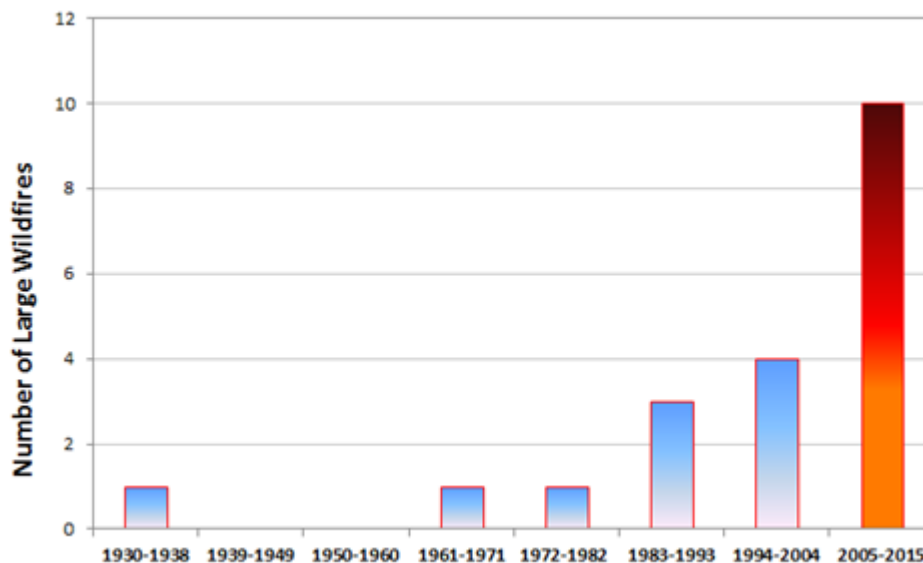




Greenhouse Gas Emission Reductions

There is growing international recognition that greenhouse gas emissions are changing the climate with wide-ranging impacts. California is vulnerable to a variety of climatic changes, including changes in temperature and precipitation patterns, extreme events (including wildfire, inland and coastal flooding, and heat storms), and sea-level rise. Higher temperatures due to climate change are likely to exacerbate future droughts like the one California is experiencing. More than 102 million drought-stressed trees have died as result of bark beetle infestation since 2010. Further, about half of the 20 largest wildfires in California burned in the last decade as shown in **Figure 1**.¹

Figure 1: 13 of California's 20 Largest Wildfires Burned Since 2000



Source: California Energy Commission staff using data from http://fire.ca.gov/communications/downloads/fact_sheets/Top20_Acres.pdf

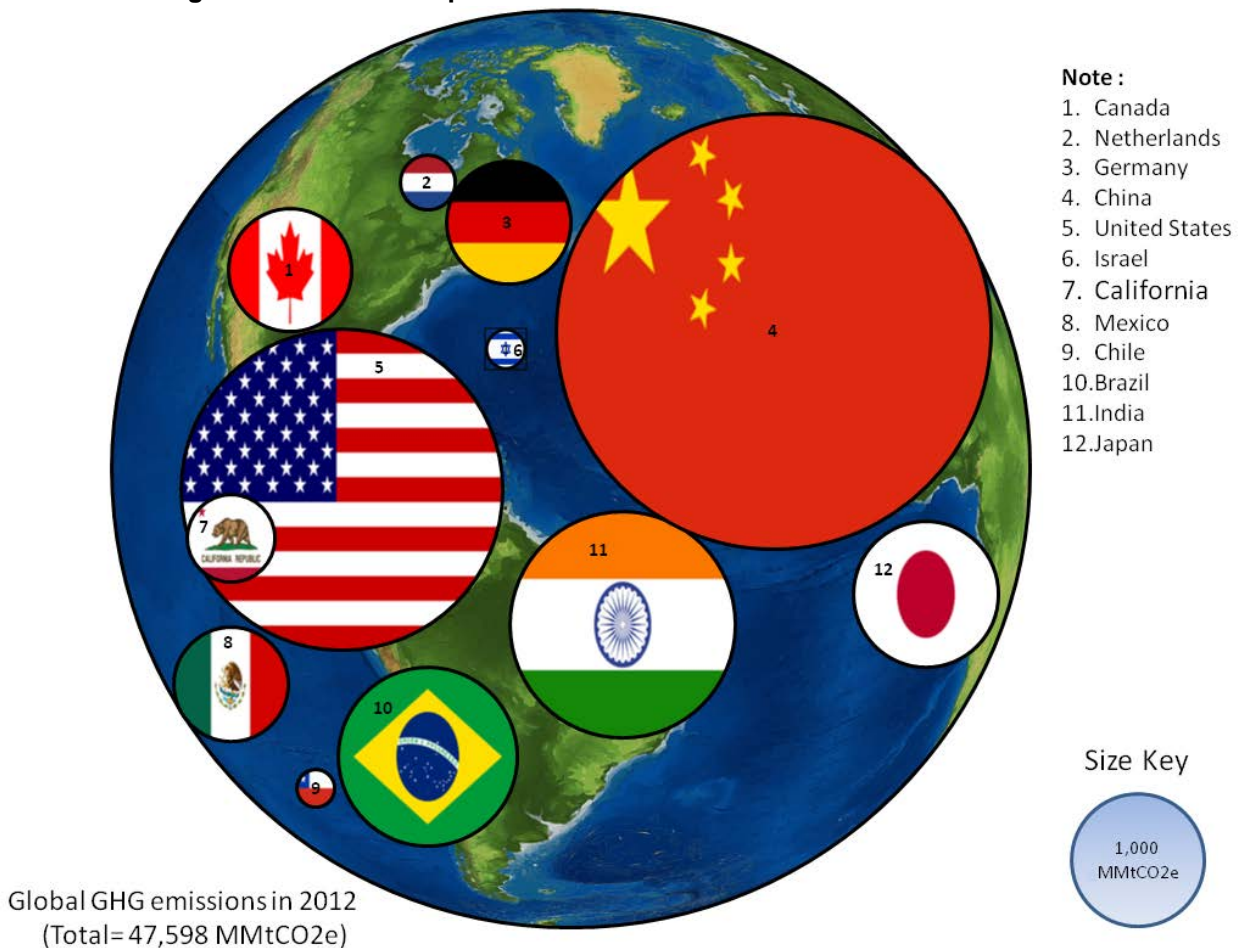
While Californians are becoming acutely aware of climate change, the state generates only 1 percent of global emissions—reducing California’s greenhouse gas emissions will not be enough to solve climate change. **Figure 2** on the next page shows the relative contribution of California and various nations that contribute to global greenhouse gas emissions.

