exports can also affect mill activity. Mill residue represents about half of saw log weight. A large fraction of this material is technically available for use, and about 1.3 million dry tons are already in use for power generation in the state<sup>14</sup> with additional amounts used for landscape and other products. Much of the power generated is used on-site at the mill and is not exported to the grid. Around 6 million BDT/y are estimated to be generated at mills.
- *Shrub or chaparral* is comprised of mostly shrubby evergreen plants adapted to the semi-arid desert regions of California, especially in the south state. Shrublands range over a large area but so far there has been little development of this biomass for energy. Because shrub biomass has no current commercial value, it is only available as an energy resource through habitat improvement activities (such as thinning) or fuel treatment operations designed to reduce wildfire risks. Nearly 5 million BDT/y were estimated to be available.

---

<sup>13</sup> Healthy Forests Restoration Act, 2003 (HR 1904).

<sup>14</sup> Morris, G. 2003. The status of biomass power generation in California, July 31, 2003. NREL/SR-510-35114, National Renewable Energy Laboratory, Golden, CO.

**Table 2.2.1. Gross forest biomass (BDT/yr)**

County Name	Forest Thinnings	Forest Slash	Shrub	Mill Residue	Total Forestry
Alameda	2,200	10,800	9,200	800	23,000
Alpine	8,500	38,300	11,000	55,100	112,900
Amador	87,200	64,600	6,800	46,100	204,700
Butte	185,200	141,000	7,600	117,100	450,900
Calaveras	132,700	109,100	42,900	78,700	363,400
Colusa	15,800	27,000	41,400	9,700	93,900
Contra Costa	100	4,300	10,000	100	14,500
Del Norte	138,700	207,700	7,500	170,100	524,000
El Dorado	241,600	238,600	21,400	233,800	735,400
Fresno	63,300	252,600	25,500	270,100	611,500
Glenn	9,800	44,200	23,600	32,100	109,700
Humboldt	1,347,700	871,000	10,800	583,300	2,812,800
Imperial	-	-	180,800	-	180,800
Inyo	5,300	34,600	476,700	22,200	538,800
Kern	23,500	100,900	266,600	32,200	423,200
Kings	-	-	2,400	-	2,400
Lake	118,900	119,800	125,900	64,400	429,000
Lassen	170,100	168,500	289,400	203,100	831,100
Los Angeles	1,400	38,100	219,500	17,200	276,200
Madera	52,300	114,900	9,200	122,300	298,700
Marin	25,200	15,800	8,100	3,400	52,500
Mariposa	79,000	82,300	39,800	40,600	241,700
Mendocino	1,393,700	797,200	59,100	515,700	2,765,700
Merced	-	2,700	1,600	-	4,300
Modoc	95,300	155,900	123,800	120,600	495,600
Mono	11,400	47,900	99,000	42,000	200,300
Monterey	1,000	132,500	95,200	12,000	240,700
Napa	94,700	51,200	51,600	13,200	210,700
Nevada	181,300	127,900	9,500	115,300	434,000
Orange	-	2,500	28,900	600	32,000
Placer	125,900	144,700	11,900	136,200	418,700
Plumas	209,600	320,100	15,800	421,900	967,400
Riverside	800	14,700	442,700	7,400	465,600
Sacramento	-	700	200	-	900
San Benito	2,600	43,500	33,000	3,000	82,100
San Bernardino	8,200	66,400	984,700	32,100	1,091,400
San Diego	24,900	43,800	381,900	9,000	459,600
San Francisco	-	-	-	-	-
San Joaquin	1,500	2,000	600	300	4,400
San Luis Obispo	20,500	114,500	77,100	7,300	219,400
San Mateo	42,800	25,700	17,600	22,800	108,900
Santa Barbara	6,000	83,700	129,900	12,800	232,400
Santa Clara	38,100	72,200	56,800	10,600	177,700
Santa Cruz	100,500	61,600	13,900	51,800	227,800
Shasta	597,500	493,300	82,800	363,300	1,536,900
Sierra	58,200	99,400	13,200	128,800	299,600
Siskiyou	631,100	786,200	89,000	781,700	2,288,000
Solano	-	2,100	2,800	100	5,000
Sonoma	359,700	199,700	24,800	100,000	684,200
Stanislaus	-	10,200	16,100	800	27,100
Sutter	-	-	-	-	-
Tehama	141,900	211,500	57,100	151,700	562,200
Trinity	559,600	670,100	19,100	586,700	1,835,500
Tulare	59,500	210,200	23,400	194,900	488,000
Tuolumne	110,400	187,300	42,200	197,800	537,700
Ventura	-	37,500	74,200	15,400	127,100
Yolo	-	14,300	22,900	300	37,500
Yuba	72,900	55,400	700	37,100	166,100
Other- not located	-	-	-	-	-
<b>STATE TOTALS</b>	<b>7,700,000</b>	<b>8,000,000</b>	<b>4,900,000</b>	<b>6,200,000</b>	<b>26,800,000</b>

**Table 2.2.2. Technical forest biomass (BDT/yr)**

County Name	Forest Thinnings	Forest Slash	Shrub	Mill Residue	Total Forestry
Alameda	900	4,800	2,400	300	8,400
Alpine	3,900	10,300	3,700	14,700	32,600
Amador	62,600	44,700	5,300	30,500	143,100
Butte	118,100	91,800	4,700	79,900	294,500
Calaveras	90,600	77,000	26,800	55,900	250,300
Colusa	8,400	16,400	28,000	5,500	58,300
Contra Costa	100	2,500	2,400	100	5,100
Del Norte	48,700	61,500	1,200	46,000	157,400
El Dorado	179,600	175,600	15,000	175,100	545,300
Fresno	33,300	108,200	8,400	109,200	259,100
Glenn	4,900	23,900	14,900	16,700	60,400
Humboldt	632,800	401,800	3,100	275,800	1,313,500
Imperial	-	-	142,400	-	142,400
Inyo	1,400	8,900	119,200	5,800	135,300
Kern	8,900	48,200	158,000	16,900	232,000
Kings	-	-	1,000	-	1,000
Lake	74,100	74,000	79,500	37,500	265,100
Lassen	148,900	143,200	221,200	173,100	686,400
Los Angeles	500	16,000	102,800	5,900	125,200
Madera	38,400	74,000	5,800	75,300	193,500
Marin	14,300	9,400	200	2,000	25,900
Mariposa	56,900	56,200	20,600	27,800	161,500
Mendocino	627,400	368,200	26,100	220,500	1,242,200
Merced	-	1,800	700	-	2,500
Modoc	84,000	134,700	105,900	101,100	425,700
Mono	7,400	25,800	42,800	26,000	102,000
Monterey	400	65,900	26,900	2,400	95,600
Napa	59,800	32,800	30,500	8,200	131,300
Nevada	129,600	91,100	6,000	82,300	309,000
Orange	-	1,200	8,700	200	10,100
Placer	74,600	87,100	5,500	85,100	252,300
Plumas	149,800	216,500	8,800	291,700	666,800
Riverside	500	6,000	219,400	2,800	228,700
Sacramento	-	600	100	-	700
San Benito	900	23,800	16,200	1,600	42,500
San Bernardino	3,700	42,300	576,500	17,000	639,500
San Diego	14,200	28,600	202,100	5,600	250,500
San Francisco	-	-	-	-	-
San Joaquin	700	1,200	400	100	2,400
San Luis Obispo	8,100	70,900	39,600	3,800	122,400
San Mateo	16,400	10,000	1,900	9,000	37,300
Santa Barbara	2,100	39,200	37,600	4,000	82,900
Santa Clara	12,100	34,000	21,800	4,400	72,300
Santa Cruz	43,300	27,500	4,900	23,200	98,900
Shasta	321,900	289,400	51,900	234,600	897,800
Sierra	37,600	63,800	6,600	85,200	193,200
Siskiyou	325,300	355,100	52,300	358,300	1,091,000
Solano	-	1,600	1,400	100	3,100
Sonoma	179,200	101,500	12,500	45,200	338,400
Stanislaus	-	5,600	6,000	400	12,000
Sutter	-	-	-	-	-
Tehama	82,400	130,600	33,100	89,400	335,500
Trinity	241,100	267,300	7,900	223,000	739,300
Tulare	22,900	88,300	6,600	82,200	200,000
Tuolumne	78,800	124,600	24,600	135,200	363,200
Ventura	-	14,900	15,100	4,200	34,200
Yolo	-	10,200	12,100	200	22,500
Yuba	54,100	41,200	500	27,800	123,600
Other- not located	-	-	-	-	-
STATE TOTALS	4,110,000	4,250,000	2,580,000	3,330,000	14,300,000

## 2.3. Municipal wastes

Municipal wastes are classified as municipal solid wastes (MSW), municipal waste water or sewage, and biosolids from waste water treatment.

### 2.3.1. Municipal Solid Wastes

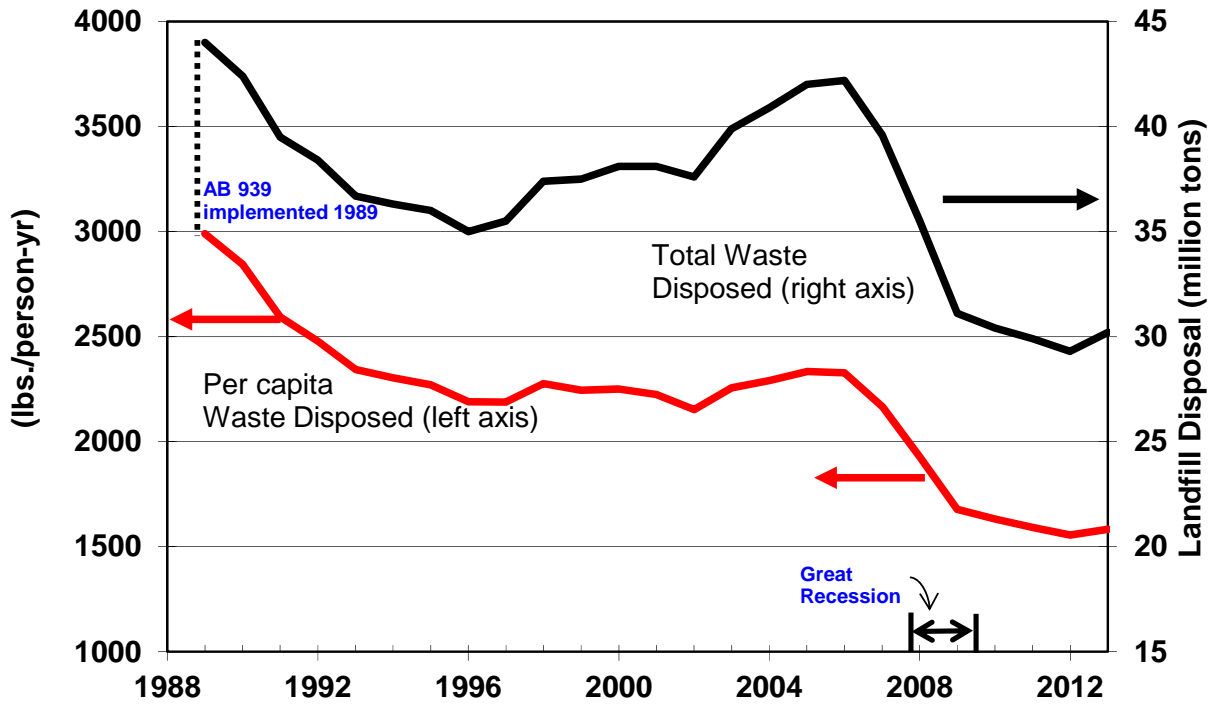
The amount of California MSW disposed in landfills was 30.2 million tons in 2013 (31.7 million tons when you include green waste used as alternative daily cover (ADC)).<sup>15</sup> Total and per-capita and waste disposal have decreased by about 30% since 2006, partly due to economic downturn and increased diversion (Figure 2.3.1).

The composition and amount of landfilled MSW assumed for this study is shown in Table 2.3.1.<sup>16</sup> The biomass component of MSW includes construction and demolition wood, paper, grass and other green waste, food waste, and other organics not including plastics and tires. Only the landfilled biomass fraction is considered in the resource estimates reported here. The total biomass in MSW (landfilled and diverted) is estimated at 25 million BDT/y, or roughly 2/3 BDT biomass per person per year in the state. Resource quantities by biomass type were computed for the fraction disposed in landfills. CalRecycle does not track composition of diverted MSW.

---

<sup>15</sup> CalRecycle (2014). "California's 2013 Disposal" Accessed January, 2015;  
<http://www.calrecycle.ca.gov/LGcentral/goalmeasure/disposalrate/MostRecent/default.htm>

<sup>16</sup> Based on 2008 California waste stream composite data  
(<http://www.calrecycle.ca.gov/Publications/Detail.aspx?PublicationID=1346>)  
& California Solid Waste Generation and Diversion  
(<http://www.calrecycle.ca.gov/LGCentral/GoalMeasure/DisposalRate/Graphs/Disposal.htm>) .



**Figure 2.3.1. Per-capita and total solid waste disposal in California (1989-2013)**

The technical availability factor for biomass recovery from MSW in the landfill stream was assumed to be 0.67 (0.5 was used in previous editions of the resource report). This change was informed by comments and discussion with numerous solid waste practitioners and experts whose general opinion that 50% technical recovery factor was too conservative (low). The current factor (0.67 or 67%) is still conservative and the reader should use his/her own recovery factors for specific project assessments.

The diverted fraction is not well characterized and is currently utilized (by definition). Therefore, the MSW diverted fraction technical availability factor is considered to be zero. Diverted materials are used primarily in recycling, composting, and power generation. Additional use for energy will compete with other markets for the diverted materials. Estimated gross and technical biomass quantities for MSW by county are listed in Tables 2.3.2 and 2.3.3.

**Table 2.3.1. MSW composition, properties and amount landfilled in 2013. \***

Component	Landfilled <sup>a</sup> (million tons, wet)	% of Total Wet MSW	Moisture <sup>b</sup> (%wb)	Landfilled (million tons, dry)	Ash <sup>b</sup> (% wb)	Ash (Million ton/yr)	HHV <sup>b</sup> (MJ/kg, as received)	HHV contribution to composite (MJ kg <sup>-1</sup> as received)	(HHV MJ/kg dry)
<b>Biomass</b>									
Paper/Cardboard	5.2	16.5	10	4.7	5.3	0.3	16	2.64	17.8
Food	4.7	14.8	70	1.4	5.0	0.2	4.2	0.62	14.0
Leaves and Grass	1.1	3.6	60	0.5	4.0	0.0	6	0.22	15.0
Other Organics	1.3	4.1	4	1.2	10.0	0.1	8.5	0.35	8.9
C&D Lumber	4.4	13.8	12	3.9	5.0	0.2	17	2.35	19.3
Prunings, trimmings, green ADC	2.3	7.2	40	1.4	3.6	0.1	11.4	0.82	19.0
Branches and stumps	0.2	0.6	40	0.1	3.6	0.0	11.4	0.07	19.0
Biomass Carbon Compounds -									
<b>Total</b>	<b>19.2</b>	<b>60.6</b>	<b>31.5</b>	<b>13.1</b>	<b>5.2</b>	<b>1.0</b>	<b>11.7</b>	<b>7.06</b>	<b>17.0</b>
<b>Other Organics</b>									
All non-Film Plastic	1.9	5.9	0.2	1.9	2.0	0.0	22	1.30	22.0
Textiles	1.6	5.2	10	1.5	7.0	0.1	17.4	0.90	19.3
Film Plastic	1.0	3.2	0.2	1.0	3.0	0.0	45	1.46	45.1
Non-Biomass Carbon Compounds -									
<b>Total</b>	<b>4.5</b>	<b>14.3</b>	<b>3.7</b>	<b>4.4</b>	<b>4.0</b>	<b>0.2</b>	<b>25.6</b>	<b>3.66</b>	<b>26.5</b>
<b>Inorganic</b>									
Other C&D	1.7	5.2	-	1.7	100	1.7	-	-	-
Metal	1.4	4.4	-	1.4	100	1.4	-	-	-
Other Mixed and Mineralized	4.5	14.1	-	4.5	100	4.5	-	-	-
Glass	0.4	1.3	-	0.4	100	0.4	-	-	-
<b>Mineral Total</b>	<b>7.9</b>	<b>25.1</b>	<b>-</b>	<b>7.9</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>
<b>Total Landfilled MSW</b>	<b>31.7</b>	<b>100</b>	<b>20</b>	<b>25.5</b>	<b>29.4</b>	<b>9.3</b>	<b>10.7</b>	<b>10.7</b>	<b>13.3</b>

\* Total disposal shown here includes 1.6 million tons of green waste used as alternative daily cover (ADC) [included in the 'Prunings, trimmings, green ADC' row]. See <http://www.calrecycle.ca.gov/LGCentral/GoalMeasure/DisposalRate/Graphs/Disposal.htm> & <http://www.calrecycle.ca.gov/LGCentral/Reports/DRS/Default.aspx>

a) California waste stream composite data w/ green ADC added (<http://www.calrecycle.ca.gov/Publications/Detail.aspx?PublicationID=1346>),

b) Adapted from Tchobanalglous, G., Theisen, H. and Vigil, S. (1993), "Integrated Solid Waste Management", Chapter 4, McGraw-Hill, New York & Themelis, N. J., Kim, Y. H., and Brady, M. H. (2002). "Energy recovery from New York City municipal solid wastes." Waste Management & Research, 20(3), 223-233.

### 2.3.2. Biosolids

Organic solids or sludge resulting from waste water treatment are another source of biomass. Estimates of biosolids production were adapted from US EPA data for California reported by water treatment facility.<sup>17</sup> Biosolids generation and the amounts landfilled and diverted are listed in Tables 2.3.2 and 2.3.3. Of the diverted fraction, 80% is assumed to be technically available for conversion. The landfilled fraction is considered separately as unavailable to avoid double counting the resource in landfilled MSW.

#### Landfills and Waste Water Treatment Plants

Landfills generate a methane-rich biogas that in some instances is already being used for power generation and can be further developed. Some sewage and other waste water treatment facilities employ anaerobic digesters to stabilize a portion of the waste and also produce biogas. Though derived from the municipal waste resource, landfill gas and sewage digester gas are not included in Tables 2.3.2 and 2.3.3 but are instead included directly under the power generation estimates described later (Section 3.2.3).

