NONYARD WOOD WASTE REPORT

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EXECUTIVE SUMMARY

The nonyard wood waste study was developed in an attempt to answer three basic questions regarding nonyard wood waste and the resulting effects of diverting it from permitted disposal facilities. The three issues involved quantifying the amount of nonyard wood waste diverted from permitted disposal facilities, assessing the economic implications of promoting or discouraging diversion, and assessing the environmental impacts. Following the conclusions made from this study, recommendations could be made regarding the California Integrated Waste Management Board's (CIWMB) position on whether to encourage or discourage the diversion of nonyard wood waste from permitted disposal facilities.

In order to accomplish the first task, quantifying nonyard wood waste diversion, the term "nonyard wood waste" needed to be defined. As the term has not been used in the past, a working definition needed to be developed for this report. For the purposes of this report, nonyard wood waste has been defined along the lines of urban wood waste which includes pieces of wood generated during the manufacture or processing of wood products, the harvesting or processing of raw woody crops, as well as the wood debris from construction and demolition activities.

An additional aspect that made quantification difficult was the fact that the major avenue for reuse of wood waste, other than disposal, was as fuel for biomass facilities. This introduced a barrier because biomass facilities are considered transformation facilities under Section 18720(a)(77) of Title 14 of the California Code of Regulations. However, biomass facilities are not permitted as solid waste facilities under the CIWMB. This means that waste currently going to biomass facilities is not considered diversion from permitted disposal facilities yet biomass transformation is also not considered disposal at a permitted facility. If the wood waste is not being diverted, it technically should not be considered for discussion within this report. However, for the purposes of this report, biomass facilities are considered diversion and discussed in this report. Biomass facilities should be assessed in this report because they are the largest market outside of disposal and represent the largest future market that will reduce loadings to landfills.

Another factor that makes the biomass industry a critical aspect of this report is the potential future loadings to landfills that the industry represents. The biomass industry is currently in a transitional period. Many biomass facilities are enjoying a relatively high rate of return for the energy they produce as a result of long term contracts that were negotiated in the mid-

1980s. Due to this rate of return, many facilities have remained profitable during a time when retail energy prices are below the biomass facility's cost of producing energy. The eleventh year of the energy contracts represents a point of renegotiation and all the biomass facilities will have reached their "year eleven" by the end of the 1990s. The "year eleven" renegotiations, and inevitable loss of income, in conjunction with the potential deregulation of public utilities in California may result in the downsizing and/or closure of many biomass plants in California. If this occurs, it is likely that much of the wood currently burned for fuel will be disposed of in landfills. It is therefore important to evaluate the biomass industry not only as an avenue for disposal reduction, but also as a potential future source of waste that has not entered the landfill in the past.

Based on the criteria used to define nonyard wood waste, essentially two sources of data were used to quantify wood waste tonnages. According to Source Reduction and Recycling Elements (SRRE) submitted to the CIWMB by Cities and Counties, 3,854,254 tons of wood waste were generated in 1990 in California. This is considered nonyard wood waste since yard waste was reported in another category. Of this amount, 3,400,116 tons (88 percent) were disposed in landfills and 454,139 tons were diverted. Very little of this reported diverted wood waste was burned in biomass facilities because most of the cities and counties reporting did not include biomass consumption as part of their diversion estimates. The second principal source of information used for quantification was the California Energy Commission's (CEC) Biomass Resource Assessment Report. This report compiled a listing of various materials used for fuel by biomass facilities that went far beyond the scope of this report. Of the fuel materials listed, only forest slash, fruit and nut crops, lumber mill waste and urban wood waste were considered within the makeup of nonyard wood waste. The CEC reported that the summation of these woody materials amounted to 14.2 million bone dry tons (BDT) generated. The material with the greatest potential to both reach a landfill and be potentially diverted was urban wood waste. The CEC study reported 1.62 million BDT generated in 1990. Of that amount, 810,000 BDT were used by the biomass industry and 244,000 BDT of urban wood waste was recycled that year. Caution should be used when comparing the wood waste tonnages reported by the CEC and those reported within the SRREs. The CEC study lists wood tonnages in bone dry tons while the SRREs report the wet weight of wood. The weight in the SRREs could potentially be cut in half if converted to bone dry tons. This is only an estimate as moisture content will vary significantly between materials and locations throughout the state.

Assessing the environmental impacts was much more difficult than estimating quantities of nonyard wood waste. It appears that the greatest environmental impacts from nonyard wood waste diversion results from the air emissions of criteria pollutants generated during both the processing of the material, which included separation, grinding and sifting, and the actual burning in a biomass facility. Additional air emissions are realized through collection of nonyard wood waste, but it is assumed that the material must be collected regardless of whether it is diverted from or disposed in a permitted disposal facility. The processing emissions may be offset by the fact that there are emissions attributed to heavy machinery working the face of the landfill if the material reached the disposal site; this was not assessed in this report.

Even calculating and assigning the air emissions resulting from the combustion of diverted nonyard wood waste in biomass facilities is not as straight forward as it might first appear. Assuming the biomass facilities continue to operate regardless of the fuel source, approximately the same air emissions would be generated whether the facility uses diverted wood waste or a dedicated fuel source. Therefore one can not state with confidence that if the wood waste were disposed in a landfill, the stack emissions from the biomass facility would not occur. Conversely, if the wood waste reaches the landfill, both air emissions and leachate are generated from the wood waste. The emissions from wood waste in the landfill however, are insignificant when compared to the emissions generated from municipal solid waste in the landfill. This is confirmed by the data contained in LEA Advisory #13 issued by the CIWMB. Data collected from 46 wood waste disposal sites indicated that neither air emissions nor leachate contamination are of any great concern.

The greatest impact resulting from diverting the wood waste to biomass and reuse would be the landfill space that is saved. The most desirable option would be reuse of the wood waste, but the this represents such a limited option at this time that the total impact of reuse is insignificant as compared to biomass use.

The economics of wood waste diversion is extremely volatile. California landfill tipping fees, as reported in a June 1994 survey of the Solid Waste Digest, average less than $29 per ton while fuel for biomass facilities derived from urban wood waste varies between $26 and $32 per bone dry ton (BDT) with the price dropping as low as $22.50 per BDT at the drafting of this report and as high as $40.00 per BDT only six months ago. A comparison of these prices would seem to favor the conversion of wood waste to fuel. Unfortunately, the cost of processing urban wood waste results in a delivered price of over $35 per ton. This means long term contracts would need to be secured or outside economic influences would need to be in effect in order for a wood waste processing operation to remain profitable under the current market.

Agricultural waste, although generally regarded as a less desirable fuel, can fetch a higher price during certain periods because some biomass facilities need to burn a minimum percent of agricultural wastes to meet offset requirements in their permits. To compound this, many biomass facilities are currently under contract and are receiving a higher rate for electricity than the avoided cost of the utility buying the energy.

The standard offer contracts developed under the Public Utilities Regulatory Policy Act of 1978 guarantees a rate for energy produced by qualified facilities. Most of the contracts were negotiated in the mid-eighties when energy costs were high and future estimates were even higher. As a result, any facility that entered into a Standard Offer #4, the most lucrative of the standards offers, would currently be receiving a rate of return on energy produced that is well above the public utilities' avoided cost of producing energy.

Public utilities are beginning to negotiate new prices for energy with many of the biomass facilities under contract. With current fuel prices remaining low, the public utilities will attempt to negotiate a much lower price for energy it purchases to put the purchased energy in-line with the cost of producing energy. As a result many biomass facilities may find it difficult to continue to operate in the near future. This may result in prices dropping for wood fuel and/or an increase in wood waste disposal. The current economy does not in itself justify biomass electricity unless the facility is very efficient in producing energy. Biomass burning of wood waste can be justified via the greater public need served by the wood waste diverted from landfills. However, current regulatory constraints, such as biomass falling under the definition of transformation, limits the State's ability to encourage redirection of wood waste from a landfill to biomass facilities. Reuse of the wood is an option, but this constitutes a very small portion of the market and would result in a minor diversion.

Based on the available data on nonyard wood waste, diverting nonyard wood waste from permitted disposal facilities would have a limited, if any, effect on the environment and have a limited economic effect outside the biomass industry. The greatest benefit realized from promoting diversion of nonyard wood waste would be the additional landfill space that would become available. Part of the landfill space is currently available from existing diversion practices, however the biomass industry represents a much greater potential for diversion as well as the potential, if downsizing of the industry occurs, to introduce new waste into the waste stream that previously did not exist.

Transformation is given a preference over disposal, although slight, by enabling cities and counties to use transformation practices to count towards 10% of waste reduction goals of 50% by the year 2000. However, the current transitions occurring in the industry may result in significant reductions in the number of facilities before the year 2000. As a result California may experience a significant increase in wood waste tonnages being directed towards landfills before the 10% transformation allowance occurs. Furthermore, this does little to assist the biomass industry. in order for a transformation facility to be eligible for 10% of the 50% waste reduction requirements, the facility must be permitted by the CIWMB as a solid waste disposal facility. Currently no biomass facilities are permitted by this agency.

In order to verify end uses of diverted wood waste, more extensive information regarding types of wood waste disposed, diverted, and reused will be needed from the various jurisdictions. In order to further quantify and accurately assess the various types of wood waste and their end uses, a mechanism or network would need to be implemented to periodically count and report not only the amount of wood waste disposed, but the types and possible diversion options available.

Conversely, progress towards waste reduction goals are now determined by a comparison of current tonnages of waste crossing the scales versus amounts of waste disposed of during the base year. Due to this, it seems to matter very little where the wood waste goes as long as it does not cross the scales at a permitted facility. It is therefore difficult to justify further study attempting to quantify this portion of the waste stream. Furthermore, the current data available has such a questionable level of confidence associated with it such that any incremental change between annual reports, as required by Section 42512 of the PRC, would be overshadowed by the uncertainty intrinsic in the current available data. As a result, the Legislature may want to consider suspending the annual reporting requirements to update the quantification of non yard wood waste diversion and assessment of the environmental and economic impacts. The variable nature of the industry compounded by lack of adequate environmental data for various wood reuse and disposal options would require extensive original research and prohibitive amounts of resources to adequately assess the quantities and impacts of nonyard wood waste diversion.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1.

The term "nonyard wood waste" needs to be defined.

Recommendation

The CIWMB should define, in regulation, the term "nonyard wood waste" to include pieces of wood generated during the manufacture or processing of wood products, the harvesting or processing of raw woody crops, and the wood debris from construction and demolition activities.

Conclusion 2.

Wood waste currently going to biomass burners cannot count towards AB 939 diversion goals because these facilities are not CIWMB permitted facilities. However, at the time of printing of this document, the legislature sent AB 688 to the Governor for approval. If signed, this Bill would specifically exclude biomass conversion from the definition of transformation and allow biomass conversion to count up to 10% of the waste reduction mandated by the year 2000.

Recommendation

Option 1:
The CIWMB may choose to seek legislation allowing wood waste going to biomass burners to count towards the AB 939 goals; or,

Option 2:
The CIWMB may choose to consider biomass burners as solid waste facilities and permit them.

Either of the above options would necessitate that some sort of weighing or accounting system be developed by local jurisdictions to quantify wood waste being counted for diversion.

Conclusion 3.

The data needed to quantify the amount of nonyard wood waste is incomplete, conflicting, or non-existent.

Recommendation
If nonyard wood waste is to be better quantified, the CIWMB should require each regulated jurisdiction to develop a system to categorize and quantify woody materials. This should be accomplished after the CIWMB has defined nonyard wood waste. Local jurisdictions would need to incorporate into their existing systems a method to quantify sources of wood waste that have traditionally gone to unpermitted biomass facilities.

Conclusion 4.

The environmental impacts of diversion of nonyard wood waste from permitted facilities are minimal.

Recommendation

Since the quantities of nonyard wood waste and the environmental effects of nonyard wood waste disposal to permitted facilities are minimal, no immediate action is required of the CIWMB now or later and continued annual tracking and reporting would have limited usefulness. It is therefore suggested that the need for the annual reporting under Section 42512 be reassessed. However, the CIWMB should continue to support the reduce, reuse, and recycle hierarchy of AB 939 with respect to the management of nonyard wood waste.

Conclusion 5.

By consuming wood waste, biomass facilities are providing a disposal alternative to society while at the same time generating electric power.

Recommendation

The CIWMB should encourage biomass facilities to continue operating and accepting wastes that have not previously been normally disposed to avoid the potential increase in waste that may appear at landfills if biomass plants cease operation.

Conclusion 6.

Biomass facilities assist in reducing air emissions of criteria pollutants by burning agricultural waste in a controlled combustion environment. This material would have otherwise be burned uncontrolled in open fields causing greater emissions of air pollutants.

Recommendation

The CIWMB should actively encourage biomass facilities to continue to accept and burn agricultural wastes to assist in the reduction of criteria pollutants emitted from open field burning.

Conclusion 7.

The best method for managing the greatest fraction of the large quantities of wood waste in California at the present time is for its use as a fuel for biomass burning facilities.

Recommendation

The Board should focus its efforts on assisting the industry in developing programs for such operations as mining and processing landfilled wood waste, collecting and processing agricultural wastes, collection of non-traditional fuels such as Christmas trees, and in general developing a regulatory atmosphere that encourages alternatives to landfill disposal or open field burning.

DEFINITIONS

Ash: Noncombustible residue composed chiefly of alkali and metal oxides.

Attainment area: A geographic region where the concentration of a specific air pollutant does not exceed federal standards.

Biomass: Any organic matter which is available on a renewable basis including, but not limited to, forest residues, agricultural crops and wastes, wood and wood wastes, animal wastes, livestock operation residue, aquatic plants, and municipal wastes.

Biomass Energy: Biomass fuel, energy, or steam derived from the direct combustion of biomass for the generation of electricity, mechanical power, or industrial process heat.

Biomass fuel: Any liquid, solid, or gaseous fuel produced by conversion of biomass.

BDT: Bone dry ton. An amount of wood that weighs 2,000 pounds at zero percent moisture.

BTU: British Thermal Unit. The amount of energy it takes to raise the temperature of water one degree Fahrenheit at, or near, its point of maximum density (39.1 $^{\circ}$F).

Cellulose: A complex polymeric carbohydrate, which is the primary constituent of tissues and fibers of all plants.

Chemical Oxygen Demand (COD): A measure of the quantity of oxidizable components present in water.

Cogeneration: The technology of producing electric energy and other forms of useful energy through the sequential use of an energy source.

Energy Crop: Plant grown primarily for energy production purposes. For the purposes of this report, energy crops include canola, hardwood trees such as eucalyptus and poplar, kenaf, casuarina, lupine, and sweet sorghum.

Fly ash: Small ash particles carried in suspension in combustion products.

Lignin: A principal constituent of wood, second in quantity to cellulose. It encrusts the cells and cements the cells together.

Nonattainment area: For any air pollutant, an area which is shown by monitoring data or which is calculated by air quality modeling to exceed any national ambient air quality standard for such a pollutant.

Nonyard Wood Waste: Nonyard wood waste includes pieces of wood generated during the manufacture or processing of wood products, the harvesting or processing of raw woody crops, as well as the wood debris from construction and demolition activities. Nonyard wood waste excludes green waste such as tree trimmings, grass clippings, brush, leaves, and weeds.

PURPA: Public Utilities Regulatory Policy Act of 1978.

Recycle: Means the process of collecting, sorting,cleansing, treating, and reconstituting materials that would otherwise become solid waste, and returning them to the economic mainstream in the form of raw material for new, reused, or reconstituted products which meet the quality standards necessary to be used in the marketplace. "Recycling" does not include transformation as defined in section 40201 (Section 40180 of the Public Resource Code).

Silviculture: The act of forest management. Activities used to improve the health and productivity of the forest.

Slash: The unmerchantable material left on site subsequent to harvesting a timber stand.

Total Dissolved Solids: The total dissolved (filterable) solids as determined by use of the method specified in 40 Code of Federal Regulations Part 136.

Transformation: Means incineration, pyrolysis, distillation, gasification, or biological conversion other than composting. "Transformation" does not include composting (§ 40201 of PRC).

Transformation Facility: Means a facility whose principal function is to convert, combust, or otherwise process solid waste by incineration, pyrolysis, destructive distillation, or gasification, or to chemically or biologically process solid wastes, for the purposes of volume reduction, synthetic fuel production, or energy recovery. Transformation facility does not include a composting facility.

Urban wood waste: Includes pruned branches, stumps, whole trees from street and park maintenance, used lumber, trim, shipping pallets, and other debris from demolition and construction. The definition varies, but generally is considered to be the wood found in the solid waste stream that is generated by municipal, commercial, industrial, agricultural, construction, and demolition practices.

