California Biomass Collaborative (CBC) summary of current biomass energy resources for power and fuel in California[1]

May 15, 2011

In 2008, California consumed approximately 8, 350 trillion btus of energy,. Approximately 10 % was derived from renewable sources, with biomass providing 2.8 % of total energy use in the state (EIA, 2011). Biomass is diverse, widely distributed, and can be used for many purposes, including for energy and as a source of feedstock chemicals. California has extensive areas of forest that can produce residues and post harvest materials for power and fuel. It has a large and diverse agricultural economy which produces potentially usable crop and tree residues. Under supportive circumstances, crops may be grown as power or biofuel or energy feedstocks. Its large urban population also produces residual biomass wastes as MSW (municipal solid wastes or urban derived materials) and urban wastewater, adding additional sources of potential biomass feedstocks.

Biomass power systems can operate as base-load generators without the intermittency inherent in wind and solar power systems. Base-load operation provides firm supply of electricity during peak demand periods, allowing greater opportunities for natural gas generators to reduce fossil fuel consumption. Integrated biorefineries that may be created for biofuel production will also generate power under many possible scenarios, so it is difficult to estimate separately the potential for fuel and power for the new projects proposed for California or for those developing outside of California currently.

The renewable and technical potential of biomass in California is summarized briefly here. More detailed assessments have been created for the California Energy Commission in a series of reports since the CBC was established, including the Biomass Whitepaper (Jenkins, et. al., 2005) the California Biomass Roadmap (Jenkins, et. al., 2006), and the 2007 California Biomass Resources Assessment (Williams, et. al., 2008) . Estimates of biomass supplies and the availability of that biomass are subject to change. One of the continuing activities of the CBC is developing new and more accurate estimates. Supplemental materials with greater detail from current investigations or data sources not reflected in earlier CBC reports are included here as well. These brief narratives are divided by biomass types. Each requires different answers to the questions posed. These are given briefly as supplemental materials. Greater detail will be present in the final reports resulting from the current PIER contract with the CBC, or are already reported in previous analyses submitted to the California Energy Commission.

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The most significant barriers to biomass use for energy and other purposes in California are not technical, but more infrastructure/policy barriers. The science of biomass conversion is well understood. Now the state desires to develop commercial conversion industries that create jobs, wealth and enhance the environment for California. These barriers apply to most biomass pathways and include:

1. Siting and permitting costs and uncertainty or delays in securing permits are significant barriers to bioenergy project startups.
2. Low energy prices available to developers.
3. Lack of a uniform state or federal carbon tax and a low carbon market price have been barriers. It is not clear how the state's new Cap and Trade program in California will affect this situation. Since the state's Cap and Trade policy applies only to California, it is uncertain how a state level regulation will affect companies that operate in national or international markets.
4. Some types of ecological or societal benefits from bioenergy projects are difficult to value and monetize, or to assign a carbon value. This situation is not unique to California.
5. There are many and diverse inhibitory definitions in statute, most evident currently in the regulation of MSW and urban wastewater conversion technologies for energy.
6. There is uneven support and inconsistent policies supporting technology innovation and improvement at different scales, including uneven net metering regulations that may disadvantage smaller, distributed facilities.
7. There are unequal policies or incentives across different renewable technologies. Some used with success elsewhere, such as the combustion of MSW, are seen as undesirable without an objective basis, biopower from the combustion of biomass residuals is not subsidized equivalently to more costly technologies like solar.

Sandra Fromm questions: Renewable technical and economic potential in California and the West

1. **Remaining technical potential by county.** Fig. 1. Illustrates the most recent statewide estimates made by the CBC of the distribution of the important sources of biomass in California for power, or biofuel production. Technical potential varies by biomass type and location across the state, and boundary conditions assumed for its availability. Currently, woody biomass from urban sources and forestry residues are used to fuel the state's older biomass power facilities. Most residues from commercial tree harvests, however, are consolidated in the forests and burned or chipped and scattered in place rather than transported for power conversion.
   - About 15 % of the fuel used in current biomass to energy facilities comes from forest residues[2].
   - Agricultural residues (prunings, old trees) from the production of nuts and tree fruits are used for power in the Central Valley of California at existing biomass

[2] Personal communication, F. Tornatore, TSS, Inc. and CBC board member.

power facilities. About 30% of the fuel supply for existing biomass facilities comes from these sources.

- The remainder derives largely from urban wood wastes. Otherwise, there are few other agricultural residues or crops originating in California used for energy or fuels. There are three facilities that combust MSW, two in the Los Angeles region and one in Stanislaus County.

There is substantial post-recycling MSW currently being land-filled that could be used for power and transportation fuel production. Many food processing industry residues could be converted to biogas for power, and biogas can be produced at wastewater treatment facilities and used for power or concentrated for biofuel. These residues are still largely unused for energy. Some play a role in the livestock industry or have other uses.

