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ENERGY
COMMISSION

APPENDICES
COSTS AND BENEFITS OF A BIOMASS-TO-ETHANOL PRODUCTION INDUSTRY IN CALIFORNIA

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Appendix III-A

Direct Impacts

The cases described in this work were generated using several inputs. The California gasoline energy demand was established using 1999 gasoline consumption data. The gasoline pool was then decomposed into three separate component volumes: conventional gasoline, MTBE, and RFG gasoline void of MTBE. The total energy contained in these fuel components is held constant across all scenarios.

With historical gasoline components identified, the amount of ethanol required by the state of California was calculated based on Federal oxygenate levels for ozone non-attainment, and the fraction of California gasoline consumed in ozone non-attainment regions. For the purposes of the study, it is assumed that the Federal oxygenate standard for ozone non-attainment in California is 2% by weight, and that 80% of California gasoline is used in ozone non-attainment regions. The Federal oxygenate standards required are in motion, however, California has applied for a waiver to lower Federal oxygenate standards. The actual percentage of gasoline consumed in ozone non-attainment regions is similarly fluid, as attainment status is under review, particularly that of the San Joaquin Valley. If the San Joaquin region is found to be in ozone non-attainment, as expected, 80% of California gas is anticipated to be consumed in ozone non-attainment regions.

With total ethanol demand established, several scenarios were created to examine potential outcomes in terms of ethanol usage. It is worth noting that a fraction of the pentane hydrocarbons present in gasoline must be removed for ethanol-gasoline blending, to meet Reid Vapor Pressure (RVP) requirements for evaporative emissions. With the removal of pentanes from the fuel inventory – and the associated decrease in transportation fuel energy – it is assumed that additional gasoline will be consumed to compensate for any energy shortfall.

In several scenarios outlined in the appendix, ethanol is blended without pentane extraction. This is not an omission, despite the caveat listed above regarding RVP standards. For relatively low volumes of ethanol-gasoline blending, it is believed that a “split pool” strategy can be employed. Using this approach, pentanes are extracted from any gasoline to be blended with ethanol and reincorporated into the balance of the gasoline pool. This strategy effectively extends the transportation fuel pool, as both pentanes and ethanol can be used without the exclusion of the other.

With ethanol demand defined, the appendix develops production scenarios in terms of biomass-to-ethanol plants and jobs associated with these enterprises. Two major economic implications come from this examination: capital investment and employment impacts. These factors are quantified based on plant construction costs and estimated work force requirements for ethanol production facilities. These factors become inputs for the economic Input-Output (IO) model used to quantify the general equilibrium economic costs and benefits that stem from biomass-to-ethanol conversion. Another input to the IO model is the tax revenue and sales due to ethanol consumption. These impacts are quantified in this appendix.

The final major component of the scenarios is the quantification of the biomass required to achieve listed ethanol output. The types of biomass, and the feedstocks needed for each plant are also developed. Using specific plant locations, feedstock collection regions and the transportation required to move this biomass is also developed to complete the biomass analysis as it pertains to ethanol production.

Other factors considered within this appendix are electricity production due to displaced (or augmented) biomass power production, differential natural gas consumption to compensate for marginal power requirements, and electricity co-production from biomass-to-ethanol conversion.

Appendix III-B

Model Inputs

This appendix contains tables of inputs for the cost benefit analysis.

Summary of Feedstocks for Ethanol Production Cases

Plants Used	ZERO CA ETOH 1,3,4,7,8 (biomass power only) [c]	CA ETOH 1,3,4,7,8, 12-21[a]	HIGH CA ETOH All
Ethanol Cap. (M Gal/yr)	0	200	400
Forest Materials (BDT/yr)	723,514	1,033,592	2,067,183
Agricultural Residues (BDT/yr)	400,000	1,273,231	2,196,308
Urban Waste (BDT/yr)	—	404,040	1,010,101

a - Any four plants to be chosen from the lot of plants 12 through 21
b - Any eight plants to be chosen from the lot of plants 12 through 21
c - Plants 1, 7 and 8 will use only 40% of biomass when operating without a collocated ethanol plant

Agricultural Residue Plants and Feedstocks

Type	Rice Straw	Rice Straw	Ag Residue Orchard pruning	Ag Residue Orchard pruning	Ag Residue Orchard pruning
Plant ID	7	8	9	10	11
Ethanol Cap. (M Gal/yr)	40	40	20	20	20
Capital (M $)	120	120	60	60	60
Rice Straw Feed (EtOH %) - a	41	41			
Consumption (tons/yr) - b	368,000	368,000			
Consumption (BDT/yr)	276,000	276,000			
Ag. Residue Feed (EtOH %) - c	59	59	100	100	100
Consumption (tons/yr) - b	480,821	480,821	410,256	410,256	410,256
Consumption (BDT/yr)	360,615	360,615	307,692	307,692	307,692
Total Agricultural Residues, BDT/yr	636,615	636,615	307,692	307,692	307,692

a - Based on available rice straw information gathered from industry stakeholders
b - Consumption data calculated from ethanol yield data shown in Plant Parameters Table in this Appendix
c - Based on availability data from CEC 1999 report "Evaluation of Biomass-to-Ethanol Potential."

Urban Waste Plants and Feedstocks

Type	Urban Waste	Urban Waste	Urban Waste	Urban Waste	Urban Waste
Plant ID	12	13	14	15	16
Ethanol Cap. (M Gal/yr)	10	10	10	10	10
Capital (M $)	45	45	45	45	45
Waste Paper Feed (EtOH %) - a	60	60	60	60	60
Consumption (tons/yr) - b	63,796	63,796	63,796	63,796	63,796
Consumption (BDT/yr)	60,606	60,606	60,606	60,606	60,606
Other Waste (EtOH %) - a	40	40	40	40	40
Consumption (tons/yr)	42,531	42,531	42,531	42,531	42,531
Consumption (BDT/yr)	40,404	40,404	40,404	40,404	40,404
Tree Prunning Feed (EtOH %)	0	0	0	0	0
Consumption (tons/yr)	0	0	0	0	0
Consumption (BDT/yr)	0	0	0	0	0
Construction Material (EtOH %)	0	0	0	0	0
Consumption (tons/yr)	0	0	0	0	0
Consumption (BDT/yr)	0	0	0	0	0
Total Urban Waste, (BDT/yr)	101,010	101,010	101,010	101,010	101,010

a - Data inferred from discussions with Material Recycling Facilities operators, Ventura County, and California Integrated Waste Management Board.
b - Consumption data calculated from ethanol yield data shown in Plant Parameters Table in this Appendix

Urban Waste Plants and Feedstocks (cont.)

Type	Urban Waste	Urban Waste	Urban Waste	Urban Waste	Urban Waste
Plant ID	17	18	19	20	21
Ethanol Cap. (M Gal/yr)	10	10	10	10	10
Capital (M $)	45	45	45	45	45
Waste Paper Feed (EtOH %) - a	60	60	60	60	60
Consumption (tons/yr) - b	63,796	63,796	63,796	63,796	63,796
Consumption (BDT/yr)	60,606	60,606	60,606	60,606	60,606
Other Waste (EtOH %) - a	40	40	40	40	40
Consumption (tons/yr)	42,531	42,531	42,531	42,531	42,531
Consumption (BDT/yr)	40,404	40,404	40,404	40,404	40,404
Tree Prunning Feed (EtOH %)	0	0	0	0	0
Consumption (tons/yr)	0	0	0	0	0
Consumption (BDT/yr)	0	0	0	0	0
Construction Material (EtOH %)	0	0	0	0	0
Consumption (tons/yr)	0	0	0	0	0
Consumption (BDT/yr)	0	0	0	0	0
Total Urban Waste, (BDT/yr)	101,010	101,010	101,010	101,010	101,010

Forest Material Plants and Feedstocks

Type	Forest Materials	Forest Materials	Forest Materials	Forest Materials	Forest Materials	Forest Materials
Plant ID	1	2	3	4	5	6
Ethanol Cap. (M Gal/yr)	40	40	20	20	20	20
Capital (M $) - c	90	90	60	60	60	60
Forest Thinning/Slash Feed (EtOH %) - a	87	87	87	87	87	87
Consumption (tons/yr) - b	642,303	642,303	321,152	321,152	321,152	321,152
Consumption (BDT/yr)	449,612	449,612	224,806	224,806	224,806	224,806
Lumbermill Waste Feed (EtOH %) - a	13	13	13	13	13	13
Consumption (tons/yr) - b	89,578	89,578	44,789	44,789	44,789	44,789
Consumption (BDT/yr)	67,183	67,183	33,592	33,592	33,592	33,592
Total Forest Materials, BDT/yr	516,796	516,796	258,398	258,398	258,398	258,398

a - Assumption based on various reports and communications
b - Consumption data calculated from ethanol yield data shown in Plant Parameters Table in this Appendix
c - Landucci, R., Proforma Systems, “Evaluation of Ethanol Production Costs, Appendix VII-B, in Evaluation of Biomass to Ethanol Fuel Potential in California,” California Energy Commission Report P500-99-022A, December 1999.

Plant Parameters [a]

Biomass Type	Moisture (%)	Ethanol Yield (Gal EtOH/BDT)	Collocated Plant Electricity Production (kWh/gal)	Collocated Plant Net Electricity Production (kWh/gal)	Equivalent NG required for electricity in ethanol plant[b] (kBtu/gal)	Equivalent NG required for electricity in ethanol plant (scf/gal)
Forest Materials						
Forest Slash/Thinnings	30	77.4	3.2	2	-	-
Lumbermill Waste	25	77.4	3.2	2	-	-
Agricultural Residues						
Rice Straw	25	60	0	-1.3	-	-
Ag. Residue	25	65	3.2	2	-	-
Urban Waste						
Waste Paper	5	81.7	0	-1.1	9.900	9.61
Other Waste	30	65	0	-1.1	9.900	9.61
Tree Prunnings	30	65	0	-1.1	9.900	9.61
Construction Materials	30	65	0	-1.1	9.900	9.61

Assumed NG Elec. Conversion	Btu/kWh	9000
NG Volume	Btu/scf	1030
NG Price	$/MMBtu	3
Biomass Power Heat Rate	Btu/kWh	17,000
Biomass Heating Value	Btu/lb (HHV)	8500

a - Plant parameters data was provided by Mr. Ron Landucci, ProForma Systems
b- Assume rice straw does not use natural gas but uses additional agricultural residue to provide the required electricity

Rice Straw Burn Scenarios

Bone Dry Tons, BDT

	Total Rice Straw Produced	Reincorporated into soil	Available for ethanol	Total Burned	Alternate markets	Ethanol production (mill gal)	Rice straw available for bailing
	BDT	**BDT**	**BDT**	**BDT**	**BDT**	**(Million Gal)**	**BDT**
Zero CA Ethanol	840,000	696,360	-	126,000	17,640	-	588,000
CA Ethanol	840,000	126,000	570,360	126,000	17,640	34.22	588,000

Assumption: legislation states the lesser of 25% or 125,000 acres may be burned

No-burn days also limit the ability to burn rice straw to approximately 15% of acreage.

Available for baling	70%	
Yield (gal/BDT)	60	<-- Based on Proforma Systems data
Moisture	30%	<-- Based on Proforma Systems data
Alternate markets	3%	(assumes growth of current market which is less than 2%)
Rice straw density (tons/acre)	2	<-- based on a range of 1 to 2.5 by Ken Collins, Rice Straw Cooperative
Total acres	600,000	<-- Paul Buttner, CARB

ETHANOL TRANSPORTATION											
Plant ID		1	2	3	4	5	6	7	8	9	10
Ethanol Production Capacity	M Gal/yr	40	40	20	20	20	20	40	40	20	20
	K Gal/day	110	110	55	55	55	55	110	110	55	55
	ton/day	723,288	723,288	361,644	361,644	361,644	361,644	723,288	723,288	361,644	361,644
Ethanol Movement											
Truck (7.8 K Gal/trk)	Trucks/day	14	14	7	7	7	7	14	14	7	7
Railcar (29 K Gal/railcar)	Railcar/day	4	4	2	2	2	2	0	0	0	0
Nearest Ethanol Unloading Point											
Truck											
Location		Marysville	Dunsmuir	Reno	Redding	Reno	Redding	Marysville	SAC	Fresno	Fresno
Distance	Miles	100	10	40	10	60	20	10	20	40	5
Total Truck Miles (one-way)	Miles	1405	140	281	70	421	140	140	281	281	35
Railcar											
Location		SAC/STK	SAC/STK	SAC/STK	SAC/STK	SAC/STK	SAC/STK	SAC/STK	—	SAC/STK	SAC/STK
Distance	Miles	50	250	100	200	100	200	50	—	200	200
Total Railcar Miles (one-way)	Miles	50	250	100	200	100	200	50	—	200	200

SAC - Sacramento Terminals
STK - Stockton Terminals
LAP - Los Angeles Port Terminals

