Energy Research and Development Division
FINAL PROJECT REPORT

# BIOMASS MANAGEMENT ZONES AND NEW PATHWAYS TO BIOENERGY

Prepared for: California Energy Commission
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CALIFORNIA BIOMASS COLLABORATIVE

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# PREFACE

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# ABSTRACT

The objective of this analysis was to assess the potential of biomass resources to partially meet local and state energy demand for electricity, biogas for use as electricity or biomass for the creation of transportation fuel. This report focused on aggregating, modeling and summarizing biomass resource data in the Oroville Biomass Management Zone located in California's Northern Sacramento Valley/Sierra region. This assessment identified abundant, diverse forms of biomass within the Oroville Biomass Management Zone with varying accessibility. The most readily available biomass was from agricultural and urban sources. Some forestry biomass was available from private lands, but access to surplus biomass on public lands was limited and therefore costly.

**Keywords: biomass, management zones, new pathways to bioenergy, conversion technologies.**

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# EXECUTIVE SUMMARY

## Introduction

Local biomass resources have the potential to support stable local economic development and diversify domestic energy sources, leading to less reliance on imported and domestic fossil fuels. California generates large amounts of diverse biomass resources distributed throughout the state. Development of biomass materials, including currently uneconomic residues, will enhance the economic value of biomass and contribute to the state's greenhouse gas reduction goals. Much biomass remains unused due to declining prices for domestic natural gas, existing regulations, legal and regulatory uncertainty, changing technology, limited access to biomass, and limits on access to investment capital.

Biomass is a chemically rich set of feedstocks suitable for multiple processes and markets including power, heat, fuels, chemicals, and other products. Biomass was the source of energy for human society throughout much of its history and remains so in large portions of the underdeveloped world. Its importance for energy has diminished, however, with the advent of the use of fossil fuels to produce energy. Over the last century, practices for handling and managing undervalued, residual biomass have concentrated on biomass to power facilities, incineration of municipal solid waste, in-field burning (both agricultural and forestry residues) and landfilling. Large-scale use of crops for conversion to transportation fuel such as ethanol and biodiesel have developed more recently. New federal and state energy policies support converting biomass to energy and bio-products as part of a broader set of goals to reduce greenhouse gas emissions and improve energy security. These policies will result in increased local use and transformation of biomass resources to energy.

Biomass Management Zones are defined as "sustainably managed woodsheds or production regions" that will promote the management of urban interface, woodlands and forested lands to accomplish three objectives: (1) reducing fuel loading and the potential of uncontrolled wildfires; (2) utilizing biomass and residues from forest management/products, combined with other regionally appropriate resources, to produce bioenergy and bio-products; and (3) stimulating local economic activity and long-term stability.

## Project Purpose

The goal of this project was to assess the potential of biomass resources to partially meet local and state renewable energy goals for electricity, biogas for use as electricity, or biomass for the creation of transportation fuel. The objectives to meet this goal included compiling, modeling and summarizing biomass resource data in the Oroville Biomass Management Zone located in California's Northern Sacramento Valley/Sierra region. The biomass resources for a 1.3 million acre area with a population of 278,000 were characterized, including forest, agricultural, and urban. Identifying functioning Biomass Management Zones supported the objectives of Executive Order S-06-06 to support fuel reduction in areas considered at risk from wildfire.

## Project Results

There are several sources of biomass material or feedstocks in California, including agriculture, municipal solid waste (garbage), forestry, and food processing industry wastes. This study of the Oroville Biomass Management Zone, encompassing the city of Oroville, estimated biomass from all these sources. The most readily available biomass within the Oroville Biomass Management Zone was from agricultural and urban sources. Some forestry biomass was available, especially from private lands, but access to surplus biomass on public lands was limited and therefore costly. At least one new conversion method was also evaluated: anaerobic digestion of rice straw, possibly combined with food processing wastes and some additional silage materials. This method was included in the analysis to add possible bioenergy development pathways within the Biomass Management Zone and as an example of potential benefits and costs for new biomass energy projects.

The Oroville Biomass Management Zone is predominantly rural and currently has higher levels of unemployment than the state as a whole. The authors concluded that new biomass energy businesses would aid this region. This zone is composed of approximately 30 percent forest and shrub lands, 65 percent agricultural and 5 percent urban lands. Special consideration was given to the potential of localized anaerobic digestion of rice straw for biogas and electricity production and forest and wildland biomass in areas classified by CAL FIRE's Forest and Range Assessment Program as needing fuel load reduction for wildfire prevention.

Fire is a natural feature of the state’s forested landscape. Large, destructive wildfires result in unproductive loss of biomass, large emissions of criteria pollutants that cause smog or other health hazards as well as greenhouse gases, property destruction, adverse public health consequences, and sometimes permanent loss of ecosystem structure and function. These effects lead to increased soil erosion, sedimentation of dams, declining water quality, and habitat and species loss. Fighting massive wildfires is very costly. There is a strong scientific consensus that levels of woody biomass accumulation in forests within and near the Oroville Biomass Management Zone are excessive and that these fuel loads should be reduced to prevent increasing numbers and intensity of fires in the future, especially given the impacts anticipated from climate change in California.

This analysis found many different types of biomass available within the Oroville Biomass Management Zone that offer diverse opportunities for energy production, or alternatively, opportunities for integration at more centralized biorefineries. Agriculture provided the largest amount of available biomass. The amount of forest biomass is based on conservative availability assumptions and could be larger than agriculture’s share if access was improved. This analysis reported several ways of estimating available woody biomass. An initial estimate of biogas potential using rice straw as a feedstock was developed, as well as biogas yield estimates from other sources of biomass, including food processing industry wastes. High moisture materials like food processing wastes are easily converted to biogas. Potential biomass power yields were estimated, but not for biofuels, since for the most part economic technologies for converting woody biomass and materials like rice straw into fuels have not yet been developed.

Progress toward increased biomass use for in-state production of biopower and biofuels has been modest. New objectives identified by Governor Brown include further increasing alternative sources of biopower and employment in the alternative energy sector. In terms of total amounts, however, less biomass is used currently than in recent years for biopower production, and little new domestic biofuel production from state-produced feedstocks is being created within the state. This assessment identified abundant, diverse forms of biomass within the Oroville Biomass Management Zone, but with varying accessibility.

A Biomass Management Zone is useful for several purposes. One is to estimate the biomass potentially available within a rationally-specified area. A Biomass Management Zone must first be based on the biogeography of the landscape accommodated to the social infrastructure, including roads, power lines, cities and existing biomass-based businesses. Together, biomass supply and social infrastructure form the first levels for organizing a Biomass Management Zone and the most important limitation on the development of new biomass-based energy supply. Laws, regulations, and public incentives also affect the development of new biomass-based energy supplies. Once it becomes clear that sufficient supplies of biomass are available within a region to support bioenergy enterprises, policy-related constraints become the dominant factor in the development process.

A number of factors act as barriers to biomass use for energy. These include dispersal of woody biomass and low energy density of all forms of biomass compared to fossil sources of energy. New biomass conversion technologies are still developing and the most promising technologies are not yet mature. The capital costs of new facilities that are first-of-a-kind tend to be very large, creating an economic barrier to commercialization. On the whole, however, policy and regulatory barriers appear to be more important contributors to cost.

Woody biomass from forest lands is expensive to acquire and transport and is unavailable from federal and state forests. The authors concluded that a prudent boundary for a Biomass Management Zone must include other significant sources of biomass that are more readily accessible and have lower costs. Bioenergy facilities or biorefineries that can convert multiple sources of biomass should first be developed based on readily available sources and then expanded to include additional woody biomass from forests as such supplies increase with time. Creating a biorefinery that includes more than one conversion technology or which produces multiple types of energy and bio-products is technically challenging but should be encouraged by policy and through incentives. This analysis considered multiple sources of biomass in describing a potential Biomass Management Zone to reflect the need for diverse sources of biomass to support new biomass energy facilities.

The authors concluded that a Biomass Management Zone can be the basis for implementing new models for governance by using it as a case study for community/government interaction organized around achieving both local and statewide goals for local biomass energy businesses. The character of any Biomass Management Zone is shaped by biogeography and existing social infrastructure. Each zone should be a separate instance or case study for adapting governance to what is needed for developing beneficial biomass uses. This analysis also concluded that community-based processes were essential to identifying which resources are most readily available within a zone, where development of projects may be most advantageous, and to a degree, the most important environmental and social values to be preserved as projects develop. The authors concluded that a landscape-based learning and development community focused on a rationally defined Biomass Management Zone was the best way to achieve a harmonized vision for new biomass uses within it.

More supportive participation by state agencies in these processes appeared to be essential. Most biomass energy facilities were developed in California under provisions of the 1978 federal Public Utility Regulatory Policies Act and related regulations. There has been no similarly effective program to stimulate the development of biomass energy since that time. Both the state and federal government have programs to encourage or mandate the use of renewable forms of power and low carbon biofuels. The number of laws, regulations and incentive programs is very large, however, creating both numerous opportunities and obstacles. State agency participation should be focused on providing creative solutions to specific regulatory obstacles that arise in a Biomass Management Zone-based development process. California's Bioenergy Interagency Work Group, through the Biomass Action Plan, is working on streamlining regulation and coordination of state programs, but further progress is needed. The work group provides one mechanism for improved coordination among resource and regulatory agencies, and the new Biomass Action Plan provides some goals or benchmarks against which to measure progress. The Biomass Management Zone described in this report could be a useful case study for the working group to identify additional roles to promote local applications. It could work with local Biomass Management Zone community groups focused on project development in a collaborative, learning-rich process. The benchmark for success would be the construction and successful commercial operation of biomass energy businesses within the Biomass Management Zone. A recently announced program from the Office of the President to modernize and invigorate the National Environmental Policy Act supports a new United States Forest Service initiative called the Programmatic Impact Statement. This plan established an adaptive management strategy that uses public involvement, learning and consultation to create unique management plans suited to diverse locations. It may provide a useful model for California as well. Active participation by government may require some rethinking of current ideas about regulation and governance. This should be carried out within the context of actual case studies on biomass energy development, including the Oroville Biomass Management Zone.

## Project Benefits

This study promoted the utilization of biomass and wastes from forest management along with other regionally appropriate resources to produce renewable bioenergy that can help California meet its goals for increasing the use of renewable energy and reducing greenhouse gases. Using renewable bioenergy will produce additional co-benefits for Californians, including reducing the potential for uncontrolled wildfire, producing useful bio-products, and stimulating local economic activity and long-term stability in economically-depressed rural areas of the state.

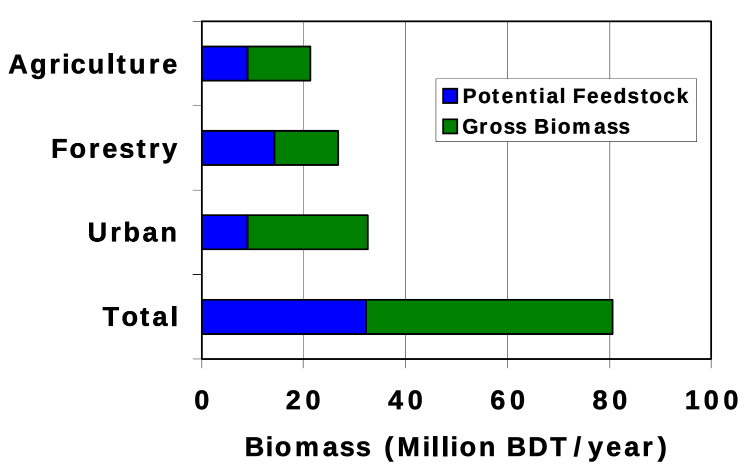
# CHAPTER 1:
# Overview

## 1.1 Introduction

Local biomass resources have the potential to support stable local economic development and diversify domestic energy sources, with less reliance upon imported and domestic fossil fuels (Jenkins et al., 2006). California generates large amounts of diverse biomass resources (Fig. 1.1), distributed throughout the state (Fig. 1.2). Development of biomass materials, including currently uneconomic residues, will enhance the economic value of biomass and contribute to the state's greenhouse gas reduction goals. Much biomass remains unused (Fig. 1.1) due to a variety of reasons including declining prices for domestic natural gas, existing regulations, legal and regulatory uncertainty, changing technology, limited access to biomass, especially forest biomass, and limits on access to capital for investment (Morris, 2009, 1999).

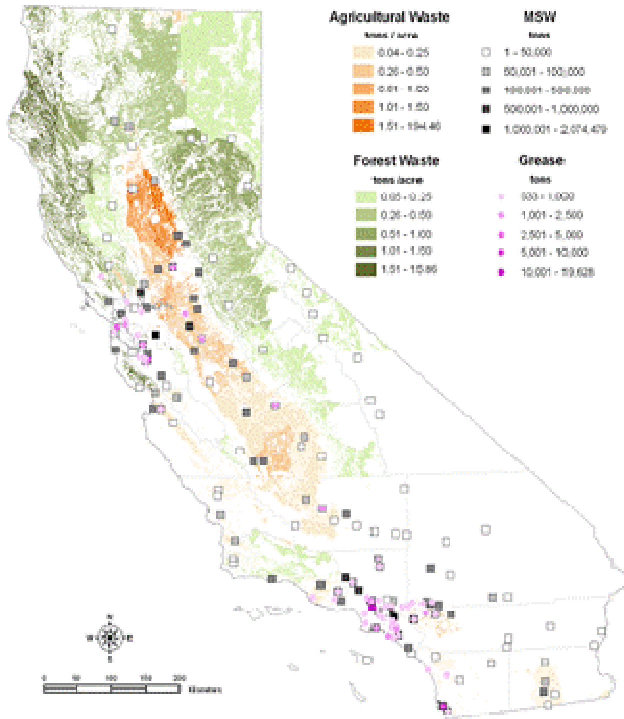
Biomass is a chemically rich set of feedstocks suitable for multiple processes and markets including power, heat, fuels, chemicals, and other products (Jenkins et al. 2006; Parker et al., 2010). Such biomass was always the source of energy for human society and remains so in much of the underdeveloped world. But with the advent of the use of fossil fuels, its importance for energy has diminished. Over the last century, practices to handle and manage undervalued, residual biomass have concentrated on biomass to power facilities, incineration of municipal solid waste, in-field burning (both agricultural and forestry residues) and landfilling. More recently, large scale use of crops for conversion to transportation fuel, like ethanol and biodiesel, has developed. New federal and state energy policies support converting biomass to energy and bio-products as part of a broader set of goals to reduce greenhouse gas emissions and improve energy security. If effective, these policies will result in increased local use and transformation of biomass resources to energy.

**Figure 1: California's Potential Biomass Feedstock Resources**




Williams, et al., 2008.

**Figure 2: Distribution of Biomass by Type in California**




(From Tittmann et al., 2008)

Executive Order S-06-06 (2006) encourages the production and use of energy from the abundant biomass resources found in California. This order places emphasis on utilizing all available biomass resources to produce transportation fuels and electricity.[1] Special emphasis was placed

[1] Governor Schwarzenegger sanctioned a California Bioenergy Action Plan (BAP) in April 2006. Direction was given to the California Energy Commission to continue leadership of the Bioenergy Interagency Work Group (BIWG) in Executive Order S-06-06. The Governor directed the Air Resources Board, Energy Commission, California Environmental Protection Agency, California Public Utilities Commission, Department of Food and Agriculture, Department of Forestry and Fire Protection, Department of General Services, Integrated Waste Management Board, and the State Water Resources Control Board to continue to participate in the BIWG, chaired by the Energy Commission. The Bioenergy Action Plan (BAP) committed the members of the BIWG to meeting the Plan's goals. The Plan provides the specific actions and timelines that the agencies have agreed to take to implement the Executive Order. The action item from that list addressed by Task 3.2.7 in the CBC-PIERS contract is the identification of "Biomass Management Zones" (BMZ). This task was developed in part in consultation with the California Department of Forestry and Fire. The Bioenergy Action Plan calls on the Department of Forestry and Fire to: "Identify "Biomass Management Zones" (BMZs) in key forest and range areas of California, based on known resources, contribution to the maintenance of forest health, and reduction in large, high-intensity wildfires by December 31, 2007."

on the management and utilization of forest biomass to help reduce the risk of catastrophic wildfire, agricultural biomass to reduce air pollution from open burning and overall greenhouse gas emissions from all biomass sources. Senate Bill 1X2[2], signed by Governor Brown in April of 2011, makes the utilization of biomass as a source of renewable energy a crucial component to meet the state's goals of increased renewable energy.

Although a major focus of recent efforts is on energy production, utilization of biomass (both waste and purpose grown) provides a variety of real or potential social and environmental benefits including:

- Reducing the severity and risk of wildfire,
- Improving forest health and providing watershed protection,
- Improving air and water quality,
- Restoring degraded soils and lands,
- Reducing greenhouse gas emissions,
- Improving management of residues and wastes,
- Reducing dependency on fossil energy sources,
- Improving electric power quality and supporting the power grid,
- Creating new economic opportunities for forestry, agriculture and other industries,
- Creating jobs and economic revitalization of rural agricultural and forest communities.

This list of benefits is based on recognition of the multiple consequences of biomass management. All biomass eventually decomposes and returns to the atmosphere where it resides ultimately as carbon dioxide ($CO_2$). New biomass growth removes $CO_2$ from the atmosphere, making biomass carbon neutral.[3] Biomass resources that may be converted to energy would otherwise be burned in uncontrolled forest fires, or in residue piles following commercial wood harvest. Excessive wood accumulation in forests eventually decomposes or remains as overgrowth, increasing wildfire risk. Especially for forested ecosystems, these pathways may lead to greater carbon emissions and larger effects on climate than when used for bioenergy or power. Prudent woody biomass use may also affect ecosystem structure and function less adversely than allowing forested ecosystems to remain unmanaged (USFS, 2010; WFLC, 2010; Morris, 2009).

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[2] http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0001-0050/sbx1_2_cfa_20110214_141136_sen_comm.html

[3] US EPA is not in agreement with the IPCC and the US DOE on this determination. They have delayed their determination on this conflict in US policy for three years. For further information see the discussion below on US EPA MACT standards and also the section in Chapter 3 on Federal: GHG Programs.

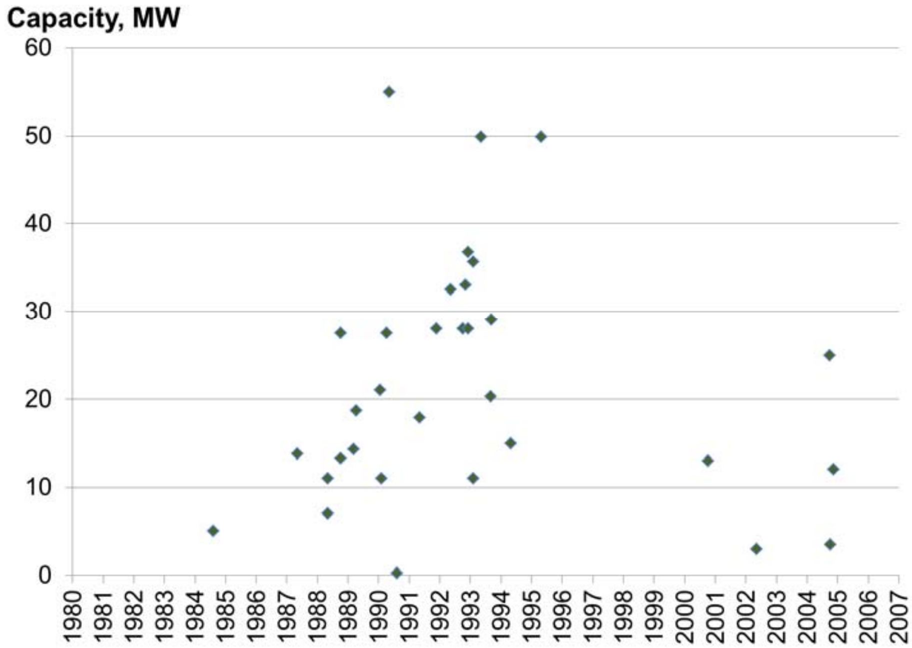
The search for alternative energy sources goes back several decades in the United States. The energy crisis of the 1970's (primarily politically motivated curtailment of oils supplies from the Middle East) led to enacting the Public Utility Regulatory Policies Act (PURPA) at the federal level in 1978. California responded to this act by instituting policies to stimulate renewable, domestic energy sources through economic incentives. During the 1970's and 1980's, a number of facilities that converted biomass into electricity were constructed. This phase of infrastructure development focused on cogeneration (Co-gen) and combined heat and power (CHP) facilities located primarily at sawmills. These facilities utilized the abundant residual process wood (sawdust, bark and pieces) and wood chips were transported to these facilities under favorable market conditions. Other biomass-to-electricity facilities were constructed to use urban wood wastes (to reduce landfilling) and residual woody materials from agriculture.

An important use of biomass today is as a fuel for California's existing biomass power plants. Most are steam power facilities with approximately 20 percent to 25 percent conversion efficiency. The number of facilities that operate in California varies depending on the status of individual contracts, feed-in tariff rates, and the costs of biomass feedstock. The 29 facilities currently operating represent approximately 2 percent of the state's electrical generation capacity. The most recent map of existing biomass to electricity facilities and the primary feedstocks combusted was created by Mayhead and Tittmann (2012).[4]

These biomass plants use about 5 million bone-dry tons (BDT) of biomass per year representing approximately 600 megawatts (MW)-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 (Birdsall et al., in preparation). The current low price received at many of these facilities has some of them in curtailment (approximately 80 MW; Mayhead and Tittmann, 2012). Figure 3 shows MW of biomass energy capacity installed in California from 1980 to 2005. Many of the early power plants are no longer in operation and new installations have not replaced these. The amount of biomass used for this purpose has declined with time, despite the general state objective to increase the amount of power from renewables.

[4] http://ucanr.org/repository/CAO/landingpage.cfm?article=ca.v066n01p6&fulltext=yes

**Figure 3: Temporal Trend of Biomass Power Plant Capacity Installed in California from 1980 to 2005**




Source California Biomass Collaborative

In-forest biomass is only a portion 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 percent of the total consumed (5,250,000 BDT total). Estimates by region in 2009 were: Coast (Humboldt, Trinity, Del Norte, and Mendocino) equal to 35 percent; Northern California (Sacramento north) equal to 50 percent; Central CA equal to 20 percent. Southern California facilities consume primarily urban wood waste.[5] Two of the state's existing biomass to energy facilities operate within the Oroville BMZ discussed here. Issues associated with their continued operation and viability are discussed in detail in Birdsall, et al. (in preparation).

Those facilities that rely on largely urban woody waste materials or which use mixed biomass feedstocks may be especially affected by new air pollution and greenhouse gas emission rules. New US EPA boiler Maximum Achievable Control Technology (MACT) standards that are part of Clean Air Act regulation, could lead to permanent closure of a number of facilities.[6] EPA at

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[5] The most current list of the status of California's biomass power facilities is available at: http://ucanr.org/sites/WoodyBiomass/Woody_Biomass_Utilization_2/California_Biomass_Power_Plants/ , maintained by Garreth Mayhew at UC Berkeley. This compiles information from several sources, including the CBC.

[6] "On February 21, 2011, EPA issued final standards for major and area source boilers and commercial and industrial solid waste incinerators. On May 16, 2011, EPA announced it is allowing time to seek and review additional public input on the final standards for boilers and certain solid waste incinerators. EPA

this writing had not yet issued final guidelines, but many of California's existing biomass power facility operators have been concerned that several components of the rules will make it difficult for facilities with narrow profit margins to continue to operate.[7] Summarized industry's concerns to US EPA's boiler MACT rule include:[8]

1. Restrictions on what qualifies as acceptable feedstock in a competitive biomass market (e.g. urban wood waste and agricultural fuels that have relatively higher levels of salts and metals),
2. A requirement for large new capital expenses to meet new emissions limits, and uncertainty about long-term performance of expensive new systems. Most California facilities have fixed rates for sale of electricity, which may not allow for expensive new investments.
3. Classifying biomass facilities in California as solid waste incinerators increases regulatory uncertainty and risk. An unknown number of companies may not be able to make expenditures when costs cannot be recovered and choose to suspend activity, and
4. Concerns that installing additional control systems and equipment such as wet scrubbers would increase energy and water consumption, and reduce the efficiency of the plant.

In addition, many of these facilities will be reverting from stable, higher fixed price contracts to variable prices just as these rules come into effect in 3 to 5 years. The closure of these facilities will make economic management of woody biomass materials for energy in California more difficult, at least in the short- to mid-term, and compromise state objectives to increase reliance on alternative energy sources.

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is also issuing a stay to delay the effective date of the standards for major source boilers. Additional public comments were sought to attempt to avoid closure of existing facilities. Non-Hazardous Secondary Materials Rule,[6] which EPA promulgated at the same time as the Boiler Maximum Achievable Control Technology Rules, was not changed. This rule has the potential to classify urban wood fuel (approx. 30% of total biomass fuel in California) as a "solid waste" and thus biomass facilities using this feedstock would fall into the Commercial and Industrial Solid Waste Incinerator category. A major source facility emits or has the potential to emit 10 or more tons per year (tpy) of any single air toxic or 25 tpy or more of any combination of air toxics. 22 of the 31 existing solid-fuel biomass facilities in California would be classified as a major source emitter. The final rule will reduce emissions of a number of toxic air pollutants including mercury, other metals, and organic air toxics (polycyclic organic matter (POM) and dioxins). Toxic air pollutants, also known as hazardous air pollutants or air toxics, are those pollutants known or suspected of causing cancer and other serious health effects." US EPA boiler MACT fact sheet: http://www.epa.gov/airquality/combustion/docs/20110516nextstepfs.pdf

[7] On December 2, 2011 EPA issued proposed reconsiderations for rules to reduce emissions of air pollutants from new and existing boilers and solid waste incinerators. http://www.epa.gov/airquality/combustion/actions.html#jun11

[8] US EPA boiler MACT fact sheet: http://www.epa.gov/airquality/combustion/docs/20110516nextstepfs.pdf

## 1.2 Woody Biomass from Fuel Load Reduction in Forests

Reduction in the risk of wildfire loss is one reason to increase use of excess woody biomass that has accumulated in many of the state's forests over the last decades. Excess forest biomass that would otherwise be lost to wildfire could be beneficially used for energy. Reducing excess forest biomass to reduce wildfire losses is referred to as *fuel load reduction*. Wildfire risk is estimated to be increasing in many forested areas of California due to biomass accumulation (Nechodom, et al., 2008) and shifts in climate (projected warming; Bryant and Westerling, 2009; Westerling, et al., 2009). The United States Forest Service (USFS) evaluated the potential to maintain or increase the forest inventory on public lands. They found that current management of underutilized woody biomass will lead to lower forest inventories within two decades, due primarily to forest disturbance events such as pests and wildfire.[9] In looking at several management options, USFS concluded that significant investment in management actions including pre-fire forest thinning and post fire reforestation will be needed to maintain forest inventory and health.

### 1.2.1 Benefits of California Forest Fuel Load Reduction

Supporting USFS conclusions, a recent modeling study from CAL FIRE (Robards, 2010) estimated current annual net growth in tons of $CO_2$ for all California forests. He reported that carbon was accumulating in all California forests, but especially in forests on public lands. Using CAL FIRE's 2008 Forest Inventory Analysis Data and the Forest Vegetation Simulator model, results predicted an annual net growth of 25 million metric tons per year (MMt/yr) of carbon on public lands, and 5 MMt/yr of carbon on private lands, equivalent to approximately 30 MMT/yr (Lower right hand cell of Table 1). One dry ton of biomass is equal to approximately 1.8 tons of $CO_2$. A summary of the model estimates for all California forestlands, including public and private lands, is reported in Table 1. Estimates account for losses of carbon stocks from harvest, mortality, and wildfire. The storage of carbon in long-term wood products was also considered.

The USFS and CAL FIRE reports suggest that some of this increasing woody biomass inventory can and should be removed to sustain or improve forest ecosystem resilience. The amount of biomass will vary locally based on current forest stand conditions, including quantities to be removed to reduce potential losses from pests and wildfire. A number of studies examining the changes in forest structure after the implementation of strong fire suppression policies have concluded that the forest stand densities (trees per acre) are increasing. That this increased tree density adds to the risk of large damaging fires, particularly in consort with a drying climate (Hurteau and North 2009). Though this condition has increased the total biomass (carbon) on many forest stands, a disproportional amount of the total biomass is in the lager stems within each stand (Fellows and Gould, 2008). The smaller stems create fuel conditions that are conducive to large intense wildfire and thus removal of a portion of this dense understory will result in a forest stand with greater wildfire resilience. The extent of the removal required to

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[9] National Forest Carbon Inventories for the Pacific Southwest Region, 2009 http://www.fs.fed.us/r5/climate/carboninventoryassessment/assessment201007.pdf

reduce the wildfire and retain a full health forest ecosystem has been examined by groups such as the Society of American Foresters and processes for outlining forest stand treatments have been developed (Morris, Peterson, and Raymond, 2007) have been developed. Since this examination, guidelines for fuel hazard reduction treatments have been developed. An example of such guidelines is the " Comprehensive Fuels Treatment Guide for Mixed Conifer Forests: California, Central and Southern Rockies, and the Southwest."[10] These guides and studies speak to the initial treatment of the current wildfire fuel conditions as do the current estimates of biomass available from forest thinnings.

**Table 1: Model Estimates for Carbon Stocks for All California Forestlands (tonnes) (32,114,317 acres)[11]**

| Source | Type | C | $CO_2$e |
|---|---|---|---|
| Growth | Storage | 16,367,285 | 60,067,936 |
| Model Mortality | Emission | -5,455,351 | -20,021,137 |
| Wildfire | Emission | -1,719,915 | -6,312,087 |
| Harvest (merchantable) | Emission | -565,315 | -2,074,706 |
| Harvest (non-merchantable) | Emission | -792,776 | -2,905,819 |
| Wood Products (in-use) | Pool | 389,436 | 1,429,231 |
| Wood Products (landfill) | Pool | 48,796 | 179,081 |
| Net | | 8,272,160 | 30,362,499 |

These same studies indicate that retreatments or maintenance of the initial fuel hazard reduction will be required in the range of 30 years following the initial treatment. The amounts of biomass available from these following treatments are yet to be estimated. Thus consideration of the commercial use of biomass needs to include the amount of area needing treatment near a proposed facility, the volume that can be produced from that area annually, and the time over which those treatments will occur. After the full areas at risk of wildfire have been treated there will likely be a decrease in biomass available from forest thinnings. This needs to be considered in estimating feedstock needs for proposed facilities.

[10] http://www.forestguild.org/mixed_conifer.html

[11] "The estimated annual sequestration rate for all California forestlands was about 30 Tg (MMt) of $CO_2$eq. A third of the approximately 60 Tg of $CO_2$e per year that could be sequestered was lost to non-wildfire related mortality. Ten percent was estimated to be lost to wildfire-related mortality. About eight percent was lost to harvest-related emissions while less than three percent was estimated to be in wood product pools. This left about one half of the potentially sequestered live tree carbon after estimated emissions deductions. These percentages varied slightly for private and public landowner classes due to most harvesting being associated with private lands." page 6, Robards, 2010.

Due to the costly and harmful effects of wildfires, a number of efforts have been extended to provide policy makers with information on their full cost in the US. A 2010 report by the Western Forest Leadership Council (WFLC)[12] reviewed six case studies in the Rocky Mountain and Pacific West. When full costs were evaluated the conclusion was that they exceeded the reported suppression cost from 2 to 30 times.

