Committee Draft Investment Plan Terrabon Comments 052411.

Gasoline Substitutes

Gasoline substitutes, including ethanol, represent a significant opportunity to use existing technologies to expand lowcarbon alternative fuel use. Gasoline substitutes refer to any liquid fuel that can significantly displace gasoline in internal combustion engines, which includes both ethanol and non-oxygenated gasoline blendstock fuels. This section also refers to renewable dropin gasoline substitutes, which are physically identical to gasoline but are produced through alternative technologies. These drop-in gasoline substitutes and have energy densities (BTUbtu/gal) that are 50% higher than that of ethanol and already have a developed pipeline and distribution infrastructure.

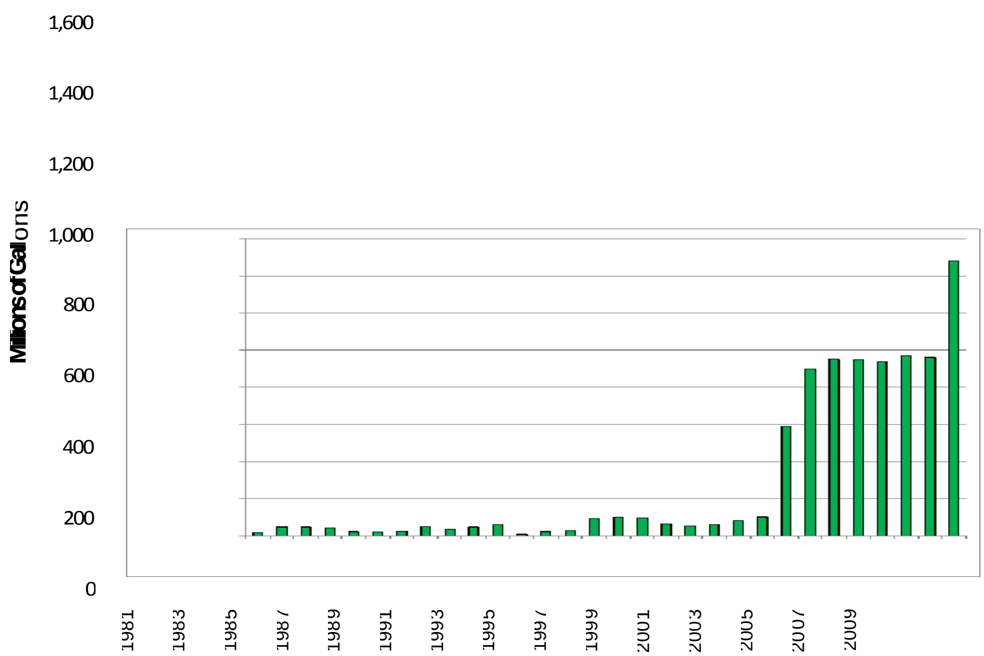
Ethanol is the most prominent alternative fuel produced and consumed in the United States and California. Between 1997 and 2010, nationwide production has increased more than 19.5 percent per year, with about 13.1 billion gallons of ethanol produced in 2010. Similar increases in ethanol production were seen within California throughout the previous dec ade. Between 2004 and 2008, California ethanol production capacity grew at an average annual rate of more than 55 percent to its current capacity of 240 million gallons per year. However, this capacity has been significantly underused in recent years, with just 21 million GGE produced in 2009.[248]

Despite its relatively small production of ethanol, California consumes a significant amount of the fuel each year. In 2003, California ethanol consumption jumped from a little more than 100 million gallons to a little less than 600 million gallons, due to its replacement of methyl tertiary butyl ether as a prominent gasoline additive. Consumption jumped another 44 percent in 2004 and almost 10 percent in 2005, and remained fairly steady until 2010, when the ethanol blend in California reformulated gasoline increased to 10 percent, and total ethanol use grew to nearly 1.5 billion gallons. However, California ethanol facilities contributed less than 4 percent of the state’s needs during 2010. Figure 4 shows California ethanol consumption.

Figure 4: California Ethanol Consumption, 1981-2010

Source: California Energy Commission and Energy Information Administration

248 O'Neill, Garry, John Nuffer. 2011. *2011 Bioenergy Action Plan*. California Energy Commission, Efficiency and Renewables Division. Publication Number: CEC3002011001CTF.



