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TRANSPORTATION FUEL PRICE AND DEMAND FORECASTS: Inputs and Methods for the *2009 Integrated Energy Policy Report*

DRAFT STAFF REPORT

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Arnold Schwarzenegger, *Governor*

Corrections to Staff Draft Report
Transportation Fuel Price and Demand Forecasts

In this report, the Low Case Crude Oil Price Forecast proposed by staff has been incorrectly attributed to the U.S. Energy Information Administration. This error appears in Chapter 4 at pages 11, 13, and 17, and in the headers of Table 2 and Figure 2. The correct attribution should be to California Energy Commission staff. References in the report to the U.S. EIA Reference Case crude oil price forecasts are unaffected. All prices discussed in text, figures, and tables in the report are also unaffected.

CALIFORNIA ENERGY COMMISSION

Aniss Bahreinian, Libbie Bessman, Ryan Eggers, Nick Janusch, Laura Lawson, Bob McBride, Malachi Weng-Gutierrez, Gerald Zipay
Principal Authors

Gene Strecker
Project Manager

Jim Page
Manager
FOSSIL FUELS OFFICE

Mike Smith
Deputy Director
FUELS AND TRANSPORTATION DIVISION

Melissa Jones
Executive Director

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Abstract

For the *2009 Integrated Energy Policy Report*, California Energy Commission staff has developed Transportation Fuel Price Forecasts. Price forecasts were developed for the following transportation fuels: petroleum, renewable sources, electricity, natural gas, propane, and hydrogen. The price forecasts are then used in the long-term demand models: CALCARS, Freight, Transit, and Civil Aviation. Analysis of the various fuels showed that most retail fuel prices are linked to crude oil fluctuations. EIA long term crude oil forecast predict increasing crude oil prices until 2030, which lead to increasing retail fuel costs in all fuel types.

Keywords: California fuel price forecasts, transportation energy, gasoline, diesel, jet fuel, ethanol, E-85, propane, biodiesel, fuel demand model, retail market, natural gas, CNG, LNG, hydrogen, crude oil, electricity

Executive Summary

Senate Bill 1389 (Bowen, Chapter 568, Statutes of 2002), requires the California Energy Commission (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 to establish the quantitative baseline to support its analysis of petroleum reduction and efficiency measures, introduction and commercialization of alternative fuels, integration of energy use and land use planning, and transportation fuel infrastructure requirements. Transportation fuel price forecasts are an essential input to the transportation energy demand forecasts.

This report summarizes the transportation fuel price forecasts and the methods used to form them. Analysis of the various transportation fuels indicate that most transportation fuels are linked to the crude oil price. Forecasts were generated for gasoline, diesel and jet fuel, as well as emerging fuels such as biodiesel, ethanol, CNG, LNG, hydrogen, electricity, and propane. U.S. Energy Information Administration crude oil price forecasts are the primary basis of the fuel price forecasts. Staff assumes that fuel price margins and taxes will remain at historical levels in real terms over the forecast period and that historical price relationships found between petroleum fuels and emerging fuels will characterize future relative prices. Crude oil prices in 2030 are forecast to be $130 per barrel in 2008 dollars in the High Price Case and $77 per barrel in the Low Price Case. Gasoline prices in 2030 are forecast to be $4.78 per gallon in 2008 dollars in the High Price Case and $3.34 per gallon in the Low Price Case. In nominal terms, gasoline prices in 2030 will reach $6.72 per gallon and $4.70 per gallon, respectively, in the High and Low Price Cases.

CHAPTER 1:
Overview of the Transportation Fuel Price and Demand Forecast Background Process

Background

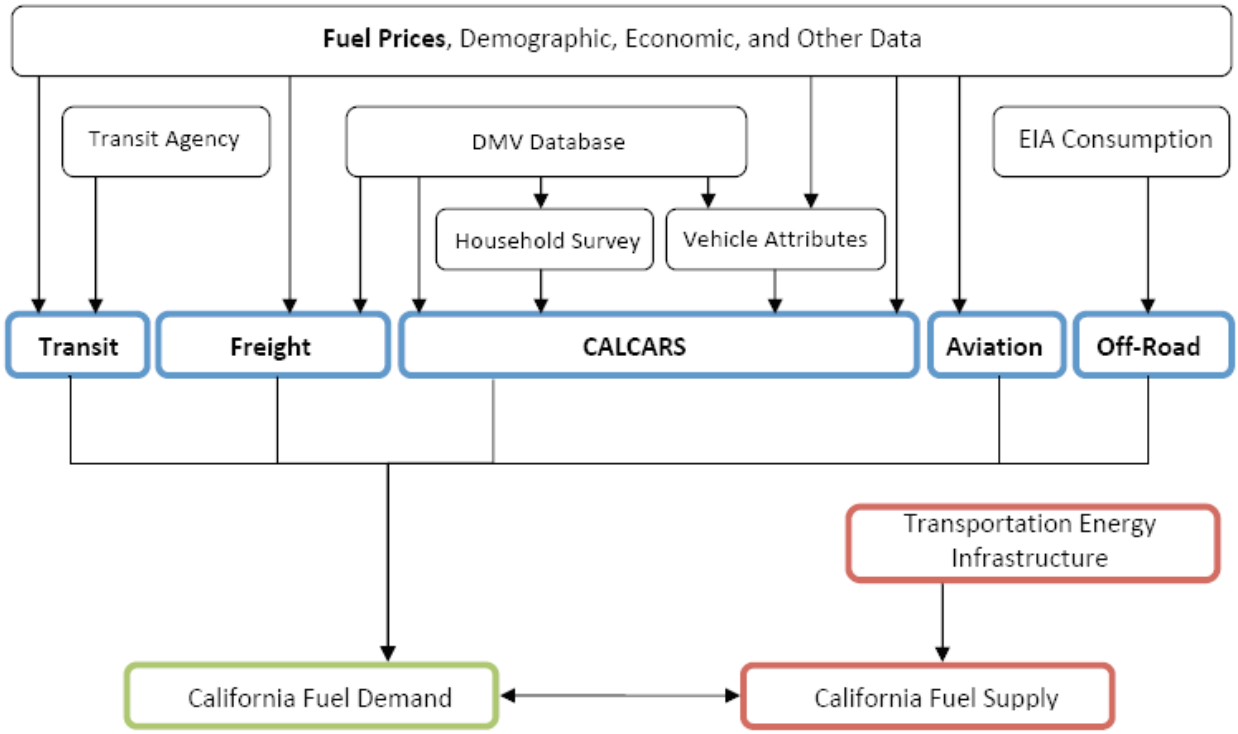
As required by Senate Bill 1389 (Bowen, Chapter 568, Statutes of 2002), the California Energy Commission (Energy Commission) conducts "assessments and forecasts of all aspects of energy industry supply, production, transportation, delivery and distribution, demand, and prices." The Energy Commission uses these assessments and forecasts to develop transportation energy policies for the *Integrated Energy Policy Report* (*IEPR*), adopted every odd-numbered year. In even-numbered years, the Energy Commission produces an energy policy review to update analysis from the previous *IEPR* or to examine energy issues that have emerged since the previous report (Public Resources Code §25302[d]).

Purpose of Transportation Fuel Price and Demand Forecasts

The Fossil Fuels Office of the Fuels and Transportation Division develops forecasts and analyses of the transportation fuels industry and related markets. Transportation energy demand and fuel price forecasts support several related energy policy and program activities, including AB 118 Alternative and Renewable Fuel and Vehicle Technology Program investment allocation analyses, petroleum use reduction assessments, and transportation fuel infrastructure requirements assessments. The California transportation fuel demand forecast is essential in assessing the adequacy and needs of the state's petroleum, renewable, and other alternative fuels infrastructure over the next 20 years. The demand forecast will provide California with another tool to measure and address the state's growing need for petroleum-related imports and alternative fuels.

Inputs to the transportation energy demand forecasts include transportation fuel price forecasts, economic and demographic data and projections, surveys of vehicle purchase and use by households and commercial fleets, vehicle registration data, and projections of vehicle manufacturer offerings. The Energy Commission assesses future transportation fuel import infrastructure requirements from historic data and projections for regional transportation fuel demand, refinery distillation and process capacity, and rates of crude oil production decline in California. Figure 1 illustrates the flow of data, forecasts, and other information for these transportation fuel analyses.

Figure 1: Transportation Energy Data Flow Diagram



Source: California Energy Commission

Organization of This Report

This staff report will provide information to receive public comment for the *2009 IEPR* on work products that are in various stages of development. This report includes summaries of methods for producing the transportation fuel demand forecasts, including related inputs and assumptions, but with a particular emphasis on transportation fuel price forecasts. The Energy Commission will present and discuss these and other related materials at the February 10, 2009 staff workshop to be held at the Energy Commission. A second workshop will be held in late March or April 2009 to discuss infrastructure issues affecting transportation fuels supply in California, including methods to estimate fuel import projections and assess infrastructure needs. A final workshop will be conducted in early summer to present staff's proposed transportation fuel demand and import requirements forecasts.

The next two chapters of the report will briefly review the modeling methods used for the demand analysis and the structure and assumptions of the modeling cases. The final four chapters of the report will present assumptions, methods, and forecasts of proposed crude oil and petroleum transportation fuel prices (including gasoline, diesel, and jet fuel), renewable fuels (E-85 and biodiesel), electricity, and gaseous-type fuels (compressed natural gas, liquefied natural gas, propane, and hydrogen).

CHAPTER 2:
Long-Term Fuel Demand Forecasting Methods

As part of the *2009 IEPR*, staff will produce a long-term fuel demand forecast using four forecasting models: the California Conventional and Alternative Fuels Response Simulator (CALCARS), the freight model, the transit model, and the aviation model. Each model forecasts fuel demand for different transportation sectors and has been used in past *IEPRs* to varying degrees. The proposed transportation fuel forecasting methods will closely follow previous years' methods. However, various inputs and assumptions to the models have been updated. In some cases, the models have been changed to allow for new input values, but the forecasting methods have remained consistent with previous forecasts.

Light Duty Vehicle Fuel Demand Model

CALCARS is a discrete choice model that forecasts California light duty vehicle ownership and fuel use, vehicle miles traveled (VMT), and the potential effects of various government policies. These forecasts are based on changes in California demographic and economic projections, fuel prices, trends in vehicle attributes, and consumer vehicle preferences.

The CALCARS model simulates vehicle purchase decisions and fuel use by California motorists. It was designed to evaluate impacts of public policy on overall light-duty vehicle fuel demand and accommodate the development of strategies to reduce California's dependence on petroleum and help promote alternative fuels and vehicles. Since 1992, the CALCARS model has been updated with new data several times, including for the *2009 IEPR*. Updated data will include:

- Forecasts of light-duty vehicle fuel economy and attributes.
- Forecasts of transportation fuel prices in California.
- Department of Motor Vehicles (DMV) registered on-road vehicle counts.
- Evaluated vehicle types.
- Vehicle choice coefficients from the Energy Commission 2009 California Household and Commercial Vehicle Survey (2009 California Vehicle Survey).
- Forecasts of California demographics, such as population, employment, and personal income.
- As a discrete choice model, CALCARS requires consumer preference data as well as vehicle and consumer attribute data. The consumer preference data are collected through a statewide representative survey of consumers, which was last conducted in 2007 and which is being updated currently. The 2009 California Vehicle Survey is currently collecting data from 3,000 residential and 1,800 commercial vehicle owners in California and will be the basis of the CALCARS model. The detailed information collected will integrate demographic and commercial data with consumer preference data to simulate consumer vehicle choices.

The CALCARS model assumes:

- Current consumer-stated preferences, as updated with the 2009 California Vehicle Survey, will remain the same over the forecast period.
- The current survey, although updated with a range of potential vehicles and vehicle characteristics, does not represent all future potential vehicles. Therefore, the CALCARS model cannot directly indicate the future preferences of these potential vehicles.

- Fuel economy values represent typical on-road driving fuel economies.
- The U.S. Environmental Protection Agency (EPA) revised the method for evaluating fuel economies of new vehicles in 2007. The fuel economy values used in the CALCARS model are based on those current fuel estimates but are revised to reflect true driving conditions. It is anticipated that the recent change in EPA fuel economy evaluation methods will bring the published EPA fuel economy numbers closer to the CALCARS fuel economy values.
- Recent vehicle sales trends, as depicted in the Department of Motor Vehicles (DMV) October 2007 vehicle registration database, will continue over the forecast period.
- The current light-duty vehicle demand model will use vehicle counts from DMV's October 2007 vehicle registration database. The vehicle counts represent the DMV's most recent data but do not directly correspond to the existing consumers' purchase choices. However, given that survey preferences are more current than vehicle counts, there will be little impact on projected vehicle counts.

The *2007 IEPR* forecast included 45 classes of vehicles and 17 model years. Currently, staff is evaluating the addition of another 60 vehicle classes, which would expand the assessment to include flex-fuel vehicles, plug-in hybrids, electric vehicles, and compressed natural gas vehicles. The addition of these vehicles and the update of the model for the *2009 IEPR* will be contingent upon timely completion of the 2009 California Vehicle Survey.

California Freight Energy Demand Model

The California Freight Energy Demand Model projects the volume of freight transported by truck and rail, truck stock and vehicle miles traveled, and truck and rail consumption of energy (Btus) for four types of fuel and for five California regions. These outputs are driven by fuel price projections and growth projections of industrial activity in 16 economic sectors.

The California Freight Energy Demand Model takes disaggregated base year data that includes vehicle miles traveled, ton-miles, and truck stock and applies economic and fuel price projection inputs to forecast goods movements that are then distributed to different modes by a modal diversion model. The modal diversion model allocates the transportation of these goods movement forecasts to either rail or truck modes based on costs and fuel efficiency inputs. The annual detailed forecast provides freight transportation and fuel demand forecast by economic sector, region, mode, vehicle type, and fuel type.