¹ Summary information available at [Our Changing Climate 2012 Vulnerability & Adaptation to the Increasing Risks from Climate Change in California - Brochure](http://www.climatechange.ca.gov/climate_action_team/reports/third_assessment/index.html). Publication # CEC-500-2012-007. July, 2012. For more complete information on the Third Assessment from the California Climate Change http://www.climatechange.ca.gov/climate_action_team/reports/third_assessment/index.html.



California Energy Commission – Tracking Progress

Figure 2: California Represents 1 Percent of Global Climate Emissions



Source: California Energy Commission staff

Note: MMtCO₂e is million metric tonnes of CO₂ equivalent

The year 2015 was the third year in a row in which global emissions grew by less than 1 percent while global GDP exceeded 3 percent growth. Global emissions from fossil fuels and industry did not grow in 2015 and are expected to increase slightly in 2016. **Figure 3** on the next page shows the growth in greenhouse gas emissions for various countries since 1990.

Speaking in Beijing China in 2013, Governor Edmund G. Brown Jr. called for unified action to combat climate change:

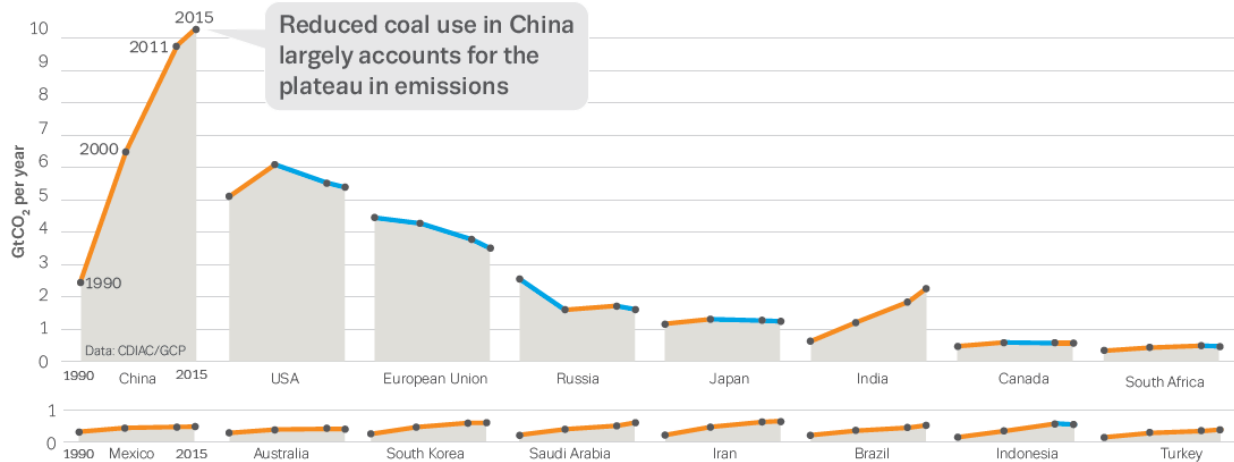
“We’re in one world. We’ve got one big problem and we all have to work on it. And what’s beautiful and exciting about climate change is no one group can solve the problem—not the United States, not California, not Japan, not China—we all have to do it,” said



California Energy Commission – Tracking Progress

Governor Brown in remarks at Tsinghua University. “This is a great unifier. This is an imperative where human beings could collaborate.”²

Figure 3: Emission Trends Vary Among Countries



Source: Tyndall Centre for Climate Change Research <http://www.tyndall.ac.uk/node/4533>

Governor Brown signed accords with leaders from Mexico, China, Japan, Israel, Peru, Chile, Netherlands, and others to reduce greenhouse gas emissions.³ California was also active at the 2015 United Nations Climate Change Conference in Paris, convened to develop an agreement among nations worldwide to sufficiently reduce greenhouse gas emissions to avoid catastrophic climate change. On December 12, 2015, nearly 200 nations reached an agreement to commit to lowering greenhouse gas emissions to avoid a 2 degrees Celsius (3.6 degrees Fahrenheit) increase in global average temperature above preindustrial levels, and efforts toward a 1.5 degree Celsius goal.⁴ The Paris Agreement entered into force on November, 4, 2016, 30 days after ratification of emission reductions by at least 55 parties to the Convention representing at least 55 percent of the global greenhouse gas emissions. This means that the emission reduction targets are legally recognized for those countries that sign and ratify the agreement.

The Governor is also working to advance global action by spearheading the Subnational Global Climate Leadership Memorandum of Understanding (the “Under 2 MOU”), a commitment by cities, states, and countries to help limit the rise in global average temperature to below 2 degrees Celsius. Signatories agree to reduce greenhouse gas emissions 80 to 95 percent below 1990 levels by 2050 or achieve a per capita annual emissions target of less than 2 metric tons by 2050. Collectively, 165 jurisdictions representing 33 countries, 1.08 billion people, and 35 percent of the global economy have signed or endorsed the Under 2 MOU as of December 2016. See <http://under2mou.org/> for the latest statistics as they grow frequently.

² <https://www.gov.ca.gov/news.php?id=17992>

³ http://www.climatechange.ca.gov/climate_action_team/partnerships.html.

⁴ United Nations Framework Convention on Climate Change, Adoption of the Paris Agreement, December 12, 2015, <http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf> .



