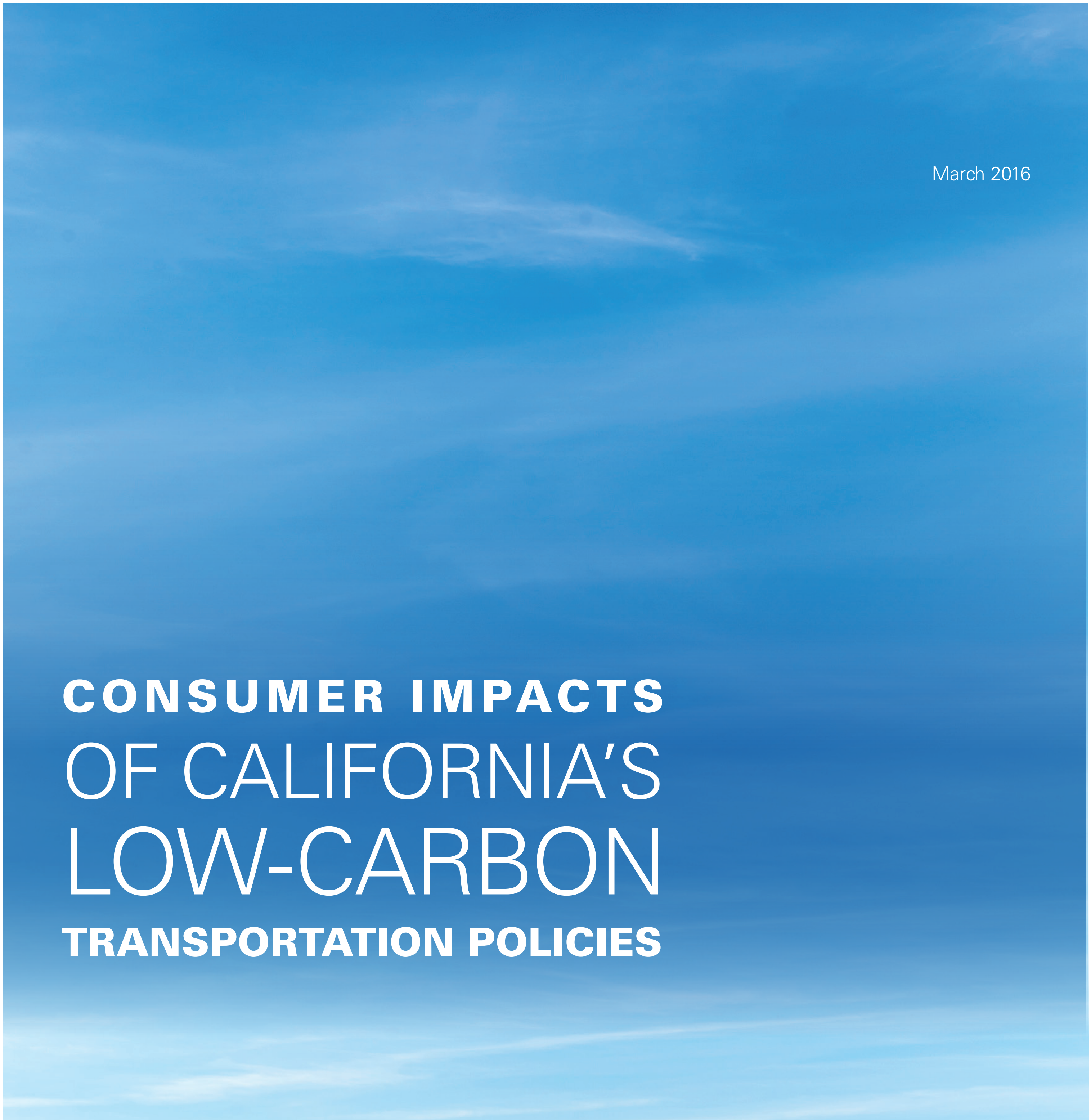

March 2016

CONSUMER IMPACTS OF CALIFORNIA'S LOW-CARBON TRANSPORTATION POLICIES

Prepared for

Consumers Union

Prepared by

ICF
INTERNATIONAL

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List of Abbreviations and Acronyms

AEO	Annual Energy Outlook
BEV	Battery Electric Vehicle
CAFE	Corporate Average Fuel Economy Standards
CARB	California Air Resources Board
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CI	Carbon Intensity
CNG	Compressed Natural Gas
DGE	Diesel Gallon Equivalent
EIA	Energy Information Administration
EPA	Environmental Protection Agency
FCO	First Cost of Ownership
FCV	Fuel Cell Vehicle
GGE	Gasoline Gallon Equivalent
GGRF	Greenhouse Gas Reduction Fund
GHG	Greenhouse Gas
IEPR	Integrated Energy Policy Report
LCFS	Low Carbon Fuel Standards
LNG	Liquefied Natural Gas
MGY	million gallons per year
MPG	Miles per Gallon
MPO	Metropolitan Planning Organization
NHTSA	National Highway Traffic Safety Administration
NOX	Nitrogen Oxide
ORNL	Oak Ridge National Laboratory
PHEV	Plug-in Hybrid Electric Vehicle

PM2.5	Particulate Matter less than 2.5 micrometers in diameter
RFS2	Renewable Fuel Standard
RHNA	Regional Housing Needs Allocation
RTP	Regional Transportation Plan
SB 375	Senate Bill 375
SCC	Social Cost of Carbon
SCS	Sustainable Communities Strategy
TCO	Total Cost of Ownership
TZEV	Transitional Zero Emission Vehicle
UMS	Urban Mobility Scorecard
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound
ZEV	Zero Emission Vehicle

Executive Summary

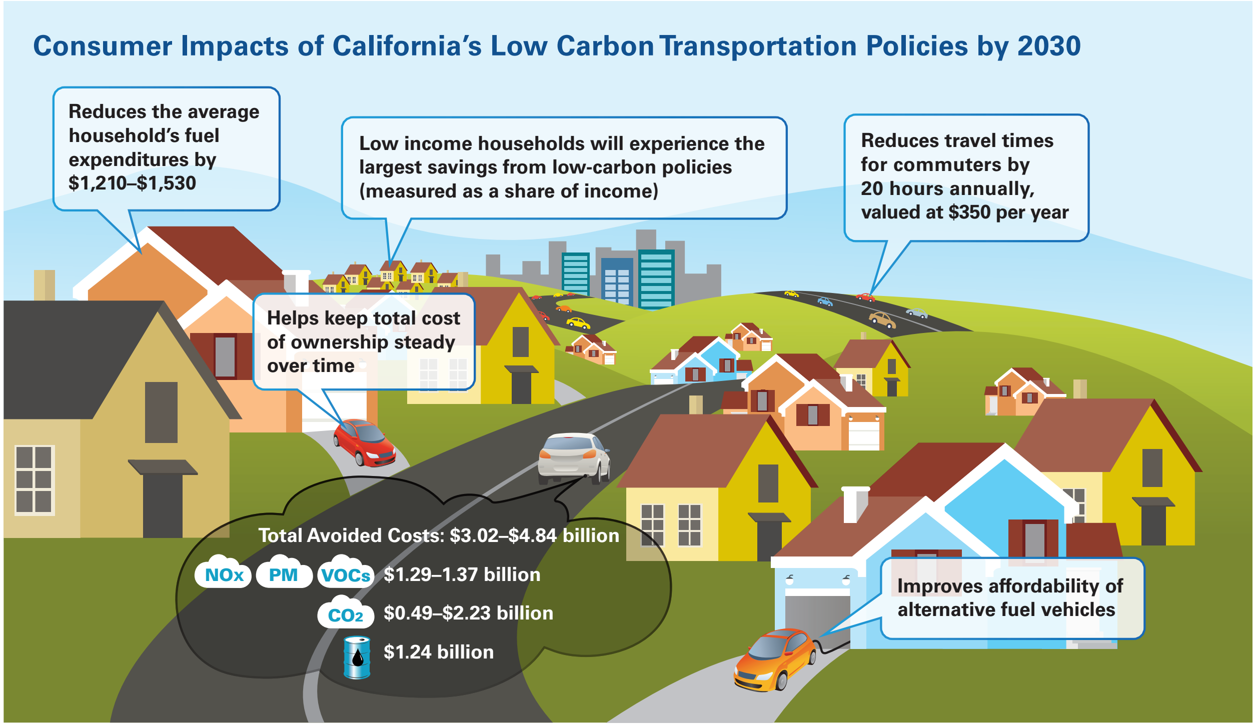
California is a global leader in developing and implementing clean transportation policies. The State's regulatory approach is multifold, using various policy instruments to improve the efficiency of vehicles, reduce the carbon intensity of fuels, and increase options for mobility. These policies are a mix of market-based approaches, direct regulation approaches, and planning opportunities. These policies will have impacts on the pricing of consumer goods such as automobiles and fuels– both of which represent a significant share of consumer expenditures. Focusing exclusively on vehicle and fuel pricing, however, can be misleading. Ultimately, consumer expenditures on travel are a function of vehicle and fuel pricing, as well as parameters such as vehicle efficiency and vehicle miles traveled. Outside of direct consumer impacts, there are also benefits associated with reducing pollutants like carbon dioxide and criteria pollutants.

The objective of this report is to review some of the measurable impacts of California's transportation policies, focusing on impacts such as fuel expenditures (including a disaggregated review of impacts by income group), vehicle ownership, impacts on travel time and congestion, and avoided damage costs. ICF's analysis included the compliance associated with California's Low Carbon Fuel Standard, light-duty greenhouse gas standards (at the tailpipe), the Zero Emission Vehicle Program, sustainable communities strategies (as required by Senate Bill 375, 2008), and the Cap-and-Trade Program (a major element of California's landmark Global Warming Solutions Act of 2006, Assembly Bill 32). The key results of our findings include:

- ICF estimates that households will save between $1,210–1,530 annually by 2030 (after accounting for the impacts of California's transportation policies) and that consumers will face considerably lower annual fuel expenditures moving forward. This net savings estimate includes the potential for increased fuel pricing as a result of compliance costs with California's low carbon transportation policies, as well as the improved efficiency of vehicles and lower vehicles miles traveled that result from these policies.
- ICF finds that the combination of improved vehicle efficiency and reduced vehicle miles traveled from sustainable community planning will reduce lower income groups' exposure to fuel price shocks. Even though lower income groups buy a larger share of used vehicles, vehicle efficiency improvements will extend into the used vehicle market as well. More specifically, we find that vehicle efficiency improvements (even amongst used vehicles) and a decrease in vehicle miles traveled will reduce the lowest income groups' exposure to fuel price increases by 40–45 percent by 2030.

- By 2030, ICF finds that the total cost of ownership of alternative fuel vehicles and advanced vehicle technologies will be competitive with, and in several cases, cheaper than conventional vehicles using gasoline.
- Even when reviewing the first cost of ownership for vehicles, whereby only the first year of new vehicle ownership is considered and the lifetime benefits of using cheaper fuels are not fully captured, ICF finds that alternative fuel vehicles and advanced vehicle technologies will be competitive with conventional vehicles using gasoline.
- As a result of California's sustainable community strategies, ICF estimates that by 2030 Californians will save 350 million hours that they would have otherwise spent sitting in traffic, with a cumulative value of over $6 billion. This translates into an annual savings of roughly 20 hours and $350 per worker. Commuters living and working in greater Los Angeles, California's largest metropolitan area and one of the most congested regions in the country, will likely receive the largest benefits, as do those in the Sacramento region.
- ICF estimates avoided damage costs, attributable to reduced criteria pollutant emissions, reduced greenhouse gas emissions, and reduced petroleum consumption, in the range of $3.0–4.8 billion annually by 2030 as a result of California's transportation policies. This monetized value is linked to benefits such as: a) reduced incidences of premature mortality, bronchitis, upper and lower respiratory symptoms, asthma exacerbation, nonfatal heart attacks, hospital admissions, emergency room visits, work loss and restricted activity days, b) avoided costs of climate change, and c) reduced exposure to volatile petroleum markets.
- ICF finds that California's low carbon transportation policies will yield significant benefits to the state as a whole. For instance, over the next five years, California will spend between $42–$52 billion annually on gasoline fuel expenditures. Without California's low carbon transportation policies, California would have spent up to $60 billion annually in that same time period.