California Transit Energy Demand Model

The California Transit Energy Demand Model develops long-range forecasts of energy consumption by urban and intercity bus and rail, school buses, and other buses operating in California.

The model estimates the effects of changes in transit fares, service policies, automobile fuel economy, fuel prices, population, employment, and income on transit energy consumption. The model also estimates the effectiveness of policies designed to save energy by promoting diversions from automobiles to transit. The model has been modified to incorporate expanded service areas and fuel types, and currently, more than 75 state transit agencies are represented in this model.

As part of the current effort to update the input data files of the model, the transit agencies included in the model have been polled using a survey letter to collect current information about their service characteristics and energy consumption. Additional data is gathered from the National Transit Database.

California Civil Aviation Jet Fuel Demand Model

Staff developed an aviation model to forecast California's civil aviation jet fuel demand. This model has been revised and updated several times. The aviation model uses economic, demographic, and technology projections to estimate future jet fuel demand including: forecasts of California demographics, such as population and personal income; Federal Aviation Administration (FAA) aviation forecast data; estimates of average commercial jet fuel economy and airline revenue per passenger mile.

Historic aviation travel and California annual personal income data are used to estimate annual air passenger travel. The accuracy of the aviation jet fuel demand is closely related to the accuracy of the forecast estimates of population, income, average commercial jet fuel economy, and airline revenue per passenger mile.

CHAPTER 3:
Simulated Policy Cases

With the exception of vehicle technology attribute and consumer preference data, Energy Commission staff will provide the input data from appropriate sources that are required for the forecasts, including current vehicle counts, fuel price forecast scenarios, and base case projections of demographic/economic growth, consistent with the values used for other sectors in the *2009 IEPR*. Historic and projected vehicle technology attribute data, such as price and fuel economy by model year and vehicle class, will be developed by contract using Energy Commission inputs and assumptions. Consumer preference data will be collected through the 2009 California Vehicle Survey.

Assumptions regarding the market links between alternative fuels and either gasoline or diesel are assumed to be maintained throughout the forecast. Decoupling of fuel prices may occur but on average will not lead to significant variation from the average linked prices as defined. Note that one policy assumption is that the Economic Stimulus Act of 2008 (H.R. 5140) tax incentives and credits will be extended throughout the forecast.

Based on these input data, staff proposes to develop fuel demand forecasts for gasoline, diesel, jet fuel, E-85, biodiesel, electricity, compressed natural gas, liquefied natural gas, propane, and hydrogen identified in Table 1. For fuel prices, the cases assume either staff's Low Fuel Price forecast or High Fuel Price forecast while also varying greenhouse gas and vehicle fuel economy regulations. Questions for which public comment is sought include whether and how alternative and renewable fuel prices should be varied across cases. Staff intends for these fuel demand cases to provide a reasonable range of fuel demand projections that reflect potential future demands for transportation energy within California.

Table 1: *2009 IEPR* Fuel Demand Forecast Cases

Policy Scenario	Low Petroleum Fuel Prices	High Petroleum Fuel Prices
GHG Regulations and EISA	Case 1	Case 2
Pavley 2 Regulations	Case3	Case 4
Lower or Incentivized Alternative Fuel Prices	Case 5	Case 6
Incentivized Alternative Fuel Vehicle Prices	Case 7	Case 8

Source: California Energy Commission

The alternative fuels price forecasts will provide staff an opportunity to evaluate the potential for accelerating the use of emerging vehicle technologies and the successful deployment of non-petroleum transportation fuels.

Assumptions

The following are some of the assumptions associated with the proposed demand forecast:

- Recent trends in the transportation energy sector are statistically representative of future trends.
- All current Energy Commission forecasting models are quantitative and based on historical data. As such, the forecasts will represent recent trends in transportation energy usage. Large changes to the transportation energy sector such as the adoption of future, unforeseeable legislation or technologies are not represented in the forecasts. Similarly, the effects of low probability but high impact events, which change the use of transportation energy in California and worldwide, are not represented in the existing models. Therefore, in the context of the demand forecasts, it is assumed the modeled mathematical equations adequately describe potential future trends given the trends in input historical data.
- Demographic and economic data from the California Department of Finance is adequately representative of California.
- The Department of Finance's demographic and economic data is consistent with other Energy Commission evaluations and is the appropriate representative data set to use. This does not preclude the evaluation of other data sets in the forecasts, given time.

CHAPTER 4:
Proposed California Petroleum Transportation Fuel Price Forecasts

Summary

Staff has developed High and Low Case price forecasts for California highway fuels based on the U.S. Energy Information Administration (EIA) *2009 Annual Energy Outlook* (AEO) Reference Case and Low Case oil price forecasts, respectively. The Energy Commission's High Case starts at $2.79 per gallon for gasoline and $2.97 for diesel in 2009, jumps to $4.34 and $4.41, respectively, in 2015, and then continues to rise to $4.78 and $4.85 by 2030 (all prices are reported in inflation-adjusted 2008 dollars).[1] Energy Commission Low Case forecasts start at $2.77 for gasoline and $2.84 for diesel per gallon in 2009, climb to $3.50 and $3.51, respectively, in 2015, and then decline gradually to $3.34 for gasoline and $3.36 for diesel per gallon by 2030. Staff has prepared price forecasts or proposed forecasting methods for prices of other transportation fuels, including railroad diesel, jet fuel, E-85, biodiesel, electricity, compressed natural gas, liquefied natural gas, propane, and hydrogen, that are also discussed later in this report.

Crude Oil Price Forecast

Staff has based California-specific High and Low Case regular-grade gasoline and diesel price forecasts on, respectively, the EIA *2009 AEO* Reference Case and Low Case crude oil price forecasts. See Figure 2 and Table 2 for a comparison of recent EIA oil price forecasts and the International Energy Agency (IEA) *2009 World Energy Outlook* forecast.[2] The EIA oil price index used in this analysis is for the United States refiner acquisition cost (RAC) of imported crude oil index. This RAC index is the average price of all imported crude oil and is roughly $4 to $7 per barrel less than the index for higher-quality imported light sweet oil.[3]

Petroleum Transportation Fuel Price Forecasting Method

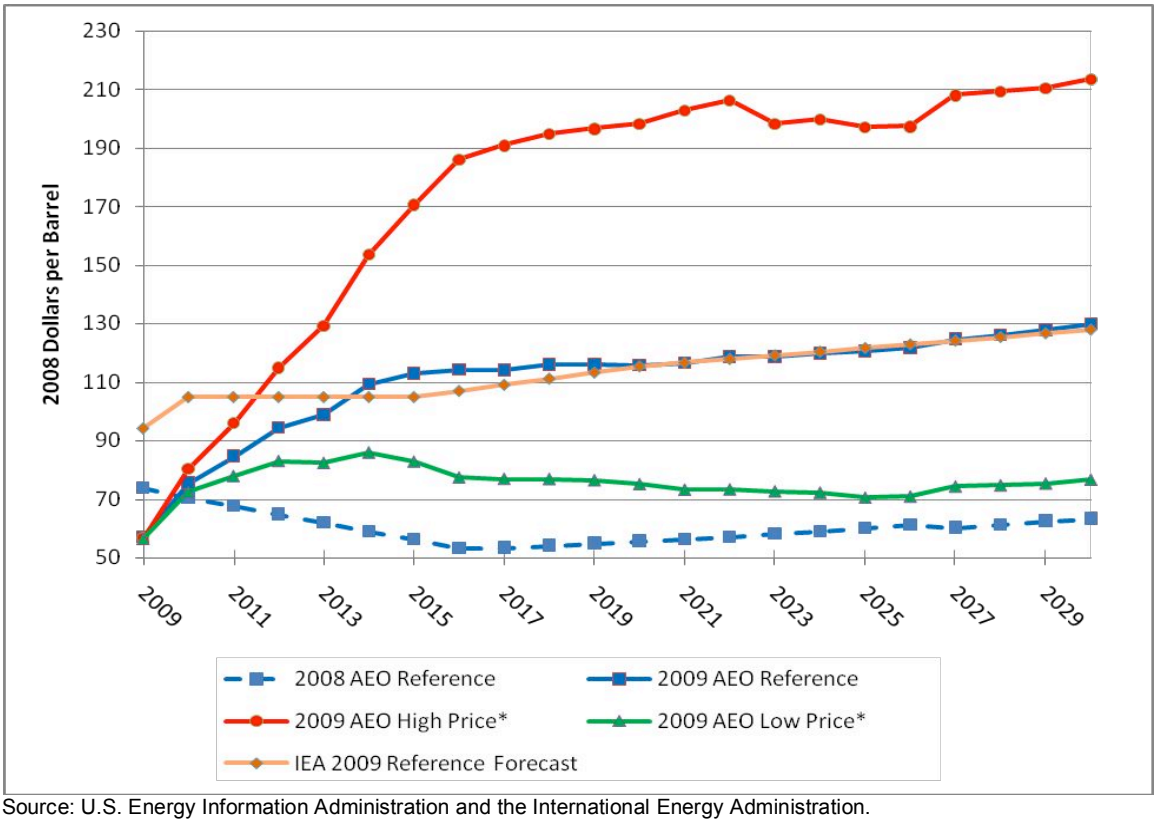
Staff established relationships between crude oil and wholesale fuel prices using monthly data from the EIA for world crude oil prices and average monthly California rack prices for gasoline and diesel from the Oil Price Information Service (OPIS). This exercise used the January 2003 to December 2008 period due to MTBE-free reformulated gasoline becoming the dominant gasoline refined and used in the state during this period.

Staff first determined the historical differences between EIA's monthly refiner acquisition cost of imported crude oil figures and the monthly OPIS California regular-grade gasoline and diesel rack prices. This difference is referred to as the "crude oil to rack price" margin. This margin varies substantially between months so that the use of one period's historical margin over another's makes a difference in the final retail fuel price forecast. Staff has assumed that annual averages should be used to remove the impact of seasonal and other fluctuations in these

[1] All prices used in this work are in 2008 dollars, using the November 17, 2008, California Energy Commission deflator series from Moody's Economy.com unless specifically stated otherwise.
[2] This Low Case projection is estimated from a graphical representation of the EIA *2009 AOE Low Case* projection which was shown in the EIA *AOE 2009 Power-Point Presentation*. Actual values will be used when they become available from EIA.
[3] The subset of premium light sweet oil constitutes a relatively small percentage of the oil actually refined in the United States or California, but prices for it are those most commonly referred to in the media.

margins. Annual average crude oil to rack price margins from 2003 to 2008 for gasoline and diesel have ranged from a high of $0.79 per gallon to a low of $0.35 per gallon in 2008 dollars using this estimation method.

Figure 2: Comparison of EIA AEO 2009, AEO 2008, and IEA WEO 2009 Oil Price Forecasts (in 2008 dollars)



Source: U.S. Energy Information Administration and the International Energy Administration.
(*) denotes that price forecasts are Energy Commission estimates of EIA graphical information.

Table 2: EIA 2009 AEO and IEA 2009 WEO Oil Price Projections (2008 dollars per barrel)

Year	AOE Reference Forecast	AOE Low Price Forecast	IEA Reference Forecast
2009	57.1	56.6	94.2
2010	75.5	72.6	104.9
2011	84.7	77.9	104.9
2012	94.4	82.9	104.9
2013	98.8	82.3	104.9
2014	109.3	85.8	104.9
2015	112.9	82.7	104.9
2016	114.2	77.4	107.0
2017	114.1	76.9	109.1
2018	116.1	76.9	111.2
2019	116.0	76.4	113.3
2020	115.8	75.1	115.4
2021	116.5	73.2	116.7
2022	118.7	73.3	117.9
2023	118.7	72.7	119.2
2024	119.8	72.2	120.4
2025	120.6	70.6	121.7
2026	121.7	70.9	122.9
2027	124.7	74.3	124.2
2028	126.1	74.7	125.5
2029	127.9	75.3	126.7
2030	129.9	76.6	128.0

Source: U.S. Energy Information Administration and the International Energy Agency

The next step was to determine the "rack-to-retail" price margin. This was done by calculating the historical differences between the average monthly OPIS rack price and the average monthly EIA retail price series (excluding taxes) for both California regular-grade gasoline and diesel. Again, the decision to choose one period's margin as representative of future expectations will affect the final retail price forecast. In the case of rack-to-retail price margins for gasoline and diesel, annual averages seen between 2003 and 2008 ranged from a high of $0.26 per gallon to a low of $0.10 per gallon.

Table 3 summarizes the High and Low Case crude oil to rack price margins and the rack-to-retail price margins (excluding taxes) proposed for use, respectively, with the EIA *2009 AEO* Reference and Low Case Crude oil prices. All prices are in 2008 cents per gallon and were averaged annually in all cases. The High Case margins were based on recent years of higher combined margins (2006–2008 data) and the Low Case on lower combined margin values (2003–2008 data).

In 2007, the California Air Resources Board (ARB) adopted changes in the predictive model to permit gasoline with 10 percent ethanol content, which Energy Commission staff expects to raise the price of gasoline. Adders were estimated for the gasoline price forecast to reflect these changes. In the Low Case 5 cents per gallon were added, and in the High Case 10 cents per gallon were added starting in 2012. For the early adoption years of 2010 and 2011, these values were divided in half.

The last step in generating a final retail price forecast for each of the fuels is to add excise and sales taxes and fees. In the case of regular-grade gasoline, combined federal and state excise taxes (including fuel use and underground storage tank levies) totaled $0.378, and sales tax was estimated at 8 percent. For diesel, the federal excise taxes are $0.244 and the state excise taxes $0.194. In the case of diesel, however, $0.18 of the state excise tax was included after sales tax was calculated over the remainder of the costs, as that portion is exempt from sales taxation.