ETHANOL TRANSPORTATION												
Plant ID		11	12	13	14	15	16	17	18	19	20	21
Ethanol Production Capacity	M Gal/yr	20	10	10	10	10	10	10	10	10	10	10
	K Gal/day	55	27	27	27	27	27	27	27	27	27	27
	ton/day	361,644	180,822	180,822	180,822	180,822	180,822	180,822	180,822	180,822	180,822	180,822
Ethanol Movement												
Truck (7.8 K Gal/trk)	Trucks/day	7	4	4	4	4	4	4	4	4	4	4
Railcar (29 K Gal/railcar)	Railcar/day	0	0	0	0	0	0	0	0	0	0	0
Nearest Ethanol Unloading Point												
Truck												
Location		LAP	LAP	LAP	LAP	LAP	LAP	Crockett	Crockett	LAP	LAP	LAP
Distance	Miles	40	30	40	40	40	100	50	50	10	100	100
Total Truck Miles (one-way)	Miles	281	105	140	140	140	351	176	176	35	351	351
Railcar												
Location		—	—	—	—	—	—	—	—	—	—	—
Distance	Miles	—	—	—	—	—	—	—	—	—	—	—
Total Railcar Miles (one-way)	Miles	—	—	—	—	—	—	—	—	—	—	—

SAC - Sacramento Terminals
STK - Stockton Terminals
LAP - Los Angeles Port Terminals

FEEDSTOCK TRANSPORTATION

Plant ID		1	2	3	4	5	6	7	8	9	10
Ethanol	Gal/BDT	77	77	77	77	77	77	65	65	65	65
Feedstock	BDT/day	1,423	1,423	712	712	712	712	1,686	1,686	843	843
Truck Capacity	BDT/Truck	22	22	22	22	22	22	14	14	14	14
Truck trips per day	Trucks/day	65	65	32	32	32	32	120	120	60	60
Trucks trips	Truck Trips/MGal	590	590	590	590	590	590	1,099	1,099	1,099	1,099
Average One-way Distance per trip	miles/trip	40	40	25	25	25	25	25	25	25	25
Average Speed	miles/hr	40	40	40	40	40	40	40	40	40	40
Average #of hour loading/unloading	hr/trip	2	2	2	2	2	2	2	2	2	2
Number of trips by truck (10-hr days)	trips/day	3	3	3	3	3	3	3	3	3	3
Load per truck per day	BDT/truck/day	55	55	68	68	68	68	43	43	43	43
Number of trucks per day	Trucks/day	26	26	11	11	11	11	39	39	20	20
Number of trucks	Trucks/MGal	0.6	0.6	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0

Plant ID		11	12	13	14	15	16	17	18	19	20	21
Ethanol	Gal/BDT	65	78	78	78	78	78	78	78	78	78	78
Feedstock	BDT/day	843	354	354	354	354	354	354	354	354	354	354
Truck Capacity	BDT/Truck	14	25	25	25	25	25	25	25	25	25	25
Truck trips per day	Trucks/day	60	14	14	14	14	14	14	14	14	14	14
Trucks trips	Truck Trips/MGal	1,099	516	516	516	516	516	516	516	516	516	516
Average One-way Distance per trip	miles	25	20	20	20	20	20	20	20	20	20	20
Average Speed	miles/hr	40	40	40	40	40	40	40	40	40	40	40
Average #of hour loading/unloading	hr	2	2	2	2	2	2	2	2	2	2	2
Number of trips by truck (10-hr days)	trips/day	3	3	3	3	3	3	3	3	3	3	3
Load per truck per day	BDT/truck/day	43	83	83	83	83	83	83	83	83	83	83
Number of trucks per day	Trucks/day	20	4	4	4	4	4	4	4	4	4	4
Number of trucks	Trucks/Mgal	1.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Appendix IV-A

Economic Evaluation

IV-A-1 Total Economic Impacts

Total economic impacts were estimated for a moderate demand California Ethanol case (200 million gallons/year produced in California) and a high demand California Ethanol case (400 million gallons/year produced in California). Direct impacts are based upon a comparison with a Zero California Ethanol case in which California imports and consumes 300 million gallons/year or 600 million gallons/year in the high demand case. The direct impacts were then used as inputs to IMPLAN (a regional economic input-output model) to estimate the secondary economic impacts on the California economy (see detailed discussion below). Impacts were estimated for different time periods depending on the type of impact. Impacts due to construction activity were specified to occur between 2001 and 2008. Recurring impacts due to California ethanol production occur between 2004 (when the first plant begins operations) and 2029 (when the last plant is shut down). The positive and negative direct and indirect impacts were then summed by year to produce a total benefit stream for each case. A net present value analysis is used to compare these benefit streams with estimated government outlays (in the form of personal income losses).

The following table presents the main assumptions associated with each case analyzed.

Table IV-1. Changes in Key Variables Used to Define Each Case

Variable	CA Ethanol Case	High CA Ethanol Case
Change in CA Ethanol Production (M gal/yr)	200	400
Change in Ethanol Imports (M gal/yr)	-200	-400
Change in Pentane Extraction (M gal/yr)	0	264
Change in CA Gasoline Production (M gal/yr)	0	-32
Change in Gasoline Imports (M gal/yr)	0	-33
Change in Total Fuel Volume (M gal/yr)	0	122
Change in Electricity Peak Production (GW)	0	0
Change in Electricity Production (GW-hr)	-510	-383
Change in Process Natural Gas (M ef/yr)	2,000	4,000

M = million
GW = Giga Watt

IV.A.1.1 Overview of Approach

Overview of Approach

The economic impacts of an ethanol industry are estimated using a regional economic impact model. This model is used to estimate the indirect and induced impacts in California.

Possible Methods to Estimate Economic Impacts

- Economic Base
- Input-Output
- RIMS II
- IMPLAN
- REMI
- CGE

Types of Economic Impacts

Most economic stimuli generate three types of impacts: direct impacts, indirect impacts, and induced impacts. Direct impacts generally refer to those impacts that occur first in the economy. These first round effects are often associated with changes in employment (these impacts can be measured in different metrics: e.g., employment, output, income, value added, etc.) in an industry or institution. For example, assume that a significant rise in the price of forest products causes paper manufactures to use relatively more recycled paper in their production process. Two direct impacts ensue. Employment falls in the forest products industry and increases in the paper recycling industry.

Indirect and induced impacts occur after the direct impacts and are often referred to as secondary impacts. Indirect impacts reflect changes in downstream support industries. Continuing the example, the forest products industry utilizes fuel for its trucks; employment in the petroleum products industry, therefore, would probably decline due to the reduced demand for forest products. The increased demand for recycled paper, on the other hand, would give rise to additional demand for chemicals used in the deinking process. As a result, employment in the chemical manufacturing industry would increase.

Induced impacts are the result of employees spending their disposable income. Changes in expenditure levels generate related employment changes in the manufacture and distribution of consumer products. For example, total earnings in both the recycled paper industry and the chemical industry would increase as a result of the increased demand for recycled paper. Part of these increased earnings would be spent on clothing, which would generate employment in its manufacture and distribution.

Model Selection and Overview

Calculating all of these impacts requires an economic model that can appraise impacts through multiple tiers of expenditures. There are a number of different models that could be used for this purpose: e.g., IMPLAN, REMI, or RIMS II. IMPLAN was used for several reasons. First, IMPLAN is both easier to understand and is much less expensive than the REMI model. Second, to improve the accuracy of the impact estimates it is desirable to create custom multipliers based upon the specifics of the California economy and the ethanol industry being evaluated. This is not possible with RIMS II but, as discussed later, can easily be done with IMPLAN.

IMPLAN uses input-output analysis (a method of examining relationships between producers and consumers in an economy) to analyze the effects of an economic stimulus on a specified economic region. IMPLAN provides data at three geographic levels: national, state, and county. These geographic units can be combined to construct any regional grouping the user desires. The ease with which alternative regional aggregations can be constructed while preserving critical trade flow information is a principal advantage of IMPLAN.

There are two major components in the IMPLAN model: a descriptive model and a predictive model. The descriptive model is represented by accounting tables that describe the trade flows between producers and consumers in the region. The trade flows detail not only intra-regional flows but also flows between the study area and the "rest of the world". The descriptive model also incorporates Social Accounting Matrices (SAMs), which show money flows between institutions: e.g., taxes paid by consumers to governments and transfer payments from governments to businesses and households.

The predictive model consists of a set of multipliers that can be used to forecast changes in the economy. Multipliers are the means by which the initial change is translated into direct, indirect, and induced impacts. Thus, IMPLAN can be used to predict the regional economic repercussions due to changes in supply or demand or due to changes in model parameters (e.g., income tax rate).

The IMPLAN multipliers are based on the descriptive model and are computed only after the regional economic accounts have been completely defined. This is an important advantage of IMPLAN. In the descriptive model, all of the model parameters can be changed to reflect a particular scenario or situation. Consequently, the resulting multipliers embody such changes. Examples of parameters that can be changed include regional purchase coefficients, margin rates, and production coefficients. Some regional models, such as RIMS II, only provide the multipliers for evaluating economic impacts and do not provide the descriptive accounts that can be used to developed custom multipliers. Since they are not able to incorporate specific conditions in a local economy, the impacts predicted by these models are usually less accurate than impacts predicted by models such as IMPLAN.

IMPLAN conducts its analysis for 528 industrial sectors, primarily a mix of 4-digit and 3-digit SIC sector detail. This highly detailed sectoring plan is critical in input-output modeling, where the production function determines the indirect impacts associated with increased output in an industry. In a highly aggregated sectoring plan (for example, 2-digit SIC level) the production function coefficients and impact multipliers are averaged over all the different firms that comprise each 2-digit SIC group. Therefore, a specific facility of interest may have a production process that differs substantially from that represented at the 2-digit SIC level. Modeling impacts at the 4-digit level reduces the inaccuracies associated with industry aggregations.

The model is stimulated using estimates of the direct impacts. All direct impacts are defined in terms of the differences between the "with" and "without" scenarios.

These impacts are estimated outside of the model. These first round effects can be measured in different metrics: e.g., employment, output, income, or value added. After a model scenario has been run, results are available for all metrics and type of impact (direct, indirect, and induced).

Estimation of Indirect Impacts

Operations

Two approaches can be used to estimate the economic impacts associated with ethanol production operations. The easiest approach is simply to stimulate the output of those industries that are directly impacted. As noted above, there are problems with this approach due to how industries are aggregated in IMPLAN (or any other regional model). For example, IMPLAN's transportation sector consists of numerous industries with very different production processes. Note that the transportation production function represents an average of all of these different industry production processes. If the focus of analysis is on only one of these transportation industries, stimulating the entire transportation sector may lead to large inaccuracies if that industry's production process is very different from the average sector production process.

The ability to group events in IMPLAN is an important feature that can be used to deal with these type of aggregation problems. Stimulating a sector's output is an individual event in IMPLAN, so multiple sectors can be stimulated simultaneously. Rather than stimulating the output of the directly impacted industry, sometimes it is better to simultaneously stimulate the sectors associated with the inputs to that industry. To some extent, this helps circumvent the aggregation problem.

To carry out this approach, it is first necessary to determine the production function of the directly impacted industry. Data is gathered on the inputs into ethanol production. A concordance between the data's sectoring plan and IMPLAN's industry scheme is developed. Knowledge of SIC coding is used whenever possible. In some cases there may not be a one-to-one correspondence, and the data may have to be aggregated or split accordingly.

The next step is to determine the output in the industries directly impacted by the stimulus. These figures are multiplied by the production coefficients (estimated in the first step), yielding estimates of the total cost of each input used.

Finally, the total cost associated with each input is used to stimulate a sector in IMPLAN. At this point, note that only the costs of intermediate inputs are being stimulated. However, the impacts resulting from payroll expenditures will also be estimated; the procedure for doing so is described below under "Induced Impacts".

Investment

It should be noted that the production equations in an input-output model do not include capital investment (rather, capital depreciation is included with value added). While data on employment/output and intermediate inputs allows us to estimate the impacts resulting from current operations, they do not allow us to estimate those impacts associated with initial investments. Such investments include purchases of machinery and equipment (e.g., bailers and sorters) and purchases of construction services if new structures have to be built. This issue is relevant since we are evaluating different growth scenarios for the ethanol production industry. Industry growth depends upon these types of investments.

The procedure used to estimate the economic impacts associated with capital investment is similar to the one used for operations. First, total investment needs to be allocated to equipment and structures. Total equipment investment then needs to be further allocated to the different types of equipment that will be purchased. Next, the investment categories are mapped to the relevant IMPLAN sectors. For example, investment in conveyors would be mapped to IMPLAN sector 315 (Conveyors and Conveying Equipment). The output of these IMPLAN sectors is then stimulated with the respective investments. Investment or industrial margins (primarily transportation) are applied to each stimulated sector; regional purchase coefficients are also assigned to take into account purchased equipment and machinery that are manufactured out of the state.

Estimation of Induced Impacts

As pointed above, induced effects are the result of employees spending their disposable income. The estimation of these impacts entails a three stage process. First, employee earnings for each impacted industry are converted into disposable income using assumed tax rates and savings rates. Disposable income is then allocated to income groups using data on consumption expenditures by income group, which are available from secondary data sources. Finally, personal consumption expenditure (PCE) vectors for each income group are stimulated in IMPLAN using the above disposable income estimates. Household margins are applied to these expenditures to ensure that the wholesale trade, retail trade, and transportation sectors are appropriately stimulated.

