CALIFORNIA ENERGY COMMISSION

INVENTORY OF CALIFORNIA GREENHOUSE GAS EMISSIONS AND SINKS: 1990 TO 2004

STAFF FINAL REPORT

December 2006
CEC-600-2006-013-SF

STATE OF CALIFORNIA
ENERGY COMMISSION

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Subject: REVISIONS TO THE 1990 TO 2004 GREENHOUSE GAS EMISSIONS INVENTORY REPORT, PUBLISHED IN DECEMBER 2006 (CEC-600-2006-013)

As we finalized the technical report titled *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004* in late December 2006, my staff discovered a need to change greenhouse gas (GHG) emissions estimates for in-state electricity production. They discussed the need for these changes with both Peggy Taricco and Webster Tasat of your staff. They requested that we document these changes as we transmit them to the Air Resources Board.

Enclosed in this package is the published version of Table 6 from the referenced report, a revised version of Table 6 showing the needed changes for GHG emissions from in-state electricity production, and a detailed description of the specific changes needed. Gerry Bemis of my staff is available to assist your staff to provide whatever additional assistance may be needed to implement these changes. He will also provide your staff with a final version of all GHG inventory files.

December 20, 2006 Changes Identified for In-State Electricity GHG Emissions

1. Refinery Self-Generation
   The Energy Balance (Assembly File) has an entry on Row 22 under "Transfer, Oil Refineries". This was erroneously thought to be "Refinery Self-Generation" and was listed as such in both the GHG inventory published in 2005 and the one published in 2006. These values should be removed from all years, but entries for 1990 to 1992 were zero, so those years are not affected. This reduces GHG emissions values published in 2006 by 0.7 to 4.3 $MMTCO_2E$, depending on year.

   Change Needed:
   Remove all columns of Row 178 from Table A-4 in the main file[1] including removing this row from the equation in Row 172. Also remove all columns of Row 184 from the Fossil Fuel CO2 tab and the summary equation in Row 178 of this tab.

2. Coal
   There was an error made in multiplying Thousand Short Tons of coal by the energy content of the coal. This was a simple mechanical error, which shows up in the GHG inventory published in 2006, but was not in the 2005 GHG inventory.

   Changes Needed:

   On "Appendix B in the main file, Columns "G" through "U":
   a) Change Row 193 to read as follows:
   ='[assembly(July 2006 Update).xls]COAL'!C16*'[assembly(July 2006 Update).xls]Conv Energy'!**C49**/10^3 (change "C13" to "C49")

   b) Change Row 194 to read as follows:
   ='[assembly(July 2006 Update).xls]COAL'!C17*'[assembly(July 2006 Update).xls]Conv Energy'!**C50**/10^3 (change "C14" to "C50")

   c) Change Row 195 to read as follows:
   ='[assembly(July 2006 Update).xls]COAL'!C19*'[assembly(July 2006 Update).xls]Conv Energy'!**C52**/10^3 (change "C16" to "C52"; see below for "C19")

   For changes a) through c), change each column correspondingly to apply the change to each year, 1990 through 2004.

3. Merchant Power (natural gas)
   On the "Appendix B" tab in the main file, Row 195 had the wrong reference cell for BTUs used by Merchant Power facilities. This is another mechanical error which appears in the 2006 GHG inventory but not in the 2005 GHG inventory.

[1] 2005 GHG Inventory (1990 to 2004).xls

Change Needed:
Change the first term from “COAL’C18” to “COAL’C19” as indicated above for Row 195. Make this change for all columns, “G” through “U”.

Changes #2 and #3 taken together increase values above those published in 2006 for GHG emissions from coal-based electricity generation by 1.0 to 2.5 $MMTCO_2E$, depending on year.

4. <u>“Other” Petroleum Products</u>
   These fuel uses were left off of both the 2005 and 2006 GHG inventories. This was an oversight. To fix this problem and because the Energy Balance (Assembly File) did not identify “Other Petroleum Products” fuel uses by fuel type, it was necessary to use an Energy Information Administration (EIA) database, specifically the one for EIA Form 906. This database provides fuel use for in-state fuel consumption to produce electricity.

   There is a separate file for each year from 2001 through 2005. Each file was data-filtered for California, then data-filtered for each fuel and each sub-category of fuel use as listed in Appendix B of the main file. End results of filtering for natural gas and coal (after making the adjustments above) match very closely to Energy Balance (Assembly) values when comparing physical units (TCFs and BBLS). This shows that the proper sub-categories (Utility, Merchant Plant, etc) were identified in the Form 906 database. Corresponding values for BTU equivalents to the physical units were also close, but differed slightly because the Form 906 database has monthly values for conversion from physical unit to BTUS, while the Energy Balance uses a yearly approximation. The corrections below include using BTU values from the Form 906 database for natural gas and coal (years 2001 to 2005) because they are viewed to be slightly more accurate than Energy Balance BTUs. The results of filtering, done for each year, are in new files for each year and a summary file titled “Electric GHG Emissions” within a new folder “EIA Electricity Data”.

   This process yields in-state electricity fuel uses for distillate oil, residual fuel oil and petroleum coke, each of which has a tab in the Energy Balance (Assembly file) which was empty. The process also yields a modest amount of “Other Organic Gases” from the EIA 906 database, which could not be identified. For purposes of making emissions calculations, these were <u>assumed to be refinery still gas for purposes of calculation</u>. These Other Organic Gases are calculated to contribute 0.6 to 1.3 $MMTCO_2E$. If the carbon content of these unknown gases is different from refinery still gas, their correct emissions are likely to be similar.

   Rows were added to the “Fossil Fuel CO2” tab (new file, Rows 189 to 194) to accommodate this change. Row 177 was also revised to include Row 189, the subtotal for petroleum. Table 2 was likewise expanded to add a subtotal for petroleum under Electricity Generation (In-State).

   Changes Needed (as described in the revised main file[2]):
   Add Rows 410 to 462, column “A” through “U” to Fossil Fuel CO2 tab in the main file. These new cells link to a new file “Electric GHG Emissions” within a new folder “EIA Electricity Data” where new calculations are made from EIA forms.

   Link these new cells to corresponding cells in “Electric GHG Emissions” file. Then make the following changes to Fossil Fuel CO2 file:

[2] 2005 GHG Inventory (12-20-06 edits--1990 to 2004).xls

(Note: no changes needed for rows 178 to 188, columns "F" through "P")

a) Make new summary Row 189 for petroleum subtotal and new Rows 190-194.

b) For Columns "F" through "P":
Make Row 190 = Row 450
Make Row 191 = Row 451
Make Row 192 = Row 452
Make Row 193 = Row 453
Make Row 194 = Row 454

c) For Columns "Q" through "U":
Make Rows 179-184 = Rows 415-420, respectively;
Make Rows 186-188 = Rows 423-425, respectively;
Make Row 190 = row 430;
Make Row 191 = Rows 441+445;
Make Row 192 = Rows 431+437+442+446+447;
Make Row 193 = Rows 428+435;
Make Row 194 = Rows 429+436+440

Add Row 189 to the equation in Row 177, for all columns.

One effect of these changes is to make slight modifications for years 2001 through 2004 in the natural gas data. This was possible because the Form 906 file has monthly values for fuel energy content, so the revised annual BTUs are slightly different. Coal data were revised as discussed above. The change discussed here will be limited to natural gas GHG emissions, which increase by 0.9 $MMTCO_2E$ in 2002 and 2003, and 2.1 $MMTCO_2E$ in 2004.

The second effect of these changes is to add petroleum fuel GHG emissions in years 1990 to 2005 (2005 shown for information). These changes add 2.5 to 4.6 $MMTCO_2E$ depending on year.

The net effect of all these changes is to increase emissions from in-state electricity production. The maximum increase is in 2004, +8.0[3] $MMTCO_2E$. The smallest increase is in 2003, +1.8[4] $MMTCO_2E$.

5. <u>Electricity Imported to California</u>
Staff are still in the process of updating the method used to estimate out-of-state emissions for electricity imported into California. However, if the current method continues to be used, GHG emissions should be increased to account for transmission line losses which were not included in the previous calculation. The Energy Commission uses an overall bulk average of 7.5% for transmission line losses, but this includes all sources, local and imported. In-state line losses are implicit in the existing methodology, which is based upon fuel used, not electricity used. In the methodology currently being used, GHG emissions from imported electricity are computed from imported electricity, not fuel use, and this method should have included an estimate of transmission line losses. This can be done by multiplying the computed results by 1.075, if 7.5% is the appropriate value. However, imported electricity would travel over greater distances than

[3] 2004 value increases 1.8 for natural gas, 2.6 for coal and 3.6 for petroleum fuels, all $MMTCO_2E$.
[4] 2003 value decreases 3.4 for natural gas, and increases 2.0 for coal and 3.2 for petroleum fuels, all in $MMTCO_2E$.

in-state electricity and thus may have larger transmissions losses than the bulk average. The bulk average transmission losses (7.5%) can be determined from Form 1.2 of the document *California energy Demand 2006-2016, Staff Energy Demand Forecast, Revised September 2005*, CEC-400-2005-034-SF-ED2, September 2005.

The above change was not made in the December 20, 2006 revisions because the entire methodology is expected to change.

ABSTRACT

This report provides estimates of California's greenhouse gas emissions over the 1990 to 2004 time period. Emissions estimates in the report are derived from data provided by the U.S. Energy Information Administration and additional data collected by the California Energy Commission. Analysis in the report uses protocols established for country-level greenhouse gas emissions inventory reporting as established by the Intergovernmental Panel on Climate Change and the U. S. Environmental Protection Agency. The report includes both in-state emissions and emissions from electricity imported into California. These emissions and emissions from international fuel uses are shown at the bottom of the inventory to allow the reader to decide whether to include them.

California's greenhouse gas emissions are large in a world-scale context and growing over time. If California was considered to be an independent country, its emissions would rank seventeenth largest.

This report also includes projections of California greenhouse gas emissions to 2020. These projections are based upon forecasts adopted by the Energy Commission in its *2005 Integrated Energy Policy Report*. This report also includes an estimate of reductions needed to meet 2010 and 2020 greenhouse gas emissions reduction targets established by California's Governor, Arnold Schwarzenegger.

KEYWORDS

Greenhouse gas emissions inventory, climate change, carbon dioxide, methane, nitrous oxide, high global-warming potential gases

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report updates California's statewide inventory of greenhouse gas (GHG) emissions to support evaluation of state policies that address climate change and climate variability or more commonly known as global warming. Information in this report extends the inventory period through 2004, which is the most recent year that data are available from the California Energy Commission (Energy Commission) or the United States Department of Energy's (DOE's) Energy Information Administration. This inventory reports GHG emissions from out-of-state electricity used in California along with in-state generation GHG emissions and estimates future emissions trends using fuel demand and other forecast data from the Energy Commission's *2005 Integrated Energy Policy Report*.

California's economy experienced the second largest percentage growth in terms of gross state product (in dollars, not adjusted for inflation) of any state in the country from 1990 to 2003.[1] During that period, California's GSP grew 83 percent while its GHG emissions grew more slowly at 12 percent. This demonstrates the potential for uncoupling economic trends from GHG emissions trends.

Nonetheless, California's GHG emissions are large and growing. As the second largest emitter of GHG emissions in the United States and twelfth to sixteenth largest in the world,[2] the state contributes a significant quantity of GHGs to the atmosphere.

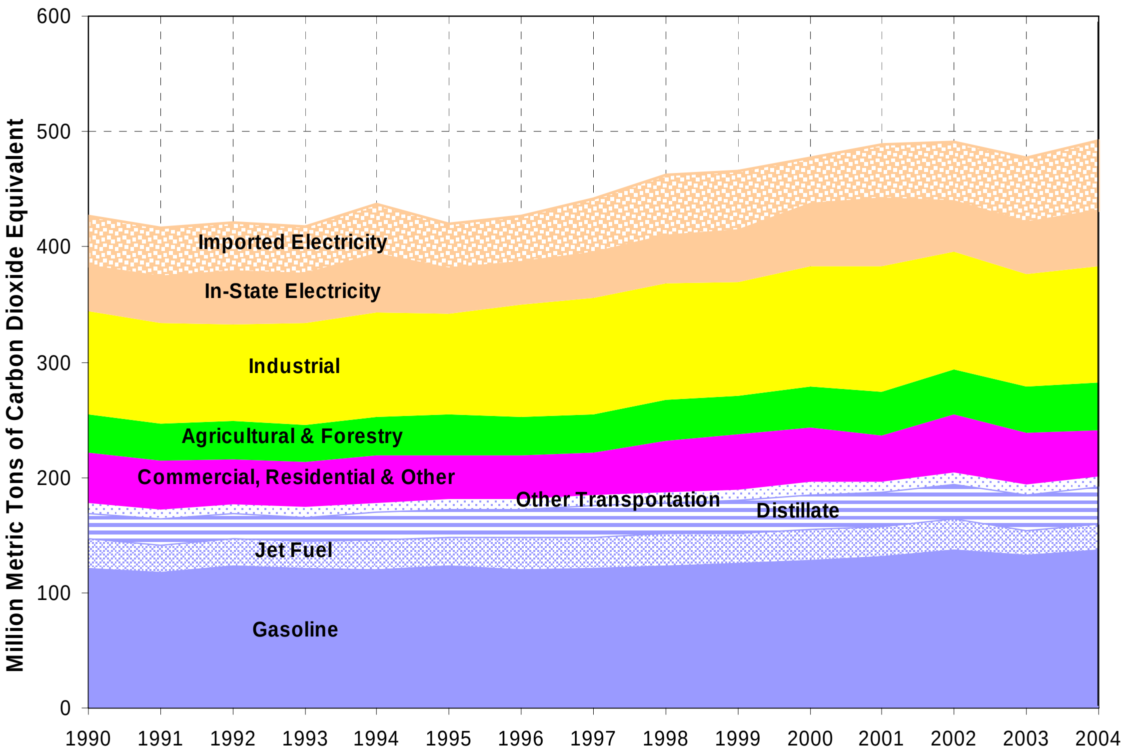
California's ability to slow the rate of growth of GHG emissions is largely due to the success of its energy efficiency and renewable energy programs and a commitment to clean air and clean energy. In fact, the state's programs and commitments lowered its GHG emissions rate of growth by more than half of what it would have been otherwise.[3] Moreover, California's energy programs and policies have had multiple benefits that include not only reducing GHG emissions, but reducing energy demand and improving air quality and public health.

Although California's total GHG emissions are larger than every state but Texas, California has relatively low carbon emission intensity. In 2001, California ranked fourth lowest of the 50 states in carbon dioxide emissions per capita from fossil fuel combustion and fifth lowest of the 50 states in carbon dioxide emissions from fossil fuel combustion per unit of gross state product. Emission trends per unit of gross state product are encouraging; most states have reduced their emissions per unit of gross state product over the 1990 to 2001 period.

In 2004, California produced 492 million gross metric tons of carbon dioxide-equivalent[4] GHG emissions, including imported electricity and excluding combustion of international fuels and carbon sinks or storage.

Figure 1 shows year-by-year trends in GHG emissions for the major energy sectors. Values differ yearly due to changes in fuel uses, meteorological variations, and other factors.

Figure 1 -- California's Gross GHG Emissions Trends



Source: California Energy Commission

The transportation sector is the single largest category of California's GHG emissions, producing 41 percent of the state's total emissions in 2004. Most of California's emissions, 81 percent, are carbon dioxide produced from fossil fuel combustion.

This California GHG emissions inventory excludes all international fuel uses, reporting them separately. Including these international emissions would increase total emissions by 27 to 40 million metric tons of carbon dioxide–equivalent GHG emissions, depending on the year.

Electricity generation is the second largest category of GHG emissions (behind transportation). In particular, out-of-state electricity generation has higher carbon intensity than in-state generation. While imported electricity is a relatively small share of California's electricity mix (ranging from 22 to 32 percent of total electrical energy used), out-of-state electricity generation sources contribute 39 to 57 percent of the GHG emissions associated with electricity consumption in California. Electricity imported to California from the Southwest has a significant percentage that is coal-based generation, while imports from the Pacific Northwest have a significant portion that is hydroelectricity.

Because GHGs affect the entire planet, not just the location where they are emitted, policies developed to address climate change should include an evaluation of emissions from the entire fuel cycle whenever possible.

Staff recommends the following steps to further improve the accuracy and utility of the California GHG emissions inventory:

- Update fuel use and other emissions-related activity data.

- Perform a more detailed review of industrial uses of fossil fuels to classify when they are used as fuel versus when they are used as a process input and not released into the atmosphere at that step in their usage chain.

- Add industrial wastewater emissions. These occur from processing fruits and vegetables, red meat and poultry, and pulp and paper. Methane and nitrous oxide emissions from these activities are not yet included in this inventory and should be added since California is a major producer of these products.

- Study in more detail landfill methane emissions. Values in this inventory represent a facility-by-facility review of emissions by local air quality district staff; as of July 2006, local air quality districts are updating their data but have yet to finish this work. Also, landfill emissions are being studied by the Energy Commission's Public Interest Energy Research Program but results are not expected before 2008. Improved data for landfill emissions are expected to result from both of these efforts.

- Develop California-specific data for sulfur hexafluoride emissions from electric utilities for the 1990-to-present time period.

- Develop California-specific emission factors for methane and nitrous oxide from enteric fermentation and manure management.

INTRODUCTION

This report updates California's statewide inventory of GHG emissions, using the most current data available from the EIA and the Energy Commission. The report also adds two years to the period covered by the inventory, extending it from 2002 to 2004. Major changes from the previous state inventory are summarized in Appendix D.

The California GHG emissions inventory is an estimate of anthropogenic[5] emissions of carbon dioxide (CO_2), methane, nitrous oxide, and various high global warming potential (GWP) gases that contribute to warming of the earth's atmosphere and oceans. All these gases have been identified as forcing the earth's atmosphere and oceans to warm above naturally occurring temperatures.[6]

The last State of California inventory of anthropogenic GHG emissions was reported in *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002 Update.*[7] It covered the period from 1990 to 2002, and was prepared by Energy Commission for the *2005 Integrated Energy Policy Report*.

In November 2002 the Energy Commission published a previous State of California GHG emissions inventory in a report titled *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999*.[8] It covered the period from 1990 to 1999 and was prepared under contract to the Energy Commission by ICF Consulting of Washington, D.C.

All three GHG inventories are based on guidance documents also prepared by ICF Consulting for the U.S. Environmental Protection Agency (EPA).[9]

Because they provide a comprehensive and consistent data source without significant gaps or overlap, where available, U.S. Energy Information Administration (EIA) fuel data were used in the 1990-1999 inventory and for subsequent updates. These EIA fuel data were supplemented with Energy Commission fuel data in a report titled *California Energy Balances Report (Energy Balance)*[10] prepared by Lawrence Berkeley National Laboratories for the Energy Commission's Public Interest Energy Research (PIER) Program. For non-fuel emissions, a variety of sources are used as documented later in this report.

The new inventory relies heavily upon data sources and procedures used by ICF Consulting in preparing the 1990-1999 California inventory and the national GHG emissions inventory.[11] In some instances, staff used newer data available from the Energy Commission and the California Air Resources Board (ARB), which allow for a more refined treatment. These changes are explained in the body of this document.

This report presents the methodology and approach used in the current inventory update. Where a change is made in either data or analysis, staff has provided information in this report to fully document the change. The 1990-1999 inventory provides full technical documentation. All changes are applied over the entire time span of the inventory to more properly show GHG inventory trends.

The report next provides a summary of California's GHG emissions, followed by a discussion of projected GHG emissions trends. The trend section ends with a comparison of California GHG emissions to those of other states. This discussion is limited to CO_2 emitted from fossil fuel combustion because it was not possible to get 50-state data for the non-fossil fuel emissions.[12] Fossil fuels produce more than 80 percent of California's GHG inventory and are responsible for large, but varying, percentages of GHG emissions for the other states.

After the CO_2 trend analysis, the report summarizes the methods used to estimate California's inventory of GHG emissions. Next, this report discusses ways to improve future versions of the California GHG emissions inventory.

Appendix A provides documentation for improvements made to the California GHG inventory. Appendix B provides a table showing energy used in fossil fuel combustion in California, largely derived from the California Energy Balance. Appendix C provides a comparison of alternative methods of estimating GHG emissions from imported electricity. Appendix D compares the 1990 to 2002 inventory to the 1990 to 2004 inventory for the years that match. Appendix E provides the methane speciation profile used by ARB to calculate methane emissions for the categories for which they provided data. Finally, Appendix F compares the CAT emissions inventory and projections to the 1990 to 2004 GHG inventory and projections using the *2005 IEPR*.

Early California GHG Inventories

In October 1990, the California Energy Commission published[13] the first inventory of GHG emissions for the State of California. This inventory was only for one year (1988) and only for CO_2, with results expressed in million short tons of carbon. Table 1 shows a summary of these emissions estimates in the units originally used and converted into million metric tons of carbon dioxide equivalents ($MMTCO_2E$). Gross GHG emissions are shown, which means that CO_2 sinks are not included.

Table 1 – 1988 Gross California GHG Emissions (Million Tons) (Published October 1990)

	Million Short Tons of Carbon	Million Metric Tons CO_2E
In-state	125.1	416
Out-of-state	19.4	64.5
Total	144.5	480.5

In March 1997, the Energy Commission published[14] its second inventory of GHG emissions for the State of California. This second inventory was also only for one year (1990) but included an estimate for methane and nitrous oxide, in addition to CO_2. It used a 100-year GWP[15] of 11 for methane (this report uses 21) and 270 for nitrous oxide (this report uses 310). Both these weighting factors are values multiplied by the weight of the gases emitted to convert them to CO_2 equivalents. Results were expressed in short tons of CO_2 equivalent, using the GWPs to obtain the CO_2 equivalents for methane and nitrous oxide. These estimates included international bunker fuels.[16] Gross California emissions (excludes CO_2 sinks) for this second inventory are summarized in Table 2.

Table 2 – 1990 Gross California GHG Emissions (Million Tons) (Published March 1997)

	Million Short Tons of Carbon Dioxide Equivalent	Million Metric Tons of Carbon Dioxide Equivalent
In-state	482.3	437.5
Out-of-state	16.0	14.5
Total	498.3	452.0

In January 1998, the Energy Commission published[17] its next GHG inventory. This inventory covered 1990 through 1994 and included methane and nitrous oxide in addition to CO_2. It used 100-year GWPs of 21 for methane and 310 for nitrous oxide, as did subsequent GHG inventories. Results were expressed in short tons of CO_2 equivalent. The report includes an estimate for out-of-state GHG emissions only for 1990. This 1990 value was estimated from Figure 5 of the 1990 to1994 GHG inventory report. Thus, the "Total" row in each of the two tables below is left empty except for 1990. Table 3 shows a summary of gross California emissions from this inventory in the original short tons of CO_2 equivalent units. Table 4 shows the same inventory converted to million metric tons of CO_2 equivalents to facilitate comparison to other inventory vintages.

Table 3 – 1990 Gross California GHG Emissions (Million Short Tons CO_2 Equivalent) (Published January 1998)

	1990	1991	1992	1993	1994
In-state	456.3	440.7	443.6	435.6	458.2
Out-of-state	59 (est.)	N.A.	N.A.	N.A.	N.A.
Total	515.3				

Table 4 – 1990 Gross California GHG Emissions (Million Metric Tons CO_2 Equivalent) (Published January 1998)

	1990	1991	1992	1993	1994
In-state	414.0	399.8	402.4	395.2	415.7
Out-of-state	53.5 (est.)	N.A.	N.A.	N.A.	N.A.
Total	467.5				

From Tables 3 and 4 one can see that emissions decrease beginning in 1990 and then rebound to values slightly above 1990 levels by 1994. The trend is consistent in subsequent California GHG inventories, including the 1990 to 2004 GHG inventory.

As information on activity levels and GHG emissions estimating techniques improve over time, estimated emissions for a selected year can and will change. It is accepted practice to improve and recalculate historical emissions inventories even if the end result causes a change in reported emissions and trends.[18] Table 5 below shows estimated gross emissions levels from five California GHG emissions inventories published by the Energy Commission, their dates of publication, and total estimated 1990 California emissions in million metric tons of carbon dioxide, including both in-state and imported electricity.

Table 5 – Various Estimated 1990 Gross California GHG Emissions

CEC Publication Number	Date Published	Million Metric Tons of Carbon Dioxide Equivalent
P500-97-004	March 1997	452
P500-98-001V3	January 1998	468
P600-02-001F	November 2002	425
CEC-600-2005-025	June 2005	439
CEC-600-2006-013	October 2006	427

The first two rows of Table 5 are from Tables 2 and 4 above, respectively. The next two rows of Table 5 are 1990 values from the referenced reports and the last row of Table 5 is from Table 6 of this report. As can be seen from Table 5, estimated 1990 GHG emissions range from a low of 425 million metric tons of carbon dioxide equivalent to a high of 468 million metric tons of carbon dioxide equivalent. The "exact" value for 1990 will always remain unknown.[19]

Legislative Requirements for Inventory Updates

In 2000, the California Legislature required the Energy Commission to update the state's inventory of GHG emissions in consultation with other agencies. Senate Bill (SB) 1771 (Sher, Chapter 1018, Statutes of 2000) required the Energy Commission to update the inventory in January 2002 and every five years after that. The next GHG inventory update required by this legislation is due in January 2007.

The Energy Commission prepared its first statewide GHG inventory in response to SB 1771 and published it in a report titled, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999*,[20] based on the best information available at the time of publication. The inventory was developed using guidelines adopted by the Intergovernmental Panel on Climate Change (IPCC) and was consistent with the methods being used by the EPA. An update[21] to this inventory was prepared and published in June 2005 to incorporate newer information and to allow policy makers to use the most current information and data available.

Summary of California's 2004 GHG Emissions

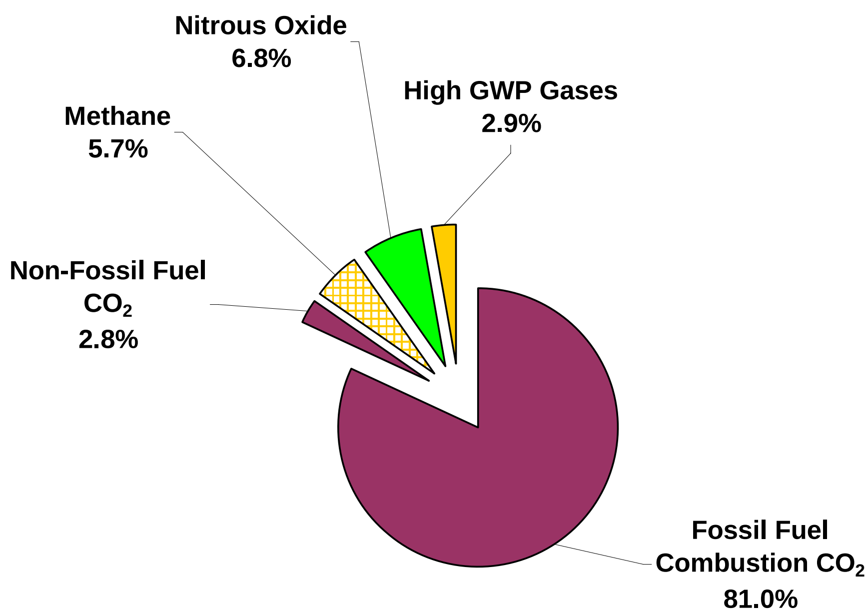
In 2004 California produced 492 million metric tons of CO_2-equivalent GHG emissions, including emissions associated with imported electricity. As shown in Figure 2, 81 percent were emissions of CO_2 from fossil fuel combustion, 2.8 percent were from other sources of CO_2, 5.7 percent were from methane, and 6.8 percent were from nitrous oxide. The remaining source of GHG emissions was high GWP gases, 2.9 percent.

The percentage of climate change associated with each specific gas is similar for each year over the 1990 to 2004 period. However, high GWP gas percentages are rising somewhat.

Composition of California's GHG Emissions

CO_2 emissions represent about 84 percent of California's total GHG emissions in 2004. CO_2 emissions are mainly associated with carbon-bearing fossil fuel combustion with a portion of these emissions attributed to out-of-state fossil fuel used for electricity consumption within California. Other activities that produce CO_2 emissions include mineral production, waste combustion, and land use and forestry changes. Some anthropogenic activities lead to a reduction in atmospheric concentration of CO_2. These are called "CO_2 sinks."

Figure 2 -- California GHG Composition by Type of Gas in 2004 (Includes electricity imports and excludes international bunker fuels)



Source: California Energy Commission

Methane emissions also contribute to global warming and they represented 5.7 percent of total GHG emissions in 2004. Methane emissions are reported in CO_2-equivalent units to reflect their GWP compared to CO_2. Agricultural activities (enteric fermentation and manure management) and landfills compose the major sources of these emissions.

Another gas that contributes to global warming is nitrous oxide (N_2O). Agricultural soil management activities and mobile source fuel combustion compose the major sources of these emissions. After using the appropriate GWP adjustment, N_2O emissions comprised 6.8 percent of California's overall GHG emissions in 2004.

A class of gases called "high GWP gases" makes up the final set of gases that contribute to global warming,[22] composing about 2.9 percent of total emissions in 2004. These are composed mostly of gases used in industrial applications to replace gases associated with ozone depletion over the Earth with an additional modest contribution from sulfur hexafluoride (SF_6) used as insulating materials in electricity transmission and distribution.

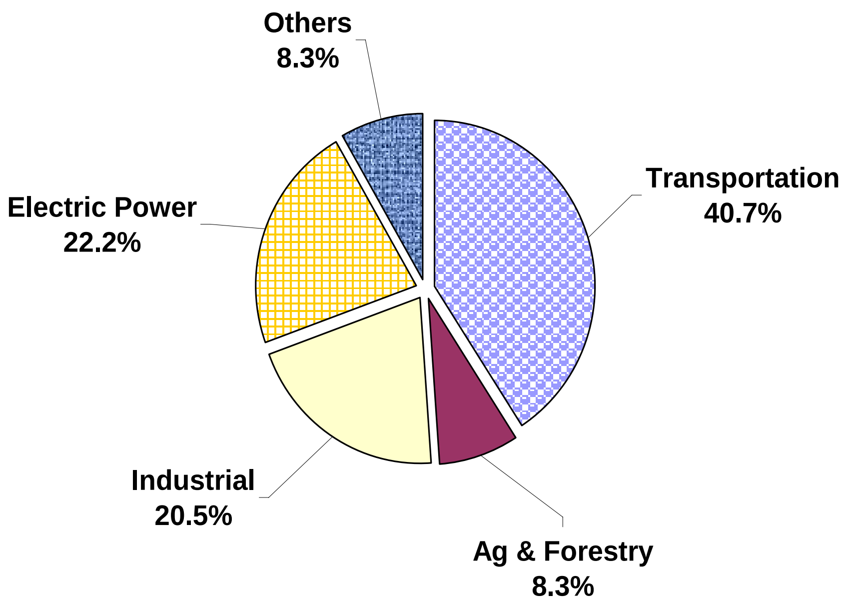
High GWP gases compose a low percentage of overall GHG emissions over this time period, although the estimated emissions are difficult to quantify and are less certain than other emissions categories. Although small in magnitude, emissions of these gases are increasing at a faster rate than other GHGs. In California, high GWP gases are largely composed of refrigerants, although electric utility transmission and distribution equipment are also sources.

End-Use Sectors Contributing to California's GHG Emissions

As shown in Figure 3, fossil fuel consumption in the transportation[23] sector was the single largest source of California's GHG emissions in 2004, with electric power from both in-state and out-of-state sources second, and the industrial[24] sector as the third largest source category. Agriculture,[25] forestry,[26] commercial,[27] and residential[28] activities composed the balance of California's GHG emissions.

Care must be exercised when looking at emissions from different sectors of the economy. For example, the GHG inventory identifies cement production from clinker manufacturing in a stand-alone category and fuel used to heat the cement production process within the industrial fuel category. Thus, CO_2 from clinker production does not represent total GHG emissions from cement production. Likewise, the GHG inventory reports landfill methane emissions in the methane portion of the inventory and CO_2 sinks associated with landfills in the CO_2 portion of the inventory. Taken together, the landfill CO_2 sinks approximately offset the landfill methane emissions. However, there are additional fuel related GHG emissions from transporting wastes to landfills, and these emissions are included in transportation fuels.

Figure 3 -- Sources of California's 2004 GHG Emissions (By End-Use Sector) (Includes electricity imports and excludes international bunker fuels)



Source: California Energy Commission

Historical GHG Emissions Trends

This section discusses historical trends in California's gross GHG emissions. The values discussed in this section do not account for CO_2 sinks from forest, rangelands, or landfill and yard trimming disposal.

This section also excludes international aviation and marine vessel uses of jet fuel, residual oil,[29] and distillate oil because they are international fuel uses and the standard GHG emissions inventory protocol excludes them. Domestic aviation gasoline, jet fuel, residual oil, and distillate oil uses are included in the analysis.

The trends discussed in this section include carbon emissions from imported electricity, including out-of-state coal-fired power plants owned by California electric utility companies that provide electricity to California.

California's GHG emissions are large and growing as a result of population and economic growth and other factors. From 1990 to 2004 total gross GHG emissions rose 14.3 percent; they are expected to continue to increase in the future under "business-as-usual" unless California implements programs to reduce emissions.

Trends in California GHG Composition

In 1990, fossil fuel-related CO_2 emissions composed 81 percent of California's total GHG emissions, including CO_2 emissions from electric power imported to the state.[30] This percentage held steady at 81 percent in 2004. Non-fossil fuel CO_2 contributed 2.2 percent in 1990 and increased to 2.8 percent in 2004.

Methane emissions composed 6.4 percent of California's total GHG emissions in 1990. The percentage decreased to 5.7 percent in 2004. Nitrous oxide emissions trends held steady, representing 6.7 percent of total emissions in 1990, increasing slightly to 6.8 percent in 2004. High GWP gas emissions composed 2.0 percent of California's total GHG emissions in 1990, increasing to 2.9 percent in 2004.

Trends in California's GHG Emissions End-Use Categories

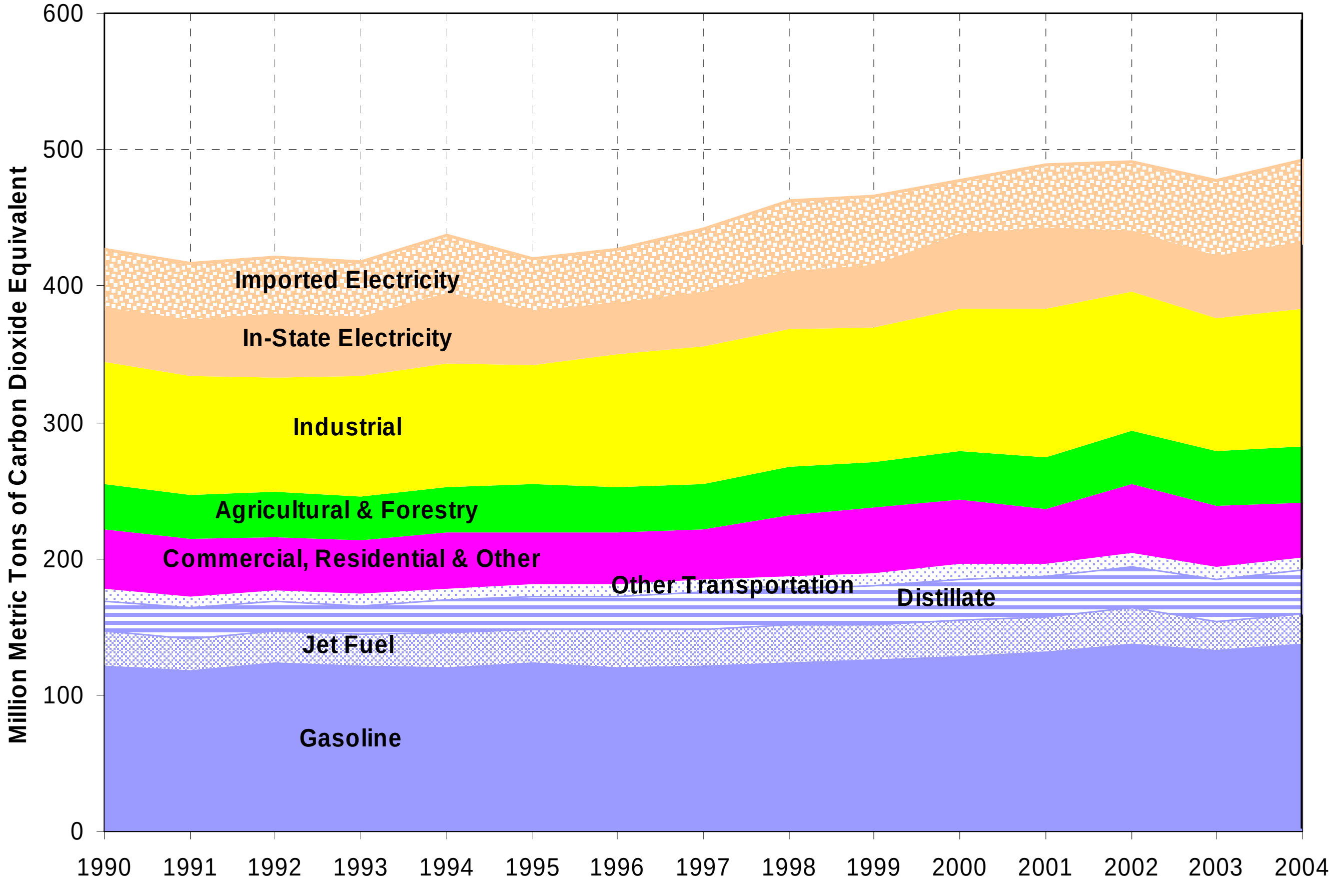
Figure 4 shows year-by-year trends in GHG emissions from transportation (gasoline consumption, jet fuel consumption, distillate fuel consumption, and other transportation fuel use); commercial, residential and other fuel use; agricultural and forestry fuel use; industrial fuel use; and electricity production (both in-state and imported electricity). These data represent gross GHG emissions.

Transportation

The bottom band in Figure 4 shows the 1990 to 2004 trends for CO_2, methane, and nitrous oxide emissions from gasoline consumption in California. The second band from the bottom shows trends for the same three gases from domestic jet fuel consumption, the third band shows trends for CO_2 emissions from distillate fuel use, including diesel, and the fourth band shows trends for the same three gases due to other[31] transportation fuel uses. The four bands together show trends for total transportation fuel consumption.

These data show a modest increase over the 1990 to 2004 period, 12.6 percent overall. Gasoline emissions increased 12.3 percent; jet fuel emissions decreased 8.4 percent. Jet fuel actually increased 11.0 percent from 1990 to 2000, but then declined in 2001-2004, likely due to the events of September 11, 2001. Distillate (includes diesel) emissions increased by 41.0 percent, while other emissions decreased 0.4 percent.

Figure 4 -- California's Gross GHG Emissions Trends (Includes electricity imports and excludes international bunker fuels)



Source: California Energy Commission

Commercial, Residential, Agricultural, Forestry, and Industrial Sectors

GHG emissions from fuel use in the commercial, residential, and other[32] end-use sectors are also shown in Figure 4. These emissions are composed mostly of CO_2 but include small amounts of methane and nitrous oxide gases. These emissions both increase and decrease over the 1990 to 2004 period, with an overall decrease of 9.7 percent by 2004.