A variety of federal and state policy mandates will necessitate an increase in the consumption of renewable fuels through this decade. Given that California is about 11.5 percent of the U.S. population, California's "fair share" consumption of biofuels under the federal RFS2 is expected to be roughly 3 billion gallons. [249] At the state level, the ARB's LCFS outlines four scenarios for achieving GHG emission reductions from gasoline, each of which prominently includes contributions from ethanol. These scenarios include a broad range, from 2.2 billion gallons to 3.1 billion gallons per year by 2020.[250] The state's *Bioenergy Action Plan* establishes a 2 billion GGE target for biofuel consumption by 2020, in which ethanol is likely to feature prominently. The *Bioenergy Action Plan* also calls for 20 percent of the state's biofuel consumption to be met by in state resources. For ethanol, this will entail approximately 500 million gallons per year in additional production (in addition to the full resumption of production at existing plants).[251]

Currently, California' s ethanol is a mixture of ethanol produced instate, in the Midwest, and from foreign sources. California is uniquely positioned, however, to use vast low carbon feedstocks and to produce both ethanol and renewable drop-in gasoline blend stocks from feedstocks other than corn. For example, California has significant waste streams from the agricultural, municipal, and forest sectors that are available for use as feedstocks for advanced biofuels with low carbon content.[252] Specialty bioenergy crops such as cane, sweet sorghum, and perennial grasses can also be grown on marginal soils to produce very low carbon biofuels (with 75 percent and higher GHG reductions from the petroleum baseline).

However, at this time, these types of renewable fuel technologies have not been demonstrated to be commercially successful. The U.S. EPA issues renewable volume obligations each December to provide guidance on the mandated minimum volumes of renewable fuels by various categories for the upcoming calendar year. Over the last two years, the EPA has significantly reduced the cellulosic renewable fuel requirement due to the lack of production capacity in the United States, most recently reducing the RFS cellulosic requirement for 2011 down from 250 million gallons to 6 million gallons.

To encourage further development of low carbon liquid fuel options, the Energy Commission intends to allocate $7.5 million for the development of new production facilities that can convert sustainably derived cellulosic feedstocks into a low carbon ethanol and renewable drop-in gasoline substitutes. This fundi ng will also be open to projects that produce dropin gasoline substitutes, rather than ethanol.

Additionally, process energy efficiency measures and alternative fuels used for process energy can further reduce the GHG emissions from California gasoline substitutesethanol. At the Energy Commission's

249 Orta, Jason, Zhiqin Zhang, and et. al. 2010. *2009 Progress to Plan – Bioenergy Action Plan for California*. California Energy Commission. CEC5002010007.

250 Air Resources Board, *Proposed Regulation to Implement the Low Carbon Fuel Standard: Volume II, Appendices*, March 5, 2009, http://www.arb.ca.gov/fuels/lcfs/030409lcfsisorvol2.pdf.

251 California Energy Commission, *2009 Progress to Plan – Bioenergy Action Plan for California*, http://www.energy.ca.gov/2010publications/CEC5002010007/CEC5002010007.PDF

252 *An Assessment of Biomass Resources in California, 2007* Draft Report, PIER Collaborative Report, March 2008. Using a California Biomass Collaborative average value of 82 gals of ethanol derivable from each BDT of a mix of biomass wastes and residues yields a technical potential in 2010 of 2.9 billion gallons of ethanol.

2010-2011 Investment Plan Biofuels Workshop, several project developers described strategies to produce very lowcarbon intensity biofuels (with more than 80 percent reductions from the CaRFG baseline) at competitive prices in California. These strategies include:

- Separation of feedstocks into multiple valueadded products including ethanol, renewable diesel, green electricity, and other coproducts.
- Development of specialty bioenergy feedstocks such as energy cane, sweet sorghum, and perennial grasses that can be grown on marginal, nonfood crop soils.
- Capital investments to increase biorefinery production outputs to meet shifting an d new market demands, similar to the production strategy used by petroleum refiners.[253]

However, a lack of capital and debt financing is impeding biofuel plant development and upgrades at existing plants. If capital and debt financing were readily available, California's existing and planned plants could initiate use of California's biomass wastes and other alternative lowcarbon feedstocks. Many instate developers of advanced biofuels projects are positioned to provide technology specifically designed to convert agricultural, forest, and municipal waste streams to transportation fuel. However, the present poor operating economics associated with these potential projects is the primary reason that financing has not been forthcoming.

