# California Greenhouse Gas Emissions for 2000 to 2013 – 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 toward the goal set by the Global Warming Solutions Act of 2006 (AB 32) to reduce the State's GHG emissions to 1990 levels by 2020. The GHG emission inventory tracks the emissions of seven GHGs identified in the California Health and Safety Code[1] for years 2000 to 2013. In 2013, total GHG emissions decreased by 1.5 million metric tons of $CO_2$ equivalents ($MMTCO_2e$) from 2012, representing an overall decrease of 7% since peak levels in 2004.

During the 2000 to 2013 period, per capita GHG emissions in California have continued to drop from a peak in 2001 of 14.0 tonnes per person to 12.0 tonnes per person in 2013; a 14% decrease[2]. Overall trends in the inventory also demonstrate that the carbon intensity of California's economy (the amount of carbon pollution per million dollars of GDP) is declining; representing a 23% decline since the 2001 peak.[3]

**Figure 1. California Total and Per Capita GHG Emissions, 2000-2013**

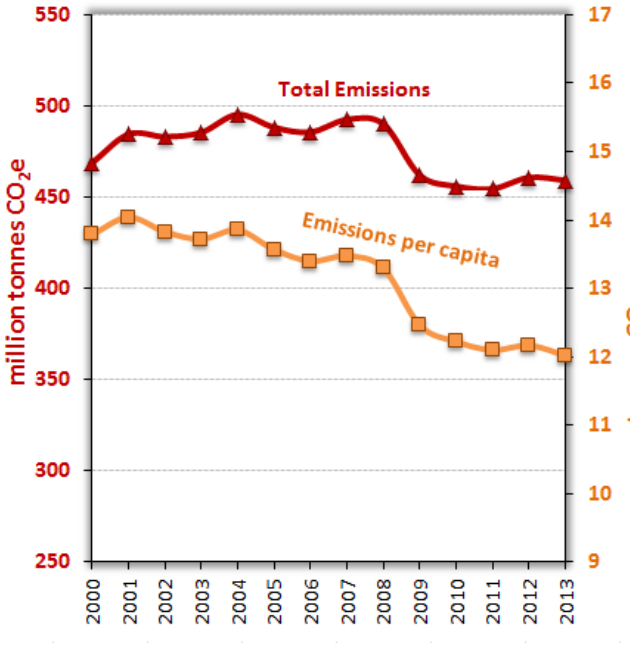



**Figure 2. Carbon Intensity of California's Economy**

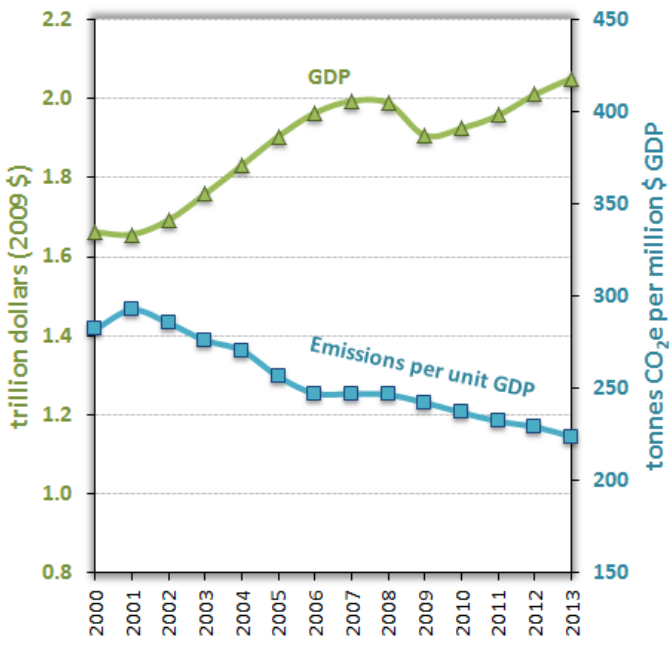


Figure 3 below provides an overview of the emission trends by sector since 2000. Figure 4 provides the percent breakdown by sector of total emissions in 2013. Emissions data below are organized by the categories in the AB 32 Scoping Plan[4] and use global warming potentials (GWPs) from the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (AR4).[5]

The transportation sector remains the largest source of GHG emissions in the state, accounting for 37% of the inventory. The electricity sector, the second largest source of emissions in most previous years, dropped to a level slightly below the industrial sector in 2013. Emissions from the remaining sectors have remained relatively constant over the past few years, although emissions from high-GWP gases have continued to climb as they replace ozone depleting substances banned under the Montreal Protocol. The following sections provide additional information on emission trends for each major sector of the statewide GHG inventory.