Table 3: Margins Used in Fuel Price Forecast Cases (2008 cents per gallon)

Case	RFG Crude-to-Rack	Diesel Crude-to-Rack	RFG Rack-to-Retail	Diesel Rack-to-Retail
CEC High	67.2	76.7	15.5	18.1
CEC Low	66.7	66.9	14.9	16.9

Source: California Energy Commission

California Gasoline and Diesel Price Forecasts

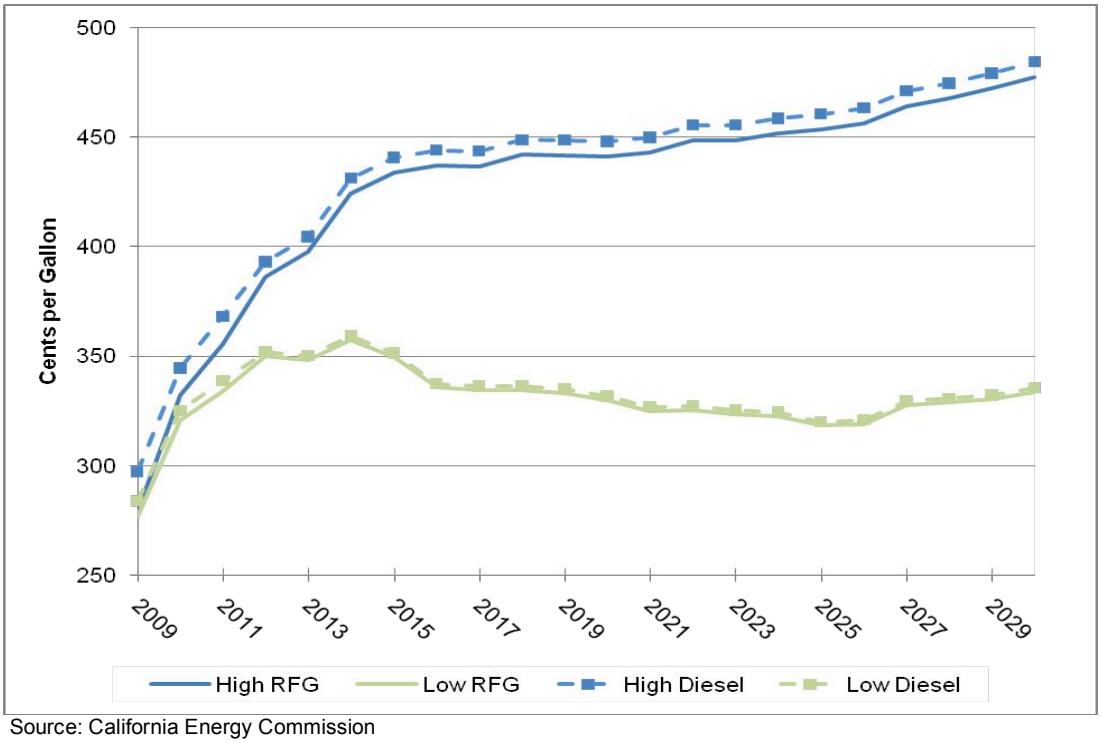
Table 4 and Figure 3 show the proposed California retail fuel price forecasts in 2008 cents per gallon for regular-grade California gasoline and California diesel fuel using the assumptions outlined above. These final estimates are generated by adding the margin estimates for each fuel type to the corresponding imported crude oil price forecast, along with the corresponding tax structure for that fuel type. The *AEO 2009* Reference Case crude oil prices were used to generate the Energy Commission's High Price Forecast. For the Low Price Forecast, the *AEO 2009* Low crude oil price case was used. Figure 4 shows these proposed retail fuel price forecasts in nominal dollars.

Table 4: Retail Gasoline and Diesel Price Forecasts (2008 cents per gallon)

Year	RFG		Diesel	
	High	Low	High	Low
2009	279.1	276.6	297.3	284.0
2010	332.1	320.5	344.7	325.2
2011	355.8	334.2	368.3	338.8
2012	386.4	350.1	393.3	351.9
2013	397.8	348.4	404.7	350.2
2014	424.6	357.6	431.5	359.3
2015	434.0	349.6	440.9	351.4
2016	437.4	335.7	444.3	337.5
2017	437.0	334.6	443.9	336.3
2018	442.1	334.5	449.0	336.2
2019	442.0	333.3	448.9	335.1
2020	441.3	330.0	448.2	331.8
2021	443.2	325.1	450.1	326.9
2022	449.0	325.4	455.9	327.2
2023	448.8	323.6	455.7	325.4
2024	451.8	322.6	458.7	324.4
2025	453.9	318.3	460.8	320.0
2026	456.6	319.1	463.5	320.9
2027	464.4	327.9	471.3	329.7
2028	467.8	328.9	474.7	330.7
2029	472.5	330.5	479.4	332.3
2030	477.7	333.9	484.6	335.6

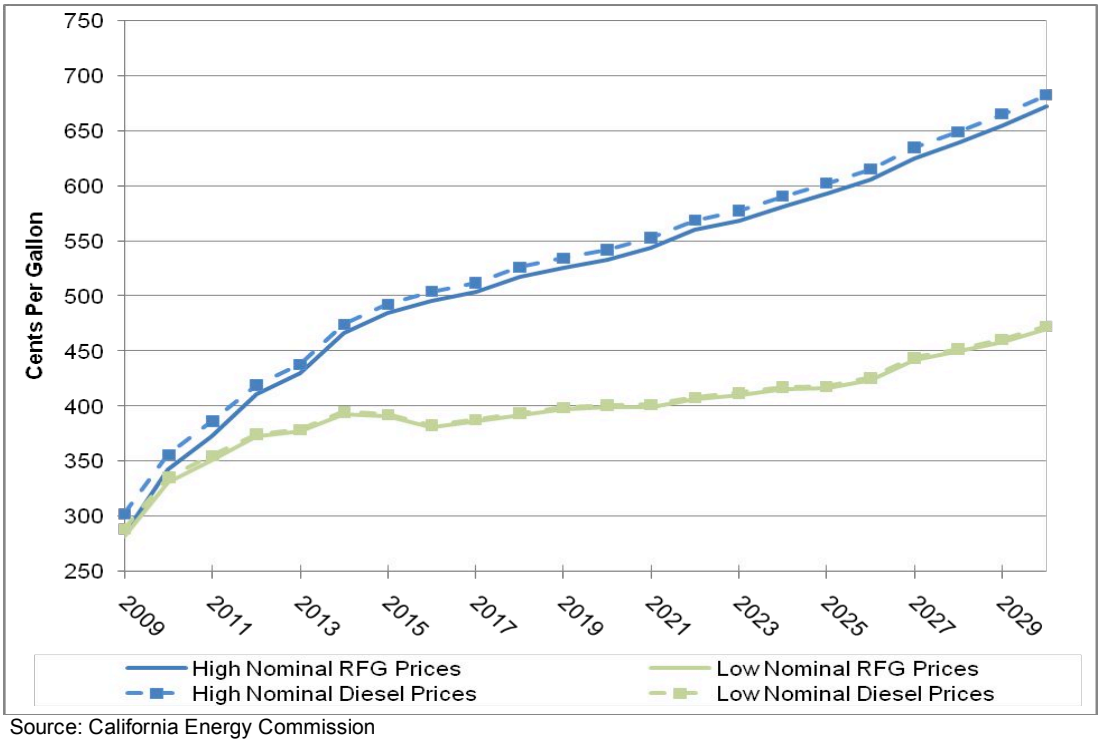
Source: California Energy Commission

Figure 3: California Gasoline and Diesel Price Forecasts
(2008 cents per gallon)



Source: California Energy Commission

Figure 4: California Gasoline and Diesel Price Forecasts
(Nominal cents per gallon)



Source: California Energy Commission

Railroad Diesel and Jet Fuel Price Forecasts

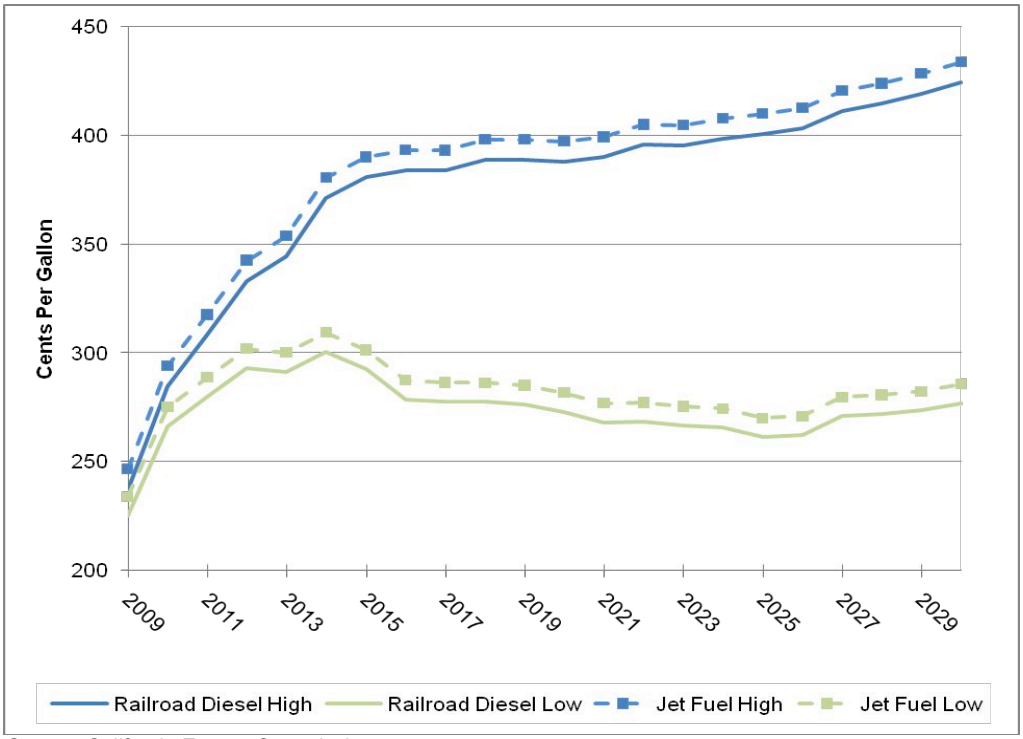
Using the previously described diesel fuel crude-to-rack price margins and the EIA *AOE 2009* Reference and Low Case crude oil price forecasts, staff also developed railroad diesel and jet fuel High and Low Case price forecasts for the period of 2009 to 2030. For railroad diesel, $0.069 per gallon excise tax on railroad diesel and 8 percent California sales tax are added to the wholesale diesel fuel price to generate the final price forecast estimates. For jet fuel, $0.064 per gallon for excise taxes and a distribution adder equal to half the corresponding diesel rack-to-retail margin (reflecting that airport refueling facilities are supplied by both pipeline and truck distribution systems) are included to generate the final jet fuel price forecast. It should be noted that, like the regular gasoline and diesel fuels, both railroad diesel and jet fuel price forecasts hold future crude-to-rack and rack-to-retail margins constant in real terms. Table 5 and Figure 5 show the High and Low Case forecasts for railroad diesel and jet fuel.

Table 5: Railroad Diesel and Jet Fuel Price Forecasts (2008 cents per gallon)

Year	Railroad Diesel		Jet Fuel	
	High	Low	High	Low
2009	237.4	225.5	246.7	234.1
2010	284.8	266.6	294.1	275.2
2011	308.4	280.2	317.7	288.8
2012	333.4	293.3	342.6	301.9
2013	344.8	291.6	354.0	300.2
2014	371.6	300.8	380.9	309.3
2015	381.1	292.8	390.3	301.4
2016	384.4	279.0	393.6	287.5
2017	384.0	277.8	393.3	286.4
2018	389.1	277.7	398.4	286.3
2019	389.0	276.5	398.3	285.1
2020	388.3	273.2	397.6	281.8
2021	390.2	268.3	399.4	276.9
2022	396.0	268.6	405.2	277.2
2023	395.8	266.9	405.0	275.4
2024	398.8	265.8	408.0	274.4
2025	400.9	261.5	410.2	270.0
2026	403.6	262.3	412.9	270.9
2027	411.4	271.1	420.7	279.7
2028	414.8	272.1	424.1	280.7
2029	419.5	273.8	428.8	282.3
2030	424.7	277.1	433.9	285.6

Source: California Energy Commission

Figure 5: California Railroad Diesel and Jet Fuel Price Forecasts (2008 cents per gallon)



Source: California Energy Commission

CHAPTER 5:
Renewable Fuels Price Forecasts

Petroleum and greenhouse gas reductions goals require increasing the use of renewable fuels. The two most prominent renewable fuels examined in this report are E-85 and biodiesel. E-85 is a fuel blend of RFG and up to 85% ethanol. Biodiesel is a fuel blend of diesel with biomass-based fuels.

E-85 Price Forecast

Two boundary conditions were used to develop the range of potential E-85 prices compared with given gasoline prices. First, staff assumed that the ethanol blend market was setting the current price of ethanol for transportation uses and that this would lead to E-85 prices being equivalent to gasoline prices on a volume (per gallon) basis. Alternatively, increasing familiarity with and use of alternative fuels, greater fuel availability, and increased ethanol production could also be assumed to drive the E-85 price down to equivalence with gasoline on an energy basis. Since ethanol, and hence E-85, has a lower Btu content per gallon than gasoline, E-85 would be priced lower per gallon than gasoline by equalizing their prices on a Btu basis. Staff calculated the Btu content of gasoline using the current 5.7 percent ethanol concentration for California gasoline and higher concentrations in the future, at 10 percent from 2012 onward. While staff used one Btu figure for gasoline, there are slight variations of Btu values depending upon the characteristics of the blend and its components, such as butane that is blended in the winter.