Estimation of Tax Revenue Impacts

The total economic impacts, defined in terms of changes in total personal income (TPI), are used to estimate the annual gains in tax revenues. The estimates are based upon ratios of tax revenues to TPI developed using data for California. State and local government tax revenues are provided by the U.S. Census Bureau. These revenues include property taxes, sales and gross receipts, and other tax revenues. TPI by state is furnished by the U.S. Bureau of Economic Analysis.

IV.A.1.2 Direct Impacts

Direct economic impacts were defined and estimated for different types of events that would result from the establishment of a California ethanol production industry. For example, two events that were considered were (1) reduced ethanol imports and (2) increased sales of California produced ethanol. Several direct impacts were associated with each event. For example, the reduction in imports would negatively impact both the wholesale trade and fuel transportation sectors in California. Each of these was defined as a direct impact. Offsetting these negative impacts were positive impacts on the wholesale and fuel transportation sectors due to the increase in California ethanol production.

All direct impacts were measures in terms of changes in industry output or commodity demand.

Capital Investments

Capital investments include purchases and installation of equipment, construction costs, and other minor expenses. Acquisition of land is not included in the analyses, since those purchases represent an economic transfer. The analyses consider investments in ethanol plants/biomass power facilities and in truck fleeting needed to transport feedstock and distribute ethanol to storage terminals.

The manufacture of the equipment and the construction of the facilities create jobs and positive economic impacts over short periods of time. However, since the proposals under consideration do not affect the cost of capital, total capital expenditures are assumed to remain the same in the U.S. and abroad. This means the investments displace investments that would have occurred both in California and outside of the state. Displaced investment that would have occurred outside of the state is considered a benefit since it represents positive economic growth in California that otherwise would not have occurred. Based on the amount of manufacturing investment that takes place in California relative to the U.S., it is assumed in this report that 11% of the total capital investment would have occurred in California in the reference case. Therefore, 89% of the principal represents new investment in California.

Plant Construction and Modification

New plant investment was allocated to those economic sectors involved in building the plants. Based upon engineering cost estimates, the following percentages were used to carry out the allocation:

Construction Services:	32.9%
Cost of Equipment:	39.5%
Equipment Installation (Labor):	19.7%
Engineering/Architectural Services:	7.9%

The following table presents the results of the allocation. Note that expenditures for labor will be assigned to IMPLAN's personal consumption expenditure vector. In addition, the "New Investment in California" figures do not necessarily represent the total direct impact on the California economy. For example, some of the purchased equipment is manufactured in other states. During the model runs, IMPLAN's regional purchase coefficients were used to assign portions of the direct expenditures to California. Finally, the table presents the total amount of investment planned for each scenario. These investments will take place gradually over a construction phase. The timing of these investments and their associated economic impacts are taken into account in the present value analysis.

Table IV-2. Capital Investment in Ethanol Plant and Biomass Power Facilities (in million dollars)

Investment	CA Ethanol	High California Ethanol
Total Investment	660	1,426
New Investment in California	587	1,269
Construction	193	418
Equipment Manufacturing	232	501
Personnel Consumption Expenditures (labor)	116	250
Engineering/Architectural Services	46	100

Truck Fleet Investment

Ethanol Distribution

Additional truck fleeting will be required to distribute the ethanol. Ethanol produced in California will have to be carried by rail or truck from the production sites to wholesalers and blending points. It is assumed that imported ethanol will be carried by ship or rail to these distributors.

The calculations to estimate the additional trucks consist of several steps. First, annual California ethanol production was converted into daily demand by dividing it by a capacity factor (360 days). Next, this demand was divided by the average truck tank size to estimate the number of truck trips per day. The number of truck-trips per day was then divided by an estimate of daily trips per truck[1], yielding the actual number of trucks needed to deliver the product. Auxiliary trucks were added to this number to take into account overhauls and other major downtime. Finally, the total fleet size was multiplied by the estimated truck purchase price to yield the total capital investment.

Table IV-3 presents the parameters used in the calculations. Table IV-4 presents the results of the calculations and the required capital investment. These figures were used to stimulate IMPLAN sector 384 (Motor Vehicles). It is assumed that the trucks will be not be manufactured exclusively in California; therefore, the investments do not represent the total direct impact on the California economy. During the model runs, IMPLAN's regional purchase coefficients were used to assign portions of these direct expenditures to California.

[1] Estimates of daily trips per truck are based on assumptions about round-trip mileage per trip, average travel speed, loading and unloading time, and the number of hours each truck is used.

Table IV-3. Parameters Used to Estimate Fleet Investment

Transportation Parameter	Value
Tank size (Gal)	10,000
Truck Price ($)	100,000
Miles per Trip (Roundtrip)	120
Capacity (days)	360
Average Speed (mph)	40
Downtime per trip (hr)	2
Travel Time per Trip	3
Total Trip Time	5
Hours per Day	16
Trips per Truck per Day	3.2
Reserve Adjustment	1.2

Table IV-4. Investment in Truck Fleet for Fuel Distribution

Distribution of CA Ethanol Production to Storage Terminal	CA Ethanol Production	High CA Ethanol Production
Million Gallons Per Year	200	400
Gallons Per Day	556,000	1,110,000
Total Truck Trips Per Day	56	111
Additional Fleet Required	17	35
Total Fleet Required	21	42
Capital Investment ($)	2,083,000	4,167,000

Feedstock Transportation

Additional truck fleeting will be required to transport the feedstock. Table IV-5 presents the required capital investment for each case. Note that the estimates represent net new investment in California: i.e., the displaced capital has been subtracted from the total. The figures were used to stimulate IMPLAN sector 384 (Motor Vehicles). It is assumed that the trucks will be not be manufactured exclusively in California; therefore, the investments do not represent the total direct impact on the California economy. During the model runs, IMPLAN's regional purchase coefficients were used to assign portions of these direct expenditures to California.

Table IV-5. New Capital Expenditures for Feedstock Transportation Fleet

Case	Expenditures ($)
3	26,878,000
4	41,296,000
6	26,878,000
7	53,934,000

Finance

Given the fluidity of financial capital, it is assumed for this report that there would be no economic impact on California's investment banks or brokerage firms. Although the additional investment in ethanol production would occur in California, it is assumed that the borrowed funds used to pay for the purchases would be obtained from sources across the nation (e.g., consider a firm that issues stocks to pay for new investments). California currently accounts for 12.5% of U.S. personal income. Therefore, it is assumed in all scenarios that Californians would finance 12.5% of new investment in the U.S., regardless of where the investments actually takes place. In other words, it is assumed that the case definitions do not contain policy instruments that would give rise to additional investment by California residents or institutions.

Operating Expenditures and Other Recurring Impacts

Processing Materials Used in Ethanol Production

Because there are a number of industries that produce the non-feedstock materials used in ethanol production, it was necessary to distribute total expenditures on these materials to the various sectors that produce them. The primary materials used in ethanol production other than feedstock include sulfuric acid, lime, yeast, corn steep liquor solids, anhydrous ammonia, denaturant and zeolite. Tonnage figures for each plant and material were used to estimate the total quantity of each material required in the California Ethanol and the High California Ethanol cases. The material requirements were based on ProForma ethanol plant modeling. Shares for each case and material were contructed based upon the total tonnage of materials consumed in each case. Multiplying these shares by the total expenditures on processing materials produced the desired allocation. Note that the expenditure figures do not necessarily represent the direct impact on the California economy because some of the materials are manufactured in other states. During the model runs, IMPLAN's regional purchase coefficients were used to assign portions of the direct expenditures to California.

Table IV-6. Expenditures for Processing Materials ($)

Case	Total Cost	Sulfuric Acid	Lime	Yeast	Corn Steep Liquor	Anhydrous Ammonia	Denaturant (gasoline)	Zeolite
CA Ethanol	22,000,000	600,000	400,000	40	6,600,000	2,600,000	11,000,000	600,000
High CA Ethanol	44,000,000	1,200,000	800,000	80	13,200,000	5,200,000	22,000,000	1,200,000

Water Used in Ethanol Production

Expenditures for water were assigned to IMPLAN sector 445 (Water Supply and Sewage Systems) and are presented below for each case.

Table IV-7. Annual Ethanol Plant Operating Expenditures for Water

Case	Expenditures ($)
CA Ethanol	5,225,000
High CA Ethanol	10,450,000

General Maintenance of Ethanol Plants

Expenditures for maintenance was assigned to IMPLAN sector 472 (Services to Buildings). While ethanol plants may provide their own maintenance, it is assumed that the production function of this activity is similar to the production function of maintenance service companies. Expenditures for maintenance are presented below for each case.

Table IV-8. Annual Ethanol Plant Operating Expenditures for Maintenance

Case	Expenditures ($)
CA Ethanol	605,000
High CA Ethanol	1,200,000

Employee Compensation

The average annual salary for plant personnel is $37,573, based on ProForma statistics. Marketing personnel earn $74,107 per year on average based on Abbott, Langer & Associates, Inc. marketing and sales survey. When employees spend these earnings, additional economic impacts are generated. The number of items in the normal consumer basket is quite large, and it is not possible to enumerate all of them here. However, IMPLAN has a feature that distributes specified income into numerous personal consumption categories. Different expenditure patterns are provided for different income groups. Given the average salaries noted above, we chose to use the medium income group for plant personnel and the high-income group for marketing personnel. Table IV-9 below presents the total employee earnings that were used to stimulate IMPLAN's personal consumption expenditure (PCE) vectors.

Table IV-9. Annual Employee Earnings ($) for Ethanol Plant and Marketing Operations

Case	Plant Personnel	Marketing Personnel
CA Ethanol	8,453,952	2,000,880
High CA Ethanol	19,725,888	4,668,720

Ethanol Distribution Costs

In addition to plant operation and feedstock collection and production expenditures, an ethanol production industry would also give rise to growth in the transportation and trade sectors used to distribute the fuel. It is assumed that these impacts would occur exclusively within California.

The calculation of these impacts entailed several steps. First, production volumes were converted into revenues and then adjusted for Federal and State taxes. The adjusted sales figures were then allocated to industry sectors using margin percentages obtained from IMPLAN. We used the margin percentages associated with the petroleum-refining sector, which is dominated by the manufacture of gasoline. Margins associated with the sector, in which ethanol production is classified (190: Cyclic Crudes, Intermediate and Industrial Organic Chemicals) appeared to be heavily biased by output associated with non-fuel products. One adjustment was made to the petroleum sector's transportation margins: transportation expenditures for pipeline services were allocated to truck and rail sectors. Table IV-10 below presents the parameters used in the process, whereas Table IV-11 presents the resulting economic impacts associated with the distribution of California produced ethanol.

Table IV-10. Parameters Used to Calculate the Impacts of California Ethanol Distribution

Parameter	Value
Ethanol Price ($/gal)	1.44
Margin Percentages	
Manufacturing	65%
Rail	1%
Truck	2%
Wholesale Trade	15%
Regional Purchase Coefficients	
Manufacturing	100%
Rail	100%
Truck	100%
Wholesale Trade	100%

Table IV-11. Direct Impacts of Distributing California Ethanol Production

	CA Ethanol	High CA Ethanol
California Ethanol Production		
Volume (Gal/Yr)	200,000,000	400,000,000
Sales ($)	288,000,000	576,000,000
Margins ($)		
Manufacturing	203,580,000	407,160,000
Rail	3,132,000	6,264,000
Truck	6,264,000	12,528,000
Wholesale Trade	46,980,000	93,960,000
Service Station	53,244,000	106,488,000
Impacts on California Economy ($)		
Rail	3,132,000	6,264,000
Truck	6,264,000	12,528,000
Wholesale Trade	46,980,000	93,960,000
Service Station	53,244,000	106,488,000

Feedstock Collection

Transportation

Expenditures for feedstock transportation were assigned to IMPLAN sector 435 (Motor Freight Transport and Warehousing) and are presented below for each case. Note that these figures represent net increases in feedstock transportation costs relative to the case with no ethanol. It is assumed that the expenditure occurs entirely within California.

Table IV-12. Annual Expenditures for Feedstock Transportation

Case	Expenditures ($)
CA Ethanol	5,000,000
High CA Ethanol	10,000,000

Collection

Assumptions about feedstock collection efforts vary depending on the type of feedstock and the location of the plants. In the Zero California Ethanol case, some forest materials would be collected and used in biomass production facilities. Controlled burns would also be used to reduce the amount of forest residues in areas susceptible to fire damage. The alternative cases, on the other hand, would require an expansion of forest material collection efforts to feed the ethanol plants. As a result of relatively less forest residue, the need for controlled burns would decline. In all cases, it is assumed that expenditures on controlled burns would decline by $500,000 per year, based on a cost of $50-$70 per acre.

In the Zero California Ethanol case, some agricultural residues would be burned or collected for feedstock. Most of the rice straw would be tilled back into the ground. Collecting the straw for ethanol production would require additional manpower, but at the same time would reduce the need for tilling operations. It is assumed that the cost of reworking the straw into the ground is equal to labor expenditures for equipment operators involved in agricultural feedstock collection. To estimate this expense, we allocated total equipment operator earnings based on the ratio of the tons of agricultural and forest material feedstocks used in each case. These percentages are presented below.