GHG emissions from the agricultural and forestry sectors are composed mostly of nitrous oxide from agricultural soil management, CO_2 from forestry practice changes, methane from enteric fermentation, and methane and nitrous oxide from manure management. These emissions also both increase and decrease over the 1990 to 2004 period, with an overall increase of 23.8 percent.

GHG emissions from the industrial sector are produced from many industrial activities. For example, CO_2 is produced from fossil fuels, with the major contributions from oil and natural gas extraction; crude oil refining; food processing; stone, clay, glass, and cement manufacturing; chemical manufacturing; and cement production.

Other industrial activities produce methane emissions, with the major contributions from petroleum and natural gas supply systems and wastewater treatment. Still other industrial activities produce nitrous oxide emissions with the major contributions from nitric acid production and municipal wastewater treatment. The industrial sector also includes a category of emissions comprised of high GWP gases, comprised mostly of gases used to replace ozone-depleting[33] gases. The apparent spike in emissions in 2002 is due to a significant increase in non-specified natural gas usage in that year. This appears to be caused by not being able to attribute the use of the gas to a particular end-use sector rather than an error in data input since the trend for total natural gas use from year-to-year does not show the spike.

Industrial sector GHG emissions both increased and decreased over the 1990 to 2004 period, with an overall increase of 10.1 percent by 2004.

GHG Emissions from Electricity Generation

The top two bands of Figure 4 show GHG emissions from electricity produced for use in California. The solid band includes emissions from electricity production within California, and the stippled band shows emissions from electricity produced outside California that is used within California. Although values vary from year-to-year, California's longer-term electricity gross generation (includes transmission line losses and private supplies) has grown modestly, increasing from 248,135 gigawatt-hours in 1990, to 292,927 gigawatt-hours in 2004, an overall increase of 18 percent in 13 years.[34]

In-state emissions are composed of CO_2 from natural gas combustion in utility power plants, combined heat-and-power facilities and merchant power plants, and from coal[35] combusted in combined heat-and-power facilities. In-state emissions also include SF_6 emissions associated with operation of power switching equipment and transformers. In-state emissions peaked in 2001, and then decreased in 2002 due to a reduction in natural gas use for electricity production compared to 2001. Then in-state emissions gradually increased in 2003 and 2004. These trends are most likely associated with the unstable period when electricity market deregulation made some market participants less eager to import power into California.

In-state electricity generation emissions decreased by 7.2 percent in 1996 and increased as much as 53 percent in 2001 over 1990 emissions. Overall, in-state electricity emissions increased by 29 percent over the 1990 to 2004 period.

Out-of-state emissions are composed of CO_2 emissions, mostly from coal-fired power plants. Although out-of-state electricity composes only about 22 to 32 percent of California's total electrical energy consumption, it composes 39 to 57 percent of the total GHG emissions associated with electricity use in California. Some out-of-state emissions are from coal-fired electric power plants owned by California electric utility companies. Out-of-state emissions increased and decreased annually relative to1990, with an overall increase of 40.4 percent by 2004.

Out-of-state electricity generation has shown higher carbon intensity than in-state generation in the past. Since 1990, in-state electricity produced 187 to 280 metric tons of CO_2 per gigawatt-hour, while imported electricity from fossil fuels produced 544 to 735 metric tons of CO_2 per gigawatt-hour.[36] This carbon intensity variation is affected by the year-to-year availability of hydropower and other factors.

GHG Emissions Intensity[37] *Trends*

This section places California's GHG emissions into context with its population and its level of economic activity as measured by its gross state product (GSP). Because all 50 states are included, only in-state emissions are addressed in this section. Due to limited availability of data, this section addresses only CO_2 from fossil fuel combustion for the 1990 to 2001 period.

CO_2 emissions from fossil fuel combustion compose 58 to 90 percent of the total GHG emissions of individual states,[38] and the trends that follow should be viewed within this context. Although some states indicate that CO_2 emissions from fossil fuel combustion is much less than 90 percent of total GHG emissions, total emissions from these states are modest in magnitude. On a national average, CO_2 emissions from fossil fuel combustion composed 80 percent of total GHG emissions in 2004.

To mitigate some of the effects of its large and growing population and expanding economy, California began in the 1970s to aggressively implement energy efficiency measures for fuel-burning equipment and electricity use. Both of these policies have significantly reduced fuel consumption and associated GHG emissions. Compared to other states, California has relatively low carbon use intensity due to the success of state air quality and energy efficiency programs.

Another factor that has reduced California's fuel use and GHG emissions is its mild climate compared to that of many other states. The mild climate reduces the use of heating fuel during winter but somewhat increases electricity use for summer air conditioning. This mild climate, combined with a complex topography and meteorology, also produced some of the nation's worst air pollution over the past quarter century, which has led to aggressive pollution reduction efforts. As a direct result, California uses relatively low carbon intensity fuels in its power plants and other industrial sectors.

Over the 1990 to 2000 period, California's population grew by 4.1 million people, the largest increase in the United States; however, California ranks only eighteenth from the largest when its population growth is measured in percent increase.

Correspondingly, California's economic base, measured by GSP, grew from $788 billion in 1990 to $1.1 trillion in 2000, the largest GSP growth in the United States;[39] however, California ranks only thirtieth when its GSP growth is measured in percentage increase.

Figure 5 shows in-state CO_2 emissions from fossil fuel combustion in each of the 50 states over the 1990 to 2001 period, as calculated by the EPA. Year 2001 is the most current year available from EPA.

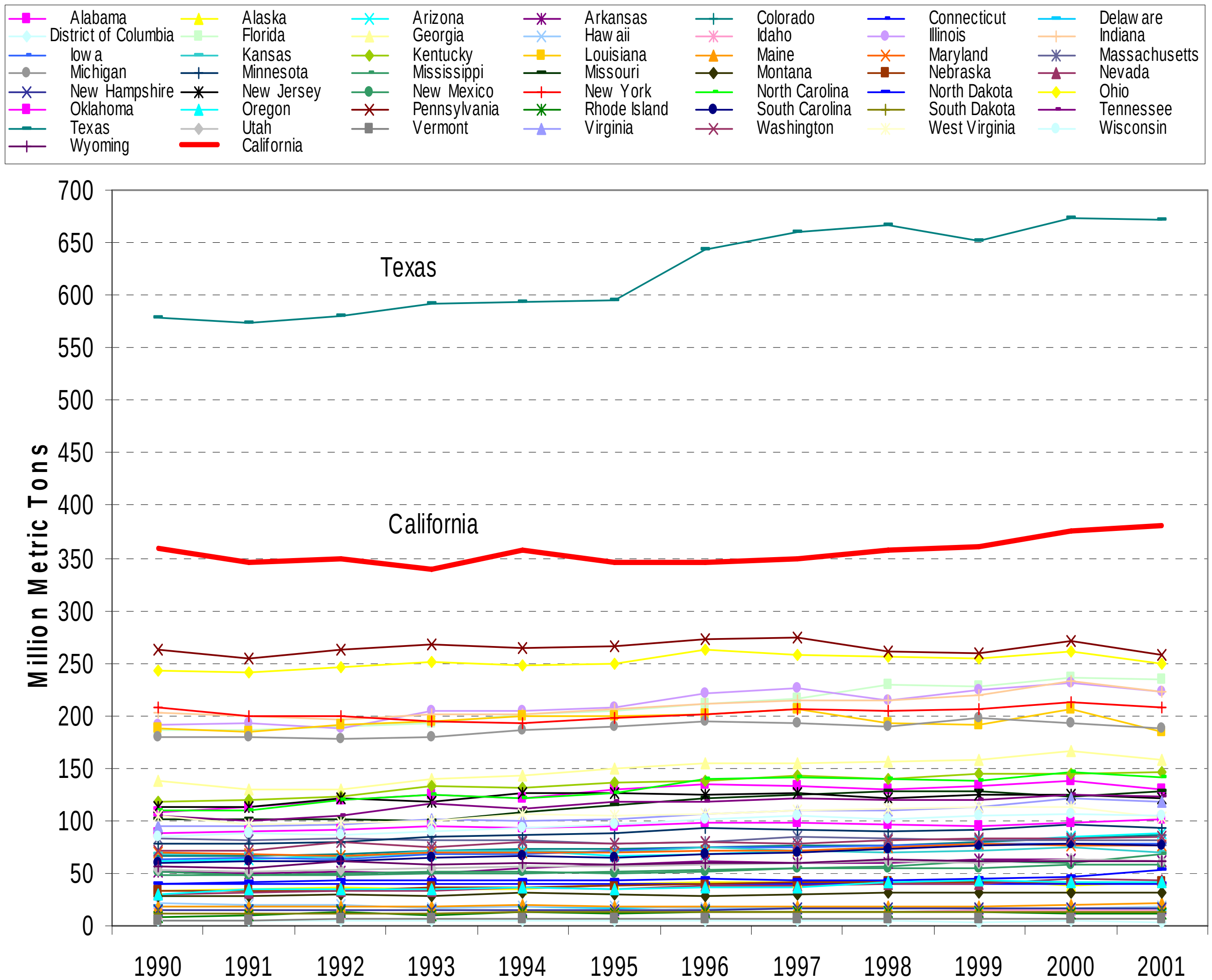
Although it is difficult to identify individual states, several factors are apparent from Figure 5: (1) most states show a fairly stable trend over the 1990 to 2001 period; (2) Texas has the highest in-state CO_2 emissions from fossil fuel combustion and shows a rising trend; and (3) California has the second highest emissions, which are fairly stable over the time horizon.

California has about half as much CO_2 emissions as Texas. However, Texas' emission growth rate ranks twenty seventh out of the 50 states, and California's growth rate ranks forty fourth when measured in percentage increase. Emissions from other states are all so similar to one another that they need not be individually identified; for the most part they are all considerably lower than Texas or California.

Figure 6 shows in-state fossil fuel CO_2 emissions per person for each of the 50 states. This figure was developed by dividing the population of each state into the fossil fuel emissions from Figure 5. Again, individual states are difficult to identify although several trends are apparent from the figure. First, Wyoming and North Dakota have the highest emissions per capita, not Texas or California. California is difficult to identify, near the bottom of the figure. It is second lowest in the nation in per capita CO_2 emissions from fossil fuel combustion with only the District of Columbia lower. Second, emissions per capita show a fairly flat trend for most states. This means that population growth and CO_2 emissions from fossil fuel combustion are well correlated for most states. In terms of per capita emissions, most states show remarkably stable emissions over the 1990 to 2001 period.[40]

Figure 7 shows fossil fuel CO_2 emissions per GSP[41] unit for each of the 50 states. In this figure, once again individual states are difficult to identify, but trends are apparent. Wyoming has the largest emissions in terms of CO_2 emissions from fossil fuel combustion per unit of GSP and North Dakota ranks second. Texas ranks near the bottom one-third, and California ranks near the bottom.

Figure 5 -- CO_2 Emissions from Fossil Fuel Combustion



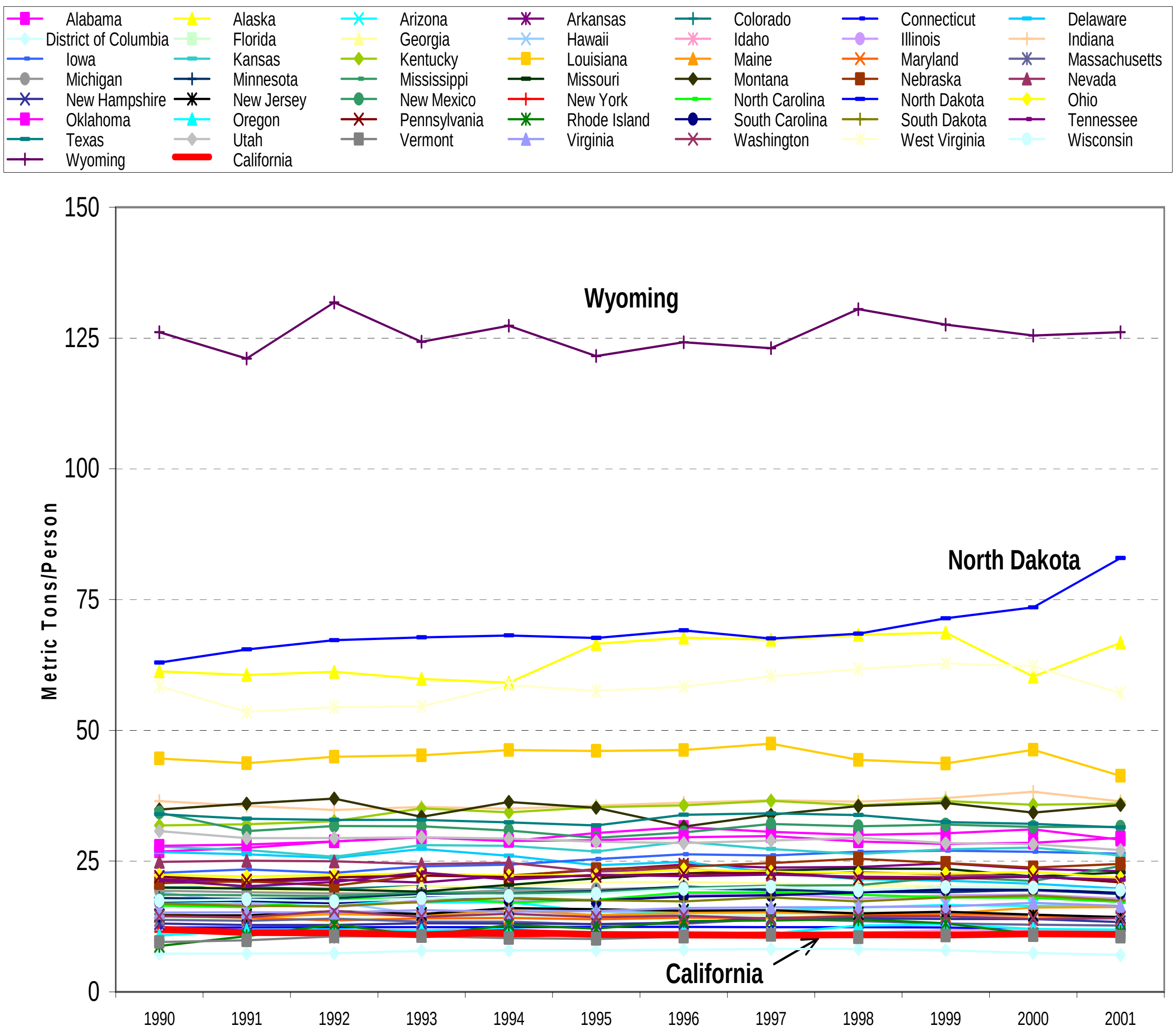
Source: California Energy Commission

This figure shows a trend of reduced GHG emissions per million dollars of GSP for most states. In general, GSP increases while CO_2 emissions from fossil fuel combustion remain steady over the same time period, as shown in Figure 5. In Figure 7, each state shows a reduction over time because the increase in GSP is greater than the increase in CO_2 emissions from fossil fuel combustion. This means that most states are successfully decreasing the carbon intensity of their economic base. The District of Columbia and the states of Connecticut, New York and

California have the lowest CO_2 emissions from fossil fuel combustion per unit of GSP.

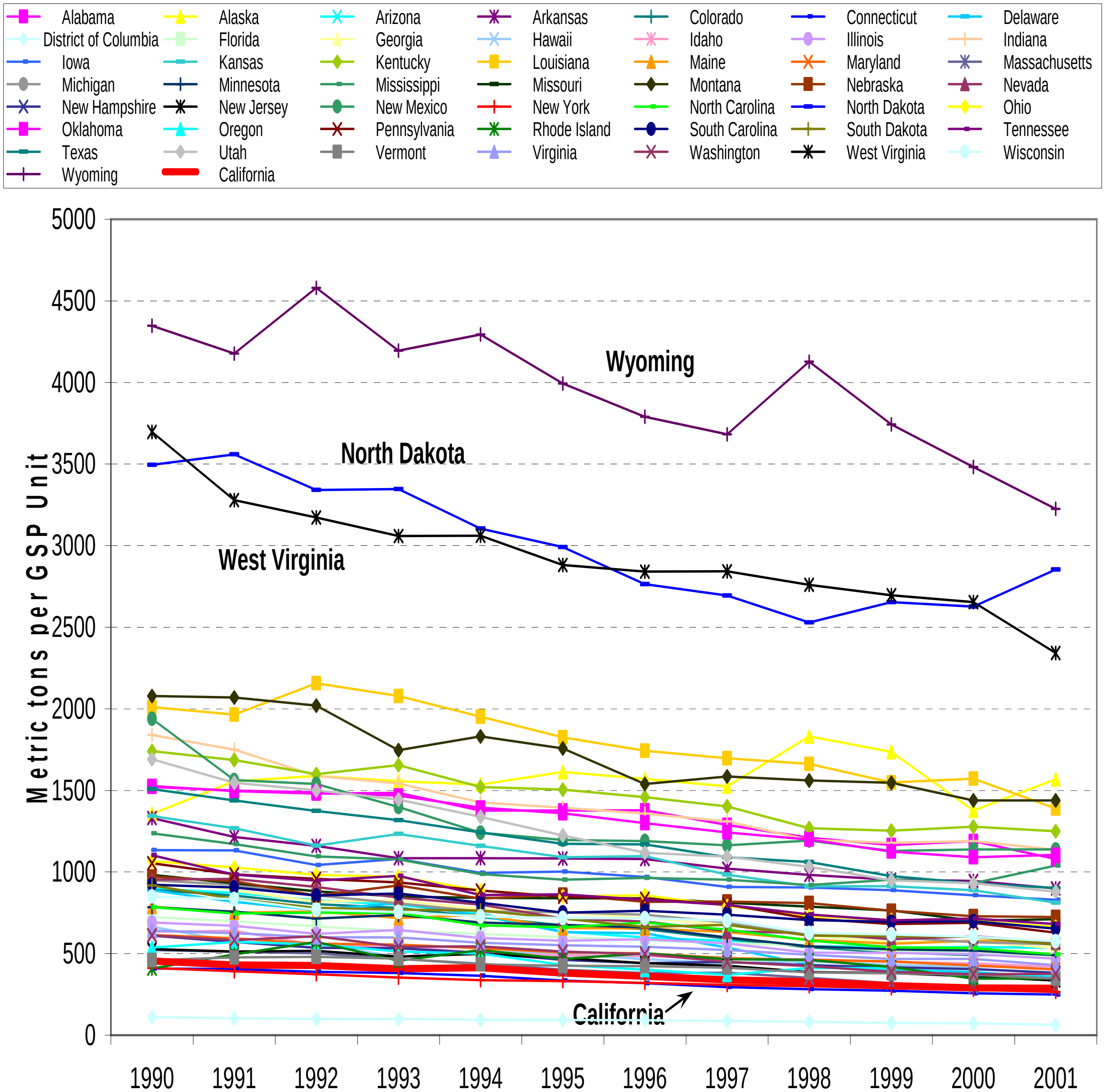
Figures 5, 6, and 7 all show a similar result in terms of relative ranking by state, regardless of year. Data for 2001 were used to construct Figure 8, which shows the ranking of the states for CO_2 from fossil fuel combustion per capita, and Figure 9, which shows the ranking of the states for CO_2 from fossil fuel combustion per million dollars of GSP. Because Figures 5, 6, and 7 all show similar trends, Figures 8 and 9 would look similar regardless of the year chosen to display these relative rankings.

Figure 6 -- CO_2 Emissions from Fossil Fuel Combustion per Capita



Source: California Energy Commission

Figure 7 -- CO_2 Emissions from Fossil Fuel Combustion per GSP Unit



Source: California Energy Commission

Figure 8 shows the relative ranking of states for emissions of CO_2 from fossil fuels per capita for the year 2001. California has the fourth lowest emissions per capita, following Washington (District of Columbia), Vermont, and New York.

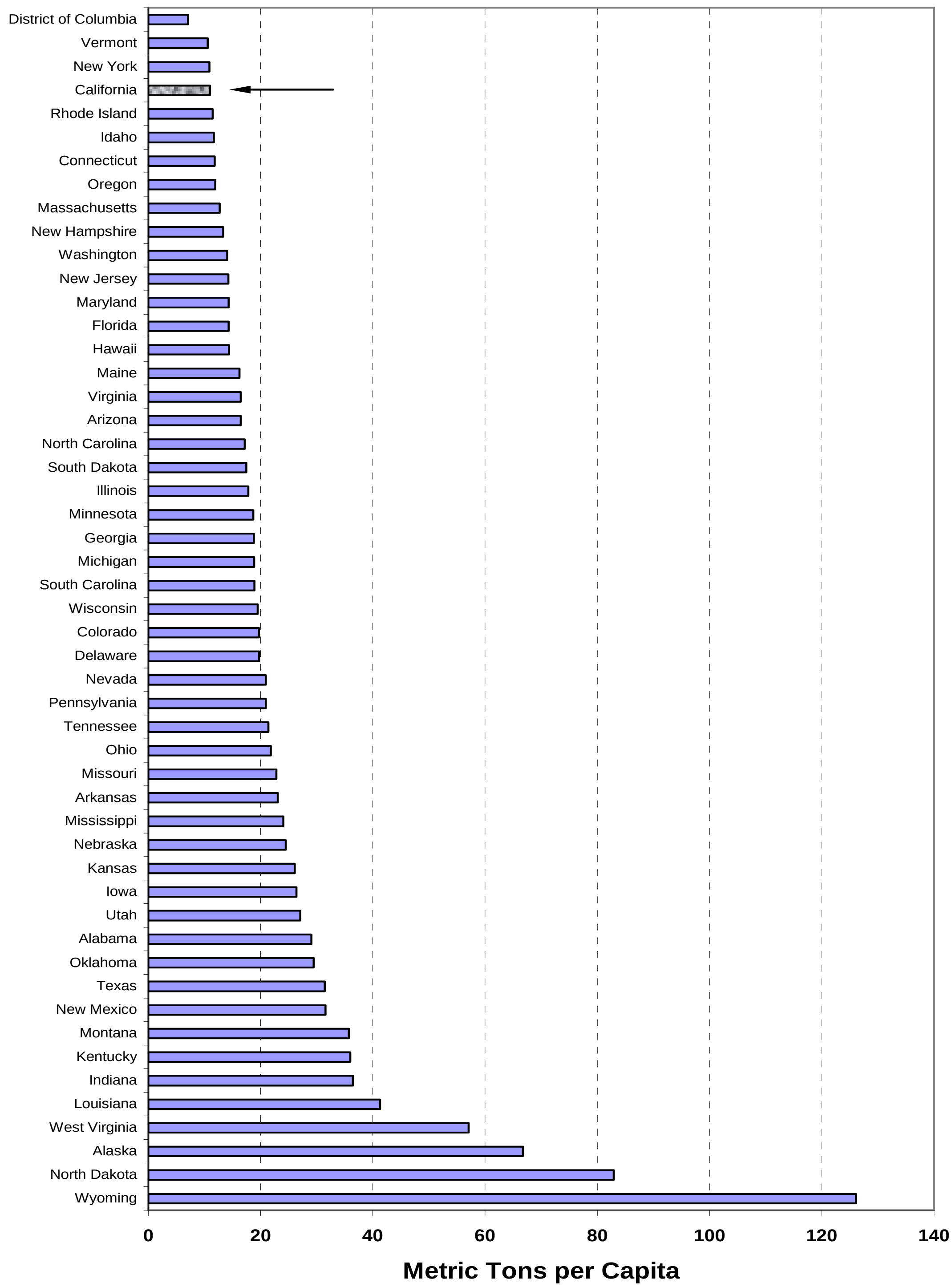
Figure 9 shows relative ranking of states in terms of CO_2 emissions from fossil fuels per unit of GSP for the year 2001. California has the fifth lowest emissions per million dollars of GSP, following Washington (District of Columbia), Connecticut, New York, and Massachusetts.

California's GHG Emissions In a World-Scale Context

Figure 10 shows how California and Texas each would rank if considered separate countries. The figure includes Texas since their emissions are larger than California's. As shown on the figure, Texas would rank as the ninth largest "country," and California would rank as the sixteenth largest. Note that the Texas data are for year 2001 while the other entries on the figure are for 2002. Other attempts to place California GHG emissions into a world-scale context have California placed as high as tenth or so. The data in Figure 10, from the World Resources Institute, do not have California ranked that high, although there is not much difference in emissions from about the eleventh largest (Italy) to the nineteenth largest (Australia).

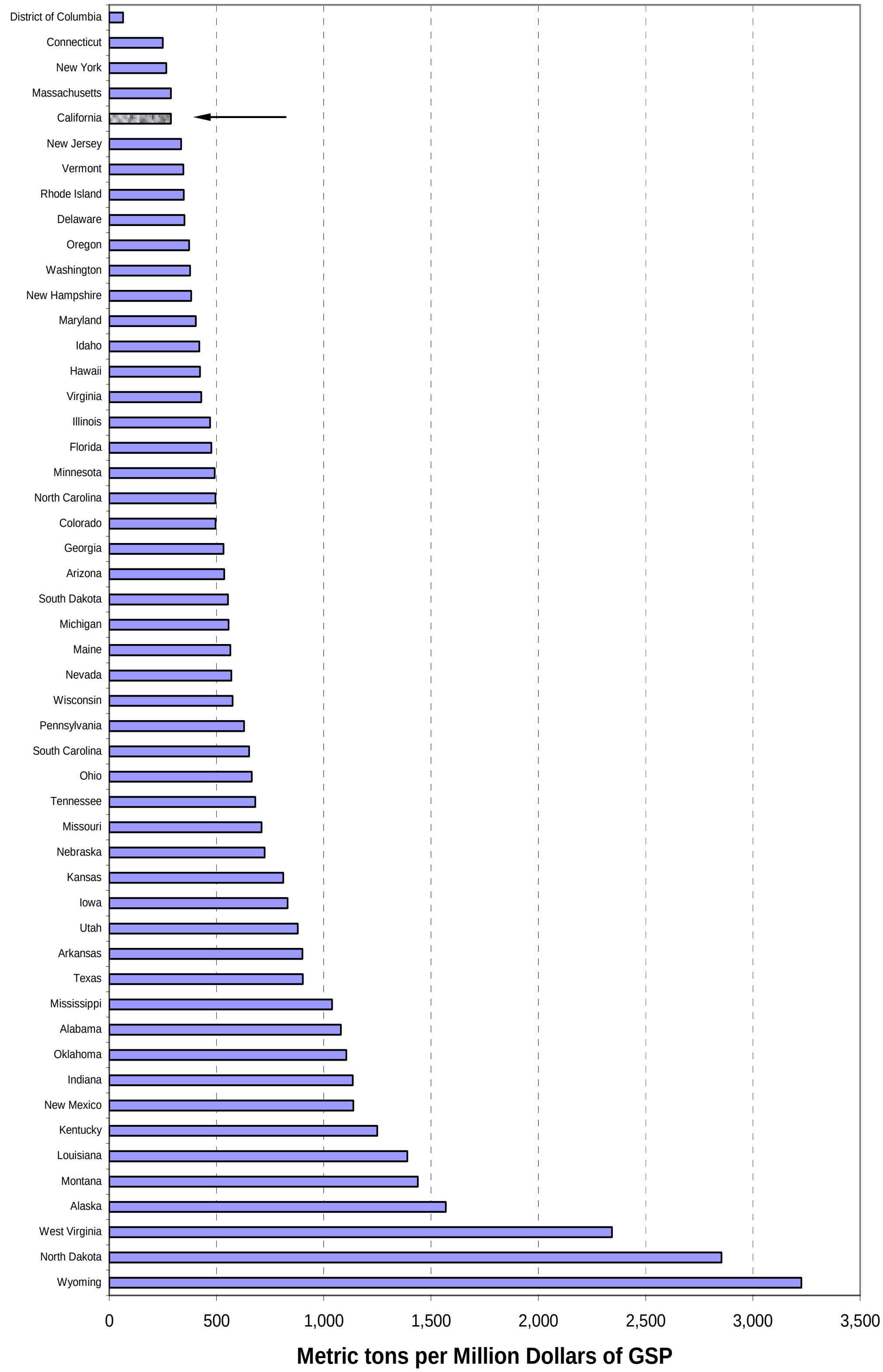
Figure 11 shows how California and Texas each would compare to the top 30 GHG emitting countries on an emissions intensity basis. California's GHG emissions intensity is higher than most of these countries when measured on a per capita basis but lower than most of them when measured per unit of GSP. Texas's emissions are high on a per capita basis because of the scale of its industrial and electric power emissions relative to the size of its population. State GHG emissions data are from the U.S. EPA[42] and state GSP data are from the U.S. Department of Commerce, Bureau of Economic Analysis.[43] Country GHG emissions data are from the World Resources Institute[44] and country GDP data are from the United Nations.[45]

Figure 8 -- CO_2 Emissions from Fossil Fuels per Capita (2001)



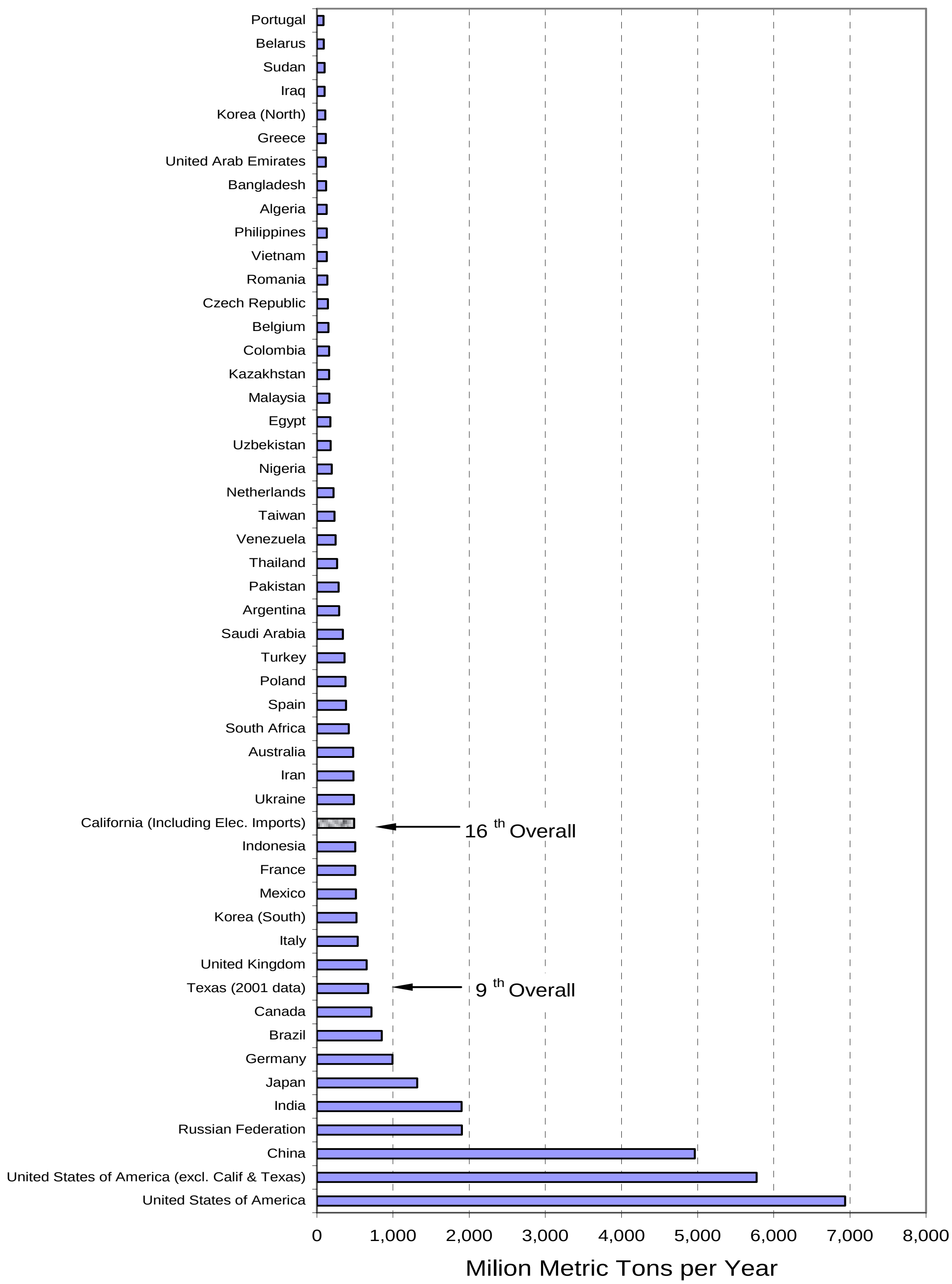
Source: California Energy Commission

Figure 9 -- CO_2 Emissions from Fossil Fuels per Unit of GSP (2001)



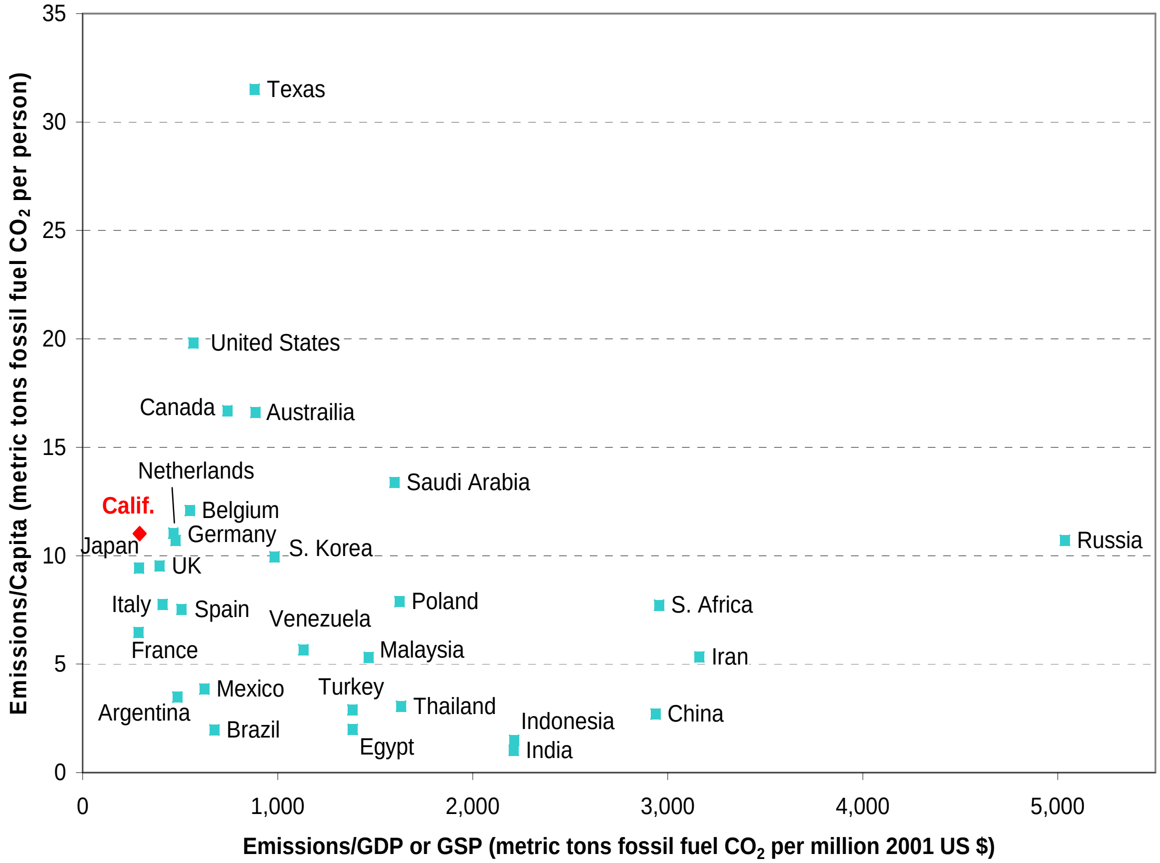
Source: California Energy Commission

Figure 10 -- California GHG Emissions in a World-Scale Context (2002 data)



Source: California Energy Commission (data from World Resource Institute, Climate Analysis Indicator Tool)

Figure 11 – 2001 Emissions Intensities for California, Texas and Top 30 GHG Emitting Countries



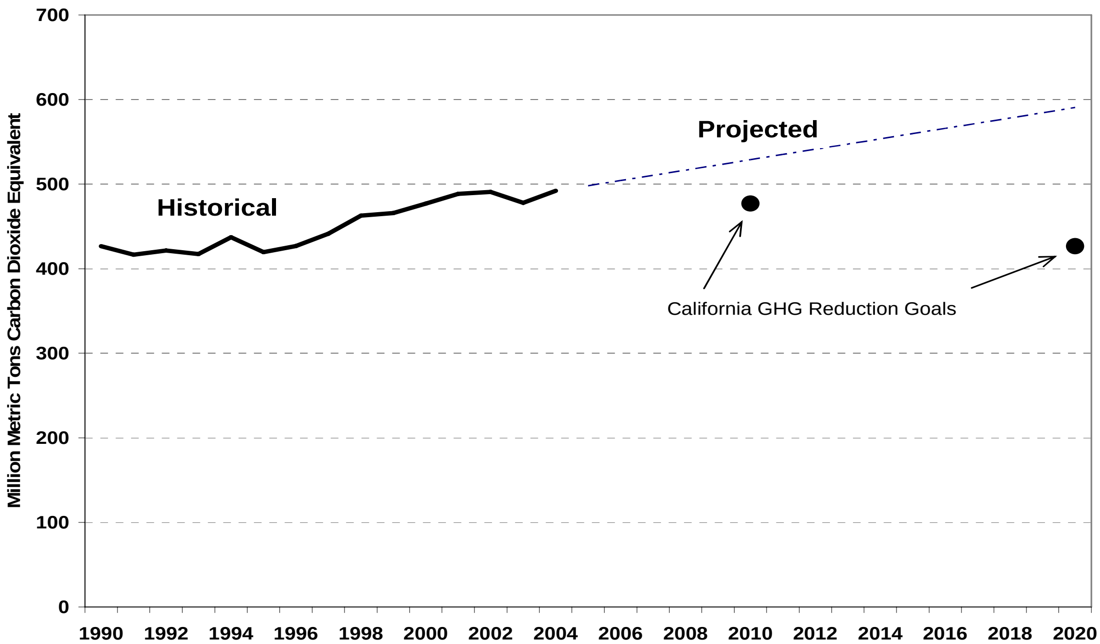
Source: California Energy Commission (country data from World Resources Institute and United Nations; state data from U.S. EPA and U.S. Department of Commerce)

Future GHG Emissions Trends

GHG emissions are expected to grow in the future as California continues its population and economic expansion. Figure 12 shows historical GHG emissions from this GHG inventory and projected future GHG emissions under a "business-as-usual" trend.

Staff projected GHG emissions using forecasts of gasoline demand from the *2005 Integrated Energy Policy Report (IEPR)*, but excluding California Air Resources Board's (ARB's) regulations for GHG emissions from light-duty vehicles that were implemented to comply with AB 1493 (Pavley, Statutes of 2002, Chapter 200). Except as discussed further below, staff assumed that GHG emissions for other categories remained constant at 2002 to 2004 average values. This was necessary because Energy Commission forecasts were not available for the activities associated with them that lead to GHG emissions. These categories generally constitute only a small fraction of California's GHG emissions. Finally, natural gas rather than another coal-fired power plant would replace Mohave, which shut down at the end of 2005.