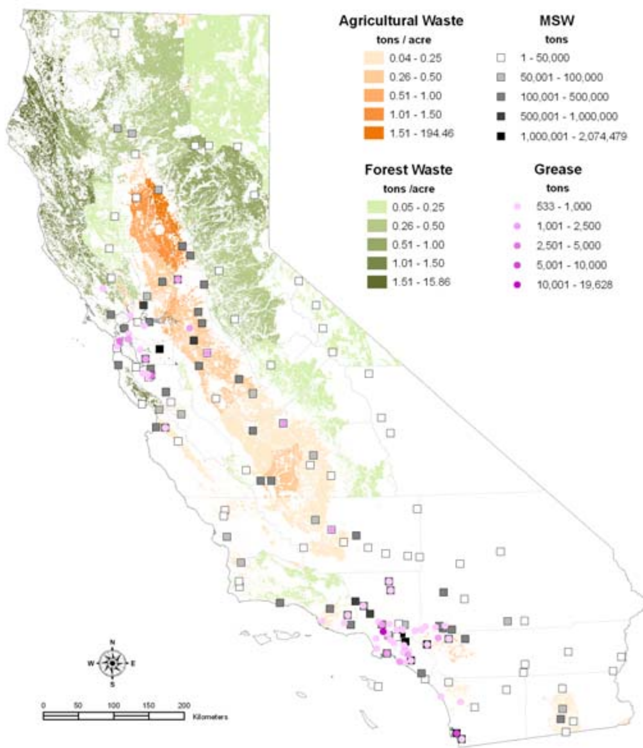

Figure 1. Distribution of biomass by type in California. (Figure 12 in Tittman et al., 2008)

2. **Qualitative discussion of difference between technical and economic potential, including factors affecting economic potential for each renewable technology.**
   Fig. 2 provides a recent estimate of the cost and amount of biomass potentially available in California, based on price per ton, derived from the surveying modeling

efforts of Tittman, Parker, et al, (2008) who created the California Biorefinery Siting Model. This work, submitted as report to CEC is based on earlier CBC reports and data collection. The optimization modeling identifies the best locations for bio-refinery and biopower facilities in California as a function of biomass distribution, type and relevant infrastructure like roads and power lines and cost of biomass regionally. While large amounts of biomass are technically available in California, the costs to purchase, collect and assemble biomass, including regulatory costs, are high and limit its use significantly. Supply is contingent on feedstock price. (Tittman, Parker et al., 2008). Some biomass access is restricted for environmental purposes, like forest biomass in national parks, nature reserves and wild and scenic areas, or erosion and stream protection. Economic potential cannot be separated from policy issues that affect or constrain the use of biomass. Additionally, new developments in conversion technologies will continue to influence and alter the profitability of biomass conversion to energy.

In general, biomass resources are expensive to consolidate, and both this expense and their energy content limit the distance from which they can be assembled. If the energy content of distributed biomass supplies can be increased through pre-treatment technologies (pyrolysis and torrefaction are examples of technology with possible application for forested biomass, crop residues and perennial grass crops), then biomass can be assembled at combustion or gasification facilities or refineries from larger distances. Currently, in the absence of cost-effective concentration technologies, the distance of 50 miles is commonly used as a limit for truck transportation.

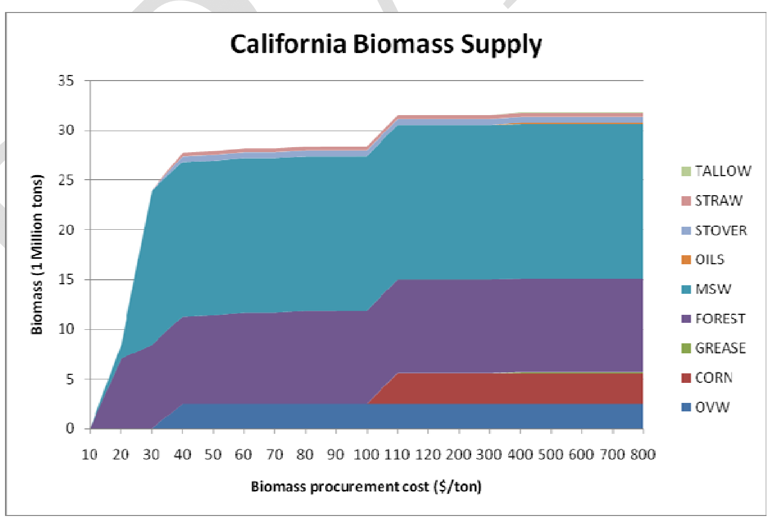

Figure 2. Estimated availability of biomass by price (Figure 13 in Tittman, Parker et al., 2008. OVW. = Orchard and vineyard waste).

The mode of transportation matters. Corn grain can be imported to California from mid-western states via rail at low enough cost to support in-state ethanol and by-product feed production. Wood chips are exported to Europe and Asia via ship from North and South America where higher electricity prices and mandates create strong demand. In general, transportation fuels are worth more than electricity. At current oil prices, biomass will tend to be diverted to fuel rather than power. The initial conversion facilities are being built outside of California.

3. **Description of performance issues with renewable resources (each renewable), how that may affect technical or economic potential, and what has been done to address those issues**. Performance issues include reliability, efficiency, availability, and capacity among others. Biopower systems can operate on a 24-hour basis, but older facilities apart from the three that use unsorted MSW have had difficulty remaining in operation over time as power prices and the cost of feedstock fuels vary. Older facilities use mostly dated, less efficient steam power technology and now must comply with new, more stringent federal boiler MACT emission rules (particularly for mercury, HCl, and dioxins). Many older facilities will likely not be able to meet these new rules economically, with possible closure once new stadards are implemented. The cost and potential for facility upgrades is being analyzed by the CBC.

Woody biomass, including forest residues, can be converted to fuels, but the cost of doing so is not currently economically feasible. This is unlikely to change in the near term, though a pilot facility in Alpena, Michigan, created by a California company, is breaking ground. Another project in Ontario, Canada (Rentech) will make jet fuel. Biofuel producers have increased the US national biofuel (ethanol-almost entirely from corn grain) supply to nearly 14 billion gallons per year, including meeting California's growing demand. While some individual producers have entered and left the business, overall supply has increased and is approximately equal to total US demand. In California, there is some idled capacity for producing grain based ethanol due to market prices for grain and project finance difficulties.

Some projects in California have been granted awards under the AB 118 program to develop pilot-scale facilities or plans for commercial operation using agricultural crops and residues for both biofuel and combined heat and power facilities, but these have not started construction yet. Optimistically, the first one may begin operation in two to three years.

