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The Implications of an E10 Ethanol-Blend Policy for California

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We evaluate the effects of an E10 ethanol-blend policy on ethanol consumption and greenhouse gas reduction in California. Under an E10 policy in California, the ethanol consumption in 2020 under the base case scenario will be 1.68 billion gallons. The average greenhouse gas emission reduction in 2020 using an E10 policy for the present combination of feedstock will be 1.37% compared to the current E5.7 blend.

National attention has emerged in support of biofuels development and use. The motivating factors include high oil prices, security concerns from relying on foreign energy sources, support for economic growth in the U.S. agricultural community, and environmental goals related to criteria pollutants and climate change emissions. Given the existing production infrastructure and experience with fuel blending, the biofuel of choice is currently ethanol. Currently, gasoline fuel in California includes approximately 5.7% ethanol (E5.7).

E10 is a fuel mixture of 10% ethanol and 90% gasoline that can be used in the internal combustion engines of most modern automobiles and light-duty vehicles. E10 blends are mandated in some areas for emissions and other reasons.

The effects of an E10 ethanol-blend policy in California are uncertain. In California, ethanol fuel or corn feedstock is largely imported from midwest states creating interstate transport challenges. Ethanol fuel cannot be transported in the fuel pipeline system and needs to be blended with gasoline near the end-market locations. Additionally, certain blend fractions of ethanol in gasoline can increase evaporative emissions and permeation, resulting in larger air quality concerns. Moreover, especially in California, E10 from corn is supported largely because it facilitates the transition away from petroleum and toward biofuels. But this issue has not been thought through, and is subject to a variety of uncertain assumptions.

How much ethanol would be consumed in CA each year for the next ten years if there were a mandatory E10 policy? To obtain estimates of future ethanol demand we estimate gasoline fuel demand under several different scenarios and use the projected demand to estimate the required ethanol quantity under an E10 policy. We estimate ethanol consumption based on projections of fuel demand as a base case, and then analyze different scenarios.

In order to estimate the required ethanol quantities under an E10 mandate, we first estimate future gasoline fuel demand. The estimation of demand models for gasoline has produced varying results over the past few decades and continues to be a subject of great interest. Estimates drawn from analysis that includes recent data and California-specific data are scarce, however.

A key parameter in the estimation of gasoline demand is the price elasticity of demand, which measures the percent change in gasoline demand for a percent change in gasoline price. It is a measure of how responsive consumers are to changes in the price of gasoline. The higher the elasticity in magnitude, the more consumers will decrease gasoline consumption in response to an increase in gasoline price. According to six previous studies estimating the elasticity of demand for gasoline,

