DOCKETED

Docket Number:	15-IEPR-10
Project Title:	Transportation
TN #:	210539
Document Title:	Transportation Energy Demand Forecast, 2016-2026
Description:	CEC Staff Draft Report
Filer:	Laura Laurent
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	2/26/2016 10:19:49 AM
Docketed Date:	2/26/2016

California Energy Commission

STAFF DRAFT REPORT

Transportation Energy Demand Forecast, 2016-2026

California Energy Commission

Edmund G. Brown Jr., Governor

February 2016 | CEC-200-2015-008-SD

California Energy Commission

Aniss Bahreinian
Eva Borges
Jesse Gage
Bob McBride
Gordon Schremp
Ysbrand van der Werf
Gary Yowell
Primary Authors

Gene Strecker
Project Manager

Elise Brown
Manager
DEMAND ANALYSIS OFFICE

Sylvia Bender
Deputy Director
ENERGY ASSESSMENTS DIVISION

Robert P. Oglesby
Executive Director

ACKNOWLEDGEMENTS

Staff Providing Support

Leon Braithwaite

Dawn Chan (student intern)

Lynn Marshall

John Michel

Organizations/Individuals

Stanfield Systems Incorporated/Tim Jacobs

Christensen Associates/Brad Wagner

Sierra Research, Inc./Thomas Carlson, James Lyons, Matthew Malchow

Aspen Environmental Group/Marshall Miller

California Air Resources Board/Anna Wong

ABSTRACT

This report, prepared by California Energy Commission staff in support of the *2015 Integrated Energy Policy Report*, provides long-term forecasts of California's transportation energy demand and fuel prices. These forecasts support analysis of petroleum reduction and efficiency measures, introduction and commercialization of zero-emission vehicles, alternative fuels, alternative fuel infrastructure requirements, and energy diversity and security. The magnitude of future contributions from efficiency improvements and various alternative fuels and technologies is uncertain. Energy Commission staff found that efficiency and emerging fuels and technologies can displace potentially significant amounts of petroleum, which may reduce the need for petroleum-specific infrastructure enhancements. Many of these alternative fuels, however, may require additional infrastructure, including production facilities, pipelines, and storage tanks. Moreover, transportation-related industries must develop the means to distribute these emerging fuels (including electricity, natural gas, and hydrogen) through both public and home refueling and recharging systems and align the installation of these sites and technologies with the rollout of appropriate numbers of vehicles.

Keywords: California, energy, demand, forecast, transportation, gasoline, diesel, jet fuel, crude oil, electricity, natural gas, hydrogen, prices, light duty, vehicles, medium duty, heavy duty, high-speed rail, internal combustion engine, renewable fuels, zero-emission vehicles, alternative fuels, consumer preference, behavioral models, recharging

Please use the following citation for this report:

Bahreinian, Aniss, Eva Borges, Jesse Gage, Bob McBride, Gordon Schremp, Ysbrand van der Werf, Gary Yowell. 2015. *Staff Draft Report, Transportation Energy Demand Forecast, 2016-2026*. California Energy Commission. Publication Number: CEC-200-2015-008-SD.

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Background

With more than 46,500 miles of interconnected highways, more than 29 million vehicles on California roads, and delivery ports for a large share of U.S. international trade, the transportation sector plays an important role in California's economy and is responsible for a large share of the greenhouse gas emissions in the state. Senate Bill 1389 (Bowen, Chapter 568, Statutes 2002) requires the California Energy Commission to conduct "assessments and forecasts of all aspects of energy industry supply, production, transportation, delivery and distribution, demand, and prices to develop policies for its *Integrated Energy Policy Report*." The Energy Commission develops long-term projections of California transportation energy demand that support its analysis of petroleum reduction measures, introduction and commercialization of alternative fuels, transportation fuel infrastructure requirements, and energy diversity and security.

While the Energy Commission expects consumption of transportation energy in California to increase under a variety of fuel price and regulatory conditions, there are uncertainties associated with the future contributions of various renewable and alternative transportation fuels and technologies. These emerging fuels are expected to displace substantial amounts of petroleum fuel products, which would reduce the need for petroleum-specific infrastructure enhancements. However, each of these alternative fuels has a set of marketing, supply, infrastructure, and regulatory challenges affecting market penetration. Moreover, transportation-related energy industries must develop the means of distributing these emerging fuels through public retail refueling and recharging sites and home refueling and recharging systems, and aligning the installation of these systems with the rollout of appropriate numbers of vehicles. Various recently passed bills and executive orders address the infrastructure needs of zero-emission vehicles and advance renewable fuels, related infrastructure, and market penetration in California.

CHAPTER 1: Introduction to Transportation Energy

Transportation has an important role in California's economy and requires a large amount of energy, which contributes 37 percent of all greenhouse gas (GHG) emissions in California. State and federal policies encourage the development and use of renewable and alternative fuels and vehicle technologies to reduce California's dependence on petroleum-based fuels, cut GHG emissions, and promote sustainability. Former California Governor Arnold Schwarzenegger's Executive Order S-03-05 requires a reduction in statewide GHG emissions to 80 percent below 1990 levels by 2050. This was followed by California Governor Edmund G. Brown Jr.'s Executive Order B-30-15, establishing a 40 percent GHG reduction goal for 2030.

While California continues to lead the nation in the growth of renewable and alternative transportation fuels and vehicle technologies, the California Energy Commission's transportation energy demand forecast, presented at a workshop on November 24, 2015[1] indicates that gasoline and diesel will continue to be the primary sources of transportation fuel through 2026. California's transportation sector has grown with population and the economy, but due to environmental policies, innovation, and technological growth, the transportation sector has become more energy-efficient. Between 2005 and 2014, per capita consumption of transportation energy in California declined by 14.5 percent.

Transportation energy is used for moving people and goods for personal and commercial purposes, in light duty vehicles (LDVs), medium duty vehicles (MDVs), and heavy duty vehicles (HDVs), using multiple travel modes on the ground, in the air, and at sea. LDVs serve the personal transportation needs of the residential and commercial sectors, as well as the overall needs of the rental and government sectors. LDVs compete with bus and rail in urban (local) travel and with bus, rail, and airplanes in intercity (long-distance) travel. MDVs and HDVs are used in mass transit of people, services, and in freight transport, where they compete with rail and air freight. Heavy duty trucks also provide services for local activities, such as construction and refuse movement, in the absence of competition from other modes. The *Transportation Energy Demand Forecast, 2016-2026* covers all of these activities in all sectors, accounting for vehicle populations, their fuel economies, as well as vehicle miles traveled (VMT).

This report presents the staff forecasts of vehicles and transportation energy demand for fuel types and vehicle technologies that exist in California markets, as well the vehicle technologies that are projected to penetrate in some vehicle classes in the future. This *Transportation Energy Demand Forecast, 2016-2026* accounts for fuel and vehicle substitutions in five behavioral

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1 http://docketpublic.energy.ca.gov/PublicDocuments/Forms/AllItems.aspx?FolderCTID=0x012000854EBC55F6E2AC47926325FA751AA84F&View={e5456901-115a-4dca-85a3-f2f8b644f541}&RootFolder=%2FPublicDocuments%2F15-IEPR-10&TreeField=Folders&TreeValue=15-IEPR-10&ProcessQStringToCAML=1&SortField=Modified&SortDir=Desc

models, each representing one transportation or vehicle sector. Furthermore, three growth models represent government, rental, and neighborhood electric vehicles. This group of models was used to generate six forecast cases, including high, mid, and low energy demand cases. The models were also used to generate electricity and natural gas demand, as well as three transportation-specific demand cases covering high and low petroleum demand and high alternative fuel demand. Staff used the California High-Speed Rail Authority forecast of high-speed rail (HSR) electricity demand, and added that electricity demand to the total electricity demand in the mid case mentioned above.[2] An aggregate model was used to generate jet fuel demand for the aviation sector, and staff worked with a consultant on projecting off-road transportation electrification.

The forecast used inputs based on staff analysis of U.S. Energy Information Administration (EIA), California Board of Equalization (BOE), California Department of Motor Vehicles (DMV), California Department of Transportation (Caltrans) and Federal Aviation Authority (FAA) data, as well as a variety of input data from multiple sources including California Air Resources Board's (ARB) emissions (EMFAC) model, Argon National Laboratory's Truck 5 model, and Sierra Research.

This report presents staff's *Transportation Energy Demand Forecast, 2016-2026*. Chapter 2 discusses the trends in the transportation energy sector. Chapter 3 explains the inputs and assumptions used in the transportation energy demand forecast. Chapter 4 presents the vehicle demand forecast and the transportation fuel demand forecasts. Unless specifically mentioned as off-road or including off-road, all references to transportation energy imply only on-road transportation energy demand. In this report, off-road applications include vehicles and fuel used in agriculture, construction, and marine port activities.

2Further discussion of the reasons to add high speed rail electricity demand to only one demand case can be found in Chapter 4 in the section titled "High Speed Rail Demand Forecast"

CHAPTER 2: Recent Transportation Trends

The transportation sector in California is an important part of California's economy and was responsible for 37 percent of GHG emissions in California in 2013.[3] Therefore, it is important to place the forecast in the historical context of the transportation sector. This chapter opens with a discussion of historical trends in fuel consumption, namely gasoline, diesel, natural gas, jet fuel, and off-road consumption. This is followed by trends in vehicles, including vehicle stock and ownership, sales prices, and fuel economy. A discussion on travel volume concludes this chapter.

Fuels

For decades, the concept of "transportation fuel" nearly always implied one of two things: gasoline or diesel. Today there are numerous choices when it comes to transportation fuel, including ethanol, natural gas and electricity. Hydrogen is also making its initial entry into the market. Comparing these disparate fuels requires a common unit of comparison, as the energy content of one gallon of gasoline is not equal to one gallon of diesel, and electricity is not measured in gallons. The most widely used cross-fuel measurement of transportation energy is the gallon of gasoline equivalent (GGE). A GGE is the amount of fuel required to equal the energy content of one liquid gallon of gasoline. In mathematical terms, a GGE is the number of British thermal units (BTU) per unit of gasoline divided by the number of BTUs per unit of alternative fuel.[4] Throughout this report, alternative fuels are often referred to in terms of their GGE. For example, one gallon of gasoline is equivalent to 118,000 BTUs and one kWh of electricity is equivalent to 3600 BTUs. Therefore, one GGE of electricity is 118,000 divided by 3600, or 32.78 kWh. A complete list of GGEs and BTUs for all fuels in the transportation energy demand forecast can be found in Appendix A.

More than 22.2 billion GGE were consumed in California in 2014. Gasoline and diesel are the primary fuels used in the transportation sector, including 14.7 billion gallons of finished gasoline and 3.8 billion gallons of diesel in 2014. Generally, gasoline is used primarily to fuel personal automobiles, diesel is the primary fuel for goods movement and long distance transit, and natural gas is the primarily fuel for short-distance urban mass transit.

Figure 2-1 shows the percentage of total fuel distribution by fuel type. While there is a clear decline in the gasoline share, gasoline still accounts for the highest percentage of total transportation fuels. In 2014, ethanol represented 4.5 percent of total transportation energy

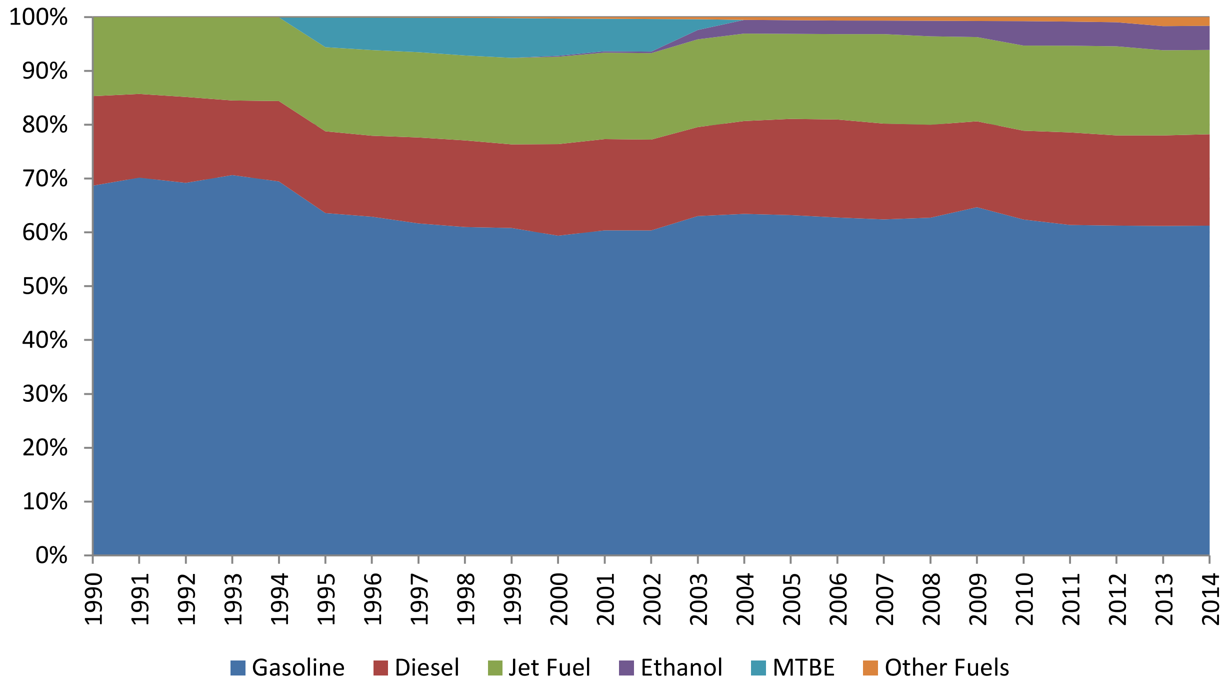
3 http://www.arb.ca.gov/cc/inventory/data/data.htm

4 A BTU is defined to be the amount of energy (or heat) required to raise the temperature of one pound of water by one degree Fahrenheit.

consumption, and other alternative fuels contributed 1.7 percent, for a total of 6.2 percent being attributed to renewable and alternative fuels. Fuel demand increased 12.6 percent between 1990 and 2014, or about 2.8 billion GGE, and population, a primary driver of fuel demand, grew 28 percent, resulting in lower consumption per capita.

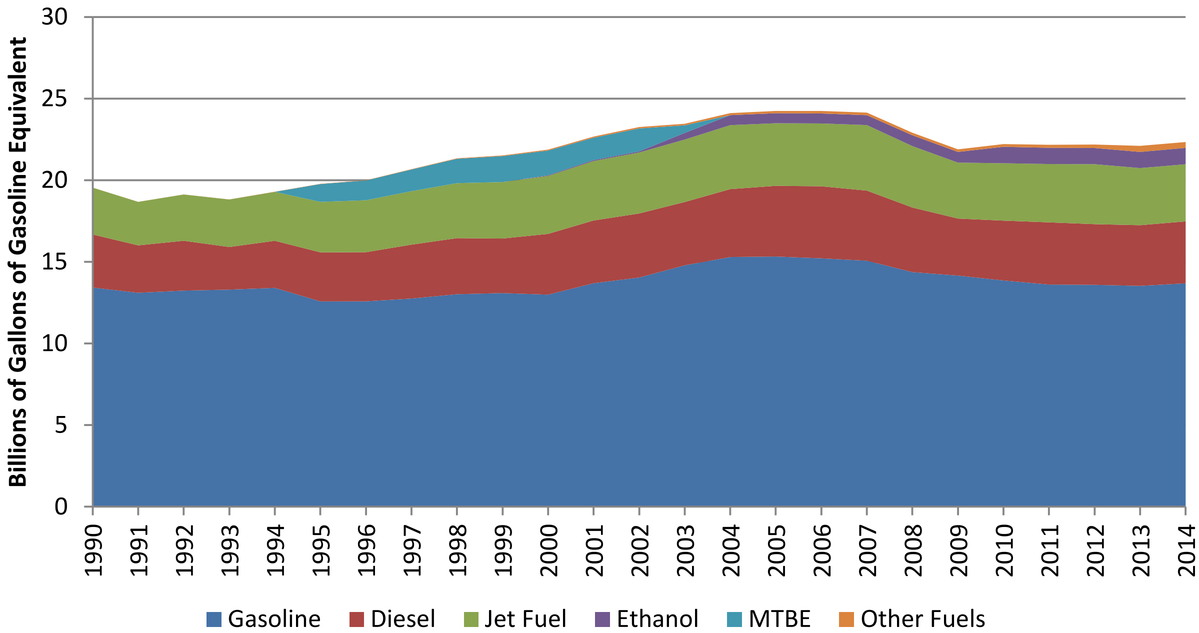
Figure 2-2 shows the transportation fuel volume changes over the last 24 years in GGE. The use of methyl tertiary butyl-ether (MTBE) as an octane booster to finished gasoline began in 1995, but was prohibited in 2003. Ethanol has since taken its place as shown in Figure 2-2.

Figure 2-1: California Transportation Energy Fuel Distribution by Fuel Type, 1990-2014



Source: California Energy Commission analysis of BOE sales reports. "Diesel" includes on- and off-road diesel. "Ethanol" includes ethanol used as an octane booster to gasoline as well as E85. "Other Fuels" includes aviation gasoline, biodiesel, electricity, hydrogen, natural gas, and propane.

Figure 2-2: California Total Transportation Energy Consumption, 1990-2014



Source: California Energy Commission Analysis of BOE, Petroleum Industry Information Reporting Act, and industry sales reports. See Figure 2-1 for explanation of categories.

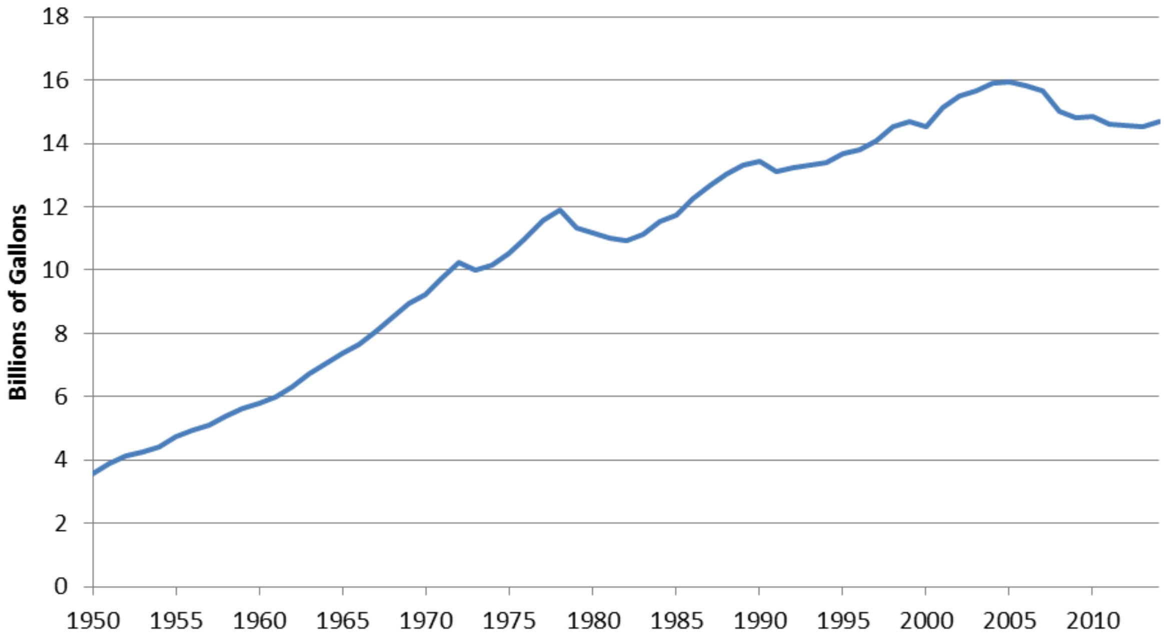
Gasoline Consumption

On a per gallon basis, gasoline is the most widely used transportation fuel in California. Within the transportation sector, gasoline is primarily used by LDVs. In 2014, gasoline powered 91 percent of the LDV fleet in California (6 percent less than 2004), and 87 percent of the fleet was for personal use.[5] With this strong link to personal vehicle ownership, gasoline demand is primarily influenced by household travel behavior. Factors that influence gasoline consumption include income, fuel prices, VMT, unemployment, population, vehicle stock, fuel efficiency or fuel economy, and alternative fuel consumption.

Gasoline consumption in California increased until 2005 but was then interrupted by fuel price hikes and the recession and began to slide in 2006, as seen in Figure 2-3. The 2014 decline in crude oil and gasoline prices, along with the growing strength of the economy, show an uptick, not necessarily a trend, in gasoline consumption in 2014.

5 Ninety-eight percent is the sum of traditional gasoline powered, hybrid, and flex-fuel vehicle percentages of the total LDV fleet. Personal ownership is determined through Energy Commission analysis of the DMV vehicle registration database.

Figure 2-3: California Gasoline Consumption 1950-2014

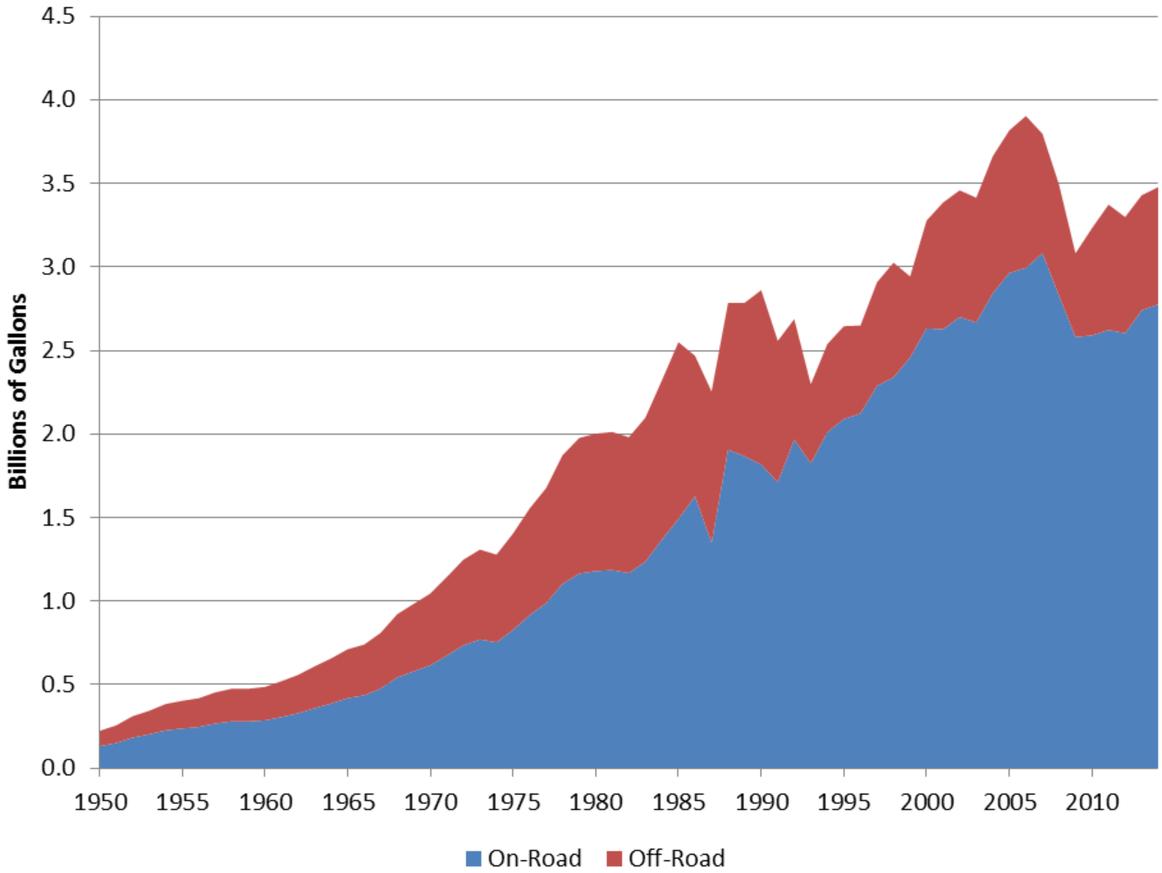


Source: California Energy Commission Analysis of BOE taxable gasoline sales (excludes aviation gasoline)

Diesel Consumption

Diesel is consumed for on-road passenger transportation in California, goods movement, and off-road applications such as agriculture, construction, and ports (see Figure 2-4). The off-road diesel volume in this graph includes diesel used in rail, transport, by the military, and by equipment for farming and construction.

Figure 2-4: Diesel Consumption in California, On-Road and Off-Road, 1950-2014



Source: California Energy Commission analysis of BOE data

Diesel consumption in California has grown with the economy and freight movement from less than half a billion gallons in 1950 to almost 4 billion gallons in 2005. Diesel consumption dropped significantly in 2008 due to the Great Recession, though diesel consumption has been increasing as the economy recovers.

Off-Road Fuel Consumption

Energy Commission staff relies on the EIA estimate of off-road diesel for the demand forecast. The EIA estimate includes rail diesel in off-road, while the Energy Commission forecast includes rail diesel in the on-road transportation energy demand forecast, and excludes military use from the demand forecast entirely. Off-road diesel demand fluctuates with the economy, since it includes construction, industrial, agricultural, and other sectors directly influenced by economic activity.

Staff used the following categories of the EIA's estimate of off-road diesel:

- Residential
- Commercial
- Industrial

- Oil Companies
- Farms
- Electric Utilities
- Vessel Bunkering
- Off-Highway

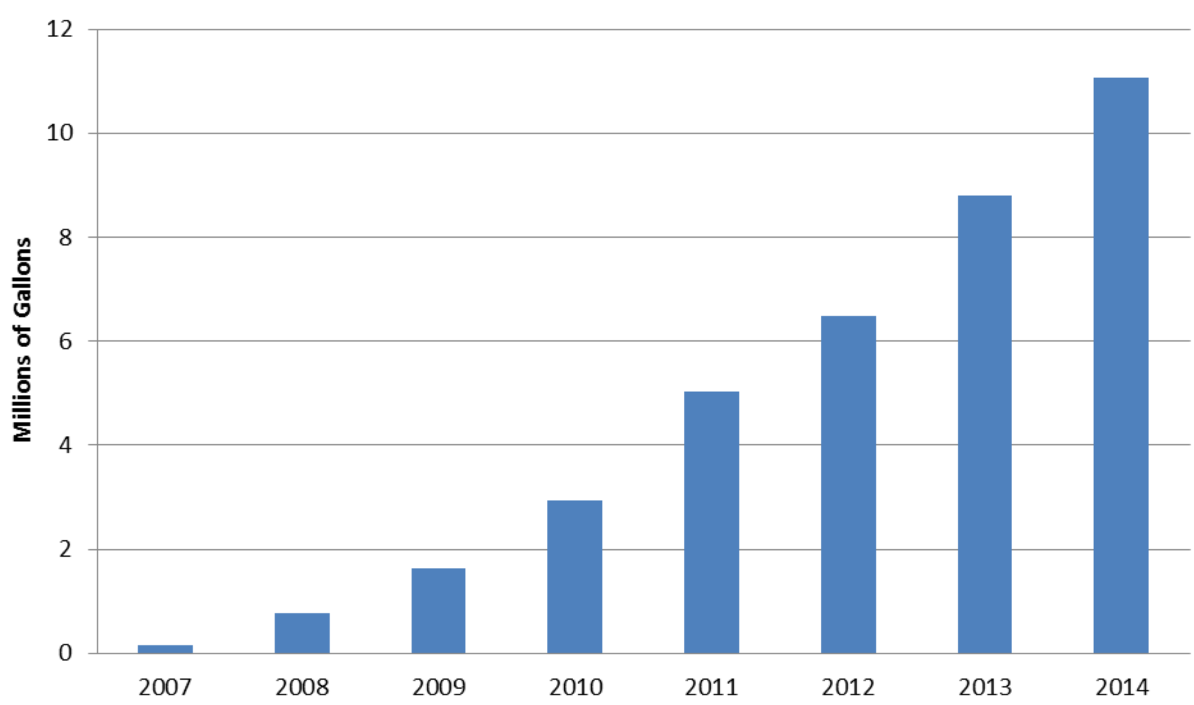
EIA data show California off-road diesel consumption to average 817 million gallons annually over 2010-2013.

Marine transportation is not separately accounted for, except for boats fueling within the state and for in-state transportation. Based on reporting by the BOE, staff estimates about 3 percent of gasoline sold in California is used for off-road purposes, such as boats, garden equipment, motorcycles, recreational all-terrain vehicles, jet skis, and the like.

E85

In California, ethanol is blended into gasoline as an oxygenate. Under current regulations, retail gasoline may contain up to 10 percent ethanol for this purpose, known as E10 or finished gasoline. Flex-fuel vehicles (FFV) can be fueled with either E10 or E85, which consists of 85 percent ethanol and 15 percent gasoline. FFVs are solely responsible for E85 consumption in California, as shown in Figure 2-5.

Figure 2-5: E85 Consumption in California, 2007-2014



Source: Air Resources Board Test Program Exemption E85 Monthly Reports

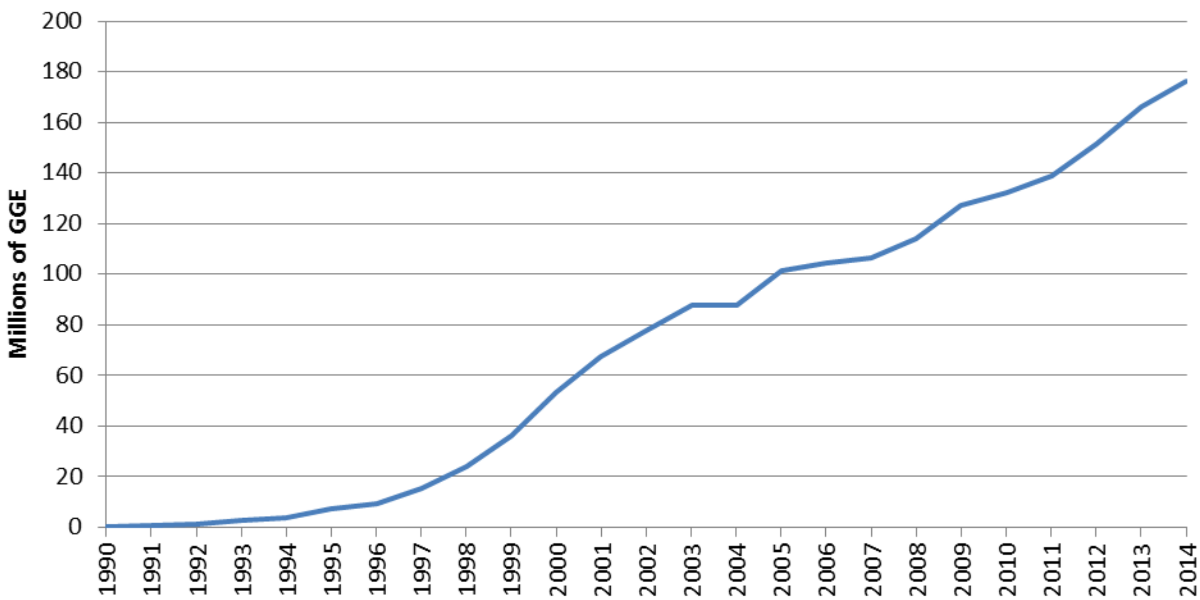
Annual E85 consumption has grown from less than half a million gallons in 2007 to more than 11 million gallons in 2014 when there were more than one million flex-fueled vehicles on

California roads. While there has been significant growth in overall E85 consumption, the per-vehicle consumption remains very low at about 10 gallons. This indicates that while flex-fuel vehicles have the ability to use E85, they are using gasoline the majority of the time.

