

2016 Edition  
California GHG Emission Inventory

## California Greenhouse Gas Emissions for 2000 to 2014 – Trends of Emissions and Other Indicators

### Overview

California's annual statewide greenhouse gas (GHG) emission inventory is an important tool for establishing historical emission trends and tracking California's progress in reducing GHGs. Most importantly, the GHG inventory is a critical piece, in addition to California Global Warming Solutions Act (AB 32) program data, in demonstrating the state's progress in achieving the 2020 statewide GHG target.\* The 2016 edition of the GHG inventory tracks the emissions of seven GHGs identified in AB 32<sup>1</sup> for years 2000 to 2014 and uses an inventory scope and framework consistent with international and national GHG inventory practices.<sup>2</sup> Other programs within ARB address additional climate pollutants not included in AB 32 or the GHG inventory; for example, the Proposed Short-Lived Climate Pollutant (SLCP) Strategy<sup>3</sup> includes black carbon and sulfur dioxide (SO<sub>2</sub>).

In 2014, total GHG emissions were 441.5 million metric tons of CO<sub>2</sub> equivalent (MMTCO<sub>2</sub>e), a decrease of 2.8 MMTCO<sub>2</sub>e compared to 2013. This represents an overall decrease of 9.4% since peak levels in 2004. During the 2000 to 2014 period, per capita GHG emissions in California have continued to drop from a peak in 2001 of 13.9 tonnes per person to 11.4 tonnes per person in 2014; an 18% decrease.<sup>4</sup> Overall trends in the inventory also demonstrate that the carbon intensity of California's economy (the amount of carbon pollution per million dollars of gross domestic product (GDP)) is declining, representing a 28% decline since the 2001 peak, while the state's GDP has grown 28% during this period.<sup>5</sup>

Figure 1. California Total and Per Capita GHG Emissions

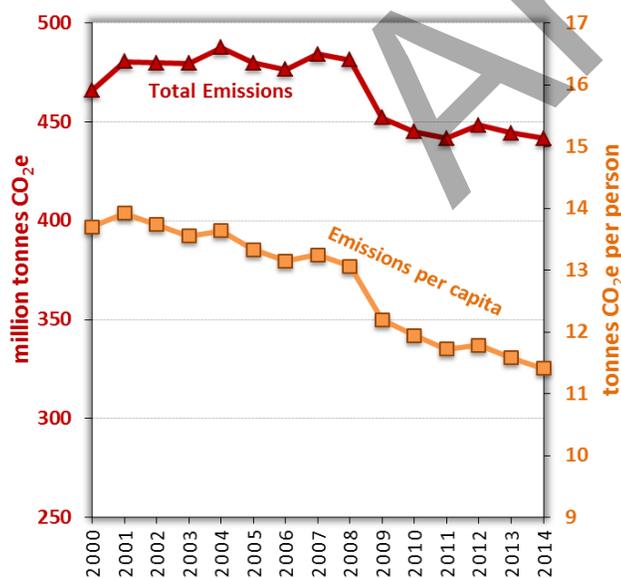
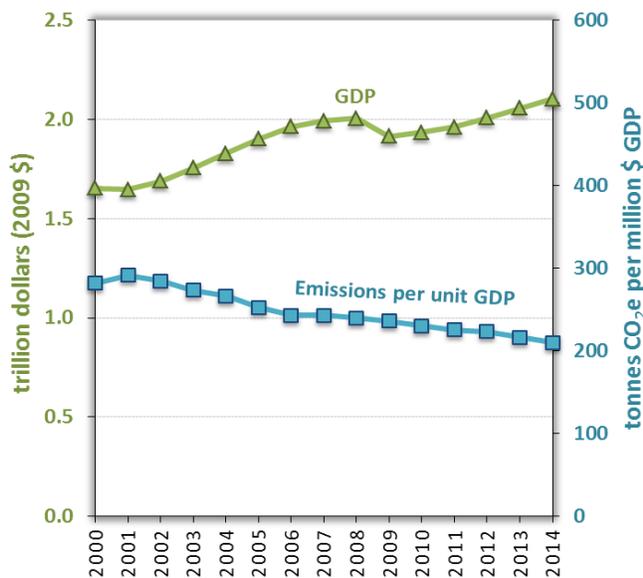


Figure 2. Carbon Intensity of California's Economy



\* As part of the 2030 Target Scoping Plan Update, to better track progress towards achieving our statewide GHG targets, ARB will be exploring how to structure a separate accounting framework that uses the GHG inventory, but incorporates GHG emissions related to land use conversion when biofuels are produced and supplied to California as a result of our Low Carbon Fuel Standard. ARB will also be exploring how flows of cap-and-trade program compliance instruments between California and Québec can be incorporated into such an accounting framework.

*2016 Edition*  
*California GHG Emission Inventory*

Figure 3 provides an overview of the emission trends by sector since 2000, while Figure 4 provides the relative breakdown of 2014 emissions by sector. Emissions in Figures 3 and 4 are organized by the categories in the Initial AB 32 Scoping Plan<sup>6</sup> and use the 100-year global warming potentials (GWPs) from the Intergovernmental Panel on Climate Change (IPCC) 4<sup>th</sup> Assessment Report (AR4)<sup>2</sup> consistent with current international GHG inventory practices. However, other ARB programs may use different GWP values. For example, the SLCP strategy uses a 20-year GWP and the Cap-and-Trade program currently uses a 100-year GWP from the IPCC Second Assessment Report.

The transportation sector remains the largest source of GHG emissions in the state, accounting for 36% of the inventory, and shows a small increase in emissions in 2014. Emissions from the electricity sector continue to decline due to growing zero-GHG energy generation sources. Emissions from the remaining sectors have remained relatively constant, although emissions from high-GWP gases have continued to climb as they replace ozone depleting substances banned under the Montreal Protocol.<sup>7</sup> The following sections provide additional information on emission trends for each major sector of the statewide GHG inventory.