The graphic and table below summarize the impacts of California's low carbon transportation policies in 2030.



Consumer Impacts of California's Low Carbon Transportation Policies by 2030

Reduces the average household's fuel expenditures by $1,210–$1,530

Low income households will experience the largest savings from low-carbon policies (measured as a share of income)

Reduces travel times for commuters by 20 hours annually, valued at $350 per year

Helps keep total cost of ownership steady over time

Total Avoided Costs: $3.02–$4.84 billion

$1.29–1.37 billion

$0.49–$2.23 billion

$1.24 billion

Improves affordability of alternative fuel vehicles

Impact Area	Change by 2030
Annual Household Fuel Expenditures	• Savings of $1,210–$1,530 per household*
Low Income Group Exposure to Fuel Prices	• Reduces low income households’ exposure to fuel pricing by 40–45 percent
Vehicle Ownership	• Helps keep all drivers’ total cost of ownership steady over time • Improves the value proposition of alternative fuel vehicles
Travel Time and Congestion	• Reduces congestion by 350 million hours annually • Valued at more than $6 billion
Avoided Damage Costs–All	• $3,021–$4,836 million
Avoided Damage Costs from Criteria Air Pollutants	• *$1,292–$1,367 million*
Avoided Damage Costs from GHG Emissions	• *$488–$2,228 million*
Avoided Damage Costs from Petroleum Consumption	• *$1,241 million*

*Based on data from the American Community Survey 2010–2014, the average occupied household in California has 1.86 vehicles.

1 Introduction

California is a global leader in developing and implementing clean transportation policies. The State's regulatory approach is multifold, using various policy instruments to improve the efficiency of vehicles, reduce the carbon intensity of fuels, and increase options for mobility. Two of these policies—the AB 32 Cap-and-Trade Program and the Low Carbon Fuel Standard (LCFS)—use price signals via market based approaches to encourage both short-term and long-term emission reductions. The regulatory compliance costs incurred by fuel providers as a result of these policies will likely be passed on to consumers. However, the regulations also will provide benefits to consumers, such as improved health outcomes from better air quality, decreased travel time resulting from congestion relief, and lower barriers to entry for potentially cheaper alternative fuels and advanced vehicles. The value of these regulatory costs and benefits are dependent on how compliance is achieved and future market conditions. The goal of this report is to estimate how California's clean transportation policies will affect consumers through 2030, based on existing analyses of regulatory compliance. ICF has assessed a broad range of measurable impacts of these policies including: consumer microeconomic (e.g., "pocketbook") impacts for all consumers and for low- and middle-income households; the monetized value of avoided damages, and savings realized through impacts to travel time and mobility options.

Section 2 of the report provides an overview of the policies we considered. Section 3 includes the impact analysis, including our approach, data sources, and assumptions, as well as the statement of impacts. Additional details on compliance outlooks are provided in the Appendix.

2 Overview of California's Low Carbon Transportation Policies

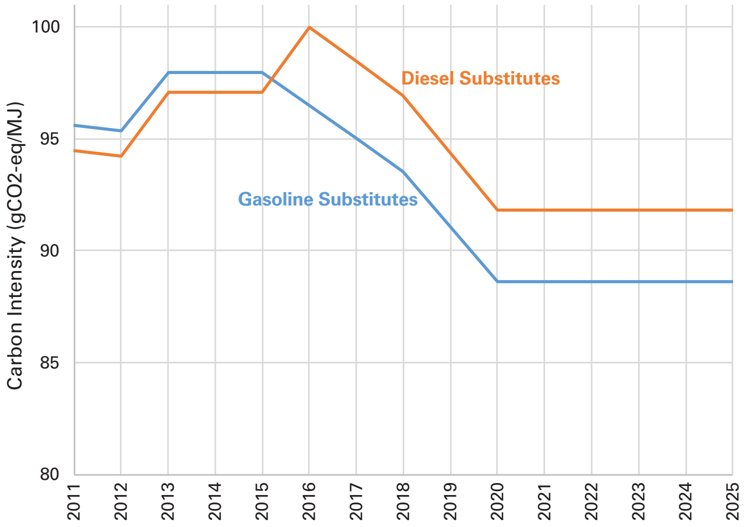
For this analysis, ICF considered the Low Carbon Fuel Standard (LCFS), transportation fuels under the Cap-and-Trade Program, greenhouse gas (GHG) emissions standards, the Zero Emission Vehicle (ZEV) Program, and SB 375 Sustainable Communities Strategy (SCS). The following subsections provide an overview of these programs and a brief discussion of how they will impact transportation over the next several years.

Low Carbon Fuel Standard (LCFS)

California's LCFS is designed to be a flexible market-based mechanism to reduce GHG emissions of transportation fuels, like reformulated gasoline and diesel, on a lifecycle basis. The LCFS was established in 2007 through a Governor's Executive Order and requires those who produce petroleum-based transportation fuels to reduce the carbon intensity (CI) of their fuels by 10 percent by 2020.

The LCFS applies to transportation fuel that is sold, supplied, or offered for sale in California and to any regulated party that produces those transportation fuels, like oil refineries and other distributors. The program is administered by the California Air Resources Board (CARB) and is implemented using a system of credits and deficits. Figure 1 below shows the carbon intensity standard against which fuels are measured to determine whether they generate deficits or credits. Transportation fuels that have a higher carbon intensity than the compliance standard yield deficits, and fuels that have a lower carbon intensity (such as ethanol, biodiesel, renewable diesel, natural gas, or electricity) generate credits.

Figure 1. CARB's LCFS Compliance Schedule for Gasoline and Diesel



LCFS compliance can be achieved using an array of solutions. The most common pathways to date are described here:

- **Lower CI corn ethanol:** In most gasoline markets, ethanol is blended at 10 percent by volume with gasoline (as an oxygenator to produce reformulated gasoline). Corn ethanol producers can decrease their CI to differentiate themselves from their competitors. For instance, the "standard" gallon of corn ethanol prior to the introduction of the LCFS in California had a CI around 95 g/MJ; more than 30 ethanol production facilities have submitted 85 ethanol pathways with a low of 64 g/MJ.[1]
- **Sugarcane ethanol:** Based on its carbon intensity, the availability of supply—as demonstrated by the 500 million gallons imported to the US as recently as 2012—and fuel pricing, sugarcane ethanol will definitely play an important role towards compliance as programs are currently structured. The potential for cross-compliance with the Renewable Fuel Standard Program (RFS2) at the federal level using Brazilian sugarcane ethanol also serves to increase the likelihood of Brazilian sugarcane ethanol playing a significant part of LCFS compliance in multiple markets.
- **Biodiesel:** Biodiesel is blended into conventional diesel at low levels (generally at 5–20 percent, B5-B20). Biodiesel blended up to 5 percent by volume can actually be labeled as diesel. To date, biodiesel blends have generated about 13 percent of LCFS credits in California.
- **Renewable diesel:** Renewable diesel is a drop-in replacement and can be blended into the conventional diesel supply without limitations. The most active player in this market is Neste, who has a large production facility in Singapore that delivers low carbon fuel to the West Coast of the United States. The company has delivered around 100–130 million gallons in the last two years and is expected to increase those volumes considerably in the near-term future.
- **Natural gas:** Natural gas is consumed as a transportation fuel when compressed (CNG) or liquefied (LNG). It can be sourced from conventional/fossil sources or renewable resources like landfills, wastewater treatment plants, and dairy digesters.
- **Electricity used in plug-in electric vehicles:** both plug-in hybrids like the Chevrolet Volt and full battery electric vehicles like the Nissan LEAF or Tesla Model S generate LCFS credits, primarily for utilities. These currently represent a small part of the market at about 2 percent; however, given other regulations (i.e., federal fuel economy / GHG standards and the ZEV Program), these are poised to increase considerably moving forward.

Light-Duty Vehicle GHG Standards

California, under Clean Air Act authority, has adopted light-duty vehicle GHG standards that are consistent with federal fuel economy and GHG standards. The most recent passenger vehicle standards, covering cars and light trucks, were promulgated by the National Highway Traffic Safety Administration (NHTSA) and the Environmental Protection Agency (EPA) in 2012 for model years 2017 and beyond. The standards are a combination of fuel economy standards (referred to

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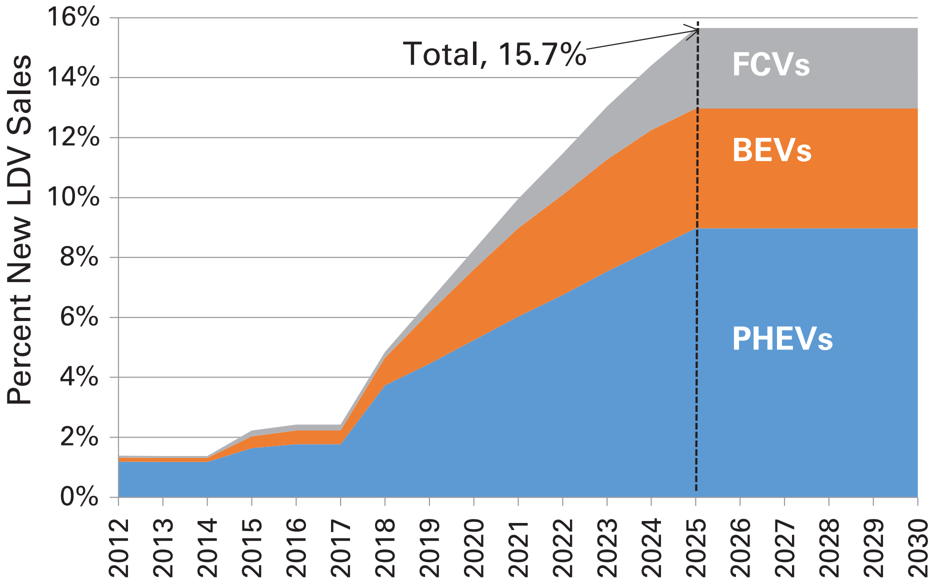
[1] ICF notes that these CI values will change substantially under the re-adopted version of the LCFS Program. For instance, the so-called indirect land use change emissions factor for corn ethanol has been reduced from its previous value of 30 g/MJ to 19.8 g/MJ.

as Corporate Average Fuel Economy standards or CAFE standards)[2] established by NHTSA and GHG emission standards from the EPA.[3] NHTSA and EPA projected that the fleet-wide on-road fuel economy of new passenger vehicles to be in the range of 40 miles per gallon (MPG) in 2025.

Zero Emission Vehicle (ZEV) Program

CARB established the Zero Emission Vehicle (ZEV) Program in 1990 to increase penetration rates of ZEVs to reduce criteria pollutant emissions. The program today requires a certain percentage of light duty vehicles sold in California to be ZEVs, which includes battery electric vehicles (BEVs), fuel cell vehicles (FCV), and transitional zero emission vehicle (TZEVs) like plug-in hybrid electric vehicles (PHEVs). Because of the limited availability of true ZEVs until recently, manufacturers were allowed to comply with the regulations by selling larger numbers of very low emitting vehicles. In March 2008, CARB directed staff to strengthen the ZEV Program requirements for 2015 and beyond by focusing solely on electric and hydrogen vehicles. Proposed modifications to the ZEV Program were accepted as part of the Advanced Clean Cars Program, dramatically increasing the requirements for sales of ZEVs beginning in 2018. As a result of the program, over 1.4 million ZEVs and so-called TZEVs (which are effectively PHEVs) are expected to be produced cumulatively in California by 2025, with 500,000 of those vehicles being pure ZEVs (BEVs and FCVs).[4]

Figure 2. Percent New LDV Sales of ZEVs in CARB's Illustrative Compliance Scenario



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[2] Under the authority of the Energy Policy and Conservation Act (EPCA) and amend by the Energy Independence and Security Act (EISA).