Transportation Natural Gas

Compressed natural gas (CNG) can be used to fuel LDVs, MDVs, and HDVs, while liquefied natural gas (LNG) is limited to only HDVs. Consumption of natural gas[6] in California's transportation sector has grown from less than one million GGE in 1991 to almost 180 million GGE in 2014, as seen in Figure 2-6. Natural gas is used in the transportation sector primarily to fuel urban transit buses and in the South Coast Air Quality Management District where rules require alternative fuel trucks and buses.

Figure 2-6: Transportation Natural Gas, 1990-2014



Source: California Energy Commission analysis

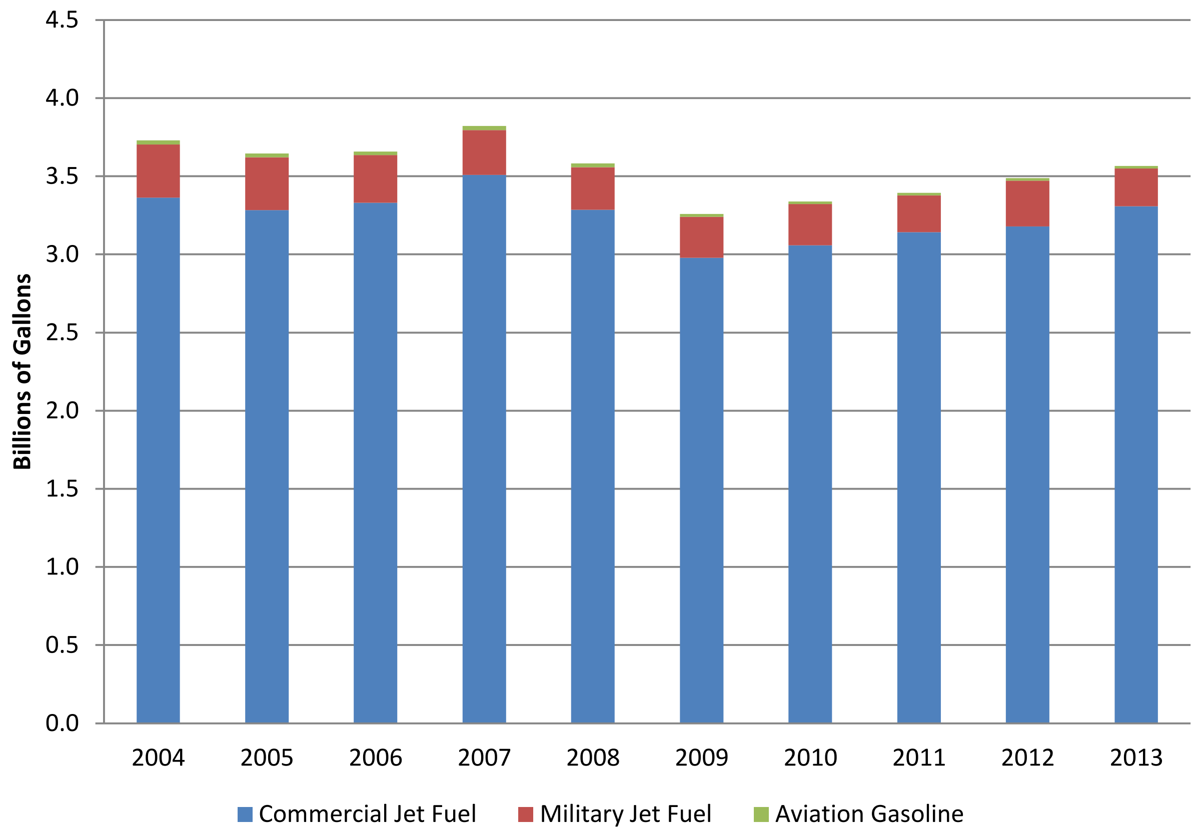
Jet Fuel Consumption

California aviation fuels consist primarily of commercial jet fuel, followed by military jet fuel and aviation gasoline (used in small private planes). Commercial jet fuel dominates California aviation fuel use, accounting for 91.4 percent of the total over the last decade, while military jet fuel accounted for 8 percent, and aviation gasoline only 0.6 percent.[7] Figure 2-7 shows the relative contribution from the various uses and types between 2004 and 2013.

6 Natural gas as a transportation fuel can take two forms: Compressed natural gas (CNG), which serves as fuel for LDVs, MDVs, and HDVs; and liquefied natural gas (LNG), which is limited to HDVs.

7 California aviation fuel consumption in California in 2013 amounted to 3,307 million gallons commercial jet fuel, 242 million gallons of military jet fuel, and 16 million gallons of aviation gasoline.

Figure 2-7: Aviation Fuel Consumption by Use and Type



Sources: California Energy Commission analysis of BOE, Defense Logistics Agency, and Petroleum Industry Information Reporting

Like other sectors, aviation experienced a significant decline in 2009 in response to the Great Recession. Jet fuel demand has been steadily growing since 2009 to reach more than 3 billion gallons of jet fuel consumption, meeting increased demand for air travel within California, between states, and internationally.

Vehicles

The Energy Commission receives biannual snapshots of the DMV's vehicle registration database. In 2014, there were more than 29 million vehicles registered for operation on California's roads. To examine the impact of different factors on fuel consumption, the Energy Commission divides vehicles into two broad classifications: *LDVs*, and *MDVs* and *HDVs*. The MDV and HDV classes include all vehicles exceeding 10,000 pounds (lbs), like buses, ambulances, truck trailers, and others.

The Energy Commission defines LDVs as any vehicle that weighs less than 10,000 lbs, using interior volume as the main criterion to differentiate between LDV classes. Neighborhood electric vehicles, with a top speed of 35 miles per hour, are accounted for separately.

The LDV fleet can be further analyzed in two groups, LDV-cars and light trucks. Table 2-1 identifies 15 classes of LDV, and includes examples of the makes and models for each class. These class definitions are specific to the Energy Commission.

Table 2-1: Light Duty Vehicle Classes

Car Classes			
	Class	**Interior Volume Definition**	**Examples**
1	Subcompact (1 - 6000 lbs)	Less than 89 cubic feet	Toyota Echo, Hyundai Accent, Volkswagen Golf, BMW i3, Kia Soul Electric, Mitsubishi i-Miev
2	Compact (1 - 6000 lbs)	89 to 95 cubic feet	Honda Civic, Ford Focus, Honda Fit, Chevy Volt, VW -golf
3	Midsize (1 – 6000 lbs)	96 to 105 cubic feet	Honda Accord, Ford Taurus, Toyota Camry, Nissan Leaf, Toyota Prius, Honda Fcx, Ford Fusion, Toyota Mirai
4	Large (1 – 6000 lbs)	Over 105 cubic feet	Buick LeSabre, Tesla Model S, Porsche Panamera S E-Hybrid
5	Sport (1 – 6000 lbs)	Two door, high performance subcompact (Weight/HP ratio less than 18)	Ford Mustang, Toyota Celica, Chevrolet Camaro
6	Cross Utility – Small* (1 – 6000 lbs)	Small wagons (passenger volume less than 95 cubic feet); with flexible seating (fold down rear seat to provide flat floor to front seat)	Chrysler PT Cruiser, Toyota Matrix
Light Truck Classes			
	Class	**Interior Volume Definition**	**Examples**
7	Cross Utility – Small* (1 – 6000 lbs)	Unibody SUV less than 140 cubic feet	Toyota RAV4, Honda CRV, Toyota RAV4 EV, Porsche Cayenne S E-Hybrid, Ford Escape
8	Cross Utility – Midsize (1 – 6000 lbs)	Unibody SUV over 140 cubic feet	Toyota Highlander, Honda Pilot, Lexus RX300
9	Sport Utility – Compact (1 – 6000 lbs)	Body on frame SUV less than 140 cubic feet	Chevrolet Blazer, Nissan XTerra, Hyundai Tucson (Gasoline), Hyundai Tucson (FCEV)
10	Sport Utility – Midsize (1 – 6000 lbs)	Body on frame SUV 140 to 180 cubic feet	GMC Envoy, Dodge Durango, Acura MDX
11A	Sports Utility – Large (6,001 – 8,500 lbs)	Body on frame SUV over 180 cubic feet	Toyota Sequoia, Chevrolet Tahoe, Ford Expedition
11B	Sports Utility – Heavy (8,501 – 10,000 lbs)	Body on frame SUV over 180 cubic feet & 8501 – 10000 GVW	Chevrolet R2500 Suburban, Ford Excursion

12	Van Compact (1 – 6000 lbs)	Less than 180 cubic feet	Ford Windstar, Dodge Caravan, Honda Odyssey
13A	Van – Large (6,001 – 8,500 lbs)	Over 180 cubic feet	Ford Econoline, Dodge Ram Van, Chevrolet Express
13B	Van – Heavy (8,501 – 10,000 lbs)	Over 180 cubic feet & 8,501 to 10,000 GVW	Chevrolet Express Van G30, Dodge Ram Van b350, Ford Comm Strip E350
14	Pickup – Compact (1 – 6000 lbs)	Inertia weight (IWT) less than 4,250 lbs (2WD); IWT = curb weight + 300 lbs (rounded to nearest 250 lb)	Chevrolet S10, Ford Ranger, Nissan Frontier
15A	Pickup – Standard (6,001 – 8,500 lbs)	Inertia weight over 4250 lbs (2WD)	Ford F150, GMC Sierra, Toyota Tundra
15B	Pickup – Heavy (8,501 – 10,000 lbs)	Inertia weight over 4250 lbs (2WD) & 8,501 – 10,000 lbs	GMC Sierra C3500, Ford F350, Dodge D300/350
16	Neighborhood Electric Car (1 – 6000 lbs)	Small Car with top speed of 25 MPH (per NHTSA Definition 49 CFR Part 571)	Ford Think, Club Car, Dynasty, Global Electric

Source: California Energy Commission

LDVs are primarily used for personal transportation in the household and commercial sectors, while almost all MDVs and HDVs are used for commercial movement of people and goods, with motor homes being one of the few exceptions. Table 2-2 identifies different classes of MD/HDVs.

Table 2-2: Medium and Heavy Duty Vehicle Classes

Rating		Weight	Duty	Examples
GVWR 3		10,001 - 14,000	Medium	Pickups, Vans, Chassis & Cab
GVWR 4 to 6	GVWR 4	14,001 - 16,000	Medium	Vans, Flatbed & Platform, Conventional Cab, Refrigerated
	GVMR 5	16,001 - 19,500	Medium	
	GVWR 6	19,501 - 26,000	Heavy	
GVWR 7 & 8	GVWR 7	26,001 - 33,000	Heavy	Tractor Truck, Conventional Cab, Bus, Vans, Dump, Fire trucks
	GVWR 8 Single Unit	33,001 and more	Heavy	Bus, Dump, Tank, Fire trucks
GVWR 8	Combination	33,001 and more	Heavy	Tractor Truck, Tandem, Logger, Auto Carrier, Gliders, Dromedary
GVWR 8	Garbage	33,001 and more	Heavy	Refuse & Recycle trucks
GVWR 8	IRP	33,001 and more	Heavy	IRP Tractor Trailers
GVWR 3 to 8	Motorhomes	-	Medium/Heavy	All Motorized Homes

Source: California Energy Commission

Light Duty Vehicles

California's vehicle population has grown from about 27 million in 2005 to more than 29 million in 2014, with more than 26 million LDVs in 2005 and more than 28 million LDVs in 2014. In the last 10 years, LDVs have comprised 96 percent of total vehicles in California. LDV stock declined between 2008 and 2010 but has been growing since 2011 and continues to grow with population and economy. Table 2-3 shows the distribution of California's fleet of LDVs by fuel type. Electric and plug-in electric vehicles (PEV) started showing a faster growth rate in 2011 with the introduction of a midsize electric car by Nissan (LEAF) and a compact PEV by Chevrolet (Volt), followed by a midsize plug-in hybrid electric vehicle (PHEV) in 2012 by Toyota (Prius) and a large electric car by Tesla. By 2014, there was a considerably larger list of makes and models offering battery electric vehicles (BEV) and PHEVs in the market.

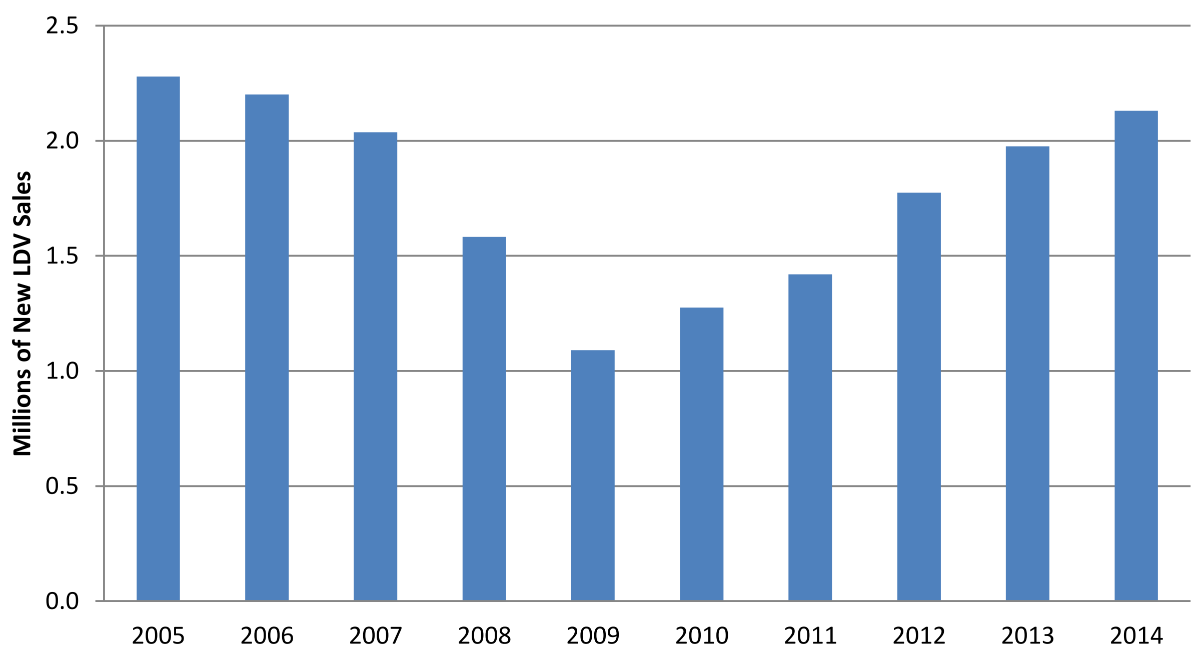
Table 2-3: California On-Road Registered LDV Population by Fuel Type, 2001-2014

Year	Gasoline	Flex Fuel	Hybrid	Diesel	Electric	Natural Gas	PHEV	Total
2005	25,440,904	269,857	91,438	424,137	13,947	24,471	-	**26,264,754**
2006	25,741,051	300,806	154,165	449,305	14,071	24,919	-	**26,684,317**
2007	25,815,758	340,910	243,729	465,654	13,956	25,196	-	**26,905,203**
2008	25,654,102	381,584	333,020	463,631	14,670	24,810	-	**26,871,817**
2009	25,240,074	409,636	384,567	462,936	15,031	24,819	-	**26,537,063**
2010	25,008,880	463,756	442,138	464,187	15,882	23,059	-	**26,417,902**
2011	24,959,862	571,958	496,540	471,585	19,091	24,063	1,312	**26,544,411**
2012	25,053,542	774,464	579,460	489,666	23,149	19,673	10,298	**26,950,252**
2013	25,225,012	950,196	690,828	511,201	41,191	25,497	33,300	**27,477,225**
2014	25,500,537	1,101,184	798,751	540,910	66,618	25,116	65,900	**28,099,016**

Source: California Energy Commission analysis of DMV data

New vehicle sales increase as the fleet ages, and fluctuate with economic performance. Figure 2-8 shows new vehicle sales between 2005 and 2015. The new vehicle sales in this graph account for two or more model years, sold as new vehicles, in each calendar year. The Great Recession brought new vehicle sales to the lowest level in 2009 with fewer than 1.1 million vehicles sold. With the economy recovering since 2009, new vehicle sales have been continuously increasing in California to more than 2.17 million vehicles in 2014.

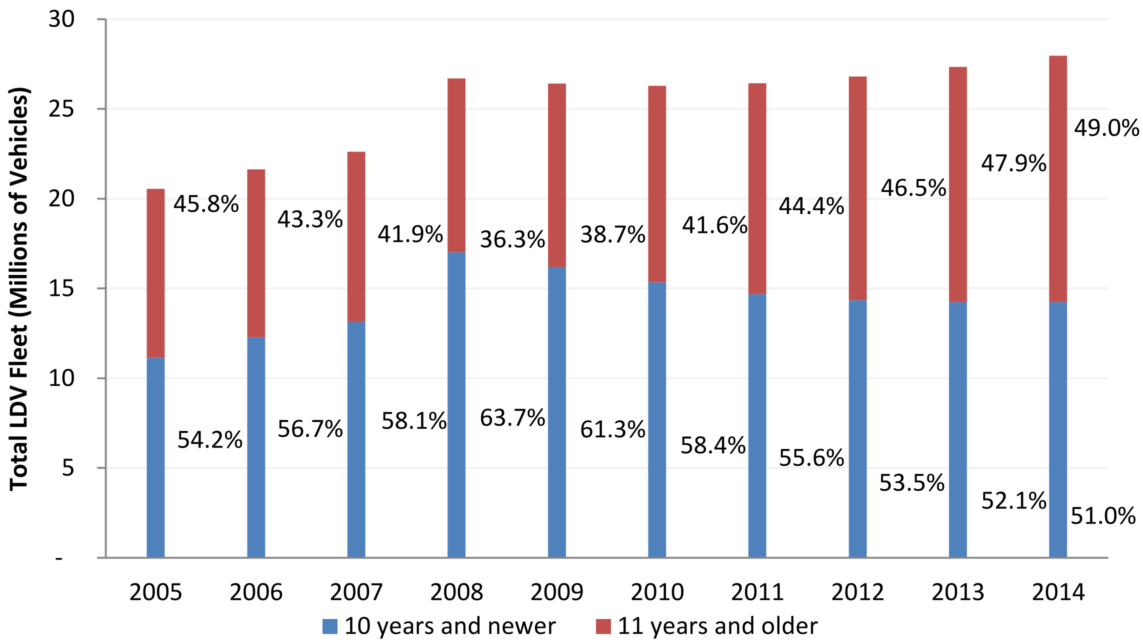
Figure 2-8: Annual New LDV Sales in California



Source: California Energy Commission analysis of DMV data

At the same time new vehicle purchases are accelerating, vehicles currently on the road are lasting longer. Figure 2-9 shows total LDV population per year divided in two categories: vehicles on the road with an age of 11 years or older and vehicles that are 10 years and newer. The percentage of older on-road vehicles has increased from 36 percent in 2008 to 49 percent in 2014.

Figure 2-9: Percentage of Vehicles 11 Years or Older



Source: California Energy Commission analysis of DMV data

One factor contributing to the decline in gasoline consumption is the penetration of alternative fuel vehicles in California's fleet. Table 2-4 shows the total market share of new LDV sales, including all vehicle classes shown above in Table 2-1, by fuel and technology type from 2010-2014. Gasoline vehicles have lost market share by 8.8 percent in the last five years. Moreover, diesel gained market share in 2014 due to an overall increase in diesel-fueled compact cars (45,585 vehicles in 2002 to 70,711 in 2014).

As shown in Table 2-4, light duty alternative fuel cars including hybrid, plug-in hybrid, electric, natural gas, and hydrogen, show an increasing share of sales from 7.3 percent in 2010 to 13.9 percent in 2014.[8]

In contrast, alternative fuel vehicles in the light duty truck vehicle classes (including hybrid, electric, and natural gas) went from 1.7 percent of new vehicle sales in 2010 to less than 1 percent in 2014.[9] Gasoline and FFVs have primarily dominated this market in the last five years

8 This refers to total number of vehicles in the light duty car classes (1 through 6) in Table 2-1.

9 This refers to the total number of vehicles in the light duty truck classes (7 through 16) in Table 2-1.

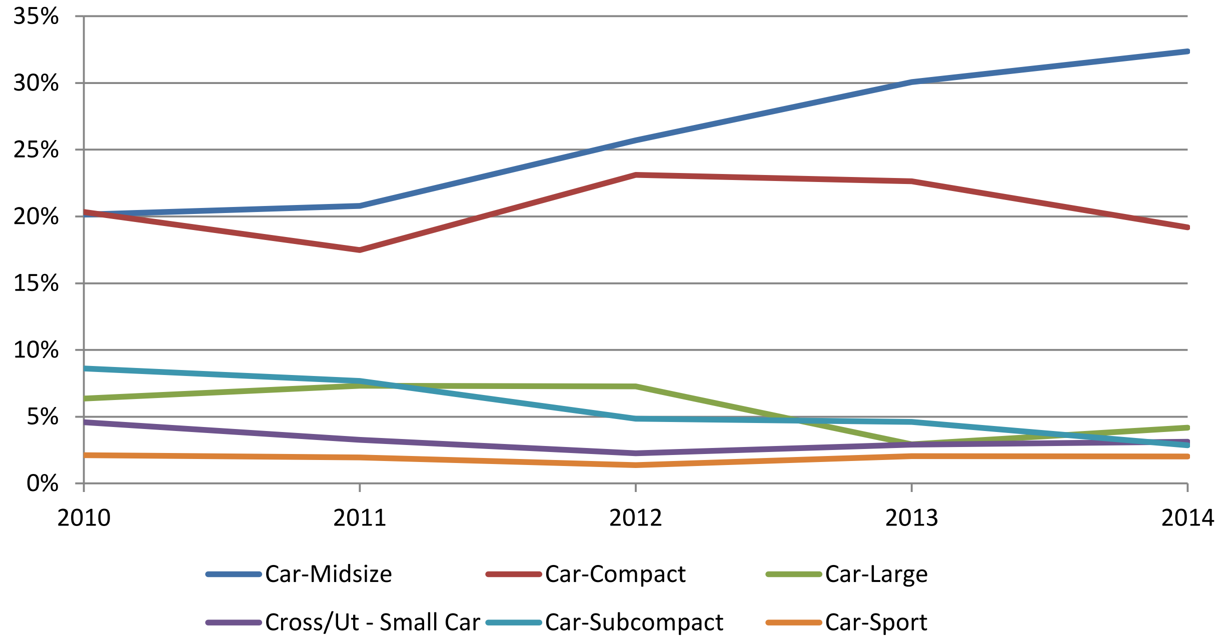
Table 2-4: Percentage of New Light Duty Vehicles Sold in California, in Car and Truck Category, by Fuel Type, 2010-2014

Light Duty Cars					
	2010	2011	2012	2013	2014
Gasoline	88.1%	83.3%	80.6%	76.5%	79.3%
Flex Fuel	3.4%	6.5%	7.1%	7.2%	5.1%
Diesel	1.2%	1.6%	1.2%	1.2%	1.7%
Hybrid	7.2%	7.5%	9.3%	10.8%	9.2%
PHEV	0%	0.2%	1.2%	2.4%	2.8%
Electric	0%	0.8%	0.4%	1.8%	1.8%
Natural Gas	0.07%	0.14%	0.14%	0.02%	0.03%
Hydrogen	0.001%	0.004%	0.001%	0.0004%	0%
Light Duty Trucks					
	2010	2011	2012	2013	2014
Gasoline	80%	77%	74%	75%	77%
Flex-Fuel	16%	19%	22%	21%	18%
Diesel	2.3%	2.8%	3.1%	2.8%	3.6%
Hybrid	1.7%	1.0%	0.8%	0.9%	0.5%
Electric	0%	0.001%	0.04%	0.14%	0.2%
Natural Gas	0%	0.02%	0.01%	0.05%	0.04%

Source: California Energy Commission analysis of DMV data

In recent years, California motorists have become more inclined to purchase midsize vehicles, as shown in Figure 2-10, with more midsize cars purchased between 2010 and 2014 than any other car class. This is likely in response to changes in fuel prices and fuel efficiency.

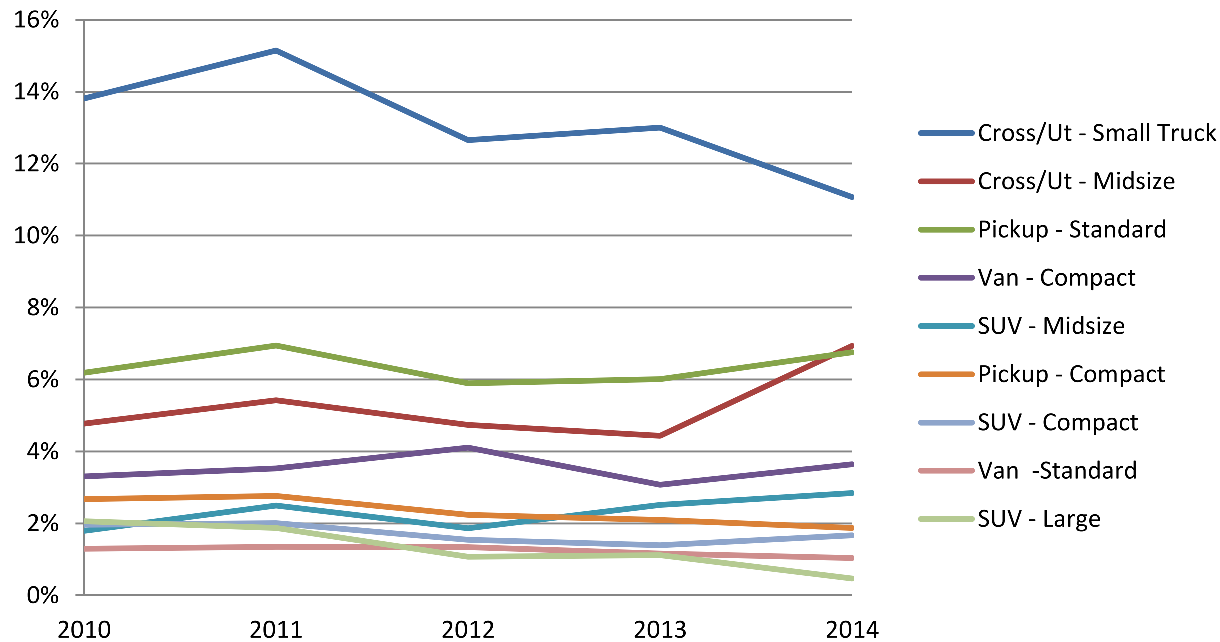
Figure 2-10: Percentage of New Light Duty Cars Sold in California by Vehicle Class, 2010-2014



Source: California Energy Commission analysis of DMV data

Within light trucks, cross-utility small trucks are still the largest class of trucks sold, although it exhibits a downward trend since 2011, as seen in Figure 2-11. Other light truck classes, such as cross-utility midsize trucks, show an increase in sales between 2013 and 2014.

Figure 2-11: New Light Duty Trucks as Percentage of All LDVs Sold in California by Vehicle Class, 2010-2014



Source: California Energy Commission analysis of DMV data

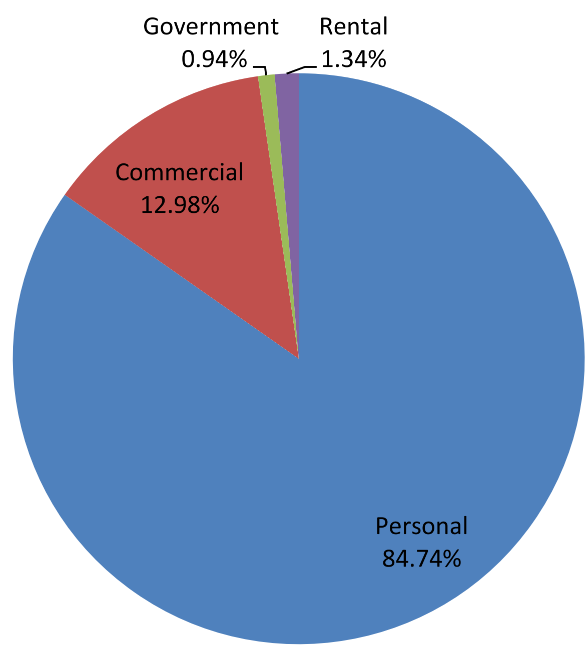
Light Duty Vehicle Ownership by Sector

Vehicles exhibit different patterns of usage and turnover depending on ownership. For instance, commercial entities tend to purchase a higher percentage of new vehicles, drive them for more miles, and replace them at a “younger” age as compared to households. For the transportation demand forecast, vehicle ownership is broken down into four categories:

- Household – vehicles owned and registered by residents in the state
- Commercial – vehicles owned and registered by commercial entities with the exception of rental cars
- Government – vehicles owned by state and local agencies and registered in California
- Rental – vehicles owned by rental agencies and registered in California

On-road vehicles are composed of LDVs used for transportation in both commercial and residential sectors, as well as MDVs and HDVs used mostly in the commercial sector. As Figure 2-12 shows, 85 percent of LDVs are registered to households, followed by commercial sector with almost 13 percent of LDVs.

