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California Environmental Protection Agency

Air Resources Board

2014 Edition

California Greenhouse Gas Emission Inventory: 2000-2012

Archive

May, 2014

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Summary

This report presents an overview of the 2014 Edition of the California greenhouse gas (GHG) emission inventory, which tracks emissions and trends from 2000 through 2012. As California strives to achieve its benchmark goals under AB 32, the California inventory is an increasingly valuable tool to keep track of greenhouse gas emissions from each sector. Maintaining and updating greenhouse gas inventory methodologies and data are imperative for a successful greenhouse gas reduction program.

In 2012, total California greenhouse gas emissions were 459 million metric tons (or tonnes) of carbon dioxide equivalent ($MMTCO_2e$). This represents a 1.7 percent increase in total GHG emissions from 2011 and the first emissions increase since 2007. This increase was driven primarily by strong economic growth in the state, the unexpected closure of the San Onofre Nuclear Generating Station (SONGS), and drought conditions that limited in-state hydropower generation. Since 2000, GHG emissions have decreased by 1.6 percent (from 466 to 459 $MMTCO_2e$) after reaching a peak of 493 $MMTCO_2e$ in 2004.

Emissions in this report are aggregated based on an Economic Sector categorization. In 2012, the transportation sector is the largest source of emissions, accounting for approximately 37 percent of the total emissions. On-road vehicles accounted for more than 90 percent of emissions in the transportation sector. Transportation related GHG emissions have dropped 11 percent since 2006. The industrial sector accounted for approximately 22 percent of the total emissions. Emissions from electricity generation were about 21 percent of total emissions, with higher contribution from in-state than from imported electricity.

Per capita emissions in California have decreased by 12 percent from 2000 to 2012, in spite of the overall 11.4 percent increase in population during the same period. Per capita emissions from in-state electricity generation have declined by 22 percent from 2000 to 2012.

From a broader geographical perspective, California ranks second in the United States in total greenhouse gas emissions; Texas remains as the #1 GHG emitting state. However, from a per capita and per GDP standpoint, California has the 45th and 46th lowest emissions respectively. On an international scale, California has the 20th largest greenhouse gas emissions and the 38th largest per capita emissions for year 2010.

The 2014 edition GHG inventory represents a transition to global warming potentials (GWPs) in the IPCC 4th Assessment Report (AR4). Previous GHG inventories relied on GWPs from IPCC's Second Assessment Report (SAR).

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I. Background

A major challenge of today's world is to meet the energy needs of the growing population while protecting the earth and its climate. Governments and organizations at national as well as regional levels have started to take necessary actions to reduce greenhouse gases (AB 32, 2006; United Nations, 2012). The generation of a consistently updated emission inventory with an emission baseline year to monitor the progress of greenhouse gas sources and reductions is vital to these efforts.

The California Legislature and Governor took significant steps to address the concerns raised about climate change with the passage and signing of the Assembly Bill (AB) 32, the Global Warming Solutions Act of 2006 (AB 32, 2006). The California Air Resources Board (ARB) was designated as the lead implementation agency of this landmark legislation. AB 32 set a target to reduce California greenhouse gas emissions to 1990 levels by year 2020. In addition, the Governor signed Executive Order S-3-05 to further require California to reduce greenhouse gas emissions by 80 percent below the 1990 levels by year 2050 (EO, 2005). Parallel to these actions, the California Legislature passed and the Governor signed AB 1803, making the ARB responsible for developing the GHG emission inventory.

Parallel to these actions in 2006, the California Legislature passed and the Governor signed AB 1803 making the ARB responsible to prepare, adopt, and update an inventory of greenhouse gas emissions from all sources located in the state.

The California greenhouse gas emission inventory serves as a foundation for the State's emission reduction goals. ARB regularly updates California's greenhouse gas inventory on its Greenhouse Gas Emission Inventory website (http://www.arb.ca.gov/cc/inventory/inventory.htm). The first set of inventory data covering statewide greenhouse gas emissions and sinks from 1990 through 2004 was published in 2007. In addition, ARB also published a staff report titled "*California 1990 Greenhouse Gas Emissions Level and 2020 Emissions Limit*" that discusses the determination of the 1990 statewide emissions level and provides a summary of the methodologies and main sources of data used to calculate the greenhouse gas emissions (CARB, 2007). These past reports and other inventory related documents are available from ARB's California Greenhouse Gas Emission Inventory website http://www.arb.ca.gov/cc/inventory/inventory.htm.

The 2014 edition of the inventory compiles statewide anthropogenic greenhouse gas emissions from 2000 through 2012. This document presents

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a summary of the 2000 to 2012 emissions data, and discusses the statewide greenhouse gas emission trends and relative contributions of emission sources to the total emissions. It is important to note that ARB has updated the estimates of emissions for the full 2000 to 2012 time series, to reflect the latest estimation data and methodologies. This is consistent with the Intergovernmental Panel on Climate Change (IPCC) *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC, 2000), which states that "It is good practice to recalculate historic emissions when methods are changed or refined, when new source categories are included in the national inventory, or when errors in the estimates are identified and corrected." A comprehensive technical support document detailing the data sources and methods used to develop the 2000 to 2012 inventory is available on the ARB website (CARB, 2014). A technical support document detailing the data sources and methods used to develop the 2000 to 2012 inventory is also available

II. Overview of Climate Change and Greenhouse Gases

Emissions of carbon dioxide (CO_2) have increased greatly following the industrial revolution from combustion of fossil fuels, and later from the production of synthetic greenhouse gases such as chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perflurocarbons (PFCs) and sulfur hexafluoride (SF_6). In the past years, numerous scientific studies have shown that the enhanced greenhouse effect causes climatic shifts that will have an adverse effect on human survival (Meehl et al., 2005; Patz et al., 2005; Dettinger and Cayan, 1995). An emission inventory that identifies and quantifies the sources and sinks of these greenhouse gases is essential for addressing climate change.

A. Greenhouse Gases

The Kyoto Protocol identifies the following six gases for emission reduction targets: CO2, methane (CH4), nitrous oxide (N2O), HFCs, PFCs and SF6. Each GHG has a global warming potential (GWP) value, calculated to reflect the relative climate forcing of a kilogram of emissions and how long emissions remain in the atmosphere. The global warming potential allows for a comparison of the warming influence of different greenhouse gases relative to CO2 and provides a single consistent emission unit (IPCC, 2007). For example, it would take 22,800 CO2 molecules to have same effect as one SF6 molecule. This is because SF6 absorbs infrared radiation in a different energy range and has a longer lifetime in the atmosphere than CO2. Thus, small amounts of high GWP gases have a large effect on global warming. GWPs from IPCC's Fourth Assessment Report for greenhouse gases defined in AB 32 are shown in Figure 1.

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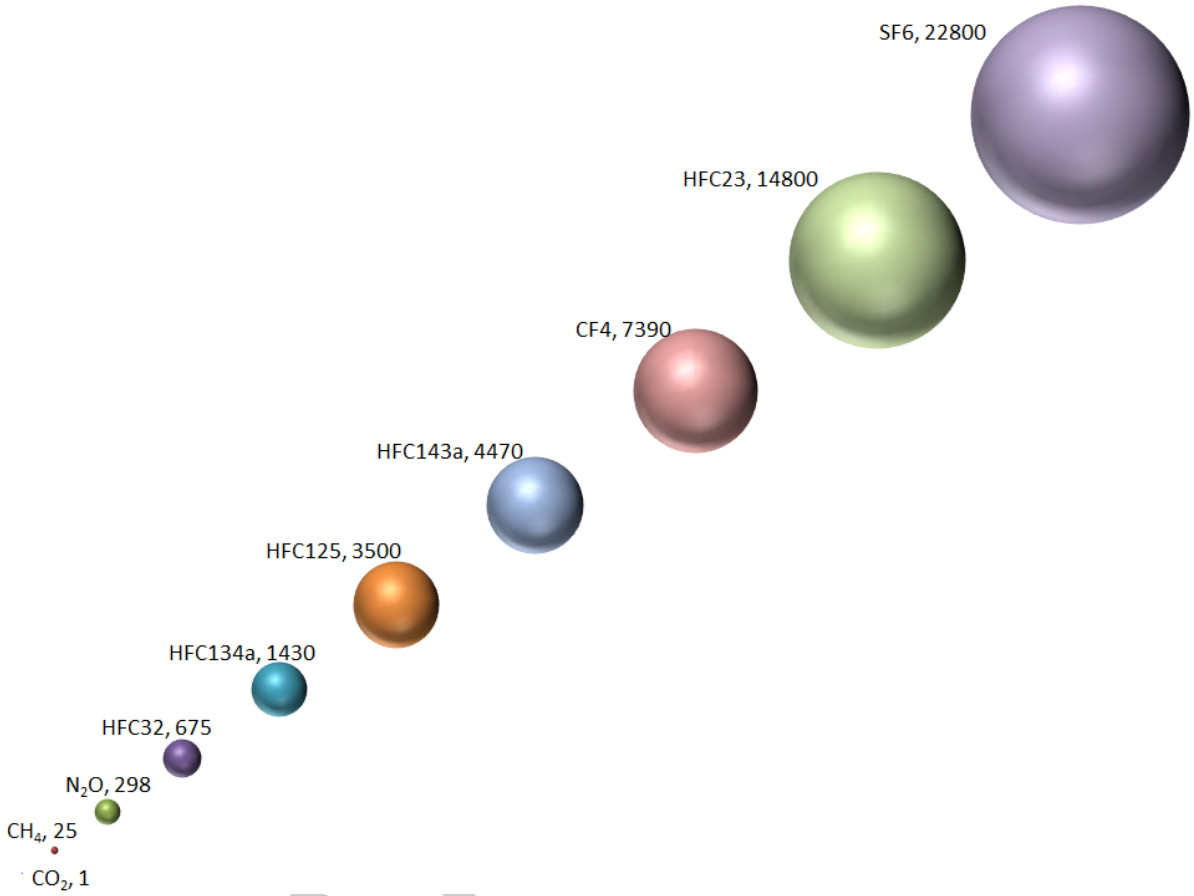
Figure 1. Global Warming Potentials of Greenhouse Gases



Source: IPCC Fourth Assessment Report

B. Anthropogenic and Natural Emissions

The California GHG inventory is primarily focused on anthropogenic emissions. Anthropogenic emissions directly result from human activities or from human influence on natural and other processes subject to human control (U.S.EPA, 2008). Increases in anthropogenic emissions from pre-industrial times have substantially increased atmospheric greenhouse gas concentrations.

Natural CO_2 emissions are emitted as part of the biogeochemical cycling of carbon and tend to average out over time even though emissions may be significant (IPCC, 2006). For quantification of greenhouse gas fluxes on forest, range, and other natural lands, ARB is updating the methodology under a research contract with UC Berkeley initiated in late 2011. The new quantification procedures under development integrate regularly updated

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federal and state ground-based data with geospatial and remotely sensed data and models. Forest and natural lands are not included in the 2014 edition of the inventory while ARB continues to update the methodology.

III. California Greenhouse Gas Emission Inventory

The California greenhouse gas emission inventory serves as the foundation for the State's greenhouse gas emission reduction program. The inventory is a living repository of detailed methodologies for estimating greenhouse gas emissions. The inventory is also a time series of emissions, thus providing a platform to compare the relative contribution of different emission sources and gases to climate change over time.