**Figure 3. California GHG Emissions by Category 2000-2013**

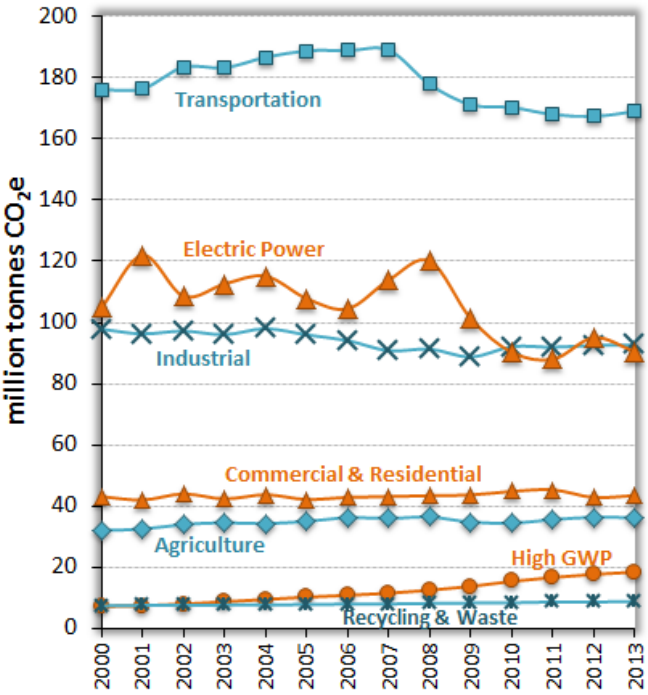
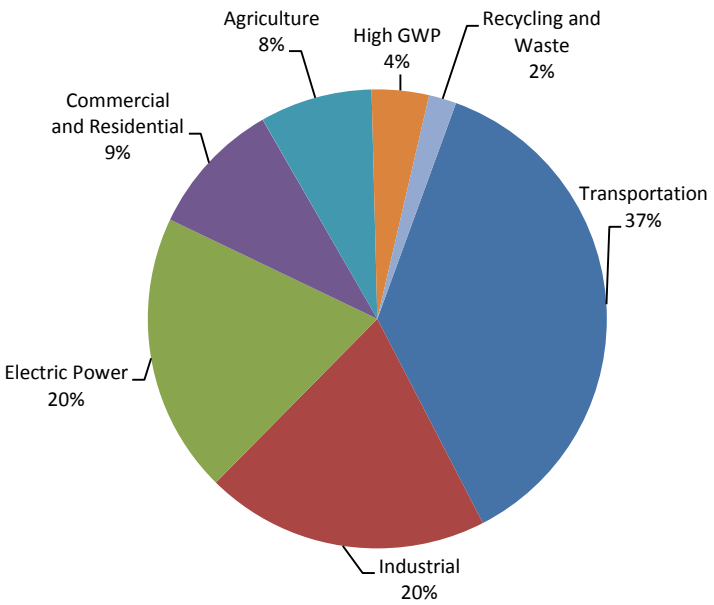



**Figure 4. 2013 GHG Emissions by Sector**



## Transportation

The transportation sector remains the largest source of GHG emissions in 2013, accounting for 37% of California's GHG emission 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. Emissions from interstate and international aviation, fuel combusted by ships beyond 24 nautical miles from California's shores, fuels purchased outside of California that are used by vehicles and trains crossing California border, as well as upstream emissions under the Low Carbon Fuel Standard (LCFS) program, are not included in the GHG emission inventory. Emissions from transportation sources increased through 2007, but then declined through 2012. While in-state transportation GHG emissions showed a slight increase of 1% in 2013, emissions from this sector are 11% lower than peak levels in 2007.

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). The largest category, light-duty vehicles, accounted for approximately 71% of transportation emissions in 2013. Passenger vehicle GHG emissions showed a small increase of less than 0.3% in 2013 compared to 2012. The increase in transportation sector emissions in 2013 was largely driven by the increase in heavy-duty vehicles. Emissions from these vehicles, which predominantly use diesel, track trends in diesel fuel sales.[6]

**Figure 5. GHG Emissions from Transportation Sector***

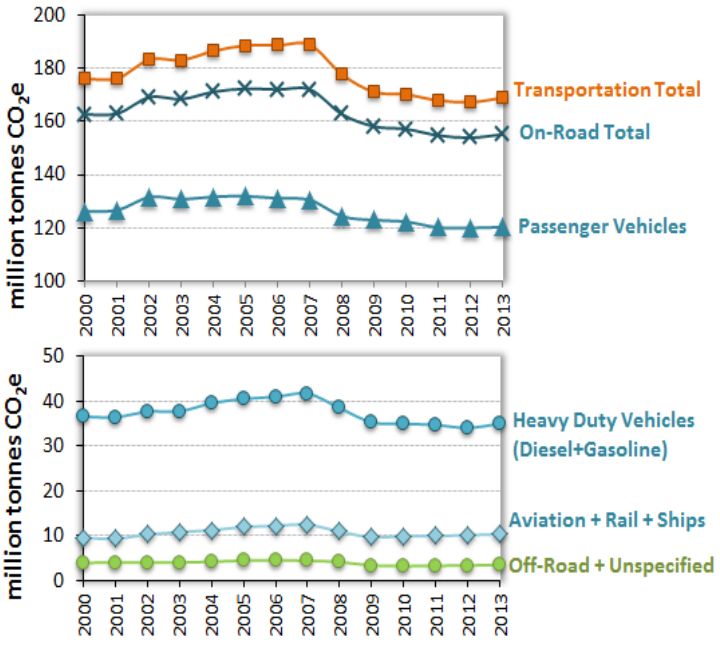
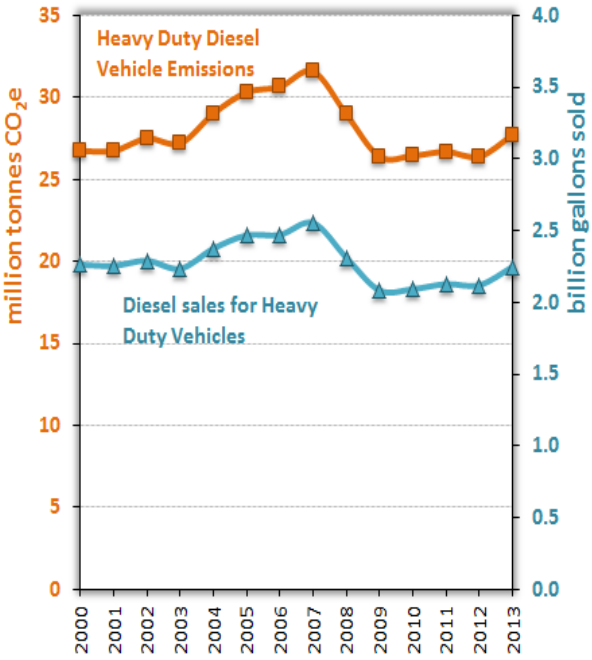