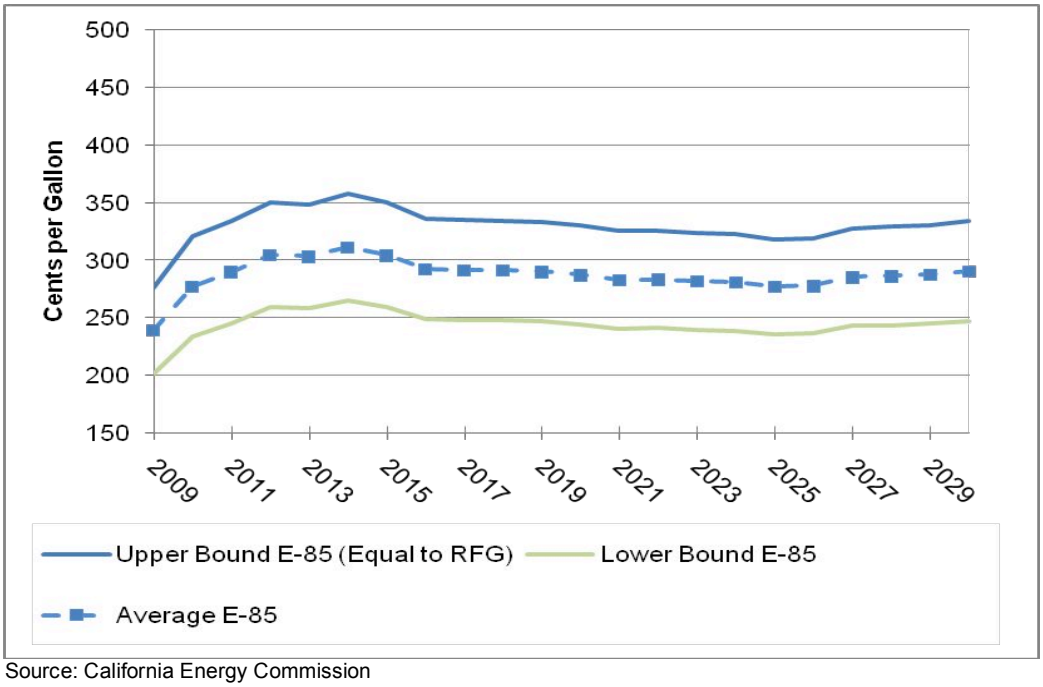
Therefore, this approach provides a range of potential E-85 values for both the High and Low Case gasoline price forecasts. In other words, each of these two gasoline price forecasts could be accompanied by two separate E-85 price forecasts, requiring a total of four demand forecast cases as shown in Table 6. A simpler but less informative approach would be to estimate one E-85 price forecast for each gasoline price case by averaging the higher and lower E-85 boundary calculations into a single price time series, thus maintaining only two demand forecast cases. Figures 6 and 7 illustrate these comparative E-85 price formulations. This example of how forecast cases can proliferate if the uncertainty over all potential inter-fuel price relationships is captured should be kept in mind as other fuel prices are discussed. Staff is limited in the number of these cases that can be projected. An important point for public comments to address is which cases reflecting these inter-fuel price uncertainties have the highest priority for analysis.

Table 6: E-85 Price Forecasts
(2008 cents per gallon)

Year	Low RFG Price Scenario			High RFG Price Scenario		
	RFG Forecast	Upper Bound E-85 (Equal to RFG)	Lower Bound E-85	RFG Forecast	Upper Bound E-85 (Equal to RFG)	Lower Bound E-85
2009	276.6	276.6	202.0	279.1	279.1	203.9
2010	320.5	320.5	234.1	332.1	332.1	242.6
2011	334.2	334.2	245.7	355.8	355.8	261.6
2012	350.1	350.1	259.5	386.4	386.4	286.4
2013	348.4	348.4	258.3	397.8	397.8	294.9
2014	357.6	357.6	265.1	424.6	424.6	314.8
2015	349.6	349.6	259.1	434.0	434.0	321.8
2016	335.7	335.7	248.9	437.4	437.4	324.2
2017	334.6	334.6	248.0	437.0	437.0	324.0
2018	334.5	334.5	247.9	442.1	442.1	327.8
2019	333.3	333.3	247.1	442.0	442.0	327.7
2020	330.0	330.0	244.6	441.3	441.3	327.2
2021	325.1	325.1	241.0	443.2	443.2	328.5
2022	325.4	325.4	241.2	449.0	449.0	332.8
2023	323.6	323.6	239.9	448.8	448.8	332.7
2024	322.6	322.6	239.1	451.8	451.8	334.9
2025	318.3	318.3	235.9	453.9	453.9	336.5
2026	319.1	319.1	236.6	456.6	456.6	338.5
2027	327.9	327.9	243.1	464.4	464.4	344.3
2028	328.9	328.9	243.8	467.8	467.8	346.8
2029	330.5	330.5	245.0	472.5	472.5	350.3
2030	333.9	333.9	247.5	477.7	477.7	354.1

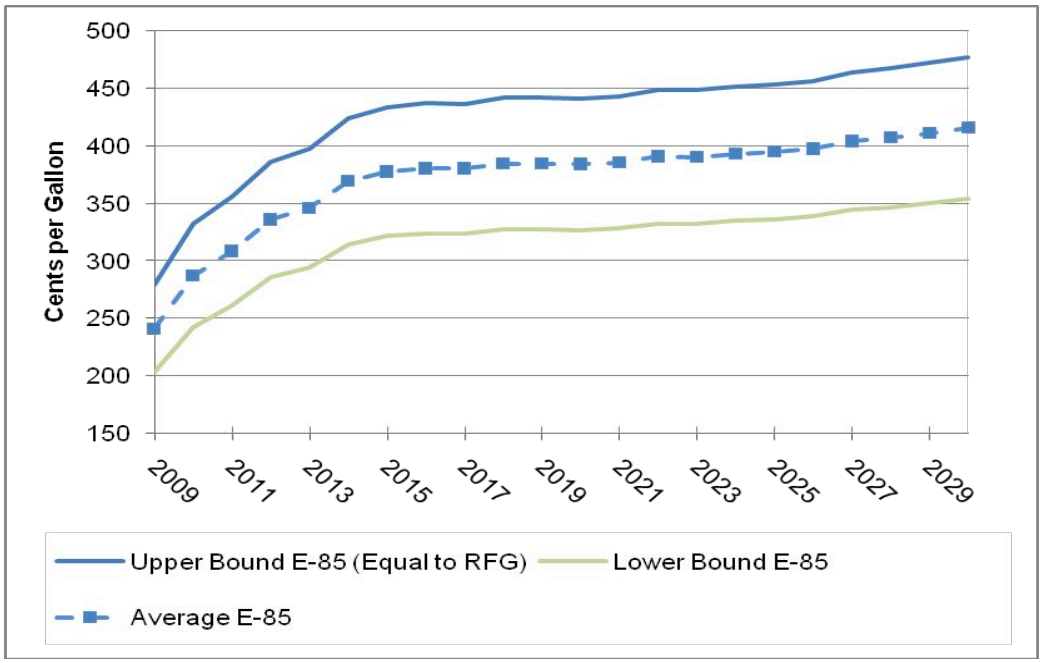
Source: California Energy Commission

Figure 6: E-85 Price Forecasts for Low RFG Price Case (2008 cents per gallon)



Source: California Energy Commission

Figure 7: E-85 Price Forecasts for High RFG Price Case (2008 cents per gallon)



Source: California Energy Commission

Biodiesel Price Forecast

Biomass-based diesel fuel products have been commercially produced in the United States since the early 1990s and can use a number of different feedstocks in the production process. Common feedstocks for biomass-based diesel include soybean oil, canola oil, palm oil, and yellow grease. In the United States, 73 percent of all biodiesel produced in 2006 was from soybean oil[4] and, in the past few years, nearly 20 percent of all soybean oil produced in the United States was for the production of biodiesel.[5] Although the specific feedstock used to produce the biomass-based diesel can influence the retail price, feedstock commodity prices have not been directly considered in this forecast.

The forecasted retail biodiesel prices are for a 20 percent blend of biomass-based diesel with refined ultra-low sulfur diesel (ULSD), blended on a volumetric basis. The 20 percent blended product is commonly referred to as "B20." Other typical reported blend prices include 99 percent, 30 percent, 5 percent, and 2 percent blends. Blends other than B20 can be produced and sold but the associated retail prices are not forecast here. The largest influences on the production volumes, and consequently productions costs, result from legislative policies. Staff analysis associated with the Alternative and Renewable Fuels and Vehicle Technology Program discusses policies affecting both production and market potential of biomass-based diesels.[6] For instance, the Low Carbon Fuel Standard (LCFS) is one potential standard that may result in a significant increase in biomass-based diesel production volumes. Additionally, continued federal subsidies, state and local grants, and biofuel production goals may all influence both the retail price and volume of biomass-based diesel in California.

For this price forecast, staff compared regional and nationwide retail and rack prices for biodiesel and diesel fuels. The blended biomass-based diesel price forecast for California will be closely linked with retail prices for ULSD since staff will focus on B20 and not higher blends. As shown in Figure 8, over the last six months West Coast regional B20 prices have been closely correlated with ULSD. For the week of December 15, 2008, national B100 rack prices declined 21 percent from the previous week while diesel declined 20.5 percent.[7]

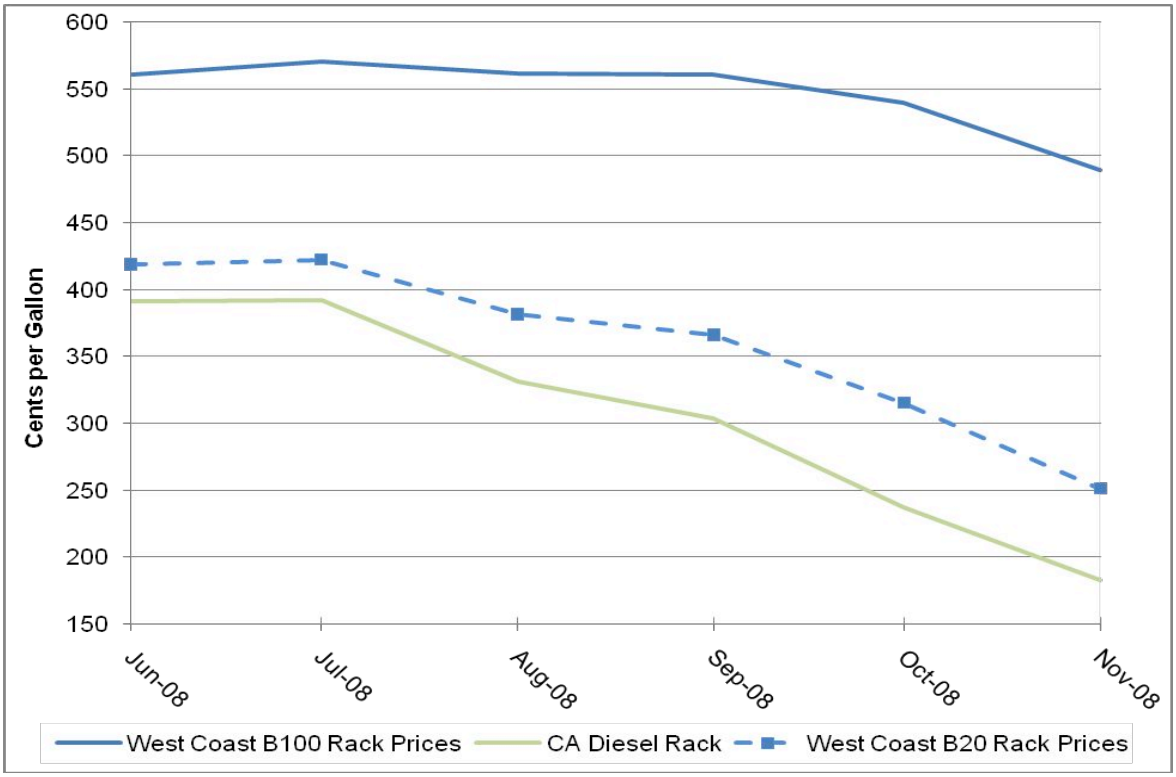
[4] Purdue University, *Is Biodiesel as Attractive an Economic Alternative as Ethanol?*, ID-341, http://www.ces.purdue.edu/extmedia/ID/ID-341.pdf

[5] United States Department of Agriculture, Economic Research Service, Soybeans and Oil Crops: Market Outlook. USDA Soybean Projections, 2008-17, http://www.ers.usda.gov/briefing/soybeansoilcrops/2008baseline.htm.

[6] California Energy Commission, http://www.energy.ca.gov/altfuels/index.html.

[7] OPIS, Ethanol & Biodiesel Information Service, Volume 5, Issue 50, December 15, 2008.

Figure 8: West Cost Biodiesel (B100 and B20) and California Diesel Rack Prices (Nominal)



Source: Oil Price Information Service and California Energy Commission

Staff used historical OPIS data on West Coast biodiesel rack prices to compare with California retail diesel rack prices. All data was converted to monthly prices for comparisons. The final retail price forecast for biodiesel includes the same excise and sales taxes and fees as diesel.[8] Once the relationship between the West Coast rack biodiesel and the California rack diesel products was determined, it was used to forecast future prices using the developed Energy Commission 2009 High and Low Case diesel price forecasts as the basis.

For the retail biomass-based diesel price forecast a number of assumptions were made:

- The relationship between the West Coast biodiesel rack prices and California retail prices will remain the same over the forecast period and represents the retail fuel price of biodiesel in California.
- Federal fuel excise tax credits will remain[9] at $1.00 for blended biomass-based diesels from soy methyl ester and animal fat feedstocks, such as yellow grease.[10]
- State and local taxes will remain at their current rates, in real terms, over the forecast period.
- Over the forecast period, feedstock market prices do not affect the final retail price of biomass-based diesels, and it is assumed that final retail prices would not appreciably be different from the forecasted values presented below. This is, in part, due to a change

[8] Biodiesel, waste vegetable oil (wvo), and straight vegetable oil (svo) are taxed at the same rate as diesel fuel. California BOE, http://www.boe.ca.gov/sptaxprog/spftdrates.htm.
[9] Currently the excise tax credit will expire on December 31, 2009, as defined in House Resolution 1424, 2008, and 26 U.S. Code 40A.
[10] http://www.ethanolrfa.org/policy/regulations/federal/biodiesel/

in the market driven by legislative changes, specifically federal Renewable Fuels Standard (RFS) and California LCFS.
- The potential variation in fuel margins and feedstock prices is bounded by the high and low price forecasts presented in this report.