Figure 3. Trends in California GHG Emissions

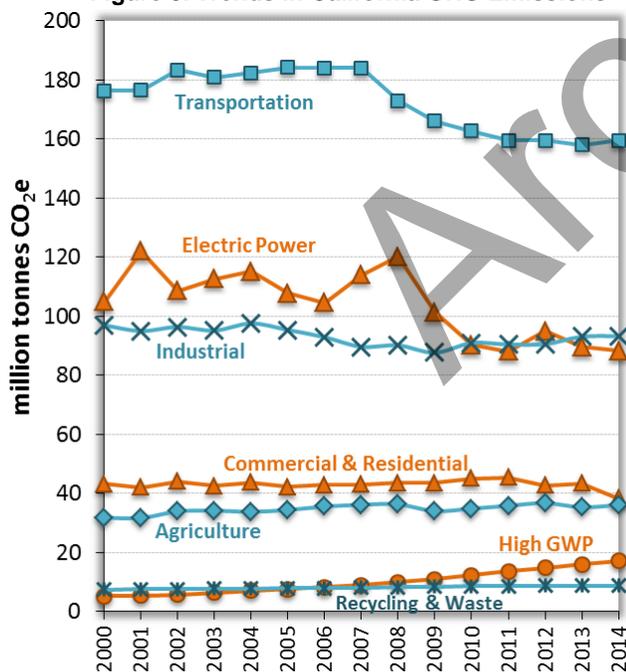
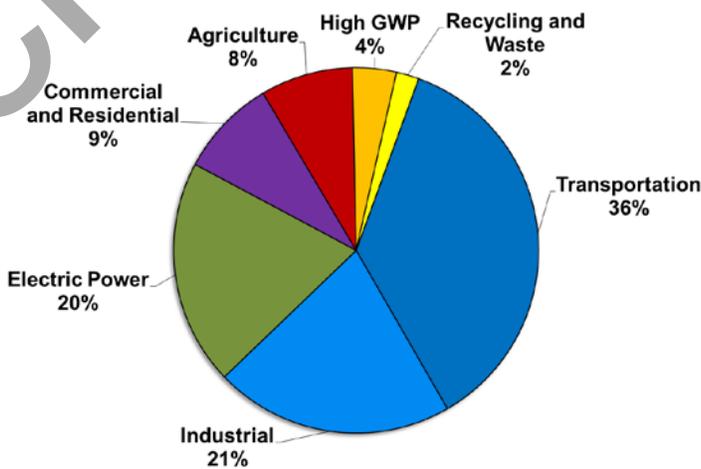


Figure 4. 2014 GHG Emissions by Sector

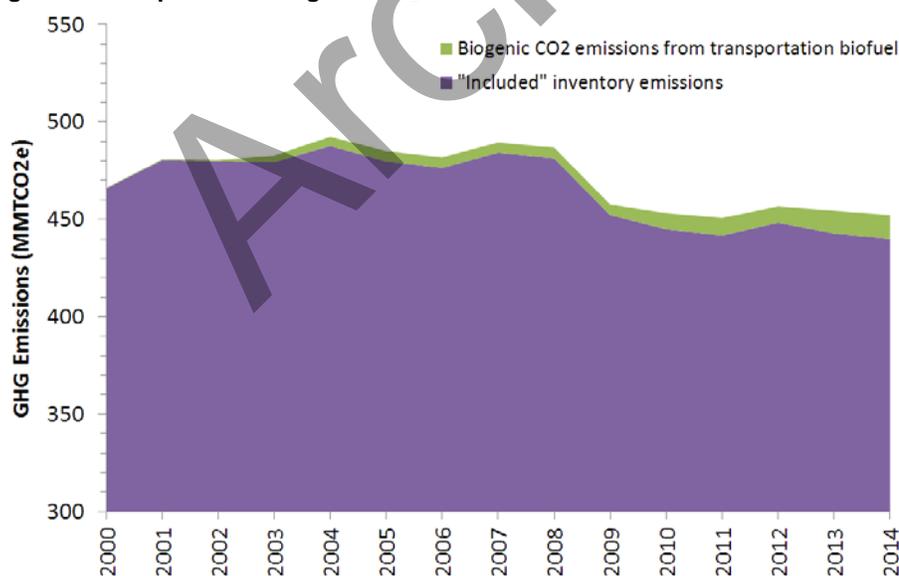


*2016 Edition**California GHG Emission Inventory***Transportation**

The transportation sector remains the largest source of GHG emissions in 2014, accounting for 36% of California's GHG inventory. Contributions from the transportation sector include emissions from combustion of fuels sold in-state that are used by on-road and off-road vehicles, aviation, rail, and water-borne vehicles, as well as a few other smaller sources.\*

In previous editions of the GHG inventory, the biofuel components of fuel combustion CO<sub>2</sub> emissions were accounted for and summed together with fossil fuel emissions. In this edition of the inventory, biodiesel, renewable diesel, ethanol and renewable natural gas have been disaggregated from the generic diesel and natural gas fuel categories. Consistent with the *IPCC Guidelines for National GHG Inventories*<sup>8</sup> and the annual GHG inventories submitted by the U.S. and other nations to the United Nations Framework Convention on Climate Change (UNFCCC), the biofuel components of fuel combustion CO<sub>2</sub> emissions are classified as "biogenic CO<sub>2</sub>" and are tracked separately as informational items. This change in classification allows for a more accurate comparison of the California GHG inventory with other subnational and national GHG inventories, which follow the same IPCC Guidelines. Please refer to the Frequently Asked Questions document released with this edition of the inventory for additional information on the alignment of the GHG inventory with IPCC guidelines.\*\* Consistent with the IPCC Guidelines, the biofuel CO<sub>2</sub> reclassification is applied to the entire inventory time series from 2000 to 2014. Figure 5 shows biofuel CO<sub>2</sub> emissions as compared to the total emissions in the "included" inventory.