California Energy Commission – Tracking Progress

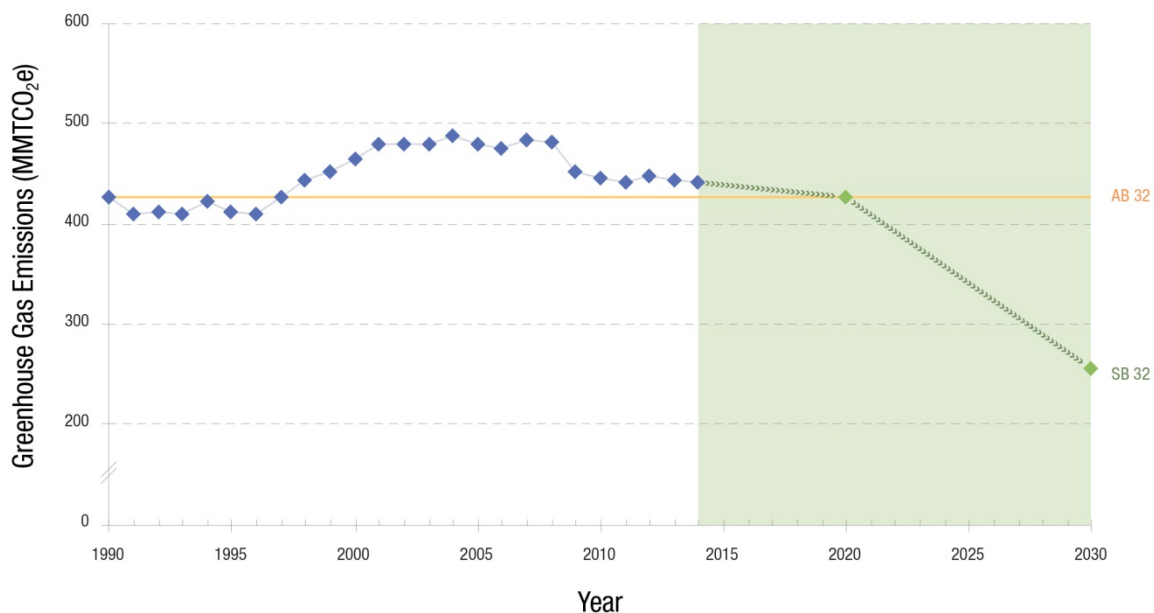
Strong, near-term action to cut greenhouse gas emissions is critical. Under the Governor's leadership, California continues to spur action to address climate change and share its successes and approach with others.

California's 2030 Greenhouse Gas Reduction Requirement

On September 8, 2016, Governor Brown took an important new step in the state's commitment to reduce greenhouse gas by signing Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016) (SB 32). This put into law a statewide goal to reduce greenhouse gas emissions 40 percent below 1990 levels by 2030. A companion bill, Assembly Bill 197 (Garcia, Chapter 250, Statutes of 2016) (AB 197), assures that the state's implementation of its climate change policies is transparent and equitable, with the benefits reaching disadvantaged communities.

These bills codify the 2030 greenhouse gas reduction goal in Governor Brown's Executive Order B-30-15 and come 10 years after enactment of the California Global Warming Solutions Act of 2006 (Assembly Bill 32, Núñez, Chapter 488, Statutes of 2006), the landmark legislation to reduce statewide greenhouse gas emissions to 1990 levels by 2020. California is well on its way to meeting the 2020 target, but the new 2030 requirement is much more ambitious. **Figure 4** plots California's greenhouse gas reduction goals against historical greenhouse gas emissions.

Figure 4: California's Path to Progress to Meet Climate Goals



Source: California Energy Commission staff using data from California Air Resources Board's 2000-2014 inventory <http://www.arb.ca.gov/cc/inventory/data/data.htm>.

Note: Not shown is California's 2050 goal to reduce greenhouse gas emissions 80 percent below 1990 levels by 2050 as set in Executive Order B-30-15.



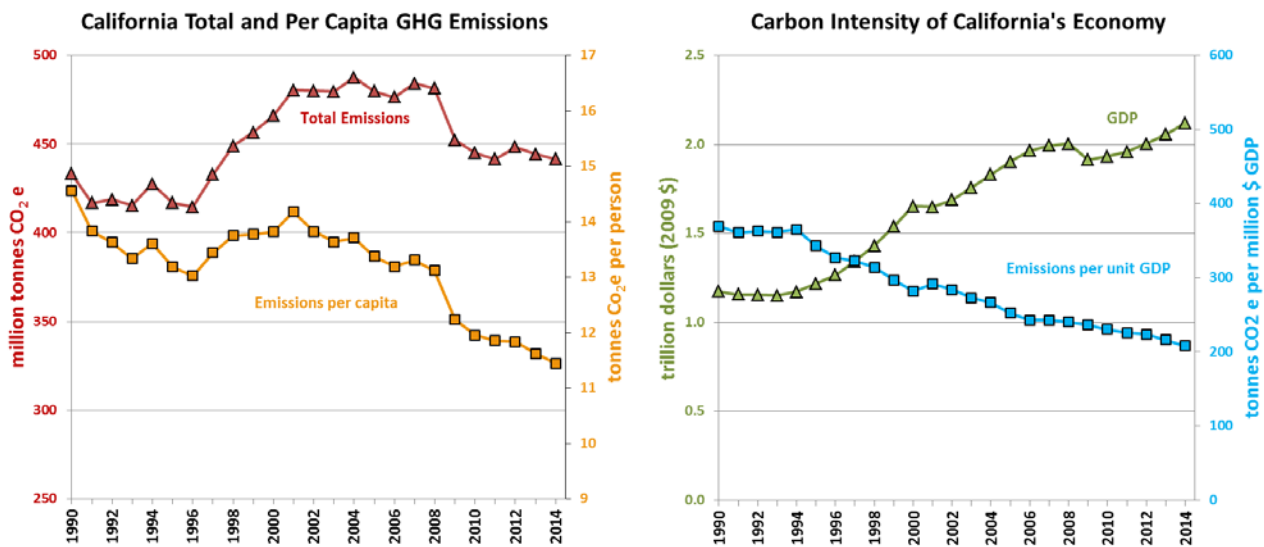
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The Governor and Legislature allocated \$900 million from the Greenhouse Gas Reduction Fund to help achieve the state's 2030 greenhouse gas reduction goal.⁵ The funding distributes proceeds from California's Cap-and-Trade Program to reduce greenhouse gas emissions by supporting programs that benefit disadvantaged communities, advance clean transportation, protect the natural environment, and reduce short-lived climate pollutant emissions.

California's Economy Grew While its Greenhouse Gas Emissions Went Down

Figure 5 shows that since 1990, California's economy (represented by California gross domestic product, California GDP) has grown nearly 80 percent since 1990. Population has also increased by about 30 percent since 1990 (not shown). Meanwhile, greenhouse gas emissions have declined over the last decade. Greenhouse gas emissions per economic output have declined by about 44 percent and emissions per capita have declined by about 20 percent since 1990.

Alternate Figure 5: California has Reduced its Greenhouse Gas Emissions While its Population and Economy have Grown



Source: California Energy Commission staff using data from the California Air Resources Board's *Greenhouse Gas Emissions Inventory – 2016 Edition*

The Governor's Pillars for Reducing Greenhouse Gas Emissions

In his 2015 inaugural speech,⁶ Governor Brown set the following goals for 2030:

- Increase from one-third to 50 percent electricity derived from renewable sources
- Reduce today's petroleum use in cars and trucks by up to 50 percent
- Double the efficiency of existing buildings and make heating fuels cleaner

⁵ This was achieved through: Assembly Bill 1613 (Chapter 370, Statutes of 2016), SB 859 (Chapter 386, Statutes of 2016), AB 1550 (Gomez, Chapter 369, Statutes of 2016), and AB 2722 (Burke, Chapter 510, Statutes of 2016).