There are two main types of inventory approaches used to determine the amount of greenhouse gas emissions from a region: the top-down and bottom-up approach (CLIISE, 2007). The California GHG inventory uses both approaches. The top-down approach utilizes nationwide or statewide data, while the bottom-up approach uses facility-specific data to estimate emissions from each source. The total number of emissions from each source are then summed together to generate an inventory for a particular geographic region. For certain industry sectors, ARB draws data from various federal and state government agencies in a top-down approach. For other industry sectors, the data collected through the Regulation for the Mandatory Reporting of Greenhouse Gas Emissions (MRR) program enables ARB to utilize the bottom-up approach. Verified data from the MRR for specific sectors such as in-state power generation, specified electricity imports, refineries and cement manufacturing were used in the 2012 emission inventory.

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California Inventory and Other Greenhouse Gas Inventories

The California inventory is developed in a manner consistent with international and national guidelines to the greatest extent possible. Consistency maximizes the comparability of the inventory with similar inventories from other states and nations. This is important as California considers participation in standardized regional, national and international greenhouse gas emission reduction programs.

At an international level, the IPCC has developed standard international guidance for emission inventories (IPCC, 2006). Nations that have adopted the United Nations Framework Convention on Climate Change (UNFCCC) must prepare and report their emissions and sinks of CO_2, CH_4, N_2O, SF_6, PFCs, and HFCs using IPCC methodologies to ensure comparability among national inventories. The IPCC guidelines delineate the sectors and processes for which nations must report their greenhouse gas emissions and

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sinks, and how they should report these emissions. They also describe various methodologies to estimate emissions depending on the available data sources (IPCC, 2006). The guidelines allow for use of state-specific data and methodologies rather than the more generic international ones when available. In the California inventory, state-specific emissions data were used whenever possible.

As a nation, the United States follows the IPCC guidelines (with the United States Environmental Protection Agency (U.S.EPA) acting as the lead agency) and submits its national greenhouse gas inventory to UNFCCC Secretariat annually. The U.S.EPA supplements the widely applicable IPCC methodologies with more US-specific methodologies and data (U.S.EPA, 2008).

Inventory Organization

ARB has presented the GHG emissions estimates in California inventory in three formats. First, the GHG emission estimates are presented in the categories outlined in the 2008 Scoping Plan, which focuses on areas for emission reductions. These Scoping Plan sectors include: transportation, electric power, commercial and residential, industrial, recycling and waste, High GWP gases, and agriculture.

Second, the emission estimates are categorized into traditional economic sectors based on economic activity within California, as defined by North American Industry Classification System (NAICS, 2012). These sectors include: agriculture and forestry, commercial, in-state electricity generation, imported electricity, industrial, residential, transportation, and others. The economic sector categorization allows for comparison with other ARB emission inventories, which are similarly categorized. This categorization scheme also provides a familiar reference for readers accustomed to reviewing emission estimates generated by national, state, and local air agencies. The primary difference with Scoping Plan sector categorization is that emissions from High GWP gases are placed under the appropriate sectors of industrial, transportation,

This categorization of the inventory based on economic sectors includes emissions from international and domestic ships operations within California waters under the transportation sector. The aviation category, located within the transportation sector, only includes emissions for intrastate flights. Interstate and international flight emissions are calculated and included as an informational item, but their greenhouse gas emissions are not counted (these are listed as “excluded emissions” in the inventory) in California’s overall inventory. Unless otherwise indicated, emissions estimates in this report are categorized by the economic sectors and emission categories. A small portion of the total emissions could not be

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attributed to any of the economic sectors and are therefore aggregated into a "not specified" group[1].

Finally, the emissions data have been categorized by IPCC levels, which is based on groupings of related emission processes and sinks as indicated in the IPCC Guidelines (IPCC, 2006), to ensure comparability with international and national inventories. This version includes five main sectors based on the IPCC categorization: energy; industrial processes and product use; agriculture and other land use; waste; and other.

Changes in the 2000-2012 Inventory

Updates to the methodologies used in the California inventory are an ongoing process. ARB staff regularly evaluates scientific developments in greenhouse gas inventories. In general, the majority of the methodologies and calculations used to generate the emission values have remained constant. However, every year ARB makes improvements to the methods or data used to determine greenhouse gas emissions.

The 2000-2012 GHG inventory represents a transition to global warming potentials (GWPs) in the IPCC's 4th Assessment Report (AR4) compared to previous GHG inventories that relied on GWPs from IPCC's Second Assessment Report (SAR). As a result, the GWP of methane changed from 21 to 25 and also revised the GWPs of other gases to their updated values (IPCC, 2007). For detailed discussions on the updated methodologies and changes to the emission estimates, refer to the Technical Support Document for the 2000 to 2012 inventory (CARB, 2014).

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IV. Statewide Emission Estimates and Emission Trends

This section summarizes the latest information on **greenhouse gas emissions and trends in California based on the economic sectors categorization of the inventory**. The estimates reflect revisions to methodologies and data for the 2000 to 2012 time series. Detailed discussions on emission calculations and methodologies are comprehensively discussed in the technical support documents.

Emissions Trends

In 2012, total GHG and per capita emissions increased by 1.7% from 2011 emissions. This increase was driven largely by the increased reliance on natural gas-generation sources of in-state electricity due to the closure of the San Onofre Nuclear Generating Station (SONGS) as well as dry hydrological

[1] Unspecified emissions include emissions from categories that could not be attributed to a particular traditional economic sector.

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conditions in 2012 (drought) causing a drop in the in-state hydropower generation. Total statewide greenhouse gas emissions have decreased from 466 million tonnes of carbon dioxide equivalent ($MMTCO_2e$) in 2000 to 459 $MMTCO_2e$ in 2012, a decrease of 1.6 percent.

Figure 2 depicts the general trend in the emissions by greenhouse gas from 2000 to 2012. Figure 2 also shows the percent contribution of each GHG to the 2012 statewide emission total. CO_2 is the largest contributor to statewide greenhouse gas emissions. CO_2 emissions accounted for approximately 88 percent of the emissions in 2000 and 85 percent in 2012. CH_4 and N_2O account for 8.3 and 2.9 percent of the total emissions in 2012, respectively. SF_6 emissions accounted for 0.1 percent of the total emissions. Other halogenated gases constituted approximately 4 percent of the total emissions.

Figure 2. California Greenhouse Gas Emission by Gas

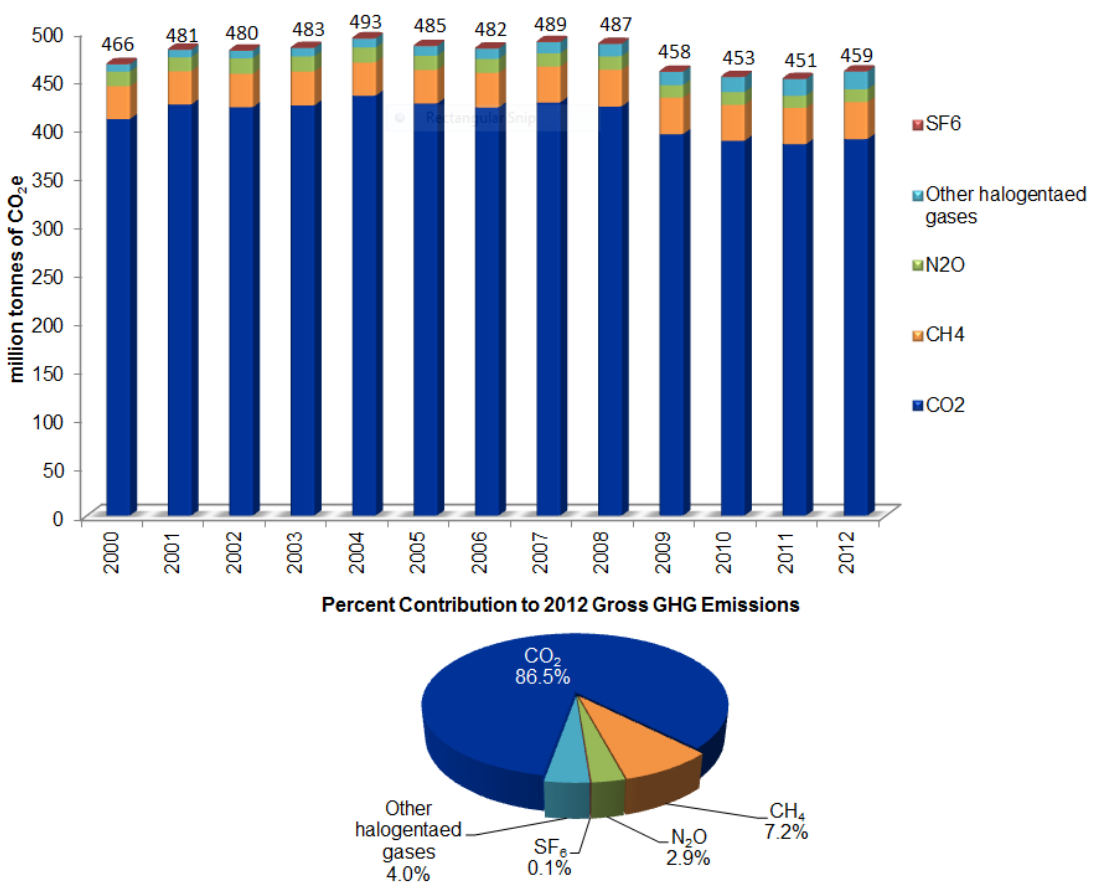

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Table 1 shows the total statewide greenhouse gas emissions by gas type. Table 1 shows that the emissions of methane and halogenated gases increased from 2000 to 2012 and CO2, N2O, and SF6 decreased during the same period. Overall, CO2 emissions decreased by 5 percent from 2000 to 2012, and increased by 1.4 percent from 2011 to 2012. N2O and SF6 emissions also decreased by 10.9 and 30.1 percent, respectively, while CH4 and halogenated gas emissions increased by 12.3 and 137 percent respectively, from 2000 to 2012. Though the magnitudes of emissions increase of SF6 and halogenated gases are comparatively smaller from 2000 to 2012, their emissions are significant because of their high GWPs and longer atmospheric lifetimes.

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Table 1. California Greenhouse Gas Emissions by Gas

Greenhouse Gas	GHG Gross Emissions ($MMTCO_2e$)*													Percent Change	
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2000-2012**	**2011-2012**
CO_2	409.3	424.4	421.5	423.4	433.5	425.3	421.4	426.3	422.3	393.8	386.8	383.5	388.7	-5.0%	1.4%
CH_4	34.0	34.3	34.5	35.0	34.3	34.7	35.7	37.3	37.9	37.7	37.3	37.5	38.1	12.3%	1.7%
N_2O	15.0	14.5	16.1	15.8	15.4	14.7	14.4	13.7	14.0	12.9	13.0	12.6	13.4	-10.9%	6.5%
SF_6	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	-30.1%	-3.2%
Other Halogentaed Gases	7.6	7.6	7.8	8.5	9.2	10.0	10.8	11.5	12.6	13.7	15.6	17.1	18.1	137.3%	6.3%
Total Gross Emissions	**466.3**	**481.2**	**480.3**	**483.1**	**492.9**	**485.1**	**482.5**	**489.2**	**487.1**	**458.4**	**453.1**	**450.9**	**458.7**	**-1.6%**	**1.7%**

* All greenhouse gases are weighted relative to CO_2 based on the IPCC's 4th Assessment Report.

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Figures 3 illustrates the annual percent change in greenhouse gas emissions, where the maximum change occurred from 2008 to 2009 when the emissions decreased by almost 6 percent.