**Figure 5. Transportation Biogenic CO<sub>2</sub> Emissions and the Total "Included" Inventory**



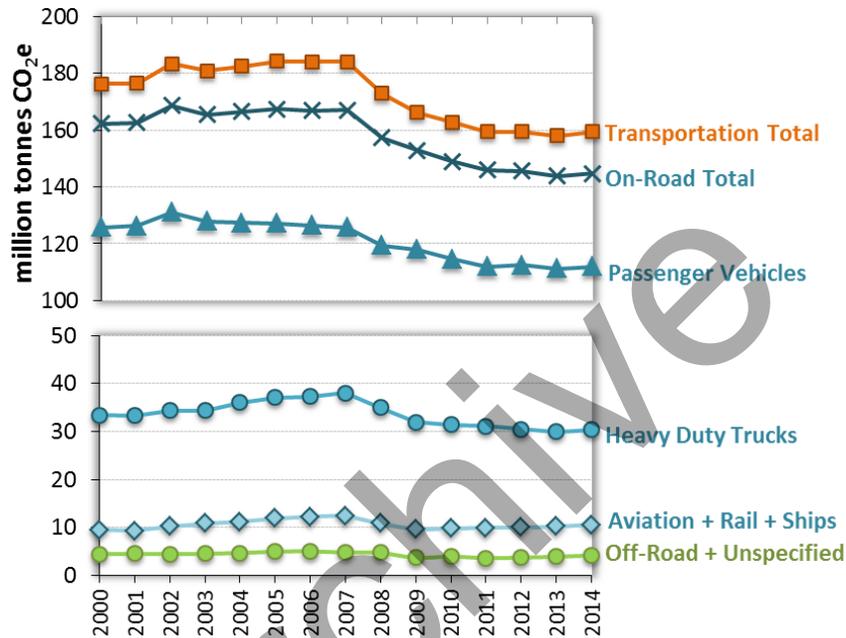
\* Emissions from interstate and international aviation diesel, jet fuel use at military bases, and a portion of bunker fuel purchased in California that is combusted by ships beyond 24 nautical miles from California's shores are not included in the GHG emission inventory, but are tracked separately as informational items. Fuels purchased outside of California that are used in-state by passenger vehicles and trains crossing into California, and upstream emissions tracked by the Low Carbon Fuel Standard (LCFS) program are not included and tracked in this version of the GHG emission inventory.

\*\* Frequently Asked Questions document is available at GHG inventory webpage at: <http://www.arb.ca.gov/cc/inventory/data/data.htm>

**2016 Edition**  
**California GHG Emission Inventory**

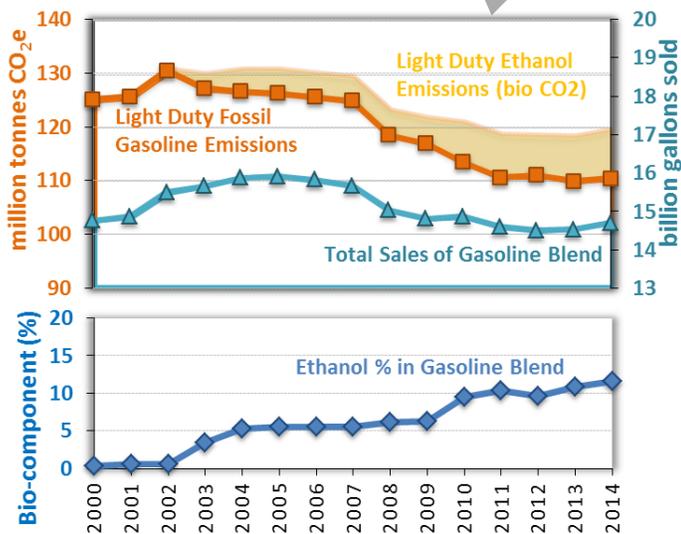
Emissions from transportation sources were relatively constant through 2007, then declined through 2011. Although transportation GHG emissions grew by 1% in 2014, emissions from this sector are still 13% lower than peak levels in 2005. The majority of emissions in the transportation sector are from on-road vehicles, which consist of light-duty vehicles (cars, motorcycles, and light-duty trucks) and heavy-duty vehicles (heavy-duty trucks, buses, and motorhomes). Light-duty vehicles accounted for approximately 70% of transportation emissions in 2014.

**Figure 6. GHG Emissions from the Transportation Sector**

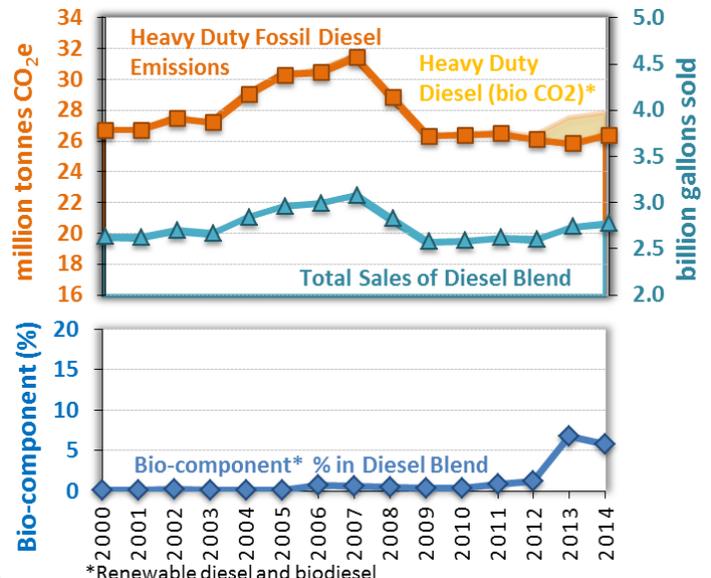


Figures 7a and 7b show the trends in emissions and fuel sales for light-duty gasoline and heavy-duty diesel vehicles. Total fuel combustion emissions, inclusive of both fossil component (orange line) and bio-component (yellow shaded region) of the fuel blend, track trends in fuel sales.

**Figure 7a. Trends in On-Road Light Duty Gasoline Emissions**



**Figure 7b. Trends in On-Road Heavy Duty Diesel Vehicle Emissions**



\*Renewable diesel and biodiesel

## 2016 Edition

## California GHG Emission Inventory

Electric Power

Emissions from the electric power sector comprise 20% of 2014 statewide GHG emissions. GHG emissions from this sector declined by 1.6% in 2014 compared to 2013. The GHG emission inventory divides the electric power sector into two broad categories: emissions from in-state power generation (including the portion of cogeneration emissions attributed to electricity generation) and emissions from imported electricity (gross imports are used in the inventory, not net imports which reduce gross imports by the amount of electricity exported). The overall decrease in this sector is driven by the Renewable Portfolio Standard (RPS), requiring a greater share of power to come from renewable sources. The GHG intensity of imported electricity has been declining steadily over time, while the GHG intensity of in-state electricity has been relatively constant.