Fire is a natural feature of the state's forested landscape. Increasingly, however, destructive wildfires result in unproductive loss of biomass, large emissions of criteria pollutants and Greenhouse gases (GHG), property destruction, adverse public health consequences, and sometimes permanent loss of ecosystem structure and function. These changes in turn lead to increased soil erosion, sedimentation of dams, declining water quality, and habitat and species loss. Fighting massive wildfires is very costly. Since 2005, wildfires have burned more than 900,000 acres statewide on average, while over the last two decades, the area burned has been increasing. The California Department of Forestry and Fire Protection (CAL FIRE) has estimated the costs of fighting fires on the 200,000 acres in its area of responsibility cost over $200 million per year for suppression with an associated average property loss over $100 million annually.[13]

Active 20th century fire suppression in western US forests, and a resulting increase in stem density, is thought to account for a significant fraction of the North American carbon sink. We Comparing California forest inventories from the 1930s with inventories from the 1990s reveals that stem density in mid-montane conifer forests increased by 34 percent, while live, aboveground carbon stocks decreased by 26 percent. Increased stem density reflected an increase in the number of small trees and a net loss of large trees. Large trees contain a disproportionate amount of carbon, and the loss of large trees accounts for the decline in biomass between surveys. 20th century fire suppression and increasing stand density may have decreased, rather than increased, the amount of aboveground carbon in western US forests (Fellows, 2008).

A recent assessment reported to the CPUC by Placer County Air Pollution Control District attempted to summarize the economic costs of current forest management policies and contrast them to a set of policies that include additional (modest) levels of fuel load reduction[14]. This work included evaluating a pilot-scale biomass utilization plant and was supported by the US DOE. Wildfire management costs in California for all sources of data were reported to average approximately $1.2 billion dollars per year from 2006 to 2010. These costs include those for post-fire landscape mitigation and compensation to landowners for fires related to transmission

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[12] The True Cost of Wildfire in the Western US; 2010. Six case studies in the Rocky Mountain and Pacific West were reviewed. http://www.wflccenter.org/news_pdf/324_pdf.pdf.

[13] D. Pimlott. 2011, CAL FIRE, cited in: Placer County Air Pollution Control District: Opening Comments to October 13, 2011 Renewable Feed in Tariff staff proposal. Rule Making 1105-005, May 5, 2011; and D. Wickizer, CAL FIRE, personal communication, Placer County estimates rely on CAL FIRE data.

[14] Op.cit. Placer County Air Pollution Control District: Opening Comments to October 13, 2011 Renewable Feed in Tariff staff proposal. Rule Making 1105-005, May 5, 2011.

infrastructure or other public responsibilities.[15] Climate change predictions suggest that wildfire losses will increase in a warmer and perhaps drier future (Bryant and Westerling, 2009; Westerling et al., 2009).

Aside from accounting for the costs of wildfire suppression, estimating accurately all the costs of diverse ecosystem functions lost from uncontrolled wildfires is difficult. Nonetheless, fuel load reduction in at-risk forests is regarded as a means of minimizing costly and ecologically harmful consequences of intense wildfires.[16] In addition to direct costs for fire management and damage to ecological values, there are adverse public health effects from fires.[17] Open burning of all types of biomass produces as much as 100 times more conventional pollutants than controlled combustion or gasification in a power boiler, and much greater quantities of greenhouse gases due to poor (incomplete) combustion conditions. In addition the Placer County report cited estimates that with some developmental second generation (thermochemical) conversion technologies, up to a 24 percent reduction in GHG ($CO_2$) emissions could be achieved compared to open burning of harvest residue piles.[18]

Woody residues derived from fuel load reduction in at-risk forests can be used for biopower or, potentially, biofuels. Placer County has recently estimated the economic benefits from forest biomass use for power in its part of the Sierra Nevada region. They estimate that a modest increase in fuel load reduction that treats an additional 31,000 acres of forestland per year, if converted to power in 50 MW of new, locally distributed facilities, would generate an additional 372 (gigawatt-hours) GWh per year.[19] To treat forests in this way, they assume $0.055/kilowatt-hour (kWh) is paid to the power producer (to pay for wildfire hazard reduction) and estimated total power costs to Investor-Owned Utility (IOU) ratepayers to be equal to $0.15/kWh per month. These values represent the most recent attempt to estimate costs and benefits from fuel load reduction in heavily forested areas near the BMZ discussed here.

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[15] Op.cit.

[16] USFS Southwest Research Station.2009. Biomass to Energy: Forest management for Wildfire Reduction, Energy Production and Other Benefits. California Energy Commission, PIER program. CEC-500-2009-080. http://www.energy.ca.gov/2009publications/CEC-500-2009-080/index.html

[17] "Wildfire Smoke a Guide for Public Health Officials", 2008 discusses the general impacts and suggested health preventative actions. Health risks are eye irritation, pulmonary damage, increase risk of heart attack. These are especially important for at risk populations like the very young and elderly, and asthmatics. http://www.arb.ca.gov/smp/progdev/pubeduc/wfgv8.pdf.

[18] Placer County Air Pollution Control District & TSS consultants, November 2011, Air/Water Emissions and Carbon Credits/Emissions Offsets Task 1.0 http://www.placer.ca.gov/Departments/CommunityDevelopment/Planning/Biomass/~/media/cdr/Planning/Biomass/Reports/PlacerDOEProjectTask1.a

[19] Placer County Air Pollution Control District: Opening Comments to October 13, 2011 Renewable Feed in Tariff staff proposal. Rule Making 1105-005, May 5, 2011.

### 1.2.2 Power or Fuel from Biomass

Over the last decade, the promise of new technologies capable of transforming biomass into liquid fuels of various types has driven a variety of pilot projects, fuel availability reports and investigations. An assessment of the relative availability of biomass on a statewide basis, combined with the location of key transportation infrastructure facilities and estimates of the cost of conversion was carried out by the California Biomass Collaborative for the Public Interest Energy Research (PIER) program (Tittmann, et al., 2008).[20] The optimization model 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 (Tittmann et al., 2008). Based on their price and technology assumptions, biomass supply curves were developed that estimated the availability of biomass for either biofuels or for biopower (Fig.1.3). These curves indicate biomass quantities that could be consumed given various biofuel prices in dollars per billion gallons of gasoline equivalents ($/bgge, vertical axis).

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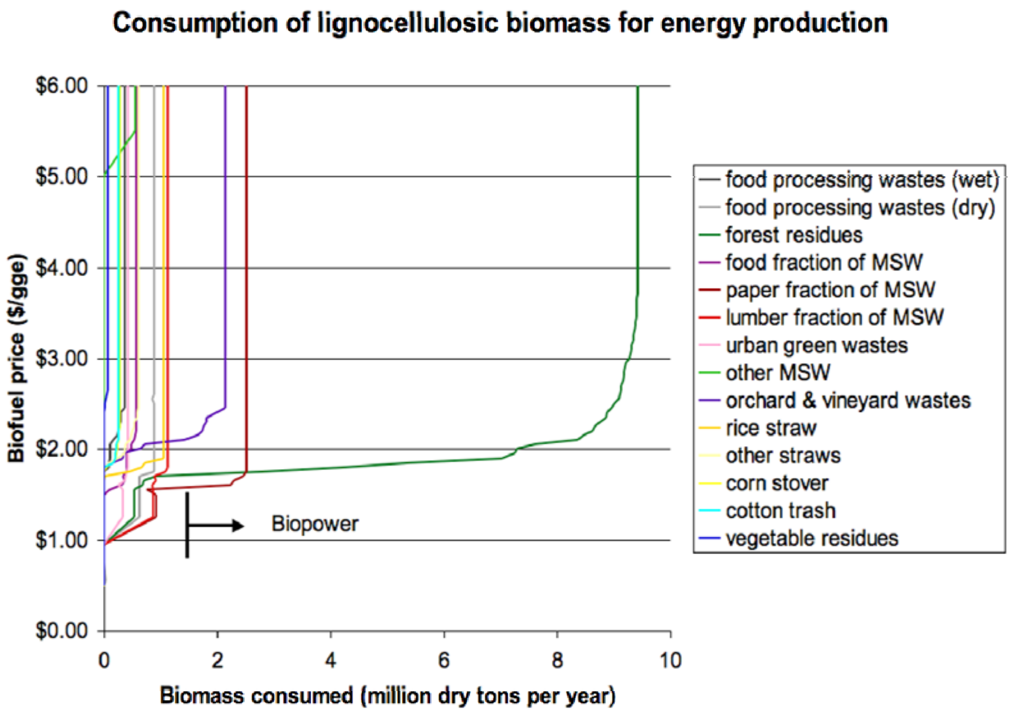
[20] The California Biorefinery Siting Model integrates geographically explicit biomass resource assessments, engineering and economic models of the conversion technologies, models for multimodal transportation of feedstock and fuels based on existing transportation networks, and a supply chain optimization model that locates and supplies a biorefinery based on inputs from the other models . To identify the locations for biorefineries, the model first maximizes the profitability of the entire state bioenergy industry. The profit maximized is the sum of the profits for each individual feedstock supplier and fuel/power producer. Costs minimized in the model are those associated with feedstock procurement, transportation, conversion to fuel, and fuel transmission to distribution terminals. Fuel production and selling price determine industry revenue. Co-product revenues are included, Tittmann, et al., (2008).

**Figure 4: Estimated Biofuel Price at which Different Types of Biomass are Converted to Fuels or Power**




(Tittmann et al., 2008).

Transportation fuels are worth more than electricity in the absence of regulations, mandates or other factors that would favor renewable electricity over biofuels. Without biopower policy incentives and at current oil prices, biomass will tend to be diverted to fuel rather than power. The Biorefinery Siting Model assumptions and prices are of value for comparison purposes and no longer reflect either current prices or the current state of technology options. The model is indifferent to policies that might affect siting, or to local circumstances that might either inhibit or favor biomass use. Economic potential cannot be separated from policy issues that affect or constrain the use of biomass. Additionally, new developments in conversion technologies continue to influence and alter estimates of the profitability of biomass conversion to energy reported in the model.

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. A limiting distance of 50 miles is commonly used and assumed in the model, but is not absolute. If the energy content of distributed biomass supplies can be increased through pre-treatment technologies, then biomass can be assembled at combustion, gasification facilities, or mixed biorefineries from larger distances.[21]

Recently, Governor Brown and the legislature have increased the state's renewable power production goals to reach a target of 33percent of power consumed in California by 2020 (Table 2). To meet its policy goals, the state will need to add between 20,000 and 40,000 MW of additional renewable generation capacity to meet projected growth in demand to achieve the goal of more than 33 percent renewable energy sources over the next 15-20 years, mandated by Senate Bill 1X2. To meet local and statewide goals of increased renewable energy production, use of all prudently accessible sources of biomass resources is essential. Unlike intermittent wind and solar energy sources, biomass can be used for base load production of energy, complimenting these other intermittent sources.

**Table 2: Peak Demand and Energy Consumption Forecast**

| | 2008 | 2013 | 2016 | 2020 | 2030 |
|---|---|---|---|---|---|
| Peak Demand (MW) | 62,946 | 67,524 | 70,174 | 74,094 | 84,877 |
| Energy (Billion kWh) | 289.0 | 309.1 | 320.2 | 337.0 | 383.1 |

Source: California Energy Commission. California Energy Demand 2008 - 2018: Staff Revised Forecast - Final Staff Report, 2nd Edition. Forecast values for 2020 and 2030 based on 2008-2016 forecast growth rates.

Public policy, specifically the state's Low Carbon Fuel Standard (LCFS) and the federal Energy Independence and Security Act (EISA) mandate the use of some biofuels for transportation in California in billion gallons of gasoline equivalent (bgge, Table 3).

**Table 3: Projected Biofuel Demand in California by 2020**

| Year | Displaced Petroleum (bgge) | Distribution | Sources |
|---|---|---|---|
| 2009 | 0.6 | 100% | Conventional biofuels |
| 2020 | 3.0 | 20% | Conventional biofuels |
| | | 10% | CNG, electricity, $H_2$ |
| | | 70% | Advanced Biofuels |

**Advanced biofuels can be made from crops other than corn and soybeans, crops residues, forestry residues and MSW. AB32 scoping document (CARB).*

The absolute amount and percentage of renewable electricity produced in California has declined since 2000, despite abundant biomass in California and recent governors' intentions and state policies that biomass be used for alternative energy and fuel production within California. Similarly, the amount of ethanol produced within California currently is less than in

[21] Mobile pyrolysis and torrefaction are examples of technology with possible application for forested biomass, crop residues and perennial grass crops.

2006, and the number of operating biodiesel facilities has declined. The causes of these declines are varied. A large number of biomass to energy facilities were located at lumber mills, relying on the forestry industry for feedstock. When the mills closed, feedstock supplies disappeared. Others have seen the price they receive for electricity decline past the point of profitability, or seen increases in the costs of feedstocks, or both. In-state ethanol production has been affected by financial difficulties of some of the firms operating ethanol refineries, price increases in feedstocks (corn grain), and changes in federal regulations and support programs. Local or regionalized analysis of biomass resources and compatible potential conversion technologies may help reverse this trend, and indicate what forms of biomass energy are most prudent to produce.

## 1.3 Biomass Management Zones

Biomass Management Zones (BMZ) have been defined as 'sustainably managed woodsheds and other biomass production regions' that will support the sustainable management of commercial and non-commercial forestlands, provide wildfire control, provide local bioenergy, and stimulate local economic activity. The study area of this report is referred to as the Oroville BMZ because Oroville is the largest city within the 1.3 million acres of the study area BMZ.

There have been many attempts in recent years to improve access to and increase the use of forest biomass for traditional wood products and for other uses, including energy. Federal forests for many years have restricted tree removal and biomass accumulation rates and standing biomass density have increased. In parts of California with forest located in drier or seasonally dry conditions, excess biomass accumulation has increased the risk of wildfire. Despite agreement about the need for fuel load reduction, little progress has been made on forest maintenance to reduce the risk of wildfire and ecosystem alteration.

One of the most intensive and politically important efforts to improve forest management in part of the forested areas of the Oroville BMZ analyzed has been by the Quincy Library Group (QLG).[22] It was initiated in 1992 by local residents but soon attracted interest, broad participation by many groups, including environmental groups, and the attention and participation and support from then Congressman Herger and Senator Feinstein. It was active until 2009. The QLG worked to develop a "Community Stability Proposal" that suggested improvements in management for the Lassen National Forest (NF), the Plumas NF, and the Sierraville Ranger District of the Tahoe NF. This plan suggested many progressive modifications to traditional forest management practices as well as reduction in unmanaged areas and increasing risk to catastrophic wildfire.[23]

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[22] Quincy Library Group (QLG) Background, http://www.qlg.org/pub/contents/overview.htm

[23] These included: a consensus definition of the *Desired Future Condition* for these forests, characterized by "an all-age, multistory, fire-resistant forest; deferral of certain sensitive areas from scheduled harvest; timber management plans based on group selection and single tree selection; implementation of California Spotted Owl (CASPO) fire and fuels management objectives; riparian habitat protection and watershed restoration; continuation of SBA/SSTS set-asides; expanded stewardship contracting; and a northern Sierra working circle." There was also a desire to help slow the loss of the local timber industry

One of the projects initiated by the QLG with the National Renewable Energy Lab (NREL, 1997) was a study of the potential of biomass from fuel load reduction treatments to be converted ethanol.[24] The NREL carried out synthetic analysis of ethanol production potential and costs using different acid hydrolysis treatment of woody biomass. While the result of this analysis are no longer current in terms of costs and treatment technologies, it was reported that large amounts of biomass from fuel load reduction treatments, residues from commercial timber harvests and some mill wastes would provide potential for up to four ethanol facilities in the study area with capacities ranging from approximately 15 million gallons per year (mgy) to 30 mgy, based on harvest areas of approximately 25 miles around each facility. Projected costs and returns only appeared feasible when a plant that produced 40 mgy could be built given ethanol and gasoline prices at the time. A feedstock cost of $20 per BDT was assumed, low by current standards. The analysts reported that the environmental benefits and long-term potential for the state's biofuel market supported project development, but no ethanol project was ever built.

Despite efforts to be inclusive and to follow a careful deliberative process, and the occurrence of a catastrophic wildfire within the region with significant ecosystem loss during this period, the Quincy Library Group and its plans met significant opposition.[25] The default policy remains tolerance of wildfire risk and eventual loss of forest resources and ecosystem character to wildfire. The Quincy Library website documents the legal and political challenges to implementing its objectives through 2009.[26] It has a reduced level of activity currently after nearly twenty years of intensive effort.

A new BMZ-based analysis might be a means of increasing forest biomass use in these remote areas, especially by including newer, perhaps smaller scale or more mobile technology than previously considered. The development of the BMZ and application of new biomass transformation technologies could provide access to forest biomass in ways that overcome the objections of groups opposed to more traditional forest management practices. New transformation technologies include torrefaction, pyrolysis, or smaller distributed power facilities involving gasification or even traditional combustion technology. This approach has recently been suggested by the Placer County Air Resources District discussed above.[27]

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vital to the region, including a *Forest Health Pilot Program*.
http://www.qlg.org/pub/contents/overview.htm

[24] Northeastern California Ethanol Manufacturing Feasibility Study, Quincy Library Group, California Energy Commission, California Institute of Food and Agricultural Research, Plumas Corporation, TSS Consultants, National Renewable Energy Lab, November 1997, http://www.qlg.org/pub/act_acp/ethanol/feasibility.htm#ProjectTeam

[25] http://www.qlg.org/pub/miscdoc/antelopefireanalysis.pdf

[26] The Quincy Library website documents the legal and political challenges to implementing its objectives through 2009 (http://www.qlg.org/pub/bill/misperfacts.htm#convern5).

[27] Placer County Air Pollution Control District: Opening Comments to October 13, 2011 Renewable Feed in Tariff staff proposal. Rule Making 1105-005, May 5, 2011.

New federal programs like Biomass Crop Assistance Program (BCAP) in recent years have subsidized the collection and transport of forest management residual materials to biopower facilities in several locations in the state.[28] The reduction of these costs of material collection and transport are the most important cost cited in the Quincy-NREL study about ethanol manufacture. This program has been created to bridge the gap between the cost of removing forest residues to a power facility and their combustion in place in forests. Other state or locally based programs might also be created to supplement or support biomass collection activities. New mobile biomass densification technology may increase the amount of woody biomass available in the state, but the economic costs of forest treatment for fuel load reductions still emphasize the need for some traditional tree harvest for timber products to support fuel load reduction.[29] Fried et al, 2005 reported substantial differences in fuel load reduction in forests in southeastern Oregon and northern California, depending on the degree to which treatments were correlated with commercial wood harvest. In the absence of economic levels of commercial wood harvest, subsidies for biomass collection and removal requires a public policy decision to use tax revenues or supplemental fees for energy instead. Even if the use of these residues was increased, large amounts of forest biomass would remain legally inaccessible and at risk of loss to wildfire in protected areas or public lands. While there is consensus about the need for forest management to reduce the risk of catastrophic wildfire, access to much of this biomass is subject to legal and political conflict. This uncertainty currently prevents investment in new biomass recovery and transformation systems based solely on woody biomass from forests.

In the absence of social permission to remove larger amounts of forest biomass, and in the absence of significant public subsidies for their removal, an alternative to defining a BMZ strictly as a forest biomass based activity makes sense. Combining forest and other more readily accessed types of biomass in combined power or biorefinery systems may allow markets to create the means to use some amounts of forest biomass without being entirely dependent upon one type of material. The amount of forest biomass used could then increase with time once initial processes and facilities were in place, in a gradual and sustainable manner, as communities adjusted to the facilities and their impacts, and as social values evolve.

No single type of biomass may be sufficient to support a biorefinery or conversion facility in all regions of the state. In practice, it makes sense to expand the concept of a BMZ to integrate all sources of useful biomass generated within logically defined regions in California's diverse and productive natural, managed and urban ecosystems. A broader definition better supports production of renewable energy, local economic stability, waste reduction, natural and managed ecosystem maintenance, and the protection of life and property threatened with loss to wildfire.

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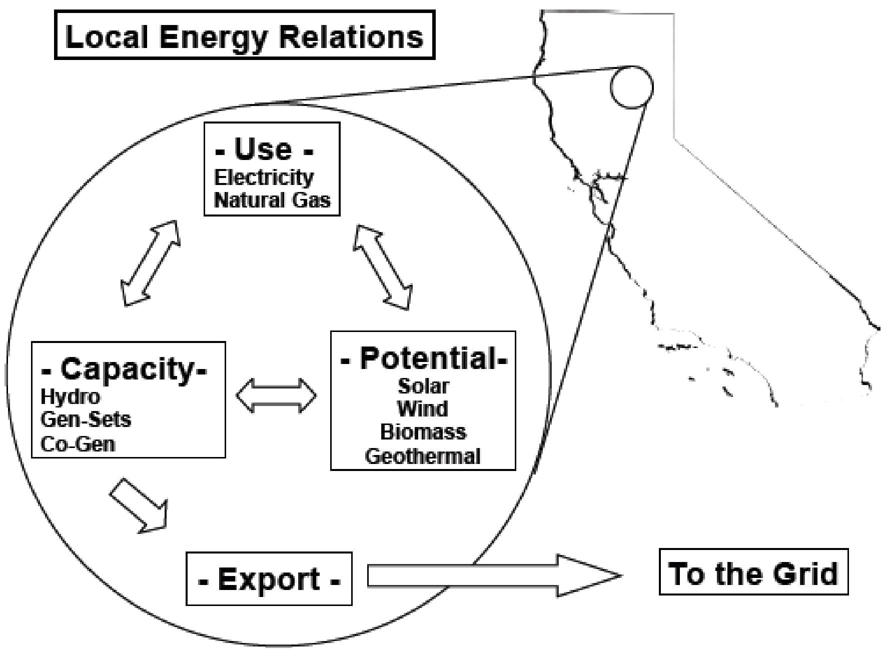
[28] See chapter 3 below for a discussion of this program.

[29] A Strategic Assessment of Forest Biomass and Fuel Reduction Treatments in Western States - RMRS-GTR-149, 2005. http://www.fs.fed.us/rm/pubs/rmrs_gtr149.html-

BMZs then provide a framework for integrated assessment of local energy potential and production, carbon balance and offsets, reduction of potential wildfire severity, economic development, promoting ecosystem resiliency and reducing strain on local waste disposal systems (Fig. 1.4). There may be opportunities to consider the integration of several forms of alternative energy. BMZs should help facilitate interactions between local, willing partners and funding sources to create location specific systems to account for the production, utilization and transformation of biomass resources and the various factors (environmental, social and economic) that shape policy and management decisions.

**Figure 5: Local Energy Relations, with Excess Production Available for Export to Other Regions**



# CHAPTER 2:
# Oroville BMZ and Its Resources

## 2.1 BMZ Infrastructure Description

The lands around the city of Oroville in the Northern Sacramento Valley are the focus of the Biomass Management Zone detailed below. Figure 6 shows the location and shape of the Oroville BMZ. Covering approximately 1.29 million acres, this area has diverse biomass feedstocks, existing bioenergy conversion capacity, relevant land management issues and connectivity to transportation and electrical grids. It is largely rural with a modest population (Table 4) and includes productive natural and managed lands. Natural resource use and biomass-based industry have been traditional contributors to this area's economic development and economy. There are many large underutilized potential biomass sources and annual supplies available for existing and expanded renewable energy conversion capacity. This mixture of available resources makes it a likely place for further biomass energy development. High rural unemployment in this region provides another justification for focusing on this area.

The counties of Butte, Colusa, Glenn, Plumas, Sutter and Yuba include cumulatively approximately 5,000,000 acres with an array of diverse and productive agricultural crops and forested lands. Table 4 shows the acreage of these counties divided by land use.

**Table 4: Six County Area (Total Acreage per County) and General Land Classification[30]**

| County | Acres | Forested | Shrub | Agriculture And Other |
|---|---|---|---|---|
| Butte | 1,049,273 | 772,899 | 33,747 | 242,634 |
| Colusa | 7,364,335 | 359,971 | 97,009 | 282,990 |
| Glenn | 841,465 | 465,401 | 111,383 | 272,626 |
| Plumas | 1,634,361 | 1,599,209 | 67,776 | 5,655 |
| Sutter | 385,625 | 131,413 | 15 | 258,012 |
| Yuba | 403,641 | 262,505 | 2,585 | 146,880 |
| Total | 5,050,801 | 3,591,398 | 312,515 | 1,208,797 |

The BMZ's footprint is shaped by consideration of biogeography, and practical limits to biomass, transportation. This allows evaluation of both centralized and distributed biomass facilities. Biomass estimates developed here are conservative, and include a well-characterized annual biomass stream (rice straw), biomass from orchard management from known acres of these crops, and potential woody biomass quantities derived from likely *landscape scale*

[30] Data adapted from California's Forests and Rangelands: 2010 Assessment (CAL FIRE) http://frap.cdf.ca.gov/

*vegetation*[31] management activities, especially fuel load reduction in wildland-urban interface areas (WUI). In addition, food processing residuals and urban MSW supplies are included.

**Figure 6: Location and Shape of Oroville BMZ Footprint in the Northern Sacramento Valley**

## 2.1.1 BMZ Human Resources

Only three of the six counties in the Oroville BMZ have significant population. The county populations for Butte, Colusa, and Glenn are presented in Table 8. The actual populations within the BMZ will be smaller than for the entire county. For instance the BMZ boundary runs right through the larger town of Chico. Smaller parts of Glenn and Colusa counties are included. Total county populations are presented here, so the actual populations of these three counties are larger than presented. But people are highly mobile and employment in practice will not be limited to those living only within the BMZ itself. Nevertheless, many rural areas are among those with the highest levels of unemployment, and new businesses in the BMZ area can help alleviate that condition.

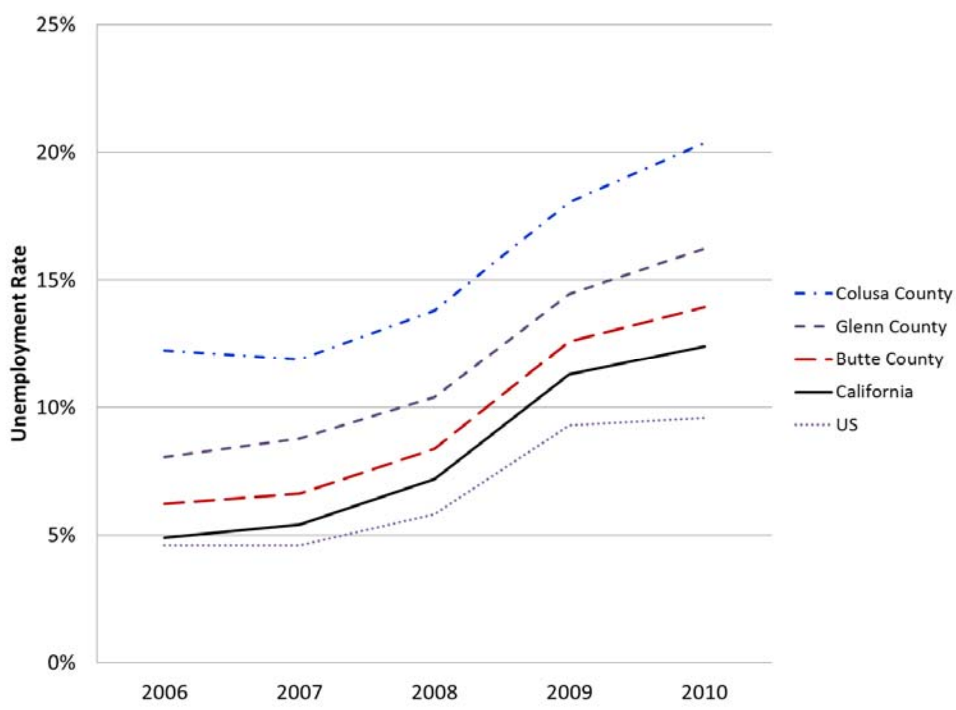
[31] *Landscape scale vegetation* refers to the dominant forest vegetation across the landscape, often known as matrix lands, and includes both near-stream and upland areas. Central Stanislaus Watershed Analysis, 2002. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5126224.pdf

**Table 5: County Population Data for Areas within the BMZ Region** [32]

| County | Population |
|---|---|
| Butte | 220,000 |
| Colusa | 21,419 |
| Glenn | 28,122 |
| Total | 268,531 |

In 2010, Butte County had an unemployment rate approaching 14 percent (California Employment Development Department, 2011). Colusa and Glenn Counties in 2010 had unemployment rates of 20 and 16 percent, respectively. Figure 7 illustrates the growth of the Colusa, Glenn and Butte County unemployment rate compared with California, and US unemployment rates for the last five years (California Employment Development Department, Bureau of Labor Statistics, 2011).[33]

**Figure 7: Growth in Unemployment within BMZ Counties, California and the USA during the Last Five Years**




[32] Data Source US Census – http://quickfacts.census.gov/qfd/states/06000.html

[33] Bureau of Labor Statistics (BLS). 2011. BLS Information. Regional and State Unemployment – Annual Averages. http://www.bls.gov/schedule/archives/all_nr.htm#SRGUNE

California Employment Development Department. 2011. Monthly Labor Force Data for Cities and Census Designated Places (CDP). Labor Market Information Division. http://www.labormarketinfo.edd.ca.gov

Data in Table 6 indicate that while the county unemployment rate may be 14 percent, towns within Butte County such as Gridley and Thermalito had unemployment rates greater than 25 percent. Many of those unemployed are from disadvantaged populations. One solution that would begin to reverse the rising unemployment rate would be creating new jobs at bioenergy facilities. The promise of jobs and economic growth from biofuels justifies prudent public investment and policy incentives for the biomass energy industry (Swenson, 2006).

**Table 6: Monthly Labor Force Data for Cities and Census Designated Places (CDP), Annual Average 2010 - Revised, Data Not Seasonally Adjusted**

| Area Name | Labor Force | Employment | Unemployment Number | Unemployment Rate |
|---|---|---|---|---|
| *Butte County* | *104,600* | *90,000* | *14,600* | *13.9%* |
| Gridley, city | 2,900 | 2,000 | 900 | 30.5% |
| Thermalito, CDP | 2,700 | 2,000 | 700 | 26.7% |
| South Oroville, CDP | 2,900 | 2,200 | 700 | 23.7% |
| Palermo, CDP | 2,700 | 2,200 | 600 | 20.6% |
| Oroville, city | 5,600 | 4,500 | 1,100 | 19.4% |
| Biggs, city | 900 | 700 | 200 | 18.5% |
| Concow, CDP | 500 | 400 | 100 | 17.9% |
| Magalia, CDP | 4,400 | 3,700 | 700 | 15.8% |
| Chico, city | 34,100 | 29,700 | 4,400 | 13.0% |
| Paradise, town | 12,000 | 10,700 | 1,300 | 10.9% |
| Oroville East, CDP | 4,200 | 3,800 | 300 | 8.1% |
| Durham, CDP | 3,000 | 2,800 | 200 | 5.7% |

### 2.1.2 Local Power Generation and Transmission Grid

Power plant capacity and annual power production of the region are presented in Tables 7 and 2.5, respectively. This region produces approximately 23,489 million kWh/year of electricity mainly from hydroelectric generation on the Feather River at Oroville Dam and other, smaller hydroelectric facilities (Table 8). Current biomass to electricity capacity is found at the Covanta Pacific Oroville Power plant is about 18 MW (from two 9 MW boilers). This facility utilizes approximately 500 tons of biomass each day, primarily from urban rather than forest sources. The BMZ is nearly self-sufficient on a power basis and new energy could be exported.

The BMZ has an important place in the electrical grid with 4 north-south 500 kV transmission lines, the Northwest Intertie that connects the Pacific Northwest with California and the Los Angeles area, passes through it. Additional lines nearby provide new electricity supplies a direct path to markets in more populated regions of the state that might not have the resources or ability to contribute to renewable power mandates.