Figure 2-12: Light Duty Vehicle by Ownership Sector in 2014

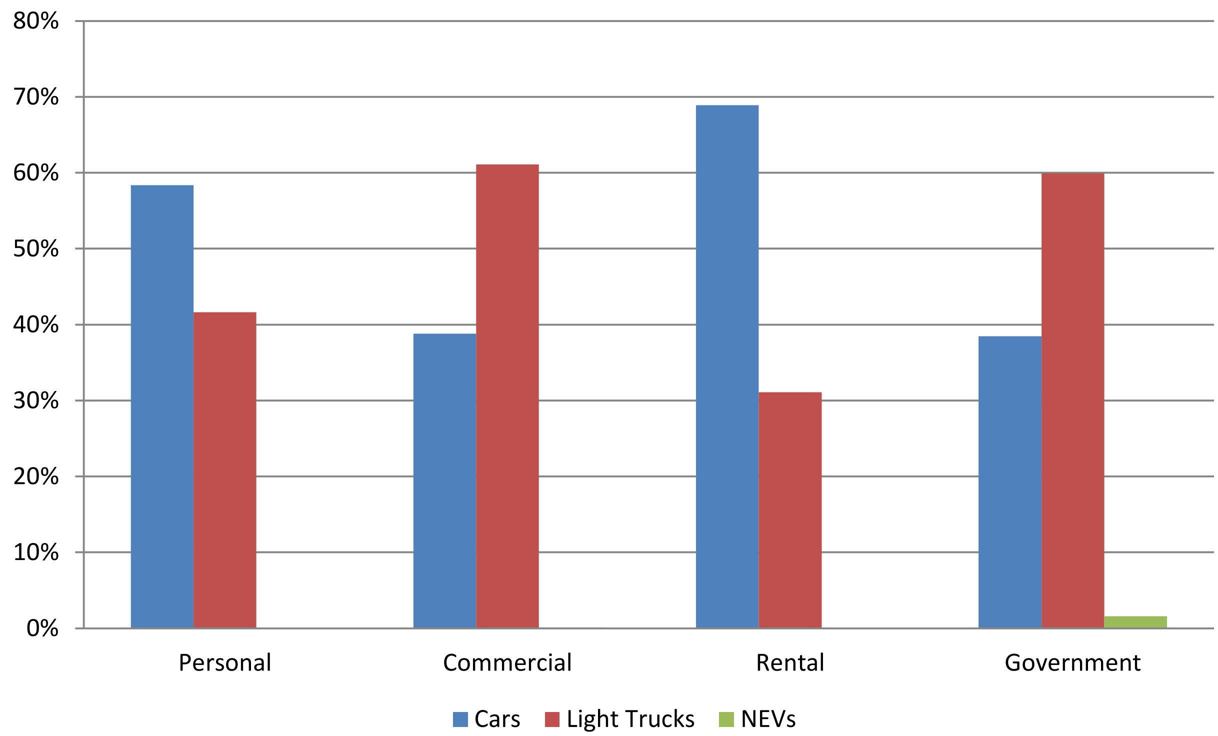


Source: California Energy Commission analysis of DMV data

Although both the personal and commercial sectors use LDVs, there are differences in the fuel types and vehicle class composition in households and in commercial use.

The Energy Commission’s vehicle surveys, as well as differences in the distribution of different vehicles by ownership, support the notion that different groups of buyers have different needs and preferences for both vehicles and fuel type. It is therefore important to model behavior in the four ownership categories (personal, commercial, rental and government) separately. For instance, Figure 2-13 shows that the commercial and government sectors have more light duty trucks than cars compared to the personal and rental sectors. The majority of the light duty trucks, such as vans and pickups, are offered in diesel or as FFVs, which have the option of using E85. However, the commercial sector owns only 13 percent of the LDV fleet. This limits the expansion of these fuels and vehicle classes into the LDV market as a whole.

Figure 2-13: 2014 Vehicle Class Distribution by Ownership Sector



Source: California Energy Commission analysis of DMV data

Another example of different consumer behaviors in these sectors is the fact that rental and commercial sectors purchase newer vehicles and place greater emphasis on range due to their higher trip distance, among other factors. Generally speaking, 97 percent of the rental fleet is four years old or newer while in the personal fleet only 24 percent have that model year range. However, the rental sector owns only 1.29 percent of the LDV fleet, and as such this limits the impact of all these new vehicle sales in the total population in 2014.

New Vehicle Prices

One of the key factors in consumer choice is the vehicle price. New vehicle prices play a more important role in the choice of alternative fuel vehicles, as zero-emission vehicles (ZEV) do not currently have a long enough history to play a more significant role in the used vehicle market at this time. Energy Commission staff used DMV data to generate sales-weighted average new vehicle prices for each of the 15 classes of LDVs. Prices reported to DMV exclude government incentives such as rebates and tax credits and represent the transaction price. In California, the

Clean Vehicle Rebate Project (CVRP) offers up to $5,000 in electric vehicle rebates for the purchase or lease of new, eligible zero-emissions and plug-in hybrid light duty vehicles.[10] This is in addition to a federal tax credit of up to $7,500 offered for electric drive vehicles.[11] These incentives are not reflected below in the transaction price.

Table 2-5 shows the sales-weighted average prices of new light duty car sales by fuel type or technology. Gasoline, hybrids and flex-fuel cars have been very close in price, while natural gas car prices have been lower than any other fuel type in the last two years. There is a general declining trend in average PHEV price, while the significant increase in the average electric vehicle (EV) price in 2014 can be attributed to the rise in luxury EVs sold in California market.

Table 2-5: Sales-Weighted Average Transaction Price, New Light Duty Cars, by Fuel and Technology Type

LDV-Car[12]	2010	2011	2012	2013	2014
Diesel	$ 30,255	$ 31,325	$ 30,657	$ 28,302	$ 35,306
Electric		$ 35,651	$ 38,556	$ 54,981	$ 50,924
FFV	$ 24,113	$ 24,698	$ 25,869	$ 26,752	$ 29,317
Gasoline	$ 26,144	$ 27,525	$ 25,971	$ 27,032	$ 28,114
Hybrid	$ 26,717	$ 27,083	$ 26,849	$ 27,644	$ 28,214
Hydrogen		$ 69,664	$ 69,020	$ 63,300	
Natural Gas	$ 25,542	$ 27,629	$ 27,326	$ 25,628	$ 26,148
PHEV		$ 43,697	$ 37,532	$ 34,874	$ 35,049

Source: Energy Commission analysis of the DMV data

Table 2-6 shows sales-weighted average prices of new light duty truck sales. Diesel and flex-fuel light truck prices have been stable in the last five years. There is no historic stock of light duty trucks that are PHEVs or hydrogen fuel cell electric vehicles (FCEVs), though EV truck prices show a declining trend.

New natural gas light truck prices show a sharp rise in 2012, when a number of unique, special purpose vehicles were sold at higher prices. Overall, the sales-weighted average of new vehicle prices showed a declining trend in 2013 and 2014.

10 California Clean Vehicle Rebate Program: https://cleanvehiclerebate.org/eng/eligible-vehicles

11 Plug-In Electric Vehicle Drive Vehicle Credit: https://www.irs.gov/Businesses/Plug-In-Electric-Vehicle-Credit-IRC-30-and-IRC-30D

12 Includes vehicle classes: subcompact, compact, midsize, large, sport and cross utility small car

Table 2-6: Sales-Weighted Average Transaction Price, New Light Duty Trucks, by Fuel and Technology Type

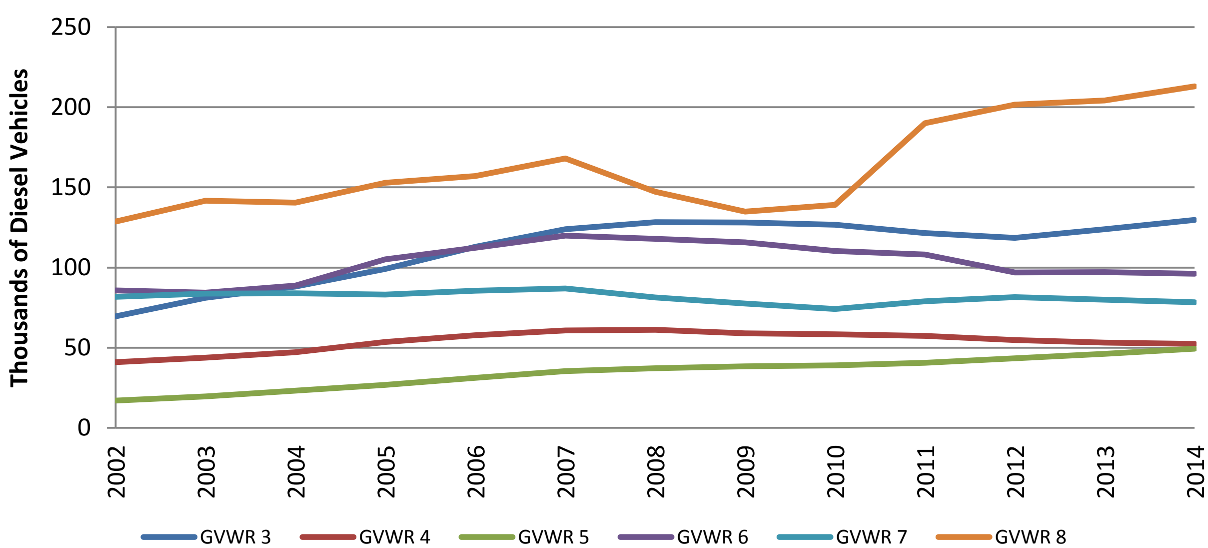
LDV-Truck[13]	2010	2011	2012	2013	2014
Diesel	$ 52,219	$ 52,024	$ 53,299	$ 54,750	$ 52,927
Electric		$ 65,600	$ 51,806	$ 48,987	$ 49,674
FFV	$ 37,248	$ 35,000	$ 33,680	$ 34,912	$ 36,392
Gasoline	$ 31,835	$ 32,247	$ 32,493	$ 33,521	$ 33,461
Hybrid	$ 46,041	$ 48,596	$ 51,580	$ 52,431	$ 51,691
Natural Gas		$ 38,154	$ 51,583	$ 37,962	$ 35,327

Source: Energy Commission staff analysis of DMV data.

Medium and Heavy Duty Vehicles

Due to the many commercial applications, diesel is the most common fuel for MDVs and HDVs in California. Gross vehicle weight rating (GVWR) refers to the maximum operating weight of a vehicle, including the passenger and cargo load. In 2014, 84 percent of the total diesel powered vehicles registered in California were pickup trucks (8,500-10,000 lbs) and MD and HD buses and trucks – those with a GVWR of 3 or higher (see Table 2-2 for complete list). Figure 2-14 displays the number of diesel-powered vehicles for GVWR 3 to 8.

Figure 2-14: California Diesel Medium and Heavy Duty Stock, 2000 to 2014

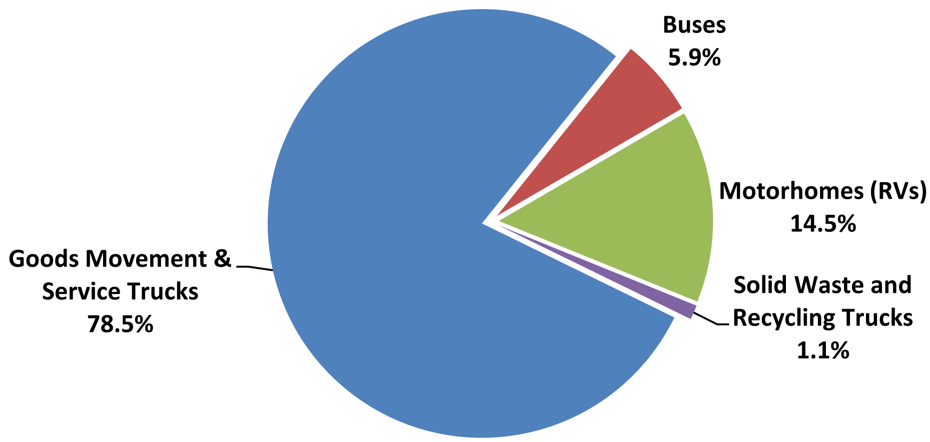


Source: California Energy Commission analysis of DMV data

13 Includes vehicle classes: cross utility small truck, cross utility midsize, sport utility compact, sport utility midsize, sport utility large, van compact, van standard, pickup compact, and pickup standard (see Table 2-1 for the complete list of LDV classes)

HDVs include buses used in public and private transit, trucks used in freight transport, and trucks used in providing services such as concrete mixers and refuse trucks, among others. The majority of HDVs are used in freight transport and service activities, as shown in Figure 2-15.

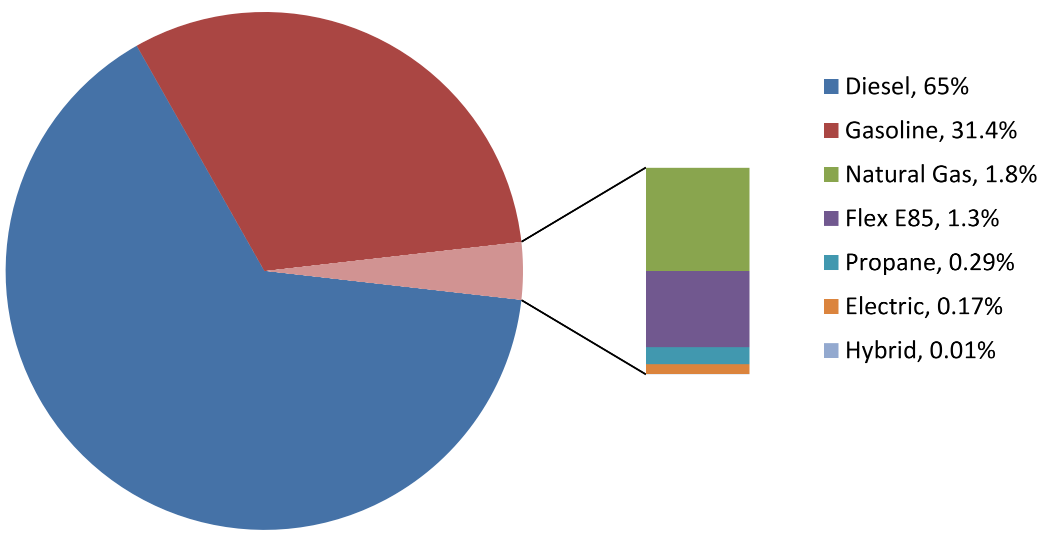
Figure 2-15: California Medium and Heavy Duty Vehicles by Type of Operation, 2014



Sources: California Energy Commission Analysis of DMV Data, EMFAC and National Transit Database

Diesel makes up the majority of MDVs and HDVs, accounting for more than 65 percent of the fleet, as shown in Figure 2-16.

Figure 2-16: California Medium and Heavy Duty Vehicles Distribution by Fuel Type, 2014

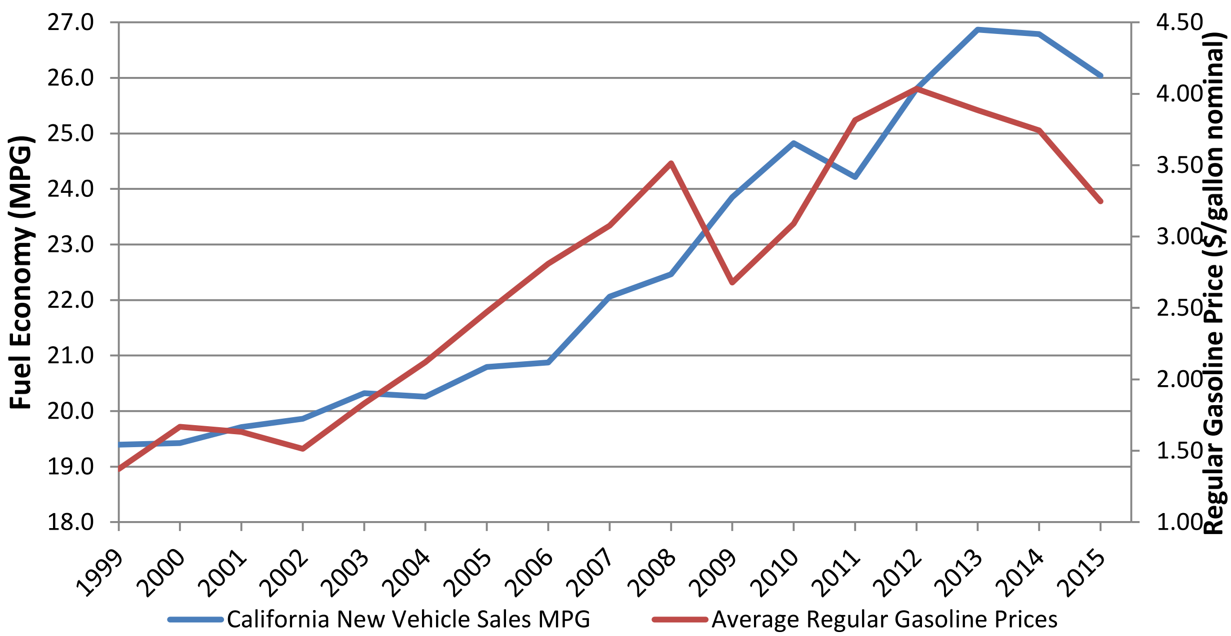


Source: Energy Commission and Department of Motor Vehicles

Fuel Economy

The U.S. Department of Transportation's National Highway Traffic and Safety Administration (NHTSA) regulates the Corporate Average Fuel Economy (CAFE) standards, which set the "fleet-wide average that must be achieved by each automaker for its car and truck fleet." The final passenger car and light truck CAFE standards for model years 2017-2021 were set in 2012, and "the agency projects will require in model year 2021, on average, a combined fleet-wide fuel economy of 40.3-41.0 mpg." While CAFE standards have historically applied to LDVs, the most recent update expanded standards to cover MDVs and HDVs beginning in 2017. CAFE standards have significantly improved fuel economy, and NHTSA estimates[14] that this trend will continue through 2025. Figure 2-17 shows the combined impact of regulation and fuel prices on the fuel economy of new LDVs in California. Average fuel economy for new LDVs in California has increased from about 18 miles per gallon (MPG) for new LDVs being sold in 1999 to almost 27 MPG for new LDVs being sold in 2013, which holds significant implications for fuel consumption.

Figure 2-17: Historical National Gasoline Prices vs. California New Light Duty Vehicle Sales-Weighted Average Fuel Economy, 1990-2015



Source: EIA Gasoline Prices and U.S. EPA – Fuel Economy

Figure 2-18 shows NHTSA's estimates of cumulative fuel savings, in the U.S. market, as these standards are applied over time.

14 http://www.transportation.gov/mission/sustainability/corporate-average-fuel-economy-cafe-standards.

Figure 2-18: NHTSA's Estimates of CAFE's Cumulative Fuel Savings for the U.S. Fleet

Source: U.S. Department of Transportation[15]

In addition to producing and selling the more fuel-efficient conventional fuel vehicles, manufacturers can increase their CAFE by selling more ZEVs which have significantly higher fuel economy than average conventional fuel vehicles.

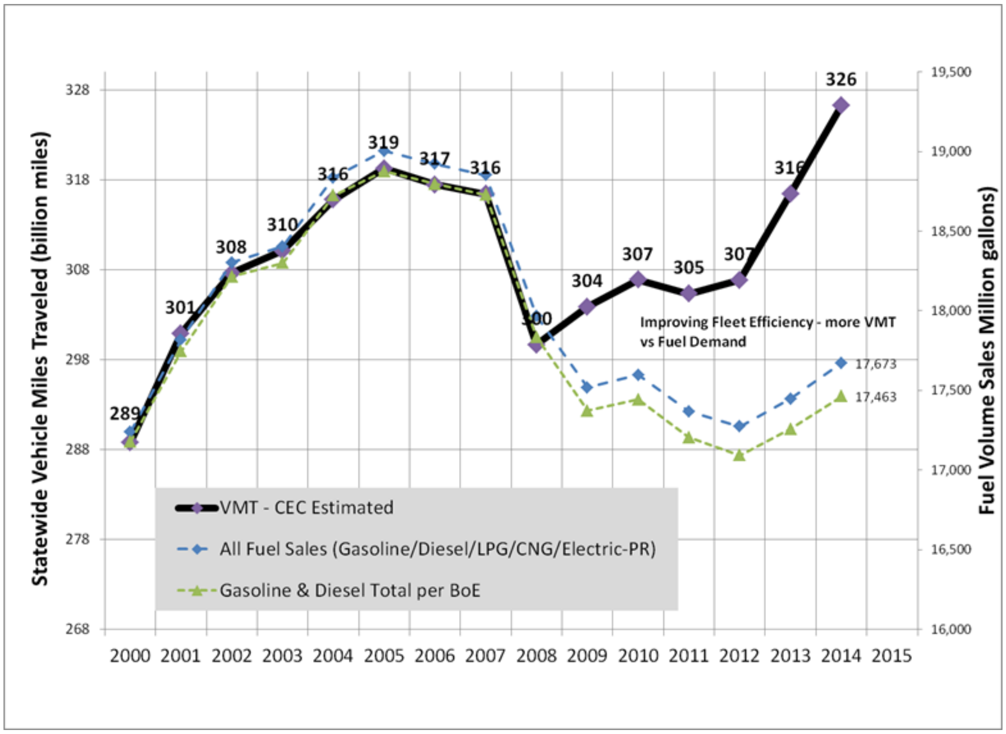
Travel Volume

The volume of travel on California roads has been increasing for decades, reaching a peak in 2005 and a trough in 2008 during the Great Recession, as seen in Figure 2-19. With improvement in economic conditions, however, VMT reached a new high in 2014 at 326 billion miles, continuing the growth trend throughout the last decade.

While the total annual VMT has continued to increase, once population and number of drivers are taken into account, a decline in per-capita and per-driver gasoline consumption in California is apparent as shown in Figure 2-20. Gasoline per-capita consumption peaked in 1978 at 525 gallons per person and has since declined 27.4 percent to 381 gallons per person by 2013.

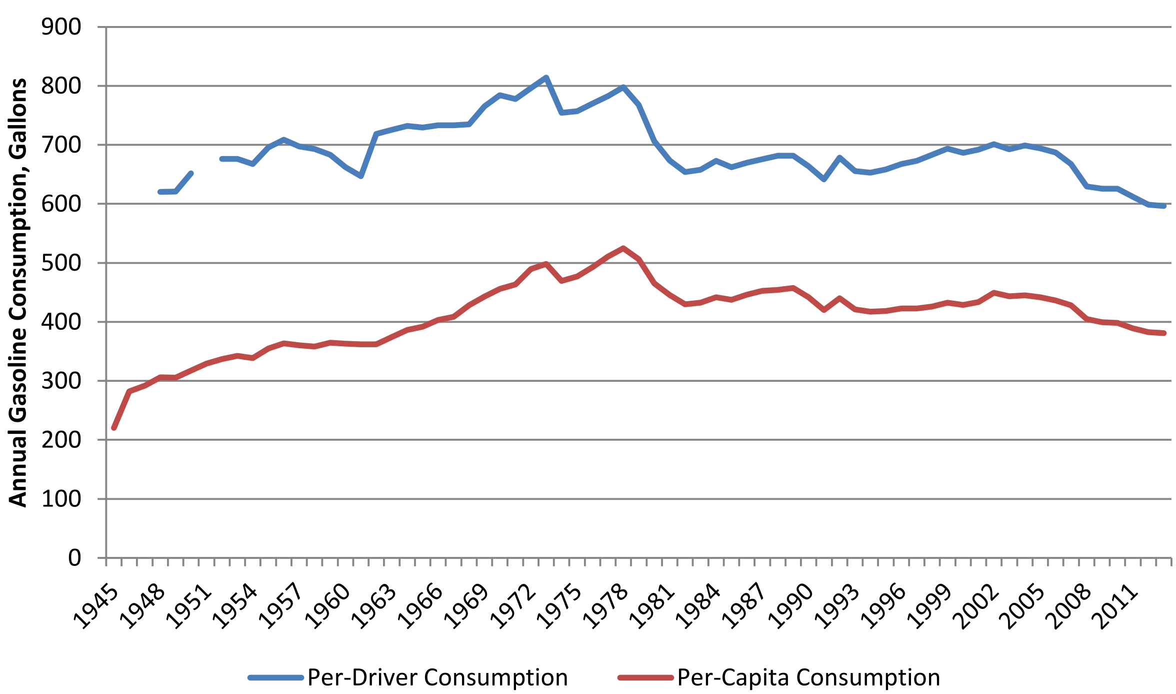
15 http://www.transportation.gov/mission/sustainability/corporate-average-fuel-economy-cafe-standards.

Figure 2-19: Statewide Total Vehicle Miles Traveled, 2000-2014



Source: California Energy Commission, Transportation Fuels Data Unit

Figure 2-20: California Per-Capita and Per-Driver Gasoline Consumption, 1945-2013



Source: California Energy Commission, Federal Highway Administration and California Department of Finance

CHAPTER 3:
Demand Forecast Inputs and Assumptions

The forecasts presented here are based on a large amount of input data as well as implicit and explicit assumptions that represent the current and future market, regulatory environments, and inherent uncertainties. This chapter focuses on the inputs and assumptions of key importance to the cases developed for the *Transportation Energy Demand Forecast, 2016-2026*.

Policies and Regulations

There are numerous regulations, standards, and incentive programs that apply to the transportation sector at the local, state, and federal levels. These policies have several goals, including mitigating climate change, improving air quality, and improving energy security. The primary regulations and incentives considered in this forecast include the federal CAFE standards,[16] California's ZEV regulation, and California's Low Carbon Fuel Standard (LCFS). Unlike the electricity demand forecast which considers some proposed regulations and statewide goals as part of the additional achievable energy efficiency (AAEE) analysis, the transportation demand forecast does not consider proposed legislation and regulations.

Corporate Average Fuel Economy Standards

NHTSA regulates CAFE standards, which set the "fleet-wide average that must be achieved by each automaker for its car and truck fleet."[17] The final passenger car and light truck CAFE standards for model years 2017-2021 were set in 2012, which require a combined fleet-wide fuel economy of 40.3-41.0 MPG in 2021.[18] While CAFE standards have historically applied to LDVs, the most recent update expanded standards to cover MDVs and HDVs begin in 2017.

Truck fuel economy influences not only fuel consumption, but the choices available to fleet managers as they replace old vehicles or grow their fleet. The Energy Commission's freight model uses two recent sets of federal fuel economy standards, one of which is already in place, and the other is in rulemaking. (This is the only exception to consideration of proposed regulations.) In 2011, NHTSA "and United States Environmental Protection Agency (U.S. EPA) jointly issued a first phase of fuel efficiency and GHG standards that apply to MDVs and HDVs

16 CAFE standards are integral to the forecast because they include specific fuel economy requirements. ARB's Advanced Clean Cars policy package does not discuss specific fuel economy requirements. Many of the regulations packaged together in the ACC cannot be represented in the forecast models.

17 http://www.transportation.gov/mission/sustainability/corporate-average-fuel-economy-cafe-standards.

18 Ibid.

on-highway engines and vehicles for model years 2014 to 2018 and beyond."[19] Moreover, a NHTSA fact sheet reports:

> "[H]eavy-duty pickup trucks and vans must meet targets for gallons of fuel consumed per mile as well as grams of carbon dioxide (CO_2) emissions per mile. The other two categories of trucks – combination tractors or semi-trucks and vocational vehicles – must meet targets for gallons of fuel consumed and GHG emissions per ton-mile. Within each of the three categories of trucks, even more specific targets are laid out based on the design and purpose of the vehicle – such as a semi-truck with a low roof versus a semi-truck with a high roof."[20]

Energy Commission staff used the Phase 1 standards (referenced above as the "first phase") in the high demand case, high petroleum demand case, and mid demand case of the freight forecast.

Phase 2 of Federal Fuel Economy and GHG standards was proposed in July 2015 and is in the rulemaking process. The proposed rule addresses the same three categories of trucks as Phase 1: combination tractors, heavy duty pickups and vans, and vocational vehicles. Moreover, the proposed rule includes new standards for combination trailers. A regulatory impact analysis identified a range of technologies that would improve fuel economy and reduce GHG emissions for each of the four categories.[21] The cost of applying each of the technologies is identified, which enabled Energy Commission staff to identify fuel economy and the increment to truck price for each milestone in the Phase 2 proposed rules. Staff used the Phase 2 standards in the low demand, low petroleum demand, and high alternative fuel vehicle cases.

Zero-Emission Vehicle Regulations

The landmark ZEV regulations set by the ARB in January 2012 established ZEV credit requirements for automakers selling LDVs in California. It is expected that the largest automakers will have derived 1.4 million vehicles of their cumulative California sales from electric vehicles and other zero or near zero-emissions vehicles by 2025,[22] while providing a number of options for manufacturers to meet these requirements. The ZEV program serves as the core technology of ARB's Advanced Clean Cars Program. This is a regulatory approach that

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19 Reinhart, Thomas. *Commercial Medium- and Heavy-Duty Truck Fuel Efficiency Technology Study – Report #2.* National Highway Traffic Safety Administration. June 2015. http://www.nhtsa.gov/Laws+&+Regulations/CAFE+-+Fuel+Economy/supporting-phase-2-proposal.

20 NHTSA. *Phase 1 Fact Sheet*. August 9, 2011.

21 NHTSA and U.S EPA. *Proposed Rulemaking for GHG Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles–Phase 2 Draft Regulatory Impact Analysis.* June 2015. http://www.nhtsa.gov/fuel-economy; under Notice of Proposed Rulemaking.

22 http://gov.ca.gov/news.php?id=17463.

aims to "combine the control of smog, soot causing pollutants, and greenhouse gas emissions into a single coordinated package of requirements for model years 2015 through 2025."[23]

The 2012 ZEV regulations were followed by California Governor Edmund G. Brown Jr.'s Executive Order B-16-2012[24] for state agencies under his direction and control to "support and facilitate the rapid commercialization of zero-emission vehicles" and to "establish benchmarks to help achieve by 2025"a target of more than 1.5 million ZEVs on California roads. The Governor's executive order also calls for "widespread use of zero-emission vehicles for public transportation and freight transport" and sets quantitative ZEV requirements for the replacement of California's State Fleet of vehicles as part of the normal State Fleet retirement. Portions of this executive order were codified into the law by passage of the Clean Energy and Pollution Reduction Act of 2015 (Senate Bill 350, De León, Chapter 547, Statutes of 2015) in October 2015.

ZEV regulations will affect the vehicle technologies offered for sale in the California market, and CAFE standards will drive fuel economies (MPG) of LDVs sold by each manufacturer across the nation. Since both the ZEV regulation and CAFE standards apply to automobile manufacturers, they are met by the projected attributes of vehicles (such as vehicle price and MPG) in the market. For instance, to comply with the ZEV regulation, original equipment manufacturers (OEMs) may offer these vehicles at a price that can compete with the internal combustion engine equivalents, even if the cost to produce them is higher. To comply with CAFE standards, the OEMs may offer conventional vehicles with higher fuel economies or sell more ZEVs. The current ZEV regulation and CAFE standards are captured in all transportation energy demand cases used in this forecast, through the vehicle attribute projections which are used as inputs to the models.