Figure 3. Annual Percent Change in California Greenhouse Gas Emissions

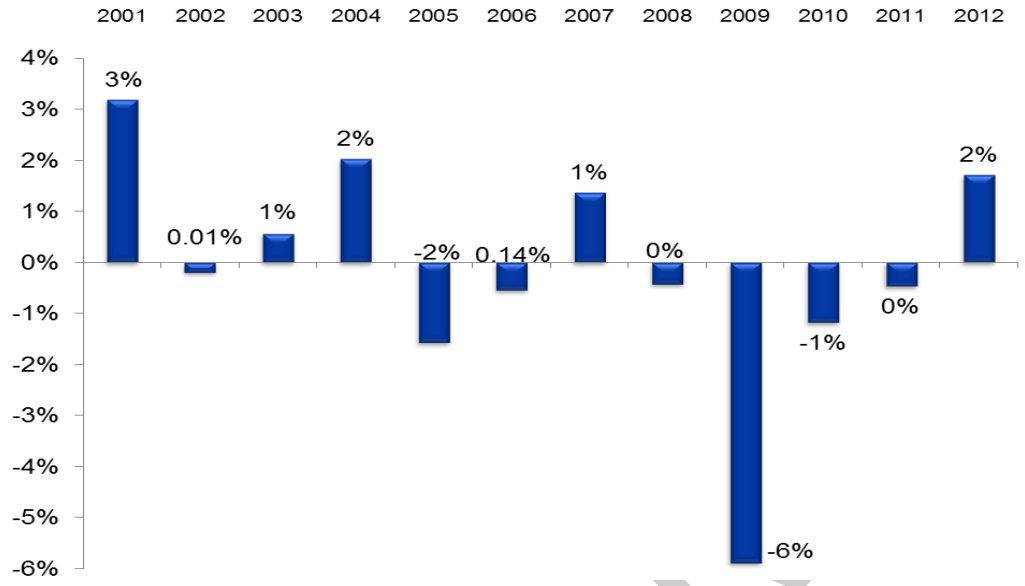

Figure 4 shows the cumulative change in emissions relative to the year 2000. absolute change in emissions from 2000 through 2012 cumulative effect of greenhouse gas emissions change from 2000 to 2012. The decline in the greenhouse gas emissions reversed from in 2012 for the first time since 2008.

Figure 4. Cumulative Change in California Greenhouse Gas emissions Relative to 2000

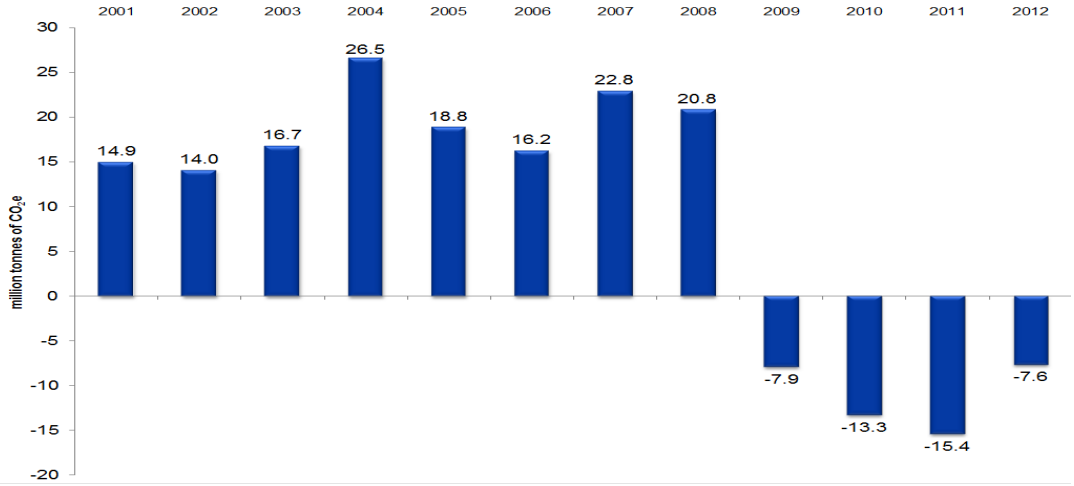

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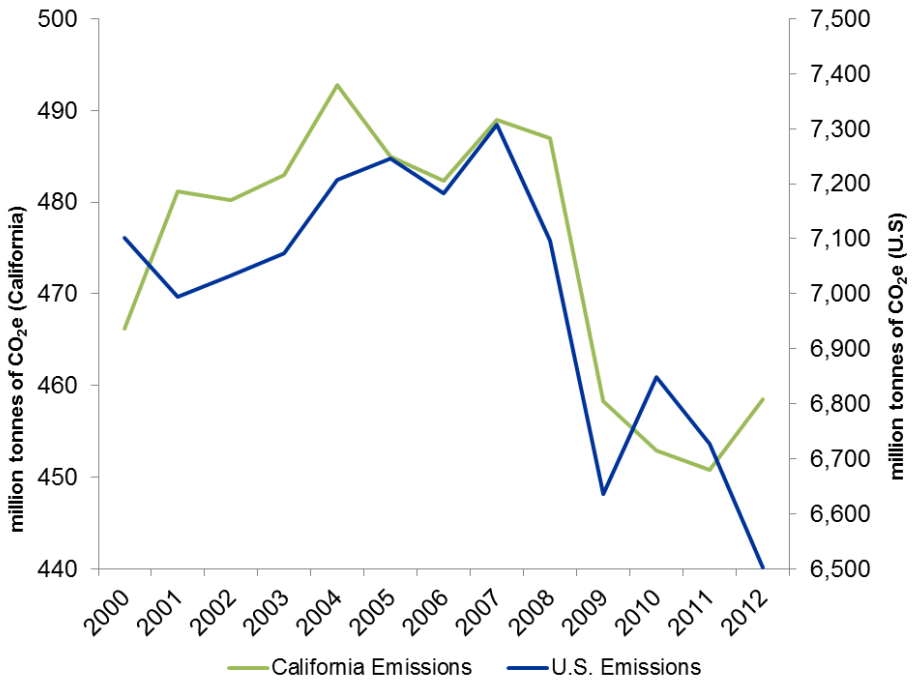
Figure 5 illustrates the trends in greenhouse gas emissions at the national and state level between 2000 and 2012. While the total emissions in 2012 increased by 5.9 percent from 1990 (431 $MMTCO_2e$), the emissions decreased by 5.9 percent from 2008 to 2009, the likely effect of the economic recession that began in late 2007. This decrease in emissions from 2008 to 2009 is also observed in the national emissions, a 7.2 percent decline from 2008 to 2009. From 2010 to 2012, the national emissions and the California emissions exhibit opposite trends. However, it is important to note that California emissions are based on the AR4, while national emissions are based on the SAR.

Figure 5. Recent Trends in Greenhouse Gas Emissions (U.S. and California)



Source: U.S emissions from Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012 (U.S.EPA, 2014)
Note: CA emissions are based on AR4 while US emissions are based on SAR.

Table 2 summarizes the emissions from these economic sectors in the California inventory in $MMTCO_2e$. The table also presents the percent change in emissions for each of the sectors between 2000 and 2012. The percent changes in the emissions from 2011 to 2012 are also included. Table 3 presents the same 2000 to 2012 emissions by scoping plan categories.

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Table 2. Recent Trends in California Greenhouse Gas Emissions by Inventory Economic Sectors

Sector	**GHG Emissions ($MMTCO_2e$)[1]**													**% of Total Emissions in 2012**	**Percent Change**	
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**		**2000-2012**	**2011-2012**
Transportation	178.5	178.9	186.1	186.0	189.5	192.0	192.1	192.3	181.3	174.9	174.0	171.7	171.0	37.3%	-4%	0%
Industrial	103.3	101.5	101.6	101.2	103.3	101.5	99.7	96.7	97.5	95.2	99.3	99.7	100.7	21.9%	-3%	1%
Electricity Generation (in-state)	59.2	63.2	49.9	48.3	49.4	45.3	50.1	54.3	54.5	53.4	46.9	41.3	51.2	11.2%	*-14%*	*24%*
Electricity Generation (imports)	46.0	59.1	59.1	64.7	66.1	62.9	54.8	59.9	65.9	48.1	43.7	46.9	44.1	9.6%	*-4%*	*-6%*
Agriculture	32.5	32.8	36.0	36.5	36.3	36.5	37.8	37.0	38.0	35.8	35.7	36.3	37.9	8.3%	*16%*	*4%*
Residential	31.8	30.8	30.9	30.4	31.5	30.2	30.6	30.8	31.2	31.0	32.1	33.0	31.6	6.9%	-1%	-4%
Commercial	14.6	14.6	16.6	15.8	16.5	16.6	17.3	17.9	18.5	19.8	21.1	21.8	22.0	4.8%	51%	1%
Unspecified[2]	0.4	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0%	-43%	0%
Total Gross Emissions[3]	**466.3**	**481.2**	**480.3**	**483.1**	**492.9**	**485.1**	**482.5**	**489.2**	**487.1**	**458.4**	**453.1**	**450.9**	**458.7**	**100.0%**	**-1.6%**	**1.7%**

[1] All greenhouse gases are weighted relative to CO_2 based on the IPCC's 4th Assessment Report.
[2] Unspecified includes emissions from evaporative losses, which could not be attributed to an individual sector.
[3] The sector emissions may not add up exactly to the above listed gross and net total emissions due to rounding.

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Table 3. Recent Trends in California Greenhouse Gas Emissions by Scoping Plan Categories

Sector	**GHG Emissions ($MMTCO_2e$)[1]**													**% of Total Emissions in 2012**	**Percent Change**	
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**		**2000-2012**	**2011-2012**
Transportation	176.2	176.6	183.8	183.5	186.9	189.1	189.2	189.3	178.0	171.5	170.5	168.1	167.4	36.5%	-5.0%	-0.4%
Industrial	95.0	93.2	93.1	92.5	94.5	92.3	90.3	87.1	87.5	84.9	88.5	88.3	89.2	19.4%	-6.2%	0.9%
Electric Power (In-state)	59.0	63.0	49.7	48.1	49.2	45.1	49.9	54.1	54.3	53.3	46.7	41.2	51.0	11.1%	-13.5%	23.9%
Electric Power (Imports)	45.9	59.0	59.0	64.6	66.0	62.8	54.7	59.8	65.8	48.0	43.6	46.9	44.1	9.6%	-4.0%	-6.0%
Commercial and Residential	42.3	41.2	43.2	41.5	42.9	41.2	41.9	42.1	42.4	42.7	43.8	44.3	42.3	9.2%	-0.1%	-4.6%
Agriculture	32.5	32.8	36.0	36.5	36.3	36.5	37.8	37.0	38.0	35.8	35.7	36.3	37.9	8.3%	16.4%	4.2%
High GWP	8.0	8.0	8.1	8.8	9.6	10.4	11.1	11.8	12.9	14.0	15.9	17.3	18.4	4.0%	129%	6.1%
Recycling and Waste	7.2	7.4	7.3	7.4	7.4	7.6	7.7	7.8	7.9	8.1	8.2	8.2	8.3	1.9%	15.5%	0.9%
Total Gross Emissions[3]	**466.3**	**481.2**	**480.3**	**483.1**	**492.9**	**485.1**	**482.5**	**489.2**	**487.1**	**458.4**	**453.1**	**450.9**	**458.7**	**100%**	**-1.6%**	**1.7%**

[1] All greenhouse gases are weighted relative to CO_2 based on the IPCC's 4th Assessment Report.
[2] Unspecified includes emissions from evaporative losses, which could not be attributed to an individual sector.
[3] The sector emissions may not add up exactly to the above listed gross and net total emissions due to rounding.