Figure 12 -- Historical and Projected California GHG Emissions (Includes electricity imports and excludes international bunker fuels)



Source: California Energy Commission

Refinery still gas and petroleum coke emissions at refineries declined steadily from 2001 to 2004. These emissions were assumed to continue this downward trend. Future CO_2 emissions from calcinations in cement kilns were projected from the *2005 IEPR* using natural gas demand projections for that sector. Petroleum and natural gas supply system methane emissions were projected to decrease since these emissions declined overall from 1990 to 2004. CO_2, methane, and nitrous oxide emissions from waste combustion (excluding landfill emissions) were projected to increase slightly at the rate of population growth.

Methane emissions from landfills were projected to increase somewhat, based upon Table 14 from the Energy Commission report titled *Emission Reduction Opportunities for Non-CO_2 Greenhouse Gases in California.*[46] Methane emissions from enteric fermentation and manure management were assumed to continue at the same rate as 1990 to 2004, with manure management emissions increasing somewhat and enteric fermentation decreasing slightly. Nitrous oxide from agricultural soil management was projected to increase at the average of the 1990 to 2004 growth rate.

Methane and nitrous oxide emissions from mobile sources were projected to grow at the same rate as gasoline and diesel demand consumption projections. Methane and nitrous oxide emissions from stationary source combustion were projected to grow at the same rate as population growth.

These projected GHG emissions should be considered rough estimates. They assume no new emissions reduction strategies beyond those currently in place. The State of California, through its Climate Action Team, is developing more than 40 strategies to reduce these “business-as-usual” emissions to meet GHG emissions reduction targets established by Governor Schwarzenegger in Executive Order S-3-05.[47]

Figure 12 shows the historical California GHG emissions, projected “business-as-usual” emissions and the emissions reduction targets for years 2010 and 2020. The Executive Order calls for reducing California GHG emissions to year 2000 levels by 2010, and year 1990 levels by 2020**.** The corresponding target for year 2050 of reducing emissions to 80 percent below 1990 levels is not shown because it is beyond the ending point of the figure.

Current GHG Emissions Inventory Compared to California Climate Action Team Report Values

In response to the Governor’s Executive Order S-3-05, in March 2006 the California Environmental Protection Agency (CalEPA) published a Climate Action Team (CAT) report[48] detailing how state agencies could implement a series of policies to meet the 2010 and 2020 goals. The Governor’s Executive Order called for reducing 2010 “business-as-usual” emissions to year 2000 emissions and reducing 2020 “business-as-usual" emissions to 1990 emissions. Using the earlier 1990 to 1999 GHG emissions inventory prepared by ICF[49] and fuel demand projections from the Energy Commission's *2003 Integrated Energy Policy Report*,[50] the CAT report indicated that emissions would have to be reduced from business-as-usual trends by 59 million metric tons CO_2-equivalent by 2010 and 174 million metric tons CO_2 -equivalent by 2020 (derived from Table 5-5 on page 64 of CAT report). See Table F-1 in Appendix F for details.

The current 1990 to 2004 GHG inventory is updated from the 1990 to 1999 inventory. In addition, the Energy Commission published its *2005 Integrated Energy Policy Report* in November 2005. Both of these updates cause changes in the number of metric tons of emissions reductions needed to meet the Executive Order goals. The newer numbers indicate that 2010 business-as-usual emissions would need to be reduced by 68 million metric tons to meet the 2010 goal and 177 million metric tons to meet the 2020 goal. See Appendix F for more details.

GHG INVENTORY UPDATE

Table 6 on the next page summarizes the updated GHG emissions inventory, covering the 1990 to 2004 period. This table displays GHG emissions for CO_2, methane, nitrous oxide, and high GWP gases. More detail for each of these gases can be found in Appendix A. The line numbers in the following descriptions provide the reader a reference to the data in Table 6.

Total gross CO_2 emissions from anthropogenic activities are shown in Line 1. These values are obtained by adding Line 2 and Lines 9 through 15. Line 2 is a summary of Lines 3 to 8. These show gross CO_2 emissions for fossil fuel combustion in residential, commercial, industrial, transportation, electricity generation, and other end-use sectors. Lines 9 through 15 show CO_2 emissions from non-fossil fuel sources, and line 16 shows changes in anthropogenic activities that consume CO_2 (also called sinks).

Land use and forestry changes cause CO_2 atmospheric concentrations to increase when carbon-consuming plants are removed or stop growing. These changes cause CO_2 concentrations to decrease when carbon-consuming plants are added to the landscape. When these activities lead to a net reduction they are called carbon sinks.

Land use and forestry changes from anthropogenic activities have caused CO_2 concentrations to increase in some years and to decrease in others. The carbon released in the form of CO_2 from burning wood waste from land uses and forestry practices are included as emissions in the GHG inventory, Line 15. The carbon taken out of the atmosphere in the form of increased acreage of growing trees is

Table 6 -- California Greenhouse Gas Emissions and Sink Summary: 1990 to 2004 (MMTCO_2Eq.)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1 Carbon Dioxide (Gross)	317.4	310.8	316.3	311.4	329.8	313.7	318.6	328.8	346.4	348.7	368.3	372.5	365.3	347.1	355.9
2 Fossil Fuel Combustion	306.4	300.2	305.0	301.8	318.3	302.1	306.7	316.7	332.5	337.5	356.6	359.0	354.1	334.0	342.4
3 Residential	29.0	29.5	27.9	28.4	29.3	26.7	26.6	26.3	30.6	31.9	30.2	27.2	27.3	26.4	27.9
4 Commercial	12.6	12.0	9.7	9.6	10.3	9.8	9.6	9.6	13.5	14.8	15.6	12.0	17.8	15.1	12.2
5 Industrial	66.1	64.8	61.3	64.3	66.0	62.6	68.8	73.0	75.4	71.0	76.2	80.5	71.5	65.5	67.1
6 Transportation	161.1	156.7	161.9	158.9	163.9	166.2	167.4	170.8	173.3	176.3	181.7	182.5	190.2	180.6	188.0
7 Electricity Generation (In State)	36.5	36.6	43.7	40.1	48.3	36.4	33.9	36.5	39.8	43.0	51.9	56.1	41.9	44.1	47.1
8 No End Use Specified	1.1	0.6	0.5	0.6	0.6	0.5	0.5	0.4	-0.1	0.6	0.9	0.7	5.4	2.4	0.2
9 Cement Production	4.6	4.3	3.8	4.4	5.1	5.0	5.3	5.5	5.4	5.6	5.9	5.6	6.1	6.3	6.5
10 Lime Production	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
11 Limestone & Dolomite Consumption	0.2	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
12 Soda Ash Consumption	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
13 Carbon Dioxide Consumption	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
14 Waste Combustion	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
15 Land Use Change & Forestry Emissions	5.5	5.6	6.8	4.4	5.6	5.8	5.8	5.9	7.7	4.8	5.1	7.3	4.3	6.0	6.1
16 *Land Use Change & Forestry Sinks*	*(22.7)*	*(22.3)*	*(21.9)*	*(21.5)*	*(21.1)*	*(20.7)*	*(20.3)*	*(19.9)*	*(19.5)*	*(19.1)*	*(19.6)*	*(19.9)*	*(20.3)*	*(20.5)*	*(21.0)*
17 Carbon Dioxide (Net)	294.7	288.5	294.4	289.9	308.7	293.0	298.3	308.9	326.9	329.6	348.7	352.6	345.1	326.6	334.9
18 Methane (CH_4)	26.0	24.9	23.8	25.4	25.4	26.2	25.5	24.2	25.3	26.3	26.4	26.7	27.1	27.5	27.9
19 Petroleum & Natural Gas Supply System	1.0	0.9	0.4	0.8	0.7	0.7	0.7	0.6	0.6	0.7	0.6	0.6	0.5	0.5	0.5
20 Natural Gas Supply System	1.6	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.4
21 Landfills	8.1	8.0	7.7	8.4	8.2	7.9	8.3	6.1	7.6	7.8	8.0	7.9	8.2	8.3	8.4
22 Enteric Fermentation	7.5	7.3	7.4	6.6	7.1	7.3	6.8	6.9	6.8	7.1	6.7	7.0	7.1	7.2	7.2
23 Manure Management	3.3	3.9	3.9	4.0	4.3	4.6	4.6	4.9	4.8	5.2	5.4	5.6	5.8	5.9	6.0
24 Flooded Rice Fields	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.6
25 Burning Ag & Other Residues	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
26 Wastewater Treatment	1.4	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7
27 Mobile Source Combustion	1.2	0.1	0.1	0.7	0.2	1.0	0.2	0.8	0.6	0.5	0.8	0.5	0.7	0.7	0.6
28 Stationary Source Combustion	1.3	1.3	0.8	1.2	1.2	1.2	1.4	1.4	1.4	1.4	1.4	1.4	1.2	1.2	1.3
29 Nitrous Oxide (N_2O)	32.7	30.4	30.5	31.5	30.0	31.9	30.8	28.8	29.2	29.4	31.4	30.8	34.5	33.9	33.3
30 Nitric Acid Production	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.2
31 Waste Combustion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32 Agricultural Soil Management	14.7	13.1	13.4	14.4	13.8	15.5	15.1	13.6	14.0	14.3	15.9	15.3	19.4	19.2	19.2
33 Manure Management	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.9	0.9	0.9	0.9	0.9
34 Burning Ag Residues	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
35 Wastewater	0.9	0.9	0.8	0.9	0.8	0.8	0.9	1.0	1.0	1.0	0.7	1.0	1.0	0.9	1.1
36 Mobile Source Combustion	15.6	14.9	14.8	14.8	14.1	14.1	13.6	13.0	13.0	12.8	13.3	13.0	12.8	12.4	11.8
37 Stationary Source Combustion	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
38 High GWP Gases (HFCs, PFCs & SF_6)	7.1	7.4	7.9	8.4	8.9	9.3	11.4	12.6	8.9	9.9	10.5	11.2	12.0	12.9	14.2
39 Substitution of Ozone-Depleting Substances	4.5	4.9	5.3	5.7	6.1	6.5	8.4	9.8	6.7	7.8	8.6	9.5	10.5	11.4	12.6
40 Semiconductor Manufacture	0.4	0.4	0.4	0.5	0.5	0.7	0.7	0.8	0.9	0.9	0.8	0.5	0.5	0.5	0.6
41 Electricity Transmission & Distribution (SF_6)	2.3	2.2	2.2	2.2	2.2	2.1	2.3	2.1	1.3	1.2	1.1	1.1	1.0	1.0	1.0
42 Gross California Emissions (w/o Electric Imports)	383.3	373.5	378.5	376.5	394.0	381.1	386.2	394.5	409.8	414.3	436.6	441.1	439.0	421.4	431.3
43 *Land Use Change & Forestry Sinks*	*(22.7)*	*(22.3)*	*(21.9)*	*(21.5)*	*(21.1)*	*(20.7)*	*(20.3)*	*(19.9)*	*(19.5)*	*(19.1)*	*(19.6)*	*(19.9)*	*(20.3)*	*(20.5)*	*(21.0)*
44 Net Emissions (w/o Electric Imports)	360.6	351.2	356.6	355.1	373.0	360.4	366.0	374.6	390.3	395.1	417.0	421.2	418.7	400.9	410.3
45 Electricity Imports	43.3	43.1	43.0	40.8	43.2	38.5	40.6	47.0	52.9	51.7	40.5	47.4	51.7	56.4	60.8
46 Gross California Emissions with Electricity Imports	426.6	416.6	421.5	417.4	437.2	419.6	426.8	441.5	462.7	465.9	477.1	488.5	490.7	477.9	492.1
47 Net California Emissions with Electricity Imports	403.9	394.3	399.7	395.9	416.2	398.9	406.5	421.6	443.1	446.8	457.5	468.6	470.4	457.3	471.1
48 International Bunker Carbon Dioxide Emissions	39.9	34.6	28.0	27.9	32.4	35.8	35.4	27.0	26.8	30.3	33.8	31.8	31.8	24.5	26.5

also included as sinks of CO_2 from anthropogenic activities, Line 16 (repeated for clarity on Line 43).

Net CO_2 emissions are gross emissions from Line 1 minus the sinks from Line 16. These net emissions are shown in Line 17.

The next portion of Table 6 (Lines 18 through 28) includes anthropogenic activities that generate methane emissions. These are reported in CO_2-equivalent units to reflect the GWP of methane compared to CO_2. Agricultural activities and landfills compose the major sources of these emissions. Methane emissions compose 5.7 percent of overall GHG emissions in 2004.

The next portion of Table 6 (Lines 29 through 37) includes anthropogenic activities that generate nitrous oxide emissions. This gas should not be confused with a class of conventional air pollutants called “oxides of nitrogen.” The major sources of nitrous oxide emissions are agricultural activities and mobile source fuel combustion. Emissions of nitrous oxide produced 6.8 percent of overall GHG emissions in 2004.

A class of gases called high GWP gases makes up the final set of gases (Lines 38 through 41) that contribute to global warming. Major categories within this set include various gases used in industrial applications to replace gases associated with ozone depletion over the Polar Regions of the Earth, and SF_6, which is used as insulating materials in electricity transmission and distribution.

These high GWP gases composed a small percentage of overall GHG emissions over this time period, although the estimated emissions are difficult to quantify and are thus less certain than other emissions categories. High GWP gases, although small in magnitude, constituted the greatest rate of growth in GHG emissions.

Line 42 is labeled “Gross California Emissions (w/o Electric Imports).” It is the sum of Lines 1, 18, 29, and 38. Gross CO_2 emissions from fossil fuel combustion comprised 81 percent of total GHG emissions in 2004, the largest component of the inventory. Non-fossil fuel CO_2 emissions contributed another 2.8 percent. Total sinks are repeated on Line 43 for clarity. Net CO_2 emissions are shown in Line 44. These are obtained by subtracting Line 43 from Line 42.

A significant portion of the GHG emissions that occur to meet the needs of California’s economy comes from fuel combusted in out-of-state power plants that provide electrical energy to California, including two coal-fired power plants owned by California utilities. These emissions are shown on a separate line to avoid double counting. The carbon emissions associated with importing electricity to California are shown on Line 45 and are not part of the California GHG inventory according to IPCC protocol, but are shown for information purposes.

Line 46 is the sum of gross GHG emissions from Line 42 plus CO_2 from imported electricity from Line 45. Line 47 is Line 46 minus CO_2 sinks from Line 43. Line 48 shows international bunker fuels, made up of international use of jet fuel and marine vessel use of residual oil and distillate. These are not part of the California GHG inventory and are shown for information purposes, similar to imported electricity.

Figures 1 and 4 show this information by sector. Appendix A contains documentation of the methods used to prepare the California GHG inventory and a more detailed breakdown of the values in Table 6.

FUTURE GHG INVENTORY IMPROVEMENTS

One major category of GHG inventory improvement that staff recommends is to use a more current estimate of GWP weighting factors for non-CO_2 GHG emissions when they become approved for use by the IPCC. Values used in this inventory are a bit outdated, as they are based upon values approved for use by the IPCC in 1996. Newer GWP factors were developed in 2001, but they have not yet been approved for use. The other major category of GHG inventory improvements that staff recommends is using more recent energy flow data and more local activity and emissions factor data.

GWP Weighting Factors for Non-CO_2 Gases

The current IPCC guidance is to use GWP factors from the Second Assessment Report[51] (SAR, 1996 vintage), since the Third Assessment Report (TAR, 2001 vintage) values have yet to be approved. For methane, the SAR value is 21, and the TAR value is 23 (+0.1 percent). For nitrous oxide, the SAR value is 310, and the TAR value is 296 (-4.5 percent). The most recent *Inventory of U.S. GHG Emissions and Sinks: 1990—2004*[52] uses the SAR values for the nationwide GHG inventory.

Given the relative magnitude of CO_2 and other GHG emissions attributable to California using either the SAR or TAR values, the choice of SAR or TAR has little impact on California's GHG emissions. If TAR GWPs are used, methane emissions reported in 2004 would be unchanged at 27.9 million metric tons CO_2-equivalent (MMTCO_2E). Correspondingly, if TAR GWPs are used, nitrous oxide emissions reported in 2004 would be 32.8 MMTCO_2E, rather than the SAR value of 33.3 MMTCO_2E. These differences are small in a total inventory of more than 480 MMTCO_2E.

Data Improvements or Refinements

During the process of developing this GHG update, Energy Commission staff identified the following areas where improvement should be considered for the next inventory update.

- Use more current activity data.

  The most current complete data set for fossil fuel use in California is for 2004. Since more than 80 percent of the California GHG emissions inventory is generated from fossil fuel combustion, it is not possible to report complete GHG data for more current years at this time. These data should be updated as soon as more current data become available.

- Perform a more detailed review of industrial uses of fossil fuels to classify when they are used as fuel versus their use as a process input (and therefore not released into the atmosphere at that step in their usage chain).

  As discussed in Appendix A, petroleum and natural gas are sometimes used in an industrial process rather than combusted as a fuel in an industrial facility. In some cases, feedstock use leads to carbon emissions, but in most cases the carbon in the fuel is transformed at the industrial site into the product of the industrial operation. In this case, no carbon emissions occur at this point in the product's production and use cycle, and there are no CO_2 emissions to document. CO_2 emissions may occur when the object being produced is used in an end use application. This is the point in the usage chain where CO_2 emissions should be counted in the GHG emissions inventory.

  The 1990-1999 California GHG emissions inventory used national data to estimate the amounts of petroleum and natural gas that were used as industrial process feedstocks rather than burned as fuels. This assumes that California's industrial sector exactly matches the national average of industrial activities.

  In the previous and current inventory, staff examined each subcategory of industrial use and judged whether the petroleum or natural gas was used as a feedstock or as a fuel. If they were judged to be used as a feedstock, then the national average values were used. If they were judged to be used as a fuel, staff used the normal calculation process and assumed that the emissions would occur on the site of the industrial process. In addition, methane generation at refineries was assumed to release CO_2 at the refinery. Differences between approaches are minor.

- Industrial wastewater emissions occur from processing fruits and vegetables, red meat and poultry, and pulp and paper. Methane and nitrous oxide emissions from these activities are not yet included in the California inventory and should be added in future updates.

  California produces much of this country's fruits, vegetables, red meat, poultry, and pulp and paper. These products all involve industrial waste water, which should be estimated and added to the California GHG inventory. The EPA guidance document[53] recommends that emissions be estimated for these industrial sources (see page 14.4-5). However, since we do not yet have data on the quantity of waste water generated by these activities, staff was unable to estimate methane or nitrous oxide emissions from waste water used to produce these products.

- Landfill methane emissions should continue to be studied to improve their accuracy. Values are low (40 to 52 percent lower) compared to1990-1999 inventory; these discrepancies need to be resolved. The 1990-1999 inventory was prepared by ICF Consulting under funding by the Energy Commission's PIER Program. In some cases, ICF applied national average values to calculate landfill emissions, and their results may not represent California conditions because California has been aggressive in implementing state level policies to recover energy from landfills and to reduce emissions. Reliance on EPA data does not seem to represent California conditions. GHG emissions from California landfills may be considerably lower, especially at large, well operated landfills with a comprehensive gas collection system and appropriate cover and cap material placement.

The EPA guidance document[54] recommends obtaining state-level data on the volume of wastes stored in large landfills (that is, those greater than 1.1 million tons of waste in place), and small landfills (less than 1.1 million tons of waste in place), over the previous 30 years to calculate methane emissions from municipal waste landfills (see page 13.4-2). Lacking that, the document recommends using state-level volumes disposed at landfills. If neither of these types of local data is available, the document recommends using state-level population data and national average per-capita landfill rates to calculate emissions.

The 1990 to 1999 California GHG emissions inventory used state-level data on volumes of waste disposed at California landfills from 1990 to 1999, national data to estimate volumes of waste from 1960 to 1989, and the amount going to small versus large landfills for 1990 to 1999. Estimates were made for methane recovery in landfill gas-to-energy facilities, flares, and oxidation. Emissions were about 17 $MMTCO_2E$ in 1990 and decreased to about 13 $MMTCO_2E$ in 1999 because methane recovery grew faster than waste disposal rates and associated emissions.

The current California GHG inventory was developed from emissions data obtained from local air pollution control agencies via the ARB. It is more of a "bottoms up" approach based upon a facility-by-facility assessment conducted by the local air districts. Emissions were estimated at about 8 $MMTCO_2E$ in 1990 and remain essentially flat over the entire 1990 to 2004 time period. These data represent emissions only from those facilities that have permits.

GHG inventory guidance documents indicate that some methane is oxidized in the landfill surface cap and not emitted into the atmosphere. The percentage is uncertain, and EPA recommends using local data where available and 10 percent removal where local data are not available. Work is underway to develop a California-specific estimate of this effect.

Local air quality district personnel are updating their landfill data but the results of this work were not available as of September 2006 and are not expected to become available in the near future. In addition, the Energy Commission has active research in progress to better quantify emissions from California, but the results of this work are not expected to become available until 2008.

- Develop California-specific data for SF_6 emissions from electric utilities.

  SF_6 emissions were estimated using national emissions data, and pro-rating state electric energy production to national values. However, California utilities have been actively involved in identifying and implementing methods to reduce these emissions and reducing associated maintenance costs. Individual electric utility companies in California should be contacted to obtain actual state-level data, if available. Since utilities have apparently not tracked their SF_6 as an individual maintenance cost, it may not be possible to use utility-specific data for the entire 1990 to 2004 period.

- Develop California-specific emissions factors for emissions of methane and nitrous oxide from manure management.

  Emissions calculations are based upon national data for animal characteristics, including percentage of dairy versus meat cattle, nitrogen production per head of animal, animal mass, and so forth. These data should be updated with state-specific values and methods of animal management.

- Develop California-specific emissions factors for enteric fermentation.

  Studies indicate that the currently accepted emissions factors may not properly quantify emissions of methane emissions from cattle processing their feed. The ARB is developing new emissions factors for regulatory purposes, and these should be considered for future updates.

- Update data used to calculate emissions for land use and forestry changes.

  The current inventory and the previous one for 1990 to 2002 used forecasted values for changes in acreage of forests provided by the federal Secretary of Agriculture. As satellite data for these changes becomes available, they should be used in place of these forecasted values. California has also recently experienced significant acreage converted to viticulture and pasture, and associated changes in soil carbon need to be reviewed and possibly updated.

- Obtain California-specific data for nitrous oxide emissions of several crops.

    The current inventory and the previous one for 1990 to 2002 used national estimates of nitrous oxide emissions resulting from cultivation of sorghum, oats, rye, soybeans, peanuts, and beans. State-specific data should be obtained if possible. This should be a low-priority activity as estimated emissions are very small.

APPENDIX A

DETAILED DOCUMENTATION OF CALIFORNIA GREENHOUSE GAS EMISSIONS

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CALCULATION METHODOLOGY

This appendix includes detailed documentation of methods used to construct the updated California GHG emissions inventory. First, a discussion of the methodology is provided. Next, a detailed table of California GHG emissions is provided. This detailed table is summarized in Table 6 (page 23 of the main body of this report). Line numbers included in the text below refer to rows in Table 6, unless otherwise stated. Where possible, values in Appendix A that are used to obtain subtotals are shown right justified to facilitate identification by the reader. This is not possible for all levels of subtotaling.

CO_2 Emissions

CO_2 emissions occur largely from combustion of fossil fuels. In 2004, fossil fuel combustion accounted for 96.2 percent of gross CO_2 emissions. Other CO_2 emissions sources included cement and lime production, limestone and dolomite consumption, soda ash, CO_2 consumption, waste combustion, and finally, changes in land use and forestry operations.

CO_2 Emissions from Fossil Fuel Combustion

Fossil fuels used in California include natural gas, petroleum (including liquefied petroleum gas [LPG]), motor gasoline, kerosene, distillate oil, residual oil, petroleum coke, lubricants, asphalt, and small amounts of coal. Biomass is also used as a fuel in some applications, but these emissions are excluded because the net amount of CO_2 released is zero when averaged over the life of the biomass itself. For example, a tree takes as much CO_2 out of the air as it releases into the air when it is burned. Any fuel used to plant, cultivate, and harvest the tree is included in the appropriate fuel use category.

Under contract with the Energy Commission's PIER Program, Lawrence Berkeley National Laboratory evaluated fossil fuel supplies and uses in California and developed a balance between them. Their work led to a document titled *California Energy Balances Report*,[55] (*Energy Balance)* and included a database of energy consumption that can be expressed in volumetric units or trillion British Thermal Units (trillion BTUs, or TBtus). GHG emissions are calculated from TBtus, using appropriate emissions factors provided by the EPA that are consistent with guidance documents from the IPCC.

The *Energy Balance* was developed using data from the EIA, supplemented with data from the Energy Commission. Much of the data used in the *Energy Balance* was obtained from the same EIA data sources used in the 1990-1999 GHG emissions inventory and is thus consistent with it. In some cases, EIA revised and updated its data, and these changes are reflected in the *Energy Balance* and in the updated GHG emissions inventory.

In the current update, these data were supplemented with data from the Energy Commission to enable calculation of emissions for 2004. At the time the current inventory was prepared, the newer Energy Balance data have yet to be published in a report, although the data were made available by the contractor.[56] These data revisions extend the fuel use data to 2004 and make some revisions to data for previous years. The reader is referred to the previous *Development of Energy Balances for the State of California (Energy Balance)* [57] for documentation of most data used in this report. Appendix D contains further discussion of the newer data used for 2004 and describes major differences between the current inventory and the previous one that covers the 1990 to 2002 period.

Energy Commission data were used to provide more detailed resolution of fuel use by end-use sector. One example of major improvements implemented in the two most recent inventories, when compared to the 1990-1999 GHG inventory, is the treatment of electricity generation fuel use. The earlier GHG inventory reported electricity fuel used in the industrial sector unless the electric facility was owned by an electric utility company. The last two GHG inventories identify all fuel used to generate electricity as “Electricity Generation” regardless of the facility’s ownership.

Fossil fuel CO_2 emissions are estimated by multiplying standardized emissions factors (EF) recommended by the EPA in their Emissions Inventory Improvement Program documentation[58] by the TBtu data from the *Energy Balance,* converting from carbon emissions to CO_2 emissions, and then using conversion factors to obtain results in million metric tons of CO_2.

The equation typically used for CO_2 is:

CO_2 = Billion BTUs * Percent Oxidized * EF (lbs C per million BTU) * 0.9072 (converts short tons to metric tons) * 44/12 (converts lbs C to lbs CO_2) * 0.0005 (converts lbs to short tons) / 1,000,000 (expresses results in millions)

This result is expressed in million metric tons of carbon dioxide ($MMTCO_2$). Some manuscripts use the term teragrams rather than metric tons. One million metric tons equals one teragram (Tg).

The trillion BTUs (10^{12} BTUs, also expressed “TBTUs”) of fuel used in various end-use applications in California are shown in Appendix B. These data are largely obtained from the *Energy Balance.* Energy use data are listed in the same series order as the California GHG emissions inventory. For some fuels, data are provided by generally focused categories of end use. Fuels with insufficient data to report detailed end-uses are reported as “Non-specified.”

Emissions are calculated for each fuel using fuel-specific values for percentage oxidized and carbon content as shown in Table A-1 (for fuels which have values that do not change from year-to-year) and Table A-2 (for fuels which values that change from year-to-year). These values were obtained from the EPA[59] and are consistent with IPCC protocol.

CO_2 emissions are calculated individually for each fuel and end-use sector and are then totaled to get sums for CO_2 and for each end-use sector, such as residential, commercial, and so forth.

This method is the same as used in the 1990-1999 GHG emissions inventory with new data as available (except imported electricity, as explained below). See Appendix B for energy use rates used to estimate CO_2 emissions for each end use category and sub-category.

Line 1— CO_2 (Gross)
This line represents the sum of all CO_2 emissions, including fossil fuels, non-fossil fuel CO_2 emissions, and land use and forestry activities that increase CO_2 emissions.

Line 2—Fossil Fuel Combustion Totals
This line is the sum of fossil fuel combustion, Lines 3 through 8.

Line 3—Residential CO_2 Emissions
In California, residential CO_2 emissions are produced from the combustion of natural gas, LPG, kerosene, and distillate fuel.

Line 4—Commercial CO_2 Emissions
Commercial CO_2 emissions are produced from the combustion of coal, petroleum, and natural gas. Only small quantities of coal and petroleum fuels are used in California, so natural gas composes the majority of the fuel used. Most commercial petroleum fuel use is gasoline or distillate, with small amounts of residual oil and LPG. Natural gas is used in applications that range from education through non-specified services.

Line 5—Industrial CO_2 Emissions
Industrial CO_2 emissions are produced from the combustion and feedstock uses of coal, petroleum, and natural gas. This end-use sector uses only a small amount of coal, moderate amounts of petroleum, and relatively large amounts of natural gas.

Even though this sector uses almost twice as much natural gas petroleum on a BTU basis, resulting CO_2 emissions for natural gas and petroleum are similar in magnitude. This results because petroleum has greater carbon intensity per unit of energy and because much of the industrial petroleum use is in feedstock applications (such as asphalt manufacturing) rather than fuel applications (such as making steam for an onsite industrial process). Feedstock applications may or may not cause direct emissions because the carbon may be stored rather than emitted to the atmosphere. For some feedstock applications, the carbon is used in a product that is burned at another step in the product cycle, and that is where the carbon emissions are accounted for in the normal inventory protocol to avoid double counting.

Industrial uses of coal, petroleum, and natural gas must be adjusted to account for these feedstock uses and associated carbon storage. These feedstocks can either be stored on a long-term basis (such as in asphalt pavement) or a short-term basis but later emitted (such as natural gas used as a feedstock to make hydrogen in a petroleum refinery).

In the first case, the carbon associated with the feedstock is locked into the pavement and assumed to never be emitted, and the computed emissions are zero. In the second case, the carbon is released during operation of a steam reformer located at or near a refinery and emitted after separating the hydrogen from the carbon.

In summary, it is necessary to subtract the amount of feedstock used and stored from the amount used as a fuel at the industrial facility.

The approach requires: (1) identification of the percentage of each industrial fuel that is used as a feedstock, not a fuel, and (2) the percentage of the feedstock that is stored rather than emitted in the associated industrial process.

The EPA guidance document indicates that state-level data should be used if available. However, if state-level data are not available, national data can be used. The 1990-1999 California GHG inventory used national data.[60] However, since the *Energy Balance* now provides much more state-level detail for industrial uses of coal, petroleum, and natural gas, it is no longer necessary to assume that these national factors apply in California for every industrial use.

In the new GHG inventory, each industrial subcategory of end-use was examined individually, and the most likely use of the fossil fuel was estimated by the category name. If it was most likely that the fuel was burned onsite for process heat or steam, then all of the fossil fuel was assumed to be burned on site. If it was most likely that the fossil fuel was used as a process input, the national average storage factor was assumed to apply to that subcategory.

The percent feedstock use and storage factor were both assumed to be zero if the subcategory appeared to be a fuel use. Otherwise, the inventory assessment uses the same national numbers as the 1990-1999 inventory. There is room for improvement with either method of assessing the industrial category of fossil fuel emissions.

To determine the degree to which this change impacts the estimated industrial sector CO_2 emissions, they were calculated each way. The results are similar using either approach. For example, for natural gas industrial emissions in 1999, the 1990-1999 method yielded a value of 33.4 $MMTCO_2E$, and the current method yields a value of 34.3 $MMTCO_2E$. The new approach was chosen because state-level energy data were available and the national values did not seem appropriate for some of the industrial subcategories. Using national average data for feedstock use of fossil fuels is equivalent to assuming California has exactly the same industries as all 49 other states.

Industrial fossil fuel use data were available for all fuels each year except liquefied petroleum gas. For this fuel, the average of 1990 to 2001 fuel usage rates was assumed for 2002 through 2004.

While reviewing the Energy Balance data file, it was determined that the 1990 to 2002 GHG inventory inadvertently double counted emissions from burning natural gas while manufacturing stone, clay, glass, and cement. Removing this double counting reduces emissions by 1.5 to 4 $MMTCO_2E$, depending on year. This change is reflected in the 1990 to 2004 inventory for all years.

<u>Line 6—Transportation</u>
CO_2 emissions from the transportation sector constitute the single largest category of California's GHG emissions: 188 $MMTCO_2E$ in 2004. Motor gasoline is the single largest subcategory of transportation emissions at 131 $MMTCO_2E$ in 2004. On-road distillate fuel and jet fuel are the next two largest subcategories, with jet fuel higher in early years and distillate fuel use higher in the later years. In 2004, distillate fuel emissions were 32.2 $MMTCO_2E$ and domestic jet fuel emissions were 22.2 $MMTCO_2E$.

Motor gasoline is used in light-duty vehicles in a wide variety of applications, although most is used in privately owned vehicles. Jet fuel is used in domestic aviation and military aviation. Emissions values do not include international aviation (or international marine) uses.

GHG emissions inventory guidance[61] is to identify international jet and marine fuel uses and report their emissions separately from corresponding domestic uses, if sufficient data are available. These are called "international bunker fuels." This is a bit of a misnomer because the traditional use of the term "bunker fuels" is for <u>marine</u> fuel use, not jet aircraft fuel use. Bunker fuels are heavy, often require heating to flow, and are not used in jet aircraft. However, the term "international bunker fuels" is used in GHG emissions inventories to describe distillate and residual fuels used for international business.

The California GHG inventory includes jet fuel and residual and distillate oils used as domestic fuels. It excludes international jet fuel and marine residual and distillate fuel uses, but values are reported on separate lines for comparison purposes. Prior to the last two California GHG inventories, it was not possible to separate out all international and domestic aviation and marine fuel uses. Thus, for the two most recent inventories, reported transportation GHG emissions values are lower for the entire reporting period than earlier inventories.

In 2004, international aviation accounted for approximately 38 percent of California's total reported jet fuel use and international marine fuel use accounted for 94.5 percent of California's residual oil use and 1 percent of its distillate fuel use.

California Air Resources Board regulations required removal of methyl-tertiary butyl-ether (MTBE) from gasoline by 2004. The petroleum industry responded beginning in 2002, replacing MTBE with ethanol. Approximately 12 percent of the gasoline pool was converted in 2002, 65 percent in 2003 and 98 percent in 2004 and beyond.[62] A small percentage is exempt from this regulation. According to most estimates, ethanol requires about 0.74 gallon of fossil fuel to produce one gallon of ethanol.[63] The net effect of switching from MTBE to ethanol is to reduce CO_2 emissions from gasoline consumption by 0.2 $MMTCO_2E$ in 2002, 1.3 $MMTCO_2E$ in 2003 and 2.0 $MMTCO_2E$ in 2004.

Transportation fossil fuel use data were available for each year for all fuels except liquefied petroleum gas. For this fuel, the average of 1990 to 2001 fuel usage rates was assumed for 2002 through 2004.

Line 7—Electricity Generation (In-State)

CO_2 emissions from electricity generation are produced from the combustion of fossil fuels. Due to environmental and other restrictions, most fossil fuel used to produce electricity in California is natural gas (approximately 43 percent of the total electrical energy produced for use in California in 2001 and 36 percent in 2004).

The 1990-1999 GHG emissions inventory identified utility-owned electricity production, but electricity produced by other entities was reported as a part of industrial emissions. The *Energy Balance* identifies industrial, commercial, and electrical combined heat and power fuel uses, as well as independent power producers, utility-owned electricity generation and non-specified electricity generation. Each is identified as a separate fuel used to generate electricity, as shown in Appendix B. This is a major improvement in the tracking of electricity generation and industrial CO_2 emissions for the California GHG emissions inventory, compared to earlier GHG inventories.

Line 45—Imported Electricity

During the 1990 to 2004 period, California imported 22 to 32 percent of its electric energy from nearby states. The method of generating this imported electric energy ranges from coal-fired power plants to nuclear and hydroelectric power plants. Electricity generated from burning coal releases relatively large amounts of GHG emissions while electricity generated from nuclear and hydroelectric power plants do not emit GHGs.

Electricity imported from the Pacific Northwest has a large hydroelectric component compared to the Southwest, which is largely coal based. Thus, energy imported from the Southwest is much higher in carbon content than is energy imported from the Pacific Northwest.

Due to the nature of imported electrical energy transactions, it is oftentimes not possible to determine the type of facility and associated carbon-based fuel used to generate the imported electricity. However, to estimate carbon emissions from imported electricity, it is necessary to estimate the source(s) of electricity and associated rates of carbon emissions per gigawatt-hour of imported electricity. Thus, an estimate must be made of the fuel used to generate this portion of the imported electricity.

The EPA GHG emissions inventory guidance document[64] recommends that states estimate emissions from net imports of electricity. California occasionally exports a small amount of electricity, but nearly all of the transactions are imports. The GHG inventory of in-state emissions could be reduced to account for the electricity exported from California, but the amount is small enough to ignore this factor. However, 2000 experienced greater than average electricity exports due to the turbulent market conditions that existed at that time.

To estimate the CO_2 emissions from Pacific Northwest electricity imports, we assume 20 percent was generated by coal and 80 percent from hydroelectricity. Correspondingly, for electricity from the Southwest we assume 74 percent coal and 26 percent hydroelectricity. These values were adopted for use in the *1994 Electricity Report* for the 1994 to 1999 period.

This report assumes that these percentages apply for the entire 1990 to 2000 time period. Additional electrical energy is also generated from two out-of-state coal-fired power plants[65] owned by California electric utilities. The fuel used to generate this energy is known to be coal, and there is no need to estimate its fuel source. These emissions are calculated separately and the results added to the values estimated for the Pacific Northwest and Southwest to obtain overall carbon emissions from imported electricity.

To estimate CO_2 emissions from out-of-state electricity generation for 2001 and later years, data from the Energy Commission's Electricity Office was used. This data is based upon reported electrical energy transactions to estimate the percentage of energy from coal, natural gas, oil, nuclear, and other sources. These percentages were used for 2001 through 2004, after removing the two known coal-fired electricity generating facilities.

The State of California's Department of Finance publishes a table (J11) of electrical energy generation from utility-owned and non-utility owned power plants with gigawatt-hours (GWh) of electrical energy production intended for use in California shown by fuel type.[66] The table also shows overall gigawatt imports from the Pacific Northwest and Southwest.

This table is used, along with the percentage data above, to derive annual values for total GWhs of imported electrical energy by fuel type. To convert electrical energy into its British Thermal Unit (BTU) equivalent, staff assumed a thermal conversion rate of 10,000 BTUs per kilowatt-hour (BTU/kWh). This is an approximate value which could be refined, but this step is deemed not necessary due to the uncertainty of other assumptions needed to estimate imported energy levels by type of fuel.

After obtaining annual BTU estimates for each fuel type using the method described above, CO_2 emissions are calculated in the same manner as other sources of fossil fuel emissions for Lines 2 through 8. Appendix C discusses two other approaches for estimating CO_2 emissions from electricity imported to California.

The Energy Commission is developing a more refined way to estimate fuel used to import electricity into California. When these values become available, they will be applied to out-of-state electricity imported to California to provide an improved estimate of these emissions. As of August 2006, this newer approach was not yet available.

Line 8—No End-Use Specified
The *Energy Balance* identified a small amount of natural gas and liquefied petroleum gas use that could not be associated with a specific end-use. The associated CO_2 emissions are listed on Line 8.