INTRODUCTION

This report has been developed to fulfill the requirements set forth in Section 42512 of the Public Resource Code (PRC). The California Integrated Waste Management Board (CIWMB) is required to report on the quantities of nonyard wood waste diverted from permitted disposal facilities in California and assess the environmental and economic impacts of promoting or discouraging nonyard wood waste diversion from those facilities. Any recommendations this report makes must be consistent with the hierarchy set forth in Section 40051 of the PRC. That hierarchy places source reduction at the top, followed by recycling and composting, with environmentally safe transformation and disposal at the bottom.

The first objective of the study was to define nonyard wood waste: Nonyard wood waste includes pieces of wood generated during the manufacture or processing of wood products, the harvesting or processing of raw woody crops, as well as the wood debris from construction and demolition activities. Nonyard wood waste excludes green waste such as tree trimmings, grass clippings, brush, leaves, and weeds.

Nonyard wood waste has certain inherent qualities that make it a desirable material to divert from landfills. It is generally bulky and irregular in shape which would occupy considerable volume and be resistant to compaction in landfill operations. Additionally, waste wood in landfills is highly resistant to degradation due to the lignins in the wood and the standard practice to minimize moisture entering the landfills. Finally, waste wood lends itself towards many alternative uses and provides an excellent source of fuel.

Waste wood from construction sites and furniture manufacturing is often suitable for reuse in small building projects or further manufacturing processes and can be processed and used for the production of particle board or other engineered wood products. Although the reuse option is at the top of the CIWMB's hierarchy, it is quite limited in practice and requires the wood to be fairly uniform and free of contaminants which leaves considerable amounts of waste wood available for other alternatives.

Waste wood can be mulched and used for bedding or compost. Wood is high in carbon content which is a necessary component for composting operations. Unfortunately lignins constitute a major component of wood waste and nonyard wood waste generally has a low moisture content. As a result, nonyard wood waste is not the ideal material for composting, but is a useful bulking agent when composting a high moisture material. Composting and mulching operations prefer to use greener yard waste which breaks down more readily.

One of the areas with the greatest potential for diversion of nonyard wood waste is for fuel. Although transformation is last on the list of desirability in the CIWMB hierarchy, the burning of wood to produce electricity or cogenerate electricity and steam could be considered a higher order use than disposal to landfills. As this area of use has the greatest potential for diversion, this report will examine biomass burning facilities for their current and future potential as both a diversion option for combustible wood wastes and as a source of power generation. Wood waste can also be used as a fuel when it is a feedstock to produce ethanol through fermentation. This process has not been used extensively; however with the addition of ethyl and methyl alcohols to automotive fuel in non attainment air districts, fermentation operations may be expanding in the near future.

II QUANTIFICATION

The task of accurately quantifying the amount of nonyard wood waste being generated or used is difficult. The sources and types of wood waste vary and are categorized differently by the various entities that collect this data. Furthermore, there seems to be little correlation between various studies particularly when attempting to assess nonyard wood waste tonnages that are defined under other wood waste categories. Therefore, it has been quite difficult to obtain reliable numbers on the quantities of nonyard wood waste that are being generated, disposed of, and diverted from landfills.

Several studies have been conducted in the past to quantify the amounts of wood waste generated, disposed and reused. Unfortunately, none of the results of the studies agree to any great extent. The discrepancies between the studies can be attributed to a number of factors. Any study undertaken represents a particular audience and may emphasize a specific concern of that audience. Additionally, the basic definition and resulting subcategories of wood waste varies significantly and is dependent on the sources of information used. Furthermore, the discrepancies between wood waste definitions do not take into account the various meanings associated with the terms "urban wood waste" or "nonyard wood waste" which further obscure the criteria for defining the material.

In addition to the ambiguity surrounding the definition of nonyard wood waste, past reports and studies have placed various meanings on the terms such as recycle, diversion, and transformation. These terms will be defined in this report to remain consistent throughout the report. However, the terms defined in this report may not necessarily agree with the definitions used in past waste generation studies and reports.

It should also be noted that some figures are reported in bone dry tons (BDT) while other are reported as the wet weight recorded at the facility scales regardless of the percent moisture of the material and special attention should be paid to tables representing the wood waste tonnages and whether the designation of BDT is made.

The primary information sources used to assess quantities of wood waste generated in the State were the California Integrated Waste Management Board's (CIWMB) Source Reduction and Recycling Elements (SRRE) submitted by cities and counties, the Biomass Facilities Survey and Biomass Resource Assessment Reports, currently in draft form, developed by the California Energy Commission (CEC), and the CIWMB's Disposal Cost Fee Study. Dozens of other information sources were utilized in a meeting the requirements of this report and are referenced in the bibliography. These three sources were highlighted because it was felt that the information was reasonable due to the fact that the data was timely and verifiable and, in order to minimize conflicting data, a heavier dependence on fewer sources for quantifying wood waste tonnages was deemed more desirable than relying on a larger array of conflicting information.

The SRRE is part of each city's and county's Countywide Integrated Waste Management Plan (CIWMP). The CIWMP is a plan developed by each jurisdiction outlining the course of action being taken to achieve the disposal reduction goals (reduce 25% of the waste going to landfills by 1995, and 50% of the waste by 2000) mandated by the State. The SRRE lists estimates of average waste stream composition as well existing or planned diversion programs within the jurisdiction. The SRRE data base consists of data compiled from all jurisdictions and has been periodically updated with the current report containing 94.9% of the jurisdictions reporting. The database contains separate fields for wood waste and yard waste. Therefore, it must be assumed that the wood waste listed in the SRRE database does not include yard waste, but that would be entirely dependent on each jurisdiction that was reporting and how it defined each material.

The following breakdown of wood waste was reported for the 1990 wastestream:

TABLE 2.1
Wood Wastes
SRRE 1990 Waste Stream Estimates
Revised 2/2/94

Tons Disposed	Tons Diverted	Tons Generated
3,4000,116	454,139	3,854,254

As stated above, these numbers are only estimates and are based on 1990 waste stream characterizations. There is also an additional factor of uncertainty attributed in the fact that each city or county may define wood waste differently in the survey. Even if the overall quantities are somewhat questionable, the ratios are probably representative of the percentages being disposed and recycled. Based on the SRREs, over 88 percent of the wood waste generated in the jurisdictions that responded is being disposed of to landfills while less than 12 percent is being diverted. These numbers indicate that there is a largely untapped potential (approximately 3.4 million tons) for diversion of wood waste currently being disposed at permitted facilities.

It is however, unclear as to exactly what constituents make up the wood waste stream reaching disposal facilities and, in turn, what potential reuse options are available for the wood waste. The potential is there for reuse, regardless of the makeup of the wood waste reaching disposal. This can be stated because we know that yard waste has been quantified and listed in a separate category in the SRREs independent of wood waste. This indicates that the wood waste streams listed in the SRREs are largely urban wood waste and would available for reuse options, the very least of which would be biomass burning to produce energy to be consumed by the public.

A certain, and potentially significant portion, of the wood waste stream being disposed is contaminated and as a result is not considered a highly desirable resource. Contaminants could include solids such as metal, cncrete, or other bulding materials, such as insulation, mixed with the wood waste. Contamination could also consist of organic compounds from wood treatments, pigments, or coatings that are incorporated into the wood or bonded to the surface. If however, the contaminants consist of only metal, concrete, or mixed construction material, as is part of the urban wood waste stream, the nonyard wood waste may be readily separated from the contaminants and used as a fuel source.

The CEC studies, the Biomass Resource Assessment and the Biomass Facilities Survey, were conducted to compile a listing of the biomass facilities in the state and assess the biomass resources available. The latest printing of the study is dated November 1, 1993, but the majority of data in the study has been collected between 1989 and 1990. The report is still in draft form at the time of this report. In assessing the resources of the biomass industries, the categories of biomass fuel defined in the CEC report that are applicable to this report are urban wood waste, lumber mill waste, forest slash, and possibly fruit and nut crop trimmings. The other categories, including some crops and associated wastes, were either insignificant or not a wood waste material and will not be evaluated in this report.

All the biomass fuel sources evaluated in the CEC report are listed below in Table 2.2. All the fuel sources are listed rather than just the wood waste subcategories of urban wood waste, lumber mill waste, forest slash, and fruit and nut crops, for two reasons: First, as a mass comparison and to present other sources of fuel used by biomass facilities that provide an alternative to wood waste; and secondly to include potential categories of wood waste (such as nursery prunings) that may fall under the definition nonyard wood waste since non-yard wood waste has only been loosely defined in the past.

TABLE 2.2
Biomass Resources in California
CEC, Biomass Resource Assessment Report

MATERIAL	ANNUAL AMOUNT (BDT)	% RESIDUE
Field & Seed Crops (1989 data)	6,618,782	14.20
Fruit & Nut Crops (1989 data)	**1,880,105**	**4.03**
Vegetable Crops (1989 data)	919,140	1.97
Nursery Crops (1990 data)	24,878	0.05
Food Processing Waste (1989 data)	1,743,267	3.74
Forest slash (1990 data)	**5,232,971**	**11.22**
Lumber mill waste (1985 data)	**5,468,286**	**11.73**
Urban wood waste (1990 data)	**1,621,118**	**3.48**
Energy Crops (1990 data)	508,310	1.09
Urban yard waste (1990 data)	3,054,411	6.55
Livestock manure (1989 data)	11,901,829	25.53
Chaparral (1985 data)	7,651,000	16.41
TOTAL	46,624,098	100.00

The categories of fruit and nut crops, forest slash, lumber mill waste, and urban wood waste, are bold in Table 2.2 because it was felt that these categories most closely conform to the definition of nonyard wood waste being used in this report.

The tonnages are a compilation of the amounts of biomass reported that were generated in California. There are regional variations of the composition throughout the state. Forest slash is found in most abundance in the northern regions of California with estimates of 91 percent coming from fir, douglas fir, redwood, and ponderosa pine logging. Urban wood waste is generated primarily in the high population centers of California, with the South Coast and Bay Area Air basins generating in 1990 approximately 740(46%) and 230(14%) thousand BDT, respectively, with Los Angeles County accounting for 540 thousand BDT (33%) alone (3).

Of the materials that are a concern in this report, forest slash, lumber mill waste, fruit and nut crops, and urban wood waste, the summarized tonnages that may be of suspect would be lumber mill wastes due to the age of the data (reported 1985). This number has probably decreased over the last nine years. The decrease would be due to the overall downsizing of the industry, a trend in exporting bulk lumber in lieu of finished products, and the advancements of lumber mill technologies, such as thinner blades, which leads to less waste. The disparity in the numbers of mill waste is a minor issue however, because the majority of mills had power plants built on-site to assist in their individual energy needs or the waste is dedicated to a specific reuse and is rarely destined for landfills in the first place.

Fruit and nut crops were included in the definition of nonyard wood waste because it includes pruned branches and wood resulting from agricultural practices. The orchard prunings that result from the maintenance of fruit and nut crops fall under this category. However, a very small portion of this waste stream currently goes to the landfill. Current regulations for commercial agricultural operations allow orchard trimmings to be burned on-site. A small portion does end up as biomass fuel, but very little reaches landfills due to the cost compared to on-site burning. This waste stream is included due to it future potential to be landfilled resulting from tightening regulations for air emissions from agricultural practices.

The material that most coincides with the focus of this report is urban wood waste. Although by its definition, urban wood waste does include prunings and branches as well as other wood materials, the green waste aspect of the material does not generally fall under the category that is considered yard waste. Additionally, urban yard waste has its own subcategory and therefore would not be included in urban wood waste generation and usage numbers. Therefore, it is reasonable to conclude that urban wood waste will act as a fairly accurate barometer of the uses and diversions of nonyard wood waste since urban wood waste is a subset of non yard wood waste and may in fact constitute a major portion of nonyard wood waste.

A great deal of text in this report is being devoted to estimating or representing the amounts and uses of nonyard wood waste through other wood waste terms such as urban wood waste. This is because wood waste subcategories such as urban wood waste have been defined and quantified at least to a small degree. Generally speaking however, most facilities, such as landfills and biomass burners, do not expend a great deal of effort classifying and then quantifying the categories of various materials that pass through their facilities if it is not a vital aspect of daily operations. Landfills need to estimate the amount of material diverted and may in fact quantify wood diverted. But there is little incentive to differentiate between tree trimmings and fence posts diverted if the processor who receives it does not care. Similarly, a biomass facility is concerned with parameters such as moisture content, heating value, and cost of fuel. But if the fuel being received is processed wood chips, the biomass facility will care little (assuming no contamination) if the source of the wood chips falls under the definition of nonyard wood waste. It is therefore fortunate that there is as any data at all available for tonnages of waste categories such as urban wood waste. It is also unreasonable to assume that there would be any quantification of nonyard wood waste since the term was developed as part of the language of Section 42512 in the PRC, which required this report, and was otherwise not a term used by the waste wood industry. As a result, all nonyard wood waste quantities represented in this report will be estimates at best and will usually be expressed in its relationship to other wood waste categories.

A considerable part of urban wood waste consists of construction and demolition debris (C&D). C&D would include: dimensional lumber (framing, beams, etc.), pallets, land clearing operations-woody material such as stump and trees cleared as a result of a land clearing operation and/or demolition project, and manufactured/treated wood-this includes plywood, oriented strand board, and wood treated with creosote and other chemicals. Wood debris is thought to constitute thirty-five to forty percent of C&D debris (11). A considerable part of this waste stream can be recycled, however more than 3 million tons are annually disposed of in California landfills (1990 SRRE wood waste disposal/diversion estimates).

New construction and remodeling contributes a considerable amount of wood waste to urban wood waste tonnages. Research conducted by the Greater Toronto Homebuilders Association (GTHA) estimated that a typical 2,000 ft^2, two story produced as much as one ton of wood waste (7, pg 5-43). Another study estimated that in the construction of an average house, approximately 1700 pounds of lumber waste was produced. This is equivalent to 200 two-by-four studs and represents a considerable amount of material that would lend itself to reuse or recycling. This can translate into four percent of the total cost of a construction job being dedicated towards waste disposal and up to eight percent of a renovation job dedicated to waste disposal. Construction wood waste certainly represents a significant source of wood waste that could potentially be reused or processed for fuel.

As mentioned, pallets constitute a part of the C&D waste stream and in fact, constitute a considerable part of that stream. Western pallet manufacturers rely on softwood lumber while eastern pallet manufactures use hardwoods. This is such an extensive use of wood that pallet manufacturing is the largest use of domestic hardwood lumber in the country and the second largest use of sawed wood (7, pg 3-14).

Over 500 million wood pallets are manufactured annually in the United States. Of these, 200 million (approximately 40%) are intended for one time use with an individual pallet weighing approximately 60 pounds. There is a growing market involved in repairing pallets or building new ones from waste wood, but this industry is small and its future is dependent on market prices for virgin lumber. There is also some innovative techniques being used in pallet construction. A recently developed reusable pallet is constructed of a thin sheet of plastic which substitutes for the traditional wood pallet. The sheets are durable, take up less space and are inexpensive. Unfortunately, in order to move stock around on the sheet, capital investment is needed to retrofit forklifts at both the shippers and the receiver's end. This constraint in itself will probably limit the use of this type of pallet, or at the very least, slow down its introduction on a large scale for quite some time.

Used pallets can be processed into fuel by having them delivered directly to combustion facilities, or waste haulers can deliver them to recycling facilities that would process the pallet and sell them as fuel. It is estimated that pallet manufacturing through 1994 will see an annual growth rate of 2.5% (7). The National Wood Pallet and Container Association is involved in a testing program to create a pallet that has a usable life span of up to six years as compared to the current one to two year life span. The extended life pallets would use wood treated with epoxy, urethane, or polyurethane coatings. If this program is successful and the pallets are marketed, it would certainly diminish their desirability as a fuel source, at the same time decreasing the wood waste stream.

Demolition practices is another large contributor to the urban wood waste stream. Most demolition activities use heavy equipment that increases efficiency, and as a result, decreases the time needed to demolish a structure. this keeps cost down to the customer, but does very little to assist in separating the materials. Some firms, practice hand-wrecking in an interest to save structural and architectural elements of the buildings for reuse (34).

The processing of demolition debris is often the step that determines both the material's end-use and marketability. The size of the waste, contamination with other solids and toxic paints and chemicals will often limit the ability to reuse the material or increase the processing cost to eliminate a particular market. However, if the wood waste can be source separated, or is free from toxic and other contaminants, several options are opened up for consideration.