Table IV-13. Ratios of Feedstocks Used to Allocate Equipment Operator Earnings

	CA Ethanol	High CA Ethanol
Forest Material Feedstocks	**44.8%**	**48.5%**
Forest Slash/Thinnings	39.0%	42.2%
Lumbermill Waste	5.8%	6.3%
Agricultural Residue Feedstocks	**55.2%**	**51.5%**
Rice Straw	23.9%	12.9%
Other Agricultural Residue	31.2%	38.6%

It is assumed that there is no net impact on feedstock collection efforts in urban areas.

Table IV-14 below presents the net impact on labor expenditures for harvesting personnel and equipment operators. The figures were used to stimulate IMPLAN's PCE vector.

Table IV-14. Net Labor Expenditures for Feedstock Collection

Case	Expenditures ($)
CA Ethanol	2,164,924
High CA Ethanol	5,788,979

Ethanol Imports

There are a number of industries associated with the importation of ethanol; therefore, any policy, which affects import levels, will have an impact on these sectors. After subtracting federal and state taxes, the price of ethanol can be divided into manufacturing costs, transportation costs for distribution, and trade margins. Regarding transportation margins, it is assumed that ethanol is brought into the state by rail and ship. Trade margins include wholesale blending services.

These activities do not take place entirely within California. Changes in activities that occur outside of the state do not represent an impact on the California economy. The manufacturing process was assumed to take place in the U.S. Midwest; therefore, the analysis does not address the changes in manufacturing output levels resulting from induced changes in California ethanol demand. Truck and wholesale margins, on the other hand, were assumed to take place entirely within California. Rail and ship margins include services provided both within California and outside of the state. Therefore, it was necessary to divide the expenditures for rail and ship into California services and out-of-state services.

The calculation of the impacts on the California economy entailed several steps. First, changes in import volumes were converted into revenue changes and then adjusted for Federal and State taxes. The adjusted sales figures were then allocated to industry sectors using margin percentages obtained from IMPLAN. We used the margin percentages associated with the petroleum-refining sector, which is dominated by the manufacture of gasoline. Margins associated with the sector in which ethanol production is classified (190: Cyclic Crudes, Intermediate and Industrial Organic Chemicals) appeared to be heavily biased by output associated with non-fuel products. Two adjustments were made to the petroleum sector's transportation margins. First, transportation expenditures for pipeline services were allocated to truck and rail sectors. We then slightly reapportioned the truck and rail expenditures. This adjustment was made because the IMPLAN margins are associated with California production, which is delivered primarily for domestic consumption; therefore, the relative relationship among the transportation margins presumably differ from those associated with imported fuel. Finally, a regional purchase coefficient was used to allocate a portion of the rail margin to California. Table IV-15 below presents the parameters used in the process, whereas Table IV-16 presents the resulting economic impacts associated with the considered changes in ethanol import volumes.

Table IV-15. Parameters Used to Calculate Impacts of Ethanol Imports

Parameter	Value
Ethanol Price ($/gal)	1.44
Margin Percentages	
Manufacturing	65%
Rail	2%
Truck	1%
Regional Purchase Coefficients	
Manufacturing	0%
Rail	50%
Truck	100%

Table IV-16. Direct Impacts of Changes in Ethanol Imports

	CA Ethanol	High CA Ethanol
Change in Ethanol Imports		
Volume (Gal/Yr)	(50,000,000)	50,000,000
Sales ($)	(72,000,000)	72,000,000
Margins ($)		
Manufacturing	(50,895,000)	50,895,000
Rail	(1,566,000)	1,566,000
Truck	(783,000)	783,000

Gasoline Imports

There are a number of industries associated with the importation of gasoline; therefore, any policy that affects import levels will have an impact on these sectors. After subtracting Federal and State taxes, the price of gasoline can be divided into manufacturing costs, transportation costs for distribution, and trade margins. Regarding transportation margins, it is assumed that imported gasoline is brought into the state by pipeline and then distributed to retail outlets by truck. Trade margins include wholesale services and retail services.

These activities do not take place entirely within California. Changes in activities that occur outside of the state do not represent an impact on the California economy. The manufacturing process takes place outside of the state; as a result, the analysis does not address the changes in manufacturing output levels resulting from changes in California gasoline imports. Truck, wholesale, and retail margins, on the other hand, were assumed to take place entirely within California. Pipeline margins include services provided both within California and outside of the state. Therefore, it was necessary to divide the expenditures for pipe transportation into California services and out-of-state services.

The calculation of the impacts on the California economy entailed several steps. First, changes in import volumes were converted into revenue changes and then adjusted for federal and state taxes. The adjusted sales figures were then allocated to industry sectors using margin percentages obtained from IMPLAN. We used the margin percentages associated with the petroleum-refining sector, which is dominated by the manufacture of gasoline. Two adjustments were made to the petroleum sector's transportation margins. First, all transportation margins were allocated to truck and pipeline service sectors. We then slightly reapportioned the truck and pipeline expenditures. This adjustment was made because the IMPLAN margins are associated with California production, which is delivered primarily for domestic consumption; therefore, the relative relationship among the transportation margins presumably differ from those associated with imported fuel. Finally, a regional purchase coefficient was used to allocate a portion of the pipeline margin to California. Table IV-17 below presents the parameters used in the process, whereas Table IV-18 presents the resulting economic impacts associated with the considered changes in gasoline import volumes.

Table IV-17. Parameters Used to Calculate Impacts of Gasoline Imports

Parameter	Value
Gasoline Price ($/gal)	1.9115
Margin Percentages	
Manufacturing	65%
Rail	2%
Truck	1%
Regional Purchase Coefficients	
Manufacturing	0%
Rail	50%
Truck	100%

Table IV-18. Direct Impacts of Changes in Gasoline Imports

	CA Ethanol	High CA Ethanol
Change in Gasoline Imports		
Volume (Gal/Yr)	—	(33,000,000)
Sales ($)	—	(63,079,500)
Margins ($)		
Manufacturing	—	(29,461,575)
Pipeline	—	(906,510)
Truck	—	(453,255)
Impacts on California Economy ($)		
Pipeline	—	(453,255)
Truck	—	(453,255)

California Gasoline and Pentane Production

In either case, positive economic impacts are projected for the petroleum-refining sector. Although motor fuel sales may drop, these revenue changes will be more than offset by sales of extracted pentanes.

To reduce the volatility of ethanol fuel products, pentanes are extracted from gasoline through an additional refining process. In the California Ethanol case, it is assumed the pentanes are not removed from the gasoline. As a result, costs associated with this activity in the alternative scenarios represent increased output for the petroleum refining industry (IMPLAN sector 210: Petroleum Refining). It is assumed that this activity occurs entirely within California.

To estimate the impact, the volume of pentanes produced was multiplied by the retail price of gasoline, which was assumed to be fairly close to the wholesale price of pentanes. The result was then distributed to industrial margins (manufacturing and transportation between the producer and wholesaler); since pentane is an industrial chemical used in other manufacturing processes, wholesale and retail margins were not added.

The two impacts were then added by sector to produce the net impact. For each case, the following table shows the resulting direct impacts.

Table IV-19. Net Impact ($) of Changes in Gasoline Production and Pentane Extraction on California's Petroleum Refining Sector

	CA Ethanol	High CA Ethanol
Petroleum Refining	251,218,804	474,884,483
Pipeline Transportation Services	1,967,777	3,511,659
Truck Transportation Services	3,935,554	7,023,319

Electricity

The net change in total electricity produced in the state was used to stimulate IMPLAN sector 443 (Electric Services). Depending on the operating characteristics of the ethanol plants, the net change could be positive or negative. Chapter V discusses the flexibilities in operating collocated ethanol plants and the energy environment that would lead to various ethanol and electricity production choices. The scenario used in the model assumed that forest material and agricultural biomass power plants were operating prior to the addition of ethanol facilities.

Consumer Expenditures for Fuel

Since the energy content of ethanol is lower than it is for gasoline, consumers will have to purchase more fuel to travel the same distance over the year. This fact combined with differences in prices between the two products could affect consumer purchasing power. To deal with this issue, it was assumed that the ratio of equilibrium prices for ethanol and gasoline would equate with the ratio of the energy content of the two products. This implies that consumer welfare would not change since they would be able to travel the same distance for the same cost. Given a retail price of $1.44 per gallon of ethanol, the equilibrium prices for gasoline was assumed to be $1.9115.

IV.A.1.2 Total Economic Impacts

The direct impacts associated with developing an ethanol production industry in California are defined below in Tables IV-22 through 24. They are associated with various events (e.g., reduced ethanol imports); they are defined for each case, and their measurement is based upon a comparison with the Zero California Ethanol case.

Table IV-20. Capital and Operations Direct Impacts

CAPITAL AND OPERATIONS DOLLAR INPUTS TO THE I/O ECONOMIC MODEL		
	CA ETHANOL	HIGH CA ETHANOL
Annual California Ethanol Production (Million gal)	200	400
Number of Plants	9	21
Total Capital Investment[a], TCI (Million $)		
Equipment Cost	$261	$563
Installation	$130	$281
Construction Totals	$217	$469
Engineering/Design/Architectural/Other Services	$52	$113
Total Capital Investment, TCI (Million $)	**$660**	**$1,426**

[a] TCI dollar amount derived from ProForma, Inc., collocated ethanol plant model

[b] Land (Acquisition of land is not included in the analyses since those reflect economic transfer

Construction also includes permitting and preparation costs.

[c] Other services include financing and related costs

Note 1 Ethanol storage terminal capital costs are included in the above costs and are approximately $1/gallon TCI for a 60-day storage capacity of 30,000,000 gallons.

Note 2 Co-product process equipment related costs are included in the above costs.

Table IV-21. Operating Cost Direct Impacts

Operating Costs ($/Year)	CA ETHANOL	HIGH CA ETHANOL
Feedstock Collection and Processing	$18,948,000	$32,588,758
Processing Materials	$19,645,040	$39,290,080
Maintenance	$605,497	$1,210,994
Ethanol Transport	$3,540,000	$7,080,000
Feedstock Transport	$4,738,708	$9,477,415
Total Operating Costs ($/yr)	$47,477,245	$89,647,247

Table IV-22. Employment Direct Impacts

Employment	CA # of	HIGH CA # of
Fleet	64	130
Feedstock Collection and	630	1,084
Processing	64	81
Maintenanc	21	42
Ethanol	34	68
Feedstock	46	91
Plant & Infrastructure	3,893	8,410

The direct impacts were then used as inputs into IMPLAN to estimate the secondary economic repercussions on the California economy. Separate runs were executed for each case and event listed below:

Plant Investment
Truck Fleet Investment
Usage of Processing Materials
General Maintenance Activities
Usage of Water
Compensation of Plant and Marketing Personnel
Distribution (trade and transportation) of Domestic Ethanol
Transportation of Feedstocks
Collection of Feedstocks
Production Electricity
Natural Gas Imports
Ethanol Imports
Gasoline Imports
California Petroleum Sector Output

For each case and event, the model generated the direct, indirect, and induced impacts on the California economy. The results were presented in several metrics including changes in output, changes in employment, changes in personal income, and changes in value added. Table IV-23 shows the multipliers used to calculate these impacts in various industry sectors.

The results were then scaled to take into account differences in activity levels at different time periods. Impacts due to construction activity were scaled based upon the projected capital outlays presented in Table IV-24. Construction activities are slated to occur between 2001 and 2008. Reoccurring impacts due to California ethanol production were scaled based upon the volumes of ethanol production forecast for each year. These volumes vary depending upon when plants first begin operations and when they shut down. Operations are expected to occur between 2003 and 2028. The factors used to scale the reoccurring impacts are shown in the following table.

Table IV-23. Indirect and Induced Impacts Multipliers

Industry Sectors	Metric	Direct	Indirect	Induced
Plant Investment	Output	1.00	0.35	0.38
	Employment	7.53E-06	3.80E-06	4.79E-06
	Personal Income	0.48	0.14	0.14
	Value Added	0.55	0.21	0.24
Fleet Investment	Output	1.00	0.30	0.41
	Employment	1.27E-05	2.91E-06	5.16E-06
	Personal Income	0.38	0.11	0.15
	Value Added	0.59	0.17	0.26
Processing Materials	Output	1.00	0.28	0.32
	Employment	4.02E-06	3.25E-06	4.06E-06
	Personal Income	0.26	0.13	0.12
	Value Added	0.62	0.17	0.20
Maintenance	Output	1.00	0.30	0.59
	Employment	3.44E-05	3.30E-06	7.43E-06
	Personal Income	0.58	0.12	0.22
	Value Added	0.69	0.18	0.37
Plant Earnings	Output	1	0.21	0.27
	Employment	2.41E-05	2.13E-06	3.39E-06
	Personal Income	1	0.08	0.10
	Value Added	1	0.12	0.17
Distribution	Output	1	0.63	0.46
	Employment	9.64E-06	6.01E-06	5.72E-06
	Personal Income	0.33	0.22	0.17
	Value Added	0.42	0.33	0.29
Feedstock Collection	Output	1	0.21	0.27
	Employment	3.33E-05	2.12E-06	3.42E-06
	Personal Income	1	0.08	0.10
	Value Added	1	0.12	0.17
Feedstock Transport	Output	1	0.63	0.46
	Employment	9.64E-06	6.01E-06	5.72E-06
	Personal Income	0.33	0.22	0.17
	Value Added	0.42	0.33	0.29
Ethanol Imports	Output	1	0.32	0.43
	Employment	5.4E-06	2.8E-06	5.4E-06
	Personal Income	0.39	0.12	0.16
	Value Added	0.67	0.64	0.18
Net Power	Output	1	0.07	0.19
	Employment	1.77E-06	6.97E-07	2.35E-06
	Personal Income	0.20	0.03	0.07
	Value Added	0.85	0.04	0.12
Corporate Income Tax	Output	1	0.21	0.27
	Employment	2.41E-05	2.13E-06	3.39E-06
	Personal Income	1	0.08	0.10
	Value Added	1	0.12	0.17

Table IV-24. Factors Used to Scale Impacts Due to Plant Operations

	CA Ethanol	High CA Ethanol
2002	0%	0%
2003	0%	0%
2004	30.00%	20.00%
2005	50.00%	40.00%
2006	60.00%	60.00%
2007	85.00%	75.00%
2008	90.00%	85.00%
2009	95.00%	92.50%
2010	100.00%	100.00%
2011	100.00%	100.00%
2012	100.00%	100.00%
2013	100.00%	100.00%
2014	100.00%	100.00%
2015	100.00%	100.00%
2016	100.00%	100.00%
2017	100.00%	100.00%
2018	100.00%	100.00%
2019	100.00%	100.00%
2020	100.00%	100.00%
2021	100.00%	100.00%
2022	100.00%	100.00%
2023	100.00%	100.00%
2024	70.00%	80.00%
2025	50.00%	60.00%
2026	40.00%	40.00%
2027	15.00%	25.00%
2028	10.00%	15.00%
2029	5.00%	7.50%

The direct, indirect, and induced impacts were then summed by year to produce a total benefit stream for each case. These are presented in Table IV-25 below. A net present value analysis is used to compare these benefit streams with estimated government outlays.