Also in this issue

Figure 1. California Gasoline Price, 2008 Dollars per Gallon

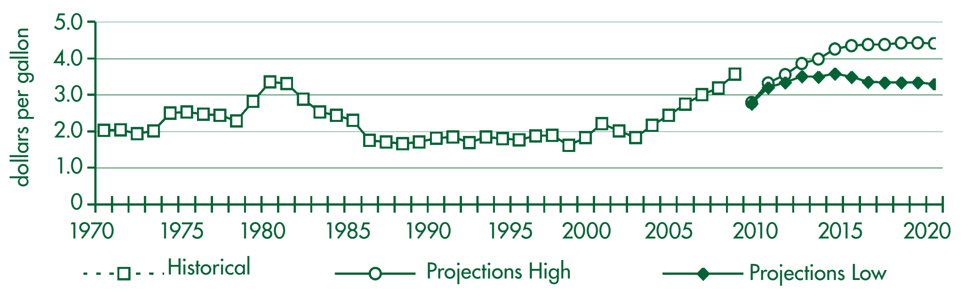


Figure 2. California Population in Millions

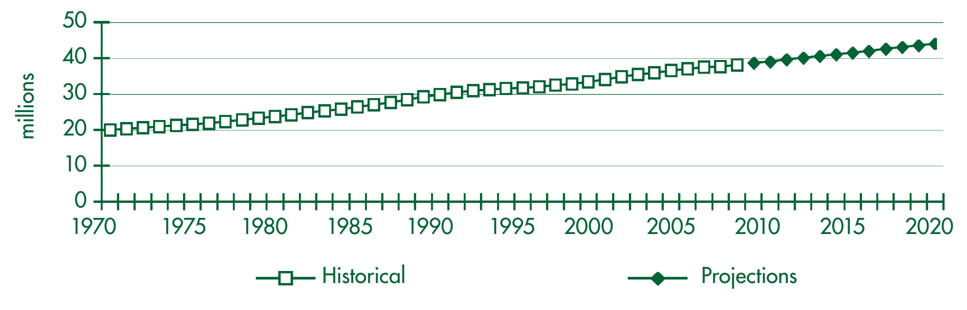
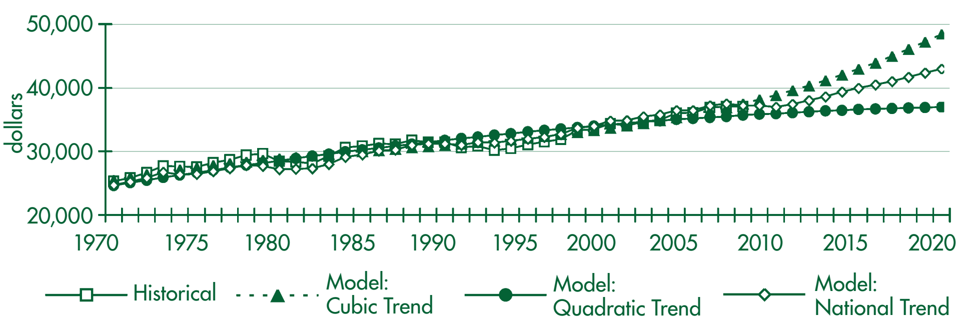


Figure 3. California Per Capita Disposable Income, in 2008 Dollars



using data spread over the years 1929 to 2000, the mean short-run elasticity ranged from –0.25 to –0.28. Short-run elasticities measure the responsiveness over a time span of several months. One recent study, Hughes et al. (2008), shows that demand has become more inelastic over the recent years. In particular, they find that short-run elasticities have decreased by up to an order of magnitude from a range of –0.21 to –0.34 for the years 1975 to 1980, to a range of –0.034 to –0.077 for the recent years 2001 to 2006.

To determine how much ethanol would need to be supplied in California each year from 2010 to 2020, if there were a mandatory national E10 policy that required 10% of the fuel blend to be ethanol, we start with a model of fuel demand for California:

$$\ln D_t = \beta_0 + \beta_1 \ln P_t + \beta_2 \ln Y_t + \varepsilon_t$$

where ln*X* is the natural log of the variable *X*, D_t is per capita gasoline demand in gallons per day for year *t*, P_t is the real price of gasoline in 2008 constant dollars in year *t*, Y_t is real per capita disposable income in 2008 constant dollars in year *t*, and ε_t is a mean zero error term. The coefficient β_1 is the price elasticity of demand over the intermediate run, which spans a time frame of a few years. We would like to use this model for gasoline demand to project fuel demand from 2010 to 2020. Under an E10 policy, 10% of this fuel demand would have to be ethanol.

We run our regression model estimating the demand for gasoline in California using data from 1970 to 2007. To address the identification problem inherent in estimating demand, industrial production in India is used as an instrument for California's gasoline price. Industrial production in India is an ideal instrument for California's gasoline price because it is correlated with California's gasoline price but does not have a direct effect on the demand for gasoline in California. The results, with the standard errors in parentheses, are:

$$\begin{array}{l} \ln D_t = -5.005 - 0.221 * \ln P_t + 0.512 * \ln Y_t \\ \qquad\quad (1.522) \ \ (0.097) \qquad\quad (0.166) \end{array}$$

In particular, we find the intermediate-run price elasticity of demand for gasoline in California to be –0.221. Unlike the previous estimates of the elasticity of demand, our estimate is specific to California and the data used in its estimation include data from recent years. In alternate specifications, we also use a range for the elasticity, from –0.101 to –0.28, which encompasses the range of mean elasticities found in the literature.

To project California's future fuel demand, we used projections of California gasoline price, California per capita disposable income, and California population in our model for California gasoline demand. Retail gasoline price projections are from the "Transportation Fuel Price and Demand Forecasts: Inputs and Methods for the 2009 Integrated Energy Policy Report," prepared by the California Energy Commission (CEC). The data are in 2008 dollars and include a high-price scenario and a low-price scenario. The projections incorporate the E10 policy. CEC staff expects the policy would raise the price of gasoline. The projected price, along with historical price data, are plotted in Figure 1.