California's Low Carbon Fuel Standard

The LCFS requires fuel suppliers to lower the carbon intensity of fuels supplied at retail stations in California by using more renewable fuels, which will result in an increased supply. It is expected that consumers will see an increase in fuel prices, which is captured in the fuel price forecasts. The behavioral models that are used to forecast energy demand, however, do not include a component to allow choice between two fuel types for the same vehicle (for example, E85 and gasoline for FFVs). Therefore, the effect of LCFS cannot be completed as part of the modeling performed for the transportation energy demand forecast and must be accounted for as a separate analysis after the demand forecast is complete.

Finally, the Energy Commission's behavioral demand models do not account for all transportation regulations and goals. For example, the Sustainable Communities and Climate Protection Act of 2008 (Senate Bill 375, Steinberg, Chapter 728, Statutes of 2008), which

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23 California Air Resources Board, Advanced Clean Cars Summary, http://www.arb.ca.gov/msprog/clean_cars/acc%20summary-final.pdf

24 http://gov.ca.gov/news.php?id=17472

requires the reduction of GHG emissions through coordinated transportation and land-use planning, is not considered at this time. In addition, the Governor's executive order calling for a 50 percent reduction in petroleum consumption is not incorporated into forecasting assumptions as the mechanisms to achieve this goal are still being determined.

Forecasting Models

The revised forecast presented here resulted from various inputs and assumptions used in behavioral models that represent key transportation sectors in California. Staff used five behavioral models, each representing one transportation or vehicle sector, as well as three growth models representing government, rental, and neighborhood electric vehicles to generate demand for six cases. These behavioral models represent LDV demand for residential and commercial sectors; urban and intercity travel demand; and travel demand for freight transport and service provisions. The effects of both HSR and transportation electrification were accounted for as a separate analysis after the transportation energy demand forecast was completed. The off-road applications included electrification of California's ports, as well as forklifts and other vehicles.

Unlike the transportation energy demand forecast prepared in 2011, the aviation fuel demand forecast was not derived from behavioral models at the Energy Commission due to resource and data constraints, and as such, does not respond to variations in key inputs used for other transportation sector models presented here.

The transportation energy demand forecast shows the results for six cases, including three "common" energy demand cases referenced throughout the *2015 IEPR.* These common cases are the same energy demand cases used in the electricity and natural gas demand forecasts prepared by the Energy Commission: each energy sector applied the same economic and demographic inputs, as well as the same energy prices.

Energy Demand Cases

The rapidly changing regulatory and market environments introduce a significant amount of uncertainty in the future of different conventional and alternative fuels, vehicle technologies, and associated infrastructure. It is important to capture these uncertainties in the transportation energy forecasts.

The distribution of vehicles by fuel type between LDVs and MDVs/HDVs also influence fuel demand. Table 3-1 shows that gasoline HDVs are only 1 percent of all gasoline vehicles, while diesel vehicles are more equally distributed between LDV and HDV but use a much higher portion of diesel due to greater VMT and much lower fuel economy in the heavy duty sector. Table 3-1 also shows the distribution of LDVs and HDVs by fuel type in 2013 and 2014.

Table 3-1: 2013 and 2014 Number of On-Road Vehicles by Fuel/Technology Type

Fuel Type		2013		2014	
		LDV	MDV/HDV	LDV	MDV/HDV
Gasoline		25,225,012	302,721	25,500,537	299,212
E85-FFV		950,196	9,118	1,101,184	12,573
Gasoline Hybrid		690,828	95	798,751	95
Diesel		511,201	604,729	540,910	618,864
Diesel Hybrid		-	1	-	468
Electricity	PHEV	33,300	0	65,900	0
	BEV	26,746	1,124	51,740	1,623
	NEV	14,445	-	14,878	-
Natural Gas		25,497	15,458	25,116	17,054
Propane		3,492	2,437	3,519	1,910
Methane		1,679	59	1,348	49
Hydrogen FCV		160	0	174	0
Butane		24	12	27	12
Total		**27,482,580**	**935,753**	**28,104,084**	**951,392**

Source: California Energy Commission analysis of DMV data

The 2013 distribution of vehicles was used as an input for all energy demand cases because this is the latest year in which all inputs into the various models are available.

Common Energy Demand Cases

The inputs for three energy demand cases are the same as the electricity and natural gas demand forecasts and are referred to as "the three common energy demand cases," which are defined below:

- High energy demand case: high population and income, and low energy prices
- Mid energy demand case: mid population, income, and energy prices
- Low energy demand case: low population and income, and high energy prices

Transportation-Specific Energy Demand Cases

There are three additional energy demand cases specific to transportation energy, which are defined as follows:

- High petroleum demand case: high population and income; high CNG, hydrogen and electricity prices; and low petroleum fuel prices
- Low petroleum demand case: low population and income; low CNG, hydrogen and electricity prices; and high petroleum fuel prices
- High alternative fuel demand case: high population and income; low CNG, hydrogen and electricity prices; and high petroleum fuel prices

In addition to the inputs that are common in different forecasting efforts at the Energy Commission, there are other key inputs that are specific to transportation energy demand forecasts. These inputs include vehicle attributes, consumer preferences, and market penetration rates.

Table 3-2 summarizes input scenario assumptions for both the common and transportation-specific energy demand cases.

Table 3-2: Input Scenario Assumptions by Demand Case

Demand Case		Econ Demo	Fuel Prices		LDV		MDV and HDV	
			Liquid Fuels	NG, Electric, Hydrogen	Preference	Vehicle Price	DSL/NG Vehicle Price	NG Adoption Rate
Common Energy Demand Cases	High Energy Demand	H	L	L	High for ZEV	Transition 2030[25]	L/L	H
	Low Energy Demand	L	H	H	2013 Survey	H	H/H	L
	Mid Energy Demand	M	M	M	High for ZEV	Transition 2050	M/M	M
Transportation - Specific Energy Demand Cases	High Petroleum Demand	H	L	H	2013 Survey	H	L/H	L
	Low Petroleum Demand	L	H	L	High for ZEV	Transition 2030	H/L	H
	High Alternative Fuel Demand	H	H	L	High for ZEV	Transition 2030	H/L	H

Source: California Energy Commission

25 A discussion of "Transition 2030" and "Transition 2050" is below, in the *Zero-Emission Vehicle Prices* section

Key Inputs and Assumptions

Vehicle Attributes

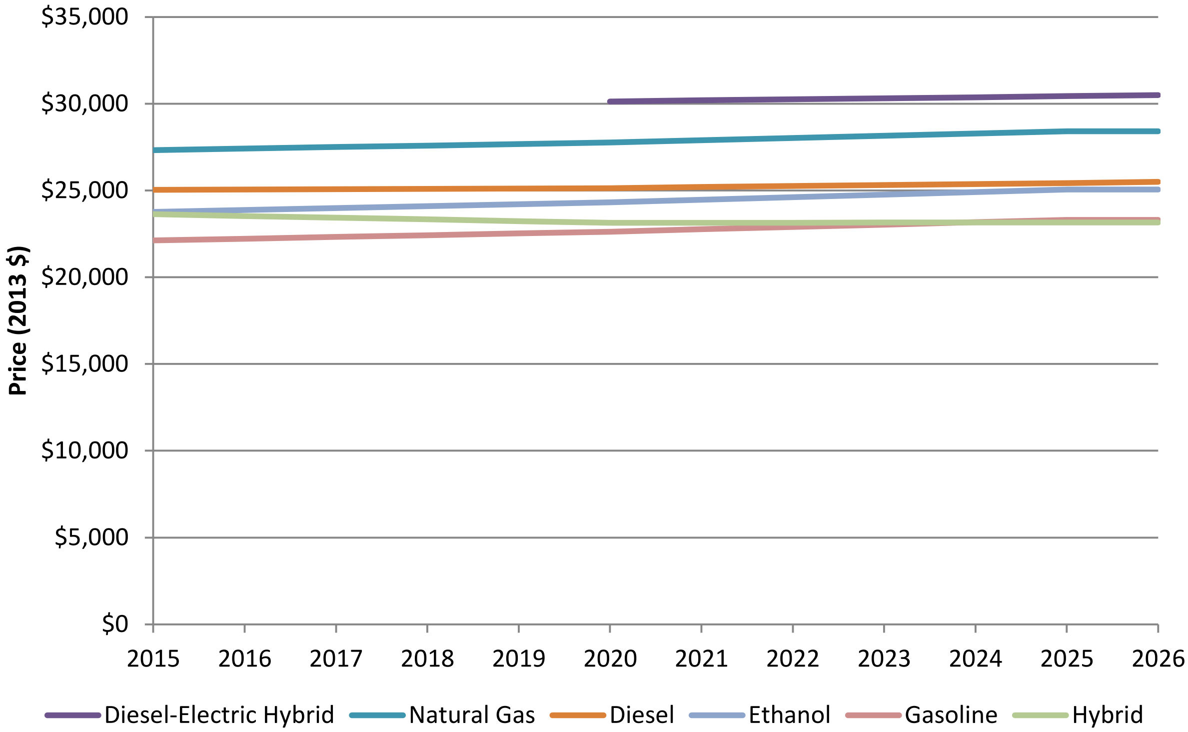
Vehicle attributes refer to characteristics of vehicles such as price, fuel economy, range, performance, storage/cargo space, refueling time, and others. The vehicle attributes are important factors in consumer choice of vehicle classes and fuel types, the most important of which is the vehicle price. Energy Commission staff used Sierra Research, Inc. (Sierra Research) projections of these attributes for different fuels and vehicle technologies. However, the Energy Commission did not use Sierra Research's vehicle prices for ZEVs and an additional case of range projections for PEVs.[26]

Figure 3-1 shows retail price projections for compact passenger cars, by fuel type, for all fuels and technologies except for ZEVs, which are discussed separately in this section (see "Zero-Emission Vehicle Prices"). Compact passenger cars have been chosen by way of illustration as they are the most common class of vehicle. Diesel electric hybrids are forecasted to have the highest price in this group of fuels and technologies in compact cars, while gasoline vehicles have the lowest price.

Figure 3-2 shows retail price forecasts for different classes of gasoline vehicles. Sport cars are forecasted to have the highest prices in this group, while compact cars have the lowest price. Overall, prices show an upward trend in all car classes.

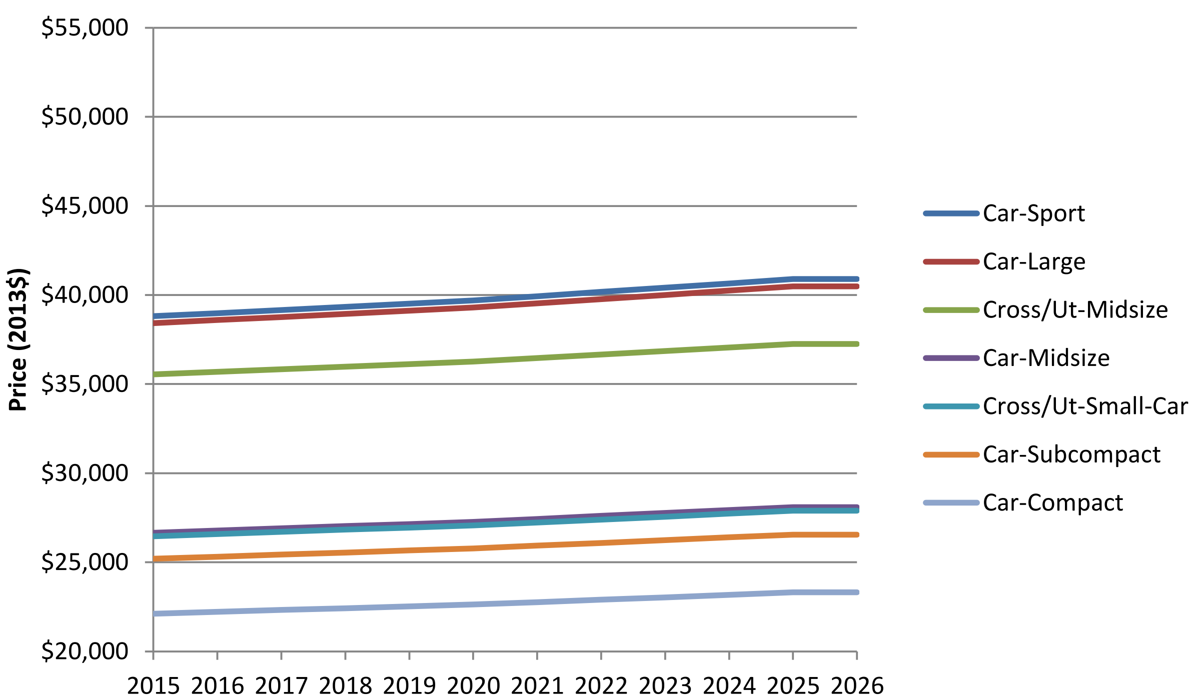
26 Carlson, Thomas, James Lyons, Matthew Malchow. (Sierra Research, Inc.), 2015. ***Development of Vehicle Attributes for the 2015 Integrated Energy Policy Report.*** California Energy Commission. Publication Number: CEC-XXX-XXXX-XXX

Figure 3-1: Price Projections for Selected Fuels and Technologies in Compact Car Class



Source: California Energy Commission and Sierra Research

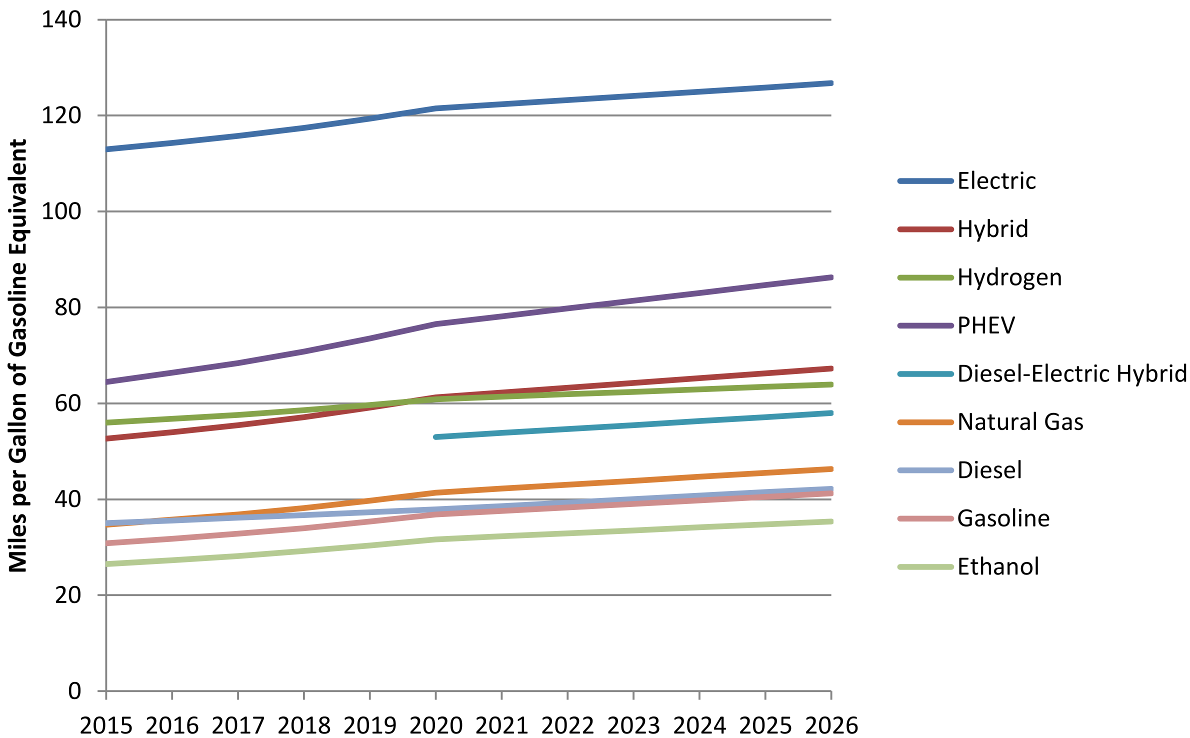
Figure 3-2: Retail Price Forecast of Gasoline Vehicles by Car Class



Source: California Energy Commission and Sierra Research

Light duty fuel economy figures were supplied by Sierra Research, which focused on two primary sources: The National Academy of Sciences' *Transitions to Alternative Vehicles and Fuels*, and docket material and analysis tools from U.S. EPA CAFE rulemakings. Figure 3-3 shows fuel economy projections for the compact class by fuel and technology type. While BEVs have the highest fuel economy – almost twice as high as hydrogen FCEV and hybrids – fuel economies for diesel, gasoline, and FFVs are the lowest in the compact class.

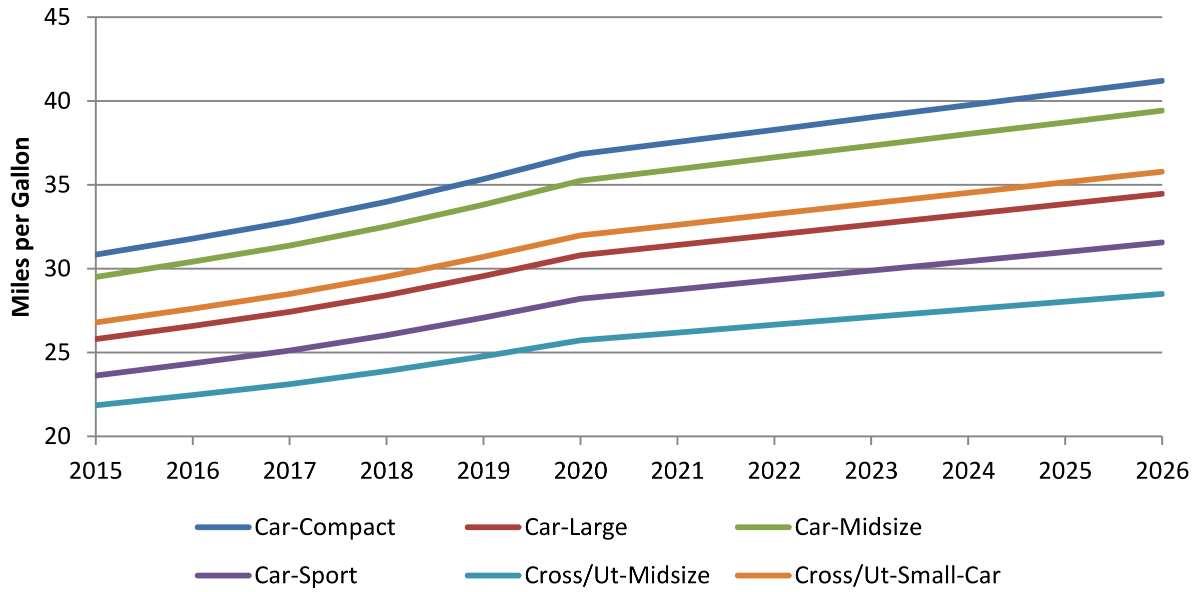
Figure 3-3: On-Road Fuel Economy Projections for Compact Class of Vehicles, by Fuel and Technology Type



Source: California Energy Commission and Sierra Research.

Figure 3-4 shows the on-road fuel economy of gasoline vehicles by class. Sierra Research derived on-road fuel economy by applying a 20-30 percent discount to U.S. EPA's sticker or laboratory tested fuel economy rating. CAFE standards project average MPG for cars and light duty trucks, using lab ratings. Additionally the Energy Commission includes vehicles with 8,500-10,000 pound weight in the light duty fleet, while they are excluded from CAFE standards for LDVs. Among gasoline cars, compact and subcompact have the highest fuel economy, while sport and midsize cross-utility cars have the lowest fuel economies, as shown in Figure 3-4. Regardless, fuel economy continues to rise over the forecast period for all vehicle classes.

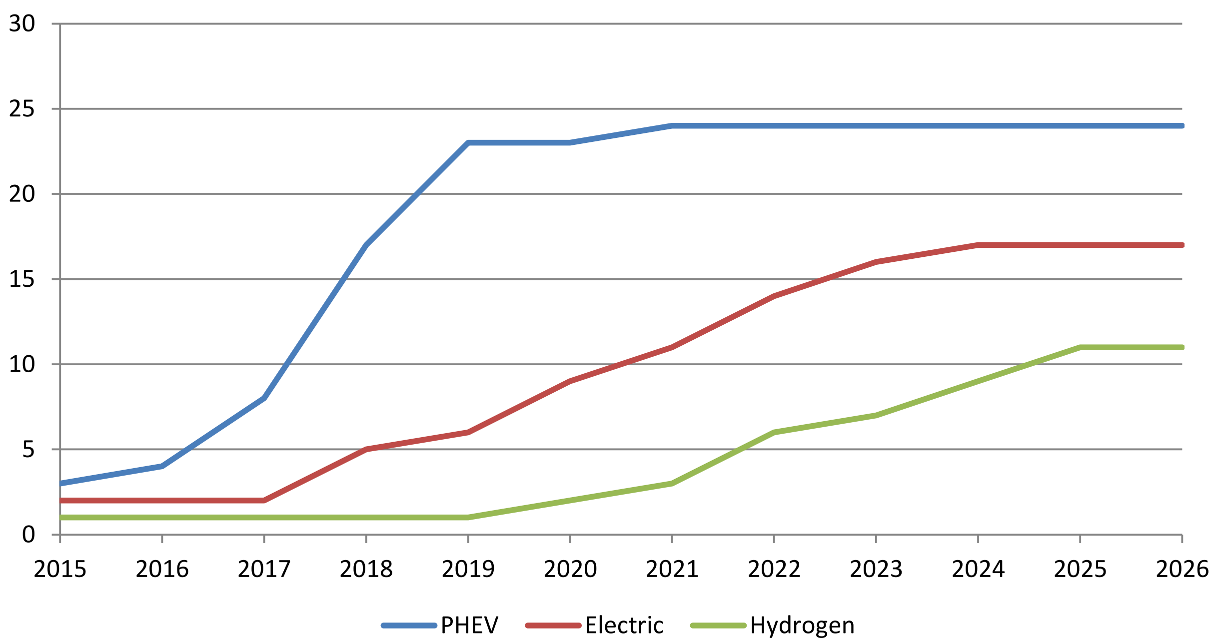
Figure 3-4: On-Road Fuel Economy Projections of Gasoline Cars, by Vehicle Class



Source: California Energy Commission and Sierra Research

The number of makes and models for new fuel and technology types continues to increase with ZEV requirements for manufacturers and provides more choices to consumers. Sierra Research projected makes and models for all vehicles, including ZEV vehicles. Figure 3-5 shows number of makes and models for ZEV compact vehicles in the mid case.

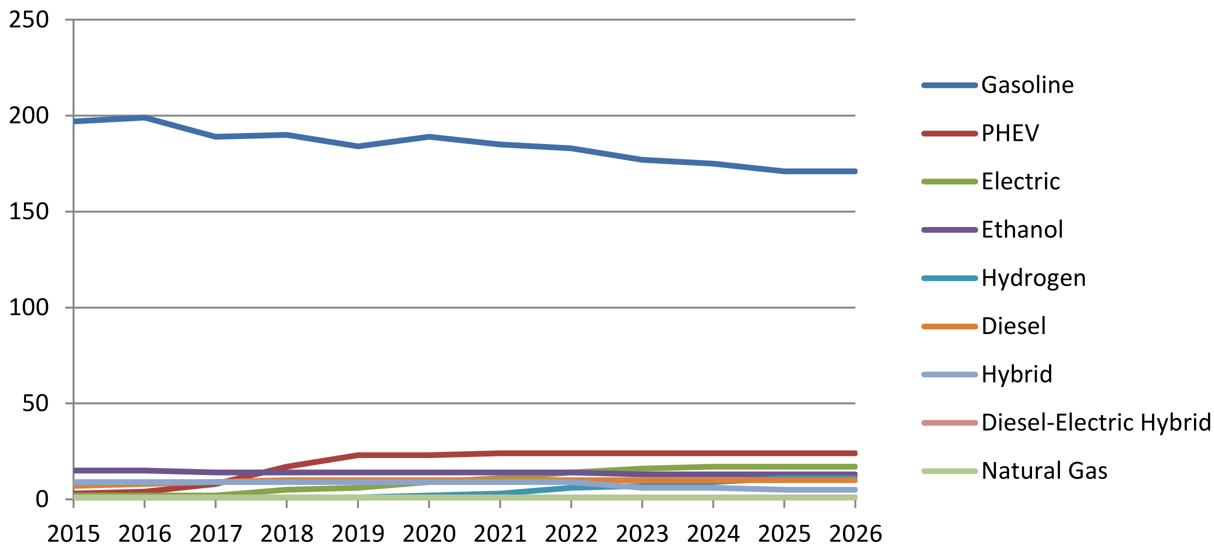
Figure 3-5: Number of Makes and Models for ZEV Compact Vehicles, Mid Case



Source: California Energy Commission and Sierra Research

Figure 3-6 shows Sierra Research's forecast of makes and models for all fuel and technology types in the compact car class. In 2019, PHEVs take the lead in the number of available makes and models for non-gasoline fuel and technologies. The makes and models in gasoline vehicles remain several times higher than all other fuel and technology types throughout the forecast.

Figure 3-6: Number of Makes and Models by Fuel/Technology Types, Compact Car, Mid Case



Source: California Energy Commission and Sierra Research

Zero-Emission Vehicles

The National Research Council (NRC) Transitions report technology assessment found that "by reducing vehicles' power requirements via reductions in mass, aerodynamic drag and rolling resistance, efficiency improvements help make e-drive vehicles cheaper than ICEs after 2040," as depicted in Figure 3-7.[27] This suggests that retail prices of battery electric and fuel cell passenger cars can benefit from both economies of scale and learning curves to reach market parity with internal combustion engine vehicle prices around 2050, while PHEV prices continue to remain higher than other vehicles.

Staff assumed that all federal and state incentives, including tax credits, rebates and high occupancy vehicle (HOV) lane access, will remain at their 2015 levels over the forecast period.

Zero-Emission Vehicle Prices

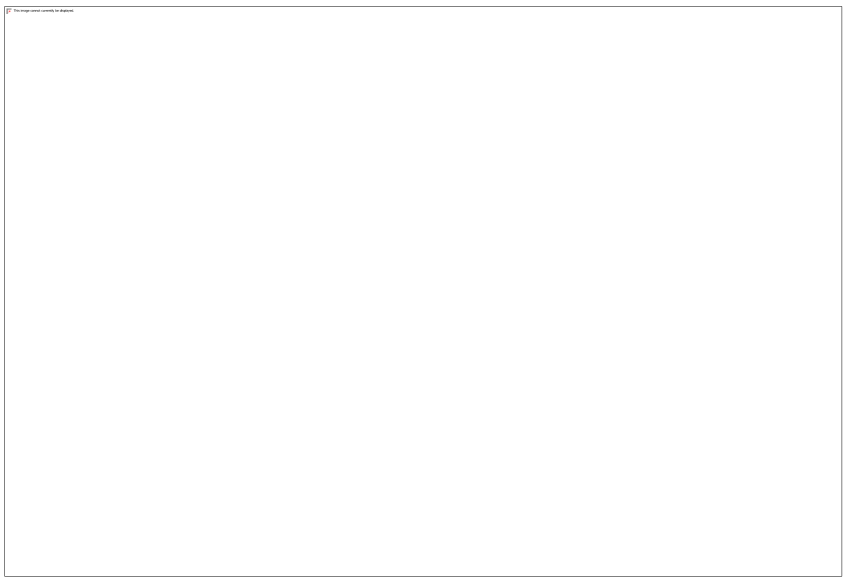
In this forecast, Energy Commission staff uses the term "Transition 2050" to refer to a vehicle price scenario where ZEV prices will be the same as conventional vehicle prices, in each of the comparable vehicle classes, by 2050. This is a similar approach to the NRC and David Green's aforementioned study, which is consistent with goals set in place by Former California

27 David L. Greene, Sangsoo Park, and Changzheng Liu. May 2015. http://onlinepubs.trb.org/onlinepubs/conferences/2015/sustainability/24.DavidGreene.pdf.

Governor Arnold Schwarzenegger's Executive Order S-03-05. Similarly, "Transition 2030" refers to a vehicle price scenario where ZEV prices will be the same as the gasoline vehicle prices in each of the comparable vehicle classes by 2030, which is more consistent with the Governor's goal.

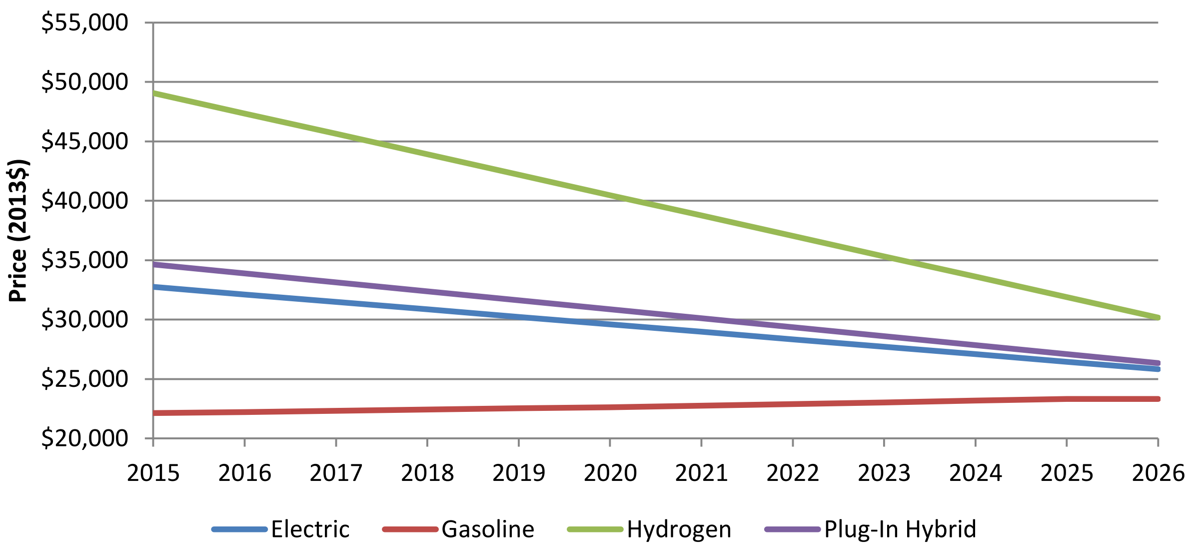
The high demand case is based on the assumption that Transition 2030 ZEV prices will prevail in the market, with faster conversion of ZEV and gasoline vehicle prices over the forecast period. Figure 3-8 shows these vehicle prices in the compact car class, as they have high market penetration and are thus representative of trends.

