BIOMASS CONVERSION
(June 18, 2013 Draft)

I. INTRODUCTION

The primary focus of this paper is to identify opportunities, challenges, and potential solutions for achieving greenhouse gas (GHG) and waste reduction goals from biomass conversion facilities in California. This paper does not cover other biomass conversion processes such as anaerobic digestion or fermentation, composting, trans-esterification, rendering, or gasification. This paper also does not address waste-to-energy facilities that handle only municipal solid waste (MSW).

The sections that follow describe the biomass conversion process, feedstocks, current utilization of biomass in California, and the goals, challenges, and potential solutions for achieving additional reductions in GHG emissions and waste through the use of biomass conversion facilities. This paper is one of several papers being prepared to provide information on the role that the Waste Sector can play in meeting the goals of AB 32 and waste reduction. Companion papers discuss Recycling, Reuse, and Remanufacturing; Composting and Anaerobic Digestion; Municipal Solid Waste Thermal Technologies; and Landfilling of Waste.

II. GENERAL DESCRIPTION OF THE BIOMASS CONVERSION PROCESSES AND FACILITIES IN CALIFORNIA

What is biomass conversion?

Biomass conversion is the process of creating energy by burning materials of recent biological origin, such as wood waste. Typically, biomass conversion is used to generate electricity for sale to a utility. Biomass conversion can also produce marketable products such as fly ash used in cement manufacturing.

There are many benefits to the conversion of biomass, including reducing the volume of material that is landfilled, reducing forest fire hazards, generating renewable power, creating jobs, and reducing GHG emissions.

What types of biomass are available for conversion?

As mentioned above, biomass is material of recent biological origin. Included are materials such as trees and agricultural products, but not materials like natural gas, oil, or coal. The main feedstocks for biomass conversion are forest products, agricultural waste, and urban wood waste. Table 1 below provides an estimate of the amount each feedstock, measured in terms of the energy content in the feedstock. As shown in Table 1, each of these biomass types is used in significant quantities. Many biomass conversion facilities use more than one of these types of biomass as a feedstock. Some plants also use a small amount of supplemental fossil fuel.

Table 1: Biomass Use in California by Energy Content (2011)[1]

Biomass Type	Energy Content (mm BTU)	Percentage
Agricultural Waste	19,000,000	28%
Forest Wood Waste	24,000,000	36%
Urban Wood Waste	24,000,000	36%
Total	67,000,000	100%

1 California Energy Commission

Agricultural waste includes orchard prunings, nut shells, fruit pits, grain straw, and many other specialized agricultural waste products. Forest wood waste typically includes undergrowth from forest thinning or logging, and sawmill waste such as bark, sawdust, shavings, and trimmings. Urban wood waste includes lumber from construction and demolition, yard and garden clippings, prunings and nonrecyclable pulp or nonrecyclable paper. Biomass does not included recyclable pulp, recyclable paper or hazardous materials such as treated wood waste as defined by the Department of Toxic Substance Control (DTSC).

What biomass conversion systems are currently being used?

According to information from the California Biomass Collaborative, there are 22 biomass conversion facilities in commercial operation in California (see Table 2). However, the list is subject to frequent changes due to the challenging economics of operating these facilities. These plants are located throughout the state, often near timber harvest or agricultural operations. Most of these facilities were built in the 1980s or early 1990s, after the federal Public Utilities Regulatory Policy Act (PURPA) of 1978 required utilities to purchase power provided by qualifying independent power producers at relatively attractive rates. However, California’s regulatory policies were restructured in 1996, decreasing the financial incentives available for biomass conversion facilities.

Biomass conversion facilities generally accept waste feedstock deliveries by truck and then move the feedstock with conveyors. In the boiler, the feedstock is burned and combustion gases flow past water tubes where steam is produced at high pressure. The steam is used to power a turbine-driven generator that produces electrical power that is sold to a utility. The boiler combustion designs include “stoker” type furnaces with traveling or fixed (inclined) grates, and potentially more efficient circulating fluidized bed (CFB) designs. As shown, six of the facilities use cogeneration (“cogen”) systems which improve overall efficiency by recovering waste heat.