⁶ Governor Brown's 2015 inaugural address, January 5, 2015, <https://www.gov.ca.gov/news.php?id=18828>.



California Energy Commission – Tracking Progress

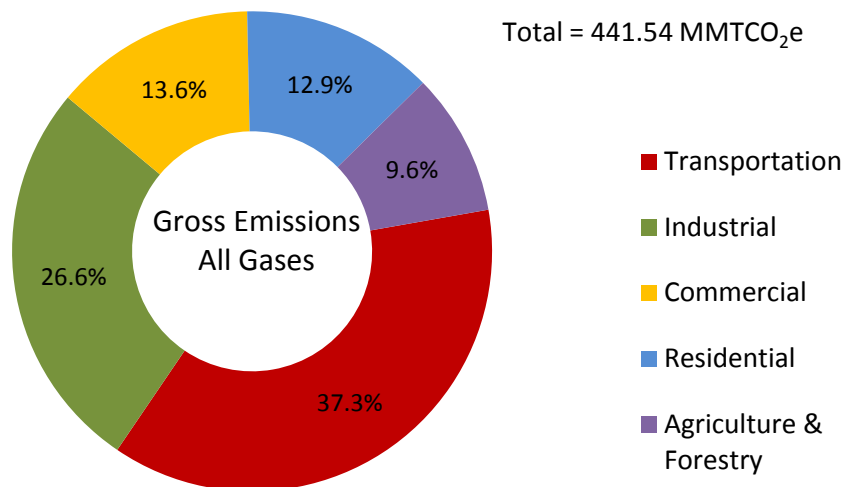
Further, he stated, “We must also reduce the relentless release of methane, black carbon, and other potent pollutants across industries. And we must manage farm and rangelands, forests, and wetlands so they can store carbon.”

These goals are aimed at reducing the biggest sources of greenhouse gases in California as well better managing the state’s natural resources that capture carbon emissions. On October 7, 2015, Governor Brown signed the Clean Energy and Pollution Reduction Act of 2015 (Senate Bill 350, De León, Chapter 547, Statutes of 2015), codifying the Governor’s 2030 goals for energy efficiency and renewable electricity, while encouraging electrification of the transportation sector.

Greenhouse Gas Emission Sources

Figure 6 shows GHG emissions from each economic sector, including electricity sector emissions, by end use. Transportation is the largest source of greenhouse gas emissions in California, accounting for about 37 percent. Further, the industrial sector (26.6 percent) includes oil refinery emissions. Although not shown as a discrete category in **Figure 6**, electricity consumed in California (including electricity generated out-of-state to serve California) accounts for about 20 percent of the state’s greenhouse gas emissions. (In **Figure 6**, emissions associated with electricity consumption are prorated to the end-use sectors.) The residential and commercial sectors account for 26.5 percent of emissions. **Figure 6** includes energy and non-energy-related emissions from the agricultural and industrial sectors.⁷

Figure 6: California’s 2014 Greenhouse Gas Emissions by End Use



Source: California Energy Commission staff using data from the California Air Resources Board’s *Greenhouse Gas Emissions Inventory – 2016 Edition* and 2014 energy consumption data from the Energy Commission’s *California Energy Demand 2016-2026, Revised Electricity Forecast*.

⁷ Examples of non-energy-related greenhouse gas emissions from these sectors include nitrous oxide from nitrogen-based fertilizers and carbon dioxide from the production of cement.



California Energy Commission – Tracking Progress

Transforming California’s transportation system away from gasoline to electrified, zero-emission vehicles is fundamental to the state’s efforts to reduce greenhouse gas emissions. Increasing the use of renewable resources for electricity generation must occur in lockstep with electrification of the transportation sector.

As shown in **Figure 6**, energy use in existing buildings accounts for more than one-quarter of all greenhouse gas emissions in California, including both fossil fuel consumed on-site (for example, gas or propane for heating) and emissions associated with electricity consumed in existing buildings (for example, for lighting, appliances, and cooling). Thus, improving the efficiency of existing buildings is another high priority for achieving the state’s climate goals. See the Tracking Progress pages on “Zero-Emission Vehicles and Infrastructure,” “Renewable Energy,” and “Energy Efficiency” for more information.

Although California’s greenhouse gas emissions are primarily (about 82 percent)⁸ carbon dioxide (CO₂), **Figure 6** includes short-lived climate pollutants (SLCP), powerful climate forcers that remain in the atmosphere for a much shorter time than climate pollutants such as CO₂. SLCP include methane, black carbon (soot), and fluorinated gases. The relative potency of these climate pollutants to heat the atmosphere can be tens to thousands of times greater than CO₂ and are estimated to account for about 40 percent of climate forcing from anthropogenic pollution (pollution associated with human activities).⁹ The California Air Resources Board (ARB) is working to reduce SLCP emissions to make an immediate beneficial impact on climate change.¹⁰ Further, Senate Bill 1383 (Lara, Chapter 395, Statutes of 2016) requires the ARB to develop a strategy to reduce SLCP emissions below 2013 levels by 2030 as follows: cut methane emissions by 40 percent, hydrofluorocarbon gases by 40 percent, and anthropogenic black carbon by 50 percent. **Figure 7** on the next page shows the relative contribution of SLCP and CO₂.

8 The 82 percent estimate includes an accounting for black carbon, which is not part of the ARB’s *Greenhouse Gas Emissions Inventory – 2016 Edition*. If black carbon is not included, CO₂ accounts for about 84 percent of the state’s GHGs.