Figure 3-7: Retail Price Equivalents: Passenger Cars, High Volume, Fully Learned



Source: http://onlinepubs.trb.org/onlinepubs/conferences/2015/sustainability/24.DavidGreene.pdf

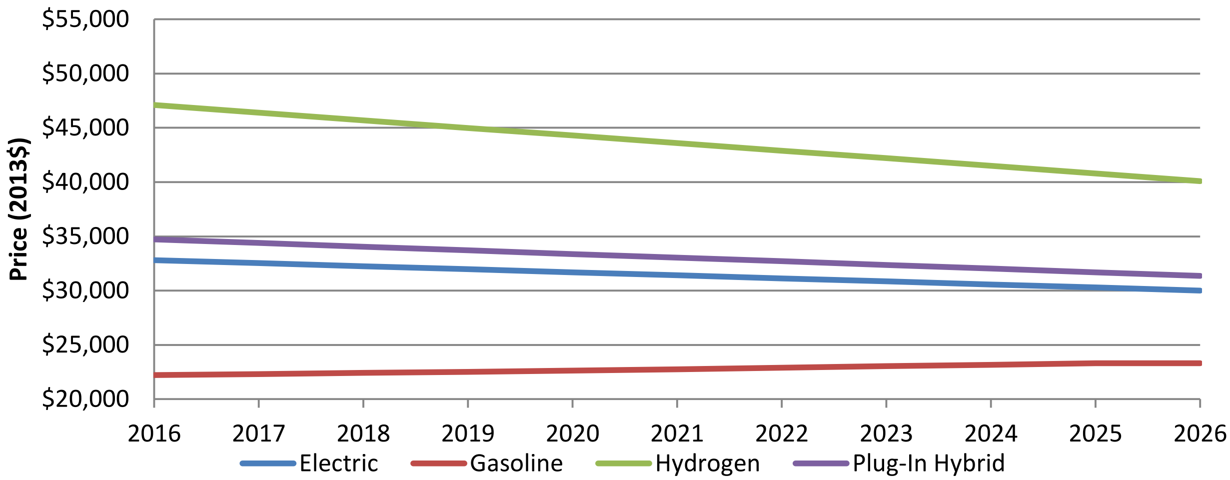
Figure 3-8: High Demand Case – Transition 2030 ZEV Prices: Compact Class



Source: California Energy Commission and Sierra Research

The mid demand case is based on the assumption that Transition 2050 vehicle prices will prevail in the market, with ZEV prices converging to gasoline vehicle prices in 2050. Figure 3-9 shows vehicle prices in this scenario for vehicle prices in compact class.

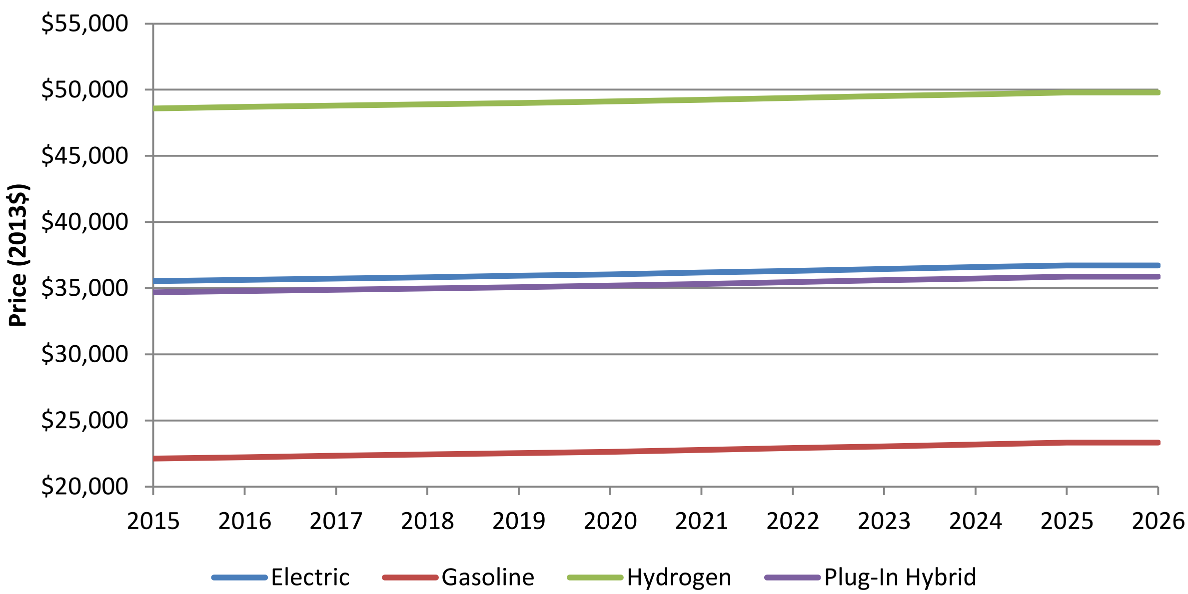
Figure 3-9: Mid Case – Transition 2050 ZEV Prices: Compact Class



Source: California Energy Commission and Sierra Research

The low demand case is based on the assumption that incremental price of ZEV will move in tandem with gasoline vehicles throughout the forecast period. Figure 3-10 shows vehicle prices for the compact class, with ZEV prices rising along with gasoline vehicle prices.

Figure 3-10: Low Demand Case – Tandem ZEV Prices: Compact Class



Source: California Energy Commission and Sierra Research

Technology Introduction

Energy Commission models include more detailed LDV classes than most other models and forecasts. As such, the forecast is more sensitive to the class in which a specific technology is introduced. Sierra Research used a class distribution that is implied in the ZEV regulation as a guide to distribute technology introduction by class.

Table 3-3 shows at least one ZEV technology in every class of vehicle, under 8,500 lb. gross vehicle weight. The technology years in this table correspond to the earliest vintage in the 2014 vehicle stock.[28] The figures in italics indicate Sierra Research's prediction of the technology introduction year.

Table 3-3: Technology Introduction Table

Class	Gasoline	Hybrid	Diesel	Diesel Hybrid	Flex Fuel	CNG	DUAL	Plug-in Hybrid Electric	Electric	Fuel Cell
Subcompact	1966	2000	1967	*2020*	2003	1970	-	2012	1966	2003
Compact	1965	1997	1969	*2020*	2001	1996	-	2011	1969	-
Midsize	1956	2004	1969	*2020*	1996	2000	-	2012	1969	2013
Large	1961	2010	1967	*2020*	2006	1996	-	2015	2012	*2018*
Sport	1962	2014	1980	-	2011	1962	-	2014	1972	-
Cross Utility - Small	1998	2011	2011	*2020*	2009	2009	-	*2015*	2006	2011
Cross Utility - Small Trk	1966	2005	2004	*2020*	2007	2008	-	2015	1998	2015
Cross Utility - Midsize	1993	2006	2008	*2020*	2013	2008	-	*2015*	2006	2009
Sports Utility - Compact	1966	2014	2013	*2020*	2007	2010	-	*2017*	1995	-
Sports Utility - Midsize	1966	2009	1970	*2020*	2002	1966	-	-	2006	-
Sports Utility - Large	1966	2008	1982	-	2002	1977	-	-	1987	*2018*
Sports Utility - Heavy	1987	*2020*	1987	-	2009	2000	-	-	-	-
Van - Compact	1966	*2020*	1966	-	1998	1994	-	*2017*	1973	-
Van - Large	1966	*2020*	1974	*2020*	2007	1975	*2013*	-	1995	*2018*
Van - Heavy	1966	*2020*	1981	-	2008	1992	-	-	1989	-
Pickup - Compact	1966	*2020*	1981	-	1999	1992	-	*2017*	1982	-
Pickup - Standard	1951	2009	1974	*2020*	2002	1995	-	-	2004	*2018*
Pickup - Heavy	1958	*2019*	1982	-	2010	1996	1999	-	1996	-

Source: California Energy Commission Staff Analysis of DMV Data and Sierra Research. Italics indicate predictions of introduction. "-" indicates a technology is not projected to be introduced to a given vehicle class over the forecast period.

28 Vehicle Identification Numbers were not standardized until 1981. As such, older vintages may not be fully represented in this analysis.

Consumer Preferences

Consumer preferences for different vehicle technologies play a significant role in market penetration of these technologies. Consumers start the forecast period preferring gasoline vehicles to ZEVs in 2013 in most market segments. Past transportation energy demand forecasts were based on the assumption that consumer preferences remain the same. New evidence, however, shows consumer preferences have increased in favor of ZEVs, tracking higher public awareness and market penetration. In the high ZEV preference cases, Energy Commission staff assumed that by 2025 consumers would have higher preferences for all ZEVs than comparable class gasoline vehicles.

Medium and Heavy Duty Truck Alternative Fuel Type Penetration Rates

Staff used the Energy Commission fuel price forecasts; while the fuel economy, and vehicle price forecasts were generated by Sierra Research. The MD and HDV stock at the outset of the forecast is drawn primarily from staff analysis of DMV 2013 vehicle registration data, EMFAC2014[29] model data, and the 2013 National Transit Database. Buses and demand response (for example, paratransit) vehicle trends were included in three cases to represent a likely range of future stock but were not modeled by staff. The changes in truck fleets in the freight model depend on modeled market penetration rates of alternative fuel and technology types as an input.

Penetration rate analysis began by running the Argonne Truck 5 model, a vehicle choice model used by the Argonne National Labs[30] to evaluate programs at the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy's Vehicle Technologies Office; and by the National Petroleum Council in a 2012 report,[31] which was in response to a request from the U.S. Secretary of Energy. Staff identified fuel and technology types for trucks in the freight model that could be evaluated using the Argonne Truck 5 model: CNG, LNG, diesel-electric hybrid, ethanol (E85), and battery electric. The Argonne Truck 5 model is limited to a baseline technology and three alternatives. As such, staff did not include all possible alternative technologies in every truck class where they have only been demonstrated or may eventually emerge. In general, staff applied technologies in a class where they are likely to first be competitive, to result in the most market penetration, and to have at least one of the six cases where they show some market share by 2026. Some key assumptions are outlined below:

- Natural gas trucks have a better chance of adoption in the larger classes of HDVs since the high annual miles traveled allows the fuel savings to offset the high cost of the vehicle technology.

29 California Air Resource Board Emissions Factor (EMFAC) Model.

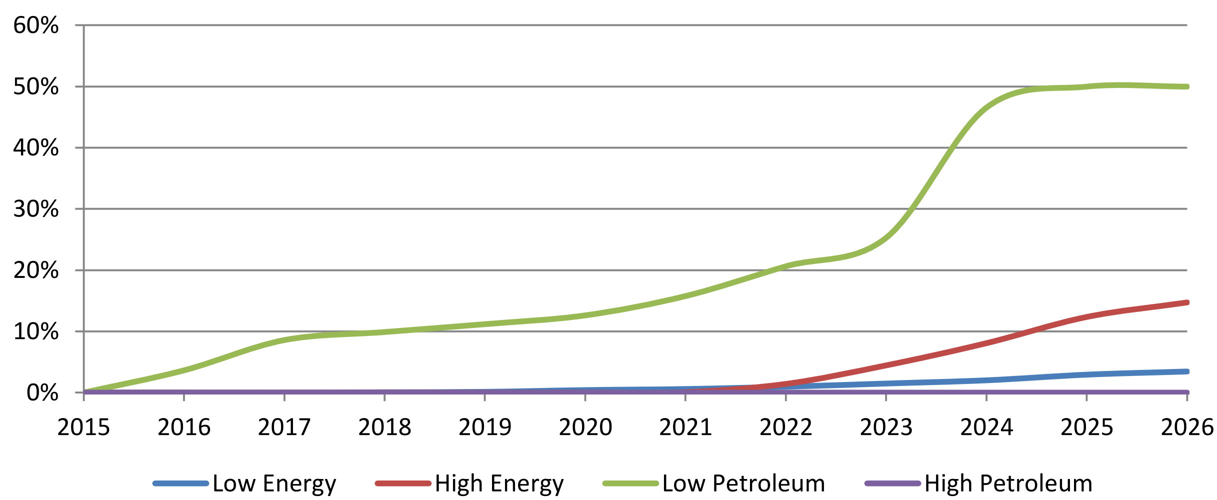
30 http://www.transportation.anl.gov/pdfs/G/955.PDF.

31 http://www.npc.org/ - Transportation.

- Interstate trucks, as identified from the ARB's analysis of the International Registration Program (IRP) for the EMFAC model, have the highest annual distance.
- Battery electric and diesel-electric hybrid vehicles were included in the GVWR 4 to 6 truck classes, where they can provide short distance ("last mile") delivery service.
- The dedicated E85 "Ethos" engine developed by Cummins is applied to GVWR 3, although it has also been demonstrated in a GVWR 5 step van.
- Either CNG or LNG was applied in all classes.
- Diesel-electric hybrids were included in the following categories:
    - Class 3
    - Class 4 to 6
    - Class 7 and 8 single-unit trucks
    - Class 8 tractor-trailer combinations
- Staff also used California–specific truck travel data in the Argonne Truck 5 Model.

Figure 3-11 shows that penetrations of IRP Class 8 combination trucks are highest in the low petroleum demand case (high petroleum fuel prices, and low natural gas prices), reaching about 13 percent in 2020 and 50 percent in 2025.

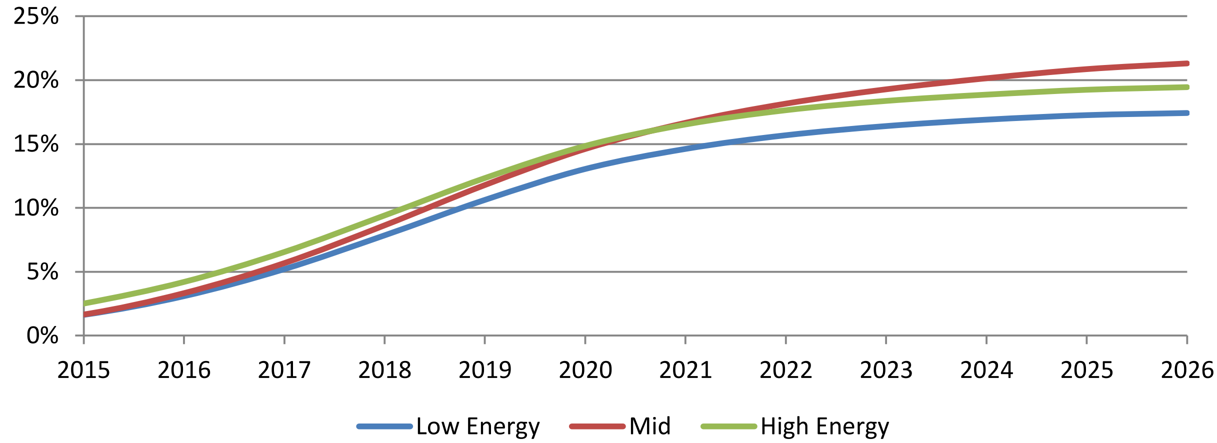
Figure 3-11: Natural Gas Penetration Rate in IRP Class 8 Combination Trucks



Source: California Energy Commission and Sierra Research

Less than 0.5 percent of Class 4-6 trucks in 2013 were natural gas trucks, but the penetration rate is projected in the mid case to increase to 15 percent in 2020 and 21 percent in 2025. Fuel prices, vehicle prices, and fuel economy all contribute to the competition among fuel types in the Argonne Truck 5 Model, resulting in higher market penetration in the mid case for this truck class, as shown in Figure 3-12.

Figure 3-12: Natural Gas Penetration Rate in Class 4-6 Trucks



Source: California Energy Commission and Sierra Research

Natural gas penetration in refuse trucks is driven by regulations. The penetration rate was at 48 percent in 2013 and is projected to reach 86 percent in the low demand case (high energy prices).

Transit vehicles currently consume the highest share of transportation natural gas in California. The National Transit Database (NTD) identifies the following fuel type distribution among transit and commuter buses in California. Regional air quality rules require alternative fuel buses in the South Coast Air Quality Management District, and CNG and LNG buses have been eligible for incentives in other urban transit districts. Some battery electric and hydrogen buses have also been eligible for incentives, allowing the transit industry to log some real-world experience with the advantages and limitations of these fuels used in frequent-stop service. Gasoline buses are preferred in lighter-duty, low annual mileage service such as vanpools[32] using smaller, less expensive buses. The distribution of transit and commuter buses by fuel type is depicted in Table 3-4. DMV vehicle registration data from 2014 indicate that new propane buses outnumber new natural gas buses, 384 to 244, for the first time. Also, DMV vehicle registration data shows that new heavy duty natural gas tractor-trailer registrations dropped from 314 in 2012 to 128 in 2013.

32 Vans used for vanpools are generally less than 10,000 pounds, since the operators are generally coworkers, not professional drivers. More than 16 passengers in larger vans over 10,000 pounds GVW would require a Class B driver's license and additional driver's training.

Table 3-4: 2013 Transit and Commuter Bus Distribution by Fuel Type

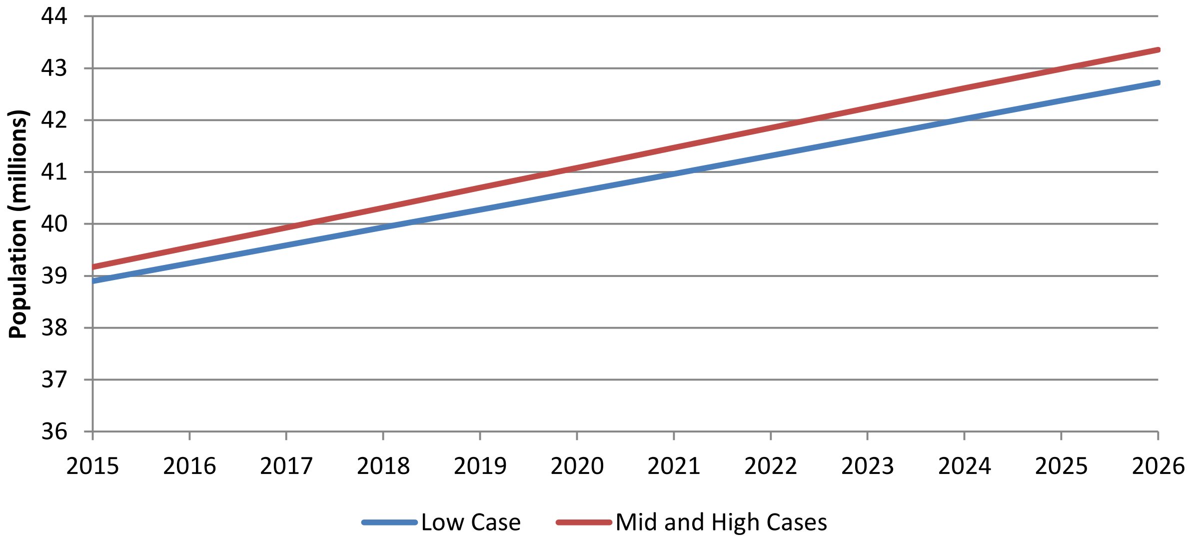
Sector	On-Road Transit Fuel by Mode (NTD 2013)	Bus	Bus Rapid Transit	Commuter Bus	Demand Response	Demand Response Taxi	Trolley Bus	Van Pool	Total
Urban Transit	Biodiesel(BD)	44			70				114
	Compressed Natural Gas (CNG)	5,445	137	806	568	316			7,272
	Diesel Fuel	3,438		538	624				4,600
	Electric Battery	24							24
	Electric Propulsion						301		301
	Gasoline	515		110	7,604	5,286		3,744	17,259
	Hybrid Diesel	159							159
	Hybrid Gasoline	192			14	110			316
	Hydrogen (HY)	27							27
	Liquefied Natural Gas (LNG)	334							334
	Liquefied Petroleum Gas (LPG)	265			26				291
	Total	10,443	137	1,454	8,906	5,712	301	3,744	30,697
Intercity*	Diesel	2,050							

Source: California Energy Commission analysis of the 2013 NTD data
*Intercity motor coach data from ARB's EMFAC data

Economic and Demographic Data

Energy Commission staff used population projections consistent with the common energy demand cases, as discussed earlier in this chapter. These projections stem from three sources: IHS Global Insight, Moody's Analytics, and the California Department of Finance. Three input scenarios were created: high, mid, and low population projections, respectively, and were discussed at a February 26, 2015 *IEPR* workshop on forecast assumptions. The three population scenarios presented at this workshop were reduced to two cases – where one is used for both high and mid energy demand cases – because of the similarity between the two forecasts. These two scenarios are presented in Figure 3-13. The difference in population at the beginning of the forecast is very close to that in the final year of the forecast, as the rate of change per year is effectively equal in all scenarios.

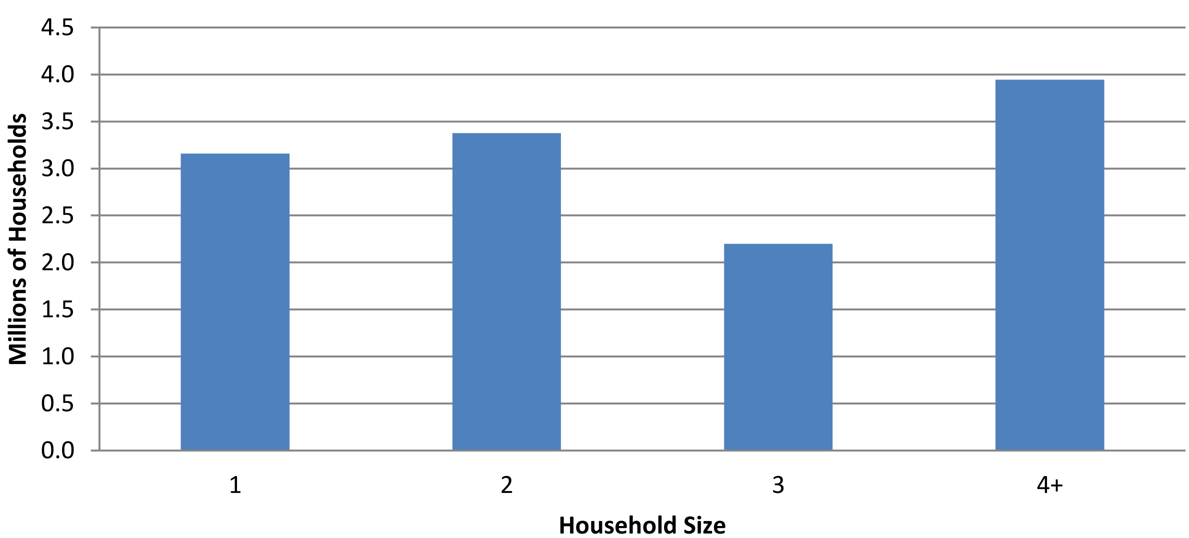
Figure 3-13: California Population Forecast Scenarios



Sources: IHS Global Insight, Moody's Analytics (https://www.economy.com/), and California Department of Finance

Energy Commission staff used the 2013 American Community Survey for the total number of households in the state, as well as the distribution of these households by size, income category, and number of vehicles. The household size distribution is displayed in Figure 3-14, showing almost 4 million households with four or more members.

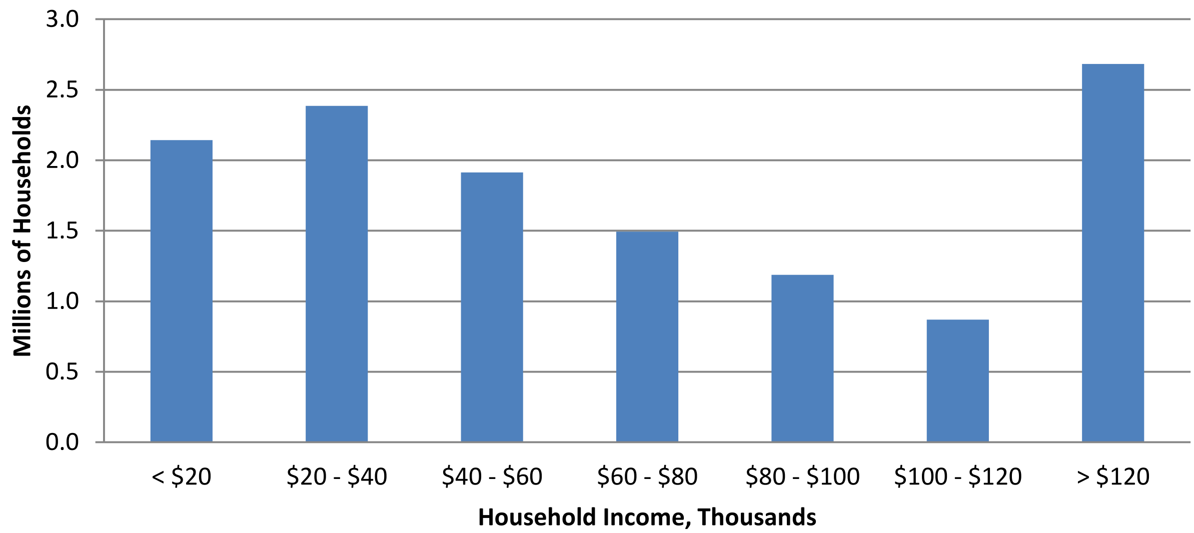
Figure 3-14: California Household Distribution by Size, 2013



Source: California Energy Commission Analysis of the 2013 American Community Survey. https://www.census.gov/programs-surveys/acs/data.html

Figure 3-15 shows household distribution by income group, with almost 6.5 million households earning less than $60,000 and almost 2.7 million households earning more than $120,000.

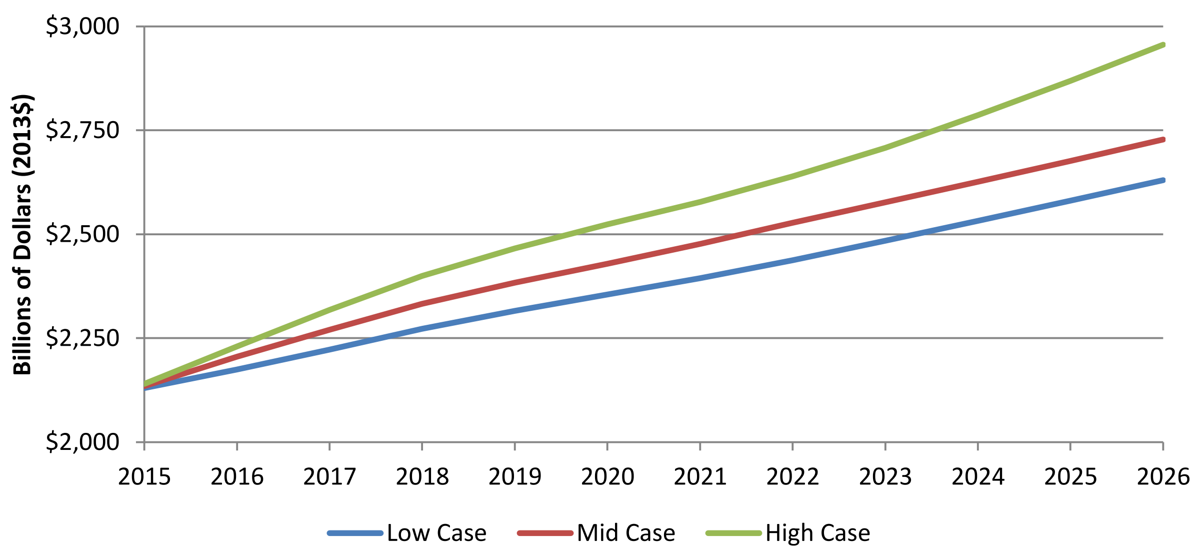
Figure 3-15: California Household Distribution by Income Category, 2013



Source: California Energy Commission Analysis of the 2013 American Community Survey. https://www.census.gov/programs-surveys/acs/data.html

Unlike population, there are three gross state product inputs, as shown in Figure 3-16. The high demand case is derived from IHS Global Insight, while the mid and low energy demand cases are separate projections from Moody's Analytics. The high, mid, and low cases grow by an average of 3.0, 2.3 and 2.0 percent, respectively. All three cases start from the same base value in 2013, and by 2026, the low and high cases differ by 12.3 percent.

Figure 3-16: California Gross State Product Forecast



Sources: IHS Global Insight and Moody’s Analytics (https://www.economy.com/)

Off-Road Transportation

Data from the BOE includes all diesel and gasoline purchased at retail stations across California. To account for all fuels sold in California, staff generated off-road diesel use estimates and projections of off-road gasoline and diesel in past *IEPRs*. While past *IEPR* forecasts implicitly assumed no electrification, the *2015 IEPR* made an adjustment to off-road diesel and gasoline demand forecasts based on Aspen Environmental Group's projections of off-road electrification and petroleum fuel demand reductions.

While off-road diesel is entirely integrated into the transportation demand forecasts, the new projections of off-road electricity demand have been incorporated into the transportation, communication, and utility (TCU) electricity demand forecast of the *2015 IEPR*. The criteria for allocating off-road transportation electricity to TCU and transportation energy are whether the equipment is registered with DMV and if it is used as a stationary source. Transportation energy demand for diesel and gasoline will only be adjusted downward to account for the increase in electricity in these instances.

Transportation Energy Prices

This section opens with a discussion of current price conditions for petroleum fuels and a crude oil price forecast. Price forecasts for other transportation fuels follow.

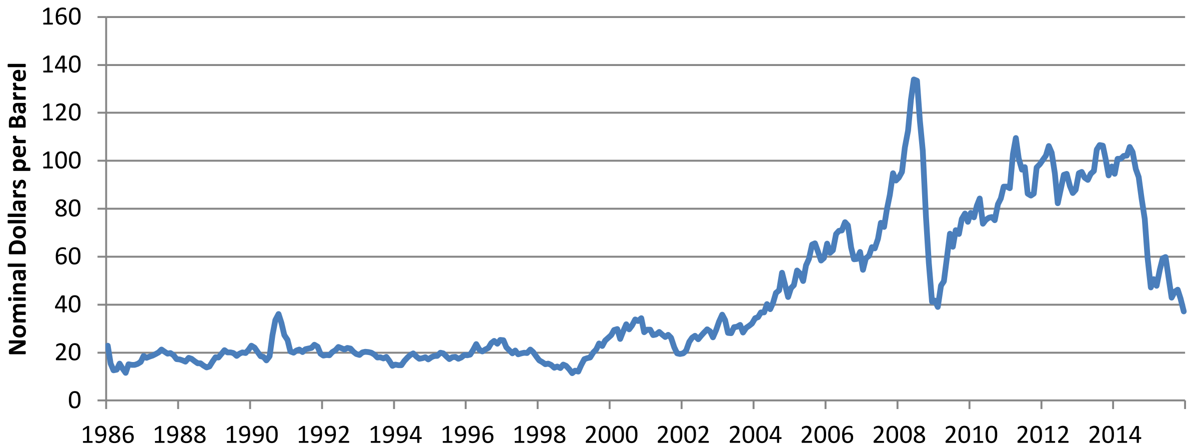
Petroleum Fuels

According to EIA, prices for petroleum fuels have seen a significant shakeup since 2013, driven by a precipitous drop in crude prices, as shown in Figure 3-17. For example, the spot price of a barrel of West Texas Intermediate crude had fallen nearly 65 percent from about $106 in June 2014 to $37 in December 2015. For further discussion on crude oil prices and national and global trends in production, see Chapter 9 of the *2015 IEPR*, on "Changing Trends in California's Sources of Crude Oil."[33]

Refineries acquire crude oil to produce gasoline, diesel, and other petroleum products. The refinery wholesale prices are the daily "spot pipeline" prices quoted by the Oil Price Information Service (OPIS) for the Los Angeles Basin. Figure 3-18 shows the relationship between wholesale and retail prices in California.