<sup>17</sup> Fondahl, L.V. US Environmental Protection Agency, Region 9. (2013). Personal Communication

**Table 2.3.2. Gross biosolids and biomass in MSW (BDT/yr), 2013**

County Name	Biosolids Generation	Biosolids Landfilled	Biosolids Diverted	Total MSW Biomass Landfilled	Landfilled MSW Components						Est. MSW Biomass Diverted	
					Paper/ Cardboard	C&D Lumber	Leaves, Grass	Prunings & Trimmings	Branches & Stumps	Other Biomass (+Biosolids)		Food Waste
Alameda	33,000	15,000	-	466,000	178,000	145,900	17,380	19,950	4,120	47,200	53,200	464,000
Alpine	-	-	-	1,000	300	200	20	30	10	100	100	1,000
Amador	-	-	-	12,000	4,500	3,700	440	500	100	1,200	1,300	12,000
Butte	-	-	-	72,000	27,400	22,500	2,680	3,060	630	7,300	8,200	72,000
Calaveras	-	-	-	16,000	5,000	4,100	490	3,180	120	1,300	1,500	13,000
Colusa	-	-	-	7,000	2,700	2,200	270	280	60	700	800	7,000
Contra Costa	23,000	-	-	316,000	104,600	85,700	10,210	53,730	2,420	27,700	31,200	273,000
Del Norte	-	-	-	7,000	2,700	2,200	270	280	60	700	800	7,000
El Dorado	-	-	-	56,000	21,300	17,400	2,080	2,960	490	5,600	6,400	55,000
Fresno	19,000	-	-	280,000	107,300	87,900	10,470	11,860	2,480	28,400	32,000	280,000
Glenn	-	-	-	9,000	3,200	2,700	320	550	70	900	1,000	8,000
Humboldt	-	-	-	34,000	13,100	10,800	1,280	1,370	300	3,500	3,900	34,000
Imperial	-	-	-	92,000	31,800	26,000	3,100	12,000	730	8,400	9,500	83,000
Inyo	-	-	-	9,000	3,100	2,600	310	860	70	800	900	8,000
Kern	-	-	150,000	316,000	118,200	96,900	11,540	20,050	2,730	31,300	35,300	308,000
Kings	-	-	-	34,000	12,700	10,400	1,240	2,060	290	3,400	3,800	33,000
Lake	-	-	-	16,000	6,000	4,900	590	630	140	1,600	1,800	16,000
Lassen	-	-	-	7,000	2,800	2,300	280	290	70	700	800	7,000
Los Angeles	190,000	42,000	-	3,588,000	1,287,100	1,054,800	125,650	364,870	29,760	341,200	384,400	3,357,000
Madera	-	-	-	48,000	17,800	14,600	1,740	3,400	410	4,700	5,300	46,000
Marin	-	-	-	75,000	28,700	23,500	2,800	3,580	660	7,600	8,600	75,000
Mariposa	-	-	-	6,000	2,400	2,000	230	250	60	600	700	6,000
Mendocino	-	-	-	23,000	8,800	7,200	860	910	200	2,300	2,600	23,000
Merced	-	-	44,000	88,000	32,400	26,500	3,160	7,260	750	8,600	9,700	84,000
Modoc	-	-	-	2,000	800	700	80	90	20	200	300	2,000
Mono	-	-	-	10,000	3,300	2,700	320	2,020	80	900	1,000	9,000
Monterey	-	-	-	138,000	52,900	43,300	5,160	5,510	1,220	14,000	15,800	138,000
Napa	-	-	-	52,000	16,600	13,600	1,620	10,880	380	4,400	5,000	43,000
Nevada	-	-	-	28,000	10,700	8,800	1,050	1,120	250	2,800	3,200	28,000
Orange	58,000	-	-	1,439,000	429,400	351,900	41,920	364,200	9,930	113,800	128,200	1,120,000
Placer	-	-	-	99,000	37,900	31,100	3,700	3,970	880	10,100	11,300	99,000
Plumas	-	-	-	7,000	2,600	2,100	250	270	60	700	800	7,000
Riverside	34,000	-	-	749,000	287,000	235,200	28,010	30,060	6,630	76,100	85,700	748,000
Sacramento	23,000	-	22,000	478,000	173,300	142,000	16,920	43,930	4,010	45,900	51,800	452,000
San Benito	-	-	-	22,000	8,400	6,900	820	880	200	2,200	2,500	22,000
San Bernardino	30,000	-	39,000	654,000	245,500	201,200	23,970	39,250	5,680	65,100	73,300	640,000
San Diego	45,000	23,000	-	1,326,000	468,200	383,700	45,710	153,790	10,830	124,100	139,800	1,221,000
San Francisco	-	-	-	204,000	74,200	60,800	7,240	18,210	1,720	19,700	22,200	193,000
San Joaquin	-	-	-	250,000	95,700	78,400	9,340	10,290	2,210	25,400	28,600	250,000
San Luis Obispo	-	-	-	106,000	36,600	30,000	3,570	14,080	850	9,700	10,900	95,000
San Mateo	-	-	-	239,000	84,700	69,400	8,260	27,020	1,960	22,400	25,300	221,000
Santa Barbara	-	-	4,000	152,000	56,400	46,200	5,510	10,510	1,300	15,000	16,800	147,000
Santa Clara	54,000	68,000	-	473,000	176,400	144,600	17,220	31,030	4,080	46,800	52,700	460,000
Santa Cruz	-	-	-	66,000	25,200	20,600	2,460	2,620	580	6,700	7,500	66,000
Shasta	-	-	-	67,000	25,500	20,900	2,490	2,650	590	6,800	7,600	66,000
Sierra	-	-	-	1,000	400	300	40	40	10	100	100	1,000
Siskiyou	-	-	-	11,000	4,300	3,500	420	450	100	1,100	1,300	11,000
Solano	-	29,000	7,000	153,000	50,300	41,300	4,910	26,590	1,160	13,300	15,000	131,000
Sonoma	-	-	9,000	132,000	50,100	41,100	4,900	5,990	1,160	13,300	15,000	131,000
Stanislaus	-	-	-	92,000	35,300	28,900	3,440	3,670	820	9,300	10,500	92,000
Sutter	-	-	-	26,000	10,100	8,200	980	1,050	230	2,700	3,000	26,000
Tehama	-	-	-	18,000	7,100	5,800	690	730	160	1,900	2,100	18,000
Trinity	-	-	-	3,000	1,300	1,100	130	130	30	300	400	3,000
Tulare	-	-	-	130,000	49,000	40,100	4,780	7,070	1,130	13,000	14,600	128,000
Tuolumne	-	-	-	15,000	5,800	4,700	560	600	130	1,500	1,700	15,000
Ventura	-	14,000	-	331,000	123,500	101,200	12,060	21,540	2,860	32,800	36,900	322,000
Yolo	-	-	-	69,000	24,700	20,300	2,420	6,550	570	6,600	7,400	65,000
Yuba	-	-	-	26,000	10,100	8,200	980	1,050	230	2,700	3,000	26,000
Other- not locater	171,000	29,000	185,000	-	-	-	-	-	-	-	-	-
STATE TOTALS	680,000	220,000	460,000	13,100,000	4,700,000	3,900,000	460,000	1,360,000	109,000	1,200,000	1,400,000	12,300,000

**Table 2.3.3. Technical biosolids and biomass in MSW (BDT/yr), 2013**

County Name	Biosolids Generation	Biosolids Landfilled	Biosolids Diverted	Total MSW Biomass Landfilled	Landfilled MSW Components							Est. MSW Biomass Diverted
					Paper/Cardboard	C&D Lumber	Leaves, Grass	Prunings & Trimmings	Branches & Stumps	Other Biomass (+Biosolids)	Food Waste	
Alameda	12,000	12,000	-	312,053	119,260	97,753	11,645	13,367	2,760	31,624	35,644	-
Alpine	-	-	-	509	201	134	13	20	7	67	67	-
Amador	-	-	-	7,866	3,015	2,479	295	335	67	804	871	-
Butte	-	-	-	48,086	18,358	15,075	1,796	2,050	422	4,891	5,494	-
Calaveras	-	-	-	10,512	3,350	2,747	328	2,131	80	871	1,005	-
Colusa	-	-	-	4,697	1,809	1,474	181	188	40	469	536	-
Contra Costa	-	-	-	211,425	70,082	57,419	6,841	35,999	1,621	18,559	20,904	-
Del Norte	-	-	-	4,697	1,809	1,474	181	188	40	469	536	-
El Dorado	-	-	-	37,674	14,271	11,658	1,394	1,983	328	3,752	4,288	-
Fresno	-	-	-	187,875	71,891	58,893	7,015	7,946	1,662	19,028	21,440	-
Glenn	-	-	-	5,856	2,144	1,809	214	369	47	603	670	-
Humboldt	-	-	-	22,948	8,777	7,236	858	918	201	2,345	2,613	-
Imperial	-	-	-	61,325	21,306	17,420	2,077	8,040	489	5,628	6,365	-
Inyo	-	-	-	5,789	2,077	1,742	208	576	47	536	603	-
Kern	-	-	-	211,733	79,194	64,923	7,732	13,434	1,829	20,971	23,651	-
Kings	-	-	-	22,706	8,509	6,968	831	1,380	194	2,278	2,546	-
Lake	-	-	-	10,492	4,020	3,283	395	422	94	1,072	1,206	-
Lassen	-	-	-	4,851	1,876	1,541	188	194	47	469	536	-
Los Angeles	33,600	33,600	-	2,403,813	862,357	706,716	84,186	244,463	19,939	228,604	257,548	-
Madera	-	-	-	32,127	11,926	9,782	1,166	2,278	275	3,149	3,551	-
Marin	-	-	-	50,545	19,229	15,745	1,876	2,399	442	5,092	5,762	-
Mariposa	-	-	-	4,181	1,608	1,340	154	168	40	402	469	-
Mendocino	-	-	-	15,323	5,896	4,824	576	610	134	1,541	1,742	-
Merced	-	-	-	59,208	21,708	17,755	2,117	4,864	503	5,762	6,499	-
Modoc	-	-	-	1,467	536	469	54	60	13	134	201	-
Mono	-	-	-	6,914	2,211	1,809	214	1,353	54	603	670	-
Monterey	-	-	-	92,386	35,443	29,011	3,457	3,692	817	9,380	10,586	-
Napa	-	-	-	35,162	11,122	9,112	1,085	7,290	255	2,948	3,350	-
Nevada	-	-	-	18,706	7,169	5,896	704	750	168	1,876	2,144	-
Orange	-	-	-	964,365	287,698	235,773	28,086	244,014	6,653	76,246	85,894	-
Placer	-	-	-	66,297	25,393	20,837	2,479	2,660	590	6,767	7,571	-
Plumas	-	-	-	4,543	1,742	1,407	168	181	40	469	536	-
Riverside	-	-	-	501,629	192,290	157,584	18,767	20,140	4,442	50,987	57,419	-
Sacramento	-	-	-	320,166	116,111	95,140	11,336	29,433	2,687	30,753	34,706	-
San Benito	-	-	-	14,673	5,628	4,623	549	590	134	1,474	1,675	-
San Bernardino	-	-	-	438,180	164,485	134,804	16,060	26,298	3,806	43,617	49,111	-
San Diego	18,400	18,400	-	888,507	313,694	257,079	30,626	103,039	7,256	83,147	93,666	-
San Francisco	-	-	-	136,727	49,714	40,736	4,851	12,201	1,152	13,199	14,874	-
San Joaquin	-	-	-	167,460	64,119	52,528	6,258	6,894	1,481	17,018	19,162	-
San Luis Obispo	-	-	-	70,819	24,522	20,100	2,392	9,434	570	6,499	7,303	-
San Mateo	-	-	-	160,157	56,749	46,498	5,534	18,103	1,313	15,008	16,951	-
Santa Barbara	-	-	-	101,652	37,788	30,954	3,692	7,042	871	10,050	11,256	-
Santa Clara	54,400	54,400	-	316,796	118,188	96,882	11,537	20,790	2,734	31,356	35,309	-
Santa Cruz	-	-	-	43,992	16,884	13,802	1,648	1,755	389	4,489	5,025	-
Shasta	-	-	-	44,575	17,085	14,003	1,668	1,776	395	4,556	5,092	-
Sierra	-	-	-	663	268	201	27	27	7	67	67	-
Siskiyou	-	-	-	7,484	2,881	2,345	281	302	67	737	871	-
Solano	23,200	23,200	-	102,215	33,701	27,671	3,290	17,815	777	8,911	10,050	-
Sonoma	-	-	-	88,139	33,567	27,537	3,283	4,013	777	8,911	10,050	-
Stanislaus	-	-	-	61,593	23,651	19,363	2,305	2,459	549	6,231	7,035	-
Sutter	-	-	-	17,594	6,767	5,494	657	704	154	1,809	2,010	-
Tehama	-	-	-	12,382	4,757	3,886	462	489	107	1,273	1,407	-
Trinity	-	-	-	2,271	871	737	87	87	20	201	268	-
Tulare	-	-	-	86,886	32,830	26,867	3,203	4,737	757	8,710	9,782	-
Tuolumne	-	-	-	10,043	3,886	3,149	375	402	87	1,005	1,139	-
Ventura	11,200	11,200	-	221,676	82,745	67,804	8,080	14,432	1,916	21,976	24,723	-
Yolo	-	-	-	45,922	16,549	13,601	1,621	4,389	382	4,422	4,958	-
Yuba	-	-	-	17,594	6,767	5,494	657	704	154	1,809	2,010	-
Other- not locatec	23,200	23,200	-	-	-	-	-	-	-	-	-	-
STATE TOTALS	176,000	176,000	-	8,805,924	3,152,484	2,583,386	307,758	912,373	72,883	835,624	941,417	-



## **2.4. Dedicated Biomass Energy Crops**

Dedicated biomass energy crops are not currently grown to any significant extent in California. There is some potential that they will develop in combination with phytoremediation efforts for contaminated lands such as salt-affected soils in the San Joaquin Valley.<sup>18</sup> Sugar and starch crops may develop to support the production of ethanol and other biofuels and bioproducts. Residues from these crops could be used for power generation or the fuel products used directly. Dedicated crop production could lead to crop shifting on existing agricultural lands but might also be associated with more marginal lands.

## **2.5. Biomass Resource Summaries**

Gross and technical biomass resource potentials are summarized by principal resource categories in Tables 2.5.1 and 2.5.2 respectively. Quantities allocated to thermal and biological conversion for the purposes of estimating power generation potentials are also listed in the tables. Biomass associated with landfill gas to energy (LFGTE) and sewage digester gas from waste water treatment plants (WWTP) is not shown in the table but these categories appear in the power estimates shown later (see section 3.3).

---

<sup>18</sup> Jenkins, B.M., G. Sun, V. Cervinka, J. Faria, P. Thy, D.H. Kim, T.R. Rumsey and M.W. Yore. 2003. Salt separation and purification concepts in integrated farm drainage management systems. Paper No. 032236, ASAE, St. Joseph, Michigan.