[3] Under the authority of the Clean Air Act.

[4] Advanced Clean Cars Summary, CARB, Available online at **http://www.arb.ca.gov/msprog/clean_cars/acc%20summary-final.pdf**

SB 375 Sustainable Communities Strategies (SCS)

California's Senate Bill 375 (2008) aims to reduce energy use and GHG emissions from the transportation sector by reducing the amount that Californians drive. The goal of SB 375 is to expand transportation choices that reduce the need to drive by focusing on new development in places where residents can travel by foot, bicycle, or transit. In all metropolitan areas with populations over 200,000, metropolitan planning organizations (MPOs) are responsible for preparing a regional transportation plan (RTP) describing how transportation revenues across the region will be spent over the next 25 years. SB 375 requires that MPOs include a SCS that includes a regional land use plan and details how land use changes, in combination with the transportation projects and policies in the RTP, will help the region meet regional GHG reduction targets set by the state. Prior to SB 375, there were no state-issued GHG reduction targets for RTPs, and the land use scenarios included in RTPs were more likely to be a compilation of local plans than a cohesive regional plan. However, local governments in California have exclusive authority over land use changes, and neither SB 375 nor any of the other vehicle miles travelled (VMT) measures described in this report does anything to change that. Instead, the bill aligns other planning processes with the SCS and creates a set of incentives to help implement the strategy:

- SB 375 requires MPOs to spend the federal and state transportation funds that they allocate in a manner consistent with the SCS—so an MPO cannot increase the amount of growth in central neighborhoods that are well-served by transit in its SCS while spending its RTP funding on new highways that serve the suburbs.
- The bill amends the California Environmental Quality Act (CEQA) to limit the environmental review for some projects that conform to the SCS. CEQA review is the primary mechanism that opponents use to delay development projects, so this can be a powerful incentive if the SCS is clear about where growth will go and developers have confidence in CEQA streamlining.
- Finally, SB 375 aligns the Regional Housing Needs Allocation (RHNA) process with the SCS, and creates penalties for local governments that do not zone to meet their allocation. Local governments have a fiscal incentive not to plan for new housing, which generates fewer revenues and requires more services than commercial development, so these penalties are designed to ensure that the housing envisioned in the SCS is planned for and ultimately built.

AB 32 Cap-and-Trade

California's Cap-and-Trade Program is one of the strategies included under California's Assembly Bill (AB) 32 Scoping Plan, also called the California Global Warming Solutions Act of 2006. AB 32 aims to sharply reduce California GHG emissions and return them to 1990 levels by 2020, a 15 percent reduction from the "business-as-usual" scenario. The Cap-and-Trade Program took effect in early 2012 and regulated parties began complying on January 1, 2013. Beginning in 2013, stationary sources including electricity generators and large industrial facilities emitting 25,000 $MTCO_2e$ or more annually were regulated. Distributors of petroleum-based fuels (i.e., gasoline and diesel), natural gas, and other fuels were regulated under the cap (on a tailpipe or direct combustion emissions basis, not on a lifecycle basis) starting in 2015.

Under the Cap-and-Trade Program, CARB set a limit (cap) on major sources of GHG emissions from capped sectors. The cap declines approximately 3 percent each year beginning in 2013. Regulated parties can trade permits (allowances) to emit GHGs or reduce their GHG emissions. Allowances are auctioned quarterly and these auctions are held by CARB. Parties are also allowed to bank allowances to protect themselves against shortages and price swings in the market. If a regulated party does not meet CARB's compliance standards, they must provide four allowances for every ton of emissions not covered by the compliance deadline.

Proceeds from the state-owned allowance auction are deposited into the Greenhouse Gas Reduction Fund (GGRF), which was established under AB 1532 (Pérez). The legislature and Governor allocate funds from GGRF to projects that help California achieve its GHG reduction goals while realizing additional health, economic, and environmental benefits. In addition, a minimum of 25 percent of GGRF funds will fund projects that provide a benefit to disadvantaged communities, and at least ten percent of funds need to be spent in disadvantaged communities. The state estimates that the auction revenue from the Cap-and-Trade Program will raise $12–45 billion dollars in funding between 2012 and 2020.[5] The first $500 million of GGRF funds raised in the first five auctions were loaned to the General fund.

Of the $850 million GGRF funds appropriated in 2014–2015, 71 percent were allocated to sustainable communities and clean transportation, 16 percent to energy efficiency and clean energy and 13 percent to natural resources and waste diversion. A total of $300 million was allocated to low-emissions vehicle rebates and transit-oriented development grants. Using GGRF funds for these types of projects can help make the transition to cleaner transportation more affordable for consumers. The administration's expenditure plan provides continuous appropriations for 60 percent of future GGRF funds to high-speed rail, affordable housing, transit and intercity rail capital, and low-carbon transit operations. The remaining 40 percent of GGRF funds are used for annual appropriations.

The 2016–17 budget proposes a $3.1 billion Cap and Trade Expenditure Plan (including those funds not appropriated in 2014–15). Of the 40 percent that is appropriated annually, 54 percent ($1 billion) will be used to support clean transportation programs, including incentives and rebates that will make ZEVs more affordable.[6] It is uncertain if similar levels of funding from the 40 percent of auction revenues that are annually appropriated will be allocated to projects targeting sustainable communities and clean transportation; however, there is significant potential for returning value to consumers by funding programs that reduce transportation and home energy bills.

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[5] California State Legislative Office. February 2014. The 2014–15 Budget: Cap-and-Trade Auction Revenue Expenditure Plan. Retrieved from **http://www.lao.ca.gov/reports/2014/budget/cap-and-trade/auction-revenue-expenditure-022414.pdf**.

[6] State of California – Edmund G. Brown Jr. Governor. January 2016. Governor's Budget Summary—2016–17. Retrieved from **http://www.ebudget.ca.gov/2016-17/pdf/BudgetSummary/FullBudgetSummary.pdf**.

Cross Policy Interactions

The policies discussed above are interconnected and compliance in one regulatory market affects compliance in another market. The LCFS and SB 375, for instance, are considered complementary measures for AB 32. These complementary measures reduce the consumption of gasoline and diesel, which in turn contributes towards compliance with the Cap-and-Trade Program as a result of regulated parties (in this case, refineries) having to purchase fewer allowances for the emissions from transportation fuels. This example is one of many that illustrates the overlap in compliance between California's transportation policies. California's LCFS, ZEV Program, and SB 375 are connected to California's Cap-and-Trade Program because they ultimately displace gasoline and diesel fuel.

3 Impact Analysis

ICF's analysis includes changes to a) consumer fuel prices attributable to the compliance costs of LCFS and Cap-and-Trade, b) vehicle ownership costs attributable to the shift to cleaner vehicles and low carbon fuels, and c) vehicle miles and travel time attributable to SB 375. We include an estimate of how fuel price changes will affect different income groups based on the efficiency of new and used vehicle populations. We also estimate the co-benefits of these policies, some of which will be realized directly by consumers (e.g., health cost savings) and others will manifest as macroeconomic benefits, such as our vulnerability to oil supply shocks and price spikes. The following section introduces each impact considered and the methodology, data sources, and assumptions used to develop our findings. Unless otherwise noted, dollar values are presented in 2015 dollars.

ICF notes that California's low carbon transportation policies will impact consumers in ways that are not captured in this report. For instance, we did not consider the consumer benefits associated with spending auction revenues from the Cap-and-Trade Program to fund programs that reduce transportation and home energy bills. This reduced spending, particularly in low income households, can yield significant consumer benefits, but these were not included in the scope of our analysis. Similarly, we did not consider how the reduced demand for fuels can impact fuel pricing. In principle, as the demand for gasoline decreases, so too can the price of the fuel. However, there are a variety of factors that impact fuel pricing, including crude pricing (which is a global commodity), refinery runs, and refining capacity. The full implementation of California's transportation policies will yield decreases in the demand for gasoline (this is discussed in subsequent parts of the report), which could put downward pressure on the price of gasoline. This generally assumes, however, that the supply of gasoline is largely unchanged from today's levels. Refineries in California may not simply cut production runs and hope to remain profitable; rather, they may seek other markets for their refined product or opt to shutter capacity due to reduced margins. In the event of the latter, as refining capacity is taken offline, it is possible that the decrease in demand for gasoline is offset by the decreased supply of refined products in California, thereby pushing prices back up. Regardless, gasoline pricing is a function of multiple variables, and it is beyond the scope of this analysis to parse out the explicit impacts linked to California's low carbon transportation policies.

Fuel Expenditure Impacts: LCFS and Cap-and-Trade Compliance Costs

ICF's analysis of fuel price impacts focuses on the compliance costs associated with the LCFS Program and the Cap-and-Trade Program. To estimate fuel price impacts of California's transportation policies, ICF spread the annual cost of compliance over the volume of fuel consumed in that year, assuming that fuel providers will pass their LCFS and Cap-and-Trade compliance costs onto consumers.[7] We used compliance scenarios from CARB, as detailed below. Since the compliance costs are dependent on LCFS credit and Cap-and-Trade allowance prices, we developed three credit pricing scenarios—low, medium, and high—that are driven by varying industry projections. The following data sources and assumptions were used in the fuel price impact analysis.

ICF developed baseline and adjusted gasoline and diesel fuel demand projections that account for a) LCFS compliance, b) fuel economy and light-duty GHG tailpipe standards, and c) VMT reductions achieved via implementation of SB 375's SCS. These demand projections were developed over the following steps:

- ICF used baseline gasoline and diesel fuel projections for 2015–2025 from CARB's April 2015 LCFS illustrative compliance scenario;[8] for 2026–2030, ICF applied the California Energy Commission's (CEC) 2013 Integrated Energy Policy Report (IEPR) reference case growth rate for gasoline and diesel to CARB's projections.[9]
- ICF adjusted these baseline gasoline and diesel demand projections based on CARB's illustrative compliance scenario. We assumed that compliance volumes will remain at 2025 levels through 2030 for all fuels except hydrogen and electricity used in light/medium duty vehicles, which we assumed would increase by the average rate of growth of the prior five years. Table 1 presents the volumes of each low-carbon fuel included in CARB's illustrative compliance scenario in units of native gallons, gasoline gallon equivalents (GGE), or diesel gallon equivalents (DGE).[10]

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[7] ICF notes that for competitive reasons, some refiners may choose to absorb some of the compliance costs, rather than pass on the full compliance cost to the consumer. Anecdotal evidence to date suggests that refiners are passing along compliance costs; however, this may change as both the LCFS and Cap-and-Trade Programs evolve over the next several years.

[8] California Air Resource Board. April 2015. Public Workshop. Retrieved from **http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/040115_LCFS_Update_to_Illustrative_Compliance_Scenario.xlsx**.

[9] California Energy Commission. 2013. Integrated Energy Policy Report—unpublished transportation fuel demand forecasts provided to ICF via personal communication with CEC staff.