**Figure 6. Transportation Diesel**




* Emissions from interstate and international aviation, ships beyond 24 nautical miles from California's shores, fuels purchased outside of California that are used by vehicles and trains crossing California border, as well as upstream emissions under the LCFS program, are not included in the GHG inventory.

## *Electric Power*

Emissions from the electric power sector comprise a little less than 20% of the 2013 statewide GHG emissions. GHG emissions from this sector showed a slight decrease in 2013 compared to 2012. The GHG emission inventory divides the electric power sector into two broad categories: emissions from in-state power generation and emissions from imported electricity. The overall decrease in this sector is driven by decreases in emissions from both in-state and imported electricity as the State gradually moves toward more efficient and renewable sources.[7]

**Figure 7. GHG Emissions from Electric Power Sector**

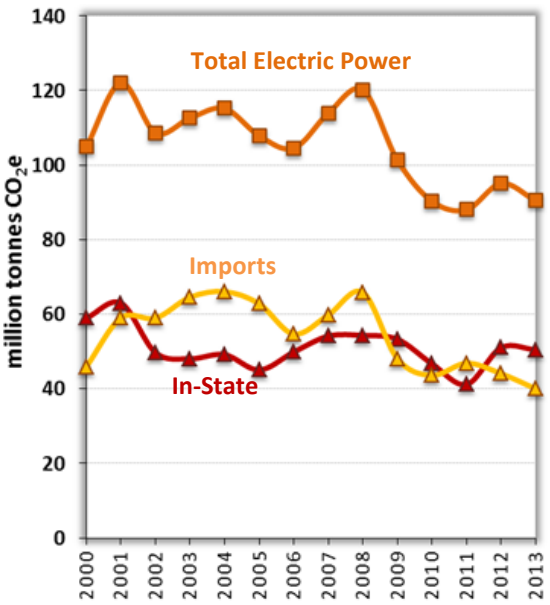
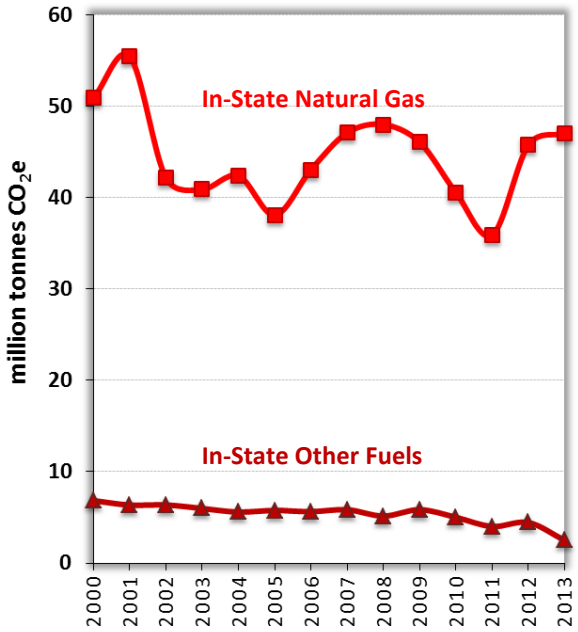



**Figure 8. Electric Power Emissions (In-State)**




In 2012, the state saw an increase in electricity emissions as the sector responded to the loss of zero-GHG generation from the closure of the San Onofre Nuclear Generating Station (SONGS) and lower hydropower generation as a result of California's drought. The lost zero-GHG generation was replaced by power in-state from natural gas powered generation plants. Although the drought and reduced availability of hydropower continued in 2013, in-state power generation has adapted by utilizing the more efficient combined-cycle power plants [7] and continuing recent trends of greater use of renewable power. The closing of the last of the high-carbon-intensity petroleum coke power plants also reduced the emissions associated with power generation.

