NAVIGANT CONSULTING

# Renewable Energy Blueprint
# Chapter 4: Biofuels and Hybrid, Electric, and Alternative Fuel Vehicles

## FINAL REPORT

### Presented to the Community Environmental Council

**NOVEMBER 7, 2006**

Presented by:
Navigant Consulting, Inc.
One Market St, Spear St. Tower 1200
San Francisco, CA 94105

415-356-7100
www.navigantconsulting.com

Contributors:
Richard Germain
Ryan Katofsky
Michele Rubino

NAVIGANT CONSULTING

## Table of Contents


Assessment of Technologies and Resources ..... 2

Overview ..... 2
Biofuels ..... 3
What are biofuels and how are they produced? ..... 3
Use of biofuels in engine technologies and in the petroleum infrastructure ..... 8
Current status of consumption and production of biofuels in SBC ..... 10
Potential for consumption and production of biofuels in SBC ..... 11
Hybrids and Plug-in Hybrids ..... 12
Electric Vehicles ..... 13
Alternative Fueled Vehicles ..... 14
Hydrogen Vehicles ..... 14
Natural Gas Vehicles ..... 15

Action Plan 17

Key Principles for Promoting Biofuels and Alternative Fuel Vehicles (AFVs) ..... 17
Proposed Actions for Local Governments ..... 18
Leverage State and Federal Policies and Incentives ..... 18
Demonstration Projects ..... 19
Address Financial Barriers ..... 20
Siting and Permitting ..... 20
Leading by Example ..... 21
Education/Outreach (including recognition programs) ..... 21
Advocacy ..... 22
Feedstock supply ..... 22
Proposed Actions for Businesses ..... 23
Proposed Actions for Individuals ..... 23
Case Studies ..... 24
San Francisco, CA ..... 24
Seattle, WA ..... 24
City of Austin, TX / Austin Energy ..... 25

Appendix – Biofuels Incentives & Programs ..... 26

## Assessment of Technologies and Resources

### Overview

Transportation fuels are a significant component of Santa Barbara County's (SBC)[1] energy requirements. A key objective of the Community Environmental Council's (CEC) "Fossil Free by '33" initiative is to shift the county's transportation fuel mix away from petroleum. As such it is important to understand what technologies and resources are available to reach this objective. Furthermore, it is necessary to assess the availability of substitute resources as well as the stage of development and cost competitiveness of these technologies. It is also important to realize that alternative fuels may be derived from non-petroleum fossil fuels, and that the production of biofuels currently entails the use of varying amount of fossil fuels, depending on the fuel, the feedstock and the conversion technology.

Table 1 summarizes SBC's current and projected energy use. This chapter focuses on the transportation fuel (gasoline and diesel) component of the energy use total.

Table 1. *Energy use, current and projected, in Santa Barbara County (in millions of kilowatt hours).*[2]

| | Electricity | Natural Gas | Gasoline and Diesel | Total |
|---|---|---|---|---|
| **2004** | 3,037 | 6,475 | 7,662 | 17,174 |
| **2010** | 3,253 | 6,692 | 8,715 | 18,660 |
| **2020** | 3,444 | 6,878 | 9,717 | 20,039 |

Broadly speaking there are two distinct paths to curbing SBC's (and the nation's) "addiction to oil," both worth pursuing:

1. The use of transportation fuels derived from energy sources other than crude oil. These include:

    - Fuels derived from renewable sources, including:

        - Biofuels, i.e., fuels derived from organic feedstocks, such as ethanol, biodiesel, biogas and bio-methanol. Fuels obtained through biomass gasification, such as Fischer-Tropsch (FT) liquids[3] and hydrogen, also fall in this category, although these technologies are less developed for use with biomass feedstocks.

[1] SBC will be used to designate the county geographic area and its residents. "County government" will be used to indicate the Santa Barbara County government.

[2] Sources: Community Environmental Council. (Note: kWh is not commonly used as a measure of fuel consumption but the data are shown here in kWh to enable comparisons with data provided in other chapters of this report. 1 kWh contains 3,412 Btu of energy. Gasoline has an energy content of about 125,000 Btu/gallon and diesel 140,000 Btu/gallon. Thus, 1 gallon of gasoline is roughly equal to 37 kWh and 1 gallon of diesel fuel 41 kWh.

[3] The FT process has been in use for many decades. FT synthesis produces a mixture of a wide range of hydrocarbons that can then be refined like crude oil. Refined FT liquids can be substituted directly for diesel and gasoline. They have the advantage of having no sulfur or aromatic compounds.

  - Electricity generated from renewable sources (wind, hydro-electric, biomass, etc.) can be used as a source of transportation energy, directly in electric vehicles and plug-in hybrids or, using hydrogen as an energy carrier, to power fuel cell vehicles.

- Other, non-renewable, fuels. Compressed natural gas (CNG) is a commonly used alternative transportation fuel in many parts of the world. Gas-to-liquid (GTL) and coal-to-liquid (CTL) technologies also fall in this category. However, such a shift would be in the direction of non-renewable, mostly fossil, sources of energy, thus contravening the CEC's objective of weaning the region off fossil fuels.

2. Improvements in the *efficiency* of the use of all energy resources. This includes not only "hard" technologies such as hybrid powered vehicles but also more energy conscious behaviors, such as purchasing vehicles that have greater fuel economy, changing driving patterns, and making greater use of mass transit.[4] The European Union recently announced an action plan for reducing total energy use (including petroleum) 20% by 2020.[5]

While the ultimate goal of CEC's "fossil free" initiative requires a commitment to renewable sources of energy, a broader approach that embraces the benefits of all these technologies may be pursued in the short-term to advance the rebalancing goal and to position the county for future technology developments. It is important for SBC to recognize the challenge posed by the existence of a well developed and hard to displace infrastructure to serve its transportation needs – one that has been built over 100 years around the physical and chemical properties of crude oil.

The focus of this assessment is on those resources and technologies that can be readily promoted within SBC today or in the not too distant future. Specifically, the focus is on biomass-based fuels (biofuels) and more efficient vehicle technologies such as hybrid cars, electric cars and plug-in hybrid cars. Biofuels are seen as one of the few alternatives to fossil fuels that can, today, significantly contribute to reducing petroleum use in transportation in SBC. In this chapter we also examine hybrid cars and electric cars because they are available today and the growth curves for hybrid car sales in particular are very encouraging, and plug-in hybrids because this is a technology that has received much attention lately and may be commercially viable within the next decade.

## Biofuels

### What are biofuels and how are they produced?

Biofuels represent one of just a few practical near-term renewable energy options to achieve significant petroleum reduction as well as achieving environmental and climate protection goals.

Ethanol and biodiesel, mostly derived from valuable agricultural crops such as corn and soybeans, are today's commercially viable biofuels. They are readily available in California through fairly well developed supply chains, on a wholesale basis. As discussed below, they are not as readily available on a retail basis. At current crude oil prices, they are generally cost competitive vis-à-vis their petroleum

[4] This chapter focuses on technology options and not on other options such as greater use of mass transit. Other CEC documents will look at a broader range of options for conserving energy in the transportation sector.
[5] Available at http://ec.europa.eu/energy/action_plan_energy_efficiency/index_en.htm (last visited Oct. 20, 2006).

alternatives.[6]

**Ethanol** is a clean-burning, high-octane alternative to gasoline. Ethanol has 30% lower volumetric energy content (in Btu/gallon) than gasoline. It is mainly used in blends up to 10% in regular gasoline as an oxygenate additive for environmental compliance purposes. Over 95% of the four billion gallons of fuel-grade ethanol sold in the United States in 2005 (nearly 25% of which was sold in the State of California alone) was produced from corn, through the conversion of the starch to sugar and subsequent fermentation to alcohol. The use of blends up to 10% (E10) in gasoline does not require engine modifications. Thirty percent of all gasoline sold in the United States contains ethanol.[7]

E85, a fuel containing 85% ethanol and 15% gasoline has recently been aggressively promoted by some automotive companies. It can be used only in modified "flex fuel" vehicles (FFV), which are increasingly available in the market, but still a small fraction of the fleet (<5% nationally[8]). More problematic is the availability of E85 at retail fuel stations in the State of California: there is only one public E85 fueling station as of August, 2006, in California. As such, most of the approximately 300,000 FFVs in California are simply running on regular gasoline. As part of the CEC's energy program, it has secured funding to offset the cost to four station owners in the Central Coast for installing E85 stations. CEC anticipates completion of the new stations within a year or so.