Table IV-24. Total Economic Impacts by Case, Metric and Year

Year	Output	Employment	Personal Income	Value Added	Output	Employment	Personal Income	Value Added
2002	128,347,268	1,196	56,918,832	74,102,576	170,871,944	1,592	75,777,471	98,654,620
2003	214,393,589	1,998	95,078,243	123,782,278	359,053,977	1,592	159,231,538	207,303,392
2004	159,127,255	1,669	73,242,750	95,883,506	530,591,805	2,478	187,596,242	272,816,725
2005	186,104,842	2,037	87,164,556	114,079,543	642,988,855	3,364	189,969,608	304,113,273
2006	184,135,030	2,076	87,299,186	114,243,558	774,440,728	4,250	200,793,315	346,411,312
2007	145,612,975	1,869	72,502,210	95,326,317	872,146,526	4,914	208,578,493	377,607,155
2008	148,568,888	1,922	74,404,886	97,657,125	930,198,868	5,357	210,646,330	394,307,932
2009	121,453,661	1,699	62,854,816	82,661,354	899,262,073	5,689	179,154,167	363,838,478
2010	94,338,434	1,476	51,304,746	67,665,584	868,764,279	6,022	147,827,175	333,631,394
2011	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2012	92,025,545	1,442	50,118,327	66,057,600	867,447,275	4,429	147,331,664	332,844,283
2013	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2014	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2015	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2016	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2017	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2018	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2019	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2020	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2021	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2022	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2023	93,903,617	1,471	51,141,150	67,405,714	867,447,275	4,429	147,331,664	332,844,283
2024	65,732,532	1,030	35,798,805	47,184,000	693,957,820	3,543	117,865,332	266,275,426
2025	46,951,808	735	25,570,575	33,702,857	520,468,365	2,658	88,398,999	199,706,570
2026	37,561,447	588	20,456,460	26,962,286	346,978,910	1,772	58,932,666	133,137,713
2027	14,085,543	221	7,671,173	10,110,857	216,861,819	1,107	36,832,916	83,211,071
2028	9,390,362	147	5,114,115	6,740,571	130,117,091	664	22,099,750	49,926,642
2029	4,695,181	74	2,557,058	3,370,286	65,058,546	332	11,049,875	24,963,321

IV.A.2.3 Present Value Analysis

In this section, the methodology described in Section IV.3.5 is used to compare the ethanol production benefits with the costs to the State. It should be noted that the assignment of economic benefits depends on the vantage point of the interested party. Given that government investments are funded in one way or another by the public, it is assumed that the California public is the correct perspective to use. This means that benefits cannot be defined simply in terms of government revenues.

The costs and benefits associated with the proposals will occur over different periods of time. Subsidized capital outlays may be financed. The construction phase of the projects will create jobs and income for a short period of time (2001-2008). Plant operations will result in reoccurring economic benefits over the lives of the ethanol plants (each plant is assumed to operate for twenty years).

Three considerations had to be addressed to compare these different cost and benefit streams. First, all costs and benefits have to be reported in the same metric. For example, it is not possible to compare employment data with dollar figures. Since costs are defined in terms of dollars spent, it was necessary to define the benefits on a dollar basis. Second, to remove the effects of inflation from the analyses, all costs and benefits were defined in terms of constant 2000 year dollars. Finally, we had to take into account the fact that a $100 benefit twenty years in the future is not equal to $100 received today. For example, if you received $100 today and invested it for twenty years, you would have more than $100 at the end of the time period. To deal with this issue, we discounted all future benefits and costs using a rate of return on government investments of similar risk.

Calculate Cost Vectors

Opportunity costs are associated with funds used to subsidize government programs. Regardless of funding source (e.g., bonds or taxes), the true opportunity cost of all government revenues is assumed to be taxpayer income. Reductions in personal income to cover the cost of a government program result in lower consumer spending; hence, additional losses in income accrue through secondary economic repercussions.

Capital Subsidy

It was assumed that the state would fund 10% of the initial investments required to construct or modify the ethanol plants. According to the construction schedule shown in Table IV-26, annual capital outlays are projected to occur between 2001 and 2008, with each plant taking two years to build. Table IV-27 shows the total capital outlays and State's portion that are projected to occur.

Table IV-25. First Year of Construction by Plant ID

Year	CA Ethanol	High CA Ethanol
2002	4, 7	4, 5, 7
2003	8	6, 8, 9
2004	3	2, 3, 10
2005	1, 12	1, 12, 16
2006	13	11, 13, 17
2007	14	14, 18, 20
2008	15	15, 19, 21

Table IV-26. Capital Outlays for Plant Construction with 10% Government Subsidy

(Millions of Constant 2000 Dollars)				
	CA Ethanol		High CA Ethanol	
Year	Total	State	Total	State
2002	91.3	9.1	121.4	12.1
2003	152.5	15.3	255.1	25.5
2004	91.3	9.1	251.2	25.1
2005	97.8	9.8	207.8	20.8
2006	90.3	9.0	177.9	17.8
2007	45.3	4.5	155.5	15.6
2008	45.3	4.5	135.8	13.6
2009	22.6	2.3	67.9	6.8
Total	636	64	1373	137

It is assumed the state would finance these outlays for twenty years (the expected life of the plants) at a 5.77% interest rate. This rate is the average rate over the last 12 months for state and local government obligation bonds maturing in twenty years (obtained from the *Federal Reserve Bulletin* published by the Board of Governors of the Federal Reserve System).

The state would presumably obtain the funds through the issuance of bonds. Both California residents and non-California residents would be able to purchase the bonds. These bond purchases would come at the expense of other investments made since the case definitions do not contain policy instruments that would give rise to additional investment by California residents. In other words, it is assumed that bond purchases by California residents would not come at the expense of personal consumption.

In subsequent years, the state would have to cover the cost of the annual bond payments. These could be financed by additional taxes, use of government surpluses, budget diversions, or some other mechanism. In all cases, it is assumed the payments would come at the expense of personal income, which would lead to a resulting decline in personal consumption expenditures over the entire bond period.

Although annual dividends would lead to increased personal consumption in years after the bonds were sold, it is assumed in the reference case that California residents would receive such income from other investments. Therefore, no economic impact ensues.

Table IV-28 shows the annual bond reimbursements the state would have to make to finance its investment in ethanol production capital (shown in the columns labeled "Direct") The payments represent the annual opportunity cost to the taxpayer in terms of lost income. These figures were used to stimulate IMPLAN's PCE vectors to estimate the total economic repercussions.

Table IV-27. Annual Cost to the State of Subsidizing 10% of Initial Capital Investment in Ethanol Plants

Year	CA Ethanol Production				High California Ethanol Production			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
2002	($770,458)	($61,140)	($78,135)	($909,733)	($1,024,388)	($81,290)	($103,887)	($1,209,564)
2003	($2,057,446)	($163,269)	($208,653)	($2,429,367)	($3,176,938)	($252,106)	($322,184)	($3,751,228)
2004	($14,827,904)	($1,176,668)	($1,503,748)	($17,508,320)	($5,296,733)	($420,322)	($537,160)	($6,254,215)
2005	($23,652,788)	($1,876,966)	($2,398,710)	($27,928,464)	($7,050,276)	($559,474)	($714,993)	($8,324,743)
2006	($28,414,698)	($2,254,847)	($2,881,632)	($33,551,177)	($8,551,801)	($678,628)	($867,267)	($10,097,696)
2007	($38,796,609)	($3,078,703)	($3,934,497)	($45,809,808)	($9,864,281)	($782,780)	($1,000,371)	($11,647,431)
2008	($41,178,519)	($3,267,719)	($4,176,054)	($48,622,293)	($11,010,013)	($873,699)	($1,116,563)	($13,000,276)
2009	($43,369,475)	($3,441,582)	($4,398,247)	($51,209,304)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2010	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2011	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2012	($44,569,475)	($3,536,808)	($4,519,943)	($52,626,226)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2013	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2014	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2015	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2016	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2017	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2018	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2019	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2020	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2021	($45,369,475)	($3,600,292)	($4,601,074)	($53,570,841)	($11,582,879)	($919,159)	($1,174,659)	($13,676,698)
2022	($44,599,016)	($3,539,153)	($4,522,939)	($52,661,108)	($10,558,492)	($837,869)	($1,070,773)	($12,467,133)
2023	($43,312,029)	($3,437,024)	($4,392,421)	($51,141,474)	($8,405,942)	($667,053)	($852,475)	($9,925,470)
2024	($30,541,570)	($2,423,625)	($3,097,325)	($36,062,520)	($6,286,146)	($498,837)	($637,500)	($7,422,483)
2025	($21,716,687)	($1,723,327)	($2,202,363)	($25,642,377)	($4,532,604)	($359,685)	($459,667)	($5,351,955)
2026	($16,954,777)	($1,345,445)	($1,719,442)	($20,019,664)	($3,031,079)	($240,531)	($307,392)	($3,579,002)
2027	($6,572,866)	($521,589)	($666,577)	($7,761,032)	($1,718,598)	($136,379)	($174,289)	($2,029,266)
2028	($4,190,955)	($332,573)	($425,019)	($4,948,547)	($572,866)	($45,460)	($58,096)	($676,422)

Appendix V-A

Energy Impacts

The following table shows the power production assumptions for a California Ethanol industry that are discussed in Chapter V.

		BIOMASS POWER PRODUCTION			ETHANOL PRODUCTION					
Plant ID	**Feedstock**	**GWh/yr**	**BDT/yr**	**BTU/lb**	**Feedstock BDT/yr**	**Ethanol Cap., MGal**	**Lignin (tons/yr)**	**Power Consumption (GWh/yr)**	**Power Production from Lignin (GWh/yr)**	**Net Power Production (GWh/yr)**
1	Forest Matl	210	210,000	8,500	520,000	40	160,000	50	200	150
3	Forest Matl	260	260,000	8,500	260,000	20	80,000	20	100	80
4	Forest Matl	260	260,000	8,500	260,000	20	80,000	20	100	80
7	Ag Residue	200	200,000	8,500	640,000	40	190,000	50	230	180
8	Ag Residue	200	200,000	8,500	640,000	40	190,000	50	230	180
12 through 15	Urban Waste					40		50	0	-50
Total		**1,130**						**240**	**860**	**620**

Unnasch, S., Browning, L., "Fuel Cycle Energy Conversion Efficiency, Status Report, "Prepared for California Energy Commission and California Air Resources Board, May 2000.

Appendix VI-A

Environmental Valuation

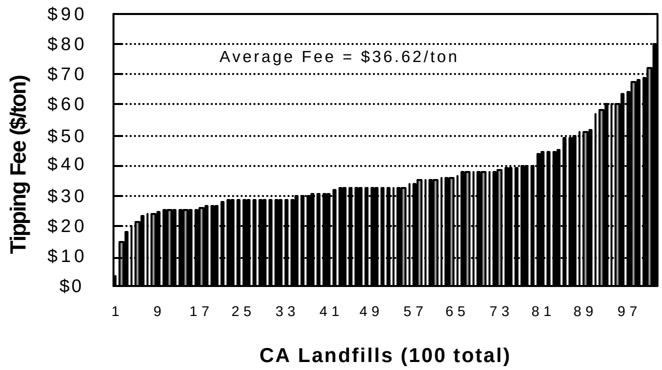
Monetizing Economic Valuation of Landfill Diversion:

When a particular parcel of land is being considered for a new use, one way to measure the value people have for that land is to measure the "option value." This refers to the premium that people are willing to pay to preserve the parcel over and above the use-value of the parcel. In essence, how sure are they that even though they have little use for it now, they won't need the piece of land later. This is an appropriate method to assess the value of landfill diversion and avoidance of new landfills but it is difficult to measure.