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Figures 6 shows the trend in emissions and Figure 7 shows the percent contribution of each inventory economic sector to the total emissions from 2000 through 2012.

Figure 6. Greenhouse Gas Emission Trends by Economic Sector

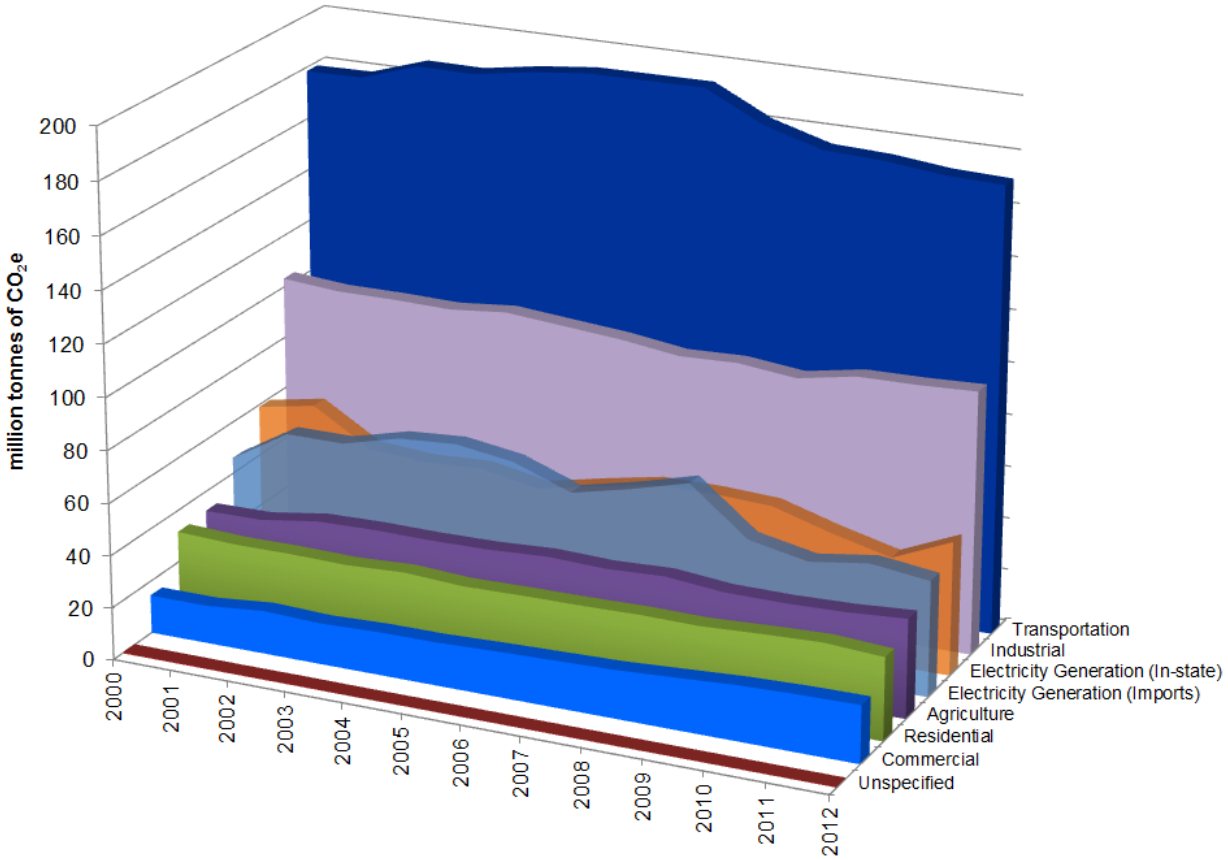

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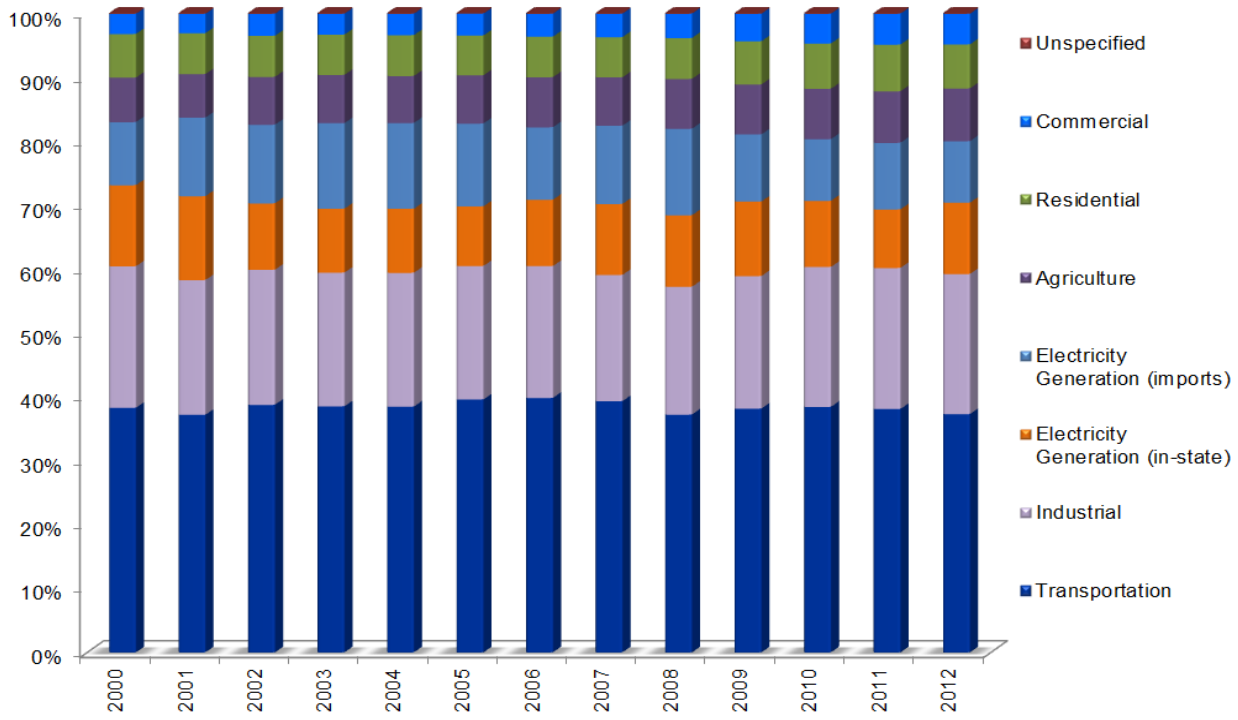
Figure 7. Contribution of Economic Sectors to Greenhouse Gas Emissions



Transportation was the major emitter of greenhouse gases in both 2000 and 2012, producing 171 $MMTCO_2e$ in 2012. The industrial sector was the next largest greenhouse gas contributor, emitting approximately 100 $MMTCO_2e$ in 2012.

Emissions by Economic Sectors

This section presents the greenhouse gas emissions by the California inventory economic sectors: agriculture, commercial, electricity generation, industry, residential, transportation and unspecified.

Figure 8 displays the sectoral contribution to the total 2012 gross emissions, with transportation at more than 36 percent of statewide emissions thus making it the largest contributor to the total statewide emissions. Emissions from industrial sector, the second largest, accounted for 22 percent of the total emissions. Electricity generation accounted for approximately 21 percent of the total in 2012, with 11 percent in state generation. These three sectors accounted for approximately 80 percent of the statewide greenhouse gas emissions in 2012. Emissions from agriculture (8.3 percent), residential (6.9

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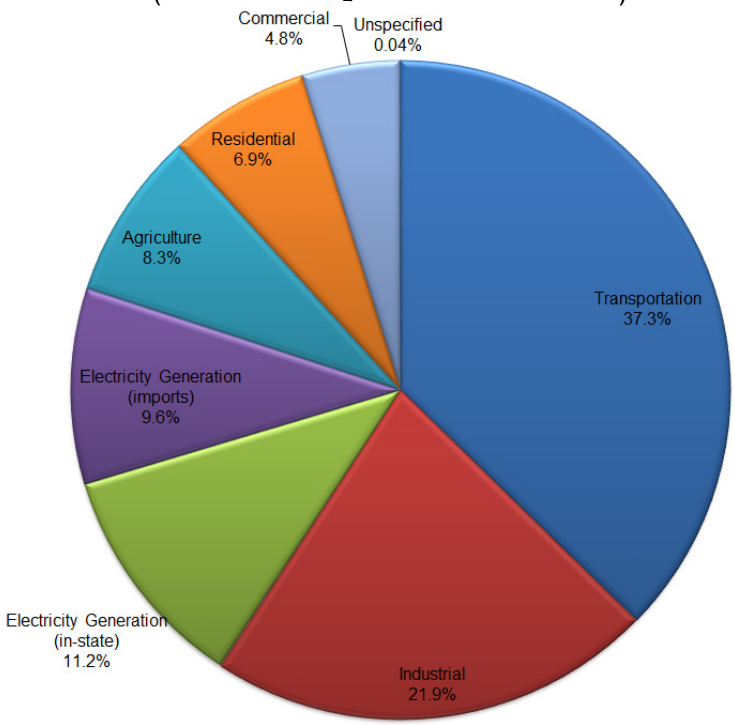
percent), and commercial (4.9 percent) sectors accounted for approximately 20 percent of the total.

Figure 8. 2012 Greenhouse Gas Emissions by Economic Sector
(459 $MMTCO_2e$ Gross Emissions)



The majority of statewide greenhouse gas emissions were tied to fuel use activities, ranging from transportation to electricity generation to heating buildings. Emissions from fuel combustion comprised 72 percent of overall statewide greenhouse gas emissions in 2012. Primary fuels combusted include natural gas, which was used mainly for in-state electricity generation, residential and industrial uses, and gasoline, which was consumed almost entirely by the transportation sector. Detailed breakdown of the emissions from each of the economic sectors and their relative contribution to the total emissions is discussed in the following sections.