CO_2 Emissions from Non-Fossil Fuel Emissions Sources

Some human activities release CO_2 gases without burning fuel. These sources contribute a modest portion of gross CO_2 emissions (2.8 percent in 2004).

Line 9—Cement Production
Cement production involves a chemical conversion process that releases CO_2 gas as limestone is heated in a kiln to produce lime. The resulting clinker is further processed to produce cement. Additional emissions associated with kiln heating are included under fossil fuel combustion and are not repeated here to avoid double counting of these emissions.

Quantities of masonry cement and Portland cement produced in California were obtained from U.S. Geological Survey (USGS) Minerals Yearbook (various years): Table 1, Masonry & Portland Cement Production. Masonry cement and Portland cements were added to determine total cement manufactured, with the bulk of production being Portland cement. See Table A-3 for Masonry and Portland cement production in California.

Clinker production was multiplied by 0.65 to obtain the lime content of the clinker and this value was multiplied by 44/56[67] to convert to CO_2. This value was multiplied by 1.02 to account for clinker dust.

This method is the same as used in the 1990-1999 GHG emissions inventory but with updated or revised data from the USGS Minerals Yearbook (various years) where available.

Line 10—Lime Production

Lime is used in a wide variety of applications, including construction, pulp and paper manufacturing, and sewage treatment. The analysis assumes that California's lime production matches its lime use. Lime production leads to CO_2 emissions in a process similar to cement production. Limestone is heated in a kiln to produce lime, releasing CO_2.

Lime production data for California are obtained from the USGS website [http://minerals.usgs.gov/minerals]. California values are available from USGS for 1990 to 1998 but are withheld for later years to avoid disclosing company proprietary data. Production decreased from 1990 to 1993 but increased thereafter. Values for the 1999 to 2004 time period were extrapolated from 1993 to 1998 values.

California lime production data are shown in Table A-3. There is a decreasing number of lime producing facilities in California. This explains why the lime production data are withheld after 1998. Future inventory methods may not be able to rely upon USGS for California lime production data.

CO_2 emissions are calculated by multiplying lime production by 44/56, the ratio of the molecular weight of CO_2 to lime (CaO).

This method is the same as used in the 1990-1999 GHG emissions inventory with new or revised data as available.

Line 11—Limestone & Dolomite Consumption

Some uses of limestone and dolomite (both are called "limestone" in mineral industry terms) produce CO_2 emissions,[68] but others do not. No data are available to differentiate limestone and dolomite uses in California that emit CO_2 from those that do not. It is necessary to assume that the national percentage of uses applies equally to California and obtain California's portion by ratio.

Nationwide and California limestone and dolomite consumption are both available from the USGS. Nationwide CO_2 emissions were obtained from the United States GHG inventory. California emissions were obtained by adding limestone and dolomite production and obtaining emissions by ratio. This assumes that the same mix of CO_2-producing uses and non CO_2-producing uses is the same (including flue gas desulfurization), which is not likely. However, no better method is available to estimate these emissions. The small magnitude of these emissions means that further refinement of this data does not appear to be warranted at this time.

This method is the same as used in the 1990-1999 GHG emissions inventory with new or revised data as available.

Line 12—Soda Ash Consumption

CO_2 emissions occur when soda ash (Na_2CO_3) is used to make glass and soap. Payroll data for California and nationwide were used to estimate the magnitude of CO_2 released from these activities, using the ratio of California to national payrolls to determine California emissions. California's glass-making payroll was 8.5 percent of the national glass-making payroll in 1996, and California's soap-making payroll was 7.6 percent of the national soap-making payroll in 1996. An average of 8.0 percent was used to estimate the California CO_2 emissions from glass- and soap-making activities.

This method is the same as used in the 1990-1999 GHG emissions inventory with new or revised data as available. The payroll data were not updated.

Line 13— CO_2 Consumption

Nationally, CO_2 is emitted from natural gas wells, as a by-product of chemical production, and when separating crude oil and natural gas. It is also used for a wide variety of activities, including chemical production, food processing, and consumption of carbonated beverages.

California's CO_2 emissions from CO_2 consumption was scaled from national emissions by using the ratio of California's CO_2 production capacity to the national production capacity from year to year.

This method is the same as used in the 1990-1999 GHG emissions inventory with new or revised data used (as available) for the national CO_2 emissions from CO_2 use.

Line 14—Waste Combustion

CO_2 and nitrous oxide emissions to the atmosphere occur when municipal solid waste (MSW) is combusted to make electricity. A portion of the waste stream is biogenic, and these CO_2 emissions are not counted because the carbon is recycled during the growth period of the biogenic materials. Another portion of the waste stream is made from plastic, synthetic rubber, and synthetic fibers, and this portion is counted because they are derived from fossil fuels. The nitrous oxide emissions calculations (Line 31) are documented below.

There are three MSW facilities in California: Commerce Refuse-to-Energy, Southeast Resource Recovery, and Ogden Martin Systems of Stanislaus, Inc. Representatives of each were contacted to obtain annual tons of municipal wastes processed for 1990 through 2004. These values were multiplied by 0.1104 tons of carbon per ton of MSW for plastics, 0.0174 tons of carbon per ton of MSW for synthetic rubber, and 0.0343 tons of carbon per ton of MSW. These emissions factors are national average values derived by the EPA. Results are summed and converted to million metric tons of CO_2 to get total CO_2 emissions from MSW.

This method is updated from the 1990-1999 GHG emissions inventory, with new emissions factors for waste stream constituents.[69]

Land Use Change & Forestry Overview

The 1990-1999 GHG emissions inventory estimated net CO_2 flux caused by changes in forest carbon stocks, changes in agricultural soil carbon stocks, and changes in yard trimming carbon stocks in landfills. Forested land in California was estimated based on California Department of Forestry's (CDF) five-year inventories, with the last inventory conducted in 1994. Therefore, all values for 1995 through 1999 were extrapolated from 1994 data. The forested land was categorized by ownership, use, and type of vegetation. Net changes in carbon stocks were tracked by modeling carbon flows related to tree growth, forest removals, and decomposition.

The current inventory uses a different approach to reflect methodology and quantification changes developed by Winrock International.[70] Changes in canopy cover were tracked through the California Land Cover Mapping and Monitoring Program (LCMMP) conducted by the CDF's Fire and Resource Assessment Program (FRAP).

LCMMP uses Landsat Thematic Mapper satellite imagery to map vegetation and changes over five-year periods. Carbon flux estimates are derived principally from Forest Inventory and Analysis (FIA) data. This approach allows for use of newer, California-specific information developed by the Energy Commission's Public Interest Energy Research Program.

Winrock provided emissions and removals of GHG by land-use sector for five-year intervals, that is, between 1994 to 2000 for 84 percent of the forests and 42 percent of the rangelands. This was extrapolated to 100 percent of the area. A portion of the carbon associated with harvested forest wood is sequestered in long-term wood products. For softwoods, 75 percent is extracted from the forest and 44 percent of the extracted volume is stored in these long-term products. For hardwoods, 73 percent is extracted and 23 percent of the extracted hardwood volume is stored in long-term products.

Emissions and reductions for 1990 to 1994 were calculated using a FRAP analysis of a 7 percent reduction in forest land between 1953 and 1994. Emissions and reductions for 2002 and later years are based on forecasted reductions in land by the federal Secretary of Agriculture. These values should be updated with future satellite imagery.

Agricultural acreages were based primarily on the National Resource Inventory (NRI) database and provided in discrete values for 1987, 1992, and 1997. Linear regression analysis was used to provide the values for 1990 to 1991, and 1993 to 1996. For 1998 to 2004, acreage data from the California Agricultural Statistics Services were used.

Carbon estimates for woody crops were made by Winrock based on above- and below-ground biomass, crop type (for example, fruit, nut, and vineyard) and planting densities. Changes in agricultural soil carbon were not tracked because it was assumed agricultural land in California has been under cultivation long enough that changes in soil carbon stocks based on soil types are minimal. This may not be true for soils converted to viticulture and pasture, and this factor should be evaluated in future inventory updates.

Inventory categories were changed to reflect the new methodologies and baseline. However, because carbon changes cannot be detected from satellite and there is a lack of data on carbon densities of cropland, this inventory uses the 1990-1999 inventory method for land filling of lumber and urban wood waste and liming of soils as explained below.

Line 15—Land Use Change & Forestry Emissions

Winrock International tracked measurable decreases in canopy cover and the resulting decreases in carbon stocks (carbon emissions) separately from measurable increases in canopy cover (carbon storage). Decreases in carbon stocks (gross and net changes) varied by the cause of the change. Fire and harvest were the dominant causes of emissions on forestlands, and fire was the cause of emissions on rangelands.

Field measurements by Winrock and literature sources indicated no changes in soil carbon with land use or management except in the conversion to some forms of agriculture. Therefore, emission categories attributed to forest and agricultural soils were removed from this inventory.

Agricultural land was categorized by the types of crop grown – woody or non-woody. Total carbon stock was estimated based on area and crop type within the broad categories (fruit, nut, vineyard, berry, row crops, close crops, hay crops, and other).

Although there was an overall decrease in both woody and non-woody crops between 1987 and 1997, the inventory fluctuated between emissions and reductions for agricultural lands based on periods when woody crops increased and annual fluctuations in non-woody crop acreages. The apparent sudden, relatively large increase in reductions between 1997 and 1998 is an anomaly caused by a change in 1998 from NRI data to CASS data. 1990-1999 NRI data points were correlated to CASS acreages to determine they were within the uncertainty range.

Liming of Soils

Limestone and dolomite applied to agricultural soils degrades and releases CO_2. The amount of CO_2 generated from using these soil treatments is estimated using the same method as used in the 1990-1999 inventory[71] with new data as needed.

Tonnage data of limestone and dolomite applied to California soils was obtained from the USGS's *Minerals Yearbook* for various years. These values were multiplied by the appropriate emissions factor (0.12 metric ton of carbon per metric ton of limestone, and 0.13 metric ton of carbon per metric ton of dolomite) and then converted to CO_2 by multiplying by the molecular weight ratio of CO_2 to carbon (44/12).

Line 16—Land Use Change & Forestry Sinks

Since satellite imagery only identifies measurable changes in canopy coverage during the time interval, carbon estimates are derived from FIA for forests and rangeland types with corresponding canopy closures. Tracking carbon stocks through satellite imagery measured changes in canopy overcomes problems with apparent changes in stocks due to land reclassification (for example, moving acreage from private ownership to public ownership).

Agricultural sinks are estimated in the manner described above for Land Use Change and Forestry Emissions (Line 15).

Landfilling Lumber and Urban Wood Waste

Lumber and urban wood wastes disposed at landfills contain significant amounts of lignins, which contain carbon, which is sequestered in anaerobic landfills.

The methods used for Lumber Disposal and Yard Trimming Disposal are the same as the 1990-1999 inventory with new data as needed.

Tonnage of lumber and urban yard trimmings disposed at landfills was obtained for 1990, 1999, and 2003 from the California Integrated Waste Management Board (CIWMB) surveys.[72] Tonnage values for 2004 were estimated by extrapolation from the 1999 and 2003 tonnage values. These surveys inventoried disposal in place (in situ). Therefore, the tonnage reported represented lumber and wood trimmings entering the landfill and not the municipal waste stream, as was assumed in the 1990-1999 inventory.[73]

Emissions factors of -0.30 metric tons of carbon per short ton of lumber, and -0.2082 tons of carbon per short ton of yard trimmings (grass, leaves, and branches) were applied to obtain annual estimates of carbon emissions from theses sources, and then converted to CO_2 by multiplying by the molecular weight ratio of CO_2 to carbon (44/12). Emissions factors are negative because this carbon is sequestered within the landfill.

Line 17— CO_2 (Net)
This line is Line 1 minus Line 16.

Methane Emissions

Methane (CH_4) emissions occur from operation of petroleum and natural gas supply systems, waste operations (landfills and wastewater treatment), agricultural operations (enteric fermentation, manure management, rice fields and agricultural burning), and from mobile and stationary fuel combustion. Methane emissions are converted into CO_2- equivalent emissions by multiplying the methane emissions in millions of metric tons by their 100-year GWP. For this inventory, we used a GWP from the Second Assessment Report to be consistent with IPPC guidance and the U.S. EPA methodology. The 100-year GWP for methane emissions is 21 times CO_2 emissions. In the previous report covering the 1990 to 2002 period, some subcategories were inadvertently evaluated using 23 times rather than 21 times. Once the newer GWPs become accepted for use (from the Third Assessment Report or later), all will be evaluated using the newer number. In the meantime, for this report, all of the data have been made consistent using the older GWP, 21.

Line 18—Methane Total Emissions
This line is the sum of Lines 19 to 28.

Line 19—Petroleum & Natural Gas Supply System
The ARB provided the Energy Commission a data file of estimated methane emissions from area sources, including emissions from the petroleum and natural gas supply system. Data were provided annually for 1990 to 2004. ARB documents their methodology for estimating emissions and provides criteria pollutant emissions data on their website.[74]

Essentially, local air districts provide detailed field data to ARB, who summarizes it into statewide emissions. Methane emissions were estimated by ARB from total organic gas (TOG) emissions using a speciation profile[75] to determine the fraction of TOG comprised of methane. The ARB's most recent speciation profile is included in Appendix E. ARB provided data in tons/day. These were multiplied by 365 to convert to tons per year, and then by 0.9072 to convert from short tons to metric tons.

The current method uses data derived from local and regional analyses while the 1990-1999 GHG inventory method used national data. The current method combines emissions from both petroleum and natural gas extraction because they usually occur simultaneously in California due to the fact that natural gas is co-located and co-produced with crude oil. The current method is considered more representative of California's GHG emissions.

Petroleum and natural gas field operations release fugitive methane from oil/water separators, well operations, pumps and compressors, fittings and valves. Emissions also occur from operation of field reciprocating engines and from petroleum seeps.

Petroleum refining also releases small amounts of methane. Petroleum marketing emissions also occur from barge loading, lightering and ballasting and tanker loading.

Line 20—Natural Gas Supply System

Additional natural gas supply system methane emissions were obtained in the same manner explained above for the petroleum and natural gas supply system.

Some natural gas methane emissions are embedded in line 19, which includes emissions associated with producing both petroleum and natural gas. Additional natural gas methane emissions occur from wet gas stripping and field separation and especially from natural gas transmission losses. These are included in Line 20.

Line 21—Landfill Emissions

Landfill methane emissions occur from organic decomposition of wastes placed in them. Most methane production typically occurs one to two years after waste placement and significant emissions can occur for up to 60 years. The quantity of methane generated at a landfill depends upon the amount of waste placed, age of wastes placed, composition of wastes placed, and climate at the waste disposal site. In California, most landfills have methods of controlling these emissions, including methane recovery for electricity production, methane flaring. In addition, methane oxidation in the landfill cover material (or surface layer) also reduces the net emissions. The amount of this oxidation is uncertain and varies by latitude of the landfill, soil characteristics, and other factors. US EPA guidance is to use local oxidation rates if available; if not, 10 percent reduction due to oxidation is recommended. California has an aggressive waste diversion program, aimed at reducing the quantities of wastes placed annually.

Methane emissions from California landfills were obtained in the same manner explained above for the petroleum supply system. These data are collected by local air regulatory agencies and are considered a better representation of California GHG emissions than the method used for the 1990-1999 GHG inventory. Local air pollution district personnel provided these data to the Air Resources Board and are in the process of reviewing and updating this information, but the results are not yet available.

Line 22—Enteric Fermentation

The amount of methane emissions from a domesticated animal depends on whether the animal is a ruminant,[76] the age and weight of the animal, and characteristics of feeding. Quantities of methane generated by ruminant animals are much greater than from non-ruminant animals, therefore, the focus of the quantification is on California's largest population of ruminant animals–cattle.

Although beef cattle populations have declined over the last 12 years, the dairy cattle population has increased significantly. California is the leading dairy state in the nation, and dairy products are the state's number one agricultural commodity.

The 1990-1999 GHG emissions inventory[77] modeled each stage of the cattle population monthly from birth to slaughter. These monthly values are estimates and the method implies an accuracy that is not justified. Current studies indicate emission factors used in the inventory for California cattle may be much higher than what is actually produced with the industry's feeding regimes and may overstate emissions. The ARB is developing new emissions factors for regulatory purposes, and these should be used in future updates to the inventory.

For this inventory, annual data for cattle and other agricultural livestock population (head) were taken from the California Agricultural Statistics Services (CASS). California specific emission factors from the 1990-1999 inventory were applied to these animal populations. This method increases the GHG emissions by approximately 10 percent within the category. The reader is referred to the 1990-1999 California GHG inventory,[78] pages 109 to 115, for an explanation of the method used to estimate these emissions.

Line 23—Manure Management

Methane emissions from livestock are generated through manure management systems. Emission factors for each type of livestock varies considerably since domestic livestock types vary from cattle to poultry.

The annual average animal populations were tabulated for:

1. Cattle (by type such as dairy or beef, and by size)
2. Swine (by type and by size)
3. Poultry (by type)
4. Sheep (by type)
5. Goats
6. Horses

Non-equine animal populations were obtained from California Livestock and Dairy Reports, and County Agricultural Commissioners' Data. Equine populations were estimated from 1999 data for horse populations but are probably low because data is not collected for groups of fewer than 50 horses.

This method is the same as used in the 1990-1999 GHG emissions inventory with new or revised data as available.

Livestock manure produces methane by anaerobic decomposition of the manure for that fraction that is managed in a liquid storage system such as lagoons, ponds, tanks, or pits. Little or no methane is produced from methane managed as a solid or deposited on rangeland, etc. As ambient temperatures and moisture levels increase, methane emissions increase. Diets higher in energy content produce more methane.

Methane emissions are based on the quantity of volatile solids produced by livestock. This is determined from typical animal mass (TAM) and livestock populations. Methane emissions are estimated using emissions rates typical of each type of animal. These are adjusted by multiplying by a management factor to represent the percentage of emissions based upon type of management practice with zero representing practices that eliminate emissions and 1.0 representing practices that tend to maximize methane production.

Emission factors are based on national animal characteristics and should be updated to reflect California-specific values in future updates to the inventory. These factors range from 18 percent for cattle and goats to 48 percent for swine, with all values depending on type of animal and typical management practice.

Line 24—Flooded Rice Fields
Anaerobic decomposition of organic material by methanogenic bacteria in flooded rice fields produces methane. Some of the methane is oxidized, some is leached to ground water, and the remaining methane is diffused to the atmosphere, primarily through the rice plants.

Methane emissions from rice cultivation is small – representing less than 2 percent of the total methane emissions tracked for California. Although methane emissions increase significantly with ratoon or secondary crops grown from stubble, California does not grow ratoon rice.

The methane emission factor used was based on California studies and is lower than the average factor used by the EPA,[79] which represents rice soil temperatures and management practices throughout the eight rice-growing states. Acreage data for rice was obtained from the CASS.

This method is the same as used in the 1990-1999 GHG emissions inventory[80] with new or revised data as available. Essentially, annual acreage in hectares is multiplied by an emissions factor of 122 kilogram methane per hectare. This is multiplied by the GWP of 21 times CO_2 from the Second Assessment Report, and then divided to obtain million metric tons of CO_2 equivalent.

Line 25—Burning Agricultural Residues and Other Wastes
Field burning is often used to dispose of pruned branches from crops and to dispose of unwanted crop components such as rice straw and field stubble. Agricultural burning is divided into two categories – crop residue burning and other agricultural waste burning. Crop residues are identified as non-woody or field residues, and woody or orchard/vineyard residues. The methodology for estimating GHG emissions from field burning of agricultural residues was based on the type and amount of residues produced, and the crop specific emission factors for methane (and nitrous oxide, see Line 34) released during combustion.

The inventory used California-specific factors for residue tonnages per crop acreage to determine total amounts of non-woody and woody residues. The percentage of the residues burned in the field was applied to these total amounts. Burning permits for other agricultural wastes were used to determine other non-crop agricultural burning.

California's crop residue profile differs from the national profile. Almonds, walnuts, wheat, barley, corn, and rice produce almost 98 percent of the field and woody crop residue burned in California. Adding cherry, apricot, and grape residue captures almost 100 percent of the agricultural residues burned in California, especially since grape acreages have increased substantially in recent years.

Changes in rice residue burning practices have decreased the amount of rice straw burned. California's cultivated rice acreage increased from 425,000 acres in 1990, to 595,000 acres in 2004,[81] and rice residue tonnage has increased proportionally. However, the percent of rice residue burned has decreased from 99 percent before 2001, to 25 percent for 2001 and later years. This change is reflected in the inventory data.

<u>Agricultural Crop Residues</u>
Acreage data for all crops are taken from the annual Crop Reports compiled by the California County Agricultural Commissioners and from the California Agricultural Statistics Service. Emissions for this subcategory are estimated as described above.

<u>Other Waste Burning</u>
Some other agricultural wastes produced and burned in California cannot be calculated based on crop acreages. These emissions are tracked through agricultural burning permits administered by individual air districts. The ARB maintains a database of agricultural emissions based on these permits and supplements these data with estimates where permit information is not available. The estimated Agricultural Crop Residues emissions based on acreages were subtracted from the emissions inventory provided by ARB to get a category we call "Other Agricultural Waste Burning." These emissions include non-agricultural open burning, wild fires, and other miscellaneous waste burning.

<u>Line 26—Wastewater Treatment</u>
Anaerobic degradation of waste water produces methane emissions. These are calculated using California population data and appropriate generation rates and emissions factors from EPA. First, biochemical oxygen demand estimated by the "five-day test" (BOD_5) is estimated at 0.065 kilogram per capita per day. The anaerobic treatment fraction of BOD_5 is estimated at 16.25 percent, and the methane generation rate is assumed to be 0.6 kilograms of methane per kilogram of BOD_5. These factors are multiplied together to get the daily methane production rate and then multiplied by 365 to get a yearly value.

The methodology is the same as the 1990-1999 inventory, but the emission factors have been updated as of June 2003.

<u>Line 27—Mobile Source Combustion</u>

Methane emissions from mobile sources were obtained in the same manner explained above for the petroleum supply system, except the data was generated by ARB staff, not local air quality districts. This updated data source is similar to the overall approach used in the 1990-1999 inventory, except it uses ARB computer representation of the California fleet and is likely to be more detailed than the 1990-1999 approach.

The ARB provided data for gasoline vehicles (passenger cars, light-, medium-, and heavy-duty vehicles, boats, off-road vehicles, motorcycles, and others), for diesel vehicles (passenger cars, light-, medium-, and heavy-duty trucks), and for aviation.

<u>Line 28—Stationary Source Combustion</u>
Methane emissions from electricity combustion were developed in the following manner:

1. Obtain coal, oil, natural gas, and wood higher heating value (HHV) energy consumption data from the EIA for 1990 to 2004.

2. Multiply by 0.95 (for coal and oil) or by 0.90 (for natural gas and wood) to convert HHV to lower heating value (LHV).

3. Multiply by 1055 to convert from LHV BTUs to Joules.

4. Multiply by the appropriate emission factor (1.0 for natural gas and coal, 3.0 for petroleum, and 30.0 for wood) to convert from gigajoule to grams of methane.

5. Adjust to million metric tons.

6. Multiply by the GWP (21 for methane, second assessment report) to convert to CO_2-equivalents.

Methane emissions from other stationary source combustion were developed in the same manner explained above for the petroleum supply system, using data from the ARB. The ARB data were not used for electricity production because the data indicated that these values were only for cogeneration. The ARB values were lower, which is consistent with the fact that they did not include all electricity production.

Industrial stationary source methane emissions include gasoline and diesel used in a variety of equipment, including manufacturing and industrial sectors, food and agricultural processing, off-road equipment of all types, ships and commercial boats, and trains. Industrial methane emissions also include natural gas used in airport ground equipment, mineral processing, surface treatment, industrial equipment, and other industrial processes.

Commercial stationary source methane emissions include diesel and liquefied petroleum gas used in trains, asphalt paving and roofing, commercial lawn and garden equipment, boats, and others. Commercial methane emissions also include natural gas emissions from commercial water and space heating, cooking, and commercial off-road equipment. Another commercial activity is commercial cooking. Additional commercial methane emissions are associated with wood and paper processing.

Residential stationary source methane emissions include LPG and distillate oil combustion; natural gas used in water heating, space heating, and cooking. Residential methane emissions are also associated with wood combustion in wood stoves and fireplaces.

Other stationary source methane emissions include timber and brush fires, structure fires, and other processes not specified.

Nitrous Oxide Emissions

Nitrous oxide (N_2O) emissions occur from nitric acid production, waste combustion, agricultural activities (agricultural soil management, manure management, and burning of agricultural residues), human sewage treatment, and from mobile and stationary fuel combustion. Nitrous oxide emissions are converted into CO_2-equivalent emissions by multiplying the N_2O emissions in millions of metric tons by their 100-year GWP. For this inventory, we choose a GWP from the Second Assessment Report to be consistent with IPPC guidance and the U.S. EPA methodology. The GWP for nitrous oxide emissions is 310 times CO_2 emissions. In the previous report covering the 1990 to 2002 period, some subcategories were inadvertently evaluated using 296 times rather than 310 times. Once the newer GWPs become accepted for use (from the Third Assessment Report or later), all will be evaluated using the newer number. In the meantime, the data have been made consistent using the older GWP, 310.

Line 29—Nitrous Oxide Total Emissions
This line is the sum of Lines 30 to 37.

Line 30—Nitric Acid Production
Nitric acid is used for producing synthetic fertilizer; making adipic acid, rocket propellant, and explosives; for treating stainless steel; for metal etching; and processing nuclear fuel. Nitrous oxide is a by-product of making nitric acid.

California's nitrous oxide emissions were estimated using the same method as the 1990-1999 GHG inventory.[82] The first step was to develop a ratio of California's nitric acid production capacity to the federal production capacity and then multiplying this ratio times the national estimates of CO_2-equivalent nitrous oxide emissions from nitric acid production.

California's nitric acid production capacity data were available for 1990, 1992, 1993, 1995, 1996, and 1998. Values for intervening years were estimated by interpolation, and values after 1998 were held constant at 1998 capacity. California's percentage of the national production capacity decreased steadily from 3.0 percent in 1990, to 1.4 percent in 1998. Thus, holding this percentage constant for 1999 through 2004 may slightly overstate California's nitrous oxide emissions from nitric acid production.

Line 31—Waste Combustion

CO_2 and nitrous oxide emissions to the atmosphere occur when MSW is combusted to make electricity. See Line 14 (above) for a brief description of waste combustion and resulting CO_2 emissions. Nitrous oxide emissions are estimated in the same manner but using an emission factor of 0.0001 ton of nitrous oxide emitted per ton of municipal solid waste combusted.

Line 32—Agricultural Soil Management

Nitrous oxide emissions from agricultural soils are affected by fertilizer use, amounts and types of residues incorporated into the soil, the type of soil, animal manures, and the amount of leaching and runoff. This method is the same as used in the 1990-1999 GHG emissions inventory with the following exception.

In the 1990-1999 inventory, the residue tonnages produced and incorporated into the soil were based on a residue-to-crop mass ratio. When these tonnages were compared to the total tonnages produced based on California factors (see Burning Ag Residues), they were up to five times greater than were calculated for agricultural burning. Therefore, the residue-to-crop mass ratio and the fraction of residue applied was adjusted down for barley, corn, rice, and wheat to reflect California factors for the amount of residue produced per acre and the fractions not burned. California specific factors for sorghum, oats, rye, soybeans, peanuts, and beans were not determined for this inventory.

Line 33—Manure Management

Nitrous oxide emissions from manure (and urine) occur from a nitrification process when ammonia in the waste first decomposes to nitrites in the presence of oxygen (aerobic conditions), followed by further decomposition to nitrous oxide under anaerobic conditions. Dry lot systems are generally aerobic. However, these may evolve to anaerobic conditions after rainfall.

A portion of the nitrous oxide generated from these wastes is included under Agricultural Soil Management (Line 32), including manure and urine in pastures and rangeland, and in paddocks, as well as manure used as a soil amendment. The remaining sources of nitrous oxide from manure management are estimated in this category of emissions.

Nitrous oxide emissions from this sector depend heavily on amount of un-volatilized organic nitrogen and ammonia in manure. This is called "total Kjeldahl nitrogen" and is estimated by multiplying animal population times TAM and the ratio of TAM to Kjeldahl nitrogen, times 0.80 (80 percent is assumed to not volatialize) and remain behind to decompose. All values are specific to type of animal and the feeding regimen. TAM and Kjeldahl nitrogen values are based on national animal characteristics and should be updated to reflect California-specific values in future updates to the inventory.

Line 34—Burning Agricultural Residues

Crop-specific nitrous oxide emissions are calculated in the same manner as methane emissions from burning agricultural residues (Line 25), except nitrous oxide emissions factors are substituted for methane emissions factors.

Line 35—Wastewater (formerly, Human Sewage)

Nitrous oxide emissions occur as a natural by-product of organic-laden domestic (human sewage) and industrial waste water, converting nitrate to nitrous oxide under anaerobic conditions.

Municipal wastewater emits nitrous oxide as a consequence of nitrogen in protein digested in the human diet. These emissions are estimated in the following steps:

- Obtain U.S. per capita protein consumption from the EPA Emissions Inventory Improvement Program guidance document[83] (this data shows the same value for 1998 to 2000, analysis assumes the value also applies through 2004).
- Multiply by the state population for each year,
- Multiply by 0.01 kilogram N_2O-N per kilogram N,
- Multiply by 44/28 (ratio of molecular weight of nitrous oxide to atomic weight of nitrogen),
- Multiply by GWP of nitrous oxide to obtain metric tons of CO_2- equivalent,
- Divide by 1,000,000 to get million metric tons CO_2-equivalent.

This is the same approach used in the 1990-1999 GHG emissions inventory.

Industrial wastewater emissions occur from processing fruits and vegetables, red meat and poultry, and pulp and paper. These are not yet included in the California inventory but should be added.

Line 36—Mobile Source Combustion

Combustion of gasoline and diesel in internal combustion engines releases small quantities of nitrous oxide in the exhaust. The rate of emissions depends on engine type and type of pollution control applied to the engine.

ARB staff provided annual nitrous oxide emissions from gasoline and diesel fueled vehicles from their EMFAC model. These were adjusted to tons per year by multiplying by 365, then from short tons to metric tons by multiplying by 0.9072, and by the nitrous oxide GWP to convert to CO_2-equivalents.

Line 37—Stationary Source Combustion
Nitrous oxide data were not available from the ARB. Instead, emissions were calculated using fuel consumption data from the EIA's *State Energy Data Report* for 1990 to 2001. Because data were no more current than 2001 and magnitude of emissions is small, values for 2002 through 2004 were assumed to equal 2001 values. Values were derived for electricity generation, industrial, commercial/ institutional, and residential fuel uses. The process is the same as Line 28, Stationary Source Combustion (methane) for electricity production, except the emission factor in Step 4 is replaced with the appropriate value for nitrous oxide, in units of grams nitrous oxide per gigajoule of fuel use: coal = 1.4, petroleum = 0.6, natural gas = 0.1, and wood = 4.0

High GWP Gas Emissions

High GWP gas emissions include atmospheric release of gases used in place of ozone-depleting gases, semiconductor manufacturing, and electricity transmission and distribution. Substitution of ozone-depleting gases involves a number of hydrofluorocarbons (HFCs).

High GWP gas emissions are converted into CO_2-equivalent emissions by multiplying the methane emissions in millions of metric tons by their 100-year GWP. For this inventory, we choose GWPs for each gas from the Second Assessment Report to be consistent with IPPC guidance and the U.S. EPA methodology. The GWP for high GWP gases is different for each gas. Most of the values used in this inventory are shown in Table 5 of the 1990-1999 California GHG inventory.[84]

Line 38—High GWP Gas Total Emissions
This line is the sum of Lines 39 to 41.

Line 39—Substitution of Ozone-Depleting Substances
Several anthropogenic substances have been linked to ozone depletion over the Earth's Polar Regions and are being phased out due to international agreements. These ozone-depleting substances (ODS) were historically used in industrial refrigeration and space conditioning equipment, solvents, foams, etc. A wide range of replacement substances are being used in increasing amounts in the United States, and these are associated with global warming.

California ODS GHG emissions were estimated by scaling U. S. ODS emissions by the ratio of California-to-United States population, about 12 percent. This is the same method used in the 1990-1999 GHG inventory.[85]

Line 40—Semiconductor Manufacture

Semiconductor manufacturing releases several compounds that have strong global warming impacts, including trifluoromethane, perfluoromehtane, perfluoroethane, and SF_6. The exact combination of compounds is difficult to estimate.

California GHG emissions from semiconductor manufacturing operations were estimated by scaling U.S. semiconductor manufacturing emissions by the ratio of California-to-United States population, about 12 percent. This is the same method as the 1990-1999 GHG emissions inventory.[86] This approach may underestimate California emissions due to the significance of this industry to California.

Line 41—Electricity Transmission & Distribution (Sulfur Hexafluoride)

Electricity transmission and distribution requires the use of circuit breakers, gas-insulated substations, and switch gear. Sulfur hexafluoride (SF_6) is used to insulate this equipment and can leak out, especially in older equipment. Emissions also occur during installation and servicing.

The Second Assessment Report GWP for SF_6 is 23,900 times that of CO_2, so a small amount of SF_6 can significantly impact global warming. Fortunately, California utilities are finding that they can reduce maintenance costs by better management of SF_6. However, since California-specific data are not currently available, SF_6 emissions are estimated from national values, prorated by ratio of California to national energy consumption, expressed in GWh. This method is the same method as the 1990-1999 GHG inventory.[87] This approach probably overstates California's sulfur hexafluoride emissions because California utilities are implementing procedures to control their SF_6 emissions and reduce their maintenance costs.[88]

Table A-1. Fossil Fuel Emissions Factors and Percentage Oxidized (Fuels Where Values Do Not Vary from Year to Year)

Fuel	Percent Oxidized	Emission Factor (lb C/mm BTU)
Natural Gas	99.5	31.9
Petroleum Products		
- Asphalt	99	45.5
- Aviation Gasoline	99	41.6
- Distillate	99	44.0
- Jet Fuel	99	43.5
- Kerosene	99	43.5
- Liquefied Petroleum Gas	99.5	37.8
- Motor Gasoline	99	42.8
- Misc. Petroleum Products	99	44.7
- Petroleum Coke	99	61.4
- Refinery Still Gas	99	38.6

Table A-2. Fossil Fuel Emissions Factors and Percentage Oxidized
(Fuels Where Values Vary from Year to Year)

	Percent Oxidized	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000 to 2004
Coal												
- Commercial	99	55.66	55.69	55.66	55.66	55.66	55.66	55.66	55.66	55.67	55.66	55.66
- Industrial	99	55.80	55.80	55.69	55.66	55.66	55.66	55.66	55.71	55.79	55.80	55.80
- Utility	99	56.62	56.65	56.65	56.67	56.70	56.75	56.75	56.78	56.78	56.78	56.78

(Assume 2000 to 2004 values are constant at 1999 values)

Table A-3. Minerals Production in California
(Thousand Metric Tons)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002-04
Cement													
- Portland	8,874	8,178	7,289	8,510	9,640	9,360	9,910	10,300	10,000	10,300	10,900	10,100	11,200
- Masonry					99	154	198	169	410	466	484	564	637
Total Cement	8,874	8,178	7,289	8,510	9,739	9,514	10,108	10,469	10,410	10,766	11,384	10,664	11,837
Lime Production	313.2	278.7	254.2	193.0	203.2	228.2	207.9	199.7	185.2	181.6	185.7	182.2	178.6
								(Shaded areas extrapolated from 1993-98)					
Limestone & Dolomite		17.8		18.2	23.5	23.4	25.3	23.2	25.0	26.9	28.3	27.9	35.7
	(1990 assumed equal to 1991; 1992 assumed equal to 1993)												
Soda Ash Consumption	522	502	506	502	501	520	511	518	514	514	511	510	514