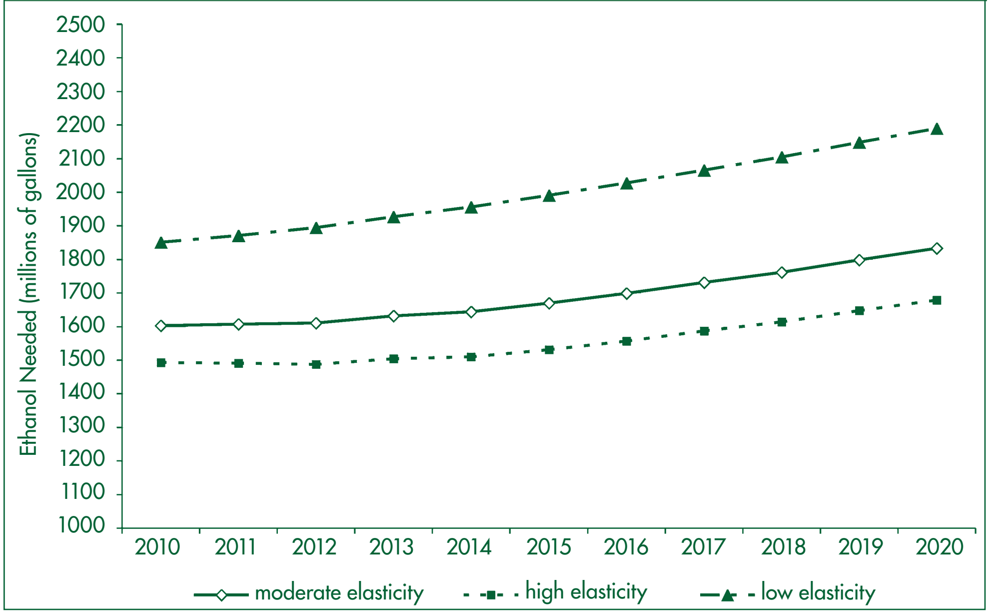
For California population, we use the projections from the California

Department of Finance's report on "Race/Ethnic population with Age and Sex Detail, 2000-2050." Figure 2 plots the historical and projected population.

For California per capita disposable income, we construct three models, from which the predicted values are plotted with the historical data in Figure 3. The first model, Quadratic Trend, is based on a regression of historical California per capita disposable income on time and time squared. The second model, Cubic Trend, is based on a regression of historical California per capita disposable income on time, time squared, and time cubed. The third model, National Trend, is based on a regression of historical California per capita disposable income on historical U.S. per capita disposable income. National historical per capita disposable income data used in the regression are collected from Bureau of Economic Analysis. Projections of national per capita disposable income data used to project the California per capita disposable income are from the Energy Information Administration.

Figure 4 presents estimates of the ethanol needed in California under an E10 policy, using the high-price scenario and the income projected using the national trend. The main assumption used is that the fuel market will be dominated by gasoline over 2010–2020, and ethanol will be used as a 10% additive to gas. The graph presents projections under three elasticities (low= –0.101, moderate= –0.221 and high= –0.28). Using the low-price scenario instead of the high-price scenario, and the quadratic or cubic trends for income instead of the income projected using the national trend, produces similar results. For the base-case scenario of high fuel prices, income as projected using the national trend and moderate elasticity, the ethanol consumption in 2020 under an E10 policy will be 1.68 billion gallons. When considering all 18 price-income-elasticity scenarios, the ethanol consumption in 2020 under an E10 policy will range from 1.56 billion to 2.40 billion gallons.

Figure 4. Projections Using the High Price Scenario and Income Projected from the National Trend



Ethanol has a high octane number and can increase the octane of gasoline (or cetane number for biodiesel). This will lead to better fuel efficiency for vehicles with ethanol-blended fuel. On the other hand, the average energy content of gasoline (114,000 Btu/gallon) is higher than that for ethanol (76,000 Btu/gallon). As a result, ethanol-blended fuel will have lower energy content. Different studies have found a wide range of fuel economy for ethanol-blended fuels. Some report slightly worse fuel economy than pure gas-fueled vehicles, while others report substantially better. Other factors such as motor load, temperature, and traffic congestion may also affect the relative fuel economy of cars with and without ethanol-blended fuel.

If as an average, we considered 5% more fuel efficiency for E10 fuel then, if the VMT and fuel efficiency stays the same with and without an E10 policy so that the total fuel demand is 5% lower, the ethanol consumption in 2020 under an E10 policy would be from 1.55 billion to 2.39 billion gallons. Nevertheless, the rebound effect, in which consumers might respond to the increased fuel efficiency for E10 fuel by driving more or buying less fuel-efficient cars, can offset some of this effect.

The amount of greenhouse gas emissions from ethanol-blended fuel depends on the type of feedstock used to produce the ethanol. Ethanol produced by cellulosic feedstock has low greenhouse gas emissions, while corn ethanol has relatively high greenhouse gas emissions.