Urban wood waste processing to fuel, among other things, requires screening, shredding, ferrous separation, sizing, and fines separation. Each of these processes may require some of the following equipment (24, pg 2-32):

Screening - initial screening on the tipping floor removes undesirable materials. Depending on the characteristics of the feedstock and the nature of the processing operation, screening may occur again prior to shredding. Screening may include visual inspection and hand picking of contaminants, and the use of equipment such as a slider belt conveyor or density indicator to detect metals in the feedstock.

Shredding - Various types of shredders process urban wood waste, including tub grinders and hammermills.

Ferrous removal - A magnet removes iron scrap. Another screening step may occur here.

Sizing - Sizing is done by screening systems which include disc and trommel screens that return oversized materials (overs) to the shredder for additional processing.

Fines removal - Properly sized materials pass through an additional screen to remove fines. Vibrating conveyor systems also separate fines. Soil amendment products are often good outlets for the removed fines.

Loadout - Following screening and fines removal, the processed wood fuel goes to a storage area for trailer loadout to market.

Beyond the steps listed transportation is needed to deliver the final product to a biomass facility. As a result, the time, effort and machinery needed to process "contaminated" urban wood waste, such as construction and demolition debris, can elevate the cost of a fuel source that uses a raw feed stock that was obtained for almost no cost.

II.a REUSE

The most desirable option in waste stream reduction would be to reuse the wood as a building material. However, several barriers exist. Very little dimensional framing lumber is available for reuse due to the fact that it is destroyed during demolition. If the lumber remains intact however, it must be recertified by a lumber inspector before it can be used in another construction project. This is often not economical unless it is a very large operation.

A cottage industry that seems to be taking hold in California (and possibly other parts of the country) is one that mill lumber and develops value-added consumer products from tree and wood waste. One such facility, Into the Woods, located in Petaluma, processes native trees to produce lumber that offers alternatives to exotic hardwood imports. Into the Woods processes native and locally grown trees such as eucalyptus, tan oak, black locust, acacia, and madrone among others. Sources of the trees include orchards that have been pulled out due to low productivity, contractors that have cleared a lot for construction, wood waste from arborists or salvage operations. More than half the dealer's supply comes from municipal government or local tree companies. The milled wood is generally used for such items as furniture, trimwork, or cabinetry or flooring rather than used as structural materials due to the quality, appearance, and higher cost of the final product when compared to framing lumber.

This type of business takes advantage of the highest order use of the high quality woods that, by and large, are still disposed of in landfills or chipped and burned. Dave Faison, co-owner of Into the Woods, stated that he could run his business just from what they get from firewood suppliers, and not dent their supply. They could focus entirely on walnut and almond orchard cuttings and not use all of that either. There is an incredible amount of wood being thrown away, he noted, and a business like his could support itself in every town in northern California. These statements are certainly an indication that a great deal of fine quality woods are being landfilled and a greater effort must be placed on taking advantage of opportunities to utilize wood to its highest order.

Another option for reuse would be to create engineered wood from the wood waste. Engineered wood is the term given to material derived from smaller pieces of wood that are bound together through a variety of glues, resins, and other chemicals to make a wood like product. Engineered woods include particle board, laminated wood, and plywood. Ninety-six percent of the plywood and strandboard products manufactured in the United States in 1991 use phenolic resins. The proportion of adhesives range from 2 to 15 percent by weight depending on the product (7). If thin linear strips of wood are laminated together, the resulting piece can be used ,in many cases, in lieu of virgin lumber. This is somewhat of a limited use and one should consider that the engineered wood would most likely be the final use as it would be difficult to recycle due to the chemical treatment involved in the manufacturing process.

Both the primary wood products industries (those that create such products as dimensional lumber, beams, and pulp) and the secondary wood products industries (engineered wood products) tend to burn all or a large portion of their waste wood for fuel on-site. The wood is typically used for space heating, low temperature steam, hot water, and/or power generation. The availability of this waste stream for other sources of power generation or diversion is therefore limited. Due to the on-site use, these wood scraps also are not considered a major component of the wood waste stream available for diversion from landfills since they rarely reached the landfill in the first place.

A portion of demolition debris, which is part of urban wood waste, can consist of chemically-treated woods. Chemically-treated and pressure-treated woods lend themselves to reuse primarily because they have an extended lifespan and are generally banned from municipal solid waste landfills. The landfill ban is actually a limited ban. The California Department of Health Service issued a variance from hazardous designation of woods treated with cresols and pentachlorophenols. The treated wood can be disposed of in Class II landfills or Class III landfills with approval of the Regional Water Quality Control Boards. If the material fails the federal TCLP test, it is considered a RCRA regulated hazardous waste and must be disposed of in a Class I (hazardous materials) landfill.

Chemically-treated woods are impregnated with chemicals to resist rot, decay, infestation, and moisture. Examples would include construction wood that has been treated, railroad ties and telephone poles. Treated woods include materials impregnated with preservatives, such as creosote, pentachlorophenol, and chromated copper arsenate (CCA). Treated woods are broken down into four groups with a 1989 national survey attributing the following volumes to these groups: creosote solutions make up 16% (90 million ft^3), pentachlorophenol accounts for 9% (49 million ft^3), waterborne preservatives, such as CCA account for 73% (407 ft^3), and fire retardant chemicals consist of 2% (11 million ft^3) (7, pg 3-20).

Chemically-treated woods generally cannot be burned in biomass facilities as air quality permits in California forbid operators from including treated woods in their feed streams. The prohibition is due to concerns of incomplete destruction of chemicals or formation of toxic substances such as dioxins and furans in the combustion process and eventual emission of these materials into the atmosphere. However, discussions with staff of the CEC and the California Air Resources Board (CARB) reveal that some biomass facilities are allowed to burn treated wood in limited quantities along with their baseline fuels. Although there is limited emission data available regarding the combustion of treated wood, the data available indicates that organic emissions of treated woods, are generally no greater than the emissions from "clean wood" at the same facilities. The same data also indicated that only slightly higher levels of metal emissions are realized from the combustion of treated woods (7, pg ES-11).

The facility permits issued by the local air quality control districts require that certain operational standards are maintained to avoid violation of local air quality requirements. Aside from the limited uses of treated wood, the wood must, in most cases, be used in its current form. It does not lend itself to be used as a fuel source nor can it be mulched for bedding. Therefore efforts should be placed in developing a network to market the material to be reused in its current form.

There is another option available for treated wood that would allow its reuse. An article in the November/December 1992 issue of MSW Management (28) made note of a company that began operating in the summer of 1991. The company, Microterra of Boca Raton, Florida, is able to recycle some treated woods, such as telephone poles, into chemical free products. The process involves chipping and crushing the wood, followed by bioremediation through microscopic organisms that consume more than 99.9 percent of the toxins. Initially, the company will only accept creosote and pentachlorophenol treated wood. Some of the resulting products include pressed wood, masonite, and particle board. Recycled hardwood can also be used as a component in producing rayon fabric (28). Other facilities may have begin operating using bioremediation techniques to neutralize toxins in treated lumber at the writing of this report.

II.b MULCH & COMPOST

If the wood waste is unsuitable be reused as a building material or it is not economically feasable, its use as a mulch is often considered. In order to mulch the wood, the operator must make certain that the material is free of contaminants and have access to chipping equipment. The resulting wood chips decay slowly and require large amounts of nitrogen in the process. The chips can be used as a bulking agent in compost or as ground cover. This market is somewhat limited and does not constitute the greatest potential for reuse of wood waste.

Another option for wood waste would be conversion to compost. Compost operations are generally not thought of as a competing market for wood waste destined for biomass facilities. This is due to the fact that compost operations covet green leafy yard waste while the biomass industry prefers dry wood (less than 18% moisture). The waste woods addressed in this report tend to be too low in nitrogen content as compared to its carbon content in order to encourage successful composting by itself. Wood chips from waste wood can be used as a bulking agent when composting materials such as sewage sludge. Wood chips mixed with sewage sludge aids the aeration of the compost pile and promotes the activity of the aerobic bacteria that results in the compost. But generally speaking, dry wood with high lignin content is not suitable for composting because it does not readily biodegrade, but is highly sought after for its fuel value. The following empirical relationship, containing lignin content, can be used to estimate the biodegradable fraction of plant wastes: (19)

BF = Biodegradable fraction
L = lignin content of the volatile solids (percent of dry weight)

$$BF = 0.83 - (0.028)(L)$$

From the above formula, it is easy to see the linear relationship between lignin content and biodegradability. As the lignin content increases, the biodegradable fraction of the material decreases along with its desirability as a compostable material.

One potential use for wood waste as soil amendment is the soil application of wood fines resulting from wood processing. The fines have been incorporated in a soil amendment in forestry reclamation, mine reclamation or landfill closure. The wood fines add organic matter to the soil and inhibit erosion while the relatively slow decay rate is not a concern in reclamation and closure operations.

Currently there is no way to accurately estimate the quantities of wood waste being used in compost operations, much less quantify the amount of nonyard wood waste. The CIWMB has permitted seventeen composting and mulching operations in California at the writing of this report which by no means represents all the composting sites currently operating in the state. An accurate count of facilities probably will not be available until some time after the CIWMB requires permits by all composting operations in the State. That permitting effort is in its preliminary stages at the writing of this report. The facilities currently permitted by the CIWMB use various feedstocks in their operations which include manure, green waste, wood waste, agricultural waste,cannery discards, food waste, saw dust, and sewage sludge. The combined annual quantities produced by the seventeen facilities approaches one million tons per year.

Some of the facilities produce biofuels while others compost nonwood materials, but use wood materials as bulking agents. Several of the facilities compost green waste materials which are not included in this report. The facilities were mentioned primarily to present another available market to wood waste.

The CIWMB is currently compiling listings which involve wood waste issues. One list has descriptions of receivers and processors that deal with recycling of construction and demolition materials in California. The list contains thirteen categories of materials of which wood waste is one. The second list has businesses that sell products manufactured from recycled construction materials in California. Both lists are currently in draft form, but should be complete by the time this report is finalized. The lists will be available to the public and can be obtained by contacting the CIWMB hotline and requesting a copy.

II.c FERMENTATION

Currently a small market for wood waste that has potential for expansion in the future is conversion to ethanol through fermentation. Wood waste must first be processed by chipping or grinding. It than can be converted to ethyl alcohol (ethanol) through conventional fermentation technologies. The wood waste must be converted into fermentable sugars. This can be done chemically, using acid hydrolysis or biochemically using enzymes. Yeast is then used to ferment the sugars. The resulting product must be purified and the alcohol distilled to concentrate it enough for use as a fuel.

The current markets for automotive fuels containing alcohol additives is expanding. This is particularly evident in nonattainment areas in California that use "oxygenated" fuels during high smog months of the year. Oxygenated fuels use either an ethanol or methanol based additive to assist in the combustion process. The oxygen introduced into the process has been shown to reduce carbon monoxide emissions by as much as 17 percent (29).

The U.S. Department of Energy (DOE) has a biofuels systems division that currently is involved in research and development of the production of versatile, domestic, economical, renewable liquid fuels from biomass feedstock in hopes of achieving many of the national priorities including the goals set forth in the National Energy Strategy, the Alternative Motor Fuels Act of 1988, and the Clean Air Act Amendments of 1990. The overall goal of the DOE's ethanol research program is to reduce the cost of producing fuel-grade ethanol to $0.67/gallon making it competitive with current gasoline prices (26).

It would be difficult for either methanol or ethanol enhanced fuels to flourish on their own based purely on economics or their energy value when compared to gasoline. However, since the winter of 1992-93, 39 cities nationwide have been required to use oxygenated fuels during the winter season. Additionally, the U.S. EPA mandated that, beginning January 1, 1995, nine cities would be required to use alcohol in reformulated gasoline year round (29). Moreover, 30 percent of the alcohol must come from renewable sources. This implies grain derived ethanol rather than methanol derived from coal or natural gas. Methanol can however be produced from biomass using thermochemical conversion processes. Thermal processes convert the biomass directly to a synthesis gas (syngas) composed of carbon monoxide and hydrogen. Following cleaning, the syngas from biomass can be used in commercial units to produce methanol (26).

The source of ethanol from fermentation more than likely would be derived from corn and other fermentable crops. This does not exclude however, the use of wood waste as a source of ethanol. All plants including woody plants contain a structural portion composed of lignocellulosic fibers. These fibers contain three major components: cellulose, hemicellulose, and lignin. Cellulose and hemicellulose in the wood are chains of sugar molecules that can be broken down (hydrolyzed) and fermented to produce ethanol. The lignin portion of the plant, or biomass in this instant, is a highly ordered complex of phenolic molecules that can be converted to high-value chemicals. In the near term, the most cost effective use for the lignins in the wood will be as a fuel to power the biomass to ethanol process (26). Ethanol fuel production, presents a potential market for waste wood that warrants additional consideration and investigation.

II.d TRANSFORMATION

As discussed earlier, biomass plants play a significant role regarding the use of wood waste in as much that the biomass industry constitutes the largest single market for wood waste resulting from construction in California. The CIWMB however considers the use of wood waste by biomass facilities transformation as dictated by Title 14 of the California Code of Regulations, Section 18722(a)(77), and therefore cannot count towards the waste reduction goals of 25% by 1995 and part of the 50% diversion required by the year 2000. It should be recognized that the biomass industry supplies a commodity in the form of energy to consumers in California in addition to reducing the waste that would have otherwise been deposited in the landfills.

According to Pacific Gas and Electric (PG&E) over 900 MW of biomass and solid waste power plants were operating in PG&E's planning area in 1991. This output is delivered using the following fuel sources (5):

TABLE 2.3
Fuels Used by Biomass Facilities on PG&E's Grid

FUEL TYPE	OUTPUT IN MEGAWATTS (PERCENT)
Wood residue	571 (61%)
Agricultural residue	209 (22%)
Landfill and biogas	49 (5%)
Industrial and municipal waste	117 (12%)

The fuel sources used by biomass and solid waste power plants listed in Table 2.3 go beyond the wood waste sources that this report is concerned with. The table does show however that wood waste is by far the greatest source of fuel for biomass burners. PG&E stated that the plants are providing four to five percent of its system's capacity or approximately 900 MW. The majority of the power (approximately 780 MW) is supplied from about 50 plants in California. Although biomass currently supplies only a fraction of the current energy needs in the state, it is predicted that electricity demands in California will increase by 50 percent in the next 20 years (1, pg 1-5). This will undoubtedly put a much greater emphasis on alternative energy sources such as biomass.

PG&E is the largest purchaser of power from biomass facilities in California. The CEC, in its survey of biomass facilities, listed the 47 direct combustion facilities in California and the utility districts that purchased their power. They are as follows:

TABLE 2.4
Direct Combustion Biomass Facilities in California and Current Contracts with Utility Districts

UTILITIES DISTRICT	NUMBER OF FACILITIES	TOTAL NET POWER OUTPUT (MW)
Pacific Gas & Electric	41	627.0

Southern California Edison	4	66.8
Sierra Pacific Power	1	14.5
Not under Contract	1	0.7
TOTAL	47	709.0

There is some disparity between the number of facilities listed in the CEC study and shown in Table 2.4 and those compiled by PG&E shown in Table 2.3. The differences can be attributed to two possible factors. The first being that the CEC data was compiled primarily before or during 1990, while the PG&E data was compiled in 1991. The other factor, which is probably more significant, is that the CEC study accounted for only the direct combustion facilities in California which contributed 627 MW to PG&E's power grid. Direct combustion facilities account for 75% of the total capacity supplied by biomass energy conversion systems and about 2% of the total electric capacity in California. The PG&E study, on the other hand, referenced the 50 largest biomass burners in California supplying 780 MW to their system. The 50 largest facilities in PG&E's system are not necessarily direct combustion burners.

Although the data in Table 2.4 from the CEC study and the data in Table 2.3 from PG&E do not directly correlate, both clearly illustrate that biomass facilities contribute to the power needs of California and that PG&E is the biggest user of that energy. It is estimated that biomass represents approximately two percent of the total power needs of the state and represents about four percent of PG&E's power output. These number vary throughout the year based on demand and rates.

Discussions with George Simons of the CEC revealed that there are currently 64 biomass facilities operating in California. The number fluctuates based on facility closures and startups. For purposes of this report, the number of facilities referenced will be 64 due to the fact that the CEC has the most updated and comprehensive database available by any public agency in California at this time.

Although the number of biomass facilities may fluctuate slightly from time to time, it is not anticipated that there will be any new construction of biomass facilities in the near future. Significant increases in landfill tipping fees, along with changes in the economic and environmental aspects of biomass technology, as well as the public's perception of the safety and aesthetics of incinerators, would be needed to prompt any significant upsurge in construction of new biomass facilities.