Agriculture: Emissions from agricultural activities were responsible for emissions of 37.9 $MMTCO_2e$, approximately 8.3 percent of total statewide greenhouse gas emissions in 2012. Agricultural emissions represent the sum of emissions from agricultural energy use, agricultural residue burning, agricultural soil management (the practice of utilizing fertilizers, soil amendments, and irrigation to optimize crop yield), enteric fermentation (fermentation that takes place in the digestive system of animals, e.g. cows and sheep), histosol (soils that are composed mainly of organic matter) cultivation, manure management and rice cultivation

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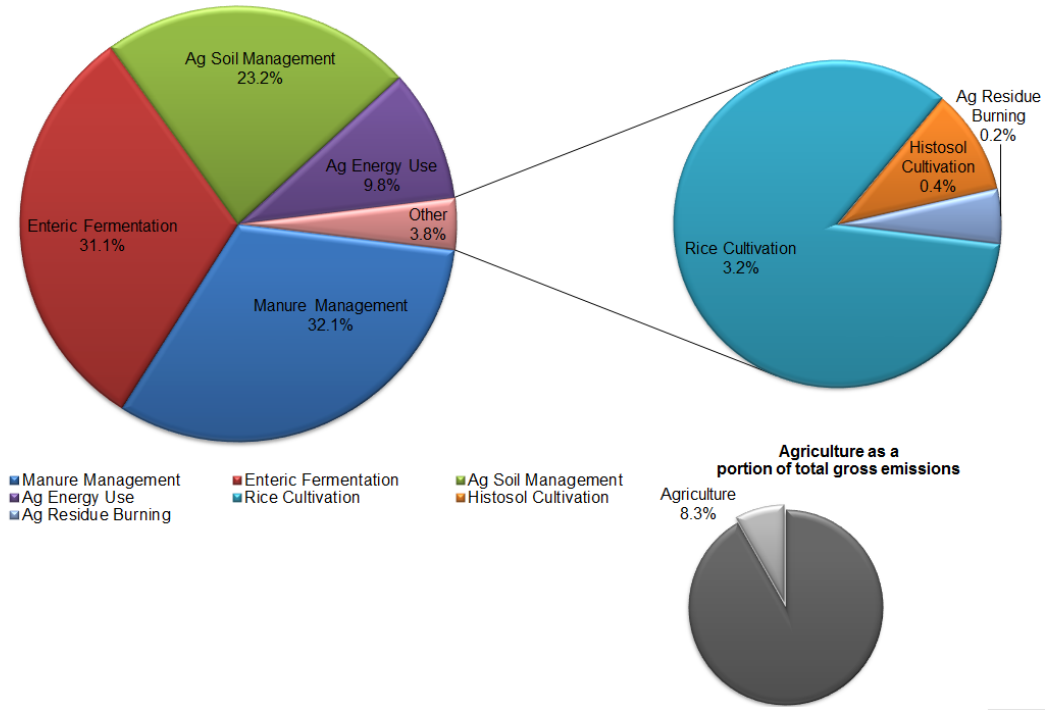
Figure 9. 2012 Greenhouse Gas Emissions from Agriculture
(38 $MMTCO_2e$ Gross Emissions)



The contribution of the categories that contributed towards the 2012 agricultural greenhouse gas emissions is shown in Figure 9. Unlike other economic sectors, N_2O emissions from agricultural soil management and CH_4 emissions from enteric fermentation and manure management contributed towards most of the agricultural sector emissions. The majority of the emission contributions (86 percent) are due to manure management (32 percent), enteric fermentation (31 percent) and agricultural soil management (23 percent). The remaining 14 percent of the agricultural emissions was dominated by emissions from agriculture energy use category (10 percent).

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Figure 10. Greenhouse Gas Emission Trends for Agriculture

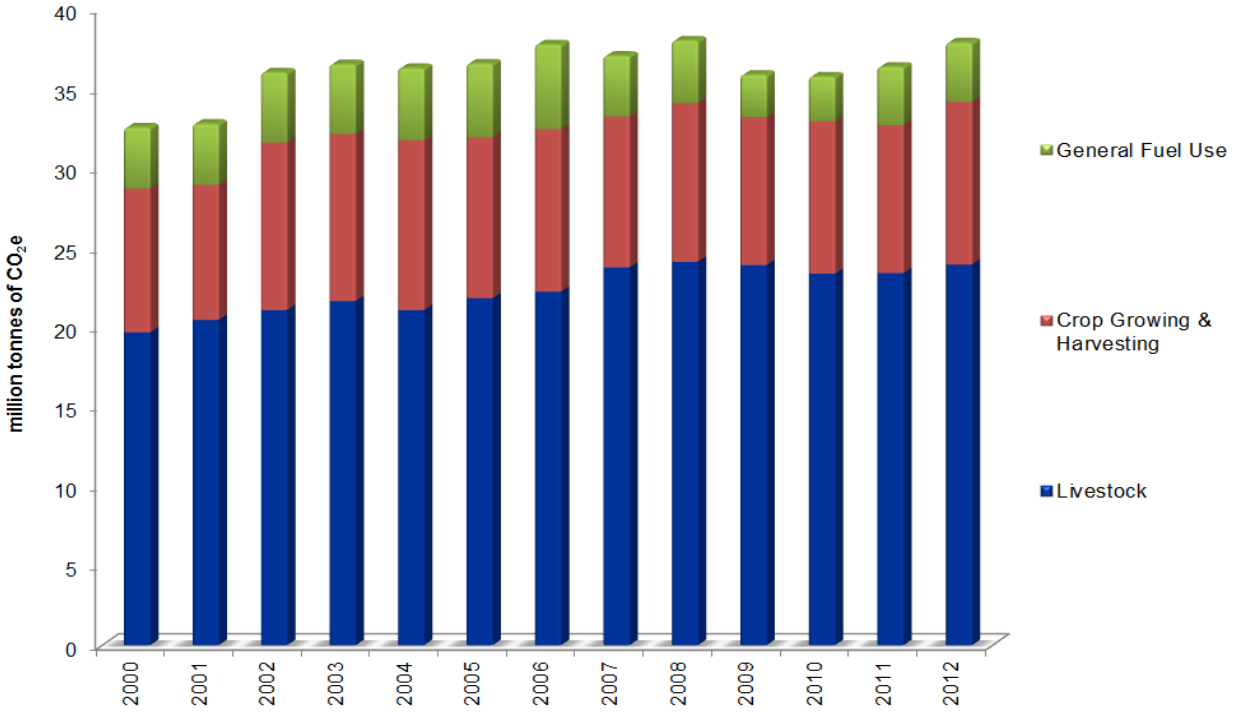

Figure 10 shows the trend in the emissions from each of these categories from 2000 through 2012. The agriculture sector increased its emissions from 32 $MMTCO_2e$ in 2000 to 38 $MMTCO_2e$ in 2012, a 16 percent increase. Agricultural fuel use was the only category that decreased their greenhouse gas emission from 2000 to 2012. Agricultural energy use decreased by 3 percent from 2000 to 2012, while manure management increased 29 percent during the same period.

Commercial: The commercial sector accounted for approximately 4.8 percent of the total statewide emissions in 2012. Greenhouse gas emissions from the commercial sector increased from 14.6 $MMTCO_2e$ in 2000 to 22 $MMTCO_2e$ in 2012. Commercial sector emissions grew approximately 51 percent from 2000 to 2012 and, approximately 1 percent from 2011 to 2012. The commercial sector in this version of the inventory includes the emissions from the substitutes for the ozone depleting substances (ODS).

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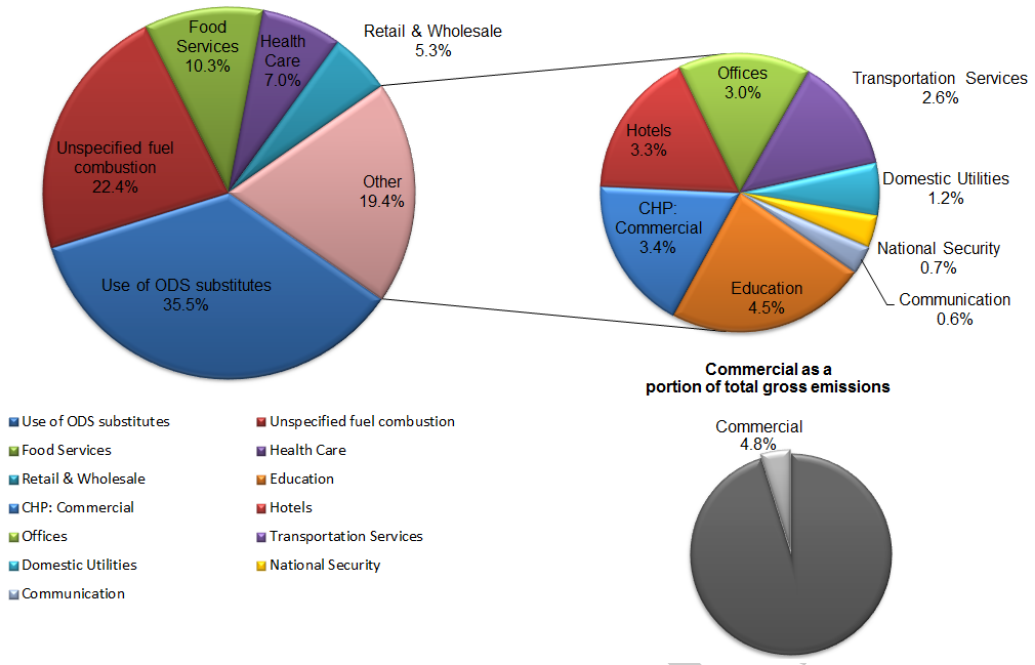
Figure 11. 2012 Greenhouse Gas Emissions from Commercial
(22 $MMTCO_2e$ Gross Emissions)



The emission contributions from the commercial sector are from commercial CHP, domestic utilities, education, food services, health care, hotels, national security, offices, retail and wholesale, transportation services, and unspecified sources. The sector includes fuel combustion for all commercial activities such as heating buildings, hot water and steam, and energy for natural gas transmission through pipelines. The primary fuel combusted was natural gas. Approximately 22 percent of the total emissions from this sector are due to natural gas combustion.

The percent contributions of each of these categories to the total 2012 emissions for this sector are shown in Figure 11. The largest contributor to emissions from the commercial sector was the use of ODS substitutes (36 percent). The second largest contributor in the commercial sector was the unspecified combustion of fuels (22 percent). Food services (10 percent) and healthcare (7 percent) were next two major contributors in this sector.

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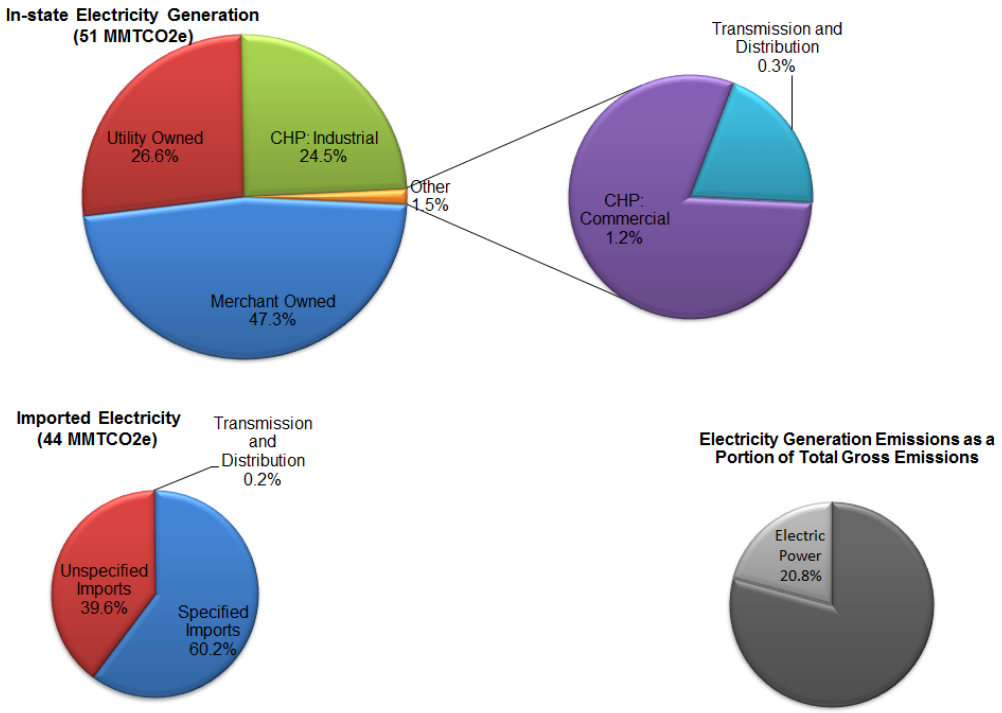
Electricity Generation: Electricity generation, transmission, and distribution accounted for 21 percent of total statewide greenhouse gas emissions in 2012. This sector was the third highest emitting sector in 2012, emitting 95 $MMTCO_2e$ that year. This sector includes power plants and cogenerators that generate electricity for on-site use and for sale to the power grid. This sector specifically includes greenhouse gas emissions from both in-state generated power and imported generation of electricity delivered to and consumed in California. Emissions from transmission line losses of electricity, as well as SF_6 emissions from transmission equipment, are also included. Figures 12 and 13 show the contribution of electricity generation sector to the total emissions and the trends in the emissions.