The International Energy Agency has compiled data from different studies on the well-to-wheels greenhouse gas emissions from different types of ethanol compared to those from gasoline fuel (per km traveled). For corn ethanol, the greenhouse gas emissions range from a 30% increase to a 47% decrease compared to gasoline fuel, with an average of approximately 25% decrease. For cellulosic ethanol, the greenhouse gas emissions vary from a 51% to 117% decrease, with an average decrease of approximately 70%. According to Macedo (2001), the greenhouse gas reductions from sugarcane ethanol is about 90%. In addition to feedstock, the greenhouse gas emissions also depend on the production process (e.g., dry or wet mill).

Table 1. California's Consumed Ethanol Feedstock Scenarios

	Imports from other countries (mainly sugarcane)	Corn (either domestic or imports from other states)	Cellulosic	Sugarcane
Present	10%	89%	1%	–
High-emission scenario	–	95%	5%	–
Low-emission scenario	20%	40%	25%	15%

Table 2a. GHG Percent Reduction Using E10 Compared with 0% Ethanol

Present	lower bound	–2.07
	upper bound	5.50
	average	3.20
High-emission secenario	lower bound	–2.19
	upper bound	5.40
	average	2.95
Low-emission scenario	lower bound	2.00
	upper bound	9.01
	average	5.90

Table 2b. GHG Percent Reduction Using E10 Compared with Current Blend

Present	lower bound	–0.89
	upper bound	2.37
	average	1.37
High-emission secenario	lower bound	–0.94
	upper bound	2.32
	average	1.27
Low-emission scenario	lower bound	0.86
	upper bound	3.87
	average	2.54

In order to project the effects of an E10 policy on greenhouse gas emissions, one must therefore predict the sources of ethanol feedstock for California. This is a hard job because we do not know the future combination of feedstock that may be used to produce ethanol. In 2004, California's total ethanol production was about 33 million gallons, which was 3.7% of domestic ethanol production. The current ethanol refineries in California are two plants in the Los Angeles area that use waste products and residuals from food and beverage as feedstocks, and new corn-to-ethanol plants mainly in Central Valley with about 65 million gallons capacity.

We used two different scenarios for the future: (1) a high greenhouse gas emissions scenario based on more corn-based ethanol, and (2) a low greenhouse gas emissions scenario based on more imports from sugarcane-based ethanol producers or more production of cellulosic or sugarcane-based ethanol. The scenarios are presented in Table 1. Currently, imports are assumed to be from other countries, not other states. Most of the domestic ethanol from outside is from central or eastern states, which will lead to high transportation costs. If greenhouse gas emissions and future costs are of concern, cellulosic- or sugarcane-based facilities should be constructed, since (1) California has the potential for sugarcane production, (2) sugarcane has lower costs and lower emissions than corn, (3) cellulosic ethanol will be cheaper in the future and has lower emissions than corn, with a range of –0.94% to 3.87%, and (4) transportation cost both for transporting corn or ethanol will be higher than using available cellulosic or sugarcane feedstock.

We apply the greenhouse emission reduction ranges and averages for each feedstock to the feedstock combination scenarios in Table 1 to project upper bounds, lower bounds, and averages for the greenhouse gas emissions reductions in 2020 of an E10 policy compared to gasoline fuel. Table 2a shows the greenhouse gas reductions comparing the E10 policy to a 0% ethanol blend; Table 2b compares the E10 policy to the current ethanol blend in California of E5.7. As shown in the table, the average greenhouse gas emission reduction in 2020 using an E10 policy for the present combination of feedstock will be 3.20% compared to 0% ethanol, and 1.37% compared to the current E5.7 blend. The average greenhouse gas emission reduction in 2020 using an E10 policy for the high-emissions scenario will be 2.95% compared to 0% ethanol, and 1.37% compared to the current E5.7 blend. The average greenhouse gas emission reduction in 2020 using an E10 policy for the low-emission scenario will be 5.90% compared to 0% ethanol, and 2.54% compared to the current E5.7 blend.

If implemented, an E10 policy in California would have impacts on ethanol consumption and greenhouse gas emissions, among other effects. Under an E10 policy in California, the ethanol consumption in 2020 will range from 1.56 billion to 2.40 billion gallons, with a base case value of 1.68 billion gallons. The average greenhouse gas emission reduction in 2020 using an E10 policy for the present combination of feedstock will be 1.37% compared to the current E5.7 blend, with a range of –0.94% to 3.87%.

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