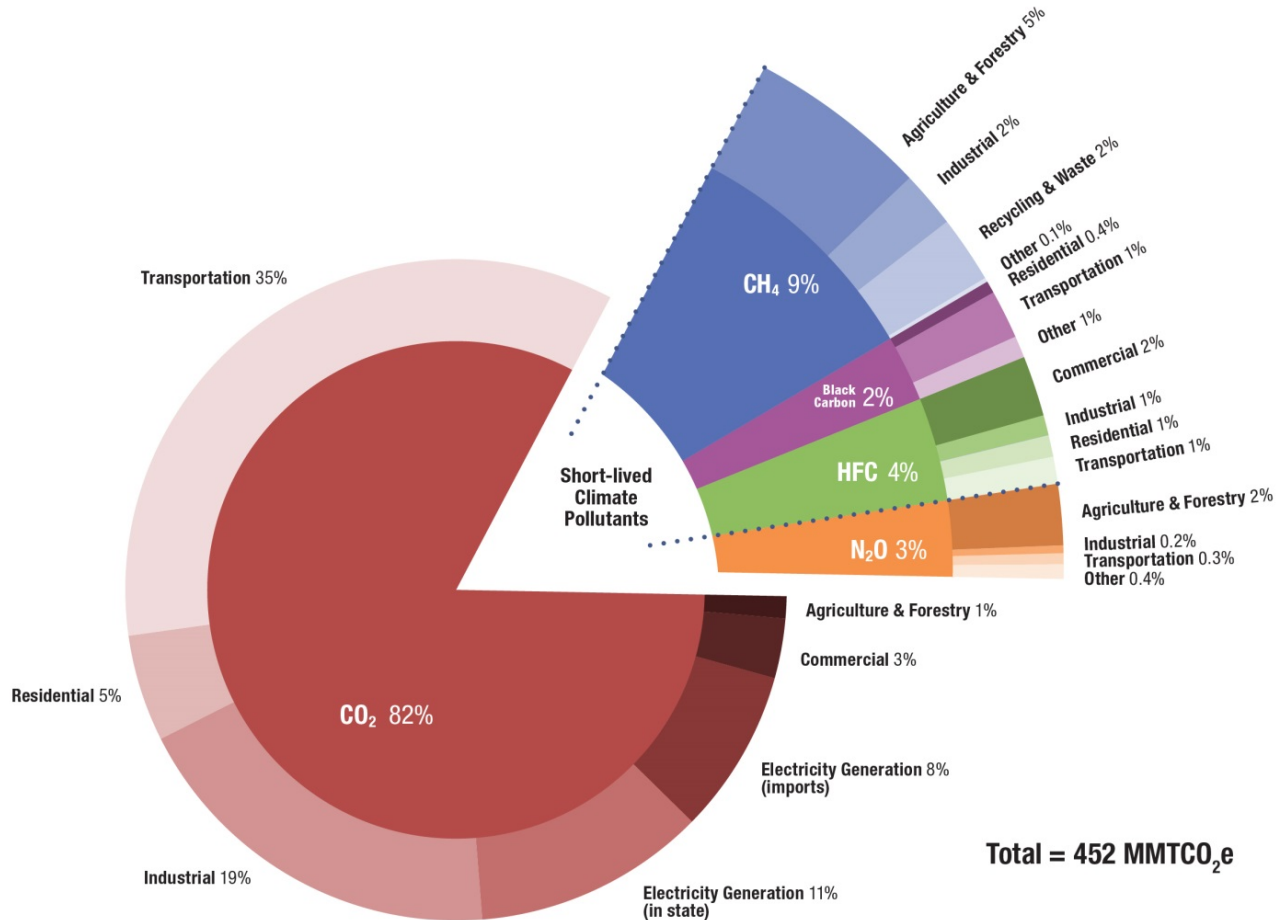
9 *Climate forcing* refers to the difference between energy that Earth receives from the sun and the amount of energy radiated back into space. Man-made climate forcing is the additional energy that is retained in the Earth’s atmosphere, oceans, and land due to the presence of greenhouse gases and aerosols in our atmosphere, as well as changes in land surface reflectivity.

10 California Air Resources Board, *Revised Proposed Short-Lived Climate Pollutant Reduction Strategy*, November 2016, <http://www.arb.ca.gov/cc/shortlived/shortlived.htm>.



California Energy Commission – Tracking Progress

Figure 7: Relative Contribution of Various Greenhouse Gases in California



Source: California Energy Commission staff using data from the California Air Resources Board's *Greenhouse Gas Emissions Inventory – 2016 Edition* (available at <https://www.arb.ca.gov/cc/inventory/data/data.htm>)

Note: 2014 data shown with the exception of black carbon for which 2013 are the most recent data available.

Methane accounts for about 9 percent of the state's overall greenhouse gas emissions. **Figure 8** on the next page shows the sources and relative magnitude of methane emissions. Enteric fermentation¹¹ and manure from dairy cows and steer are the largest sources, accounting for about 45 percent of methane emissions in 2014. Landfills are the third largest source, accounting for about 20 percent. The natural gas system accounted for about 10 percent of methane emissions in 2014.¹²

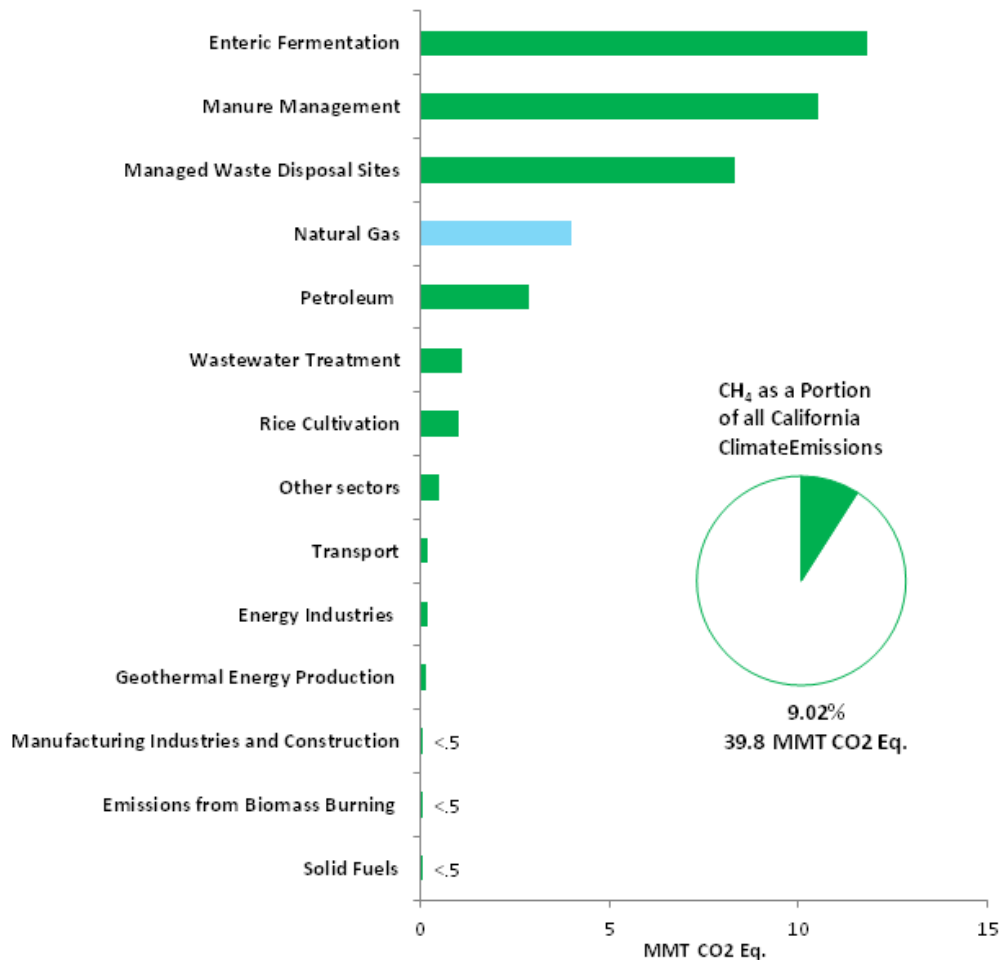
¹¹ *Enteric fermentation* is a natural part of the digestive process for many ruminant animals where anaerobic microbes decompose and ferment food in the digestive tract and produce compounds for absorption by the animal.