[10] California Air Resource Board. April 2015. Public Workshop. Retrieved from **http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/040115_LCFS_Update_to_Illustrative_Compliance_Scenario.xlsx**

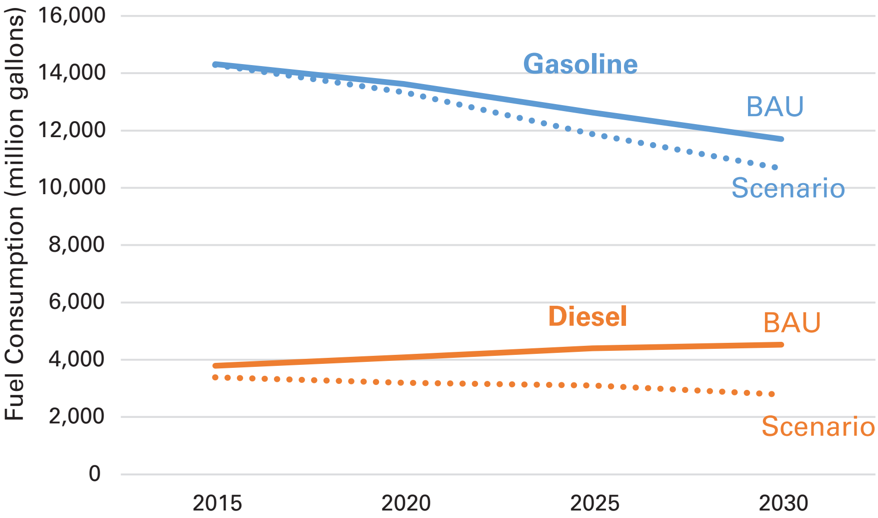
Table 1. LCFS Illustrative Compliance Scenario—Low Carbon Fuel Volumes

Low-Carbon Fuel	2015	2020	2025	2030
Ethanol (MGY)	1,520	1,485	1,455	1,455
Renewable Gasoline (MGY)	0	25	250	250
CNG in LDVs and MDVs (MGY GGE)	17	17	17	17
Hydrogen (MGY GGE)	0	7	27	45
Electricity for LDVs (MGY GGE)	14	51	136	216
Biodiesel (MGY)	97	180	190	190
Renewable Diesel (MGY)	180	400	600	600
CNG in HDVs (MGY DGE)	125	285	485	485
Electricity for HDVs/Rail (MGY DGE)	0	24	24	24

- ICF adjusted fuel demand for SB 375 by using the population weighted percent reduction in annual VMT set forth in the SCS plans of the six major MPOs in California.

Figure 3 below illustrates the baseline gasoline and diesel demand projections (solid lines) and the adjusted demand projections accounting for LCFS compliance and SB 375 (dotted lines).

Figure 3. Baseline and Scenario Fuel Demand Projections 2015–2030



The scenario gasoline and diesel fuel volumes are used to determine the costs of compliance with the LCFS and Cap-and-Trade Programs, as outlined in the subsections below.

LCFS Compliance Costs

Based on the low-carbon fuel volumes shown in Table 1, CARB's illustrative scenario calculates the total deficits incurred by refineries. To estimate how much it will cost refineries to reduce these deficits, ICF developed three LCFS credit price scenarios ranging from $50 to $180 in 2030 (see Table 2). ICF is not aware of any publicly available forecasts in the LCFS market. With that in mind, and given the objective of this report to provide a range of consumers impacts in California, we selected credit prices based on the average credit price traded over the last several years of the program (about \$50), and the potential for credit price increases. The program is currently operating with a maximum clearance credit price of \$200.[11] We assumed that credit prices remain constant post-2020 because the current program maintains the 10 percent carbon intensity reduction.

Table 2. LCFS Credit Price Assumptions (\$/MMTCO$_2$e)

Scenario	2015	2020	2025	2030
Low	\$40	\$50	\$50	\$50
Medium		\$100	\$100	\$100
High		\$180	\$180	\$180

Cap-and-Trade Compliance Costs

The fuel price impacts of Cap-and-Trade are exclusively linked to the amount of transportation fuel–gasoline and diesel–that regulated parties sell into the market, and the Cap-and-Trade Program is linked to how other complementary programs reduce the demand for petroleum-based fuels. Therefore, the volume of fuel we used to determine refinery costs with fuels under the cap is equal to the demand projections minus the LCFS compliance fuel volumes (see Table 1). For Cap-and-Trade allowance prices, ICF used the low, medium, and high price scenarios shown in Table 3 below. For 2015, we used the average allowance settlement price from the four auctions held by CARB.[12] In subsequent years, the low price scenario represents the minimum allowance price (i.e., annual auction reserve price) set by the regulation.[13] The medium and high price scenarios are based on data from ICIS Industries 2015 report that projects a 2030 allowance price range of \$30–\$70.[14] The Appendix provides further information on these features and the other studies ICF considered when establishing our allowance price assumptions.

Table 3. Cap-and-Trade Allowance Price Assumptions from (\$2015/MMTCO$_2$e)

Scenario	2015	2020	2025	2030	2030
Low	\$12.42	\$15.44	\$19.71	\$25.16	CARB (min. allowance price)
Medium	\$12.42	\$24.73	\$37.37	\$50.00	Based on ICIS Industries (2015)
High	\$12.42	\$31.40	\$50.70	\$70.00	Based on ICIS Industries (2015)

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[11] The credit clearance mechanism provides an opportunity for entities without enough credits to purchase them during a defined clearance period, during which time entities with credits can pledge to sell them at a price of up to \$200 per ton. However, ICF notes that there is no mechanism whereby CARB can compel entities to supply credits for sale via the credit clearance mechanism. Furthermore, there is no hard cap on credit prices in the current version of the program.

[12] CARB. November 2015. California Cap-and-Trade Program Summary of Auction Settlement Prices and Results. Retrieved from **http://www.arb.ca.gov/cc/capandtrade/auction/nov-2015/ca_proceeds_report.pdf**.

[13] CARB. January 2015. Final Regulation Order – California Cap on Greenhouse Gas Emissions and Market-based Compliance Mechanisms. Retrieved from **http://www.arb.ca.gov/cc/capandtrade/capandtrade/unofficial_c&t_012015.pdf**.

[14] ICIS. January 2015. ICIS launches 2030 Forecast for California Carbon Allowances press release. Retrieved from **http://www.icis.com/press-releases/icis-launches-2030-forecast-for-california-carbon-allowances/**.

Our analysis also looked at how the estimated compliance costs could affect the average Californian's annual gasoline expenditures. To do so, we used the CEC's draft 2015 IEPR reference gasoline and diesel price projections[15] and the annual average light-duty vehicle efficiency from the EMissions FACtor (EMFAC) model developed and maintained by CARB.

Summary of Compliance Costs on Fuel Expenditures

Without California's low carbon transportation policies, the average California household[16] faces annual fuel expenditures of $4,300 by 2020 and nearly $5,000 by 2025, up from around $3,500 today. However, as a result of California's low carbon transportation policies, households will likely spend $3,000–$3,800 annually over the next 3–5 years on gasoline, and decreasing post-2020 to the range of $3,500–$3,700 thereafter (as shown in Figure 4 below).

Figure 4. Annual Household Fuel Expenditures in California ($2015)

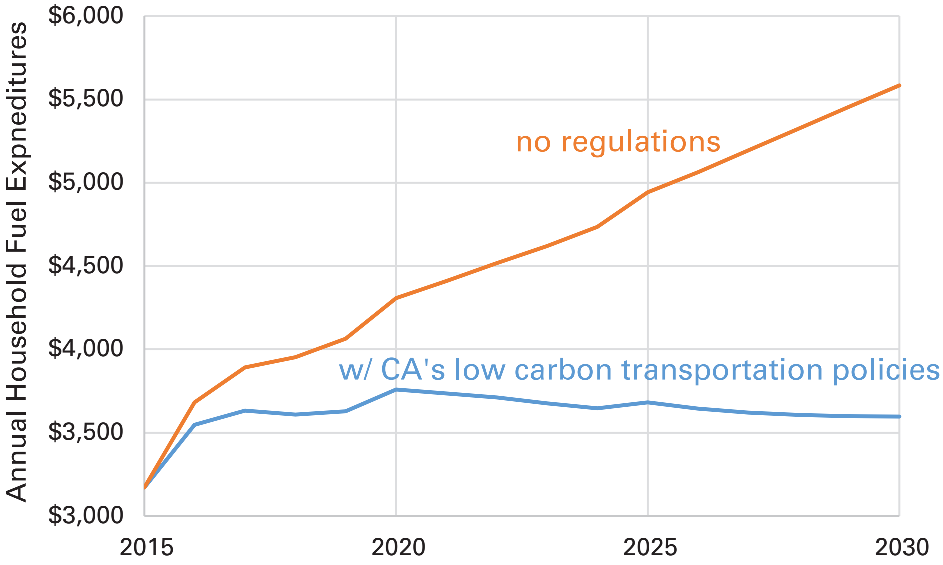

Figure 5 below illustrates the net impact of California's portfolio of low carbon transportation policies on the annual fuel expenditures of average households: As a result of decreasing per capita fuel consumption from improved vehicle efficiency and SB 375 (the orange line), and after accounting for potential fuel price increases linked to compliance with LCFS and Cap-and-Trade (the blue lines; representing the low, medium, and high price scenarios), the average household will save $1,209–$1,531 per year by 2030.

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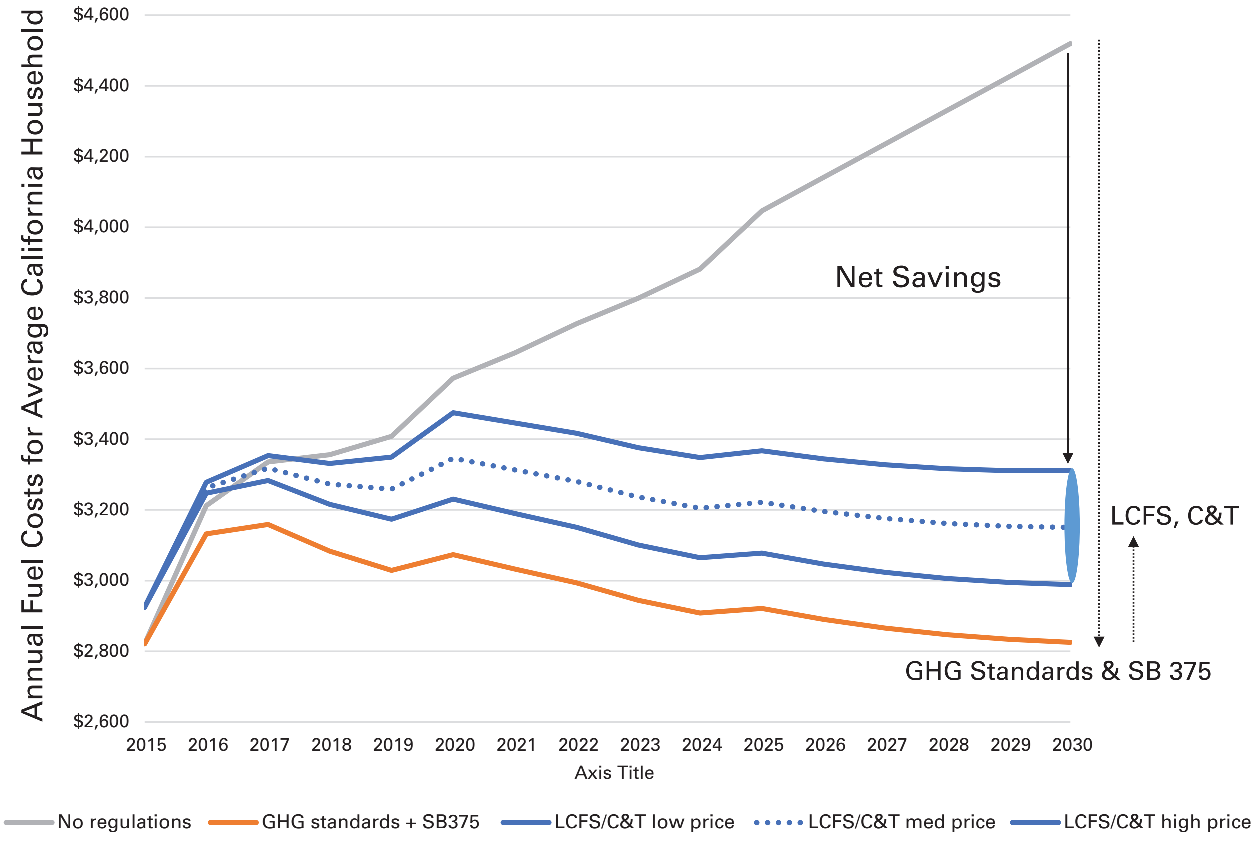
[15] California Energy Commission. June 2015. Workshop presentation - Crude Oil and Transportation Fuel Price Cases for the 2015 IEPR. Retrieved from **https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=15-IEPR-10**.

[16] Based on data from the American Community Survey 2010–2014, the average occupied household in California has 1.86 vehicles.