Table 7 presents the values used to estimate the average difference observed between the West Coast Region and California Rack ULSD prices.

Table 7: Comparison of California ULSD Rack Prices and West Coast B20 Rack Prices (cents per gallon)

Date	California ULSD Rack Prices	West Coast Retail Rack Biodiesel B20 w/ULSD Prices	Difference
Jun-08	391.22	419.03	27.81
Jul-08	392.15	422.51	30.35
Aug-08	331.29	381.60	50.32
Sep-08	303.96	366.30	62.34
Oct-08	237.07	315.46	78.39
Nov-08	183.12	251.29	68.17
		Average	52.90

Source: OPIS and California Energy Commission

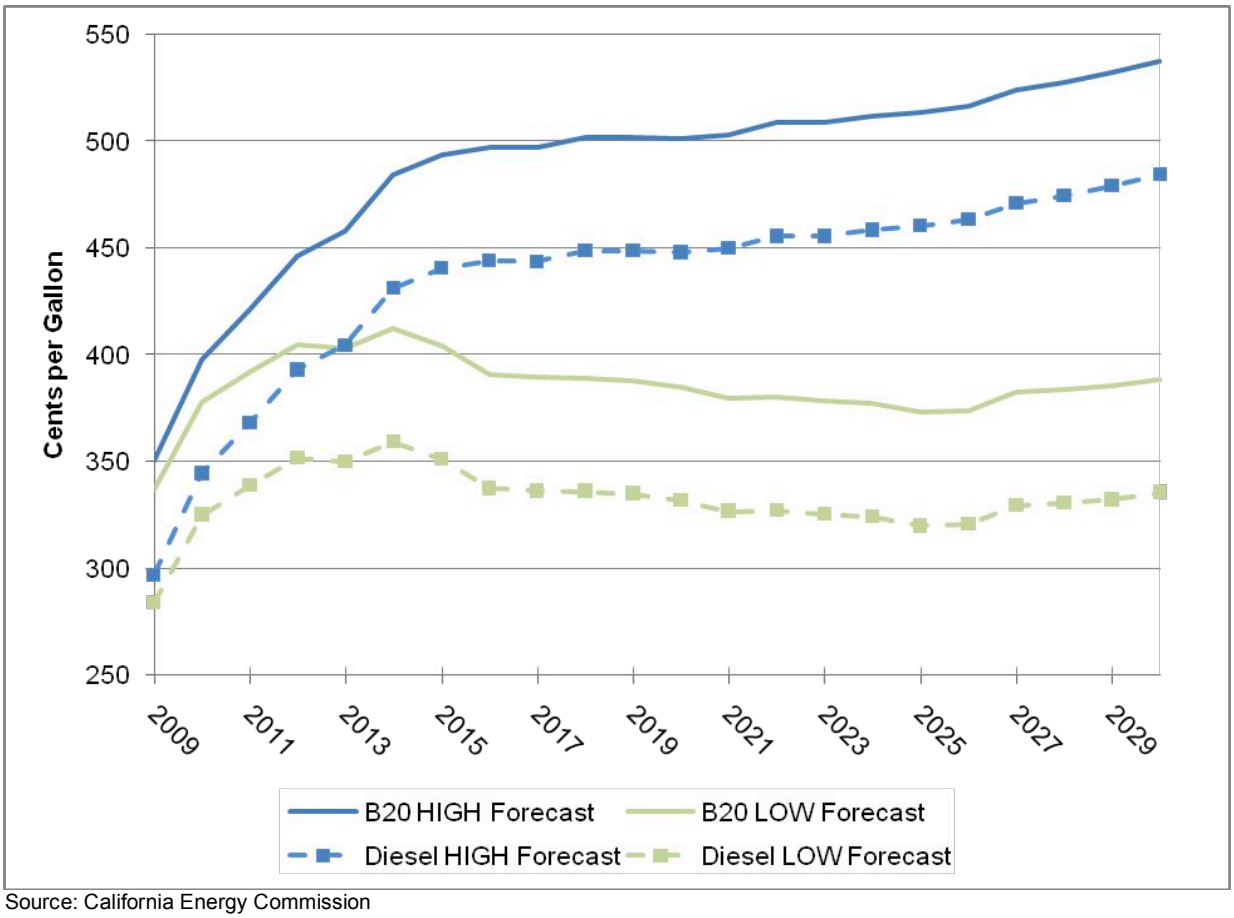
The price forecast for B20 blends sold in California is presented in Table 8 and Figure 9 below in 2008 cents per gallon.

Table 8: California B20 and Diesel Retail Price Forecasts (2008 cents per gallon)

Year	Diesel		B20	
	HIGH	LOW	HIGH	LOW
2009	297.3	284.0	335.7	323.0
2010	344.7	325.2	380.9	362.2
2011	368.3	338.8	403.4	375.2
2012	393.3	351.9	427.2	387.7
2013	404.7	350.2	438.1	386.1
2014	431.5	359.3	463.7	394.8
2015	441.0	351.34	472.6	387.2
2016	444.3	337.5	475.8	374.0
2017	443.9	336.3	475.5	372.9
2018	449.0	336.3	480.3	372.8
2019	448.9	335.1	480.2	371.7
2020	448.2	331.8	479.6	368.5
2021	450.1	326.9	481.3	363.9
2022	455.9	327.2	486.8	364.2
2023	455.7	325.4	486.7	362.5
2024	458.7	324.4	489.5	361.5
2025	460.8	320.0	491.6	357.4
2026	463.5	320.9	494.1	358.2
2027	471.3	329.7	501.6	366.5
2028	474.8	330.7	504.8	367.5
2029	479.4	332.3	509.3	369.1
2030	484.6	335.6	514.2	372.2

Source: California Energy Commission

Figure 9: California Diesel and Biomass-Based Diesel Forecasted Retail Prices to 2030 (2008 cents per gallon)



Source: California Energy Commission

CHAPTER 6:
Transportation Electricity Price Forecast

Recent national, state, and consumer trends indicate an interest in higher fuel efficiency vehicles with lower carbon footprints such as plug-in hybrid electric vehicles (PHEV) and electric-only vehicles (EV). Therefore price forecasts of electricity used by these vehicles will help with better understanding of the potential usage of these vehicles in California. Staff have examined standard and electric vehicle residential rate structures of Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas & Electric (SDG&E), Los Angeles Department of Water & Power (LADWP), and Sacramento Municipal Utility District (SMUD) to develop electricity price forecasts for Californian PHEV and EV users. CARE (California Alternative Rates for Energy) rates, an electricity discount program for low-income Californians, are not considered in this analysis.

Method

Electricity providers in California are either an investor-owned utility (IOU) or a municipal-owned Utility (MOU). These two types of utilities have distinctly different rate structures for electricity used by vehicles. PG&E, SCE, and SDG&E are IOUs represented in the regional electricity price forecast. The two MOUs used in the electricity price forecasts are LADWP and SMUD.

Electric vehicle rate structures were analyzed for both MOUs and IOUs, and weighted averages were constructed using each utility's 2006 customer base as the corresponding weight. Utility generation and non-generation costs are the basis for forecasted prices and are assumed to be the same as in the *2007 IEPR*. Generation costs are calculated by multiplying the previous year's price by the forecasted percentage change in natural gas prices. Non-generation costs are calculated by multiplying the previous year's price by the GSP deflator, thus keeping them constant in real terms.

The following assumptions apply to these price forecasts: all EVs and PHEVs use 175 kilowatt hours (kWh) per month; of the total electricity used to power vehicles, 88 percent occurs during off-peak hours, 8 percent in part peak, and 4 percent in peak hours; 30 percent of PG&E customers were assumed to use the single metered rate, Rate A, and the rest use the dual metered rate, Rate B. It should be noted that customers pay the monthly charge rate as part of their residential consumption regardless of their vehicle choice, and the per kWh charges do not include initial meter installation costs, which vary by utility. If meter installation costs are high, customers could elect to forego special EV rates, thus changing the forecasting equation. It should also be noted that not all counties' metering regulations are known, however, where appropriate staff inferred potential single- and dual-meter rates such as those described for PG&E.

Electricity Price Forecast

Using the approach and assumptions discussed above, staff developed High and Low Case forecasts for 2009 to 2030. As seen in Table 9, kilowatt hour (kWh) prices for the High Case electric vehicle forecasts rise from 13.6 cents per kWh in 2009 to 16.8 cents per kWh in 2030 (all prices listed are in real 2008 cents). This represents a 23.5 percent change in electricity prices over the 22-year period for this price forecast. In the Low Case price forecast, in 2009 the forecast starts at 13.0 cents per kWh and rises to 13.8 cents per kWh in 2030, a more modest 6.1 percent increase over the forecast period. For comparison purposes, the 2009 PG&E E-9 Rate B (dual meter) off-peak electricity rate for electric vehicles excluding any metering charges is 4.0 cents per kWh in 2009.

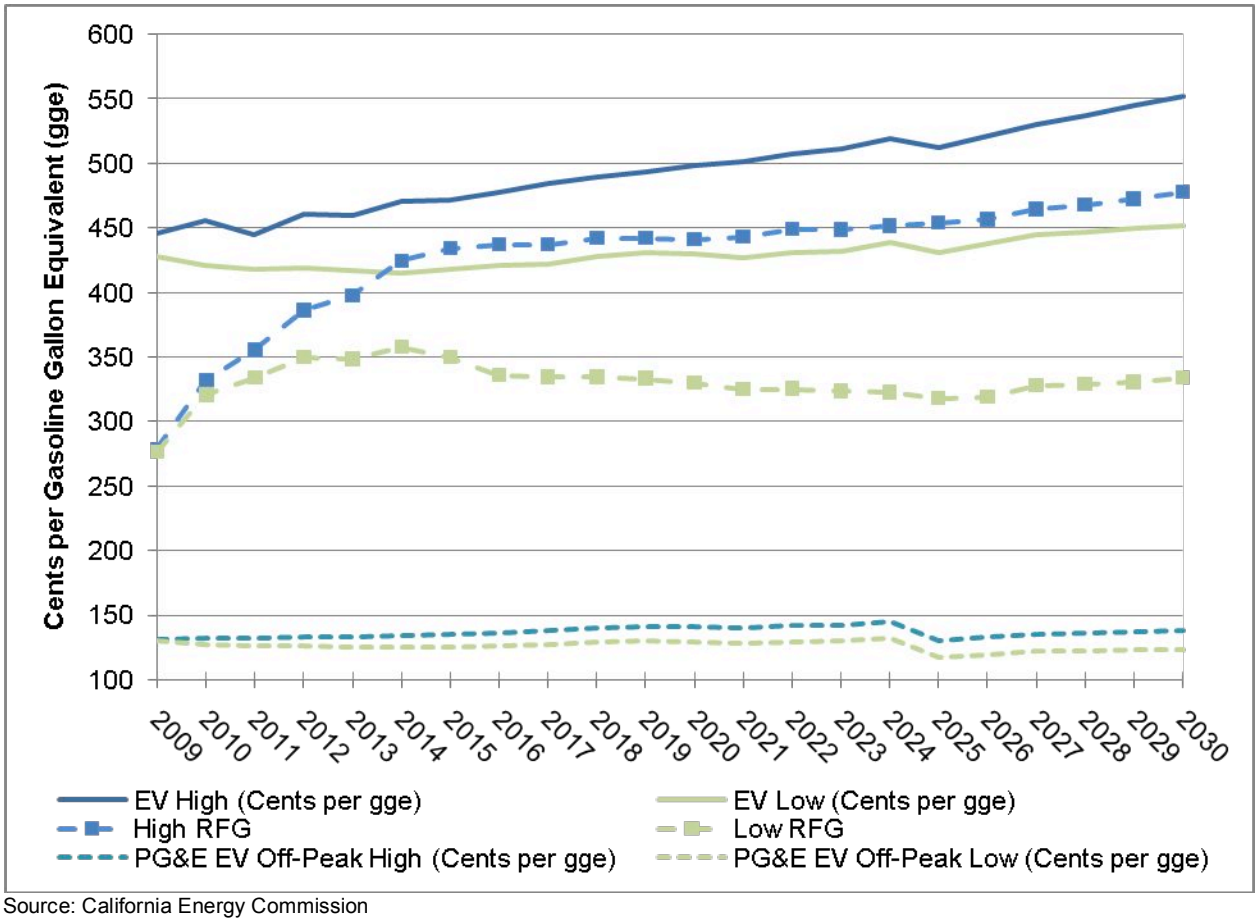
Table 9: California Transportation Electricity Price Forecast (2008 cents)

Year	Weighted Average Electricity Price for EV use (¢/kWh)		Weighted Average Electricity Price for EV use (¢/GGE)	
	High	Low	High	Low
2009	13.6	13.0	446.2	427.7
2010	13.9	12.8	456.0	420.7
2011	13.6	12.7	445.0	418.0
2012	14.1	12.7	461.1	418.1
2013	14.0	12.7	459.5	416.7
2014	14.3	12.6	470.7	414.6
2015	14.4	12.7	472.0	417.4
2016	14.6	12.8	477.9	420.2
2017	14.8	12.9	484.8	421.9
2018	14.9	13.0	489.6	427.4
2019	15.0	13.1	493.7	430.9
2020	15.2	13.1	498.3	429.4
2021	15.3	13.0	501.7	426.4
2022	15.5	13.1	507.2	430.5
2023	15.6	13.2	511.7	431.9
2024	15.8	13.4	519.4	438.7
2025	15.6	13.1	512.8	430.9
2026	15.9	13.3	521.4	437.7
2027	16.2	13.6	530.4	444.8
2028	16.4	13.6	537.3	446.8
2029	16.6	13.7	545.0	450.0
2030	16.8	13.8	552.4	451.5

Source: California Energy Commission

When converted to a gasoline gallon equivalent (GGE), these kilowatt hour prices equate to $4.46 for the High Case projection and $4.28 in the Low Case projection initially for 2009. These prices rise to $4.98 and $4.29, respectively, by 2020, and then continue to rise to $5.52 and $4.52 by 2030. These GGE price forecasts are shown in Figure 10 along with the proposed 2009 RFG price forecasts. Additionally, for comparison purposes, High and Low forecasts of PG&E's 2009 E-9 Rate B (dual metering) Tier 1 off-peak rates excluding metering charges are also provided in Figure 10. Note that while these prices have been converted into gasoline gallon equivalent terms, fuel efficiency differences between conventional vehicles and electric-powered vehicles are what determine the actual per-mile cost of driving a vehicle. Rates vary greatly by utility, ranging from four to twenty-one cents per kilowatt hour. Customers served by the more expensive EV rate structures may instead charge their vehicles using standard household electricity rates.