Figure 8. GHG Emissions from the Electric Power Sector

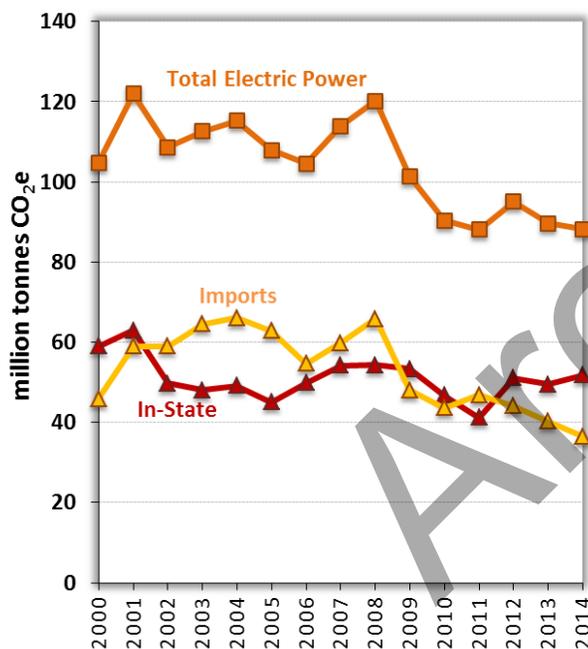
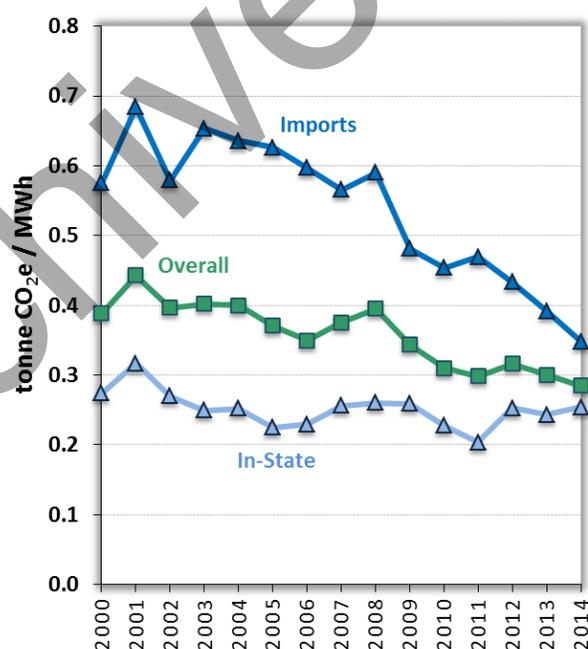


Figure 9. GHG Intensity of Electricity \*



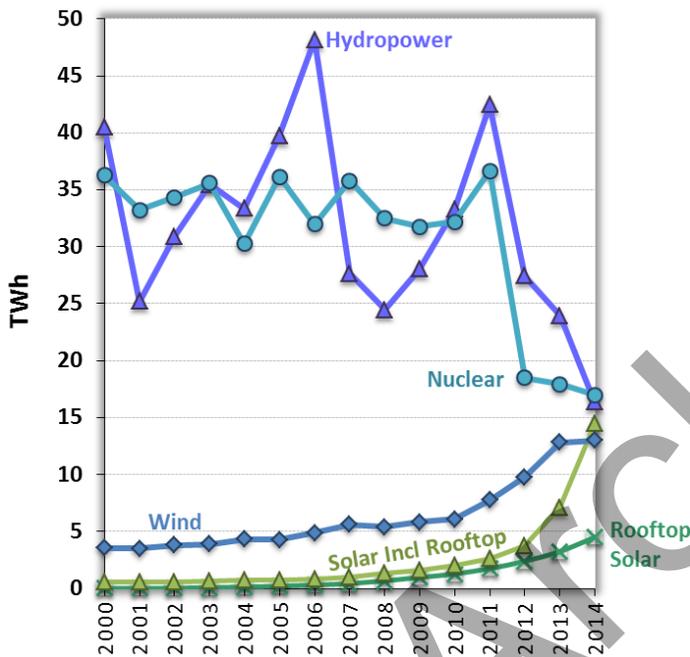
\* All three GHG intensities account for renewables and exclude biogenic CO<sub>2</sub> emissions. For calculating in-state and overall intensities, in-state electricity emissions and MWh generation include on-site generation for on-site use, cogeneration emissions attributed to electricity generation, in-state generated electricity exported out of state, and rooftop solar. The denominator of overall intensity is the total MWh consumed in and exported from California, and excludes MWh lost during transmission and distribution.

[Figure 9 was updated on July 6, 2016, adding to the overall intensity calculation the amount exported and the amount consumed in California that was not supplied to end users via the grid.]

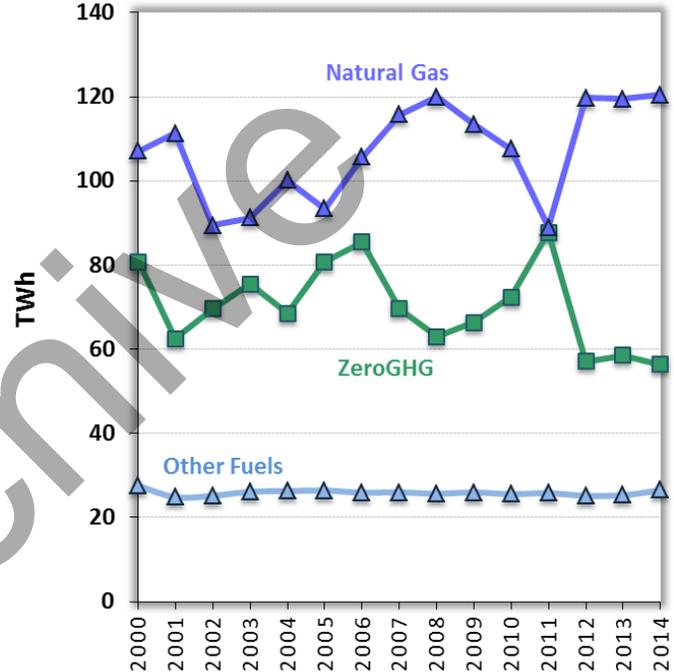
**2016 Edition**  
**California GHG Emission Inventory**