Of the four wood waste categories of primary concern listed in

Table 2.2: urban wood waste, lumber mill waste, forest slash, and fruit and nut crops, only a portion of the wood waste generated has been used as an fuel source by the biomass industries. The following is a breakdown of the potential quantities available from each of the materials generated and the actual amounts used (3).

TABLE 2.5
Wood Waste Used for Energy Generation

Material	Total Generated (BDT x 10^6)	Used by Biomass facilities (BDT x 10^6)	Other uses (BDT x 10^6)
Urban Wood Waste	1.62	0.81	0.24
Lumber Mill Waste	5.47	3.43	1.93
Forest Slash	5.23	1.52	0.00
Fruit & Nut Crops	1.88	0.33	0.00
Total (BDT)	14.20	6.09	2.17

Included in the "other uses" category, 244,000 BDT (15%) of urban wood waste was recycled and 1,930,000 BDT of lumber mill waste was used for particle board and plywood production. Even after eliminating the other uses and recycled portions of these materials, it is apparent that the vast majority of the total potential reuse of this material remains untapped. Although the potential uses are limited, the opportunity to use these materials as a fuel and generate electricity rather than commit the material to rapidly shrinking landfill space would certainly present itself as a desirable option. To further illustrate this point, the tonnages of the three materials listed in Table 2.5 represent the following potential energy production (3):

TABLE 2.6
Energy Potential of NonYard Wood Waste Components

Material	Total Potential trillion BTUs	Biomass Use-trillion BTUs	Other Uses trillion BTUs
Urban Wood Waste	28.50	14.17	4.28

Limber Mill Waste	100.00	62.72	35.29
Forest Slash	91.60	26.52	0.00
Fruit & Nut Crops	31.70	5.57	0.00
Total	251.80	108.98	39.57

Another source of information that was used to assess wood waste fuel sources consumed by the biomass industry was a study conducted by Pacific Gas & Electric entitled PG&E Biomass Qualifying Facilities Lessons Learned Scoping Study-Phase I, 1991. The study identified the following materials as available waste and residues for the California biomass industry:

Table 2.7
Wood Waste Used By Biomass
PG&E Study

MATERIAL	**BDT/YR**
Sawdust, pulp mill process waste	500,000 - 800,000
Hog fuel	2,000,000 - 2,700,000
In-forest residues, thinnings	500,000 - 1,000,000
Landfill waste wood	1,000,000 - 2,000,000
Orchard and Vineyard fuels	1,000,000 - 1,500,000
Other agricultural residues	500,000 - 1,500,000
Totals	5,500,000 - 9,000,000

There are several things that warrant attention regarding Table 2.7. The categories of wood waste are defined differently from those contained in Table 2.5. Additionally, the category of landfill wood waste was not identified in any other studies. This material, estimated at one to two million BDT per year being consumed by the biomass industry, is most certainly a diversion from landfills whether or not it meets the criteria for diversion contained in Chapter 6, Article 1 of the Public Resource Code. It is not clear however at which point the wood waste is redirected. It is assumed that the material is separated from the mixed municipal waste just prior to entering the landfill. This further illustrates the difficulty in accurately quantifying portions of the wood waste stream when data disagrees or dissimilar terms are used between studies.

The orchard, vineyard, other agricultural residues, as well as the forest thinnings, represent a sizable amount of fuel, both in tonnages and BTUs, consumed by the biomass industry. However, there is very little chance that these wastes would be disposed in a landfill if the biomass industry did not use them for fuel. The current practice in agricultural operations involves open field burning of residue. Therefore these wastes that could be considered wood waste do not pose a significant potential for diversion.

As orchard wastes represent a potential future waste stream if the biomass industry were downsized or open field burning was curtailed, specific yields should be mentioned. Almond, walnut, vineyards, and fruit orchards provide fuel via prunings and renewals. The quantity removed represents about 20 percent of the growth stock. Orchards can yield up to 1.5 dry tons of prunings per acre per year with a conservative estimate of approximately one dry ton per acre per year. Vineyard prunings can yield 0.75 to one dry ton per acre per year. Prunings of almonds, walnuts and fruit are seasonal rather than yearly (24, pg 2-35).

Renewal of orchards, which entails removing mature stock to replace it with young, more productive trees, offers another fuel source. Stock removal can yield as much as 24 to 30 dry tons per acre after the stock reaches its productive limit, usually eight to 12 years (24, pg 2-35).

Another issue to consider regarding the biomass use of wood waste is the term "diversion". The landfill waste wood listed in Table 2.7 being burned by biomass facilities is obviously being either removed from or diverted from landfills. As such, it is freeing up space within the landfill for other wastes. This certainly is diversion in its most basic form regardless of the regulatory meaning. It may even be counted towards diversion goals, or more accurately waste reduction goals, of various jurisdictions. For example, if a wood waste processor is separating the woody material prior to disposal in the landfill and chipping it on-site, is it important to the landfill operator where the wood chips go after processing? Even if the operator knows the material is going to be burned, and does not incorporate that portion of the "diverted" material into the jurisdiction's SRRE when projecting waste reduction goals, the net result is the same. The landfill will realize the same overall reduction in waste being received and waste reduction goals will be met. Although the same ends are achieved, the accounting on paper cannot use this waste in the estimate. The final tally however will be incorporated towards satisfying the State's mandate.

III ENVIRONMENTAL IMPLICATIONS

The environmental concerns regarding nonyard wood waste and its handling and disposal options are multi-media in nature. The migration of contaminants leaching or emitted from the processing or disposal of wood waste have the potential to migrate through the soil, the water, and the air. Because of this, the best way to describe potential environmental concerns is to address pathways available when wood waste is disposed and then compare the potential pathways which have inherent risks associated with them when one of the reuse options listed above are used.

It is impossible to quantify the total environmental impact of the various diversion options practiced with nonyard wood waste because of the inability to accurately quantify the amounts of nonyard wood waste being generated and the difficulty in attributing contaminant contributions by wood waste when mixed with other materials. Additionally, the environmental impacts of non yard wood waste disposal have never been quantified because the environment that the material is exposed to in a landfill varies from site to site making it difficult to estimate the various interactions of materials within a particular landfill cell. However, this report will present various scenarios along with the constituents of concern for each of the handling methods presented.

III.a LANDFILLING

The prime environmental concerns with landfilling material, in general, are the effects the landfill has on the groundwater in the area and potential for atmospheric contamination from landfill gas emissions. A third concern has less to do with media contamination than it does with exhausting valuable space in the landfill.

The concern with diminishing landfill space is a major concern in itself and was one of the prime reasons to evaluate diversion opportunities for nonyard wood waste. On April 29, 1992, the CIWMB published Reaching the Limit, An Interim Report on Landfill Capacity. The data in the report was generated primarily in 1990 and stated that as of January 1, 1990 the population of California was 29,500,230 and that each person in California, on an average, disposed of 1,387 lbs of waste each year. Of the 56 counties in the state, ten had less than five years remaining in their permitted disposal capacity and 39 counties had less than 15 years remaining on their disposal capacity. To put this in population terms, as of January 1, 1990, 69.4% of California's population lived in counties that would exhaust the current landfill space by the year 2005 (30). This estimate does not include 2.5% of the population that lives in counties that totally export its waste to other counties. Another study put it in these terms: There are over 350 active landfills in California accepting 44,000,000 tons of waste per year and by the year 2000 California will have less than 50 percent of its current landfill capacity (13, pg 4-1).

The above statement assumes a constant disposal level and does not account for increasing diversion. On the other hand, there is no accurate estimate on the rate of increase of the population of California which would have a direct effect on the waste generation figures. The bottom line is that landfill capacity is an important consideration when evaluating the effects of diverting nonyard wood waste from permitted disposal facilities.

III.a.i Air Emissions:

Quantifying air emissions from landfills is extremely difficult and attributing an accurate portion of the emissions to wood waste is virtually impossible. The gases produced by a landfill are primarily products of anaerobic decomposition of the organic material in the landfill. As such, the primary gases produced are methane and carbon dioxide along with, to a lesser degree, nitrogen, oxygen, hydrogen, sulfides, and other trace constituents. The percentages of landfill gas components, shown in Table 3.1, were averages found in landfill gas on a national study as determined by U.S.EPA weighted average data of four studies summarized in "Report to Congress: Solid Waste Disposal in U.S.", 1988 p.4-31 (13).

TABLE 3.1
Average Landfill Gas Composition in U.S.

COMPONENT	WEIGHTED AVERAGE OF USEPA DATA (% DRY VOLUME BASIS)
Methane	48.49%
Carbon Dioxide	37.45%
Nitrogen	12.66%
Oxygen	0.88%

Sulfides, Disulfides, Mercaptans, etc.	0.17%
Hydrogen	0.08%
Carbon Monoxide	0.03%
Trace Constituents	0.24%
Total	100.00%

Gas emission capture rates between 0.046 and 0.12 ft^3/lb/yr (cubic feet of gas per pound of waste per year) have been monitored in California landfills with collection systems with a median of 0.078 ft^3/lb/yr being liberated(13, pg 5-5). Using a CARB estimate of 60% efficiency (22, pg 29) in landfill gas collection systems, an uncontrolled landfill would release a conservative average rate of 0.13 ft^3/lb/yr. The average rate from an uncontrolled landfill was calculated by the median generation rate of 0.078 and dividing it by 0.6 (60%).

We will use the physical properties of the component gases listed in Table 3.1 to estimate the amount of gas that is generated by wood waste in a landfill.

First we will assume that landfill gas acts as an ideal gas at standard conditions in order to use the ideal gas law (21, pg 4-55)

$PV=nRT$

where:

P = Pressure (1 atmosphere)
T = temperature (68°F or 527.7 degrees Rankine)
V = volume (ft^3)
n = number of moles
R = ideal gas constant= 0.730 (atm)(ft^3)/(lb-mol)($^\circ$R)

We rearrange the formula to obtain a molar volume (V/n):

Substituting in the values used above obtains: $V/n=RT/P$

$V/n= (0.73)(527.7)/(1) = 385.22$ ft^3/lb-mol

The next step is to calculate the molecular weight of typical landfill gas. Using the volume percentages of the first four components of landfill gas (CH_4, CO_2, N_2, and O_2: which makes up over 99% of landfill gas) listed in Table 3.1, an average molecular weight (MW) of landfill gas can be calculated. The calculation is made by multiplying each component's molecular weight by its volumetric percentage in landfill gas (Table 3.1) and adding up the products. It should be noted that the mole fraction of a gas is equivalent to the volumetric percentage.

MW of CH_4 = 16.04 lb/lb-mol
MW of CO_2 = 44.01 lb/lb-mol
MW of N_2 = 28.01 lb/lb-mol
MW of O_2 = 32.00 lb/lb-mol

Taking each of the molecular weights and multiplying them by the average volumetric percent in the landfill gas results in:

Ave.MW =
(16.04)(.4849)+(44.01)(.3745)+(28.01)(.1266)+(32.00)(.0088)
= (7.78) + (16.48) + (3.55) + (0.28)

Ave. molecular weight of landfill gas = 28.09 lb/lb-mol

Next, the molar volume calculated above will be divided by the molecular weight to determine a specific volume of the landfill gas:

385.33 ft^3/lb-mole/(28.09 lb/lb-mol) = 13.72 ft^3/lb

Specific volume of landfill gas = 13.72 ft^3/lb

Each of the major components of landfill gas are made up of various elements such as carbon, nitrogen, oxygen, etc. In order to estimate the gas generated by wood waste in a landfill, an ultimate analysis of wood waste in municipal solid waste was needed to determine the wood waste's elemental contribution to landfill gas generation. This was obtained from a study conducted by SCS Engineering's "New York City Solid Waste Ultimate Analysis", 1990 and published in CIWMB's Disposal Cost Fee Study (13, pg 5-40).

TABLE 3.2
Elemental Contribution of Wood Waste to Landfill Gas Generation Based on MSW Content

ELEMENT	WEIGHTED AVERAGE BASED ON MSW CONTENT
Carbon	2.07%
Hydrogen	1.05%
Nitrogen	0.07%

Oxygen	1.15%
Sulfur	0.38%
Chlorine	1.18%

Using the specific volume for landfill gas (13.73 ft^3/lb) as well as the assumption that the carbon percentage listed in Table 3.2 contributes to the production of CO_2, CH_4, and CO in roughly equivalent percentages for each of these components listed in Table 3.1, we can estimate the amount of gas generated by wood waste in a landfill. It is also assumed that the total sulfur content (represented as 0.38 percent) results in sulfide production.

Sample calculation:

Methane generation in uncontrolled landfill per ton of wood:

(2000 lb/ton of wood)(.0207*)(0.13 ft^3 gas/lb wood-yr)(1 lb gas/13.72 ft^3)(.4849 lb CH_4/lb gas)=

=0.184 lb CH_4 gas/ton of Wood waste per year

* 0.0207 is the 2.07% of carbon available to produce carbon based gas (such as CH_4) in wood waste based on MSW content listed in Table 3.2.

Using the same calculation, with substitutions for the percent gas generated from Table 3.1, along with appropriate substitutions for gas generated for controlled landfill (0.078 vs. 0.13 ft^3/lb/yr) and using sulfur content (0.38%) to calculate sulfide generation rather than carbon content (2.07%) when calculating carbon based gases (CH_4, CO, CO_2), we can construct the following table:

TABLE 3.3
Estimates of Gases Liberated Into the Atmosphere by Wood Waste in Landfills

GAS GENERATED	UNCONTROLLED LANDFILL LBS GAS/TON WOOD (FT^3)	CONTROLLED LANDFILL LBS GAS/TON WOOD (FT^3)
Carbon Monoxide	1.18×10^{-4} (1.62×10^{-3})	7.06×10^{-5} (9.69×10^{-4})
Carbon Dioxide	0.147 (2.02)	0.088 (1.21)

Methane	0.184	(2.52)	0.114	(1.56)
Sulfides	1.22×10^{-4}	(1.67×10^{-3})	4.00×10^{-4}	(5.49×10^{-3})

The gas generation numbers were calculated using available data and making certain assumptions that may not hold true at all landfills. These include assuming the ultimate analysis of wood waste in the New York City study listed in Table 3.2 hold true for wood waste in California landfills and assuming landfill gas behaves like an ideal gas under normal conditions in California. The calculations also do not account for possible interactions between the wood waste and other materials in the landfill which could increase or decrease emissions or cause the generation of other byproducts that were not evaluated here. One conclusion that can be made, is that the breakdown of wood waste in landfills generates greenhouse gases (primarily methane and carbon dioxide) as well as other air pollutants that may migrate into the upper atmosphere. Beyond that, it would be impossible to state the amount of gas that is generated with any certainty or what percentage of the gas is collected and put to beneficial use. The gas generation numbers are presented only as one possible scenario to use as a reference against the types and amounts of pollutants emitted from other uses of wood waste.

The CIWMB developed Local Enforcement Agency (LEA) Advisory Number 13 on Wood Waste Landfills which was issued on May 17, 1994. In developing the LEA advisory, information was compiled on approximately 46 wood waste disposal sites. The majority of the sites were located in rural logging and wood product manufacturing areas of northern California. The solid waste at the wood waste landfills included bark, scrap lumber, sawdust, and mixed soil and rock generated as waste material from log decks and milling facilities.

Emissions from wood within a wood waste landfill is not necessarily a true indicator of emissions from wood within a municipal solid waste landfill. This is because the interactions occurring between wood in a monofill will not necessarily mimic the interaction between different waste materials in a municipal solid waste landfill. This data was mentioned as another potential information source to estimate typical gas emissions from wood waste.

Site specific assessment data indicate that methane may comprise a substantial portion of airspace deep within a wood waste landfill. However, methane has not been found at levels of concern for ambient, surface crack, and shallow field screenings. This is in sharp contrast to many municipal solid waste landfills which frequently show significant emissions of methane to the surface and shallow subsurface, in addition to significant subsurface methane levels (27).

The typical compositions and volumes of gas emitted from landfills have been established in guidelines by the California Air Resources Board (CARB). In addition, in September 1990, the CARB approved a Suggested Control Measure (SCM) for landfill gas emissions. Each air quality district may adopt the standards which would require installation of landfill gas collection systems at new, active, and inactive landfills having more than 500,000 tons of waste in place. The SCMs also contain performance standards for the collection system and specifies testing requirements. If the gas is flared after collection, the combustion must consume greater than 98% of non-methane hydrocarbons and must not cause excessive emissions of Nitrous Oxides (NO_x) and carbon monoxide (CO). Although the net effect of a gas collection system in reducing greenhouse gas contributions is not quantifiable at this time, an overall reduction is realized. Additionally, operation of a gas collection system is expected to reduce emissions of ozone depleting contaminants such as 1,1,1 trichloroethane, which was measured in 52 percent of the sites in the CARB database of air quality solid waste assessment test results (22, pg 49).