Figure 12. 2012 Greenhouse Gas Emissions from Electricity Generation
(95 $MMTCO_2e$ Gross Emissions)



Electricity Generation (imports): The contributions from imported electricity generation are from specified imports (60 percent), unspecified Imports (40 percent) and transmission and distribution (< 1 percent).

Electricity Generation (in-state): Contributions from in-state electricity generation are from categories such as CHP commercial, CHP industrial, merchant owned (privately owned power plant), transmission and distribution, and utility owned (investor-owned power plant). The percent contributions from each of these categories to the total 2011 emissions from this sector are shown in Figure 12.

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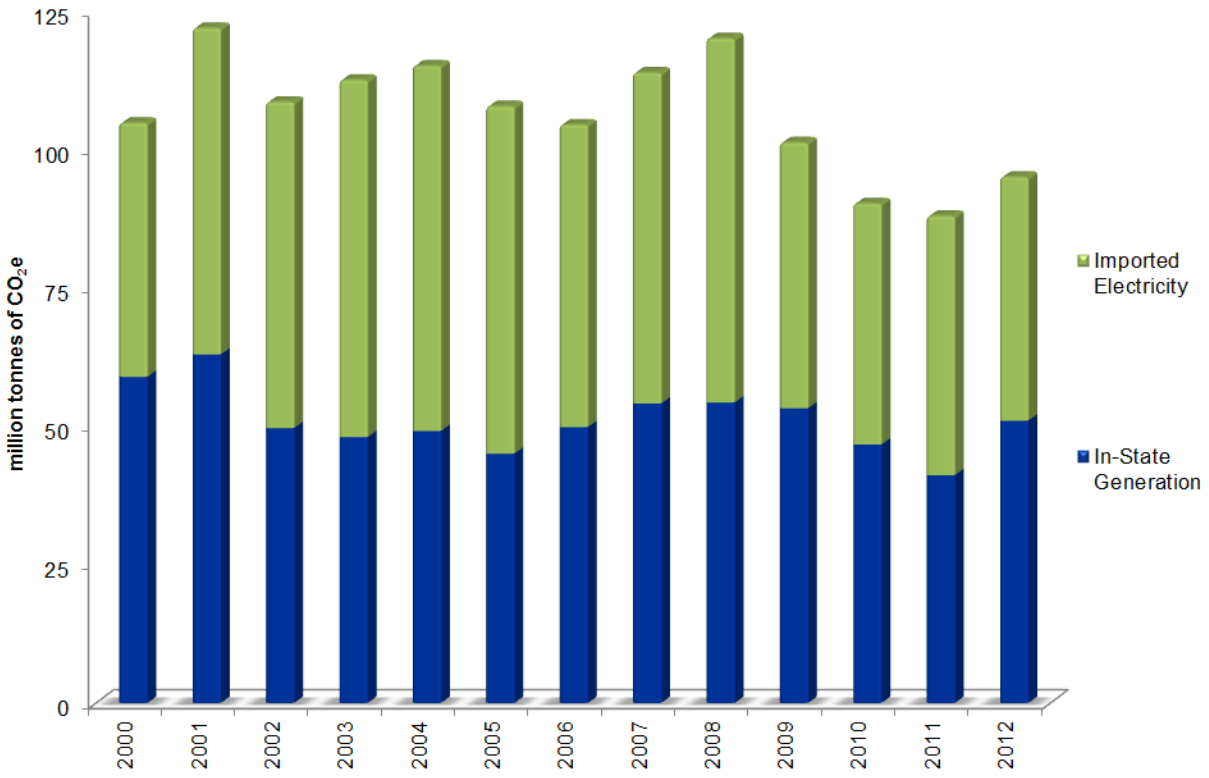
The merchant owned (47 percent) and CHP industrial (27 percent) contribute most to the in-state electricity generation emissions.

Figure 13. Greenhouse Gas Emission Trends from Electricity Generation



Industrial: Industrial sector includes contributions from CHP industrial, landfills[1], manufacturing, mining, oil and gas extraction, petroleum refining, petroleum marketing, pipelines, wastewater treatment, and other sources. The percent contributions from each of these categories to the 2012 total emissions from this sector are shown in Figure 14. Major contributors from this sector are petroleum refining (30 percent), manufacturing including cement plants (25 percent), oil and gas extraction (17 percent), CHP (11 percent), and landfills (8 percent). Approximately 90 percent of the total emissions from this sector can be attributed to these major categories. For the petroleum refining category, the combustion of fuels is the main source of emissions. Within manufacturing, fuel combustion and clinker production from cement processing are two of the largest sources. Landfills, wastewater treatment, and solid waste treatment, while serving an important societal function, account for only 9 percent of the total emissions from this sector.

[1] Landfill emissions are primarily due to the release of CH_4 (anaerobic decomposition). Carbon dioxide from paper/wood decomposition and from the combustion of landfill gas is included in the flux (See the Technical Support Document for more details).

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Figure 14. 2012 Greenhouse Gas Emissions from Industry
(101 $MMTCO_2e$ Gross Emissions)

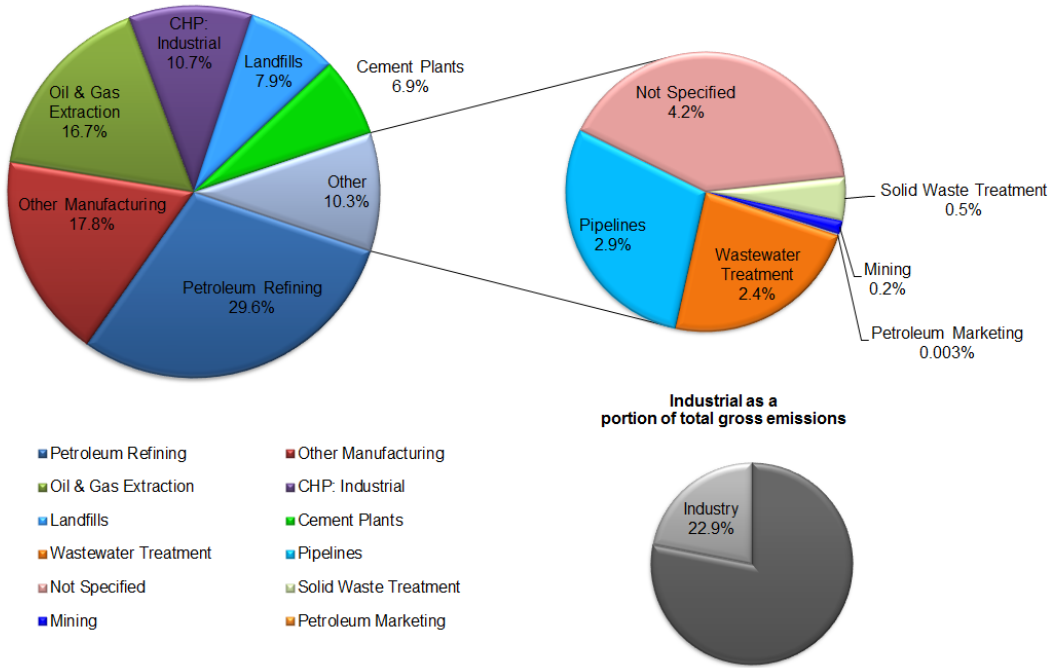
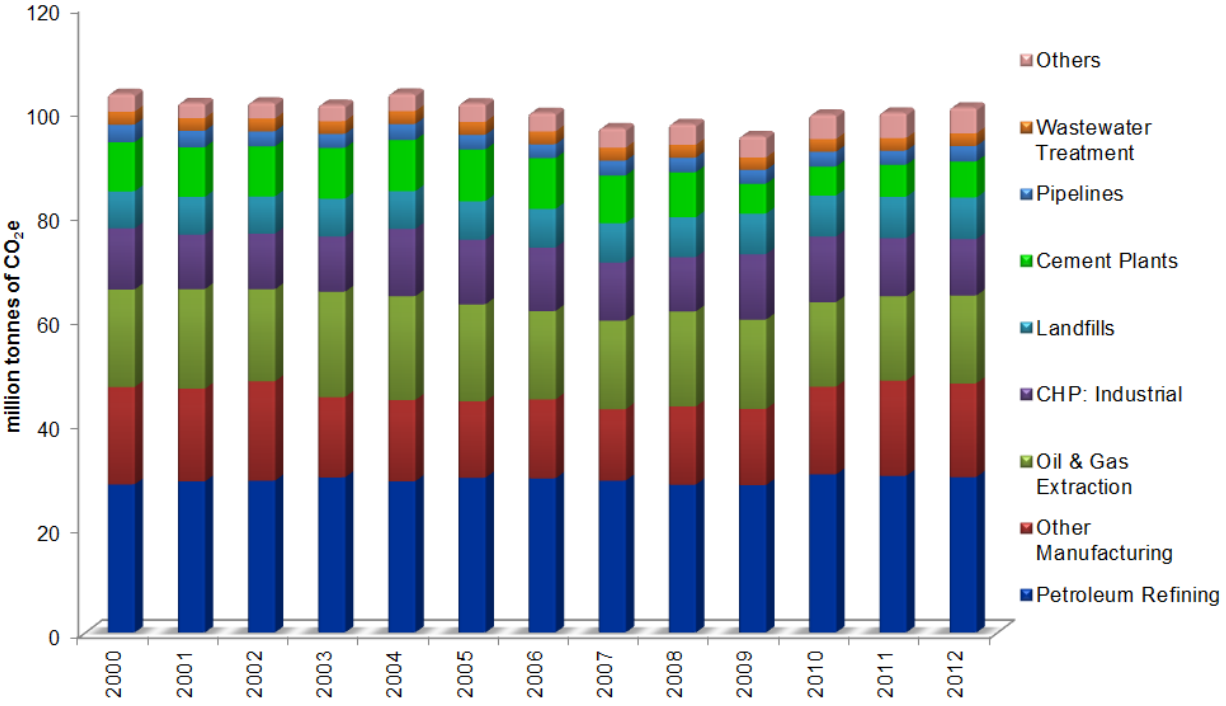


Figure 15. Greenhouse Gas Emission Trends from Industry



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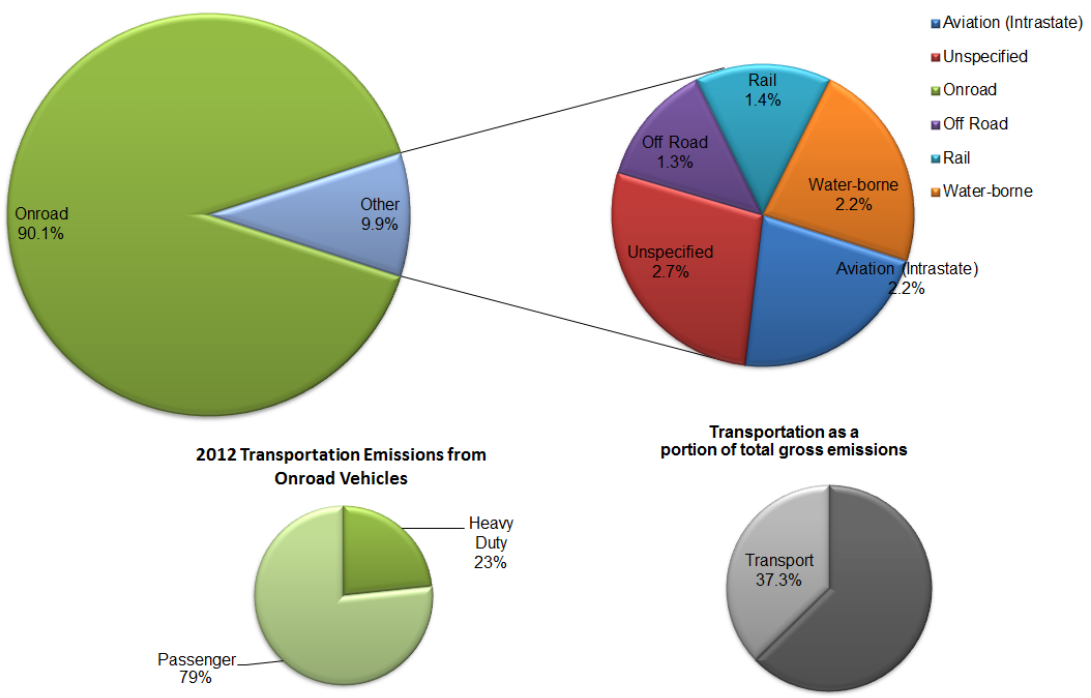
Overall, emissions from industrial sector were 103 $MMTCO_2e$ in 2000 and 101 $MMTCO_2e$ in 2012. The emissions decreased to 95 $MMTCO_2e$ in 2009 mainly due to the decrease in demand for cement.