Figure 5. Fuel Costs Impacts to the Average California Household ($2015)



We estimate compliance costs of $3.65–$10.84 billion by 2030 based on the credit and allowance pricing used in our analysis;[17] we assume that all of these compliance costs are passed onto the consumer. Table 4 presents our compliance cost estimates for the three pricing scenarios developed for this analysis.

Table 4. Compliance Costs for LCFS and Cap-and-Trade ($2015, Billions)

Pricing Scenario	2015	2020	2025	2030
Low Price Scenario	$1.90	$3.13	$3.36	$3.65
Medium Price Scenario	$1.90	$5.43	$6.46	$7.26
High Price Scenario	$1.90	$7.99	$9.59	$10.84

As shown in Figure 5 above, compliance costs will be offset by significant improvements in vehicle efficiency and reduced VMT.

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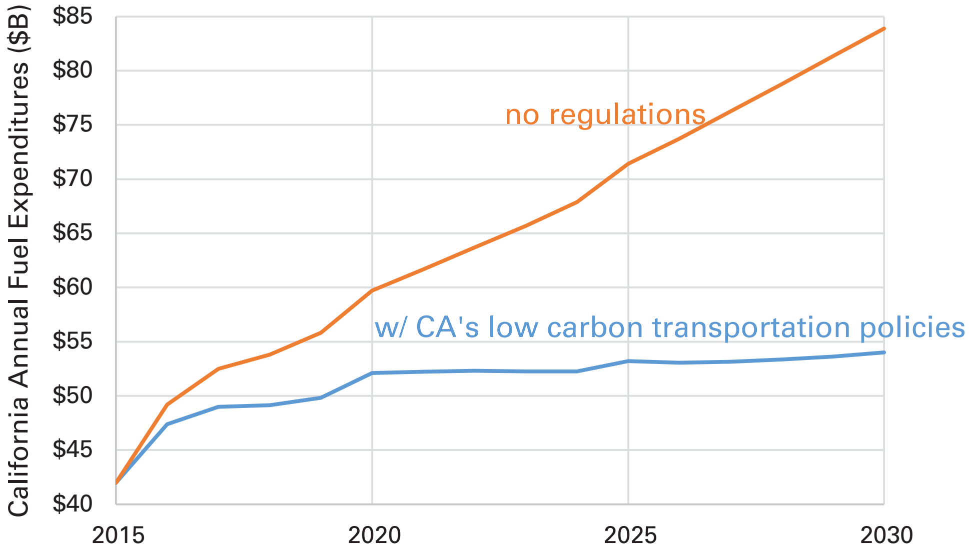
[17] ICF notes that some of the compliance costs are recycled back to consumers as benefits via the GGRF, which helps lower consumers' energy expenditures.

California’s low carbon transportation policies will also yield significant benefits to the state as a whole. For instance, over the next five years, California will spend between $42–$52 billion annually on gasoline fuel expenditures. Without California’s low carbon transportation policies, California would have spent up to $60 billion in that same time period, rising to $84 billion by 2030 without intervention, as shown in Figure 6 below.

Figure 6. Annual Gasoline Fuel Expenditures in California



Fuel Price Impacts by Income Group

As noted in the previous sub-section, the average household stands to benefit significantly from California’s low carbon transportation policies; however, the distribution of those benefits across income groups is also important to understand. To determine how fuel price changes will impact different income groups, ICF estimated the average vehicle efficiency for 10 income brackets based on DMV vehicle registration data obtained from IHS Automotive. This data set covers over six million new and used vehicles registered in California between July 2014 and August 2015. ICF matched each vehicle included in the registration data with the relevant EPA combined MPG for the specified make and model year.[18] High end sports cars were removed from the data set due to their low mileage.

Fuel price impacts will have varying economic burdens on households depending on the efficiency of their vehicle. The table below illustrates that average vehicle efficiency of new and used cars purchased from August 2014 to July 2015, based on ICF analysis of data from IHS Automotive.

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[18] U.S. Environmental Protection Agency. November 2015. Fuel economy data for all model years (1984–2016). Retrieved from **https://www.fueleconomy.gov/feg/download.shtml.**

Table 5. Average Vehicle Fuel Economy and Model Year by Income Bracket (New and Used Combined)

Income Bracket	# Vehicles	Average MPG	MPG Standard Deviation	Average MY
UNDER $15,000	446,183	22.7	6.6	2006
$15,000–$19,999	138,501	23.1	7.2	2007
$20,000–$29,999	256,949	23.2	7.2	2007
$30,000–$39,999	255,085	23.2	7.2	2008
$40,000–$49,999	278,147	23.3	7.4	2008
$50,000–$74,999	772,877	23.7	8.1	2009
$75,000–$99,999	584,091	24.1	9.3	2010
$100,000–$124,999	341,760	24.7	10.8	2010
$125,000–$149,999	187,941	24.9	11.5	2011
$150,000 AND OVER	432,534	25.3	12.9	2011
UNKNOWN	2,326,656	22.9	7.8	2006
TOTAL	6,020,724	23.5	8.7	2008

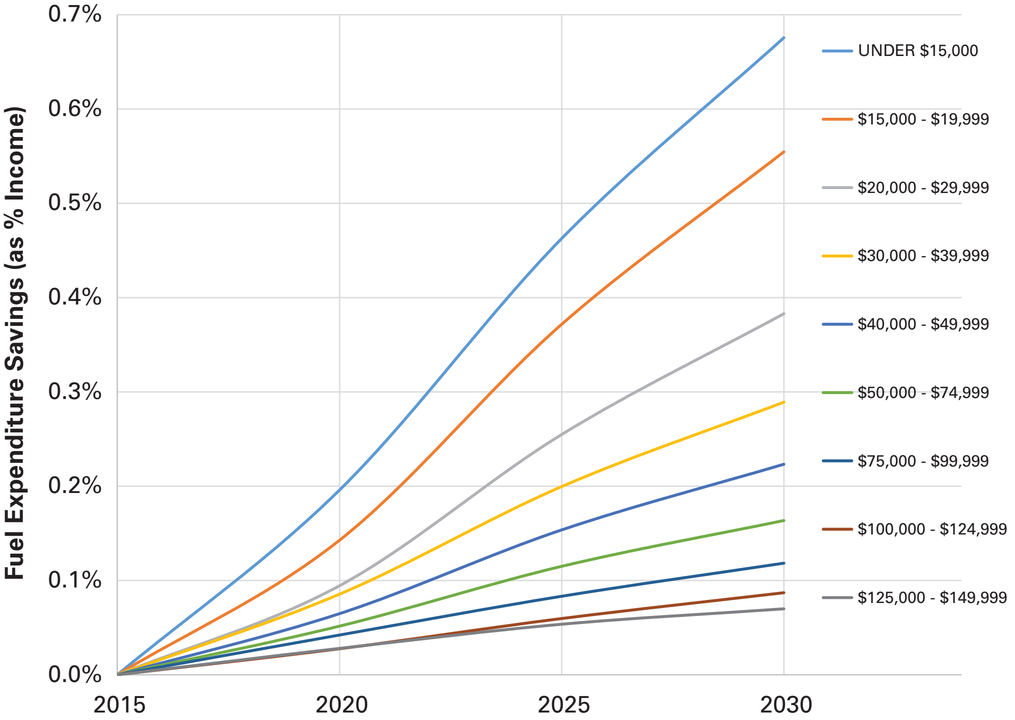
Source: ICF analysis of data from IHS Automotive

The data illustrate that wealthier income groups are purchasing a much larger share of newer vehicles, which yields more efficient vehicles. As a result, lower income populations see a delay in reaping the benefits of fuel savings from newer vehicles. In addition, low-income households already spend a disproportionate share of their household income on fuel expenditures, due to the essential nature of energy costs.

Moving forward, however, there are three key impacts that drivers will face in California: the prospect of improved fuel economy even via used cars sales (decreasing household fuel expenditures), the prospect of higher fuel prices as a result of carbon policies like LCFS and Cap-and-Trade (increasing household fuel expenditures), and finally the reduction in VMT as a result of SB 375 (decreasing household fuel expenditures).

For our analysis, ICF sought to understand the impact to various income groups of increasing the price of gasoline between 2015 and 2030 as a function of fuel economy improvements and decreased VMT. To do so, we introduced a theoretical $0.50 per gallon price increase to gasoline, and determined what percent of a household's income that change represents after accounting for vehicles miles traveled and vehicle fuel economy. The $0.50 per gallon increase is used for illustrative purposes and is a proxy for changes in fuel pricing that could be attributed to transportation policies (e.g., LCFS and Cap-and-Trade) and/or volatility in the marketplace.

Figure 7. Fuel Expenditure Savings as a Percent of Income for Various Income Groups



As shown in the graph, the lowest income groups stand to gain the most from fuel economy improvements and reduced VMT (the top three lines), as they have the steepest positive slopes, indicating greater savings. For instance, the graph shows the savings that households would achieve as a result of improved fuel economy and reduced VMT, shown as the percent change in income from a 2015 baseline year. In other words, even with a hypothetical $0.50 per gallon increase in the price of gasoline by 2030, households making less than $15,000 per year (the blue line) would save 0.7% of their household income due to projected fuel economy improvements and reduced VMT. Conversely, households making $125,000–$150,000 per year (the grey line) would save just 0.07% of their household income as a result of the same fuel price increase, fuel economy improvements, and reduced VMT.

There are other opportunities to reduce transportation fuel costs for low income households. CARB, for instance, recently partnered with the South Coast Air Quality Management District and the San Joaquin Valley Air Pollution Control District to announce a Plus Up program, whereby vehicle purchase incentives are provided to low income individuals buying a new or used vehicle.[19] If programs like these are successful, then they will pull forward the fuel economy of vehicles in lower income groups, thereby reducing these income groups' exposure to increased fuel prices more rapidly. Furthermore, the Plus Up program provides additional incentives for the purchase of an electric vehicle (up to $12,000 when combined with the Clean Vehicle Rebate

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[19] The Enhanced Fleet Modernization Program Plus-Up is administered by the Air Districts. More information is available online at **http://www.arb.ca.gov/newsrel/efmp_plus_up.pdf**.

Project); if this aspect of the program is effective at pushing plug-in electric vehicles into lower income groups, then that will have an even larger impact than what is characterized in the figure above.

Vehicle Ownership

Vehicle ownership is a function of the following parameters: acquisition, vehicle operation costs, and maintenance costs. ICF developed two types of metrics to estimate the impacts on vehicle ownership: Firstly, we considered the changes over time in the cost of vehicle ownership in the first year of owning a new vehicle. We refer to this as the First Cost of Ownership (FCO). Secondly, we considered the changes over time in the total cost of vehicle ownership (TCO). There are competing theories regarding consumer behavior in car buying scenarios.[20] For instance, rationale economic theory suggests that consumers would use the TCO approach; however, the little empirical evidence that does exist suggests that this model is rarely used. Conversely, behavioral economics posits that because future fuel savings are uncertain, consumers discount them compared to known initial costs (i.e., vehicle acquisition costs). According to the previously cited paper from David Greene at Oak Ridge National Laboratory, prepared for the EPA, there is "very substantial uncertainty about how consumers make decisions about fuel economy, as well as how much they value expected future fuel savings." As a result of this limitation, ICF finds it useful to consider the two aspects of vehicle ownership outlined here.

Variables Considered in Ownership Calculations

Acquisition costs include the vehicle purchase price (the manufacturer's suggested retail price, excluding tax, license, registration, options, and destination charges), and California state vehicle sales tax. The federal tax credit for electric vehicles (based on battery capacity) and the California Vehicle Rebate Project (for zero-emission vehicles) can lower the purchase price of many electric and zero-emission vehicles, but these incentives were not included in the calculations below.