**Table 7: Current Electrical Generation Capacity – MW [34]**

| County | Hydro | Oil/Gas | Bioenergy | Total |
|---|---|---|---|---|
| Butte | 1,038.9 | 8.4 | 18.8 | 1,066.1 |
| Colusa | 0.3 | 0.0 | 29.1 | 29.4 |
| Glenn | 5.5 | 0.0 | 0.0 | 5.5 |
| Plumas | 648.7 | 5.7 | 39.5 | 693.9 |
| Sutter | 0.4 | 819.1 | 0.0 | 819.5 |
| Yuba | 346.9 | 0.0 | 0.0 | 346.9 |
| Total | 2,058.8 | 833.2 | 87.3 | 2,979.3 |

[34] Data Source California Energy Almanac http://energyalmanac.ca.gov/electricity/index.html

**Table 8: Current electrical Generation Capacity – Million kWh [35]**

| County | Hydro | Oil/Gas | Bioenergy | Million kWh Capacity ** |
|---|---|---|---|---|
| Butte | 8,190.9 | 66.2 | 147.8 | 8,404.7 |
| Colusa | 2.4 | 0.0 | 229.2 | 23.2 |
| Glenn | 43.4 | 0.0 | 0.0 | 7.9 |
| Plumas | 5,114.3 | 44.9 | 311.4 | 5,470.7 |
| Sutter | 3.1 | 6,458.1 | 0.0 | 6,460.9 |
| Yuba | 2,877.2 | 0.0 | 0.0 | 2,735.0 |
| Total | 16,231.3 | 6,569.2 | 688.4 | 23,488.8 |

*** This capacity assumes 90% annual operation*

**Table 9: Mean Use of Electricity and Natural Gas by County (2006-2009)[36]**

| County | Non-Residential | | Residential | | Total | |
|---|---|---|---|---|---|---|
| | Million kWh | Million Therms | Million kWh | Million Therms | Million kWh | Million Therms |
| Butte | 732.0 | 17.3 | 721.4 | 29.0 | 1,453.4 | 46.3 |
| Colusa | 188.7 | 25.4 | 65.0 | 2.3 | 253.6 | 27.7 |
| Glenn | 248.5 | 5.6 | 92.3 | 2.6 | 340.8 | 8.2 |
| Plumas | 113.3 | 0.0 | 104.0 | 0.0 | 217.3 | 0.0 |
| Sutter | 347.0 | 8.1 | 276.8 | 13.2 | 623.8 | 21.3 |
| Yuba | 302.8 | 5.3 | 200.1 | 7.4 | 502.9 | 12.7 |
| Total | 1,932.3 | 61.7 | 1,459.6 | 54.5 | 3,391.9 | 116.2 |

### 2.1.3 Biogeography and Management Factors

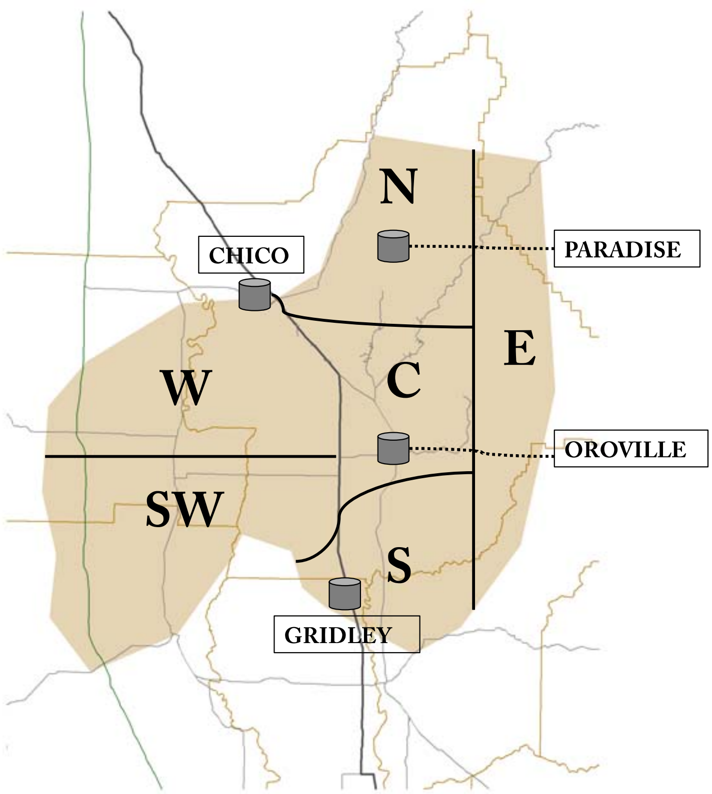
The BMZ can be subdivided into 6 management units: W, SW, N, C, S and E (Figure 8). These units have distinct biomass resources, with distinct management and environmental challenges. The W and SW units are dominated by the production of rice across the greater Butte Basin in Butte, Colusa and Glenn counties. Rice straw is one of the largest, consistent, concentrated

[35] Data Source California Energy Almanac http://energyalmanac.ca.gov/electricity/index.html

[36] Data source the California Energy Consumption Data Management System (ECDMS) http://ecdms.energy.ca.gov/

biomass resources in the state with comparatively easy access (Williams et al, 2008). Since the early 1990's when open-field burning was determined to cause unacceptable deterioration of air quality (Schuetzle, et al., 2008b). Rice straw management changed at that time from open-field burning with as much as 1.5 million tons of rice straw generated annually (NREL, 2005). There are four urban areas, Chico and Paradise in the N unit, Oroville in the C unit and Gridley in the S unit. These areas concentrate most of the urban derived materials in the Neal Road Landfill and have individual green waste programs to handle urban forest residues and yard waste.[37] Extensive orchard lands are found on the greater Feather River alluvial fan between Gridley and Yuba City in the S unit. These orchards are a considerable source of woody biomass from annual pruning and orchard removal. The C unit is the industrial hub of the region with historic and current sites around Oroville including mills and the Covanta Pacific Oroville biomass facility.

**Figure 8: Oroville BMZ Management Units and Urban Centers**




[37] Neal Road Landfill: http://www.buttecounty.net/Public%20Works/Divisions/Solid%20Waste/Neal%20Road%20Recycling%20and%20Waste%20Facility.aspx

N and E hold a mixture of WUI and productive, managed mixed conifer forests. Approximately 95 percent of this land is classified to be at moderate to severe risk of damage from wildfire, including the lower Paradise Ridge, Concow region, and areas North and East of Lake Oroville. The extensive public forestlands of the Lassen and Plumas National Forests further east are excluded from the BMZ due to concerns over excessive travel distances on largely narrow, winding roads. These lands can be included in adjacent BMZ's that will have more direct access to biomass supplies from within their local region, including the mountain communities of Chester and Quincy. Extensive analyses exist of biomass resources in the public and private forests at high elevations in this region at CAL FIRE, USFS and from organizations like the Quincy Library Group, discussed above. Overall this BMZ region could provide a variety of continuous biomass streams that either exist currently or could be generated as land management objectives change to reduce potential wildfire, wildfire costs, and correlated degradation of forest ecosystem services.

The majority of Butte County production timber lands are not included. This excludes areas east of Concow through Feather Falls to the south. Biomass located to the east up the Hwy 70 corridor must be moved a great distance outside the BMZ as defined, so the BMZ excludes lands within the Plumas National Forest. The access road to Feather Falls and the middle fork of the Feather River is narrow, winding and slow for many miles from Hwy 162 east. Long-distance transport increases biomass cost, and increases traffic on rural roads. Biomass in remote areas is best treated, if possible, close to where it is collected. Such localized treatment systems have recently been proposed by Placer County[38] in a study that emphasizes creating a number of small scale, distributed biomass power facilities, and by TSS (2010) for nearby areas in Yuba County. These analyses are relevant to higher elevation, more distant locations adjacent to the current BMZ as well.

Previously, the CBC has provided gross and technical estimates of available biomass on a county-level basis. The 2007 resource assessment included a base-year estimate and then forecast for future years. Table 10 includes the county level estimates for the six counties included in the BMZ for 2007. It also includes the percent of land area of each county in the BMZ, but biomass estimates in bone dry tons s (BDT) have not been reduced to correspond to the smaller area of the BMZ. These larger biomass estimates represent additional feedstocks that might become available if costs and technology options change to favor larger, centralized facilities.

[38] Placer County Air Pollution Control District: Opening Comments to October 13, 2011 Renewable Feed in Tariff staff proposal. Rule Making 1105-005, May 5, 2011.

**Table 10: Previous CBC Estimates (2007) of Technically Available Biomass by Location within the BMZ in Annual Bone Dry Tons (BDT)** [39]

| | Butte | Colusa | Glenn | Plumas | Sutter | Yuba |
|---|---|---|---|---|---|---|
| Percent of BMZ | 61.1% | 17.1% | 11.8% | 5.8% | 3.1% | 1.1% |
| Biosolids Diverted, BDT | 0 | 0 | 400 | 200 | 1,200 | 900 |
| Total MSW Biomass Landfilled, BDT | 41,085 | 4,760 | 4,590 | 4,850 | 13,785 | 13,785 |
| Total Animal Manure, BDT | 6,100 | 4,900 | 31,500 | 4,000 | 4,000 | 11,500 |
| *Total Cattle Manure, BDT* | *5,900* | *4,900* | *31,400* | *4,000* | *3,900* | *11,500* |
| *Dairy Manure, BDT* | *500* | *0* | *18,200* | *0* | *600* | *3,300* |
| Total Orchard and Vine, BDT | 47,700 | 22,400 | 31,000 | 0 | 32,060 | 17,090 |
| Total Field and Seed, BDT | 168,490 | 244,000 | 151,440 | 0 | 174,200 | 54,810 |
| Total Vegetable, BDT | 10 | 1,210 | 0 | 0 | 640 | 0 |
| Total Food Processing, BDT | 26,580 | 12,350 | 7,930 | 0 | 9,560 | 5,990 |
| Total Forestry, BDT | 294,500 | 58,300 | 60,400 | 666,800 | 0 | 123,600 |

- *BDT values represent the estimate for the entire county. BDT estimates adjusted for BMZ percentage are presented in Figure 9.*
- *Cattle manure and dairy manure are subsets of total animal manure and should not be summed in a total biomass tonnage estimate.*

The resulting BMZ biomass estimates based on the percent of acreage from each county within the BMZ (percent of county in BMZ x county acres, summed for all acres) are presented in Figure 9. The agricultural (largely rice producing) areas are in the southwestern portion of the BMZ include the largest single amount of material. The forest and WUI area resources are in the east and to the north. For Butte, Colusa, and Glenn counties, the field and seed biomass resource is 90 percent of the county agriculture acreage for those three counties rather than the BMZ acreage distribution. The land cover and urban areas are presented in Figure 10. The total county land use acreage described in Table 4 has been adjusted by the percent of land area within the BMZ by land cover in Table 11. The distribution of agricultural, forestry, and herbaceous shrub land cover for the 1.3 million acre BMZ described in the last rows of Table 11 are presented in Figure 11.

[39] Data adapted from the California Biomass Collaborative 2007 Resource Assessment (Williams, et. al, 2008) - http://biomass.ucdavis.edu/reports/

**Figure 9: Summary of Biomass Amounts (BDT) within the BMZ by Type**

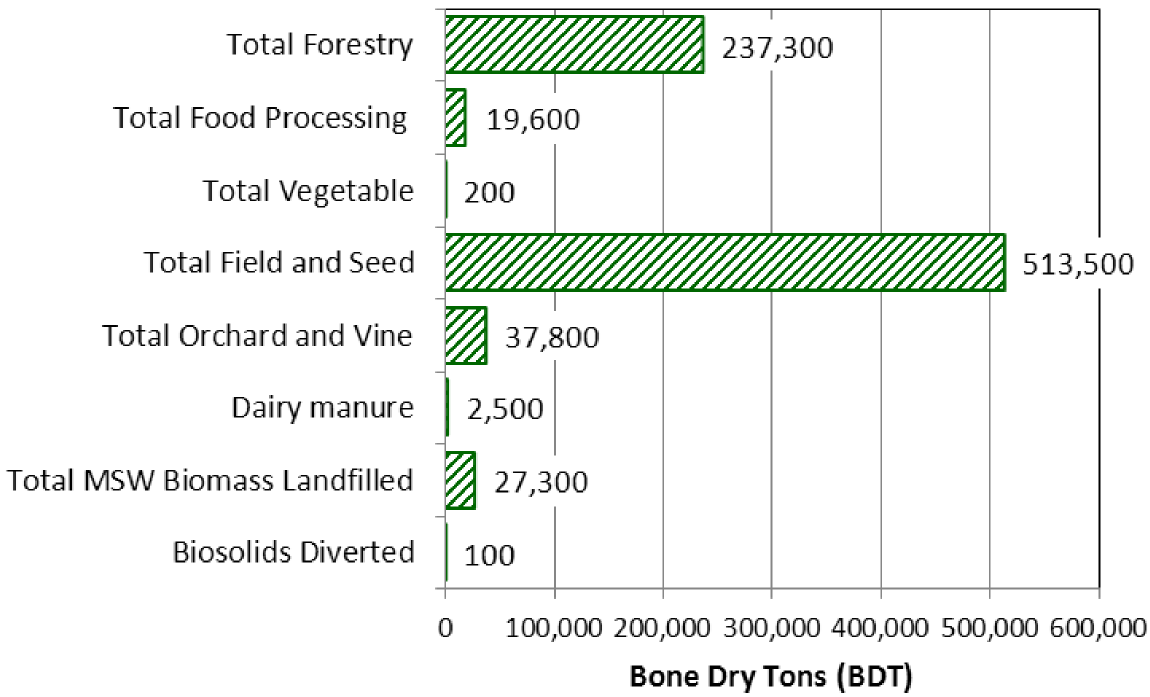


**Figure 10: Oroville BMZ map with Land Cover**

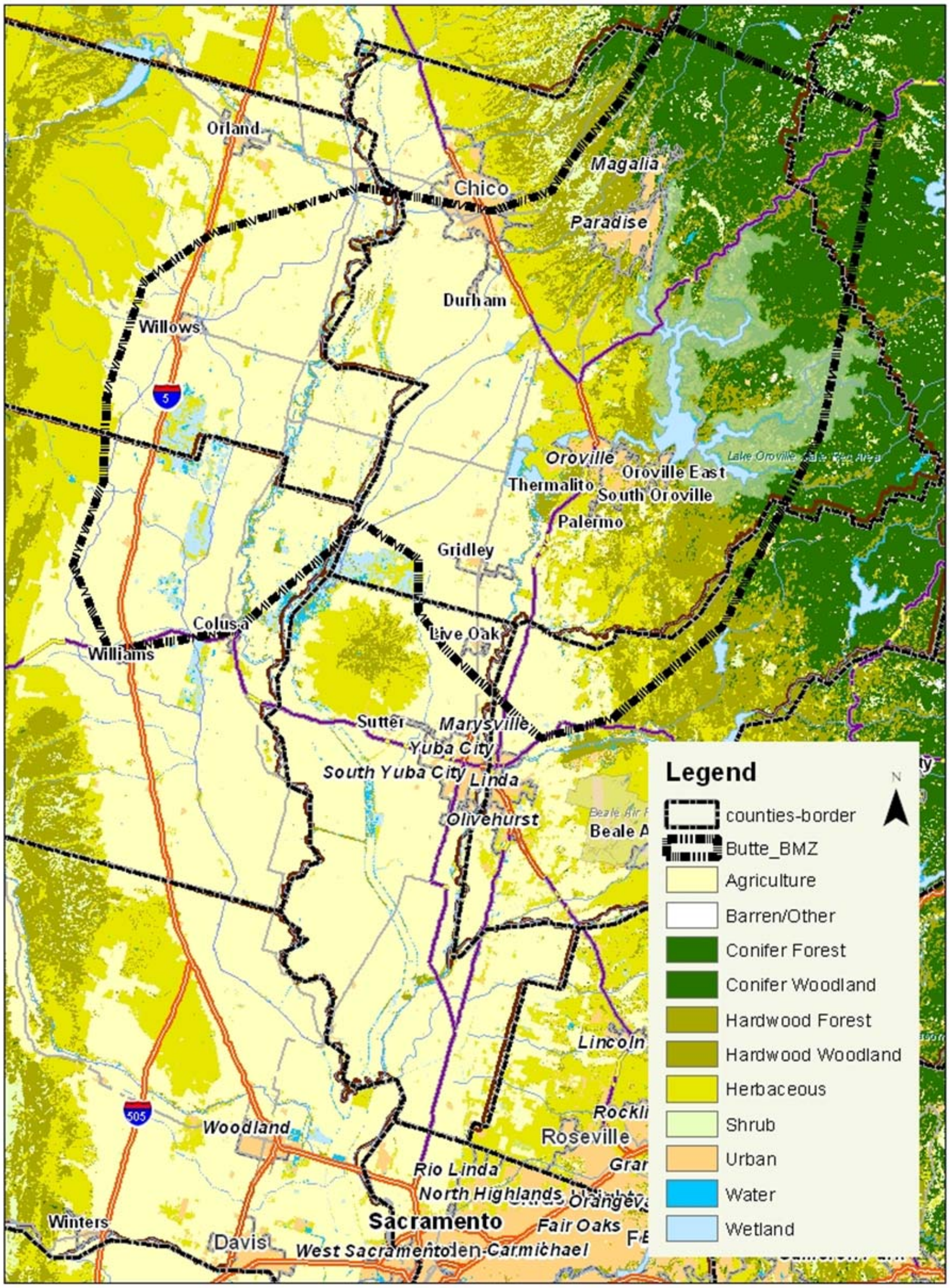
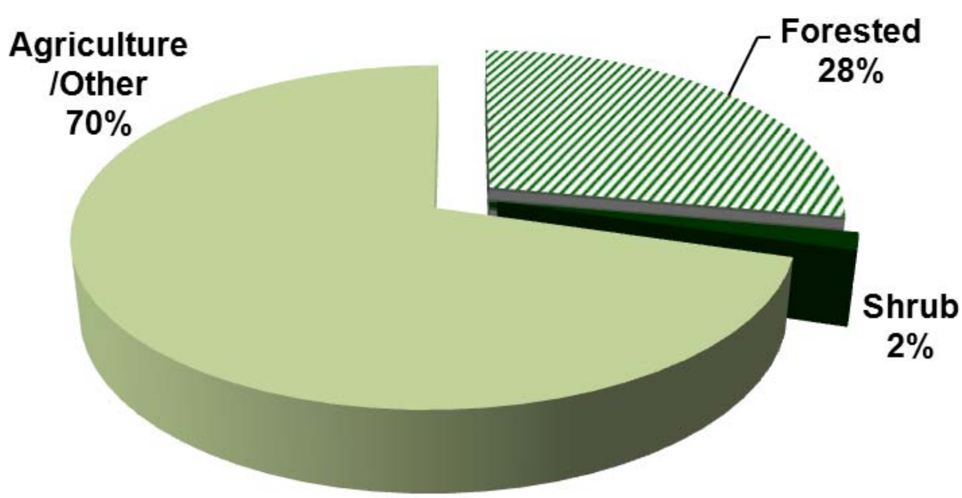


**Table 11: Oroville BMZ Acreage by Biomass Source** [40]

| County | Acres | % of BMZ | Forested | Shrub | Agricultural /Other |
|---|---|---|---|---|---|
| Butte | 797,517 | 61.1% | 303,045 | 19,075 | 475,397 |
| Glenn | 222,624 | 17.1% | 1,840 | 0 | 220,783 |
| Colusa | 154,346 | 11.8% | 0 | 0 | 154,346 |
| *3 main counties* | *1,174,487* | *90.0%* | | | |
| Yuba | 76,157 | 5.8% | 22,471 | 250 | 53,436 |
| Plumas | 40,067 | 3.1% | 36,536 | 2,700 | 831 |
| Sutter | 14,942 | 1.1% | 0 | 0 | 헬 4,949 |
| *3 other counties* | *131,166* | *10.0%* | | | |
| **Total, acres** | **1,305,653** | | **363,892** | **22,025** | **919,742** |
| Total, percent | | | 27.9% | 1.7% | 70.4% |

**Figure 11: Current Distribution of Land Cover in Oroville BMZ**




## 2.2 Woody Biomass

Woody biomass includes the by-product of commercial wood harvest, forest restoration, and fuel reduction activities in forests and other wildlands, trimming or removal of orchards and

40 Data adapted from California's Forests and Rangelands: 2010 Assessment (CALFIRE) http://frap.cdf.ca.gov/

urban trees or wood diverted from municipal solid waste streams. This broad definition emphasizes total supply regardless of source or ownership patterns. Doing so identifies the BMZ's biomass energy potential comprehensively. Limitations on access to this biomass are discussed subsequently.

Some feedstocks are readily accessible, others are not. More accessible feedstocks include timber product residuals, orchard prunings and tree removals, and urban construction and demolition wastes. Less accessible, or as yet underdeveloped feedstocks include biomass from vegetation management for fuel load reduction (especially from public lands), post Material Recovery Facility (MRF) organic fractions of municipal solid waste (MSW), and some food processing industry wastes that are currently underutilized or used for alternative purposes.

### 2.2.1 Fire Threat and the Wildfire Urban Interface (WUI)

The threat of wildfire is an issue that arises annually in rural, forested communities around the state. This threat is due to the natural occurrence of fire in Mediterranean climates with a long dry summer, a growing population that is moving deeper into the forest wildlands, and a century of fire suppression that has increased the quantity or loading of woody biomass in California's forests. To classify the potential risk of wildfire in California, the Fire and Resource Assessment Program (FRAP) of CAL FIRE (2010a & 2010b) has performed analysis to assess and classify the potential risk to human life and property for lands around the state. In addition this assessment has estimated working timber lands that are also at risk of fire that could change the function of these lands for future use and management, and the loss of important ecological values. Combined analysis has classified approximately 95 percent of the 364,000 acres of forestland as high priority and in need of resource protection or management.

The wildland-urban interface (WUI) is defined as the geographical intersection of two distinct ecosystems, undeveloped wildlands and areas of human development. This interface aligns structures and native vegetation with the potential for fire to spread from vegetation to structures, or from structures to vegetation. A structural fire could ignite vegetation. In the Butte BMZ approximately half of the forested area is classified as WUI by CAL FIRE. Active fire suppression over that last century has altered fuel loads and increased the potential for environmental degradation after high intensity fires pass through. Roads are a particular pathway for the spread of fire in a WUI. It is estimated that 13-15 BDT/acre could be generated along many road corridors and rights-of-ways in the state's forested areas [41].

Climate change predictions suggest that wildfire losses will increase (Bryant and Westerling, 2009, Westerling et al., 2009). Aside from accounting for the costs of wildfire suppression, estimating accurately all the costs of diverse ecosystem functions lost from uncontrolled wildfires is difficult. Nonetheless, fuel load reduction in at-risk forests is regarded as a means of minimizing costly and ecologically harmful consequences of intense wildfires[42]. This was the

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[41] Steve Brink. Personal communication, 2011

[42] USFS Southwest Research Station. 2009. Biomass to Energy: Forest management for Wildfire Reduction, Energy Production and Other Benefits. California Energy Commission, PIER program. CEC-500-2009-080. http://www.energy.ca.gov/2009publications/CEC-500-2009-080/index.html

conclusion of a post-fire analysis conducted following the massive Antelope Complex, Wheeler Fire in 2006 (Fites, et al., 2007) adjacent to this BMZ. The analysis reported that areas that had received fuel load reduction treatments reduced fire behavior and tree and soil impacts compared to untreated areas. It was recommended to treat larger areas to prevent fire escalation and significant alteration of ecosystem values. The report also recommended more widespread fuel load reduction treatments in similar forests, including in protected areas, to preserve the most important ecological values of such areas.

### 2.2.2 Current Residue Management and Air Quality

Current practices of onsite forest biomass management include open pile burning which emits particulate air pollution, costs money to implement and captures none of the stored energy of those resources. Recent research has shown substantial reductions in criteria pollutant (PM-10, $NO_x$, CO and VOCs) emissions when forest biomass is transported to a biomass conversion facility compared to open pile burning (Placer County APCD). This same study estimates about 0.5 tons of $CO_2e$ reduction for biomass to energy compared to open pile burning. In addition, fires release large amounts of particulates and other pollutants that are harmful to health. Springsteen et al., 2011 (Table 5), report that compared to conversion in a biomass to energy facility, open pile burning increases $NO_x$ by 54 percent, particulates by 96 percent, NMOC by 99 percent, CO by 97 percent, and $CH_4$ by 96 percent. Fig. 2.7 show the city of Los Angeles covered by smoke from the 2003 Old Grand Prix fires.

**Figure 12: Old Grand Prix Fire (2003).**

Smoke covers the Los Angeles Basin.
Health effects from this fire were estimated by Phularia et al., 2005.

### 2.2.3 Recent Research About Fuel Management

Recent research has focused on the effectiveness of fuels treatment in reducing the impacts of wildfire and on Life Cycle Analysis (LCA) for utilization of forest biomass. LCA is used to estimate the amount of greenhouse gases (GHG) released into the atmosphere from the harvesting of biomass and subsequent energy production.

As discussed, a number of recent research papers agree that fuel treatment effectiveness will reduce wildfire intensity and contribute to sustainable ecosystems (North et al., 2009; Hurteau et al., 2009; Safford et al., 2009; Fites et al., 2007). This body of work supports the need for management to reduce wildfire effects; that ladder fuels (forest understory) need to be reduced; that surface fuels need to be minimized; and that some intermediate size tree removal can reduce the risk of crown fire. There is also agreement that mechanical treatments followed by the use of prescribed fire will result in forested ecosystems better adapted to fire (Fig. 2.7). However, no single fuel treatment prescription works for all forest stand conditions. Professional judgment is needed to set standards that will reduce wildfire effects yet maintain a landscape that provides sustainable water quality and wildlife habitat. Forest and wildland fuel management have the primary goals of minimizing threats to human life and property, promoting healthy and resilient ecosystems and reducing suppression costs (Collins et al, 2011). Finney et al (2007) suggested that by managing and maintaining 20 percent of the landscape with strategically planned treatment, an optimal level fire size and intensity reduction could be achieved. They suggested this goal could be met by carrying out fuel load reduction on approximately 2 percent of the area per year.[43]

Life Cycle Analysis, or GHG effects of fuels treatment projects, are still uncertain about what criteria and metrics should be considered for analysis. Criteria for boundary conditions, the scale of project, and the time horizon for evaluating forest biomass use must be included and identified. One report of a project-scale assessment for northeastern USA forests asserted that a significant period of time must pass before any climate benefits accrue from fuels treatment projects (Manomet Center, 2010). However, a comprehensive review of forest biomass use for the California Energy Commission identified significant potential GHG savings and climate benefits (CEC, 2010). The Biomass to Energy Report [CEC-500-2009-080] includes careful estimates of life cycle climate change benefits for a 2.7 million acre study, including a 65 percent net reduction in greenhouse gas emissions (from 17 million tons of carbon dioxide ($CO_2$) equivalents to 5.9 million tons of $CO_2$ equivalents) and a 22 percent reduction in the number of acres burned by wildfires compared to a business as usual case.[44]

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[43] Finney, et al., (2007) calculate a statewide average rate of treatment to reduce fire losses. This would represent treating between 120,000-130,000 statewide acres per year for the 32 million acres of forestland in California (32 total million acres of forest x targeted 0.20 of area treated x 0.02 annual treatment = 128,000 acres). This formula is meant to apply to watershed level assessments. Removal of fuels from WUI for protection of rural communities and structures may require a larger percentage of removal, especially where problems are severe.

[44] Some LCA's fail to account for all wood product uses and varying levels of management. An overview of woody biomass utilization opportunities is found at the USFS Forest Products Laboratory website at http://www.fpl.fs.fed.us/research/research_emphasis_areas/introduction.php?rea_id=5.

**Figure 13: Reduction in Wildfire Damage because of Fuel Treatment**


Untreated forest is on the left, and treated forest on the right.
Hurteau and North (2009/M. North photo

## 2.2.4 The USDA, FSA-Administered BCAP Program

The Biomass Crop Assistance Program (BCAP) has been used since 2009 to support the cost of biomass fuel acquisition for many of the state's biomass to power facilities.[45] This program is administered by the USDA Farm Service Agency (FSA) and supports/offsets some costs of using biomass in local bioenergy facilities. Payments for woody biomass in diverse counties in California are reported in Table 12. In 2010, California received BCAP payments of $31.4 million for 1 million tons of biomass affected. Butte County received nearly $5 million in 2010 for 157,600 tons of biomass, which is 15 percent of the program-supported biomass within the state. Within the six BMZ counties, 183,000 tons of biomass were supported with payments in 2010 through this program. This is only an additional 2.4 percent of the total 2010 California BCAP-supported biomass. In 2011, *Camelina sativa* was added to the list of supportable forms of biomass, in this instance for alternative jet fuel manufacture. No Camelina was produced within the BMZ. It is unclear how long BCAP funds will continue to be available.

[45] http://www.fsa.usda.gov/FSA/webapp?area=home&subject=ener&topic=bcap

**Table 12: USDA-BCAP Funds Paid in 2009 and 2010 with Tonnage Estimates**

| County | 2009 Payments | Estimated Tons | 2010 Payments | Estimated Tons |
|---|---|---|---|---|
| Shasta | $1,735,477 | 57,849 | $9,787,505 | 326,250 |
| **Butte** | **$3,563,599** | **118,786** | **$4,727,370** | **157,579** |
| Kern | $570,043 | 19,001 | $2,800,750 | 93,358 |
| Siskiyou | $5,657 | 189 | $2,674,085 | 89,136 |
| San Joaquin | $1,405,669 | 46,856 | $2,039,558 | 67,985 |
| Humboldt | $127,175 | 4,239 | $1,811,955 | 60,399 |
| Tuolumne | | | $1,507,961 | 50,265 |
| Fresno | $1,650,460 | 55,015 | $1,485,994 | 49,533 |
| Tulare | $101,802 | 3,393 | $1,110,000 | 37,000 |
| Mendocino | | | $526,200 | 17,540 |
| Placer | | | $475,650 | 15,855 |
| Stanislaus | $188,318 | 6,277 | $405,620 | 13,521 |
| **Plumas** | **$403,202** | **13,440** | **$402,310** | **13,510** |
| **Sutter** | **$0** | **0** | **$336,000** | **11,200** |
| Yolo | $119,961 | 3,999 | $333,920 | 11,131 |
| Lassen | | | $280,000 | 9,333 |
| Ventura | | | $252,000 | 8,400 |
| Sonoma | | | $172,000 | 5,733 |
| Merced | $81,704 | 2,723 | $111,000 | 3,700 |
| Sierra | | | $76,500 | 2,550 |
| Madera | | | $28,800 | 960 |
| **Glenn** | **$12,207** | **407** | **$17,600** | **587** |
| San Mateo | | | $15,573 | 519 |
| Contra Costa | | | $6,000 | 200 |
| **Colusa** | **$105,850** | **3,528** | **$0** | **0** |
| **Yuba** | **$0** | **0** | **$0** | **0** |
| **Totals** | **$10,071,124** | **335,702** | **$31,384,351** | **1,046,244** |

Yellow-shaded rows represent counties that are included in the BMZ
Source: USDA-FSA, 2011

## 2.2.5 Treatment Approaches and Physical and Administrative Filters

### *2.2.5.1 Residuals from Production Forestry*

The eastern portion of the BMZ and areas farther east are productive public and industrial forestlands. This area has a long history of timber harvest and timber products industry. Although much of the productive forestland of Butte and Plumas Counties were intentionally excluding from the BMZ to reduce excessive haul distances. There is still a considerable area classified as forest with the majority being privately owned with the potential for harvest. Figure 14 illustrates a 25 year trend of forestry production for Butte County. This figure shows that the harvests of public forest are declining. And while this figure indicates that there is a mean annual harvest of a significant amount, the private forest harvests appear to be declining also. Table 13 shows the average harvest and potential stream of biomass from timber harvest residues. These materials are the tops and branches left on the ground at harvest where only the logs typically are removed. This Butte County timber harvest data was adapted from California timber yield tax records from the California board of equalization (Spero, 2011). Table 13 includes the commercial value of processed lumber on the left-hand side and the volume of residues, remaining on the ground after harvest, on the right-hand side.