Residential: The residential sector accounted for 6.9 percent of the total emissions in 2012, and primarily consisted of CO_2 emissions from fossil fuel combustion. Residential emissions are related to the use of fuel for general household needs. Approximately 99 percent of the fuel related emissions are from the burning of natural gas and LPG, with the majority attributed to the burning of natural gas. Emissions from residential fuel use increased from 31.6 $MMTCO_2e$ in 2000 to 32.7 in 2011.

Transportation: Transportation activities accounted for 37.3 percent of the statewide greenhouse gas emissions in 2012. Contributions from the transportation sector include emissions from aviation, on-road, off-road, rail and water-borne and other unspecified sources. Emissions from military transportation activities are not included in the inventory total for the State. The percent contributions from each of these categories to the total emissions from this sector are shown in Figure 16 for 2012.

Figure 16. 2012 Greenhouse Gas Emissions from Transportation
(171 $MMTCO_2e$ Gross Emissions)



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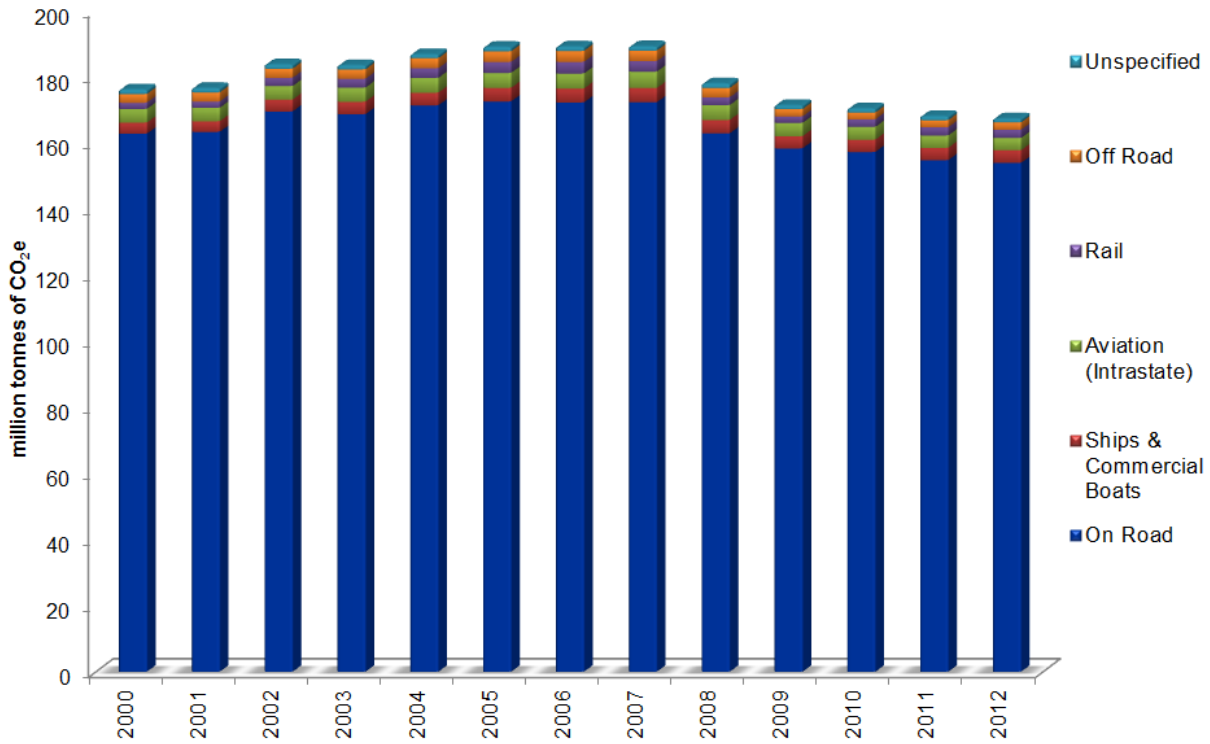
An overwhelmingly large majority of emissions from this sector is due to on-road transportation (90 percent). The on-road category also accounts for more than 33 percent of the statewide 2012 greenhouse gas emissions. Of the on-road vehicles, light duty passenger vehicles accounted for approximately 69 percent of the total sector emissions in 2012. Figure 17 shows the trend in emissions for this sector from 2000 through 2012. Transportation emissions showed a marked decline since 2007 (from a high of 192 $MMTCO_2e$ in 2007 to 171 $MMTCO_2e$ in 2012).

Figure 17. Greenhouse Gas Emission Trends from Transportation



Summed together, the above sectors along with the unspecified emissions in the inventory not attributed to any sector, equal the total emissions accounted for in the California inventory. Unspecified emissions include emissions from evaporative losses, which could not be attributed to a specific economic sector. In the previous version of the inventory, emissions from the use of ODS substitutes was categorized in the unspecified emissions. However, in this version, those emissions are attributed to individual sectors. The ODS substitute category includes hydrofluorocarbon (HFC) and perfluorocarbon (PFC) emissions, which are substitutes to chlorofluorocarbons (CFCs), compounds that were phased out under the Montreal Protocol due to their ozone depleting ability.

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This sector-specific methodology (except for electricity imports and internationally-flagged shipping) generally reflects the reporting methods used by the U.S.EPA and the IPCC.

Per Capita Emissions

For the year 2012, California has a gross per capita emissions of 12.2 $MTCO_2e$ per person (Figure 18). This represents a 12 percent reduction from the 13.7 $MTCO_2e$ per person in 2000 (Figure 18). The population increased by 11.4 percent during the same period.

Per capita emissions from industrial, transportation, and electricity generation (in-state) have decreased from 2000 to 2012, with a 22 percent decrease in the 2012 in-state electricity generation per capita emissions from 2000. The per capita comparison is a useful metric for emissions evaluation because it shows that emissions have not grown consistently with population, indicating that energy conservation may have led to significant emission reductions.

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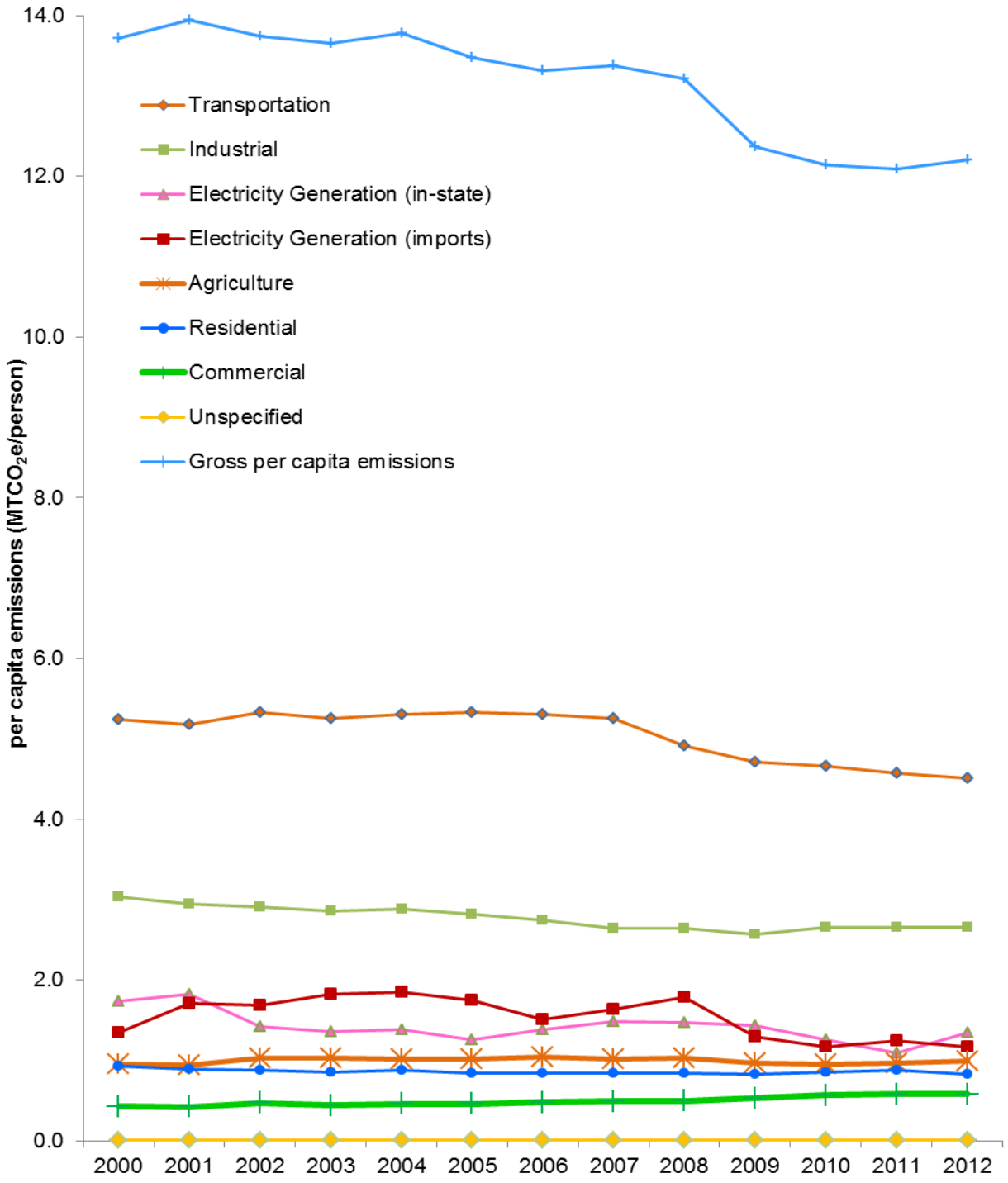
Figure 18. 2012 Greenhouse Gas Emissions per Capita



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Carbon Intensity of California Economy - Gross Domestic Product

California's Gross Domestic Product (GDP) increased from $1.47 trillion in 2000 to $1.75 trillion in 2012 (in 2005 dollars)(DoF, 2014). While California's economy has continued to grow, the "carbon intensity" of the economy, the amount of carbon emissions related to the state's overall economy (tonnes CO_2/ GDP$), has continually declined since 2001. The carbon intensity of California's economy has decreased from 316.6 tonnes CO_2e per million dollars in 2000 to 261.9 tonnes per million dollars in 2012. That equates to a 17 percent decrease and California ranks as the 46th lowest state in the nation in terms of carbon intensity.