In-state power generation from renewable sources continued to grow, driven by actions to comply with the Renewable Portfolio Standard requirement that 33% of all electricity retail sales be from renewable sources by 2020. Between 2012 and 2013, total solar generation increased by about 13%[8], rooftop photovoltaic solar generation increased by 31%[8b], while in-state wind energy generation increased by 32%.[8a] The GHG intensity (tonnes $CO_2e$ per MWh generation) of in-state generation dropped slightly in 2013. The GHG intensity of electricity imports continued its general decline since 2000 as well.[7]

**Figure 9. In-State Zero-GHG Generation**

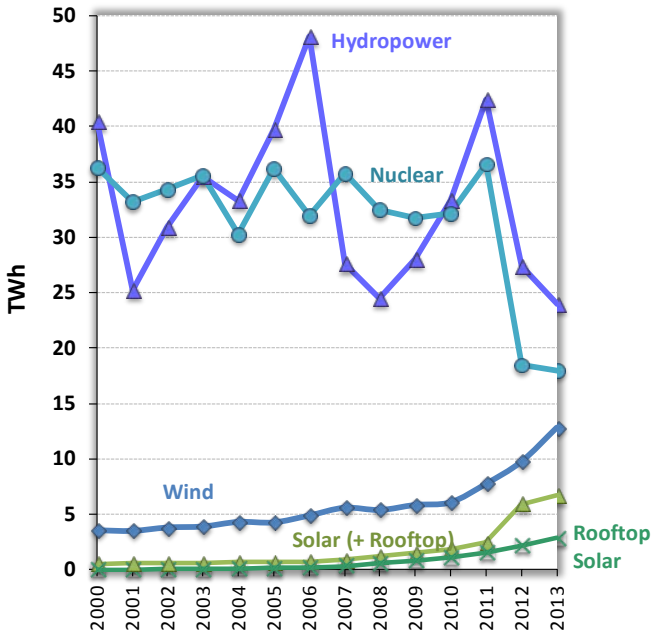
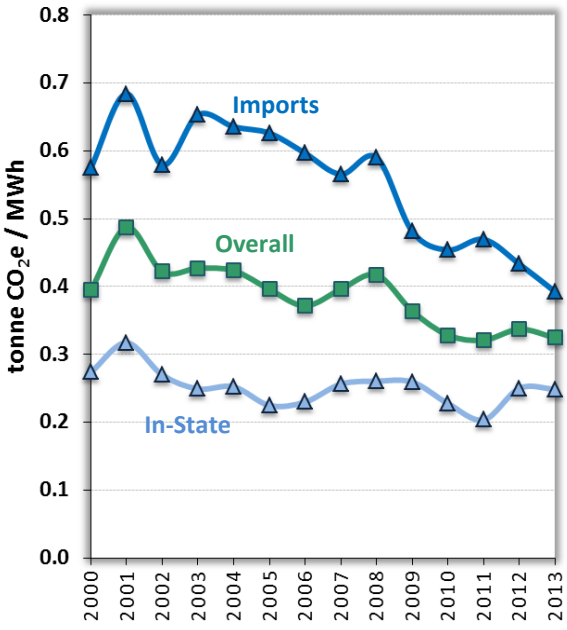



**Figure 10. GHG Intensity of Electricity Consumption**

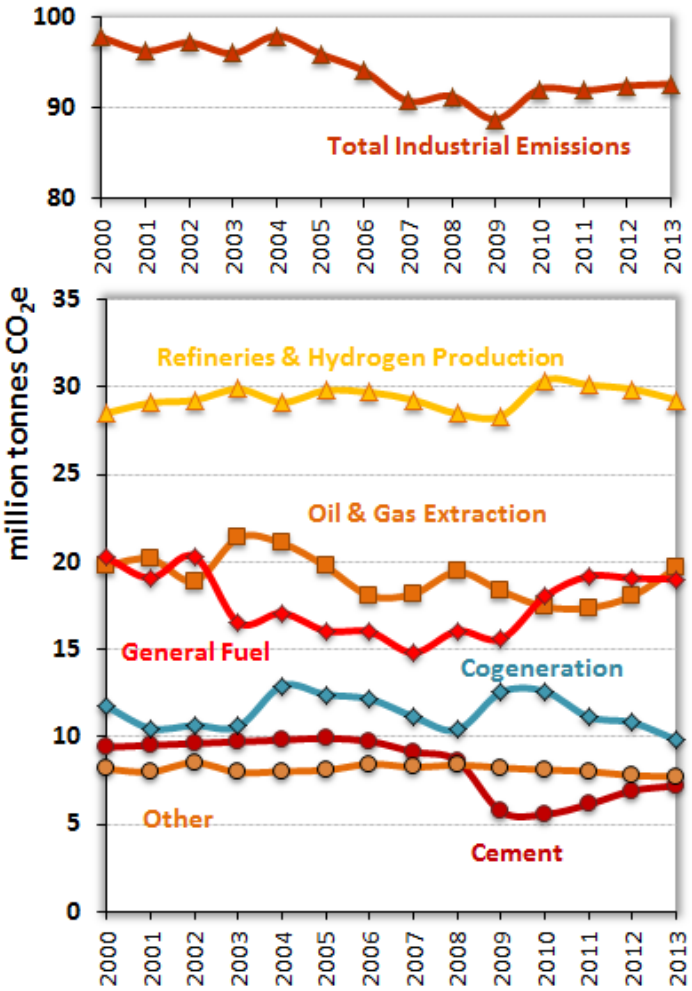


## Industrial

Emissions from the industrial sector contributed 20% of the total GHG emissions in 2013. Emissions in this sector are driven by fuel consumption from sources that include refineries, oil & gas extraction, cement plants, and other stationary sources. Emissions from this sector declined through 2009, but have remained relatively constant over the past few years.