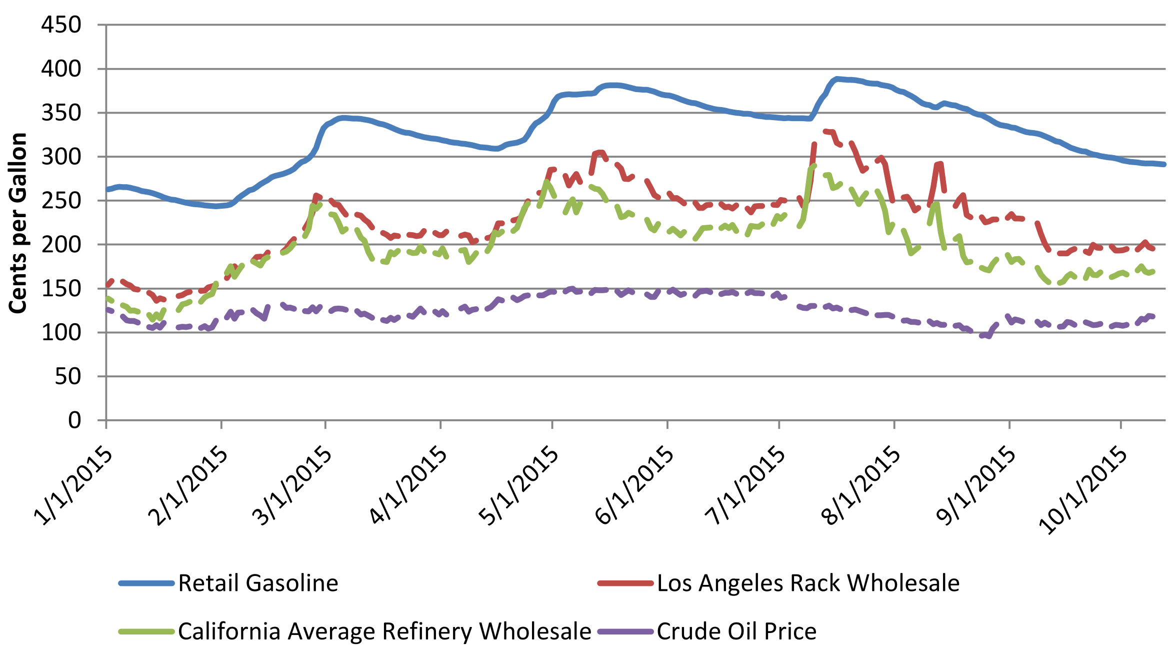
33 http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-01/TN206330_20151012T134153_2015_Draft_Integrated_Energy_Policy_Report.pdf.

Figure 3-17: West Texas Intermediate Crude Oil Monthly Spot Prices



Source: U.S. Energy Information Administration

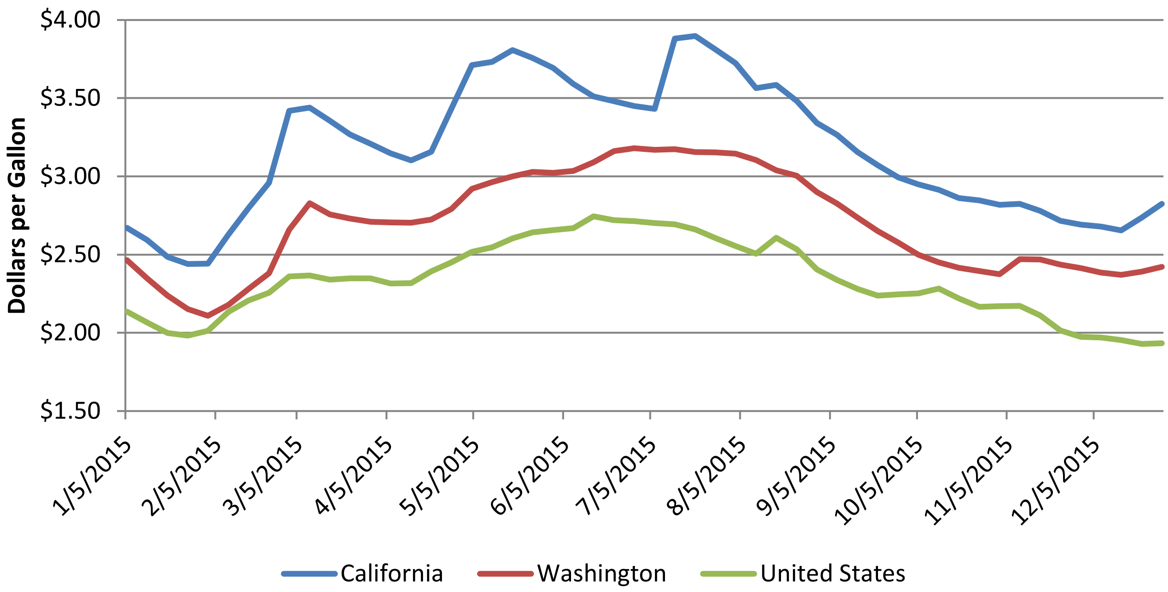
Figure 3-18: Wholesale Crude Oil and Retail Gasoline Prices in California, 2015



Source: California Energy Commission Analysis of AAA and OPIS Prices

California fuel prices are typically higher than the rest of the United States. Figure 3-19 shows the California retail price differences for gasoline as compared to the rest of the United States. This price difference peaked at $1.095 on July 20, 2015, and the overall 12-month average price difference has increased from 65.1 to 66.9 cents per gallon.

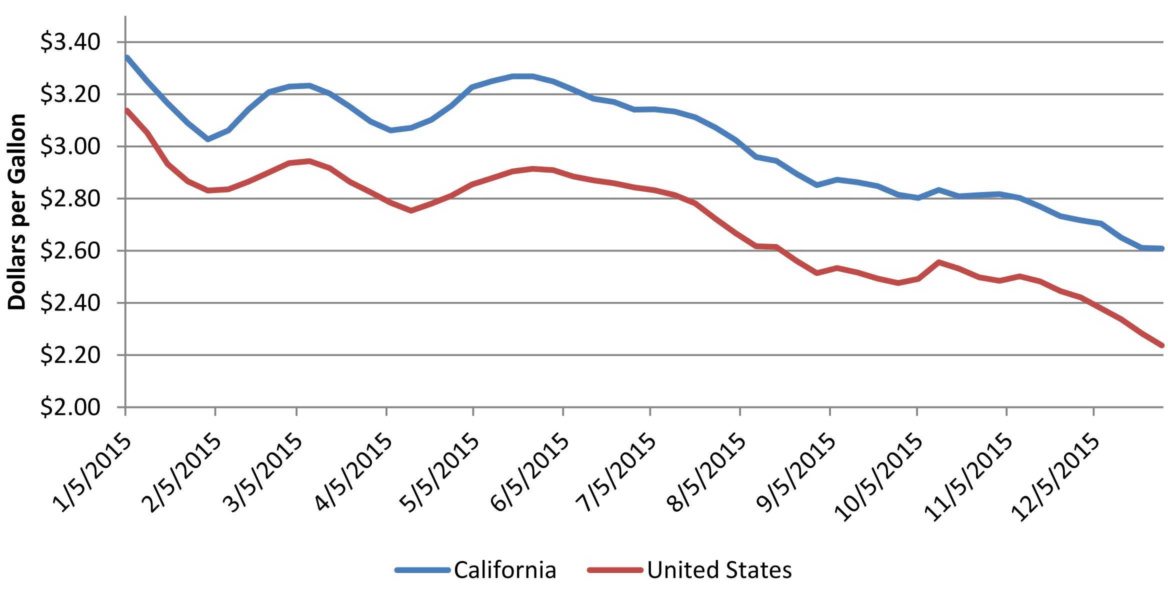
Figure 3-19: Retail Gasoline Prices – U.S., Washington and California, 2015



Source: U.S. Energy Information Administration

California diesel prices show a consistently higher price than the U.S. average in 2015. Figure 3-20 shows the differences in retail diesel prices.

Figure 3-20: Retail Diesel Prices – U.S. and California, 2015



Source: U.S. Energy Information Administration

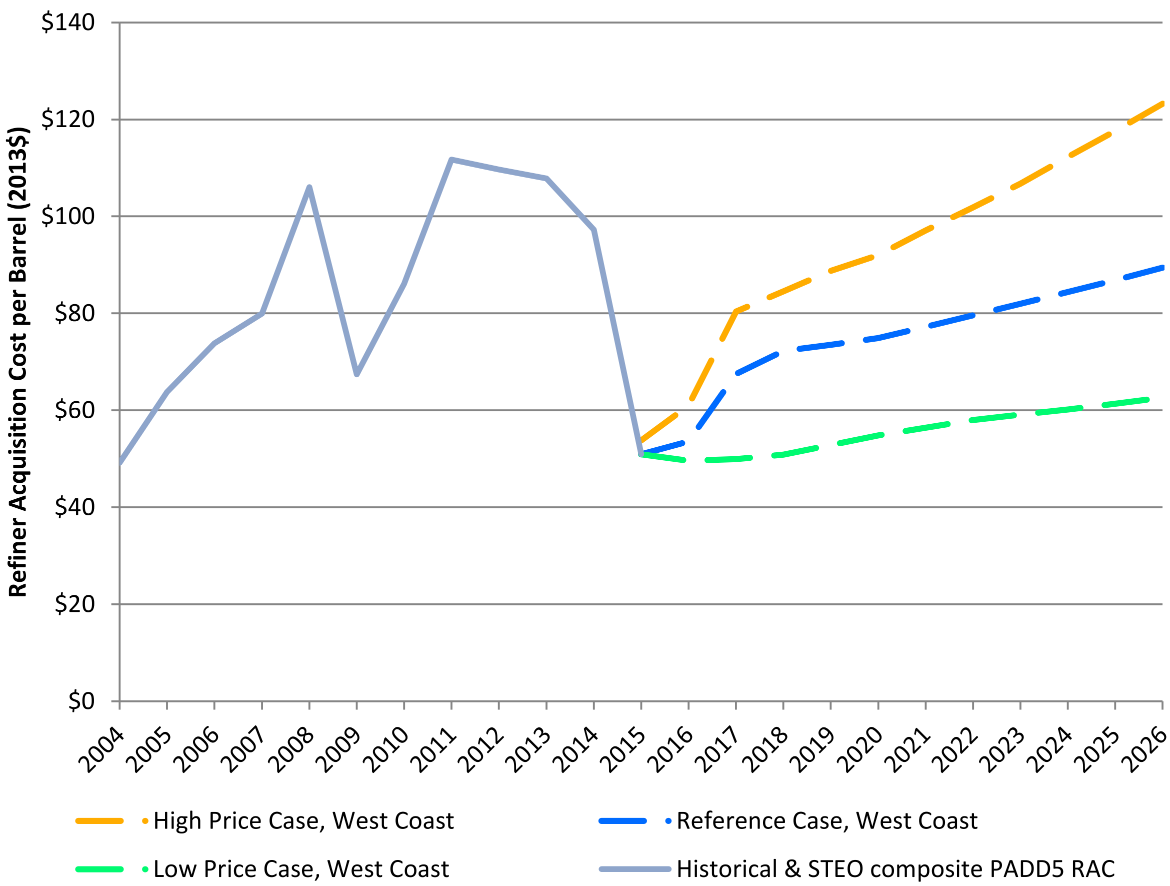
The highest difference between the California and U.S. average retail diesel prices was reached in February 2007 at 43 cents per gallon. In the last 12 months, this difference has averaged 16 cents per gallon.

Crude Oil Price Forecast

The Energy Commission traditionally looks to the *Annual Energy Outlook*, published by the EIA, for crude oil price forecasts to serve as inputs to the transportation liquid fuel price forecasts. *Short-Term Energy Outlook* and the *Annual Energy Outlook* scenarios were combined in various ways to produce usable scenarios for the price of crude oil paid by American refineries, known as the refiner acquisition cost (RAC).[34]

Energy Commission staff calculated West Coast composite RAC prices. These are based on the most recent EIA forecast available, which is the 2015 update of the 2014 petroleum price forecast made in the *Annual Energy Outlook*.[35] The crude oil prices in Figure 3-21 were used to forecast liquid fuel prices (gasoline, diesel, and E85).

Figure 3-21: Revised Crude Oil Cost Forecast



Source: California Energy Commission, Supply Analysis Office and U.S. Energy Information Administration

34 The crude oil refiner acquisition cost is the cost of crude oil, including transportation and other fees paid by the refiner.

35 The most recent forecast numbers are based on an EIA forecast that was made before the large decline in crude oil prices that began in 2014 and continued into 2015.

Transportation Energy Price Forecasts

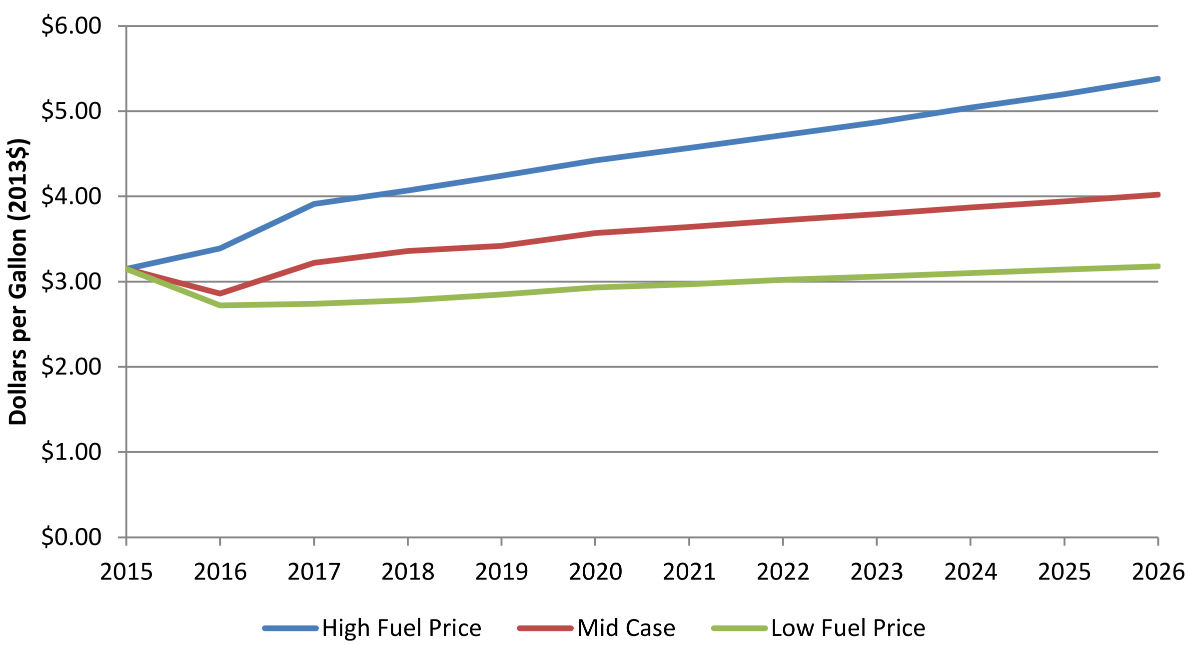
Staff used the crude oil price forecast and the California price margins to generate gasoline, diesel, and E85 retail prices in California. Staff also generated electricity, natural gas and hydrogen prices using different sets of models. The electricity prices used in the forecast are those used in the *2015 California Energy Demand*[36] forecast and throughout the *IEPR*.

Gasoline, Diesel, and E85 Price Forecasts

The three price forecasts for gasoline, diesel, and E85 are depicted in Figures 3-22, 3-23 and 3-24, respectively. Because demand varies inversely with price, the high energy demand case uses the low fuel price inputs, and the low energy demand case uses the high fuel inputs. Petroleum fuel prices closely follow the crude oil price movements.

Figure 3-22 shows gasoline prices declining in 2016, in both low and mid cases, and start increasing in 2017, in all cases. The price differentials between the high and low price forecasts continue to grow over time, reaching over $2.00 in 2026.

Figure 3-22: Gasoline Price Forecast



Source: California Energy Commission

Figure 3-23 shows diesel prices also increase, starting in 2017, in all input scenarios. The high and low price difference continues to grow over time, reaching over $2.50 in 2026.

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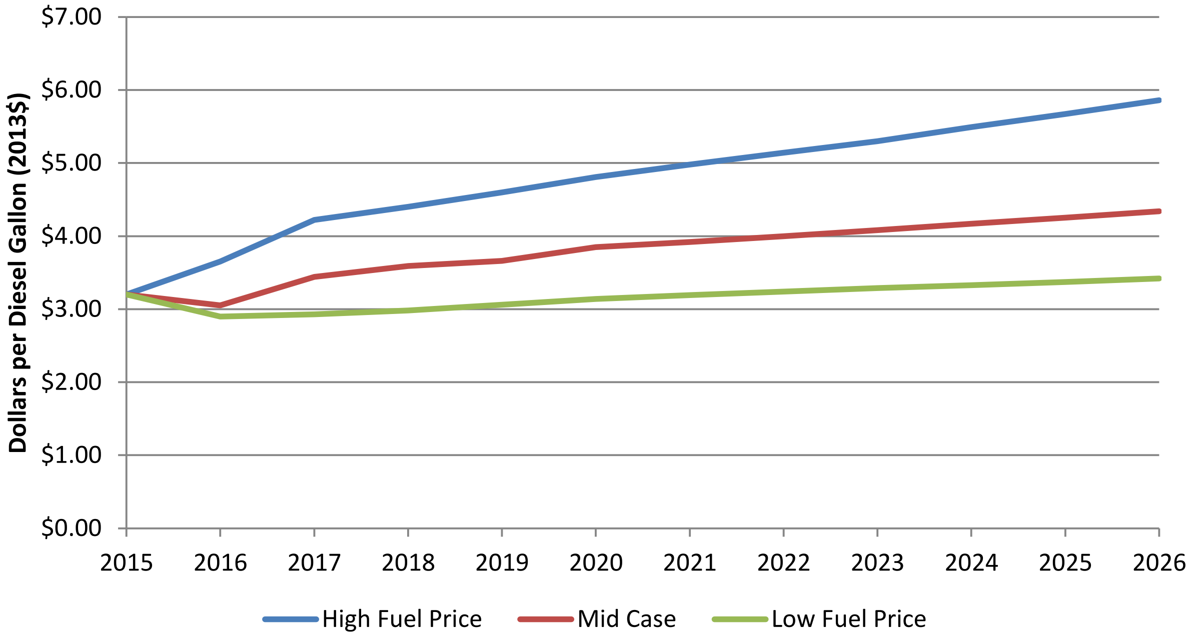
36 This report can be found as part of the *IEPR 2015* docket at https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=15-IEPR-03

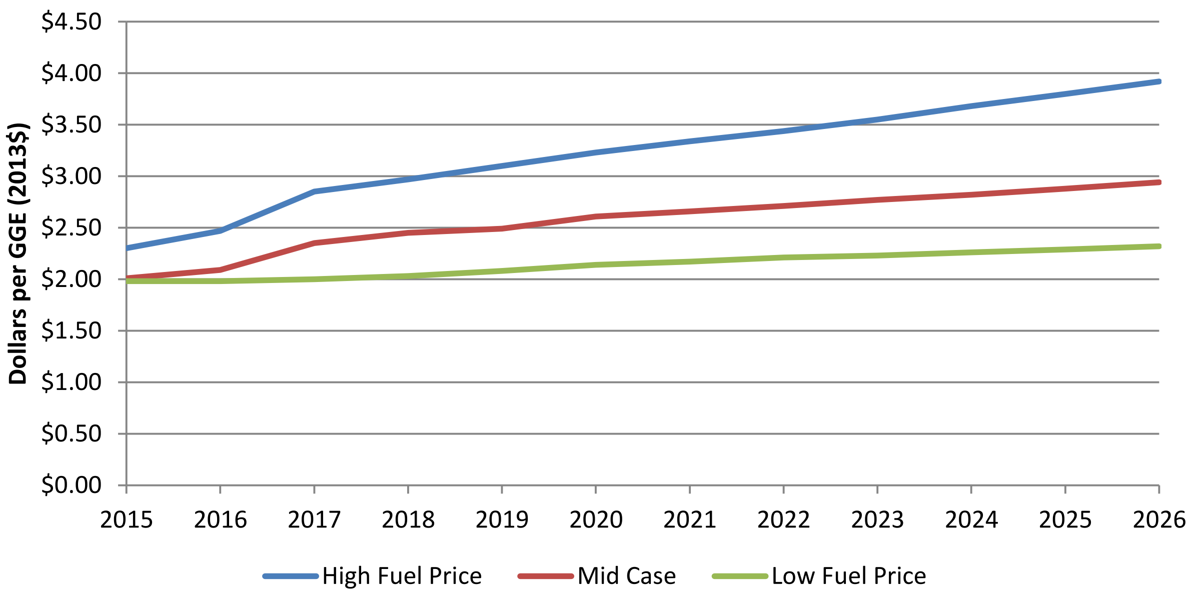
Figure 3-23: Diesel Price Forecast



Source: California Energy Commission

The E85 price is depicted in dollars per GGE. Figure 3-24 shows E85 prices continue to increase over the entire forecast period, in all input scenarios. The difference between the high and low price scenarios continues to grow over time. The price difference exceeds $1.60 in 2026, and the E85 price reaches a high of almost $4.00 per GGE in 2026, in the high price scenario.

Figure 3-24: E85 Price Forecast



Source: California Energy Commission

Electricity Price Forecast

The staff electric rate model was used to generate mid, high and low rate projections of annual average retail electric rates by sector and forecast planning area (as defined for the *2015 California Energy Demand* forecast). The model projects revenue requirements as a function of electricity demand, natural gas prices, carbon prices, infrastructure costs, and other costs of service. Revenue requirements are allocated to each sector using the most current factors available from each utility.

Natural gas projections used were prepared as part of the *2015 IEPR Revised Natural Gas Outlook*.[37] Utility-specific data submitted via the *2015 IEPR* supply and demand forms were used to characterize the portfolio mix and procurement costs, renewable portfolio standard (RPS) targets, public program costs, and other costs of service in each planning area.

Basic economic theory stipulates that demand for a good is inversely proportional to its price. Therefore, the high energy demand case uses the low electricity rate inputs. These low rates assume relatively high economic and demographic growth, low natural gas and carbon prices, lower investment in distribution infrastructure, and relatively low efficiency program and self-generation impacts. Conversely, the low energy demand case uses the high rate case, which assumes lower economic and demographic growth, higher natural gas and carbon prices, higher efficiency program and self-generation impacts, and higher investment in distribution infrastructure. The mid case uses input assumptions at levels between the high energy demand and low energy demand cases.

The transportation electricity price forecast uses a statewide sales-weighted annual average of rates for the residential and commercial sectors based on factors discussed in both the *2015 California Energy Demand Forecast* and the *2015 IEPR Revised Natural Gas Outlook*. The use of annual average rates may overestimate electricity costs in the transportation energy demand forecast, depending on charging behavior and the future design of special tariffs for electric vehicle customers, or on-peak and off-peak time of use rates.[38]

Natural Gas Price Forecast

The Energy Commission generates wholesale price forecast using the North American Natural Gas (NAMGAS) Model. More detail about the model and the price forecast can be found in *Draft Staff Report: 2015 Natural Gas Outlook*.[39] The wholesale prices are then used in generating CNG prices at retail market, which are used in transportation sector.

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37 This report can be found as part of the *IEPR 2015* docket at https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=15-IEPR-03

38 Staff has begun work with Lawrence Berkeley National Lab and Idaho National Lab to gain insight into EV load shapes and behaviors, which will provide for a more nuanced result in future *IEPR* forecasting processes.

39 http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-03/TN206501_20151103T100153_Draft_Staff_Report_2015_Natural_Gas_Outlook.pdf

Hydrogen Price Forecast

In December 2015, the Energy Commission and the ARB released a *Joint Agency Staff Report on Assembly Bill 8: Assessment of Time and Cost Needed to Attain 100 Hydrogen Fueling Stations in California* (AB 8 Report).[40] The analysis presented here was conducted by the National Renewable Energy Laboratory (NREL) as part of the AB 8 Report, and can be found in more detail in this report.

According to the AB 8 Report, current hydrogen fuel prices range from $12.85 to more than $16 per kilogram (kg), but the most common price is $13.99 per kg (equivalent on a price per energy basis to $5.60 per gallon of gasoline), which translates to an operating cost of $0.21 per mile. Automakers are including three years of hydrogen fuel with their initial sales and lease offerings, which will shield early market adopters from this initially high fuel price.

While future price is uncertain, NREL estimates that hydrogen fuel prices may fall to the $10 to $8 per kg range in the 2020 to 2025 period, as shown in Table 3-5. A kilogram of hydrogen has about the same energy content as a gallon of gasoline. FCEVs are about twice as efficient as gasoline-powered vehicles: an FCEV travels about twice as far as a conventional vehicle given the same amount of fuel energy. At $3.50 per gallon of gasoline, a conventional vehicle costs about $0.13 per mile to operate, while an FCEV using $8 per kg hydrogen fuel would cost about $0.12 per mile.

Table 3-5: New Vehicle Fuel Economies, Fuel Economy Ratios, Gasoline Fuel Prices, and Gasoline-Equivalent Hydrogen Prices

Attribute	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Vehicle Fuel Economies (mpgge)											
New Fuel Cell Electric Vehicle (FCEV)	72	74.1	77.6	79.3	81.4	83	85.3	87.3	88.9	90.8	93.3
New Conventional Gasoline Vehicle (CGV)	28.6	29.8	31.6	32.7	33.9	35.1	36.5	37.8	39.1	40.4	42.1
Fuel Economy Ratio (FCEV/CGV)	2.52	2.49	2.46	2.43	2.40	2.36	2.34	2.31	2.27	2.25	2.22
Fuel Prices											
Gasoline Price ($/gal)	$2.89	$3.35	$3.54	$3.63	$3.75	$4.01	$4.15	$4.32	$4.48	$4.64	$4.81
Gasoline-Equivalent Hydrogen Price ($/kg)	$7.28	$8.33	$8.7	$8.8	$9.00	$9.48	$9.71	$9.97	$10.19	$10.43	$10.66
Hydrogen Price used in Scenario Analyses ($/kg)	$14.00	$13.71	$13.42	$13.13	$12.85	$12.56	$12.27	$11.98	$11.69	$11.4	$11.11

Source: NREL, derived from the 2015 ARB VISION model (AB 8 Report)

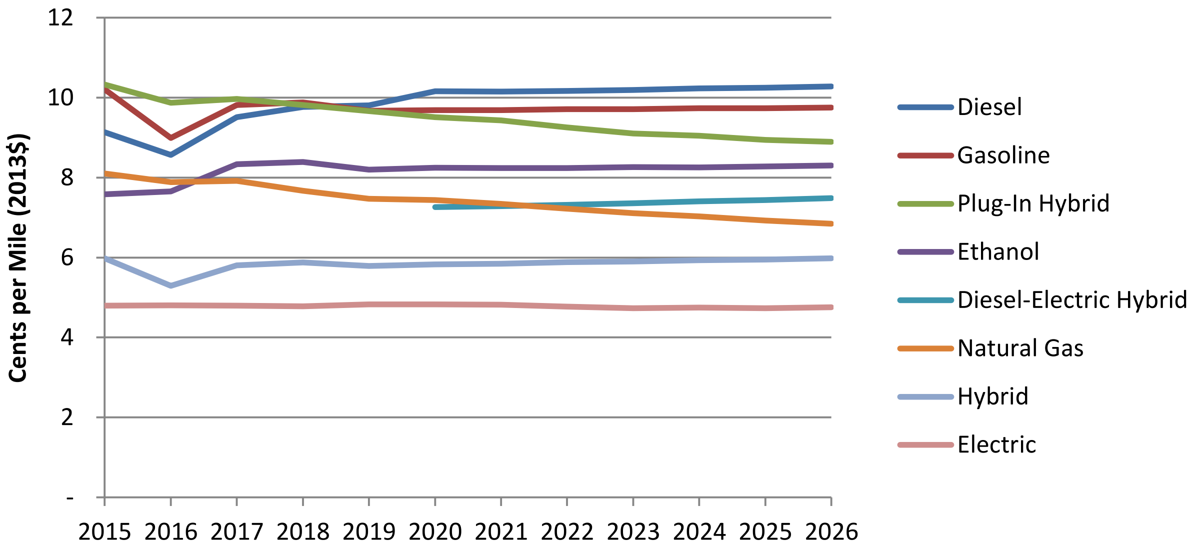
Overall Fuel Cost Per Mile

The energy price forecasts were used along with Sierra Research's projections of fuel economy to derive the cost–per-mile. To summarize the preceding discussions, Figure 3-28 depicts the

40 *Joint Agency Staff Report on Assembly Bill 8: Assessment of Time and Cost Needed to Attain 100 Hydrogen Fueling Stations in California* : http://www.energy.ca.gov/2015publications/CEC-600-2015-016/CEC-600-2015-016.pdf

fuel cost per mile by different fuel and vehicle technologies for the compact class of vehicles. Throughout the forecast, the cost per mile for EVs is lower than all other fuels and technologies in the compact class and remains fairly consistent at just under $0.05 per mile. Note that hydrogen is not included in Figure 3-28 due to the extensive work previously completed by NREL.