Table 2: Operational Biomass Conversion Facilities in California[1]

Facility Name	Location (City)	Electrical Capacity (MW)
Blue Lake Power	Blue Lake	11
Burney Forest Power	Burney	31
Collins Pine Co. Project	Chester	12 (cogen)
Colmac	Mecca	47
Delano Energy Co., Inc.	Delano	50
Dinuba Energy Inc.	Dinuba	12
Honey Lake Power	Wendel	32
Madera Power LLC	Firebaugh	28
Mendota Biomass Power Ltd.	Mendota	25
Pacific Oroville Power Inc.	Oroville	18
Pacific Ultrapower Chinese Station	Jamestown	22
Rio Bravo Fresno	Fresno	25
Rio Bravo Rocklin	Rocklin	25
Scotia Biomass	Scotia	28 (cogen)
Sierra Power Corporation	Terra Bella	10 (cogen)
Sierra Pacific Industries (SPI) Burney	Burney	20 (cogen)
SPI Anderson	Anderson	4 (cogen)
SPI Lincoln	Lincoln	18
SPI Quincy	Quincy	25 (cogen)
Wadham	Williams	27
Wheelabrator Shasta	Anderson	50
Woodland Biomass Power Ltd.	Woodland	25
Total		**545**

1 Mayhead, Gareth, UC Berkeley, May 10, 2011

III. CURRENT STATUS OF BIOMASS CONVERSION FACILITIES IN CALIFORNIA

How much power is generated from biomass facilities in California?

According to the California Energy Commission (CEC), biomass-derived power provides about 2% of California's electricity demand, and about 19% of in-state produced renewable power. As shown in Table 2, the currently operating biomass facilities have a net capacity to generate over 500 MW, with individual plants able to provide between 4 and 50 MW of electrical capacity. In addition to the facilities listed in Table 2, there are six idled facilities with the potential to generate an additional 90 MW (CEC PIER draft). The idled facilities are generally not operating because the price of electrical power received under their contracts with utilities is insufficient to justify operation. However, some of these plants may be brought online in the future if electricity prices for renewable power increases due to the 33% 2020 Renewable Portfolio Standard.

How much GHGs and co-pollutants are emitted from biomass conversion facilities?

The 2011 reported GHG emissions from biomass conversion are shown in Table 3. Total GHG emissions are estimated to be 6.3 million metric tons of CO_2 equivalent (CO_2e) emissions. There is some uncertainty in these estimates because these facilities shutdown and restart relatively frequently based on economics and other factors. Of the total emissions, nearly all

(6.2 million metric tons) were biomass-based. The distinction between biomass based (biogenic) and non-biomass based (non-biogenic) emissions is important because only the emissions from combustion of non-biogenic material (such fossil fuels) are counted as GHG emissions that contribute to climate change per protocols established by the Intergovernmental Panel on Climate Change (IPPC).

Table 3: GHG Emissions from Biomass Conversion Facilities in California (2011)[1]

Facility Name	Biogenic Emissions (MT CO_2e)	Non-biogenic Emissions (MT CO_2e)	Total Emissions (MT CO_2e)
Blue Lake Power	18,200	400	18,600
Burney Forest Power	391,100	14,100	405,200
Collins Pine Co. Project	117,200	2,000	119,200
Colmac[2]	516,100	16,200	532,300
Delano Energy Co., Inc.	630,400	3,400	633,800
Dinuba Energy Inc.	147,400	1,600	148,900
Honey Lake Power	226,100	6,400	232,500
Madera Power LLC	405,100	6,700	411,800
Mendota Biomass Power Ltd.	227,100	2,200	229,300
Pacific Oroville Power Inc.	256,800	600	257,400
Pacific Ultrapower Chinese Station	226,100	1,300	227,400
Rio Bravo Fresno	285,800	10,000	295,800
Rio Bravo Rocklin	289,700	9,300	299,000
Scotia Biomass/Eel River	265,200	5,600	270,800
Sierra Power Corporation	119,900	2,400	122,200
Sierra Pacific Industries Burney	223,300	2,800	228,100
SPI Anderson	69,900	0	69,900
SPI Lincoln	207,800	6,400	214,300
SPI Quincy	342,300	1,300	343,500
Wadham	269,900	3,700	273,600
Wheelabrator Shasta	684,100	15,000	699,100
Woodland Biomass Power Ltd.	252,400	6,400	258,800
Total	**6,171,900**	**119,800**	**6,291,500**