Several biogas facilities to generate power have been constructed on California dairy farms but only a few have been able to operate in compliance with air quality limitations, or were permitted at emission levels higher than current standards. These emissions limits from internal combustion engine-generator systems (primarily NOx) remain a technical and economic barrier to expansion of this resource. Additionally, rules prohibiting the addition and use of other, more productive feedstocks in dairy digesters limit the amount of gas extracted from manure and the viability of new projects on dairies. Gas quality standards vary among potential utility scale customers for this gas.

The state's diverse food processing industry is beginning to develop energy from its residues, and we expect this development to continue and gain speed under the stimulus of the state's new Cap and Trade program. Wastewater treatment facilities and landfills produce some biogas that is converted to power. Waste Management Inc. and Linde Inc. have begun operation of biogas to fuel facility in Contra Costa County.

4. **Discussion of where individual renewable technologies are in terms of industry maturity and what needs to happen for them to be considered fully mature.** Ethanol or other biofuels made from advanced and cellulosic feedstocks have not developed any significant supply in the US.
   - Technical challenges remain in converting plant cell walls to fuels at a reasonable price. Groups creating fuels from California feedstocks are using plant sugars or starches rather than cellulose, and it is technically feasible.
   - Policy instability at the federal level around the RFS2 mandate have slowed development of cellulosic fuels. The RFS2 mandate for such fuels has been adjusted downwards twice since 2009 and will be again in 2011.
   - Policy disputes about biodiesel and ethanol blenders' credits and tax policies are currently occurring, creating an unstable investment climate.
   - US ethanol demand is saturated at the 10 % blend level (the blend wall), and this limits investment in alternative ethanol enterprises, except for California, which has erected its own regulatory barrier to mainstream ethanol supplies through the Low Carbon Fuel Standard. US EPA has raised the blend limit in the US to 15% for some vehicles but that decision is subject to current litigation. Brazil produces large quantities of ethanol from sugarcane and this qualifies as an advanced biofuel under US EPA rules and may be imported into California to meet the state's LCFS mandate.
   - New technologies to transform the organic fractions of MSW into power or transport fuels are being developed outside of California, but adoption of these technologies in California has been stymied by statutory and administrative barriers. Projects have been constructed or are under construction outside of California. The CBC is reviewing this situation for the CEC.
   - Existing biomass to power facilities are mostly reliant on less efficient, older boiler technology. To remain competitive for biomass feedstocks in the future, modernization may be required. It will likely not be economically feasible for many current facilities to meet new EPA boiler MACT standards that will take effect in May. Liittle biomass co-firing at coal powered facilities is planned or underway in California.

5. **Environmental issues associated with each renewable technology.** Biomass is derived from landscapes, so natural resources are used in both the production of biomass, and in its extraction. There can be unintended or secondary consequences of harvest and transportation of biomass feedstocks. Each is feedstock type and site-specific but can include emissions of CO_2 and other green house gases (GHG), and emissions to surface and groundwater, soil erosion, and decline in soil organic matter.

That these may occur does not mean that they will occur or occur excessively in all instances, merely that they are possible consequences. It is generally thought that the use of residues and by-products from other economic processes like food processing or sorted, post recycling MSW residues for power or fuels offers efficient pathways for their production with minimal direct environmental effects.

The state's Low Carbon Fuel Standard favors such fuel production pathways. The production of agricultural residues, purpose grown crops, or plantation tree systems, requires the use of land, water, nutrients from fertilizer, pesticides, and energy for farm machinery and biomass collection and transport. Often there are competing markets for many residues. Substitutes for new uses of these residues for energy will be needed.

The costs of production and assessment of net GHG benefits is needed to see if improvements are associated with fuel or power uses compared to current uses. Net benefits of the use of residues and crops, and correlated emission levels vary by project and must be evaluated on that basis. At the moderate levels of use of farm residues for biofuels likely to occur in California, impacts on resource use would be unaffected or improved. The use of forest residues for power occurs at lumber mills and biomass power facilities around the state, but due to mill closure, many residues have no nearby destination.

In many of the forests in California, especially on federal lands, rates of wood accumulation exceed removal and increasing fuel loads heighten the risk of fire each year. Catastrophic fires can alter the character of forested ecosystems for many years, sometimes permanently. The removal of some of this fuel and its use for power or transportation fuels could protect California's forests and reduce the public's exposure to the adverse health effects of fires, and to the cost of fires and related loss of property and life. If use and harvest is done poorly, important natural habitats of great beauty could be disrupted, and the risk of soil erosion and diminished supply or adverse effects on water quality could occur. Forest harvest practices in California are the most stringently regulated in the United States, minimizing the likelihood of adverse outcomes.

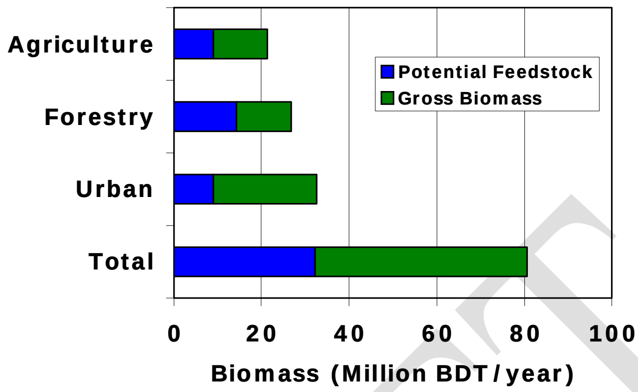

Figure 3. Consolidated Estimates of biomass feed stocks by source from the California Biomass Roadmap. (Jenkins et al, 2006).