**Figure 14: Butte County Private and Public Timber Harvest in Thousand Board Feet (MBF), 1984 - 2009**

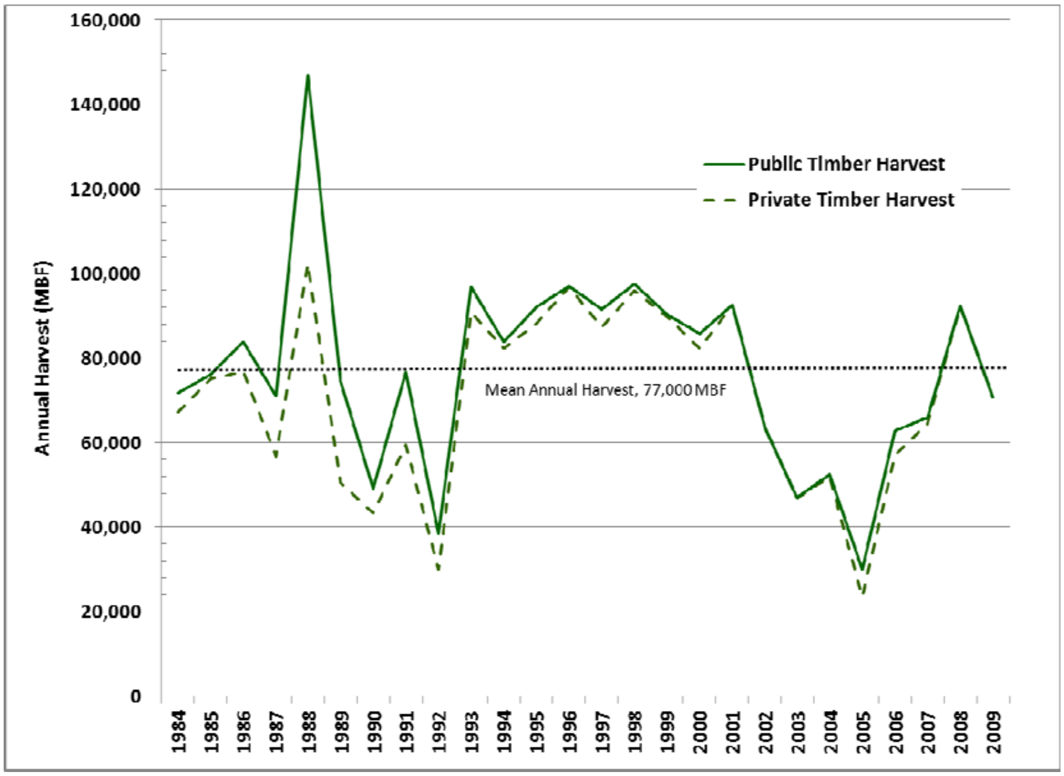


**Table 13: Average Timber Harvest Residuals for Butte County**

| | Timber Harvest Data 1984-2009 Thousand Board Feet(MBF/Year) | | | Timber Harvest Residuals - 25 year avg. (BDT/Year) | | | Potential MW |
|---|---|---|---|---|---|---|---|
| **Source** | **Average** | **Max** | **Min** | **Gross*** | **Technical**** | **, and combin** | |
| Private | 70,000 | 102,000 | 23,000 | 57,000 | 36,900 | 29,000 | 5.4 |
| Public | 6,800 | 44,000 | 0 | 5,500 | 36,000 | 2,900 | 0.4 |
| Total | 77,000 | 142,000 | 30,000 | 62,000 | 40,000 | 32,000 | 6.0 |

*All values rounded to the nearest hundred BDT. Calculations based on the following assumptions:*

* *Gross biomass – 1 MBF = 0.9 BDT biomass. Harvest levels will be 90 percent of the 25 year average.*

** *Technically Available Biomass - An estimate of 65 percent recovery was used due to limitations associated with steep slopes and potential transport distances.*

*** *Economically Available Biomass – A factor of 80 percent was used to account for constraints in road networks that do not permit chip vans and are not economically renovated to allow chip transport.*

Land management for the production of timber or thinning for biomass generation generally occurs on lower angle slopes (0-45percent) that facilitate the access and use of ground based harvesting equipment. On steeper slopes (greater than 45percent) highline or helicopter logging is employed with limitations of cost or concern of accelerated erosion. Across all slope classes areas classified as Stream Management Zones (SMZ) are restricted to management but often have high biomass loadings or complicated operations on the ground. At present, the majority of forest biomass is generated from activities on private lands associated with timber harvest and fuel management, depending on the price of timber and biomass as fuel, with little biomass coming from public lands.

Efforts by CAL FIRE to characterize the WUI across the landscape and prioritize locations where resource assets (roads, structures or power lines) reside, juxtaposed with estimates of degree of risk of wildfire loss, provide a basis for identifying locations that would benefit most from fuel load reduction treatments. These areas are classified as "Priority Landscapes." Much of the forested area within the BMZ qualifies as priority landscape. This classification includes all forms of ownership categories, from public to private. Successively more restrictive limits on forest biomass removal and use are discussed below.

#### *2.2.5.2 Forestlands*

Land classified as forest accounts for 28 percent (approximately 364,000 acres) of the BMZ.[46] Table 14 shows this total forested area subdivided by ownership based on common physical (slope classes), administrative (SMZ), or social/biophysical (WUI and Priority Landscape) metrics. In addition to the public lands of US Forest Service (USFS) and the State of California, other public land owners include the Bureau of Land Management and US Fish and Wildlife Service. These help understand access and restrictions currently in place across this landscape.

**Table 14: Land Classification by Acres within the BMZ Area**

| | Total | Slope class (%) | | | | SMZ* | | WUI** | | Priority** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Owner** | **Acres** | **0-30** | **30-45** | **0-45** | **> 45** | **Stream** | **Lake** | **In** | **Out** | **In** | **Out** |
| Private | 253,453 | 197,249 | 38,934 | 236,183 | 17,270 | 29,798 | 1,292 | 153,818 | 99,635 | 244,797 | 8,656 |
| USFS | 97,761 | 48,921 | 22,713 | 71,634 | 26,126 | 10,086 | 81 | 24,137 | 73,624 | 92,083 | search |
| Other | 9,854 | 5,928 | 2,476 | 8,404 | 1,450 | 1,379 | 403 | 6,148 | 3,706 | 8,416 | 1,438 |
| State | 2,827 | 1,774 | 516 | 2,290 | 536 | 289 | 267 | 1,843 | 983 | 2,350 | 477 |
| Total Acres | 363,895 | 253,873 | 64,639 | 318,512 | 45,383 | 41,552 | 2,043 | 185,946 | 177,949 | 347,646 | 16,249 |
| Total % | 100 | 69.8 | 17.8 | 87.6 | 12.5 | 11.4 | << 1 | 48.4 | 51.6 | 95.5 | 4.5 |

Stream Management Zone, ** Wildland-Urban Interface, *** Priority landscapes
Yellow shaded columns represent a subset of the 0-45% slope column

[46] All forest biomass estimates are calculated from data published in the CAL FIRE Forest and Range Assessment Program report (CAL FIRE, 2010a).

The majority of forestland (70 percent) is found in the 0-30 percent slope class, but some commercial forestry operations will utilize land up to 45 percent slope. The larger slope class includes up to 88 percent of forestland in the BMZ. Management is generally restricted on slopes greater than 45 percent due to concerns about soil erosion from disturbance and higher operating costs to remove logs (highline cable or helicopter logging).

In Table 15 acres are converted to tons of biomass. The land class with slopes less than 45 percent generates 84 percent (19,635,000 bone dry tons) of total forest biomass.

**Table 15: BMZ Gross Biomass (thousand BDT)**

| | Total | Slope class (%) | | | | SMZ* | | WUI** | | Priority** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Owner** | **BDT** | **0-30** | **30-45** | **0-45** | **> 45** | **Stream** | **Lake** | **In** | **Out** | **In** | **Out** |
| Private | 13,139 | 9,817 | 2,234 | 12,051 | 1,078 | 1,537 | 63 | 7,321 | 5,807 | 12,731 | 397 |
| USFS | 9,511 | 4,839 | 2,243 | 7,082 | 2,429 | 999 | 9 | 2,257 | 7,254 | 9,091 | 420 |
| Other | 486 | 288 | 122 | 410 | 76 | 65 | 17 | 313 | 172 | 421 | 64 |
| State | 127 | 68 | 25 | 93 | 34 | 12 | 17 | 75 | 52 | 104 | 23 |
| Total BDT | 23,252 | 15,012 | 4,623 | 19,635 | 3,617 | 2,612 | 106 | 9,966 | 13,286 | 22,348 | 904 |
| Total % | 100 | 64.5 | **19.8** | 84.3 | 15.6 | 11.2 | <<1 | 42.9 | 57.1 | 96.1 | 3.9 |

Yellow-shaded columns represent a subset of the 0-45% slope column

The removal of lands classified as stream management zones (SMZ) results in a modest reduction of potential management areas in the 0-45 percent slope class (12 percent reduction). Although any scenario proposing the harvest of most or all available forest biomass is impractical, employing the gross total or gross *non-merchantable biomass* pools allows baseline estimates of potential biomass supplies to be developed.[47] . In practice, many considerations will limit total amounts of forest biomass actually used for energy. Lumber products are a more valuable use of suitably sized trees.

Table 15 shows the total standing tree biomass with Table 16 showing tons of biomass in the non-merchantable class, which is a subset of the total. Table 17 converts these biomass pools into energy capacity potentials (MW) based on conversion factors and calculations used in the 2007 Biomass Assessment of California (Williams, et al., 2008). Potential energy capacity from non-merchantable biomass equals 3,664 MW of potential power generation capacity (Table 17). For example if 1 percent of the total forested area was treated annually (approximately 3,600 acres), 17 MW of energy potential could be harvested as non-merchantable biomass and 43 MW could be harvested from the total biomass pool (FRAP, 2010).[48]

[47] Non-merchantable biomass is defined as standing trees with smaller than 8 inch diameter trunks at breast height and non-commercial hard wood species.

[48] These capacity values show up in the second-to-last row of Table 2.14 as 4,341 MW and 1,692 MW for total biomass and non-merchantable biomass totals, respectively (1 percent).

**Table 16: Non-Merchantable Biomass (thousand BDT)**

| | Total | Slope class (%) | | | | SMZ* | | WUI** | | Priority** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Owner** | **BDT** | **0-30** | **30-45** | **0-45** | **> 45** | **Stream** | **Lake** | **In** | **Out** | **In** | **Out** |
| Private | 5,583 | 4,194 | 938 | 5,132 | 452 | 663 | 28 | 3,286 | 2,297 | 5,409 | 174 |
| USFS | 3,219 | 1,583 | 763 | 2,346 | 872 | 341 | 3 | 799 | 2,420 | 3,073 | 146 |
| Other | 215 | 127 | 54 | 181 | 34 | 29 | 8 | 140 | 76 | 186 | 29 |
| State | 57 | 32 | 11 | 43 | 15 | 5 | 7 | 35 | 23 | 47 | 10 |
| Total BDT | 9,075 | 5,936 | 1,767 | 7,703 | 1,373 | 1,039 | 46 | 4,216 | 4,259 | 37 | 360 |

Yellow-shaded columns represent a subset of the 0-45% slope column

**Table 17: Power Production (MW) from All Forestland Acres (Total MW) and from Non-Merchantable Acres (NM MW) for Various Slope Classes in the BMZ**

| | | | 0-30% Slope | | 30-45% Slope | | 0-45% Slope | | > 45% Slope | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Owner** | **Total MW** | **NM MW** | **Total MW** | **NM MW** | **Total MW** | **NM MW** | **Total MW** | **NM MW** | **Total MW** | **NM MW** |
| Private | 2,452 | 1,041 | 1,831 | 782 | 417 | 175 | 2,248 | 957 | 201 | 84 |
| USFS | 1,774 | 600 | 903 | 295 | 418 | 142 | 1,321 | 437 | 453 | 163 |
| Other | 91 | 40 | 54 | 24 | 23 | 10 | 77 | 34 | 14 | 6 |
| State | 24 | 11 | 13 | 6 | 5 | 2 | 18 | 8 | 6 | 3 |
| Total, MW | 4,341 | 1,692 | 2,801 | 1,107 | 863 | 329 | **3,664** | 1,436 | 674 | 256 |
| Total, % | 100 | 39.0 | | | | | | | | |

Yellow-shaded columns represent a subset of the 0-45% slope column

### *2.2.5.3 Estimates of Annual Woody Biomass Harvest from Forest Fuel Treatment*

To estimate annual supply of forest biomass based on forest standing stocks, an average yield of 13.5 BDT/acre is assumed.[49] This factor is somewhat more conservative than a value of 15 BDT/acre at 90 percent collection efficiency from the Yuba Foothills Biomass Feasibility Study discussed below (TSS Consultants, 2010). A range of treatment rates is possible, from very aggressive (15 years to treat the entire forest) through more moderate goals (100 years to treat the entire forest). Three basic scenarios and three area classifications were chosen here. In all

49 Steve Brink, the California Forestry Association, personal communication.

cases ownership is not regarded as a constraint. Currently, intensity of management varies based on ownership with limited management on public lands, intermediate on some state forests, and most biomass being supplied from private, industrial forest lands.

Ecologically, fire does not respect property boundaries so at one level, a comprehensive analysis of fuel within a BMZ must start with absolute amounts. Using only physical landscape constraints, three possible management scenarios include:

- No constraints on potential management (no physical, administrative or social/biophysical limitations)
- Management on lands 0-30 percent slope with SMZ's removed.
- Management on lands 0-45 percent slope with SMZ's removed.

The three areas classifications include:

- The total forested area in the BMZ
- Lands classified as WUI
- Lands outside the WUI.

The largest category are CALFIRE's designated priority landscapes, which include 95 percent of the forest area classified as moderate to severe threat of damage by wildfire or other disturbance (Table 14). Paradise Ridge, Concow, and areas around Lake Oroville have had or have been threatened recently by wildfire. These locations are identified as priority areas because population growth continues.

Table 18 outlines treatment estimates for the entire landscape using the three management scenarios. At the most aggressive levels of management, 24,000 acres might be treated annually supplying as much as 1,000 BDT/day for energy conversion (assuming 330 days of operation). Utilizing the most efficient cogeneration technology available, this would support 44 MW of conversion capacity (Birdsall, et al., in preparation). Currently in the BMZ, this large amount of biomass could not be harvested and concentrated due to a lack of both industrial infrastructure and skilled labor. With the closure of many older timber mills, new facilities would be needed and additional trained forest workers. In addition, public opposition to high rates of f biomass removal likely would occur. More modestly, fuel management treatments located strategically across approximately 20 percent of the landscape over accomplished over a fifty year period have been recommended to reduce wild fire severity, the risk of ecosystem loss to catastrophic wildfire (Nechodom, et al., 2008). Acceptable fire threat reduction and prevention could be achieved at a rate of approximately 2 percent per year (Kinney, et al., 2002), accounting for both treatment of new lands and the maintenance of already treated areas. At this level of management, 2 percent of the land area (4,300 – 7,200 acres/year) could be treated annually depending on the treatment scenario employed, generating between approximately 58,000 and 100,000 BDT/year.

#### *2.2.5.4 Wildland-Urban Interface*

The Wildland-Urban Interface (WUI) is a portion of the landscape that poses a great risk to life and damage to property from wildfire, and should receive the highest priority for directed fuel management. The analysis in Table 19 focuses on the areas classified as WUI, projecting area treated and the annual supply of biomass across a range of treatment targets (area/year). Table 20 shows the same analysis for areas classified as outside the WUI.

**Table 18: Treatment Scenarios: Areas Treated (acres) and Annual Biomass (BDT/year)**

| Total Forested Area (363,895 acres) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Complete | Area | No Constraint | | 0-30% slopes with SMZ | | 0-45% slopes with SMZ | |
| Treatment (years) | Treated (%) | Acres Treated/yr | Potential BDT/yr | Acres Treated/yr | Potential BDT/yr | Acres Treated/yr | Potential BDT/yr |
| 15 | 6.6 | 24,017 | 324,230 | 14,347 | 193,692 | 18,287 | 246,881 |
| 20 | 5.0 | 18,195 | 245,629 | 10,869 | 146,737 | 13,854 | 187,031 |
| 25 | 4.0 | 14,556 | 196,503 | 8,695 | 117,389 | 11,083 | 149,624 |
| 30 | 3.3 | 12,008 | 162,115 | 7,174 | 96,846 | 9,144 | 123,440 |
| 35 | 2.8 | 10,189 | 137,552 | 6,087 | 82,173 | 7,758 | 104,737 |
| 40 | 2.5 | 9,097 | 122,814 | 5,435 | 73,368 | 6,927 | 93,515 |
| 45 | 2.2 | 8,006 | 108,077 | 4,782 | 64,564 | 6,096 | 82,294 |
| **50** | **2.0** | **7,278** | **98,251** | **4,348** | **58,695** | **5,542** | **74,812** |
| 75 | 1.3 | 4,164 | 56,212 | 2,826 | 38,152 | 3,602 | 48,628 |
| 100 | 1.0 | 3,203 | 43,240 | 2,173 | 29347 | 2,771 | 37,406 |

Assumption of 13.5 BDT/acre fuel produced by fuel treatment
Yellow highlighting indicates example described in text

**Table 19: Wildland-Urban Interface (185,946 acres)**

| Years of complete treatment | Percent Area Treated | No Constraints | | 0-30 with SMZ | | 0-45 with SMZ | |
|---|---|---|---|---|---|---|---|
| | | Acres | Annual BDT | Acres | Annual BDT | Acres | Annual BDT |
| 15 | 6.6 | 12,272 | 165,678 | 8,076 | 109,033 | 9,773 | 131,937 |
| 20 | 5.0 | 9,297 | 125,513 | 6,229 | 82,601 | 7,404 | 99,952 |
| 25 | 4.0 | 7,438 | 100,410 | 4,895 | 66,080 | 5,923 | 79,962 |
| 30 | 3.3 | 6,136 | 82,839 | 4,038 | 54,516 | 4,886 | 65,968 |
| **35** | **2.8** | **5,206** | **70,287** | **3,426** | **46,256** | **4,146** | **55,973** |
| 40 | 2.5 | 4,649 | 62,757 | 3,059 | 41,300 | 3,702 | 49,976 |
| 45 | 2.2 | 4,091 | 55,226 | 2,692 | 36,344 | 3,258 | 43,979 |
| **50** | **2.0** | **3,719** | **50,205** | **2,447** | **33,040** | **2,961** | **39,981** |
| 75 | 1.3 | 2,417 | 32,633 | 1,591 | 21,476 | 1,952 | 25,987 |
| 100 | 1.0 | 1,859 | 25,103 | 1,224 | 16,520 | 1,481 | 19,990 |

Assumption of 13.5 BDT/acre fuel produced by fuel treatment
Yellow highlighting indicates example described in text

**Table 20: Out of Wildland-Urban Interface (177,949 acres)**

| Years of complete treatment | Percent Area Treated | No Constraints | | 0-30 with SMZ | | 0-45 with SMZ | |
|---|---|---|---|---|---|---|---|
| | | Acres | Annual BDT | Acres | Annual BDT | Acres | Annual BDT |
| 15 | 6.6 | 11,745 | 158,552 | 6,271 | 84,660 | 8,514 | 114,944 |
| 20 | 5.0 | 8,897 | 120,115 | 4,751 | 64,136 | 6,450 | 87,079 |
| 25 | 4.0 | 7,118 | 96,092 | 3,801 | 51,309 | 5,160 | 69,663 |
| 30 | 3.3 | 5,872 | 79,276 | 3,125 | 42,330 | 4,257 | 57,471 |
| 35 | 2.8 | 4,982 | 67,265 | 2,660 | 35,916 | 3,612 | 48,764 |
| 40 | 2.5 | 4,449 | 60,058 | 2,375 | 32,068 | 3,225 | 43,539 |
| 45 | 2.2 | 3,915 | 52,851 | 2,090 | 28,220 | 2,838 | 38,314 |
| **50** | **2.0** | **3,559** | **48,046** | **1,900** | **25,654** | **2,580** | **34,831** |
| 75 | 1.3 | 2,313 | 31,230 | 1,235 | 16,675 | 1,677 | 22,640 |
| 100 | 1.0 | 1,779 | 24,023 | 950 | 12,827 | 1,290 | 17,415 |

Yellow highlighting indicates example described in text

Data from each of these tables is used to estimate the energy potential of a prudent rate of biomass removal from the WUI areas (Table 19). This final assessment results from treating a cumulative annual level of 2.8 percent of the forested landscape (treating between 3,400-5,200 acres/year) and produces 46,000 – 70,000 DBT/year, for the No Constraints, 0-30 percent with SMZ, and 0-45 percent with SMZ treatments, respectively (Table 19). Over time this level would be reduced to 2 percent per year lowering annual biomass supplies to 33,000 – 50,000 BDT/year. Lands classified as outside the WUI would be treated at a rate of 2 percent per year (Table 20). This would treat between 1900 – 3500 acres/year, yielding 25,000 – 48,000 BDT/year (for the No Constraints, 0-30 percent with SMZ, and 0-45 percent with SMZ, respectively). Combined, between 4,300 – 8,700 acres producing 71,000 – 118,000 BDT/year of woody forest biomass could be accessed.

Energy potential (Megawatt equivalents - MW) were calculated for baseline, WUI – in and WUI – out cases in Table 21. All calculations are based on the approach used in the California Biomass Collaborative, 2007 biomass assessment (Williams, et al., 2008).

**Table 21: Potential MW from Fuel Reduction Treatment**

| Years of complete treatment | Percent Area Treated | No Constraints | | | 0-30 with SMZ | | | 0-45 with SMZ | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | All | WUI-in | WUI-out | All | WUI-in | WUI-out | All | WUI-in | WUI-out |
| 15 | 6.6 | 60.5 | 30.9 | 29.6 | 36.1 | 20.3 | 15.8 | 46.1 | 24.6 | 21.4 |
| 20 | 5.0 | 45.8 | 23.4 | 22.4 | 27.4 | 15.4 | 12.0 | 34.9 | 18.6 | 16.2 |
| 25 | 4.0 | 36.7 | 18.7 | 17.9 | 21.9 | 12.3 | 9.6 | 27.9 | 14.9 | 13.0 |
| 30 | 3.3 | 30.2 | 15.5 | 14.8 | 18.1 | 10.2 | 7.9 | 23.0 | 12.3 | 10.7 |
| 35 | 2.8 | 25.7 | 13.1 | 12.5 | 15.3 | 8.6 | 6.7 | 19.5 | 10.4 | 9.1 |
| 40 | 2.5 | 22.9 | 11.7 | 11.2 | 13.7 | 7.7 | 6.0 | 17.4 | 9.3 | 8.1 |
| 45 | 2.2 | 20.2 | 10.3 | 9.9 | 12.0 | 6.8 | 5.3 | 15.4 | 8.2 | 7.1 |
| 50 | 2.0 | 18.3 | 9.4 | 9.0 | 10.9 | 6.2 | 4.8 | 14.0 | 7.5 | 6.5 |
| 75 | 1.3 | 10.5 | 6.1 | 5.8 | 7.1 | 4.0 | 3.1 | 9.1 | 4.8 | 4.2 |
| 100 | 1.0 | 8.1 | 4.7 | 4.5 | 5.5 | 3.1 | 2.4 | 7.0 | 3.7 | 3.2 |

### *2.2.5.4 Treatment Costs*

The best cost estimates for fuel reduction treatments in the Southern Cascades are from Hartsough, et al., (1998 that show mechanical fuel treatments costs range from $1,400 to $2,600/acre (mean value: $2,100/acre). Depending on the quality and quantity of timber production that was extracted, the revenues ranged from $2,200 to $4,300/acre (mean value: $3,300/acre). This cost structure provides a net benefit of $800 to $1,700/acre (mean value: $1,200/acre) and estimates are based on plots where the majority (80 percent) of the biomass removed was logs, with the slash, small trees and other woody debris being used as chips. In practice, work accomplished by the USFS in the Sierra is resulting in the production of 5, 000 bd.ft of sawlogs per acre plus more than 13 dry tons of chips per acre (personal communication, Steve Brink Feb. 2012). Private land sawlog yield from fuels treatments may be smaller ( in the range of 2-4,000bdft/acre of sawlogs) but chippable material will be similar to the 13 dry tons per acre yield The value of this material will have significant variation because lumber and wood chip markets are volatile. In sum, there are market opportunities for forest biomass that will offset part or all of the cost for fuel hazard reduction treatments. The stronger the market for chips or fiber (v. dimension lumber), the more likely fuel hazard reduction treatments can become a self-supporting activity.

In another study that looked at mechanical removal with small track mounted equipment (Delsaux et al., 2009), the cost per acre was estimated as $450 - $3,000/acre, depending on local conditions. This study looked at a combination of small tree removal and mastication but could serve as a reasonable analog for fuel reduction treatments that would produce biomass fuel for renewable power. Current price estimates (2010) for biomass fuel range from approximately $37 to $54 per BDT. These estimates are similar to those reported by TSS Consultants (2010) more recently. Using these estimates, and a removal rate of 13.5 BDT/ac, $500- $730/acre could be generated to offset treatment costs.

#### *2.2.5.6 Mill Residues*

Mill residues provide a low cost stream of biomass fuel with most of the cost of production and transport being offset by the production of lumber and wood products. To estimate mill waste residuals from the landscape, two potential treatment scenarios that would produce mill waste are reported, both derived from FRAP data. These scenarios essentially represent business as usual, with more frequent return intervals and stand entries in private industrial forestlands and less frequent management and harvest on public forestlands. Table 22 provides the annual estimated quantities of mill waste residuals and MW they would support from the four land ownership categories.

**Table 22: Potential Mill Waste**

| County | Annual Mill waste 5-Year Average * | | Annual Mill Waste Commercial Thin ** | |
|---|---|---|---|---|
| | Tons/yr | MW | Tons/yr | MW |
| Private | 97,916 | 18.3 | 7,748 | 1.4 |
| USFS | 1,263 | 0.2 | 3,762 | 0.7 |
| Other | 7,664 | 1.4 | 219 | ~ 0 |
| State | 2,133 | 0.4 | 23 | ~ 0 |
| Total | 108,976 | 20.3 | 11,752 | 2.1 |

* *Historical data of annual mill waste from 5 year average harvest*

** *Total Annual Mill waste assuming additional biomass availability the periodic thinnings. One commercial thinning at 25 years on private or 67 years on USFS*

Actual mill waste production from the Sierra Pacific Industries Oroville mill is 225 BDT per day or 56,500 BDY/Y. This facility processes cedar trees with the residual bark and chips being a high valued landscape material most of which is sold to that market. With this in mind the economically available quantity is estimated at half the annual quantity reported in the Yuba county study (TSS Consultants, 2010).

#### *2.2.5.7 Urban Wood*

The generation of urban wood is split into two categories – wood wastes and tree trimmings - and dependent on population with rural areas producing small intermittent waste wood streams and metropolitan areas generating large consistent quantities. Urban wood waste is estimated based on a per capita solid waste generation rate of 11.5 lbs/day or about 2 tons/capita/yr. This 2-ton rate has been developed from observations both within California and regions across the country. Recoverable wood suitable for energy conversion is 10 percent of this gross waste stream. Losses incurred through handling and processing further subdivided the gross stream by the recovery factor of 65 percent leaving 130 lb/capita/yr. The production of urban wood from tree trimming and removal is estimated at 100 lb/capita/yr with the similar recovery factor of 65 percent or 65 lb/capita/year net wood recovery. Applying these rates to the population within the Oroville BMZ (270,000 residents) gives the annual urban wood production shown in Table 23. This area will generate 61,000 BDT/yr (gross) with 40,000 BDT/year available for conversion to energy. This quantity would support 7.5 MW annually.

**Table 23: Urban Wood Generation BDT/Y**

| County | Population | Urban Solids | | Urban Forestry | |
|---|---|---|---|---|---|
| | | Gross | Technical | Gross | Technical |
| Butte | 220,000 | 39,138 | 25,439 | 11,100 | 7,215 |
| Colusa | 21,419 | 3,776 | 2,454 | 1,071 | 696 |
| Glenn | 28,122 | 4,958 | 3,222 | 1,406 | 913 |
| Total | 268,531 | 47,872 | 31,116 | 13,577 | 8,825 |
| Total Urban Wood – 39,941 BDT/yr | | | Potential MW – 7.5 | | |

#### *2.2.5.8 Orchard Management and Removal*

The management and removal of orchards is a considerable source of woody biomass. There are 272,000 acres classified as orchard in parcels that range from small personal use parcels to large commercial fruit or nuts tracts (Price, 2011). Large acreage of plums, stone fruit, almonds and walnuts planted in the area generate considerable economic impact from crop sales. In this region the management of orchards represents a very large and consistent stream of biomass fuel. The commercial management of orchards has evolved over the last few decades shifting from large trees in broadly spaced orchards to the high-density orchards of small trees. This intensified management approach relies on frequent orchard removal and replanting to ensure vigorous growth and high levels of fruit and nut productivity.

Orchard turnover (removal) times vary by species from 15-30 years with approximately 10-25 BDT/acre woody biomass yield Table 24 shows orchard type, acres, removal rates and biomass yield for that Oroville BMZ area. Removal rates were calculated based on published turnover times (TSS Consultants, 2010) for the various orchard types in this area. Biomass from the removal and maintenance of orchards represents the largest annual source of biomass fuel approaching 280,000 BDT/yr.

**Table 24: Annual Orchard Removal and Pruning - BDT**

| Crop | Acres | Removal Acres/yr | Removal Gross | Trimming Gross | Removal Economic | Trimming Economic | Total | MW |
|---|---|---|---|---|---|---|---|---|
| Almonds | 108,212 | 4,328 | 108,212 | 2,164 | 102,801 | 1,082 | 103,883 | 19.4 |
| Walnuts | 82,641 | 3,305 | 82,641 | 1,652 | 78,509 | 826 | 79,335 | 14.8 |
| Prunes | 47,072 | 3,766 | 60,252 | 1,883 | 57,239 | 941 | 58,181 | 10.9 |
| Stone | 13,178 | 1,054 | 18,976 | 527 | 15,181 | 263 | 15,444 | 2.9 |
| Other | 18,976 | 1,488 | 26,781 | 744 | 21,425 | 372 | 21,797 | 4.1 |
| Total | 272,050 | 13,941 | 296,862 | 6,970 | 275,155 | 3,484 | 278,640 | 52.1 |

## 2.5.6 Summary Woody Biomass

The Oroville BMZ has plentiful woody biomass resources (Table 25). The current annual biomass yield, based solely on urban, orchard and timber harvest residuals, is 351,000 BDT/year supports a biomass power potential of 64 MW. By including biomass from fuels reduction (90,000 BDT/year) and biomass from sawmill residuals, (another 11,700 BDT/year) biomass supply increases by 101,700 BDT/year. Depending on the amount of fuel available, the total potential power production from these sources of biomass is estimated to be an additional capacity of 87 MW to 105 MW.

**Table 25: Woody Biomass Availability and Potential Power Production Summary**

| Biomass Fuel Type | Economical Availability (BDT/Y) Low range | High range | MW Low | MW High |
|---|---|---|---|---|
| **Timber Harvest Residuals** | 32,000 | 32,000 | 6 | 6 |
| **Orchard** | 279,000 | 279,000 | 52.1 | 52.1 |
| **Urban Wood** | 40,000 | 40,000 | 7.5 | 7.5 |
| ***Subtotal of Established Biomass*** | ***351,000*** | ***351,000*** | ***65.6*** | ***65.6*** |
| **Fuels Reduction*** | 90,000 | 90,000 | 18.8 | 18.8 |
| **Sawmill Residuals**** | 11,700 | 109,000 | 2.1 | 20.3 |
| **Total Biomass and Power** | **452,700** | **550,000** | **86.5** | **104.7** |

** Assumes scenario of treatment on lands 0-45% slopes with SMZ's ~ 4900 acre/year (30 year treatment) in the Wildland-Urban Interface and ~ 2580 acres/year (50 year treatment) outside the Wildland-Urban Interface*

*** Range of potential biomass generated from on four scenarios outlined in Table 21*

## 2.3 Rice Straw and Hulls

Rice production is a major agricultural land use in the Sacramento Valley with approximately 500,000 acres cultivated annually. Two million tons of rice are produced annually, with and output value of $1.8 billion and resulting in 12,700 jobs annually to the California economy.[50] During 2009 in Butte County, 61 percent of the BMZ area, rice accounted for 33 percent of all agricultural income ($544 million; Price, 2010). Rice straw and hulls produce a significant amount of agricultural residues in the state. They are relatively consistent in quality and located within a well-defined region of the Sacramento Valley, congruent in part with BMZ defined here. These properties, and the current lack of profitable alternatives for the use of this large quantity of annual material, make rice straw and hulls appealing as a feedstock source for biopower or fuels. Winter flooding of rice field provides valuable habitat for water fowl and other wildlife species, creating at the same time conditions for the evolution of methane from those fields.