**Biodiesel,** derived from vegetable oil and animal fats, is a high-cetane, sulfur-free alternative to petroleum diesel and heating oil. It has a volumetric energy content (Btu/gallon) about 10% lower than petroleum diesel (however, because biodiesel improves engine efficiency, experience suggests that fuel economy of biodiesel tends to be only 2-3% lower than petroleum diesel[9]). Biodiesel can be used with little or no modifications in most compression ignition engines and open flame burners, though warranty issues may arise with certain vehicle manufacturers with higher percentage blends of biodiesel. Due to supply limitations and unfavorable cold flow properties, it is generally used in blends with petroleum diesel, ranging from 2% to 20% (B2-B20). The fuel is more prevalent in Europe, where diesel automobiles are more common, but the United States is catching up fast. While consumption in 2006 will only total about 200 million gallons (a mere 0.3% of diesel consumption), the potential market is vast as 95% of America's freight is moved by diesel trucks. Moreover, production capacity as of September, 2006, was 580 million gallons per year, so there is significant excess capacity available for increased production.[10]

Biodiesel feedstocks are primarily food-grade vegetable oils, such as rapeseed (canola) and soybean oil; this explains the current high cost of the fuel. Future production from non-food crops, such as jatropha, promises higher land yields (gallons/acre) and lower costs, along with higher energy yields and reduced environmental impacts. There is growing criticism about the impact of biofuel production on food crops

---

[6] Biofuels prices (especially for ethanol) have actually risen dramatically in 2006 due to high demand, such that they are actually more expensive on an energy basis than conventional fuels. However, at today's crude oil prices (~ $60/barrel), ethanol is cost competitive to produce.

[7] *ETHANOL AND GASOLINE PRICES*, John M. Urbanchuk, Director, LECG, May 26, 2004., available at http://www.ethanolrfa.org/objects/documents/117/ethanolandgasprices.pdf

[8] Transportation Energy Data Book: Edition 25-2006 by US DOE and http://www.e85fuel.com/forsuppliers/e85distribution.php

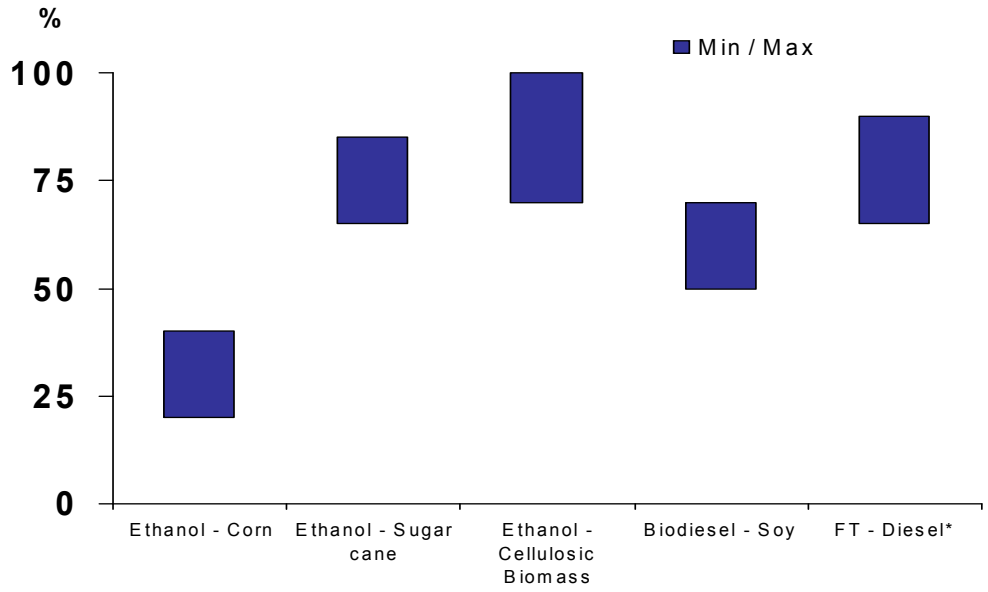
[9] http://www.nrel.gov/docs/legosti/fy98/24089.pdf#search=%22biodiesel%20and%20petroleum%20diesel%20life%20cycle%22

[10] The National Biodiesel Board, http://www.biodiesel.org/pdf_files/fuelfactsheets/Production_Capacity.pdf.

such as corn and soy beans and also about the impact of additional fuel crop production on available agricultural land. Some of this criticism has merit. However, it is very likely that the current feedstocks for biofuels are simply a step on the ladder towards more ideal feedstocks, discussed below, such as switchgrass or jatropha, which will have much less impact on food crops and prime agricultural land.

Both ethanol and biodiesel currently receive a range of federal and state support that creates powerful incentives to their production and consumption (see Appendix A). In addition to being a renewable source of energy, biofuels achieve environmental goals such as reductions in most regulated emissions and a net reduction in greenhouse gas emissions (GHGs), as illustrated by Figure 1.

Fig. 1. *Approximate well-to-wheels reductions in $CO_2$ emissions per mile vs. gasoline/diesel*[11].




*Refers to synthetic diesel obtained from thermo-chemical conversion of biomass

This chart highlights the range of reductions in $CO_2$ emissions achieved by displacing the use of crude oil-derived fuels in transportation with renewable biofuels. It is important to note that this reduction correlates well with the reduction in transportation's fossil energy use. For example, corn ethanol achieves a "modest" 30% reduction in lifecycle $CO_2$ emissions compared to gasoline which points to a similarly modest reduction in the fossil energy intensity of this fuel. This reduction is not higher due to the fact that, in most instances, the conversion of corn to ethanol currently requires significant quantities of natural gas (a fossil fuel). In effect, the use of corn ethanol rather than gasoline partially shifts the mix of transportation energy sources from crude oil to natural gas, with current industrial practices. However, it is important to highlight that, if the goal is to reduce transportation's petroleum use, then corn ethanol is an effective, although not ideal, solution. And with the goals of the Fossil Free by '33 program to not only increase the energy independence of SBC, but also to reduce SBC's climate emissions, a 30% reduction even from corn ethanol would be a significant benefit. As ethanol feedstocks

[11] Sources: Argonne National Lab http://www.transportation.anl.gov/pdfs/TA/347.pdf Pages 16-21, http://www.biodiesel.org/resources/reportsdatabase/reports/gen/20040321_gen-332.pdf http://www.lbst.de/publications/studies__d/2002/WHEC15_GM-WtW_Reinhold-Wurster_28JUN2004.pdf Page 14

change to more ideal forms, such as switchgrass and other cellulosic feedstocks, these benefits will likely be enhanced.

While production capacity for both ethanol and biodiesel is expanding at a rapid pace, there are limitations in the scalability of the existing supply chains. Approximately 15% of the US corn harvest is already used to produce ethanol. Market forces and public policy constraints will eventually limit the growth in supply of corn ethanol. Second generation biofuels, such as cellulosic ethanol and Fischer-Tropsch diesel, derived from a wide range of biomass resources (wood chips and municipal waste, just to name a couple) are on the horizon and the subject of increasingly intense development efforts and government support. If successfully commercialized, these technologies will greatly expand the resource base for biofuels.

The following chart illustrates the different biomass to biofuels pathways, identifying both feedstock and conversion technologies. Currently, the two pathways that are commercially in use are the biological conversion of sugars & starches to ethanol and the physio-chemical conversion of bio-oils to biodiesel via transesterification. The two pathways that are the subject of most current RD&D & commercialization efforts are the biological conversion of lignocellulosic biomass to ethanol and the thermochemical conversion of lignocellulosic biomass to a variety of fuels, using the gasification route.