Table 1. Resources and generation potentials from biomass in California (Williams et al., 2007)

Category	Units	Agriculture	Forestry	Municipal Wastes	Dedicated Crops	Total
Gross Resource	Million BDT/y	20.6	27	36	0	83
Technical Resource	Million BDT/y	8.6	14.3	9.6	0	33
Gross Electrical Capacity	MWe	1960	3580	3940	0	9,480
Technical Electrical Capacity	MWe	891	1907	1027	0	3,820
Gross Electrical Energy	TWh	15	27	29	0	70
Technical Electrical Energy	TWh	7	14	8	0	28
Existing and Planned Capacity	MWe	136	262	570	0	968
Existing and Planned Energy	TWh	1	2.0	4.2	0	7
Technical Capacity Net of Existing and Planned	MWe	755	1644	457	0	2857
Technical Energy Net of Existing and Planned	TWh	6	12	3	0	21

Appendix. Supplemental materials for evaluation of potential individual biomass feedstocks

The data and discussion presented here supplement or update estimates from earlier CBC studies. In particular, agricultural residues are more effectively estimated in the most recent studies, and energy potentials from the food processing industry are updated. Forestry biomass estimates resent the most current assessments from Cal Fire, and the status of biomass to power facilities by location linked here is the most current estimate.

Agricultural Feedstocks.

Agricultural feedstocks that are technically available vary from purpose grown crops that can be used for fuel and power production like sugarcane, sugarbeets, oilseed crops, and forage like materials to agricultural residues. Crop residues like straw from small grain (wheat, barley) harvests, corn stover, tree and vine prunings, and many, diverse other materials have current uses, or have proven uneconomic to recover. These are not evaluated individually, because each instance is different and space and time limitations preclude such analyses. The CBC has modeled current agricultural production systems throughout California with a specific emphasis on new and existing crops with reasonable potential for use as biomass feedstocks. Some general results from this analysis are presented. Landfill gas estimates are included as well, but reported as energy yields resulting from cumulative waste in place

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Table 2. Technically available biomass from crop residues and animal manures in California by region per year

	Northern CA	Central CA	Southern CA	Central Coast	California
Total Agricultural Crops (Million dry tons)	1.9	2.3	0.2	0.1	4.6
Field and vegetable crops	1.61	1.24	0.10	0.03	2.99
Orchard and vine crops	0.34	1.08	0.07	0.12	1.60
Total Agricultural Livestock (Million dry tons)	0.4	3.4	0.6	0.1	4.5
Dairy manure	0.04	1.62	0.22	0.00	1.90
Other manure	0.37	1.74	0.37	0.12	2.60
Landfill gas (Billion Cubic Feet/year, BCF/y)	5.1	1.2	57.1	15.6	79

Crop and livestock residuals are based on the 2007 Census of Agriculture, especially for the regional distributions. Technically available biomass other than from field crop residuals utilized the total value of dry biomass production from the 2005, Biomass in California: Challenges, Opportunities, and Potentials for Sustainable Management and Development Report: http://biomass.ucdavis.edu/materials/reports%20and%20publications/2005/2005_Biomass_in_California.pdf

Existing manure digester projects are less than 1 percent of technically available energy from manure.

Landfill gas technical potential is based on the technical potentials established in the 2005 Collaborative Report with the regional distribution based on the EPA, Landfill Methane Outreach Program (LMOP), waste-in-place for California projects (905 million tons)

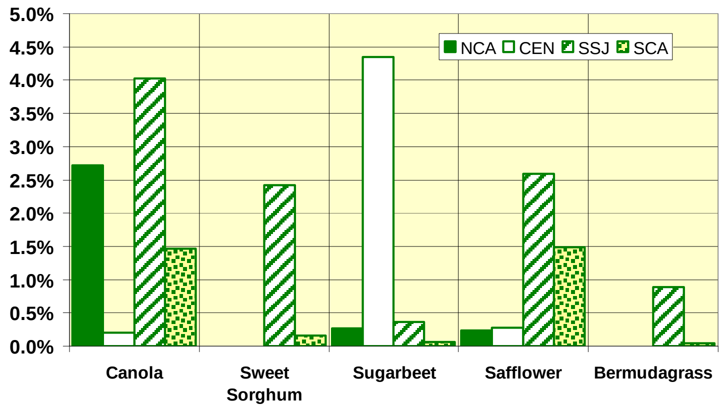

Figure 4. Location in California of agronomic crops useful as biofuel feedstocks. NCA is the region including the Sacramento Valley and intermountain areas, CEN includes the northern San Joaquin Valley and part of the Delta, SSJ is the southern San Joaquin Valley, and SCA is southern California, largely the Imperial Valley. Based on the California Bio-energy Crop Adoption Model (Kaffka and Jenner, 2011).