In addition to the option value for avoiding landfilling, the value of not landfilling materials is reflected in a cost saving to the materials recovery facilities (MRFs). Currently, MRFs sort materials that are considered recyclable from those for which there is not a developed recycling or transformation market (residual). Part of this MRF residual consists of paper products that are not considered suitable for recycling by paper mills. Once this residual is sorted at a MRF, a municipality usually incurs two additional costs to dispose it. One, the cost of transporting the residual to a landfill, and, two, the cost of depositing the residual into a landfill (otherwise known as a landfill "tipping" fee). Statewide, about 10% of all the waste that is placed in landfills consists of such post-MRF waste paper residual (over 3.5 million tons/year).

The cost of disposing of this residual in landfills thus varies from jurisdiction to jurisdiction depending on two things: the distance that residual must be transported from the MRF to the landfill (with longer transport distances resulting in higher transport costs); and, the tipping fee charged by the landfill. The range of the tipping fees that are currently being charged by California landfills is shown below. As the chart indicates, these costs range from less than $10/ton to about $80/ton, with the state average being about $36.

California Landfill Tipping Fees Per Ton



The cost of transporting waste paper from a MRF to a landfill ranges from about $3.30 ton to $12.30 per wet ton for distances of 5 and 50 miles, respectively. Thus, the total cost per ton of transporting waste paper residual from a MRF and placing it into a landfill ranges from about $10 to $90 per wet ton. The benefit of land-filling materials is -$10 per ton. This benefit is within (and internal to) the cost of ethanol production. Consequently, the cost of ethanol production decreases by $10 per ton when ethanol production uses landfill materials.

Monetizing Economic Valuation of Air Pollution:

The economics of air pollution are based upon the marginal value of clean air. This has been established through legislation, such as the Clean Air Act, which supports the philosophy that society is willing to pay the costs for cleaner air because it receives benefits from cleaner air. At a more tangible level, in order to achieve acceptable air quality or mitigate new growth, local air quality management districts limit emissions but allow trading of surplus credits. Sources that emit less pollution than is required of them may sell their surplus rights to pollute. The marginal value for the offsets (they offset emissions from other sources) are based on the supply and demand of permits, such that the last few available permits are likely to be the most expensive. Thus the value for reducing air pollution in other ways, such as ethanol production, is equal to the marginal willingness to pay for an offset.

This study has chosen to monetize cleaner air with the avoided cost of other air pollution reduction mechanisms because it is an accepted practice in California. Using this method also avoids analyses of revealed or stated consumer preferences, which require further studies specifically designed for the tradeoffs related to ethanol production.

Appendix VI-B

Emissions

This appendix contains tables of emission factors and results of the ethanol production analysis.

Biomass Power Emission Factors

	Wood (g/gal) from Greet	Biomass (lb/MMBtu) from Acurex	Biomass (lb/wet ton) from AP42*	Biomass (lb/wet ton) NRSS**	Biomass (lb/MMBtu) NRSS	For study: biomass plant, (lb/wet ton)	For study: biomass plant (lb/MMBtu)	Diesel (lb/MMBtu) from Acurex	Diesel (g/gal) from Acurex	Lignin factors assumed from biomass (lb/MMBtu)
NO_x	12.036	0.12	1.5			2	0.222	4.41	0.40	0.222
CO	8.388	0.04				1.4		0.95	0.09	0.040
CH_4	0.893	0.003	0.1			0.1	0.011			0.011
Fugitives		0.000						0.36	0.03	
Combust NMOG	1.199	0.003	0.22			0.22	0.024	0.07	0.01	0.024
NMOG		0.003	0.22			0.22	0.024	0.43	0.04	0.024
PM	1.56		8.8	0.06	13.3	0.04	0.004	0.31	0.03	0.004
CO_2 Vent	1.93									
Fossil Fuel CO_2								164	14.70	

*AP 42 assumptions: wet ton 4500btu/lb, 50% moisture
8.8 lb/wet ton for PM is for an uncontrolled wood boiler. For comparison, a boiler with electrostatic precipitator is 0.04 lb/wet ton.
**Natural Resource Strategic Services

Emissions due to lignin and diesel combustion, and ethanol production process

(lb/ton biomass)	**Biomass power plant only**	**Collocated midterm large plant Forest or Ag Material**		**Urban Waste Stand Alone**
	power plant	power plant	ethanol plant	
NO_x	4	3		0.04
CO	0.7	0.5		
CH_4	0.2	0.1		
NMOG	0.4	0.3		0.03
PM	0.08	0.05		0.04
Fossil Fuel CO_2 (diesel)	0	0	3	486

Emission Factors continued

Avoided Emissions from Ag Open Burn

Pollutant	CBEA lb/wet ton (100% orchard)	NRSS lbs/ton	For this study: ARB lb/BDT (100% orchard, 28.8% moisture)
NO_x	4.3	3.1-5.6	7.3
SO_2	0.6		0.1
CO	31.9		92.7
NMOG	4.2	4.2-5.4	8.8
PM	2.5	2.5-3.2	11

Rice Straw Emissions		AP-42 (lb/wet ton)	For Study (lb/wet ton)
30% Moisture Rice Straw			
	NO_x		23
	PM	29	29
	CO	181	181
	NMOG	23	23

Wildfires

	CBEA lb/acre (35 tons/acre)	AP-42 kg/hectare (18 tons/acre)	NRSS lbs/ton (25 tons/acre)	CDF, CARB lb/ton (15 tons/acre)	For this study: CDF, CARB lb/acre	For this study: Avoided emissions lb/ton removed	For this study: avoided prescribed burn lb/ton removed
NO_x	140	81		4	60	0.24	1.28
SO_2	140						
CO	4899	2830		260	3900	15.6	83.2
ROC	840	485		25	375	1.5	8
PM	594	343	6	42	630	2.52	13.44

Transportation NOx Emissions Sources	NOx Emissions due to feedstock transport - two way (tons/yr)							Note: Case is 1,3,4,7,8,12-15			
Plant ID	1	2	3	4	5	6	7	8	9	10	11
	FM	FM	FM	FM	FM	FM	RC/AR	RC/AR	AR	AR	AR
Forest Slash/Thinnings	86	74	43	32	43	43	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	12.8	12.8	0	0	0
Agricultural Residues	0	0	0	0	0	0	19.7	19.7	16.8	16.8	16.8
Waste Paper	0	0	0	0	0	0	0	0	0	0	0
Other Urban Waste	0	0	0	0	0	0	0	0	0	0	0
Tree Prunnings	0	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0	0
	NOx Emissions due to ethanol transport - two way (tons/yr)										
Forest Material	60	12	12	24	16	25					
RS/AR							13	3	27	24	3
UW											
Total Transportation Emissions	146	86	55	56	59	68	46	35	44	41	19

Transportation NOx Emissions Sources										
Plant ID	12	13	14	15	16	17	18	19	20	21
Forest Slash/Thinnings	0	0	0	0	0	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0	0	0	0
Agricultural Residues	0	0	0	0	0	0	0	0	0	0
Waste Paper	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Other Urban Waste	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Tree Prunnings	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0
Forest Material										
RS/AR										
UW	1	1	1	1	3	2	2	0	3	3
Total Transportation Emissions	4	4	4	4	6	4	4	3	6	6

Transportation HC Emissions Sources	**HC Emissions due to feedstock transport - two way (tons/yr)**							**Note: Case is 1,3,4,7,8,12-15**			
Plant ID	1	2	3	4	5	6	7	8	9	10	11
	FM	FM	FM	FM	FM	FM	RC/AR	RC/AR	AR	AR	AR
Forest Slash/Thinnings	4	3	2	1	2	2	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0.56	0.56	0	0	0
Agricultural Residues	0	0	0	0	0	0	0.86	0.86	0.73	0.73	0.73
Waste Paper	0	0	0	0	0	0	0	0	0	0	0
Other Urban Waste	0	0	0	0	0	0	0	0	0	0	0
Tree Prunnings	0	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0	0
	HC Emissions due to ethanol transport - two way (tons/yr)										
Forest Material	6	1	1	3	2	3					
RS/AR							1	0	3	3	0
UW											
Total Transportation Emissions	10	5	3	4	4	5	3	2	4	3	1

Transportation HC Emissions Sources										
Plant ID	12	13	14	15	16	17	18	19	20	21
Forest Slash/Thinnings	0	0	0	0	0	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0	0	0	0
Agricultural Residues	0	0	0	0	0	0	0	0	0	0
Waste Paper	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Other Urban Waste	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Tree Prunnings	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0
Forest Material										
RS/AR										
UW	0	0	0	0	0	0	0	0	0	0
Total Transportation Emissions	0.22	0.25	0.25	0.25	0.44	0.28	0.28	0.15	0.44	0.44

Transportation PM Emissions Sources	PM Emissions due to feedstock transport - two way (tons/yr)							Note: Case is 1,3,4,7,8,12-15			
Plant ID	1	2	3	4	5	6	7	8	9	10	11
	FM	FM	FM	FM	FM	FM	RC/AR	RC/AR	AR	AR	AR
Forest Slash/Thinnings	2.2	1.9	1.1	0.8	1.08	1.08	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0.32	0.32	0	0	0
Agricultural Residues	0	0	0	0	0	0	0.49	0.49	0.42	0.42	0.42
Waste Paper	0	0	0	0	0	0	0	0	0	0	0
Other Urban Waste	0	0	0	0	0	0	0	0	0	0	0
Tree Prunnings	0	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0	0
	PM Emissions due to ethanol transport - two way (tons/yr)										
Forest Material	4	1	1	2	1	2					
RS/AR							1	0	2	2	0
UW											
Total Transportation Emissions	6	3	2	2	2	3	2	1	2	2	0.49

Transportation PM Emissions Sources										
Plant ID	12	13	14	15	16	17	18	19	20	21
Forest Slash/Thinnings	0	0	0	0	0	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0	0	0	0
Agricultural Residues	0	0	0	0	0	0	0	0	0	0
Waste Paper	0.04	0.04	0.04	0.04	0.042	0.042	0.042	0.042	0.042	0.042
Other Urban Waste	0.03	0.03	0.03	0.03	0.028	0.028	0.028	0.028	0.028	0.028
Tree Prunnings	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0
Forest Material										
RS/AR										
UW	0.026	0.034	0.034	0.034	0.085	0.043	0.043	0.009	0.085	0.085
Total Transportation Emissions	0.095	0.103	0.10	0.10	0.15	0.11	0.11	0.08	0.15	0.15

Transportation CO_2 Emissions Sources	CO2 Emissions due to feedstock transport - two way (tons/yr)							Note: Case is 1,3,4,7,8,12-15			
Plant ID	1	2	3	4	5	6	7	8	9	10	11
	FM	FM	FM	FM	FM	FM	RC/AR	RC/AR	AR	AR	AR
Forest Slash/Thinnings	20465	17805	10233	7572	10233	10233	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	3048	3048	0	0	0
Agricultural Residues	0	0	0	0	0	0	4699	4699	4009	4009	4009
Waste Paper	0	0	0	0	0	0	0	0	0	0	0
Other Urban Waste	0	0	0	0	0	0	0	0	0	0	0
Tree Prunnings	0	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0	0
	CO2 Emissions due to ethanol transport - two way (tons/yr)										
Forest Material	4344	869	869	1738	1843	2063					
RS/AR							1194	649	2387	1819	649
UW											
Total Transportation Emissions	24,810	18,674	11,102	9,310	12,076	12,295	8,941	8,397	6,397	5,828	4,659

Transportation CO_2 Emissions Sources										
Plant ID	12	13	14	15	16	17	18	19	20	21
Forest Slash/Thinnings	0	0	0	0	0	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0	0	0	0
Agricultural Residues	0	0	0	0	0	0	0	0	0	0
Waste Paper	395	395	395	395	395	395	395	395	395	395
Other Urban Waste	263	263	263	263	263	263	263	263	263	263
Tree Prunnings	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0
Forest Material										
RS/AR										
UW	244	325	325	325	812	406	406	81	812	812
Total Transportation Emissions	902	983	983	983	1,470	1,064	1,064	739	1,470	1,470

Transportation CO Emissions Sources	CO Emissions due to feedstock transport - two way (tons/yr)							Note: Case is 1,3,4,7,8,12-15			
Plant ID	1	2	3	4	5	6	7	8	9	10	11
Forest Slash/Thinnings	7	6	4	3	3	4	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	1.1	1.1	0	0	0
Agricultural Residues	0	0	0	0	0	0	1.7	1.7	1.4	1.4	1.4
Waste Paper	0	0	0	0	0	0	0	0	0	0	0
Other Urban Waste	0	0	0	0	0	0	0	0	0	0	0
Tree Prunnings	0	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0	0
	CO Emissions due to ethanol transport - two way (tons/yr)										
Forest Material	8	2	2	3	2	3					
RS/AR							1.8	0.2	3.5	3.3	0.2
UW											
Total Transportation Emissions	15	8	5	6	5	7	4	3	5	5	2