1 ARB 2011 Greenhouse Gas Reporting Regulation.
2 ARB 2009 data used. Colmac facility is on an Indian reservation.

How much GHG emissions are avoided due to biomass conversion operations?

California biomass conversion operations result in net negative GHG emissions. While these facilities result in direct GHG emissions (mostly as carbon dioxide) when biomass is burned, the majority of these emissions are biogenic, and not counted as discussed above. In addition, these facilities produce electrical power that results in avoided utility emissions that would come mostly from the combustion of fossil fuels such as natural gas. Finally, biomass that is not combusted in a facility may otherwise be landfilled or “open” burned, resulting in more GHG emissions.

As shown in Table 4, preliminary estimates based on the facilities above indicate that biomass conversion facilities result in net negative GHG emissions of over 1 million MT CO_2e, or -0.24 MT CO_2e per ton of bone dry biomass. This is similar to a related ARB estimate (-0.21 MT CO_2e/ton) for the recycling of dimensional lumber, assuming that it is chipped and burned in a biomass facility. (ARB, "Methods for Estimating Greenhouse Gas Emission Reductions from Recycling, November 14, 2011) The staff estimated emissions include the direct CO_2e non-biogenic emissions from Table 3, and credits for avoided utility emissions using the power capacity from Table 2 and an assumed overall output of 85% of capacity. Staff did not estimate transportation emissions associated with delivering waste to a facility, or emissions associated with processing waste, for example chipping wood. The estimates also did not account for avoided landfill emissions or avoided emissions from open-burning of biomass.

Table 4: Preliminary Estimates of
Total Annual Net GHG Emissions from Biomass Conversion Facilities in California (year)

Biomass Waste (bone dry tons)	Non-biogenic Emissions (MT CO_2e)	Total MWh	Utility Avoided Energy Credit MT CO_2e[1]	Total Net Emissions (MT CO_2e)	Net MT CO_2e/Ton Waste
4,500,000[2]	120,000	4,051,000	-1,210,000	-1,090,000	-0.24

1 Uses a grid emission factor of 657 lb CO2e per MWh, and assumes facilities produce 85% of rated power capacity per Table 2.
2 Figure from 2012 Bioenergy Action Plan

Can GHGs and co-pollutants be reduced from existing or new biomass conversion facilities?

While acknowledging that most GHG emissions from biomass conversion facilities are biogenic, there is some potential to reduce GHG emissions from existing biomass conversion facilities, especially those that are not cogeneration facilities. When a "life-cycle" approach is used, net GHG emissions could be reduced by: (1) conversion to cogeneration, where heat (steam) is utilized on site, (2) upgrades to the boiler, turbine, or generator that could provide improvements in the efficiency resulting in more electricity generated per ton of biomass combusted; or (3) greater utilization of ash in beneficial uses such as construction materials where it could replace virgin materials that would be mined or otherwise produced through processes that result in more GHG emissions.

More significant GHG reductions could come from restarting idled or non-operational biomass facilities, the conversion of fossil fuel plants to "co-fired" or 100% biomass fueled plants, or the construction of new biomass conversion facilities. Based on the emissions estimates in Table 4, the 22 operational plants in California result in an average annual emissions credit of 50,000 MT CO_2e each. In addition, much of the biomass material available is not utilized. According to the 2012 Bioenergy Action Plan, less than 15% of the available biomass in California is utilized for energy. However, there are signs that more biomass conversion facilities could be on the horizon. Six existing nonoperational plants have recently been sold to investors, possibly driven by speculation that the utilities will pay more for electricity as the 2020 RPS deadline approaches (California Agriculture, Vol. 66, Number 1). Also, new designs in biomass conversion and gasification systems sized from 0.5 to 2 megawatts are now available that can provide heat and electricity for manufacturing or a small community. (UC, Woody Biomass Utilization). Finally, there may be benefits to the utilization of biochar, such as reducing nitrous oxide emissions, long term carbon storage, and improving soil fertility for agricultural use.