Figure 10: Transportation Electricity and RFG Price Forecasts (2008 cents per GGE)



Source: California Energy Commission

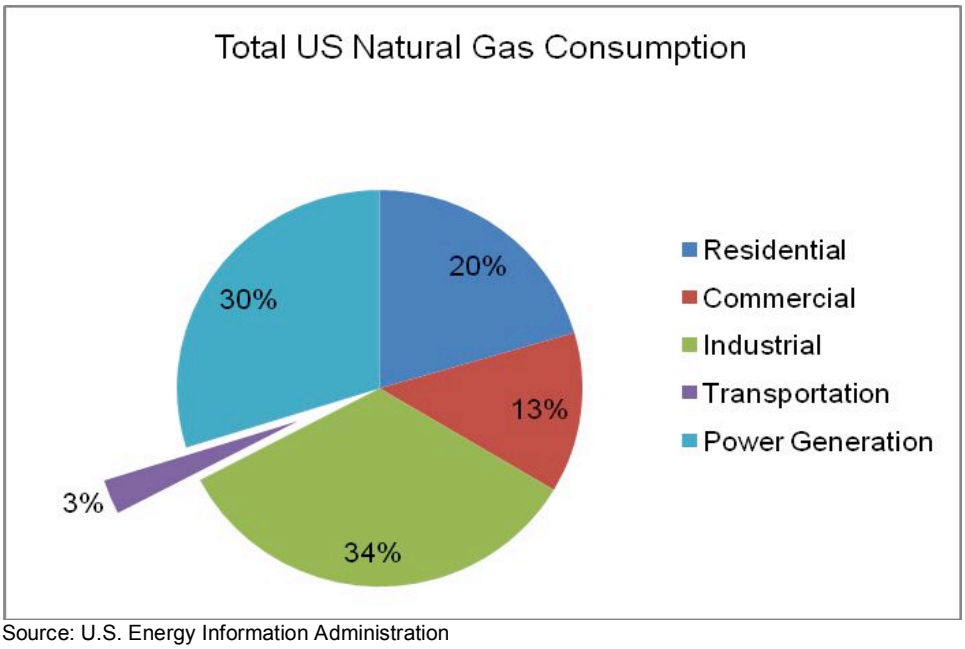
CHAPTER 7:
Compressed and Liquefied Natural Gas, Propane, and Hydrogen Price Forecasts

Natural gas accounts for approximately 25 percent of all energy consumed in the United States.[11] It is used in a variety of ways as depicted in Figure 11.[12] Natural gas is typically compressed (CNG) or liquefied (LNG) for use in transportation.

Compressed Natural Gas Price Forecast

For this price forecast, staff compared California retail petroleum fuel prices from EIA with average retail CNG prices for California. The historical relationship found between CNG and gasoline was then used to forecast CNG prices corresponding to the Energy Commission's gasoline price forecast.

Figure 11: Total U.S. Natural Gas Consumption



Source: U.S. Energy Information Administration

Compressed Natural Gas Price Forecasting Method

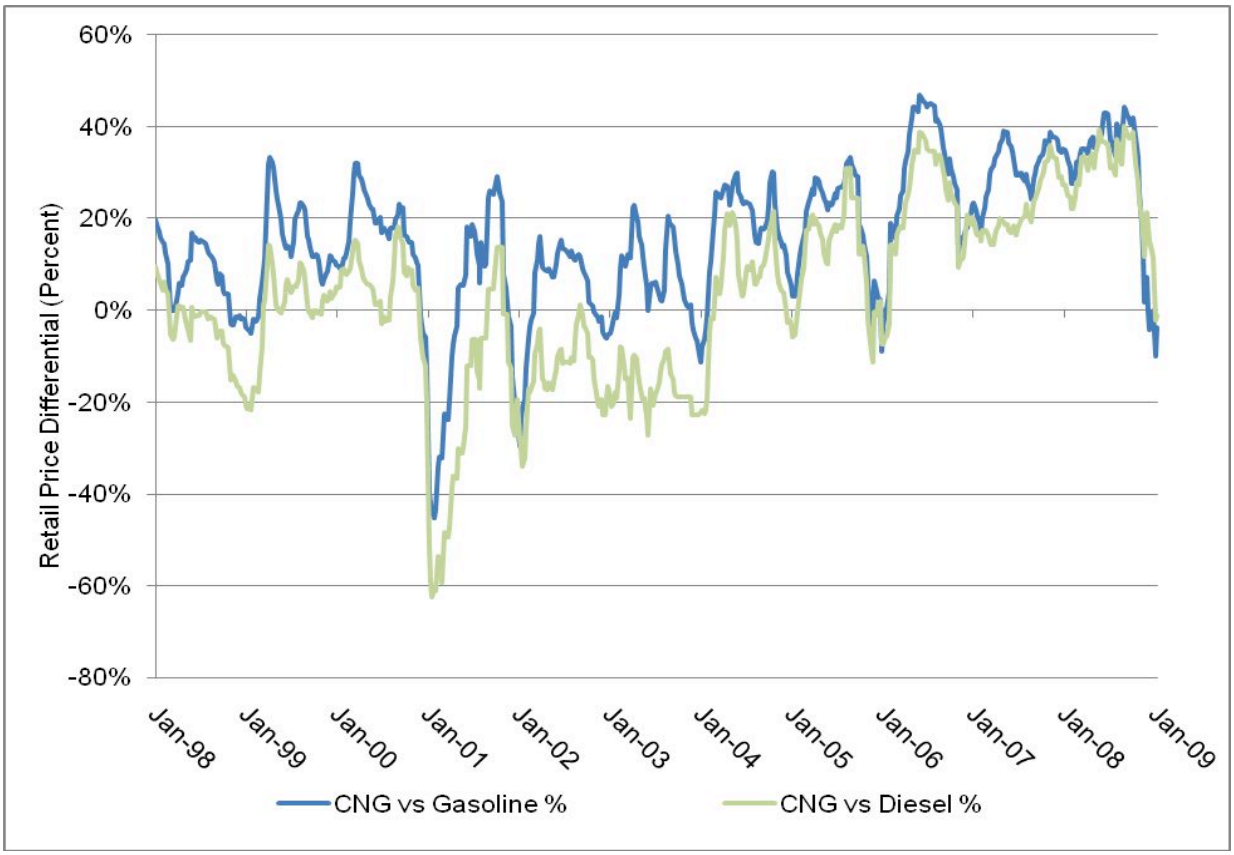
Two methods were considered to forecast potential future retail prices of CNG in California, a commodity based (bottom-up) approach and a retail market relationship (top-down) approach. Staff evaluated each approach in terms of both gasoline and diesel. The two methods are described and the results presented below.

Retail Market Relationship (Top-Down) Approach

[11] http://www.afdc.energy.gov/afdc/fuels/natural_gas_what_is.html
[12] U.S. Energy Information Administration, *Annual Energy Report*, Table 6.5. Natural Gas Consumption by Sector, 1949- 2007. http://www.eia.doe.gov/emeu/aer/txt/ptb0605.html

Staff used historic California retail gasoline and diesel prices from EIA and average retail CNG prices from PG&E and Southern California Gas Utility Company (So Cal Gas) to establish a retail price difference. Figure 12 shows the historical retail price differentials for these fuels.

Figure 12: Percent Differences in Retail Fuel Prices of Gasoline, Diesel, and CNG from 1998 to 2009 (Nominal)



Source: California Energy Commission, Emerging Fuels Office Analysis of EIA Statewide Weekly Average Retail Gasoline and Diesel prices. CNG Retail average Utility prices (PG&E and So Cal Gas)

Specifically, staff evaluated retail price spreads for the past 10 years between CNG, gasoline, and diesel to develop the commodity related price differences of CNG. In comparing CNG with gasoline and diesel, staff also reviewed fuel taxation changes and made adjustments to ensure comparable prices were evaluated. On October 1, 2005, CNG federal excise taxes increased, and staff adjusted the retail prices for the first seven years to reflect this increase. All values in reflected in Table 10 were adjusted to correct for this change.

Table 10: Summary of 10-Year Petroleum-Based Fuels and CNG Retail Price Differentials and Adjustments

(Gasoline and Diesel-CNG, with % Differences in Parenthesis)

Fuel	Retail Prices	Added Federal Excise Tax Change (.1245 ¢/GGE)	Added Retail Margin (6 ¢/GGE)	Added State & Local Sales Taxes (8%)
Gasoline	$0.55 (24%)	$0.43 (16%)	$0.37 (12%)	$0.24 (6%)
Diesel	$0.31 (13%)	$0.18 (4%)	$0.12 (0%)	-$0.01 (-7%)

Source: California Energy Commission

Commodity Based (Bottom-Up) Approach

The commodity-based approach establishes a natural gas price benchmark (California City Gate) based on crude oil prices and assumes a market price linkage between crude oil and natural gas markets.[13] From an estimated California City Gate natural gas price, staff added the CNG retail cost that So Cal Gas used in October 2008[14] to generate CNG retail prices. Table 11 lists the So Cal Gas's costs used to estimate CNG retail price. Utility CNG retail prices do not include retail station margins, which staff estimate at 16 cents/gge based on average gasoline and diesel retail stations. The station margin covers expenses related to land, labor, store utilities, profit, and rack-to-retail transportation expenses. Rack-to-retail transportation expenses are estimated to cost 10 cents per gge on average, leaving a 6 cents per GGE retail margin cost added to the utilities retail prices. Natural gas also has several local taxes included below.[15]

[13] This relationship was estimated to be 81 percent.

[14] Southern California Gas October 2008 tariff structure.

[15] SRF is State Regulatory Fee, PPP is a Public Purpose Program surcharge, UUT is utility users tax imposed by cities, SFT is State fuel use tax, FET is federal energy tax,

Table 11: Summary of Southern California Gas Costs Applied to Commodity-Based Forecast (2008 Dollars)

Cost Description	Estimated Cost
Crude Oil Based Natural Gas (City Gate $/therm)[16]	1.00
Intrastate Trans. ($/therm)	0.0880
Compression Expense ($/therm)	0.7462
Sub-Total Gas Cost ($/therm)	**1.83**
SRF ($/therm)	0.0680
PPP ($/therm)	0.02379
UUT %	0.100
SFT ($/therm)	0.0677
Sub Total ($/therm)	**2.09**
Sub Total ($/GGE)	2.52
Federal Excise Tax*	0.183
Retail Margin	0.06
Sales Tax (8%)	0.22
Estimated pump price ($/GGE)	**$2.99**
Estimated pump price ($/diesel gallon equivalence)	**$3.40**

Source: Southern California Gas, October 2008 tariff structure

Table 12 provides a summary of retail market price relationships between gasoline, diesel, and CNG between 1998 and 2008.

Table 12: Summary of CNG Retail Price Relationship of Gasoline and Diesel

Approach	CNG Price Relative to Retail Gasoline	CNG Price Relative to Retail Diesel
Commodity Based (Bottom-Up)	9 percent less	5 percent more
Retail Market Relationship (Top-Down)	6 percent less	7 percent more

Source: California Energy Commission

Staff applied the gasoline and CNG market price relationships to the two proposed *2009 IEPR* crude oil price cases to project anticipated CNG prices relative to the other fuels in the Low and High Price Cases. Table 12 lists the price relationships staff recommends for both the Low and High CNG price cases for *IEPR 2009*. The price forecast for CNG sold in California is presented in Table 13.

[16] Presented estimated cost for Crude Oil Based Natural Gas is for example purposes only and would be replaced with converted forecasted EIA crude oil price forecast values.