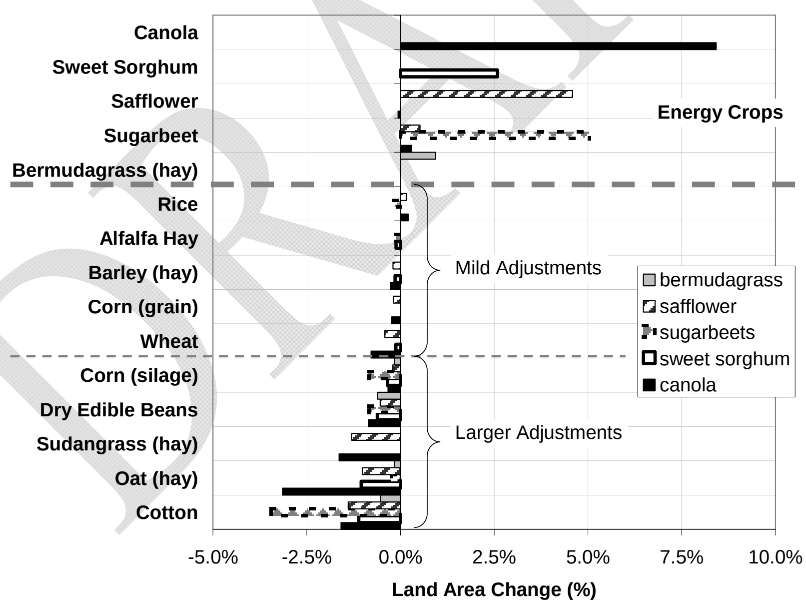

Figure 5. Predicted statewide crop land adjustments for a series of crop biofuel feedstocks modeled using the California Bioenergy Crop Adoption Model and summed across all areas of the state. (Kaffka and Jenner, 2011).

Land area changes estimated are for existing farmland currently in use excluding all land devoted to perennial crops like fruit and nut trees and vines. This equals approximately 5

% of non-perennial cropland and 10% of all irrigated cropland (400-500K acres). County and sub-county level projections are possible but depend significantly on relative crop and residue prices and other assumptions related to feedstock demand. The Bioenergy Crop Adoption Model is an agro-economic optimization model that identifies that amount of land that might be converted to potential biofuel crops under favorable economic conditions, and its location throughout the state (Kaffka and Jenner, 2011). Currently, very little crop biomass is used for biofuel production in California. Orchard and vineyard prunings and tree removals are used in biomass to power facilities in the state and are approximately 30 % of the biomass fuel supply on a statewide basis.

<u>Food Processing Industry Feedstocks</u> (Amon, et al., 2011)

Statewide the generation of power from organic residues from the food and beverage industry have an estimated a technical energy potential of 134 MW of equivalent electricity from solid residues (Matteson, G. C. and B. M. Jenkins, 2007). This study did not account for wastewater residue energy conversion potential or provided regional characteristics by type of business. An on-going 2011 California Biomass Collaborative regional food industry residue assessment estimates the technical potential to generate energy from California's Cannery, Dehydrated, Fresh and Frozen Fruit &Vegetable Industry to equal 50 MW of equivalent electricity. This estimate is calculated using data collected from 164 companies that represent 79 percent of the total sample population. The following table provides data by regions of the State. The San Joaquin Valley region has the potential to generate 28.8 MW of equivalent electricity or 57 percent of the technical potential from the Cannery, Dehydrated, Fresh and Frozen Fruit &Vegetable Industry.

Table 3. Food processing residuals by region and potential energy production

Region	Wastewater Biogas Power (kWe)	HMS Biogas Power (kWe)	LMS Biogas Power * LMS Biogas Power (kWe)	Total Biogas Power (kWe)	LMS Thermo Chemical Power (kWe)
San Joaquin Valley Region	11,147	7,505	10,141	28,793	5,345
Northern California	2,525	1,893	4,453	8,871	2,346
Central Coast	141	707	8,680	9,529	4,575
Southern California	988	822	0	1,810	0
Bay Area	329	468	907	1,704	478
Statewide Totals	15,130	11,395	24,181	50,707	12,744

HMS = High Moisture Solids; LMS = Low Moisture Solids; * = Anaerobic Phased High Solids System

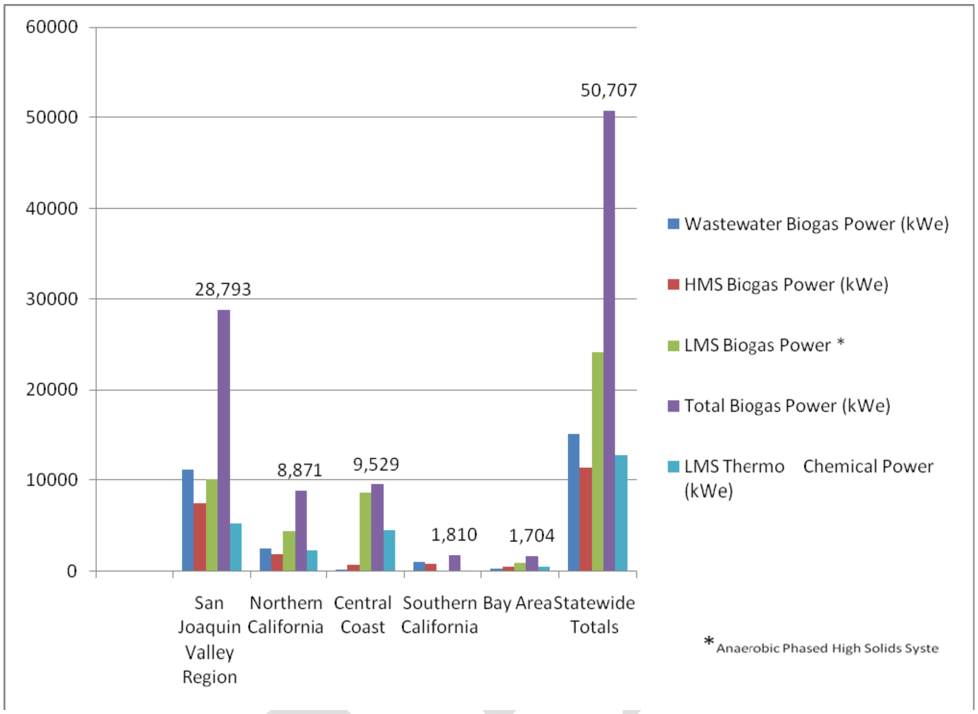

Figure 6. Regional distribution of potential biogas production from several wastewater sources (in kWe). (Amon, et al., 2011).