As indicated, the SCM is currently a voluntary set of standards that have not been adopted by all the air quality control districts at this time. It is however possible that a landfill could be required to install a gas collection system, if testing reveals that the site poses a significant health risk to the public. It should also be noted that the U.S. EPA is anticipating the adoption of New Source Performance Standards (NSPS) for landfill emissions by August, 1994. If promulgated, standards will be imposed on landfills and installation of collection equipment may be mandatory.

A secondary emission associated will landfill gas collection, although much smaller, is the by-product of combustion of the collected gas. The gas that is collected can be flared if the volume of gas is not enough to support a combustion process. Another option available is to recover energy by burning the gas to heat a boiler or used it as a fuel to run a turbine or internal combustion engine. Emission factors for landfill gas control equipment are summarized in CARB's Suggested Control Measure for Landfill Gas Emissions, 1990, based on best available control technology for the equipment. The by-products of combustion for the equipment mentioned are summarized in Table 3.4 below.

TABLE 3.4
Emission Factors for landfill Gas Control Equipment
Unit are lbs/BTUx10^6

EQUIPMENT SOURCE	HYDROCARBONS	NITROUS OXIDES	CARBON MONOXIDE
Flare	0.420	0.050	0.190
Internal Combustion Eng	0.147	0.220	0.671
Boiler	0.050	0.045	0.005
Turbine	0.007	0.07	0.10

The combustion by-products are small when compared to the order of emissions generated by any heavy equipment that may be needed to process, separate, or collect wood waste (see following discussion on indirect emissions). This is particularly true when considering the amount of gas generated from wood is a fraction of the gas generated by other wastes in a landfill. The insignificance of emissions from wood waste was verified in the conclusions contained in LEA Advisory #13.

It should be noted that Table 3.4 does not address the possibility that the landfill gas can be purified and sold to a public utility. The gas would still be burned, but would be burned in a much more efficient combustion process. This data was presented to illustrate that additional by-products are generated in small amounts, even if landfill gas is collected rather than allowed to escape to the atmosphere.

So far, the potential air emissions directly resulting from landfilling wood waste and emissions from flaring or running equipment from the collected landfill gas have been addressed. There are also the indirect emissions due to collection of wood waste. The CIWMB's Disposal Cost Fee Study (13) compiled data regarding air emissions associated with the collection of wood waste for disposal and recycling. The estimates were based on data from an EPA report "Compilation of Air Pollution Emission Factors II: Mobile Sources" along with data from CARB including "Identification of Volatile Organic Compound Species Profile", and "Technical Guidance Document to the Criteria and Guidelines Regulations for AB-2588". Both garbage collection and recycling trucks were assumed to be powered by diesel engines. The garbage collection truck would have a greater emission rate than the recycled material collection truck because larger engines would be needed to transport the heavier, more compact load of garbage. Besides identical operating conditions, the following assumptions were made in order to calculate emission levels per ton of wood waste collected (13, pp5-13):

3 pounds of waste generated per person per day;
2.6 people per household;

15% of material recycled by weight;
a recycling collection rate of 80 households per hour; and
a garbage collection rate of 60 households per hour.

Using the assumptions made above, a portion of the total calculated emissions is attributed to wood waste based on the material's average content in municipal solid waste. The estimates of wood waste in MSW were based on SCS Engineering's "New York City Solid Waste 'Ultimate Analysis,'" 1990 as represented in CIWMB's Disposal Fee Cost Study (13). Based on these assumptions, the estimated emission rates attributed to each collection practice are presented in Table 3.5.

TABLE 3.5
Emission Rates for Collection of Wood Waste and Recyclables

POLLUTANT	RECYCLING COLLECTION EMISSIONS LBS/TON OF WOOD	GARBAGE COLLECTION EMISSIONS LBS/TON OF WOOD
Carbon Monoxide	0.6597	0.20047
Nitrous Oxides	0.9308	0.28364
Sulfur Oxides	0.1330	0.04052
Volatile Organics	0.2236	0.06813
Benzene	0.0040	0.00122
Ethyl Benzene	0.0001	0.00004
Toluene	0.0040	0.00123
Xylenes	0.0014	0.00044

The emission rates would vary significantly dependent on the types of vehicles, the age and state of tune of the vehicles, the climate and geography, population density, collection equipment, and several other factors. The emission rates also assume that the wood waste content in MSW in the New York study referenced above are the same as wood waste content in California MSW. The data was presented to illustrate that air pollutants will be introduced into the environment from the collection of wood waste and that the magnitude of the emissions from collecting wood waste is at least as significant as the emissions from wood waste in the landfill itself.

This report does not address the additional emissions emitted from the equipment needed to work the material into the landfill and apply daily cover which would add to these emission factors. When considering the added environmental impacts for disposal, one should remember that collection is necessary regardless of the final use of the wood waste and therefore would be a consideration with any reuse or disposal option. For the sake of simplicity, it will be assumed that the emission data presented in Table 3.5 would apply to any reuse/disposal option of wood waste and can therefore be eliminated when weighing the environmental impacts of one option against another.

III.a.ii Water Quality

The chemistry and interactions occurring between materials within a landfill are not completely understood. Moreover, it is virtually impossible to identify and quantify all the material within a landfill that has been in operation for any length of time. It is therefore impossible to attribute specific pollutants to individual materials within a landfill. Furthermore, there is no comprehensive database currently compiled regarding the makeup of leachate from California landfills (13, pg 5-3). There is however, some data available on pollutant concentrations of leachate on a national basis which will be used in generating wood waste leachate quality estimates for California landfills.

Some generalizations regarding leachate from California landfills can be made drawing on conclusions published in the CIWMB's Disposal Cost Fee Study, February 1991 (13). Roughly, two-thirds of the landfills exist in a extremely dry climate of Southern California and the remaining one-third exist in somewhat less dry conditions of Northern California. Generally speaking, leachate quantities escaping from landfills in California are relative low, approximately 3 gallons per ton of waste over the lifetime of the landfill (25 active years and 30 post closure years) (13, pg 5-2), when compared to landfills throughout the country.

Using data compiled in the Disposal Cost Fee Study regarding total loading of pollutants, percentages of materials disposed, and the assistance of U.S. EPA's Hydrologic Evaluation of Landfill Performance (HELP) model, the environmental impacts of wood waste's contribution to leachate contaminants can be estimated.

The following two generic California landfills (Northern and Southern California) were developed in the Disposal Cost Fee Study and corresponding data were entered into the HELP model along with national leachate data to determine the concentration of metals in leachate. With the use of the model, two scenarios will be addressed. The calculations were made for hypothetical landfills both with and without a liner. The landfill parameters are as follows:

TABLE 3.6
Theoretical Parameters for California Landfill Leachate Calculations

PARAMETER	Northern California Landfill	Southern California Landfill
Tons Per Day	1,000	1,000
Acres	182.9	115.4
Square Feet	7,967,124	5,026
Depth (ft)	80	130
Years Open	25	25
Post Closure Period	30	30
Number of Cells	5	5
Yrs Cells Open	5	5
Cell Size (ft^2)	1,593,425	1,005,365
Ave. Cell Depth (ft)	40	65
Active Leachate Generation-no liner (gallons)	8,340,032	1,642,209
Active leachate generation-liner (gallons)	22,240	1,259,888
Closed leachate generation-no liner (gallons)	4,817,502	3,120,019
Closed leachate generation-liner (gallons)	0	0
Waste landfilled over 25 yrs (tons)	7,280,000	7,280,000
Annual Precipitation (inches per Year)	26.44 (S.F. Bay Area)	13.52 (L.A. Area)

Note: Both landfills have a cap consisting of: 12" loam, 36" clay, and 24" coarse sand.
The Northern California landfill's liner is composed of 60" of clay w/ a synthetic liner while the Southern California landfill's liner consists of 24" of clay.

As no specific data was found regarding the amount of leachate generated and escaping from landfills in California, the HELP model was used again in the Disposal Cost Study to estimate the amounts of leachate escaping from both lined and unlined landfills in Northern and Southern California and are presented in Table 3.7.

TABLE 3.7
Leachate Escaping Landfills in California Using Calculations from EPA HELP Model

Location of Landfill	Average Gallons of Leachate Escaping per Ton of Waste (Lined)	Average Gallons of Leachate Escaping per Ton of Waste (Unlined)
Northern California	0.08	55.11
Southern California	4.33	22.78

The average leachate amounts escaping the landfills presented in Table 3.7 is assumed to be over the lifetime of the landfill which includes 25 active years and 30 post closure years. In order to develop leachate liberation numbers for theoretical lined and unlined landfills that account for conditions in both Southern and Northern California, it was assumed that 67.6% of all waste in the State was generated in Southern California while the remaining 32.4 % of the waste was generated in Northern California. These percentages were multiplied by the leachate numbers presented in Table 3.7 and added up to give a weighted average of leachate escaping from a theoretical lined and unlined landfill in California that would represent conditions in both Northern and Southern California.

The sum of the weighted averages resulted in an unlined landfill generating 33.26 gallons of leachate per ton of waste which had Northern California landfills contributing 17.86 gallons/ton and Southern California landfills contributing 15.40 gallons/ton to the total. Likewise, the weighted averages resulted in a lined landfill generating 2.95 gallons per ton of waste which had the Northern California landfill contributing 0.025 gallons/ton and the Southern California landfill contributing 2.925 gallons/ton to the total (13, pp 5-17, 5-18).

The criteria set forth regarding the two landfills is fairly typical of landfills in each location in California. While the Southern California landfills are located in dryer climates, they tend to be older, and as a result have more permeable liners, than the more modern landfills in Northern California. This translates into a lined landfill in Northern California that will tend to allow less leachate to escape than an unlined landfill in the far dryer climate of Southern California. Once capped however, both landfills were able to collect all leachate that was generated (13, pg 5-3).

In order to estimate leachate quality from nonyard wood waste, we must assign contaminant parameters to the wood waste. We will use the parameters assigned to wood in a municipal solid waste landfill containing a residential/commercial mix of 55% and 45% respectively. The analysis came from SCS Engineers, NYC Solid Waste 'Ultimate Analysis,' 1990 (13, pp5-23)

TABLE 3.8
Contaminants in Wood Waste
in MSW Landfill

PARAMETER	UNITS	CONTAMINANT CONCENTRATION
Arsenic	ppm	2.65
Barium	ppm	24.14
Cadmium	ppm	0.55
Chromium	ppm	5.29
Lead	ppm	41.90
Mercury	ppm	0.68
Selenium	ppm	1.44
Silver	ppm	0.80
Carbon	%	42.12
Hydrogen	%	6.25
Nitrogen	%	0.29
Oxygen	%	49.85
Sulfur	%	0.06
Chloride	%	0.22

Using the above parameters and assumptions substituted into the U.S. EPA HELP model, 1984 as well as criteria for leachate constituents in landfills meeting RCRA requirements published in U.S. EPA's Characterization of Leachates from Municipal Waste Disposal Sites on Co-Disposal Sites,1987,pp4-8,4-10, pollutants were allocated to wood waste leachate while incorporating the wood waste reactivity in the landfill and percentage of material in the fill (13, pg 5-3). The resulting inorganic pollutant loadings leaching from each of the landfills attributed to wood waste is presented in Table 3.9.

TABLE 3.9
Pollutants Estimates from Wood Waste Leachate in California MSW Landfills
(lbs of pollutant in leachate per ton of wood waste)

POLLUTANT	CALIFORNIA LANDFILL (UNLINED)	CALIFORNIA LANDFILL (LINED)
Arsenic	4.75×10^{-7}	4.23×10^{-8}
Barium	9.94×10^{-5}	8.82×10^{-6}
Cadmium	5.61×10^{-8}	4.97×10^{-9}
Chromium	1.82×10^{-7}	1.62×10^{-8}
Lead	8.64×10^{-7}	7.67×10^{-8}
Manganese	8.50×10^{-4}	7.54×10^{-5}
Nickel	1.51×10^{-5}	1.34×10^{-6}
Selenium	2.39×10^{-7}	2.12×10^{-8}
Vanadium	4.44×10^{-6}	3.94×10^{-7}
Zinc	1.11×10^{-4}	9.87×10^{-6}

The potential contamination to ground water from the constituents listed in Table 3.9 is difficult if not impossible to accurately estimate. Even if site specific criteria were available such as depth of ground water, geological conditions, and an accurate analysis of materials involved, there would be no way of determining the interactions taking place between the materials in the landfill over its lifetime. Additionally, without extensive in situ testing, it would be impossible to determine if the methodology used in the "Disposal Cost Fee Study", 1991 was correct. As indicated above, the study stated that the quality of leachate for specific material (wood waste in this case) was calculated using the composition, reactivity, and quantity of the material in the landfill. The report failed to explain how the reactivity and other variables were determined or calculated and incorporated into a verifiable formula. Without a formula to apply to these variables or supporting documentation, it is impossible to check the validity of all the numbers listed in Table 3.9.

What can be concluded, based on the data available, is that the above inorganic constituents will be available to infiltrate the soil and possibly the aquifer. Beyond that, no estimates can be made on whether contamination will actually occur or, if contamination does occur, the extent of the contamination. The above scenario assumes all wood is clean and does not take into account contaminants that may be in wood waste. If the wood is contaminated, an increase (or decrease for that matter) in concentrations of certain metals can occur as well as the addition of certain organic compounds.

Another potential source of information used to determine wood waste's contribution to leachate contamination would be monitoring data on wood waste landfills. The LEA Advisory #13 issued by the CIWMB on May 17, 1994 collected data form 46 wood waste disposal sites in California. However, disposal sites containing wood waste may not be entirely representative of the contaminant levels attributed to wood waste in leachate collected from municipal solid waste facilities.

The LEA advisory concluded several things regarding leachate from wood waste landfills that can be summarized in the following statements: Leachate from wood waste landfills is typically opaque with elevated secondary contaminant constituents such as tannin, chemical oxygen demand (COD), and total dissolved solids (TDS). A significant ash component may also contribute to elevated pH levels and TDS. Recent investigations and research have shown that naturally occurring organic compounds in wood waste potentially may cause false detections of refined fuel hydrocarbons such as diesel (27).

Aside from some contamination from wood preservatives, there appeared to be very little impact from wood waste leachate. Assuming that treated woods are outside the main concern of this report, the major contaminants attributed to wood waste would be TDS and COD. These conventional pollutants have a limited impact on ground water when compared to the impact caused by organic compounds and metals typically found in leachate collected from municipal solid waste disposal facilities.

There are additional, minor contributions to water quality concerns made by waste handling and processing equipment and gas collection systems. The handling equipment area would be addressed under the Water Resources Control Board's Storm Water Waste Discharge Permits issued under the National Pollution Discharge Elimination System (NPDES)if it were deemed to be an environmental concern.

The main impact on water quality associated with gas collection systems is the generation of condensate from the landfill gas. In the past, it was standard practice to return the collected condensate through traps to the waste. Recently, however, some

Regional Water Quality Control Boards have prohibited this practice, requiring the installation of double walled tanks which would be pumped out periodically. The condensate can than be treated or disposed in the sewer system under a local sewer use permit. This practice has minimized any potential impact on water quality due to gas condensate (22, pg 49).

III.b COMPOSTING/MULCHING

Composting and wood waste mulching operations present a potential to introduce contaminants into the environment as do other waste handling and reuse operations. The extent of emissions from a composting facility would vary greatly dependent on the type of facility (indoor or outdoor), the size, and the materials being composted. The air emissions from the machinery processing the material in both composting and mulching facilities are a consideration and typical emission rates for a 300 horsepower tub grinder are summarized in the following section associated with biomass facilities.

The greenhouse gases (primarily carbon dioxide (CO_2) and to a lesser extent ammonia (NH_4) liberated during decomposition certainly have an effect on the environment. Some data has been collected regarding the potential gas emissions of compost operations. However, it would be difficult to allocate a portion of the gases generated from a composting operation to the nonyard wood waste portion of the material. The only generalization that can be made, is that the wood waste being addressed in this report is not highly desirable to composters and would not make up a great portion of the composted material. Additionally, it can be stated that the nonyard wood waste portion of the compost would break down at a much slower rate than the leafy, green material in the compost due to its composition. The lignin content in wood waste is generally higher and therefore would be a minor contributor of greenhouse gases. Odors, dust, and particulate matter being generated during a mulching and/or composting operation are as great or greater concern to the local community and controls and operational standards must be accounted for when developing a processing site.