Fig. 2. *Biomass to biofuels pathways.*

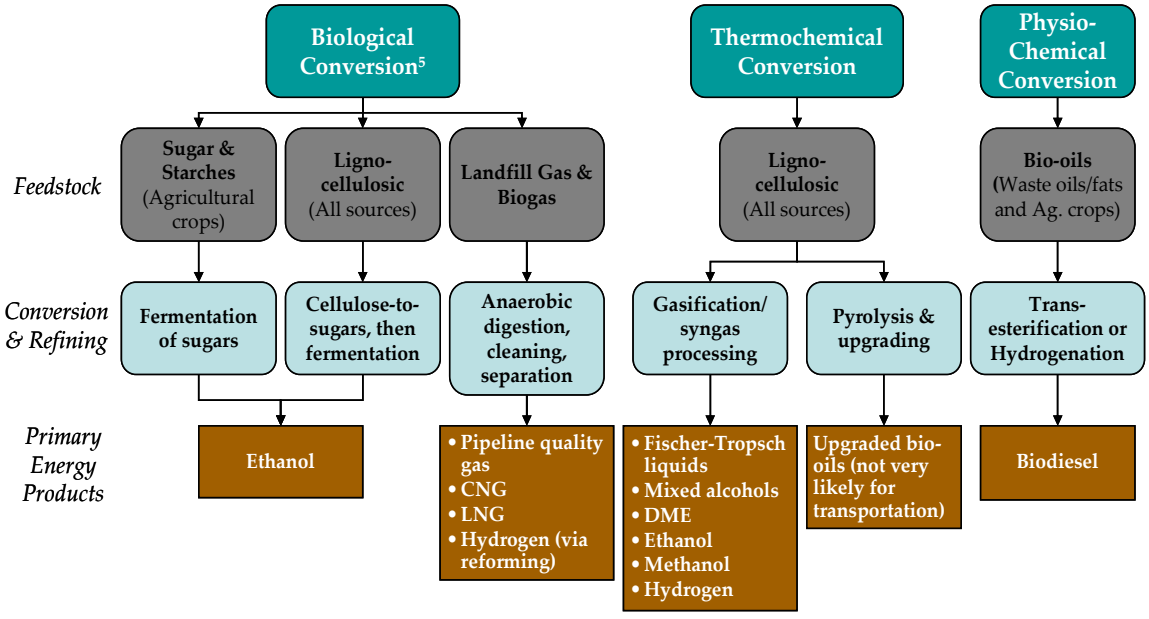


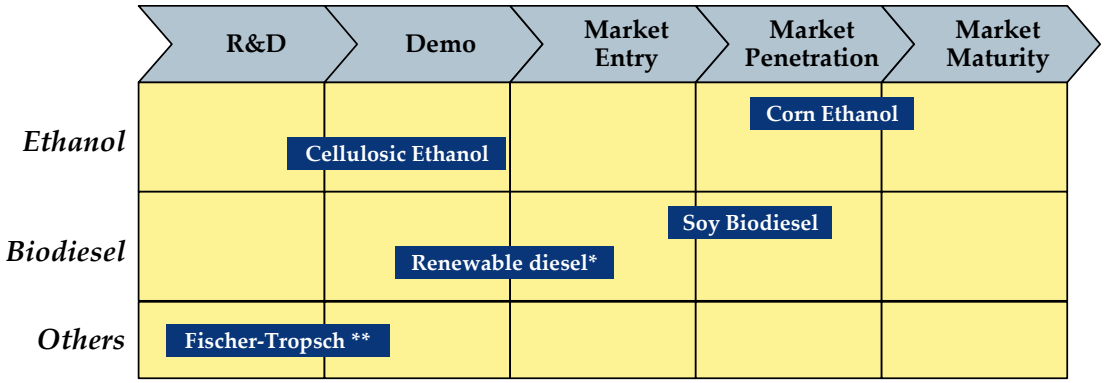

Figure 3 below further describes the stage of development and commercialization of the most promising biomass to liquid fuels paths discussed above:

- First generation biofuels (i.e., those derived from agricultural crops, such as corn ethanol and soybean oil biodiesel) are viable technologies that have found extensive commercial applications.

- Of the second generation technologies:

- The biological conversion of lignocellulosic biomass resources such as agricultural residues and non-corn energy crops to ethanol is the most promising. In addition, given the abundance of such biomass, the potential for fossil fuel displacement is significant. Due to the high oil price environment prevailing in 2006, a number of promising technologies, previously shelved within the research centers of universities, federal agencies and private companies, have received the necessary funding to be proven out and commercialized. Most notably, Iogen Corporation, a Canadian company that has developed a one million gallon per year (MGPY) pilot plant to convert wheat straw to ethanol using genetically altered yeast developed at Purdue University for the fermentation process, has been funded by large corporations such as Shell, PetroCanada and Goldman Sachs to develop a 40 MGPY facility.
- The thermochemical conversion of biomass to a range of fuels through gasification is another second generation technology being actively pursued: Choren Industries, a German company funded by DaimlerChrysler and Shell, has a biomass (wood and wheat straws) to liquid demonstration plant in operation and is in the planning stages of a commercial scale operation. The plant will produce a range of fuels, from diesel to methanol.
- Another promising second generation biofuels technology is the conversion of fatty acids contained in vegetable oils (virgin or recycled) and animal fats into a renewable diesel fuel through high-temperature and high-pressure hydrogenation. Neste Oil, a major Finnish oil company, is already building two such conversion units in Europe, and Petrobras is contemplating similar ones in Brazil.

Fig. 3. *Commercial development stage of key transportation fuel technologies*.




* Refers to the conversion of fatty acids in vegetable oils or animal fats into paraffins
** Refers to synthetic diesel obtained from thermo-chemical conversion of biomass

The following graph illustrates the rough economics of biofuels vis-à-vis petroleum fuels, i.e., at what crude oil price ($/barrel) do different biofuels break even (in terms of costs) with their petroleum alternatives (without subsidies).

Fig. 4. *Economics of biofuels in comparison to petroleum fuels.*[12]

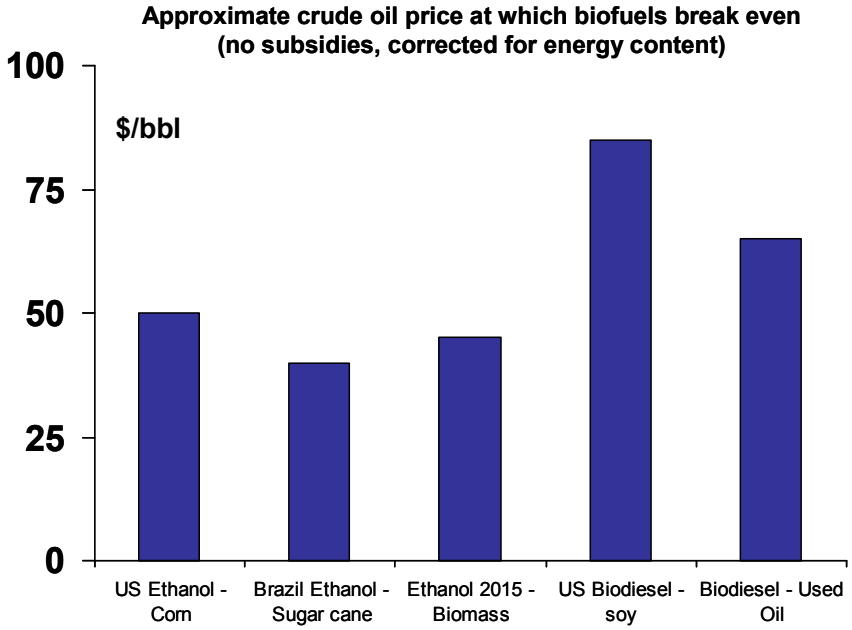



Figure 4 shows how US corn ethanol production costs are cheaper (purely on a cost basis) than gasoline when crude oil is above about $50/barrel, even if no subsidies are considered and the unit costs are corrected for energy content. (In this chart, ethanol from biomass is the same as cellulosic ethanol, a term more widely used.)

The presence of the federal subsidy will keep production costs for corn ethanol cheaper than gasoline even if crude oil were to drop to $40/barrel, well below its current trading values. If we look at market prices over the past six months, very strong demand – largely for regulatory compliance purposes – has pushed the price of ethanol significantly above the already high price of gasoline; as a consequence, the ethanol industry is in a period of unprecedented profitability. As ethanol and other biofuels become more widespread, we can expect to see prices fall again, as long as production keeps pace with demand.