**Table 2.5.1. Summary gross biomass resource potential (BDT/yr), 2013**

County Name	Total Biomass	Total for Thermal Conversion	Total for Biochemical Diversion	Biosolids Landfilled	Biosolids Diverted	Total MSW Biomass Landfilled	Total MSW Biomass Diverted	Total Animal Manure	Total Cattle manure	Dairy manure	Total Orchard and Vine	Total Field and Seed	Total Vegetable	Total Food Processing	Total Dedicated Forestry	Dedicated Crop
Alameda	991,000	878,420	127,450	15,000	-	466,000	464,000	32,700	32,700	-	4,000	950	100	370	23,000	-
Alpine	116,000	114,500	860	-	-	1,000	1,000	700	700	-	-	-	-	-	112,900	-
Amador	265,000	231,900	32,540	-	-	12,000	12,000	30,200	30,200	-	5,500	200	-	100	204,700	-
Butte	1,232,000	1,188,410	43,470	-	-	72,000	72,000	28,900	28,900	1,200	83,100	333,950	-	191,260	450,900	-
Calaveras	423,000	389,120	33,590	-	-	16,000	13,000	28,300	28,300	-	1,810	-	-	510	363,400	-
Colusa	1,036,000	986,330	50,020	-	-	7,000	7,000	30,300	30,300	-	55,300	557,690	18,310	266,840	93,900	-
Contra Costa	706,000	563,630	142,010	-	-	316,000	273,000	40,900	40,900	-	3,290	54,580	3,550	260	14,500	-
Del Norte	561,000	536,600	24,810	-	-	7,000	7,000	23,400	23,400	9,200	-	-	-	-	524,000	-
El Dorado	865,000	839,240	26,430	-	-	56,000	55,000	14,500	14,500	-	4,470	-	-	70	735,400	-
Fresno	3,767,000	2,593,820	1,173,140	-	-	280,000	280,000	877,100	723,300	390,400	496,680	227,020	239,230	755,020	611,500	-
Glenn	850,000	719,250	130,610	-	-	9,000	8,000	128,500	128,500	57,900	63,290	359,500	170	171,960	109,700	-
Humboldt	2,997,000	2,874,640	122,350	-	-	34,000	34,000	115,500	115,500	44,200	-	-	-	440	2,812,800	-
Imperial	1,117,000	573,450	543,110	-	-	92,000	83,000	421,000	421,000	16,100	4,060	237,160	96,780	2,230	180,800	-
Inyo	587,000	553,540	33,140	-	-	9,000	8,000	31,000	31,000	-	50	190	-	-	538,800	-
Kern	3,198,000	2,278,340	919,530	-	150,000	316,000	308,000	817,200	817,200	578,400	349,660	140,140	32,710	660,940	423,200	-
Kings	1,524,000	566,280	957,210	-	-	34,000	33,000	887,800	877,600	610,600	62,730	283,820	62,020	157,830	2,400	-
Lake	490,000	479,230	10,400	-	-	16,000	16,000	7,200	7,200	-	16,030	1,800	40	3,900	429,000	-
Lassen	940,000	854,950	85,240	-	-	7,000	7,000	83,800	83,800	-	-	9,810	-	1,240	831,100	-
Los Angeles	7,235,000	6,363,570	913,160	42,000	-	3,588,000	3,357,000	8,400	8,400	-	650	530	80	4,090	276,200	-
Madera	1,360,000	943,570	416,130	-	-	48,000	46,000	399,300	384,500	251,900	213,100	13,340	5,980	335,330	298,700	-
Marin	286,000	191,360	94,630	-	-	75,000	75,000	77,900	77,900	26,800	230	-	1,090	3,830	52,500	-
Mariposa	280,000	252,840	27,540	-	-	6,000	6,000	26,300	26,300	-	140	-	-	-	241,700	-
Mendocino	2,874,000	2,834,210	40,080	-	-	23,000	23,000	35,100	35,100	2,700	24,420	-	410	2,790	2,765,700	-
Merced	2,279,000	890,550	1,388,430	-	44,000	88,000	84,000	1,321,900	1,261,400	908,800	117,160	209,350	45,660	364,240	4,300	-
Modoc	636,000	520,700	115,330	-	-	2,000	2,000	106,800	106,800	-	-	21,400	8,040	-	495,600	-
Mono	231,000	216,400	14,540	-	-	10,000	9,000	10,900	10,900	-	30	170	220	-	200,300	-
Monterey	1,074,000	635,120	438,610	-	-	138,000	138,000	97,700	97,700	2,000	57,130	14,680	313,220	74,410	240,700	-
Napa	381,000	353,150	28,410	-	-	52,000	43,000	10,500	10,500	-	56,950	-	30	7,900	210,700	-
Nevada	500,000	484,850	15,220	-	-	28,000	28,000	9,600	9,600	-	550	-	-	-	434,000	-
Orange	2,594,000	2,048,650	545,820	-	-	1,439,000	1,120,000	500	500	-	50	-	1,070	1,500	32,000	-
Placer	695,000	660,320	34,500	-	-	99,000	99,000	14,600	14,600	1,000	1,260	50,170	50	12,090	418,700	-
Plumas	1,000,000	979,800	19,780	-	-	7,000	7,000	18,400	18,400	-	-	-	-	-	967,400	-
Riverside	2,293,000	1,912,870	379,760	-	-	749,000	748,000	196,200	178,700	136,100	34,160	57,070	33,160	9,740	465,600	-
Sacramento	1,304,000	1,059,630	244,080	-	22,000	478,000	452,000	122,900	116,300	50,400	45,480	161,970	4,520	16,080	900	-
San Benito	232,000	139,930	92,040	-	-	22,000	22,000	60,800	60,800	-	7,960	780	26,840	9,590	82,100	-
San Bernardino	2,763,000	2,285,700	477,740	-	39,000	654,000	640,000	333,000	297,400	187,100	3,340	20	2,540	140	1,091,400	-
San Diego	3,098,000	2,715,450	405,210	23,000	-	1,326,000	1,221,000	48,600	27,100	6,400	32,590	3,260	6,480	-	459,600	-
San Francisco	397,000	347,700	49,370	-	-	204,000	193,000	-	-	-	-	-	-	-	-	-
San Joaquin	1,910,000	1,250,630	658,820	-	-	250,000	250,000	540,400	519,100	333,600	230,980	348,950	67,980	216,800	4,400	-
San Luis Obispo	637,000	459,740	176,540	-	-	106,000	95,000	113,300	113,300	-	56,520	7,820	33,840	4,700	219,400	-
San Mateo	576,000	507,470	68,650	-	-	239,000	221,000	4,400	4,400	-	310	760	1,710	-	108,900	-
Santa Barbara	729,000	548,060	181,060	-	4,000	152,000	147,000	72,100	72,100	-	39,590	4,210	74,840	3,260	232,400	-
Santa Clara	1,173,000	1,085,140	155,450	68,000	-	473,000	460,000	40,800	40,300	17,000	2,990	6,930	9,620	1,720	177,700	-
Santa Cruz	387,000	351,340	35,080	-	-	66,000	66,000	5,100	5,100	-	4,210	-	16,820	830	227,800	-
Shasta	1,754,000	1,679,090	74,920	-	-	67,000	66,000	61,300	61,300	-	930	17,200	290	4,860	1,536,900	-
Sierra	315,000	301,400	13,790	-	-	1,000	1,000	13,600	13,600	-	-	-	-	-	299,600	-
Siskiyou	2,481,000	2,359,090	122,020	-	-	11,000	11,000	108,100	108,100	2,400	10	51,180	11,650	-	2,288,000	-
Solano	551,000	409,360	169,700	29,000	7,000	153,000	131,000	94,900	94,900	10,200	15,670	95,060	27,140	21,730	5,000	-
Sonoma	1,242,000	1,019,700	221,800	-	9,000	132,000	131,000	194,100	184,500	91,900	81,530	670	650	8,800	684,200	-
Stanislaus	1,975,000	891,790	1,082,640	-	-	92,000	92,000	1,027,600	901,400	625,900	200,460	23,180	36,610	475,550	27,100	-
Sutter	689,000	658,540	30,700	-	-	26,000	26,000	14,300	14,300	1,700	50,360	442,920	11,140	118,260	-	-
Tehama	799,000	681,260	117,760	-	-	18,000	18,000	113,900	113,900	11,700	38,660	12,340	180	35,260	562,200	-
Trinity	1,852,000	1,841,350	10,590	-	-	3,000	3,000	9,900	9,900	-	150	-	-	-	1,835,500	-
Tulare	3,702,000	1,304,470	2,397,460	-	-	130,000	128,000	2,363,000	2,332,900	1,650,200	307,810	146,010	6,880	132,550	488,000	-
Tuolumne	600,000	564,970	34,810	-	-	15,000	15,000	31,800	17,100	-	270	-	20	-	537,700	-
Ventura	897,000	767,970	143,250	14,000	-	331,000	322,000	11,500	11,500	-	33,980	4,230	58,390	9,160	127,100	-
Yolo	772,000	682,380	88,920	-	-	69,000	65,000	18,200	18,200	3,400	47,740	390,670	53,780	89,870	37,500	-
Yuba	425,000	391,750	33,660	-	-	26,000	26,000	28,400	28,400	9,100	22,120	118,000	-	38,530	166,100	-
Other- not located	992,000	352,980	668,280	29,000	185,000	-	-	286,700	98,600	-	40,430	90,450	65,720	323,960	-	-
STATE Total	77,900,000	61,167,000	16,682,000	220,000	460,000	13,100,000	12,300,000	11,650,000	10,940,000	6,040,000	2,920,000	4,500,000	1,380,000	4,541,000	26,800,000	-

**Table 2.5.2. Summary technical biomass resource potential (BDT/yr), 2013**

County Name	Total Biomass	Total for Thermal Conversion	Total for Biochemical Diversion	Biosolids Landfilled	Biosolids Diverted	Total MSW Biomass Landfilled	Total MSW Biomass Diverted	Total Animal Manure	Total Cattle manure	Dairy manure	Orchard and Vine	Total Field and Seed	Total Vegetable	Total Food Processing	Total Forestry	Total Dedicated Crop
Alameda	343,000	288,700	53,800	12,000	-	312,053	-	6,500	6,500	-	2,800	480	-	300	8,400	-
Alpine	33,000	33,000	200	-	-	509	-	100	100	-	-	-	-	-	32,600	-
Amador	161,000	153,900	7,200	-	-	7,866	-	6,000	6,000	-	3,900	100	-	80	143,100	-
Butte	726,000	712,200	13,400	-	-	48,086	-	6,100	6,100	600	58,100	165,830	-	153,010	294,500	-
Calaveras	268,000	261,200	6,900	-	-	10,512	-	5,600	5,600	-	1,300	-	-	410	250,300	-
Colusa	593,000	586,000	6,800	-	-	4,697	-	6,100	6,100	-	38,700	271,580	-	213,480	58,300	-
Contra Costa	254,000	218,400	35,900	-	-	211,425	-	8,200	8,200	-	2,300	27,150	-	210	5,100	-
Del Norte	169,000	161,400	8,100	-	-	4,697	-	7,400	7,400	4,600	-	-	-	-	157,400	-
El Dorado	589,000	580,400	8,600	-	-	37,674	-	2,900	2,900	-	3,000	-	-	60	545,300	-
Fresno	1,847,000	1,479,500	367,200	-	-	187,875	-	338,700	261,800	195,200	347,600	109,380	-	604,000	259,100	-
Glenn	467,000	423,100	44,000	-	-	5,856	-	43,100	43,100	29,000	44,400	175,790	-	137,570	60,400	-
Humboldt	1,373,000	1,333,300	39,800	-	-	22,948	-	36,300	36,300	22,100	-	-	-	350	1,313,500	-
Imperial	390,000	292,900	97,400	-	-	61,325	-	89,000	89,000	8,100	2,800	93,050	-	1,780	142,400	-
Inyo	147,000	140,300	7,000	-	-	5,789	-	6,200	6,200	-	40	10	-	-	135,300	-
Kern	1,616,000	1,247,800	368,300	-	-	211,733	-	336,900	336,900	289,200	244,760	61,880	-	528,760	232,000	-
Kings	695,000	328,300	367,200	-	-	22,706	-	363,800	358,700	305,300	43,920	137,750	-	126,270	1,000	-
Lake	292,000	289,200	3,000	-	-	10,492	-	1,400	1,400	-	11,220	900	-	3,120	265,100	-
Lassen	714,000	696,400	17,400	-	-	4,851	-	16,700	16,700	-	-	4,910	-	990	686,400	-
Los Angeles	2,568,000	2,224,900	343,300	33,600	-	2,403,813	-	1,600	1,600	-	460	270	-	3,270	125,200	-
Madera	810,000	645,000	164,600	-	-	32,127	-	159,900	152,500	126,000	149,170	6,680	-	268,260	193,500	-
Marin	103,000	72,000	31,200	-	-	50,545	-	23,600	23,600	13,400	160	-	-	3,060	25,900	-
Mariposa	171,000	165,200	5,900	-	-	4,181	-	5,300	5,300	-	100	-	-	-	161,500	-
Mendocino	1,285,000	1,274,500	10,200	-	-	15,323	-	7,900	7,900	1,400	17,090	-	-	2,230	1,242,200	-
Merced	1,083,000	518,700	563,800	-	-	59,208	-	555,200	524,900	454,400	82,020	92,180	-	291,400	2,500	-
Modoc	457,000	435,300	21,700	-	-	1,467	-	21,400	21,400	-	-	8,370	-	-	425,700	-
Mono	111,000	108,100	3,100	-	-	6,914	-	2,200	2,200	-	20	10	-	-	102,000	-
Monterey	313,000	278,800	34,200	-	-	92,386	-	20,200	20,200	1,000	39,990	5,320	-	59,530	95,600	-
Napa	215,000	208,200	6,500	-	-	35,162	-	2,100	2,100	-	39,870	-	-	6,320	131,300	-
Nevada	330,000	325,200	4,700	-	-	18,706	-	1,900	1,900	-	390	-	-	-	309,000	-
Orange	976,000	861,700	114,100	-	-	964,365	-	100	100	-	40	-	-	1,200	10,100	-
Placer	357,000	344,200	13,300	-	-	66,297	-	3,200	3,200	500	880	25,090	-	9,670	252,300	-
Plumas	675,000	670,600	4,400	-	-	4,543	-	3,700	3,700	-	-	-	-	-	666,800	-
Riverside	872,000	710,300	161,600	-	-	501,629	-	85,400	76,600	68,100	23,910	24,490	-	7,790	228,700	-
Sacramento	485,000	397,200	87,700	-	-	320,166	-	41,700	38,400	25,200	31,840	77,680	-	12,860	700	-
San Benito	83,000	68,300	14,400	-	-	14,673	-	12,200	12,200	-	5,570	110	-	7,670	42,500	-
San Bernardino	1,214,000	1,015,000	198,700	-	-	438,180	-	133,500	115,700	93,600	2,350	10	-	110	639,500	-
San Diego	1,200,000	1,057,400	142,400	18,400	-	888,507	-	18,100	7,300	3,200	22,820	1,430	-	-	250,500	-
San Francisco	137,000	117,000	19,700	-	-	136,727	-	-	-	-	-	-	-	-	-	-
San Joaquin	888,000	647,500	240,000	-	-	167,460	-	214,600	203,900	166,800	161,700	167,910	-	173,440	2,400	-
San Luis Obispo	263,000	230,600	32,400	-	-	70,819	-	22,700	22,700	-	39,550	3,800	-	3,760	122,400	-
San Mateo	199,000	175,300	23,400	-	-	160,157	-	900	900	-	220	140	-	-	37,300	-
Santa Barbara	230,000	200,400	29,300	-	-	101,652	-	14,400	14,400	-	27,710	520	-	2,610	82,900	-
Santa Clara	463,000	403,000	60,300	54,400	-	316,796	-	13,500	13,200	8,500	2,090	2,840	-	1,380	72,300	-
Santa Cruz	148,000	139,800	7,700	-	-	43,992	-	1,000	1,000	-	2,960	-	-	660	98,900	-
Shasta	968,000	948,700	19,000	-	-	44,575	-	12,200	12,200	-	650	8,600	-	3,880	897,800	-
Sierra	197,000	193,800	2,800	-	-	663	-	2,700	2,700	-	-	-	-	-	193,200	-
Siskiyou	1,143,000	1,119,400	23,600	-	-	7,484	-	22,400	22,400	1,200	10	22,050	-	-	1,091,000	-
Solano	222,000	186,200	35,400	23,200	-	102,215	-	22,100	22,100	5,100	10,970	42,710	-	17,380	3,100	-
Sonoma	560,000	477,700	82,600	-	-	88,139	-	69,300	64,500	46,000	57,080	340	-	7,040	338,400	-
Stanislaus	1,031,000	590,800	440,500	-	-	61,593	-	431,200	368,100	313,000	140,330	5,780	-	380,440	12,000	-
Sutter	367,000	360,600	6,100	-	-	17,594	-	3,400	3,400	900	35,250	215,830	-	94,620	-	-
Tehama	436,000	407,400	28,200	-	-	12,382	-	26,300	26,300	5,900	27,070	6,110	-	28,210	335,500	-
Trinity	744,000	741,300	2,300	-	-	2,271	-	1,900	1,900	-	110	-	-	-	739,300	-
Tulare	1,655,000	665,000	989,800	-	-	86,886	-	976,800	961,700	825,100	215,450	69,600	-	106,030	200,000	-
Tuolumne	384,000	371,900	12,300	-	-	10,043	-	10,800	3,400	-	190	-	-	-	363,200	-
Ventura	301,000	266,200	35,100	11,200	-	221,676	-	2,300	2,300	-	23,780	860	-	7,330	34,200	-
Yolo	360,000	348,700	11,300	-	-	45,922	-	4,700	4,700	1,700	33,420	181,510	-	71,890	22,500	-
Yuba	255,000	243,800	11,100	-	-	17,594	-	8,400	8,400	4,600	15,490	59,000	-	30,820	123,600	-
Other- not located	458,000	96,600	361,500	23,200	-	-	-	108,800	19,700	-	28,280	38,660	-	259,170	-	-
STATE Total	35,400,000	29,538,000	5,852,000	176,000	-	8,805,924	-	4,351,000	4,000,000	3,020,000	2,044,000	2,116,000	-	3,632,000	14,300,000	-

### 3. Power and Energy Generation Potentials

Estimates of gross and technical energy and electric power potential from biomass were developed from the resource projections. Principal means of converting biomass to electricity today are direct combustion steam cycles and anaerobic digesters or landfills fueling engines and boilers. Many different types of thermal and biological systems for converting biomass are in development. For this assessment, energy and power potentials were developed for each biomass type by assignment to either generic thermal or biological conversion using the methods outlined below. This classification reflects general trends based on moisture content and current perceived waste disposal practices.

#### 3.1. Energy and Power Capacities

Electric power generation capacities were derived from energy in biomass, landfill gas, or digester gas according to:

$$M_i = \left[ \frac{E_i \eta_i}{8760 h_i} \right] \quad [3]$$

where

- $M_i$  = power generation capacity from biomass type  $i$  (MWe)
  - $E_i$  = annual energy (total heating value) in biomass type  $i$  (MWh  $y^{-1}$ )
  - $\eta_i$  = overall net generation efficiency for biomass type  $i$  (--)
  - $h_i$  = power plant capacity factor for biomass type  $i$  (--)
- and 8760 is the number of hours in the year.

The energy in biomass was determined from gross and technical resource potentials:

$$E_i = \frac{1}{3.6} [q_i Q_i] \quad [4]$$

- $q_i$  = dry mass of biomass type  $i$  produced (Mg  $y^{-1}$ , Mg = metric ton)
  - $Q_i$  = higher heating value of biomass type  $i$  (MJ  $kg^{-1}$  dry basis)
- and the factor 1/3.6 is a conversion factor (MWh  $kg$   $y$   $Mg^{-1}$   $MJ^{-1}$ )

Alternatively, for input in conventional units,

$$E_i = 5.861 \times 10^{-4} [q_i Q_i] \quad [4a]$$

- $q_i$  = dry mass of biomass type  $i$  produced (BDT/ $y$ )
- $Q_i$  = constant volume higher heating value of biomass type  $i$  (Btu/lb dry basis)

For landfill gas and digester gas, the annual energy in Equation [3] was replaced with equation [4b] or [4c]:

$$E_{gas} = \frac{1}{3600} [q_{gas} Q_{gas}] \quad [4b]$$

$q_{gas}$  = volume of gas produced ( $m^3 y^{-1}$ )  
 $Q_{gas}$  = volumetric constant pressure higher heating value of gas ( $MJ m^{-3}$ )  
 and the factor  $1/3600$  is a conversion factor ( $h s^{-1}$  or  $MWh MJ^{-1}$ )  
 or in conventional units,

$$E_{gas} = 2.931 \times 10^{-7} [q_{gas} Q_{gas}] \quad [4c]$$

$q_{gas}$  = volume of gas produced ( $ft^3/y$ )  
 $Q_{gas}$  = volumetric constant pressure higher heating value of gas ( $Btu/ft^3$ )

## 3.2 Generation Potentials

### 3.2.1. Thermal and Biological Conversion Classifications

Biomass assigned to thermal and biological conversion categories varies for the gross and technical analyses (Table 3.2.1.1). The conversion assumptions are described in more detail under section 3.2.3.

### 3.2.2. Heating Values

Higher heating values (energy contents) used in the analysis are listed according to biomass type in Tables 3.2.2.1 – 3.2.2.7.<sup>19</sup> All values listed are dry basis. The reporting precision varies based on whether biomass-specific data were available or utilized. Where specific data were not available, approximate values based on related materials were utilized. For woods, a value of  $20 MJ kg^{-1}$  or  $8597 Btu/lb$  was used, for vegetative matter (e.g., vegetable crop residues) a value of  $18 MJ kg^{-1}$  or  $7738 Btu/lb$  was used.

---

<sup>19</sup> Specific data are from Jenkins, B.M, 1993, Properties of biomass, Vol. 2, EPRI TR102107, Electric Power Research Institute, Palo Alto, CA; the Phyllis on-line database of biomass properties: <http://www.ecn.nl/phyllis/>; Themelis, N. J., Kim, Y. H., and Brady, M. H., 2002, Energy recovery from New York City municipal solid wastes, Waste Management and Research, 20(3), 223-233; and Tchobanoglous, G., Theisen, H. and Vigil, S., 1993, Integrated Solid Waste Management, Chapter 4, McGraw-Hill, New York.