The collection of the material to be processed also can have an environmental impact. Although no data has been generated specifically for the collection of compost material, the emission data presented in Table 3.5 for the collection of recyclable wood waste is probably a reasonable estimate. However, as stated in other wood waste operations, the material must be collected regardless of the end use and the emissions generated during collection would be generated in all operations.

Leachate from composting and mulching facilities is generally considered to have minor environmental impacts by environmental regulatoy agencies. Leachate would occur as water, added to a windrow system, percolated through to the ground. Indoor systems of course would have less potential to create leachate than outdoor systems based on the indoor operation's shielding from rainfall and the higher likelihood of a modern leachate collection system. Additionally, there is a trend to develop closed systems that reuse the leachate in the composting process. With an outdoor system that does not have leachate recovery, there is greater concern for loss of leachate. The State Water Resources Control Board currently issues standard storm water discharge permits to composting facilities that require the operators to maintain the site in a condition that minimizes the potential to add contaminants from the processing site to rainwater runoff entering the stormwater system and eventually contaminating surface waters. A copy of the standard conditions for a facility regarding stormwater runoff is contained in attachment A. If there is potential for a composting/mulching site to contaminate surface or ground water directly, the Regional Water Quality Control Boards may require containment measures to be added or an NPDES permit could be issued to limit the contaminants in the discharge to surface waters.

III.c BIOMASS FACILITIES

As explained above, Biomass facilities are currently the largest single market in California for construction wood debris. Therefore, the potential environmental impacts associated with the combustion of nonyard wood waste for energy recovery is a significant issue.

IIIc.i Air Quality

The primary environmental concern associated with Biomass plants is the operation's effects on air quality from plant emissions. Although the combustion of wood in biomass facilities is generally thought to produce overall fewer air emissions per unit of electricity than coal or oil fire plants, air pollution control can be a major concern of a plant. Depending on the plant's location, air pollution control equipment can constitute over 20 percent of the capital cost of a new facility (2, pg 5-8).

The impacts associated with individual combustion systems are usually well defined with environmental regulations in place that dictate, to a certain degree, the performance level of the electricity production system. There are however, secondary concerns associated with the collection and processing of the wood waste and potential concerns of ash disposal. Each of these issues will be addressed along with any possible offsetting benefits that may result with each practice.

Generally speaking, biomass fuels are low in sulfur and nitrogen content and are relatively clean burning. The carbon dioxide emissions of biomass fuels, on an energy basis, are comparable to coal(7, pg 2-49). However, it has been argued that the biological growth of the biomass fuels uses carbon dioxide and thus the net contribution to global warming attributed to greenhouse gases from biomass fuels is zero. This is debatable and will not be further analyzed in this report. As the emphasis of this report is to investigate diversion of wood waste from landfills and does not evaluate biomass fuel that was grown specifically for energy purposes, the issue of consumption of carbon dioxide during the growth of the woody material is irrelevent. One must therefore be careful not to draw comparisons that cannot be quantified between the environmental impacts of biomass fuels versus other fuel sources.

On an average, biomass fuels have a low ash content, high volatility, and a lower energy density when compared to coal. The moisture content of biomass varies considerably and it contains high levels of alkali metals potassium and sodium while being relatively low in heavy metals (24,pg A-2). The heavy metal content however, along with other contaminant levels, can vary significantly when the wood waste is derived from construction and demolition debris.

The California Air Resources Board (CARB) classifies biomass plants, or wood waste incinerators, as resource recovery facilities. The primary responsibility for permitting these facilities rests with the local air pollution control districts or air quality management districts. There are currently thirty-four independent air districts in California. As a result, each facility must adhere to site specific standards developed by the local air district. The standards imposed on each facility could vary dependent on the type of facility, the type of material being burned, the size of the facility, the quality of the air in the surrounding basin, as well as several other variables including the best available control technology that can be used to curtail stack emissions.

Although each facility is evaluated on a site specific basis, the CARB provides guidelines to assist the local air districts in developing achievable emission standards. Table 3.10 contains the guidelines the CARB offers to local air district to assist them in calculating facility stack emissions. It should be noted that the numbers in Table 3.10 are guidelines and individual air districts must calculate site specific emission standards that could vary from the ranges listed in Table 3.10.

TABLE 3.10
CARB Guidelines for Resource Recovery Facility Stack Emissions

Constituent	NO_x	SO_x	PM	CO	THC
Wood Waste Incinerator Limits	70-100	1-10	0.01	50-100	1-10

- Units are in part per million dry volume at 12% carbon dioxide using an 8 hour average
- NO_x are nitrogen oxides
- SO_x are sulfur oxides
- PM stands for particulate matter in units of grains per dry standard cubic foot at 12% carbon dioxide and front half of sampling train
- THC is total hydrocarbons

The criteria to be used as guidelines present ranges for which the air district must calculate explicit limits to incorporate in each permit. Attachments B and C contain examples of permits issued to biomass burners with the criteria that each must meet. Attachment B is a copy of the authority-to-construct which contain relevant limits for the Delano Energy Facility. Attachment C contains the permit for the Woodland Biomass Facility. A comparison shows that not only do the limits differ, but a constituent can have more than one limit presented in different units.

The CARB has published a 1991 update to its Air Pollution Control at Resource Recovery Facilities. In the document the CARB published the results of air emission tests taken at four biomass facilities. The plants vary in design and capacity, and it would therefore be useful to show the magnitude of emissions for criteria pollutants from each of these facilities as they compare to emission guidelines listed in Table 3.10.

PLANT #1: Confidential Facility

This facility burns wood chips and agricultural wastes in twin fluidized bed boilers to produce electricity. The plant was running near its capacity of 25.6 Megawatts during the test. The facility is limited to an input fuel rate of 890 tons per day of wood waste calculated at 40% average moisture. Air pollution control devices include vaporized ammonia injection, multiclone, and an electrostatic precipitator.

PLANT #2: Pacific Oroville Power, Inc.

This facility operates twin ZURN spreader stoker wood fired boilers in parallel. Each boiler normally consumes 16 tons of wood fuel per hour and produces the steam for 11 megawatts of electricity. The test consisted of two parts: the first part evaluated emissions of fuels allowed under the existing permit while the second part of the test evaluated emissions from the burning of permitted fuel supplemented by urban wood waste in a ratio of 70% permitted fuel to 30% urban wood waste. Air pollution control devices include an ENELCO "three field" ESP for each boiler exhaust gas stream.

PLANT #3: Louisiana Pacific Hardboard Plant.

This facility operates a Wellons 4-celled wood fired steam generator rated at 127 million BTUs/hr. The fuel is non-industrial wood chips and bark with a throughput capacity of 7.48 dry tons per hour. The air pollution control devices include a Wellons multiclone and PPC Industries ESP.

PLANT #4: Koppers Company

This facility operates a Wellons 4-cell wood fired boiler which normally operates at 5 megawatts. The air pollution control devices include a multiclone air pollution control device prior to entering the stack.

Table 3.11 summarizes the range of concentrations of stack emissions for criteria pollutants for each of the facilities summarized above.

Table 3.11
Stack Emission Data of Four Biomass Facilities

Plant	NOx	SOx	PM	CO	THC	NH_3	CO_2 %	O_2 %
#1	105.7 (14)	ND (14)	0.007 (3)	49.8 (14)	ND (14)	896.9 (2)	9.5 (14)	10.5 (14)
#2	68.6 (7)	ND (7)	0.011 (3)	1427 (7)	42.1 (7)	N/A	7.5 (7)	
#3	104.9 (10)	ND (10)	0.021 (3)	56.5 (10)	ND (10)	N/A	8.1 (10)	12.2 (10)
#4	80.6 (7)	ND (7)	0.011 (3)	55.0 (7)	ND (7)	N/A	12.7 (7)	7.1 (7)

- Nitrogen Oxides (NOx)- Units of part per million (ppm)
- Sulfur Oxides (SOx) - Units of parts per million (ppm)
- Particulate matter (PM) - Units of grains per dry standard cubic foot.

- Carbon Monoxide (CO) - Units of parts per million (ppm)
- Total hydrocarbons (THC) - data reported as propane in parts per million (ppm)
- All data on Table 3.11 was corrected to 12% CO_2.
- The numbers in parentheses "( )" indicate the number of samples taken for the results.
- All data in Table 3.11 are averages (mean) of number of samples listed in parenthesis.
- ND indicates below detection.
- N/A indicates that constituent was not sampled.

Reviewing the data summarized in Table 3.11, it can be seen that the criteria pollutants emitted from the four facilities generally fall within the guidelines listed in Table 3.10. There are a couple of exceptions, the most notable being the CO and THC emissions from the Oroville Power (plant # 2). Without first-hand knowledge of the facility, it is difficult to determine the reason for the variances from the other facilities' emissions. From facility descriptions, it is notable that Plant # 2 does not include a multiclone as part of its pollution control devices as the other plants did. Additionally, the plant was burning material outside of its permit requirements as specified in the test parameters. Regardless of the specific numbers, it should be noted that Table 3.10 contains only guidelines and specific emission criteria is placed on individual facilities. The purpose of presenting the data in the CARB report(23) was to illustrate the types and magnitude of pollutants that can be expected from the emissions of facilities burning biomass fuel.

The data does not take into account all facilities or the type of facility or material being burned. There are essentially four categories of combustion facilities classified by the manner in which the fuel is burned. They are pile burners, spreader stokers, suspension burners, and fluidized bed burners. Each has its advantages and disadvantages relating to its handling capabilities, economics, combustion flexibility, and emissions with the fuel being burned as the major factor dictating the type of facility to be constructed(23, pg 32).

One of the variables that may have been incorporated into the process of calculating permit limits for a biomass burner would be the accounting of agricultural offsets. Agricultural offsets are terms to define a pollution emission credit given to the facility when calculating the limits. Assembly Bill 1223 (1983) and Assembly Bill 2158 (1987) established procedures for applying credits to facilities based on air quality benefits that were incurred due to the reduction of open field burning that would have occurred had the biomass facility not been put in operation and used this material as a fuel source. As one might imagine, the procedure for calculating the credits to assign to each facility would be a cumbersome and complicated one and it would be a difficult task to quantify the amount of pollutants released. Additionally, the agricultural offset could only be considered for facilities that would reasonably cause a reduction in open field burning. A review of the materials burned by Biomass facilities reveals that agricultural waste is not the sole or even primary source of fuel at most plants. This is not to discount the benefit of burning the material in a controlled environment compounded by the energy generated by the plant which would have been lost in the field. The point was made primarily to illustrate that for the purposes of this study, it is impossible to adequately compare the environmental benefits/impacts of one waste management practice versus another without totally understanding the secondary issues that would effect the net emission rates.

Although current agricultural practices involve a considerable amount of open field burning, the regulatory trend is to reduce this practice. Current California legislation proposes a phased reduction for rice straw open field burning but does not address open field burning of other agricultural crops. However, it is not beyond the realm of possibilities that open field burning of other crops will be limited by either the state or federal government, especially in nonattainment areas. The current practice in orchards is to burn the trimmings on-site or use as fuel for biomass if available. If legislation curtails this practice, the woody waste will be directed towards landfills. This could represent a potential fuel source for biomass facilities if a mechanism for collecting the waste could be implemented to keep the cost of the processed wood fuel down. On possible avenue to collect and process the wood would be use of a mobile chipper followed by collection units scheduled to travel though a given region during the time of year that most trimming occurs. If the collection operation was convenient enough for the growers, voluntary participation my even occur before legislatively mandated reduction forces participation by orchard operators.

II.c.ii Ash

An additional environmental concern associated with energy recovery of wood waste is the disposal of ash. Ash resulting from the burning of wood waste tends to be cleaner than other forms of incinerator ash under the assumption the wood fuel was relatively clean (not contaminated). Of course the ash quality depends on the feedstock quality, the air pollution control devices in use, and most importantly the combustion technology in use. Generally speaking, the more efficient the combustion process, the more concentrated the contaminants in the ash are. Even with clean wood, the resulting ash contains a higher concentration of the metals and contaminants than existed in the wood. This is true only because of the significant mass reduction that occurs when wood is reduced to ash.

Most biomass facilities generating ash handle their ash in more than one fashion. The handling methods include use of ash as a soil amendment, disposal, reuse (asphalt, road base, activated carbon), and composting (18, appendix B). In one instance, the State University of New York, at Stony Brook, constructed an artificial off-shore reef using blocks made from ash aggregate. Since then, the reef has attracted and supported marine life (33, pg 15).

The amount of ash generated was not readily available, but the biomass facilities in California estimated ash generation for the R.W. Beck survey (18). The ratio of ash generated to fuel used by biomass facilities varied greatly between facilities. Estimates by the biomass industry ranged from over 99% reduction in mass to less than 70% reduction and ash generation estimates ranging between 1,328 tons per day and 2,000 tons per day throughout the state (18 and 1). Biomass ash generation represents over 61% of the ash generated by incinerators in the state. To put this in terms of power output, the electricity producing plants produced ash at an average of 168.9 lbs/MWh (1, pg 5-10).

Of the sixty-four biomass facilities currently in operation in California, twenty-five facilities produce ash that is used as a soil amendment, three store ash on-site, 23 dispose ash at landfills, one disposes ash in a Class I landfill, five produce ash that is reused, two have ash that is composted, and six produce ash that is disposed on-site.

Both bottom and fly ash have been found useful as a soil amendment on acidic soils and mine spoils, to improve the texture of the soil and supply nutrients, and as an additive in animal and poultry feed. Recent tests have shown that wood waste ash is high in potassium and naturally releases nutrients over a longer period of time than artificially designed fertilizer products, (25, pg 10).

Nutrient needs of the crop planned for the area of ash application need to be considered. Ashes containing chemicals at quantities exceeding those needed for the soil and the crop have the potential to leach into the ground water or contaminate the surface run off. Applications of ash rich in carbon may hinder nitrogen availability for plant growth and microbial decomposition of the ash necessitating the need to add nitrogen to the soil.

When ash is used in the manufacture of construction materials (concrete/asphalt, aggregate, cement, and road base), it is substituted, in varying amounts, for raw materials. The environmental impacts of ash used as a manufacturing feedstock are primarily limited to problems associated with the insertion of the ash into the manufacturing process. Once the material has been introduced into the process, the loop closes and the opportunity for environmental contamination has been eliminated.

Studies have shown that ash use for agricultural and silvicultural purposes can be maximized if hauling distances can be limited to a radius of 25 miles from source to end user. The viability of ash as an agricultural supplement can also be limited by handling, storage and application constraints (25, pg 12).

In Phase II of the R.W. Beck ash characterization study conducted for the CIWMB (25), the quality of ash from ten biomass facilities were analyzed with the characterization of ash from nine of the facilities summarized in this report. The only facility excluded in this reports summary is the Operational Energy Company-Williams Biomass Facility. The reason this facility was not included as that it's fuel source is rice hulls which falls outside of the scope of nonyard wood waste. The nine biomass facilities for which ash was characterized are listed in Table 3.12.

TABLE 3.12
Biomass Facility Characterization

Plant #	Facility Name	Feedstock	Technology
1	Burney Forest Products	Lumber wood waste	Fixed grate
2	El Nido Biomass Power Plant	Almond trees, walnut shells, grape pumas	Fluidized bed
3	Fairhaven Power Co.	Redwood lumber operations wood waste	Fixed grate
4	Hudson Lumber Co.	Lumber wood chips	Fixed grate
5	Mendota Biomass Power,	Urban wood waste and prune pits	Fluidized bed

	Ltd.		
6	Pacific Lumber Co.	Redwood scraps	Moving grate
7	Sierra Pacific-Burney	Lumber operations wood waste	Fixed grate with after burner for bottom ash
8	Wheelabrator Shasta Energy Co.-Anderson	Wood waste from timber & lumber operations	Moving grate
9	Soledad Energy Partnership	Half almond, pine & eucalyptus trimming & half urban wood waste	Fluidized bed

These facilities were sampled between May 7, 1992 and May 5, 1993. The field samples had ferrous materials and overs (pieces over two inches in diameter) removed as part of the preparation. The ash samples were analyzed for both soluble and total metal levels. The sampling was not designed to meet regulatory requirements and as a result are invalid from a regulatory standpoint. The results are useful however in determining toxicity levels of the ash. Tables 3.13 and 3.14 contain the results of California's Soluble Threshold Limit Concentration tests (STLC) and Total Threshold Limit Concentration tests (TTLC). All samples also passed the federal TCLP test, but results are not presented here as Phase II of the R.W. Beck study elected not to publish the results of this test in the final report.