**Use of biofuels in engine technologies and in the petroleum infrastructure**

One of the most recognized upsides of biofuels compared to other alternative transportation technologies is that they are compatible with existing engine technologies and with the existing petroleum distribution infrastructure. However, some distinctions need to be made:

- Ethanol is considered compatible with spark ignited engines if blended with gasoline in concentration below 10% in volume. Car manufacturers do not yet extend warranties to higher concentrations due to compatibility issues with fuel system components.

[12] Source: Navigant Consulting estimates based on 2006 production costs for different biofuels, including delivery from the plant gate to the wholesale terminal. Biofuel costs are then corrected for energy content and compared to their fossil fuel counterpart.

- Flexible fuel vehicles (FFV) are powered with engines that have been upgraded for the use of ethanol (up to E85, an 85% blend of ethanol). The upgrades entail fuel system parts that are compatible with the higher corrosion potential of alcohol fuels. Also, fuel injectors, computer system, anti-siphon device and dashboard gauges have been modified and a fuel sensor has been added to detect the ethanol / gasoline ratio and manage the higher oxygen content of ethanol. The increased cost of FFVs compared to regular gasoline vehicles is minimal (estimates vary between $100-300) and recent models are being sold at the same price to the consumer as their gasoline equivalent. It is important to point out that FFVs are not optimized for ethanol and, as a consequence, will not prevent the reduction of fuel economy (in miles per gallon or MPG) consequent to the 30% lower energy content of ethanol compared to gasoline (BTU/gallon). If engines are optimized for ethanol, the decreased MPG fuel economy would not occur as the higher octane rating of ethanol allows for higher design compression ratios which would, at least partially, offset the reduction in fuel economy.[13] In order for engine manufacturers to optimize the engine design for ethanol use, a much higher displacement of gasoline in favor of ethanol would need to take place.

- Currently, six million FFVs are on the road in the United States[14], but the automotive industry has geared up to offer many more FFV models in an effort to gain "green recognition". As noted earlier, most of these vehicles run on regular gasoline (or low ethanol blends) as the availability of E85 at retail stations is extremely limited (there are approximately 1,000 stations nation-wide that offer E85 most of which are concentrated in the Midwest; only four are present in California and only one is public, as mentioned above). This scarcity of stations is due to several factors, which include: the lack of a regulatory framework that facilitates the creation of a long-term market for ethanol; the limited availability of E85, caused by a run up in demand for the fuel as a low blend oxygenate for compliance purposes (in California, the Northeast and Texas); and the infrastructure costs to set-up a separate E85 retail sale point (estimated at about $50,000 per retail outlet). Some federal and state incentives are available to partially reduce this infrastructure cost. In addition, the consumption of E85 receives further support (in addition to the IRS volumetric excise tax credit) at a state level in some Midwest states (see Appendix). The number of ethanol stations is, however, growing, according to the National Ethanol Vehicle Coalition, from just 100 stations in 2003, to 600 at the beginning of 2006 and now more than 1,000 in October of 2006.

- Additional concerns exist relative to the compatibility of ethanol with the petroleum distribution infrastructure. Because it is more corrosive and water soluble than gasoline, ethanol cannot be transported in existing petroleum product pipelines, the preferred option to move refined petroleum products in the U.S. As a consequence, it cannot be blended with gasoline in the "upstream" refineries but needs to be blended directly at the "downstream" terminals. These wholesale terminals require modest upgrades to be ethanol compatible. In addition, ethanol needs to be moved from the production sites to such terminals with dedicated trucks, railcars and, if possible, barges; this is expensive and inefficient by the standards of the high-volume petroleum supply chain.

- Biodiesel is considered 100% compatible with modern diesel engines. Some concerns exist with older models (1992 and earlier) when natural rubber seals were still used in engine parts (biodiesel is a

[13] http://hybridcars.com/blogs/blog.php?thread_id=22&post_number=712 and Greet Model: http://www.transportation.anl.gov/software/GREET/index.html

[14] Transportation Energy Data Book: Edition 25-2006 by US DOE and http://www.e85fuel.com/forsuppliers/e85distribution.php

strong solvent and will rapidly degrade natural rubber). The fuel will also blend seamlessly at any concentration with petroleum diesel; in addition, biodiesel is a good lubricant even at very low blends (2% biodiesel and less), a property that petroleum diesel itself lacks, especially if sulfur is removed. As the EPA required a nation-wide switch to Ultra Low Sulfur Diesel (ULSD) in 2006, petroleum refiners and wholesalers are looking at biodiesel as a lubricity additive. In general, both the automotive and the petroleum industry seem to prefer biodiesel over ethanol. However, some challenges do exist:

- Pure biodiesel (B100) made from most sources has poor cold flow properties (soybean biodiesel, the most prevalent in the US, will solidify below 25°F). As a consequence, the way it can be distributed in its pure form, in cold climates, is limited and expensive (heated railcars and trucks are generally used). In the case of SBC with its mild climate, if all biodiesel were produced and consumed locally, this issue could be minimized. If biodiesel is blended with petroleum, these issues disappear; this would suggest that, as is done in Europe, biodiesel should be blended in high volumes and low blends directly at the refineries. However, this option is being resisted by the operators of the pipelines that move clean petroleum products throughout the country because of the fear that biodiesel could contaminate other fuels, such as jet fuels, that are very sensitive to cold flow degradation (the problem being that pipelines are fungible and different fuels are transported at different times). As a consequence, for the time being, biodiesel is being splash blended with conventional diesel "below the rack", i.e. at the wholesale terminals These issues (similar to the ethanol distribution challenges) constrain the ability of biofuels to fully utilize the efficient supply chains of petroleum fuels (and ultimately penalize biofuels with inefficiencies and extra costs).
- Engine manufacturers have also limited warranties to the use of low blends (B20 is the maximum allowed). In addition to the abovementioned cold flow issues and some concerns relative to the stability of biodiesel to time induced oxidative degradation, warranty issues are mainly explained by the lack of trust in the ability of biodiesel manufacturers (mainly in the U.S.) to produce to the specifications required by engine manufacturers. These issues will be resolved over time as the biodiesel industry matures and the fuel comes into the mainstream.
- Other than the well documented benefits on regulated emissions of burning biodiesel vs. diesel in internal combustion engines, biodiesel exudes other environmental benefits: in addition to being bio-degradable, extensive testing showed that biodiesel (SME) exhaust emissions cause no pronounced toxicity at any concentration. As a consequence, in 2000 biodiesel passed Tier I and Tier II testing by the EPA, the only alternative fuel to do so to date.[15] Finally, while engine emissions of diesel fuels have been classified as carcinogenic, biodiesel exhaust emissions are not; this has been scientifically explained by the much lower concentrations of sulfur and PAH found in biodiesel compared to regular diesel.

**Current status of consumption and production of biofuels in SBC**

Aside from the ethanol consumed in gasoline in SBC, the use of biofuels is limited. It is estimated that less than 5,000 gallons per month of biodiesel is used (<60,000 gallons/year). This compares to about 200 million gallons per year (MGPY) of gasoline and diesel consumption. Assuming all gasoline used in SBC is the required type of reformulated gasoline, ethanol consumption is about 9.5 MGPY.[16]

[15] http://biodiesel.org/pdf_files/fuelfactsheets/HealthEffectsTesting.PDF.

[16] CARFG3 is the current reformulated gasoline standard. It contains 5.7% ethanol by volume. SBC consumed an estimated 166 million gallons of gasoline in 2005.

There are two public biodiesel refueling stations and one military ethanol refueling station. No biofuels production facility is currently reported in SBC, though there are early plans to construct at least one plant locally and much interest among station owners to develop E85 and biodiesel fueling facilities with grant assistance.

**Potential for consumption and production of biofuels in SBC**

In the near term, if California moves to an E10 standard, ethanol consumption in SBC would rise to approximately 17 MGPY, an increase of 7.5 MGPY. As more FFVs are introduced in the marketplace and the supply of ethanol, possibly produced from in-state biomass resources, catches up with demand, a 20% E85 penetration could be targeted over the next few years. Based on the 166 MGPY of gasoline consumed in 2005, this would equate to a total consumption of ethanol (including that in the lower blends) of approximately 42 MGPY.[17] After correcting for the lower energy content in ethanol, this would result in displacing approximately 18% of total in-county gasoline consumption. Such a target may require local incentives for the development of the E85 retail infrastructure.