**Table 3.2.1.1. Conversion classifications for gross and technical power potentials.**

Resource Category	Gross Potential	Technical Potential
Biosolids: landfilled	Included in MSW Other Landfilled	Included in MSW Other Landfilled
Biosolids: diverted	Thermochemical	Thermochemical
MSW: Waste in-place (2003)	Landfill gas	Landfill gas
MSW: paper/cardboard landfilled	Thermochemical	Landfill gas
MSW: lumber landfilled	Thermochemical	Landfill gas
MSW: leaves, grass, trimmings landfilled (green waste)	Biochemical	Landfill gas
MSW: other landfilled	Thermochemical	Landfill gas
MSW: food waste landfilled	Biochemical	Landfill gas
MSW: diverted	Thermochemical	Thermochemical
Animal manure	Biochemical	Biochemical
Orchard and Vineyard	Thermochemical	Thermochemical
Field and Seed	Thermochemical	Thermochemical
Food Processing-meat	Biochemical	Biochemical
Food Processing-others	Thermochemical	Thermochemical
Forest	Thermochemical	Thermochemical

**Table 3.2.2.1. Higher heating values of orchard and vineyard residues**

Orchard and Vineyard Residues	Higher Heating Value	
	(MJ/kg dry basis)	(Btu/lb dry basis)
Apples	20	8597
Apricots	20	8597
Avocados	20	8597
Cherries	20	8597
Dates	20	8597
Figs	20	8597
Grapes	19	8168
Kiwifruit	20	8597
Nectarines	20	8597
Olives	20	8597
Peaches	20	8597
Pears	20	8597
Persimmons	20	8597
Plums & Prunes	20	8597
Pomegranates	20	8597
All Citrus	20	8597
Almonds	20	8597
Pecans	20	8597
Pistachios	20	8597
Walnuts	20	8597
Fruits & Nuts, unspecified	20	8597

**Table 3.2.2.2. Higher heating values of field and seed crop residues.**

Field and Seed Crop Residues	Higher Heating Value	
	(MJ/kg dry basis)	(Btu/lb dry basis)
Corn	17.65	7587
Sorghum	15.4	6620
Wheat	17.51	7527
Barley	17.31	7441
Oats	17	7308
Rice	16.28	6998
Safflower	19.23	8266
Sunflower	18	7738
Cotton	18.26	7849
Beans	17.46	7506
Lima Beans	17.46	7506
Cowpeas & Southern Peas	17.46	7506
Potatoes	18	7738
Sweetpotatoes	18	7738
Sugar Beets	18	7738
Unspecified Field & Seed	18	7738
Alfalfa Seed	18.45	7931
Bermuda Grass Seed	18	7738

**Table 3.2.2.3. Higher heating values of vegetable crop residue.**

Vegetable Crop Residues	Higher Heating Value	
	(MJ/kg dry basis)	(Btu/lb dry basis)
Artichokes	18	7738
Asparagus	18	7738
Green Lima Beans	18	7738
Berries	18	7738
Snap Beans	18	7738
Broccoli	18	7738
Cabbage	18	7738
Cantaloupe Melons	18	7738
Carrots	18	7738
Cauliflower	18	7738
Celery	18	7738
Cucumbers	18	7738
Garlic	18	7738
Honeydew Melons	18	7738
Lettuce and Romaine	18	7738
Dry Onions	18	7738
Green Onions	18	7738
Hot Peppers	18	7738
Sweet Peppers	18	7738
Spices & herbs	18	7738
Spinach	18	7738
Squash	18	7738
Sweet Corn	18	7738
Tomatoes	18	7738
Unspecified vegetables	18	7738

**Table 3.2.2.4. Higher heating values of food processing residue.**

Food Processing Residues	Higher Heating Value	
	(MJ/kg dry basis)	(Btu/lb dry basis)
Almond Shell	19.38	8331
Almond Hull	18.2	7824
Walnut Shell	20.18	8675
Cannery Residue	15	6448
Dehyd. Fruit & Veg.	15	6448
Fresh/froz. Fruit & Veg.	15	6448
Winery	15.4	6620
Rice Hull	16.14	6938
Cotton Gin Waste	16.42	7058
Meat Processing	20	8597



**Table 3.2.2.5. Higher heating values of animal manures.**

Animal Manures	Higher Heating Value	
	(MJ/kg dry basis)	(Btu/lb dry basis)
Beef Cow Manure	17.25	7414
Milk Cow Manure	17.00	7308
Other Cattle Manure	16.66	7161
Swine	15.91	6839
Poultry Layer Chickens	15.50	6663
Poultry Broiler Chickens	15.91	6839
Poultry Turkeys	15.65	6727

**Table 3.2.2.6. Higher heating values of forest and dedicated crop biomass.**

Forestry and Dedicated Crops	Higher Heating Value	
	(MJ/kg dry basis)	(Btu/lb dry basis)
Forest Thinnings and Slash	21	9027
Forest Other	20	8597
Chaparral	18.61	8000
Mill Residue	20	8597
Dedicated Biomass Crops	19	8168

**Table 3.2.2.7. Higher heating values of municipal waste biomass.**

Municipal Wastes	Higher Heating Value	
	(MJ/kg dry basis)	(Btu/lb dry basis)
Biosolids Landfilled	15.4	6620
Biosolids Diverted	15.4	6620
Paper/Cardboard Landfilled	17.8	7642
C&D Lumber Landfilled	19.3	8304
Leaves, Grass, Prunings, Trimmings, Stumps Landfilled	15.0	6448
Other Composite Landfilled	8.9	3806
Food Waste Landfilled	14.0	6018
MSW Biomass Diverted	16.7	7179

Heating values for animal manures were derived from a regression model based on ash content,<sup>20</sup> but were developed along with conversion efficiencies for the purposes of applying a consistent computational methodology to the resource data using total solids. Generation potential was actually derived from considerations of the biodegradability of the volatile solids (organic) fraction via anaerobic digestion by manure type as described below under conversion efficiencies. Similar methodology was employed for certain fractions of the MSW disposal stream (as diverted to a conversion technology), landfill gas and sewage digester gas.

### 3.2.3. Conversion Efficiency Assumptions and Biogas Production Estimates

#### Thermal Conversion Systems

Net generation efficiencies,  $\eta_i$ , for thermal conversion was assumed to be 20% (higher heating value basis) or 17,064 Btu/kWh heat rate. Increasing additions of small modular and other distributed technologies operating at lower electrical efficiencies but at improved economies compared with larger centralized facilities could lead to lower aggregate electrical efficiencies. Smaller systems will not necessarily operate at lower efficiencies, and in combined heat and power installations overall conversion efficiencies will typically be substantially higher than independent power generation at any scale. For these reasons, the estimates of gross and technical power generation reported here should be used only as order of magnitude measures of potential.

#### Bioconversion Systems

Gross and technical electric capacity for biogas systems is based on biogas production potentials (gross and technical) and electricity conversion efficiency of 30% and annual capacity factor of 85%. Biogas production potential for animal manures, landfills, wastewater treatment plants, and food and green waste components of MSW are discussed below.

#### Animal Manures

Net efficiencies for animal manure bioconversion systems were derived on the basis of the biodegradability of the volatile solids fraction of the biomass. Theoretical yield of biogas was assumed to be 12 ft<sup>3</sup>/lb of VS destroyed (0.75 m<sup>3</sup> kg<sup>-1</sup> of VS destroyed). Methane content in biogas from manure systems was assumed to be 60%.

Biodegradable fractions for animal manures vary from 0.45 for cattle to 0.76 for poultry (Table 3.2.3.1).<sup>21</sup> The biodegradable fraction is expressed as the ratio of volatile solids destroyed per unit volatile solids in the biomass (lb VS destroyed/lb VS). Overall conversion efficiencies assume a biogas heating value of 600 Btu/ft<sup>3</sup> (22.4 MJ m<sup>-3</sup>) and a biogas to electricity conversion efficiency of 30% (heat rate of 11,373 Btu/kWh). The conversion assumptions are equivalent to biomethane potentials of 3.2 to 5.5 ft<sup>3</sup> CH<sub>4</sub>/lb VS (0.20 – 0.34 m<sup>3</sup> CH<sub>4</sub> kg<sup>-1</sup> VS). By comparison, the theoretical biomethane potential of glucose is 6.0 ft<sup>3</sup> CH<sub>4</sub>/lb (0.37 m<sup>3</sup> CH<sub>4</sub> kg<sup>-1</sup>) and 6.6 ft<sup>3</sup> CH<sub>4</sub>/lb (0.42 m<sup>3</sup> CH<sub>4</sub> kg<sup>-1</sup>) for cellulose (with the addition of 1 mole of water per mole cellulose). The assumption of a constant biogasification rate of 12 ft<sup>3</sup>/lb VS destroyed may tend to overestimate at higher biodegradabilities although the estimate is likely good within an overall error of 30% and the methane potentials are consistent with the biodegradability source data. Resulting power generation per animal ranges from about 1 We for chickens to nearly 190 We for dairy cattle (Table 3.2.3.1).

<sup>20</sup> Jenkins, B.M, 1993, Properties of biomass, Vol. 2, EPRI TR102107, Electric Power Research Institute, Palo Alto, CA

<sup>21</sup> Loehr, R.C. 1984. Pollution control for agriculture. Academic Press, Orlando.

**Table 3.2.3.1. Biodegradability and overall conversion efficiencies for animal manures.**

Manure Type	TS (lb/animal-day)	Ratio VS/TS (%)	Biodegradable fraction (–)	Biogas Production Potential (cu. ft./animal-day)	Ave. Power per Animal (We), cap. factor = 1	Overall Bioconversion-to-Electricity Efficiency (%)
Milk Cow	18.7	84.9	0.45	85.5	187.9	11.3
Beef Cow	15.0	86.7	0.45	70.2	154.3	11.4
Other Cattle	6.0	83.3	0.45	27.0	59.3	11.3
Swine	1.0	85.0	0.73	7.4	16.4	19.6
Poultry Layer Chickens	0.05	73.5	0.76	0.3	0.7	18.1
Poultry Broiler Chickens	0.06	75.0	0.76	0.4	0.9	18.0
Poultry Turkeys	0.15	80.0	0.76	1.1	2.4	19.5

### Landfill Gas

Landfill gas generation is dependent on past waste disposal practices including amount and when disposed. A model similar to the LandGEM model developed by USEPA<sup>22</sup> was used to estimate gross and technically recoverable landfill gas from waste-in-place (WIP) data.

The model assumes a first order decay of waste beginning the first year after placement. The gas generation rate,  $g_n$  (ft<sup>3</sup>/y or m<sup>3</sup> y<sup>-1</sup>), as a function of time for waste placed in the landfill in any year  $n$  is

$$g_n = W_n L e^{-kt} \quad [5]$$

$W_n$  = quantity of waste placed in year  $n$  (wet tons or Mg (megagrams or metric ton))

$L$  = methane generation potential factor (ft<sup>3</sup>/ton-y or m<sup>3</sup> Mg<sup>-1</sup> y<sup>-1</sup>)

$k$  = rate constant (y<sup>-1</sup>)

$t$  = time from base year (y)

Total gas generation,  $g_t$  (ft<sup>3</sup>/y or m<sup>3</sup> y<sup>-1</sup>), is the sum overall years up to the current year as shown by equation [6].

$$g_t = \sum_n g_n = L \sum_n W_n e^{-kt} \quad [6]$$

Total waste-in-place (disposal) is estimated to be 1.4 billion tons (which includes 823 million tons since 1990 and an estimated 600 million tons between approximately 1940 and 1990). Gross statewide landfill gas generation is estimated here for 1.2 billion tons of waste-in-place for the period 1970 – 2012. Waste disposal was estimated from statewide population and per capita disposal rates for years 1970-1990. Actual disposal data were used for the period between 1990 and 2012 (CalRecycle).

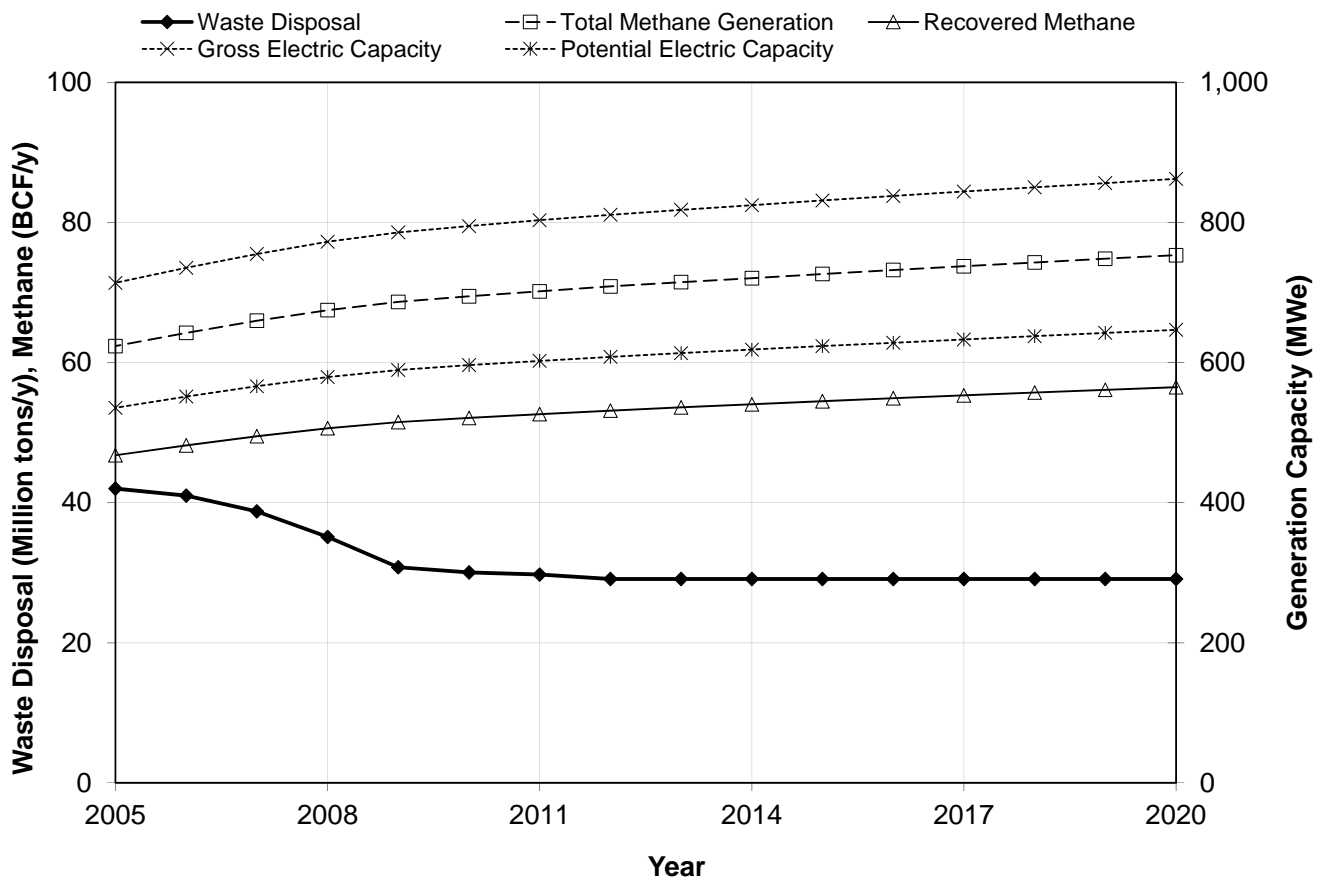
The parameters for the model (Eq. 5) are based on USEPA AP-42<sup>23</sup> recommendations for  $k = 0.025$  y<sup>-1</sup> (for regions w/ rainfall < 25 inches per year) and  $L = 2.53$  m<sup>3</sup> Mg<sup>-1</sup> y<sup>-1</sup> yielding an ultimate methane generation potential of 100 m<sup>3</sup>/Mg (3,200 ft<sup>3</sup>/ton) for disposed material over a 150 year period.<sup>24</sup>

<sup>22</sup> Alexander, A., C. Burklin and A. Singleton (2005). Landfill Gas Emissions Model (LandGEM) Version 3.02 User's Guide, Eastern Research Group, Morrisville, NC. Contractor Report to USEPA. EPA-600/R-05/047.. & (2008). Background Information Document for Updating AP42 Section 2.4 Municipal Solid Waste Landfills. Contractor Report to USEPA, Eastern Research Group, Inc. EPA/600/R-08-116.

Net, or technically recoverable, landfill gas is assumed to be 75% of gross. Gross and technical electric capacity is based on biogas to electricity conversion efficiency of 30% and annual capacity factor of 85%.

Total and net recoverable landfill methane is estimate to be 70.9 and 53.1 billion cubic feet per year (bcf y<sup>-1</sup>), respectively. Corresponding gross and technical electrical generation capacity is 811 and 608 MWe respectively (Table 3.2.3.2).

The total methane and energy generation potential for California conventional landfilling assuming no change in the current waste disposal is projected in Figure 3.2.3.1.



**Figure 3.2.3.1. Electricity generation potential from conventional landfill gas in California. \***

\*Model estimates based on first order decay of waste using USEPA AP-42 parameters (methane generation potential = 100 m<sup>3</sup>/Mg, methane generation rate constant k = 0.025 y<sup>-1</sup>) for disposal post-1970. Gross electric capacity based on total methane generation, 30% methane conversion efficiency, and 85% capacity factor. Potential electric capacity assumes 75% methane recovery (recovered methane), 30% electrical conversion efficiency, and 85% capacity

<sup>23</sup> USEPA-42, op cit.

<sup>24</sup> AP-42 recommends, for conventional landfills,; k= 0.04 y-1 for areas with more than 25” annual rainfall and k= 0.02 y-1 if less than 25” rainfall. The vast majority of populated regions in the state receives less than 25” average annual rainfall.

factor. Future MSW disposal is held constant at 29 million tons (approximate current disposal amount). Actual waste disposal data used for period 1990-2012. Disposal pre-1990 estimated from population. Methane production is estimated only for waste disposed post-1970.

### **Wastewater Treatment**

Annual biogas potential from sewage treatment was computed from the influent waste water flow rate for facilities that currently employ anaerobic digestion.<sup>25</sup> A factor of 1.15 cubic of biogas per 100 gallons of wastewater inlet flow with methane content of 65% was used to estimate potential biogas production.<sup>26</sup> Gas potential from waste water treatment (existing digesters) is about 7.3 billion cubic feet of methane per year using 95% technical recovery factor (Table 3.2.3.3).