TABLE 3.13
Summary of Results for TTLC Analysis of Ash

Plant # -type of ash	Cd (mg/kg)	Cr (mg/kg)	Be (mg/kg)	As (mg/kg)	Pb (mg/kg)	Hg (mg/kg)
1 -Fly/ Bottom	1.3/4.5	6.9/19	ND/0.74	ND/10	9.2/20	ND/ND
2 -Only Bottom samples	ND/ND	19/16	ND/ND	22/23	24/17	ND/ND
3 -Fly/	ND/ND	21/16.4	ND/ND	ND/ND	36/ND	ND/ND

Bottom						
4 -Only bottom samples	8.0/7.6	42/45	ND/ND	25/19	31/29	ND/ND
5 -Fly/ Bottom	ND/ND	38.1/ 16.6	ND/ND	ND/ND	79.3/ ND	0.09/ND
6 -Fly/ Bottom	ND/ND	27.7/ 27.7	ND/ND	12.6/ 11.5	13.7/ 13.2	ND/ND
7 -Fly/ Bottom	2.9/6.9	15/37	ND/0.97	24/78	64/35	ND/ND
8 -Only bottom samples	8.0/5.3	56/51	ND/ND	18/20	29/30	ND/ND
9 -Fly/ Bottom	6.1/ND	100/84	ND/ND	130/53	1100/ 21	3.8/ND

TABLE 3.14
Summary of Results for STLC Analysis of Ash

Plant # -type of ash	Cd (mg/l)	Cr (mg/l)	Be (mg/l)	As (mg/l)	Pb (mg/l)	Hg (mg/l)
1 -Fly/ Bottom	0.02/ 0.03	0.12/ 0.03	ND/0.01	0.23/ 0.37	ND/0.67	ND/ND
2 -Only Bottom samples	ND/0.03	0.42/ 0.03	ND/ND	ND/ND	ND/0.11	ND/ND
3 -Fly/ Bottom	ND/ND	0.36/ 0.15	ND/ND	ND/ND	1.37/ 0.60	ND/ND
4 -Only bottom samples	0.05/ 0.04	0.19/ 0.23	0.01/ 0.01	0.37/ 0.26	0.23/ 0.22	ND/ND
5 -Fly/ Bottom	ND/ND	0.38/ 0.20	ND/ND	ND/ND	ND/ND	ND/ND
6 -Fly/ Bottom	0.06/ND	0.19/ 0.09	ND/ND	ND/ND	0.04/ 0.49	ND/ND
7 -Fly/ Bottom	0.02/ 0.03	0.36/ 0.14	ND/ND	0.40/ 0.25	0.11/ND	ND/ND
8 -Only bottom samples	0.04/ 0.04	0.25/ 0.18	0.01/ 0.01	0.51/ 0.25	0.94/ 0.48	ND/ND

9 -Fly/ Bottom	ND/0.02	2.5/1.8	ND/ND	1.5/1.3	0.68/ 0.20	0.0004/ ND

TABLE 3.15
Hazardous Levels (STLC & TTLC) of Metals
Contained in Title 22 of CCR

TEST	**Cd**	**Cr(VI)**	**Cr or Cr III**	**Be**	**As**	**Pb**	**Hg**
STLC (mg/l)	1.0	5	5	0.75	5	5	0.2
TTLC wet weight mg/kg	100	500	2500	75	500	1000	20

When comparing the concentrations of metals in the ash analysis contained in Tables 3.13 and 3.14 to hazardous waste levels in Title 22 of the California Code of Regulations and summarized above in Table 3.15, it is apparent that the ash from biomass facilities are generally low in toxic levels of metals. Additionally, the fly ash generally contains higher levels of soluble metal as compared to the bottom ash.

The feedstock used as fuel strongly influences the quality of ash with facilities burning urban wood waste producing ash generally higher in total and soluble levels of metals. The only facility that exceeded the Title 22 criteria was facility #9 (Soledad Energy Partnership) which exceeded total lead, but not soluble lead concentrations. As mentioned the sampling was not based on regulatory criteria and therefore invalid from a regulatory standpoint. The results do however, show a significant variance between facilities and differences in total and leachable metals at some facilities.

The ash was also analyzed for micro-nutrients and macro-nutrients for its use as an agricultural supplement. The results shown in Table 3.16 and 3.17.

TABLE 3.16
Macronutrients in Biomass Ash

Plant # -type of ash	**Nitrogen (%)**	**Phosphorus (%)**	**Potassium (%)**	**Sulfur (%)**	**Magnesium (%)**	**Calcium (%)**
1 -Fly/ Bottom	0.01/ <0.01	0.3/0.51	1.39/ 2.04	0.03/ 0.04	0.6/0.97	1.77/ 2.77

2 -Only Bottom samples	0.27/ <0.01	0.8/0.68	2.52/ 2.50	0.29 /0.21	0.93/ 0.86	4.74/ 4.36
3 -Fly/ Bottom	0.11/ 0.14	0.4/0.15	2.38/ 0.98	1.15/ 0.23	0.83/ 0.42	5.95/ 2.33
4 -Only bottom samples	0.07/ 0.68	0.46/ 0.43	1.45/ 1.35	0.07/ 0.12	0.9/0.91	2.46/ 2.72
5 -Fly/ Bottom	0.01/ 0.01	0.23/ 0.40	0.76/ 1.84	0.08/ 0.24	0.41/ 0.74	4.34/ 39.51
6 -Fly/ Bottom	0.14/ 0.07	0.29/ 0.05	2.31/ 0.22	0.82/ 0.09	0.8/0.39	3.10/ 0.84
7 -Fly/ Bottom	<0.01/ 0.28	2.11/ 2.15	2.74/ 2.76	0.45/ 0.71	1.65/ 1.30	29.72/ 33.11
8 -Only bottom samples	0.09/ 0.07	0.41/ 0.42	1.44/ 1.53	0.31/ 0.32	0.82/ 0.76	3.21/ 3.30
9 -Fly/ Bottom	0.05/ 0.07	0.64/ 0.16	2.01/ 1.40	0.46/ 0.08	0.71/ 0.68	23.64/ 2.16

TABLE 3.17
Micronutrients in Biomass Ash

Plant # -type of ash	Iron (ppm)	Manganese (ppm)	Copper (ppm)	Zinc (ppm)
1 -Fly/ Bottom	36200/46700	1720/3070	70/90	162/194
2 -Only Bottom samples	21300/14700	590/630	450/420	298/265
3 -Fly/ Bottom	24100/21100	1870/970	90/38	297/174
4 -Only bottom samples	29000/34600	2150/2030	390/380	229/358
5 -Fly/ Bottom	6400/17200	490/410	220/260	245/333
6 -Fly/ Bottom	24400/9400	1100/325	70/20	225/62
7 -Fly/ Bottom	19600/18800	13300/13500	200/200	910/912
8 -Only bottom samples	28100/23000	2340/2280	80/80	451/308

9 -Fly/ Bottom	28600/24400	117/69	310/160	2580/530

The results in Tables 3.16 and 3.17 show that the ash samples from the facilities in the group contain both macro- and micronutrients in concentrations that would make the material useful as a soil conditioner or for its fertilizing properties.

Table 3.16 shows that the El Nido Biomass Power Plant (#2) and the Sierra Pacific Plant (#7) had higher levels of macronutrients than the other facilities in the test group. Also notable is the fact the micronutrients in the ash of these facilities were not significantly different than that of the other facilities. Copper and Zinc levels were elevated in the ash samples from El Nido (#2), Hudson (#4), Sierra Pacific (#7), and Soledad (#9). These concentrations of metals could be harmful to soils that were already enriched with reasonably balanced micronutrients (25, pg 27).

III.c.iii Secondary Emissions

Secondary emissions associated with biomass facilities, and mulching facilities for that matter, are the air emissions emanating from the processing of the material. One of the preferred methods used to process these materials are industrial tub grinders. Grinders have advantages over chippers due to the fact that the size of the product can be regulated by changing the screens on the equipment. In a conversation between Bruce Leiseth of Haybuster Manufacturing and staff of the CIWMB, it was learned that portable industrial tub grinders are generally powered by diesel engines that have outputs in the 110 horsepower to 800 horsepower ranges with intermediate sizes generating approximately 300 and 500 horsepower.

In order to make an estimate of emissions emanating from a tub grinder, certain assumptions must be made based on data provided from Mr. Leiseth and staff of CARB. Mr. Leiseth indicated that his company's model HD 10, powered by a 300 horsepower Caterpillar motor, would be the typical size tub grinder used by a city or county landfill. This grinder can process between 15 and 25 tons per hour. It will be assumed the grinder is not equipped with an optional loader, which would require a larger engine, and that it processes an average of 20 tons per hour. CARB staff, quoting from a U.S. EPA document "AP-42", was able to attribute emission data for diesel engines ranging between 45 and 600 horsepower. Although it seems that a 600 horsepower engine would have different emission characteristics than a 45 horsepower engine, the data will suffice for emission estimates of a typical tub grinder. The following data was available:

TABLE 3.18
Emissions from Diesel Engines (45-600 HP)
U.S. EPA Document AP-42

Constituent	Emission Rate (gm/hr)
CO	197
THC	72.8
NOx	910
SOx	60.5
PM	60.0
Aldehydes	13.7

Using this data and applying it to a typical tub grinder powered by a 300 HP engine processing 20 tons of wood waste per hour, the following emission rates are calculated for each ton of wood waste.

TABLE 3.19
Estimated Emissions from a 300 Horsepower Tub Grinder
(pounds of contaminant per ton of wood waste)

CO	THC	NOx	ALDEHYDES	SOx	PM
0.022	0.008	0.10	0.002	0.007	0.007

Although the emission rates calculated are not of the magnitude of those generated during the collection of waste material presented in Table 3.5, the emissions generated during the processing of wood waste is worth mentioning due to it's contribution to overall air pollution. Often, a greater local concern is the noise and dust generated during the grinding of the wood waste which requires additional operational or engineering measures to minimize the noise and dust outside the immediate area.

An additional consideration regarding processing constraints worth noting is permitting requirements. Many tub grinders are mounted on trailers, thus making them mobile industrial sources. Several of the air quality control districts place a limit on permit lifespans up to 90 days on-site for mobile industrial sources. Furthermore, certain air districts, such as the Los Angeles air basin, are extremely difficult to obtain this type of permit due to constraints imposed by poor air quality in the district. As a result it may be easier to set up a remote processing site outside of a particular air basin. This, in turn increases both emissions and costs of processing due to the additional transportation involved.

The CARB is however, currently reviewing a proposal set forth by the California Air Pollution Control Officers Association (CAPCOA) that would require registration rather than a limited permit for operation of, among other things, woodchippers within a single district. If the CARB accepts the registration option being proposed, it would only be a recommended measure that could be adopted by individual air districts, it would not be mandatory. If adopted by an air district, the proposal could make it easier for a mobile chipper to operate throughout the district under a single registration rather than requiring a new permit for each site the chipper operates within the district.

IV ECONOMICS

Evaluating the economic advantages and disadvantages of each of the wood waste reuse and disposal options available is extremely difficult due to the variable nature inherent in supply and demand economies. Certain factors of waste disposal however are a bit more stable. Landfill tipping fees generally apply the same fee to a load regardless of the waste (non hazardous) at each landfill. However, the rates vary between landfills and tend to increase as time passes and rates may be different at an individual landfill between commercial and noncommercial loads. Similarly, composting operations are not necessarily cost effective, but rather present an opportunity to divert some of the waste entering the landfill and present a social benefit rather than an economic opportunity. The same can be said, to a certain degree regarding biomass facilities.

Determining the cost of alternatives to landfilling wood waste is much more difficult. There are various economic forces involved beyond cost of material versus operating cost and price of energy produced. The economies of landfills and biomass operations will be evaluated with the understanding that direct comparisons are not always obtainable.

The capital costs of alternative uses and disposal options of wood waste will not be addressed to any great degree in this report. It is assumed that the operations are already in existence and an attempt to present the "consumer's" cost of disposal or reuse will be made. Likewise, the overall benefit or cost to society will have little input in this section. Benefits to society will be addressed in a summary as part of the conclusions of this report. Environmental benefits would also be too difficult to quantify on a monetary basis based on the limited data available for quantification of nonyard wood waste.

IV.a LANDFILLING

The tipping fees for landfills remain relatively low in California compared to other parts of the country. Furthermore, tipping fees within California vary significantly. Besides a wide range of fees, the landfills often have different rates for commercial and noncommercial wastes. The primary source of information regarding tipping fees in California was the June edition of the Solid Waste Digest. This publication listed fees based on commercial hauler rates.

Beyond the rate variances themselves, the rates can be expressed on a mass (dollars per ton) or on a volumetric (dollars per cubic yard) basis. Therefore, Table 4.1 will represent high, low, and average tipping fees on a mass basis (and volumetric when available) determined entirely by what was reported by the facility. The tipping fees in California as of April 1994 are presented in Table 4.1.

TABLE 4.1
Tipping Fees in California
April 1994

FEE	Landfill Rate $/Ton ($/Cubic Yd.)	Transfer Station $/Ton ($/Cubic Yd.)
High	83.62 (34.50)	85.70 (18.75)
Low	No Charge	No Charge
Average	28.85	37.95

The tipping fee data was extracted from the Solid Waste Digest's Solid Waste Price Index (32). The price index is a weighted average calculation based on facility volume and MSW gate fees for commercial haulers. Capacities and tip fees were obtained by the digest through direct phone contacts with facility owners and operators.

The landfill data represents information from 206 landfills with a total capacity of 110,436 tons per day and 74.45 percent of the daily waste intake in California. Of the 206 landfills listed, 37 landfills had tipping fees listed as unknown which could affect the average listed in Table 4.1.

The transfer station data represents information from 215 transfer stations with a total capacity of 35,227 tons per day and 23.75 percent of the daily waste intake in California. Of the 215 transfer stations, 70 facilities were listed as unknown for their tipping rates which could significantly affect the true average tipping rate at transfer stations in the state.

The combined capacity of both transfer stations and landfills in the state for April, 1994 is approximately 148,336 tons per day. The combined average tipping fee for both transfer stations and landfills during the same time period in California is $31.00/Ton.

As noted, the capital costs of the various operations are not being emphasized when evaluating the cost of disposal or reuse of wood waste. One of the reasons for this is it would be difficult to determine the true capital cost of a MSW landfill for only the wood waste portion of the solid waste stream. It also would be difficult to estimate capital costs of a biomass facility without knowledge of specific incentives available when the facility was constructed or if a relatively short depreciation rate was used. For example, Internal Revenue Code 1986 Section 168(e)(B)(3)(vi)(III) rules that biomass facilities not financed with tax exempt debt may be eligible for depreciation over five years (24, pg 4-22). If a plant was on an accelerated five year depreciation schedule, the economics of its operations would completely change, at least for the original investor.

However for a documented sample of landfill capital costs, the CIWMB Disposal Cost Guide estimated that a reference 1000 ton per day landfill would have a mean operating and capital cost of $11.80 per ton and closure/post closure cost of $1.30 per ton. These are only estimates which would vary with each specific facility.

Collection and transportation costs are not represented in Table 4.1. As a reference, the CIWMB Disposal Cost Fee Study (13, pg 6-19) contained wood waste collection cost estimates. They are shown on Table 4.2.

TABLE 4.2
Cost of Collecting Wood Waste

Type of Collection	**Wood Waste Collection Cost ($/Ton)**	**Recyclable Wood Collection Cost ($/Ton)**
Residential	64.87	64.37
Commercial	76.89	50.71

The costs were determined using County Solid Waste Management Plans. Each residential household was assumed to generate an average of 70 pounds of garbage a week while commercial customers were charged by the container. Collection costs for both residential and commercial wastes included on-route costs of collection and any long distance hauling costs if waste was sent to a transfer station first (13. pg 6-6).

IV.b BIOMASS

As noted, the operating parameters of each biomass facility differs. In turn, the capital and operating costs, and the resulting economic viability, of each facility will vary greatly. As a result, accurately describing the economics of operating an individual biomass facility, much less the industry as a whole, is extremely difficult.

Generally, pertinent cost related data such as fuel prices, transportation costs, and O&M cost were not readily available from individual biomass facilities because the information was thought to be competition sensitive or proprietary. However some general cost estimates can be estimated.

A significant issue relating to the economic performance of a biomass facility was the initiation of the Public Utility Regulatory Act of 1978 (PURPA). At least a basic understanding of PURPA must be had in order to understand that the economies of biomass facilities are not always directly comparable.

The energy crisis of the early 1970's spurred research and development of nontraditional power generation options in an effort to reduce dependence on foreign and non-renewable fuels such as oil and gas. The United States Congress passed the Public Utility Regulatory Policies Act in 1978 to expand the electricity supply industry and aid the development and use of renewable fuels for electric power production. PURPA is administered by the Federal Energy Regulatory Commission (FERC) whose purpose is to assure that adequate supplies of energy are available for consumers that also provide sufficient rate of returns to energy producers. FERC promulgated rules that implement PURPA under Code of Federal Regulations Title 18, part 292 that determines that status of qualified facilities eligible for PURPA benefits (7, pg 2-45).