Based on 27 million gallons of annual diesel consumption, a 20% biodiesel consumption target would require 5.4 million gallons per year of biodiesel in SBC. This target will require incentives for the development of the wholesale and retail infrastructure necessary to support the distribution of the fuel and possibly some form of incentive or mandate for the in-county heavy duty diesel fleet to switch over to the B20 blend. A very encouraging development in mid-2006 was the wholesale switch to B20 in the City of Santa Barbara diesel fleet. The County of Santa Barbara and the Santa Barbara School District are reportedly also considering such a switch.

The California Energy Commission report "An Assessment of Biomass Resources in California" indicates an availability of biomass resources in SBC of 225,000 bone dry tons per year. If half of this biomass were converted to ethanol at today's yields for biological conversion, approximately 10 MGPY of ethanol could be produced in the county – enough for about one fourth of the 20% E85 penetration level discussed above.

A fascinating, even though longer-term, opportunity to locate biomass plantations and conversion to liquid transportation fuels in SBC is given by the potential to harvest aquatic biomass, such as algae. Algae are produced as slurries in lakes and ponds (natural or artificial); the nutrient for algae production can be supplied by municipal bio-solids or other wastewaters. Some species of algae are ideally suited for biodiesel production due to their high lipid content (well over 50%), and these tryglicerides are easily accessible without cell destruction (eliminating the need for expensive crushing and extraction of the oil) and exude extremely fast growth rates. To this last point, NREL's research project called "Aquatic Species Program" projected potential yields of 12,500 gallons/ha-year of biodiesel (which corresponds to roughly 5,000 gallons/ac-year of biodiesel); if such projections were realized (and no one has even come close to achieving them), then the 30 MGPY of diesel fuel consumed in SBC could be produced by dedicating a mere 6,000 acres to algae plantations. In addition, a high quality fertilizer could be extracted from the algae as a by-product, providing an attractive solution for recycling soil nutrients. In terms of noteworthy developments are the commercial harvesting of giant brown kelp off the California coast

[17] If 80% of gasoline use was E10 and 20% were E85, this represents a total volumetric displacement of gasoline of 25%. Since ethanol contains 1/3 less energy per gallon, this represents an 18% replacement of gasoline with ethanol. This simplified calculation assumes the volume of fuel sold does not change. In reality, the volume would need to increase slightly since more gallons of E85 are required to travel the same distance on an equal volume of gasoline.

(not for fuels production) and recent efforts to use the $CO_2$ from power plant smokestacks as nutrient for algae growth. Although undeniably interesting and appealing for SBC, all these developments should be considered long-term opportunities.

With the current state of biofuels production, the large majority of feedstocks will be produced outside SBC. However, CEC is working with local companies and farmers to identify feasible energy crops in the region, such as jatropha and possibly switchgrass. CEC hopes to incentivize farmers to grow significant feedstock crops in SBC for use in local biofuel production.

## Hybrids and Plug-in Hybrids

*Hybrid Electric Vehicles (HEVs)*
Any vehicle is a hybrid when it combines two or more sources of power. Today's HEVs run off a rechargeable battery and gasoline. Depending upon the driving circumstance and the hybrid configuration, the vehicle will be powered by the internal combustion engine, by the electric motor, or both simultaneously. Power generated by the engine and, often, the braking energy are used to charge the battery. Hybrid cars top the list of the least polluting and most fuel efficient vehicles on the road today and are increasingly available in the marketplace.

In contrast to the fairly flat sales of conventional automotive sales, hybrids are experiencing very rapid growth in the U.S. From 2000 through 2004, annual sales of hybrids have grown from 9,000 to 180,000, an annual rate of more than 100%. However, as a percent of all vehicles sold, hybrids are still less than 2%.[18] From the end of 2004 through 2011, most market forecasts show hybrids climbing to between 5-10% of new vehicle sales, which could effectively move hybrids from a niche player to a viable mainstream automotive alternative.

*Plug-in Hybrids*
Plug-in hybrids (PHEVs) are similar to today's hybrid cars but use a larger battery and add a plug to allow charging of the battery from an outside source, therefore adding the benefits of electric vehicles without the main drawback of limited driving range on the battery alone. The ability to top-off the battery with grid power would further extend the range of these vehicles, and therefore reduce petroleum consumption, and facilitate the introduction of renewable electricity into the transportation sector. Alternatively, homeowners, businesses and local governments could purchase their own solar or small wind systems, allowing PHEV charging from these sources of clean power.

An interesting variation to this option would be to transfer electricity the opposite way, from the vehicle to the grid, thus transforming the vehicle into a renewable (if charged with renewable electricity) and dispatchable source of distributed power generation. Amory Lovins, Hunter Lovins and Paul Hawken explore this possibility in their book *Natural Capitalism*, and in other documents.

As automotive companies increase their HEV offerings, costs should decrease making these efficient vehicles more affordable. While no car manufacturer has yet announced a plug-in-hybrid model, a

[18] Office for the Study of Automotive Transportation, UMTRI

number of them are reported to have such technology in advanced stages of development. Toyota and Ford have announced publicly plans to develop PHEVs.[19]

Even though hybrids have been marketed as electric vehicles that never need plugging in, PHEVs are receiving attention because of their ability to extend driving range and thus conserve greater amounts of high-priced fossil fuels. Thus, as part of an overall strategy to reduce petroleum consumption, the PHEV is a natural extension of the HEV that could be introduced with relative ease. To the extent that PHEVs also use biofuels (in either low- or high-level blends) they would also serve to extend the "reach" of biofuels. From a macro perspective, however, PHEVs need to be evaluated on a well-to-wheels basis to determine the net impact on fossil fuel use and greenhouse gas emissions, since fossil fuels remain a major input for electricity generation. At high-levels of market penetration, there could also be issues of electricity supply adequacy and the ability of the grid to charge large numbers of PHEVs simultaneously. Nevertheless, the petroleum benefits would be significant as the power grid continues to transition to greater amounts of renewable energy. Thus PHEVs appear to be an important technology platform for meeting the county's climate protection goals.

*Diesel Hybrids*

Finally, diesel light duty vehicles are being developed and will likely reach the market over the next decade. The main hurdle has been that the elevated emissions profile of diesel engines (which, in most cases, do not meet EPA standards) has prevented the widespread introduction of these engines in the US marketplace. After ultra low sulfur diesel (ULSD) is rolled out nationwide, clean diesel technologies that were not compatible with the high sulfur fuel, will be introduced also in the US market resolving the emissions challenge. Diesel electric hybrids will likely follow suit. Diesel hybrids have been used for a long time in heavy duty vehicles; their application in the light duty vehicle segment would lead to extremely fuel efficient cars, even relative to gasoline-electric hybrids because diesel engines are about 30% more efficient than gasoline engines.

In conclusion, hybrid technology is key to the immediate need to rebalance the fuel mix away from petroleum fuel by achieving important gains in efficiency. The benefits of this technology are important, and incentives should be put in place to reward (not only financially) the ownership of these vehicles. Hybrids could also be designed to run on biofuels with relatively minor modifications.

## Electric Vehicles

Electric vehicles exist today in many different forms, from electric powered scooters to golf carts to the Tesla Roadster, a new full-size high performance sports car.[20] According to the company, the Roadster, with a $100,000 price tag, can go from 0-60 miles per hour in about four seconds - a benchmark that rivals gasoline-powered sports cars. In addition to the Roadster, there are a number of other electric vehicles on the market today or soon to be on the market, including the GEM electric car, which is

[19] Los Angeles Times, http://www.latimes.com/business/la-fi-briefs12.4may12,1,1757014,print.story?coll=la-headlines-business.

[20] http://www.teslamotors.com/index.php?js_enabled=1.

essentially a street legal golf cart style vehicle.[21] The GEM is a "neighborhood electric vehicle" (NEV) and is not meant to replace a full-size car. Instead, it is designed to provide transportation for short trips only. The GEM is available today in a number of models and costs about $8,000. Zap! is a company that sells a number of vehicles, including (pre-orders only as of October, 2006) a Brazilian import: the Obvio 828E, a 100% electric powered vehicle.[22] There are other electric vehicles slated for production in the near future.

Electric cars have a mixed history in the U.S. General Motors' EV1 electric car was leased for a short time in the 1990s, but had a relatively short range (80 miles or less) on one charge. Owners generally liked the cars very much and many were dismayed when GM did not provide a purchase option at the end of the lease. U.S. auto manufacturers concluded from the EV1 experience that there was limited demand for electric cars, but the political and economic climate has changed significantly in the last decade, such that electric cars may become more available in the next decade or so.