What is the current status of emissions control at biomass conversion facilities?

These facilities are generally subject to local air quality district regulations and permit requirements. For new or modified facilities, "New Source Review" (NSR) regulations may require the use of "best available control technology" (BACT) for PM, NOx, SOx, or other emissions. NSR may also require the use of emission reduction credits (ERCs). In addition, federal rules that govern the permitting of new or modified facilities may apply.

The primary GHG emitted from biomass conversion plants is carbon dioxide, which is not controlled. However, as noted above, these facilities result in net negative GHG emissions. The plants have air pollution controls to reduce emissions of PM and NOx. For PM control, the facilities are equipped with various control devices, including multi-cyclones, baghouses, and electrostatic precipitators (ESPs). Permitted limits range from 0.01 to 0.2 gr/dscf at 12 percent carbon dioxide. For NOx control, the facilities most often employ selective non-catalytic reduction (SNCR).

IV. GOALS FOR REDUCING GHGS FROM THE WASTE SECTOR WITH BIOMASS CONVERSION FACILITIES

Biomass conversion facilities can play a role in achieving California's goals for reducing GHG emissions and reducing the volume of material deposited in landfills. These facilities can help reduce GHG emissions from the Waste Sector in two ways: (1) new facilities can process additional waste that would otherwise be sent to landfills or open burned, and (2) as discussed above, existing facilities could be upgraded to improve energy efficiency. Discussed below are some existing state programs that will affect the extent to which GHG emissions can be reduced through biomass conversion facilities.

Renewable Portfolio Standard

The Renewable Portfolio Standard (RPS) program requires utilities to increase their procurement of eligible renewable energy resources from 20% of total procurement by December 31, 2013, to 25% by December 31, 2016, and 33% by December 31, 2020. Under the program, utilities may pay a premium for energy from renewable sources. Under existing state law, biomass conversion facilities are eligible for renewable energy credit[1]. As noted above, six existing plants have recently been sold to investors, possibly driven by speculation that the utilities may pay more for electricity as the 2020 RPS deadline approaches.

Biomass Conversion Facilities and the Cap-and-Trade Program

California's Global Warming Solutions Act (AB 32) established the goals of reducing GHG emissions to 1990 levels by 2020, and then an 80% reduction below 1990 levels by 2050. A central element of AB 32 is the Cap-and-Trade Program, which specifies an enforceable GHG emissions cap that will decline over time. Cap-and-Trade applies to major sources of GHG emissions, sources that emit more than 25,000 MT CO_2e per year. As shown in Table 3 above, biomass conversion facilities in California do not qualify as major sources since biogenic

[1] *Renewables Portfolio Standard Eligibility Guidebook, Seventh Edition.* California Energy Commission, Efficiency and Renewable Energy Division. Publication Number: CEC-300-2013-005-ED7-CMF

emissions are not counted toward the 25,000 MT CO_2e major source threshold. Further, as explained above, these facilities result in net negative GHG emissions.

Governor's Clean Energy Jobs Plan

In 2010, Governor Brown set a goal of installing 20,000 MW of renewable electricity by 2020. To spur investment in renewable energy and help meet the state's ambitious climate goals, Governor Brown established a Clean Energy Jobs Plan. The Plan included a specific target of 12,000 MW of distributed generation, which could include small biomass conversion facilities.

V. CHALLENGES FACING BIOMASS CONVERSION FACILITIES

This section discusses the current and future challenges facing biomass conversion facilities. The challenges discussed below are divided into short-term and long-term issues.