Transportation CO Emissions Sources										
Plant ID	12	13	14	15	16	17	18	19	20	21
Forest Slash/Thinnings	0	0	0	0	0	0	0	0	0	0
Lumbermill Waste	0	0	0	0	0	0	0	0	0	0
Rice Straw	0	0	0	0	0	0	0	0	0	0
Agricultural Residues	0	0	0	0	0	0	0	0	0	0
Waste Paper	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Other Urban Waste	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Tree Prunnings	0	0	0	0	0	0	0	0	0	0
Construction Materials	0	0	0	0	0	0	0	0	0	0
Forest Material										
RS/AR										
UW	0.09	0.11	0.11	0.11	0.29	0.14	0.14	0.03	0.29	0.29
Total Transportation Emissions	0.32	0.35	0.35	0.35	0.52	0.37	0.37	0.26	0.52	0.52

NOx Emissions

	Ethanol Plant Types	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Reopened	Forest Thinnings/ Lumbermill Waste Reopened
	Plant IDs	1	2	3	4	5	6
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20	20
	Yield (gal/BDT)	77.4	77.4	77.4	77.4	77.4	77.4
	Feedstock (BDT/yr/ plant)	516,796	516,796	258,398	258,398	258,398	258,398
Without Ethanol	Power plant (tons/yr)	390.47	390.47	488.08	488.08	-	-
	Prescribed burn (tons/yr)	17.36	17.36	-	-	14.47	14.47
	Wildfire/Agric. burn (tons/yr)	33.95	33.95	-	-	28.29	28.29
	Transportation feedstock emissions (tons/yr)	58.3	34.6	54.8	56	0	0
With Ethanol	Collocated power plant (tons/yr)	689.37	275.75	344.69	345	344.69	344.69
	All open burns (tons/yr)	-	-	-	-	-	-
	Transportation emissions (tons/yr)	146	86	55	56	59	68
	No EtOH: % at risk Wildfire/open burn	55%	55%	0%	0%	91%	91%
	No EtOH: % Prescribed Burn	5%	5%	0%	0%	9%	9%
	No EtOH: %Feedstock to Power Plant	40%	40%	100%	100%	0%	0%
	No EtOH: % feedstock other use	0%	0%	0%	0%	0%	100%
	Power plant prior (BDT/yr)	206,718.35	206,718.35	258,397.93	258,397.93	-	-
	Emissions Reduction (tons/yr)	(334.99)	114.14	143.40	143.40	(360.81)	(370.11)
	Tons of biomass at risk for wildfire	282,946	282,945.74	-	-	235,788	235,788
	Acres at risk for wildfire	18,863	18,863	-	-	15,719	15,719

NOx Emissions						
	Ethanol Plant Types	Rice Straw/Ag Residue Continued	Rice Straw/Ag Residue Continue	Ag Residue Reopened	Ag Residue Continued Operation	Ag Residue Continued Operation
	Plant IDs	7	8	9	10	11
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20
	Yield (gal/BDT)	63	63	65	65	65
	Feedstock (BDT/yr/ plant)	634,921	634,921	307,692	307,692	307,692
Without Ethanol	Power plant (tons/yr)	377.78	377.78	-	377.78	377.78
	Prescribed burn (tons/yr)	-	-	-	-	-
	Wildfire/Agric. Burn(tons/yr)	628.17	628.17	1,123.08	393.08	393.08
	Transportation feedstock emissions (tons/yr)	10.6	10.6	-	26.74	12.67
With Ethanol	Collocated power plant (tons/yr)	846.94	846.94	410.44	410.44	410.44
	All open burns (tons/yr)	-	-	-	-	-
	Transportation emissions (tons/yr)	46	35	44	41	19
	No EtOH: % at risk Wildfire/open burn	27%	27%	100%	35%	35%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%
	No EtOH: %Feedstock to Power Plant	32%	32%	0%	65%	65%
	No EtOH: % feedstock other use	41%	41%	0%	0%	0%
	Power plant prior (BDT/yr)	200,000.00	200,000	-	200,000.00	200,000.00
	Emissions Reduction (tons/yr)	123.78	134.44	669.12	346.01	353.59

*372,100 BDT rice straw used for ethanol in plants 7 and 8

NOx Emissions											
	Ethanol Plant Types	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation
	Plant IDs	12	13	14	15	16	17	18	19	20	21
	EtOH Production (Mgallons/yr/plant)	10	10	10	10	10	10	10	10	10	10
	Yield (gal/BDT)	99	99	99	99	99	99	99	99	99	99
	Feedstock (BDT/yr/ plant)	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010
Without Ethanol	Power plant (tons/yr)	0	0	0	0	0	0	0.00	0.00	0.00	0.00
	Prescribed burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Wildfire/Agric. burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Transportation feedstock emissions (tons/yr)	3.77	4.11	4.11	4.11	6.15	4.45	4.45	3.09	6.15	6.15
With Ethanol	Collocated power plant (tons/yr)	2	2	2	2	2	2	2	2	2	2
	All open burns (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Transportation emissions (tons/yr)	4	4	4	4	6	4	4	3	6	6
	No EtOH: % at risk Wildfire/open burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: %Feedstock to Power Plant	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % feedstock other use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Power plant prior (BDT/yr)	-	-	-	-	-	-	-	-	-	-
	Emissions Reduction (tons/yr)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)

NOx Emissions					
	Ethanol Plant Types	Forest Material	Agricultural Residue	Urban Waste	Total
	EtOH Production (Mgallons/yr/plant)	80	80	40	200
	Yield (gal/BDT)	-	-	-	-
	Feedstock (BDT/yr/ plant)	1,033,592	1,269,841	404,040.4	2,707,473
Without Ethanol	Power plant (tons/yr)	1,367	756	0	2,122
	Prescribed burn (tons/yr)	17	0	0	17
	Wildfire/Agric. burn (tons/yr)	34	1256	0	1,290
	Transportation feedstock emissions (tons/yr)	169	21	16	206
With Ethanol	Collocated power plant (tons/yr)	1,379	1,694	8.191717	3,081
	All open burns (tons/yr)	-	-	-	-
	Transportation emissions (tons/yr)	256	81	16	353
	Total decrease (tons/yr)		202		

PM Emissions

	Ethanol Plant Types	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Reopened	Forest Thinnings/ Lumbermill Waste Reopened
	Plant IDs	1	2	3	4	5	6
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20	20
	Yield (gal/BDT)	77.4	77.4	77.4	77.4	77.4	77.4
	Feedstock (BDT/yr/ plant)	516,796	516,796	258,398	258,398	258,398	258,398
Without Ethanol	Power plant (tons/yr)	7.81	7.81	9.76	9.76	-	-
	Prescribed burn (tons/yr)	182.33	182.33	-	-	151.94	151.94
	Wildfire/Agric. Burn (tons/yr)	356.51	356.51	-	-	297.09	297.09
	Transportation feedstock emissions (tons/yr)	2.4	1.1	1.8	2.3	0.0	0.0
With Ethanol	Collocated power plant (tons/yr)	13.79	5.51	6.89	6.89	6.89	6.89
	All open burns (tons/yr)	-	-	-	-	-	-
	Transportation emissions (tons/yr)	6	3	2	2	2	3
	No EtOH: % at risk Wildfire/open burn	55%	55%	0%	0%	91%	91%
	No EtOH: % Prescribed Burn	5%	5%	0%	0%	9%	9%
	No EtOH: % Power Plant	40%	40%	100%	100%	0%	0%
	No EtOH: % feedstock other use	0%	0%	0%	0%	0%	100%
	Power plant prior (BDT/yr)	206,718.35	206,718.35	258,397.93	258,397.93	-	-
	Emissions Reduction (tons/yr)	529.29	539.55	2.87	2.87	440.20	439.51

PM Emissions

	Ethanol Plant Types	Rice Straw/Ag Residue Continued	Rice Straw/Ag Residue Continue	Ag Residue Reopened	Ag Residue Continued Operation	Ag Residue Continued Operation
	Plant IDs	7	8	9	10	11
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20
	Yield (gal/BDT)	63	63	65	65	65
	Feedstock (BDT/yr/ plant)	634,921	634,921	307,692	307,692	307,692
Without Ethanol	Power plant (tons/yr)	7.56	7.56	-	11.62	11.62
	Prescribed burn (tons/yr)	-	-	-	-	-
	Wildfire/open burn (tons/yr)	946.55	946.55	1,692.31	592.31	592.31
	Transportation emissions (tons/yr)	0.266	0.266	0.0	1.3	0.3
With Ethanol	Collocated power plant (tons/yr)	16.94	16.94	8.21	8.21	8.21
	All open burns (tons/yr)	-	-	-	-	-
	Transportation emissions (tons/yr)	2	1	2	2	0.5
	No EtOH: % at risk Wildfire/open burn	27%	27%	100%	35%	35%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%
	No EtOH: % Power Plant	32%	32%	0%	65%	65%
	No EtOH: % feedstock other use	41%	41%	0%	0%	0%
	Power plant prior (BDT/yr)	200,000.00	200,000.00	-	200,000.00	200,000.00
	Emissions Reduction (tons/yr)	935.82	936.55	1,682.09	595.04	595.55

PM Emissions											
	Ethanol Plant Types	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation
	Plant IDs	12	13	14	15	16	17	18	19	20	21
	EtOH Production (Mgallons/yr/plant)	10	10	10	10	10	10	10	10	10	10
	Yield (gal/BDT)	99	99	99	99	99	99	99	99	99	99
	Feedstock (BDT/yr/ plant)	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010
Without Ethanol	Power plant (tons/yr)	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Without Ethanol	Prescribed burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
Without Ethanol	Wildfire/open burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
Without Ethanol	Transportation emissions (tons/yr)	0.09	0.10	0.10	0.10	0.15	0.11	0.11	0.08	0.15	0.15
With Ethanol	Collocated power plant (tons/yr)	2	2	2	2	2	2	2	2	2	2
With Ethanol	All open burns (tons/yr)	-	-	-	-	-	-	-	-	-	-
With Ethanol	Transportation emissions (tons/yr)	0.09	0.10	0.10	0.10	0.15	0.11	0.11	0.08	0.15	0.15
	No EtOH: % at risk Wildfire/open burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Power Plant	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % feedstock other use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Power plant prior (BDT/yr)	-	-	-	-	-	-	-	-	-	-
	Emissions Reduction (tons/yr)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)	(2.05)

PM Emissions

	Ethanol Plant Types	Forest Material	Agricultural Residue	Urban Waste	Total
	EtOH Production (Mgallons/yr/plant)	80	80	40	200
	Yield (gal/BDT)	-	-	-	-
	Feedstock (BDT/yr/ plant)	1,033,592	1,269,841	404,040	2,707,473
Without Ethanol	Power plant (tons/yr)	27	15	0	42
Without Ethanol	Prescribed burn (tons/yr)	182	0	0	182
Without Ethanol	Wildfire/open burn (tons/yr)	357	1,893	0	2,250
Without Ethanol	Transportation emissions (tons/yr)	7	0.5	0.41	7
With Ethanol	Collocated power plant (tons/yr)	28	34	8	70
With Ethanol	All open burns (tons/yr)	-	-	-	-
With Ethanol	Transportation emissions (tons/yr)	10	2	0	13
	Total decrease (tons/yr)		2,399		

CO Emissions							
	Ethanol Plant Types	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Reopened	Forest Thinnings/ Lumbermill Waste Reopened
	Plant IDs	1	2	3	4	5	6
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20	20
	Yield (gal/BDT)	77.4	77.4	77.4	77.4	77.4	77.4
	Feedstock (BDT/yr/ plant)	516,796	516,796	258,398	258,398	258,398	258,398
Without Ethanol	Power plant (tons/yr)	70.28	70.28	87.86	87.86	-	-
	Prescribed burn (tons/yr)	1,128.68	1,128.68	-	-	940.57	940.57
	Wildfire/Agric. Burn (tons/yr)	2,206.98	2,206.98	-	-	1,839.15	1,839.15
	Transportation feedstock emissions (tons/yr)	6.2	3.2	5.2	5.9	0.0	0.0
With Ethanol	Collocated power plant (tons/yr)	124.09	49.63	62.04	62.04	62.04	62.04
	All open burns (tons/yr)	-	-	-	-	-	-
	Transportation emissions (tons/yr)	15	8	5	6	5	7
	No EtOH: % at risk Wildfire/open burn	55%	55%	0%	0%	91%	91%
	No EtOH: % Prescribed Burn	5%	5%	0%	0%	9%	9%
	No EtOH: % Power Plant	40%	40%	100%	100%	0%	0%
	No EtOH: % feedstock other use	0%	0%	0%	0%	0%	100%
	Power plant prior (BDT/yr)	206,718.35	206,718.35	258,397.93	258,397.93	-	-
	Emissions Reduction (tons/yr)	3,272.61	3,351.57	25.81	25.81	2,713.03	2,710.67