In California, PURPA was implemented by the California Public Utilities Commission through standardized contracts developed by the Public Utilities. Four Standard Offer (SO) contracts specified how the utilities would pay qualifying facilities for capacity (megawatts) and energy (kilowatt/hour). The Standard Offer #4 contracts, the most desirable to qualifying facilities, guaranteed payments (approximately $0.09 kWH in 1991) for a period of ten years to offset the financial risks inherent to construction and operation of an alternative energy resource power plant. Cogeneration facilities and facilities that utilized non-traditional fuels, such as biomass, as well as met other criteria, qualified for the Standard Offer contracts.

The offer was based on the public utilities projected avoided cost (approximately $0.05/KWh in 1983, rising to as much as $0.12/KWh by 1995)(1, pg 2-21); the cost is defined as the incremental cost of the utility generating the power from its own sources. During 1983-1985, the utilities' avoided costs where high due to high fossil fuel prices (approximately $38.00 per barrel of oil). Since 1985, utility avoided costs have fallen, corresponding to the decrease in fossil fuel prices. Currently the short term avoided costs are approximately $0.03 kWH. Approximately 78 percent of the biomass combustion facilities currently operating have these lucrative SO#4 contracts.

Other versions of the Standard Offer contracts were set up to be periodically adjusted to reflect utilities current avoided costs, thus biomass facilities with the SO#4 contracts are at a substantial advantage. Concern is growing among biomass combustion facility operators as the contracts come due for renewal. The decrease in energy sales revenue will have a major impact on the biomass combustion industry.

Many biomass facilities are approaching what has been termed "year 11" in their PURPA contracts. This is in reference to eclipsing the first ten years of a thirty year contract which opens the opportunity for renegotiations. The largest purchaser in California of biomass energy is PG&E with over 50 facilities generating more than 900 MW (5, pg 1-1) under contract. Discussions with Ken Abreu of Pacific Gas & Electric revealed that all of the biomass facilities under PG&E contracts will have passed the 10 year renegotiation milestone by the year 2000. With PG&E's current short term avoided cost of producing electricity at $0.025 to $0.03 per KWH, it is certainly in PG&E's interest to renegotiate the price of the contracts since some are currently paying over $0.10 per KWH. Unfortunately, some biomass facilities have a fairly high cost of producing energy which could run as high as $0.05 to $0.08 per KWH.

It is obvious that PG&E would not want to pay more than its current avoided cost while a biomass facility would want to recover its cost and ensure a reasonable profit. Unfortunately, satisfying both requirements would be impossible at current market prices. This means either certain facilities will cease to operate or the economics of the industry must change.

To adapt to the prospects of reduced energy payments, operators are concerned with keeping operational costs manageable. Fuel sources and transportation issues are major concerns that must be addressed by operators if they are to continue to operate profitably. While PURPA and the resulting contracts allowed for rapid development of biomass combustion facilities, the fuel sources and transportation networks did not develop as swiftly. Some biomass combustion facilities do have long term contracts for fuel and transportation; others do not and are subject to a highly variable market.

The variability of fuel prices can be attributed to many factors. The demand for fuel has increased by 800% from 1985 to 1991 corresponding to the addition of 700MW of on line capacity in this same time frame (3, 3-26). Decreased activity in the lumber industry, due to a slow economy and increased environmental pressure, also has put a strain on the amount of wood fuels available for biomass combustion facilities. In addition to long-term trends in fuel price fluctuation, the seasonality of wood waste generation also affects fuel prices. More wood waste tends to be generated during the summer and fall due to increased timber harvesting and production of wood products, construction of housing, etc., as well as increased tree maintenance. With the above factors affecting wood fuel prices, facilities direct interest towards wood fuels from other sources to stabilize the market. Wood that can not feasibly be reduced, reused, recycled, or composted can be diverted from landfills and is one such potential fuel source. If the current network of processors, suppliers, and transporters of diverted landfill wood can be enhanced thus moderating supplies and prices, it could aid biomass combustion operators absorb the impacts of decreased revenues due to the end of the fixed rate payment by utilities.

Historically, prices for processed wood waste used by the biomass industry ranged between $35-45 per BDT with prices generally higher on the spot market. However, recent prices for processed wood waste to be used as fuel have dropped and facilities not tied to long term contracts have paid between $27 - $32 per BDT for processed urban wood waste. It would have been difficult to anticipate the current prices for biomass fuel during the period when most of the facilities were starting up. As a result, few of the facilities would have been able to predict the current upside down economy that many facilities are operating under. This situation may result in operations ceasing at several biomass facilities throughout the state and as a result diminish the market for processed wood waste. Only the most economically viable will be able to continue operation over the next few years.

Discussions with representatives of Louisiana Pacific indicated that current fuel production costs from wood waste landfill mining operations result in a delivered price of approximately

$35.00 per green ton. This is slightly higher than cost estimates made in the previous paragraph based on bone dry tonnages. What was stressed by Louisiana Pacific staff was the need for biomass as an integral part of their wood waste management strategy. For example, the Mendocino County landfill was mined for 180,000 yds of wood waste for fuel use alone with a total of 380,000 yds mined. The company has also mined Crescent Mills landfill and Lagoon Co landfill for wood waste. The mined wood waste fines are also used in forest and mine reclamation as an amendment to add organic matter to the soil. Louisiana Pacific felt that without the biomass industry, wood waste disposal would become a real concern in California.

Case Study: K&M Industries, Inc.

K&M Industries is a wood waste processor with collection and grinding facilities in Modesto and Sacramento. The Sacramento facility began operations in July of 1986 and employs 23 people with the intentions of expanding to 35 employees by 1995.

A plant tour of the Sacramento facility revealed a somewhat low technology yet relatively clean operation for the type of industry. In fiscal year 1993-94, the plant processed 105,000 green tons of wood waste into biomass fuel and 10,000 tons of green waste into a combination of biomass fuel, soil amendments, and ground cover. The plant collects 30 percent of its urban wood waste itself, 10 percent comes from commercial haulers, and the remaining 60 percent is brought in by self haulers.

K&M markets the processed biomass fuel to four power plants and one cogeneration plant. K&M anticipates it will process a total of 170,000 green tons at both the Sacramento and Modesto locations in fiscal year 1994-95. This equates to 1,792,480 million BTUs of electrical energy. This calculation is based on 40% moisture, 10.54 million BTUs/ton recoverable, and does not account for efficiency of the biomass burner. Aside from the potential energy recovered, K&M anticipates processing over 940,000 cubic yards of material that would otherwise be disposed of in a landfill. K&M is one of he largest processors in the State and the volumes of wood waste diverted and potential energy recovered are prime examples of the benefits available via wood processors and the biomass industry in the state.

The current market for biomass is somewhat depressed. K&M representative James Howell quoted the following prices for wood waste fuels:

TABLE 4.3
K&M Case Study
Processed Wood Waste Prices

DATE	BARK $/BDT	IN FOREST CHIPS $/BDT	URBAN WOOD WASTE $/BDT
12/31/93	60.00	45.00	40.00
6/30/94	55.00	37.50	22.50

As one can see in Table 4.3, the price drop for urban wood waste is quite dramatic for a six month period. This price is even more depressed than quotes and estimates received from other processors throughout the state and stated earlier in this report. Under current conditions, it would not be profitable to process urban wood waste unless long term contracts were in effect or a substantial increase in tipping fees were levied to offset market prices.

James Howell of K&M feels that the current trend of the Public Utilities Commission, along with some of the Public Utilities is towards conversion to natural gas firing rather than biomass energy recovery. Currently, natural gas is quite inexpensive and an excess supply currently exists. However, unlike biomass, this is not a renewable energy source and there is no benefit regarding the redirection of waste from landfills. These are both points that should be considered when developing a local, statewide or national energy policy. -End Case Study.

There is some potential economic assistance available to biomass facilities which is contained in proposed federal rulemaking. In the draft regulation package of 10 Code of Federal Regulations Part 451 published in the May 13, 1994 Federal Register, there is a proposal to offer incentives to qualified renewable energy facilities beginning at a rate of 1.5 cent per KWH for ten years with adjustments for inflation. In order for a facility to be qualified it must be either owned by a State, subdivision of a State, or nonprofit electrical cooperative. Preference will be given to those biomass facilities that burn fuel derived from organic matter grown exclusively for use in generating electricity. Based on the preceding criteria, the draft legislation would have an effect on a very small portion, if any, of biomass facilities in operation. The legislation was noted primarily because it has the potential to affect the economics of biomass facility operations, although it may be a small segment.

It is very difficult to estimate future economic trends in the biomass industry. If current avoided costs for producing electricity remain low, it is possible that some of the facilities will either go out of business or be subsidized to not produce energy. This is not necessarily true for all facilities. The biomass facilities which came into existence during the PURPA subsidized rapid growth era of the early eighties, that are not technologically advanced, located a considerable distance from adequate fuel supplies, and are not located on a desirable part utility's grid where high demand would minimize the transmission of electricity will undoubtedly be scrutinized the most regarding the viability of their operation.

The rapidly dropping price of processed urban wood waste would certainly offset some of the lost revenue to biomass facilities due to the drop in avoided cost of producing electricity. However, the current price of processed wood waste is below what several processors have quoted as the delivered cost of producing the fuel. As a result many processors not bound by long term contracts may stockpile wood waste until the market recovers offering little economic assistance to biomass facilities in the near term.

The potential reduction in biomass consumption incurred if several facilities ceased operations would decrease demand. Basic economics dictates when demand is down, resulting in an increase in supply, the cost of materials will decrease. This in turn would decrease the cost of producing energy and make the power produced by biomass more economically attractive. This scenario is based on a very simple view and does not account for other operating costs or changes in demand or avoided costs of disposal.

Transportation costs of bringing the fuel to the Biomass facility can be significant due to the relatively low density of the biomass fuel. Not only is the cost significant, but the price of wood waste transportation tends to fluctuate. To put the cost in perspective, an average truckload of wood waste weighs 25 tons; therefore, a typical 20 MW plant requires as much as 25 truck deliveries or more in a single day to sustain operations. This is based on 20 percent moisture content in the wood and a power plant efficiency of 20 percent (1, pg 3-42). The same 25 ton payload vehicle costs an average of $55 per hour to operate during transportation. For a source 40 miles from the power plant, assuming an average total loading and unloading time of one-half hour and an average travel speed of 40 mile per hour, the transportation cost would be $5.50/ton(wet). Assuming a 40 percent moisture content of the wood, the resulting transportation cost would be $9.20 per BDT.

V REGULATORY CONSTRAINTS

In addition to market forces, there are several regulatory factors that could have a direct influence on the profitability of the biomass industry. The first regulatory factory being the definition of transformation. According to section 40201 of the

Public Resource Code (PRC), "transformation means incineration, pyrolysis, distillation, gasification, or biological conversion other than composting. Transformation does not include composting". Furthermore, Section 18722(a)(77) of Title 14 of the California Code of Regulations defines a transformation facility as a facility whose principal function is to convert, combust, or otherwise process solid waste by incineration, pyrolysis, destructive distillation, or gasification, or to chemically or biologically process solid wastes, for the purpose of volume reduction, synthetic fuel production, or energy recovery. Transformation facility does not include a composting facility. Both these definitions would include biomass facilities burning wood waste to generate power. This in itself is not so significant. However, under Section 41780 of the PRC, Cities and Counties are required to divert 25% of the solid waste from landfills and transformation facilities by January 1, 1995, through source reduction, recycling, and composting activities.

Furthermore, this Section of the PRC requires that 50 percent of the solid waste be diverted by January 1, 2000. Since the requirement is that the waste be diverted from transformation facilities as well as landfills, the statute could pose as a hindrance to use of wood waste a fuel. This is not definitive; primarily because it is assumed the diversion must come from permitted transformation facilities and biomass facilities, although considered transformation, are not permitted by the CIWMB.

There is a contingency in Section 41783 of the PRC that allows transformation to make up 10% of the diversion requirement to be met in January 1, 2000. Unfortunately, the use of transformation as a diversion from permitted disposal facilities will not be exercised until Cities and Counties need to achieve 50% diversion when January 1, 2000 approaches. It is unlikely however that biomass facilities could take advantage of this. In order for a transformation facility to be eligible for the 10% of the waste stream reduction credit, it would have to be permitted as a disposal facility by the CIWMB and the waste would have to have been going to a disposal facility during the base year. Biomass facilities are currently not permitted by the CIWMB and it is unlikely that the fuel that they are currently using was a waste stream that normally went to a landfill in 1990. In the interim, the current regulations limit the options to encourage the use of wood waste for energy recovery through diversion.

There is currently a proposal that would allow biomass facilities to be eligible for up to 10% of the waste reduction requirements mandated by the year 2000. Assembly Bill 688, which is before the Governor at the writing of this report, would exclude biomass conversion from the regulatory definition of transformation and allow jurisdictions to apply biomass conversion towards 10% of the waste diversion mandate of 50% by the year 20000. This would require new SRREs to document the amount of material that was going to biomass facilities in the baseline year and would not be a significant factor regarding diversion until jurisdictions need to achieve the 50% diversion rate which presumably would not occur until the year 2000 approaches. Additionally, the change in the law, if the Bill is signed, would not significantly effect the cost of operations of a biomass facility as there is currently a glut of waste wood driving fuel prices down.

VI. CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1.

The term "nonyard wood waste" needs to be defined.

Recommendation

The CIWMB should define, in regulation, the term "nonyard wood waste" to include pieces of wood generated during the manufacture or processing of wood products, the harvesting or processing of raw woody crops, and the wood debris from construction and demolition activities.

Conclusion 2.

Wood waste currently going to biomass burners cannot count towards AB 939 diversion goals because these facilities are not CIWMB permitted facilities. However, at the time of printing of this document, the legislature sent AB 688 to the Governor for approval. If signed, this Bill would specifically exclude biomass conversion from the definition of transformation and allow biomass conversion to count up to 10% of the waste reduction mandated by the year 2000.

Recommendation

Option 1:

The CIWMB may choose to seek legislation allowing wood waste going to biomass burners to count towards the AB 939 goals; or,

Option 2:

The CIWMB may choose to consider biomass burners as solid waste facilities and permit them thus allowing the diversion to count.

Either of the above options would necessitate that some sort of weighing or accounting system be used by local jurisdictions to quantify wood waste being counted for diversion.

Conclusion 3.

The data needed to quantify the amount of nonyard wood waste is incomplete, conflicting, or non-existent.

Recommendation
If nonyard wood waste is to be better quantified, the CIWMB should require each regulated jurisdiction to categorize and quantify woody materials. This should be accomplished after the CIWMB has defined nonyard wood waste. Local jurisdictions would need to incorporate into their existing systems a method to quantify sources and uses of wood waste.

Conclusion 4.
The environmental impacts of diversion of nonyard wood waste from permitted facilities are minimal.

Recommendation
Since the quantities of nonyard wood waste and the environmental effects of nonyard wood waste disposal to permitted facilities are minimal, no immediate action is required of the CIWMB now or later and continued annual tracking and reporting would have limited usefulness. It is therefore suggested that the need for the annual reporting under Section 42512 be reassessed. However, the CIWMB should continue to support the reduce, reuse, and recycle hierarchy of AB 939 with respect to the management of nonyard wood waste.

Conclusion 5.
By consuming wood waste, biomass facilities are providing a disposal alternative to society while at the same time generating electric power.

Recommendation
The CIWMB should encourage biomass facilities to continue operating and accepting wastes that have not previously been normally disposed to avoid the potential increase in waste that may appear at landfills if biomass plants cease operation.

Conclusion 6.
Biomass facilities assist in reducing air emissions of criteria pollutants by burning agricultural waste in a controlled combustion environment. This material would have otherwise be burned uncontrolled in open fields causing greater emissions of air pollutants.

Recommendation
The CIWMB should actively encourage biomass facilities to continue to accept and burn agricultural wastes to assist in the reduction of criteria pollutants emitted from open field burning.

Conclusion 7.

The best method for managing the greatest fraction of the large quantities of wood waste in California at the present time is for its use as a fuel for biomass burning facilities.

Recommendation

The Board should focus its efforts on assisting the industry in developing programs for such operations as mining and processing landfilled wood waste, collecting and processing agricultural wastes, collection of non-traditional fuels such as Christmas trees, and in general developing a regulatory atmosphere that encourages alternatives to landfill disposal or open field burning.

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