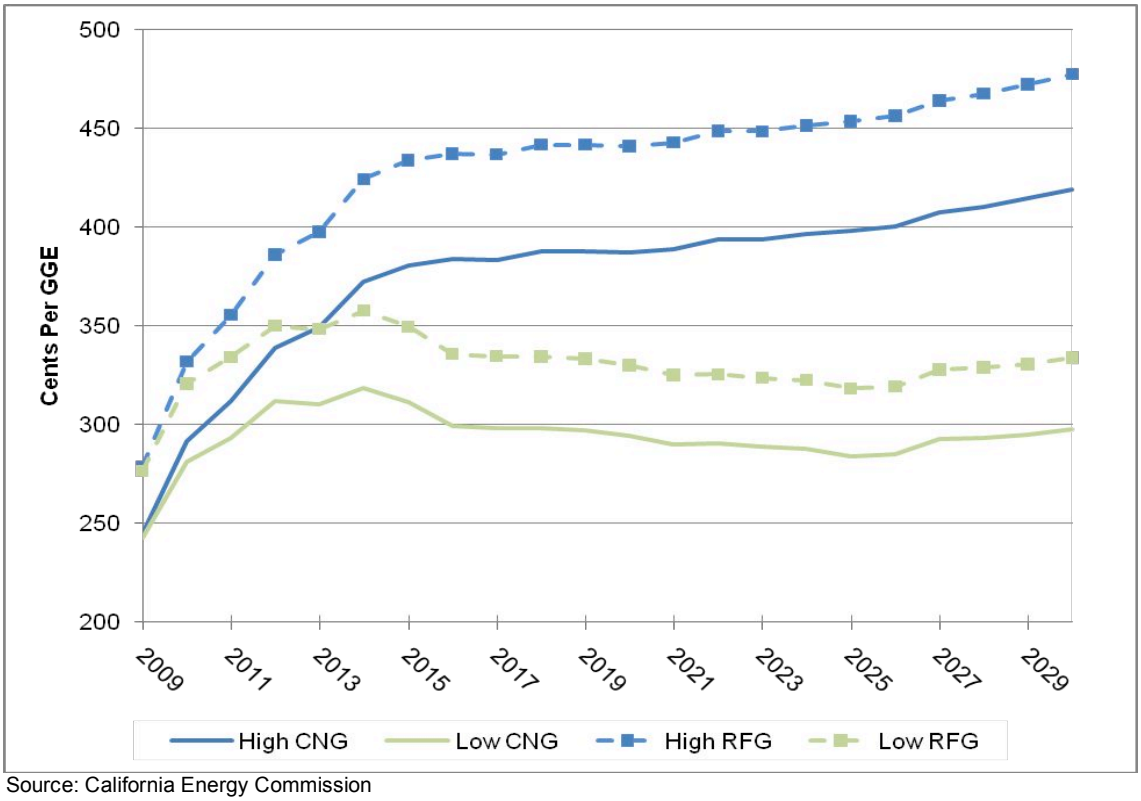
Table 13: California CNG Retail Price Forecast
(2008 cents per diesel gallon equivalents)

Year	Commodity Based Prices				Retail Market Relationship Prices			
	Gasoline		Diesel		Gasoline		Diesel	
	High CNG	Low CNG	High CNG	Low CNG	High CNG	Low CNG	High CNG	Low CNG
2009	239.8	237.7	294.3	281.2	247.8	245.6	299.9	286.6
2010	284.8	274.9	340.8	321.6	294.3	284.1	347.4	327.8
2011	304.8	286.5	364.0	335.0	315.0	296.1	371.0	341.4
2012	330.8	304.8	388.5	347.8	341.9	315.0	396.0	354.5
2013	340.5	303.4	399.7	346.2	351.9	313.5	407.4	352.8
2014	363.3	311.2	426.1	355.2	375.4	321.5	434.3	362.0
2015	371.2	304.4	435.3	347.3	383.6	314.6	443.7	354.0
2016	374.1	292.6	438.6	333.8	386.6	302.4	447.0	340.2
2017	373.8	291.6	438.2	332.6	386.3	301.4	446.7	339.0
2018	378.1	291.6	443.3	332.5	390.7	301.3	451.8	338.9
2019	378.0	290.6	443.2	331.4	390.7	300.3	451.7	337.8
2020	377.4	287.8	442.5	328.1	390.0	297.4	451.0	334.4
2021	379.0	283.6	444.3	323.3	391.7	293.1	452.8	329.5
2022	383.9	283.9	450.0	323.6	396.7	293.4	458.6	329.8
2023	383.8	282.4	449.8	321.9	396.6	291.8	458.5	328.1
2024	386.3	281.5	452.7	320.8	399.2	290.9	461.5	327.0
2025	388.1	277.8	454.8	316.6	401.1	287.1	463.6	322.7
2026	390.4	278.5	457.5	317.4	403.5	287.8	466.3	323.5
2027	397.0	286.0	465.1	326.0	410.3	295.5	474.1	332.3
2028	399.9	286.8	468.5	327.0	413.3	296.4	477.5	333.3
2029	403.9	288.2	473.1	328.6	417.4	297.8	482.2	335.0
2030	408.2	291.0	478.1	331.9	421.9	300.8	487.4	338.3

Source: California Energy Commission

Staff proposes to use the commodity based prices associated with gasoline, which amounts to a 9 percent lower CNG price than gasoline. Figure 13 illustrates the Energy Commission gasoline retail price forecast and the retail CNG price forecast.

Figure 13: California CNG and Gasoline Retail Price Forecasts (2008 Cents per GGE)



Source: California Energy Commission

Liquefied Natural Gas Price Forecast

LNG prices were determined by first estimating the likely natural gas market prices anticipated in the low and high crude oil cases. Over the forecasted period, staff assumed RAC crude oil and natural gas markets are linked.[17,18,19] Staff used the 2000, 2002-2005 RAC crude oil prices and natural gas City Gate prices to develop a price relationship for the forecasted years.[20] Natural gas prices in 2001 and 2006-2008 years were not used as these years exhibited delinked, non-sustained, price events. Staff applied an 81 percent conversion factor to the average refinery acquisition costs to align crude oil prices with the minimum differences with historical California natural gas City Gate prices. Figure 14 shows the energy-equivalent price relationship for past and future crude oil prices and the past alignment with California natural gas City Gate prices.

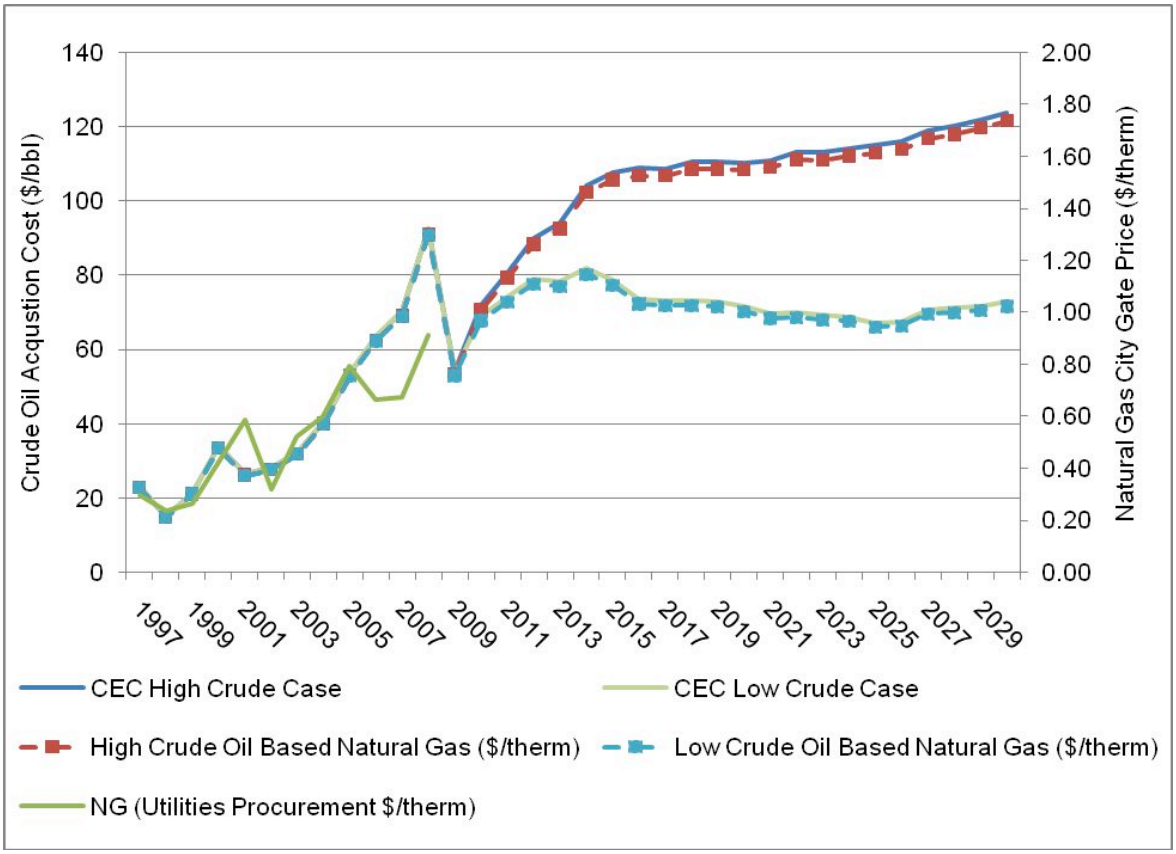
Figure 14: Crude Oil and Natural Gas Price Relationships Applied to Forecast Natural Gas Prices

[17] Southwest Economy, "Natural Gas Pricing: Do Oil Prices Still Matter?," Issue 4, July/August 2005, Federal Reserve Bank of Dallas.

[18] "An Econometric Evaluation of the Demand for Natural Gas in the Power Generation and Industrial Sectors," Peter Hartley, Professor, Economic Department, Rice University, unpublished, 2006.

[19] "The Relationship Between Crude Oil and Natural Gas Prices," Jose A. Villar, Natural Gas Division, Energy Information Administration.

[20] EIA crude oil acquisition cost and natural gas California City Gate prices were used.



Source: California Energy Commission

Liquefied Natural Gas Price Forecasting Method

Table 14 lists the costs staff used to estimate LNG retail prices. The first column is in $/LNG gallon, except the first row and the second column is in $/million Btus. The natural gas City Gate costs were kept consistent at the 81 percent price relationship with the values for RAC found in Table 2. All other costs remained unchanged over the forecast period. The LNG added costs are in 2008 real dollars. Because LNG is not presently retailed, nor do staff anticipate it would be sold in conventional retail stations, staff did not apply retail margins but did include 8 percent sales tax.

Table 14: Summary of LNG Cost Used to Estimate Retail Prices (2008 Dollars)

		($/mill Btus)
Natural Gas ($/Therm) (Varied annually)	$1.05	
NG feed cost ($/LNG gallon)	$1.27	$16.56
Cost to Liquefy ($/LNG)	$0.08	$1.14
Storage /Terminal Cost ($/LNG)	$0.01	$0.14
Transportation Cost ($/LNG)	$0.10	$1.36
Customer/Storage Cost ($/LNG)	$0.03	$1.36
Capital Recover of Dispenser ($/LNG)	$0.02	$0.22
	$0.00	$0.00
Excise taxes State (per LNG gallon)	$0.02	$0.27
Excise taxes Federal (per LNG gallon)	$0.14	$1.71
Sub total	$1.76	$23.01
Sales Tax (8%)	$0.14	$1.84
Total Price ($/LNG gallon)	$1.91	$24.84
LNG Total Price per Diesel Gallon Equivalent	$3.17	

Source: California Energy Commission

Staff applied the conversion factor to the future crude oil price cases to determine an equivalent natural gas City Gate price for use in estimating LNG retail cost and final retail prices. Table 15 shows the summary results of the assumed natural gas City Gate prices and the retail LNG prices.

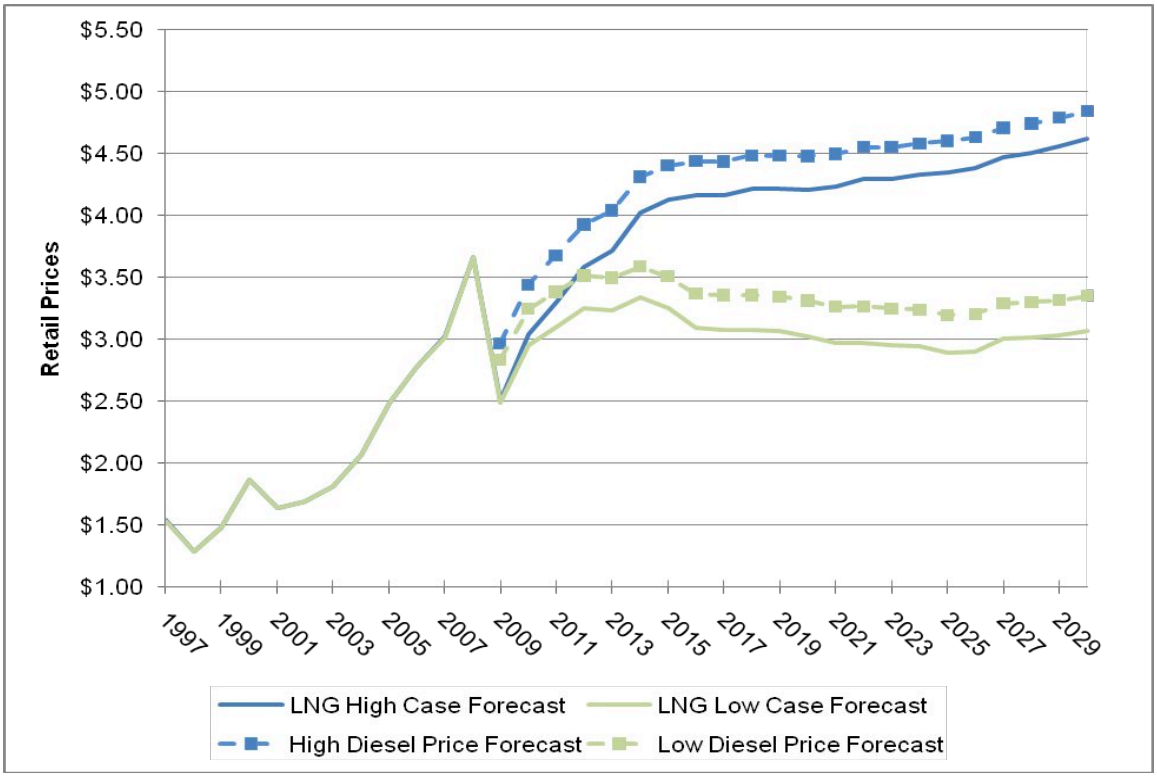
Table 15: Natural Gas Prices and LNG Retail Price Forecasts (2008 Dollars)

Year	High Natural Gas Converted into $/therm	Low Natural Gas Converted into $/therm	LNG High Case Forecast	LNG Low Case Forecast
2007	$1.04	$1.04	$3.17	$3.17
2008	$1.36	$1.36	$3.85	$3.85
2009	$0.80	$0.80	$2.62	$2.61
2010	$1.06	$1.02	$3.19	$3.09
2011	$1.19	$1.09	$3.46	$3.26
2012	$1.32	$1.16	$3.77	$3.41
2013	$1.38	$1.15	$3.90	$3.40
2014	$1.53	$1.21	$4.22	$3.50
2015	$1.58	$1.16	$4.32	$3.41
2016	$1.61	$1.08	$4.36	$3.24
2017	$1.59	$1.08	$4.36	$3.23
2018	$1.63	$1.08	$4.43	$3.23
2019	$1.63	$1.07	$4.43	$3.22
2020	$1.63	$1.05	$4.42	$3.18
2021	$1.64	$1.03	$4.44	$3.12
2022	$1.67	$1.03	$4.50	$3.13
2023	$1.67	$1.02	$4.50	$3.11
2024	$1.68	$1.02	$4.54	$3.08
2025	$1.69	$0.99	$4.56	$3.03
2026	$1.71	$1.00	$4.59	$3.04
2027	$1.75	$1.04	$4.69	$3.15
2028	$1.76	$1.05	$4.73	$3.17
2029	$1.79	$1.06	$4.78	$3.18
2030	$1.81	$1.07	$4.85	$3.22

Source: California Energy Commission

From the natural gas price estimates in Table 13, staff constructed a LNG retail price forecast. Figure 15 shows the forecasted LNG prices relative to diesel retail prices.