CO Emissions

	Ethanol Plant Types	Rice Straw/Ag Residue Continued	Rice Straw/Ag Residue Continue	Ag Residue Reopened	Ag Residue Continued Operation	Ag Residue Continued Operation
	Plant IDs	7	8	9	10	11
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20
	Yield (gal/BDT)	63	63	65	65	65
	Feedstock (BDT/yr/ plant)	634,921	634,921	307,692	307,692	307,692
Without Ethanol	Power plant (tons/yr)	68.00	68.00	-	104.62	104.62
	Prescribed burn (tons/yr)	-	-	-	-	-
	Wildfire/Agric. burn (tons/yr)	7,976.84	7,976.84	14,261.54	4,991.54	4,991.54
	Transportation emissions (tons/yr)	0.8872446	0.8872446	0.0	3.1	1.1
With Ethanol	Collocated power plant (tons/yr)	152.45	152.45	73.88	73.88	73.88
	All open burns (tons/yr)	-	-	-	-	-
	Transportation emissions (tons/yr)	4	3	5	5	1.6
	No EtOH: % at risk Wildfire/open burn	27%	27%	100%	35%	35%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%
	No EtOH: % Power Plant	32%	32%	0%	65%	65%
	No EtOH: % feedstock other use	41%	41%	0%	0%	0%
	Power plant prior (BDT/yr)	200,000.00	200,000.00	-	200,000.00	200,000.00
	Emissions Reduction (tons/yr)	7,888.79	7,890.32	14,182.73	5,020.62	5,021.70

CO Emissions

	Ethanol Plant Types	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation
	Plant IDs	12	13	14	15	16	17	18	19	20	21
	EtOH Production (Mgallons/yr/plant)	10	10	10	10	10	10	10	10	10	10
	Yield (gal/BDT)	99	99	99	99	99	99	99	99	99	99
	Feedstock (BDT/yr/ plant)	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010
Without Ethanol	Power plant (tons/yr)	0	0	0	0	0	0	0.00	0.00	0.00	0.00
	Prescribed burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Wildfire/Agric. burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Transportation emissions (tons/yr)	0.32	0.35	0.35	0.35	0.52	0.37	0.37	0.26	0.52	0.52
With Ethanol	Collocated power plant (tons/yr)	0	0	0	0	0	0	0	0	0	0
	All open burns (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Transportation emissions (tons/yr)	0.32	0.35	0.35	0.35	0.52	0.37	0.37	0.26	0.52	0.52
	No EtOH: % at risk Wildfire/open burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Power Plant	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % feedstock other use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Power plant prior (BDT/yr)	-	-	-	-	-	-	-	-	-	-
	Emissions Reduction (tons/yr)	-	-	-	-	-	-	-	-	-	-

CO Emissions

	Ethanol Plant Types	Forest Material	Agricultural Residue	Urban Waste	Total
	EtOH Production (Mgallons/yr/plant)	80	80	40	200
	Yield (gal/BDT)	-	-	-	-
	Feedstock (BDT/yr/ plant)	1,033,592	1,269,841	404,040	2,707,473
Without Ethanol	Power plant prior (tons/yr)	246	136	0	382
	Prescribed burn (tons/yr)	1,129	0	0	1,129
	Wildfire/Agric. burn (tons/yr)	2,207	15,954	0	18,161
	Transportation emissions (tons/yr)	17	2	1	20
With Ethanol	Collocated power plant (tons/yr)	248	305	0	553
	All open burns (tons/yr)	-	-	-	-
	Transportation emissions (tons/yr)	27	7	1	35
	Total decrease (tons/yr)		19,103		

HC Emissions

	Ethanol Plant Types	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Continued Operation	Forest Thinnings/ Lumbermill Waste Reopened	Forest Thinnings/ Lumbermill Waste Reopened
	Plant IDs	1	2	3	4	5	6
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20	20
	Yield (gal/BDT)	77.4	77.4	77.4	77.4	77.4	77.4
	Feedstock (BDT/yr/ plant)	516,796	516,796	258,398	258,398	258,398	258,398
Without Ethanol	Power plant (tons/yr)	42.95	42.95	53.69	53.69	-	-
	Prescribed burn (tons/yr)	182.33	182.33	-	-	151.94	151.94
	Wildfire/Agric. Burn (tons/yr)	212.21	212.21	-	-	176.84	176.84
	Transportation feedstock emissions (tons/yr)	4.0	1.8	3.1	3.9	0.0	0.0
With Ethanol	Collocated power plant (tons/yr)	75.87	30.35	37.93	37.93	37.93	37.93
	All open burns (tons/yr)	-	-	-	-	-	-
	Transportation emissions (tons/yr)	10	5	3	4	4	5
	No EtOH: % at risk Wildfire/open burn	55%	55%	0%	0%	91%	91%
	No EtOH: % Prescribed Burn	5%	5%	0%	0%	9%	9%
	No EtOH: % Power Plant	40%	40%	100%	100%	0%	0%
	No EtOH: % feedstock other use	0%	0%	0%	0%	0%	100%
	Power plant prior (BDT/yr)	206,718.35	206,718.35	258,397.93	258,397.93	-	-
	Emissions Reduction (tons/yr)	312.63	361.48	(37.93)	(37.93)	287.33	286.32

HC Emissions

	Ethanol Plant Types	Rice Straw/Ag Residue Continued	Rice Straw/Ag Residue Continue	Ag Residue Reopened	Ag Residue Continued Operation	Ag Residue Continued Operation
	Plant IDs	7	8	9	10	11
	EtOH Production (Mgallons/yr/plant)	40	40	20	20	20
	Yield (gal/BDT)	63	63	65	65	65
	Feedstock (BDT/yr/ plant)	634,921	634,921	307,692	307,692	307,692
Without Ethanol	Power plant (tons/yr)	41.56	41.56	-	63.93	63.93
	Prescribed burn (tons/yr)	-	-	-	-	-
	Wildfire/open burn (tons/yr)	129.08	129.08	230.77	80.77	80.77
	Transportation emissions (tons/yr)	0.4611915	0.4611915	0.0	2.1	0.6
With Ethanol	Collocated power plant (tons/yr)	93.21	93.21	45.17	45.17	45.17
	All open burns (tons/yr)	-	-	-	-	-
	Transportation emissions (tons/yr)	3	2	4	3	1.0
	No EtOH: % at risk Wildfire/open burn	27%	27%	100%	35%	35%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%
	No EtOH: % Power Plant	32%	32%	0%	65%	65%
	No EtOH: % feedstock other use	41%	41%	0%	0%	0%
	Power plant prior (BDT/yr)	200,000.00	200,000.00	-	200,000.00	200,000.00
	Emissions Reduction (tons/yr)	33.52	34.66	182.08	34.45	35.25

HC Emissions

	Ethanol Plant Types	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation	Urban Waste New Operation
	Plant IDs	12	13	14	15	16	17	18	19	20	21
	EtOH Production (Mgallons/yr/plant)	10	10	10	10	10	10	10	10	10	10
	Yield (gal/BDT)	99	99	99	99	99	99	99	99	99	99
	Feedstock (BDT/yr/ plant)	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010	101,010
Without Ethanol	Power plant (tons/yr)	0	0	0	0	0	0	0.00	0.00	0.00	0.00
	Prescribed burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Wildfire/open burn (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Transportation emissions (tons/yr)	0.22	0.25	0.25	0.25	0.44	0.28	0.28	0.15	0.44	0.44
With Ethanol	Collocated power plant (tons/yr)	2	2	2	2	2	2	2	2	2	2
	All open burns (tons/yr)	-	-	-	-	-	-	-	-	-	-
	Transportation emissions (tons/yr)	0.22	0.25	0.25	0.25	0.44	0.28	0.28	0.15	0.44	0.44
	No EtOH: % at risk Wildfire/open burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Prescribed Burn	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % Power Plant	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	No EtOH: % feedstock other use	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Power plant prior (BDT/yr)	-	-	-	-	-	-	-	-	-	-
	Emissions Reduction (tons/yr)	(1.64)	(1.64)	(1.64)	(1.64)	(1.64)	(1.64)	(1.64)	(1.64)	(1.64)	(1.64)

HC Emissions

	Ethanol Plant Types	Forest Material	Agricultural Residue	Urban Waste	Total
	Plant IDs				
	EtOH Production (Mgallons/yr/plant)	232	126	396	754
	Yield (gal/BDT)	1,033,592	1,269,841	404,040	2,707,473
	Feedstock (BDT/yr/ plant)	150	83	0	233
Without Ethanol	Power plant (tons/yr)	182	0	0	182
	Prescribed burn (tons/yr)	212	258	0	470
	Wildfire/open burn (tons/yr)	11	1	1	13
	Transportation emissions (tons/yr)	152	186	7	345
With Ethanol	Collocated power plant (tons/yr)	0	0	0	0
	All open burns (tons/yr)	17	4	1	23
	Transportation emissions (tons/yr)	1	1	0	1
	Total decrease (tons/yr)			987	

CO_2 Emissions		Zero EtOHCase	CA EtOH Case	Difference
Ethanol Produced in California (Mgal)		-	200	
Electricity Produced (GWh)		1,124	163	
Process Gas Required (Mscf)		-	1,592	
Additional CO_2 from electricity	(tons/yr)	(643,700)	(93,176)	
Additional CO_2 from process gas	(tons/yr)	-	106,503	
Displaced CO_2 from reduced gasoline use	(tons/yr)	-	(1,541,850)	
CO_2 from ethanol and feedstock transportation	(tons/yr)	54,138	66,409	
CO_2 from ethanol transport	(tons/yr)	15,253	10,012	
CO_2 from feedstock transport	(tons/yr)	38,885	56,397	
Global Emissions Reduction	(tons/yr)			872,552

CO_2 from electricity (g/kWh)	520
CO_2 from process gas (lb/scf)	0.134
CO_2 from displaced gasoline (g/gal ethanol)	7000

Vehicle Emission Factors

Diesel Truck Emission Factors		
	(g/mi)	**(g/gal diesel)**
NOx (a)	12	0.1
HC (b)	0.14	0.5
PM (a)	0.3	0.01
CO_2 (c)		11,500
CO (b)	1.01	
Source for g/mi:	(a) Carl Moyer Program for MY 1998-2002	
	(b) EMFAC 2000 values for 2003	
	(c) ADL for ARB (fuel cycle analysis)	

Locomotive Emission Factors (1973-2001 model years)		
	(g/bhp-hr)	**(g/ton-mile)**
NOx	9.5	0.8265
HC	1	0.087
PM	0.6	0.0522
CO_2	687	59.769
CO	1.3	0.1131
Source: Carl Moyer Incentive Program		
bhp-hr/ton-mile	0.087	

Imported Ethanol Emission Factors		
	Marine Emissions	**Rail Emissions**
	g/gal etoh	**g/gal etoh**
NOx	0.0733	0.282
HC	0.0133	0.0412
PM	0.0057	0.004
CO_2		
CO	0.0034	0.0524

Imported Ethanol Emissions

For Marine and Rail Transport		Zero-ethanol case marine	Zero-ethanol case rail	Total zero-ethanol case in CA
Imported Ethanol	M Gal/yr	150	50	200
Transport in CA (one-way)	Miles in CA	103	140	-
Emissions (two-way)				
NOx	(ton/yr)	12.11	15.53	28
HC	(ton/yr)	2.20	2.27	4
PM	(ton/yr)	0.94	0.22	1
CO_2	(ton/yr)	0.00	0.00	0
CO	(ton/yr)	0.56	2.89	3

Transport of Ethanol by Truck: Emissions

Plant ID		1	2	3	4	5	6	7	8	9	10
Ethanol Production Capacity	M Gal/yr	40	40	20	20	20	20	40	40	20	20
Truck Transport (one-way)	Miles/yr	51,282	512,821	102,564	25,641	153,846	51,282	51,282	102,564	102,564	12,821
Truck Fuel Economy	Mi/gal	4	4	4	4	4	4	4	4	4	4
Emissions (two-way)											
Nox	(ton/yr)	1	14	3	1	4	1	1	3	3	0
HC	(ton/yr)	0	1	0	0	0	0	0	0	0	0
PM	(ton/yr)	0	0	0	0	0	0	0	0	0	0
CO_2	(ton/yr)	325	3,247	649	162	974	325	325	649	649	81

Plant ID		11	12	13	14	15	16	17	18	19	20	21
Ethanol Production Capacity	M Gal/yr	20	10	10	10	10	10	10	10	10	10	10
Truck Transport (one-way)	Miles/yr	102,564	38,462	51,282	51,282	51,282	128,205	64,103	64,103	12,821	128,205	128,205
Truck Fuel Economy	Mi/gal	4	4	4	4	4	4	4	4	4	4	4
Emissions (two-way)												
NOx	(ton/yr)	3	1	1	1	1	3	2	2	0	3	3
HC	(ton/yr)	0	0	0	0	0	0	0	0	0	0	0
PM	(ton/yr)	0	0	0	0	0	0	0	0	0	0	0
CO_2	(ton/yr)	649	244	325	325	325	812	406	406	81	812	812

Transport of Ethanol by Rail: Emissions								
Plant ID		1	2	3	4	5	6
Ethanol Production Capacity	M Gal/yr	40	40	20	20	20	20
Rail Transport (one-way)	ton/day	362	362	181	181	181	181
	Rail Miles	250	50	100	200	100	200
	Ton-miles/yr	33,000,000	6,600,000	6,600,000	13,200,000	6,600,000	13,200,000
Emissions (two-way)							
NOx	(ton/yr)	60	12	12	24	12	24
HC	(ton/yr)	6	1	1	3	1	3
PM	(ton/yr)	4	1	1	2	1	2
CO_2	(ton/yr)	4344	869	869	1738	869	1738

Note: Only plants 1-6 involve transportation of ethanol by rail