A. Short-Term

Permitting of New Facilities

The vast majority of California's biomass conversion facilities were built in the 1980s, when regulatory and economic conditions were more favorable. Now these plants are 25-30 years old and will need to be upgraded or replaced. The overall permitting process, and local opposition, makes it very difficult to construct new plants. A recent report noted that a number of attempts have been made to restart non-operational facilities since it is significantly less expensive than building a new facility. One reason for that is that old plants retain their original permits, while obtaining a permit for a new facility can be expensive, uncertain, and time consuming. (California Agriculture, Volume 66, No. 1). The 2012 Bioenergy Action Plan also points out that some jurisdictions are ill-equipped to site and permit these projects, as they do not have the technical expertise or resources. Staff anticipates that the overall permit and construction process will take 3 to 5 years for biomass facilities.

New facilities are required to obtain several permits from different agencies. They are required to obtain permits from local jurisdictions, the Regional Water Quality Control Board, and local air quality management districts. Regarding the air quality permits, it would be difficult and expensive to site new plants using standard direct burn technology in California's non-attainment regions. New facilities would also face challenges preparing environmental documentation required by CEQA. For example, CEQA requires that the environmental impacts be addressed and if significant, be mitigated to lessen the impacts of the project.

Financial Risk

Some of the existing biomass conversion facilities are locked into long-term contracts with the utilities that will be expiring in within the next five years. The prices paid to these facilities vary, but most are paid under fixed-price amendments to their contracts[2]. Other facilities have, through bilateral negotiations, agreed to alternative price agreements. Some of the facilities continue to operate at the margin or at a loss, which has resulted in facilities shutting down for periods of time when they cannot afford to operate. This has significant impacts on the rural

[2] For example, http://www.pge.com/b2b/energysupply/qualifyingfacilities/prices/

communities where these facilities are often located since they are often a major employer and contributor to the tax base (California Agriculture, Vol. 66, No. 1).

Barriers to Increased Utilization of Biomass

According to the 2012 Bioenergy Action Plan, there are a number of challenges to increasing the utilization of biomass for energy. Among the challenges is the concern that increased markets for forest wood waste would promote more intensive harvest practices, resulting in unanticipated environmental impacts. Most biomass conversion facilities rely on a combination of agricultural, forestry, and urban wood waste as feedstock. Addressing barriers to utilization of a particular feedstock, such as forestry waste, improves the viability of biomass conversion facilities as an end use market for all biomass feedstocks to achieve a net reduction in GHG emissions through bioenergy production.

B. Long-Term

Development of Small Community-Scale Biomass Conversion Facilities

According to the 2012 Bioenergy Action Plan, smaller facilities would be a good fit for many rural communities. However, additional technical and financial support, and a stable supply of feedstock material, is needed to encourage their development.

Emerging Technology

Conventional mass-burn plants produce combustion byproducts that require costly air pollution control equipment, and result in ash with limited market value. Gasification technology may offer advantages in these areas, but the technology is not operational in California on the scale comparable to current biomass conversion facilities.

Beneficial Uses for Ash Byproducts

In order to achieve a sustainable, zero waste system, beneficial uses need to be identified for the ash from biomass conversion plants. This includes both the boiler "bottom" ash and the "fly ash" from the air pollution control systems. A challenge with using ash is that it often contains toxic components which will impact acceptable uses of the material.

VI. POTENTIAL SOLUTIONS

Discussed below are some potential solutions to the challenges described above in our effort to achieve waste diversion and GHG reduction goals. As with the discussion of Challenges, the potential solutions are organized by short-term and long-term categories. Many of the potential solutions are discussed in the 2012 Bioenergy Action Plan. There may be additional solutions to the challenges beyond those mentioned below.

A. Short-Term

Permitting of New Facilities

The 2012 Bioenergy Action Plan (BAP) provided a number of suggestions to improve the permitting process for biomass facilities. First, it suggested that Cal-EPA funnel these projects through its Consolidated Permit Application process (Public Resources Code § 71020 *et seq.*)

to coordinate the process. It also recommended that bioenergy developers consult with GO-Biz and Cal-EPA before they submit their project application to determine if the Consolidated Permit route would help their permit applications.