The key for electric cars to become economically competitive will be improvements in battery design and lower costs. The Tesla Roadster claims a 250 mile range on a single charge. Time will tell if electric vehicles will become more affordable and appealing to mainstream consumers. From the perspective of CO2 emissions, the contribution that EVs can make to SBC's goals will depend in part on the makeup of the electric power system fuel mix.

## Alternative Fueled Vehicles

### Hydrogen Vehicles

*Hydrogen Fuel Cell Vehicles*

Fuel cells are electrochemical conversion devices that convert hydrogen and oxygen into water, creating electricity in the process. Vehicle fuel cells remain very uneconomical compared to the internal combustion engine in today's cars, and the technology still faces a range of technical challenges. A further challenge is the production, storage and delivery of the hydrogen fuel needed to power fuel cells. "Green hydrogen" can be produced by electrolysis of distilled water powered by renewable electricity or via thermo-chemical conversion of biomass. Current costs for producing renewable hydrogen range, according to leading researchers at UC Davis, from about $7-10/kg, or about $7-10/gallon of gasoline equivalent energy.[23] Currently, renewable hydrogen production is found only in a handful of demonstration projects. As hydrogen production from renewables develops, however, we will learn more about the true costs of production and its long term potential as a competitive replacement for fossil fuels.

The degree to which hydrogen becomes competitive with gasoline and diesel will depend on a range of factors, not the least of which is the continued development of hybrid vehicle technology, which raises the bar for a fuel cell vehicle in terms of relative fuel economy. Fuel cell technology does offer environmental benefits, such as zero tailpipe emissions (other than water). However, it is currently highly dependent on fossil fuels for hydrogen production. In addition, fuel cell vehicles are generally not

[21] http://www.gemcar.com/.
[22] http://www.zapworld.com/ZAPWorld.aspx?id=386.
[23] "High Hopes for Hydrogen", *Scientific American*, September 2006

expected to be available on a wide scale for at least another 10-15 years, though GM has stated its intention to have commercially available vehicles by 2010.[24] Nevertheless, fuel cell vehicles could play an increasingly important role in the later years of the Fossil Free By '33 initiative

In considering the notion of a *hydrogen economy* built upon electrolysis as a means of producing hydrogen, one question that arises relates to the use of electricity for electrolysis versus electricity as a direct fuel source for electric vehicles or plug-in hybrid vehicles. If electricity (renewable or otherwise) is the primary energy supply for hydrogen creation (through electrolysis) or for direct use in electric vehicles or PHEVs, it may be more efficient to use the electricity directly in vehicles. Using electricity for electrolysis and then using hydrogen to power a fuel cell vehicle involves a two-step process that is currently less efficient and much more costly than simply using the electricity as a fuel. Improvements in electrolysis and fuel cell energy efficiency might improve the advantages of the hydrogen-fuel cell powered vehicles versus direct electric vehicles, but cost and consumer interest will play an important role in determining which, if any, of these technologies are deployed into the market .

A further challenge is the lack of infrastructure to support the distribution of the fuel. Because of this, the first practical applications will probably be with centrally fueled fleets (these too are still many years away, though there are a few Honda FCX vehicles being used by fleets already[25]); this may provide SBC an opportunity to be an environmental leader by converting its public fleets to hydrogen fuel if this is found to be the most desirable of the various options available - which is not at all clear. Instead of storing hydrogen on-board a fuel cell vehicle another option is to store a liquid fuel and to reform it into hydrogen on-board the vehicle as it is needed. This would eliminate the hydrogen infrastructure issue, but is more technically challenging from a vehicle standpoint. As such, the majority of automobile manufacturers are focused on the direct hydrogen option.

*Hydrogen Internal Combustion Engine Vehicles*

As a transition, hydrogen could be used in internal combustion engines with good efficiency and low emissions, once those vehicles are commercially available. BMW recently announced it will be giving 100 hydrogen ICE 7 series vehicles to various parties around the world for testing.[26] An important difference between hydrogen ICE and hydrogen fuel cell vehicles is the fact that BMW's design, and others, can run on either gasoline or hydrogen. Time will tell what cost breakthroughs occur with the design of electric vehicles, PHEVs, hydrogen fuel cell vehicles and hydrogen ICE vehicles.

**Natural Gas Vehicles**

*Compressed Natural Gas (CNG)*

The natural gas powered internal combustion engine is a mature technology. Two million such vehicles are on the streets world-wide, of which 130,000 are in the United States. The technology experienced a period of remarkable growth in the 1990s, driven by low natural gas prices and by the low cost differential of these vehicles compared to gasoline powered vehicles. In the United States, many city fleets have converted to CNGs. In addition to lower GHG emissions compared to other fossil fuels, environmental and health benefits are significant since natural gas burns cleaner than diesel fuel. The

[24] Reuters, "GM expect to mass produce fuel cell cars by 2010," http://www.planetark.org/dailynewsstory.cfm/newsid/12408/story.htm.
[25] Honda website: http://corporate.honda.com/environment/fuel_cells.aspx?id=fuel_cells_fcx.
[26] Los Angeles Times, Sept. 13, 2006: http://www.latimes.com/business/la-fi-bmw13sep13,1,2296162,print.story.

lack of development of the necessary fueling infrastructure is the main limit to more extensive adoption (and the reason for which the main deployment of the technology has been for fleets with centralized fueling stations). For personal transportation options, the limited range and impact on vehicle storage space (taken up by the bulky CNG tanks) has limited the adoption of this technology.

Despite the fact that natural gas is a fossil fuel, a percentage of CNG vehicles in SBC may be consistent with the Fossil Free by '33 objective, because these engines could eventually be powered by biogas, a renewable version of natural gas, or methane seeps, which are places in the ocean where methane naturally bubbles to the surface from geological deposits. There are currently about 300,000 cubic feet per day captured off the coast near UC Santa Barbara by Venoco, Inc.[27] Hypothetically, 300,000 cfd would be enough for about 60,000 miles per day in a car that achieved 25 miles per gallon equivalent. If we consider an average commute in SBC to be about 20 miles, this naturally occurring methane would be enough to fuel about 3,000 commutes each day[28] (assuming that the heat content of methane produced locally is compatible with CNG vehicles).

There are also other sources of methane that do not contribute to climate change when burned, such as methane captured from landfills. Currently, the County's only large landfill, Tajiguas, has a 3 MW electrical generation plant that runs entirely on landfill gas.

*Liquefied Natural Gas (LNG)*

Natural gas is liquefied by cooling it to -260°F (-160° Celsius) at atmospheric pressure. This process has been developed mainly in response to the challenges of transporting natural gas around the globe, in cases where pipelines are not an option. This cryogenic liquefaction process is expensive and energy intensive; in addition, the infrastructure costs involved to liquefy, store, transport and re-gasify are significant. For this reason, LNG has been developed as a large scale energy source to supplement traditional sources of natural gas. Industrialized countries in Asia (Korea and Japan) have been importing LNG for years as local natural gas resources do not exist in those countries. The United States also imports LNG to supplement domestic production and pipeline imports from Canada and Mexico. Interest LNG has seen a resurgence in recent years as concerns over the long-term availability of pipeline accessible natural gas have mounted. Currently, 2% of the demand for natural gas in the United States is met with LNG (4% worldwide).

As a transportation fuel, LNG has the advantage of a very high energy density compared to CNG, thus solving the issues of the limited range and bulky fuel tanks of CNG vehicles. However, the complexity of the engine, fuel tank and fueling infrastructure (for example double-walled, vacuum-insulated tanks are needed for LNG storage) keeps the cost of this technology prohibitively high compared to mainstream technologies. Nevertheless, attracted by the perceived low emissions profile of LNG, a number of fleet operators in the United States (mainly in California and Texas) have purchased LNG vehicles. However, given the energy required to produce and transport LNG, the actual GHG emissions from LNG can be expected to be higher than for domestically produced natural gas. Thus, LNG does not appear to be a transportation fuel compatible with the Fossil Free By '33 objective, today or in the future.[29]

---

[27] Venoco, Inc., website: http://www.venocoinc.com/environment/natural-seeps/index.html.