The profitability of the U.S. ethanol industry has fluctuated with gasoline price and demand as well as corn prices. Consequently, in recent years the industry has had very narrow margins, as the impact of the global economic slowdown and decline in oil demand and prices, as well as upward pressure on corn price, have made survival more difficult. This poor performance has occurred despite a number of policy actions that support the ethanol industry, including:

- The Volumetric Ethanol Excise Tax Credit: a $0.45 per gallon excise tax credit for refiners and blenders. It is set to expire in 2011.
- The Secondary Tariff on Ethanol: a $0.54 per gallon ethanol import tariff intended to support domest ic production. It is set to expire in 2011.
- The Small Ethanol Producer Tax Credit: a $0.10 per gallon tax credit for ethanol production up to 15 million gallons. The credit is available only to small scale ethanol producers with an annual production capacity of no more than 60 million gallons. It is set to expire in 2011.
- The Cellulosic Biofuel Producer Tax Credit: a $1.01 per gallon tax credit for producers of cellulosic biofuel, intended to spur cellulosic production. It is set to expire in 2012.

California Ethanol Producer Incentive Program

253 Testimonies of David Rubenstein of California Ethanol and Power, Brian Pellens of Great Valley Energy, and Bob Walker of Swan Biomass, AB 118 20102011 Investment Plan Workshop, September 1415, 2009, California Energy Commission, Sacramento, California.

The Energy Commission developed the CEPIP to provide operators of existing corn ethanol production plants (minimum 10 million gallons per year) in California with temporary financial assistance during periods of difficult economic operating conditions. Currently, five plants are eligible for this assistance. This funding would be repayable under specifically identified favorable market conditions. The CEPIP is designed to stimulate operational improvements at existing ethanol facilities and the use of advanced process technology to convert cellulose and other low carbon feedstocks. The objectives of the CEPIP are to increase statewide biofuel production, retain and create California jobs, and reduce GHG emissions. CEPIP was provided $6 million in initial funding, with the understanding that funding could be increased by $9 million.

The CEPIP requires participants to comply with biorefinery operational enhancement goals (BOEG) in one of two ways. The first BOEG is based on the participants' reducing the ca rbon intensity value of their produced fuel by at least 10 percent, relative to the default value adopted under the LCFS for their particular process application and type of feedstock. The second BOEG requires the biorefiner to displace at least 20 percent of their existing feedstock with waste-based feedstocks. Participants in the CEPIP must achieve either of these goals according to a set timeline of milestones. The first milestone, not yet reached by any of the participants, requires the biorefiner to submit a draft plant for compliance with either of the BOEGs within six months of participation. In the first quarter of 2011, two of the five eligible CEPIP facilities are producing ethanol. It is expected that two more facilities could start operations in 2011.

The objectives of the CEPIP reflect the Energy Commission's broader objectives for alternative fuels. These include the production of an in-state alternative fuel that is wide ly used to meet state gasoline oxygenate content requirements. California consumed more than 1.4 billio n gallons of ethanol in 2010. However, before CEPIP, more than 95 percent of this volume was imported from outside the state. The reopening of in-state biorefiners also has important job benefits, as each facility has been able to rehire dozens of workers who had been laid-off. In-state biorefiners also ensures a technology and facility base for California to expand into next-generation biofuels. Finally, the continued operation of these plants protects millions of dollars in existing private investment into California alternative fuels production and gives par ticipants an opportunity to leverage additional private investment in their facilities.

During the administration of the CEPIP, market conditions have becoming increasingly unfavorable for ethanol production, particularly within California. This is due in part to near - record commodity costs for corn. Given uncertain market conditions and future price projections, it is unclear whether a modest state price support program can offset the effects of this unprecedented change in the ethanol fuel market. In addition, new technologies using non-food feedstock material for drop-in gasoline production, which utilize the existing fuel transportation distribution system, continue to make progress towards commercial development. As a resu lt, the Energy Commission will reevaluate the future of the CE PIP and study the benefits from its proposed $6 million investments before making a recommendation on funding. New technology to use non-food feed stocks to produce a drop-in gasoline blendstock that can utilize the existing fuel transportation distribution system continues to be developed for commercialization.

As part of this reevaluation, the Energy Commission is planning a forum for summer 2011 that will investigate the connections among alternative fuels, agriculture markets, and food commodities. This forum will incorporate input from ethanol producers, federal and state agriculture agencies, and livestock and poultry farmers, and will provide information for a long-term strategy for supporting in-state biofuel production.