¹² A major natural gas leak (natural gas is composed primarily of methane) was detected at the Aliso Canyon natural gas storage facility on October 23, 2015, and permanently sealed on February 18, 2015. The leak was near Porter



California Energy Commission – Tracking Progress

Figure 8: California's 2014 Methane Emissions by Source



Source: California Energy Commission staff using data from the ARB, *Greenhouse Gas Emissions Inventory – 2016 Edition* (available at <https://www.arb.ca.gov/cc/inventory/data/data.htm>)

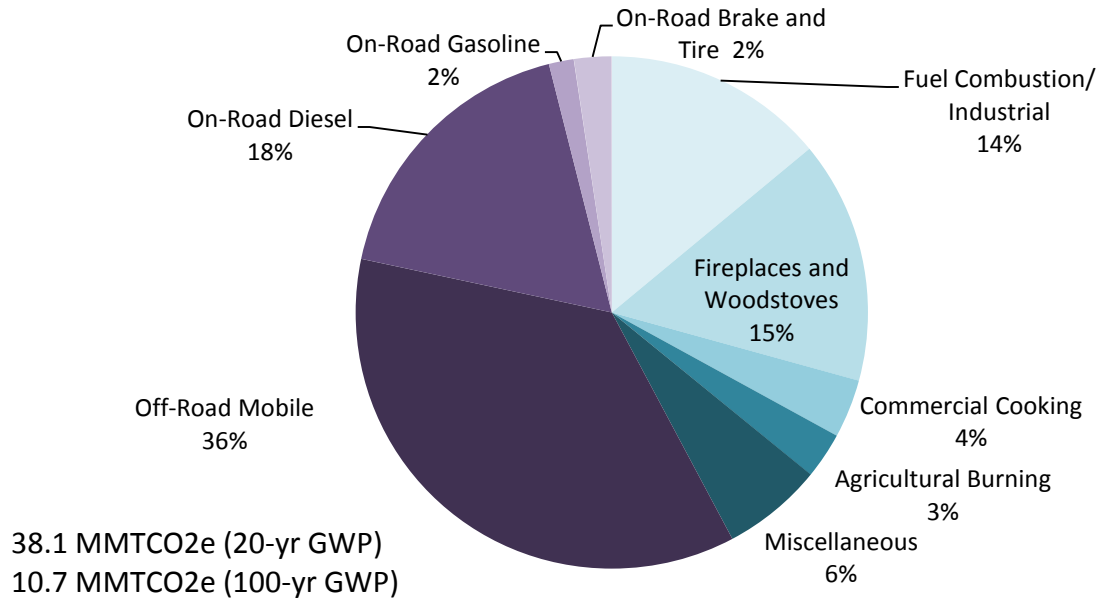
Figure 9 on the next page shows the sources of black carbon in 2013, the most recent data available. Transportation is the largest source of black carbon emissions, with off-road mobile sources accounting for 36 percent, on-road diesel accounting for 18 percent, and on-road gasoline and on-road brake and tires each accounting for 2 percent. Fireplaces and woodstoves account for 15 percent, and other fuel combustion/industrial sources account for 14 percent.

Ranch of the San Fernando Valley. It has had far-reaching impacts including an ongoing risk of energy service interruption in the region. The ARB estimates that the leak added about 20 percent to statewide methane emissions over the duration of the leak. The Southern California Gas Company has committed to mitigate methane emissions from Aliso Canyon, including signing letters of intent with several dairies to help reduce emissions.



California Energy Commission – Tracking Progress

Figure 9: California 2013 Anthropogenic (Non-Forest) Black Carbon Emission Sources



Source: California Air Resources Board *Revised Proposed Short-Lived Climate Pollutant Reduction Strategy*, Figure 1, p. 45, November 2016, <http://www.arb.ca.gov/cc/shortlived/shortlived.htm>

Greenhouse Gas Emissions From the Electricity Sector

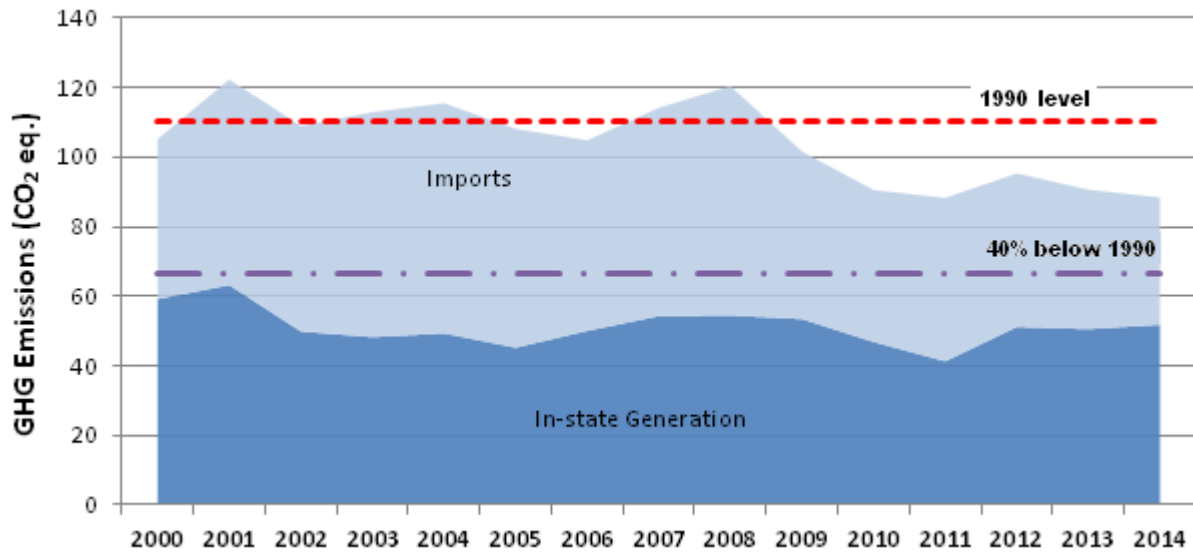
Greenhouse gas emission reductions from the electricity sector have helped advance the state's climate goals. The state's policies to advance energy efficiency, increase the use of renewable resources, and reduce reliance on coal-fired electricity have helped reduce greenhouse gas emissions from the electricity sector. As noted above, the electricity sector accounts for about 20 percent of statewide greenhouse gas emissions.