Table A-4 Full Detail--California Greenhouse Gas Emissions ($MMTCO_2E$)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Carbon Dioxide	**317.43**	**310.78**	**316.28**	**311.35**	**329.76**	**313.68**	**318.60**	**328.82**	**346.40**	**348.69**	**368.30**	**372.52**	**365.35**	**347.08**	**355.88**
Residential	**28.97**	**29.54**	**27.86**	**28.42**	**29.26**	**26.65**	**26.61**	**26.34**	**30.60**	**31.91**	**30.25**	**27.21**	**27.32**	**26.40**	**27.86**
Natural Gas	27.52	27.84	26.62	27.15	28.00	25.46	25.59	25.41	29.12	30.50	28.53	25.92	25.98	25.06	26.49
Petroleum	1.44	1.70	1.24	1.27	1.26	1.20	1.02	0.93	1.49	1.41	1.71	1.29	1.34	1.33	1.37
LPG	1.30	1.57	1.09	1.14	1.13	1.11	0.92	0.83	1.38	1.29	1.55	1.07	1.20	1.20	1.20
Kerosene	0.05	0.04	0.05	0.04	0.04	0.01	0.03	0.03	0.04	0.05	0.06	0.10	0.08	0.08	0.11
Distillate	0.09	0.08	0.10	0.10	0.10	0.08	0.06	0.07	0.07	0.08	0.11	0.13	0.06	0.05	0.06
Commercial	**12.65**	**11.99**	**9.70**	**9.61**	**10.25**	**9.80**	**9.58**	**9.61**	**13.49**	**14.77**	**15.63**	**12.04**	**17.84**	**15.06**	**12.19**
Coal	0.05	0.09	0.00	0.27	0.34	0.27	0.38	0.22	0.23	0.06	0.05	0.00	0.00	0.00	0.00
Natural Gas	9.40	8.71	7.94	8.00	8.59	7.83	7.82	8.07	11.70	13.15	13.88	10.46	16.56	13.93	11.13
Education	1.41	1.27	1.08	1.12	1.27	0.98	0.94	1.04	1.26	1.38	1.39	0.95	1.14	1.10	1.15
College	0.69	0.60	0.53	0.54	0.69	0.51	0.47	0.56	0.68	0.74	0.84	0.54	0.62	0.63	0.66
School	0.71	0.67	0.55	0.57	0.58	0.47	0.47	0.48	0.58	0.64	0.55	0.41	0.53	0.47	0.49
Food Services	1.88	1.87	1.85	1.87	1.90	1.89	1.94	2.02	2.15	2.26	2.33	2.10	2.23	2.33	2.49
Restaurant	1.62	1.63	1.61	1.62	1.64	1.64	1.68	1.74	1.84	1.93	1.99	1.80	1.93	2.02	2.11
Food & Liquor	0.25	0.25	0.24	0.25	0.26	0.25	0.26	0.28	0.31	0.33	0.33	0.31	0.30	0.30	0.38
Retail & Wholesale	0.60	0.55	0.54	0.61	0.65	0.59	0.49	0.55	0.56	0.62	0.60	0.22	0.58	0.58	0.57
Retail	0.29	0.26	0.22	0.23	0.24	0.19	0.19	0.19	0.19	0.23	0.25	0.22	0.20	0.26	0.27	0.25
Warehouse	0.31	0.29	0.32	0.24	0.26	0.37	0.27	0.32	0.30	0.33	0.33	0.00	0.29	0.27	0.26
Warehouse, refrigerated	0.00	0.00	0.00	0.15	0.15	0.03	0.03	0.03	0.04	0.04	0.04	0.02	0.03	0.04	0.06
Health Care	1.31	1.32	1.12	1.05	1.22	1.13	1.14	1.15	1.24	1.35	1.31	1.15	1.18	1.21	1.27
Hotel	0.67	0.65	0.62	0.60	0.62	0.60	0.60	0.61	0.64	0.67	0.67	0.61	0.62	0.61	0.63
Office	1.45	1.39	1.27	1.31	1.40	1.31	1.36	1.35	1.54	1.75	1.60	1.35	1.82	1.78	1.87
Transportation Services	0.03	0.04	0.03	0.04	0.04	0.03	0.04	0.03	0.05	0.06	0.06	0.04	0.00	0.00	0.00
Transportation	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Water Transportation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Airports	0.02	0.03	0.02	0.03	0.03	0.02	0.04	0.02	0.04	0.05	0.04	0.03	0.00	0.00	0.00
Communication	0.07	0.07	0.06	0.04	0.06	0.06	0.06	0.08	0.06	0.07	0.06	0.05	0.10	0.08	0.08
U.S. Postal Service	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
Telephone & Cell Phone Service	0.05	0.05	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.01	0.01
Other Message Communication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04	0.04
Radio Broadcasting Stations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Non-Specified (Communication)	0.00	0.00	0.00	0.00	0.02	0.01	0.02	0.03	0.01	0.01	0.01	0.01	0.00	0.01	0.01
Utilities	0.34	0.33	0.36	0.27	0.29	0.32	0.41	0.39	3.98	4.10	4.85	3.16	3.51	3.86	2.89
Electric, Nat'l Gas, Steam	0.14	0.16	0.16	0.10	0.11	0.12	0.17	0.15	3.71	3.79	4.53	2.94	3.34	3.47	2.43
Sewerage Systems	0.07	0.07	0.08	0.07	0.08	0.09	0.13	0.13	0.18	0.17	0.16	0.14	0.08	0.13	0.26
Water Supply	0.12	0.10	0.11	0.10	0.10	0.10	0.11	0.11	0.10	0.13	0.16	0.09	0.09	0.25	0.20
Street Lights	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
National Security	0.56	0.64	0.54	0.54	0.50	0.40	0.36	0.46	0.34	0.29	0.24	0.30	0.17	0.17	0.18
Non-specified (Services)	1.09	0.57	0.48	0.56	0.65	0.53	0.47	0.40	-0.12	0.60	0.78	0.52	5.21	2.21	0.00
Petroleum	3.20	3.18	1.77	1.35	1.32	1.70	1.38	1.32	1.55	1.56	1.70	1.58	1.28	1.12	1.05
LPG	0.23	0.28	0.19	0.20	0.20	0.20	0.16	0.15	0.24	0.23	0.23	0.23	0.23	0.23	0.23
Motor Gasoline	0.71	0.61	0.55	0.10	0.08	0.09	0.08	0.08	0.09	0.08	0.09	0.09	0.09	0.09	0.10
Kerosene	0.07	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.03	0.01	0.02	0.03
Distillate	1.78	1.89	0.99	1.03	1.03	1.40	1.12	1.09	1.17	1.22	1.37	1.21	0.95	0.78	0.70
Residual Oil	0.41	0.37	0.02	0.01	0.00	0.00	0.01	0.00	0.04	0.00	0.00	0.02	0.00	0.00	0.00
Industrial	**66.12**	**64.77**	**61.32**	**64.30**	**66.00**	**62.58**	**68.81**	**73.00**	**75.37**	**70.96**	**76.17**	**80.48**	**71.53**	**65.47**	**67.13**
Natural Gas	27.81	27.56	24.25	24.70	25.15	28.31	31.89	35.24	38.72	35.09	36.70	36.66	31.34	27.30	30.41
Agriculture	0.54	0.50	0.48	0.41	0.62	0.53	0.59	0.66	0.72	0.86	0.95	0.63	0.65	0.64	0.67
Crop Production	0.44	0.42	0.41	0.34	0.45	0.40	0.49	0.57	0.63	0.70	0.75	0.54	0.57	0.57	0.61
Livestock Production	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.08	0.09	0.07	0.07	0.06	0.07
Irrigation	0.04	0.02	0.02	0.02	0.12	0.08	0.05	0.04	0.03	0.08	0.11	0.03	0.01	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining	0.03	0.03	0.04	0.04	0.04	0.31	0.34	0.32	0.39	0.32	0.33	0.30	0.39	0.41	0.13
Metal	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minerals	0.03	0.03	0.04	0.04	0.04	0.30	0.34	0.32	0.39	0.32	0.33	0.29	0.39	0.41	0.13
Manufacturing	12.32	11.68	10.51	10.43	11.04	11.10	11.47	11.14	12.57	12.04	12.37	13.07	10.72	8.28	7.73
Food	3.05	3.25	3.21	3.26	3.25	3.16	3.11	3.14	3.56	3.74	3.72	3.17	3.15	2.83	3.02
Food Processing	1.19	1.32	1.36	1.33	1.24	1.35	1.39	1.37	1.60	1.66	1.51	1.19	1.43	1.24	1.30
Sugar & Confections	0.46	0.47	0.37	0.41	0.47	0.42	0.27	0.23	0.30	0.36	0.40	0.34	0.00	0.00	0.00
Non-specified (Food Processing)	1.40	1.46	1.49	1.53	1.53	1.39	1.44	1.54	1.66	1.73	1.81	1.64	1.73	1.59	1.72
Tobacco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A-4 Full Detail--California Greenhouse Gas Emissions ($MMTCO_2E$)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Textiles	0.38	0.35	0.35	0.39	0.43	0.43	0.45	0.48	0.51	0.56	0.57	0.46	0.10	0.08	0.09
Textile Mills	0.32	0.30	0.31	0.34	0.38	0.39	0.40	0.43	0.46	0.52	0.53	0.42	0.07	0.06	0.07
Leather	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apparel	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.03	0.03	0.02	0.02
Wood & Furniture	0.23	0.22	0.23	0.25	0.26	0.40	0.35	0.30	0.31	0.30	0.30	0.32	0.16	0.13	0.11
Lumber & Wood Products	0.18	0.18	0.19	0.22	0.22	0.36	0.31	0.27	0.26	0.26	0.26	0.28	0.12	0.09	0.07
Furnature & Fixtures	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.04	0.04	0.04	0.04
Pulp & Paper	1.79	1.52	1.04	1.15	1.55	1.57	1.84	1.48	1.78	1.39	1.61	1.43	0.93	0.94	0.56
Pulp Mills	0.06	0.08	0.13	0.05	0.03	0.00	0.00	0.00	0.20	0.00	0.20	0.00	0.00	0.00	0.00
Paper Mills	0.39	0.33	0.25	0.40	0.67	0.65	0.71	0.48	0.57	0.56	0.54	0.50	0.74	0.66	0.37
Paperboard Mills	0.90	0.73	0.35	0.40	0.54	0.65	0.82	0.72	0.69	0.53	0.58	0.63	0.00	0.09	0.00
Non-specified (Pulp & Paper)	0.44	0.38	0.32	0.30	0.30	0.27	0.31	0.28	0.32	0.30	0.29	0.30	0.19	0.18	0.18
Printing & Publishing	0.11	0.12	0.11	0.12	0.13	0.15	0.14	0.14	0.15	0.15	0.12	0.11	0.08	0.08	0.08
Chemicals & Allied Products	1.75	1.57	1.21	0.97	1.12	1.11	1.16	0.98	1.31	1.05	1.28	1.06	1.04	0.61	0.63
Plastics & Rubber	0.23	0.22	0.19	0.19	0.19	0.20	0.20	0.23	0.25	0.27	0.27	0.20	0.00	0.00	0.00
Plastics	0.18	0.17	0.15	0.15	0.15	0.16	0.16	0.18	0.21	0.22	0.23	0.16	0.00	0.00	0.00
Non-specified (Plastics & Rubber)	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.00	0.00	0.00
Stone, Clay, Glass, Cement & Other	1.82	1.64	1.60	1.53	1.47	1.54	1.64	1.70	1.87	1.70	1.67	1.49	1.31	1.22	1.32
Flat Glass	0.09	0.06	0.08	0.09	0.08	0.09	0.16	0.17	0.16	0.17	0.15	0.12	0.00	0.00	0.00
Glass containers	0.68	0.64	0.62	0.61	0.60	0.53	0.53	0.51	0.54	0.51	0.50	0.45	0.57	0.53	0.53
Cement	0.18	0.19	0.17	0.19	0.13	0.19	0.19	0.16	0.23	0.14	0.16	0.11	0.17	0.17	0.18
Non-specified (Stone, Clay, Glass & Cement)	0.87	0.75	0.73	0.65	0.66	0.73	0.77	0.86	0.94	0.88	0.86	0.82	0.56	0.53	0.60
Primary Metals	0.94	0.89	0.75	0.76	0.85	0.79	0.82	0.84	0.86	0.88	0.91	0.75	0.67	0.67	0.46
Metal Durables	0.91	0.82	0.77	0.78	0.76	0.79	0.81	0.83	0.86	0.81	0.81	0.75	0.81	0.68	0.78
Fabricated Metal Products	0.58	0.58	0.55	0.55	0.53	0.56	0.57	0.59	0.60	0.59	0.60	0.57	0.53	0.44	0.48
Computers & Office Machines	0.13	0.12	0.10	0.10	0.09	0.08	0.08	0.08	0.09	0.09	0.09	0.07	0.17	0.15	0.17
Industrial Machinery & Equipment	0.20	0.12	0.12	0.13	0.14	0.15	0.16	0.16	0.17	0.13	0.12	0.10	0.10	0.09	0.13
Electric & Eletronic Equipment	0.35	0.33	0.32	0.29	0.29	0.28	0.29	0.31	0.33	0.37	0.34	0.26	0.21	0.18	0.15
Telephone & Broadcasting Equipment	0.06	0.04	0.04	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.00	0.00	0.00
Semiconductors & Related Products	0.19	0.20	0.19	0.18	0.18	0.18	0.20	0.21	0.22	0.23	0.22	0.16	0.17	0.15	0.12
Non-specified (Elec. Equipment)	0.10	0.09	0.09	0.09	0.08	0.08	0.07	0.08	0.09	0.11	0.09	0.07	0.04	0.03	0.03
Transportation Equipment	0.53	0.53	0.53	0.51	0.51	0.47	0.43	0.44	0.48	0.51	0.50	0.44	0.41	0.28	0.25
Instruments & Related Products	0.07	0.09	0.08	0.10	0.09	0.08	0.09	0.09	0.10	0.11	0.10	0.09	0.00	0.00	0.00
Construction	0.12	0.11	0.08	0.09	0.09	0.09	0.11	0.13	0.15	0.13	0.12	0.10	0.09	0.10	0.17
Non-specified (Industrial)	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.06	0.06	0.06	2.43	1.76	0.47	0.13
Energy Industrial Sector	14.78	15.28	13.14	13.78	13.43	16.34	19.42	23.04	24.94	21.76	22.98	22.55	19.48	17.84	21.79
Transformation at Refinery	0.00	0.00	0.00	1.30	1.89	1.26	2.62	2.01	2.52	1.87	2.07	1.81	0.65	0.65	0.65
Refining	4.38	4.11	3.73	3.68	3.15	4.27	5.61	5.86	5.48	5.00	5.57	4.87	5.45	1.82	6.68
Oil & Gas Extraction	10.39	11.17	9.41	8.81	8.39	10.81	11.18	15.18	16.94	14.90	15.34	15.86	13.38	15.36	14.47
Flaring	0.15	0.07	0.08	0.04	0.03	0.04	0.07	0.07	0.09	0.10	0.07	0.11	0.09	0.14	0.08
Natural Gas Liquids	0.10	0.06	0.08	0.08	0.08	0.07	0.04	0.04	0.04	0.04	0.21	0.19	0.03	0.03	0.03
Petroleum	35.23	34.15	34.41	37.65	38.57	31.85	34.06	34.38	32.77	31.44	34.95	39.44	35.90	33.87	32.51
LPG	1.63	1.47	2.36	1.65	1.80	1.34	1.01	0.84	0.66	0.78	0.76	0.97	0.76	0.99	0.88
Manufacturing	0.83	0.55	0.79	0.59	0.64	0.55	0.45	0.39	0.37	0.52	0.30	0.30	0.51	0.51	0.51
Chemicals & Allied Products	0.19	0.19	0.22	0.21	0.22	0.22	0.24	0.24	0.25	0.26	0.24	0.22	0.22	0.22	0.22
Non-specified (Industry)	0.64	0.36	0.58	0.39	0.42	0.33	0.21	0.14	0.12	0.26	0.06	0.08	0.29	0.29	0.29
Oil Refinery Use	0.80	0.92	1.57	1.05	1.16	0.79	0.56	0.46	0.29	0.25	0.47	0.66	0.25	0.48	0.37
Motor Gasoline	1.17	1.21	1.22	0.99	1.02	1.05	0.99	1.04	1.17	0.69	0.71	1.64	1.74	1.81	2.04
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.51	0.51	0.59
Non-specified (Agriculture)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.39	0.40	0.51
Non-speified (Industrial)	1.17	1.21	1.22	0.99	1.02	1.05	0.99	1.04	1.17	0.69	0.71	0.81	0.85	0.90	0.95
Refinery Still Gas	15.69	15.63	15.11	18.72	18.95	13.26	15.33	15.16	14.93	13.66	13.12	14.80	14.70	15.68	14.84
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.05	0.07	0.07	0.03	0.01	0.02
Industrial	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.07	0.06	0.01	0.01	0.01
Agricultural	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Distillate	7.35	6.01	5.45	5.63	6.09	5.12	5.12	6.07	5.61	6.51	8.16	9.18	6.28	4.62	5.92
Agriculture	3.29	2.70	3.17	3.10	3.17	2.55	2.87	3.62	3.33	3.91	3.98	3.99	3.58	2.82	3.35
Industry	3.85	3.20	2.14	2.37	2.77	2.47	2.20	2.39	2.22	2.48	4.09	5.07	2.58	1.70	2.44
Oil and Gas Extraction	0.21	0.11	0.14	0.16	0.14	0.10	0.05	0.05	0.06	0.11	0.10	0.10	0.12	0.10	0.12
Oil Refinery Use	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Residual Oil	0.82	0.81	0.81	0.75	0.74	0.77	0.21	0.10	0.08	0.33	0.05	0.23	0.09	0.02	0.01
Refining	0.21	0.21	0.16	0.18	0.18	0.12	0.09	0.06	0.06	0.03	0.00	0.00	0.00	0.00	0.00
Oil & Gas Extraction	0.01	0.03	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.22	0.07	0.01	0.00
Industry	0.59	0.57	0.58	0.57	0.56	0.65	0.12	0.04	0.02	0.28	0.05	0.01	0.02	0.02	0.01

Table A-4 Full Detail--California Greenhouse Gas Emissions ($MMTCO_2E$)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Petroleum Coke	6.76	7.48	7.76	8.20	8.42	8.87	10.09	9.83	8.71	7.59	10.56	10.97	10.56	9.23	7.48
Oil Refinery Use	6.76	7.42	7.61	7.66	7.52	7.43	9.50	9.09	8.07	6.95	9.77	10.25	9.71	8.38	6.63
Cement	0.00	0.05	0.15	0.55	0.90	1.43	0.60	0.74	0.65	0.64	0.79	0.72	0.85	0.85	0.85
Lubricants	0.87	0.78	0.79	0.81	0.84	0.83	0.81	0.85	0.89	0.90	0.89	1.08	1.07	0.99	1.00
Waxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asphalt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Special Naptha	0.93	0.75	0.89	0.89	0.69	0.60	0.48	0.47	0.69	0.94	0.63	0.51	0.66	0.52	0.33
Other Petroleum Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	2.98	3.00	2.58	1.87	2.20	2.35	2.81	3.34	3.85	4.39	4.30	4.18	4.26	4.27	4.18
Transportation	**161.08**	**156.70**	**161.88**	**158.85**	**163.86**	**166.16**	**167.38**	**170.84**	**173.34**	**176.26**	**181.68**	**182.49**	**190.19**	**180.64**	**187.95**
Natural Gas	0.16	0.18	0.17	0.17	0.17	0.17	0.21	1.42	0.71	0.73	0.77	0.78	0.74	0.65	0.87
Rail	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Road	0.06	0.06	0.05	0.06	0.07	0.07	0.10	0.11	0.12	0.14	0.14	0.11	0.09	0.07	0.05
Freight	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02
Passenger	0.02	0.02	0.02	0.02	0.03	0.03	0.05	0.05	0.05	0.06	0.07	0.05	0.03	0.03	0.01
Private Auto	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Taxi & Buses	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.00	0.00	0.00
Non-spedified (Local Transit)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.02	0.03	0.03	0.01
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Air	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.04	0.01	0.06	0.06	0.06
Non-specified (Air Transport)	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.04	0.01	0.06	0.06	0.06
Pipeline	0.07	0.09	0.09	0.09	0.07	0.08	0.09	1.29	0.55	0.57	0.57	0.64	0.57	0.50	0.74
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.21	0.48	0.50	0.50	0.56	0.50	0.45	0.67
Other Than Natural Gas Pipeline	0.07	0.09	0.09	0.09	0.07	0.08	0.09	0.08	0.07	0.06	0.07	0.08	0.07	0.05	0.07
Petroleum	160.92	156.52	161.71	158.69	163.69	165.99	167.17	169.42	172.62	175.53	180.92	181.71	189.45	179.98	187.09
LPG	0.21	0.17	0.15	0.15	0.23	0.13	0.11	0.08	0.15	0.09	0.36	0.43	0.19	0.19	0.19
Motor Gasoline	111.33	108.69	115.01	113.14	112.72	114.84	113.85	114.51	116.91	120.21	122.01	125.28	130.97	126.30	130.92
Aviation Gasoline	0.38	0.38	0.37	0.28	0.27	0.28	0.27	0.29	0.20	0.29	0.25	0.23	0.25	0.25	0.21
Jet Fuel	24.00	22.77	21.92	22.56	24.98	24.10	26.24	26.08	26.64	24.95	26.04	24.58	25.87	20.92	22.24
Domestic Jet Fuel Aviation	24.00	22.77	21.92	22.56	24.98	24.10	26.24	26.08	26.64	24.95	26.04	24.58	25.87	20.92	22.24
Distillate	22.66	22.49	22.50	20.79	23.55	24.48	24.65	26.78	27.02	28.08	30.23	29.58	30.61	31.02	32.16
Railroad	2.24	2.37	2.16	1.90	2.06	2.35	2.51	2.48	2.61	2.70	2.97	2.80	2.94	2.69	3.08
Road Transportation	18.28	17.78	18.52	18.33	19.95	21.00	21.26	22.99	23.50	24.70	26.45	26.40	27.17	27.87	28.58
Water Transportation	0.30	0.69	0.41	0.14	0.44	0.02	0.06	1.09	0.68	0.57	0.71	0.00	0.00	0.05	0.00
Non-specified (Transport)	1.82	1.64	1.43	0.41	1.10	1.12	0.82	0.21	0.23	0.11	0.10	0.38	0.50	0.41	0.50
Residual Oil	1.19	0.97	0.70	0.68	0.82	1.07	0.98	0.56	0.51	0.72	0.84	0.79	0.77	0.56	0.61
Water Transportation	1.19	0.97	0.69	0.67	0.81	0.99	0.91	0.52	0.50	0.71	0.84	0.79	0.76	0.55	0.61
Non-specified (Transport)	0.00	0.00	0.01	0.01	0.01	0.08	0.07	0.03	0.02	0.01	0.00	0.00	0.01	0.01	0.00
Lubricants	1.16	1.04	1.06	1.08	1.13	1.11	1.08	1.14	1.19	1.20	1.19	0.81	0.81	0.74	0.75
Electricity Generation (In State)	**36.53**	**36.62**	**43.75**	**40.10**	**48.27**	**36.41**	**33.90**	**36.49**	**39.85**	**43.03**	**51.93**	**56.09**	**41.86**	**44.08**	**47.14**
Natural Gas	36.42	36.51	43.61	39.96	48.13	36.28	33.79	36.39	39.75	42.94	51.84	56.00	41.76	43.99	47.14
Commercial CHP	0.64	0.57	0.64	0.66	0.73	0.75	0.77	0.73	0.74	0.73	0.71	0.65	0.64	0.81	0.82
Electric CHP	6.46	6.70	7.36	7.65	7.87	7.85	7.80	8.23	8.16	8.15	7.98	7.30	9.60	8.21	9.12
Industrial CHP	4.19	4.52	4.38	4.41	4.55	4.58	5.05	4.75	4.78	4.76	4.73	4.80	5.22	4.90	7.49
Utility	24.89	24.37	30.78	25.34	32.66	21.40	17.23	20.33	14.57	7.68	6.85	6.35	4.73	5.20	5.37
Merchant Power	0.24	0.35	0.46	0.62	0.42	0.42	0.34	0.34	9.05	19.78	29.44	35.04	20.91	20.58	23.99
Refinery Self Generation	0.00	0.00	0.00	1.29	1.91	1.28	2.60	2.01	2.44	1.84	2.13	1.86	0.67	4.29	0.36
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	0.11	0.11	0.13	0.14	0.13	0.13	0.11	0.10	0.09	0.10	0.10	0.09	0.10	0.09	0.00
Electric CHP	0.07	0.10	0.10	0.11	0.10	0.09	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.08	0.00
Industrial CHP	0.04	0.01	0.03	0.03	0.04	0.03	0.03	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Merchant Power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Not Sector-Specific; Other End Use	**1.09**	**0.57**	**0.48**	**0.56**	**0.65**	**0.53**	**0.47**	**0.40**	**-0.12**	**0.60**	**0.88**	**0.68**	**5.38**	**2.38**	**0.17**
Natural Gas	1.09	0.57	0.48	0.56	0.65	0.53	0.47	0.40	-0.12	0.60	0.78	0.52	5.21	2.21	0.00
Liqueified Petroleum Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.17	0.17	0.17	0.17
Cement Production	**4.62**	**4.26**	**3.80**	**4.43**	**5.07**	**4.96**	**5.27**	**5.45**	**5.42**	**5.61**	**5.93**	**5.56**	**6.11**	**6.32**	**6.49**
Lime Production	**0.25**	**0.22**	**0.20**	**0.15**	**0.16**	**0.18**	**0.16**	**0.16**	**0.15**	**0.14**	**0.15**	**0.14**	**0.14**	**0.14**	**0.13**
Limestone & Dolomite Consumption	**0.16**	**0.15**	**0.13**	**0.13**	**0.17**	**0.23**	**0.26**	**0.20**	**0.21**	**0.25**	**0.18**	**0.17**	**0.23**	**0.19**	**0.27**
Soda Ash Consumption	**0.22**	**0.21**	**0.21**	**0.21**	**0.21**	**0.22**	**0.21**	**0.22**	**0.21**	**0.21**	**0.21**	**0.21**	**0.21**	**0.21**	**0.21**
Carbon Dioxide Consumption	**0.08**	**0.08**	**0.07**	**0.08**	**0.08**	**0.08**	**0.07**	**0.07**	**0.08**	**0.07**	**0.08**	**0.07**	**0.08**	**0.11**	**0.10**
Waste Combustion	**0.12**	**0.12**	**0.13**	**0.13**	**0.13**	**0.13**	**0.13**	**0.12**	**0.12**	**0.13**	**0.12**	**0.13**	**0.13**	**0.13**	**0.12**
Forests	**4.51**	**4.50**	**4.49**	**4.48**	**4.48**	**4.48**	**4.48**	**4.48**	**4.48**	**4.48**	**4.48**	**4.47**	**4.47**	**4.47**	**4.46**

Table A-4 Full Detail--California Greenhouse Gas Emissions ($MMTCO_2E$)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Rangeland	**0.65**	**0.65**	**0.65**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**	**0.64**
Woody Ag Soils	**0.27**	**0.27**	**1.15**	**(0.93)**	**(0.04)**	**(0.04)**	**(0.04)**	**(0.23)**	**(1.21)**	**(1.20)**	**(0.62)**	**0.96**	**0.21**	**0.41**	**0.44**
Non-Woody Ag Soils	**0.04**	**0.04**	**0.36**	**0.10**	**0.41**	**0.41**	**0.41**	**0.67**	**3.52**	**0.53**	**0.31**	**1.02**	**-1.24**	**0.21**	**0.34**
Ag soil Liming	**0.07**	**0.10**	**0.11**	**0.07**	**0.16**	**0.27**	**0.27**	**0.35**	**0.25**	**0.30**	**0.27**	**0.16**	**0.23**	**0.24**	**0.24**
Methane Emissions	**25.82**	**24.79**	**23.83**	**25.26**	**25.28**	**26.09**	**25.38**	**24.16**	**25.24**	**26.25**	**26.32**	**26.62**	**27.07**	**27.49**	**27.80**
Petroleum & Natural Gas Supply System	0.88	0.78	0.37	0.68	0.64	0.60	0.59	0.59	0.56	0.66	0.51	0.56	0.49	0.49	0.50
Field Production	0.87	0.76	0.37	0.67	0.63	0.59	0.58	0.58	0.55	0.65	0.50	0.56	0.48	0.48	0.50
Marketing	0.01	0.02	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Natural Gas Supply System	1.56	1.54	1.51	1.50	1.48	1.45	1.41	1.37	1.32	1.28	1.29	1.32	1.31	1.33	1.36
Processing	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.04	0.03	0.03	0.03	0.00	0.00	0.00
Transmission	1.51	1.48	1.46	1.44	1.42	1.40	1.35	1.32	1.28	1.26	1.26	1.29	1.30	1.33	1.36
Landfills	8.13	7.97	7.74	8.45	8.19	7.86	8.31	6.06	7.56	7.79	8.01	7.93	8.17	8.31	8.45
MSW (Class II & III)	8.10	7.95	7.74	8.42	8.18	7.84	7.09	6.05	5.69	7.75	7.96	7.83	8.03	8.16	8.30
Other Class II & III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.11	0.11	0.11	0.12
Others	0.02	0.02	0.00	0.03	0.01	0.02	1.22	0.01	1.87	0.00	0.00	0.00	0.03	0.03	0.03
Enteric Fermentation	7.53	7.25	7.37	6.59	7.14	7.25	6.77	6.88	6.84	7.08	6.70	7.01	7.05	7.19	7.17
Dairy Cattle	3.67	3.74	3.86	3.55	3.82	3.88	3.56	3.75	3.78	4.05	4.09	4.40	4.49	4.69	4.69
Beef Cattle	3.44	3.09	3.09	2.64	2.88	2.95	2.80	2.72	2.67	2.63	2.21	2.22	2.18	2.12	2.11
Horses	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.25	0.25	0.25	0.25	0.25	0.25
Sheep	0.17	0.17	0.17	0.15	0.18	0.17	0.15	0.15	0.13	0.14	0.14	0.14	0.13	0.12	0.11
Swine	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Goats	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manure Management	3.29	3.87	3.93	4.03	4.30	4.55	4.55	4.88	4.80	5.21	5.36	5.58	5.79	5.94	6.03
Beef Cattle	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08
Dairy Cattle	2.92	3.49	3.54	3.65	3.92	4.17	4.18	4.51	4.43	4.83	5.00	5.23	5.43	5.60	5.70
Swine	0.06	0.07	0.09	0.09	0.09	0.09	0.07	0.08	0.07	0.07	0.05	0.04	0.06	0.05	0.05
Poultry	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.15	0.14	0.14	0.14	0.13	0.13
Sheep	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Goats	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Horses	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Flooded Rice Fields	0.41	0.36	0.41	0.45	0.50	0.48	0.52	0.54	0.47	0.52	0.57	0.49	0.55	0.53	0.61
Burning Ag Residues	0.11	0.10	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12	0.10	0.10	0.10	0.10
Agricultural Crop Residues	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.03	0.03	0.03	0.03
Non-woody/Field	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.01	0.01	0.01	0.01
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.01	0.01	0.01
Wheat	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Woody/Orchard & Vineyard	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Almonds	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Walnuts	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Agricultural Waste Burning	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Wastewater Treatment	1.45	1.48	1.51	1.52	1.53	1.54	1.55	1.58	1.60	1.62	1.65	1.69	1.68	1.71	1.72
Mobile Source Combustion	1.20	0.14	0.13	0.72	0.17	1.04	0.18	0.82	0.55	0.55	0.76	0.54	0.69	0.66	0.61
Gasoline Highway Vehicles	1.05	0.00	0.00	0.54	0.00	0.85	0.00	0.62	0.36	0.35	0.55	0.32	0.47	0.44	0.39
Passenger Cars	0.49	0.00	0.00	0.23	0.00	0.39	0.00	0.29	0.16	0.16	0.27	0.15	0.23	0.21	0.19
Light-Duty Trucks	0.31	0.00	0.00	0.17	0.00	0.25	0.00	0.18	0.11	0.11	0.17	0.10	0.14	0.13	0.12
Medium & Heavy-Duty Trucks	0.23	0.00	0.00	0.13	0.00	0.19	0.00	0.14	0.08	0.08	0.11	0.07	0.09	0.09	0.08
Motorcycles	0.02	0.00	0.00	0.01	0.00	0.02	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01
Diesel Highway Vehicles	0.03	0.00	0.00	0.02	0.00	0.02	0.00	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0.02
Passenger Cars	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Light-Duty Trucks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Medium & Heavy-Duty Trucks	0.03	0.00	0.00	0.01	0.00	0.02	0.00	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0.02
Aviation	0.04	0.06	0.04	0.07	0.07	0.07	0.06	0.06	0.05	0.06	0.06	0.07	0.07	0.07	0.07
Other Transportation	0.08	0.09	0.09	0.09	0.10	0.10	0.12	0.12	0.12	0.12	0.12	0.14	0.13	0.13	0.13
Stationary Source Combustion	1.26	1.30	0.76	1.20	1.20	1.19	1.39	1.34	1.41	1.43	1.36	1.41	1.24	1.24	1.24
Electricity Generation	0.21	0.23	0.01	0.21	0.21	0.20	0.24	0.26	0.29	0.31	0.25	0.28	0.25	0.24	0.25
Industrial	0.25	0.28	0.15	0.28	0.29	0.30	0.36	0.34	0.37	0.36	0.36	0.35	0.32	0.32	0.33
Petroleum	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.02	0.02	0.02
Natural Gas	0.07	0.07	0.05	0.09	0.10	0.10	0.14	0.13	0.15	0.14	0.14	0.13	0.14	0.14	0.14
Other	0.15	0.18	0.08	0.16	0.17	0.17	0.19	0.18	0.19	0.19	0.19	0.19	0.16	0.16	0.16

Table A-4 Full Detail--California Greenhouse Gas Emissions ($MMTCO_2E$)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Commercial	0.25	0.23	0.06	0.17	0.17	0.17	0.25	0.20	0.22	0.22	0.22	0.24	0.14	0.14	0.14
Petroleum	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.02	0.03	0.02	0.02	0.02
Natural Gas	0.18	0.15	0.02	0.11	0.11	0.10	0.18	0.14	0.16	0.15	0.13	0.14	0.08	0.08	0.08
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.04	0.05	0.01	0.03	0.03	0.02	0.04	0.04	0.04	0.05	0.07	0.08	0.04	0.04	0.04
Residential	0.50	0.49	0.49	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Wood	0.47	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Other	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Nitrous Oxide Emissions	**32.75**	**30.38**	**30.54**	**31.46**	**30.04**	**31.90**	**30.79**	**28.83**	**29.20**	**29.35**	**31.43**	**30.76**	**34.48**	**33.85**	**33.34**
Nitric Acid Production	0.37	0.36	0.39	0.27	0.26	0.33	0.20	0.21	0.19	0.19	0.18	0.15	0.16	0.15	0.15
Waste Combustion	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Agricultural Soil Management	14.68	13.12	13.42	14.42	13.75	15.53	15.12	13.64	13.99	14.26	15.92	15.35	19.37	19.22	19.16
Direct	5.74	5.09	5.14	5.49	5.27	5.83	5.67	5.07	5.19	5.30	5.84	5.57	7.25	7.14	7.10
Fertilizers	2.82	2.27	2.46	2.92	2.54	3.33	3.16	2.54	2.70	2.72	3.32	3.06	4.60	4.55	4.57
Crop Residues	0.12	0.09	0.10	0.10	0.10	0.09	0.10	0.10	0.10	0.10	0.10	0.14	0.15	0.15	0.16
N-Fixing Crops	1.32	1.28	1.15	1.07	1.18	0.99	0.99	1.04	1.02	1.09	1.06	1.04	1.17	1.12	1.07
Histosols	0.18	0.16	0.16	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13
Livestock	1.31	1.29	1.27	1.24	1.30	1.28	1.27	1.25	1.24	1.26	1.22	1.21	1.19	1.19	1.17
Indirect	6.11	5.56	5.70	6.09	5.83	6.57	6.43	5.91	6.05	6.16	6.88	6.71	8.12	8.10	8.09
Fertilizers	2.50	2.02	2.19	2.60	2.26	2.96	2.81	2.25	2.40	2.42	2.96	2.72	4.09	4.05	4.06
Livestock	3.61	3.54	3.52	3.49	3.57	3.61	3.62	3.66	3.65	3.74	3.93	3.99	4.03	4.06	4.02
Leaching/Runoff	2.82	2.47	2.58	2.84	2.64	3.12	3.02	2.66	2.75	2.80	3.20	3.07	4.00	3.98	3.98
Manure Management	0.81	0.76	0.74	0.72	0.70	0.72	0.70	0.70	0.70	0.71	0.90	0.92	0.92	0.92	0.89
Beef Cattle	0.17	0.14	0.13	0.15	0.12	0.14	0.11	0.12	0.13	0.13	0.14	0.14	0.14	0.14	0.14
Dairy Cattle	0.26	0.26	0.28	0.28	0.30	0.30	0.31	0.31	0.32	0.34	0.36	0.37	0.38	0.39	0.37
Swine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.37	0.35	0.32	0.28	0.27	0.27	0.27	0.25	0.24	0.22	0.38	0.39	0.38	0.37	0.37
Sheep	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Goats	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Horses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Burning Ag Residues	0.10	0.09	0.09	0.11	0.11	0.11	0.12	0.12	0.11	0.12	0.13	0.06	0.06	0.06	0.07
Non-woody/Field	0.07	0.06	0.07	0.08	0.08	0.08	0.09	0.09	0.08	0.08	0.09	0.03	0.03	0.03	0.03
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	0.06	0.05	0.06	0.07	0.07	0.07	0.08	0.08	0.07	0.08	0.08	0.02	0.02	0.02	0.02
Wheat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Woody/Orchard & Vineyard	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04
Almonds	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Walnuts	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wastewater	0.91	0.86	0.84	0.92	0.84	0.85	0.88	0.98	1.01	1.04	0.75	1.03	0.95	0.92	1.07
Municipal (formerly Human Sewage)	0.91	0.86	0.84	0.92	0.84	0.85	0.88	0.98	1.01	1.04	0.75	1.03	0.95	0.92	1.07
Industrial	(Category not yet included in inventory)														
Mobile Source Combustion	15.62	14.94	14.81	14.80	14.15	14.13	13.56	12.98	13.00	12.82	13.33	13.04	12.80	12.37	11.78
Gasoline Highway Vehicles	7.85	7.58	7.45	7.33	7.17	6.94	6.02	5.75	5.60	5.38	5.17	4.78	4.35	3.96	3.65
Diesel Highway Vehicles	7.50	7.11	7.12	7.23	6.73	6.96	7.29	6.98	7.14	7.19	7.90	8.02	8.21	8.18	8.13
Aviation	0.27	0.25	0.24	0.23	0.24	0.23	0.25	0.25	0.26	0.24	0.25	0.24	0.25	0.23	
Stationary Source Combustion	0.24	0.23	0.23	0.21	0.21	0.20	0.20	0.18	0.17	0.18	0.19	0.19	0.19	0.19	0.19
Electricity Generation	0.02	0.02	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	0.11	0.10	0.10	0.09	0.08	0.08	0.08	0.09	0.08	0.08	0.09	0.09	0.09	0.09	0.09
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Natural Gas	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Wood	0.08	0.07	0.07	0.05	0.05	0.05	0.04	0.05	0.04	0.05	0.05	0.06	0.06	0.06	0.06

Table A-4 Full Detail--California Greenhouse Gas Emissions ($MMTCO_2E$)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Commercial/Institutional	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Wood	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Residential	0.09	0.10	0.10	0.09	0.09	0.09	0.09	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01
Wood	0.07	0.08	0.08	0.07	0.07	0.08	0.08	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
High Global-Warming Potential Gas Emissions	**7.14**	**7.43**	**7.86**	**8.38**	**8.87**	**9.31**	**11.37**	**12.62**	**8.89**	**9.88**	**10.48**	**11.19**	**12.04**	**12.94**	**14.20**
Substitution of Ozone-Depleting Substances	4.46	4.88	5.32	5.74	6.14	6.52	8.40	9.76	6.69	7.76	8.58	9.54	10.47	11.40	12.61
HFC-23	4.43	4.23	4.06	3.86	3.65	3.43	3.95	3.81	0.00	0.01	0.01	0.01	0.01	0.01	0.01
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.04	0.04	0.04	0.05	0.05
HFC-125	0.00	0.11	0.22	0.33	0.43	0.54	0.77	1.05	1.08	1.23	1.35	1.49	1.63	1.79	1.99
HFC-134a	0.00	0.44	0.89	1.33	1.77	2.21	2.99	3.84	4.32	4.96	5.47	6.02	6.50	6.92	7.52
HFC-143a	0.00	0.02	0.04	0.07	0.09	0.11	0.28	0.49	0.64	0.81	0.99	1.22	1.48	1.78	2.11
HFC-236fa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.11	0.17	0.22	0.26	0.28	0.28
CF4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C2F6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Others	0.04	0.08	0.12	0.16	0.19	0.23	0.42	0.55	0.56	0.59	0.55	0.54	0.56	0.56	0.65
Semiconductor Manufacture	0.36	0.36	0.36	0.46	0.52	0.67	0.67	0.77	0.87	0.89	0.76	0.54	0.53	0.52	0.57
Electricity Transmission & Distribution (SF6)	2.32	2.20	2.18	2.18	2.21	2.11	2.30	2.09	1.32	1.23	1.14	1.10	1.04	1.01	1.02
GROSS TOTALS:	**383.14**	**373.38**	**378.52**	**376.45**	**393.95**	**380.98**	**386.15**	**394.43**	**409.72**	**414.17**	**436.53**	**441.09**	**438.94**	**421.35**	**431.22**
Gross California Emissions with Electricity Imports	**426.45**	**416.45**	**421.54**	**417.27**	**437.13**	**419.49**	**426.72**	**441.40**	**462.59**	**465.85**	**477.00**	**488.46**	**490.67**	**477.80**	**492.04**
Electricity Imports	**43.31**	**43.07**	**43.02**	**40.82**	**43.18**	**38.51**	**40.57**	**46.97**	**52.86**	**51.68**	**40.48**	**47.37**	**51.73**	**56.44**	**60.81**
Forest Sinks	(13.14)	(13.11)	(13.09)	(13.07)	(13.05)	(13.05)	(13.05)	(13.05)	(13.05)	(13.05)	(13.05)	(13.04)	(13.03)	(13.02)	(13.01)
Rangeland Sinks	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.10)	(1.09)	(1.09)	(1.09)	(1.09)
Landfill Lumber Disposal Sinks	(3.73)	(3.54)	(3.35)	(3.17)	(2.98)	(2.79)	(2.61)	(2.42)	(2.23)	(2.05)	(2.74)	(3.31)	(3.88)	(4.33)	(5.01)
Yard Trimming Landfill Disposal Sinks	(4.74)	(4.54)	(4.34)	(4.14)	(3.94)	(3.74)	(3.54)	(3.34)	(3.14)	(2.94)	(2.72)	(2.51)	(2.30)	(2.09)	(1.87)
NET TOTALS:	**360.43**	**351.08**	**356.63**	**354.97**	**372.88**	**360.30**	**365.86**	**374.52**	**390.20**	**395.03**	**416.92**	**421.14**	**418.65**	**400.83**	**410.24**
Net California Emissions with Electricity Imports	**403.74**	**394.16**	**399.65**	**395.79**	**416.06**	**398.81**	**406.43**	**421.49**	**443.07**	**446.71**	**457.40**	**468.51**	**470.38**	**457.27**	**471.05**
International Bunker Carbon Dioxide Emissions	**39.88**	**34.61**	**28.00**	**27.95**	**32.40**	**35.76**	**35.35**	**27.03**	**26.85**	**30.30**	**33.82**	**31.80**	**31.83**	**24.47**	**26.47**
Jet Fuel (Aviation)	14.72	13.96	13.44	13.84	15.32	14.78	16.09	15.99	16.34	15.30	15.97	15.07	15.86	12.83	13.64
Distillate Oil (Marine)	1.23	1.01	0.71	0.69	0.84	1.03	0.95	0.54	0.52	0.74	0.88	0.80	0.69	0.57	0.46
Residual Oil (Marine)	23.93	19.63	13.85	13.42	16.25	19.95	18.31	10.50	9.99	14.27	16.98	15.93	15.27	11.08	12.37