Upstream Fuel Infrastructure

More than 80 percent of the nation's ethanol production is in six Midwestern states and must be shipped to distribution terminals in other regions via truck, barge, or rail, transport modes that are more expensive than pipelines. California produces less than 5 percent of the ethanol it consumes and will continue to rely heavily on imports even if this percentage increases. Ethanol is imported into California by unit train volumes moving from the Midwest to terminals in Southern and Northern California before being redistributed by truck.

In the near term, most of the projected increase in shipments of ethanol to terminals will be handled by tanker truck and rail tank car as opposed to pipelines. Except for a few proprietary pipelines, the common carriers generally do not ship ethanol in their systems. The increased risk of corrosion and potential for water contamination associated with ethanol are key factors limiting its transport via pipeline. Investment funding for distribution improvements is small. An existing infrastructure moves ethanol from production sites to service stations, and that process is not expected to change materially over the next 10-20 years. However, as ethanol demand grows due to RFS2 and LCFS requirements, the scope of the distribution system will need to expand or additional support for gasoline substitutes that can leverage the existing distribution systems will need to be increased, which is one of multiple benefits from a renewable drop-in gasoline. For the United States overall, new sources of ethanol and gasoline blendstocks from cellulosic plants will be producing ethanol gasoline substitutes from sites outside the traditional Midwest, requiring more truck, rail, and barge movements to markets.

Local Fuel Infrastructure

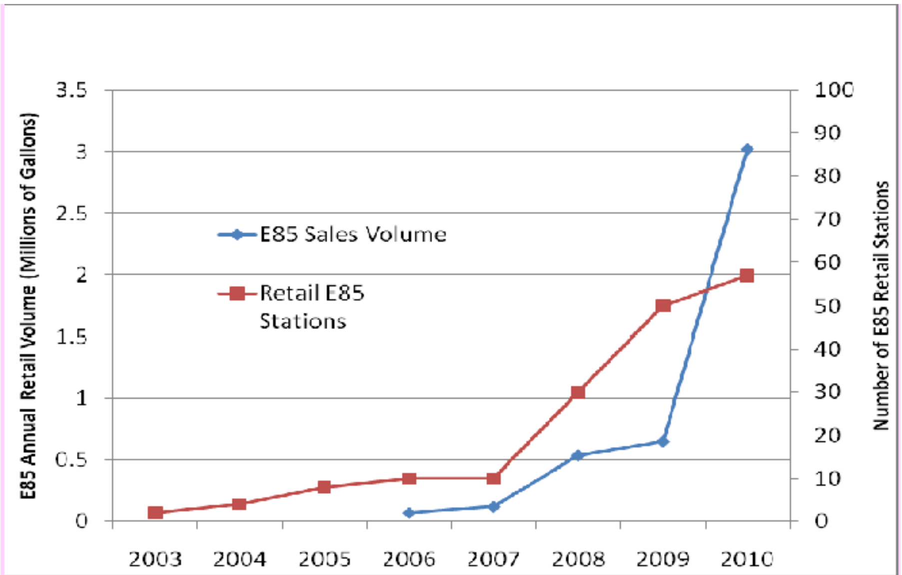
California sales of E8 5 have risen significantly over the past five years, surpassing 3 million gallons in 2010. However, the Energy Commission expects that the retail presence and sales of E85 will need to expand if the state is to meet its fair share of RFS2 compliance. [254] Depending on the average quantity of fuel sold by a typical E85 dispenser, California could require between 4,400 and 30,900 E85 dispensers by 2022. To put that estimated number of new dispensers into perspective, there were about 42,050 retail dispensers in California during summer of 2008 for all fuel types.[255] Figure 5 shows the recent trends of E85 stations and E85 sales volume.

Figure 5: Historical E85 Stations and E85 Sales Volume

254 *Transportation Energy Forecasts and Analyses for the 2009 Integrated*

Energy Policy Report, California Energy Commission, Final Staff Report, Publication Number CEC 6002010002SF, May 2010.

255 Gordon Schremp and Nicholas Janusch, 2009. *Fuel Delivery Temperature Study*, California Energy Commission. CEC6002009002CMF.



Source: Energy Commission, Board of Equalization

As of February 2011, 57 retail stations in California offered E85.[256] To date, the Energy Commission has funded two projects for 85 new E85 fueling stations using $5 million of funds from the program. The project partners will provide $14.1 million, and the DOE will contribute an additional $6.9 million.

A review of NREL's flexible fuel vehicle (FFV) density map indicates that the highest density of FFVs is observed in major population centers including San Francisco, Los Angeles, San Diego, and Sacramento. However, there are only a handful of E85 fueling stations in the Los Angeles basin.