Among the industrial categories, refineries and hydrogen production represent the largest individual source, contributing 32% of the sector's total emissions. Refinery and hydrogen production emissions increased in 2010 and then have been declining steadily to 29.3 $MMTCO_2e$ in 2013. In 2013, refineries produced less gasoline and slightly more diesel compared to the previous few years.[9] Diesel is less energy intensive to produce than gasoline, and the shift in production is likely one of the contributing factors to the decrease in emissions.

**Figure 11. Industrial emissions**



Emissions from oil and gas extraction represent about 21% of the industrial sector emissions. Since 2000, emissions have varied between a peak in 2003 and a low in 2011, with an increase of nearly 9% in 2013 compared to the previous year. Between 2000 and 2013, oil and gas production in California has declined substantially: from 307 to 200 million barrels of oil and from 379 billion cubic feet of natural gas to 208 billion.[10] Declining production from oil wells requires significant fuel use for steam generation to stimulate oil production. Although oil production drops, more energy is being utilized to extract oil from wells.

Emissions from cement plants constituted about 8% of the industrial sector emissions in 2013. Emissions in this sector increased by 4%, corresponding to a 5% increase in clinker production.[11] This correlates with the growth in new residential and non-residential construction in recent years. The residential construction sector added 43% more housing units in 2013 compared to 2012, signaling a recovering housing market.[12]

**Figure 12. Oil and Gas Extraction**

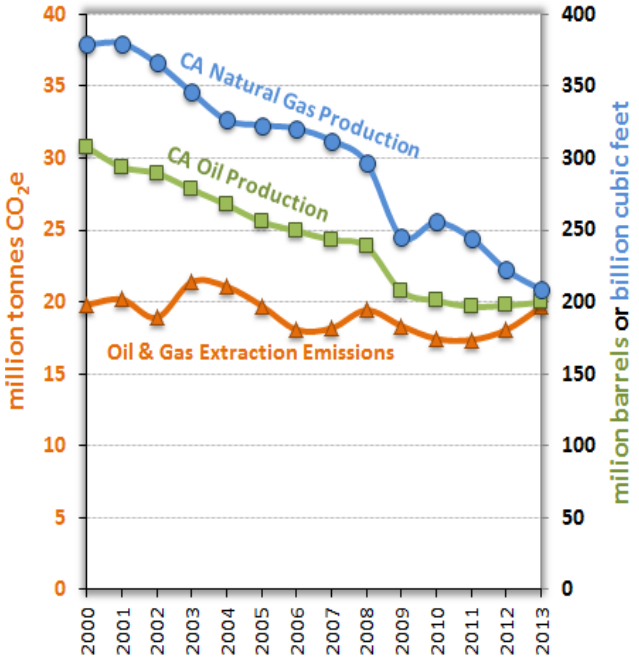
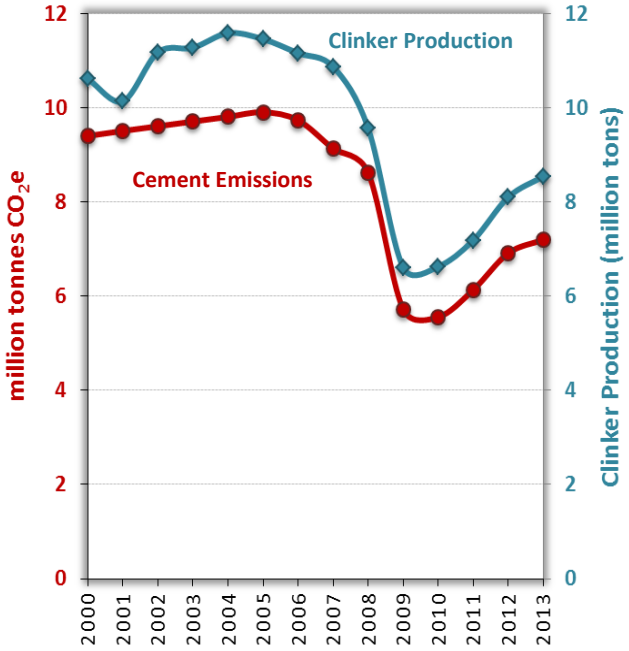



**Figure 13. Cement Plants**



## Commercial and Residential

Emissions from the commercial and residential sectors are driven by the combustion of natural gas and other fuels for household use and for providing energy for commercial businesses. Overall, emissions in this sector displayed relatively small year-to-year fluctuations. Changes in annual emissions are primarily driven by variability in weather conditions and the need for heating and cooling in buildings. In 2013, emissions increased 1.5% from the previous year.