APPENDIX B

FUEL USED IN CALIFORNIA
(TRILLION BTUS)

Sources:

California Energy Balance[89]

California Energy Commission Data

Energy Flows in Trillion (10^12) BTUs

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Statewide Energy Use (Trillion BTUs)	**5,657**	**5,770**	**5,714**	**5,647**	**5,988**	**5,763**	**5,883**	**6,003**	**6,375**	**6,515**	**6,879**	**6,917**	**6,669**	**6,264**	**6,382**
Residential	**544.16**	**554.21**	**523.76**	**534.33**	**550.22**	**501.16**	**500.77**	**496.04**	**575.10**	**600.06**	**567.58**	**511.15**	**511.22**	**493.73**	**521.21**
Natural Gas	**521.36**	**527.30**	**504.32**	**514.27**	**530.33**	**482.19**	**484.72**	**481.34**	**551.56**	**577.72**	**540.52**	**490.92**	**492.15**	**474.75**	**501.70**
Petroleum	**22.80**	**26.90**	**19.44**	**20.06**	**19.89**	**18.97**	**16.05**	**14.71**	**23.54**	**22.34**	**27.06**	**20.22**	**19.07**	**18.98**	**19.51**
LPG	20.84	25.12	17.40	18.16	18.00	17.69	14.74	13.33	22.02	20.65	24.80	17.11	17.11	17.11	17.11
Kerosene	0.74	0.61	0.67	0.52	0.49	0.20	0.43	0.42	0.49	0.64	0.78	1.38	1.08	1.15	1.57
Distillate	1.21	1.17	1.37	1.39	1.40	1.07	0.89	0.96	1.03	1.05	1.47	1.73	0.88	0.72	0.83
Commercial	**223.12**	**210.44**	**175.35**	**173.44**	**185.16**	**175.16**	**171.71**	**173.83**	**246.14**	**271.80**	**287.51**	**220.42**	**331.99**	**279.99**	**226.01**
Coal	**0.50**	**0.95**	**0.00**	**2.89**	**3.66**	**2.93**	**4.15**	**2.38**	**2.56**	**0.66**	**0.56**	**0.00**	**0.00**	**0.00**	**0.00**
Natural Gas	**178.01**	**165.06**	**150.32**	**151.49**	**162.78**	**148.34**	**148.16**	**152.83**	**221.63**	**249.03**	**262.92**	**198.15**	**313.76**	**263.94**	**210.90**
Education	26.63	24.11	20.51	21.18	24.06	18.60	17.80	19.66	23.92	26.08	26.33	18.04	21.68	20.82	21.87
College	13.12	11.38	10.02	10.30	13.09	9.75	8.94	10.52	12.89	13.97	15.93	10.20	11.73	11.98	12.51
School	13.51	12.73	10.49	10.88	10.97	8.85	8.85	9.14	11.04	12.11	10.40	7.84	9.95	8.84	9.36
Food Services	35.58	35.50	34.97	35.36	35.93	35.78	36.80	38.27	40.66	42.85	44.05	39.82	42.25	44.08	47.22
Restaurant	30.77	30.84	30.51	30.70	31.03	31.01	31.83	32.99	34.88	36.65	37.73	34.04	36.64	38.32	40.05
Food & Liquor	4.81	4.66	4.46	4.66	4.91	4.77	4.97	5.28	5.78	6.20	6.32	5.78	5.61	5.77	7.17
Retail & Wholesale	11.34	10.45	10.20	11.57	12.30	11.21	9.26	10.36	10.62	11.77	11.27	4.17	10.99	10.98	10.76
Retail	5.45	4.92	4.23	4.28	4.46	3.68	3.64	3.66	4.27	4.78	4.24	3.73	4.93	5.13	4.77
Warehouse	5.89	5.53	5.97	4.48	5.00	6.95	5.04	6.11	5.66	6.23	6.29	0.00	5.42	5.08	4.88
Warehouse, refrigerated	0.00	0.00	0.00	2.81	2.85	0.58	0.58	0.58	0.69	0.76	0.74	0.44	0.64	0.77	1.11
Health Care	24.88	25.04	21.25	19.87	23.10	21.47	21.61	21.84	23.42	25.53	24.89	21.83	22.34	22.98	23.98
Hotel	12.61	12.32	11.75	11.34	11.68	11.33	11.32	11.63	12.08	12.74	12.75	11.51	11.68	11.51	11.97
Office	27.37	26.32	23.97	24.80	26.49	24.80	25.82	25.49	29.18	33.22	30.27	25.66	34.41	33.79	35.46
Transportation Services	0.65	0.71	0.51	0.74	0.71	0.60	0.82	0.54	1.02	1.20	1.05	0.78	0.00	0.00	0.00
Transportation	0.13	0.15	0.15	0.15	0.14	0.11	0.08	0.09	0.11	0.13	0.14	0.21	0.00	0.00	0.00
Water Transportation	0.07	0.08	0.07	0.05	0.07	0.07	0.07	0.06	0.07	0.08	0.10	0.07	0.00	0.00	0.00
Airports	0.44	0.48	0.29	0.54	0.50	0.41	0.68	0.39	0.84	0.99	0.81	0.50	0.00	0.00	0.00
Communication	1.31	1.38	1.10	0.82	1.16	1.05	1.17	1.46	1.13	1.24	1.11	0.85	1.83	1.55	1.46
U.S. Postal Service	0.27	0.28	0.23	0.26	0.34	0.36	0.42	0.33	0.39	0.40	0.36	0.30	0.30	0.28	0.25
Telephone & Cell Phone Service	0.90	0.95	0.74	0.39	0.43	0.36	0.36	0.39	0.42	0.49	0.40	0.33	0.43	0.26	0.27
Other Message Communication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03	0.83	0.81
Radio Broadcasting Stations	0.09	0.09	0.08	0.08	0.09	0.08	0.09	0.12	0.11	0.12	0.10	0.12	0.00	0.00	0.00
Non-Specified (Communication)	0.04	0.05	0.05	0.08	0.31	0.25	0.30	0.62	0.20	0.24	0.25	0.11	0.07	0.19	0.14
Utilities	6.36	6.34	6.73	5.09	5.46	5.98	7.75	7.33	75.47	77.67	91.84	59.94	66.58	73.10	54.75
Electric, Nat'l Gas, Steam	2.67	2.98	3.11	1.94	2.13	2.28	3.24	2.75	70.20	71.88	85.74	55.66	63.31	65.75	46.10
Sewerage Systems	1.39	1.38	1.58	1.27	1.45	1.78	2.46	2.50	3.45	3.31	3.03	2.57	1.54	2.52	4.84
Water Supply	2.30	1.99	2.03	1.88	1.88	1.92	2.05	2.08	1.82	2.48	3.08	1.71	1.73	4.81	3.81
Street Lights	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
National Security	10.61	12.04	10.28	10.16	9.57	7.55	6.85	8.68	6.46	5.42	4.60	5.75	3.31	3.21	3.43
Non Specified (Services)	20.67	10.86	9.06	10.56	12.31	9.98	8.96	7.56	-2.32	11.32	14.77	9.79	98.69	41.93	0.00
Petroleum	**44.61**	**44.43**	**25.02**	**19.05**	**18.71**	**23.88**	**19.40**	**18.63**	**21.96**	**22.12**	**24.02**	**22.27**	**18.23**	**16.05**	**15.10**
LPG	3.68	4.43	3.07	3.21	3.18	3.12	2.60	2.35	3.89	3.64	3.64	3.64	3.64	3.64	3.64
Motor Gasoline	10.12	8.65	7.80	1.37	1.19	1.24	1.18	1.18	1.27	1.20	1.21	1.26	1.30	1.35	1.39
Kerosene	0.95	0.50	0.23	0.11	0.13	0.11	0.11	0.07	0.15	0.39	0.23	0.36	0.16	0.27	0.41
Distillate	24.61	26.05	13.67	14.27	14.17	19.38	15.43	15.01	16.19	16.89	18.93	16.77	13.12	10.79	9.66
Residual Oil	5.25	4.80	0.25	0.10	0.04	0.02	0.08	0.01	0.47	0.00	0.00	0.24	0.00	0.00	0.00
Industrial	**1,194.56**	**1,451.34**	**1,346.53**	**1,393.70**	**1,414.70**	**1,422.13**	**1,577.54**	**1,711.41**	**1,827.32**	**1,720.18**	**1,804.52**	**1,908.66**	**1,689.15**	**1,624.74**	**1,609.68**
Natural Gas	**528.18**	**814.49**	**711.15**	**731.08**	**732.99**	**848.20**	**974.65**	**1,106.85**	**1,209.54**	**1,080.87**	**1,134.04**	**1173.74**	**1000.61**	**1001.68**	**981.91**
Agriculture	10.14	9.46	9.14	7.85	11.74	9.97	11.24	12.57	13.70	16.21	18.05	12.01	12.38	12.12	12.77
Crop Production	8.42	8.03	7.84	6.49	8.53	7.63	9.36	10.86	11.92	13.22	14.26	10.14	10.80	10.87	11.51
Livestock Production	1.00	1.06	1.00	0.95	0.95	0.90	0.91	1.01	1.12	1.48	1.62	1.34	1.30	1.22	1.26
Irrigation	0.72	0.37	0.30	0.41	2.26	1.44	0.97	0.70	0.66	1.51	2.17	0.53	0.26	0.02	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Mining	0.52	0.58	0.77	0.68	0.71	5.84	6.48	6.14	7.48	6.09	6.26	5.61	7.48	7.75	2.37
Metal	0.01	0.01	0.01	0.01	0.02	0.14	0.06	0.06	0.02	0.01	0.01	0.01	0.00	0.00	0.00
Coal	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.01	0.02	0.02	0.00	0.00	0.00
Minerals	0.52	0.57	0.76	0.67	0.69	5.69	6.42	6.08	7.44	6.06	6.24	5.58	7.48	7.75	2.37
Manufacturing	234.07	513.11	450.24	460.05	464.93	521.35	587.18	649.64	713.24	643.23	671.97	679.22	575.59	565.02	555.64
Food	57.83	61.52	60.89	61.81	61.56	59.78	58.83	59.47	67.49	70.88	70.38	60.06	59.76	53.64	57.28
Food Processing	22.56	24.96	25.79	25.16	23.55	25.52	26.34	25.94	30.26	31.45	28.52	22.52	27.03	23.55	24.71
Sugar & Confections	8.73	8.94	6.96	7.73	8.94	8.02	5.20	4.33	5.72	6.75	7.64	6.38	0.00	0.00	0.00
Non-specified (Food Processing)	26.55	27.63	28.13	28.92	29.07	26.24	27.30	29.20	31.52	32.68	34.22	31.16	32.73	30.09	32.58
Tobacco	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Energy Flows in Trillion (10^12) BTUs

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Textiles	7.12	6.57	6.68	7.36	8.08	8.18	8.49	9.04	9.60	10.62	10.80	8.73	1.90	1.57	1.67
Textile Mills	6.15	5.63	5.83	6.44	7.17	7.36	7.58	8.07	8.72	9.78	9.98	7.99	1.31	1.21	1.27
Leather	0.15	0.12	0.07	0.10	0.11	0.09	0.09	0.07	0.07	0.07	0.07	0.09	0.00	0.00	0.00
Apparel	0.82	0.82	0.79	0.82	0.80	0.74	0.82	0.90	0.81	0.76	0.74	0.65	0.59	0.37	0.40
Wood & Furniture	4.45	4.13	4.38	4.80	4.94	7.51	6.60	5.77	5.81	5.74	5.72	6.11	2.99	2.49	1.99
Lumber & Wood Products	3.47	3.34	3.68	4.09	4.23	6.84	5.92	5.03	5.00	4.86	4.84	5.38	2.23	1.77	1.24
Furnature & Fixtures	0.97	0.78	0.70	0.71	0.71	0.67	0.68	0.75	0.82	0.88	0.88	0.73	0.76	0.72	0.75
Pulp & Paper	33.92	28.84	19.74	21.86	29.30	29.81	34.83	28.09	33.64	26.40	30.55	27.12	17.64	17.72	10.53
Pulp Mills	1.19	1.47	2.43	1.04	0.61	0.00	0.01	0.00	3.71	0.00	3.87	0.00	0.00	0.00	0.00
Paper Mills	7.36	6.18	4.66	7.56	12.71	12.33	13.40	9.16	10.88	10.58	10.21	9.44	13.99	12.51	7.09
Paperboard Mills	17.12	13.90	6.62	7.52	10.29	12.36	15.52	13.62	12.99	10.12	10.93	11.93	0.00	1.75	0.00
Non-specified (Pulp & Paper)	8.26	7.28	6.03	5.75	5.69	5.11	5.91	5.31	6.07	5.70	5.53	5.75	3.65	3.46	3.43
Printing & Publishing	2.13	2.29	2.09	2.28	2.50	2.82	2.69	2.67	2.90	2.75	2.22	2.04	1.59	1.46	1.56
Chemicals & Allied Products	34.36	30.65	23.59	18.93	21.97	21.63	22.62	19.21	25.58	20.59	25.13	20.76	20.34	12.00	12.40
Plastics & Rubber	4.42	4.25	3.76	3.69	3.82	3.89	3.90	4.42	4.93	5.25	5.28	3.90	0.00	0.00	0.00
Plastics	3.49	3.31	2.98	2.87	2.99	3.08	3.09	3.59	4.10	4.40	4.44	3.22	0.00	0.00	0.00
Non-specified (Plastics & Rubber)	0.93	0.94	0.78	0.82	0.83	0.80	0.81	0.83	0.83	0.85	0.84	0.68	0.00	0.00	0.00
Stone, Clay, Glass, Cement & Other	34.55	31.15	30.29	29.04	27.90	29.10	31.10	32.27	35.36	32.27	31.58	28.23	24.83	23.18	24.92
Flat Glass	1.68	1.17	1.48	1.65	1.55	1.74	2.99	3.17	3.01	3.30	2.82	2.29	0.00	0.00	0.00
Glass containers	12.97	12.20	11.73	11.58	11.28	10.06	9.98	9.70	10.16	9.70	9.42	8.45	10.89	9.98	10.05
Cement	3.48	3.51	3.20	3.55	2.48	3.54	3.59	3.07	4.42	2.67	3.03	2.02	3.30	3.13	3.44
Non-specified (Stone, Clay, Glass & Cement)	16.43	14.26	13.88	12.26	12.59	13.76	14.53	16.32	17.78	16.61	16.31	15.47	10.64	10.07	11.43
Primary Metals	17.77	16.86	14.21	14.32	16.13	14.88	15.48	15.96	16.35	16.73	17.24	14.29	12.64	12.70	8.76
Metal Durables	17.21	15.49	14.50	14.68	14.38	15.05	15.42	15.67	16.30	15.42	15.32	14.12	15.36	12.85	14.74
Fabricated Metal Products	10.94	11.04	10.42	10.46	10.13	10.64	10.88	11.17	11.42	11.24	11.39	10.81	10.13	8.32	9.01
Computers & Office Machines	2.46	2.19	1.90	1.84	1.64	1.59	1.50	1.50	1.68	1.77	1.65	1.38	3.30	2.86	3.27
Industrial Machinery & Equipment	3.81	2.27	2.19	2.37	2.62	2.82	3.04	3.00	3.21	2.41	2.28	1.93	1.93	1.67	2.47
Electric & Eletronic Equipment	6.57	6.31	5.97	5.59	5.49	5.36	5.51	5.91	6.30	6.99	6.41	4.97	3.98	3.38	2.78
Telephone & Broadcasting Equipment	1.21	0.75	0.72	0.55	0.45	0.40	0.43	0.47	0.54	0.62	0.65	0.61	0.00	0.00	0.00
Semiconductors & Related Products	3.54	3.85	3.59	3.38	3.50	3.43	3.72	3.91	4.13	4.31	4.15	3.01	3.24	2.90	2.24
Non-specified (Elec. Equipment)	1.82	1.71	1.65	1.66	1.54	1.52	1.36	1.53	1.62	2.07	1.61	1.34	0.74	0.49	0.54
Transportation Equipment	10.04	10.01	9.96	9.66	9.72	8.98	8.17	8.43	9.06	9.68	9.47	8.30	7.68	5.30	4.74
Instruments & Related Products	1.34	1.62	1.55	1.80	1.74	1.56	1.64	1.71	1.90	2.13	1.85	1.75	0.00	0.00	0.00
Construction	2.35	2.09	1.61	1.73	1.79	1.78	2.16	2.52	2.88	2.44	2.28	1.94	1.74	1.93	3.13
Non-specified (Industrial)	0.71	0.59	0.58	0.60	0.66	0.67	0.68	0.72	1.08	1.08	1.09	47.63	34.53	9.28	2.48
Energy Industrial Sector	279.92	289.47	248.96	261.12	254.36	309.53	367.77	436.49	472.37	412.27	435.33	427.12	368.94	404.88	407.09
Transformation at Refinery	0.00	0.00	0.00	24.59	35.81	23.90	49.65	38.03	47.78	35.33	39.30	34.33	12.34	79.37	6.57
Natural Gas Use at Refinery (Not transformation)	83.03	77.93	70.69	69.72	59.59	80.93	106.26	110.98	103.76	94.63	105.52	92.28	103.18	34.57	126.45
Oil & Gas Extraction	196.89	211.54	178.27	166.82	158.96	204.69	211.86	287.48	320.83	282.31	290.51	300.51	253.43	290.95	274.07
Flaring	2.82	1.28	1.47	0.78	0.59	0.84	1.29	1.29	1.67	1.99	1.34	2.16	1.68	2.63	1.56
Natural Gas Liquids	**4.94**	**3.61**	**3.96**	**4.07**	**4.14**	**4.14**	**2.38**	**2.19**	**1.96**	**2.42**	**11.60**	**10.31**	**1.48**	**1.46**	**1.47**
Petroleum	**497.94**	**477.71**	**483.32**	**525.17**	**543.89**	**436.26**	**462.65**	**464.67**	**441.90**	**428.24**	**460.09**	**523.69**	**481.46**	**458.03**	**464.81**
LPG	53.82	45.44	64.26	46.62	52.88	42.95	33.00	27.89	24.58	32.26	23.43	27.04	31.60	35.18	31.47
Manufacturing	41.03	30.70	39.21	29.75	34.40	30.24	23.99	20.54	19.98	28.20	15.95	16.41	27.53	27.53	27.53
Chemicals & Allied Products	9.21	10.54	10.67	10.29	11.93	12.20	12.65	12.82	13.38	13.94	12.70	11.86	11.85	11.85	11.85
Non-specified (Industry)	31.82	20.16	28.53	19.46	22.47	18.05	11.34	7.73	6.60	14.27	3.25	4.55	15.68	15.68	15.68
Oil Refinery Use	12.79	14.75	25.06	16.86	18.48	12.71	9.02	7.35	4.60	4.06	7.48	10.63	4.06	7.64	5.85
Motor Gasoline	16.60	17.17	17.31	13.99	14.48	14.96	14.05	14.79	16.58	9.77	10.02	23.28	24.73	25.81	29.26
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.66	7.17	7.26	8.31
Non-specified (Agriculture)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.17	5.52	5.68	7.20
Non-speified (Industrial)	16.60	17.17	17.31	13.99	14.48	14.96	14.05	14.79	16.58	9.77	10.02	11.45	12.04	12.88	13.75
Refinery Still Gas	246.92	245.98	237.75	294.61	298.08	208.59	241.13	238.49	234.96	214.91	206.46	232.79	231.34	249.42	237.39
Kerosene	0.13	0.17	0.19	0.20	0.17	0.11	0.21	0.19	0.28	0.64	1.01	0.95	0.39	0.19	0.24
Industrial	0.11	0.15	0.12	0.13	0.08	0.08	0.11	0.11	0.24	0.59	0.98	0.90	0.19	0.14	0.17
Agricultural	0.03	0.02	0.07	0.07	0.09	0.03	0.09	0.08	0.04	0.05	0.03	0.06	0.20	0.05	0.07
Distillate	102.64	83.91	76.12	78.57	85.04	71.45	71.53	84.69	78.26	90.83	113.96	128.21	87.73	64.54	82.63
Agriculture	45.90	37.64	44.21	43.33	44.30	35.55	40.12	50.52	46.49	54.59	55.55	55.74	49.98	39.34	46.82
Industry	53.81	44.71	29.91	33.05	38.67	34.55	30.70	33.44	30.93	34.61	57.05	70.78	36.01	23.74	34.05
Oil and Gas Extraction	2.87	1.50	1.97	2.17	1.98	1.34	0.66	0.72	0.83	1.60	1.36	1.45	1.74	1.44	1.73
Oil Refinery Use	0.05	0.06	0.02	0.02	0.09	0.00	0.04	0.02	0.01	0.03	0.01	0.24	0.01	0.02	0.02
Residual Oil	10.94	11.07	10.92	10.02	9.92	10.50	2.88	1.37	1.03	4.72	0.76	2.90	1.20	0.34	0.08
Refining	2.70	2.67	2.07	2.25	2.25	1.52	1.16	0.83	0.79	0.41	0.02	0.00	0.00	0.00	0.00
Oil & Gas Extraction	0.17	0.33	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	2.76	0.87	0.11	0.00
Industry	8.08	8.07	8.05	7.77	7.67	8.98	1.72	0.54	0.24	4.13	0.74	0.14	0.33	0.23	0.08

Energy Flows in Trillion (10^12) BTUs

Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Petroleum Coke	66.88	73.96	76.77	81.16	83.33	87.71	99.85	97.25	86.19	75.10	104.45	108.52	104.48	82.56	83.74
Oil Refinery Use	66.88	73.43	75.31	75.76	74.42	73.53	93.95	89.89	79.80	68.77	96.63	101.36	96.06	74.14	75.33
Cement	0.00	0.53	1.46	5.40	8.91	14.18	5.90	7.36	6.39	6.33	7.82	7.16	8.42	8.42	8.42
Lubricants	**13.06**	**11.68**	**11.91**	**12.13**	**12.68**	**12.46**	**12.09**	**12.77**	**13.37**	**13.51**	**13.31**	**16.26**	**16.07**	**14.85**	**15.05**
Waxes	**3.25**	**4.02**	**4.26**	**4.58**	**4.64**	**4.64**	**5.39**	**4.84**	**4.69**	**4.15**	**3.66**	**4.02**	**3.56**	**3.44**	**3.41**
Asphalt	**98.62**	**94.57**	**89.97**	**82.51**	**81.20**	**81.04**	**82.28**	**76.39**	**103.34**	**129.31**	**125.30**	**127.05**	**129.32**	**90.58**	**92.03**
Special Naptha	**12.88**	**10.37**	**12.32**	**12.32**	**9.55**	**8.35**	**6.67**	**6.47**	**9.60**	**13.02**	**8.72**	**7.03**	**9.17**	**7.21**	**4.57**
Other Petroleum Products	**3.29**	**2.27**	**1.49**	**1.41**	**1.58**	**1.45**	**0.73**	**0.80**	**0.97**	**0.92**	**0.98**	**1.02**	**1.10**	**1.03**	**0.93**
Coal	**32.4**	**32.6**	**28.1**	**20.4**	**24.0**	**25.6**	**30.7**	**36.4**	**41.9**	**47.7**	**46.8**	**45.5**	**46.4**	**46.4**	**45.5**
Cement	0.0	26.6	22.5	20.4	24.0	23.5	28.7	25.4	24.0	32.1	31.1	29.4	30.8	0.0	0.0
Other Industrial Use	32.4	6.0	5.6	0.0	0.0	2.1	2.0	11.0	17.9	15.6	15.8	16.1	15.6	46.4	45.5
Transportation	**2,579.09**	**2,502.60**	**2,563.95**	**2,517.23**	**2,607.48**	**2,632.14**	**2,667.72**	**2,713.65**	**2,777.33**	**2,830.09**	**2,911.74**	**2,913.53**	**3,038.26**	**2,837.38**	**2,963.57**
Natural Gas	**3.05**	**3.46**	**3.23**	**3.15**	**3.16**	**3.18**	**3.94**	**26.83**	**13.50**	**13.92**	**14.49**	**14.80**	**13.94**	**12.37**	**16.46**
Rail	0.36	0.35	0.25	0.18	0.18	0.17	0.18	0.14	0.25	0.25	0.23	0.27	0.18	0.23	0.27
Road	1.06	1.12	1.01	1.11	1.35	1.34	1.95	2.10	2.28	2.69	2.71	2.15	1.73	1.38	1.01
Freight	0.30	0.27	0.25	0.26	0.26	0.22	0.23	0.22	0.25	0.29	0.22	0.22	0.42	0.39	0.45
Passenger	0.38	0.42	0.38	0.43	0.55	0.56	0.86	0.94	1.01	1.20	1.25	0.97	0.66	0.49	0.28
Private Auto	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Taxi & Buses	0.19	0.22	0.16	0.18	0.26	0.27	0.45	0.40	0.45	0.49	0.49	0.50	0.00	0.00	0.00
Non-spedified (Local Transit)	0.20	0.21	0.23	0.25	0.28	0.29	0.41	0.54	0.56	0.71	0.76	0.46	0.66	0.49	0.28
Water	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.05	0.06	0.04
Air	0.35	0.36	0.27	0.24	0.25	0.18	0.18	0.18	0.56	0.24	0.79	0.17	1.18	1.19	1.19
Non-specified (Air Transport)	0.35	0.36	0.27	0.24	0.25	0.18	0.18	0.18	0.56	0.24	0.79	0.17	1.18	1.19	1.19
Pipeline	1.27	1.62	1.69	1.61	1.36	1.48	1.61	24.40	10.39	10.72	10.75	12.20	10.80	9.50	13.95
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.89	9.03	9.51	9.48	10.67	9.40	8.48	12.68
Other than Natural Gas	1.27	1.62	1.69	1.61	1.36	1.48	1.61	1.50	1.36	1.22	1.26	1.53	1.40	1.03	1.27
Non-specified (Transport)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	**2,576.05**	**2,499.13**	**2,560.72**	**2,514.08**	**2,604.32**	**2,628.96**	**2,663.78**	**2,686.81**	**2,763.84**	**2,816.17**	**2,897.25**	**2,898.73**	**3,024.32**	**2,825.01**	**2,947.11**
LPG	3.35	2.75	2.36	2.37	3.66	2.04	1.74	1.26	2.42	1.39	5.73	6.93	3.00	3.00	3.00
Motor Gasoline	1,579.69	1,542.34	1,632.02	1,605.45	1,599.51	1,629.49	1,615.52	1,624.85	1,658.92	1,705.69	1,731.34	1,777.74	1,861.72	1,810.37	1,885.15
Aviation Gasoline	5.58	5.51	5.35	4.13	4.00	4.07	3.88	4.22	2.90	4.16	3.65	3.31	3.67	3.67	3.00
Jet Fuel	538.12	510.66	491.52	506.01	560.16	540.38	588.39	584.83	597.54	559.48	584.02	551.22	580.08	469.10	498.77
International Jet Fuel Aviation	203.12	192.75	185.53	191.00	211.43	203.97	222.09	220.75	225.54	211.18	220.44	208.06	218.96	177.06	188.26
Domestic Jet Fuel Aviation	335.01	317.91	305.99	315.02	348.72	336.41	366.30	364.08	371.99	348.30	363.58	343.16	361.13	292.04	310.51
Distillate	317.13	314.49	314.14	288.18	327.79	340.68	342.39	370.62	373.91	388.35	418.02	409.52	424.06	429.50	445.53
Railroad	31.33	33.12	30.13	26.56	28.75	32.79	35.01	34.69	36.40	37.73	41.40	39.11	41.08	37.57	43.02
Road Transportation	252.38	245.42	255.57	253.02	275.39	289.82	293.43	317.33	324.43	340.95	365.14	364.39	374.97	384.71	394.46
Water Transportation	4.25	9.70	5.66	1.99	6.10	0.22	0.86	15.26	9.44	7.92	9.90	0.00	0.00	0.70	0.00
Non-specified (Transport)	29.17	26.24	22.79	6.61	17.56	17.86	13.10	3.34	3.64	1.75	1.58	6.02	8.01	6.52	8.05
Residual Oil	16.14	13.24	9.48	9.25	11.09	14.64	13.46	7.61	6.99	9.77	11.45	10.77	10.41	7.65	8.34
Water Transportation	16.14	13.24	9.34	9.05	10.96	13.46	12.35	7.08	6.74	9.62	11.45	10.74	10.30	7.47	8.34
Non-specified (Transport)	0.00	0.00	0.14	0.21	0.14	1.18	1.11	0.53	0.25	0.15	0.00	0.03	0.11	0.18	0.00
Lubricants	17.41	15.57	15.88	16.17	16.90	16.61	16.12	17.03	17.83	18.02	17.75	12.19	12.05	11.14	11.29
Marine Bunkers (Report separately in GHG Inventory	323.67	265.48	187.26	181.46	219.72	269.87	247.71	141.98	135.14	192.97	229.62	215.05	205.25	149.79	164.90
Distillate Bunkers	17.05	13.98	9.86	9.56	11.57	14.21	13.05	7.48	7.12	10.16	12.09	10.99	9.56	7.89	6.40
Residual Oil Bunkers	306.62	251.50	177.40	171.91	208.15	255.66	234.66	134.50	128.02	182.81	217.53	204.06	195.69	141.90	158.50
Electricity Generation (Excludes Wood, Landfill & MSW)	**691.02**	**692.71**	**827.56**	**758.53**	**913.22**	**688.62**	**641.22**	**690.36**	**754.02**	**814.39**	**982.96**	**1061.69**	**792.17**	**834.30**	**894.15**
Natural Gas	**689.82**	**691.54**	**826.12**	**757.02**	**911.78**	**687.26**	**640.08**	**689.31**	**753.04**	**813.37**	**981.93**	**1060.72**	**791.09**	**833.34**	**893.01**
Commercial CHP	12.18	10.83	12.13	12.41	13.78	14.29	14.61	13.73	14.10	13.89	13.46	12.40	12.06	15.39	15.51
Electric CHP	122.39	126.91	139.34	144.89	149.04	148.75	147.66	155.85	154.57	154.34	151.16	138.22	181.90	155.47	172.70
Industrial CHP	79.29	85.54	82.88	83.55	86.11	86.72	95.72	90.05	90.59	90.08	89.58	90.89	98.80	92.73	141.91
Utility	471.47	461.59	583.06	480.04	618.73	405.36	326.29	385.13	276.04	145.52	129.71	120.28	89.63	98.49	101.67
Merchant Power	4.50	6.66	8.71	11.73	8.02	7.92	6.49	6.47	171.47	374.63	557.74	663.76	396.04	389.93	454.49
Refinery Self Generation	0.00	0.00	0.00	24.40	36.10	24.23	49.30	38.08	46.26	34.92	40.28	35.18	12.65	81.35	6.74
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	**1.20**	**1.17**	**1.45**	**1.50**	**1.44**	**1.36**	**1.13**	**1.05**	**0.98**	**1.02**	**1.03**	**0.97**	**1.08**	**0.95**	**1.13**
Electric CHP	0.78	1.02	1.09	1.20	1.05	1.00	0.80	0.78	0.84	0.88	0.88	0.82	0.93	0.82	0.92
Industrial CHP	0.41	0.15	0.36	0.30	0.39	0.36	0.33	0.27	0.14	0.15	0.15	0.15	0.16	0.13	0.21
Merchant Power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood & Wood Waste (exclude for carbon dioxide)	**60.33**	**62.20**	**59.75**	**55.29**	**61.93**	**40.72**	**45.66**	**45.88**	**41.31**	**51.58**	**53.12**	**49.41**	**0.00**	**0.00**	**0.00**
Landfill & MSW (exclude for carbon dioxide)	**20.87**	**20.61**	**21.05**	**22.67**	**23.22**	**23.11**	**21.42**	**22.49**	**21.27**	**22.17**	**25.18**	**24.18**	**0.00**	**0.00**	**0.00**
Not Sector-Specific; Other End Use	**20.67**	**10.86**	**9.06**	**10.56**	**12.31**	**9.98**	**8.96**	**7.56**	**-2.32**	**11.32**	**16.38**	**12.45**	**100.83**	**44.06**	**2.14**
Natural Gas	20.67	10.86	9.06	10.56	12.31	9.98	8.96	7.56	-2.32	11.32	14.77	9.79	98.69	41.93	0.00
Liquefied Petroleum Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.61	2.66	2.14	2.14	2.14

APPENDIX C

DISCUSSION OF ALTERNATIVE METHODS OF ESTIMATING CO_2 EMISSIONS FROM ELECTRICITY IMPORTED TO CALIFORNIA

Introduction

At least three approaches have been used to estimate out-of-state CO_2 emissions from electricity imported to California: (1) the current GHG inventory method, (2) a method used by Joseph Loyer, and described below, and (3) the method used in the 1990-1999 inventory. Energy imported to California from the Pacific Northwest and Southwest is not correlated to specific fuel types and the fuel types need to be estimated. Emissions from two out-of-state coal-fired power plants owned by California electric utilities are evaluated in the normal manner and reported as out-of-state emissions.

Current GHG Inventory

The method used to develop the current GHG inventory is described in the main body of this paper.

Joseph Loyer Method

Joseph Loyer of the Energy Commission's Electricity Office estimated percentages of various fuels used to generate electricity for import to California for the 1994 and 1995 calendar years, and presented his results in a report titled *Fuel~Resource Profiles of Electricity Generation and Related CO_2 Emissions for The State of California, 1994 and 1995*. This report is dated April 2, 1998.

To determine CO_2 emissions from the two out-of-state coal facilities, the author used data appropriate for coal-fueled combustion. To determine CO_2 emissions from the Pacific Northwest and Southwest, the author used data from the DOE to determine the amount of energy (measured in GWh) sold by each company to California in 1994 and 1995. He then used each company's annual percentages of GWh by fuel type each year and assumed that these percentages applied to electrical energy sold to California. From this, he estimated the amount of energy in GWh by fuel type for electricity sold for use in California, and corresponding CO_2 emissions.

Using Loyer's data, in 1994 imported coal-based electricity comprised 18.9 percent of the total GWh imported for use in California. Using the approach described above for the current GHG inventory, in 1994 coal comprised 18.0 percent of the total GWh imported for use in California. Correspondingly, for 1995 Loyer's method yields imported coal energy comprising 17.7 percent of California's total GWh consumption while using the current GHG inventory method yields imported coal energy comprising 16.1 percent.

1990-1999 Inventory Method

The 1990-1999 inventory[90] also included estimates of GHG emissions from out-of-state electric power production imported to California. That analysis used the conventional approach to estimate CO_2 emissions from the out-of-state coal facilities owned by California utilities. For the remainder of the electrical energy imported to California from the Pacific Northwest and Southwest, it assumed an emissions factor of 800 metric tons CO_2 per GWh. This emissions factor was said to be uncertain because the underlying mix of fuel used to generate the GWh was unknown. This emissions factor was calculated from 1994 and 1995 data in the Loyer reference. The April 2, 1998 version of the Loyer reference produces an emissions factor of 808 metric tons of CO_2 per GWh for 1994, and 861 metric tons of CO_2 per GWh for 1995. These values were rounded to 800 due to data uncertainty.

This emissions factor was assumed to apply to the imports for the Pacific Northwest and Southwest for the entire 1990 to 1999 period. However, documentation in the 1990-1999 GHG emissions inventory report cautioned that the approach may overstate emissions because the total amount of GWh imported in 1994 and 1995 was relatively low compared to other years during the 1990 to 1999 period.

Summary of Options to Estimate CO_2 Emissions from Electric Imports

All three methods used conventional data and emissions factors for the two out-of-state coal fired electric power plants owned by California utilities. To estimate CO_2 emissions from electrical energy imported from the Pacific Northwest and Southwest, each method was different and had one or more limitations:

(1) The approach used for this inventory is based upon an Energy Commission adopted estimate of the fuel profile used to generate electricity imported from the Pacific Northwest and Southwest. This estimate was somewhat arbitrary, and was not officially adopted for the entire 1990 to 2000 period.

(2) The method used by Loyer was only done for 1994 and 1995, and it assumed each import providing company's annual average fuel profile applied to the electricity that California imported.

(3) The method used in the 1990-1999 inventory assumed that the fuel mix used to import electricity from the Southwest and Pacific Northwest in 1994 and 1995 matched the fuel mix for the entire 1990 to 1999 period.

Table C-1 compares these three different approaches for estimating CO_2 emissions from imported electricity. The Loyer approach was only done for 1994 and 1995. The current approach shows the lowest estimates for each year and the 1990-1999 inventory method shows the highest. The Loyer approach is mid range.

Table C-1. Comparing Three Methods to Estimate CO_2 Emissions from Imported Electricity (Million Metric Tons of CO_2)

Inventory Approach	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
-Current	43.3	43.1	43.0	40.8	43.2	38.5	40.6	47.0	52.9	51.7	40.5	47.4	51.7	56.4
-Loyer					48.3	45.6								
-Previous	67.5	65.4	59.6	55.0	57.5	55.1	62.7	67.5	70.5	73.0				

APPENDIX D

DIFFERENCES BETWEEN CURRENT INVENTORY AND JUNE 2005 INVENTORY

Introduction

This appendix describes the emissions categories and sub-categories with more significant changes from the 1990 to 2002 inventory published July 2005. The text is followed by a table showing the differences. Reductions are shown in parentheses.

Natural Gas Combustion CO_2 Emissions

This section summarizes differences for CO2 emissions from natural gas combustion in residential, commercial, industrial, electricity generation, and non-sector specific categories.