Carbon Intensity of California's economy

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V. Broader Perspective of California Greenhouse Gas Emissions

To get a broader perspective of California GHG emissions, it's interesting to compare with other states and nations GHG emissions. Even though the California inventory was designed to facilitate comparability with other nations and states, often the international emissions data is incomplete or of a different time. For this reason, this section uses data from the World Resources Institute (WRI) Climate Analysis Indicators Tool (CAIT) for comparing California's inventory to other states in the United States and other countries around the world (WRI, 2014). CAIT2.0 includes greenhouse gas emissions data for the period 1990-2010. The data include the six major greenhouse gases from most major sources and sinks for over 185 countries as well as state-level data for all 50 U.S. states and the District of Columbia.

California and Other States

The 2010 greenhouse gas emissions data from CAIT 2.0 (WRI, 2014) was the latest available and hence used to compare 2010 emissions from California with emissions from other states in the United States. The data for California emissions for year 2010 was based on the 2000-2012 statewide inventory. The data for all other states was from the WRI CAIT 2.0 tool.

Figure 19 shows the total and per capita greenhouse gas emissions for 2010 for all the states in the country (WRI, 2014). In 2010, California accounted for 6.8 percent of all emissions in the country and ranked second highest among the states with total emissions of 453 $MMTCO_2e$, only behind Texas with 763 $MMTCO_2e$. From a per capita standpoint, California has the 45th lowest emissions with 12.1 $MTCO_2e$/person in 2010.

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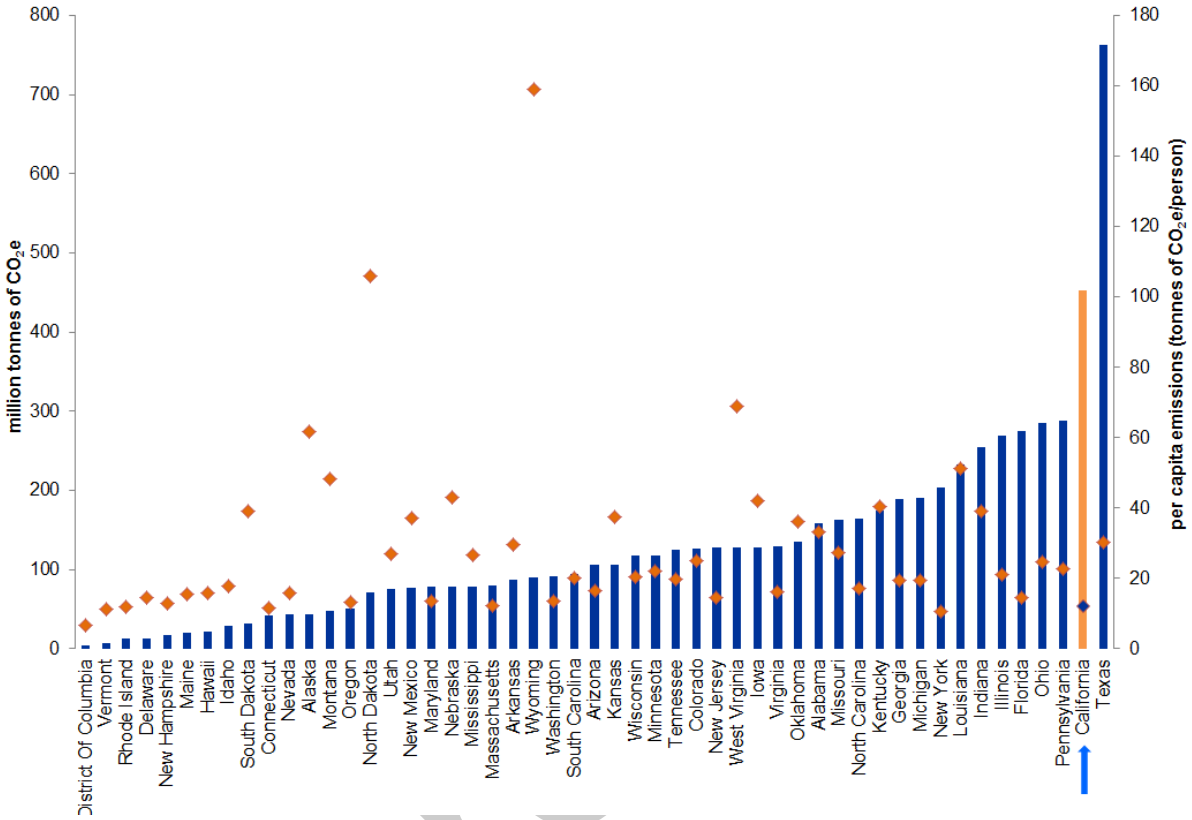
Figure 19. Total (bars) and Per Capita (markers) California and Other States Greenhouse Gas Emissions (CAIT-U.S. v4.0)

Total and Per Capita Greenhouse Gas Emissions for 2010



California and the Rest of the World

California has substantial greenhouse gas emissions when compared with the nations of the world. CAIT was used to compare 2010 California emissions against 2010 emissions from countries of the world, including the United States (WRI, 2014). A comparison of 2010 total and per capita greenhouse gas emissions as obtained from CAIT for California and the rest of the world is shown in Figure 20.

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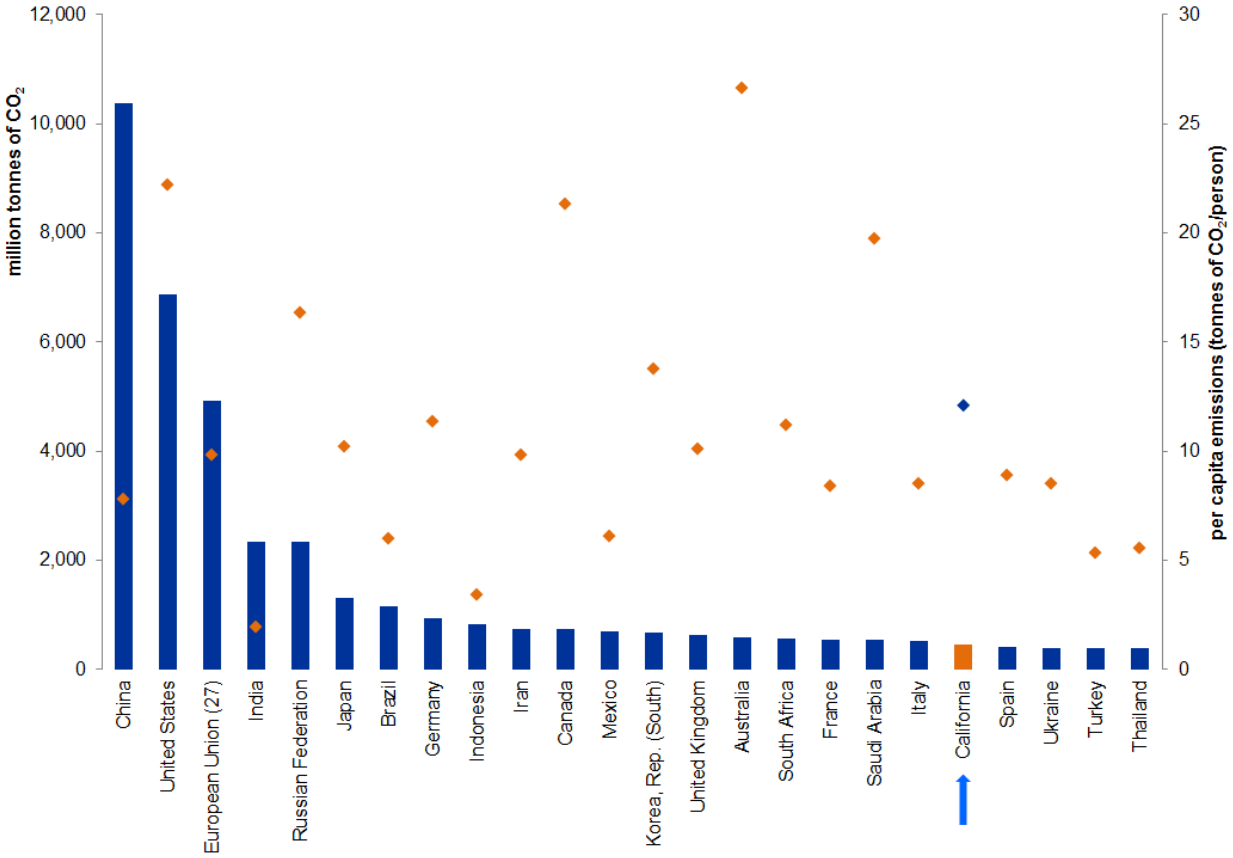
Figure 20. Total (bars) and Per Capita (markers) California and Other States Greenhouse Gas Emissions (CAIT-U.S. v4.0)
Total and Per Capita CO_2 Emissions for 2010



If California were considered as an independent state, on a global platform in 2010, California would have ranked the 20th highest in CO_2 emissions worldwide. On a per capita emissions basis, California would have ranked 38th in the world with 12.1 $MTCO_2e$/person in 2010, behind United States (including California) at rank 16 with 22.2 $MTCO_2e$/person. Kuwait had the highest per capita emissions at 71.8 $MTCO_2e$/person. The top 10 emitters (individual nations, excluding data for European Union) accounted for a large part of the total global greenhouse gas emissions in 2010 (approximately 70 percent).

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VI. Ongoing Work

ARB staff routinely evaluates the methodology used to develop the emissions estimates used in the inventory. In addition, data from a variety of sources are reviewed and compiled for use in updating the inventory each year. ARB regularly releases updated emission inventory data, summary reports, and technical support documents that detail the emission inventory for public use It is anticipated that ARB staff will continue to release updates in the future. All reports are available on ARB's greenhouse gas emission inventory webpage.

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Appendix A

2012 Statewide Greenhouse Gas Inventory Emission estimation methodology changes from year 2011:

Inventory-wide change:

- Year 2012 inventory is based on GWP values from IPCC's AR4. Year 2011 GHG inventory was based on the GWP values from the IPCC's second assessment report (SAR).

Sectoral changes are listed below:

Transportation:

- Aviation gasoline data source changed from EIA to BOE.
- On road "gasoline" gallons sold (i.e. gasoline + ethanol) changed slightly due to updates BOE made to the data series back to 2004.
- New methodology uses MRR gasoline and ethanol gallons data to create a percentage mix, instead of using CEC's reported ethanol percentage mix.
- Most water-borne categories changed due to updates in the models on recession and longer term growth forecasts.

Electric Power:

- Combined Heat & Power (CHP) data for 2009-2012 were updated to reflect the same methodology used from 1990-2008, which is the EIA method. (MRR data for these years, produced aberrations in the trend).

Industrial:

- The small amount of Coal and Coke use not reported to MRR was finally determined not to exist (based on EIA data), and was eliminated.
- Off-road Gasoline use now uses MRR totals reconciled to BOE on-road amounts.

Commercial and Residential:

- No methodology changes from year 2011 to 2012.

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Agriculture:

- An improved emission factor was derived for rice cultivation for years 2000-2012, in collaboration with USEPA.
- New categories: Dairy calves and beef calves (less than 6 months) have been added for completeness.

High GWP:

- No methodology changes from year 2011 to 2012.

Recycling and Waste:

- No methodology changes from year 2011 to 2012.

Note: For detailed changes related to each sector, please refer to the Technical Support Document 2000-2012.

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