The majority of emissions from the residential sector are from natural gas combustion. Although the number of housing units grew steadily from 12.3 million units in 2000 to slightly over 13.8 million housing units in 2013,[13] emissions and fuel consumption per housing unit have generally followed a declining trend during this period.[14] Emissions from commercial fuel use have grown by 16% since 2000. During the same period, commercial floor space grew steadily in California from 6.0 billion square feet to 7.2 billion square feet. As a result, like the residential sector, the commercial sector exhibits a slight decline in fuel use per unit of space.

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

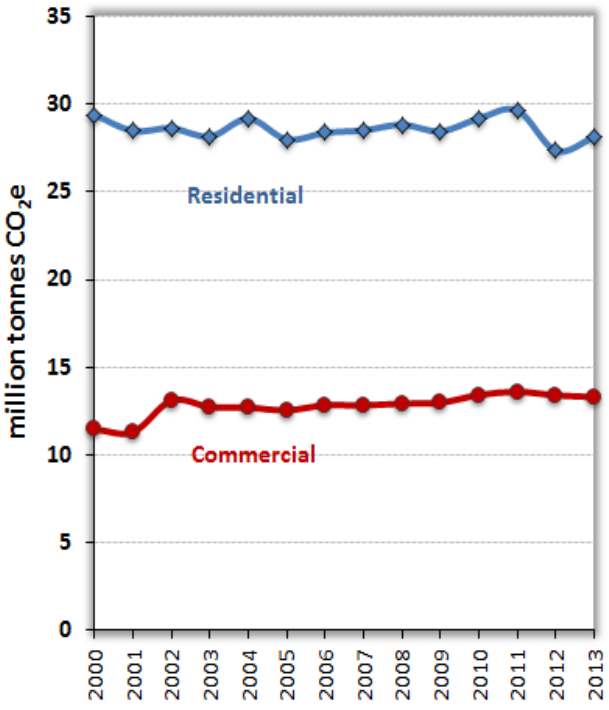
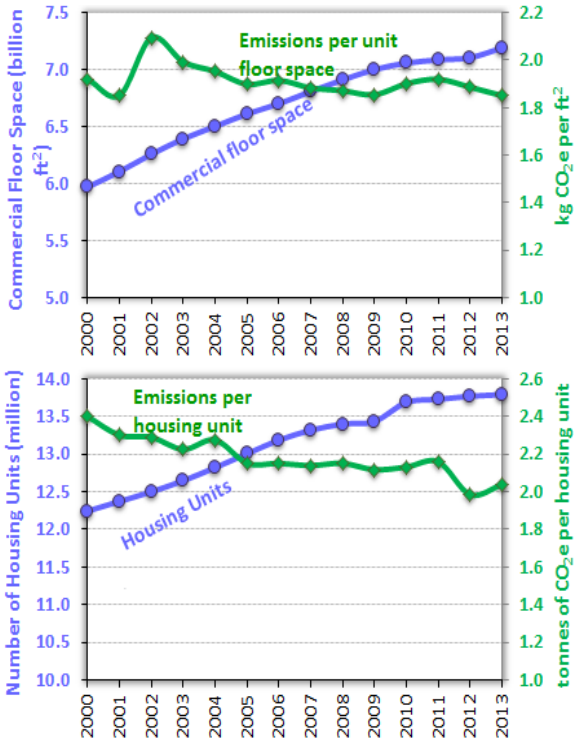



**Figure 15. Emissions per Unit Floor Space and Housing Unit**



## Agriculture

The agricultural sector contributed approximately 8% of statewide GHG emissions in 2013, mainly from methane ($CH_4$) and nitrous oxide ($N_2O$) sources. The emissions in this sector 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. Livestock accounted for approximately two thirds of the agricultural emissions. The enteric fermentation process as well as manure management practices in dairies produce methane emissions, making dairies the major emissions source in the agricultural sector. From 2000 to 2013, California dairies increased their herds 17%, while total milk production grew 28%.[15] During the same period, GHG emissions from livestock manure management and enteric fermentation increased by 22%, and overall emissions from the agriculture sector grew from 32.1 $MMTCO_2e$ to 36.2 $MMTCO_2e$.

Emissions from the growing and harvesting of crops (primarily $N_2O$ emissions from fertilizer use) have remained constant since 2000, while the value of crop production has increased steadily since 2009.[16] About three quarters of GHG emissions from crops are from fertilizer and manure use.