ICF developed vehicle acquisition costs based on data from the Energy Information Administration's (EIA) Annual Energy Outlook 2015 (AEO 2015). The AEO 2015 forecasts include annual vehicle pricing estimates for 12 vehicle types, including: mini-compact cars, subcompact cars, compact cars, midsize cars, large cars, two seater cars, small pickup, large pickup, small van, large van, small utility, and large utility. ICF developed vehicle pricing for various fuel and vehicle combinations based on the weighted sales of these types of vehicles in California.[21] The table below illustrates the results of ICF's analysis, shown in thousands of dollars. These prices do not include any available incentives.

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[20] D Greene. How Consumers Value Fuel Economy: A Literature Review, EPA-420-R-10-008, March 2010. Available online: **http://www3.epa.gov/otaq/climate/regulations/420r10008.pdf**

[21] Based on data reported by the California New Car Dealerships Association; **www.cncda.org**.

Table 6. Estimated Vehicle Prices for 2015–2030 for Various Fuel/Vehicle Combinations ($2015)

Fuel / Vehicle Type	Vehicle Pricing ($2013, thousands)			
	2015	2020	2025	2030
Gasoline	27.4	28.2	29.6	29.6
Gasoline-Hybrid	30.1	32.3	32.7	32.1
PHEV-10	35.3	35.3	35.3	34.2
PHEV-40	43.4	43.9	41.7	39.4
BEV-100	40.4	40.2	37.5	35.7
BEV-200	48.9	48.9	49.2	45.8
FCEV	59.0	55.6	61.4	55.9

For the purposes of this analysis, with a focus on consumers, ICF incorporated vehicle pricing by estimating the monthly payment associated with financing a new vehicle purchase. Edmunds reports that the average car loan term has slowly increased beyond five years, and is now closer to six-and-a-half years. Further, they report that in 2014, 62 percent of the auto loans were for terms over 60 months and nearly 20 percent of the loans were for 73- to 84-month terms.[22] Edmunds also reports that the average interest rate for a 55–60 month loan in 2015 was 2.41 percent, with higher rates (as high as 5.9 percent) for longer terms. For the purposes of this analysis, ICF assumed a six year term on a loan at an interest rate of 2.5 percent.

Given the uncertainty associated with the long-term availability of incentives such as the federal tax credit and the rebates in California for electric vehicles and fuel cell vehicles, ICF did not include these incentives in our analysis.

Operation costs consist of fuel consumption costs, including fuels such as gasoline, electricity, and hydrogen. These costs are dependent on fuel consumption as a function of VMT. In the case of PHEVs, however, the operational costs depend on the share of VMT in gasoline versus electric mode.

ICF used fuel pricing estimates developed by the CEC as part of the 2015 IEPR. The CEC reports low, reference, and high cases for each fuel considered. However, for the purposes of this report, ICF only used the reference cases for fuel pricing, as shown in the table below, in units of dollars per gasoline gallon equivalent (GGE).

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[22] Edmunds, How Long Should My Car Loan Be?, Available online: **http://www.edmunds.com/car-loan/how-long-should-my-car-loan-be.html** (accessed November 2015).

Table 7. Fuel Pricing for 2015–2035

Fuel	Fuel Price ($2012, GGE)			
	2015	2020	2025	2030
Gasoline	$2.74	$3.47	$3.93	$4.39
Electricity	$1.33	$1.42	$1.49	$1.57
Hydrogen	$5.36	$5.36	$5.36	$5.36

In the case of PHEVs (with ranges of 10 and 40 miles, PHEV-10 and PHEV-40), we assumed a mix of electricity and gasoline would be used. For PHEV-10s and PHEV-40s, we assumed 20 and 80 percent of miles traveled using electricity, respectively. We also included the monetary benefits associated with using electricity and hydrogen, as consumers using these fuels will see a reduced price as a result of LCFS credits.

Maintenance costs reflect the costs to maintain, repair, and replace vehicle parts (e.g., oil filters, air filters, spark plugs, timing chains, brakes). In the case of alternative fueled vehicles, most of the existing literature indicates that these vehicles will result in lower maintenance needs than conventional internal combustion engine vehicles. Some maintenance needs are completely eliminated (e.g., electric vehicles do not require oil changes or air filter replacements) and others are significantly reduced because of the different mechanical structures (e.g., electric vehicles require less frequent brake pad replacement than conventional vehicles).

ICF developed maintenance costs on a per-mile basis using a combination of estimates from Oak Ridge National Laboratory (ORNL)[23] and the CEC.[24] The rates are shown in the table below, and were held constant over time.

Table 8. Vehicle Maintenance Costs on a Per Mile Basis

Fuel / Vehicle Type	Maintenance Costs ($/mile)
Gasoline	$0.058
Gasoline-Hybrid	$0.054
PHEV-10	$0.043
PHEV-40	$0.043
BEV-100	$0.026
BEV-200	$0.026
FCEV	$0.026

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[23] ORNL, Plug-in Hybrid Electric Vehicle Value Proposition Study, July 2010. Available online: **http://www.afdc.energy.gov/pdfs/phev_study_final_report.pdf**.

[24] CEC, Maintenance Cost Attributes for Light Duty Vehicles, IEPR 2015 Proceedings, September 30, 2015. Available online: **http://bit.ly/1POTus0**.

First Cost of Ownership

ICF combined the three primary aspects of vehicle ownership—vehicle acquisition, vehicle operation costs, and vehicle maintenance costs —into a FCO metric for comparative purposes. The metric presented should not be confused with TCO, which has more assumptions regarding parameters and variables such as vehicle lifetime, VMT, residual value of the vehicle, etc. The next sub-section reviews TCO in more detail. The annual cost of ownership metric reported here is the sum of the following considerations:

- Monthly payment assumed of financing a new vehicle purchase on a six-year loan at an interest rate of 2.5 percent;[25]
- the associated fuel costs of driving a vehicle for 12,000 miles annually; and,
- the associated maintenance costs of driving a vehicle for 12,000 miles annually.

The table below shows the annual costs of vehicle ownership for various vehicle and fuel combinations in 5-year increments. These are just the costs of owning the vehicle for that year—these costs do not include factors such as incentives, future fuel costs over the life of the vehicle, residual vehicle value, etc.

Table 9. First Cost of Ownership for 2015–2030 in California

Fuel / Vehicle Type	Annual Costs ($2015)			
	2015	2020	2025	2030
Gasoline	$6,570	$6,830	$7,000	$7,130
Gasoline-Hybrid	$6,720	$7,220	$7,250	$7,240
PHEV-10	$7,460	$7,530	$7,490	$7,370
PHEV-40	$9,740	$9,010	$8,600	$8,230
BEV-100	$7,920	$7,900	$7,440	$7,130
BEV-200	$9,460	$9,460	$9,520	$8,930
FCEV[26]	$14,450	$13,430	$13,4200	$13,410

The costs in the table illustrate that as California's transportation policies take hold, they help keep costs across the board in check, while also allowing advanced technology vehicles to become more competitive with conventional gasoline and gasoline-hybrid vehicles. For instance, despite forecasted rising fuel prices (a 60 percent increase by 2030 from 2015 levels as shown previously in Table 7) and modest increases to vehicle pricing (largely as a result of the need to comply with fuel economy and tailpipe GHG standards), the increased fuel efficiency of vehicles and reduced VMT yield a vehicle ownership increase of less than 10 percent over the same

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[25] ICF notes that about 50 percent of electric vehicles in California are leased today. The economics of leasing are considerably different than financing a vehicle for ownership. Furthermore, automobile manufacturers are currently offering attractive leasing options, hence the disproportionate number of leased electric vehicles compared to conventional vehicles. For comparative purposes, we assumed that the consumer would own rather than lease the vehicle.

[26] There is other work that concludes that FCEVs using hydrogen will be more cost-competitive in the future, however, these studies generally use more aggressive assumptions regarding the potential for decreasing the costs of hydrogen production than the numbers that we used from the CEC. We did consider high volume hydrogen production, for instance, in our discussion of total cost of ownership (TCO), and illustrated in Figure 6.

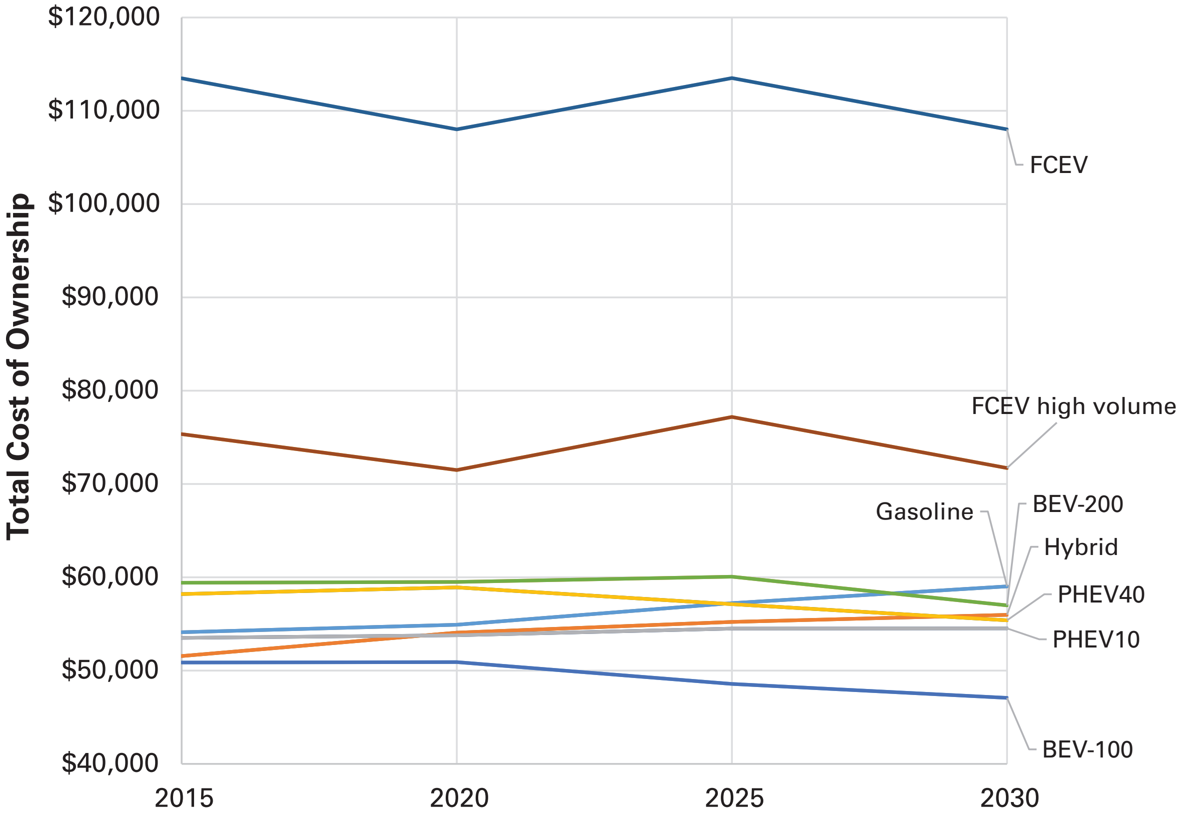
period. Similarly, over that same period electric vehicles become significantly more competitive with conventional vehicles running on gasoline. These numbers would improve for PHEVs, for instance, with increased electrification opportunities (e.g., workplace charging or other opportunities to increase VMT using electricity). In the case of hydrogen in fuel cell vehicles, the combination of very modest vehicle price reductions (via EIA) and forecasted high fuel prices (via the CEC) yield what appears to be a persistently higher annual cost than alternatives. Higher hydrogen production volumes and increased FCEV offerings could conceivably lower these costs.

Total Cost of Ownership

ICF combined the three primary aspects of vehicle ownership—vehicle acquisition, vehicle operation costs, and vehicle maintenance costs—into a TCO metric for comparative purposes. Apart from the parameters already outlined previously, ICF assumed a 10-year vehicle ownership and a discount rate of 5 percent applied to future costs (e.g., fuel and maintenance costs). ICF notes that we also included a variation on the cost of hydrogen for fuel cell vehicles given the high prices forecasted by the CEC (see Table 7). We refer to this as a high-volume estimate, whereby hydrogen costs are $5/gge.