Since 2012, the loss in electricity generation due to the shutdown of San Onofre Nuclear Generating Station (SONGS) and the continuing decline in hydropower has been replaced by a combination of wind, solar, and natural gas generation. Between 2013 and 2014, total solar generation has doubled,<sup>9,10</sup> rooftop photovoltaic solar generation increased by 39%,<sup>10</sup> while in-state wind energy generation was similar to 2013 levels.<sup>9</sup> Although renewable generation continues to increase, reaching nearly 25% of total electricity supplied by utilities in 2014, hydropower continues its decline due to the prolonged drought (at its third year in 2014). Gains in new renewable generation were offset by a roughly equivalent loss in hydropower.

**Figure 10. In-State Zero-GHG Generation**



**Figure 11. In-State Electricity Generation by Fuel Type**



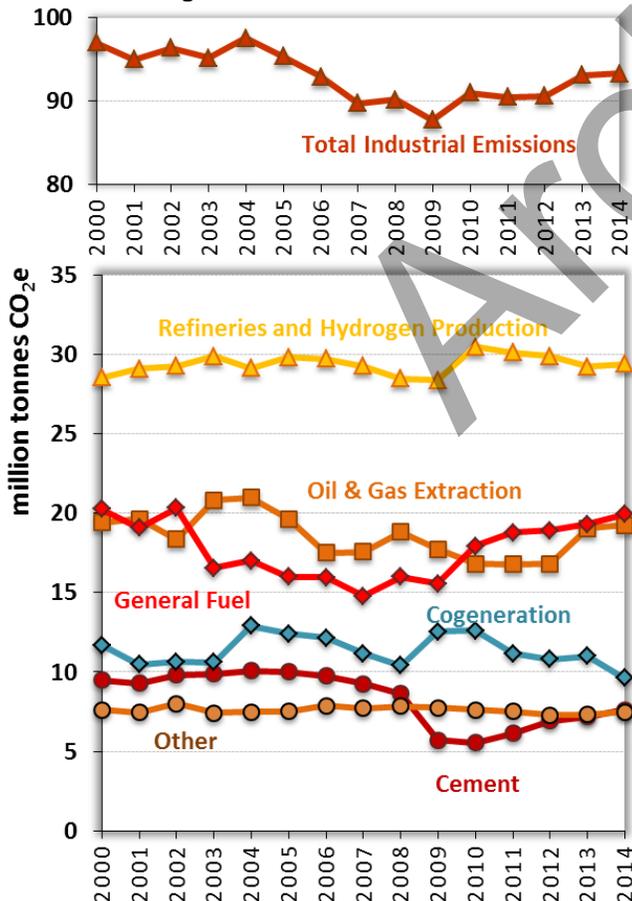
*2016 Edition*  
**California GHG Emission Inventory**

**Industrial**

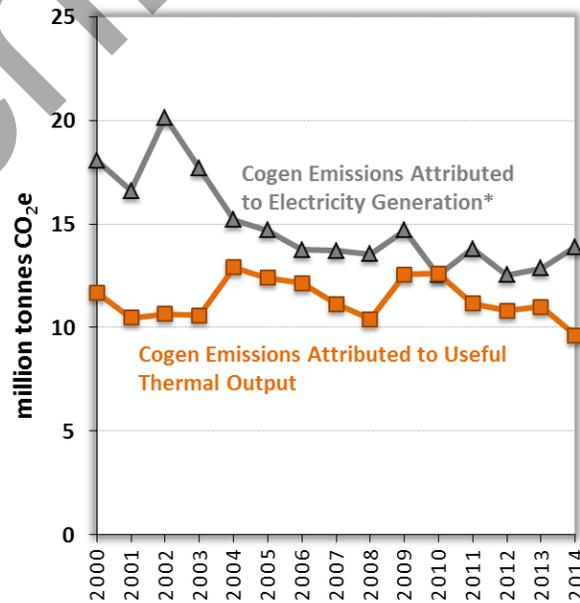
Emissions from the industrial sector contributed 21% of the total GHG emissions in 2014. Emissions in this sector are driven by fuel combustion from sources that include refineries, oil & gas extraction, cement plants, and other stationary sources, as well as the portion of cogeneration emissions attributed to thermal energy output. Emissions from this sector declined through 2009, then remain relatively consistent over the past few years.

Refineries and hydrogen production represent the largest individual industrial source, contributing 31% of the sector’s total emissions. Refinery and hydrogen production emissions have been declining since 2009, but increased by 0.6% in 2014. Emissions from oil and gas extraction represent 21% of 2014 industrial sector emissions. Although these emissions increased 13% between 2012 and 2013, emissions in 2014 increased only 1% compared to 2013. Since 2007, general fuel use by industries has gradually increased, signally a growing industrial sector. With the onset of the economic downturn around 2009, cogeneration facilities used more of their capacity to generate useful thermal energy (such as steam for industrial processes); however, useful thermal energy production has been on a downward trajectory since that time. In 2014, industrial cogeneration facilities have increased electricity generation while reducing useful thermal output compared to 2013.<sup>9</sup>

**Figure 12. Industrial emissions**



**Figure 13. Industrial Cogeneration Emissions**



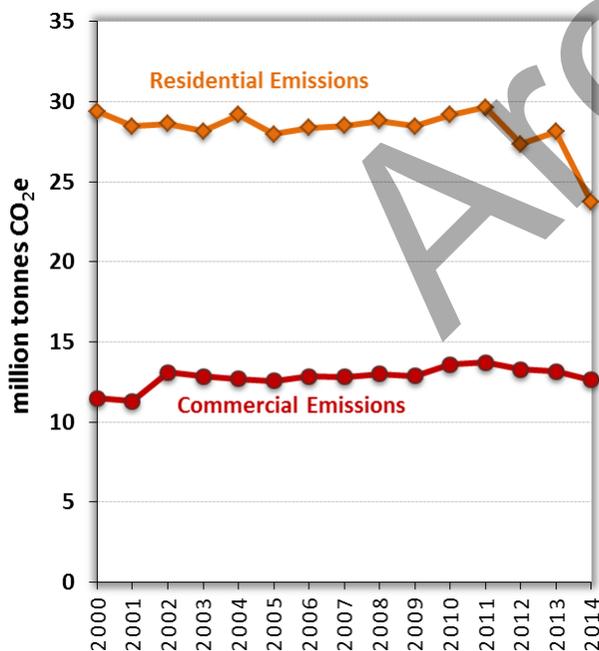
\* Cogeneration emissions attributed to electricity generation are categorized under the Electric Power Sector pursuant to the IPCC Guidelines. The electricity emissions are shown in this figure for the purpose of putting cogeneration emissions into context.