The passing of the Rice Straw Burning Reduction Act of 1991 mandated reductions to the practice of open field burning of residual rice straw in the year 1992 to no more than 25 percent of an individual farmers planted land, or a maximum of 125,000 acres within the Sacramento air basin, annually. This bill also scheduled a complete phase out of this straw management practice by the year 2001 with limited exceptions for disease outbreak, handled through a petition process. This act created a major shift in rice straw management to soil incorporation instead of burning, and initiated investigation into conversion technologies to transform straw into biopower and biofuels and other products. The chemical properties of rice straw, primarily its high silica content, provide a unique set of conditions that make it resistant to decomposition and limit its value as livestock feed. Rice plants accumulate silica and other cations in their tissue and may have as much as 13 percent ash content, which limits its use as forage and also as a fuel in thermal conversion technologies.

### 2.3.1 Current Straw Management Practices

The primary, current cultural practice is to incorporate most straw residue into the soil for decomposition. Straw incorporation in rice fields in California may improve soil fertility and increase soil carbon (C) storage. Another benefit of incorporation is retention of straw nutrients in fields which are primarily potassium (K) and phosphorus (P). Decomposition of rice straw occurs slowly under typically saturated winter soil conditions. When combined with flooding for rice production during the growing season, the potential for additional methane production is increased compared to straw disposal through burning.

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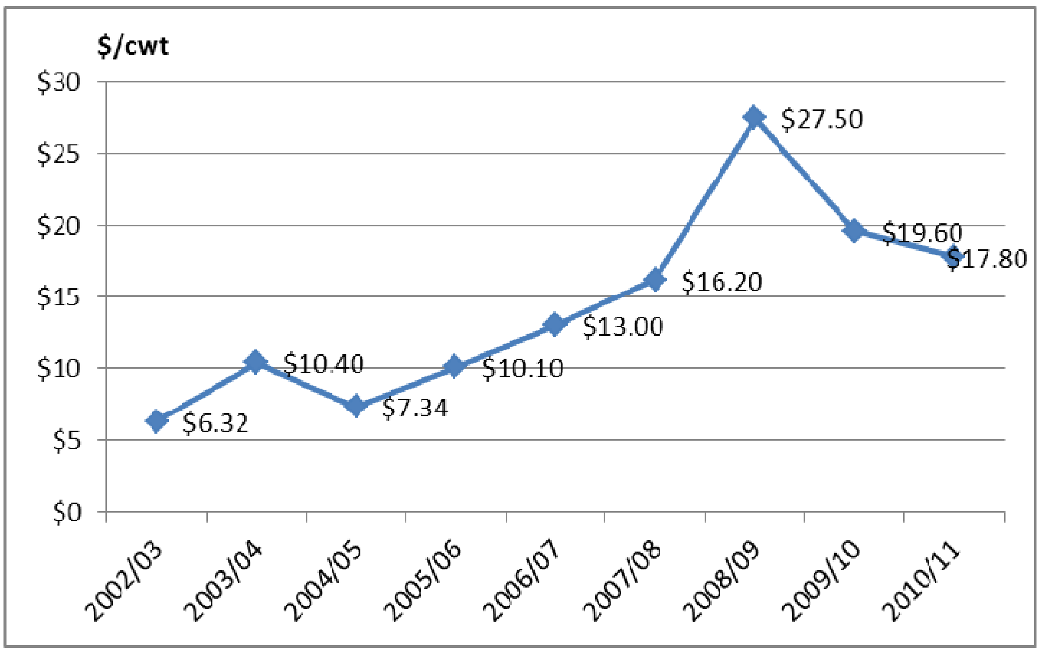
[50] Economic Contributions of the US Rice Industry to the US Economy. James W. Richardson and Joe L. Outlaw. Agricultural & Food Policy Center, Texas A&M Univeristy. College Station, TX. AFPC Research Report 10-3. August 2010. http://www.calrice.org/pdf/RR-10-03-Economic+Contributions+of+the+US+Rice+Industry.pdf.

### 2.3.2 Rice Production in the BMZ

The Butte Sink region includes a major portion of California's 550,000 acres of rice production.[51] Butte, Colusa and Glenn Counties represent 60 percent of total statewide rice acreage. This crop has a strong economic influence on these counties with average prices ranging from $13/cwt (hundredweight) to $27.50/cwt over the last five years (Figure 15, USDA-ERS, 2011). Recent Butte County average yields are 4.7 ton/acre of rice (Price, 2010). An approximately equivalent amount of straw is produced but not all straw can be collected practically. The BMZ includes 334,000 acres of rice. Sutter and Yuba counties in the BMZ do not produce significant amounts of rice. Rice produces straw yielding about 3 tons per acre (Schuetzle, et al., 2008b; Williams, et al., 2008.). However not all of this straw is available for use. Schuetzle, et al. (2008b) estimate 2 BDT of rice straw per acre are available. Williams et al (2008), estimate that only 1.5 BDT are technically available for utilization. This area would provide approximately 1,000,000 tons (500,000 dry tons, Table 26) annually. Based on an estimated energy content of 5,960 Btu/lb for rice straw, the BMZ contains 5,970,700 million btu (MMBtu) of standing rice straw energy, and nearly 3 million MMBtu of energy embodied in the available dry straw.

**Figure 15: Average Annual Price Received by Californian Rice Producers**




[51] The Butte Sink Sub-inventory Unit (SIU) covers an area of about 10,300 acres, bordered by the Biggs/West Gridley SIU to the north and east, Sutter County to the south, and Butte Creek (the Colusa County boundary) to the west. Much of the Butte Sink area consists of waterfowl refuges and privately managed wetlands habitats.
https://www.buttecounty.net/Water%20and%20Resource%20Conservation/BMO/~/media/County%20Files/Water%20Resource/Public%20Internet/BMO/2011%20BMOs/DRAFT_ButteSink_11_BMO.ashx

**Table 26: Annual Gross and Available Rice Straw by county in the BMZ**

| County | Rice Acreage | Rice Straw (Gross tons) 3 tons/acre | Rice Straw (available tons) 1.5 tons/acre |
|---|---|---|---|
| Butte | 103,400 | 310,200 | 155,100 |
| Colusa | 141,000 | 423,000 | 211,500 |
| Glenn | 89,500 | 268,400 | 134,300 |
| Total | 333,900 | 1,001,600 | 500,900 |

Fine-textured, formerly wetland soils dominate in this area and are particularly well-suited for rice cultivation. Sufficient water has been available from the Sacramento River and secondary streams in the region that formerly created permanent and ephemeral wetlands in pre-settlement times. This specialized set of soil resources is surrounded by larger areas with more easily tilled soils and better drained regions with extensive perennial tree fruit production. There are several agricultural food processing enterprises, including a large tomato processing facility.

### 2.3.3. Combustion of Rice Straw

Most previous analyses of rice straw and hulls have focused on combustion for power generation. Two biomass power facilities already exist within the rice growing region located within the Oroville BMZ. But rice straw is a problematic feedstock for combustion (Jenkins and Bakker, 1996). It is very high in biogenic silica, and contains large amounts of K and chlorine (Cl), which lead to problems with combustion (slagging) due to the low melting point of this silica or emission exceedances. There are modest amounts of nitrogen (N) in the straw. The Wadham Energy biomass power plant in Williams operates exclusively with rice hulls, not straw. It is a 25 MW, suspension-fired (as opposed to fluidized bed or grate-fired boilers) steam cycle power plant.

One suggestion has been to leave rice straw uncollected in fields overwinter to allow for leaching, and then to collect it for combustion. But degraded straw is expensive to collect and equipment for doing so has not been optimized. Straw yields are more variable in the spring than in the fall and lower (Jenkins and Bakker, 1996; Bakker, et al., 2002; Bakker and Jenkins, 2003). Removal in spring could also interfere with timely planting operations during critical planting periods in spring and be difficult to bale under dry enough conditions for storage. Processing baled rice straw will use large amounts of water and be expensive. All programs that remove rice straw also remove nutrients that must over time be replaced through fertilizer applications. Doberman and Fairhurst (2002) report that about 40 percent of the N, 30 percent of the P, and 80 percent of the K taken up by the crop remains in the straw. Removing 1.5 ton/acre of rice straw would also remove 22 lb. of N, 49 lb. of K and 2.8 lb. of P per acre per year (Nader, 2009).

### 2.3.4 Ethanol from Rice Straw

Schuetzle et al (2008) analyzed the production of ethanol from rice straw and estimated that 72-80 gallons per ton (gal/ton) could be produced thermochemically or 59 gallons per ton biochemically. There are many differing estimates of such yields but few processes operating at sufficient scale for certainty (NRC, 2011). The most comprehensive recent analysis of the potential to produce ethanol from celluosic materials, particularly *C4 perennial grasses*, found that the most reasonable value to use for such estimates is 70 gal/ton of dry matter (DM; NRC, 2011).[52] Rice straw is much higher in ash than perennial grasses, so a lower value is more likely. Using 60 gal/ton, 1 million tons of rice straw would produce up to 60 mgy of ethanol if an effective and economic commercial process could be developed.

There have been a series of research projects focused on rice straw and ethanol for nearly two decades. Funding for a project to be located in Gridley was provided by CEC, USDOE and USDA. The first project, in the mid 90's, evaluated enzymatic hydrolysis technology (DOE through NREL) and then acid hydrolysis. Eventually, gasification technology was considered by NREL for the Gridley project. Several private firms were engaged in this project (Schuetzle et al., 2008). In 2005, the National Renewable Energy Laboratory (NREL, 2005) published an analysis carried out by TSS, Inc. of a proposed project to convert rice straw to ethanol using a biomass gasification technology created by Pearson Technologies, Inc. A 20 mgy facility was envisioned. The Pearson Process was purported to use a proprietary combination of steam reformation and gasification to create syngas, electricity and ethanol from biomass. A Fischer-Tropfsch (FT) process would create a liquid fuel from the synthesis gas generated by gasification of rice straw. Tests were carried out on a pilot facility in Mississippi owned by Pearsons. The high ash content (primarily silica) and the physical difficult of handling rice straw presented obstacles in these tests. These physical characteristics of rice straw limit any efforts to transform the straw's carbon into energy (Jenkins and Bakker, 1996). All of these previous efforts have failed to result in operating facilities or energy production in any form, and have raised public concerns, including a grand jury investigation by the Butte County Grand Jury.[53]

### 2.3.5 Methane Emissions from Rice Fields

Rice is a unique plant that is adapted to saturated (flooded) soils. Prolonged saturation results in anaerobic conditions and the emission of methane ($CH_4$), a greenhouse gas 25 times more potent than carbon dioxide ($CO_2$).[54] It is estimated that 20 percent of all *anthropogenic* $CH_4$

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[52] C4 grasses are very efficient, carbon-capturing plants. These are cultivated grasses such as corn, sugarcane, sorghum, switchgrass,and miscanthus. C3 plants which are more common, but less efficient at utilizing carbon include wheat, canola, and Sugarbeets. Of all of these plants listed only switchgrass and miscanthus are perennial grasses that grow multiple years without reseeding.

[53] http://www.buttecounty.net/GrandJuryDocs/BCGJ_Final_Report_FY10-11.pdf

[54] Intergovernmental Panel on Climate Change (IPCC), Direct Global Warming Potentials. Climate Change 2007: Working Group I: The Physical Science Basis. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html. It is noteworthy that this Global Warming Potential (GWP) of 25, changes over time beginning as GWP of 21in the 1995 second

emissions come from wetland rice production (Bossio et al 1999).[55] The ultimate sources of the carbon that is transformed into $CH_4$ are the rice straw and roots that are incorporated into the fields after harvest. Since straw burning is now limited, the potential for methane emissions from rice production in California has increased. An important benefit of rice straw removal and utilization in a bioenergy system is the reduction of greenhouse gases (in this case methane, $CH_4$) emitted from rice fields.

Bossio et al (1999) estimated that 9.2 grams (g) $C/m^2$ as $CH_4$ is emitted during the spring from a field that has had rice straw incorporated. Fitzgerald, et al., (2000) provided different estimates from work carried out in fields in California in various time periods. The low value reported for $CH_4$ emissions from incorporated rice straw is 13.1 g $CH_4/m^2$ and the high was 27.3 g $CH_4/m^2$. The comparative values for burned rice straw $CH_4$ emissions reported by Fitzgerald, et al., (2000) were 5.2 g $CH_4/m^2$ and 5.7 g $CH_4/m^2$. The California Energy Commission (CEC, 2002),following the IPCC protocols, and adapting a variety of California study results, identifies 12.2 g $CH_4/m^2$ as the appropriate annual source of methane emissions averaged across all practices (including burned and incorporated).[56] Using the CEC value of 12.2 g $CH_4/m^2$, converting to acres and multiplying by the 334,000 acres of rice in the BMZ, yields a total annual methane emission of 16,500 Mg $CH_4$. This value serves as a reference point from which to reduce methane emissions from rice straw.

### 2.3.6 Using Rice Straw for Production of Biogas in Anaerobic Digestion Facilities

An alternative idea is to collect straw in fall, while still moist, ensile it similar to corn silage, and then use it as a feedstock with other readily available biomass materials collected in the region in anaerobic digestion (AD) systems. Large-scale silage making campaigns are common in agriculture but have not been attempted with rice straw before. Nader (2009) reported higher rates of *in vitro* gas (biomethane) production under controlled conditions from fresh (moist) versus dried rice straw.[57] Their tests do not replicate gas production from ensiled rice straw or from mixtures of rice straw and more highly fermentable organic residuals that might also be produced for co-digestion during winter months in rice areas, but do indicate that AD fermentation is possible.

#### *2.3.6.1 Anaerobic Digestion Technology*

AD is a mature technology with several companies providing engineered systems. It is a biochemical conversion pathway and can utilize a wide range of organic materials. The products produced are biogas, water, nutrients, and recalcitrant organic materials, enriched in lignin. Residual, highly lignified materials might be used subsequently for combustion or

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assessment, then 23 in the 2001 third, and now in the 2007 assessment, is 25. This $CH_4$ GWP changes over the target horizon (ie. 25 year vs. 100 years).

[55] *Anthropogenic* refers to emissions that are derived from man-made activities.

[56] It is noteworthy that these rice straw emission levels are highly variable across practices and seasons. Even the units in which the emissions are reported (seasonal vs. annual, or carbon vs. methane).

[57] *In vitro,* here, refers to anaerobic digestion studies which looked at rice straw digestion in isolation.

thermochemical processes because of their increased energy density compared to the original biomass. Zhang and Zhang (1999) found that digestion reduced levels of K, Cl, and S, and that preliminary combustion of digested rice straw did not show signs of fouling even at higher temperatures. Alternatively, given the large amount of biogenic silica in the rice, residues could be used for animal bedding, composted, or spread on fields directly. Anaerobic digesters are readily scalable and could be located strategically in the rice production areas, perhaps near rice drying facilities, to allow for short feedstock transport distances. Existing rice driers are strategically located throughout the rice producing region and already operate on natural gas. Biomethane from rice straw digesters could offset or replace this natural gas use and be sold offsite when driers are not in use. Purified methane could be compressed and used to power trucks, similar to the use for biogas at the Hilarides dairy near Lindsay, California.[58] Water, nutrients, and organic residues and minerals in effluent from the digester would be returned locally to surrounding fields, since the facility would be located within the feedstock supply region. If methane were captured from rice straw in AD systems, fugitive methane losses would be reduced from rice fields compared to current management. Biomethane supplies would become available within the BMZ. The use of AD holds promise to address disposal and management issues associated with rice straw in the Sacramento Valley (Zhang and Zhang, 1999). Rice straw can produce renewable bioenergy in several forms such as biogas, electricity through conversion from biogas, with or without heat capture; and conversion of AD residues to energy by combustion or gasification. Alternatively, AD residues could be composted. The majority of water used and nutrients in the straw could be recycled short distances locally to fields. Resulting alternative energy can be used locally or exported. There may be a market for carbon credits generated. Jobs would be created.

#### *2.3.6.2 Hypothetical Commercial Facility Descriptions*

The suggestion to use rice straw for biogas using a commercial AD system is hypothetical. Only limited data is available, insufficient to provide the quality of data necessary to support commercial investment. Using experimental data (Zhang and Zhang, 1999) and a generic cost calculator (Rapport, 2011), some broad, general impacts can be demonstrated. Three configurations of electricity production or direct gas use were evaluated (Table 27). It is assumed that 30 percent of all biogas produced would be required to operate the system. The three scenarios, and facility types, are based on all remaining biogas used in 1) gas export (70 percent gas export), 2) half gas export and half power sold off-site (35 percent power sales/35 percent gas export), and 3) all biogas converted to power for off-site sales (70 percent power sales).

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[58] Biomethane Fuels Dairy Fleet. BioCycle. June 2009, Vol. 50, No. 6. http://www.phase3dev.com/news/YR09.06.25_Media_Bio_Fuels.pdf

Although not commercial digester biogas, landfill gas is also being liquefied as fuel at the Altamont Landfill near Livermore, California http://www.wm.com/documents/pdfs-for-services-section/press-release-wm-receives-epa-recognition-landfill-gas-to-energy.pdf

**Table 27: Description of Three Biopower Configurations**

| Alternative Biopower Configurations* | Straw Input Rate | Electrical and Heat Use | Electricity Generated For Export | Gas Export |
|---|---|---|---|---|
| Facility Type 1 | 140 ton/day | 30% of gas production capacity | 0 | 70% |
| Facility Type 2 | | | 35% | 35% |
| Facility Type 3 | | | 70% | 0 |

** In all cases 30 % of gas production was utilized to supply the electricity and heat demands for the facility.*

By scaling AD facilities to use 140 tons of rice straw per day a single facility would require 51,100 tons of straw annually from 76,650 acres. This is 23 percent of the potentially available straw in the BMZ, a conservative estimate. Multiples of this size facility would allow more rice straw methane to be avoided. This allows for some combustion of fields, as noted, and return of large amounts of straw to soils for soil organic matter maintenance. In addition, most nutrients, water and some lignified residues are conserved in AD processes and these can be returned to fields supplying straw. Estimates for capital costs are found in Table 28. It is difficult to assign commercial values for a hypothetical commercial facility, but using sources developed by Rapport (2011), such a 140 ton/day facility would cost nearly $21 million to construct and about $1.4 million to maintain annually. Competition among commercial suppliers of AD systems may be expected to help reduce such costs over time.

**Table 28: Estimated Capital Costs for 140 ton/day AD Facility Construction**

| Cost Type | | Facility Type 1 (Million $) | Facility Type 2 (Million $) | Facility Type 3 (Million $) |
|---|---|---|---|---|
| Capital Investment | Facility – buildings and compost production | $3.000 | $3.000 | $3.000 |
| | Digester | $15.000 | $15.200 | $15.200 |
| | Generator Set | $0.640 | $1.500 | $1.500 |
| | Gas Cleaning | $2.200 | $1.200 | $1.200 |
| | Total | $20.840 | $20.900 | $20.900 |
| Operation and Maintenance | Digester | $1.250 | $1.600 | $1.600 |
| | Generator Set | $0.060 | $0.130 | $0.130 |
| | Gas Cleaning | $0.110 | $0.060 | $0.060 |
| | Composting | $0.008 | $0.008 | $0.008 |
| | Annual cost | $1.428 | $1.798 | $1.798 |

Essentially all three facilities are equivalent in design but alternatives 2 and 3 require larger or additional generator capacity to meet electricity production demands (based on model used in Rapport, et al.,2011).

### *2.3.6.3 Capital Budgeting of Facility Costs*

The annual cost of capital can be estimated easily by assigning some values for interest (0.08), and a 10 year payback period. Rounding to $20 million dollars simplifies the math. The annual operation and maintenance (O & M) costs for Facility Type 1 (all natural gas) is 6.85 percent of the $21 million in capital costs. These costs are real, but are also difficult to estimate with certainty without a specific facility to reference. More established technologies and facilities will require less O & M. More experimental technologies and facilities will have a higher O & M. A range of O&M costs as a percent of capital are presented in Table 29. Assuming a 7 percent O & M cost on a $20 million investment of this nature is reasonable (shaded in Table 29).

**Table 29: Range of Annual Operation and Maintenance (O&M) Cost for a $20 Million Investment**

| Percent of Capital | Annual O&M |
|---|---|
| 4.0% | $800,000 |
| 5.0% | $1,000,000 |
| 6.0% | $1,200,000 |
| 7.0% | $1,400,000 |
| 8.0% | $1,600,000 |
| 9.0% | $1,800,000 |
| 10.0% | $2,000,000 |

The estimated total of straw required for each 140 ton/day facility is 51,100 tons/year. We use 50,000 tons of rice straw silage for purposes of estimation. There are many ways to price rice straw removal. It requires labor, and equipment. A reasonable estimate for straw removal is $20 per ton. It costs the producers to remove the rice straw. It costs more to remove the rice straw and deliver it somewhere off site than it costs to incorporate the straw or to burn it. Using $20/ton as a value is a cost to the rice farmer. This is not a price that generates revenue. A cost-offsetting price of rice straw, or in this case, rice straw silage of $20/ton x 50,000 tons per year results in a feedstock cost to the facility of $1 million dollars, or $500,000/year for every $10 increment in the price of rice straw silage. Other straw crops are not produced at the cost of production but with the anticipation of a return higher than the costs. Therefore in the reference-case here, a commonly used biomass price of $50 per ton is used for illustration.

These fundament annual costs can be combined in different ways to establish a reference for the most significant costs involved in operating a rice straw silage digester (Table 30). The first column establishes a target capital cost in dollars. The second column provides the annualized cost of that capital based on 8 percent interest and a 10 year payback period. The subsequent column headings identify variable costs for differently priced feedstocks. The values listed in the 'Annual Cost' row are the annual feedstock costs for 50,000 tons of rice straw silage plus the $1.4 million in O&M costs. The balance of the table then is the combination of the annual variable costs in the Annual Cost row with the annualized cost of capital in the Annual Cost column. The reference-case scenario can be set at $20 million, $1.4 million in O&M, and a feedstock cost of $50/ton. Such a facility would have annual costs of $6.9 million. For a facility to breakeven would require revenues equal to the costs. To operate profitably would require revenues of significantly more than $6.9 million/year based on these assumptions.

**Table 30: Annual Variable O&M, and Feedstock Costs with Annual Capital Cost Budgeting for 140 ton/day Facility**

**Rice Straw Digesters** Fuel costs

| **Annual costs** | | **$/ton<br>$20** | **$/ton<br>$40** | **$/ton<br>$50** | **$/ton<br>$60** | **$/ton<br>$80** |
|---|---|---|---|---|---|---|
| **Capital costs** | **Annual Costs** | **$2,422,000** | **$3,444,000** | **$3,955,000** | **$4,466,000** | **$5,488,000** |
| **$10,000,000** | $1,456,000 | $3,878,000 | $4,900,000 | $5,411,000 | $5,922,000 | $6,944,000 |
| **$15,000,000** | $2,183,897 | $4,605,897 | $5,627,897 | $6,138,897 | $6,649,897 | $7,671,897 |
| **$20,000,000** | $2,911,862 | $5,333,862 | $6,355,862 | $6,866,862 | $7,377,862 | $8,399,862 |
| **$25,000,000** | $3,639,828 | $6,061,828 | $7,083,828 | $7,594,828 | $8,105,828 | $9,127,828 |

The values in Table 30 are based on specific assumptions, which when varied produce different results. Tables 31 and 32 vary reference case by the interest rate and payback period in years, respectively. The annual costs of these facilities across these ranges vary from $4 million to $10 million. The lowest cost conditions are in bold and higher costs are shaded in gray. A breakeven annual capital cost of $4 million is used in the following discussion on revenues.

**Table 31: Range of Annual capital and Variable Costs across a Range of Interest Rates**

| **Payback** | **10 years** | **$/ton** | **$/ton** | **$/ton** | **$/ton** | **$/ton** |
|---|---|---|---|---|---|---|
| **Capital Cost** | **$20,000,000** | **$20** | **$40** | **$50** | **$60** | **$80** |
| **Interest Rates** | **Annual Costs** | **$2,422,000** | **$3,444,000** | **$3,955,000** | **$4,466,000** | **$5,488,000** |
| **0.02** | $2,208,000 | **$4,630,000** | $5,652,000 | $6,163,000 | $6,674,000 | $7,696,000 |
| **0.04** | $2,430,000 | **$4,852,000** | $5,874,000 | $6,385,000 | $6,896,000 | $7,918,000 |
| **0.06** | $2,664,000 | $5,086,000 | $6,108,000 | $6,619,000 | $7,130,000 | $8,152,000 |
| **0.08** | $2,912,000 | $5,334,000 | $6,356,000 | $6,867,000 | $7,378,000 | $8,400,000 |
| **0.10** | $3,172,000 | $5,594,000 | $6,616,000 | $7,127,000 | $7,638,000 | $8,660,000 |

**Table 32: Range of Annual Capital and Variable Costs across a Range of Payback Period Years**

| Capital Cost | $20,000,000 | $/ton | $/ton | $/ton | $/ton | $/ton |
|---|---|---|---|---|---|---|
| **Interest Rate** | **0.08** | **$20** | **$40** | **$50** | **$60** | **$80** |
| **Payback Years** | **Annual Costs** | **$2,422,000** | **$3,444,000** | **$3,955,000** | **$4,466,000** | **$5,488,000** |
| **5.0** | $4,866,000 | $7,288,000 | $8,310,000 | $8,821,000 | $9,332,000 | $10,354,000 |
| **7.0** | $3,741,000 | $6,163,000 | $7,185,000 | $7,696,000 | $8,207,000 | $9,229,000 |
| **10.0** | $2,912,000 | $5,334,000 | $6,356,000 | $6,867,000 | $7,378,000 | $8,400,000 |
| **15.0** | $2,294,000 | **$4,716,000** | $5,738,000 | $6,249,000 | $6,760,000 | $7,782,000 |
| **20.0** | $2,007,000 | **$4,429,000** | $5,451,000 | $5,962,000 | $6,473,000 | $7,495,000 |

### *2.3.6.5 Rice Straw Digestion Facility Revenue Benefits*

The revenue side of the 140 ton/day rice straw digester is similarly challenging. There are several assumptions that need to be stated first. Based on the technical information provided by Zhang and Zhang (1999), a rice straw digestion facility of this size could produce 21,500 MWh of power, based on 30 percent power conversion efficiency. Since 30 percent of the biogas produced is required for parasitic load, only 70 percent of the biogas is available for power production. This reduces total power produced to 15,000 MWh.

The fiber and nutrients in the rice straw have some value. It could be composted, or it could be used as fuel in a subsequent thermal conversion process, or used as bedding for dairy cows. The value assigned in this illustration is $10 per ton. For any of these markets moisture content varies as does the volume of fiber. It is also assumed that 1 ton of digested rice straw leaving the digester is approximately the same volume as the rice straw silage entering the digester.

Similarly, it is estimated from the biogas production of the digester that the annual methane content heating value is 244,000 MMbtu. 70 percent of the biogas not consumed by the digester and conversion technologies is available, or 171,000 MMBtu.

Tables 33 and 34 show the total power revenue and heating value of the methane content of the biogas, respectively. The prices for power and heat value span a wide range and are much greater in the high end prices in which the combined energy and compost revenues begin to align with the $4 million capital cost examples above. These are presented because such high prices have been used in discussions of what green energy could cost. The higher rates for power are similar to those paid in Germany that have resulted in the construction in recent years of more than 7,000 small anaerobic digestion facilities, many of them on farms. These are much higher prices than current rates in California.

**Table 33: Power and Composting Revenue for a Hypothetical 140 ton/day Rice Straw Digester Facility**

| $/kWh | Power Revenue | Compost Revenue | Combined Revenue |
|---|---|---|---|
| $0.04 | $600,732 | $500,000 | $1,100,732 |
| $0.06 | $901,098 | $500,000 | $1,401,098 |
| $0.08 | $1,201,464 | $500,000 | $1,701,464 |
| $0.10 | $1,501,831 | $500,000 | $2,001,831 |
| $0.12 | $1,802,197 | $500,000 | $2,302,197 |
| $0.14 | $2,102,563 | $500,000 | $2,602,563 |
| $0.16 | $2,402,929 | $500,000 | $2,902,929 |
| $0.18 | $2,703,295 | $500,000 | $3,203,295 |
| $0.20 | $3,003,661 | $500,000 | $3,503,661 |
| $0.22 | $3,304,027 | $500,000 | $3,804,027 |
| $0.24 | $3,604,393 | $500,000 | **$4,104,393** |
| $0.26 | $3,904,759 | $500,000 | **$4,404,759** |

**Table 34: Natural Gas Equivalent and Compost Revenue for a Hypothetical 140 ton/day Rice Straw AD Facility**

| $/MMBTU | Biogas Revenue | Compost Revenue | Combined Revenue |
|---|---|---|---|
| $4.00 | $683,826 | $500,000 | $1,183,826 |
| $6.00 | $1,025,738 | $500,000 | $1,525,738 |
| $8.00 | $1,367,651 | $500,000 | $1,867,651 |
| $10.00 | $1,709,564 | $500,000 | $2,209,564 |
| $12.00 | $2,051,477 | $500,000 | $2,551,477 |
| $14.00 | $2,393,389 | $500,000 | $2,893,389 |
| $16.00 | $2,735,302 | $500,000 | $3,235,302 |
| $18.00 | $3,077,215 | $500,000 | $3,577,215 |
| $20.00 | $3,419,128 | $500,000 | $3,919,128 |
| $22.00 | $3,761,040 | $500,000 | **$4,261,040** |

### 2.3.6.6 Rice Straw Digestion Facility GHG Emission Avoidance Benefits

Methane that is captured by digesting rice straw in an AD facility reduces uncontrolled emissions to the atmosphere, and its use for power substitutes for the use of fossil natural gas for electricity production or other uses (Table 35). These GHG offset values are based upon a hypothetical example of real BMZ resource levels. But both the yield of energy products and the GHG emission offset estimates are modeled rather than measured. The values in Table 35 are presented for illustrative purposes. The calculations are based on a number of critical assumptions. These include the use of Zhang and Zhang (1999) laboratory conversion factors of rice straw to methane in an experimental digester. The methane yield, scaled up to cubic meters of methane per metric ton of rice straw is 172.6 $m^3$/Mg. This experimental methane yield was reduced by 75 percent to adjust for commercial conditions that would have a shorter residence time in the digester than the experimental values (reducing the digester residence time allows for a smaller digester and also lowers the yield). The natural gas and power estimates are based on the 1.5 ton/acre rice straw yield (Williams, et al, 2008).

The power generation assumptions include a conversion efficiency of 30 percent and a California electricity emissions factor of 124.06 g $CO_2$ e/MJ or 446.7 g $CO_2$/kWh (CARB, 2009). The natural gas emissions factor is based on an EPA (2012) value of 0.0053 Mg $CO_2$/therm. The table is organized by economic facility scenario as well as BMZ rice straw utilization rates of 100 percent, 66 percent, 50 percent, and 33 percent. The total $CO_2$ production in the field is based on the CEC (2002) rice straw emission value of 12.2 g $CH_4$ $m^{-2}$. The $CH_4$ Emissions Avoided estimates reflect 50 percent removal of rice straw (technically available at the 1.5 ton/acre yield with 50 percent remaining behind) plus the emission offsets created through natural gas offsets, power offsets, or both. Based on the values presented in Table 35, the rice straw AD, natural gas emissions avoided are 60 percent of the estimated field emissions while the emissions avoided from only electricity production are 57 percent of estimated field emissions. The scenario that produces both natural gas and power is at 58.5 percent of the field emissions.