**Figure 16. Agricultural Emissions**

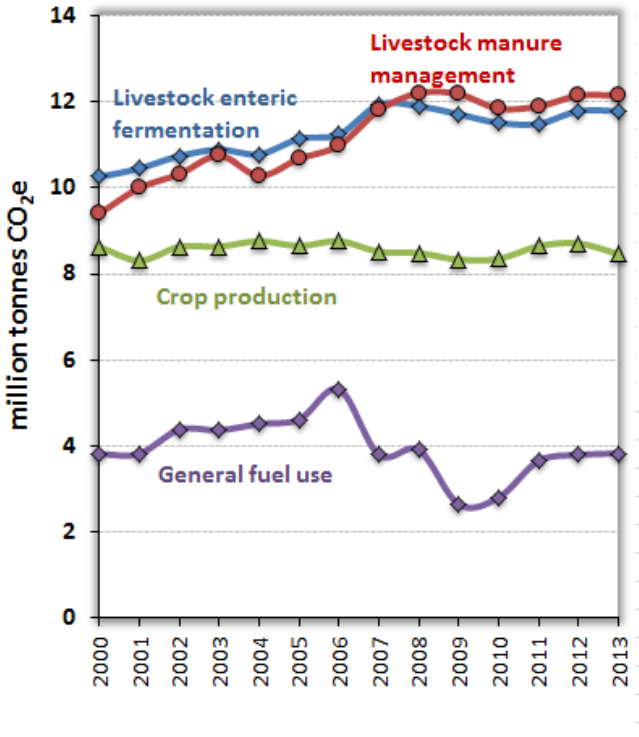
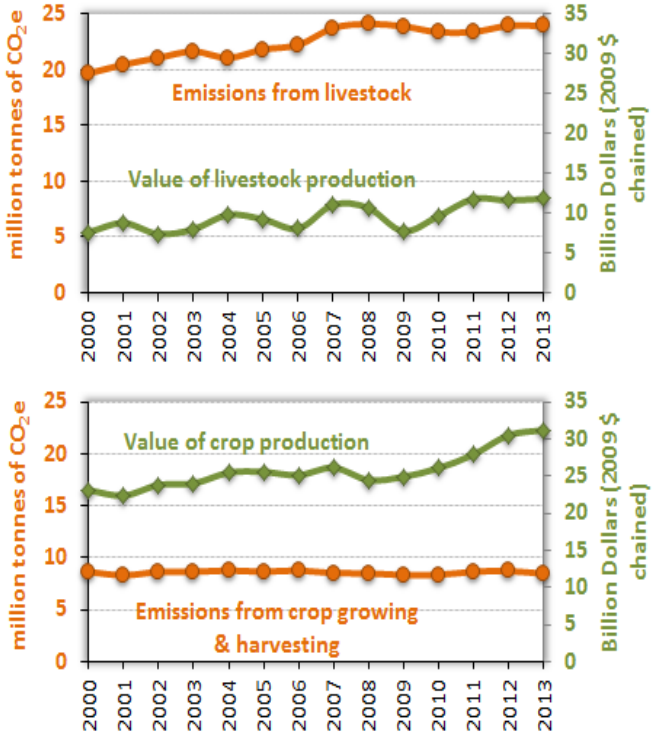



**Figure 17. Agricultural Livestock and Crop**

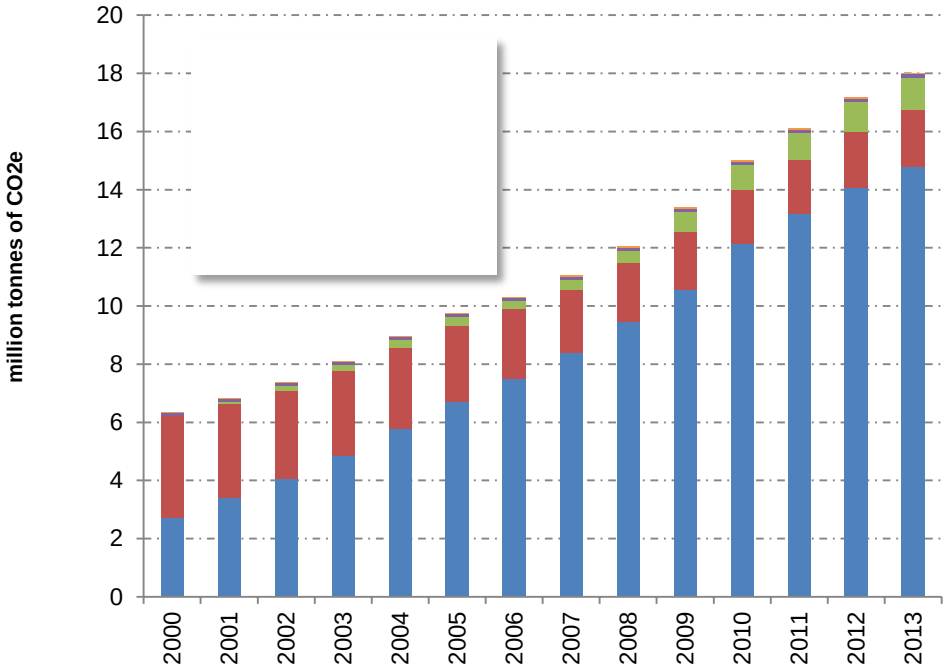


## High Global Warming Potential Gases

In 2013, the High Global Warming Potential (high-GWP) gases emissions comprise 4% of the inventory. High-GWP gases included in the inventory consist primarily of substitutes for ozone depleting substances (ODS), losses from the electricity grid, and gases that are emitted in the semiconductor manufacturing process. Out of these, 97% of the high-GWP gases are attributed to ODS substitutes, which are primarily hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). Under the Montreal Protocol, high-GWP gases such as HFCs and PFCs are phased in as replacements for ODSs such as chlorofluorocarbons and hydrochlorofluorocarbons. These are used mostly in refrigeration and air conditioning equipment, solvent cleaning, foam production, fire extinguishing, and aerosols. In 2013, refrigeration and air conditioning equipment across all sectors contributed 82% of the ODS substitutes emissions. As more ODS substitutes replaced the ODSs, their emissions are expected to continue to grow as they replace ODSs banned under the Montreal Protocol.