*2016 Edition*  
**California GHG Emission Inventory**  
**Commercial and Residential Fuel Combustion**

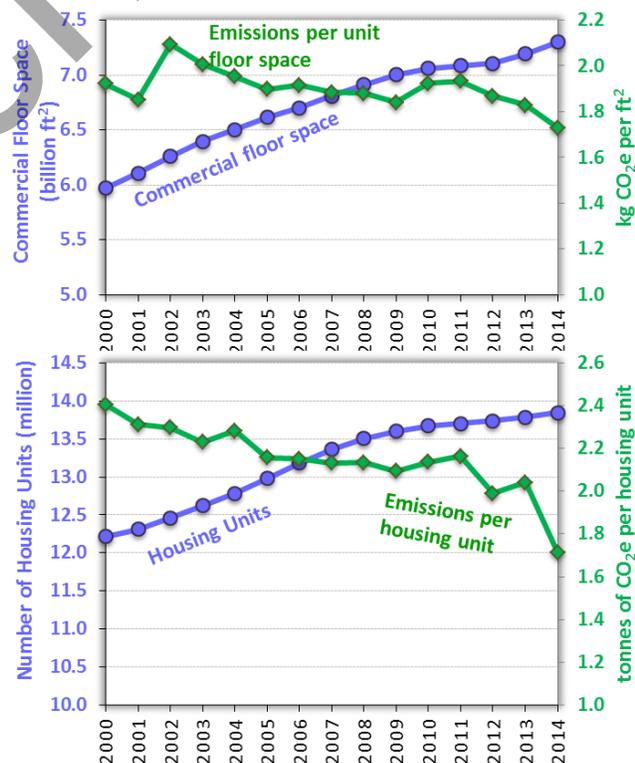
Emissions from the commercial and residential sectors are driven by the combustion of natural gas and other fuels for household use and for commercial businesses, such as space heating, cooking, and hot water or steam generation. Emissions from electricity used for cooling (air-conditioning) and appliance operation are already accounted for in the Electric Power sector. Changes in annual fuel combustion emissions are primarily driven by variability in weather conditions and the need for heating in buildings. In 2014, emissions decreased 12% from the previous year, due to the decline in residential natural gas use. The heating degree day index,<sup>11</sup> an estimate of the heating energy need in a given year, has been declining since 2011, and decreased by 10% between 2013 and 2014, signaling warming winters and less need for heating energy use.

While the number of residential housing units grew steadily from 12.2 million units in 2000 to 13.9 million units in 2014,<sup>12</sup> emissions and fuel consumption per housing unit have generally followed a declining trend during this period.<sup>13</sup> Emissions from commercial fuel use have grown by 10% since 2000; however, during the same period, commercial floor space grew by 22%. As a result, the commercial sector also exhibits a slight decline in fuel use per unit space.

**Figure 14. Emissions from Residential and Commercial Sectors**



**Figure 15. Emissions per Unit Floor Space and Residential Housing Unit**



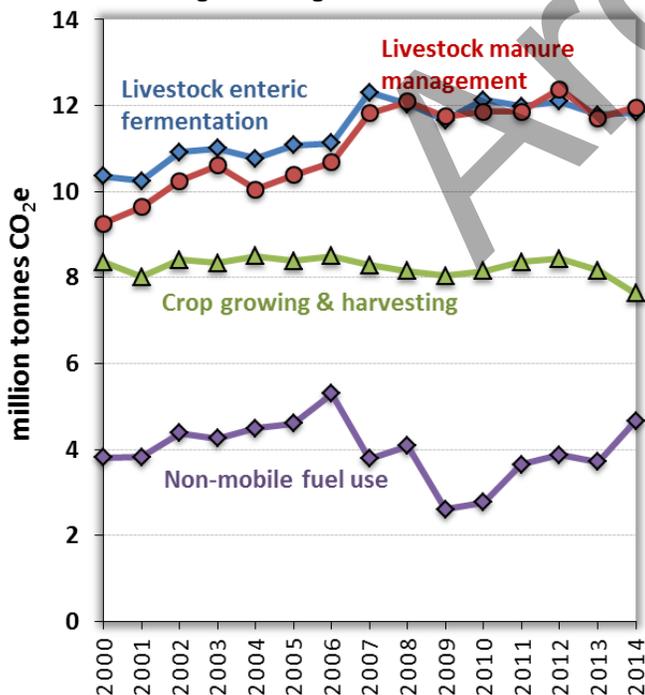
*2016 Edition*  
**California GHG Emission Inventory**  
**Agriculture**

The agricultural sector contributed approximately 8% of statewide GHG emissions in 2014, mainly from methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) sources. Sources include enteric fermentation and manure management from livestock, crop production (fertilizer use, soil preparation and disturbances, and crop residue burning), and fuel combustion associated with agricultural activities (water pumping, cooling or heating buildings and commodities). Livestock accounted for approximately two thirds of the agricultural emissions, primarily CH<sub>4</sub> from enteric fermentation and manure management. Dairies are a major source, accounting for 58% of agricultural emissions. From 2000 to 2014, California dairies increased their herds 19%, while total milk production grew 31%.<sup>14</sup> During the same period, GHG emissions from dairy manure management and enteric fermentation increased by 26%.