**Table 35: Potential $CO_2$ Equivalents Offset by AD of Rice Straw at a 140 ton/day Facility**

| Percent of BMZ straw | Mg $CO_2$ (field) | CH4 offsets from Natural Gas Generation (Mg $CO_2$) | | CH4 offsets from Power Generation (Mg $CO_2$) | | $CH_4$ Emissions Avoided (Mg $CO_2$) |
|---|---|---|---|---|---|---|
| | | 35% | 70% | 35% | 70% | |
| **Facility 1, Biogas distribution=70% NG:0% Power** | | | | | | |
| 100% | 92,500 | | 9,061 | | | 55,311 |
| 66% | 60,000 | | 5,980 | | | 35,980 |
| 50% | 47,500 | | 4,530 | | | 28,280 |
| 33% | 30,000 | | 2,990 | | | 17,990 |
| **Facility 2, Biogas distribution=35% NG:35% Power** | | | | | | |
| 100% | 92,500 | 4,530 | | 3,354 | | 54,135 |
| 66% | 60,000 | 2,990 | | 2,214 | | 35,204 |
| 50% | 47,500 | 2,265 | | 1,677 | | 27,692 |
| 33% | 30,000 | 1,495 | | 1,107 | | 17,602 |
| **Facility 3, Biogas distribution=0% NG:70% Power** | | | | | | |
| 100% | 92,500 | | | | 6,709 | 52,959 |
| 66% | 60,000 | | | | 4,428 | 34,428 |
| 50% | 47,500 | | | | 3,354 | 27,104 |
| 33% | 30,000 | | | | 2,214 | 17,214 |

These estimates suggest that digesting rice straw silage in a commercial anaerobic digester could reduce rice straw methane emissions by 57 percent to 60 percent. This estimate only considers 50 percent of the technically available rice straw removed plus the offset for either power or natural gas avoided from fossil-based sources. It does not include GHG emissions occurring from feedstock harvest, ensiling, and transportation operations to the physical site location. Methane is a more potent GHG factor, however, than $CO_2$ emissions from other types of operations.

#### *2.3.6.7 Evaluating the Benefits*

These estimates provide some rational benchmarks for policy and planning. Reducing methane emissions from rice straw emissions is feasible, but complex economically. For instance, if a $20 million facility was constructed to achieve, initially, a 60 percent reduction of methane emissions, a grant for 50 percent of capital costs would reduce these to $10 million. A low interest loan could reduce the interest to 2 percent, and a 50 percent feedstock purchase subsidy, such as those provided by the federal BCAP program, could provide a $40 per ton rice straw silage price delivered for $20 to the facility. Extending the payback period from 10 years to 20 years would further lower the annual cost of capital. There are many assumptions in this illustration. Changing them alters the costs. The annual cost of capital, O&M (even maintaining the $1.4 million annual fee), and using the $20/ton price, reduces the annual costs to $3 million. This would lower the 'green' energy costs of such a facility to $0.17/kWh for power and $17/MMBtu for natural gas.

Additional cost savings could be found in combining materials with a higher energy value than rice straw silage like food waste or glycerin from a biodiesel facility in the same digester. Perhaps there may be a way to combine rice straw silage digestion at a public wastewater treatment facility which would lower the cost of the digester portion of the capital costs. Using the residual solids in an onsite thermal conversion facility could likely increase the value of the digested solids to a value greater than $10/ton for solids. This example facility illustrates how multiple excess biomass liabilities could be combined to achieve multiple economic and environmental benefits.

Economic details remain to be determined. However on the basis of available feedstocks, conversion to power, and methane emissions avoided, the rice straw silage anaerobic digester facility has benefits. Table 36 illustrates these for a typical AD facility. The first two rows of the table show the inputs, energy output, and methane emissions avoided for a hypothetical, 140 ton/day rice straw silage facility. In this table the energy output is presented as either power (MW) or heat (MMBTU). The lower two rows scale up the 140 ton/day facility and scale this technology up to the total rice acres in the BMZ, or 4.5 AD units.

**Table 36: Estimated Benefits from Anaerobic Digestion of Rice Straw**

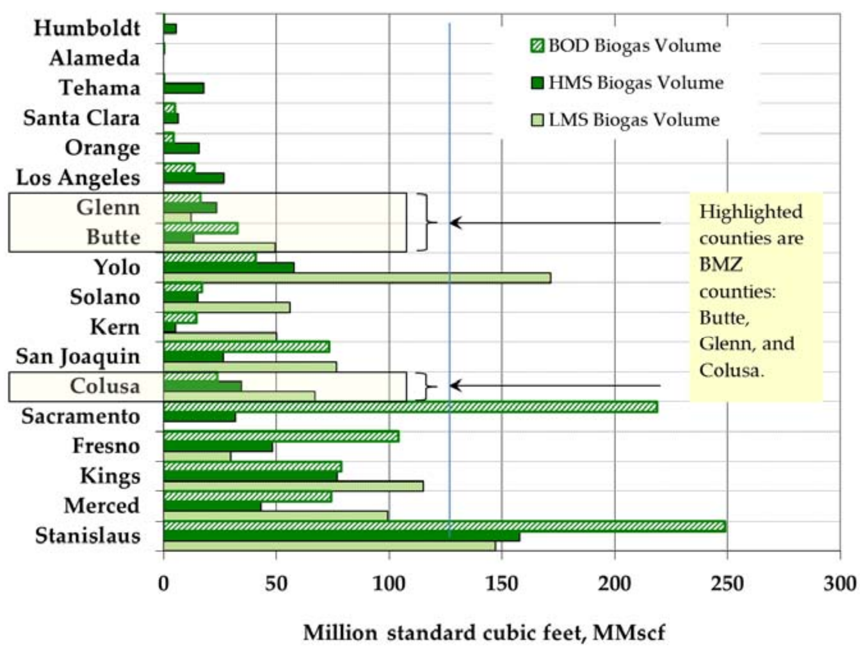
| | | Feedstock BDT | Power Capacity, MW | Heat Value MMBTU | CH4 Avoided Mg CH4 |
|---|---|---|---|---|---|
| 1, Rice straw AD unit | Power production | 50,000 | 1.9 | | 55,000 |
| 140 tons/day | Heat production | 50,000 | | 177,000 | 53,000 |
| All BMZ rice straw | Power production | 223,000 | 8.5 | | 245,000 |
| 4.5 AD units | Heat production | 223,000 | | 788,000 | 236,000 |

## 2.4 Food Processing Residuals

Waste from food processing represents an additional source of both electricity and methane production that can exceed the demand of that facility. The state of California is rich with under-valued organics resulting from the processing of fruits and vegetables for food. Amon, et al. (2011) reported that the food processing industry generates 26.3 billion gallons of wastewater and 3.5 million dry tons of solid residues, mostly nut hulls and shells, are produced annually.[59]

Within this BMZ there are 5 facilities that handle a range of agricultural waste products from fruit and vegetable canning and drying industry.  Within this sector of processed fruits and vegetables, Amon, et al. (2011) estimated 274 million standard cubic feet of biogas, or 174,000 million btu (MMBtu) of energy in the biogas.  The biogas yields for the processed fruit and vegetable residuals are presented in Figure 16.  The three BMZ counties with food processing facilities are highlighted in yellow.  The biogas yields are summed for the biological oxygen demand (BOD), high moisture solids (HMS), and low moisture solids in the BMZ counties.  This volume represents 11 percent of biogas potential from this industry across the state.

**Figure 16: Estimated Annual Biogas Production from Canned Fruits and Vegetable Processing by Feedstock Source of $BOD_5$, HMS, and LMS, by County**




(Amon, et al., 2011)

The gross potential in terms of biogas energy production for the processed fruits and vegetables in 3 BMZ counties, is summarized in Table 37 from work compiled by Amon, et. al, (2011). These values are total county values, not BMZ values.  One of the challenges in using this this very wet material is that is tends to be seasonally available.  It is neither convenient nor economic to only run a digester facility for a portion of a year.  These values from Amon, et. al., 2011, provide a starting place from which to evaluate possible AD feedstock volumes.

[59] The 26.3 billion gallons of wastewater are equivalent to 175,000 tons of 5-Day, Biological Oxygen Demand, (BOD).

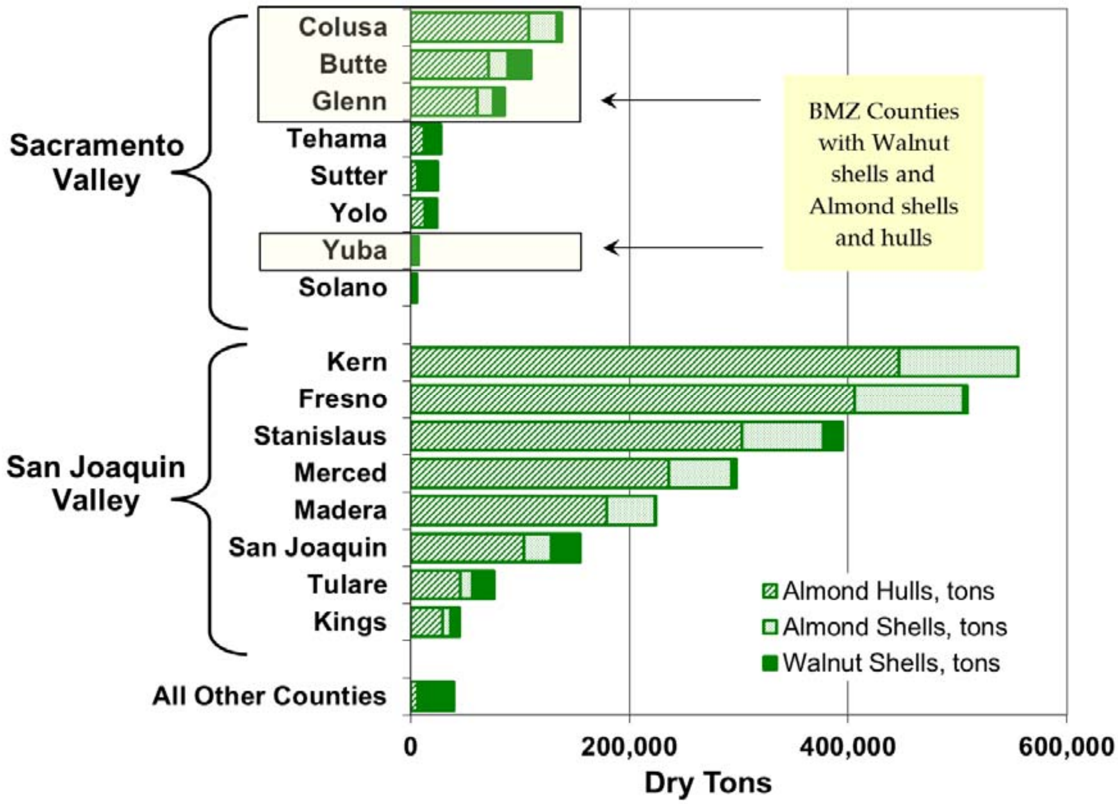
**Table 37: Feedstocks, Biogas Volumne in Million Standard Cubic Feet (Mscf), or Energy Value in Million btu (MMBtu) for BOD, HMS, and LMS by County**

| | BOD tons/year | BOD Volume (Mscf) | BOD Energy (MMBtu) | HMS dry tons/year | HMS Volume (Mscf) | HMS Energy (MMBtu) | LMS dry tons/year | LMS Volume (Mscf) | LMS Energy (MMBtu) |
|---|---|---|---|---|---|---|---|---|---|
| **Butte** | 1,900 | 32.96 | 20,880 | 1,050 | 13.51 | 8,560 | 3,840 | 49.41 | 31,300 |
| **Colusa** | 1,390 | 23.98 | 15,190 | 2,690 | 34.58 | 21,900 | 5,230 | 67.29 | 42,620 |
| **Glenn** | 950 | 16.52 | 10,460 | 1,840 | 23.66 | 14,990 | 950 | 12.17 | 7,710 |
| **Totals** | 4,240 | 73.46 | 46,530 | 5,580 | 71.75 | 45,450 | 10,020 | 128.87 | 81,630 |

(Amon, et. al, 2011)

The other large source of food processing residuals that are generated in the BMZ are walnut and almond shells and hulls. While most of California almonds are produced in the San Joaquin Valley, Colusa, Butte, and Glenn Counties grow most of the almonds produced in the Sacramento Valley (Figure 17). Amon, et al. (2011) identified that most of the nut hulls and shells are already moving into the cattle feeding industry or the biomass power industry. If the demand for these materials as a fuel for energy increases the price above what the dairy industry is willing to pay these materials could move from one use to another. These food processing residuals do not have zero value, but already have established values. Energy prices would have to increase significantly for this to happen however.

**Figure 17: Annual California Almond Hull, Shell, and Walnut Shell Production**




(Amon, et. al, 2011)

A summary of feedstock volumes, energy values and power capacities for almond hulls, almond shells, and walnut shells in the counties included in the BMZ is presented in Table 38. As mentioned above, these materials are generally committed to uses currently and new uses will need to compete for new uses with the existing use.

**Table 38: Feedstock Volumes, Energy Value, and Potential Power Capacity for Almond Hulls, Almond Shells, and Walnut Shells in the BMZ Counties**

| | Almond BDT | Almond MMBTU | Almond MW | Almond BDT | Almond MMBTU | Almond MW | Walnut BDT | Walnut MMBTU | Walnut MW |
|---|---|---|---|---|---|---|---|---|---|
| **Butte** | 71,690 | 1,232,930 | 12.1 | 17,160 | 295,030 | 2.9 | 21,510 | 369,880 | 3.6 |
| **Colusa** | 108,360 | 1,863,470 | 18.3 | 25,930 | 445,900 | 4.4 | 4,020 | 69,100 | |
| **Glenn** | 61,240 | 1,053,080 | 10.4 | 14,650 | 251,990 | 2.5 | 10,010 | 172,180 | 1.7 |
| **Sutter** | 6,680 | 114,840 | 1.1 | 1,600 | 27,490 | | 17,050 | 293,150 | 2.9 |
| **Yuba** | | | | | | | 7,610 | 130,790 | 1.3 |

**(Amo**n, et. al, 2011)

## 2.5 Urban Derived Biomass

Urban waste includes diverse organic materials that differ from wood waste from urban forestry. The primary source of Municipal Solid Waste (MSW) is the Neal Road Landfill north of the current Covanta Pacific Biomass Plant in Oroville. Estimates of the typical amounts of organic materials and their composition for central valley locations can be found at http://www.calrecycle.ca.gov/Publications/General/2009023.pdf

## 2.6 Existing Conversion Technologies and Projects

Table 39 is based on the current CBC facilities database and shows existing biomass facilities within the BMZ as well as biomass energy facilities operating in BMZ counties, but not within the BMZ itself (Other-MW).[60] The CBC has a current record of 43 MW within the BMZ and 34 MW adjacent to the BMZ from solid fuel boilers, landfill gas (LFG), wastewater treatment plant (WWTP) digesters, manure digesters and food processing anaerobic digesters.

Plumas County is also home to a 1 million gallon per year biodiesel conversion facility, Simple Fuels Biodiesel, Inc., in Chilcoot, California near the Nevada state line. Gridley, California, within the BMZ has been exploring a rice straw gasification plant for many years.

**Table 39: Current California Biomass Facilities in BMZ and Surrounding Counties**

| | BMZ-MW | Other-MW | CHP or Cogen | Feedstock | Technology | City | County |
|---|---|---|---|---|---|---|---|
| Pacific Oroville Power | 18.000 | | No | Ag & Urban | Boiler, Stoker - Grate | Oroville | Butte |
| Wadham Energy | 25.000 | | No | Ag | Suspension Fired Boiler | Williams | Colusa |
| SPI Quincy | | 20.000 | Yes | Lumber mill, Urban & Ag | Boiler, Stoker - Grate | Quincy | Plumas |
| Collins Pine | | 12.000 | Yes | Forestry | Boiler, Stoker - Grate | Chester | Plumas |
| Recology (Norcal) Ostrom Road | | 1.600 | No | Biogas-MSW | LFG - reciprocating engine | Wheatland | Yuba |
| Chico | 0.135 | | Yes | WW | WWTP - anaerobic digester | Chico | Butte |
| Yuba City | | 0.030 | | WW | WWTP - anaerobic digester | Yuba City | Sutter |

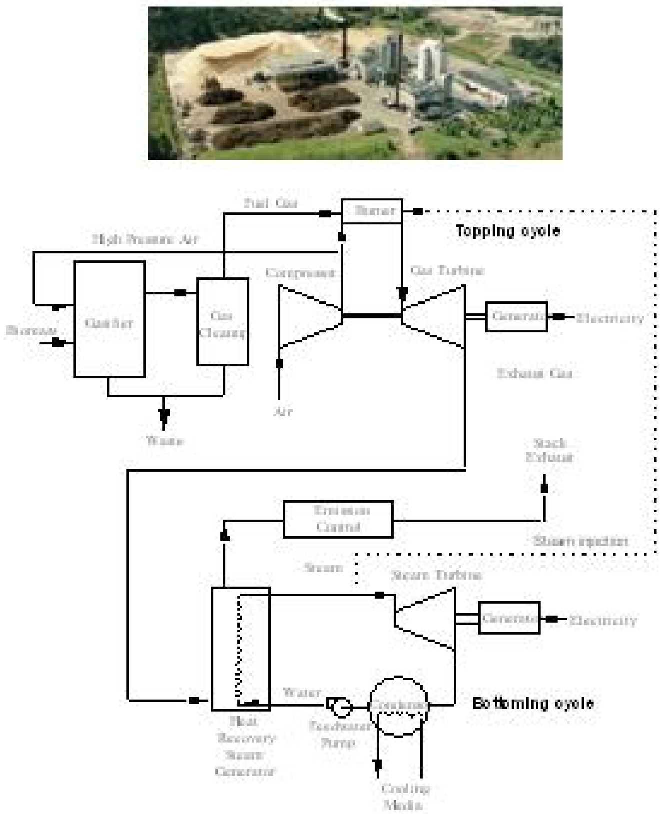
[60] California Biomass Collaborative (CBC) Facilities Database, available on the CBC website at http://biomass.ucdavis.edu/tools/

| | BMZ-MW | Other-MW | CHP or Cogen | Feedstock | Technology | City | County |
|---|---|---|---|---|---|---|---|
| Marysville | | NA | | WW | WWTP - anaerobic digester | Marysville | Yuba |
| BEALE Air Force Base | | NA | | WW | WWTP - anaerobic digester | BEALE Air Force Base | Yuba |
| Langerwerf Dairy | 0.085 | | Yes | manure, 700 cows | Plug Flow/reciprocating engine | Durham | Butte |
| Sierra Nevada Brewing | NA | | | Food processing residues | anaerobic digestion + fuel cells | Chico | Butte |
| Biomass MW | 43.220 | 33.630 | | | | | |

## 2.7 Potential Uses for Biomass in the BMZ

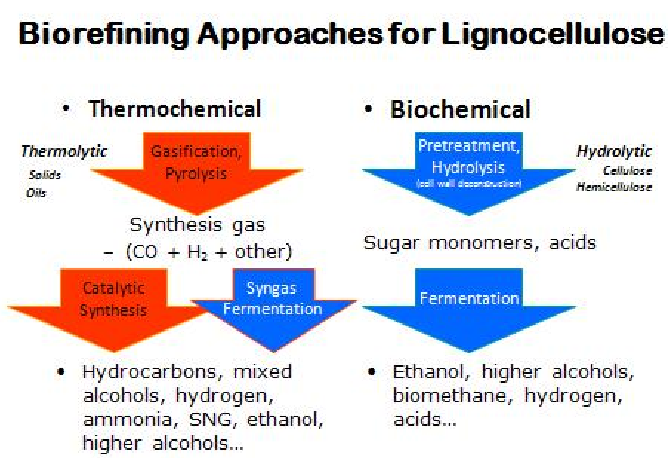
There are many types of conversion processes for biomass to energy. These can result in power, heat, liquid fuels of various types, and a range of other feedstock chemicals and useful residues. A diagram of an advanced, integrated combine cycle power facility is given in Fig. 2.13. Biopower systems are discussed in greater detail in Birdsall et al, (in-preparation). Liquid fuels of various kinds and chemical byproducts can be created through thermochemical and biochemical processes or combinations of them. Fig. 2.14 and 2.15 provide schematic diagrams of these types of processes.

**Figure 18: Schematic of an Integrated Gasification Combined Cycle (IGCC) Power Generation System**



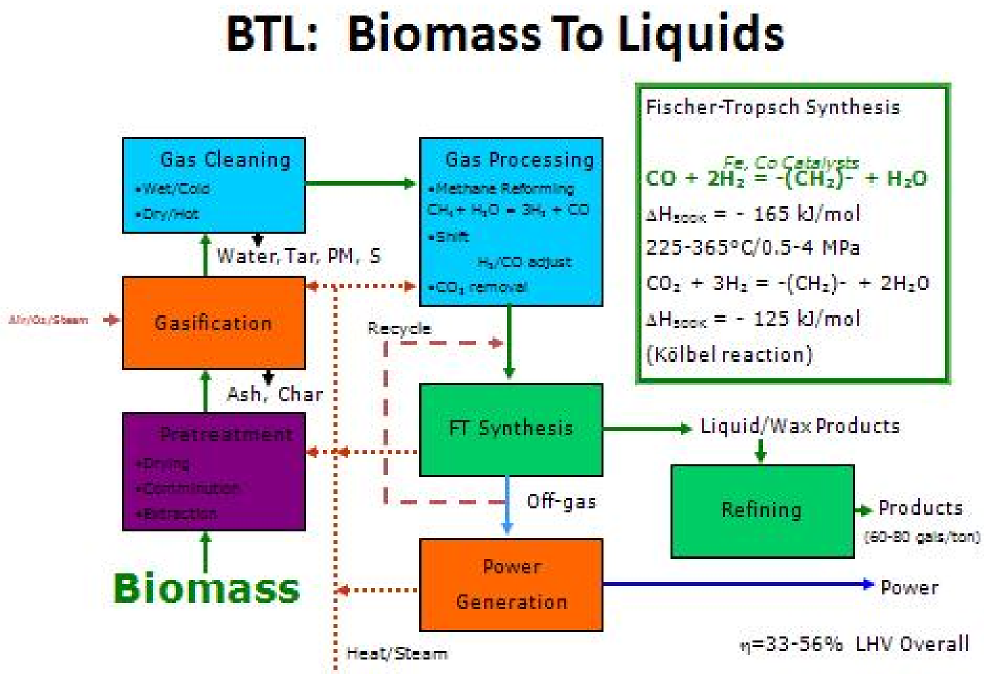

Courtesy of B. Jenkins.

**Figure 19: Different Pathways and Products for Conversion of Lignocellulosic Materials like Rice Straw and Wood**




Courtesy of B. Jenkins

**Figure 20: Biomass to Liquid (thermochemical) Processes**




These types of transformation technologies are the subject of a large amount of basic and applied research. None have reached the stage of reliable commercial operation.
Courtesy of B. Jenkins.

The most economic and carbon efficient technology or set of technologies for the BMZ considered here and for others as well is difficult to define. If biomass use for power and fuels increases in the future in this BMZ area, it will be the result of a combination of private entrepreneurial activity, public policy preferences, and private and public financial support. A number of companies are actively developing biofuel and biopower production strategies.

In Appendix, Table A-1, a list of companies using crop, wood and MSW biomass for fuel production is listed. These largely developmental processes have relevance for the types of biomass available within the BMZ. Emphasis has been placed in this analysis on the use of woody biomass from forests for power and rice straw for biogas production. But technology is constantly changing. Two commercial firms (KiOR, and Mascoma, Appendix Table A-1) are either currently using woody biomass for biofuel production or are about to begin construction on new facilities for this purpose. These firms may eventually provide a model for such use of woody biomass in California as well. Other companies intend to use MSW or agricultural residues for these purposes and may eventually have opportunities in the Oroville BMZ.

# Chapter 3: Technical and Social Issues

## 3.1 Principal Laws and Regulations Affecting Biomass Use and Transformation in the BMZ

Public policy has a profound effect on the availability and economic value of the use of biomass for power and fuels. In addition to the broader laws and regulations that govern the use of natural resources in both California and the US generally, there are a very large number of specific laws and regulations affecting the development and use of alternative energy. Because of their great diversity, sometimes conflicting focus or intent, and the novelty of new applications, these rules and regulations largely are not harmonized (Kaffka and Endres, 2011). A BMZ created to optimize the use of biomass for power and fuel will be affected by many different laws and regulations across a range of jurisdictions, from local to federal. A brief review is provided here. A comprehensive or systematic analysis of all such laws and regulations has not been attempted to our knowledge and is beyond the scope of this report.

The U.S. Department of Energy[61] has compiled a list (Table 40) of individual references to technology and other fuel incentive programs:

**Table 40: Count of Federal and State Programs Providing Incentives for Biofuels**

| | Biodiesel | Ethanol | Methane (CNG) | Propane (LPG) | Hydrogen (fuel cells) | Vehicles[1] | Fuel Economy | Other[2] |
|---|---|---|---|---|---|---|---|---|
| **Federal** | 31 | 29 | 25 | 25 | 27 | 38 | 13 | 19 |
| **State** | 408 | 399 | 334 | 266 | 254 | 473 | 55 | 171 |
| **Total** | 439 | 428 | 359 | 291 | 271 | 514 | 68 | 190 |

[1] *Electric vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles.*

[2] *Includes aftermarket conversion incentives, idle reduction technologies, and emerging fuel types and additional technologies.*
*Source: U.S. DOE.*

Although the overall number depicted in Table 40 is somewhat inflated by duplicate listings among the categories, and does not include local governments below the level of the state, the point remains that the landscape of bioenergy policies is highly populated and extremely varied.[62]

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[61] The U.S. Department of Energy (DOE) lists many federal and state incentive, tax and regulatory programs at a helpful website (http://www.afdc.energy.gov/afdc/laws/). Also, DOE, in conjunction with the N.C. Solar Center, N.C. State University, and the Interstate Renewable Energy Council, maintains a database of state and federal incentives and policies (http://www.dsireusa.org/).

[62] A single law or regulation may include more than one bioenergy provision such as a combination of incentives, technology mandates, and other regulations.

The development of a BMZ using diverse feedstock sources will have to reconcile laws and regulations that may have conflicting or overlapping provisions. Federal and state regulations provide both incentives and barriers to biofuel and biopower development that must be considered in the development of a BMZ. The most important omnibus laws affecting natural resource extractive activities like biopower and biofuel production include the National Environmental Policy Act (NEPA), the Clean Air Act, the Clean Water Act, US Farm Bill, and the Energy Independence and Security Act (EISA). For California these include the California Environmental Quality Act (CEQA), Porter-Colon Act, and the Global Warming Solutions Act (AB32). Only some of the most important biofuel and biopower laws are discussed here.

### 3.1.1 Federal: The Renewable Fuel Standard (RFS2)

Use of forestry residues, crops and crop residues for biofuels and heat and power has developed rapidly in the U.S. since federal energy bills emphasizing biomass were passed by Congress in 2005 (The Energy Policy Act)[63] and 2007 (The Energy Independence and Security Act (EISA).[64] These bills provide volumetric targets for blending of biomass-based transportation fuels and subsidies for the domestic manufacture of ethanol and biodiesel, with the objectives of promoting rural development, reducing foreign energy dependence, and decreasing the greenhouse gas footprint (GHG) of transportation fuels. The mandate, set in statute and by implementing regulations, calls for 36 billion gallons per year (bgy) of total renewable fuels by 2022.[65] A large proportion (16 bgy) should come from the kind of cellulosic sources common in the BMZ, like rice straw and woody biomass from forests. However, woody materials from federal forests, which are a large amount of total forestland in the BMZ (Table 14), are specifically excluded from use for biofuels. Some thinning for forest health is allowed, but it is unclear how this will be interpreted. So the federal law appears to restrict biomass access in the BMZ both in terms of area and potential energy generation. It is not clear if woody biomass from federal forests could be used to satisfy California's Low Carbon Fuel Standard (LCFS), which has no such restriction. The USEPA under EISA limits the land eligible to produce biofuel feedstocks in the United States to 402 million acres nationwide. In California, about 5 million predominantly cropland acres, or roughly 5 percent of the state are included in this definition.

In addition to the restrictions associated with federal regulation, the mandated amount of ethanol currently produced or anticipated equals or exceeds current and projected demand for ethanol as a component of gasoline in the U.S., at the current blending percentage maximum of 10 percent of gasoline. This limitation is referred to as the blend wall, and unless the percentage of ethanol allowed in motor fuels is increased, current and projected capacity mandated at the federal level works against investment in further ethanol production, mandated or not, simply because there will be no market for it. Stricter federal and California fuel economy standards

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[63] The Energy Policy Act of 2005, Pub. L. No. 109-58, 119 Stat 594 (Aug. 8, 2005).

[64] The Energy Independence and Security Act of 2007, Pub. L. No. 110-140, 121 Stat. 1492 (Dec. 19, 2007).

[65] The U.S. Environmental Protection Agency, *Regulation of Fuel and Fuel Additives; Changes to Renewable Fuel Standard Program; Final Rule*, 75 Fed. Reg. 14674 (Mar. 26, 2010) [hereinafter RFS2 Final Rule].

may also limit the amount of fuel needed, further lowering demand.[66] EPA recently finalized a rule increasing the blend limit to 15 percent.[67] But this increase has been contested by diverse interests and a lack of infrastructure for its sale limits it use.

An additional complication for biofuel suppliers is that under RFS2 regulations, EPA has the authority to suspend the annual mandated requirements for advanced and cellulosic fuels if supplies do not appear likely to be met domestically. This was proposed in 2011 for cellulosic biofuels as it is apparent that there will be insufficient stocks to meet the mandate of 500 million gallons in 2012.[68] EPA has proposed an overall volume range between 3.45 and 12.9 million gallons, much below mandated levels. In addition, blenders can purchase renewable energy credits (tracked through renewable identification numbers, or "RINs") for a default price if the price of ethanol is too high. These provisions were included in laws and regulations to protect fuel consumers from high prices, but introduce uncertainty for potential biofuel developers and investors.

There are also minimum standards for the greenhouse gas savings required of mandated biofuels in federal legislation. As a cellulosic source, rice straw or woody materials must meet a 60 percent reduction, while crops other than corn must meet a 50 percent reduction compared to petroleum fuels. The BMZ considered here does not account for purpose grown crops as feedstock sources. Rather rice straw and hulls, and tree and vine removals and prunings are included. These are not subject to the restrictions on land use or other greenhouse gas accounting penalties that crops must meet.

### 3.1.2 Federal: Biomass Crop Assistance Program (BCAP)

Potentially the most important subsidy from a crop production perspective is the USDA Farm Service Administration's (FSA) Biomass Crop Assistance Program (BCAP). FSA implemented BCAP throughout the later part of 2009 and early 2010, only to be halted pending finalization of a formal implementing rule. In late October 2010, the Commodity Credit Corporation (CCC) issued the final rule, with immediate resumption of implementation.[69] The program provides a "matching payment" of up to $45 for the price received by eligible material owners (EMOs) for the collection, harvest, storage and transportation of eligible biomass to qualified conversion facilities for use as heat, power, bio-based products, or biofuels. The use of biomass from forests, both public and private, is limited to prevent damage to sensitive environments and

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[66] National Highway Transportation Safety Agency, CAFE Overview-Frequently Asked Questions, http://icsw.nhtsa.gov/cars/rules/CAFE/overview.htm.

[67] EPA, Final Rule: Regulation to Mitigate the Mis-fueling of Vehicles and Engines with Gasoline Containing Greater than Ten Volume Percent Ethanol and Modifications to the Reformulated and Conventional Gasoline Programs (June 23, 2011), http://www.epa.gov/otaq/regs/fuels/additive/e15/mitigate-misfuel-e15.pdf.

[68] EPA, Proposed Rule: Regulation of Fuels and Fuel Additives: 2012 Renewable Fuel Standards (July 1, 2011), http://www.gpo.gov/fdsys/pkg/FR-2011-07-01/pdf/2011-16018.pdf.