As with manure digestion and landfill gas, the assumed conversion efficiency of biogas to electricity was 30% (heat rate of 11,373 Btu/kWh) and 85% capacity factor. County level generation is the aggregate of individual site estimates within each county.

### **Biogas Potential from MSW Landfill Stream**

For MSW, the food waste and green waste fractions are assumed to be converted by anaerobic digestion systems. Biomethane potentials used are 0.29 and 0.14 grams methane per gram of volatile solid for food waste and greenwaste respectively. VS/TS are assumed to 0.84 and 0.9 for food waste and greenwaste respectively. With 1.4 million dry tons food waste and 0.4 million dry tons green waste in the current landfill disposal stream, gross methane potential is 16.1 and 2.8 billion cubic feet per year for food waste and greenwaste respectively (technical methane potential of 10.8 and 1.8 bcf/y, respectively). A gas to electricity conversion efficiency of 30% and capacity factor of 85% is assumed for electricity capacity potential from these waste components (this is accounted for in the MSW energy columns in the gross and technical MW and MWh tables).

---

<sup>25</sup> Greg Kester (2013), Personal Communication. CASA, and WEF (2013):  
<http://www.wrrfdata.org/biogas/biogasdata.php>

<sup>26</sup> Factors modified from:

ERG and RDC (2011). Opportunities for Combined Heat and Power at Wastewater Treatment Facilities: Market Analysis and Lessons from the Field, Eastern Research Group, Inc. & Resource Dynamics Corporation. Report to the Combined Heat and Power Partnership, US EPA & Tchobanoglous, G., F. L. Burton and H. D. Stensel (2003). Wastewater Engineering: Treatment and Reuse, 4th edition. New York, McGraw-Hill Education.

**Table 3.2.3.2. Waste-in-place and landfill gas production and energy potentials.**

County Name	WIP [~ 1950-2013], (million tons)	Estimated WIP [1970-2013], (million tons)	Gross Methane (bcf/y)	Recoverable Methane (bcf/y)	Gross Electric Capacity (MWe)	Recovered Electric Capacity (MWe)
Alameda	79.1	65.8	3.82	2.86	43.7	32.7
Alpine						
Amador	0.8	0.7	0.04	0.03	0.4	0.3
Butte	4.2	3.5	0.20	0.15	2.3	1.7
Calaveras	1.0	0.8	0.05	0.04	0.5	0.4
Colusa	0.3	0.2	0.01	0.01	0.1	0.1
Contra Costa	33.7	28.0	1.61	1.21	18.4	13.8
Del Norte	0.5	0.4	0.02	0.02	0.3	0.2
El Dorado	1.8	1.5	0.08	0.06	1.0	0.7
Fresno	24.8	20.6	1.18	0.88	13.5	10.1
Glenn	0.9	0.8	0.04	0.03	0.5	0.4
Humboldt	1.9	1.6	0.09	0.07	1.0	0.8
Imperial	4.6	3.8	0.21	0.16	2.4	1.8
Inyo	0.8	0.6	0.04	0.03	0.4	0.3
Kern	27.1	22.6	1.29	0.97	14.7	11.1
Kings	7.9	6.5	0.38	0.29	4.4	3.3
Lake	1.4	1.2	0.07	0.05	0.8	0.6
Lassen	0.8	0.6	0.04	0.03	0.4	0.3
Los Angeles	518.5	431.1	24.94	18.71	285.4	214.1
Madera	3.1	2.6	0.15	0.11	1.7	1.3
Marin	16.8	13.9	0.81	0.61	9.3	7.0
Mariposa	0.4	0.3	0.02	0.01	0.2	0.2
Mendocino	1.4	1.1	0.06	0.05	0.7	0.5
Merced	6.7	5.6	0.32	0.24	3.6	2.7
Modoc	0.1	0.1	0.01	0.01	0.1	0.1
Mono	1.0	0.8	0.05	0.04	0.6	0.4
Monterey	16.5	13.7	0.79	0.59	9.0	6.8
Napa	3.8	3.2	0.18	0.13	2.0	1.5
Nevada	1.0	0.9	0.05	0.04	0.6	0.4
Orange	165.1	137.4	7.92	5.94	90.6	67.9
Placer	8.4	7.0	0.40	0.30	4.6	3.4
Plumas	0.2	0.2	0.01	0.01	0.1	0.1
Riverside	77.9	64.9	3.72	2.79	42.6	32.0
Sacramento	32.3	26.9	1.53	1.14	17.5	13.1
San Benito	1.8	1.5	0.08	0.06	1.0	0.7
San Bernardino	56.9	47.4	2.71	2.03	31.0	23.2
San Diego	115.4	96.1	5.49	4.12	62.8	47.1
San Francisco						
San Joaquin	32.9	27.4	1.58	1.18	18.1	13.6
San Luis Obispo	8.7	7.2	0.41	0.31	4.7	3.5
San Mateo	28.5	23.7	1.37	1.03	15.6	11.7
Santa Barbara	16.6	13.8	0.79	0.59	9.1	6.8
Santa Clara	60.1	50.0	2.88	2.16	33.0	24.8
Santa Cruz	8.0	6.7	0.38	0.29	4.4	3.3
Shasta	7.4	6.2	0.35	0.27	4.1	3.0
Sierra	0.1	0.1	0.00	0.00	0.1	0.0
Siskiyou	0.7	0.6	0.03	0.02	0.4	0.3
Solano	18.9	15.7	0.91	0.68	10.4	7.8
Sonoma	12.5	10.4	0.60	0.45	6.8	5.1
Stanislaus	5.1	4.3	0.24	0.18	2.7	2.1
Sutter						
Tehama	1.4	1.2	0.07	0.05	0.8	0.6
Trinity	0.2	0.1	0.01	0.01	0.1	0.1
Tulare	9.8	8.1	0.46	0.35	5.3	4.0
Tuolumne	0.9	0.8	0.04	0.03	0.5	0.4
Ventura	33.9	28.2	1.62	1.21	18.5	13.9
Yolo	7.5	6.2	0.36	0.27	4.1	3.1
Yuba	7.7	6.0	0.35	0.26	4.0	3.0
<b>Totals</b>	<b>1479.6</b>	<b>1231.4</b>	<b>70.9</b>	<b>53.1</b>	<b>810.9</b>	<b>608.2</b>

**Table 3.2.3.3. Wastewater Treatment Biogas and Energy Potential**

County Name	flow avg (MGD)	Biogas (ft <sup>3</sup> /d)	Methane (million ft <sup>3</sup> /y)	Gross Electricity Generation Capacity (MW)	Technical Electricity Generation Capacity (MW)
Alameda	130.5	1,500,980	356	4.2	4.0
Alpine	0.0	0	0	0.0	0.0
Amador	0.0	0	0	0.0	0.0
Butte	7.5	86,250	20	0.2	0.2
Calaveras	0.0	0	0	0.0	0.0
Colusa	0.0	0	0	0.0	0.0
Contra Costa	25.1	288,650	68	0.8	0.8
Del Norte	1.9	21,390	5	0.1	0.1
El Dorado	4.1	47,150	11	0.1	0.1
Fresno	69.7	801,205	190	2.2	2.1
Glenn	0.0	0	0	0.0	0.0
Humboldt	5.8	66,355	16	0.2	0.2
Imperial	11.4	130,755	31	0.4	0.3
Inyo	0.0	0	0	0.0	0.0
Kern	52.1	599,150	142	1.7	1.6
Kings	6.2	71,300	17	0.2	0.2
Lake	0.0	0	0	0.0	0.0
Lassen	0.0	0	0	0.0	0.0
Los Angeles	883.1	10,155,650	2409	28.5	27.0
Madera	6.8	78,430	19	0.2	0.2
Marin	23.3	267,720	64	0.8	0.7
Mariposa	0.5	5,980	1	0.0	0.0
Mendocino	2.5	28,750	7	0.1	0.1
Merced	13.3	152,490	36	0.4	0.4
Modoc	0.0	0	0	0.0	0.0
Mono	0.0	0	0	0.0	0.0
Monterey	22.5	258,750	61	0.7	0.7
Napa	9.3	106,950	25	0.3	0.3
Nevada	5.5	62,675	15	0.2	0.2
Orange	383.1	4,405,650	1045	12.3	11.7
Placer	10.0	115,000	27	0.3	0.3
Plumas	0.0	0	0	0.0	0.0
Riverside	91.0	1,046,040	248	2.9	2.8
Sacramento	150.0	1,725,000	409	4.8	4.6
San Benito	0.0	0	0	0.0	0.0
San Bernardino	129.3	1,487,295	353	4.2	4.0
San Diego	230.6	2,651,440	629	7.4	7.1
San Francisco	71.5	822,710	195	2.3	2.2
San Joaquin	48.1	553,380	131	1.6	1.5
San Luis Obispo	11.2	129,145	31	0.4	0.3
San Mateo	49.3	566,490	134	1.6	1.5
Santa Barbara	25.7	295,320	70	0.8	0.8
Santa Clara	121.3	1,394,950	331	3.9	3.7
Santa Cruz	15.7	180,550	43	0.5	0.5
Shasta	8.2	94,300	22	0.3	0.3
Sierra	0.0	0	0	0.0	0.0
Siskiyou	0.0	0	0	0.0	0.0
Solano	26.9	309,810	74	0.9	0.8
Sonoma	22.2	255,415	61	0.7	0.7
Stanislaus	36.6	420,555	100	1.2	1.1
Sutter	6.0	69,000	16	0.2	0.2
Tehama	1.8	20,125	5	0.1	0.1
Trinity	0.0	0	0	0.0	0.0
Tulare	30.5	350,520	83	1.0	0.9
Tuolumne	1.7	18,975	5	0.1	0.1
Ventura	62.2	715,300	170	2.0	1.9
Yolo	5.5	63,250	15	0.2	0.2
Yuba	2.6	30,245	7	0.1	0.1
Totals	2,822	32,451,045	7,699	90.9	86.4

### 3.2.4 Biogas Technical Potential

Statewide biogas production potential (technical potential) for animal manures, landfill gas based on current waste in place, anaerobic digestion of food, leaves and grass fraction of the current MSW disposal stream and from waste water treatment plants that utilize anaerobic digestion for sludge management is estimated to be about 93 billion cubic feet of methane per year (Table 3.2.4.1).

**Table 3.2.4.1 Biogas Technical Potential from California Resources**

Feedstock	Amount Technically Available	Biomethane Potential (billion cubic feet)
Animal Manure	3.4 MM BDT <sup>a</sup>	19.7 <sup>a</sup>
Landfill Gas	106 BCF <sup>a</sup>	53 <sup>d</sup>
Municipal Solid Waste (food, leaves, grass fraction)	1.2 MM BDT <sup>b</sup>	12.6 <sup>e</sup>
Waste Water Treatment Plants	11.8 BCF (gas) <sup>c</sup>	7.7 <sup>f</sup>
<b>Total</b>		<b>93</b>

**Notes and Sources:**

MM BDT = million bone dry (short) tons, BCF = billion cubic feet

a. Williams, R. B., B. M. Jenkins and S. Kaffka (California Biomass Collaborative). 2015. *An Assessment of Biomass Resources in California, 2013 – DRAFT*. Contractor Report to the California Energy Commission. PIER Contract 500-11-020.

b. Technical potential assumed to be 67% of amount disposed in landfill (2013).

c. From EPA Region 9; Database for Waste Treatment Plants

d. Assumes 50% methane in gas

e. Assumes VS/TS= 0.83 and biomethane potential of 0.29g CH<sub>4</sub>/g VS (food waste) & VS/TS = 0.9 w/ BMP= 0.143g CH<sub>4</sub>/g VS (leaves. Grass)

f. Assumes 65% methane in gas.

### 3.3 Power Generation Estimates

Estimated gross and technical power generation potentials (MWe) for all biomass resource including landfill gas and wastewater treatment digester gas are listed in Tables 3.3.1 and 3.3.2. As noted earlier, gross power potential is based on full diversion from landfill of biomass in MSW. Gross potential from landfill gas to energy (LFGTE) is based on waste in-place as of 2012. Total gross and technical generation potential is 9,878 and 4,630 MWe respectively (Tables 3.3.1 and 3.3.2). Technical potential does not account for existing capacity (i.e., we do not subtract current operating capacity).



Energy generation potentials (MWh) are listed in Tables 3.3.3 and 3.3.4. Total gross and technical energy generation potentials are 71 and 34.5 TWh per year respectively. Electrical energy demand in California is approximately 300 TWh.<sup>27</sup>

### **3.3.1. Capacity factors**

Capacity factor defines the fraction of rated power capacity for a system achieved over the year. For these estimates, the capacity factor was set at 85% for all years and all conversion types.

---

<sup>27</sup> California Energy Commission,  
[http://energyalmanac.ca.gov/electricity/total\\_system\\_power.html](http://energyalmanac.ca.gov/electricity/total_system_power.html) (total system power)

**Table 3.3.1. Summary gross power generation potentials (MWe) by principal resource category, 2013**

County Name	Total Biomass	Total for Thermal Conversion	Total for Biochemical Conversion	Landfill Gas	WWTP Digester Gas	Biosolids Landfilled (not in Total)	Biosolids Diverted	MSW Biomass Landfilled	MSW Biomass Diverted	Total Animal Manure	Total Cattle manure	Dairy manure	Orchard and Vine	Field and Seed	Vegetable	Food Processing	Forestry	Dedicated Crop
Alameda	163	104	59	44	4.2	2	-	55	54	2	2	-	1	0	-	0	3	-
Alpine	15	15	0	-	-	-	-	0	0	0	0	-	-	-	-	-	15	-
Amador	34	31	3	0	-	-	-	1	1	2	2	-	1	0	-	0	28	-
Butte	154	148	6	2	0.2	-	-	8	8	2	2	0	11	37	-	23	61	-
Calaveras	55	52	3	1	-	-	-	2	2	2	2	-	0	-	-	0	49	-
Colusa	119	115	4	0	-	-	-	1	1	2	2	-	7	62	2	32	12	-
Contra Costa	101	73	27	18	0.8	-	-	38	32	3	3	-	0	7	0	0	2	-
Del Norte	74	72	2	0	0.1	-	-	1	1	2	2	1	-	-	-	-	71	-
El Dorado	115	112	3	1	0.1	-	-	7	6	1	1	-	1	-	-	0	99	-
Fresno	435	329	105	13	2.2	-	-	33	33	63	48	26	66	27	22	94	83	-
Glenn	96	86	10	1	-	-	-	1	1	9	9	4	9	41	-	21	15	-
Humboldt	398	388	10	1	0.2	-	-	4	4	8	8	3	-	-	-	0	381	-
Imperial	111	71	40	2	0.4	-	-	11	10	27	27	1	1	29	9	0	23	-
Inyo	73	70	3	0	-	-	-	1	1	2	2	-	0	0	-	-	68	-
Kern	364	284	79	15	1.7	-	16	37	36	55	55	38	46	17	3	83	55	-
Kings	137	69	68	4	0.2	-	-	4	4	58	57	40	8	35	4	19	0	-
Lake	65	63	2	1	-	-	-	2	2	1	1	-	2	0	-	0	57	-
Lassen	119	113	7	0	-	-	-	1	1	6	6	-	-	1	-	0	110	-
Los Angeles	1,165	790	375	285	28.5	4	-	424	390	1	1	-	0	0	0	1	35	-
Madera	152	122	30	2	0.2	-	-	6	5	27	26	17	28	2	1	42	40	-
Marin	41	24	17	9	0.8	-	-	9	9	5	5	2	0	-	-	0	7	-
Mariposa	36	34	2	0	0.0	-	-	1	1	2	2	-	0	-	-	-	32	-
Mendocino	386	382	4	1	0.1	-	-	3	3	3	3	0	3	-	-	0	374	-
Merced	208	110	98	4	0.4	-	5	10	10	89	83	60	16	25	4	45	1	-
Modoc	77	69	8	0	-	-	-	0	0	8	8	-	-	3	0	-	66	-
Mono	30	28	2	1	-	-	-	1	1	1	1	-	0	0	-	-	26	-
Monterey	121	78	43	9	0.7	-	-	16	16	7	7	0	7	2	24	8	32	-
Napa	50	47	4	2	0.3	-	-	6	5	1	1	-	7	-	-	1	28	-
Nevada	67	65	2	1	0.2	-	-	3	3	1	1	-	0	-	-	-	59	-
Orange	410	287	123	91	12.3	-	-	173	130	0	0	-	0	-	0	0	4	-
Placer	93	85	8	5	0.3	-	-	12	12	1	1	0	0	6	0	1	57	-
Plumas	134	132	1	0	-	-	-	1	1	1	1	-	-	-	-	-	131	-
Riverside	308	233	75	43	2.9	-	-	88	87	13	12	9	5	7	2	1	59	-
Sacramento	170	130	39	17	4.8	-	2	56	53	9	8	3	6	19	0	2	0	-
San Benito	25	18	7	1	-	-	-	3	3	4	4	-	1	0	2	1	11	-
San Bernardino	353	283	70	31	4.2	-	4	77	74	23	20	12	0	0	0	0	138	-
San Diego	437	340	97	63	7.4	2	-	157	142	4	2	0	4	0	0	-	59	-
San Francisco	49	43	6	-	2.3	-	-	24	22	-	-	-	-	-	-	-	-	-
San Joaquin	220	154	67	18	1.6	-	-	29	29	37	35	22	30	42	6	27	1	-
San Luis Obispo	77	60	17	5	0.4	-	-	13	11	9	9	-	7	1	2	1	29	-
San Mateo	86	65	22	16	1.6	-	-	28	26	0	0	-	0	0	0	-	15	-
Santa Barbara	92	69	23	9	0.8	-	0	18	17	5	5	-	5	1	6	0	30	-
Santa Clara	175	126	49	33	3.9	7	-	56	53	3	3	1	0	1	1	0	24	-
Santa Cruz	53	46	8	4	0.5	-	-	8	8	0	0	-	1	-	1	0	31	-
Shasta	234	224	10	4	0.3	-	-	8	8	4	4	-	0	2	0	1	207	-
Sierra	42	41	1	0	-	-	-	0	0	1	1	-	-	-	-	-	40	-
Siskiyou	326	317	9	0	-	-	-	1	1	8	8	0	0	6	0	-	309	-
Solano	70	49	22	10	0.9	3	1	18	15	7	7	1	2	11	1	3	1	-
Sonoma	157	133	23	7	0.7	-	1	15	15	13	12	6	11	0	-	1	92	-
Stanislaus	194	113	81	3	1.2	-	-	11	11	72	60	41	27	3	3	60	4	-
Sutter	78	76	3	-	0.2	-	-	3	3	1	1	0	7	50	1	14	-	-
Tehama	100	91	9	1	0.1	-	-	2	2	8	8	1	5	1	-	5	76	-
Trinity	250	249	1	0	-	-	-	0	0	1	1	-	0	-	-	-	248	-
Tulare	333	169	165	5	1.0	-	-	15	15	156	153	108	41	18	0	16	66	-
Tuolumne	79	76	4	0	0.1	-	-	2	2	3	1	-	0	-	-	-	72	-
Ventura	125	93	32	19	2.0	1	-	39	37	1	1	-	5	1	5	1	17	-
Yolo	94	83	11	4	0.2	-	-	8	8	1	1	0	6	46	4	11	5	-
Yuba	55	49	7	4	0.1	-	-	3	3	2	2	1	3	13	-	4	22	-
Not located	97	36	61	-	-	3	19	-	-	26	8	-	5	11	5	31	-	-
STATE Total	9,878	7,813	2,065	811	90.9	23	48	1,554	1,430	796	727	396	388	523	108	549	3,576	-