Figure 8 below shows the results of our analysis from 2015–2020 for the various vehicles, including gasoline, gasoline-electric hybrids, PHEV-10, PHEV-40, BEV-100, BEV-200, FCEV, and FCEV in a high volume hydrogen production scenario (FCEV high volume).

Figure 8. Total Cost of Ownership of Fuel/Vehicle Combinations for 2015–2030 ($2015)



The results of our analysis demonstrate that advanced vehicles like PHEVs and BEVs are likely to become more competitive over time as advanced vehicle prices decrease, conventional vehicles become more expensive (e.g., because automobile manufacturers have to comply with more stringent fuel economy regulations), and gasoline prices increase (e.g., as a result of market trends, LCFS, and Cap-and-Trade compliance). In fact, with the exception of FCEVs, the vehicle options considered in our analysis show only a 20 percent spread in TCO by 2030 (between the BEV-100 on the low end and the conventional vehicle using gasoline on the high end). ICF notes that it is unlikely that the BEV-100 will travel the same distances as the other vehicles, therefore the low value reported in the figure is likely over-stated. Despite the variations in the assumption of hydrogen pump prices in the FCEV high volume scenario, the TCO of FCEVs remains consistently higher than other options through 2030, making only modest gains.

Impacts on Travel Time and Congestion

ICF reviewed the most recent RTPs from the MPOs in California's six largest metropolitan areas for information on how their plans affect travel times and congestion:

- Southern California Association of Governments (SCAG), which serves the greater Los Angeles region
- Metropolitan Transportation Commission (MTC), which serves the San Francisco Bay Area
- San Diego Association of Governments (SANDAG)
- Sacramento Area Council of Governments (SACOG)
- Fresno Council of Governments (Fresno COG)
- Kern Council of Governments (Kern COG)

Collectively, the regions served by these six MPOs represent over 70 percent of California's population and experience the majority of the state's congestion. They also have some of the best resources with which to reduce travel times and congestion: robust transit networks, compact neighborhoods where people can walk to destinations, and technical expertise in transportation planning. Each RTP uses performance metrics to assess how the plan impacts the issues that matter most to stakeholders, comparing results under the plan scenario to current conditions or a "no-build" scenario that envisions the future without the transportation improvements contained in the plan. MPOs typically include at least one measure that captures congestion or travel times, including total delay due to congestion, per capita delay due to congestion, and/or average travel time.

Since different MPOs use different metrics, we calculated the percentage change in results between different scenarios to provide a standardized look at impacts on travel times and congestion. Though some MPOs quantify delay or travel times by mode, we drew on results either for all modes or for driving, which is how the majority of Californians commute. RTPs cover different time periods, so we pro-rated the percentage change in delay and travel time to estimate change over the period from 2015 to 2030, consistent with the other benefits quantified in our analysis. Table 10 shows the percent change in delay and travel time between each MPO's plan compared to current conditions and their no-build scenario.

Table 10. Percent Change in Total Delay and Travel Time for Six Major MPOs

MPO	Percent Change in Total Delay		Percent Change in Per Capita Delay		Percent Change in Travel Time	
	Plan vs. Current	Plan vs. No-Build	Plan vs. Current	Plan vs. No-Build	Plan vs. Current	Plan vs. No-Build
SCAG	-5.3%	-38.0%	-13.1%	-35.4%	N/Q	N/Q
MTC	N/Q	N/Q	N/Q	N/Q	0.8%	-2.6%
SANDAG	10.1%	-19.9%	23.8%	-23.3%	N/Q	N/Q
SACOG	16.5%	-31.6%	-3.7%	-27.3%	N/Q	N/Q
Fresno COG	205.4%	-0.2%	N/Q	N/Q	2.8%	0.0%
Kern COG	220.9%	N/Q	N/Q	N/Q	1.6%	-20.3%

Note: "N/Q" indicates an impact was not quantified by the MPO in its RTP.

ICF estimated the annual consumer benefits from reduced congestion in 2030 due to SB 375 using data from the RTPs summarized in Table 10 and data from the 2014 Urban Mobility Scorecard (UMS), which quantifies the cost of congestion based on the amount of time and gas that both commuters and freight vehicles spend in traffic for the majority of U.S. urban areas.[27] For each of the six MPOs in our analysis, we estimated total and per commuter congestion for three scenarios—current conditions, 2030 without SB 375, and 2030 under SB 375—according to the following steps:

- We calculated the total delay experienced by commuters in each urban area. The UMS' estimates of total delay include delay experienced by freight vehicles, which is not as relevant to consumers, so we calculated total commuter delay based on the total number of commuters and the per capita delay experienced by commuters in the UMS data.
- We summed the total 2014 commuter delay and number of commuters for all of the urban areas within the MPO's jurisdiction for each of the six MPOs included in our analysis.[28]
- We estimated the number of commuters in 2030 by applying MPOs' estimates of regional employment growth, pro-rated to 2030, to the current number of commuters from the UMS.

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[27] Texas A&M Transportation Institute. 2015 Urban Mobility Scorecard. Retrieved from **http://mobility.tamu.edu/ums/**. Complete Urban Mobility Scorecard is available at **http://tti.tamu.edu/documents/ums/congestion-data/complete-data.xlsx**.

[28] There are several different geographies used to classify U.S. metropolitan regions. Urbanized areas consist of contiguous, densely-populated areas, and are often used in transportation analyses, including the *Urban Mobility Report* under the assumption that they represent self-contained commute sheds. Metropolitan statistical areas (MSAs), extend to the county boundaries surrounding an urbanized area, and may include more than one urbanized area. MPOs typically have jurisdiction over a single MSA, but in some cases they may serve more than one MSA. For example, MTC serves three MSAs that are centered on San Francisco, San José, and Santa Rosa, respectively.

- We estimated the total amount of commuter delay that would occur in 2030 in the absence of SB 375 by applying the percentage change in total delay between current conditions and the no-build scenario to total commuter delay in 2014.[29] We divided the result by the number of commuters in 2030 to estimate per capita benefits.
- We estimated the total amount of commuter delay that would occur in 2030 under SB 375 by applying the percentage change in total delay between the no-build and RTP scenarios (shown in the third column of Table 10) to total commuter delay in 2030 without SB 375.[30] We divided the result by the number of commuters in 2030 to estimate per capita benefits.

Table 11 shows the amount of delay due to congestion under the three different scenarios we assessed. To calculate the consumer benefits of these delay reductions, ICF applied the same methodology as the UMS, which uses the hourly value of travel time in order to estimate the cost of congestion.[31]

Table 11. Total and Per Capita Delay Due to Congestion Under Current Conditions, No-Build Scenario, and SB 375

MPO	Current Conditions (2014)			2030 without SB 375			2030 with SB 375		
	Total Delay (1000s hrs/yr)	Total Commuters (1000s)	Delay per Commuter (hrs/yr)	Total Delay (1000s hrs/yr)	Total Commuters (1000s)	Delay per commuter (hrs/yr)	Total Delay (1000s hrs/yr)	Total Commuters (1000s)	Delay per Commuter (hrs/yr)
SCAG	562,574	8,810	64	793,374	10,111	78	492,186	10,111	49
MTC	190,501	3,385	56	219,311	3,957	55	213,615	3,957	54
SANDAG	58,716	1,398	42	82,586	1,573	53	66,188	1,573	42
SACOG	38,881	939	41	64,681	1,116	58	44,239	1,116	40
Fresno COG	7,843	341	23	25,070	386	65	25,026	386	65
Kern COG	5,149	271	19	16,458	325	51	13,115	325	40

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[29] Two MPOs, MTC and Kern COG, did not quantify the change in delay between the current and no-build scenarios in their RTP. For MTC, we assumed that the increase in total delay will be proportional to regional employment growth. For Kern COG, so we assumed that the change in delay was equal to the change for Fresno COG since both serve areas with similar transportation and land use characteristics and anticipate similar levels of employment growth.

[30] MTC and Kern COG did not quantify reductions in delay between the no-build and RTP scenarios. Two MPOs, MTC and Kern COG, did not quantify the change in delay between the current and no-build scenarios in their RTP; they quantified the change in travel time instead. We assumed that the change in delay is equal to the change in travel times.

[31] The UMS uses a value of $17.67 per hour to estimate the cost of wasted travel time due to congestion. The UMS also considers the cost of wasted fuel when estimating the cost of congestion, which it calculates based on vehicle speeds, but the RTPs reviewed did not provide sufficient detail on vehicle speeds and volumes for us to duplicate those calculations in our analysis. For more information on the UMS methodology, see **http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/mobility-scorecard-2015-appx-a.pdf**.

Table 12 presents the economic benefit of consumer travel time savings in 2030 for the six major MPOs in California.

Table 12. Total and Per Capita Congestion Benefits of SB 375

MPO	Region	Total Benefits		Per Commuter	
		Reduced Vehicle Delay (1000s hrs/year)	Value of Time Saved ($millions)	Reduced Delay (hrs/yr)	Value of Time Saved
SCAG	Greater Los Angeles	301,188	$5,322	30	$526
MTC	San Francisco Bay Area	5,696	$101	1	$25
SANDAG	San Diego County	16,398	$290	10	$184
SACOG	Greater Sacramento	20,443	$361	18	$324
Fresno COG	Fresno County	44	$1	0	$2
Kern COG	Kern County	3,343	$59	10	$182
Total/Population-weighted average		347,113	$6,133	20	$352

Because of SB 375, ICF estimates that Californians will save 350 million hours that they would have otherwise spent sitting in traffic. The collective value of this time is over $6 billion. This translates into an annual savings of roughly 20 hours and $350 per worker. However, these benefits are not evenly distributed throughout the state. Commuters living and working in greater Los Angeles, which is California's largest metropolitan area and one of the most congested regions in the country, receive some of the largest benefits, as do those in the Sacramento region. Meanwhile, the San Francisco Bay Area and Fresno County also see benefits, but at a reduced level.

Avoided Damage Costs

Alternative fuels and advanced vehicles have a variety of benefits and costs: Apart from the traditional financial metrics and macroeconomic impacts associated with alternative fuel use, ICF considered several environmental and energy security externalities in the context of California's transportation policies, including: 1) reduced criteria air pollutants, 2) reduced GHG emissions, and 3) displaced petroleum. These externalities were monetized based on the most recent research corresponding to each externality.

Reduced Air Quality Pollutants

ICF used damage costs reported by EPA in rulemakings. ICF considered reduced damages from reductions in nitrogen oxides (NOx), volatile organic compounds (VOCs), and particulate matter (PM2.5). NOx and VOC combine in the presence of sunlight to produce ozone; particulate matter is a pollutant linked to respiratory problems. Damage costs represent the monetary value of avoided mortality and morbidity, and are reported on a dollar per ton basis.[32] In the case of PM2.5, the damage costs are dependent on the location of emission reductions. Areas with higher population density, for instance, tend to have higher damage costs than less populated areas.

- PM2.5 emitted in Los Angeles County has a damage cost of about $2.3 million per ton.
- PM2.5 emitted in Sacramento County has a damage cost of about $1.0 million per ton.

These damage cost values simply reflect the differences in population between California's most and least populated counties. For the purposes of this analysis, ICF assumed that criteria pollutant reductions attributable to transportation-focused carbon reduction policies will be uniform across the State. ICF developed a population-weighted average for the damage cost of PM2.5 in California based on data from the EPA Diesel Emissions Quantifier.[33] California's population weighted damage cost for PM2.5 is $1,572,048 per ton.