Figure 15: California LNG Retail Price Forecast
(2008 dollars per diesel gallon equivalent)



Source: California Energy Commission

Propane Price Forecast Assumptions and Method

Propane is a by-product of both natural gas and crude oil refining processes. While wholesale prices are influenced by the production of both fuel types, EIA research indicates that crude oil has the greater direct link to propane prices[21]. Using this linkage, staff developed forecasts for vehicle propane prices.

Staff analysis of wholesale propane prices from 2000 to 2008, published by the EIA, revealed that annual wholesale propane prices divided by the refiner acquisition cost (RAC) of imported crude oil ranged from 69 percent to 120 percent. For the High Case, staff averaged these ratios for all nine years between 2000 and 2008, for an estimated ratio of wholesale propane prices to RAC prices of 91 percent. For the Low Case, the 2007-2008 average of wholesale propane prices divided by RAC prices was used, for an estimated ratio of 76 percent.

To forecast final retail vehicle propane prices, retail margins were estimated and taxes were added. The difference between wholesale and retail outlet prices (excluding taxes) for propane averaged $0.55 for the time period of 1994 to 2004 and this value was used for the Low Case. The difference averaged $0.64 for the period of 2000 to 2004 and this value was used for the High Case. It should be noted that EIA retail outlet prices for vehicle use data is for West Coast

[21] EIA Informational Brochure: *Propane Prices, What You Should Know*
http://www.eia.doe.gov/bookshelf/brochures/propane/index.html

(PADD 5) states[22] and encompasses the period of 1994 to 2004.[23] An amount of $0.243 for state and federal excise taxes, and an 8 percent sales tax were then added to create final propane vehicle fuel prices.

As seen in the Table 16 and Figure 16, the High Case transportation propane price forecast starts at $2.34 per gallon, rises sharply to $3.65 in 2015, and then continues to rise more slowly to $4.04 by 2030 (in 2008 dollars). The Low Case forecast starts at $2.10, increases to $2.61 in 2015, and then declines slightly to $2.50 per gallon by 2030.

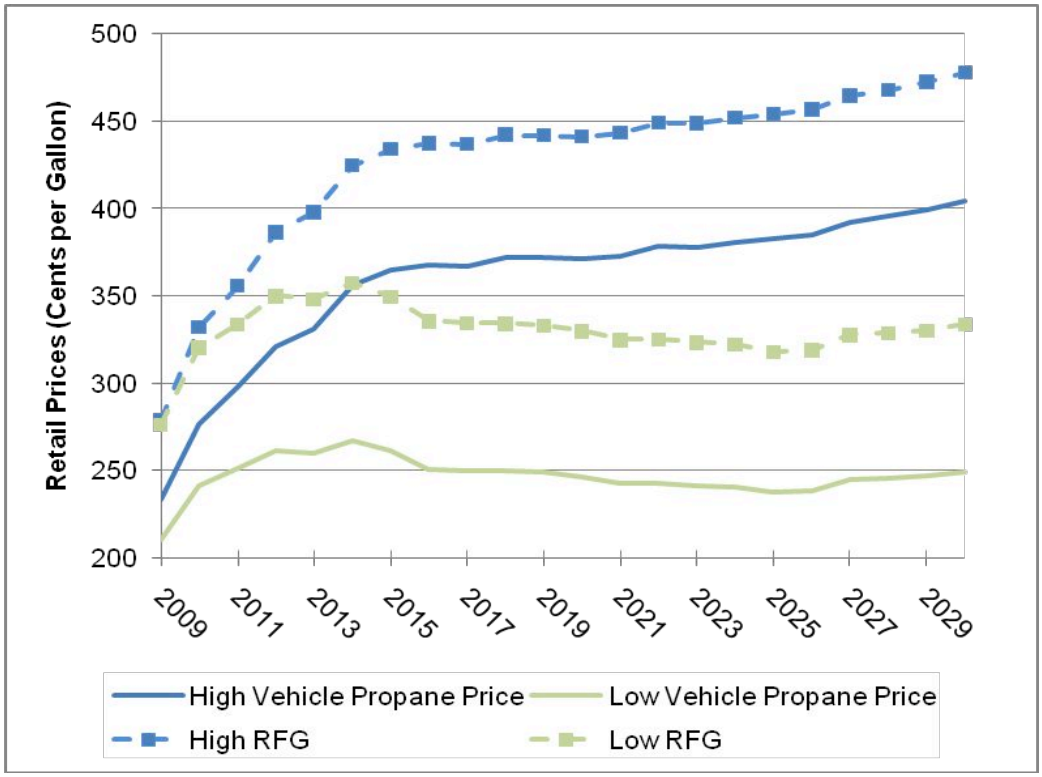
Table 16: Propane Retail Price Forecasts (2008 cents per LPG gallon)

Year	High Propane Vehicle Price	Low Propane Vehicle Price
2009	233.5	210.3
2010	276.8	241.5
2011	298.3	251.9
2012	321.1	261.8
2013	331.5	260.5
2014	355.9	267.5
2015	364.5	261.4
2016	367.6	250.9
2017	367.2	250.0
2018	371.9	249.9
2019	371.8	249.1
2020	371.2	246.5
2021	372.8	242.8
2022	378.1	243.0
2023	378.0	241.7
2024	380.7	240.9
2025	382.6	237.6
2026	385.1	238.3
2027	392.2	244.9
2028	395.3	245.7
2029	399.6	246.9
2030	404.3	249.5

Source: California Energy Commission

[22] Staff was unable to locate California specific end-user vehicle propane prices that could be used in conjunction with EIA price information.
[23] Later periods are unavailable due to it being withheld by EIA.

Figure 16: Propane Retail Price Forecasts
(2008 cents per gallon)



Source: California Energy Commission

Hydrogen Price Forecast

Currently there are 400 to 500 hydrogen powered vehicles in the United States, with most of them in California.[24] These vehicles use stored hydrogen, which is converted to electricity and then stored in a fuel cell. This technology is still relatively expensive due to high production costs of both fuel cells and hydrogen, yet it is seen as an attractive technology due to its clean emissions capabilities.

Natural gas is the primary feedstock needed for manufacturing hydrogen and is the basis for the price forecast. It should be noted that the price of natural gas is the only cost that is variable over time in this forecast. All other costs presented will be held constant in real terms over the forecast period. Starting with the same natural gas price forecast used in the CNG analysis, hydrogen production costs associated with the reforming of the natural gas are estimated. Production costs are summed together on a million Btu (mBtu) basis and are as follows: natural gas (variable forecast), variable non-fuel O&M ($0.11 per mBtu), reforming costs (24 percent of natural gas forecast), fixed operating costs ($0.56 per mBtu), capital recovery costs ($1.78 per mBtu), and electricity for production costs ($0.31 per mBtu). The next step of the price forecast is to add compression and transportation costs. These costs total $25.49 and include: compression capital recovery ($7.91 per mBtu), electricity costs for compression ($8.59 per mBtu), general maintenance ($5.05 per mBtu), and over-the-road delivery costs ($3.95 per

[24] Found on the EIA website, in the Hydrogen energy explanation section.
http://www.eia.doe.gov/kids/energyfacts/sources/IntermediateHydrogen.html

mBtu). Retail costs are then added which include retail dispenser capital recovery ($1.22 per mBtu) and a general retail markup ($1.00 per mBtu). Production costs, compression costs, and retail costs are then summed and an 8 percent sales tax is included for the final hydrogen fuel price. No state or federal excise taxes are included in the price estimates. Currently these taxes are not imposed on hydrogen vehicle fuel, but future market penetration of this fuel could lead to the inclusion of these fair-use taxes.

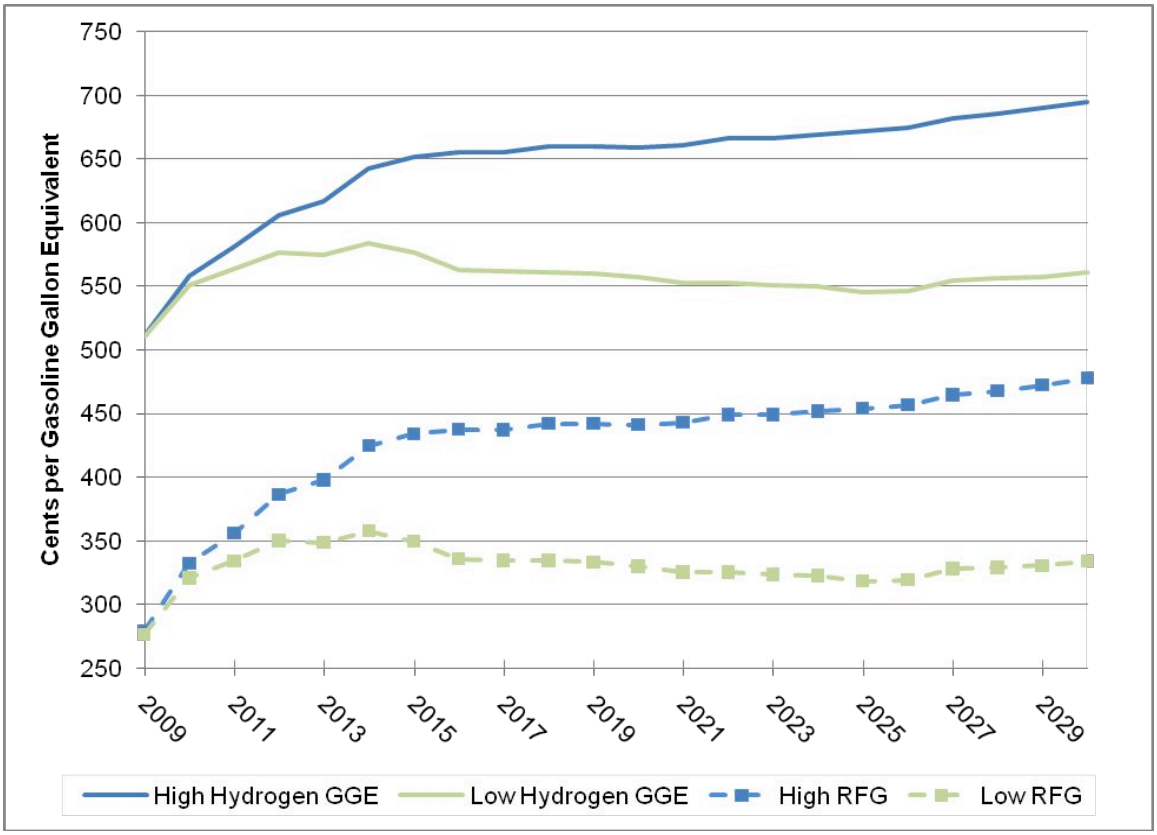
Table 17 and Figure 17 show the results. Estimates are in real 2008 cents per gasoline gallon equivalents. As seen in the table and graph, the High Case forecast starts at $5.12 per GGE in 2009, rises to $6.59 in 2020, and continues to $6.95 in 2030. For the Low Case hydrogen forecast, the price begins at $5.11 per GGE and increases to a peak of $5.84 in 2014, before settling back to $5.61 by 2030.

Table 17: Retail Hydrogen Price Forecasts (2008 cents per GGE)

Year	High Hydrogen GGE	Low Hydrogen GGE	High RFG	Low RFG
2009	511.8	510.6	279.1	276.6
2010	558.1	550.7	332.1	320.5
2011	581.1	564.0	355.8	334.2
2012	605.5	576.8	386.4	350.1
2013	616.7	575.1	397.8	348.4
2014	642.9	584.1	424.6	357.6
2015	652.0	576.3	434.0	349.6
2016	655.3	562.8	437.4	335.7
2017	655.0	561.6	437.0	334.6
2018	659.9	561.5	442.1	334.5
2019	659.8	560.4	442.0	333.3
2020	659.2	557.2	441.3	330.0
2021	661.0	552.4	443.2	325.1
2022	666.6	552.7	449.0	325.4
2023	666.5	551.0	448.8	323.6
2024	669.4	549.9	451.8	322.6
2025	671.4	545.7	453.9	318.3
2026	674.1	546.5	456.6	319.1
2027	681.7	555.1	464.4	327.9
2028	685.0	556.1	467.8	328.9
2029	689.6	557.7	472.5	330.5
2030	694.6	560.9	477.7	333.9

Source: California Energy Commission

Figure 17: California Retail Hydrogen Price Forecasts
(2008 cents per GGE)



Source: California Energy Commission