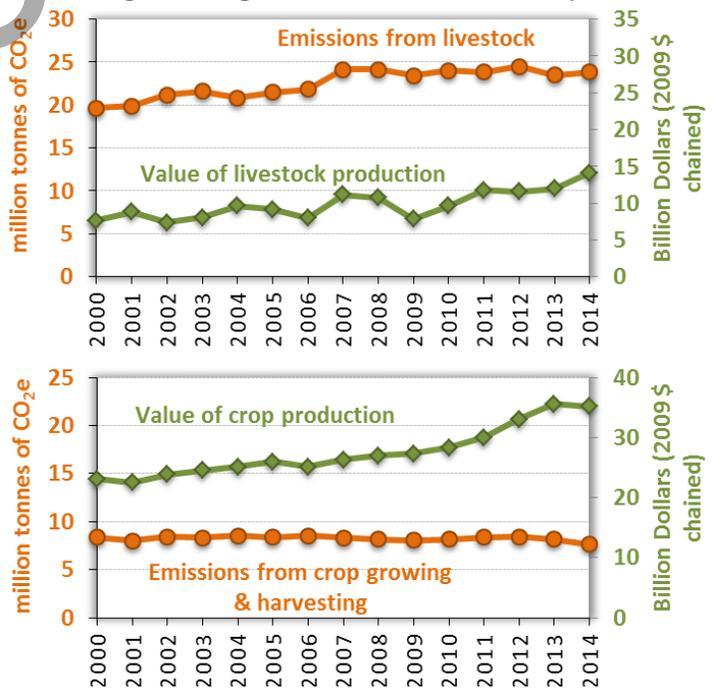
Emissions from the growing and harvesting of crops have historically been relatively consistent; however, emissions have begun to decline in 2014. This corresponds to a reduction of crop acreage likely due to drought.<sup>15</sup> About three quarters of GHG emissions from crops are from fertilizer and manure use.

Sixty-eight percent of agricultural fuel combustion emissions are due to diesel fuel combustion. Emissions from agricultural fuel use are historically variable, but have been increasing since 2009. 2014 emissions increased substantially compared to 2013, with a 26% increase in total emissions and a 40% increase in diesel fuel emissions. This increase may be related to increased groundwater pumping due to drought.

**Figure 16. Agricultural Emissions**



**Figure 17. Agricultural Livestock and Crop**



## 2016 Edition

## California GHG Emission Inventory

## High Global Warming Potential Gases

In 2014, High Global Warming Potential (high-GWP) gases comprise 3.9% of California's emissions. The GHG inventory tracks High-GWP gas emissions from substitutes for ozone depleting substances (ODS), losses from the electricity transmission and distribution system, and gases that are emitted in the semiconductor manufacturing process. Out of these, 97% of high-GWP gases are attributed to ODS substitutes, which are primarily hydrofluorocarbons (HFCs). ODS substitutes are used in refrigeration and air conditioning equipment, solvent cleaning, foam production, fire retardants, and aerosols. In 2014, refrigeration and air conditioning equipment across all sectors contributed 86% of ODS substitutes emissions. Emissions of ODS substitutes are expected to continue to grow as they replace ODSs banned under the Montreal Protocol.<sup>7</sup> Note that ODSs are also GHGs, but they are not within the inventory scope defined by the IPCC or AB 32 and therefore, are not included in the GHG inventory. Emissions of ODS have decreased significantly since the 1990s, when they began to be phased out, and the combined emissions of ODS and ODS substitutes have also decreased over time.

The remaining high-GWP gases consist of fugitive SF<sub>6</sub> emissions from electrical gas insulated switchgears (GIS) and high-GWP gases including perfluorocarbons (PFCs) from semiconductor manufacturing. These categories have followed a steadily declining trend since 2000. SF<sub>6</sub> emissions from electrical system have shown a more rapid decrease subsequent to implementation of the SF<sub>6</sub> GIS regulation in 2011.

Figure 18. Trend in ODS and ODS Substitutes Emissions

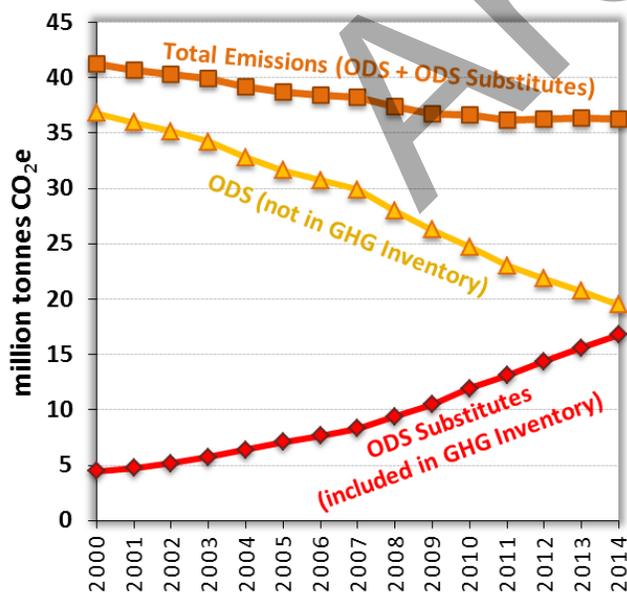
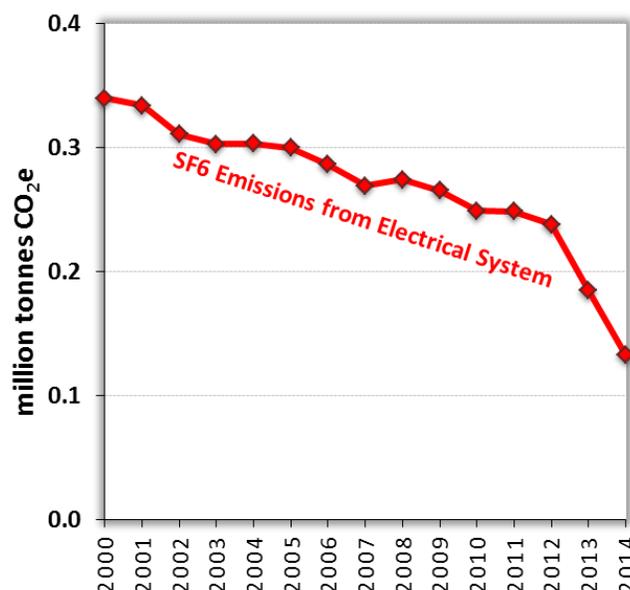