GHG Emissions Reductions

California's LCFS and Cap-and-Trade policies will result in significant economic benefits associated with avoiding damages caused by incremental increases in carbon emissions. Scientific modeling predicts that increasing carbon dioxide emissions will negatively affect net agricultural productivity, human health, property damages from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning. The monetized value of these damages is referred to as the Social Cost of Carbon (SCC). To estimate the economic impact of carbon reductions resulting from LCFS and Cap-and-Trade, ICF applied the most recent SCC damage cost estimates from the Interagency Group on Social Cost of Carbon using a 5 and 2.5 percent discount rate (presented in Table 13 below) to the GHG emissions reductions resulting from CARB's illustrative LCFS compliance scenario.[34]

Table 13. Social Cost of Carbon (2007$/metric Tonne CO_2)

Discount Rate	2015	2020	2025	2030
5.00%	$11.0	$12.0	$14.0	$16.0
3.00%	$36.0	$42.0	$46.0	$50.0
2.50%	$56.0	$62.0	$68.0	$73.0
3%, 95th percentile	$105.0	$123.0	$138.0	$152.0

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[32] Monetary values are based on avoided incidences of the following health effects: premature mortality, chronic bronchitis, acute bronchitis, upper and lower respiratory symptoms, asthma exacerbation, nonfatal heart attacks, hospital admissions, ER visits, work loss and restricted activity days.

[33] United States Environmental Protection Agency. Diesel Emissions Quantifier (DEQ). **http://www2.epa.gov/cleandiesel/diesel-emissions-quantifier-deq**.

[34] United States Government, Interagency Group on Social Cost of Carbon. July 2015. Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis -Under Executive Order 12866 Table A-1: Annual SCC Values: 2010–2050. Retrieved from **https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf**.

Petroleum Reductions

Petroleum displacement via alternative fuels and demand reduction through carbon pricing will lead to improved energy security. As outlined in a report by Paul Leiby from Oak Ridge National Laboratory regarding energy security benefits, energy security concerns arise from three problems: the concentrated crude oil supply in an historically unstable region; sustained exercise of market power by oil exporting countries; and the vulnerability of the economy to oil supply shocks and price spikes. Leiby estimates the benefits of energy security focusing on two components:

- Monopsony Component: This component reflects the effect of US import demand on the long-run world oil price. The US remains a sufficiently large purchaser of foreign oil supplies that it affects global oil pricing. This demand is characterized as monopsony power.
- Macroeconomic Disruption / Adjustment Costs: The second component of Leiby's analysis focuses on the effect of oil imports on disruptions such as a sudden increase in oil prices. These price spikes increase the costs of imports in the short run and can lead to macroeconomic contraction, dislocation, and GDP loss.

The most recently available results from Leiby's analysis regarding the monetized benefits of decreasing oil imports are shown in the table below for the years 2013 and 2022. ICF used the mean values and assumed a linear relationship between 2013 and 2022 to calculate the annual discrete values for energy security.

Table 14. Economic Benefits of Petroleum Reductions

Component	2013 ($/bbl)		2022 ($/bbl)	
	Mean	Range	Mean	Range
Monopsony	11.40	3.83–19.40	9.82	3.27–16.77
Disruption Costs	7.13	3.41–10.35	7.84	3.80–11.30
Total	18.53	10.03–26.74	17.66	9.88–24.99

Source: Leiby, EPA-HQ-OAR-2010-0133-0252, September 2012

Summary of Avoided Damage Cost Impacts

California's transportation policies will result in significant economic benefits associated with avoiding damages from emissions and petroleum dependency. Table 15 and Table 16 present our findings for the emissions and petroleum reductions achieved by LCFS, Cap-and-Trade, and the ZEV Program and their estimated economic impact. For PM2.5, NOx, VOC, and GHG reductions, we present low and high estimates for the monetized impacts; these are linked to different assumptions regarding the discount rate applied to the damage function.[35]

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[35] The low and high estimates for PM2.5, NOx, and VOC emissions are presented using a 7 and 3 percent discount rate, respectively. The low and high estimates for GHG reductions are presented using a 5 and 2.5 percent discount rate, respectively.

As shown in Table 16 below, we calculate $3.0–4.8 billion in avoided costs as a result of California's transportation policies, depending on the discount rate employed with various damage functions.

Table 15. Emissions and Petroleum Reductions from California's Low Carbon Transportation Policies

Pollutant	2015	2020	2025	2030
PM2.5 reductions, tons per day	0.0	0.3	1.1	1.9
NOx reductions, tons per day	0.1	10.0	26.5	37.7
VOC reductions, tons per day	0.0	3.8	14.7	29.3
GHG reductions, MMT CO_2e	4.2	12.5	23.3	26.7
Petroleum reduction, million barrels	11.9	27.5	50.7	59.0

Table 16. Avoided Costs from California's Low Carbon Transportation Policies (2015$MM/year)

Pollutant	Case	2015	2020	2025	2030
PM2.5 reductions	Low	$0	$214	$561	$1,185
	High	$0	$225	$591	$1,249
NOx reductions	Low	$0	$19	$45	$72
	High	$0	$21	$50	$80
VOC reductions	Low	$0	$4	$13	$35
	High	$0	$5	$14	$38
GHG reductions	Low	$53	$171	$373	$488
	High	$268	$885	$1,811	$2,228
Petroleum reductions		$241	$554	$1,068	$1,241
Total Avoided Costs	Low	$294	$962	$2,060	$3,021
	High	$509	$1,690	$3,534	$4,836

Appendix: Compliance Assumptions

Low Carbon Fuel Standard

We employed CARB's illustrative compliance scenario, updated in April 2015, to estimate the consumer impacts of LCFS compliance from 2015 to 2030. CARB's illustrative scenario makes assumptions about compliance into 2025. We have summarized CARB's assumptions into the three "buckets" listed below:

- **Feedstock switching:** CARB's compliance scenario assumes that corn ethanol will be switched out and replaced with a mix of sugarcane, cellulosic, and molasses ethanol. As mentioned earlier, ethanol is blended with gasoline to reduce the carbon intensity of the fuel. Currently, corn ethanol has a high carbon intensity ranging from 77 to 97 gCO_2e/MJ. Sugarcane ethanol produced and shipped from Brazil has a lower carbon intensity ranging from 63 to 73 gCO_2e/MJ and cellulosic ethanol has an even lower carbon intensity ranging from 25 to 35 gCO_2e/MJ. CARB's scenario assumes that switching ethanol feedstock will be a main strategy used to comply with LCFS:

Table 17. Feedstock Switching in CARB's LCFS Compliance Scenario

Fuel Type	Change	Fuel Volumes (MGPY)		
		2014	2020	2025
Corn Ethanol	Decrease	1,250	700	320
Cane Ethanol	Increase	2.5	450	500
Sorghum/Corn/Wheat Ethanol	Increase	59	75	75
Cellulosic Ethanol	Increase	0	100	400
Molasses ethanol	Increase	6	60	60

- **Increase biofuel blending:** CARB's compliance scenario indicates that the agency expects an increase in biofuel blending in order to adhere to the LCFS. Biofuel blending will displace the use of gasoline or diesel and decrease the carbon intensity of fuel. Biofuel blending includes using renewable gasoline, higher blends of ethanol (greater than 10 percent ethanol in blends), biodiesel, and renewable diesel. The following assumptions are made in CARB's scenario:
  - Increase in renewable gasoline to 25 MGPY by 2020; 10x increase to 2025 (to 250 MGPY)
  - Increase in biodiesel from 2014 to 2020 by 115 MGPY; slow increase to 190 MGPY by 2020

  - Renewable diesel increases to 400 MGPY in 2020; to 600 MGPY by 2025
  - Decreasing amount of diesel used by 8 percent from 2014 to 2020—this affects cap and trade
  - Increase in biodiesel in fuel mix from 1.8 percent in 2014 to 4.7 percent in 2020; this flattens to 4.8 percent by 2025
  - Increase in renewable diesel in fuel mix from 3.1 percent in 2014 to 10.5 percent in 2020; continues to increase to 15.3 percent in 2025.

- Increase in alternative fuels: CARB's compliance scenario assumes there will be an increase in the deployment of advanced vehicle technologies that use natural gas, electricity, and hydrogen. The following bullets reflect CARB's assumptions regarding the role that alternative vehicles will play in LCFS compliance:
  - Increase in hydrogen from 2014 to 2020 by 7 MGPY; consistent with ZEV Likely Compliance Scenario
  - Increase in electricity (per ZEV Program; discussed more below) for both LDVs and HDVs. For LDVS, electricity increases to 1629 thousand MWH in 2020; rapidly increases to 4374 thousand MWH in 2025. Electricity for HDVs increases to 900 thousand MWH in 2020; remains constant at 900 thousand MWH to 2025
  - Natural gas increases as well:
    - Fossil CNG decreases by 36 percent from 86.3 mm gal DGE in 2014 to 55 mm gal DGE in 2020; continues to decrease to 35 mm gal DGE in 2025
    - RNG increases by 883 percent from 23.4 mm gal DGE in 2014 to 230 mm gal DGE in 2020; 2x increase by 2025 to 250 mm gal DGE

Light-Duty GHG Standards

ICF used fuel economy values derived from the EMissions FACtor model, developed and maintained by the California Air Resources Board. The EMFAC model is widely used in California for these types of analyses and is the most robust tool available.

ZEV Program

ICF's analysis assumes that the ZEV Program is implemented according to CARB's likely compliance scenario; however, an alternative compliance scenario is conceivable whereby automobile OEMs accumulate banked credits in the early years of the regulation to put downward pressure on their compliance burden in later years. This compliance scenario has the potential to reduce the number of ZEVs on the road in later years by 200,000–250,000 vehicles.

SB 375 Sustainable Communities Strategies

For the purposes of this report, ICF did not modify SB 375 compliance outlined by each MPO that has submitted a plan; rather, we estimated regional and state-level VMT reductions based on the SCS plans that have been submitted to date.

Cap-and-Trade

The impacts of Cap-and-Trade Program are exclusively linked to the amount of transportation fuel—gasoline and diesel—that regulated parties sell into the market. As such, there is no version of compliance. Rather, the Cap-and-Trade Program is linked to how other complementary programs reduce the demand for petroleum-based fuels.

Estimates of compliance costs are based on projections of allowance prices. ICF reviewed the following price forecasts in the process of selecting which projections to use in our estimates:

- The March 2010 Updated AB 32 Plan Economic Analysis conducted by CARB. The modeling approach assumed allowance prices would rise exponentially at a fix percentage each year—starting out at $17.46 in 2012 and rising 7 percent annually to $30.00 in 2020.[36]
- Point Carbon's February 2011 allowance price projections which forecast prices would rise from about $13 per metric ton in 2012 to $75 per ton in 2020.[37]
- Point Carbon's revised September 2013 allowance price projections which forecast prices would rise from about $11 per metric ton in 2013 to $15 per ton in 2020. This updated forecast predicts that the carbon market would be oversupplied with allowances through 2019, which would make it likely that allowance prices remain near the floor through 2020.[38]
- ICIS Industries' January 2015 allowance price forecast of $30–$70 by 2030. The forecast notes that an ambitious target and program structure through 2030 could lift prices significantly and that this range represents various levels of ambitions of the 2030 target and associated policies. In addition, ICIS expect a shortage of offsets through 2020 and beyond.[39]
- Since the ICIS report is reflective of the most current market trends, considers fuels under the cap, and provides a range of prices, ICF used these projections as the basis of our low, medium, and high allowance price assumptions.

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[36] CARB. March 2010. Updated Economic Analysis of California's Climate Change Scoping Plan. Pg. 28. Retrieved from **http://www.arb.ca.gov/cc/scopingplan/economics-sp/updated-analysis/updated_sp_analysis.pdf**.

[37] Thomson Reuters Point Carbon. February 17th, 2011. California 2020 Carbon Price Seen at $75. Retrieved from **http://www.reuters.com/article/us-california-carbon-report-idUSTRE71G3GY20110217**.

[38] Thomson Reuters Point Carbon. September 10th, 2013. Thomson Reuters Point Carbon Lowers California Carbon Price Forecast by Two Thirds. Retrieved from **http://www.nacleanenergy.com/articles/16827/thomson-reuters-point-carbon-lowers-california-carbon-price-forecast-by-two-thirds**.

[39] ICIS. January 2015. ICIS launches 2030 Forecast for California Carbon Allowances press release. Retrieved from **http://www.icis.com/press-releases/icis-launches-2030-forecast-for-california-carbon-allowances/**.

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