Another suggestion was the development of industry-specific web-based tools for planning and permitting guidance, links, and agency contacts. The 2012 Bioenergy Action Plan noted that Cal-EPA is planning to develop a web portal with permitting guidance for dairy digester projects, and an online "drop box" for other technologies to coordinate submission of environmental permits. It was suggested that this technology could be replicated for other types of bio-energy projects, including biomass electricity generation.

It was also suggested that funding be secured to develop a programmatic Environmental Impact Report (EIR). While this suggestion was more targeted to noncombustion conversion technologies (such as gasification and pyrolysis), it could also be applied to combustion of biomass as well. The EIR could assist state and local agencies in preparing site-specific environmental documentation that may be required for conversion technology facility applications and/or permits.

Finally, it was suggested that ARB and the local air districts provide manufacturers of bioenergy generation technologies with guidance on how to expeditiously permit bioenergy projects by proposing technologies that meet the latest regulatory requirements and how to retrofit existing facilities to meet tightening air quality regulations.

Financial Risk

There are a number of approaches that could be used to improve the financial standing of new or existing biomass conversion facilities. Listed below are some of these approaches, including several suggestions from the 2012 Bioenergy Action Plan:

- Ensure that a substantial portion of the CPUC's Electricity Program Investment Charge (EPIC) fund is devoted to developing and commercializing new bioenergy facilities that are environmentally and economically sustainable, as well as upgrading and maintaining existing bioenergy facilities;
- Monitor the use of the CPUC's Renewable Market Adjusting Tariff ("Re-MAT") to assess whether and to what extent it incentivizes new bioenergy projects;
- Ensure that community-scale biomass projects benefit from the SB 32 feed-in-tariff and consider the use of other procurement mechanisms for small scale bioenergy projects, such as Senate Bill 1122, which requires the procurement of at least 250 MW of generating capacity from new bioenergy projects with an effective capacity of not more than three megawatts;
- Identify GHG, criteria, and air toxic offset or credit opportunities that could assist in financing and siting bioenergy projects; and
- Establish new incentive payments or loan/grant programs geared for biomass conversion facilities using Cap and Trade revenues.

Barriers to Increased Utilization of Biomass

The 2012 Bioenergy Action Plan provided these suggestions to increase the use of biomass:

- Update the assessment of California biomass resources, identifying locations of biomass material and uses by region, assessing the value for fire hazard reduction, and recommended cost-effective strategies for use;

- Outreach to landowners and registered professional foresters regarding the Board of Forestry and Fire Protection's regulations for Modified Timber Harvest Plan for Fuels Management;
- Outreach to the public regarding the benefits of biomass use, including reducing wildfire risk, reduce reliance on landfills, GHG reductions, and production of local energy;
- Define and ensure sustainable forest biomass utilization for energy. These efforts are already underway by the Interagency Forest Work Group; and
- Develop fire threat maps indicating areas of elevated fire risk due to power-lines (with accompanying plans removal of biomass).

B. Long-Term

Development of Small Community-Scale Biomass Facilities

The 2012 Bioenergy Action Plan provided a number of suggestions to encourage the development of these facilities, including refining the criteria of "community-scale" biomass energy facilities, identifying a few candidate projects, and seeking developers and cost-sharing partners for deployment and demonstration.

Emerging Technology

State (and potentially Federal) agencies could coordinate resources to pursue research, development and commercialization of emerging state-of-the-art thermal technologies. As an example, the Energy Commission staff recommends that California state government should target installing 2,500 MW of renewable energy on state properties to help meet the overall 20,000 MW statewide goal in the Governor's Clean Energy Jobs Plan. Cal Fire is exploring opportunities for installing one to three biomass projects for heat and power using new technologies at Forestry Conservation Camps.

Beneficial Uses for Ash

State (and potentially Federal) agencies could fund research to supplement existing programs seeking to identify safe and beneficial uses for biomass conversion facility ash or other co-products such as biochar. Research is currently underway on potential uses of ash from MSW combustion. The results of this work may be applicable to biomass conversion waste also.