Within the San Joaquin Valley region, Fresno County has the potential to generate 31 percent of the region's technical potential followed by Stanislaus County with the potential to generate another 27 percent of the region's technical potential. Both Counties have more energy potential from companies missing in the sample response. The technical potential to generate equivalent electricity is calculated by using anaerobic digestion (AD) technology at 30 to 35 percent electrical conversion efficiency. There is less than 1 MW of active bioenergy projects in this segment of the food processing industry. Gill Onions in Oxnard generates 600 kW using AD with fuel cells. Valley Fig Growers in Fresno uses biogas to feed a 100hp boiler system. There is a raisin processing facility in Fresno County producing an unreported amount of electricity using internal combustion engines. There is almost a 100 percent technical economic potential available from the Cannery, Dehydrated, Fresh and Frozen Fruit & Vegetable Industry.

Current residue disposal practices include discharging wastewater to land or wastewater treatment facilities, with the solid residue discharged on land or used as animal feed. In addition to the San Joaquin Valley region the Central Coast has the technical potential to generate another 9.5 MW of equivalent electricity or 19 percent of the technical potential from the Cannery, Dehydrated, Fresh and Frozen Fruit &Vegetable Industry. The Gill

Onions bioenergy project already generates 600 kW from this technical potential. However, 100 percent of the 8.5 MW of equivalent electricity potential is available in Monterey County. The Northern California region is a close third with a technical potential to generate 8.9 MW of equivalent electricity or 18 percent of the technical potential from the Cannery, Dehydrated, Fresh and Frozen Fruit &Vegetable Industry. The resource is distributed between Yolo, Colusa, Sacramento and Butte Counties. Additional yet very limited technical potential is available in the Urban Southern California region and the San Francisco Bay Area. Additional energy technical potential is available from dairy creameries, breweries and other food processing companies. Data for these industries will be available by mid-summer 2011.

Forestry Feedstocks

Determining the economic potential of forest biomass is not straightforward. Forest biomass (wood) generation is costly due to harvest, transportation and processing costs. Biomass technologies must be applied across a wide range of scales from small distributed systems to large centralized facilities.[3] The largest facilities (50 MW) often have to draw feedstock from longer distances, increasing feedstock costs. Smaller scale plants (< 10 MW) have higher capital costs per installed kilowatt hour, and a higher per unit energy cost.

The profitability of wood products is determined by the commodity prices set by those markets. Using biomass for fuel is often its lowest valued use. Only the material which cannot be used for higher value wood products will be used for energy. Forest biomass facilities that make use of both heat and electricity (cogeneration) are more efficient than facilities that only produce power. Large, stand-alone forest biomass facilities also incur significant expenses when they use large quantities of water to dissipate waste heat. Waste heat that is used for complimentary purposes offsets these operational expenses, which enhances the facility's financial viability.

The technical potential of forest biomass represents biomass available for removal based on topographic slope constraints and legal limitations on access. California has large amounts of woody biomass in its forest and shrub land ecosystems. Table 4, shows estimated total available standing technical biomass potential in California in Bone Dry Tons (BDT). A map of the location of total technically available forest biomass is shown in Figure 7, derived from the 2005 FRAP report and county level forest biomass supplies in Table 4, from: (http://frap.fire.ca.gov/publications/BIOMASS_POTENTIALS_FROM_CA_FOREST_AND_SHRUBLANDS_OCT_2005.pdf). Non-merchantable (< 9" d.b.h), technically available biomass is estimated as approximately 14 million BDT. To annualize total biomass data (Table 5), the assumption was made that privately owned forests are entered for commercial thinning every 25 years, with a final rotation harvest no more frequently than once in 70 years. On public lands, a single commercial thinning entry at 67 years can be assumed with a final rotation harvest no more frequently than once every 100 years. These assumptions are reasonable given the way private forestlands are managed, and

[3] Much of this data was supplied by Mark Rosenberg, Justin Johnson and Doug Wickizer of Cal Fire). Fred Tornatore of TSS Inc., provided data as well.

that harvesting has diminished on national forests in recent years as greater emphasis has been placed on fire threat reduction than commercial wood production. A 20-year rotation on shrub lands is a typical period for regeneration to pretreatment low fire-hazard levels. Annual achievable biomass harvests can be further restricted by focusing on woodlands and shrub acres near urban areas where the risk of damaging fires lends greater urgency to the fuel load reduction strategies. Non-merchantable, technical biomass capacity, and energy potential from this particular category are summarized in Table 5. This is equivalent to annual potential harvest of 14.2 MBDT, with 11.2 MBDT from woodlands and the remainder from fire prevention treatments from shrub lands. This estimate corresponds closely to the one reported in Figure 1 above and in Williams et al., 2008. Public policy will influence the actual amount of woody biomass made available for energy and related uses in the future.

Table 4. Technically available in-forest biomass by county. Biomass estimates are for in-forest material excluding steeply slopped areas, near streams, woody material in biologically sensitive areas, and areas reserved due to policy.