Residential

Residential natural gas use In the current (1990 to 2004) GHG inventory is based on Energy Commission data from utilities. There is a modest increase in 2000 (0.6 $MMTCO_2E$), followed by a decrease of 1 $MMTCO_2E$ in 2001 and then a medium increase in 2002 (2.5 $MMTCO_2E$).

Commercial

See above for changed data source. There are small decreases in the early 1990s followed by fairly large decreases in 1998 to 2000 (2.8 to 6.7 $MMTCO_2E$), followed by increases in 2001 (0.8 $MMTCO_2E$) and 2002 (2.3 $MMTCO_2E$). For Electricity Producers' own fuel use (not generation) the previous inventory was based on very high fuel uses for 1998 to 2000. There is a large decrease (6.7 $MMTCO_2E$ in 1999) in emissions from this sector. The new energy balance shows much lower numbers for these years, more consistent with other years. These changes are due to how natural gas used for thermal purposes in combined heat and power facilities are allocated.

Industrial

The 1990 to 2002 inventory inadvertently double counted "Stone, Clay, Glass, Cement & Other" emissions. This factor reduces inventory 0.8 to 1.6 $MMTCO_2E$. Refinery natural gas use now based on Energy Commission data; older inventory used EIA data. This factor increases "Transformation" emissions slightly in 2000 (0.5 $MMTCO_2E$) and decreases them somewhat in 2001 and 2002 (0.8 and 2.3 $MMTCO_2E$).

Electricity Generation

In the current 1990 to 2004 GHG inventory, natural gas used for electricity generation is from EIA's Electric Power Annual Report. Emissions increase and decrease each year by up to about 3 $MMTCO_2E$.

Non-Sector Specific

Fuel not ascribed to a specific end use is greater in 2002 due to changed data sources. Specifically, data collection changed from SIC categories to NAICS categories, with some difficulty in linking them together. This caused increases in the "non sector specific" category, but this does not represent a change in fuel use or GHG emissions. Non-sector emissions decrease by 4.7 $MMTCO_2E$ in 2002.

Coal Combustion CO_2 Emissions

This section summarizes differences for CO_2 emissions from coal combustion in the electricity generation sector.

Electricity Generation

Revised EIA data used in the current 1990 to 2004 GHG inventory indicates a much lower number for electricity generation in California using coal. Emissions decrease about up to about 3 $MMTCO_2E$.

Non-Fossil Fuel CO_2 Emissions

This section includes CO_2 emissions from agricultural soils and woody crops.

Agricultural Soils; Woody Crops

Previous inventory used different data sets for this category and for wood waste combustion. These are now consistent, causing minor changes in this category. The biggest change is in 1998, caused by moving from one data set to another for agricultural soil CO_2 emissions, in the previous inventory. In 1998 emissions increase 3.5 $MMTCO_2E$.

Methane Emissions

This section includes methane emissions from the petroleum and natural gas supply system, landfills, enteric fermentation, and manure management.

Petroleum & Natural Gas Supply System

Emissions decrease 0.2 to 0.8 MMTCO2E due to updated data from ARB.

Natural Gas Supply System (Gas Transmission Subcategory)

Emissions decreases 0.6 to 1.8 $MMTCO_2E$ due to updated data from ARB.

Landfills

Emissions decrease about 2 $MMTCO_2E$.

Enteric Fermentation

Previous inventory used TAR GWPs, not SAR values. This change reduces methane emissions in carbon-dioxide equivalents by 0.7 $MMTCO_2E$.

Manure Management

Previous inventory used TAR GWPs, not SAR values. This change reduces methane emissions in carbon-dioxide equivalents by 0.3 to 0.6 $MMTCO_2E$.

N_2O Emissions

This section includes methane emissions from fertilizer uses in agricultural applications.

Agricultural Soil Management (Direct Fertilizers and Indirect Fertilizers & Crop Residues)

Minor changes (increases of about 0.5 $MMTCO_2E$ are caused by changing data sources to California Agricultural resources Directory for consistency with other sub-categories.

High GWP Emissions

California High GWP gases are scaled from the nationwide GHG inventory proportioned by population. Nationwide GHG inventory values change each year the GHG inventory is updated. Values affected are smaller for 1990 to 1997 (about 2 $MMTCO_2E$) and somewhat larger after that (2.5 to 5 $MMTCO_2E$).

Appendix D--Differences between current, 2006 values and values published in 2005

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Carbon Dioxide (Gross)	(5.41)	(5.45)	(5.82)	(4.01)	(3.19)	(3.99)	(2.52)	(3.10)	(0.76)	(7.93)	(2.06)	1.25	5.11
Fossil Fuel Combustion	(5.41)	(5.45)	(5.82)	(4.01)	(3.19)	(3.99)	(2.52)	(3.10)	(4.31)	(8.04)	(1.92)	1.23	5.16
Residential	(0.01)	0.01	0.03	(0.01)	0.04	0.05	(0.02)	0.01	(0.13)	0.09	0.62	(1.00)	2.55
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	(0.01)	0.01	0.03	(0.01)	0.04	0.05	(0.02)	0.01	(0.13)	0.09	0.62	(1.00)	2.55
Commercial	(1.14)	(1.38)	(1.36)	(1.37)	(1.34)	(1.29)	(1.45)	(1.58)	(2.84)	(6.68)	(1.90)	0.54	2.35
Coal	(0.01)	(0.01)	0.00	(0.04)	(0.02)	(0.01)	0.00	(0.01)	(0.01)	0.00	(0.00)	0.00	0.00
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02
Natural Gas	(1.14)	(1.38)	(1.36)	(1.34)	(1.33)	(1.28)	(1.45)	(1.57)	(2.83)	(6.68)	(1.92)	0.52	2.33
Industrial	(2.04)	(1.68)	(1.59)	(1.05)	(0.82)	(1.42)	(1.33)	(1.53)	(1.86)	(1.16)	(0.64)	0.97	(3.09)
Coal	(0.38)	(0.17)	(0.17)	0.32	0.45	(0.13)	0.02	(0.18)	(0.13)	0.09	(0.05)	(0.05)	(0.05)
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.01)	0.00	(0.00)
Natural Gas	(1.65)	(1.51)	(1.42)	(1.37)	(1.27)	(1.29)	(1.36)	(1.35)	(1.73)	(1.25)	(0.58)	1.02	(3.04)
Natural Gas Liquids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation	(0.00)	0.00	0.00	(0.00)	0.00	0.00	(0.00)	0.00	(0.00)	0.00	0.01	0.93	0.30
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	0.33
Natural Gas	(0.00)	0.00	0.00	(0.00)	0.00	0.00	(0.00)	0.00	(0.00)	0.00	0.01	(0.01)	(0.02)
Electricity Generation (In State)	(2.22)	(2.40)	(2.90)	(1.57)	(1.06)	(1.33)	0.29	0.00	0.53	(0.29)	(0.03)	(0.19)	(1.61)
Coal	(2.22)	(2.40)	(2.90)	(2.86)	(2.97)	(2.60)	(2.32)	(2.01)	(1.92)	(2.14)	(2.16)	(2.05)	(2.27)
Natural Gas	0.00	0.00	0.00	1.29	1.91	1.28	2.60	2.01	2.44	1.84	2.13	1.86	0.67
Not Sector-Specific	(0.00)	0.00	0.00	(0.00)	0.00	0.00	(0.00)	0.00	0.00	0.00	0.02	(0.02)	4.66
Cement Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.06)
Lime Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Limestone & Dolomite Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.00)	(0.00)	0.00	0.00
Soda Ash Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxide Consumption	(0.00)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)
Waste Combustion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Land Use Change & Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.55	0.11	(0.13)	0.02	0.02
Forests	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Reductions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rangelands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Reductions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agricultural Soils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.55	0.11	(0.13)	0.02	0.02
Woody Crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.46	0.11	(0.13)	0.02	0.06
Non-Woody Crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	(0.00)	(0.01)	(0.04)
Liming of Soils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landfills	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lumber Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yard Trimming Disposal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon Dioxide Emissions (Net)	(5.41)	(5.45)	(5.82)	(4.01)	(3.19)	(3.99)	(2.52)	(3.10)	(0.76)	(7.93)	(2.06)	1.25	5.11
Methane (CH_4)	(5.11)	(6.22)	(7.26)	(4.76)	(5.41)	(4.68)	(4.70)	(6.27)	(4.81)	(4.37)	(3.94)	(4.21)	(4.13)
Petroleum & Natural Gas Supply System	(0.24)	(0.34)	(0.79)	(0.34)	(0.32)	(0.31)	(0.31)	(0.31)	(0.32)	(0.20)	(0.33)	(0.30)	(0.37)
Field Production	(0.40)	(0.45)	(0.79)	(0.43)	(0.42)	(0.40)	(0.39)	(0.38)	(0.39)	(0.28)	(0.40)	(0.35)	(0.42)
Refining	0.16	0.09	0.00	0.08	0.08	0.09	0.08	0.05	0.06	0.07	0.07	0.05	0.05
Marketing	0.01	0.01	(0.00)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Natural Gas Supply System	(1.75)	(1.64)	(1.54)	(1.43)	(1.32)	(1.21)	(1.10)	(0.99)	(0.88)	(0.76)	(0.60)	(0.59)	(0.62)
Processing	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.04	0.03	0.03	0.03	0.00
Transmission	(1.81)	(1.70)	(1.60)	(1.48)	(1.37)	(1.27)	(1.15)	(1.03)	(0.91)	(0.79)	(0.62)	(0.62)	(0.63)
Landfills	(1.87)	(2.00)	(2.18)	(1.44)	(1.65)	(1.95)	(1.52)	(3.79)	(2.31)	(2.11)	(1.91)	(2.06)	(1.90)
MSW (Class II & III)	(Previous Inventory did not include this sub-category)												
Other Class II & III	(Previous Inventory did not include this sub-category)												
Others	(Previous Inventory did not include this sub-category)												
Enteric Fermentation	(0.72)	(0.69)	(0.70)	(0.63)	(0.68)	(0.69)	(0.64)	(0.66)	(0.65)	(0.67)	(0.64)	(0.67)	(0.67)
Dairy Cattle	(0.35)	(0.36)	(0.37)	(0.34)	(0.36)	(0.37)	(0.34)	(0.36)	(0.36)	(0.39)	(0.39)	(0.42)	(0.43)
Beef Cattle	(0.33)	(0.29)	(0.29)	(0.25)	(0.27)	(0.28)	(0.27)	(0.26)	(0.25)	(0.25)	(0.21)	(0.21)	(0.21)
Horses	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Sheep	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Swine	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Goats	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Manure Management	(0.31)	(0.37)	(0.37)	(0.38)	(0.41)	(0.43)	(0.43)	(0.46)	(0.46)	(0.50)	(0.51)	(0.53)	(0.55)
Beef Cattle	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Dairy Cattle	(0.28)	(0.33)	(0.34)	(0.35)	(0.37)	(0.40)	(0.40)	(0.43)	(0.42)	(0.46)	(0.48)	(0.50)	(0.52)

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Swine	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)
Poultry	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Sheep	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Goats	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Horses	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Flooded Rice Fields	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Burning Ag Residues	**(0.06)**	**(0.06)**	**(0.06)**	**(0.06)**	**(0.06)**	**(0.06)**	**(0.05)**	**(0.05)**	**(0.05)**	**(0.05)**	**(0.05)**	**(0.04)**	**(0.03)**
Non-woody/Field	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.01
Wheat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Woody/Orchard & Vineyard	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Almonds	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Walnuts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Waste Burning	**0.01**	**0.01**	**0.01**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.03**	**0.04**
Wastewater Treatment	**(0.14)**	**(0.14)**	**(0.14)**	**(0.14)**	**(0.15)**	**(0.15)**	**(0.15)**	**(0.15)**	**(0.15)**	**(0.15)**	**(0.17)**	**(0.16)**	**(0.16)**
Mobile Source Combustion	**(0.13)**	**(1.14)**	**(1.11)**	**(0.47)**	**(0.98)**	**(0.06)**	**(0.86)**	**(0.16)**	**(0.36)**	**(0.31)**	**(0.04)**	**(0.21)**	**(0.02)**
Gasoline Highway Vehicles	(0.22)	(1.23)	(1.18)	(0.60)	(1.10)	(0.21)	(0.99)	(0.32)	(0.51)	(0.46)	(0.20)	(0.39)	(0.19)
Passenger Cars (subcategories revised)	(0.06)	(0.52)	(0.50)	(0.25)	(0.46)	(0.04)	(0.41)	(0.09)	(0.19)	(0.17)	(0.03)	(0.13)	(0.03)
Light-Duty Trucks (subcategories revised)	(0.02)	(0.31)	(0.30)	(0.12)	(0.28)	(0.02)	(0.25)	(0.05)	(0.10)	(0.09)	(0.01)	(0.07)	(0.02)
Medium & Heavy-Duty Trucks (subcategories revised)	(0.02)	(0.24)	(0.24)	(0.09)	(0.22)	(0.02)	(0.19)	(0.03)	(0.07)	(0.06)	(0.01)	(0.05)	(0.01)
Motorcycles (subcategories revised)	(0.01)	(0.03)	(0.03)	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Diesel Highway Vehicles	0.01	(0.02)	(0.01)	0.00	(0.01)	0.01	(0.01)	0.01	0.00	0.00	0.01	0.00	0.01
Passenger Cars	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Light-Duty Trucks	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Medium & Heavy-Duty Trucks	0.01	(0.01)	(0.01)	0.00	(0.01)	0.01	(0.01)	0.01	0.00	0.00	0.01	0.00	0.01
Aviation	0.00	0.02	0.00	0.04	0.04	0.04	0.02	0.02	0.02	0.03	0.03	0.04	0.04
Other Transportation (subcategories revised)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.00)	(0.01)	(0.01)	(0.02)	(0.03)	(0.00)	0.00
Stationary Source Combustion	**0.03**	**0.10**	**(0.43)**	**0.05**	**0.08**	**0.10**	**0.29**	**0.23**	**0.30**	**0.31**	**0.24**	**0.28**	**0.12**
Electricity Generation	0.20	0.22	(0.01)	0.20	0.19	0.19	0.23	0.25	0.27	0.30	0.23	0.26	0.24
Petroleum	(Previous Inventory did not include this sub-category)												
Natural Gas	(Previous Inventory did not include this sub-category)												
Wood	(Previous Inventory did not include this sub-category)												
Other	(Previous Inventory did not include this sub-category)												
Industrial	(0.19)	(0.15)	(0.29)	(0.13)	(0.11)	(0.10)	(0.04)	(0.06)	(0.04)	(0.06)	(0.07)	(0.07)	(0.10)
Petroleum	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)
Natural Gas	(0.28)	(0.27)	(0.28)	(0.23)	(0.22)	(0.21)	(0.17)	(0.18)	(0.17)	(0.18)	(0.18)	(0.20)	(0.19)
Wood (Previous inventory did not include this sub-categor	0.02	0.02	0.00	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Other	0.08	0.11	0.01	0.10	0.11	0.11	0.13	0.12	0.12	0.12	0.12	0.12	0.09
Commercial	0.03	0.03	(0.13)	(0.01)	(0.00)	0.01	0.10	0.05	0.07	0.07	0.07	0.09	(0.01)
Petroleum	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.01
Natural Gas	0.02	0.01	(0.12)	(0.02)	(0.01)	(0.00)	0.07	0.03	0.05	0.04	0.03	0.03	(0.03)
Wood	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Other	(0.01)	0.01	(0.03)	(0.01)	(0.02)	(0.02)	(0.00)	(0.00)	0.00	0.01	0.03	0.05	0.00
Residential	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Petroleum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other (was listed separately from residential in previous ir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitrous Oxide (N_2O)	**0.60**	**0.54**	**0.59**	**0.61**	**0.57**	**0.54**	**0.58**	**0.46**	**0.48**	**0.47**	**0.61**	**0.50**	**0.97**
Nitric Acid Production	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Waste Combustion	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Agricultural Soil Management	**0.66**	**0.59**	**0.61**	**0.65**	**0.62**	**0.59**	**0.59**	**0.50**	**0.51**	**0.50**	**0.60**	**0.53**	**0.76**
Direct	0.26	0.23	0.23	0.25	0.24	0.15	0.16	0.11	0.11	0.09	0.15	0.09	0.21
Fertilizers	0.13	0.10	0.11	0.13	0.11	0.15	0.14	0.11	0.12	0.12	0.15	0.14	0.21
Crop Residues	0.01	0.00	0.00	0.00	0.00	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
N-Fixing Crops	0.06	0.06	0.05	0.05	0.05	(0.05)	(0.04)	(0.05)	(0.07)	(0.09)	(0.06)	(0.10)	(0.05)
Histosols	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Livestock	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05
Indirect	0.28	0.25	0.26	0.27	0.26	0.30	0.29	0.27	0.27	0.28	0.31	0.30	0.37
Fertilizers	0.11	0.09	0.10	0.12	0.10	0.13	0.13	0.10	0.11	0.11	0.13	0.12	0.18
Livestock	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.16	0.17	0.18	0.18	0.18
Leaching/Runoff	0.13	0.11	0.12	0.13	0.12	0.14	0.14	0.12	0.12	0.13	0.14	0.14	0.18
Manure Management	**0.04**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.04**	**0.04**	**0.04**
Beef Cattle	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Dairy Cattle	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Swine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
Sheep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Gas/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Goats	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Horses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Burning Ag Residues	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Non-woody/Field	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wheat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Woody/Orchard & Vineyard	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Almonds	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Walnuts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wastewater	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.05**	**0.05**	**0.03**	**0.05**	**0.04**
Municipal (formerly Human Sewage)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.03	0.05	0.04
Industrial	(Category not yet included in inventory)												
Mobile Source Combustion	**0.01**	**0.01**	**0.05**	**0.01**	**0.01**	**0.01**	**0.05**	**0.01**	**0.01**	**0.01**	**0.05**	**0.01**	**0.25**
Gasoline Highway Vehicles	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00
Diesel Highway Vehicles	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00
Aviation	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.25
Stationary Source Combustion	**(0.16)**	**(0.14)**	**(0.14)**	**(0.13)**	**(0.13)**	**(0.13)**	**(0.13)**	**(0.13)**	**(0.12)**	**(0.12)**	**(0.11)**	**(0.13)**	**(0.13)**
Electricity Generation	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Coal	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Petroleum	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial	(0.13)	(0.11)	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.10)	(0.11)	(0.10)	(0.12)	(0.12)
Coal	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Petroleum	(0.10)	(0.08)	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)	(0.09)	(0.09)
Natural Gas	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commercial/Institutional	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	0.00	0.00	0.00	0.00
Coal	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	0.00	0.00
Petroleum	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Natural Gas	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	0.00	0.00	(0.00)	(0.00)
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Residential	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Coal	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	0.00	0.00
Petroleum	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Natural Gas	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	0.00	(0.00)	(0.00)
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Global-Warming Potential Gases	**(2.74)**	**(2.56)**	**(2.39)**	**(2.08)**	**(1.92)**	**(1.73)**	**(1.81)**	**(1.70)**	**(7.77)**	**(6.78)**	**(6.56)**	**(4.90)**	**(5.22)**
Substitution of Ozone-Depleting Substances	(2.39)	(2.28)	(2.19)	(2.08)	(1.97)	(1.85)	(1.93)	(1.81)	(7.38)	(6.37)	(6.34)	(4.76)	(5.05)
HFC-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(5.12)	(3.90)	(3.71)	(2.48)	(2.49)
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.04	0.04	0.04
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.23)	(0.26)	(0.29)	(0.32)	(0.34)
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.18)	(0.25)	(0.31)	(0.36)	(0.41)
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.09)	(0.11)	(0.13)	(0.16)	(0.19)
HFC-236fa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.02)	(0.05)	(0.07)	(0.10)	(0.13)
CF_4	(1.80)	(1.70)	(1.60)	(1.49)	(1.38)	(1.26)	(1.34)	(1.22)	(1.07)	(1.07)	(1.04)	(0.52)	(0.62)
C_2F_6	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)	(0.59)
Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.11)	(0.17)	(0.23)	(0.27)	(0.30)
Semiconductor Manufacture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.00)	(0.00)
Electricity Transmission & Distribution (SF_6)	(0.35)	(0.27)	(0.21)	0.00	0.05	0.12	0.13	0.11	(0.39)	(0.42)	(0.22)	(0.14)	(0.17)
Electricity Imports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net California Emissions w/o Electric Imports)	(12.66)	(13.69)	(14.89)	(10.25)	(9.95)	(9.86)	(8.44)	(10.60)	(12.85)	(18.62)	(11.95)	(7.36)	(3.27)
Gross California Emissions with Electric Imports	(12.66)	(13.69)	(14.89)	(10.25)	(9.95)	(9.86)	(8.44)	(10.60)	(12.85)	(18.62)	(11.95)	(7.36)	(3.27)
Net California Emissions with Electric Imports	(12.66)	(13.69)	(14.89)	(10.25)	(9.95)	(9.86)	(8.44)	(10.60)	(12.85)	(18.62)	(11.95)	(7.36)	(3.27)
International Bunker Carbon Dioxide Emissions	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Jet Fuel (Aviation)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Distillate Oil (Marine)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residual Oil (Marine)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Fossil Fuel Carbon Dioxide =	**(5.41)**	**(5.45)**	**(5.82)**	**(4.01)**	**(3.19)**	**(3.99)**	**(2.52)**	**(3.10)**	**(4.31)**	**(8.04)**	**(1.92)**	**1.23**	**5.16**
Gross FF CO2 & Imports & International Fuels =	**(5.41)**	**(5.45)**	**(5.82)**	**(4.01)**	**(3.19)**	**(3.99)**	**(2.52)**	**(3.10)**	**(4.31)**	**(8.04)**	**(1.92)**	**1.23**	**5.16**
Non-Fossil Fuel CO2 Portion of GHG Inventory =	**(7.26)**	**(8.23)**	**(9.06)**	**(6.23)**	**(6.76)**	**(5.87)**	**(5.92)**	**(7.50)**	**(8.55)**	**(10.58)**	**(10.02)**	**(8.59)**	**(8.43)**

APPENDIX E

METHANE SPECIATION PROFILE PROVIDED BY CALIFORNIA AIR RESOURCES BOARD

Type of Source	Percent Methane
ALCOHOLS PRODUCTION - AVERAGE (EPA 9007)	43.3%
Animal waste decomposition	70.0%
Asphalt roofing - tar kettle	21.3%
Bar screen waste incinerator- solid waste	80.4%
Carbon black manufacturing	22.4%
Cat stabilzed exhaust 2004 SSD etoh 2% O (MTBE phaseout)	17.9%
Cat stabilzed exhaust 2005 SSD etoh 2% O (MTBE phaseout)	18.7%
Cat stabilzed exhaust 2006 SSD etoh 2% O (MTBE phaseout)	19.5%
Cat stabilzed exhaust 2007 SSD etoh 2% O (MTBE phaseout)	20.3%
Cat stabilzed exhaust 2008 SSD etoh 2% O (MTBE phaseout)	21.2%
Cat stabilzed exhaust 2009 SSD etoh 2% O (MTBE phaseout)	22.0%
Cat stabilzed exhaust 2010 SSD etoh 2% O (MTBE phaseout)	22.8%
Cat stabilzed exhaust 2011 SSD etoh 2% O (MTBE phaseout)	23.7%
Cat stabilzed exhaust 2012 SSD etoh 2% O (MTBE phaseout)	24.5%
Cat stabilzed exhaust 2013 SSD etoh 2% O (MTBE phaseout)	25.3%
Cat stabilzed exhaust 2014 SSD etoh 2% O (MTBE phaseout)	26.2%
Cat stabilzed exhaust 2015 SSD etoh 2% O (MTBE phaseout)	27.0%
Cat stabilzed exhaust 2016 SSD etoh 2% O (MTBE phaseout)	27.8%
Cat stabilzed exhaust 2017 SSD etoh 2% O (MTBE phaseout)	28.6%
Cat stabilzed exhaust 2018 SSD etoh 2% O (MTBE phaseout)	29.5%
Cat stabilzed exhaust 2019 SSD etoh 2% O (MTBE phaseout)	30.3%
Cat stabilzed exhaust 2020 SSD etoh 2% O (MTBE phaseout)	31.1%
Cat start exhaust 1996 SSD etoh 2.0% o (MTBE phaseout)	5.4%
CHEMICAL MANUFACTURING - AVERAGE (EPA 9004)	5.1%
Coal combustion - bituminous - fluidized bed	83.6%
Coke oven blast furnace- process gas	40.9%
Coke oven stack gas - primary metals	45.3%
Composite jet exhaust JP-5 (EPA 1097-1099)	11.4%
Composite natural gas	93.7%
Crude oil - storage tanks - Kern county	30.0%
Crude oil evaporation- vapor composite from fixed roof tanks	8.8%
Daytime biogenic profile- Kern county crops	25.0%
Evaporative emissions-distillate fuel	4.2%
External combustion boiler - natural gas	56.0%
External combustion boiler - process gas	7.6%
External combustion boiler- coke oven gas	82.8%
External combustion boilers- distillate or residual	5.0%
Farm equipment - diesel - light & heavy - (ems=actual weight)	4.1%
Forest fires	17.7%
Gasoline - catalyst - FTP Bag 1-3 STARTS - ARB IUS summer 1994	6.2%
Gasoline - catalyst - FTP Bag 1-3 STARTS - ARB IUS summer 1996	5.3%
Gasoline - catalyst - stabilized exhaust - ARB IUS summer 1987	11.0%
Gasoline - catalyst - stabilized exhaust - ARB IUS summer 1990	12.6%
Gasoline - catalyst - stabilized exhaust - ARB IUS summer 1996	15.8%
Gasoline - catalyst - stabilized exhaust - ARB summer 1988	11.0%
Gasoline - catalyst - stabilized exhaust - ARB summer 1989	12.1%
Gasoline - catalyst - stabilized exhaust - ARB summer 1991	13.1%
Gasoline - catalyst - stabilized exhaust - ARB summer 1992	13.6%
Gasoline - catalyst - stabilized exhaust - ARB summer 1993	14.1%
Gasoline - catalyst - stabilized exhaust - ARB summer 1995	15.6%

Type of Source	Percent Methane
Gasoline - catalyst - stabilized exhaust - ARB summer 1997	16.3%
Gasoline - catalyst - stabilized exhaust - ARB summer 1998	16.8%
Gasoline - catalyst - stabilized exhaust - ARB summer 1999	17.3%
Gasoline - catalyst - stabilized exhaust - ARB summer 2001	18.1%
Gasoline - catalyst - stabilized exhaust - ARB summer 2002	18.4%
Gasoline - catalyst - stabilized exhaust - ARB summer 2003	18.7%
Gasoline - catalyst -stabilized exhaust-from 96IUS summer 2000	17.8%
Gasoline - non-cat - FTP Bag 1-3 STARTS - ARB IUS summer 1994	9.3%
Gasoline - non-cat - FTP bag1-3 STARTS - ARB IUS summer 1996	6.5%
Gasoline - non-cat - FTP Composite - ARB IUS summer 1994	8.4%
Gasoline - non-cat - stabilized exhaust - ARB IUS summer 1994	9.0%
Gasoline - non-cat - stabilized exhaust - ARB IUS summer 1996	5.6%
Geysers power plant main steam	85.9%
ICE-reciprocating-natural gas	76.6%
Industrial ice- distillate oil	11.6%
INDUSTRIAL PROCESSES - AVERAGE (EPA 9003)	9.0%
Iron production - blast furnace - ore charging	15.8%
Iron sintering - primary metals	73.3%
LANDFILLS, USEPA LANDFILL EMISSION MODEL	98.6%
MINERAL PRODUCTS - AVERAGE (EPA 9011)	18.6%
Nighttime biogenic profile - Kern county crops	60.0%
Non-cat stabilized exhaust 1996 SSD 2.0% o etoh (MTBE phaseout)	5.7%
Non-cat start exhaust 1996 SSD 2.0% o etoh (MTBE phaseout)	6.7%
OCS - gas seeps	75.0%
Oil & gas extraction - compressor seals	73.0%
Oil & gas extraction - pipeline valves & fittings	59.7%
Oil & gas extraction - pump seals	49.3%
Oil & gas extraction - well heads & cellars/oil&water separator	37.5%
Oil & gas production fugitives-gas service	61.3%
Oil & gas production fugitives-liquid service	37.6%
Oil & gas production fugitives-valves-unspecified	45.8%
Open burning dump- landscape/pruning (modified KVB 121)	56.0%
PETROLEUM INDUSTRY - AVERAGE (EPA 9012)	13.0%
Petroleum industry - refinery catalytic reformer - fugitive emissions	0.9%
PRIMARY METAL PRODUCTION - AVERAGE (EPA 9009)	29.1%
Primary metals - steel production - basic oxygen furnace	11.1%
PRINTING/PUBLISHING - AVERAGE (EPA 9026)	10.0%
Red oak combustion - wood stove (w/o catalyst)	51.1%
Refinery co boiler - fcc	36.0%
Refinery flares- natural gas	20.0%
Refinery- fugitive emissions from covered drainage/separation pits	2.9%
Refinery- pipes, valves & flanges- composite	28.6%
Refinery- pump seals- composite	3.3%
Species unknown- all category composite	25.0%
Utility equipment - gasoline - 2 cycle - CalPoly 1991	2.1%
Utility equipment - gasoline - 4 cycle - CalPoly 1991	6.3%

Derived as a subset from:
[http://www.arb.ca.gov/ei/speciate/speciate.htm (ORGPROF]

APPENDIX F

COMPARING THE CURRENT 1990 TO 2004 GHG EMISSIONS INVENTORY AND 2005 INTEGRATED ENERGY POLICY REPORT TO CORRESPOINDING VALUES USED BY THE CALIFORNIA CLIMATE ACTION TEAM

Introduction

GHG emissions inventories are by necessity approximations derived from numerous calculations and assumptions. As data and methodologies to perform this function improve, revisions are needed. In this GHG inventory, emissions estimates changed from previously published values for a variety of reasons, including revised estimates of fuel used in California and to correct problems in the previous inventory, including double counting one sub-category and instances of not using consistent GWPs to determine CO_2 equivalents for methane and nitrous oxide emissions. These are detailed in various places elsewhere in this report.

In addition, the Energy Commission updates its Integrated Energy Policy Report every two years. The Climate Action Team (CAT) used the *2003 Integrated Energy Policy Report (IEPR)* to project fuel demand, not the *2005 IEPR*. These two categories of factors cause changes in both the historical GHG emissions and in the emissions projections.

This appendix compares the current GHG inventory and projections based upon the *2005 IEPR* to the 1990 to 1999 GHG inventory and projections based upon the *2003 IEPR* as used by the CAT. The CAT emissions reduction needed to meet the Governor's 2010 goal was 59 $MMTCO_2E$ (from Table 5-5 of the CAT report) while the current GHG inventory and projections would require 68 $MMTCO_2E$ reductions in 2010. Likewise, the CAT report indicates that 174 $MMTCO_2E$ reductions would be needed in 2020 while the current GHG inventory and projections indicates that 177 $MMTCO_2E$ reductions are needed in 2020.

Projections based upon *2003 IEPR*

The California Climate Action Team used work products prepared earlier by the Tellus Institute. This work was initially conducted as part of a tri-state effort to address global warming issues and included California, Oregon, and Washington. The Tellus work was refocused to include only California and was initially produced as a draft in December 2004[91] and then in revised form in July 2005.[92]

Tellus Institute summarized emissions from in-state electricity production, out-of-state electricity produced for use in California, direct fuel use, transportation fuel use, and non-carbon GHG emissions. They first projected the 1990 to 1999 GHG inventory to 2002, then extended it to 2010 and 2020. They made adjustments to reflect the impact of recent policies that were adopted by the California Public Utilities Commission, the Energy Commission, and the Air Resources Board. Also, the CAT removed international bunker fuels from the Tellus values. California GHG emissions estimates as used by the CAT are shown in Table F-1.

Out-of-state electricity emissions were projected by first assuming California's Renewables Program goal of having 20 percent of our electrical energy supplied by renewables by 2017 and assuming 32 percent of California's electricity is supplied by out-of-state resources. The non-renewable portion of the growth in our-of-state gigawatt hours was assumed to be 50 percent coal and 50 percent natural gas.

Although the major emissions categories were projected to 2010 and 2020, several of the sub-categories were either held constant at their 2002 values or projected using draft data from a report from the Energy Commission's Public Interest Energy Research (PIER) Program.[93] Specifically:

(1) GHG emissions from cement manufacturing and other industrial processes were held constant, except the PIER report was used to project nitric acid emissions;

(2) Soils and forest sinks were held constant at 1999 values;

(3) CO_2 and nitrous oxide emissions from waste combustion were both held constant at 1999 values. Methane emissions from wastewater and nitrous oxide emissions from human sewage were projected using the PIER report;

(4) Methane and nitrous oxide emissions from manure management were projected using the PIER report while methane emissions from enteric fermentation and other agricultural activities were held constant at 1999 values;

(5) Methane and nitrous oxide emissions from mobile and stationary sources were held constant at 1999 values; and

(6) High GWP gas emissions from substitution of ozone depleting substances, semiconductor manufacturing and sulfur hexafluoride use were all projected using the PIER report.

Projections based upon *2005 IEPR*

The current inventory and publication of the *2005 Integrated Energy Policy Report* provide opportunities to update the Climate Action Team (CAT) data. These updates may prove useful to the CAT when they update their work in January 2007. While it would be prudent to use the forthcoming *2007 IEPR* work, it is not expected to be available by January 2007. As an alternative, this appendix presents the results of projecting emissions using the 1990 to 2004 GHG inventory and the *2005 IEPR*. Table F-2 summarizes the results.

An approach similar to that used by the CAT was used to project the 1990 to 2004 inventory to 2010 and 2020. Updated values from the *2005 IEPR* were used to project electricity demand. This projected demand included California Public Utilities Commission decisions and Energy Commission adopted standards for both appliances and buildings. Also, the renewable program goals were assumed to be met.

The remaining growth in electricity demand was assumed to be met by 100 percent natural gas for both in-state and out-of-state electricity supply resources. The recently-adopted SB 1368 (Perata, Chapter 598, Statutes of 2006) will ensure all electrical load growth will be served by facilities that emit no more than a modern, combined-cycle natural gas power plant. The California Public Utilities Commission (CPUC) has a current regulatory proceeding[94] to develop an appropriate emissions rate in term of pounds carbon dioxide per megawatt-hour. CPUC staff has proposed a rate of 1,100 pounds of carbon dioxide emissions per megawatt-hour. This value was used to project 2010 and 2020 emissions from the non-renewable portion of electricity demand growth.

Non-carbon emissions were either held constant at 2004 values, were projected using either underlying data, or data from a technical report prepared for the Energy Commission's PIER Program by ICF Consulting and titled *Emissions Reduction Opportunities for Non-*CO_2 *Greenhouse Gases in California*[95] or projected using fuel demand data from the *2005 IEPR*:

(1) GHG emissions from industrial processes were held constant at 2004 values. These emissions tend to be small in magnitude and do not tend to change over the 1990 to 2004 time period. Emissions from cement manufacturing were assumed to grow in proportion to the projected demand for natural gas use in the cement manufacturing sector. Although other fuels are likely used, including petroleum coke and waste tires, the amount of CO_2 emissions from cement clinker production was assumed to correlate better to expected future natural gas demand values than holding them constant, as was done in the earlier CAT report projections. This assumes that the fuel mix remains constant.

(2) Soils and forestry sink emissions were estimated at the average of their 1990 to 2004 values. Since historical values fluctuate over time, this seems to be a better representation than holding them constant at near-year values.

(3) Methane emissions from oil and natural gas production decline steadily over the 1990 to 2004 period. These were projected to continue to decline by about 15 percent to 2020 as stated in the ICF Consulting report. This treatment matches the earlier CAT report projections.

(4) GHG emissions from waste combustion and wastewater treatment were projected to increase with population. Methane emissions from landfills were assumed to increase as stated in the ICF Consulting report. The CAT report held the waste combustion and wastewater treatment emissions constant and used a

draft of the ICF report for landfill projections (no change in data in the final report).

(5) Agricultural emissions of methane and nitrous oxide were projected using either an extrapolation of historical trends or assumed constant. Methane emissions from enteric fermentation and manure management and nitrous oxide emissions from agricultural soil management were projected using extrapolation. Methane emissions from flooded rice fields and agricultural burning as well as nitrous oxide emissions from manure management and agricultural burning were each held constant at 2002 to 2004 average values. The earlier CAT projections for manure management were projected from the ICF report. However, these gases are combined in that report but need to be separated out for the projections.

(6) Methane and nitrous oxide emissions from mobile source combustion were projected using gasoline and diesel demand forecasts from the *2005 IEPR*. The CAT projections held these constant.

(7) Methane and nitrous oxide emissions from stationary source combustion were projected using population data from the *2005 IEPR*. The CAT projections held these constant.

(8) GHG emissions from high GWP gases, with the exception of non-refrigeration gases, were projected using data from the ICF Consulting report. The ICF Consulting report treats refrigeration gases separately, and this was incorporated in the current projections. In the most recent projections, the non-refrigeration gases are held constant at the average of their 2002 to 2004 values.