The primary barrier to establishing new E85 dispensers is the upfront cost. E85 retail infrastructure is expensive. Costs for installing a new underground storage tank, dispenser, an d appurtenances range between $50,000 and $200,000.[257] Statewide, the E85 retail infrastructure investment costs could be as low as $192 million to upwards of $4.7 billion between 2009 and 2020. Between 2009 and 2030 the E85 dispenser infrastructure costs could range from $251 million to $6.1 billion. Most conventional service stations are no longer owned by oil companies, and the investment needed to accomplish the conversion to E85 must be borne by the independent dealer. Moreover, most conventional service stations generate profits from

256 U.S. DOE, "E85 Fueling Stations in California," http://www.afdc.energy.gov/afdc/progs/indstate.php/CA/E85.

257 National Association of Convenience Stores (NACS) and the Society of Independent Gasoline Marketers of America (SIGMA), Letter to Congress, March 27, 2006, http://www.sigma.org/pdf/E85-Mandates.pdf. According to the National Commission on Energy Policy's (NCEP) recent report, replacing an entire system can be expected to cost substantially more than $150,000 per facility depending up on the market. *Task Force on Biofuels Infrastructure*, NCEP, May 2009, Appendix B, page 53; available from http://www.energycommission.org/ht/a/GetDocumentAction/i/10232. Additional cost estimates for both new and retrofit scenarios are provided in the following brief paper: *Cost of Adding E85 Fueling Capability to Existing Gasoline Stations: NREL Survey and Literature Search*, National Renewable Energy Laboratory, Publication NREL/FS-540-42390, March 2008, http://www.afdc.energy.gov/afdc/pdfs/42390.pdf.

convenience store sales and service or repair business, while usually breaking even on fuel sales. Investors have the challenge of recovering significant investment cost while marketing an initially lower volume product.

The most significant factors in fuels sales are location and price. Locating E85 stations at high volume stations on busy commuter routes will be an important factor in achieving the required volumes. Another factor in siting E85 stations is the size of many existing service stations, which occupy small parcels that cannot readily accommodate an additional tank. The service station owner may be reluctant to dedicate an existing tank to E85 due to ini tial low penetration and volume sales of E85. Without external funding sources, retail availability of E85 would solely rely on retail site owners voluntarily choosing to invest in E85 dispensing equipment.

Permitting for the development of stations must be done through the local Authority Having Jurisdiction – usually the local fire marshal. According to the State of California Supervising Deputy State Fire Marshal, there are local fire marshals who do not allow the permit ting of the constructi on of E85 distribution stations within their jurisdiction.[258] Other Authorities Having Jursidctio n consider E85 as a fuel equivalent to gasoline and are determining E85 distribution equipment as having natural equivalency.

In June 2010, Underwriters Laboratory UL certified two fuel dispensing systems for E85, including dispenser, hose, nozzle, swivel, breakaway, and shear valves. Because UL pol icy stipulates its listings apply only to those particular units that were manufactured after the date of certification, current retailers who sell E85 may need to purchase all new equipment. In addition, those retailers may need to ensure that their underground equipment is also listed as compatible or replace the entire system, an expensive undertaking.

Given the anticipated demand growth for E85 and the associated retail station infrastructure needs discussed above, the Energy Commission intends to allocate $4 million for the further expansion of E85 fueling infrastructure. This amount of funding could provide 40-60 stations, depending on capital cost. This funding will be guided by results of a survey of automakers, which will provide information on the numbers and locations of FFV deployments.

Vehicles

Engine modifications are needed to accommodate E85, while retaining capability to operate on gasoline or any blend containing up to 85 percent ethanol. Modification costs, however, are sufficiently low that U.S. automakers have produced FFVs since 1993, primarily to take advantage of the credit allow ed toward meeting CAFE standards, as provided by the Alternative Motor Fuels Act of 1988. According to the Office of Energy Efficiency and Renewable Energy, there were about 8.4 million E85 FFVs on the road in the United States in 2009, with more than 400,000 of these in California. Due to the limited availability of E85 and the cost relative to gasoline, most FFVs never use this fuel.

258 ICF interviewed the State of California Supervising Deputy State Fire Marshal to develop a clearer understanding of the safety and permitting issues associated with E85 stations.