	Non-merchantable forestry biomass gross				
	Forest gross				
County	Slash and thinnings	Mill waste	Potential	Shrub gross potential	Potential
Alameda	333,932	22,868	356,800	48,871	405,670
Alpine	971,399	1,372,930	2,344,329	160,375	2,504,703
Amador	3,447,597	2,633,523	6,081,120	111,931	6,193,051
Butte	7,241,805	6,614,169	13,855,973	108,881	13,964,854
Calaveras	5,837,823	4,542,965	10,380,788	550,657	10,931,445
Colusa	1,356,860	530,750	1,887,610	710,780	2,598,390
Contra Costa	177,979	5,538	183,517	47,759	231,277
Del Norte	5,639,721	4,374,535	10,014,256	62,538	10,076,794
El Dorado	14,932,236	16,022,306	30,954,542	356,950	31,311,492
Fresno	9,685,526	10,633,015	20,318,540	274,012	20,592,553
Glenn	2,279,180	1,651,894	3,931,074	558,824	4,489,897
Humboldt	29,917,128	21,222,537	51,139,666	85,133	51,224,799
Imperial				2,848,872	2,848,872
Inyo	890,963	579,449	1,470,412	2,439,610	3,910,022
Kern	3,902,696	1,576,955	5,479,651	3,337,088	8,816,739
Kings				20,483	20,483
Lake	6,129,349	3,310,795	9,440,144	1,840,970	11,281,113
Lassen	11,886,496	14,233,591	26,120,087	4,614,874	30,734,961
Los Angeles	1,530,211	583,355	2,113,566	3,709,208	5,822,774
Madera	6,763,800	7,428,290	14,192,090	144,634	14,336,724
Marin	655,343	136,717	792,060	4,832	796,891
Mariposa	4,524,838	2,532,419	7,057,257	514,623	7,571,881
Mendocino	26,465,933	16,073,048	42,538,981	613,651	43,152,632
Merced	125,341	1,959	127,300	14,665	141,965
Modoc	11,963,359	8,492,772	20,456,131	3,626,618	24,082,749
Mono	2,544,747	2,536,236	5,080,983	1,060,040	6,141,023
Monterey	4,658,404	190,492	4,848,896	595,957	5,444,854
Napa	2,293,818	576,229	2,870,047	610,350	3,480,397
Nevada	7,160,054	6,839,007	13,999,061	154,624	14,153,686
Orange	100,916	24,081	124,998	305,401	430,399
Placer	7,414,291	7,727,867	15,142,159	173,605	15,315,764

Plumas	19,855,395	26,851,328	46,706,724	253,712	46,960,435
Riverside	568,147	273,152	841,299	5,207,775	6,049,075
Sacramento	40,377	2,967	43,343	2,244	45,587
San Benito	1,663,140	110,755	1,773,895	323,932	2,097,827
San Bernardino	3,557,296	1,517,344	5,074,640	11,930,288	17,004,928
San Diego	2,167,704	466,782	2,634,486	5,080,827	7,715,313

Table 4. Continued…

	Non-merchantable forestry biomass gross				
	Forest gross				
County	Slash and thinnings	Mill waste	Potential	Shrub gross potential	Potential
San Francisco				66	66
San Joaquin	84,189	10,474	94,662	8,422	103,084
San Luis Obispo	5,028,721	290,417	5,319,138	1,025,299	6,344,437
San Mateo	699,747	629,826	1,329,572	38,529	1,368,101
Santa Barbara	2,975,768	354,099	3,329,867	1,711,311	5,041,178
Santa Clara	2,376,931	304,639	2,681,570	436,079	3,117,649
Santa Cruz	1,923,004	1,625,636	3,548,641	98,393	3,647,033
Shasta	22,862,884	18,965,516	41,828,400	1,307,774	43,136,174
Sierra	5,936,582	7,895,350	13,831,932	207,090	14,039,022
Siskiyou	30,823,342	31,863,841	62,687,182	1,435,274	64,122,457
Solano	115,395	5,470	120,865	28,078	148,944
Sonoma	7,104,598	3,163,495	10,268,093	250,945	10,519,039
Stanislaus	392,184	30,819	423,003	120,075	543,078
Sutter				3	3
Tehama	10,296,894	7,493,086	17,789,980	817,929	18,607,909
Trinity	23,981,088	21,000,747	44,981,835	255,272	45,237,107
Tulare	7,864,393	8,093,819	15,958,211	293,592	16,251,804
Tuolumne	11,223,686	12,775,961	23,999,648	618,536	24,618,183
Ventura	1,488,421	421,275	1,909,696	646,761	2,556,457
Yolo	713,682	10,733	724,415	242,071	966,486
Yuba	3,202,368	2,363,004	5,565,372	11,159	5,576,530
STATEWIDE	347,777,680	288,990,826	636,768,507	62,058,252	698,826,759

Appendix A: Table 4 - Total non-merchantable (including mill waste and slash/thinnings) Technical potential for forest and shrub biomass (BDT), power generation capacity (MWe), and energy (MWh), by ownership and county.

Figure 7 Forest biomass available after adjusting for environmentally protected areas, and difficulty of access.