[28] 300,000 cfd * 0.292 kWh/cf / 36.6 kWh per gallon gasoline * 25 miles per gallon / 20 miles per day = 2,991.8.

[29] In early 2006, the Council issued a report that concluded that the state's ambitious energy efficiency and renewable energy goals will substitute for additional natural gas demand and, even if these goals aren't met, there is sufficient new natural gas capacity coming online domestically and in Baja California to eliminate the need for any LNG import terminals in California. For a copy of the report, visit www.fossilfreeby33.org.

## Action Plan[30]

### Key Principles for Promoting Biofuels and Alternative Fuel Vehicles (AFVs)

Several principles are important in guiding SBC with respect to promoting biofuels and AFVs. In no order of priority, these are:

- **Reduce market risk to stimulate private investment**. For biofuels to become a meaningful part of the transportation energy mix, significant private capital will need to be invested – in biomass feedstock production, biofuel production, logistics, and refueling infrastructure. Local governments can do their part to create an environment that is more amenable to private investment. This includes examining existing local ordinances and permitting processes to identify barriers to private investment and ways to overcome them. Depending on the financial resources of local governments, this may also include various forms of financial incentives.

- **Facilitate access to State and Federal programs**. The policy environment for biofuels and hybrid vehicles is better now than at any time in the past. However, this also means that the landscape is more complex than it has been in the past. Non-profits, local governments and other entities can help local business and individuals navigate and understand the range of programs and incentives at the state and federal levels to maximize leverage of these programs at the local level.

  Also, to the extent the state and federal governments are promoting biofuels research, development and demonstration (RD&D) projects, policymakers in SBC should do whatever they can to bring suitable projects to the county.

- **Advocate good policies at the State and Federal level, as well as locally.** Despite the generally favorable policy environment at the state and federal levels, much more needs to be done. Many of the changes needed to significantly reduce petroleum consumption for transportation must occur at the state and federal levels, for example increasing Federal CAFE[31] standards. Policymakers in SBC should advocate at the State and Federal level for the changes needed.

- **Use the buying power of local governments to lead by example.** Stable and growing markets for biofuels are essential. Policymakers in SBC should encourage all local governments to lead by example by procuring hybrid vehicles and flex-fuel vehicles, and using biofuels. If local fleets are

[30] This section focuses on actions related to biofuels consumption and the use of alternative fuel vehicles. There are many other transportation-related actions that can be undertaken, mainly related to reducing personal vehicle use, such as car pooling, increased use of public transit, and efforts to promote cycling and walking. These are not discussed here.
[31] CAFE = corporate average fuel economy. It is the Federal average fuel economy standards that must be met by all automakers for new vehicle sales. The standard currently stands at 27.5 MPG for passenger cars, where it has been since 1990. The CAFE standard for light trucks (pickups, SUVs, minivans) was recently raised from 20.7 MPG (where it has been since 1996) to 21.6 for model year 2006, and will be 22.2 MPG for model year 2007. The largest SUVs and pickups – those that exceed 8,500 pounds gross vehicle weight – are not covered by CAFE. These include GM's Hummers and the Ford Excursion. For more details on CAFE, go to http://www.nhtsa.dot.gov/cars/rules/cafe/overview.htm, and for a discussion on the shortcomings of the current CAFÉ standards, see http://www.ase.org/images/lib/policy/cafeloopholes2.pdf.

large enough this can also include the installation of E85 refueling infrastructure. This can create the necessary "baseload" demand to spur uptake by individuals and businesses.

- **Improve availability of biomass resources in SBC.** To the extent that biofuels can be produced with local biomass resources, policymakers in SBC should examine ways in which they can improve access to these resources.

- **Promote public awareness of the importance of bioenergy.** Achieving the Fossil Free By '33 objective will require massive change in how individuals and businesses make decisions about transportation options, as the vast majority of transportation energy use is by the private sector. Although biofuels and hybrid vehicles are prominent today, the general public is virtually unaware of the larger role that biomass plays in California's energy supply. There also continue to be misconceptions about the options, such as the net energy and environmental impacts/benefits of ethanol. Given the importance of change at the individual and corporate level, education and outreach may be the areas of greatest leverage for policymakers in SBC.

- **Promote collaborations between government, academia and businesses** in order to take advantage of the skills each sector can bring to the table.

## Proposed Actions for Local Governments

### Leverage State and Federal Policies and Incentives

A wide array of state and federal policies, programs and incentives are in place or in development. They cover biomass production, fuel production, refueling infrastructure, and vehicle purchases and conversion (to using alternative fuels). Maximizing leverage of these programs to the benefit of the county and towards meeting the Fossil Free by '33 goal should be priorities of the action plan.

Appendix A summarizes key federal biofuels incentives and programs, including research and development, as well as other available biomass incentives. In addition to the information presented in these tables, other relevant federal legislation and initiatives include:

- 2002 Farm Bill, Title 9 - includes biorefinery development grants and a federal bio-products procurement program
- Biomass Research and Development Act of 2000 – describes the overall federal program in bioenergy R&D. Authorization for funding extended in the Energy Policy Act of 2005 (EPAct 2005) to $200 million per year through 2015.
- The Advanced Energy Initiative, announced by President Bush at the 2006 State of the Union Address, provides for a 22% increase in clean-energy research at the Department of Energy (DOE).
- The Biorefinery Initiative: the President's 2007 budget will include $150 million – a $59 million increase over 2006 – to help develop bio-based transportation fuels from switchgrass or agricultural residues such as wood chips. Research scientists say that accelerating research into "cellulosic ethanol" from the just-mentioned sources can make it cost-competitive by 2012, offering the potential

to displace up to 30% of the nation's current fuel use, according to the Department of Energy's "Billion Ton" plan.[32]

In addition, there are federal tax credits for the purchase of hybrid vehicles and alternative fuel vehicles, and for the conversion of existing vehicles for use with alternative fuels. The EPA also has several programs, including the Clean Cities program. For links to these and other programs at the federal level, the US Department of Energy's Alternative Fuels Data Center (AFDC) acts as a clearinghouse of information.[33] Also, the California Energy Commission contains substantial information on the state's BioEnergy Action Plan.[34]

At the state level there are a range of policies that will have a significant bearing on transportation energy use. These include:

- Petroleum Dependency Reduction. The Joint Report by the California Energy Commission and the Air Resources Board titled *Reducing California's Petroleum Dependence* has set goals for 20 percent non-petroleum fuel use by 2020 and 30 percent by 2030.

- Greenhouse Gas (GHG) Reduction. In late August of 2006, the California legislature approved AB32, considered by many to be landmark GHG control legislation in the U.S. AB32 establishes a mandatory reporting system to track and monitor greenhouse gas emission levels and institutes a limit on greenhouse gas emissions – requiring emission reductions in California to 1990 levels by the year 2020. The bill also directs the California Air Resources Board (CARB) to develop a regulatory framework of emission reduction strategies which may include programs, measures, and market-based flexible compliance options.

- Bioenergy Executive Order. In April 2006, Governor Schwarzenegger issued a Bioenergy Executive Order (S-06-06). It established ambitious targets for biofuels and biopower production and consumption, and directed state agencies to begin implementing actions to facilitate the increased use of bioenergy in California. In particular, the order requires that 25% of the biofuels consumed in California by 2020 must come from in-state sources.

While specific programs are still evolving on how to implement the above policies, a number of state programs are already in place. For a summary of these, visit: http://www.eere.energy.gov/afdc/progs/state_summary.cgi?afdc/CA.

**Demonstration Projects**

An important component of federal and state support for biofuels is the commercialization of new technology. This will require commercial-scale demonstration of these technologies. In particular, it will require the production of biofuels using emerging technologies such as cellulosic ethanol production and biomass-to-liquids. The production of biomass energy crops is another area. Local policymakers should identify appropriate demonstration projects and work with developers and federal and state agencies to

[32] Department of Energy, "Biomass as Feedstock for a Bioenergy and Bioproducts Industry: the Technical Feasibility of a Billion-Ton Annual Supply," April, 2005, available at: http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf#search=%22biomass%20billion%20tons%22.
[33] http://www.eere.energy.gov/afdc/progs/fed_summary.cgi?afdc/US/0.
[34] http://www.energy.ca.gov/bioenergy_action_plan/index.html.

bring those projects to SBC. For example, there is no local biodiesel production on a commercial scale in SBC.