**Table 3.3.2. Summary technical power generation potentials (MWe) by principal resource category, 2013**

County Name	Total Biomass	Total for Thermal Conversion	Total for Biochemical Conversion	Landfill Gas	WWTP Digester Gas	Biosolids Landfilled (not in Total)	Biosolids Diverted	MSW Biomass Landfilled	MSW Biomass Diverted	Total Animal Manure	Total Cattle manure	Dairy manure	Orchard and Vine	Field and Seed	Vegetable	Food Processing	Forestry	Dedicated Crop
Alameda	75	33	43	33	4	1	-	37	-	0	0	-	0	0	-	-	1	-
Alpine	4	4	0	-	-	-	-	0	-	0	0	-	-	-	-	-	4	-
Amador	22	21	1	0	-	-	-	1	-	0	0	-	0	0	-	0	19	-
Butte	85	82	3	2	0	-	-	6	-	0	0	0	8	18	-	11	40	-
Calaveras	36	35	1	0	-	-	-	1	-	0	0	-	0	-	-	0	34	-
Colusa	58	57	1	0	-	-	-	1	-	0	0	-	5	30	-	14	8	-
Contra Costa	45	26	18	14	1	-	-	25	-	1	1	-	0	3	-	0	1	-
Del Norte	23	22	1	0	0	-	-	1	-	0	0	0	-	-	-	-	21	-
El Dorado	80	78	2	1	0	-	-	4	-	0	0	-	0	-	-	0	74	-
Fresno	171	131	40	10	2	-	-	22	-	25	17	13	46	13	-	18	35	-
Glenn	47	43	3	0	-	-	-	1	-	3	3	2	6	20	-	9	8	-
Humboldt	184	180	4	1	0	-	-	3	-	2	2	1	-	-	-	-	178	-
Imperial	45	36	9	2	0	-	-	7	-	6	6	1	0	11	-	0	18	-
Inyo	19	18	1	0	-	-	-	1	-	0	0	-	0	0	-	-	17	-
Kern	145	107	39	11	2	-	-	25	-	22	22	19	32	7	-	16	30	-
Kings	62	35	28	3	0	-	-	3	-	24	23	20	6	17	-	9	0	-
Lake	39	38	1	1	-	-	-	1	-	0	0	-	1	0	-	0	35	-
Lassen	94	92	2	0	-	-	-	1	-	1	1	-	-	1	-	0	91	-
Los Angeles	540	260	280	214	26	4	-	284	-	0	0	-	0	0	-	-	16	-
Madera	70	58	13	1	0	-	-	4	-	11	10	8	20	1	-	8	26	-
Marin	19	9	10	7	1	-	-	6	-	2	2	1	0	-	-	0	4	-
Mariposa	23	22	1	0	0	-	-	0	-	0	0	-	0	-	-	-	22	-
Mendocino	173	172	1	1	0	-	-	2	-	1	1	0	2	-	-	0	168	-
Merced	80	38	42	3	0	-	-	7	-	37	35	30	11	11	-	10	0	-
Modoc	59	58	2	0	-	-	-	0	-	2	2	-	-	1	-	-	57	-
Mono	15	14	1	0	-	-	-	1	-	0	0	-	0	0	-	-	13	-
Monterey	39	28	11	7	1	-	-	11	-	1	1	0	5	1	-	1	13	-
Napa	29	27	2	2	0	-	-	4	-	0	0	-	5	-	-	1	17	-
Nevada	45	44	1	0	0	-	-	2	-	0	0	-	0	-	-	-	42	-
Orange	196	103	93	68	11	-	-	116	-	0	0	-	0	-	-	-	1	-
Placer	50	45	5	3	0	-	-	8	-	0	0	0	0	3	-	1	34	-
Plumas	91	91	0	0	-	-	-	1	-	0	0	-	-	-	-	-	90	-
Riverside	135	86	49	32	3	-	-	59	-	6	5	4	3	3	-	1	29	-
Sacramento	73	47	26	13	4	-	-	38	-	3	3	2	4	9	-	1	0	-
San Benito	10	9	2	1	-	-	-	2	-	1	1	-	1	0	-	1	6	-
San Bernardino	169	125	44	23	4	-	-	52	-	9	8	6	0	0	-	-	81	-
San Diego	196	126	70	47	7	2	-	105	-	2	1	0	3	0	-	-	32	-
San Francisco	18	14	4	-	2	-	-	16	-	-	-	-	-	-	-	-	-	-
San Joaquin	100	68	32	14	1	-	-	20	-	14	13	11	21	20	-	9	0	-
San Luis Obispo	36	29	7	4	0	-	-	8	-	2	2	-	5	0	-	0	16	-
San Mateo	37	21	16	12	1	-	-	19	-	0	0	-	0	0	-	-	5	-
Santa Barbara	35	25	10	7	1	-	-	12	-	1	1	-	4	0	-	0	11	-
Santa Clara	77	42	35	25	4	6	-	37	-	1	1	1	0	0	-	0	10	-
Santa Cruz	23	18	5	3	0	-	-	5	-	0	0	-	0	-	-	-	13	-
Shasta	132	127	5	3	0	-	-	5	-	1	1	-	0	1	-	0	121	-
Sierra	26	26	0	0	-	-	-	0	-	0	0	-	-	-	-	-	26	-
Siskiyou	153	151	2	0	-	-	-	1	-	2	2	0	0	3	-	-	147	-
Solano	30	18	12	8	1	2	-	12	-	2	2	0	1	5	-	1	0	-
Sonoma	75	62	12	5	1	-	-	10	-	5	4	3	7	0	-	1	46	-
Stanislaus	74	39	35	2	1	-	-	7	-	30	24	21	19	1	-	12	2	-
Sutter	41	40	1	-	0	-	-	2	-	0	0	0	5	24	-	10	-	-
Tehama	55	53	3	1	0	-	-	1	-	2	2	0	4	1	-	2	45	-
Trinity	100	100	0	0	-	-	-	0	-	0	0	-	0	-	-	-	100	-
Tulare	151	80	71	4	1	-	-	10	-	65	63	54	29	8	-	7	27	-
Tuolumne	52	50	2	0	0	-	-	1	-	1	0	-	0	-	-	-	49	-
Ventura	50	30	20	14	2	1	-	26	-	0	0	-	3	0	-	0	4	-
Yolo	42	38	4	3	0	-	-	5	-	0	0	0	4	21	-	5	3	-
Yuba	34	30	4	3	0	-	-	2	-	1	1	0	2	7	-	3	17	-
Not located	43	9	34	-	-	2	-	-	-	10	2	-	4	4	-	25	-	-
STATE Total	4,630	3,468	1,162	608	82	18	-	1,041	-	300	264	198	271	245	-	176	1,907	-

**Table 3.3.3. Summary gross energy generation potentials (MWh) by principal resource category, 2013**

County Name	Total Biomass	Total for Thermal Conversion	Total for Biochemical Diversion	Landfill	Gas	WWTP Digester Gas	Biosolids Landfilled (excl/ude)	Biosolids Diverted	MSW Biomass Landfilled	MSW Biomass Diverted	Total Animal Manure	Total Cattle manure	Dairy manure	Orchard and Vine	Field and Seed	Veg.	Food Processing	Forestry	Ded. Crop		
Alameda	1,211,100	774,000	437,100	325,130		31,310	11,600	-	407,620	401,700	18,300	18,300	-	3,850	860	-	-	22,500	-		
Alpine	114,500	114,000	500	-	-	-	-	-	680	900	340	340	-	-	-	-	-	113,000	-		
Amador	252,800	231,000	21,800	3,190	-	-	-	-	10,240	10,400	17,050	17,050	-	5,270	180	-	100	205,900	-		
Butte	1,077,400	1,033,000	44,400	16,870	1,800	-	-	-	62,750	62,300	16,120	16,120	590	83,750	275,750	-	104,670	453,800	-		
Calaveras	410,600	389,000	21,600	4,000	-	-	-	-	13,970	11,300	15,870	15,870	-	1,760	-	-	520	363,100	-		
Colusa	781,300	750,000	31,300	1,020	-	-	-	-	6,110	6,100	17,070	17,070	-	55,560	463,170	12,290	127,800	91,700	-		
Contra Costa	749,500	545,000	204,500	137,240	6,020	-	-	-	279,610	236,300	22,490	22,490	-	3,190	48,530	2,150	260	13,900	-		
Del Norte	554,000	539,000	15,000	2,110	450	-	-	-	6,110	6,100	11,520	11,520	4,490	-	-	-	-	527,500	-		
El Dorado	857,500	834,000	23,500	7,090	980	-	-	-	49,290	47,600	7,970	7,970	-	4,360	-	-	70	739,700	-		
Fresno	2,711,700	1,929,000	782,700	100,390	16,710	-	-	-	245,360	242,400	466,210	354,460	190,560	488,120	204,060	161,840	171,770	614,500	-		
Glenn	641,900	571,000	70,900	3,800	-	-	-	-	7,690	6,900	65,880	65,880	28,260	63,710	301,650	-	83,540	108,800	-		
Humboldt	2,962,700	2,889,000	73,700	7,750	1,380	-	-	-	29,220	29,400	59,980	59,980	21,580	-	-	-	-	2,833,900	-		
Imperial	830,300	530,000	300,300	18,150	2,730	-	-	-	80,820	71,900	202,410	202,410	7,860	4,090	212,950	65,840	1,850	169,500	-		
Inyo	544,900	523,000	21,900	3,150	-	-	-	-	7,640	6,900	17,670	17,670	-	50	170	-	-	509,600	-		
Kern	2,234,900	1,643,000	591,900	109,740	12,500	-	-	116,400	277,130	266,600	406,020	406,020	282,330	345,490	126,260	22,240	144,290	407,900	-		
Kings	967,000	464,000	503,000	32,460	1,490	-	-	-	29,710	28,600	435,080	427,440	298,050	62,730	257,070	29,540	88,400	2,300	-		
Lake	481,900	470,000	11,900	5,680	-	-	-	-	13,710	13,900	4,090	4,090	-	15,610	1,630	-	3,550	423,500	-		
Lassen	889,200	838,000	51,200	3,090	-	-	-	-	6,340	6,100	47,190	47,190	-	-	8,350	-	1,010	817,300	-		
Los Angeles	8,669,500	5,877,000	2,792,500	2,125,430	211,840	-	32,600	-	3,157,830	2,906,100	4,310	4,310	-	620	470	50	-	262,900	-		
Madera	895,900	670,000	225,900	12,640	1,640	-	-	-	42,040	39,800	201,300	190,350	122,960	209,800	11,880	4,070	72,210	300,400	-		
Marin	301,300	176,000	125,300	69,150	5,580	-	-	-	66,050	64,900	40,450	40,450	13,080	220	-	-	2,970	52,300	-		
Mariposa	266,200	251,000	15,200	1,680	120	-	-	-	5,430	5,200	12,580	12,580	-	130	-	-	-	240,700	-		
Mendocino	2,874,500	2,846,000	28,500	5,420	600	-	-	-	20,040	19,900	19,420	19,420	1,320	23,510	-	-	2,170	2,783,000	-		
Merced	1,303,800	571,000	732,800	27,060	3,180	-	-	34,100	77,610	72,700	664,000	619,950	443,610	117,240	187,110	27,200	89,640	4,200	-		
Modoc	574,800	513,000	61,800	580	-	-	-	-	1,930	1,700	60,260	60,260	-	-	18,980	590	-	490,700	-		
Mono	222,700	211,000	11,700	4,150	-	-	-	-	9,200	7,800	6,250	6,250	-	30	150	150	-	194,900	-		
Monterey	852,200	531,000	321,200	67,300	5,400	-	-	-	120,660	119,500	52,730	52,730	980	54,760	12,920	177,260	5,560	235,900	-		
Napa	375,400	347,000	28,400	15,240	2,230	-	-	-	46,710	37,200	5,020	5,020	-	54,530	-	-	6,130	208,700	-		
Nevada	496,800	482,000	14,800	4,310	1,310	-	-	-	24,470	24,200	5,390	5,390	-	530	-	-	-	436,700	-		
Orange	3,052,800	2,135,000	917,800	674,530	91,900	-	-	-	1,285,630	969,600	280	280	-	50	-	730	-	30,200	-		
Placer	689,900	633,000	56,900	34,180	2,400	-	-	-	86,600	85,700	6,990	6,990	490	1,250	41,320	30	9,950	421,200	-		
Plumas	995,600	985,000	10,600	840	-	-	-	-	5,890	6,100	8,800	8,800	-	-	-	-	-	973,800	-		
Riverside	2,289,800	1,733,000	556,800	317,260	21,820	-	-	-	655,010	647,500	99,620	87,320	66,430	33,740	51,310	17,590	8,060	438,200	-		
Sacramento	1,259,400	966,000	293,400	129,980	35,980	-	-	17,100	420,180	391,300	64,770	60,010	24,600	43,920	142,550	1,920	10,810	900	-		
San Benito	186,700	131,000	55,700	7,100	-	-	-	-	19,140	19,000	32,630	32,630	-	7,760	710	13,030	6,610	80,300	-		
San Bernardino	2,625,200	2,106,000	519,200	230,550	31,020	-	-	30,300	573,240	554,000	170,290	145,210	91,330	3,330	20	1,380	-	1,030,900	-		
San Diego	3,253,800	2,534,000	719,800	467,680	55,310	-	-	-	1,168,820	1,057,000	29,230	14,060	3,120	32,780	2,940	3,590	-	436,400	-		
San Francisco	363,200	320,000	43,200	-	17,160	-	-	-	179,410	167,100	-	-	-	-	-	-	-	-	-		
San Joaquin	1,526,000	1,030,000	496,000	134,590	11,540	-	-	-	218,640	216,400	272,090	257,030	162,840	226,460	309,870	44,220	87,430	4,400	-		
San Luis Obispo	573,400	444,000	129,400	35,030	2,690	-	-	-	93,330	82,200	63,420	63,420	-	54,590	6,940	15,430	4,010	215,800	-		
San Mateo	642,800	482,000	160,800	116,490	11,820	-	-	-	210,680	191,300	2,540	2,540	-	300	660	280	-	108,500	-		
Santa Barbara	687,600	514,000	173,600	67,570	6,160	-	-	3,100	133,050	127,300	38,940	38,940	-	38,530	3,750	41,210	2,480	225,100	-		
Santa Clara	1,299,500	935,000	364,500	245,810	29,100	-	-	-	414,680	398,200	22,060	21,700	8,300	2,900	6,160	5,710	120	175,200	-		
Santa Cruz	395,100	339,000	56,100	32,680	3,770	-	-	-	57,450	57,100	2,610	2,610	-	4,190	-	-	8,230	228,600	-		
Shasta	1,742,800	1,668,000	74,800	30,170	1,970	-	-	-	58,140	57,100	33,500	33,500	-	930	14,110	200	4,100	1,542,900	-		
Sierra	310,700	303,000	7,700	410	-	-	-	-	900	900	7,120	7,120	-	-	-	-	-	301,100	-		
Siskiyou	2,429,800	2,363,000	66,800	2,820	-	-	-	-	9,840	9,500	60,510	60,510	1,170	10	45,620	1,980	-	2,299,600	-		
Solano	511,300	350,000	161,300	77,240	6,460	-	22,500	5,400	135,280	113,400	50,820	50,820	4,980	15,540	84,700	9,200	8,500	4,800	-		
Sonoma	1,164,200	991,000	173,200	50,950	5,330	-	-	7,000	115,160	113,400	99,360	92,610	44,860	78,250	570	-	5,950	687,900	-		
Stanislaus	1,103,800	504,000	599,800	20,410	8,770	-	-	-	80,420	79,600	536,610	445,280	305,520	201,200	20,280	21,730	108,200	26,200	-		
Sutter	572,500	552,000	20,500	-	1,440	-	-	-	22,910	22,500	7,950	7,950	830	50,750	369,050	7,580	90,390	-	-		
Tehama	730,500	660,000	70,500	5,740	420	-	-	-	16,200	15,600	61,850	61,850	5,710	38,950	10,940	-	17,870	562,500	-		
Trinity	1,860,700	1,854,000	6,700	660	-	-	-	-	3,020	2,600	5,580	5,580	-	140	-	-	-	1,848,500	-		
Tulare	2,424,200	1,197,000	1,227,200	39,360	7,310	-	-	-	113,600	110,800	1,161,400	1,139,530	805,500	306,130	130,730	1,980	63,250	490,100	-		
Tuolumne	589,600	563,000	26,600	3,590	400	-	-	-	13,130	13,000	20,640	9,630	-	270	-	-	-	539,000	-		
Ventura	925,800	689,000	236,800	137,830	14,920	-	-	-	290,100	278,700	6,500	6,500	-	34,250	3,730	34,280	2,480	122,900	-		
Yolo	655,900	576,000	79,900	30,520	1,320	-	-	-	60,240	56,300	8,740	8,740	1,660	47,250	341,950	30,600	42,430	36,200	-		
Yuba	409,300	360,000	49,300	29,930	630	-	-	-	22,910	22,500	15,210	15,210	4,440	22,300	96,800	-	31,410	167,400	-		
Other- not located	725,300	269,000	456,300	-	-	-	-	-	22,504	143,558	-	195,320	57,820	-	40,560	38,190	229,220	-	-		
STATE Total	71,104,000	55,727,000	15,377,000	6,038,000	677,000	-	-	-	148,200	213,400	11,600,000	10,620,000	6,000,000	5,470,000	2,947,000	2,900,000	3,900,000	800,000	1,640,000	26,600,000	-