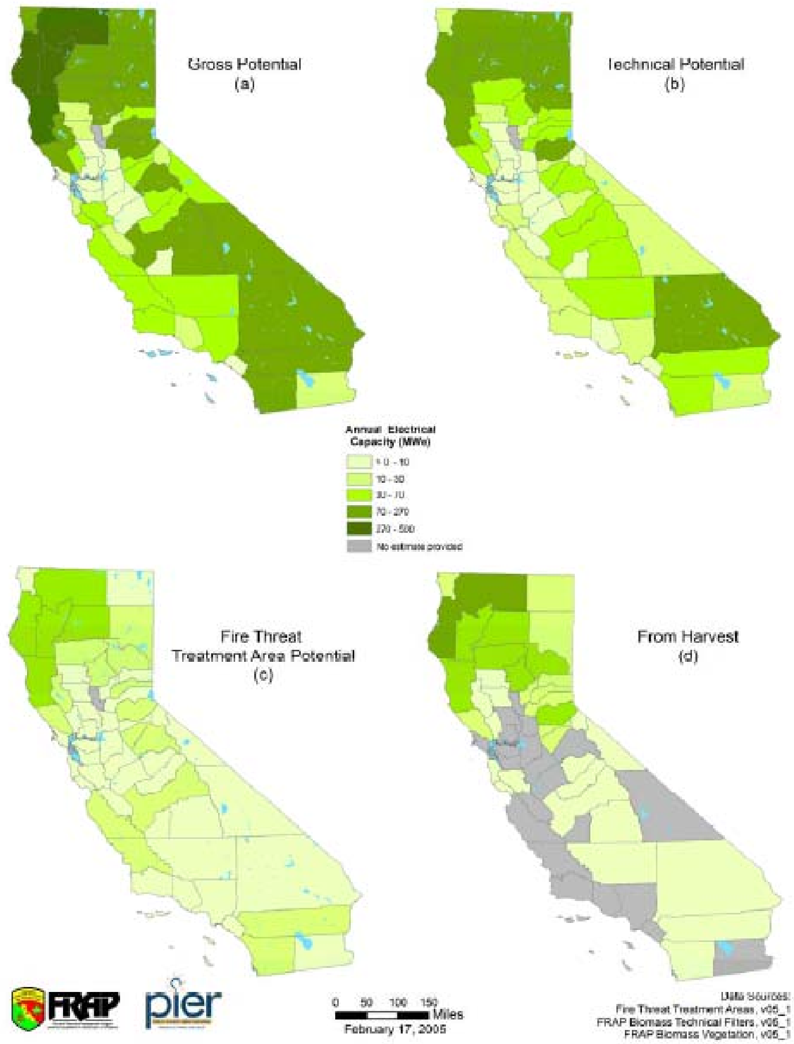

Fig. 8 Annual electricity capacity (MWe) from forestry biomass, by country for Gross potential (a); Technical potential(b); Fire Threat Treatment Area (c) and harvest (d) From FRAP 2005.

Table 5. Annual non-merchantable (including mill waste and slash/thinnings) Technical potential for forest and shrub biomass (mBDT/y), power generation capacity (MWe), and energy (mMWh/y), by ownership, statewide. (FRAP, 2005_ Table 10 in report).

Energy factor	Owner	Forestry biomass (technical)					
		Forest (technical)				Shrub tech. Potential	**Potential**
		Slash	Thinnings	Mill waste	Potential		
BDT/y	Private	2.4	3.46	1.39	7.26	1.21	**8.47**
	Federal	1.8	0.59	1.91	4.29	1.3	**5.59**
	State and local	0.45	0.057	0.03	0.13	0.72	**0.20**
	Total	4.25	4.1	3.33	11.7	2.58	**14.2**
MWe	Private	342	492	188	1023	153	**1175**
	Federal	255	84	258	597	163	**761**
	State and local	6	8	4	18	3259	**28**
	Total	604	583	451	1638	325	**1963**
mMWh/y	Private	2.55	3.66	1.4	7.6	1.14	**8.75**
	Federal	1.9	0.62	1.9	4.46	1.22	**5.66**
	State and local	0.047	0.06	0.03	0.14	0.07	**0.21**
	Total	4.5	4.35	3.36	12.2	2.42	**14.6**

mBDT/y: million BDT per year, mMWh/y: million Mega watt hours per year. Figures are rounded. Slash: from logging harvest, branches, tops, and other; thinnings: for wildfire threat reduction, ecological purposes, or stand improvement; Mill waste: sawdust, planer shavings and trim ends.

California has an existing biomass to power industry. These facilities were constructed during a period from the late 1970's to early 1990s, with the objective of preserving and extending landfill space. They also consume other low-valued biomass fuel resources that vary by region within the state. Most are steam power facilities with approximately 20 to 25 % conversion efficiency. The main use of biomass today is as a fuel for California's existing biomass power plants. The 29-35 facilities represent approximately 2% of the state's electrical generation capacity. These biomass plants use about 5 million bone-dry tons (BDT) of biomass per year representing approximately 600-650 MW of capacity. They range from 5 MW-50 MW in size. Improving the efficiency of these facilities would improve their competitiveness with other transformation pathways for biomass and increase renewable electricity supplies. This topic is part of a current research effort at the California Biomass Collaborative. A current estimate of feedstocks supplied to these facilities and an analysis of their economic potential is in preparation. The current low price received at many of these facilities has some of them in curtailment (approximately 80 MW). New EPA boiler MACT standards could lead to permanent closure of a number of facilities.

In-forest biomass is only a small fraction of the total biomass feedstock used for power production. In 2009, about 800,000 BDT of in-forest material was used as fuel. This is 15% of the total consumed (5,250,000 BDT total)[4]. Estimates by region in 2009 were: Coast (Humboldt, Trinity, Del Norte, Mendocino) = 35%; Northern California (Sacramento north) = 50%; Central CA = 20%. Southern California facilities consume primarily urban wood waste. The most up to date list of the status of California's biomass power facilities is available at:
http://ucanr.org/sites/WoodyBiomass/Woody_Biomass_Utilization_2/California_Biomas

[4] Personal communication, F. Tornatore, TSS Consultants, Inc., and CBC board member.

s_Power_Plants/ , maintained by Garreth Mayhew at UC Berkeley. This compiles information from several sources, including the CBC.

Municipal Solid Waste (MSW)

There are three mass burn facilities that combust municipal solid waste in California. One in Long Beach, one in the City of Commerce, and one near Los Banos in Stanislaus County. Only one facility qualifies as a source of renewable electricity by statute, though this is a legal distinction only and does not affect the manner in which these plants operate, or the composition of the MSW consumed. The use of post-recycled MSW for power or fuels is being pursued by many companies and municipalities in California but is complicated by inhibitory regulation and the active opposition of some non-profit groups. Most post-recycling MSW is land-filled in California. Some landfills capture methane gas produced under anaerobic conditions in land fills. This amount of gas is estimated in Table 1.

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