Figure 3-28: Fuel Cost per Mile for Compact Cars, Mid Case

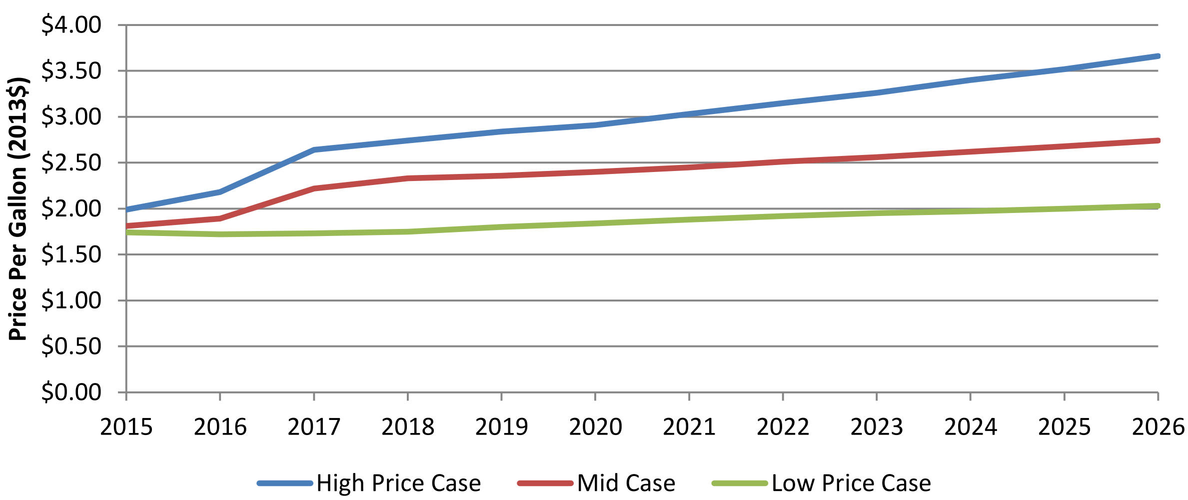


Source: California Energy Commission

Jet Fuel Price Forecast

Forecasted jet fuel prices loosely parallel those of gasoline, with a slight "recovery" priced in during the early years of the high and mid cases. Figure 3-29 shows 2026 jet fuel prices will range from almost $2.00 in the low case to almost $3.70 in the high fuel price case.

Figure 3-29: Jet Fuel Price Forecast



Source: California Energy Commission

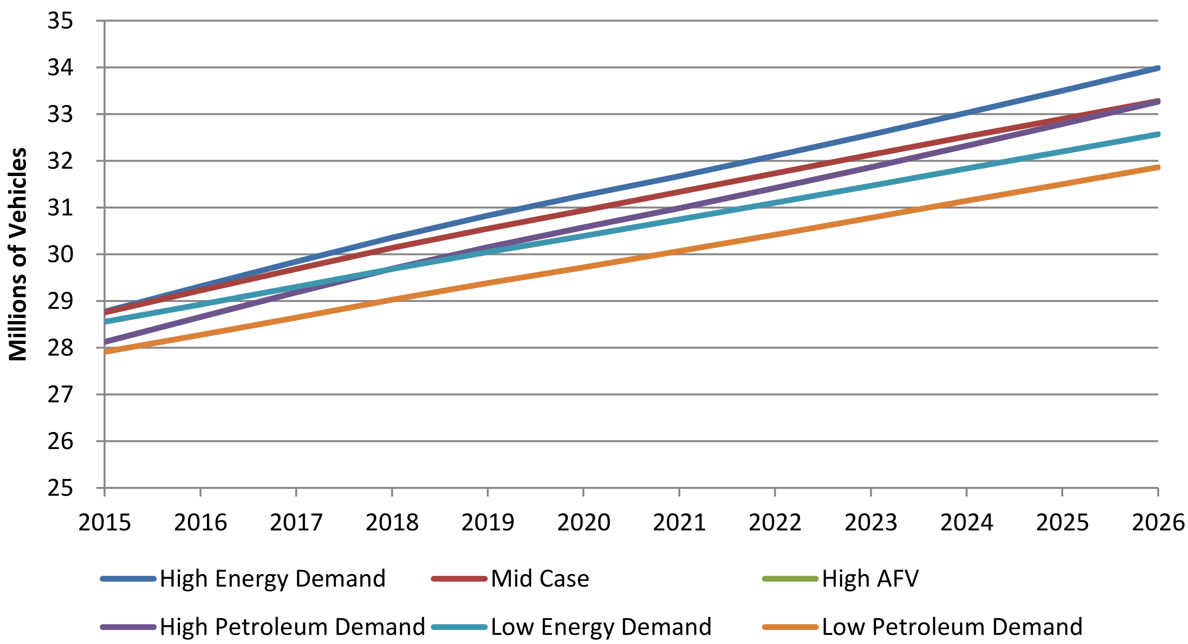
CHAPTER 4:
Transportation Energy Demand Forecast Results

This chapter presents the results of this forecast, starting with LDV demand, followed by fuel demand for the six cases as previously defined in Figure 3-2. The first three cases (High, Mid, and Low Energy Demand) are consistent with other sectors in the Energy Commission's demand forecast. The electricity, natural gas, and transportation sectors all used the same economic, demographic and fuel price projections in these cases.

Light Duty Vehicle Stock Forecast

Since 85 percent of the fleet is personally owned, population and household income are the primary drivers of the size of the LDV fleet in California. Economic growth, implied by GSP, drives the size of LDV fleet in the commercial sector. In this forecast, the LDV fleet size grows from about 28 million vehicles in 2015 to about 32 million in 2026 in the low petroleum demand case. In the high energy demand case, lower fuel prices lead to the largest demand for LDVs, reaching almost 34 million vehicles in 2026. The total LDV stock can be seen in Figure 4-1.

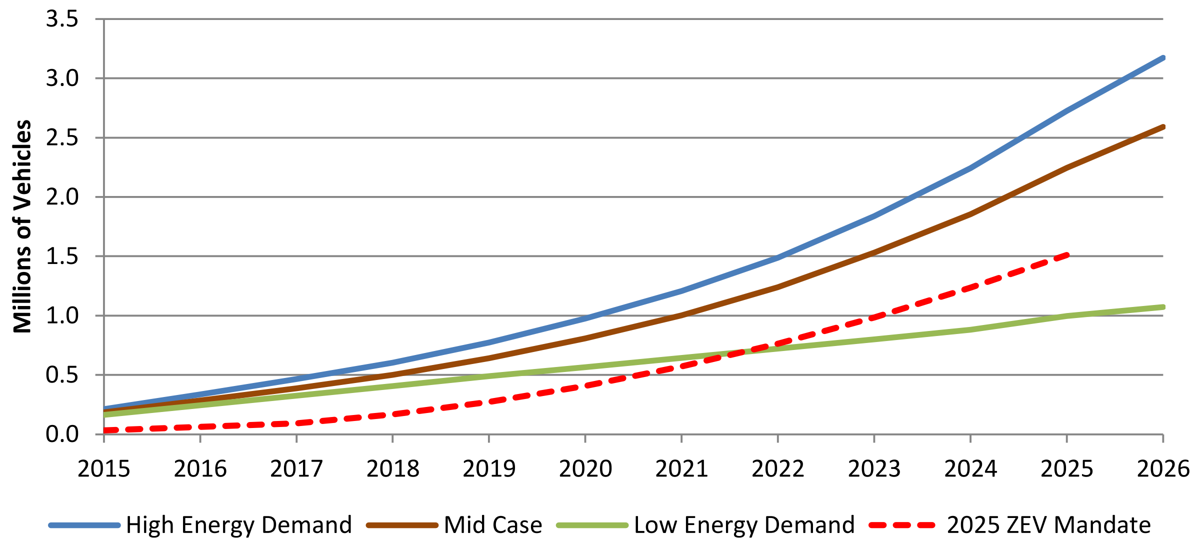
Figure 4-1: Light Duty Vehicle Stock Forecast



Source: California Energy Commission

The PEV forecast (which includes BEV and PHEV) meets and exceeds the ZEV Most Likely Scenario[41] in both the mid and high energy demand cases, as shown in Figure 4-2. In the low energy demand case, in which staff made no assumption as to ZEV price reductions made by manufacturers, PEV demand exceeds the ZEV Most Likely Scenario until 2022, where it then falls behind, reaching 950,000 on-road vehicles in 2025.

Figure 4-2: PEV Stock Forecast in Low, Mid, and High Energy Demand Cases



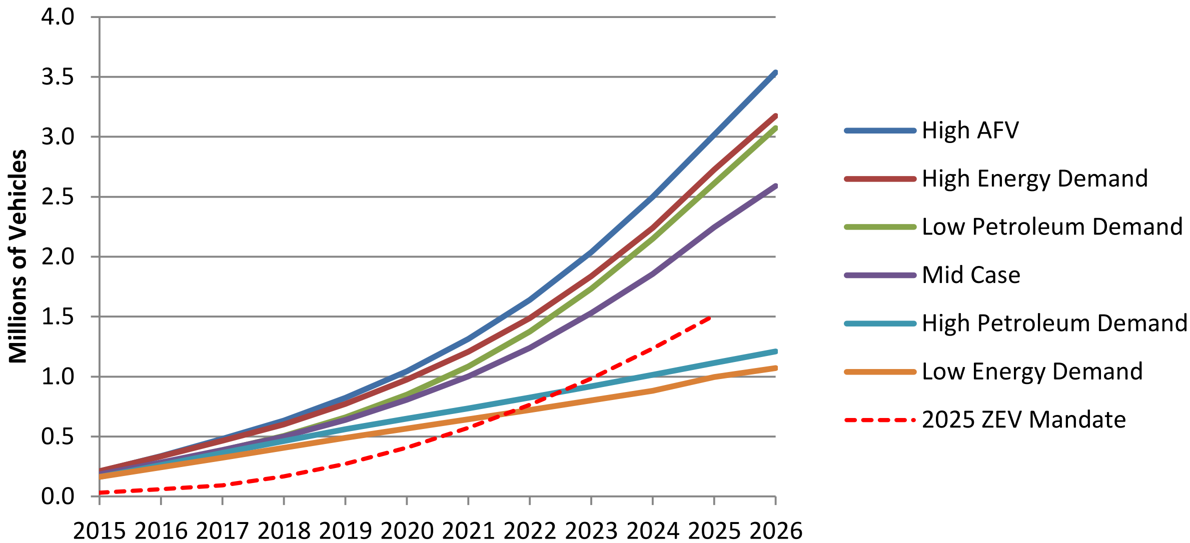
Source: California Energy Commission

Similarly, the ZEV (BEV, PHEV and FCEV) vehicle demand forecast meets and exceeds the ZEV Most Likely Scenario in the high and mid energy demand scenarios, as well as the low petroleum and the high alternative fuel vehicle (AFV) demand cases, as shown in Figure 4-3. The highest number of on-road ZEVs occurs in the high alternative fuel vehicle demand case with more than 3.5 million ZEVs in 2026.

In the low energy demand and high petroleum demand cases, the forecast shows ZEV demand to exceed the required levels through 2022 but then falls short in the final years of the forecast period. The ZEV demand forecast nears 1 million vehicles in the low energy demand case and exceeds 1.1 million vehicles in the high petroleum demand case in 2026. As with the low energy demand case, the high petroleum demand case does not include a ZEV price reduction, and accordingly both of these cases fall short of the 1.43 million cumulative ZEV sales expected by the ZEV Most Likely Scenario.

41 Staff obtained the ZEV Most Likely Scenario from ARB.

Figure 4-3: ZEV Stock Forecast, All Demand Cases



Source: California Energy Commission

Fuel Demand Forecasts

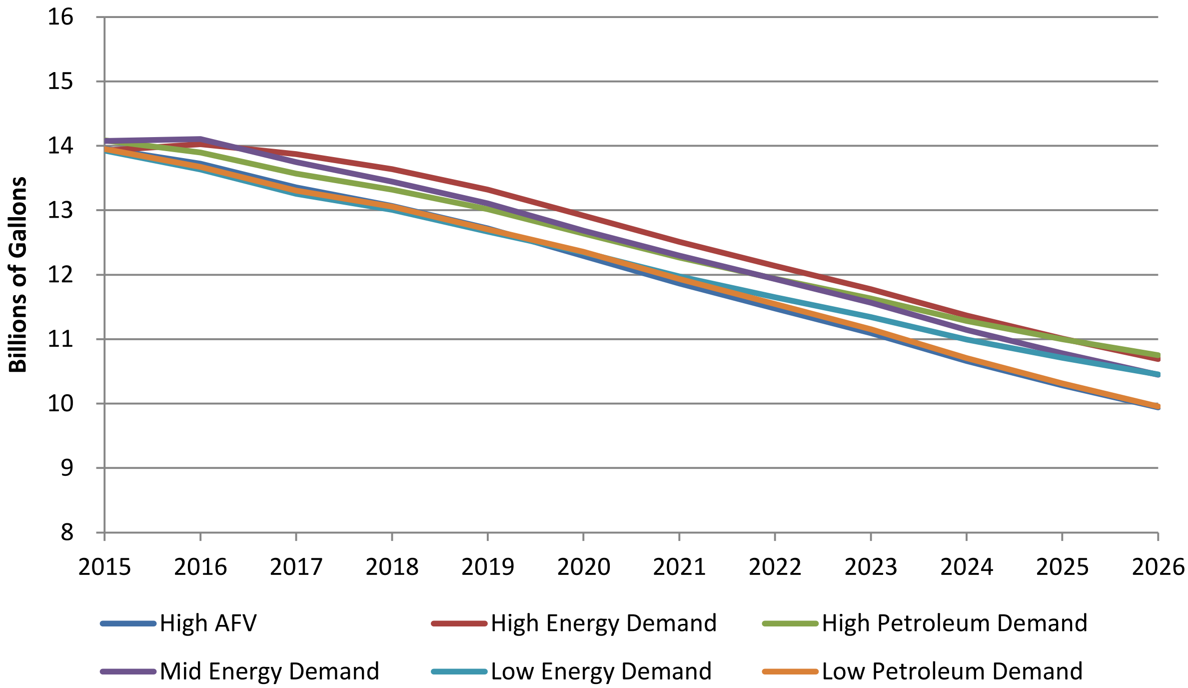
The transportation fuel demand forecast covers all the fuels discussed in this report: gasoline, diesel, E85, natural gas, electricity, jet fuel and hydrogen. High-speed rail electricity demand is forecasted separately. Energy Commission staff generated a forecast of fuel demand based on ZEV scenarios, vehicle attributes, natural gas vehicle penetration rates in freight trucks, and fuel prices. Greater numbers of ZEVs in the energy demand cases result in lower gasoline demand. All fuel demand forecasts in this section include personal, commercial, government, rental fleet, and neighborhood electric vehicles, from both LDVs and MD/HDVs.

On-Road Gasoline Demand Forecast

Figure 4-4 shows the gasoline demand forecast by case for all transportation sectors, travel modes, and on-road light, medium, and heavy duty vehicles combined in California. Individuals own more than 85 percent of LDVs, accounting for most of the gasoline demand in this sector.

All energy demand cases show a declining trend in gasoline consumption primarily due to gasoline displacement stemming from CAFE regulations and ZEV regulations. Gasoline demand shows a continuous decline in the all cases, ranging from less than 10 billion to 10.8 billion gallons in 2026, depending on the case.

Figure 4-4: On-Road Gasoline Demand Forecast

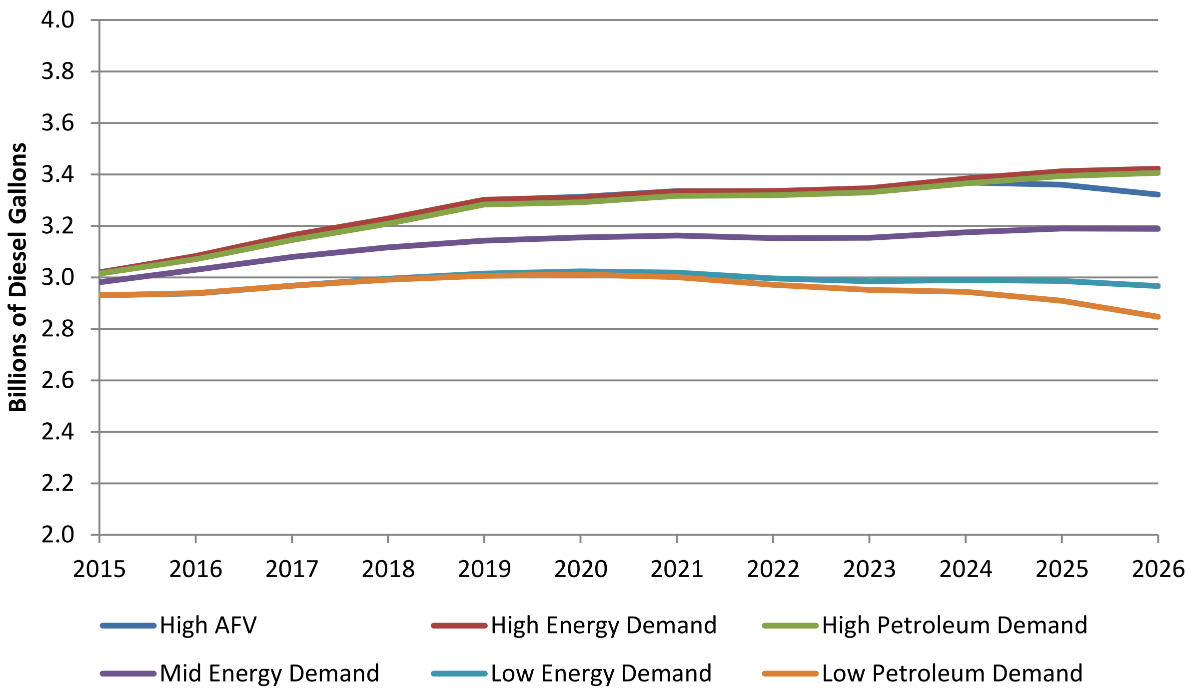


Source: California Energy Commission

On-Road Diesel Demand Forecast

Figure 4-5 shows diesel demand for on-road vehicles. Diesel demand increases modestly following economic growth through 2020. For 2021 and beyond, all energy demand cases show modest differences in response to individual trends in vehicle market penetration and fuel efficiency. In the low petroleum demand case, diesel demand declines to the lowest on-road demand at 2.8 billion gallons in 2026. For the high energy demand case, diesel consumption reaches about 3.4 billion gallons by 2026. The high alternative fuel vehicle demand case shares the economic growth input with the high energy demand and high petroleum demand cases, keeping these cases very similar until 2021. The U.S. EPA Phase 2 Fuel Efficiency Proposed Standard in the high alternative fuel and the low petroleum demand cases result in decreasing diesel demand starting gradually in 2021.

Figure 4-5: On-Road Diesel Demand Forecast

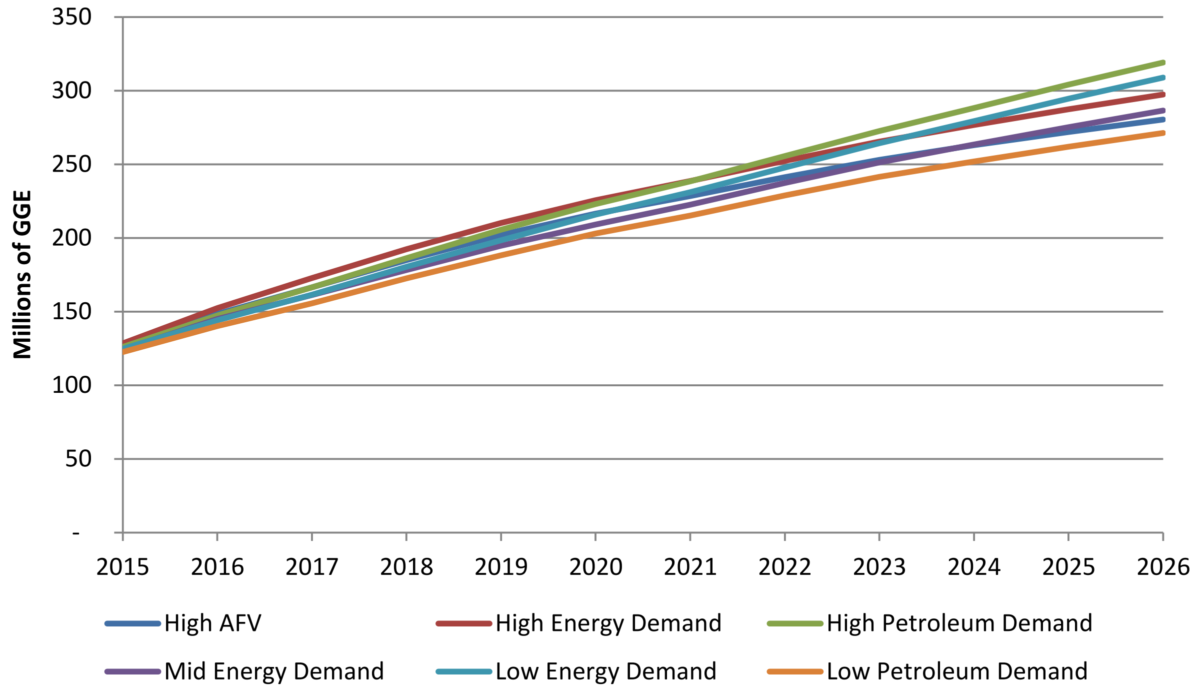


Source: California Energy Commission

E85 Demand Forecast

The Energy Commission's travel demand models forecast flex-fuel stock and fuel consumption as part of the overall fuel demand total. Fuel demand attributed to flex-fuel vehicles is allocated between gasoline and E85 as a calculation performed after the models are run. The annual volume of E85 consumed per flex fuel LDV vehicle was about 10 gallons in 2014. Starting with that value staff increased the proportion of E85 used per flex fuel LDV vehicle to reach about 50 percent of the annual fuel consumption in 2050. The dedicated E85 Cummins Ethos engine, introduced in MD trucks, contributes to this growth in 2020 and beyond. Figure 4-6 shows the Energy Commission staff forecast of demand for E85, which ranges from 280.5 million to 319 million GGE by 2026.

Figure 4-6: California E85 Demand Forecast

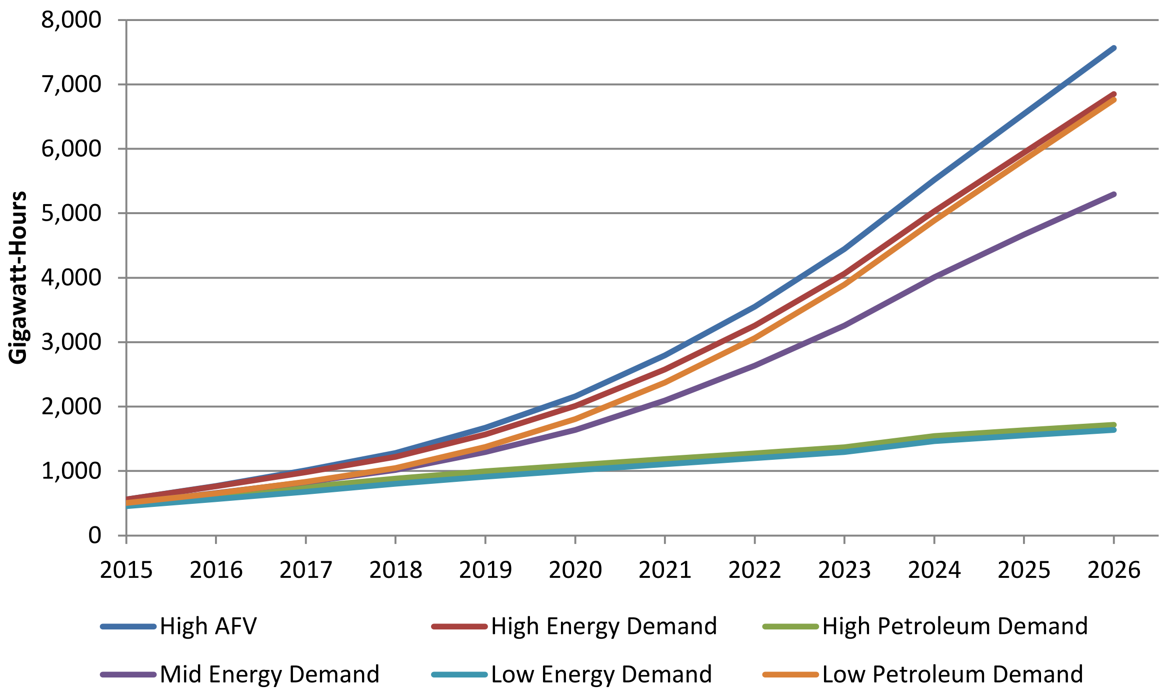


Source: California Energy Commission

Transportation Electricity Demand Forecast

Electricity is used in multiple transportation modes, including electric buses, MD delivery step vans, light rail, and personal automobiles. The transportation demand forecast in Figure 4-7 represents the total electricity demand for on-road transportation in California. The low energy demand case generates the lowest electricity consumption in 2026, about 1,600 gigawatt-hours. The highest electricity demand for transportation is reached in the high alternative fuel vehicle demand case – which is most advantageous to PEVs – at more than 7,500 gigawatt-hours. These figures exclude electricity demand for HSR.

Figure 4-7: California On-Road Transportation Electricity Demand Forecast



Source: California Energy Commission

High-Speed Rail Electricity Demand Forecast

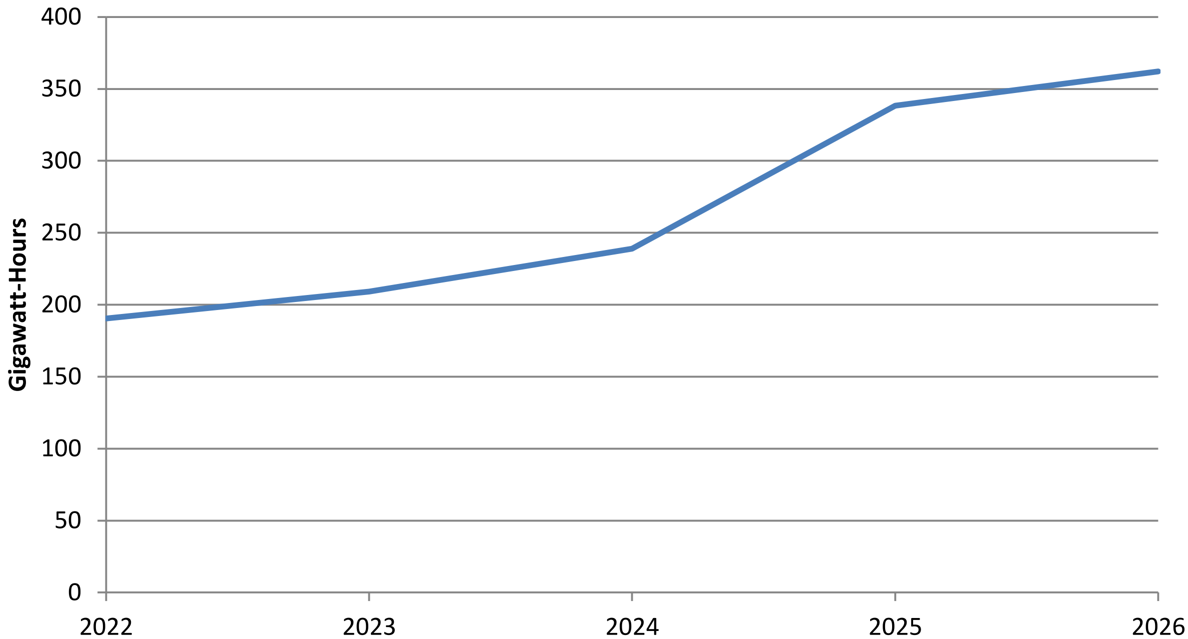
California's HSR is scheduled to begin operation in 2022 and will further drive the increase in transportation electricity in the final years of the forecast period. The HSR energy consumption forecast, presented in Figure 4-8, was provided by the California High-Speed Rail Authority and was developed in support of the authority's *Connecting California 2014 Business Plan, April 2014*.[42]

Rollout of HSR is being done incrementally, with an initial operation section slated to run 300 miles from Merced to the San Fernando Valley in 2022, followed by an extension northward to San Jose in 2026. Energy Commission staff considered only the initial operating section (Merced to the San Fernando Valley) of the HSR network for this forecast, as it is uncertain as to when exactly in 2026 the San Jose line will become operational.

The HSR forecast has been considered as an "add-on" to the mid energy case because the economic and demographic assumptions used in the California High Speed Rail Authority's base scenario most closely align with those used in the mid case. In the mid case, HSR comprises 10.2 percent of the total transportation electricity demand in 2022 and continues to increase to 14.4 percent in 2026.

42 http://www.hsr.ca.gov/docs/about/business_plans/BPlan_2014_Business_Plan_Final.pdf.

Figure 4-8: Forecasted High-Speed Rail Electricity Consumption



Source: California High-Speed Rail Authority

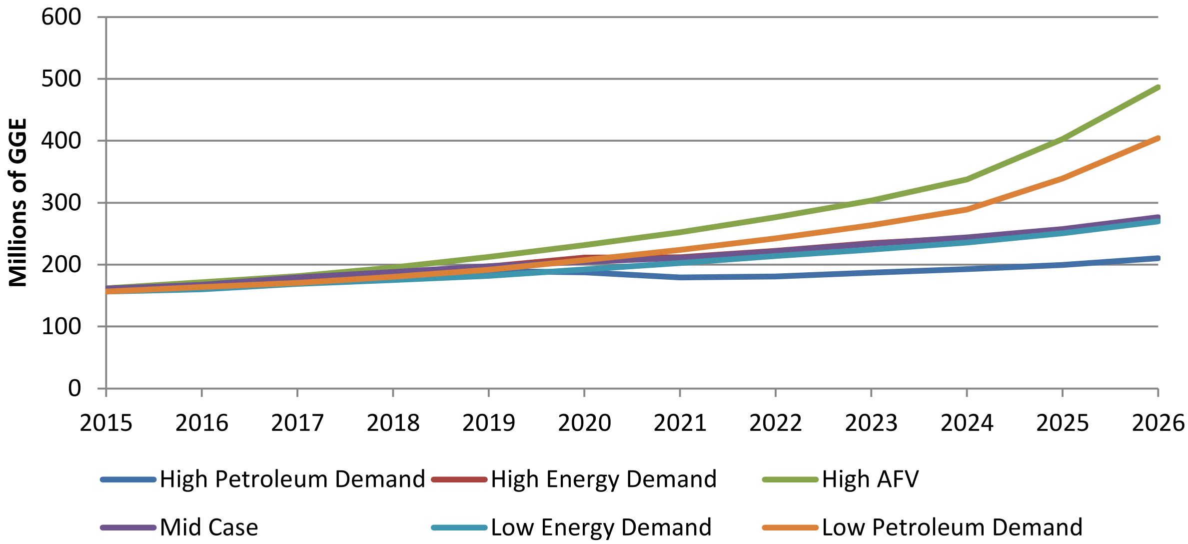
Transportation Natural Gas Demand Forecast

Public sector initiatives drive adoption of electric and other alternative fuels in public transit, school buses, refuse trucks, and public sector and utility fleets. In the urban transit and school bus sectors, public initiatives promoting ZEVs will actually reduce the number of natural gas buses in some cases, accounting for the lower consumption trends after 2020. Figure 4-9 shows the forecasts totals for all vehicles, primarily buses and trucks. More natural gas is consumed in the high energy demand, high alternative fuel vehicle, and low petroleum demand cases because alternative vehicle costs become significantly lower in later years. In the early years, natural gas buses account for most consumption, including transit buses and school buses.