**Table 3.3.4. Summary technical energy generation potentials (MWh) by principal resource category, 2013**

County Name	Total Biomass	Total for Thermal Conversion	Total for Biochemical Diversion	Landfill Gas	WWTP Digester Gas	Biosolids Landfilled (exclude)	Biosolids Diverted	MSW Biomass Landfilled	MSW Biomass Diverted	Total Animal Manure	Total Cattle manure	Dairy manure	Orchard and Vine	Field and Seed	Veg.	Food Processing	Forestry	Ded. Crop
Alameda	560,265	242,734	317,531	243,850	28,180	9,280	-	273,105	-	3,700	3,700	-	2,700	430	-	-	8,300	-
Alpine	33,156	32,982	174	-	-	-	-	456	-	100	100	-	-	-	-	-	32,600	-
Amador	160,331	153,516	6,815	2,390	-	-	-	6,861	-	3,400	3,400	-	3,690	90	-	100	143,800	-
Butte	635,403	611,277	24,125	12,660	1,620	-	-	42,043	-	3,400	3,400	300	58,630	136,850	-	83,800	296,400	-
Calaveras	267,390	260,111	7,279	3,000	-	-	-	9,360	-	3,100	3,100	-	1,230	-	-	400	250,300	-
Colusa	431,194	426,394	4,800	770	-	-	-	4,094	-	3,400	3,400	-	38,890	225,040	-	102,200	56,800	-
Contra Costa	331,759	194,387	137,372	102,930	5,420	-	-	187,339	-	4,500	4,500	-	2,230	24,140	-	200	5,000	-
Del Norte	168,274	162,064	6,210	1,580	400	-	-	4,094	-	3,600	3,600	2,200	-	-	-	-	158,600	-
El Dorado	592,584	579,749	12,835	5,320	890	-	-	33,024	-	1,600	1,600	-	3,050	-	-	100	548,600	-
Fresno	1,276,691	977,209	299,482	75,290	15,040	-	-	164,391	-	184,000	128,100	95,300	341,680	98,390	-	137,400	260,500	-
Glenn	348,162	322,928	25,234	2,850	-	-	-	5,152	-	21,600	21,600	14,100	44,600	147,260	-	66,900	59,800	-
Humboldt	1,369,006	1,340,378	28,629	5,810	1,250	-	-	20,046	-	18,500	18,500	10,800	-	-	-	-	1,323,400	-
Imperial	334,209	267,886	66,324	13,610	2,450	-	-	54,149	-	42,800	42,800	3,900	2,860	83,340	-	1,500	133,500	-
Inyo	139,129	132,452	6,677	2,360	-	-	-	5,119	-	3,600	3,600	-	40	10	-	-	128,000	-
Kern	1,080,987	793,689	287,298	82,310	11,250	-	-	185,677	-	166,000	166,000	141,200	241,840	55,710	-	115,400	222,800	-
Kings	464,586	257,214	207,372	24,350	1,340	-	-	19,906	-	178,700	174,900	149,000	43,910	124,780	-	70,700	900	-
Lake	290,596	284,122	6,474	4,260	-	-	-	9,186	-	800	800	-	10,930	820	-	2,900	261,700	-
Lassen	697,148	684,791	12,357	2,320	-	-	-	4,248	-	9,400	9,400	-	-	4,180	-	800	676,200	-
Los Angeles	4,020,846	1,933,233	2,087,613	1,594,070	190,660	26,080	-	2,115,746	-	800	800	-	430	240	-	-	118,900	-
Madera	524,817	429,199	95,617	9,480	1,470	-	-	28,167	-	80,500	75,000	61,500	146,860	5,940	-	57,800	194,600	-
Marin	141,794	66,150	75,644	51,860	5,030	-	-	44,254	-	12,000	12,000	6,500	150	-	-	2,400	26,100	-
Mariposa	168,798	164,379	4,419	1,260	110	-	-	3,638	-	2,500	2,500	-	90	-	-	-	161,200	-
Mendocino	1,290,587	1,279,627	10,960	4,070	540	-	-	13,427	-	4,300	4,300	700	16,450	-	-	1,700	1,250,100	-
Merced	592,759	282,891	309,868	20,290	2,860	-	-	51,999	-	279,100	257,100	221,800	82,070	82,240	-	71,700	2,500	-
Modoc	442,813	430,039	12,775	440	-	-	-	1,293	-	12,100	12,100	-	-	7,380	-	-	421,600	-
Mono	110,304	105,210	5,094	3,110	-	-	-	6,164	-	1,200	1,200	-	20	10	-	-	99,800	-
Monterey	288,772	210,227	78,545	50,470	4,860	-	-	80,842	-	10,800	10,800	500	38,320	4,680	-	4,400	94,400	-
Napa	219,106	200,740	18,366	11,430	2,010	-	-	31,296	-	1,000	1,000	-	38,170	-	-	4,900	130,300	-
Nevada	333,175	325,146	8,029	3,230	1,180	-	-	16,395	-	1,100	1,100	-	370	-	-	-	310,900	-
Orange	1,459,622	770,264	689,358	505,900	82,710	-	-	861,372	-	-	-	-	40	-	-	-	9,600	-
Placer	370,852	332,678	38,174	25,630	2,160	-	-	58,022	-	1,500	1,500	200	870	20,670	-	8,000	254,000	-
Plumas	677,876	674,823	3,053	630	-	-	-	3,946	-	1,800	1,800	-	-	-	-	-	671,500	-
Riverside	1,007,067	638,528	368,538	237,950	19,640	-	-	438,857	-	43,600	37,400	33,200	23,630	21,990	-	6,400	215,000	-
Sacramento	541,521	349,148	192,373	97,490	32,380	-	-	281,521	-	21,800	19,400	12,300	30,750	68,280	-	8,600	700	-
San Benito	77,204	63,311	13,893	5,330	-	-	-	12,824	-	6,600	6,600	-	5,440	110	-	5,200	41,700	-
San Bernardino	1,260,351	932,814	327,537	172,910	27,920	-	-	384,071	-	69,100	56,500	45,700	2,340	10	-	-	604,000	-
San Diego	1,457,489	935,683	521,807	350,760	49,780	14,240	-	783,109	-	11,400	3,800	1,600	22,940	1,300	-	-	238,200	-
San Francisco	135,655	102,765	32,890	-	15,450	-	-	120,205	-	-	-	-	-	-	-	-	-	-
San Joaquin	745,549	503,947	241,602	100,940	10,390	-	-	146,489	-	107,800	100,300	81,400	158,530	149,100	-	69,900	2,400	-
San Luis Obispo	269,321	219,362	49,959	26,270	2,420	-	-	62,531	-	12,700	12,700	-	38,220	3,380	-	3,200	120,600	-
San Mateo	277,496	159,107	118,389	87,370	10,640	-	-	141,156	-	500	500	-	210	120	-	-	37,500	-
Santa Barbara	263,504	186,278	77,226	50,680	5,540	-	-	89,144	-	7,800	7,800	-	26,970	470	-	2,000	80,900	-
Santa Clara	571,326	312,373	258,953	184,350	26,190	42,240	-	277,836	-	7,000	6,800	4,200	2,030	2,520	-	100	71,300	-
Santa Cruz	169,132	134,836	34,296	24,510	3,390	-	-	38,492	-	500	500	-	2,940	-	-	-	99,300	-
Shasta	982,264	945,187	37,076	22,630	1,770	-	-	38,954	-	6,700	6,700	-	650	7,060	-	3,300	901,200	-
Sierra	196,713	194,823	1,890	310	-	-	-	603	-	1,500	1,500	-	-	-	-	-	194,300	-
Siskiyou	1,136,643	1,121,004	15,638	2,120	-	-	-	6,593	-	12,500	12,500	600	10	19,620	-	-	1,095,800	-
Solano	224,658	137,522	87,135	57,930	5,820	18,000	-	90,638	-	11,600	11,600	2,500	10,870	38,000	-	6,800	3,000	-
Sonoma	555,627	465,432	90,195	38,210	4,800	-	-	77,157	-	35,400	32,000	22,400	54,770	290	-	4,800	340,200	-
Stanislaus	547,561	289,697	257,864	15,310	7,900	-	-	53,881	-	226,400	180,800	152,800	140,850	5,020	-	86,600	11,600	-
Sutter	305,710	300,251	5,458	-	1,300	-	-	15,350	-	1,800	1,800	-	35,530	179,430	-	72,300	-	-
Tehama	412,414	391,886	20,528	4,300	380	-	-	10,854	-	14,200	14,200	2,900	27,270	5,410	-	14,300	335,700	-
Trinity	748,313	746,309	2,005	490	-	-	-	2,023	-	1,200	1,200	-	100	-	-	-	744,500	-
Tulare	1,121,112	593,035	528,077	29,520	6,580	-	-	76,112	-	480,500	469,600	402,800	214,320	62,380	-	50,600	201,100	-
Tuolumne	383,937	372,047	11,890	2,690	360	-	-	8,797	-	7,500	2,000	-	190	-	-	-	364,400	-
Ventura	372,607	225,509	147,098	103,370	13,430	8,720	-	194,367	-	1,300	1,300	-	23,980	760	-	2,000	33,400	-
Yolo	313,861	281,765	32,096	22,890	1,190	-	-	40,361	-	2,200	2,200	800	33,080	158,440	-	33,900	21,800	-
Yuba	256,490	226,711	29,778	22,450	570	-	-	15,350	-	4,400	4,400	2,200	15,620	48,400	-	25,200	124,500	-
Other- not located	321,600	67,000	254,600	-	-	18,003	-	-	-	76,300	11,600	-	28,400	33,500	-	183,400	-	-
STATE Total	34,478,000	25,825,000	8,653,000	4,528,000	609,000	136,563	-	7,752,081	-	2,230,000	1,980,000	1,474,000	2,020,000	1,830,000	-	1,310,000	14,200,000	-

## 4. Summary and Conclusion

Within the resource categories considered here, total or gross estimated biomass is 78 million bone dry tons (BDT) per year. Technical (recoverable) resource is estimated at 35 million BDT/y (Table 4.1 & Figure 4.1).

Roughly 45% of the gross biomass resource is considered to be technically available for conversion or other uses. The remainder occur in sensitive habitat areas, on steep slopes not suitable for harvesting, are needed to maintain soil tilth and fertility, or unrecoverable by harvesting and recovery equipment.

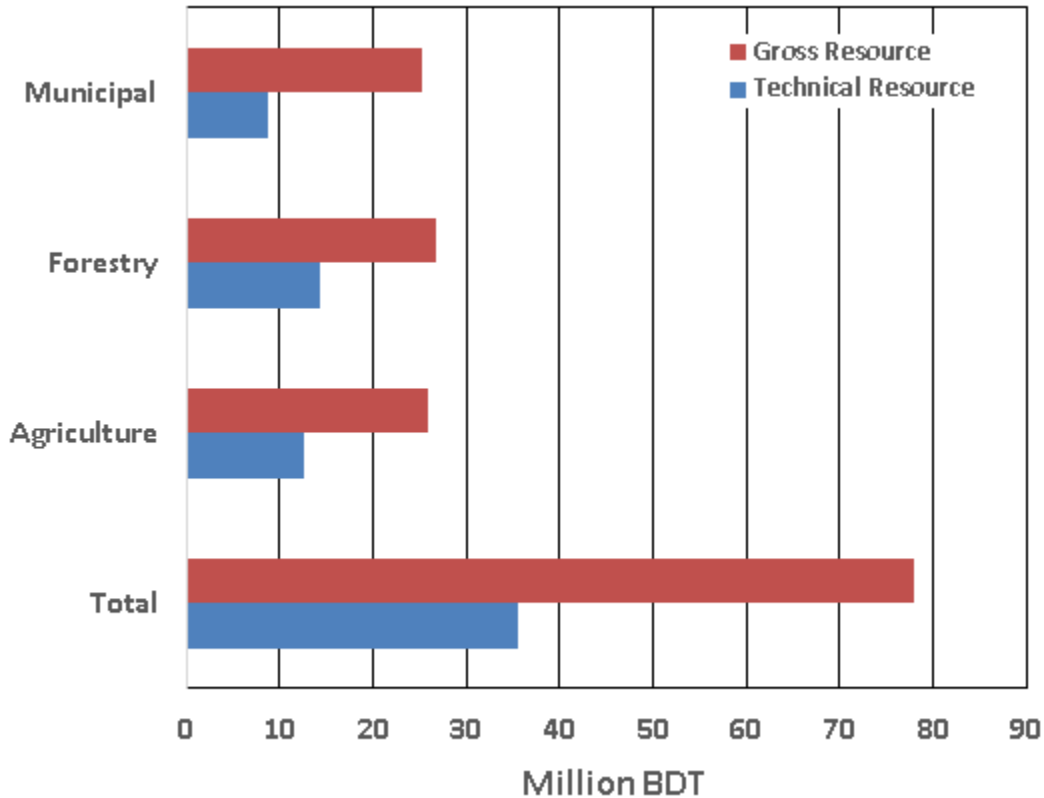
The 35 million BDT/y technical resource, coupled with landfill gas generation from waste already in place and biogas from existing anaerobic digestion represents more than 4,650 MW and 35 TWh of electrical capacity.

The available resource is roughly equally divided among the primary contributing sectors of agriculture, forestry, and municipal wastes (Table 4.1). This technical resource includes material currently used in existing bioenergy,<sup>28</sup> feed, mulch, compost, bedding and other markets.

**Table 4.1. Summarized gross and technical biomass resources in California, 2013**

Category	Units	Agriculture	Forestry	Municipal Wastes	Total
Gross Resource	Million BDT/y	25	27	26	<b>78</b>
Technical Resource	Million BDT/y	12.1	14.3	9.0	<b>35</b>
Gross Electrical Capacity	MWe	2360	3580	3957	<b>9,897</b>
Technical Electrical Capacity	MWe	990	1910	1749	<b>4,650</b>
Gross Electrical Energy	TWh	15	27	29	<b>71</b>
Technical Electrical Energy	TWh	7.4	14.2	13	<b>35</b>

<sup>28</sup> Which is roughly 1 GW capacity including solid-fuel biomass, landfill gas-to-energy, and digester gas-to-energy.



**Figure. 4. 1. Gross and Technical Resource by Category**

#### 4.1 Comparison to 2008 and 2012 Resource updates

Gross biomass resource identified is essentially the same as that for the 2012 update and is slightly less than reported in 2008<sup>29</sup> (~78 vs. 83 million BDT/y). The technical resource is about 8% higher than in 2007 (35 vs 32.6 BDT/y) [Table 4.2 & Figure 4.2]. Significant changes in gross resource for the agricultural (includes increased crop and food processing residues) and municipal resources (decreased MSW) are observed (the same forestry resource data set was used so no change for this resource category) [Table 4.2].

**Table 4.2 Biomass Resource by category (million BDT/y) for 2008, 2012 and 2013 updates**

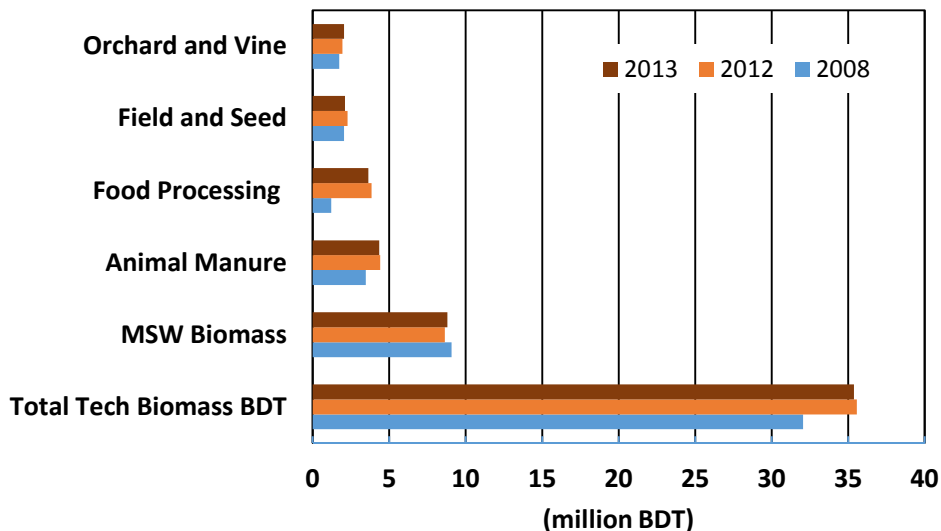
Category	2008 Update		2012 Update		2013 Update	
	Gross	Technical	Gross	Technical	Gross	Technical
Agriculture	20.6	8.6	25.8	12.5	25	12.1
Municipal	35.6	9.6	25.3	8.6	26	9.0
Forestry	26.8	14.3	26.8	14.3	26.8	14.3
Total	83.0	32.6	77.9	35.4	78	35

Gross municipal biomass decreased from 35.6 to 26 million BDT/y primarily due to approximately 30% decrease in MSW going to landfill since 2006/7 (data year for the 2008 resource update). Gross

<sup>29</sup> Williams, R. B., M. Gildart and B. M. Jenkins (2008). An Assessment of Biomass Resources in California, 2007. CEC PIER Contract 500-01-016, California Biomass Collaborative.

agricultural biomass resource increased about 4.8 million BDT/y in this update due to much improved food processing residue data that included addition of almond hull category, improved cannery/processing/grape pomace data, and larger yield factors and increased overall production of almonds and walnuts in the state due to rapidly expanding plantings.<sup>30</sup> A significant increase in dairy cow manure was estimated (6 vs 3.9 million BDT/) for approximately the same number of cows due to a ~67% per animal manure solids production (both in specific production and assumed animal size) using the latest ASAE Manure Production Characteristics standard.<sup>31</sup>

Though 2013 gross resource is lower than in the 2008 update, the technical resource increased by about 2.8 million BDT. This is explained by the increase in agricultural resources mentioned above (primarily improved food processing information, addition of almond hull category and increase in dairy manure estimate). Note that while the gross MSW resource decreased by a large amount, the technical amount is only slightly decreased. This is because the recovery factor for MSW increased from 50% to 67% in this update due to recognition that material recovery systems operate at much higher recovery rates than 50% (the 67% factor now used is still conservative).