All gasoline vehicles can now use E10 blends safely, and EPA has determined that newer (post-2000) vehicles can use E15 safely.[259] As older vehicles are retired, most of the fleet will be E15 - capable by 2015. However, several barriers would need to be overcome if E15 use were to become a reality in California. California has its own reformulated gasoline regulations that are based on vehicle testing of gasoline with ethanol no greater than 10 percent. New testing of vehicles, assuming no deleterious emission impacts, would take time – at least three years to complete. In addition, no vehicle manufacturer allows ethanol concentrations in excess of 10 percent to be used without violating the vehicle warranty. Finally, service station owners have no liability protections against misfueling damage claims for people that use E15 in vehicles older than model year 2001.

In contrast, E85 can be used only in vehicles designated as an FFV. Future emission standard s for California will make certification of FFV models more difficult in California. At the Federa l level, new fuel economy regulations phase out the fuel economy credits available to manufa cturers for producing FFV models by 2020.[260]

FFVs account for 1.5 percent of California light duty vehicles, or more than 400,000 vehicles.[261] All E85 use is in the light duty vehicle category. By 2020, projections based on DMV vehicle registration data indicate upwards of 800,000 FFVs for both light- and medium- duty applications.[262]

To make a gasoline vehicle ethanol-capable, manufacturers install a computerized optical sensor or other technology that detects how much ethanol is in the fuel mixture. Because ethanol is more corrosive than gasoline and has less energy content, manufacturers need to use modified materials and larger sizes for the gas line, gas tank, pumps, and injectors.

E85 has about 30 percent less energy per gallon so the fuel efficiency of a FFV running on E 85 will be about 30 percent lower on a volumetric basis. As a result the vehicle range will be proportionally reduced since OEMs do not typically specify larger fuel tank s for FFVs. This means that E85 prices should be reduced a comparable percentage to be fairly priced at GGE prices.

In 2006, Ford, DaimlerChrysler, and GM indicated they would produce 2 million FFVs by 2010. In May 2010, Ford announced it would fulfill its projection by the end of the year. F ord has also announced that FFV certified engines would be available on 50 percent of nameplates by model year 2013, including new small engines such as in the Focus. GM made a commitment that m ore

259 U.S. EPA, "EPA Announces E15 Partial Waiver Decision," http://www.epa.gov/otaq/regs/fuels/additive/e15/420f11003.pdf.

260 ICF International, "Technical Analysis for the Alternative & Renewable Fuel & Vehicle Technology Program - Task 2 –Evaluate Alternative and Renewable Fuel Infrastructure and Distribution

261 DMV data.

262 Energy Commission staff estimate, based on DMV data.

Development for E85," draft unpublished report, November 22, 2010.

than 50 percent of its production by model year 2013 will be FFVs. DaimlerChrysler made this same pledge.[263]

The high octane rating of E85 is a significant driver for research into vehicle technologies that improve engine technologies that capitalize on this physical property of the fuel. Most researchers focus on increased compression ratio engines operating with natural, or more frequently, boosted a spiration. For example, Ricardo Motors has demonstrated an ethanol boosted direct injectio n engine with extreme downsizing and estimated that a fuel economy improvement of up to 30 percent is possible on equal performance basis.[264]

Ford is supporting the development of a similar technological approach using ethanol boosting systems.[265] The proposed technology uses conventional gasoline fuel in higher compression ratio engines as long as a small quantity of E85 is available on board for high load conditions when engine knock is most likely to occur. Their research determined that a small, turbocharged, high compression ratio spark ignition engine can provide the same peak power as a naturally aspirated gasoline spark ignition engine but will be 20 to 30 percent more fuel efficient. As a reference, that level of fuel economy increase is provided by some of today's hybrid vehicles but at a substantial cost disadvantage.

[g1]**Table 21: Ethanol Funding Allocation**

Advanced Cellulosic Ethanol Production Plants	$7.5 Million
E85 Fueling Stations	$4 Million
Total	$11.5 Million

Source: California Energy Commission

263 ICF International, "Technical Analysis for the Alternative & Renewable Fuel & Vehicle Technology Program Task 2 –Evaluate Alternative and Renewable Fuel Infrastructure and Distribution Development for E85," draft unpublished report, November 22, 2010.
264 Ricardo Motors, "The Impact of Federal Requirements on Future Vehicle Technologies", Presentation at AVT Conference, October 30, 2009.
265 Ethanol Boosting Systems, LLC, "Ethanol Turbo Boost for Gasoline Engines," http://www.ethanolboost.com/EBSOverview.pdf.
266 Thermal depolymerization is a process in which pressure and heat reduce complex organic materials into short chain hydrocarbons (such as light crude oil).