[69] CCC, *Biomass Crop Assistance Program: Final Rule*, 75 Fed. Reg. 66202-66243 (Oct. 27, 2010) (codified at 7 C.F.R. Part 1450).

subject to interpretation by USDA-FSA locally. Also, no matching payments can be made for Title I crops (wheat, rice, corn, feed grains, oilseeds, pulses and cotton), for yard/food/animal wastes, municipal solid wastes, or algae. All BCAP-subsidized material must be produced according to a conservation or forest stewardship plan or the equivalent, and the regulation limits growing of invasive or potentially invasive species. The Biomass Crop Assistance Program (BCAP) has been used since 2009 to support the cost of biomass fuel acquisition for many of the state's biomass to power facilities.[70] Payments for woody biomass in diverse counties in California are reported in Table 12 above. These include counties within the Oroville BMZ. Many aspects of the final rule still require CCC and its advisors to provide further guidance. The BCAP Final Rule is not entirely consistent with RFS2, as RFS2 excludes biomass from federal forest lands categorically. In California, enrollment in the BCAP program to date has included many forest biomass suppliers, and most biomass has gone to power producing facilities. Electric vehicles using low carbon power comply with state regulations. If BCAP funds were used to secure biomass from federal lands, it is not clear if the use of electricity made from this biomass would be out of compliance. It is also unclear how long BCAP funds will continue to be available.

### 3.1.3 Federal: GHG Programs

Since the U.S. Supreme Court's decision in *Massachusetts, et al., v. EPA*,[71] EPA has pursued regulatory programs to reduce GHG emissions from mobile and stationary sources. In the absence of omnibus federal legislation, EPA has finalized rules under existing Clean Air Act (CAA) provisions including a stationary source "tailoring" rule.[72] EPA has delayed for three years a determination whether biomass combustion will be treated as carbon neutral under the program.[73] Policymakers must consider how to reconcile the GHG accounting and other sustainability aspects of energy biomass feedstocks between the RFS,[74] BCAP, and the CAA. It is difficult to imagine a straightforward way to do so without some form of net benefit analysis. Even so, some necessary tradeoffs will be incommensurate.

Implementation of the tailoring rule has been delayed while EPA reviews public comments. Biomass facilities in California that use urban wood wastes may combust painted or treated wood materials. Other forms of biomass are high in chlorine and produce acids on combustion. New standards included in the tailoring rule would be difficult for at least some of the existing biomass to energy facilities to control, and may lead to closure. This would have the adverse

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[70] http://www.fsa.usda.gov/FSA/webapp?area=home&subject=ener&topic=bcap

[71] 549 U.S. 497 (2007).

[72] EPA, *Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule*, 75 Fed. Reg. 31514-31608 (Jun. 3, 2010) (codified at 40 CFR Parts 51, 52, 70, and 71).

[73] EPA, Final Rule: Deferral for $CO_2$ Emissions from Bioenergy and Other Biogenic Sources under the Prevention of Significant Deterioration (PSD) and Title V Programs (July 1, 2011), http://www.epa.gov/NSR/documents/Biogenic_Deferral_pre-pub.pdf.

[74] http://apps3.eere.energy.gov/greenpower/financial/

effect of reducing the amount of electricity made from renewables in California. This issue remains unresolved and adds uncertainty for biomass developers within the BMZ.

In March of 2010, as part of its regulation of the Clean Air Act, USEPA issued rules affecting emissions from combustion systems that emit greenhouse gases, such that other pollutants subject to regulation must be considered and best available control technology (BACT) applied for their mitigation.

### 3.1.4 California: Low Carbon Fuel Standard (LCFS)

California has adopted the broadest and most aggressive state-level energy policies in the U.S. to date, including both mandates and other directed development of alternative energy and transportation fuels. The Global Warming Solutions Act (commonly known as Assembly Bill 32, or AB32) requires the state to reduce per capita $CO_2$ emissions over the next 40 year period from approximately 14 tons $CO_2$ equivalent ($CO_2e$) to 1.4, which equates to approximately a 90 percent reduction (CARB, 2008). Many strategies for GHG reductions through biofuels use are regulated under AB32. The main ones are highlighted below.

Under A.B. 32's mandate, the California Air Resources Board (CARB) has implemented the LCFS (CARB, 2010; Sperling and Yeh, 2009). It mandates an overall reduction in the carbon intensity (CI)) of transportation fuels by 10 percent in 2020, with increases in the incremental percent reduction progressively as the target date is neared. The rules governing the LCFS differ in important ways from the federal RFS2, thereby presenting fuel blenders with differing standards for compliance at the state and federal level

Because the LCFS is a performance standard, it provides a better opportunity to create biofuels within California than the RFS2, if such biofuels can be produced with lower carbon intensity than more traditional sources of biofuels like ethanol from corn grain and sugarcane. Biofuel producers using crop, forest or MSW residues may be able to produce ultra-low carbon biofuels with a market advantage and higher price in California than competing fuels. The lower a fuel's Carbon Intensity (CI), the higher its potential price because less will be needed to meet GHG reduction targets.

### 3.1.5 California: Renewable Portfolio Standard/Renewable Energy Standard/Feed-In Tariffs

Power made from biomass is renewable energy and is encouraged under California's Renewable Portfolio Standard (RPS). The RPS was established in 2002 under Senate Bill 1078, accelerated in 2006 under Senate Bill 107 and expanded in 2011 under Senate Bill 1X2[75] The RPS program requires investor-owned utilities, electric service providers, and community choice aggregators (CCA) to increase procurement from eligible renewable energy resources to 33 percent of total procurement by 2020. The California Public Utilities Commission (CPUC) and the California Energy Commission jointly implement the RPS program[76]. The RPS is a general

[75] (http://www.cpuc.ca.gov/PUC/energy/Renewables/index.htm).

[76] The CPUC's responsibilities include: 1.Determining annual procurement targets and enforcing compliance,2..Reviewing and approving each IOU's renewable energy procurement plan. 3. Reviewing IOU contracts for RPS-eligible energy. 4. Establishing the standard terms and conditions used by IOUs in

technology mandate, which specifies a desired outcome, but leaves electricity providers choice in how to meet it (Linn and Richardson, 2011). The CPUC predicts that biomass will become an increasingly less important source of alternative energy compared to other renewable sources[77].

A Renewable Energy Credit (REC) represents the environmental and renewable attributes of renewable electricity. A REC can be sold either "bundled" with the underlying energy or "unbundled", as a separate commodity from the energy itself, into a separate REC trading.[78]

The regulations governing RECs are still in development as of this writing. Morris (2009) has suggested that both avoided fossil energy emissions and avoided greenhouse gas emissions from alternative or (non) disposal pathways should be eligible for RECs. Such accounting mechanisms would improve the economic viability of biomass use for power.

### 3.1.6 California: Renewable Energy Standard[79]

The renewable energy standard was adopted by CARB in January 2012 and formally committed the state to using 33 percent of its electricity from renewable sources. All entities that deliver electricity must comply. The 33 percent target must be achieved by 2020. Biomass is a carbon neutral feedstock and biomass power helps meet the state's compliance goals. There is no specific mandate for biomass power, however.

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their contracts for eligible renewable energy. 5. Calculating market price referents (MPRs) for non-renewable energy that serve as benchmarks for the price of renewable energy. The California Energy Commission: 1. adopts regulations specifying procedures for enforcement of the RPS for publicly owned utilities, 2. certifies and verifies eligible renewable energy resources procured by publicly owned utilities and monitors their compliance, and when determined necessary, may refer the failure of a publicly owned utility to comply to CARB, which may impose penalties.

[77] http://www.cpuc.ca.gov/PUC/energy/Renewables/hot/RPS+Program+Update.htm

[78] From the CPUC website: In California, RECs are used to show compliance with the RPS, and they can be traded in voluntary markets. For the RPS, electric retail sellers must buy eligible renewable energy and its associated RECs to comply with the state RPS requirements. The California Energy Commission (CEC) tracks the RECs, and at the end of a compliance year, verifies how many RECs each retail seller has procured for compliance with the RPS. The CEC provides that information in an annual verification report to the CPUC, and then the CPUC determines whether a retail seller is in compliance with the RPS. The CPUC is considering whether to allow retail sellers to procure unbundled and tradable REC transactions for RPS compliance. If the CPUC were to allow these options, it could create additional flexibility for the regulated retail sellers to comply with the RPS. Market http://www.cpuc.ca.gov/PUC/energy/Renewables/FAQs/05REcertificates.htm ;http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/86954.pdf

[79] http://www.arb.ca.gov/energy/res/res.htm

### 3.1.7 California: Cap and Trade.

Cap and Trade regulations have been adopted by CARB.[80] Under cap-and-trade, an overall limit on GHG emissions from capped sectors will be established by the cap-and-trade program. Facilities subject to the cap will be able to trade permits (allowances) to emit GHGs. The program started on January 1, 2012, with an enforceable compliance obligation beginning with 2013 GHG emissions. In 2012, obligated parties must reduce their GHG emissions by 2 percent below those forecast for the year under business as usual. Requirements for further reductions continue each year. Large electricity providers and large industrial facilities are included in the initial list of affected emitters, including power facilities, some food processors, cement refineries and other businesses in the BMZ. Initial allowances have been provided free, but additional allowances must be purchased at auction in future years. CARB is attempting to maintain strict oversight and control of allowances to prevent adverse outcomes, including significant cost increases to consumers, as judged by the agency.

Carbon offsets are allowed under AB32 regulations to help meet RPS targets. These can equal as much as 8 percent of total yearly emissions. These are thought to reduce the overall cost of meeting Cap and Trade targets. A significant amount of offsets (up to 50 percent initially) may be derived from agreements between CARB and the states of Chiapas, Mexico and Ares, Brazil. For both domestic and foreign offsets, proof must be provided that forested areas otherwise would be developed or lost. Strict monitoring is required. In addition to this uncertainty, the acquisition of carbon offsets in foreign lands by California may exceed its authority under the US Constitution. This concern adds uncertainty to the effects of the program (Morris et al, 2011). It is unclear to what degree offsets could be acquired within the Oroville BMZ, especially forested areas. Fuel load reduction treatments that would not otherwise be economic may be possible through this pathway.[81] It would be worthwhile to evaluate that potential more explicitly in the future. Biomass energy facilities, waste to energy facilities, and waste water treatment facilities are excluded from Cap and Trade requirements if the fuel is reported to CARB and verified by them through the mandatory reporting requirement system. Other acceptable fuels (feedstocks) may include manure used in digesters, urban forest and other urban green waste biomass. Third party certification can be used to verify that fuels comply if accepted by CARB. Biomass derived fuels that are produced from lands used for offsets based on the storage of carbon in standing biomass cannot be used to meet Cap and Trade requirements. All biomass removed from forests must meet protocols established and accepted for California forest management practices, even for forests outside of California. Biomass management projects must reduce or prevent GHG emissions to the atmosphere by increasing or conserving forest carbon stocks.

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[80] http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm

[81] Recently, Winrock International has attempted to create a carbon registry that would account for changes in $CH_4$ emissions from rice fields based on changes in cultivation practices, estimated through the use of models. CARB has not yet decided about such values.

In addition to the RPS, California also has a Feed In Tariff (FIT) program.[82] FITs are a power generation subsidy. To encourage the generation of renewable energy, the state's FIT policy sets higher prices for alternative energy sources, especially for power produced during periods of peak demand. These higher prices are borne by rate-payers. California's program is designed to stimulate supply initially with high rates; these then decline with time under the assumption that technology becomes more efficient and prices decline. Biomass power facilities tend to operate continuously and thus contribute to baseload supplies. This makes them easier to integrate into regional power grids than more intermittent sources like solar and especially wind, but lowers the value of their power compared to systems that respond to peak demand.

Public policy currently seems to favor other forms of renewable energy than biomass, especially solar. Morris (2009) suggests that several policy changes are needed to increase the use of biomass for power. These include a specific target for bioenergy within the RPS, targeted credits for specific biomass feedstocks, broader distribution of renewable energy credits beyond the power generator, and an improved market for trading credits. New biomass power facilities are more likely to be sustained or created under an RPS than by using FITs, which favor lower cost renewables like wind. In general, RPS policies and FIT policies have contradictory outcomes (Linn and Richardson, 2011). This lack of policy harmonization is a barrier to greater use of biomass for power.[83]

The Oroville regional BMZ has the potential to produce 500,000 tons of annual woody biomass and post-recycling organic wastes potentially producing 96 MW of generation capacity. 43 MW of power are produced annually from two facilities within the BMZ (See Table 36). Post recycling MSW is subject to various laws and regulations which are summarized at the Cal Recycle website.[84] Currently, state regulations seek to promote recycling of most suitable materials in the urban waste stream. Post recycling organic residuals commonly are composted and used for landfill cover material or applied to farmland when possible. Some current regulations make it difficult to use these organic residues for other energy products like biofuels if they are created using thermochemical technology. Thermochemical facilities are held to a zero emission standard, unlike other transformation pathways. Increasingly, anaerobic digestion is being developed to convert these high moisture organic materials to biogas and residual products suitable for land application or use as fertilizer.

### 3.1.8 Sustainability Standards

Sustainability standards are used to require that the costs of biomass use properly acknowledge and account for effects that are difficult to price in current markets. The Federal Energy Independence and Security Act (EISA) and California's Global Warming Solutions Act (AB32) require that sustainability be considered. Apart from specific provisions to consider indirect land use change (Yeh and Sperling, 2009), sustainability provisions are left vague or are in the

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[82] http://www.cpuc.ca.gov/PUC/energy/Renewables/feedintariffssum.htm

[83] http://www.cpuc.ca.gov/NR/rdonlyres/B123F7A9-17BD-461E-AC34-973B906CAE8E/0/ExecutiveSummary33percentRPSImplementationAnalysis.pdf

[84] http://www.calrecycle.ca.gov/Laws/

process of development. Sustainability standards currently are in development for the LCFS with the help of an advisory work group.[85]

#### *3.1.8.1 Agricultural Standards*

To date, there are no formal sustainability standards required for agricultural producers in California. Arguably, however, California has the most aggressive standards for agriculture of any entity in the world. Programs for pesticide use and reporting, strict limits on the pesticides that can be used, water discharge restrictions from farms, wildlife protection at the state level similar to the endangered species act, and other rules and regulations mean that farmers in California already comply with the strictest standards that are contemplated in third party certification systems attempting to create common standards for farming nationally and internationally. There are a large number of third party efforts under development or in initial stages of implementation.[86] Compliance with third party standards developed outside California is not yet required for compliance within the state. Given California's aggressive regulatory environment, it is not clear what will be gained from compliance with such standards. The organic farming industry has nationally defined rules governing methods and relies on third party certification for verification. In more general terms, Kaffka (2009) has reported that sustainable feedstock production from agricultural crops and crop residues should be possible in California. Using a model developed by the CBC, (Kaffka and Jenner, 2011; Stoms et al., (2011) have evaluated the effects of possible biofuel crops on wildlife in California. No significant effects were identified.

#### *3.1.8.2 Forestry Standards*

California has a large and complex set of statutes and regulations that apply to the commercial harvesting of trees from timberland. The regulations are developed and adopted by CAL FIRE and subsequently administered by them.[87] This body of law addresses harvest levels and forest stand conditions, harvesting practices, reforestation, water quality maintenance, wildlife habitat, endangered species, soil erosion, hazard reduction, and cultural resources. Together

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[85] http://www.arb.ca.gov/fuels/lcfs/workgroups/lcfssustain/lcfssustain.htm

[86] Several of the better known groups or standards include: The Council on Sustainable Biomass Production, a voluntary third party group which focuses on the development of standards for the production of cellulosic biomass for energy http://www.merid.org/en/Content/Projects/Council on_Sustainable_Biomass_Production.aspx ;The Roundtable on Sustainable Biofuels (RSB) is an international, voluntary third party organization focused on the production, manufacture and distribution and trade of biofuels. "The RSB has developed a third-party certification system for biofuels sustainability standards, encompassing environmental, social and economic principles and criteria through an open, transparent, and multi-stakeholder process." http://rsb.epfl.ch/ ;The Leonardo Academy: "The objective of the sustainable agriculture standard-setting initiative is to establish a comprehensive, continuous improvement framework and common set of economic, environmental and social metrics by which to determine whether an agricultural crop has been produced and handled in a sustainable manner." http://www.sustainableagstandard.org/ A comprehensive website link is: https://sites.google.com/a/leonardoacademy.org/sustainableag-referencelibrary/guidance-documents

[87] http://www.bof.fire.ca.gov/

these rules embody concern for and provide a level of sustainability for the full suite of forest ecosystem values. Regulations are constantly being re-evaluated by the Board to assure proper protection of these values. The re-evaluation of regulations is required by the Forest Practice Act. The CAL FIRE Board receives input from interested public, industry, and academic sources on a constant basis. Each year the Board makes adjustments to the regulations based on the input it receives to improve protection of the State's natural resources.

Though there has not been a great deal of progress towards higher level of fuels treatment projects across the Sierra landscape, a body of scientific analysis supports the need for such work. This body of work has resulted in regulations and guidance documents with more refined recommendations for fuels treatments. For example the USFS Pacific Southwest Range and Experiment Station released *An Ecosystem Management Strategy for Sierran Mixed Conifers*.[88] This strategy provides criteria to guide the location and intensity of fuels treatments that are needed to reach a desired future forest condition. That future forest condition will vary by slope location, aspect, moisture regime, species composition and other factors. This type of analysis will have to be considered in adjusting the expectations of the biomass feedstock supply available from the forestlands within a BMZ that includes forestland.

Some work has been done on guidelines that are more specific for actual biomass harvests or fuels treatment projects. The CAL FIRE has recently adopted regulations for a Modified Timber Harvesting Plan that outline harvesting criteria for fuel hazard reduction that are considered to have less environmental impact and therefore the permitting requirements are more streamlined.[89] The Society of American Foresters has provided guidance on the development of specific forest stand conditions that increase wildfire resilience while maintaining ecosystem balance.[90] The USFS and Forest Guild have developed a guide for fuels treatment that considers past forest conditions and the management actions that will be conducive to attaining a desired future condition for a specific forest/watershed.[91] These policy and professional guidelines provide a base of information which may be useful in working with the variety of social and environmental interests in the development of a BMZ. Using these guidelines and standards provides transparency about the factors considered in developing the feedstock supply for a BMZ, along with the potential impacts and benefits associated with the harvesting/treatments necessary to produce the forest related biomass.

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[88] http://www.fs.fed.us/psw/publications/documents/psw_gtr220/psw_gtr220.pdf. This strategy provides criteria to consider the location and intensity of fuels treatments that are needed to reach a desired future forest condition. That future forest condition will vary by slope location, aspect, moisture regime, species composition and other factors as noted above. This type of analysis must be considered in adjusting the expectations of the biomass feedstock supply available from the forestlands within any BMZ that includes forestland.

[89] http://www.bof.fire.ca.gov/regulations/proposed_rule_packages/

[90] [http://www.treesearch.fs.fed.us/pubs/29739]

[91] http://www.forestguild.org/mixed_conifer.html

### 3.1.9 Federal and State Incentives

The USDOE compiles a list of federal and state alternative energy programs that can help fund development of new projects. This is the database of state incentives for renewable energy (DSIRE) website.[92] The California programs are rebates, tax incentives and performance standards. The state's Alternative and Renewable Fuel and Vehicle Technology Act (AB118) specifically supports the development of biomass feedstocks for fuels, and infrastructure development to support use of those fuels. It does this through grants and loan guarantees and may be one of the more promising state level programs helpful to the development of the BMZ considered here. Fuels can be liquid or gas, and electric powered vehicles supplied through renewable electricity sources also are supported.[93]

### 3.1.10 Carbon Registries

Several regulations affecting GHG emissions include accounting features that are used as carbon credits. Some of these are tradable and take on a market value. In general, carbon reduction credits must represent actual reduction in GHG emissions compared to some status quo or business as usual condition. They must not duplicate actions that may occur in any case due to other government requirements or mandates, and represent an extra reduction in GHG emissions due to actions taken by the project claiming the reduction, circumstance. For example, it is already necessary to recycle fractions of MSW in California, so claiming credits for that activity would not be allowed. Emissions reductions must be real, be able to be adequately quantified, and must be a permanent reduction in emissions. If all these criteria can be met, then carbon credits will have an economic value.

Carbon credits and carbon credit markets may provide a mechanism to help fund biomass to energy projects. In a sense, these credits embody some of the previously excluded costs of biomass projects, or any project to which they are applied. They are not synonymous with sustainability standards, but to the degree that sustainability standards also include practices which reduce carbon emissions, their objectives coincide.

The price of carbon credits varies, and reflects the costs associated with non-compliance in a regulated activity or industry. At some point, they may be sufficient to support biomass to energy projects that otherwise are uneconomic. Slow progress to date in developing biomass projects in California, despite encouragement in state policy reflects the influence of economic barriers. Compliance and certification costs may be large, depending on the project and the regulations governing the program, offsetting some of the gain from the sale of the credits. An example of a carbon credit scheme for forest biomass in the Tahoe Basin is discussed below under examples of recent BMZs.

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[92] Federal incentives are listed at: http://www.dsireusa.org/incentives/index.cfm?State=US&ee=1&re=1. State incentives are listed at:
http://www.dsireusa.org/incentives/index.cfm?getRE=1?re=undefined&ee=1&spv=0&st=0&srp=1&state=CA .

[93] http://www.energy.ca.gov/ab118/index.html

There is extensive debate in the economics and public policy literature around these issues. It remains unclear, whether carbon credits will be traded in a free market or will reflect the policy preferences of the agencies or organizations issuing them. The first Cap and Trade credits have been issued by CARB for free to the first industries to require them. CARB anticipates sales of credits in the future and a market in which credits can be traded.

## 3.2 Examples of BMZ Studies

Governance in California is complicated. Statutory and regulatory requirements exist at multiple levels of government. In addition, many non-governmental organizations, including *ad hoc* citizens groups that concern themselves with landscape related issues including biomass harvest and use. To create new business enterprises within the BMZ to generate biopower and biofuels, many local groups and organizations will need to participate. This complexity itself is a barrier to development of a BMZ, but some institutions and groups are focused on such tasks and they can help new enterprises navigate the difficult set of requirements that characterize business development in California. Several recent reports by community groups or organizations are summarized here as examples of public process essential for new project development.

### 3.2.1 Sierra Economic Development Corporation

The Sierra Economic Development Corporation (SEDC, 2008) published a regional biomass study focused on the Reno/Tahoe Basin. The focus of the study was "to address the barriers/constraints to "utility" scale and locally owned biomass power development, and lead to increased Bioenergy awareness through outreach in a two state region." This was accomplished first by creating a biomass inventory and carrying out some economic modeling to assess potential uses, and second by engaging local utilities and other affected or interested participants in discussion and planning for biomass power development.

Three biomass conversion technologies were identified as having potential in the unique air quality region formed by the Lake Tahoe basin: biomass-fueled microturbines, modular biomass gasifier power plants, and combined gasification/gas engine cogeneration plants.

Smaller scale units were judged to be more viable for the basin (the 0.5-3MW range, with interest in mobile facilities that might be moved to concentrated biomass resources). Even with the forests in the region supplying biomass, there was concern that biomass from forests alone would not provide sufficient supplies for more than three facilities, including existing ones. No project resulted from this effort but meetings with public identified public support and the need for more focused technical studies on technology development and feedstock logistics, and processes to facilitate development and permitting of any viable new facilities.

### 3.2.2 Yuba County Water Protection and Fire Safe Council and the High Sierra Resource Conservation and Development Council

The Yuba County Water Protection and Fire Safe Council and the High Sierra Resource Conservation and Development Council sponsored TSS Consultants to provide a detailed analysis of the potential for siting a Yuba County biomass power facility (TSS, 2010). This analysis coincides in part with the current BMZ definition. This analysis included site review and preliminary evaluation, assessment of potential fuel contributions from private industrial and public forests could be provided for a facility at lower elevations in Yuba County, costs estimates for delivered biomass, cost estimates for power produced based on a range of facility sizes, costs for facilities of different sizes, and a list of key project participants.

Five potential sites were ranked qualitatively, and an additional industrial site in Marysville was also evaluated. An approximately 50 mile radius was used in considering feedstock supplies. Initial focus was on fuel from forest operations, especially wood removed for fuel load reduction in forests, but to increase overall feedstock supplies, assessment of urban wood wastes, and biomass from orchards in the agricultural portions of the county were also estimated. Highly robust estimates of biomass feedstocks from all sources are reported in this analysis.

Similar to this BMZ evaluation, some initial qualitative assessment was required to evaluate biomass project feasibility, boundaries for the project were set based on *a priori* considerations, and the use of multiple feedstock sources quickly became evident as a preferred strategy. The lowest price fuels identified in the study were in fact derived from agricultural and urban wastes streams (TSS, 2010; pg 14, Table 3). These are largely readily available, especially compared to feedstock derived from forests. A serendipitous opportunity to cooperate with a commercial firm (Teichert Construction) with complimentary interests to site a biomass facility also became an important driver of the analysis.[94] This real world circumstance suggests that similar opportunities may trump strict analytical optima based on modeling in the actual development of projects in the future. The analysis suggested a small biopower facility in forested areas of approximately 2.75 MW, but a larger one (10 to 20 MW) combining multiple sources of feedstocks as discussed at the Teichert facility. Price estimates for construction and thresholds for price received were also reported in this analysis.

This report recommends additional steps to actually develop biomass power facilities in the Yuba County area. These include a more detailed feasibility study. Equally important were acknowledgements of the need to provide suitable and clear information to local jurisdictions, and state and federal regulatory entities, and community groups, careful analysis of site requirements and permitting (especially critical), and obtaining a power purchase agreement from an appropriate utility.

### 3.2.3 Placer County Air Pollution Control District

The Placer County Air Pollution Control District.[95] Placer County has recently estimated the economic benefits from forest biomass use for power in its part of the Sierra Nevada region. Placer County is attempting to meet the objectives of 1) reducing the risk large damaging wildfires, 2) improve air quality, 3) improve forest resilience, and 4) create economic

[94] Careful analysis of all feedstock sources within 50 miles of the Teichert location, suggested that an optimized fuel mix for such a facility would be derived from agricultural sources (approximately 40 %), urban sources, (30%) and forests (30%). Table 2-14, page 47.

[95] http://www.placer.ca.gov/Departments/CommunityDevelopment/Planning/Biomass/Grants.aspx .

opportunity from a previously underutilized resource. These objectives and the steps taken to meet them are consistent with those contemplated in this report for a BMZ. Placer County and the local Air Pollution Control District (APCD) initiated the effort to improve the use of forest biomass and has included a number of stakeholders and conducted an educational outreach to the public. It is currently completing work under Department of Energy, USDA and California Energy Commission grants for development of a biomass to energy project in the Tahoe Lake Basin. The county has been exploring the full range of requirements to install and operate a small combined heat and power (CHP) plant that will utilize biomass from wildfire fuel hazard reduction projects within the Tahoe Basin. This set of studies has been considered high priority due to significant national concern about the high wildfire risk within the basin (Angora Fire). Studies have been completed on the logistics of biomass, feedstock assessment, feasibility of a 1-3 MW CHP plant, air quality emissions and health effects, a protocol for determining air quality benefits of biomass utilization (including $CO_2$), and an environmental impact report for the proposed CHP plant. These studies will assist other areas in the state by setting out a series of technical steps required to determine if utilization of locally available biomass is economically and environmentally sustainable. Substantial effort has been invested in estimating social factors, including public outreach.

### 3.2.4 Biomass to Energy Project, California Energy Commission

Nechodom et al 2008 report on results from the California Energy Commissions PIER project (Biomass to Energy Project), the US Forest Service (USFS), the CAL FIRE and other groups and agencies to evaluate the state of forests and forest management in California and alternative pathways for management and use in the future.[96] This extensive analysis concluded that thermochemical processes yielding both ethanol and electricity would be economic based on the use of biomass thinned from forests for fire protection and residues from commercial activities at a cost of $45/BDT, a radius if 40 miles, and conversion efficiency of 50 percent of the carbon. This analysis focused on a 2.7 million acre region in Lassen, Plumas, Sierra, Shasta and Tehema Counties in northern California, encompassing the Feather River Basin. This is a large forestry-dominated BMZ that partially overlaps with the one discussed here. It was focused on woody biomass from forests. Treatments of both public and private lands were considered, with public lands yielding an average of 17 BDT/acre/year and private lands 30 BDT/acre/year. In the absence of treatment, approximately 66,000 acres per year were estimated to be lost to intense wildfires. Some of these results were summarized preliminarily in Jenkins, 2006.

[96] http://www.energy.ca.gov/2009publications/CEC-500-2009-080/

## 3.3 Common elements and concerns in BMZ studies

There are several common elements characterizing these BMZ studies:

- They involved the participation of multiple individuals, groups, non-governmental and governmental agencies. Most were originated within rural communities. Considerable care and attention was given to group process and documentation of activities, data review, and outcomes.
- Creative interactions and group learning are essential to success and must be emphasized. A rationally defined BMZ allows for groups and individuals to self-organize.
- Most studies concluded that large amounts of diverse biomass were available, and that if accessible in sufficient quantities, economically viable systems for collection, transformation and use were possible.
- All studies emphasize the vulnerability of large amounts of forest biomass to loss and the adverse ecological consequences of intense wildfire in the regions they study. It is reasonable to assume that there is a widespread consensus among knowledgeable and affected communities about the need for intervention and management in many forested regions in California to prevent senseless losses and ecosystem degradation.
- Additionally, all studies define and highlight employment gains in rural regions as an additional benefit of management.

Despite such consensus, no new energy projects have been developed in recent years apart from a repowering effort at an existing facility in Ione.[97] Access to woody biomass resources from publicly owned forests remains difficult despite consensus about the need to reduce wildfire risk, and obvious benefits from use of this surplus biomass, including greenhouse gas benefits. Uncertainty about public policies, at both the state and federal level, and declining prices for natural gas affect electricity prices and may make it difficult for new biomass to electricity or AD projects to compete under California's requirement for a market price referent that limits the amount that can be paid for power based on the price of natural gas which is used from much of California's power plants.[98] Alternative energy subsidies (Feed in Tariffs) for solar and wind power currently also are more generous than for biomass power, making for less incentive to develop new biomass facilities.

Many government agencies, diverse landowners, businesses, community groups and individuals must cooperate to bring about an effective, innovative biomass management strategy that most reasonably optimizes biomass use within the Oroville BMZ, consistent with public policy goals and constraints. Many of the most important organizations and agencies are listed in the Appendix Table B-1. The list is not complete.

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[97] http://www.energyinsight.info/woody_biomass_ione.html

[98] http://www.cpuc.ca.gov/PUC/energy/Renewables/mpr.htm

# CHATPER 4: Conclusions and Recommendations

## 4.1 Barriers to Biomass Use

Progress towards increased biomass use in-state production of biopower and biofuels, goals in Governor Schwarzenegger's executive order (S-06-060), has been modest. New objectives identified by Governor Brown include further increasing alternative sources of biopower and employment in the alternative energy sector. Nonetheless, in total amounts, less biomass is used currently than in recent years for biopower production, and little new domestic biofuel production from state-produced feedstocks is being created within the state (CEC, 2011; O'Neill and Nuffer, 2011). This assessment, like others, has identified abundant, diverse forms of biomass within the Oroville BMZ, but with varying accessibility. A number of factors act as barriers to biomass use for energy. These include dispersal of woody biomass and low energy density of all forms of biomass, compared to fossil sources of energy. New biomass transformation technologies are still developing and most promising technologies are not yet mature. The capital costs of new facilities that are first of a kind tend to be very large, creating an economic barrier to commercialization. But on the whole, policy and regulatory barriers may be more important contributors to cost.