According to the ARB's inventory, electricity sector emissions in 2014 were about 20 percent below 1990 emission levels. This reduction greatly exceeds the Global Warming Solutions Act of 2006 statewide goal (not sector-specific) to reduce greenhouse gas emissions to 1990 levels by 2020. Even with the historic drought that reduced hydroelectric generation and the 2012 closure of the 2,200 megawatt San Onofre Nuclear Generating Station, California's electricity sector is providing a disproportionately large share of California's greenhouse gas reductions. **Figure 10** on the next page shows the decline in greenhouse gas emissions from the electricity sector with the red dashed line showing 1990-level emissions. For reference, the purple line shows a 40 percent reduction target, assuming a 40 percent target for all sectors by 2030. The graph shows emissions associated with electricity produced both within and outside the state for use in California.



California Energy Commission – Tracking Progress

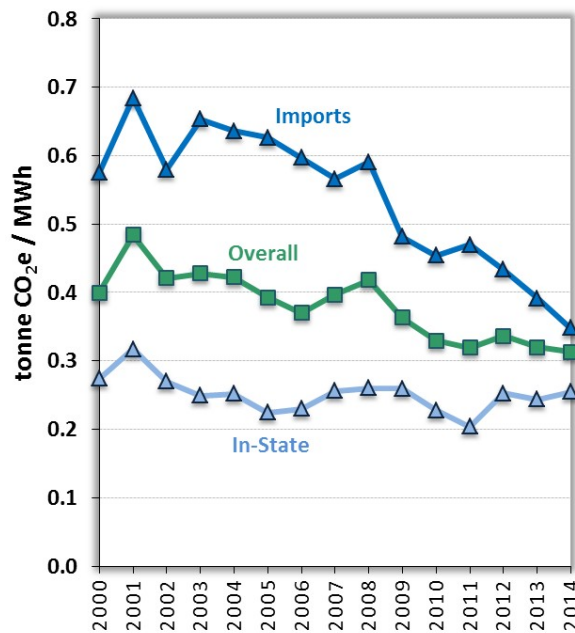
Figure 10: Historical Greenhouse Gas Emissions From the Electricity Sector



Source: California Energy Commission staff using data from the California Air Resources Board's *Greenhouse Gas Emissions Inventory – 2016 Edition*.

Figure 11 shows the decrease in greenhouse gas emissions per megawatt-hour (MWh) for the electricity sector since 2000.

Figure 11: Greenhouse Gas Emission Intensity of the Electricity Sector Is Improving



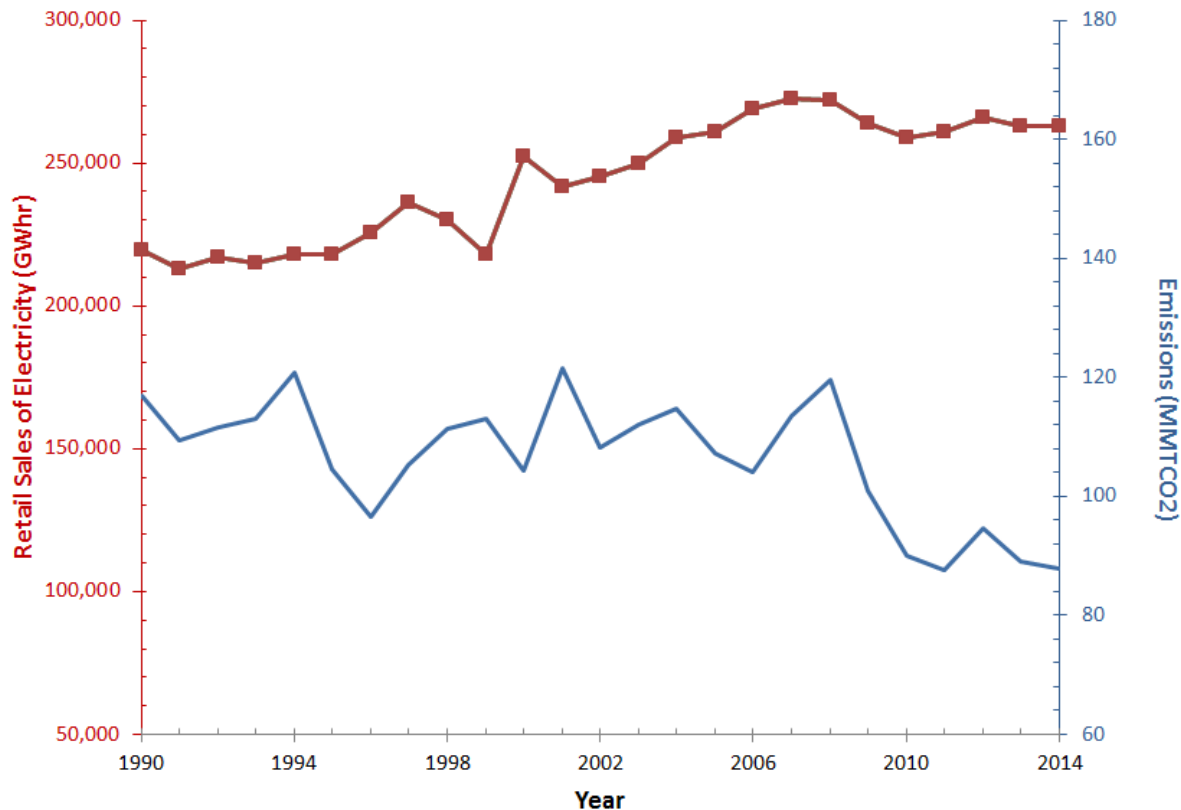
Source: California Air Resources Board, Figure 9, page 5, https://www.arb.ca.gov/cc/inventory/pubs/reports/2000_2014/ghg_inventory_trends_00-14_20160617.pdf



California Energy Commission – Tracking Progress

Figure 12 shows how electricity sales have grown while greenhouse gas emissions from the electricity sector have gone down.