Table F-1 -- California Greenhouse Gas Emissions (from Tellus Institute, final numbers used by CAT)

Buildings, Industry, Electricity	**1990**	1991	1992	1993	1994	1995	1996	1997	1998	1999	**2000**	2001	2002	**2010**	**2020**
Electricity Generation Totals with Impact of Recent Policies	**86.8**	**89.8**	**100.2**	**92.7**	**99.8**	**80.7**	**77.3**	**90.9**	**100.5**	**102.7**	**103.7**	**113.6**	**108.8**	**113.6**	**125.0**
In state generating resources	**42.5**	**45.4**	**54.9**	**50.9**	**55.5**	**41.5**	**35.0**	**42.4**	**45.7**	**48.6**	**60.2**	**61.1**	**51.0**	**54.5**	**61.4**
Existing Coal Plants	4.4	3.6	4.3	3.0	3.1	1.3	3.4	2.7	3.2	4.3	3.8	4.7	5.0	5.0	5.0
Existing Gas Plants	34.6	41.4	50.3	46.2	50.9	39.8	31.1	39.6	42.3	44.3	56.5	56.4	46.1	46.1	46.1
Existing Oil Plants	3.6	0.5	0.3	1.6	1.5	0.4	0.5	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0
New (non-renewable) Electricity Generation Sources														3.5	10.4
Out of state generating resources	**44.3**	**44.4**	**45.3**	**41.8**	**44.3**	**39.2**	**42.3**	**48.5**	**54.8**	**54.1**	**43.5**	**52.5**	**57.8**	**60.5**	**65.9**
Utility owned out of state (Coal)	18.1	20.8	29.4	20.8	22.9	17.2	23.1	25.4	32.5	33.4	34.4	37.5	37.4	37.4	37.4
Imports from NW	6.6	6.0	4.1	3.2	3.2	4.1	6.2	5.3	4.1	5.4	3.9	1.4	5.7	5.7	5.7
Imports from SW	19.6	17.5	11.7	17.8	18.2	17.9	13.1	17.8	18.2	15.2	5.2	13.6	14.7	14.7	14.7
New (non-renewable) Electricity Generation Sources														2.7	8.1
Impact of Recent Policies														**(1.4)**	**(2.3)**
CPUC Energy Savings Goals (IOUs; 2004/2005 Only)														(0.9)	(1.0)
2005 Building Standards														(0.6)	(1.3)
Direct Fuel Use	**109.1**	**104.6**	**95.3**	**94.3**	**96.6**	**97.0**	**100.7**	**104.7**	**110.2**	**106.6**	**103.4**	**101.5**	**102.3**	**107.0**	**110.4**
Natural Gas	67.0	65.5	60.0	61.9	63.8	63.4	67.4	70.8	77.0	76.9	73.7	71.9	72.6	77.4	80.8
Coal	1.6	2.3	1.6	2.2	2.2	4.3	1.5	1.8	2.7	1.6	1.6	1.6	1.6	1.6	1.6
Oil (largely in refineries)	40.4	36.8	33.7	30.2	30.6	29.3	31.8	32.1	30.5	28.0	28.0	28.0	28.0	28.0	28.0
Impact of Recent Policies														**(0.1)**	**(0.3)**
CPUC Energy Savings Goals (IOUs; 2004/2005 Only)														0.0	0.0
2005 Building Standards														(0.1)	(0.3)
Direct Fuel Use With Impact of Recent Policies	**109.1**	**104.6**	**95.3**	**94.3**	**96.6**	**97.0**	**100.7**	**104.7**	**110.2**	**106.6**	**103.4**	**101.5**	**102.3**	**106.9**	**110.1**
Transportation	**1990**	1991	1992	1993	1994	1995	1996	1997	1998	1999	**2000**	2001	2002	**2010**	**2020**
On-Road Gasoline Demand	110.0	108.8	106.9	108.9	110.0	110.1	112.7	114.1	116.2	119.5	122.1	124.0	129.0	148.9	165.4
Impact of Recent Policies (switch to 5.7% ethanol in CaRFG3)														**(1.5)**	**(1.7)**
On-Road Diesel Outlook	18.9	17.1	19.7	18.2	20.1	21.1	21.2	22.9	23.4	24.1	26.0	27.5	26.0	32.1	37.3
International Bunker Fuels (mostly residual oil)	20.4	21.7	11.8	9.7	8.5	10.1	10.0	10.2	9.2	10.2	10.2	10.2	10.2	10.2	10.2
Other Petroleum (Off-Road Diesel/Gasoline, Military jetfuel, etc.)	20.1	12.5	15.1	16.6	20.4	23.2	20.2	12.9	11.4	15.3	15.3	15.3	15.3	15.3	15.3
Natural Gas	1.1	1.0	0.8	0.7	0.7	1.1	1.1	1.3	0.6	0.7	0.7	0.7	0.7	0.7	0.7
Jet Fuel - Commercial (non-military)	38.3	36.4	35.1	36.2	40.1	38.7	42.2	41.9	42.8	40.1	41.8	36.9	30.3	41.8	60.3
Transportation Totals with Impact of Recent Policies	**208.8**	**197.5**	**189.4**	**190.2**	**199.9**	**204.3**	**207.4**	**203.3**	**203.6**	**209.9**	**216.1**	**214.5**	**211.5**	**247.4**	**287.5**
Fossil Fuel CO2 Subtotals	**1990**	1991	1992	1993	1994	1995	1996	1997	1998	1999	**2000**	2001	2002	**2010**	**2020**
With Electric Imports, Bunker Fuel, and International Fuels Included:															
Base Case Projections (Carbon Dioxide Only)	**404.7**	**391.9**	**384.9**	**377.2**	**396.2**	**382.0**	**385.5**	**398.9**	**414.3**	**419.1**	**423.2**	**429.6**	**422.6**	**467.8**	**522.6**
Non-Carbon GHG Emissions (in CO2 Equivalents)															
Agriculture (CH4 and N2O)	27.1	25.7	26.3	26.6	26.8	29.1	28.2	27.3	27.4	28.4	28.7	28.8	28.8	29.0	28.6
Soils and Forests Carbon Sinks	(25.6)	(25.2)	(21.0)	(20.7)	(20.3)	(19.9)	(19.6)	(19.3)	(19.1)	(18.8)	(18.8)	(18.8)	(18.8)	(18.8)	(18.8)
ODS substitutes	0.1	0.1	0.2	0.7	1.2	2.9	4.2	5.2	6.1	7.0	8.0	9.1	10.2	19.2	31.0
Semi-conductor manufacture (PFCs)	0.4	0.4	0.4	0.5	0.5	0.7	0.9	0.9	0.8	0.8	2.3	2.3	2.3	2.3	2.3
Electric Utilities (SF6)	1.6	1.6	1.7	1.7	1.8	1.8	1.8	1.9	1.8	1.9	0.4	0.4	0.4	0.4	0.4
Cement, Other Industrial Processes	5.8	5.4	5.2	5.1	5.7	6.0	5.9	6.1	6.2	6.5	6.5	6.5	6.5	6.5	6.5
Solid Waste Management, Landfill Gas, and Wastewater	19.5	19.5	19.7	19.9	19.6	19.2	17.7	16.9	15.0	15.9	23.3	23.6	23.8	26.0	27.7
Methane from oil and gas systems	3.9	3.8	3.9	3.4	3.3	3.4	3.3	3.3	3.3	3.3	2.2	2.2	2.2	2.2	2.2
Methane and N20 from Fossil Fuel Combustion	8.5	8.7	8.8	8.7	8.6	8.4	8.2	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.6
Total Non-Carbon GHG Emissions	**41.3**	**40.0**	**45.3**	**46.0**	**47.3**	**51.5**	**50.5**	**49.9**	**49.1**	**52.7**	**60.3**	**61.7**	**63.1**	**74.3**	**87.5**
TOTAL BASELINE GREENHOUSE GAS EMISSIONS	**1990**	1991	1992	1993	1994	1995	1996	1997	1998	1999	**2000**	2001	2002	**2010**	**2020**
	446	432	430	423	444	434	436	449	463	472	483	491	486	542	610
Totals Excluding International Bunker Fuels	**426**	**410**	**418**	**413**	**435**	**423**	**426**	**439**	**454**	**462**	**473**	**481**	**475**	**532**	**600**
Reductions Needed to Meet Governor's GHG Reduction Goals:														**59**	**174**

Table F-2 -- California Greenhouse Gas Emissions
(Energy Commission's 1990 to 2004 GHG Inventory & 2005 IEPR for Projections)

(Projections are 3-yr average centered on 2002)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2010	2020
Buildings, Industry, Electricity																	
Electricity Generation Totals with Impact of Recent Policies	**80**	**80**	**87**	**81**	**91**	**75**	**74**	**83**	**93**	**95**	**92**	**103**	**94**	**101**	**108**	**119**	**129**
In state generating resources	**37**	**37**	**44**	**40**	**48**	**36**	**34**	**36**	**40**	**43**	**52**	**56**	**42**	**44**	**47**	**63**	**69**
Existing Coal Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Gas Plants	36	37	44	40	48	36	34	36	40	43	52	56	42	44	47	63	69
Existing Oil Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Out of state generating resources	**43**	**43**	**43**	**41**	**43**	**39**	**41**	**47**	**53**	**52**	**40**	**47**	**52**	**56**	**61**	**56**	**61**
Utility owned out of state (Coal)	17	19	27	19	21	16	21	23	30	31	31	22	22	22	23	22	22
Imports from PNW	6	5	4	3	3	4	6	5	4	5	4	4	6	8	7	N/A	N/A
Imports from PSW	21	19	12	19	19	19	14	19	19	16	6	22	24	27	31	N/A	N/A
GWH Growth																34	38
Impact of Recent Policies																	
CPUC Energy Savings Goals (IOUs; 2004/2005 Only)																	
2005 Building Standards																	
Direct Fuel Use	**109**	**107**	**99**	**103**	**106**	**100**	**105**	**109**	**119**	**118**	**123**	**120**	**122**	**109**	**107**	**113**	**116**
Natural Gas	65	64	59	60	62	62	65	69	80	79	79	73	74	66	68	74	79
Coal	3	3	3	2	3	3	3	4	4	4	4	4	4	4	4	4	4
Oil (largely still gas & pet. Coke used in refineries)	40	39	37	40	41	35	36	37	36	34	38	42	39	36	35	35	32
Non-specified Fuel Use (balancing entry)	1	1	0	1	1	1	0	0	0	1	1	1	5	2	0	0	0
Natural Gas Liquids	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Impact of Recent Policies																	
CPUC Energy Savings Goals (IOUs; 2004/2005 Only)																	
2005 Building Standards																	
Direct Fuel Use With Impact of Recent Policies	**109**	**107**	**99**	**103**	**106**	**100**	**105**	**109**	**119**	**118**	**123**	**120**	**122**	**109**	**107**	**113**	**116**
Transportation																	
On-Road Gasoline Demand (before switch from MTBE to Ethanol)	111	109	115	113	113	115	114	115	117	120	122	125	131	126	131	144	145
Impact of Recent Policies (switch to ~6% ethanol in CaRFG; only needed for 2010 & 2020)																(2.0)	(2.1)
On-Road Diesel Outlook	23	22	23	21	24	24	25	27	27	28	30	30	31	31	32	38	50
International Bunker Fuels (mostly residual oil)	40	35	28	28	32	36	35	27	27	30	34	32	32	24	26	26	26
Other Petroleum (Off-Road Diesel/Gasoline, Military jetfuel, etc.)	3	3	2	2	2	3	2	2	2	2	3	2	2	2	2	2	2
Natural Gas	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0
Jet Fuel - Commercial (non-military)	24	23	22	23	25	24	26	26	27	25	26	25	26	21	22	29	38
Transportation Totals with Impact of Recent Policies	**161**	**157**	**162**	**159**	**164**	**166**	**167**	**171**	**173**	**176**	**182**	**182**	**190**	**181**	**188**	**211**	**233**

Table F-2 -- California Greenhouse Gas Emissions
(Energy Commission's 1990 to 2004 GHG Inventory & 2005 IEPR for Projections)

(Projections are 3-yr average centered on 2002)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	**2000**	2001	2002	2003	2004	**2010**	**2020**
Fossil Fuel CO2 Subtotals																	
With Electric Imports and International Fuels Included:																	
Base Case Projections (Carbon Dioxide Only)	**350**	**343**	**348**	**343**	**361**	**341**	**347**	**364**	**385**	**389**	**397**	**406**	**406**	**390**	**403**	**444**	**478**
Non-Carbon GHG Emissions (in CO2 Equivalents)																	
Agriculture (CH4 and N2O)	26.8	25.5	26.0	26.4	26.6	28.7	27.8	26.8	27.0	27.9	29.6	29.4	33.8	33.9	34.0	35.7	40.6
Soils and Forests Carbon Sinks	(17.2)	(16.7)	(15.1)	(17.1)	(15.4)	(14.9)	(14.5)	(14.0)	(11.8)	(14.4)	(14.5)	(12.7)	(16.0)	(14.6)	(14.9)	(15.1)	(15.1)
ODS substitutes	4.5	4.9	5.3	5.7	6.1	6.5	8.4	9.8	6.7	7.8	8.6	9.5	10.5	11.4	12.6	19.9	30.7
Semi-conductor manufacture (PFCs)	0.4	0.4	0.4	0.5	0.5	0.7	0.7	0.8	0.9	0.9	0.8	0.5	0.5	0.5	0.6	2.5	5.7
Electric Utilities (SF6)	2.3	2.2	2.2	2.2	2.2	2.1	2.3	2.1	1.3	1.2	1.1	1.1	1.0	1.0	1.0	1.5	1.9
Cement, Other Industrial Processes	5.7	5.3	4.8	5.3	6.0	6.0	6.2	6.3	6.3	6.5	6.7	6.3	6.9	7.1	7.3	7.4	7.3
Solid Waste Management, Landfill Gas, and Wastewater	10.7	10.5	10.3	11.1	10.8	10.5	11.0	8.8	10.4	10.7	10.6	10.9	11.0	11.2	11.5	11.8	12.8
Methane from oil and gas systems	2.6	2.4	1.9	2.3	2.2	2.1	2.1	2.0	1.9	2.0	1.9	1.9	1.8	1.9	1.9	1.9	2.1
Methane and N20 from Fossil Fuel Combustion	18.3	16.6	15.9	16.9	15.7	16.6	15.3	15.3	15.1	15.0	15.7	15.2	14.9	14.5	13.8	16.5	16.9
Total Non-Carbon GHG Emissions	**54.2**	**51.0**	**51.7**	**53.2**	**54.7**	**58.3**	**59.2**	**57.9**	**57.7**	**57.6**	**60.4**	**62.2**	**64.6**	**66.9**	**67.9**	**82.1**	**102.8**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	**2000**	2001	2002	2003	2004	**2010**	**2020**
TOTAL BASELINE GREENHOUSE GAS EMISSIONS	**404**	**394**	**400**	**396**	**416**	**399**	**407**	**422**	**443**	**447**	**457**	**469**	**470**	**457**	**471**	**526**	**581**
Reductions Needed to Meet Governor's GHG Reduction Goals:																**68**	**177**
CAT Reductions:																59	174

APPENDIX G

CHANGES AFTER THE NOVEMBER 30, 2006 WORKSHOP

Submitted Comments and Replies

The Energy Commission opened a docket to receive comments on a draft of this report. The docket number is 06-IEP-1G. The following information summarized docketed comments. More detail can be found in the docketed submissions.

Steven Brink, California Forestry Association

Mr. Brink asked for more details on the method used to estimate forest sinks. These additional details are provided on page 45 of the final report as follows:

> A portion of the carbon associated with harvested forest wood is sequestered in long-term wood products. For softwoods, 75 percent is extracted from the forest and 44 percent of the extracted volume is stored in these long-term products. For hardwoods, 73 percent is extracted and 23 percent of the extracted hardwood volume is stored in long-term products.

Mr. Brink also referred to what he described as an “inappropriate forestry protocol for the carbon equation.” The GHG inventory used research work performed by Winrock International, not a forestry protocol.

Mr. Brink stated that changes in forestry management could be an important tool for climate change mitigation. The Energy Commission agrees, although mitigation options are outside the scope of the GHG emissions inventory.

Bud Hoekstra, BerryBlest Organic Farm

Mr. Hoekstra commented that organic farming needs to be studied and that increased organic farming could be an important global warming mitigation option. Although mitigation options are outside the scope of the GHG emissions inventory, the Energy Commission agrees that changes in agricultural practices (including increased use of organic farming) could become an important mitigation option and the Energy Commission’s Public Interest Research and Development (PIER) Program is studying them.

David Coale, Palo Alto/Stanford Green Ribbon Task Force

Mr. Coale stated that it was difficult to find baseline and future “business-as-usual” values for transportation. He recommended implementing a new law requiring odometer readings to be taken at the time of vehicle registration to allow computation of fuel consumption by vehicle class by combining miles traveled with typical fuel economy of that class. This comment is outside the scope of the GHG emissions inventory, although having such information would enable transportation fuel consumption to be subdivided by vehicle class and this would enrich the GHG inventory data.

Randy S. Howard, Los Angeles Department of Water and Power

Mr. Howard submitted data that his company had reported to the California Climate Action Registry. The table below summarizes that data.

Year	LADWP Emissions (Million Metric Tons of Carbon Dioxide)
2000	18.4
2001	17.8
2002	16.4
2003	16.9
2004	17.4

The GHG inventory in this report includes data for total electricity generation within the State of California and GHG emissions associated with electricity imported into the state. It does not break down this data by load-serving entity (LSE) and the data submitted by LADWP cannot be reconciled against this GHG inventory data.

Errata

In the draft report, some of the data in Table 2, page 3 were incorrect because a portion of the data represented net emissions, when gross emissions were needed for consistency with other tables in this section. The correct values were shown in Table 5.

Endnotes number 10 & 55 were updated from a draft report on the California Energy Balance to the final report. The bibliography was also updated.

BIBLIOGRAPHY

Benjamin, Michael, mbenjami@arb.ca.gov, Methane Emissions, January 27, 2005, Personal e-mail, (January 27, 2005).

California Department of Food and Agriculture, California Agricultural Resource Directory 2005, Sacramento, CA, http://www.cdfa.ca.gov/card/card_new04.htm.

CARB, April 2005, *Areawide Source Methodologies,* (dynamic dating), www.arb.ca.gov/ei/areameth.htm.

California Air Resources Board, August 2004, *Staff Report: Initial Statement of reasons for Proposed Rulemaking, Publich Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*, Sacramento, California.

Center for Energy & Environmental Education, University of Northern Iowa, *Year 2000 Iowa Greenhouse Gas Emissions Inventory,* January 2005, Cedar Falls Iowa, page 21, http://www.uni.edu/ceee/news/Corrected%20Year%202000%20Greenhouse%20Gas%20Emissions.pdf.

California Environmental Protection Agency, March 2006, Climate Action Team Report to Governor Schwarzenegger and the Legislature, July 31, 2006.

Center for Integrated Regional Assessment, EMS Environment Institute, The Pennsylvania State University, *him that Gas Emissions Inventory for Pennsylvania Phase I Report*, June 2003, page 12, http://www.dep.state.pa.us/dep/deputate/pollprev/inventory.pdf.

Center for Sustainable Systems, University of Michigan, *Michigan Greenhouse Gas Inventory 1990 and 2002*, April 8, 2005, page ES 4, http://css.snre.umich.edu/css_doc/CSS05-07.PDF.

CIWMB, December 2004, Statewide Waste Characterization Study, Sacramento, California.

EIA, DOE, *Emissions of GHGs in The United States 2003*, December 2004, pages x and 28.

Energy Commission, October 1990, *1988 Inventory of California Greenhouse Gas Emissions*, Sacramento, CA, Final Staff Report.

Energy Commission, March 1997, *California's Greenhouse Gas Emissions Inventory 1990*, Sacramento, CA, P500-97-004.

Energy Commission, January 1998, *Appendix A. Historical and Forecasted Greenhouse Gas Emissions Inventories for California*, Sacramento, CA, P500-98-001V3.

Energy Commission, April 2, 1998, *Fuel~Resources Profiles of Electricity Generation and Related CO_2 Emissions for the State of California, 1994 and 1995*, Energy Facilities Siting and Environmental Division.

Energy Commission, November 2002, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999,* Sacramento, CA, P600-02-001F, http://www.energy.ca.gov/reports/600-02-001F/index.html.

Energy Commission, March 2004, *Baseline Greenhouse Gas Emissions for Forest, Range, and Agricultural Lands In California*, Sacramento, California, P500-04-069, http://www.energy.ca.gov/pier/final_project_reports/500-04-069.html.

Energy Commission, June 2005, *Development of Energy Balances for the State of California*, Sacramento, California, CEC-500-2005-068.

Energy Commission, June 2005, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002 Update*, Sacramento, CA, CEC-600-2005-025, http://www.energy.ca.gov/2005publications/CEC-600-2005-025/index.html.

Energy Commission, September 2005, *California Energy Demand 2006-2016; Staff Energy Demand Forecast; Revised September 2005*, Sacramento, CA, CEC-400-2005-034-SF-ED2, http://www.energy.ca.gov/2005publications/CEC-400-2005-034/CEC-400-2005-034-SFED2.PDF.

EPA, June 2003 and subsequent updates, *Introduction to Estimating Greenhouse Gas Emissions,* November 2002, Washington, DC.

EPA, January 2004, *Reducing SF_6 Emissions Means Better Business for Utilities,* Office of Atmospheric Programs, www.epa.gov/electricpower-sf6.

EPA, April 15, 2006, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004*, Washington DC.

Intergovernmental Panel on Climate Change (2001), *Climate Change 2001: Synthesis Report, Summary for Policy Makers,* page 2, http://www.grida.no/climate/ipcc_tar/vol4/english/076.htm.

Northeast States for Coordinated Air Use Management (NESCAUM), Connecticut Department of Environmental Protection, *Connecticut Greenhouse Gas Inventory 1990-2000*, August 2003, page 18, http://www.ctclimatechange.com/ct_inventory.html.

Oklahoma Department of Environmental Quality, Air Quality Division, *Inventory of Oklahoma Greenhouse Gas Emissions and Sinks: 1990 and 1999*, September 2002, page III, http://www.deq.state.ok.us/AQDnew/resources/reports/Oklahoma%20GHG%20Inventory.pdf.

Rypdal, Kristin and Winiwarter, Wilfried, (2001), Volume 4, Oslo, Norway, *Uncertainties In Greenhouse Gas Emissions Inventories—Evaluation, Comparability and Implications*.

U. S. Census Bureau, January 28, 2005, [http://www.census.gov/popest/states/], (April 2005).

U. S. Department of Commerce, Bureau of Economic Analysis, December 15, 2004, [http://www.bea.gov/bea/regional/gsp/], (April 2005).

Washington State University Energy Cooperative, State of Washington, *Washington State's Greenhouse Gas Emissions: Sources and Trends*, June 2004, page 3.

ENDNOTES

[1] Derived from U. S. Department of Commerce, Bureau of Economic Analysis, June 6, 2006, [http://www.bea.gov/bea/regional/gsp/], (accessed October 3, 2006). California's GSP grew from $788.3 trillion dollars in 1990 to $1,410.5 trillion dollars in 2003, for an increase of 83 percent. Correspondingly, Texas' GSP grew from $384.1 trillion dollars in 1990 to $828.5 trillion dollars in 2003, for an increase of 115 percent.

[2] Data are for total greenhouse gas emissions and include emissions from electricity imported into California, from World Resources Institute's Climate Analysis Indicators Tool. Strictly speaking, California was the sixteenth largest emitter of CO_2 in 2002. Other estimates place the California ranking higher, and rankings as high as tenth are possible. Since the magnitude of the differences among the ranked governmental bodies (all are countries except for California and Texas) are small, the exact ranking is rather arbitrary and not worth debating. California and Texas are both major contributors to world-scale greenhouse gas emissions.

[3] NRDC comments to the Energy Commission, April 5, 2005.

[4] Gross emissions represent emissions without taking into account emissions reductions, or sinks. The term "CO_2-equivalent" (also expressed as "CO_2-equivalent") is used to describe the ensemble of GHG gases that contribute to global warming, including CO_2, methane, nitrous oxide, and a class of gases called high GWP gases (see end note 20 for this definition). These non-CO_2 gases cause the atmosphere to heat (called "radiative forcing") at a faster rate than CO_2. To determine CO_2-equivalence of these non- CO_2 gases, CO_2 is given a weighting factor of 1.0, and the other gases are given a weighting factor that represents their rate of warming compared to CO_2. These weighting factors are called "GWPs" and are usually based upon the impact of the subject gas estimated over a 100-year period of time. These GWPs are studied and reported through an international review process.

[5] The term "anthropogenic" is used to describe something that is human-derived rather than naturally occurring.

[6] Intergovernmental Panel on Climate Change (2001), *Climate Change 2001: Synthesis Report, Summary for Policy Makers,* page 2, [http://www.grida.no/climate/ipcc_tar/vol4/english/076.htm].

[7] Energy Commission, June 2005, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002 Update*, Sacramento, California, CEC-600-2005-025, [http://www.energy.ca.gov/2005publications/CEC-600-2005-025/index.html].

[8] Energy Commission, November 2002, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999,* Sacramento, California, P600-02-001F, [http://www.energy.ca.gov/reports/600-02-001F/index.html].

[9] EPA, June 2003 and subsequent updates, *Introduction to Estimating Greenhouse Gas Emissions,* November 2002, Washington, DC.

[10] California Energy Commission, June 2005, *Development of Energy Balances for the State of California*, Sacramento, California, CEC-500-2005-068, prepared by Lawrence Berkeley National Laboratory.

[11] EPA, June 2003 and subsequent updates, *Introduction to Estimating Greenhouse Gas Emissions,* November 2002, Washington, DC.

[12] Because it was not possible to obtain full GHG inventory data for the other states, staff used estimates of CO_2 emissions from fossil fuel combustion to compare California emissions to other states and to evaluate how they compare in relative GHG emissions intensity.

[13] California Energy Commission, October 1990, 1988 *Inventory of California Greenhouse Gas Emissions*, Sacramento, California, Final Staff Report.

[14] California Energy Commission, March 1997, *California's Greenhouse Gas Emissions Inventory 1990*, Sacramento, California, P500-97-004.

[15] See Footnote 4 for definition.

[16] The term "international bunker fuels" applies to fuels used in international aviation or marine transportation. In accordance with international GHG emissions reporting procedures, in the current inventory these emissions are calculated and reported separately but are not considered a part of the California GHG emissions inventory.

[17] California Energy Commission, January 1998, *Appendix A. Historical and Forecasted Greenhouse Gas Emissions Inventories for California*, Sacramento, California, P500-98-001V3.

[18] Environmental Science and Technology, Volume 4, 2001,*Uncertainties in Greenhouse Gas Emissions Inventories—Evaluation, Comparability and Implications*, pages 107 to 116.

[19] Ibid, page 108.

[20] Energy Commission, November 2002, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999,* Sacramento, California, P600-02-001F, [http://www.energy.ca.gov/reports/600-02-001F/index.html].

[21] California Energy Commission, June 2005*, Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002*, Sacramento, CA, Publication CEC-600-2005-025, [http://www.energy.ca.gov/2005publications/CEC-600-2005-025/CEC-600-2005-025.PDF].

[22] The term "high GWP gases" is applied to a series of gases used in industrial processes, including perfluorocarbons, hydrofluorocarbons, and SF_6. These are used mainly as replacements for ozone-depleting industrial gases (see separate end note for definition), as byproducts of manufacturing processes, for semiconductor manufacturing, and for electric power transmission and distribution switchyard gear.

[23] The term "transportation" includes CO_2, methane, and nitrous oxide emissions from on-road and off-road uses of petroleum and natural gas fuels. Petroleum transportation fuel use includes liquefied petroleum gas, motor gasoline, aviation gasoline, jet fuel, distillate, residual oil, lubricants, and pipeline transport of fuels. Natural gas transportation fuel use includes rail, road, water, and air (most likely ground support equipment at airports).

[24] The term "industrial" includes CO_2 emissions from coal use and petroleum use (including LPG, motor gasoline, refinery still gas, kerosene, distillate, residual oil, petroleum coke, lubricants, and special naphtha). It also includes industrial activities that produce CO_2 directly from their production or use, including cement production, lime production, limestone and dolomite consumption, soda ash consumption, and waste combustion. Industrial GHGs also include methane emissions from petroleum and natural gas extraction, transmission, storage and marketing; landfill emissions; waste water treatment; and industrial fuel combustion. Industrial GHGs also include nitrous oxide emissions from waste combustion; municipal waste (formerly

called "human waste"); and industrial fuel use, including wood. Finally, industrial GHGs also include high GWP gases used as substitutes for ozone-depleting gases (see definition in separate note) and in semiconductor manufacture. Because the trend analysis is based upon gross emissions to the degree possible, it excludes emissions reductions from yard trimmings and lumber disposal and associated increased CO_2 emissions atmosphere.

[25] The term "agriculture" includes CO_2 emissions from natural gas used in crop production, livestock production and irrigation; rangeland, woody crop, and non-woody crop management and soil liming. Agricultural GHG gases also include methane emissions from enteric fermentation, manure management, rice field flooding, and agricultural burning. Agricultural GHG gases also include nitrous oxide emissions from manure management and agricultural residue burning. Because the trend analysis is based upon gross emissions to the degree possible, emissions reductions from expanding rangelands and associated increased CO_2 removal from the atmosphere are excluded.

[26] The term "forestry" includes CO_2 emissions from forestry management. Because the trend analysis is based upon gross emissions to the degree possible, emissions reductions from expanding forestry management and associated increased CO_2 removal from the atmosphere are excluded.

[27] The term "commercial" includes CO_2 emissions from coal, petroleum (includes LNG, motor gasoline, kerosene, distillate, and residual oil), and natural gas (includes education, food services, retail, and wholesale, healthcare, hotel, office, transportation services, communication, utilities excluding electricity production, national security, and non-specified services), and non-specified fuel uses. Commercial GHG gas also include methane emissions from petroleum, natural gas, wood and non-specified fuel use; and nitrous oxide emissions from coal, petroleum, natural gas, and wood use.

[28] The term "residential" includes CO_2 emissions from liquefied natural gas, kerosene, and distillate; methane emissions from petroleum, natural gas, and wood; and nitrous oxide emissions from coal, petroleum, natural gas, and wood.

[29] The term "residual oil" is applied to one of the distilled products from refining crude oil. Residual oil is the heavy residue that remains in liquid form after more valuable products such as gasoline and distillate are recovered. It is often used in other states as an industrial fuel but ARB regulations often preclude its use in California.

[30] The trend analysis includes out-of-state GHG emissions because energy policy decisions made by the State of California, including the Energy Commission, will affect emissions both within and outside the state. GHG inventory guidelines established by the International Panel on Climate Change (IPCC) and by the EPA do not require reporting emissions from within one political boundary that that supply energy to another political entity. Thus, out-of-state GHG emissions do not need to be considered when developing GHG inventories. Out-of-state GHG emissions from electricity production are reported separately from in-state emissions in the GHG inventory. As noted elsewhere in this document, in-state GHG emissions for electricity exported are small and included as in-state GHG emissions. Policy decisions in other end-use sectors such as petroleum fuel use should consider out-of-state emissions affected by the policy decision to the extent possible.

[31] The category "Other Transportation Fuels" includes CO_2 from aviation gasoline, liquefied petroleum gas, residual oil, and lubricating oil; nitrous oxide from diesel fuel and aviation gasoline; and other minor sources.

[32] These "other" emissions are CO_2 emissions from fuel end-uses not specified in the *California Energy Balances Report*.

[33] These industrial gases are being used in increasing amounts due to the Montreal Protocol to mitigate loss of high-altitude ozone. The Montreal Protocol on Substances That Deplete the Ozone Layer is a landmark international agreement designed to protect the stratospheric ozone layer. The treaty was originally signed in 1987 and substantially amended in 1990 and 1992. The Montreal Protocol stipulates that the production and consumption of compounds that deplete ozone in the stratosphere--chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform--are to be phased out by 2000 (2005 for methyl chloroform). Scientific theory and evidence suggest that, once emitted to the atmosphere, these compounds could significantly deplete the stratospheric ozone layer that shields the planet from damaging UV-B radiation.

[34] Data from Form 1.2, California Energy Commission, September 2005, California Energy Demand 2006-2016; Staff Energy Demand Forecast, Revised September 2005, CEC-400-2005-034-SF-ED2.

[35] The *California Energy Balances Report* indicates a small amount of coal is combusted in utility and industrial combined heat and power facilities.

[36] These emissions per gigawatt-hour (GWH) are based upon all sources of electricity used, including those that are carbon free.

[37] The term "emissions intensity trends" as used in this section represents the efficiency of using carbon-based fuels and other activities that emit GHGs. The intensity is measured with respect to the economic activity as measured by Gross State Product and as measured by the magnitude of the population. This term is not to be confused with the term "carbon intensity," which often refers to the carbon content of a fuel relative to other fuels; natural gas is considered to be a fuel with low carbon intensity while coal is considered to be a fuel with relatively high carbon intensity.

[38] California's CO_2 emissions from fossil fuel combustion comprise about 83 percent of total GHG emissions when imported electricity is excluded or about 84 percent when imported electricity is included. The percentage changes very little over the 1990 to 2001 period. These percentages are consistent with the percent gas composition for Washington (81 percent in 1990; 85 percent in 2000), Connecticut (90.5 percent in 2000), Pennsylvania (90.3 percent in 1999) and Michigan (86.2 percent in 1990; 86.5 percent in 2002) but somewhat greater than Iowa (79.5 percent in 1990; 67.1 percent in 2000) and Oklahoma (58.9 percent in 1990; 58.2 percent in 1999). Percentages for the United States overall were 77 percent in 1990; 80 percent in 2004).

[39] U. S. Department of Commerce, Bureau of Economic Analysis, December 15, 2004, [http://www.bea.gov/bea/regional/gsp/], (April 2005).

[40] Although Texas is at the top of Figure 5, it is in the middle of Figure 6. California's gross emissions are second from the top in Figure 5 but near the bottom of Figure 6. On the other hand, Wyoming is near the bottom of Figure 5, but at the top of Figure 6.

[41] The term GSP means the total value of the goods and services produced by the residents of the state during a specific period, such as a year.

[42] U.S. Environmental Protection Agency web site, [http://epa.gov/climatechange/emissions/state.html], October 26, 2006.

[43] U. S. Department of Commerce, Bureau of Economic Analysis web site, [http://bea.gov/bea/regional/gsp.htm], October 26, 2006.

[44] World Resources Institute, Climate Analysis Indicator Tool, Version 3, [http://cait.wri.org]. October 26, 2006.

[45] United Nations, [http://unstats.un.org/unsd/snaama/dnllist.asp], October 26, 2006.

[46] Energy Commission, July 2005, *Emission Reduction Opportunities for Non-CO2 Greenhouse Gases in California*, Sacramento, California, CEC-500-2005-121.

[47] Executive Order S-3-05, June 1, 2005, [http://www.governor.ca.gov/state/govsite/gov_htmldisplay.jsp?BV_SessionID=@@@@1044157704.1119371305@@@@&BV_EngineID=cccdaddemgghlmicfngcfkmdffidfng.0&iOID=69591&sTitle=Executive+Order+S-3-05&sFilePath=/govsite/executive_orders/20050601_S-3-05.html&sCatTitle=Exec+Order], June 21, 2005, [http://www.climatechange.ca.gov/climate_action_team/index.html].

[48] California Environmental Protection Agency, March 2006, Climate Action Team Report to Governor Schwarzenegger and the Legislature, July 31, 2006.

[49] Energy Commission, November 2002, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999,* Sacramento, California, P600-02-001F, [http://www.energy.ca.gov/reports/600-02-001F/index.html].

[50] California Energy Commission, December 2003, *2003 Integrated Energy Policy Report*, Publication Number 100-03-019, [http://www.energy.ca.gov/2003_energypolicy/index.html].

[51] Intergovernmental Panel on Climate Change (2001), *Climate Change 2001: Synthesis Report, Summary for Policy Makers,* page 2, [http://www.grida.no/climate/ipcc_tar/vol4/english/076.htm].

[52] U.S. Environmental Protection Agency, April 15, 2006*, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004,* Washington, DC, page 1-6, [http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html], July 19, 2006.

[53]EPA, June 2003 and subsequent updates, *Introduction to Estimating Greenhouse Gas Emissions,* November 2002, Washington, DC.

[54] Ibid.

[55] California Energy Commission, June 2005, *Development of Energy Balances for the State of California*, Sacramento, California, CEC-500-2005-068, prepared by Lawrence Berkeley National Laboratory.

[56] Personal communication with Scott Murtishaw, Lawrence Berkley Laboratory, July 24, 2006.

[57] California Energy Commission, June 2005, *Development of Energy Balances for the State of California*, Sacramento, California, CEC-500-2005-068, prepared by Lawrence Berkeley National Laboratory.

[58]EPA, June 2003, and subsequent updates, *Introduction to Estimating Greenhouse Gas Emissions,* November 2002, Washington, DC.

[59] Ibid.

[60] This can be found in Energy Commission, November 2002, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999,* Sacramento, California, P600-02-001F, [http://www.energy.ca.gov/reports/600-02-001F/index.html], Table 14.

[61] Intergovernmental Panel on Climate Change (2001), *Climate Change 2001: Synthesis Report, Summary for Policy Makers,* page 2, [http://www.grida.no/climate/ipcc_tar/vol4/english/076.htm].

[62] Personal Communication, Gordon Schremp, California Energy Commission, July 28, 2006. For 2004 and beyond, the percentage is slightly less than 100 percent because some regions of California are not required to use oxygenated gasoline.

[63] California Air Resources Board, August 2004, *Staff Report: Initial Statement of reasons for Proposed Rulemaking, Publich Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*, Table 6.4-1, Sacramento, California.

[64] EPA, June 2003, and subsequent updates, *Introduction to Estimating Greenhouse Gas Emissions,* November 2002, Washington, DC.

[65] These are the Intermountain Power Plant and the Mohave Power Plant.

[66] California Department of Finance, Economic Research Unit, California Statistical Abstract 2003, [http://countingcalifornia.cdlib.org/title/castat03.html].

[67] This adjustment accounts for the molecular weight of CO_2 (CO_2=44) and lime (CaO=56).

[68] Limestone uses as flux (or purifier) in metallurgical furnaces, glass manufacturing, and flue gas desulfurization processes do not produce CO_2 emissions.

[69] EPA, June 2003, and subsequent updates, *Introduction to Estimating Greenhouse Gas Emissions,* November 2002, Washington, DC.

[70] Energy Commission, March 2004, *Baseline Greenhouse Gas Emissions for Forest, Range, and Agricultural Lands in California*, Sacramento, California, P500-04-069, [http://www.energy.ca.gov/pier/final_project_reports/500-04-069.html].

[71] Energy Commission, November 2002, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999,* Sacramento, California, P600-02-001F, [http://www.energy.ca.gov/reports/600-02-001F/index.html].

[72]CIWMB, December 2004, Statewide Waste Characterization Study, Sacramento, California.

[73] Energy Commission, November 2002, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999,* Sacramento, California, P600-02-001F, [http://www.energy.ca.gov/reports/600-02-001F/index.html].

[74] CARB, April 2005, *Areawide Source Methodologies,* (dynamic dating), [www.arb.ca.gov/ei/areameth.htm].

[75] CARB, April 2005, Emissions Inventory Methods, Speciation and Size Fractions, [http://www.arb.ca.gov/ei/speciate/speciate.htm], July 28, 2004.

[76] Ruminant animals re-chew food that has been swallowed and usually have a four-chamber stomach.

[77] Energy Commission, November 2002, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999,* Sacramento, California, P600-02-001F, http://www.energy.ca.gov/reports/600-02-001F/index.html.

[78] Ibid.

[79] EPA, June 2003 and subsequent updates, *Introduction to Estimating Greenhouse Gas Emissions,* November 2002, Washington, DC.

[80] Energy Commission, November 2002, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999,* Sacramento, California, P600-02-001F, [http://www.energy.ca.gov/reports/600-02-001F/index.html].

[81] California Department of Food and Agriculture, *California Agricultural Resource Directory 2005*, [http://www.cdfa.ca.gov/card/card_new04.htm].

[82] Ibid.

[83]EPA, June 2003, and subsequent updates, *Introduction to Estimating Greenhouse Gas Emissions,* November 2002, Washington, DC

[84] Energy Commission, November 2002, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999,* Sacramento, California, P600-02-001F, [http://www.energy.ca.gov/reports/600-02-001F/index.html].

[85] Ibid.

[86] Ibid.

[87] Ibid.

[88] EPA, January 2004, *Reducing SF_6 Emissions Means Better Business for Utilities,* Office of Atmospheric Programs, [www.epa.gov/electricpower-sf6].

[89] Energy Commission, November 2002, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999,* Sacramento, California, P600-02-001F, [http://www.energy.ca.gov/reports/600-02-001F/index.html].

[90] Ibid.

[91] Tellus Institute, December 2004, *California Leadership Strategies to Reduce Global Warming Emissions,* Alison Bailie and Michael Lazarus.

[92] Tellus Institute, July 2005, *California Leadership Strategies to Reduce Global Warming Emissions,* Alison Bailie and Michael Lazarus

[93] California Energy Commission, July 2005, *Emissions Reduction Opportunities for Non-CO2 Greenhouse Gases in California*, Sacramento, California, CEC-500-2005-121.

[94] California Public Utilities Commission, October 2, 2006, *Final Workshop Report, Interim Emissions Performance Standard Program Framework*, R.06-04-009, June 21-23, 2006.

[95] Ibid.