Most biomass energy facilities currently operating in California were developed under provisions of the PURPA (1978) and related regulations. There has been no similarly effective program to stimulate the development of biomass energy since that time. Both the state and federal government have programs to encourage or mandate the use of renewable forms of power, and low carbon biofuels. But the number of laws, regulations and incentive programs is very large, creating both numerous incentives and obstacles. The state's Bioenergy Interagency Work Group, through the Biomass Action Plan (BAP), is working on streamlining regulation and coordination of state programs (O'Neill and Nuffer, 2011), but further progress is needed. There have been efforts to integrate programs to support biomass energy development and regulation among states. Multi-state organizations like the Western Governors' Association (WGA)[99] and NESCAUM, a non-profit organization set up to assist the northeastern states to comply with clean air regulations[100], attempt to provide adoption of regionalized goals for both alternative energy and landscape management. The WGA has important initiatives on forest health, water limitations, and bioenergy. These are largely analytical and voluntary. NESCAUM has a regionalized approach to creating a clean fuel standard, somewhat like California's LCFS.[101]

[99] http://www.westgov.org/

[100] http://www.nescaum.org/ Northeast States for Coordinated Air Management. New York, New Jersey, Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut,

[101] http://www.nescaum.org/topics/clean-fuels-standard

Still, the potential for legal conflict among different jurisdictions within the federal system of government in the United States has been demonstrated recently by a recent federal court ruling enjoining implementation of the LCFS.[102] The court held that the LCFS and the State of California violates the constitutional role of the U.S. Congress to regulate interstate commerce. Regardless of the merits of the suit, the decision, and its eventual resolution pending appeal and further litigation, regulatory uncertainty is created and becomes a significant problem for both technology developers and potential investors in biomass power and fuel production businesses. Having a single standard for biofuels does not in and of itself eliminate uncertainty. Within the federal alternative fuel standard (RFS2), mandates for fuel volumes are not absolute. The mandate for cellulosic biofuels has been reduced each of the first three years of its existence (NRC, 2011). Regulatory uncertainty in general inhibits investment and slows the development of useful biomass technology.

To help counteract these circumstances, the state of California has developed two Biomass Action Plans (BAP; O'Neill and Nuffer, 2011)[103]. The plans were created by the Bioenergy Interagency Work Group, with assistance from the California Biomass Collaborative. The Bioenergy Interagency Work Group (BIWG) includes participants from the state and regional agencies most concerned with biomass energy use[104]. These agencies use the workgroup to identify areas where regulations and agency actions can be harmonized to improve the sustainable use of biomass in the state. The most recent plan includes a number of objectives or actions that could help promote biomass use within the current BMZ. The *2011 Plan* identifies legislative and regulatory actions to facilitate permitting, support bioenergy development, support research and development of new technologies, increase use of organic material from waste streams, and preserve and create jobs in rural communities.

The importance of some of the key findings of the 2011 BAP are supported by this BMZ assessment:

- Biomass of diverse types is abundant;
- The use of biomass has diverse benefits, including many that have not been adequately quantified and incorporated into the price for bioenergy;
- Electric grid interconnection issues and the overall cost to collect and transport biomass feedstock remain economic barriers to the development of bioenergy projects in California;
- Regulatory uncertainty continues to reduce options to finance projects in the predevelopment stage, further inhibiting the development of bioenergy and other distributed energy projects; and

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[102] http://www.ascension-publishing.com/BIZ/LCFS-plaintiff-ruling-122911.pdf

[103] http://www.energy.ca.gov/2011publications/CEC-300-2011-001/CEC-300-2011-001-CTF.PDF

[104] Air Resources Control Board, California Energy Commission, California Public Utilities Commission, Cal Fire, CalRecycle, California Environmental Protection Agency, California Regional Water Quality control Board, State Water Quality Control Board, San Joaquin Valley Regional Air Pollution Control District, South Coast Regional Air Pollution Control District.

- Additional actions will be needed by the Working Group and the Legislature to streamline permitting for distributed energy projects. These are difficult challenges.

Progress to plan for the earlier version of the BAP on the more intransigent issues was limited (Orta et al., 2010).

Staff at the California Energy Commission (CEC, 2011) likewise have identified barriers to biopower adoption. These include fragmented or overlapping (redundant) licensing authority, different interpretations or standards for permitting, and unclear, duplicative and uncoordinated requirements for distributed generation projects. They include recommendations to address these and related issues. All efforts on the part of state agencies will be needed to overcome significant barriers to sustainable biomass use in the state. In effect, the broader regulatory system must evolve and adjust to new circumstances created by the need to address climate change and greenhouse gas reduction requirements now mandated by law.

The need for rationalized regulation is a profound challenge to governance, due to the complexity of existing regulation, the diversity of interests affected, and a lack of consensus about what is socially optimal. Contributing to a lack of consensus is complexity in properly identifying and valuing environmental and indirect social benefits from biomass use. Incorporating concern for GHG emissions does not make this problem easier because it is impossible to know with certainty how harmful future climate change will be. Not knowing, it is difficult to determine how much should be sacrificed economically and socially to moderate future damage. Most predictions, however, suggest that the state's forested ecosystems will be at greater risk of damage from fire and, insect pests and pathogens, making the need for long-term forest maintenance programs more, not less compelling.

## 4.2 Accounting for the Benefits of Biomass Use

While all alternative energy production facilities require or affect land, collection and harvest of biomass can affect landscapes at a larger scale through their alteration for production purposes. This is especially characteristic of agricultural landscapes (Kaffka, 2009), but landscape alteration also results from harvest practices in forestry that reduce biomass stocks and may alter ecosystem structure. These large-scale actions influence carbon emissions, water and nutrient cycles, and wildlife at a large scale. Resistance to the use of biomass for power and fuel reflects reluctance on the parts of some social actors to encourage additional productive use of the landscape (Stewart et al., 2011).

But landscape effects from resource use are not all negative from society's perspective. As discussed, there exists a consensus that fuel load reduction in Sierran and southern Cascade forests would have many beneficial environmental, economic and public health effects (Stewart et al., 2011; Morris, 2009; Nechodom et al., 2008). In this case, productive use and conservation objectives are usefully linked. Nevertheless, for the most part such forest treatments are uneconomic without integration with commercial harvesting (Fried et al. 2005), or are restricted from areas where need is greatest, like federal forests in California (Nechodom, 2008; North et al., 2008). Well-intentioned, inclusive and transparent efforts by citizen groups like the Quincy

Library Group to treat forests and preserve forest product industries and jobs in rural areas of California have met with a variety of obstacles, and so far proven unsuccessful.

New biomass transformation technologies may improve opportunities to use biomass. So too will recognition and improved valuation of the ecosystem services provided by prudent biomass use. TSS (2010) has estimated the tariff rate needed to support distributed power production from woody biomass in the Yuba County Region (relying on advanced gasification technology when it becomes commercially available) to be from $0.1025 /kWh to $0.13/kWh depending on whether or not an investment tax credit for facilities were available. Current electric power rates in California are closer to $0.05/kWh due to the low current cost of natural gas used for most in-state power production and for heating and cooking. For areas where access to biomass may be possible currently or in the near-term, Morris (2000) converted the cost of non-market based public goods into payments for green electricity from biomass in the state's existing biomass to power facilities. These were avoided fire prevention costs, loss of revenue from wood products lost to fire, and public health costs as part of a market price for such electricity. He estimated the value of non-power benefits from biomass use to be $0.0107/kWh in 1999 dollars. Depending on the range and type of benefits assumed, including social benefits, he asserted that even larger values could be justified.

The difference between the current market price of electricity and the cost of producing electricity from biomass provides an estimate of natural resource management costs that the public should support to reduce current GHG emissions and capture other public environmental goods. For example, Morris' estimates do not include the climate effects of $CH_4$ from biomass decomposition, black soot effects from fires, public health costs from smoke and soot from fires, impaired ecosystem services related to soil erosion, water supply, and wildlife habitat, changes in albedo and local climate effects, and other more recent concerns related to climate change. Morris' estimates need to be updated, and publicly available tools created for on-going assessment, since prices, costs, technology, and policy preferences change constantly. Properly accounting for such benefits should facilitate the creation of supportive and aligned public policies. Transparency of the models, tools and assumptions used supports public confidence.

A new environmental benefit identified here within the Oroville BMZ is the potential to reduce $CH_4$ emissions from current rice production practices. AD can be used to capture methane from rice straw fermentation, instead of allowing fugitive emissions from similar, uncontrolled decomposition processes in rice fields. But doing so is expensive initially. Costs can only be partially compensated from energy and by-product sales. The difference can be considered the cost associated with capturing other environmental benefits like reduced natural gas use and fewer harmful GHG emissions.

Biomass use will not always remain uneconomic compared to fossil sources. As the price of fossil fuels increases, the cost to the public of the broader set of benefits associated with biomass should decline. The cheaper the cost of fossil energy, the larger the difference in cost becomes between the current economic value of biomass energy and the cost of correlated ecosystem services. Currently, the cost difference between biomass energy and fossil alternatives remains large. But as the efficiency of biomass transformation improves, biomass energy costs will further decline as well. An incentive structure that promotes such improvements in biomass transformation efficiency, allowing public costs for alternative power and fuel to decline as improvements are achieved, would increase biomass resource use. This would only work if feedstock costs are stable or decline and if regulatory costs for transformation costs do not increase. Both circumstances have affected the older biomass to power facilities present in California.

For the most part, the prices received for avoided GHG emissions have not been sufficient to stimulate significant adoption of new technological approaches to biomass use. Methane is assigned a global warming potential that is 25 times more potent as a greenhouse gas than $CO_2$, however. Some (O'Hare et al., 2009) have argued that more immediate emission reductions are more valuable than longer term emission reductions in combating climate change. $CH_4$ is shorter lived in the atmosphere than $CO_2$, but more potent as a warming agent. Focusing on reducing methane emissions may have a greater benefit than equivalent $CO_2$ emission reductions. As judgment about the true cost of increasing $CO_2$ in the atmosphere improves, the value of GHG reduction measures can be more accurately priced.

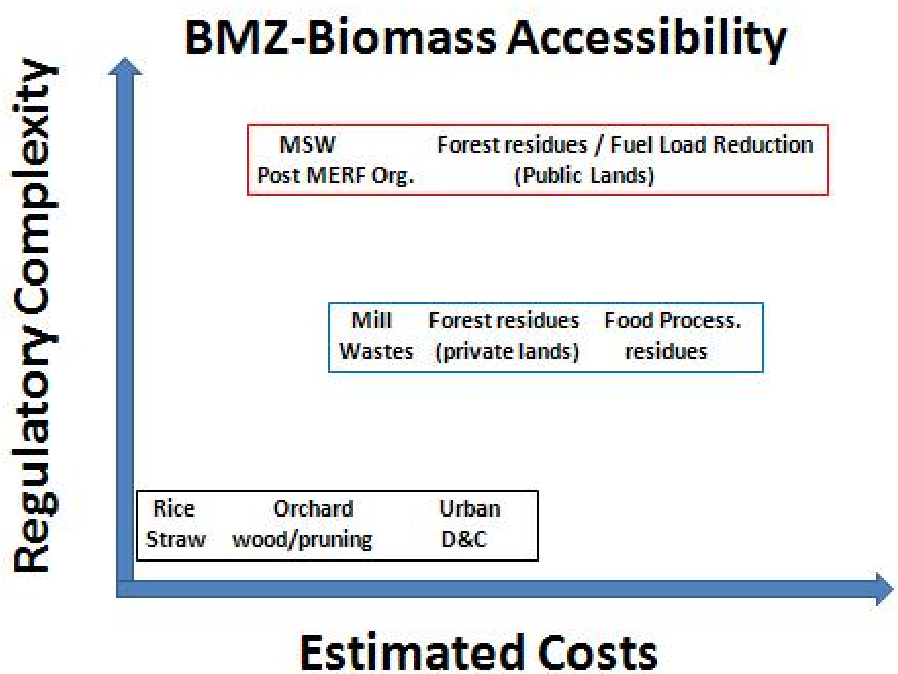
It is clear from the accounting done here, that abundant biomass resources are present within the Oroville BMZ. This is similar to previous assessments at a larger scale carried out by the CBC, but here with greater local detail. Other recent BMZ assessments in the same region discussed above come to similar conclusions. Biomass is abundant and diverse, and current or future potential biomass supply does not limit project development for the most part. Economic costs are inseparable from the nature of biomass. Low energy density and dispersed supply are barriers that make it expensive to use. So also are a long list of laws and regulations that are insufficiently harmonized. Unstable regulations and legal activity affecting regulation inhibit investment (Fig. 4.1).

To bring about more efficient biomass use, it is essential that the environmental and employment benefits of energy projects be better quantified and fully accounted for at all levels, including the policy level. There are important environmental and other public benefits from biomass energy projects that justify higher costs for power or fuels. Knowledge that using green power directly saves forests, or that using biogas captured from rice straw is an effective intervention in climate change processes, will help the public justify such expenses.

The most readily available biomass within the Oroville BMZ is from agricultural and urban sources. Some forestry biomass is available, especially form private lands, but access to surplus biomass on public lands is limited and therefore costly. Integrated biorefineries suited to the use of the most accessible forms of biomass could be developed and increased in scale with time as more diverse types and larger amounts of biomass become available. An incremental strategy of this kind could help stimulate biomass use within the BMZ. Creating a biorefinery that includes more than one transformation technology or which produces multiple types of energy and bio-products, is technically challenging, but should be encouraged in policy, and through incentives.

The state's LCFS and the federal RFS2 encourage the use of biomass for fuel production, but the state's RPS could better emphasize the use of biomass as means of meeting that standard. The use of biomass for fuel is more valuable than for power under current market conditions, but policy affects the values at which each end use of biomass will be most economic. The site-specific character of biomass also must be accounted in policy. For isolated biomass sources like some forestry residues, it may be more economic to create power than fuel, despite lower potential revenues for power. How to integrate the specificity of landscape conditions, biomass supplies, and biomass transformation options is an important topic for state agencies and the Bioenergy Interagency Work Group, among others to address.

**Figure 21: Accessibility of Different Types of Biomass within the BMZ**




Costs for biomass harvest and concentration and low biomass energy density, together with constraints on access due to regulation and statute, interact to reduce effective access to biomass resources and increase their costs.

## 4.3 The Value and Uses of a BMZ

A BMZ is useful for several purposes. One is to estimate the biomass potentially available within a rationally-specified area. A BMZ must first be based on the biogeography of the landscape, accommodated to the social infrastructure, including roads, power lines, cities and existing biomass-based businesses. Together, biomass supply and social infrastructure form the first levels for organization of a BMZ and the most important limitation on the development of new biomass-based energy supply. Once it becomes clear, however, that sufficient supplies of biomass are available within a region to support bioenergy enterprises, then policy related constraints become the dominant factor in the development process.

The state's policies commit it to seek ways to reduce society's generation of excess GHG. Within a BMZ, beneficial uses of potentially available biomass can be identified, and estimates of GHG balances associated with their use calculated. If biomass use helps achieve this goal, or is at least neutral, then concern for emissions of pollutants must next be evaluated. Current non-use or status quo policies also have correlated GHG and pollutant emissions. The two examples identified in the Oroville BMZ were various forms of pollution from wildfires, and methane emissions from rice fields, but others occur as well. If emissions from new biomass uses improve upon those generated currently from landscapes and management processes, or are at least neutral, then the BMZ can be used to identify additional positive environmental and social benefits that could be achieved with increased biomass use for energy. These might include preservation of the ecological values of forests within the Oroville BMZ, protection of property from fire, and increased opportunities for employment and development of wealth and desirable infrastructure within the BMZ.

The state's AB118 program provides economic support for innovative projects focused on transportation fuels and related infrastructure. There are federal loan and grant programs that also are available in California, as noted above. But the availability of funds does not address the regulatory and other policy issues that inhibit biomass energy project investment, either directly or indirectly by increasing uncertainty and raising the costs for projects.

Local or regional resource agencies have been active participants in planning for biomass use. What has been missing currently or ineffective is an active role of state government to facilitate the development of biomass energy businesses. Older laws and regulations helped create the state's biomass to power industry in the 1970s and 1980s, but there has been no similarly effective state-level policy since. Regulatory requirements at both the state and federal level have increased, however, making new, equivalently dramatic levels of development of biomass energy in the state more expensive and difficult (Birdsall et al, in preparation). Alignment of state alternative energy targets with policies that allow the higher cost of biomass energy to be met are another critical part of achieving more biomass energy use within any BMZ (Morris 2009; 1999). This can be done in part by including the economic value of non-market based costs associated with current management of biomass resources. In the Oroville BMZ, this would include fugitive emissions of methane from rice fields and public health costs from larger-scale wildfires, among others.

A BMZ can be the basis for implementing new models for governance by using it as a case study for community/government interaction organized around achieving community goals for local biomass energy businesses. Because the character of any BMZ is shaped by biogeography and existing social infrastructure, each BMZ provides a separate instance or case study for adapting governance to the need for increasing beneficial biomass uses. Community-based processes are essential to identifying which resources are most readily available within a BMZ, where development of projects may be most advantageous, and to a degree, the most important environmental and social values to be preserved as projects develop.

A landscape-based learning and development community, focused on a rationally defined BMZ will best be able to achieve a harmonized vision for new biomass uses in a BMZ. Supportive participation by state agencies in these processes is essential. State agency participation must be focused on providing creative solutions to the regulatory obstacles that appear to have inhibited development so far. The Bioenergy Interagency Work Group (BIWG) provides one mechanism for improved coordination among resource and regulatory agencies, and the new BAP provides some goals or benchmarks against which to measure progress towards this goal. The BMZ described here could be a useful case study for the BIWG to use to identify additional facilitative roles useful for local BMZ applications. It could work with local BMZ community groups focused on project development in a collaborative, learning rich process. The benchmark for success will be the construction and successful commercial operation of biomass energy businesses within the BMZ. Overcoming the legacy of failure for many such recent efforts in California should be the outcome. This kind of participation by government may require some rethinking of current ideas about regulation and governance. This is best done within the context of case studies on biomass energy development, including the Oroville BMZ, by identifying and reviewing specific regulatory or statutory obstacles to local project development.

Examples of supportive action by the state are the recent completion of a Programmatic Environmental Impact Report EIR for municipal solid waste anaerobic digesters[105] and for dairy digesters[106]. These EIRs were not discussed in detail in the current BMZ analysis because dairy farming is not a large biomass source within the current BMZ. There are three municipal wastewater treatment facilities (WWTF) digesters in the BMZ. Similarly, a recent announcement of a new forest planning rule[107] for federal forests that will rely on local assessment and includes consideration of multiple landscape functions has emphasized participation by local groups and site-specificity. There is abundant biomass on public forest lands within and near the Oroville BMZ defined here.

More recently, the Office of the President has announced an effort to modify and reinvigorate the National Environmental Policy Act (NEPA) in ways that, in part, will allow more rapid implementation of another newly announced plan by the USFS called the Programmatic Impact Statement.[108] This plan establishes an adaptive management strategy that uses public involvement, learning and consultation to create unique management plans suited to diverse locations .[109] Modification of the NEPA and forest planning are integrated efforts and provide an example of public processes that may lead to improved biomass use. Some examples f

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105 http://www.calrecycle.ca.gov/swfacilities/Compostables/AnaerobicDig/PropFnlPEIR.pdf

106 http://www.calrecycle.ca.gov/swfacilities/Compostables/AnaerobicDig/DairyDigDEIR.pdf

107 http://www.fs.usda.gov/planningrule ; http://www.fs.usda.gov/main/planningrule/101

108 Final Programmatic Environmental Impact Statement, National Forest System Land Management Planning, January 2012. US Forest Service. See: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5349141.pdf

109 Final Programmatic Environmental Impact Statement, APPENDIX I – MODIFIED ALTERNATIVE A. See: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5349156.pdf

progress already achieved under initial USFS efforts is contained in a USFS November, 2011 report.[110]

Using biomass for energy and related by-products is disruptive. It may disrupt or supplant uses for some biomass currently supplied to existing markets, but also potentially to the ordered relationships that have led to current regulations, formed for different objectives and under assumptions of public goods identified before the state's adoption of GHG reduction policies. Local, landscape-based learning processes (community groups) supported by appropriate technical analyses related to the multi-functionality of landscapes, and actively supported by appropriate state agencies are needed to help create beneficial biomass energy projects with multiple levels of benefits. BMZs will differ from each other in many ways, but each will need similar types of engagement across all levels of community and government.

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[110] People Restoring America's Forests: A Report on the Collaborative Forest Landscape Restoration Progra. Collaboratively developed by the CFLRP Coalition Steering Committee and the USDA Forest Service. November 2011. See: http://www.fs.fed.us/restoration/CFLR/index.shtml and

http://www.fs.fed.us/restoration/CFLR/documents/CFLRPAnnualReportNov2011.pdf

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# APPENDIX A:
# Table 1: Companies Creating Biofuels

**Table A-1: Companies creating Biofuels from Woody Biomass and MSW**

| Company | Location | Feedstock | Conversion Technology | Product | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|
| Amyris | Emeryville, CA | Sweet Sorghum | Biochemical | Drop-in fuel | 0.02 | 1.02 | 27.02 | 27.02 | 27.02 |
| Mascoma | Rome, NY | Switchgrass, Woody Biomass, Ag waste | Biochemical | Ethanol | 0.2 | 0.2 | 20.2 | 20.2 | 20.2 |
| Coskata | Green County, AL | Woody Biomass | Biochemical | Ethanol | 0.05 | 55.05 | 55.05 | 55.05 | 55.05 |
| Cobalt | Sausalito, CA | Woody Biomass | Biochemical | Drop-in fuel<br>Biobutanol | 2.01 | 102 | 102 | 102 | 102 |
| Terrabon | Bryan, TX | Woody biomass, sweet sorghum | Biochemical | Drop-in fuel | 0.1 | 1.25 | 5 | 25 | 25 |
| American Process | Alpena, MI | Woody | Biochemical | Ethanol | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 |

| Company | Location | Feedstock | Conversion Technology | Product | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|
| | | Biomass | | | | | | | |
| BlueFire Renewables | Lancaster, CA | Woody Biomass | Biochemical | Ethanol | 3.91 | 3.91 | 22.91 | 22.91 | 22.91 |
| Buckeye Technologies/UF | Perry, FL | Woody biomass, Sugarcane | Biochemical | Ethanol | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Haldor Topsoe | Des Plains, IL | Woody Biomass | Thermochemical | Drop-in fuel | 0 | 0.8 | 0.8 | 0.8 | 0.8 |
| HCL Clean Tech | Durham, NC | Woody Biomass | Biochemical | Ethanol | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Logos Technologies | Visalia, CA | Switchgrass, corn stover, woody biomass | Biochemical | Ethanol | 0 | 0.8 | 0.8 | 0.8 | 0.8 |
| Murphy Oil | Hereford, TX | Organic based MSW | Biochemical | Ethanol | 0 | 115 | 115 | 115 | 115 |
| Trenton Fuel Works | Trenton, NJ | Organic based MSW | Biochemical | Ethanol | 0 | 0 | 0 | 3.87 | 3.87 |

| Company | Location | Feedstock | Conversion Technology | Product | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|
| Virent | Madison, WI | Sugar beets, corn stover, sugarcane, woody biomass, switchgrass | Thermochemical | Drop-in fuel | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| IneosBIO | Vero Beach, FL | Organic based MSW | Gasification-Fermentation | Ethanol | 8 | 8 | 8 | 8 | 8 |
| Powers Energy | Lake County, IN | Organic based MSW | Gasification-Fermentation | Ethanol | 0 | 0 | 160 | 160 | 160 |
| ZeaChem | Boardman, OR | Woody Biomass | Gasification-Fermentation | Ethanol | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| ThermoChem Recovery (TRI) | Durham, NC | Woody Biomass | Thermochemical, Fischer Tropsch | Drop-in fuel | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Rentech | Rialto, CA | Woody biomass, corn stover, straw, bagasse, organic MSW | Thermochemical, Fischer-Tropsch | Drop-in fuel | 0.15 | 0.15 | 8.15 | 259 | 259 |
| REII | Toledo, OH | Woody biomass, rice hulls, | Thermochemical, Fischer-Tropsch | Drop-in fuel | 0.02 | 0.35 | 0.35 | 0.35 | 0.35 |

| Company | Location | Feedstock | Conversion Technology | Product | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|
| | | corn stover, straw, switchgrass | | | | | | | |
| Clearfuels | Not specified, HI | Bagasse, Woody biomass | Thermochemical, Fischer-Tropsch | Drop-in fuel | 0 | 0 | 0 | 0 | 18 |
| Clearfuels | Commerce City, CO | Woody biomass, corn stover, bagasse | Thermochemical, Fischer-Tropsch | Drop-in fuel | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 |
| Clearfuels | Collinswood, TN | Woody biomass | Thermochemical, Fischer-Tropsch | Drop-in fuel | 0 | 0 | 0 | 20 | 20 |
| Fulcrum | Reno, NV | Organic MSW | Thermochemical, gasification | Ethanol | 0.01 | 10.51 | 10.51 | 10.51 | 10.51 |
| KiOR | Columbus. MS | Woody Biomass | Thermochemical, pyrolysis | Drop-in fuel | 0.23 | 0.23 | 80 | 80 | 120 |

DATA SOURCE: modified from Biofuel Digest (2010).

# APPENDIX B:
# Table 2: Important Organizations and Agencies

**Table B-1: Important Organizations and Agencies**

| | | |
|---|---|---|
| **Forest Landowners and Managers** | | |
| Sierra Pacific Industries | http://www.spi-ind.com | The firm owns and manages nearly 1.9 million acres of timberland in California and Washington, and is the second largest lumber producer in the United States. |
| Soper Wheeler Timber Company | http://www.soperwheeler.com/ | Soper-Wheeler Company was the first California timber company to practice sustainable forestry. They manage 97,000 acres of forestland in ten California counties |
| The CHY Co. | http://www.afmllc.com/ | The CHY Company. In addition to managing CHY's lands in Butte, Placer, Plumas, Santa Cruz, and Yuba counties, AFM provides a full range of professional forestry services to many clients throughout California and the western United States. |
| Siller Brothers | None listed | Siller Brothers, Inc. in Yuba City, CA is a private company categorized under Logging Camps and Contractors. It was established in 1954 and incorporated in California. |
| Lassen National Forest | http://www.fs.usda.gov/lassen | |
| Plumas National Forest | | |
| Tahoe National Forest | http://www.fs.usda.gov/tahoe/ | |
| **Agencies/Boards/Other** | | |
| Cal Fire FRAP | http://frap.cdf.ca.gov/ | |
| State Water Resources Control Board | http://www.swrcb.ca.gov/ | |
| California Air Resources Board | http://www.arb.ca.gov/homepage.htm | |

| | | |
|---|---|---|
| California Public Utilities Commission | http://www.cpuc.ca.gov/puc/ | |
| Community Choice Power Aggregation | http://apps3.eere.energy.gov/greenpower/markets/community_choice.shtml | Community Choice Aggregation (CCA) enables California cities and counties – or groups of cities and counties – to supply electricity to the customers within their borders. |
| California Department of Food and Agriculture | http://www.cdfa.ca.gov/ | |
| California Energy Commission | http://www.energy.ca.gov/ | |
| US Forest Service | http://www.fs.fed.us/ | |
| Natural Resources Conservation Service | http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/home | |
| USDA Farm Service Agency | http://www.fsa.usda.gov/FSA/webapp?area=home&subject=landing&topic=landing | |
| US Army Corp of Engineers (404d permits) | http://www.usace.army.mil/ | |
| US EPA (including region 9) | http://www.epa.gov/ | |
| Resource Conservation Districts | http://www.carcd.org/home0.aspx | |
| UC Cooperative Extension | http://ucanr.org/ | |
| California Biomass Collaborative | http://biomass.ucdavis.edu/ | |
| **Jurisdictions** | | |
| County of Glenn Air Pollution Department | http://www.countyofglenn.net/govt/departments/air_pollution/ | |

| | | |
|---|---|---|
| Butte County Air Quality Management District | http://www.bcaqmd.org/ | |
| Feather River Air Quality Management District – Yuba and Sutter Counties | http://www.fraqmd.org/ | |
| Colusa County Air Pollution Control District | http://www.colusanet.com/apcd/ | |
| Northern Sierra Air Quality Management – Plumas County | http://www.myairdistrict.com/ | |
| **County Regional Fire Districts** | | |
| Plumas County Fire Safety Council | http://plumasfiresafe.org/ | |
| Yuba County Fire Agencies | http://www.fraqmd.org/contacts.htm | |
| Sutter County Fire Services | http://www.co.sutter.ca.us/doc/government/depts/cs/fs/cs_fire_services | |
| County of Glenn Fire Protection District | http://www.countyofglenn.net/govt/committees/committee_view.asp?group_id=53 | |
| **Water Districts and Agencies** | | |
| Yuba County Water Agency | http://www.ycwa.com/ | |
| County of Glenn Water Advisory Committee | http://www.glenncountywater.org<br>/ | |
| Butte County Water and Resource | http://www.buttecounty.net/Water%20and%20Resource%20Conservation.aspx | |
| Sutter County Water Resources | http://www.co.sutter.ca.us/doc/government/depts/pw/wr/wrhome | |
| Plumas County Water District | http://www.countyofplumas.com/index.aspx?nid=230 | |

| Non-Profit Groups | | |
|---|---|---|
| California Rice Commission | http://www.calrice.org/ | |
| Butte Fire Safe Council | http://www.firesafecouncil.org/find/view_council.cfm?c=10 | The Fire Safe Council provides resources for establishing and maintaining local Fire Safe Councils, such as the FSC Handbook, nonprofit and funding information. |
| Oroville Community Association | http://stateconservation.org/california/?q=r&id=14500 | Mobilizing Californians to protect their homes, communities and environments from wildfire. |
| Oroville Enterprise Zone | http://www.cityoforoville.org/index.aspx?page=82 | |
| Sierra Nevada Conservancy | http://www.sierranevada.ca.gov<br><br>/ | Sierra Nevada Conservancy initiates, encourages, and supports efforts that improve the environmental, economic and social well-being of the Sierra Nevada Region, its communities and the citizens of California. |
| Yankee Hill Fires Safe Council | http://yankeehillfiresafe.org/ | To educate the community and increase awareness to fire risks; reduce wildfire fuel loading, conserve natural resources, participate in fire recovery efforts, and prepare for other disasters. |
| Yuba Watershed and Fire Safe Council | http://www.co.yuba.ca.us/firesafe/ | The Yuba Watershed Protection and Fire Safe Council is a community-based group consisting of concerned citizens and local, state and federal fire professionals working together with County Government, law enforcement, professional foresters, local timber farming companies and resource conservation groups. |
| **Utilities/Other Energy Providers** | | |
| PG&E | http://www.pge.com/ | |
| SMUD | https://www.smud.org/en/index.htm | |
| Waste Management Inc. | http://www.wm.com/index.jsp | |
| Covanta Power Oroville | http://www.covantaenergy.com/ | |

| Planning Efforts/Collaborative Groups/ Partnerships | | |
|---|---|---|
| Quincy Library Group | http://www.qlg.org/ | Advocating sustainable resource management for forest health and community stability in the Feather River Watershed and surrounding areas. |
| Sierra Cascades Dialog | http://www.fs.fed.us/r5/SierraCascadesDialog/overview/ | The dialog will focus on the future of the Sierra Nevada and Cascades, with a focus on the national forests in these regions. Dialogs provide an opportunity for learning, shared meaning, aligned actions, mutual respect and understanding different perspectives. |
| Sierra Nevada Conservancy | http://www.sierranevada.ca.gov/ | Sierra Nevada Conservancy initiates, encourages, and supports efforts that improve the environmental, economic and social well-being of the Sierra Nevada Region, its communities and the citizens of California. |
| High Sierra Resource Conservation and Development Council | http://www.highsierrarcandd.org/ | The High Sierra RC&D Council will provide regional leadership and assistance to communities to strengthen the local economy, rural heritage, and the conservation and management of our natural resources. |
| Sierra Economic Development Corporation | http://www.sedcorp.biz/ | SEDCorp's mission is to alleviate unemployment and underemployment by expanding industrial resource and small business development while preserving the quality of life in the Sierra Nevada foothills. |