The current natural gas vehicle fleet in California is almost exclusively composed of MD and HDVs, such as transit buses, refuse trucks, public fleets, and utility trucks. However, these segments are at 50 percent or more natural gas penetration rates and thus have less room to grow compared to the LDV fleet. The majority of future growth is expected in the heavy duty truck segment, for which higher annual mileage leads to a faster payoff on LNG technology. While there are a limited number of light duty natural gas vehicles, the only model available on the U.S. market was discontinued in 2015 and the existing natural gas stock makes up a very small percentage of the LDV fleet.

The three common demand case forecasts of natural gas are close to one another. The high alternative fuel vehicle demand case projects almost 2.5 times the natural gas in the high petroleum demand case in 2026. Contributors to demand include fuel price advantages, lower technology prices for LNG and CNG, and the U.S. EPA Phase 2 fuel economy regulations.

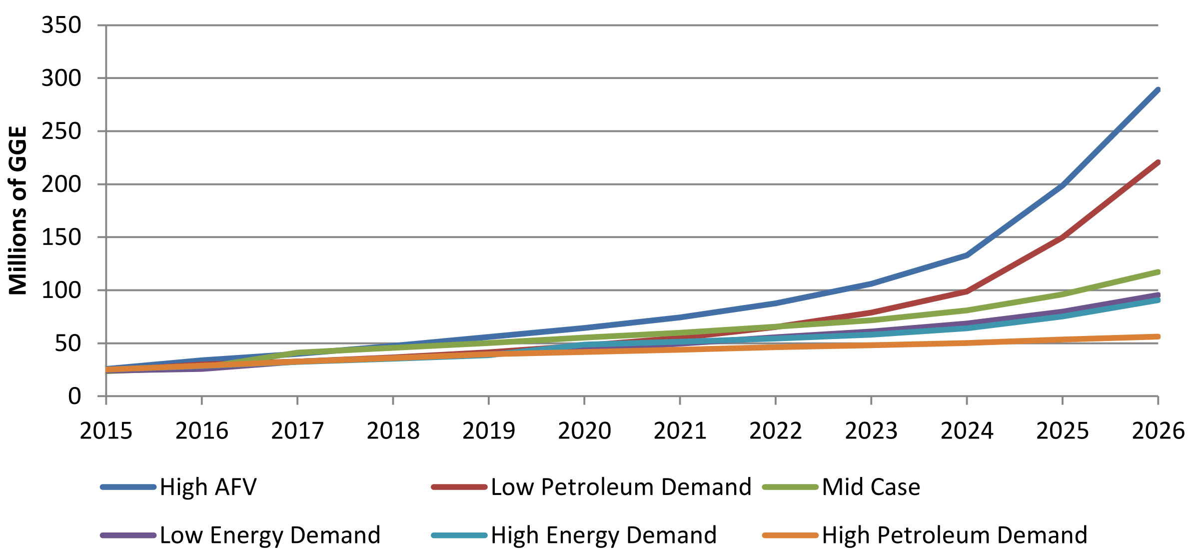
Figure 4-9: Transportation Natural Gas Demand Forecast



Source: California Energy Commission

Natural gas demand for MD and HDV trucks (excluding buses) is shown in Figure 4-10. Natural gas demand in 2026 is forecasted to range from under 100 million GGE in the high petroleum demand case to more than 330 million GGE in the high alternative fuel vehicle case. As with diesel, the volume of natural gas may be lower than expected due to vastly improved truck fuel economies as outlined by the U.S. EPA Fuel Efficiency and GHG Phase 1 Standards and Proposed Phase 2 Standards.

Figure 4-10: Medium and Heavy Duty Truck Natural Gas Demand Forecast

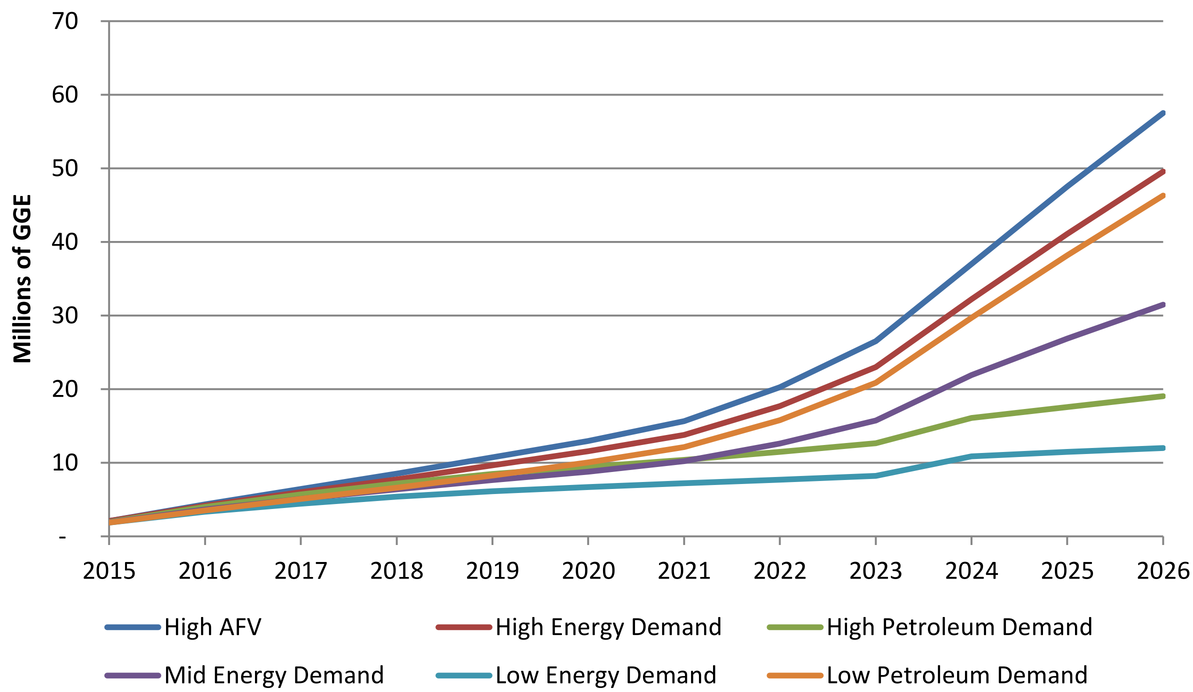


Source: California Energy Commission

Hydrogen Demand Forecast

The hydrogen demand forecast accounts only for hydrogen used in the light duty fleet and shows a continuous increase over the forecast period. As one might expect, the highest levels of demand occur in the high alternative fuel vehicle demand case, and the lowest demand occurs in the high petroleum demand case, as displayed in Figure 4-11. This demand reaches 57.6 million GGE by 2026 in the high alternative fuel vehicle case.

Figure 4-11: Hydrogen Demand Forecast



Source: California Energy Commission

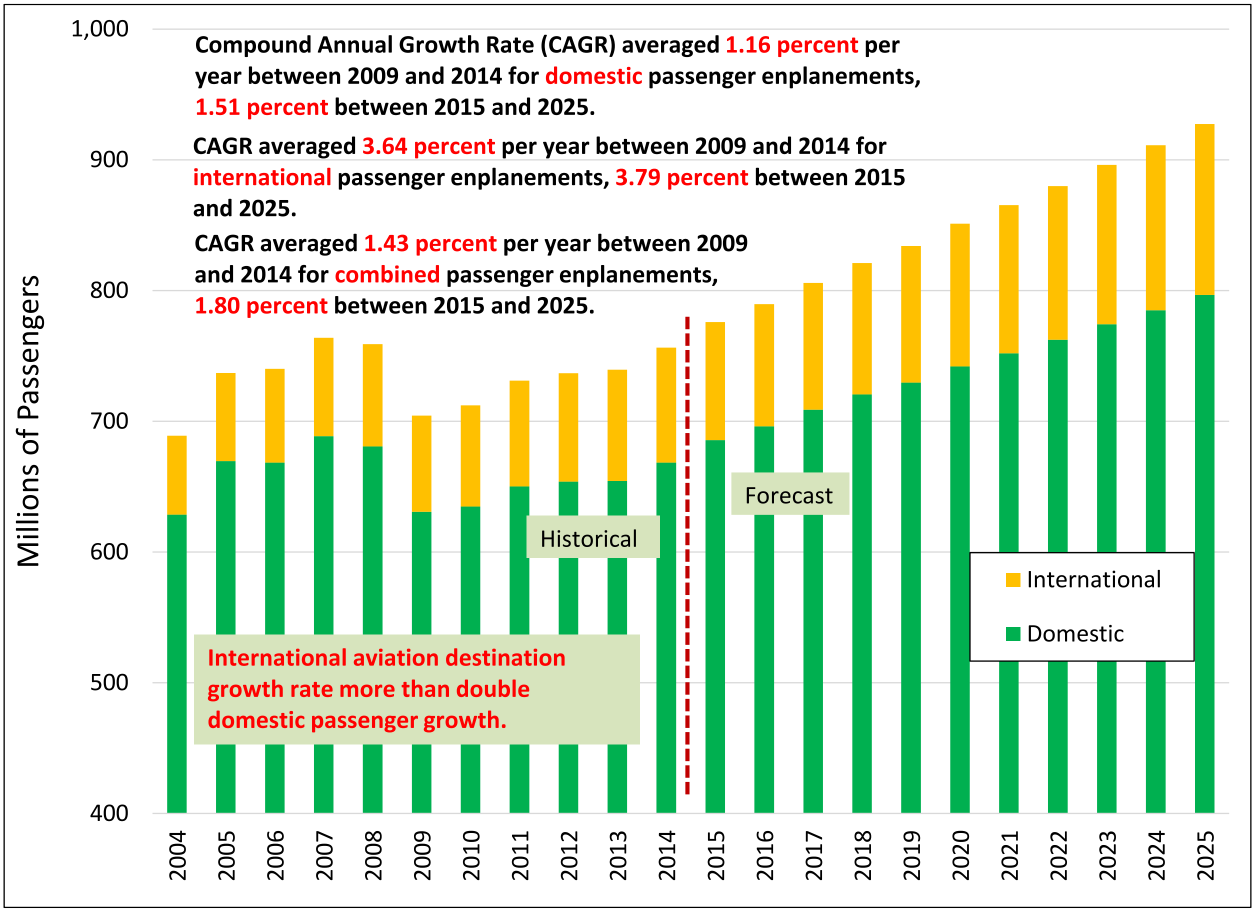
Jet Fuel Demand Forecast

Energy Commission analysis shows future consumption of aviation fuels in California will be driven by changes in fuel economy, as well as demand for airline travel to domestic and foreign destinations originating from California airports. The Energy Commission does not forecast airline passenger activity within California. Rather, the number of passengers boarding planes, or *enplaned passengers*, departing from California determines the jet fuel sold in California creating the demand. FAA tracks historical passenger activity by airport (measured by *enplaned passengers*), as well as forecasting growth by each airport.[43] The FAA also develops estimates of jet fuel consumption for both historical and forecasted periods but only for the United States

43 Federal Aviation Administration. *FAA Aerospace Forecast Fiscal Years 2015-2035*. 2015. https://www.faa.gov/about/office_org/headquarters_offices/apl/aviation_forecasts/aerospace_forecasts/2014-2035/media/2015_National_Forecast_Report.pdf.

as a whole.[44] Figure 4-12 illustrates several phenomena: the variability of historical enplaned passenger activity for the United States, the relative breakdown between domestic and foreign destinations, and projections through 2025. Although the FAA provides enplaned passenger projections for all California airports, it does not specify what portion of these passengers will be from domestic versus foreign destinations. Energy Commission staff assumed that the relative contribution of foreign destinations for California airport activity would change in a fashion similar to that of the United States: a slightly higher ratio of foreign destinations throughout the forecast period.

Figure 4-12: Enplaned Passenger Activity

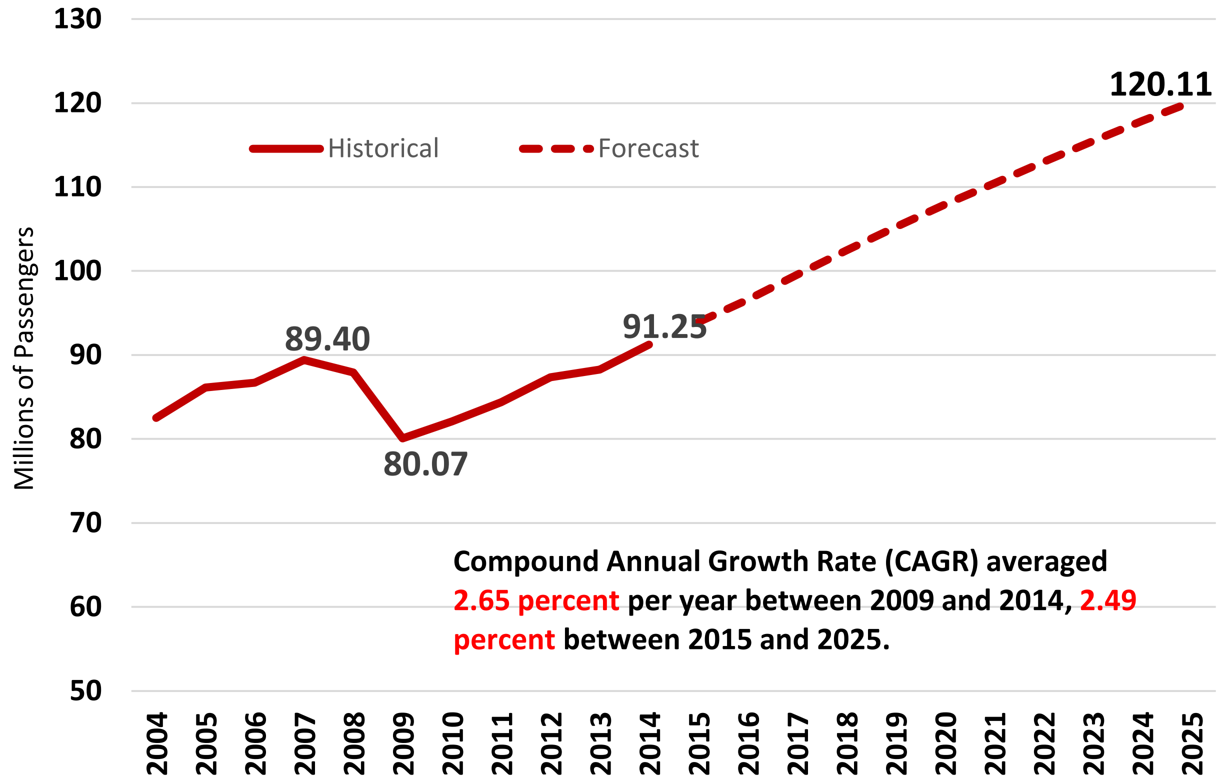


Source: California Energy Commission, Demand Analysis Office, analysis of FAA historical and forecast data

44 Ibid., Table 23, p. 120

Historical and forecast enplaned passenger activity for California is displayed in Figure 4-13.

Figure 4-13: Total Number of Passengers Enplaned in California



Source: California Energy Commission analysis of FAA historical and forecast data

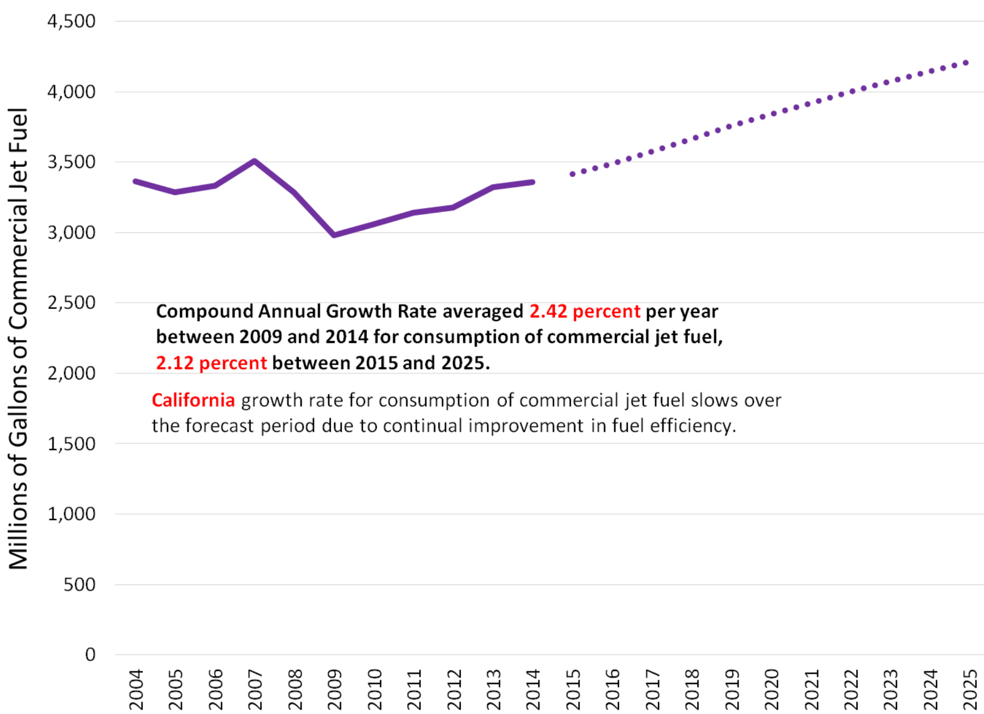
California enplaned passenger activity is forecast to grow at a rate of 2.5 percent per year, slightly lower than the near-term historical growth rate of 2.7 percent per year. By 2025, annual enplanements are expected to grow by 28.9 million passengers as compared to 2014.

Estimates of fuel consumption per passenger vary by class of destination, with domestic destinations averaging less than those for foreign destinations due to the longer flight distances for most foreign routes. For example, average consumption of jet fuel per enplaned passenger originating in the United States and headed for a domestic destination amounted to 18.5 gallons in 2014, while the average for foreign destinations averaged 72.3 gallons per enplaned passenger in the same year. The average jet fuel use for all domestic and foreign destinations in 2014 was 24.7 gallons per enplaned passenger.

In contrast, California's average jet fuel use per enplaned passenger was estimated to be 36.8 gallons during 2014, nearly 49 percent greater than the U.S. average. This higher rate is due to a greater ratio of foreign destinations for California enplaned passengers than that of the United States. Staff used enplaned passenger projections for California airports in conjunction with per-passenger fuel consumption trends for the United States to derive estimates of commercial jet fuel demand for California between 2015 and 2025.

Figure 4-14 shows commercial jet fuel consumption in California, which is forecasted to grow from 3,357 million gallons during 2014 to 4,212 million gallons by 2025.

Figure 4-14: Commercial Jet Fuel Consumption



Source: California Energy Commission analysis of FAA historical and forecast data

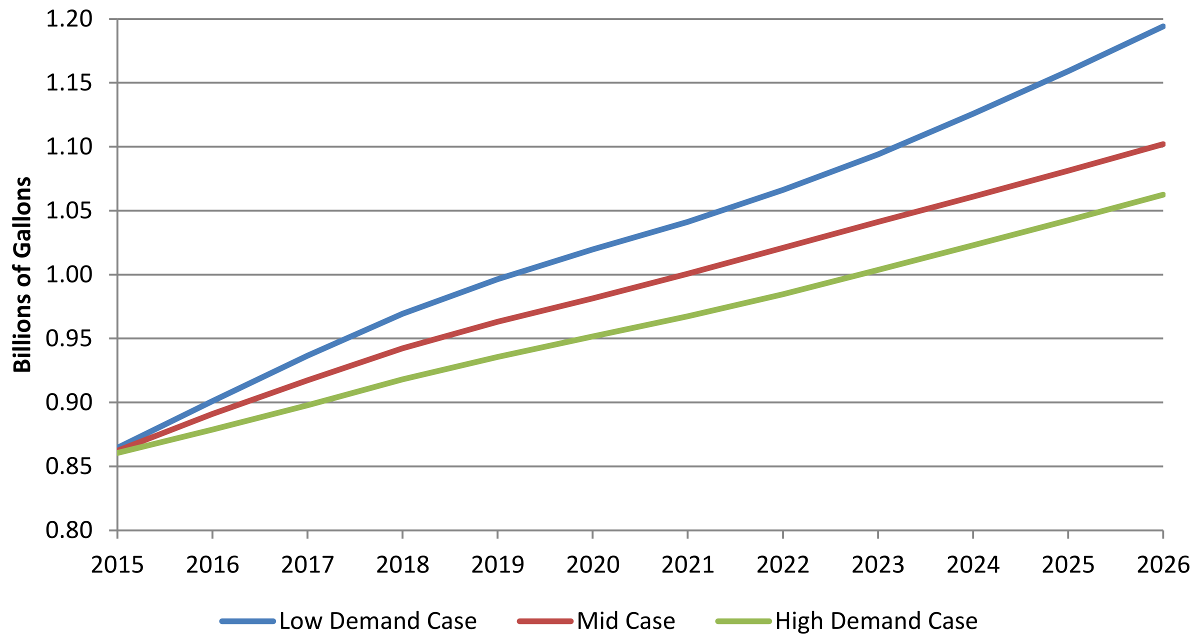
Off-Road Transportation Fuels Demand

Previous transportation energy demand forecasts have added diesel and gasoline used in off-road activities, in vehicles and equipment that may or may not have been registered by DMV, to the transportation fuel demand. With growing electrification of technologies, it is necessary to parse electricity demand for these equipment and applications.

The majority of off-road electricity demand in Aspen Environmental Group's report *California Electrification Demand Forecast for Off-Road Transportation Activities* falls into stationary uses, for which a separate Demand Analysis Office model (transportation, communication and utilities, or TCU) accounts for electricity use. The increased electrification of equipment and applications, however, will reduce what has been accounted for as off-road conventional fuel use.

Figure 4-15 shows the unadjusted off-road diesel demand in California, which increases with the projected growth of California economy in the high, mid, and low energy demand cases.

Figure 4-15 Off-Road Diesel Demand (Unadjusted)



Source: California Energy Commission

Table 4-1 shows total off-road electrification demand for transportation energy, TCU, industrial, residential, and commercial sectors in the three common energy demand cases. More detailed results, and discussion of methods, can be found in Aspen Environmental Group's report, *California Electrification Demand Forecast for Off-Road Transportation Activities.*

Table 4-1: Projected Off-Road Transportation Electricity Demand, GWh

Energy Demand Case	Electricity Use (GWh)		
	2015	2020	2025
Medium	1,365	2,086	2,749
High	1,398	2,388	3,388
Low	1,365	1,800	2,216

Source: California Energy Commission

Growth in off-road transportation electrification will reduce demand for gasoline and diesel. Table 4-2 shows the projected off-road gasoline and diesel demand reductions, resulting from off-road transportation electrification, reaching 253 million gallons in 2025 in the high energy demand case.

Table 4-2: Off-Road Transportation Electrification Impact on Off-Road Petroleum Fuel (Gasoline and Diesel) Demand Reduction (Millions of Diesel Gallon Equivalents)

Energy Demand Case	Petroleum Fuel Use Reduction (Million Diesel Gallons)	
	2020	2025
Medium	71	131
High	121	253
Low	18	30

Source: California Energy Commission

Findings

Energy Commission staff reviewed historical data and projected inputs to generate LDV demand and transportation energy demand for six cases, as defined in Chapter 3. Below are the main findings:

- California now leads the nation in the growth of renewable and alternative transportation fuels and vehicle technologies. California's transportation sector has grown with population and the economy, but due to many policies, actions, innovations, and technological growth, transportation energy consumption per capita decreased 14.5 percent between 2005 and 2014.
- Petroleum fuel prices started to slide in 2014 and have continued the slide through 2015. The forecast, however, shows an increase in the high price scenario reaching more than $120 per barrel by 2026 and recovering to less than $65 per barrel in the low price scenario.
- In response to ZEV regulations, auto manufacturers are offering a growing number of makes and models of PEVs in California. As a result, consumer preferences for purchasing ZEVs have increased since 2010.
- California's LDV population totals more than 28 million vehicles in 2014 and will continue to grow over the forecast with California's population and economy to more than 34 million vehicles in 2026 in the high energy demand case.
- The composition of LDVs in California will continue to evolve, demonstrated by increasing shares of ZEVs. In all energy demand cases, ZEVs exceed the numbers required under ZEV regulations over most or all of the forecast period. This is most likely in the high energy

demand case with low energy and vehicle prices and can reach more than 3.5 million ZEVs in 2026 in the high alternative fuel vehicle demand case.

- Natural gas demand shows the greatest growth potential in heavy duty trucks with high annual mileage. Growth of natural gas demand for refuse trucks and transit buses is limited since the current share of natural gas-powered vehicles is already high.
- The California transportation energy mix will continue to evolve as shares of electricity, hydrogen, natural gas, and other alternative fuels and biofuels grow.
- Petroleum fuels will continue to dominate demand for transportation energy over the forecast period, but a significant decline in the volume of these fuels arising from fuel economy improvements, as well as alternative fuel uptake, is expected.
- Gasoline will continue to have a prominent role in fueling primarily the LDVs in California, with nearly 10 billion gallons consumed in 2026 in the low energy demand case.
- Diesel demand remains steady over the forecast period and continues to dominate HDV transportation in California. However, it will experience declines in scenarios where fuel price and vehicle technology price conditions favor adoption of heavy duty natural gas trucks and with the adoption of proposed fuel economy standards for heavy duty trucks.
- Even when alternative fuels and EVs are adopted at high rates, consumption of the alternative fuels tends to lag behind adoption of alternative fuel vehicles due to the gradual turnover of existing fleets. For example, millions of gasoline-powered vehicles on the road today will still be on the road in 2026.
- New vehicle sales of PEVs have been increasing since their introduction in 2011. They comprised 4.6 percent of total new vehicle sales in 2014.
- BEVs, PHEVs, and FCEVs account for only 0.42 percent of the total on-road light duty fleet in 2014.
- The percentage of vehicles on-road that are 11 years and older has been growing since 2009. In 2014, 78 percent of LDVs are from model year 2010 and earlier. As the on-road fleet of LDVs are replaced with new vehicles, the percentage of BEVs, PHEVs, and FCEVs is expected to increase.
- The share of electricity will continue to grow in off-road transportation vehicles and equipment and will result in displacement of gasoline and diesel in this transportation sector over time.

Acronyms and Abbreviations

Acronym/Abbreviation	Original Term
2015 IEPR	*2015 Integrated Energy Policy Report*
AAA	American Automobile Association
AAEE	Additional Achievable Energy Efficiency
AB 8 Report	*Joint Agency Staff Report on Assembly Bill 8: Assessment of Time and Cost Needed to Attain 100 Hydrogen Fueling Stations in California*
AFV	Alternative fuel vehicle
ARB	California Air Resources Board
BEV	Battery electric vehicle
BOE	California State Board of Equalization
CAFE	Corporate Average Fuel Economy
CAGR	Compound annual growth rate
Caltrans	California Department of Transportation
CED	California Energy Demand
CNG	Compressed natural gas
CO_2	Carbon dioxide
CVC	Commercial vehicle choice model
CVRP	Clean Vehicle Rebate Program
DMV	California Department of Motor Vehicles
E10	A blend of 90 percent gasoline and 10 percent ethanol used for fueling gasoline-powered vehicles
E85	A blend of 15 percent gasoline and 85 percent ethanol used to fuel both dedicated ethanol powered vehicles and flex fuel vehicles
EER	Energy economy ratio
EMFAC	Emissions factor model
Energy Commission	California Energy Commission

EV	Electric vehicle
FAA	Federal Aviation Administration
FCEV	Fuel cell electric vehicle
FFV	Flexible fuel vehicle
GGE	Gasoline gallon equivalent
GHG	Greenhouse gas
GVWR	Gross vehicle weight rating
GWh	Gigawatt hours
HEV	Hybrid electric vehicle
HDV	Heavy duty vehicle
HOV	High occupancy vehicle
HSR	High-speed rail
IEPR	*Integrated Energy Policy Report*
IRP	International Registration Program
LCFS	Low Carbon Fuel Standard
lb	Pound
LDV	Light duty vehicle
LNG	Liquefied natural gas
MDV	Medium duty vehicle
MPG	Miles per gallon
MTBE	Methyl Tertiary Butyl-Ether
NAMGAS	North American Natural Gas
NEV	Neighborhood electric vehicle
NHTSA	U.S. Department of Transportation National Highway Traffic Safety Administration
NPC	National Petroleum Council
NRC	National Research Council
NREL	National Renewable Energy Laboratory
NTD	National Transit Database

PEV	Plug-in electric vehicle
PHEV	Plug-in hybrid electric vehicle
OEM	Original equipment manufacturer
OPIS	Oil Price Information Service
PIIRA	Petroleum Industry Information Reporting Act
PVC	Personal vehicle choice model
RAC	Refiner acquisition cost
RPS	Renewable portfolio standard
Sierra	Sierra Research, Inc.
TCU	Transportation, Communications, and Utilities
TOU	Time of Use
EIA	U.S. Energy Information Administration
U.S. EPA	United States Environmental Protection Agency
VMT	Vehicle miles traveled
ZEV	Zero-emission vehicle

APPENDIX A:
Transportation Energy Fuels – Gasoline Gallon Equivalent and British Thermal Units

Table A-1 shows the values used for GGEs and BTUs for each fuel considered as part of the transportation energy demand forecast.

Table A-1: GGE and BTU Factors by Fuel Type

Fuel	GGE per unit	BTU per unit
CNG	0.831	92,904 BTU per 100 cubic feet
Diesel	1.140	127,460 BTU per gallon
E85	0.730	81,692 BTU per gallon
Electricity	0.031	3,412 BTU per kWh
Ethanol	0.682	76,342 BTU per gallon
Gasoline	1.000	111,833 BTU per gallon
Hydrogen	1.015	113,460 BTU per kilogram
Jet Fuel	1.061	118,700 BTU per gallon
LNG	0.668	74,731 BTU per liquid gallon

Source: California Energy Commission Staff.