Figure 12: Greenhouse Gas Emissions From The Electricity Sector Have Declined As Electricity Consumption has Risen Over Time



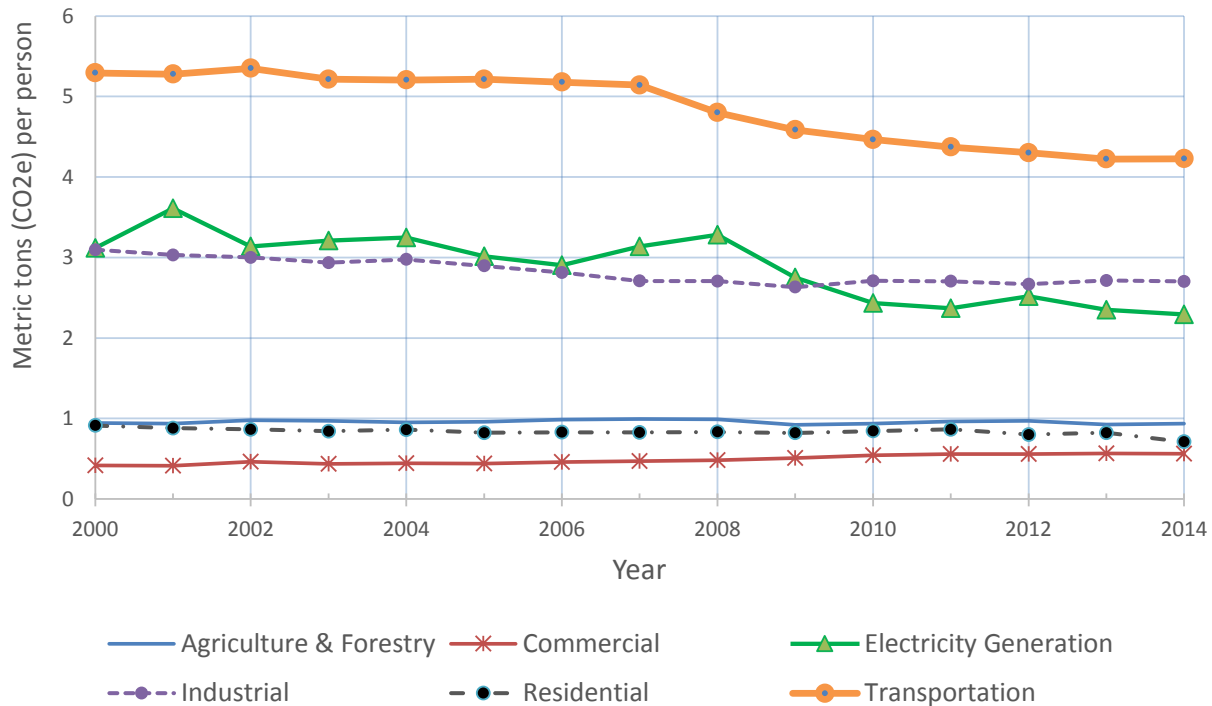
Source: California Energy Commission staff using data from the ARB, *Greenhouse Gas Emissions Inventory-2016 Edition* (available at <https://www.arb.ca.gov/cc/inventory/data/data.htm>) and energy consumption data from the Energy Commission's *California Energy Demand 2016-2026, Revised Electricity Forecast*.

Figure 13 on the next page shows greenhouse gas emissions per capita for sectors of the economy. (Unlike **Figure 6**, the electricity sector is shown as a discrete category rather than prorated by end use.) **Figure 13** shows that greenhouse gas emissions per capita from the transportation sector and electricity sectors have declined over the last decade. Further advancements on policies to electrify and transform the transportation sector to zero-emission vehicles, increase the efficiency of existing buildings, and increase the use of renewable resources will continue to drive down emissions and are critical to meeting the state's 2030 greenhouse gas reduction target. Research and development to help bring new technologies to market is also needed to meet the state's long-term climate goals.



California Energy Commission – Tracking Progress

Figure 13: Greenhouse Gas Emissions per Capita by Sector



Source: California Energy Commission staff using data from the ARB, *Greenhouse Gas Emissions Inventory-2016 Edition* (available at <https://www.arb.ca.gov/cc/inventory/data/data.htm>)

Next Steps

The ARB is updating its Scoping Plan, a framework for how California will meet its greenhouse gas reduction goals. The update will reflect actions to meet the 2030 target and is expected to be complete in Spring 2017.¹³

For the electricity sector, California is developing a comprehensive approach aimed at improving the performance of the system and achieving the 2030 greenhouse gas reduction goals. SB 350 requires investor-owned utilities, other electricity retail sellers, and larger publicly owned utilities to develop integrated resource plans that incorporate both supply- and demand-side resources to meet greenhouse gas emission reduction goals, maintain reliability, and control costs. The integrated resource plans will be the primary tool for implementing greenhouse gas reduction measures in the electricity sector. SB 350 requires the ARB to establish, in coordination with the CPUC and the Energy Commission, emission targets for the electricity sector and load-serving entities that help achieve the statewide 2030 GHG reduction goal.

Further, SB 350 requires electrical corporations to accelerate programs and investments in widespread transportation electrification. It also sets in motion the voluntary transformation of the California Independent System Operator (California ISO) into a regional organization. This

¹³ <https://www.arb.ca.gov/cc/scopingplan/scopingplan.htm>.



California Energy Commission – Tracking Progress

transformation will help integrate renewable generation for greater reductions in greenhouse gas emissions in California and neighboring states at reduced cost.

SB 350 also requires the Energy Commission to study barriers to and opportunities for low-income and disadvantaged communities to increase access to energy efficiency and renewable energy investments and programs. The Energy Commission adopted the completed report on December 14, 2016.¹⁴

Additional References:

For more information on California's efforts to address climate change, see <http://climatechange.ca.gov/>

For more information on the Under 2 MOU <http://under2mou.org/>

For more information on the ARB greenhouse gas emissions inventory <http://www.arb.ca.gov/cc/inventory/data/data.htm>.

For more information on the ARB reducing short-lived climate pollutants in California <https://www.arb.ca.gov/cc/shortlived/shortlived.htm>

Contact:

Guido Franco, guido.franco@energy.ca.gov
Heather Raitt, heather.raitt@energy.ca.gov

Next Update:

December 2017 and annually

¹⁴ http://www.energy.ca.gov/business_meetings/2016_packets/2016-12-14/Item_08.pdf.