Figure 19. Trend in Emissions of SF<sub>6</sub> from Electrical System



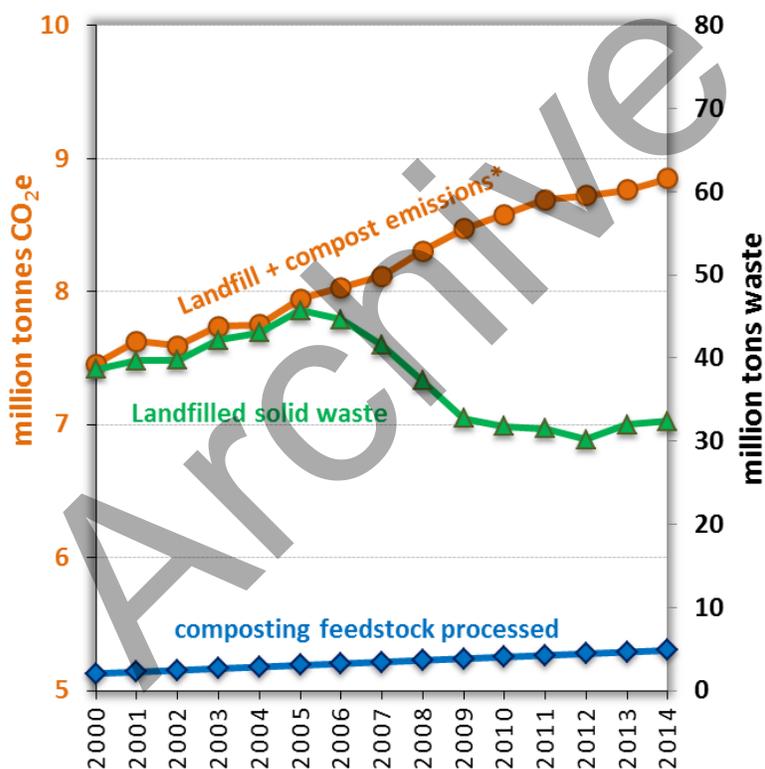
## 2016 Edition

## California GHG Emission Inventory

Recycling and Waste

Emissions from the recycling and waste sector consist of CH<sub>4</sub> and N<sub>2</sub>O emissions from landfills and from commercial-scale composting. Emissions from recycling and waste, which comprise 2% of California's GHG inventory, have grown by 19% since 2000. Landfill emissions account for 94% of the emissions in this sector,\* while compost production facilities make up a small fraction of emissions. The annual amount of solid waste deposited in California's landfills grew from 37 million tons in 2000 to its peak of 46 million tons in 2005, followed by a declining trend until 2009 when landfilled solid waste stabilized to relatively constant levels.<sup>16</sup> Landfill emissions are driven by the total waste-in-place, rather than year-to-year fluctuation in annual deposition of solid waste.

Figure 20. Emissions from Landfill and Compost



\* ARB's GHG inventory methodology has been using an assumption of 75 percent methane capture efficiency, consistent with common practice nationally. ARB is currently in the process of evaluating the effects of the Landfill Methane Control Measure. Previous estimates for the measure indicated that it may potentially increase the collection efficiency at regulated landfills to 80-85 percent. However, current landfill collection efficiency estimates vary widely and are highly dependent on a variety of site-specific factors, including landfill size, age, waste composition, local climate, soil type, landfill cover, and gas collection system. Additional California-specific data is necessary to assess the overall collection efficiency at landfills. In recognition of this, ARB and CalRecycle are planning additional research to evaluate gas collection efficiencies at California's landfills. Future inventories will incorporate the results of new research in landfill collection efficiency estimates.

*2016 Edition*  
*California GHG Emission Inventory*

## **Sources of Data Used in the GHG Emission Inventory**

Statewide GHG emissions are calculated using many data sources. The primary data source is from reports submitted to the California Air Resources Board (ARB) through the Regulation for the Mandatory Reporting of GHG Emissions (MRR). MRR requires facilities and entities with more than 10,000 metric tons CO<sub>2</sub>e of combustion and process emissions, all facilities belonging to certain industries, and all electric power entities to submit an annual GHG emissions data report directly to ARB. Reports from facilities and entities that emit more than 25,000 metric tons of CO<sub>2</sub>e are verified by an ARB-accredited third-party verification body. Emissions data from MRR are aggregated and reallocated to match existing GHG inventory classifications developed to align with IPCC guidelines. More information on MRR emissions reports can be found at: <http://www.arb.ca.gov/cc/reporting/ghg-rep/reported-data/ghg-reports.htm>

Since MRR data represent a subset of total GHG emissions in the State, ARB also relies on data from other California State and federal agencies to develop an economy-wide GHG inventory for the State of California. These additional sources include, but are not limited to, data from the California Energy Commission, Board of Equalization, Department of Conservation/ Division of Oil, Gas, and Geothermal Resources, Department of Food and Agriculture, and CalRecycle, U.S. Energy Information Administration, and U.S. Environmental Protection Agency. All data sources used to develop the GHG Inventory are listed in the GHG Emission Inventory supporting documentation at: <http://www.arb.ca.gov/cc/inventory/data/data.htm>

The main GHG inventory page is located at: <http://www.arb.ca.gov/cc/inventory/inventory.htm>

*2016 Edition**California GHG Emission Inventory***Figure References**

<b>Figure Number</b>	<b>References</b>
Figure 1	4, 17
Figure 2	5, 17
Figure 3	17
Figure 4	17
Figure 5	17
Figure 6	17
Figure 7a	17, 18
Figure 7b	17, 18
Figure 8	17
Figure 9	9, 10, 17, 19
Figure 10	9, 10
Figure 11	9, 10
Figure 12	17
Figure 13	17
Figure 14	17
Figure 15	17, 20, 21
Figure 16	17
Figure 17	15, 17
Figure 18	17, 22
Figure 19	17
Figure 20	16, 17

*2016 Edition**California GHG Emission Inventory***References**

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**2016 Edition****California GHG Emission Inventory**

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