**Figure. 4. 2. Comparison of Technical Resource, 2013, 2012 vs 2008 Update**

Gross and technical electricity generation potential are higher in this update compared the 2008 resource report (Table 4.3). Generation potential increases in both the agricultural and municipal resource categories were observed. The increase in the agricultural category is a direct result from the larger biomass resource identified in the category (as discussed above). For the municipal residues category, the increase in energy potential is due to inclusion of energy potential from landfill and wastewater treatment gas (biogas) which were not included in the gross and technical results from the 2008 update.<sup>32</sup>

<sup>30</sup> Amón, R., M. Jenner, R. B. Williams, H. El-Mashad and S. R. Kaffka (2012). California Food Processing Industry Residue Assessment, University of California. Contractor report to the California Energy Commission. **CEC 500-2013-100**.

<sup>31</sup> ASAE D384.2 MAR2005 (R2010), Manure Production Characteristics. American Society of Agricultural and Biological Engineers, St. Joseph, Michigan.

<sup>32</sup> Because landfill gas depends on waste-in-place, this gas energy resource would decline over time if MSW disposal is diverted directly to energy or other uses. More energy can be recovered by converting MSW before landfilling, compared to that which can be generated from the biogas created by the same material buried in a landfill.



**Table 4.3 Electricity generation potential by category for 2008, 2012, and 2013 updates (MW)**

	2008 Update		2012 Update		2013 Update	
	Gross	Technical	Gross	Technical	Gross	Technical
Agriculture	1960	891	2438	1015	2360	990
Municipal	3941	1027	3858	1712	39570	1749
Forestry	3576	1907	3576	1907	3576	1907
Total	9477	3825	9872	4633	9897	4650

#### 4.1.1 Other changes in assumptions or methods

- Technical availability factor changes:
  - Factor for Vegetable crop residues was set to zero (was 0.05)
  - Factor for Beans, Lima Beans, Cowpeas & Southern Peas was reduced to 0.05 (was 0.50)
  - Manure recovery factor for Beef, Other Cattle and Swine was reduced to 0.2 (was 0.25)
- Stone fruit and olive pits were omitted from this update due to low quality or lack of data.
- Improved (higher) gross yield factors for shells, rice hulls, cotton gin trash, and winery pomace, and inclusion of extensive new data for fresh and frozen fruit & vegetable processors from Amón et al. (2012).

#### 4.2 Data Limitations

This analysis has characterized physical resource potentials suggesting the state’s biomass resources are sufficient to supply a larger amount of renewable electricity than is presently generated. Technically, current resources are adequate to support a generation level 3 to 4 times larger than today’s capacity. Economic studies are needed to further refine the generation potential, but development on such a scale would clearly have important implications for the state.

In attempting to quantify gross and technical resource magnitudes, a number of limitations in the inventory data have been identified. Additional effort will be needed to overcome these limitations. Specific concerns include:

- yield factors for biomass from agricultural crops have not been systematically updated for many years. Most originate from agronomic studies not directly aimed at assessing the harvestable yield potential for biomass utilization. Data from commercial biomass fuel suppliers for more commonly used crop residues exist but have not been compiled or quality tested against field studies. Research should be directed at updating yield factors for agricultural crop biomass.
- technical availability estimates are conservative and are often not supported by qualified field studies. Physical constraints and limitations associated with agricultural and municipal waste resources in particular need to be evaluated in more detail.
- animal manure production estimates and biodegradability factors are based on national data standards developed from a wide range of sources. No comprehensive California survey has been made to better characterize production rates and material properties. The size of this

resource and the associated generation potential and environmental benefits suggest that additional effort should be directed at refining these data.

- estimates of in-forest residues are based on timber harvest models employed by CDFFP. The spatial resolution of the forest inventory data is finer than the county level data reported here, making possible improved site specific assessments. Refining the spatial resolution of agricultural data and maintaining updated crop records at this resolution would further aid local and regional assessments and resource development efforts.
- Forest biomass resources were estimated as part of a recent fuels supply assessment by the California Department of Forestry and Fire Protection (CDFFP).<sup>33</sup>
- local jurisdictions are required to track municipal solid waste disposal but landfill diversion is not comprehensively tracked nor is composition of diverted waste directly evaluated. More systematic tracking procedures are needed to better characterize the potential from this large resource.

---

<sup>33</sup> California Department of Forestry and Fire Protection, February 2005, op cit.

## APPENDIX- Comparison of earlier California biomass resource assessments

The California Biomass Collaborative, with funding from the California Energy Commission, issued a biomass resource assessment in 2004 with updates for 2005 and 2006.<sup>34, 35, 36</sup> [1, 82, 83]. These assessments follow at least three earlier comprehensive statewide assessments; Energy Commission (1991), Energy Commission (1999)<sup>37</sup>, and EERGC Corp. (2000)<sup>38, 39, 40</sup> [8, 84, 85].

The CEC (1991) assessed biomass suitable for electricity production, primarily for solid fuel combustion boiler technology. The assessment was updated in a comprehensive 1999 CEC study that looked at ethanol policy, regulations, and production from lignocellulosic resources. The EERGC (2000) assessment was part of a project investigating suitability of opportunity fuels for biomass gasification for use in NOx control via reburning in power boilers<sup>41</sup> [86].

Estimates of gross amount of biomass in California range from 47 MBDT/y in 1991 to 83 MBDT/y in 2006 (Table A1 and Figure A1). The amount considered available (or technically available) after subtracting currently used resource (primarily boiler fuel) was near 30 MBDT/ y in the CEC (1991) and the EERGC (2000) studies and is about 26 MBDT/y in the current CBC(2006) assessment.

Table A1. Estimated California biomass resource, results from four assessments (MBDT/y).

Category	CEC (1991)		CEC (1999)		EERGC (2000)		CBC (2006)	
	Gross	Available <sup>a</sup>	Gross	Available <sup>a</sup>	Gross	Available <sup>a</sup>	Gross	Available <sup>a</sup>
Agriculture	23.6	17.0	14.4	-	19.5	7.9	21	6.9
Forestry	18.4	11.5	21.4	-	21.5	10	27	11.8
Municipal	4.7	3.6	14.8	-	20.8	11.4	35	7.2
Total	47	32	51	-	62	29	83	26

Notes:

a. "Available" is that remaining after subtracting existing use of biomass from the "technical amount" (i.e., boiler fuel was subtracted from technical amount in all studies).

<sup>34</sup> Williams, R.B., M. Gildart, B.M. Jenkins, L. Yan, and R.E. Aldas, (2006). *An Assessment of Biomass Resources in California*. California Biomass Collaborative: CEC PIER Contract 500-01-016.

<sup>35</sup> Gildart, M., B.M. Jenkins, R.B. Williams, L. Yan, R.E. Aldas, and G. Matteson, C., (2005). *An Assessment of Biomass Resources in California*. California Biomass Collaborative

<sup>36</sup> von Bernath, H., G. Matteson, C., R.B. Williams, L. Yan, and B.M. Jenkins, (2004). *An Assessment of Biomass Resources in California*. California Biomass Collaborative: CEC PIER Contract 500-01-016.

<sup>37</sup> A portion of a report on ethanol feasibility for California

<sup>38</sup> Blackburn, B., T. MacDonald, M. McCormack, P. Perez, M. Scharff, and S. Unnasch, (1999). *Evaluation of Biomass to Ethanol Fuel Potential in California*. California Energy Commission, Executive order D-5-99.

<sup>39</sup> Tiangco, V., P. Sethi, and G. Simons, (1992). *1991 Biomass resource assessment report for California*. California Energy Commission.

<sup>40</sup> Springsteen, B., (2000). *Assessment of California Waste Resources for Gasification*. EERGC. EER - SDV Contract No. 500 - 98 - 037

<sup>41</sup> Rizeq, G. and V. Zamansky, (2004). *Utilization of waste renewable fuels in boilers with minimization of pollutant emissions*. GE Global Research: Irvine. California Energy Commission contract no. 500-98-037.

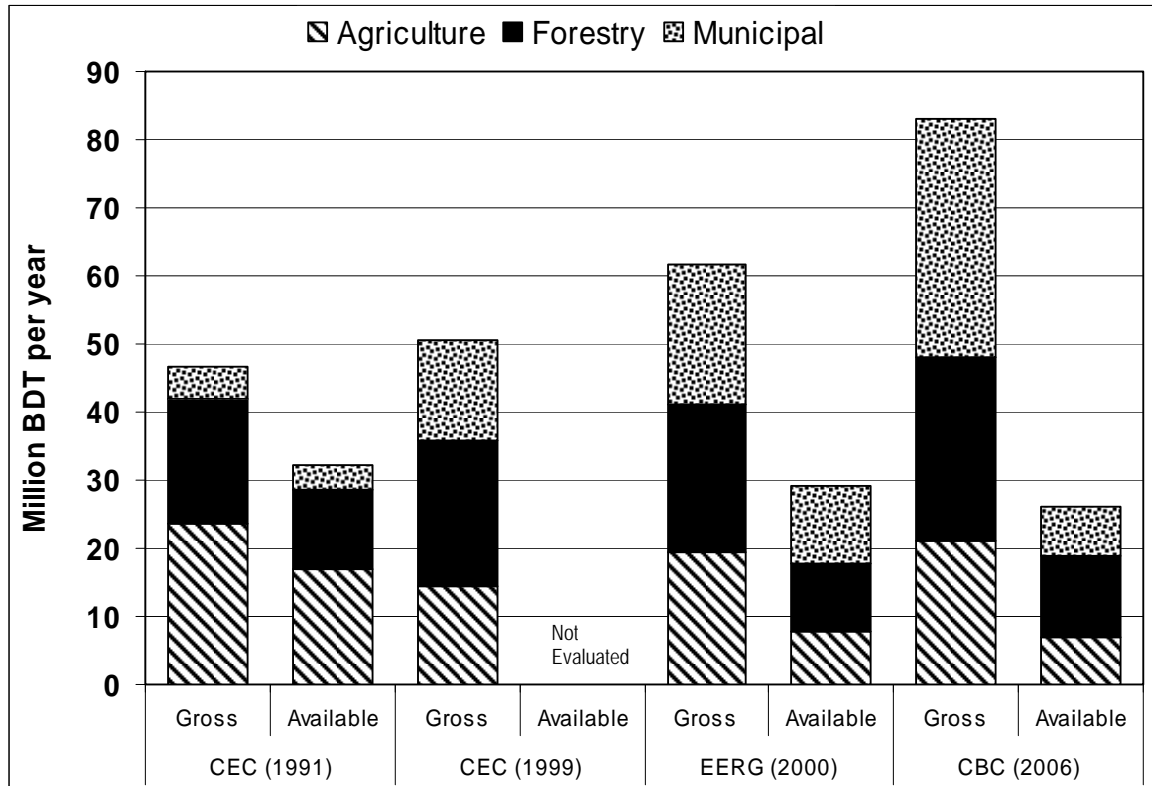


Figure A1. California biomass resource estimates

**Reasons for differences among the assessment studies:**

The studies differ primarily because 1) some studies excluded certain categories of the resource due to study intent (Table A2), 2) there are newer, and presumably, more accurate estimates for forest and municipal biomass amounts, 3) municipal wastes are linked to population and economy increases, 4) there are differences in assumptions applied to technical recovery factors.

Specific differences across studies among resource type

**Agricultural Residues:** Other than animal manures, agricultural residues are roughly equivalent across all four studies (e.g., the main difference across studies in this category is due whether or not and how manures are accounted for). Manures have a high technical availability in the CEC (1991) assessment (essentially 100% of the gross minus current use- no technical recovery factors were considered), and are not considered in the CEC (1999) study (Table 3). The EERGC and CBC assessments apply stringent technical recovery factors to gross manure production ( $\leq 0.5$  including zero recovery for pastured animals, and 50% recovery for feedlot and dairy facilities).

**Forestry and Chaparral;** The CBC (2006) assessment uses forest biomass data from a recent comprehensive assessment by California Department of Forestry and Fire Protection (CDFFP) which estimate 20.6 MBDT/y gross potential from thinnings, slash and chaparral [87].<sup>42,43</sup> Technical availability of forest biomass excludes forest reserves, stream management zones, coastal protection

<sup>42</sup> Rosenberg, M., J. Spero, and D. Cromwell, (2005). *Biomass potentials from California forest and shrublands including fuel reduction potentials to lessen wildfire threat; Draft PIER Consultant Report, Contract 500-04-004*. California Department of Forestry and Fire Protection.

<sup>43</sup> Mill residues of 6.2 MBDT/y bring the CBC(2006) forestry resource up to 27 MBDT/y.

zones, coastal sage scrub habitats, national forest lands with slopes steeper than 35%, and private and other public forest lands with slopes steeper than 30% [87].

The CEC (1991) study used timber harvest data and data on pre-commercial thinning operations to estimate in-forest residues and relied on chaparral acreage and recovery factors for biomass from 1983 and 1985 [84]. CEC (1999) added biomass from potential (or needed) thinning which also served as the basis for EERGC (2000) gross forestry data.

**Municipal Wastes;** The gross MSW biomass reported in the four assessments differ primarily because of three reasons; 1) certain fractions of the resource were excluded from three studies (Table 3), 2) the CEC studies evaluated the landfill stream only (excluded waste biomass that is recycled), and 3) waste generation and disposal has been growing with population and the economy and better disposal characterization data are available <sup>44, 45, 46</sup> [88-90].

Table A2. Specific resource types included in current and past assessments.

		CEC (1991)	CEC (1999)	EERG (2000)	CBC (2006)
Agricultural residues	Orchard & Vineyard Crops	Y	Y	Y	Y
	Field & Seed Crops	Y	Y	Y	Y
	Vegetable Crops <sup>a</sup>	Y	Y	<b>N</b> <sup>a</sup>	Y <sup>a</sup>
	Food processing (shells/hulls/ pits)	Y	Y	Y	Y
	Animal Manures <sup>b</sup>	Y	<b>N</b> <sup>b</sup>	Y	Y
Forest and forest product residues	Thinnings and Slash	Y	Y	Y	Y
	Chaparral	Y	Y	Y	Y
	Mill residues	Y	Y	Y	Y
Municipal wastes <sup>c, d, e</sup>	Paper & Cardboard	<b>N</b>	Y	Y	Y
	Urban Wood	Y	Y	Y	Y
	Yard Waste	Y	Y	Y	Y
	Food and other	<b>N</b>	<b>N</b>	<b>N</b>	Y
	Biosolids	<b>N</b>	<b>N</b>	Y	Y
	Energy Crops <sup>f</sup>	Y	Y	Y	Y

Notes: Y= resource included, N= resource not included in estimate.

a. Veg. crop residues are considered to have low technical availability (~ 5% of gross amount) due to agronomic and practical considerations and do not contribute substantially to available biomass.

b. Manures not considered in CEC (1999) because ill-suited for ethanol production.

c. CEC (1991 & 1999) considered Landfilled MSW as Gross Amount of this resource

d. EERG (2000) and CBC (2006) consider total MSW generation (landfilled plus recycled) for Gross Amount of municipal biomass.

e. CBC (2006) assumes technically available is ½ of the landfill disposal stream.

f. Though the CEC (1991) report identified some energy crops, primarily eucalyptus plantations and trials with an estimate of 0.5 MBDT gross potential, none was 'available' and no energy crops were identified in the three later assessments.

<sup>44</sup> Cascadia, (2004). *Statewide waste characterization study*. Contractor's report to CIWMB. Publication #340-04-005.

<sup>45</sup> CIWMB, (1999). *(CA) Statewide Waste Characterization Study -Results and Final Report*. Cascadia Consulting Group, Inc.: Sacramento. p. 206

<sup>46</sup> Williams, R.B., (2006). *Biomass in Solid Waste in California: Utilization and Policy*, in. . California Biomass Collaborative. University of California, Davis. *CEC PIER Contract 500-01-016*.

### Lignocellulosic Biomass Resource

Lignocellulosic materials that may be suitable as feedstock for liquid fuels include herbaceous and woody material from agricultural residues (or dedicated feedstock crops), essentially all of the forest biomass resource and paper/cardboard, urban wood and green and yard waste from the municipal waste landfill stream.

The lignocellulosic resource is less than the gross resource because it excludes;

- animal manures, food processing wastes and vegetable crop residues from the agricultural sector
- food waste, biosolids, and indeterminate ‘other’ biomass from the municipal waste stream

The gross and available<sup>47</sup> lignocellulosic resource estimate for California are 62 and 21 MBDT/y respectively (Figure A2).

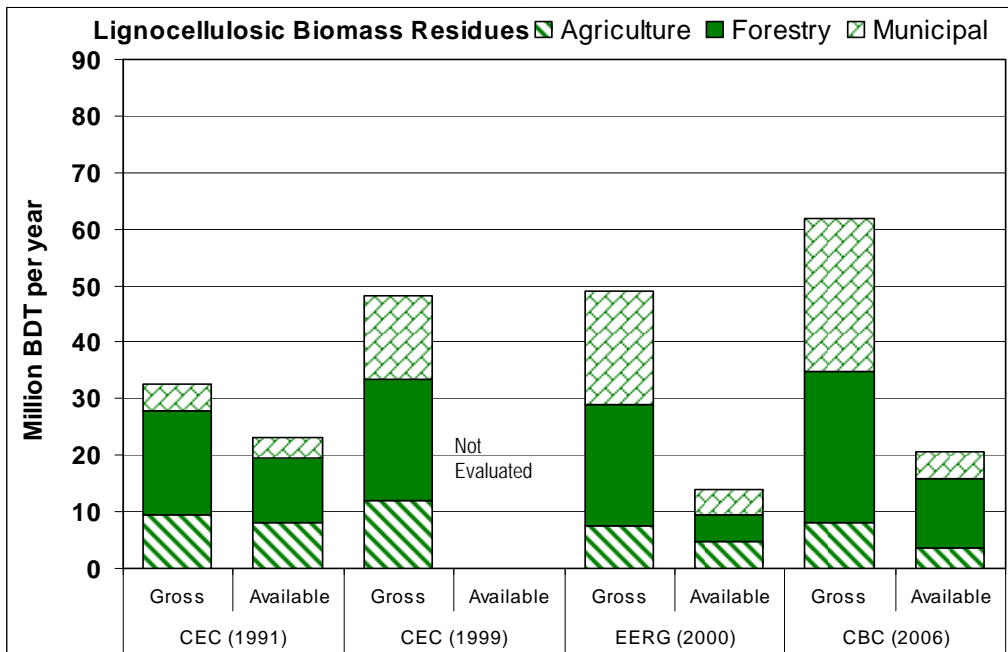


Figure A2. California lignocellulosic biomass resource estimates

<sup>47</sup> Where “available” is that remaining after subtracting existing use of biomass from the “technical amount” (i.e., boiler fuel was subtracted from technical amount in all studies).