Beside ODS substitutes, the remaining 3% of high-GWP gases emissions consist of fugitive $SF_6$ emissions from electrical switchgears and high-GWP gases emissions from semiconductor manufacturing. These categories have followed a steadily declining trend since 2000.

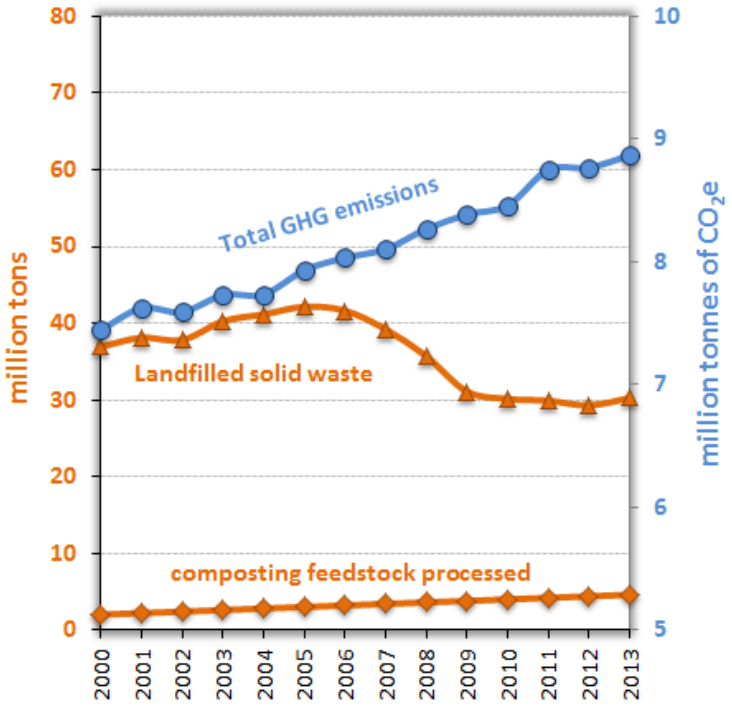
**Figure 18. Emissions from Use of ODS Substitutes**



## Recycling and Waste

Emissions from the recycling and waste sector consist of $CH_4$ and $N_2O$ emissions from landfills and from commercial-scale composting. Emissions from recycling and waste, which comprise approximately 2% of the inventory, grew 19% since 2000. Landfill emissions account for 94% of the emissions in this sector, with emissions from composting operations remaining a relatively small fraction over the last thirteen years. The amount of solid waste deposited in California's landfills grew from 37 million tons in 2000 to its peak of 42.2 million tons in 2005, followed by a consistently declining trend until 2013 when it showed a slight increase to 30.3 million tons.[17] The decrease in annual landfill deposits does not produce immediate corresponding declines in landfill GHG emissions since it is the total waste-in-place that influences the amount of landfill gas generated.

**Figure 19. Emissions of Recycling and Waste**



## Sources of Data Used in the GHG Emission Inventory

The GHG Emission Inventory is calculated using several different sources of data to estimate statewide GHG emissions. The primary source of data 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 meeting certain criteria (facilities and entities with more than 10,000 metric tons $CO_2e$ of combustion and process emissions, all facilities belonging to certain industries, and all electric power entities) to submit an annual emissions report directly to ARB. The facilities and entities with more than 25,000 metric tons of $CO_2e$ must also have their reports verified by a third-party auditor. Emissions data from MRR is aggregated and reallocated to the appropriate process categories based on the 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 agencies 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 (BOE), Dept. of Conservation/ Division of Oil, Gas, and Geothermal Resources, Dept. of Food and Agriculture, and CalRecycle. ARB also uses data from the 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

## References

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3. BEA Bureau of Economic Analysis. California state gross domestic product 2000-2013. http://www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=1#reqid=70&step=1&isuri=1&acrdn=1.

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8. (a) USEIA U.S. Energy Information Administration data, Electricity data browser for 2013. http://www.eia.gov/electricity/data/eia923/; (b) CEC, Personal Communication between Larry Hunsaker of ARB and Asish Gautam of CEC. 2014.

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18. (a) ARB *ARB's draft GHG emission inventory (GHG EI) 2000-2013*; 2015; (b) ARB, GHG emissions per capita calculated using GHG emissions and state populaiton. 2015.

19. ARB, Emissions per unit GDP calculated using emissions and state GDP. 2015.

20. ARB, On road emissions calculated using Board of Equalization (BOE) fuel sales data, EMFAC 2014, and U.S.EPA Part 98 emission factors. 2015.

21. (a) ARB, GHG intensities calculated using GHG emissions and electricity consumptions. 2015; (b) CEC, California Energy Commission – California energy consumption by county. 2013.

22. (a) ARB, Emissions per unit floor space calculated using GHG emissions and unit floor space. 2015; (b) ARB, Emissions per houseing unit calculated using GHG emissions and number of housing units. 2015.

23. ARB GHG Emission Inventory Technical Support Document 2000-2012. http://www.arb.ca.gov/cc/inventory/doc/methods_00-12/ghg_inventory_00-12_technical_support_document.pdf.

## ***Figure References***

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