The importance of new biofuels technologies to the Fossil Free by '33 goal is driven by the fact that these processes promise to be significantly less energy intensive (from a fossil fuel standpoint) than today's corn-based ethanol and soy-based biodiesel. Although ethanol and biodiesel are renewable, current production techniques involve the use of fossil fuels, particularly for fertilizer manufacture and for the process energy needs of the production plants themselves. New technologies offer the potential to improve the "fossil energy ratio"[35] significantly. Demonstrating incremental changes to corn-based ethanol is also important. For example, replacing natural gas use at corn-ethanol plants with biomass would be a significant incremental change.

**Address Financial Barriers**

Depending on the financial resources available within the county, local governments could offer direct incentives, which could include:

- Reductions in permitting fees for biofuels projects.
- Reductions in property taxes for investments in alternative fuel refueling infrastructure.
- Reductions or exemptions in auto excise taxes for AFVs.
- Reductions or exemptions in local motor fuels sales taxes for alternative fuels.
- Local government grants or low-interest loans by local banks and/or local governments. (For example, installing E85 fueling capability at 10% of the county's 135 retail fuel outlets would require a total investment of approximately $675,000[36]).

**Siting and Permitting**

The lengthy process of siting and permitting is frequently cited as a key barrier to biofuels development in California. To the extent that local governments play a role in this process, local governments in SBC should evaluate how they can facilitate permitting for biofuels production facilities, refueling facilities and other infrastructure, while maintaining appropriate oversight and protection of the environment. As mentioned in the previous section, one way of incentivizing such facilities is to lower permitting fees. One ethanol production plant already proposed for Santa Maria by American Ethanol, Inc., was, as of July, 2006, facing substantial permitting fees with the County government. These fees were reportedly much higher than for a similar plant already constructed in Goshen in Tulare County.[37]

[35] The fossil energy ratio is the energy contained in the biofuels divided by the sum of the fossil fuel inputs to the entire fuel chain, from the feedstock production to the tailpipe. For a modern corn-ethanol plant, the fossil energy ratio is about 1.3:1 (*Updated Energy and Greenhouse Gas Emissions Results of Fuel Ethanol*, Michael Wang, Center for Transportation Research, Energy Systems Division, Argonne National Laboratory Presented at The 15th International Symposium on Alcohol Fuels, San Diego, CA, September 26-28, 2005). For some of the new technologies the fossil energy ratio is expected to be >10:1.

[36] Assuming $50,000 per outlet.

[37] According to conversations between CEC and Dave Cross, with Fletcher Cross and Associates, a contractor for American Ethanol, Inc., July 26, 2006.

**Leading by Example**

When local governments lead by example, two things are accomplished. First, it helps build the market for emerging alternative fuels and technologies, which in turn helps businesses establish themselves. Second, it showcases the options for individuals and businesses, and can help lead them down the path to making similar decisions about their own transportation needs. Local governments could pursue the following measures:

- Policies requiring greater fleet fuel economy, alternative fuel vehicle purchases and biofuels usage for their own fleets (public works, schools, police, etc.)
    - For example, as mentioned above, the City of Santa Barbara recently switched to B20 for all diesel vehicles, a possibly trend-setting move
    - The City of Santa Barbara and other local jurisdictions could also purchase E85 compatible vehicles when those vehicles are otherwise suitable
    - Local jurisdictions that have their own fueling infrastructure should examine the feasibility of installing E85 pumps of their own, once CARB completes its certification process
- The hiring of local energy managers to implement various energy programs. If this also includes energy efficiency, the energy cost savings can typically fund the position and be used to fund additional investment in energy efficiency and renewable energy.
- Investments in plug-in hybrid charging infrastructure if it becomes apparent that PHEVs will become commercially available and widespread. The "infrastructure" required is simply a normal power outlet, so this step will entail minimal expense. If PHEVs result in significantly more power demand, however, the grid itself may require investment.
- Join the DOE's Clean Cities Program, the national Energy Freedom Challenge (which is a race to be the first city to produce 50% of its power needs from renewables), and other similar programs.

**Education/Outreach (including recognition programs)**

Given that most transportation energy use is by individuals and businesses, education and outreach are key elements on an action plan designed to reduce petroleum consumption in transportation. This includes:

- General Outreach and Education – lectures, workshops, flyers (e.g., with local tax bill or water bill), the use of local media, and having a presence at local festivals & events. The focus of general outreach is on building awareness of the Fossil Free By '33 objective, the benefits of biofuels and other options, and the specific options available to individuals and businesses.
- Targeted Outreach – Here the focus would be on retail fuel outlets and businesses, especially those with fleets, schools, non-profits.
- Creating an information clearinghouse on available incentives, vehicle choices, and objective information to address common misconceptions and highlight the benefits of biofuels and AFVs.
- Local governments could also work with chambers of commerce to help businesses use biofuels and AFVs and to develop recognition programs.
- Work with local schools, colleges and universities.

**Advocacy**

As mentioned above, many of the policy and regulatory changes that will be needed to achieve deep cuts in petroleum consumption must occur at the state and federal level. Local communities can help by advocating for these changes. These include:

- Raising the CAFE fuel economy standards
- Increasing the targets for the federal renewable fuels standard
- Extending current incentives that are set to expire and advocating for other suitable incentives
- Promoting greater production of FFVs by automakers
- Creating an Energy Committee to address issues such as climate change and peak oil concerns

**Feedstock supply**

SBC can potentially tap into a range of in-county biomass resources. Vegetable crops, field crops and fruit and nut crops were cultivated on nearly 125,000 acres in 2005, and an additional 600,000 acres were classified as pasture. Residues from existing and future agricultural activities could be collected for conversion to biofuels. In addition, if suitable, some pasture could be converted to energy crop production. For example, according to Biodiesel Industries, a company located in Santa Barbara, 24,000 acres of crop land (a circle with a three mile radius) would yield 30 million gallons per year of oil from matura jatropha crops, judging by experience in India.

Manure from the more than 50,000 head of cattle could also be used for bioenergy production. Finally, forest residues and diverted municipal solid waste (MSW) are also available. In total, the California Energy Commission[38] estimates that approximately 225,000 bone dry tons (bdt) per year of biomass is technically available[39] in Santa Barbara County. The largest contributors are diverted MSW and Forestry (about 85,000 BDT each), followed by orchard and vine residues of about 23,000 bdt/year and animal manure of about 13,000 bdt/yr. Other sources are each less than 10,000 bdt/yr.

If half of the technically available biomass were converted to ethanol using cellulosic ethanol technology, SBC could produce roughly 10 million gallons per year, or about 4% of current gasoline consumption on an energy basis, as discussed above. While this is a relatively small amount of fuel, the potential exists for SBC to promote additional regional development of biofuels production through growing fuel crops like jatropha, switchgrass, etc. Policymakers can take several steps to encourage the development of these biomass resources, provided they are not already being used by the existing bioenergy industry, including:

- Additional assessments of feedstock supply and importantly, delivered feedstock costs.
- Evaluation of energy crop potentials, which are not well understood at this time.
- Working directly with the agriculture industry to develop these resources and to find ways to develop energy crops in the future.

[38] *An Assessment of Biomass Resources in California, 2005*, DRAFT Report, November 2005.
[39] This is what is recoverable. It is roughly 30% of what it theoretically available.

## Proposed Actions for Businesses

In order for businesses to promote biofuels and AFVs, businesses could:

- In the agricultural sector, engage in efforts to develop biomass feedstock supplies.
- Participate in Clean Cities coalitions.
- Take advantage of existing tax credits and other programs.
- Promote and facilitate biofuels and AFV use among employees. (For example, Google, Inc., and Wells Fargo bank, among many others, offer significant rebates for employees to purchase hybrid vehicles, as does an SBC building contractor, Allen & Associates[40]).
- Work with local chambers of commerce to encourage businesses to act collectively to promote biofuels and AFV use, and to encourage development of the necessary infrastructure. For example, local businesses could agree to minimum biofuels purchases in order to encourage local fuel retailers to install the necessary fueling infrastructure.

## Proposed Actions for Individuals

Individuals can both advocate for good policies and make decisions that lead to lower petroleum use, such as:

- Reduce miles driven in cars by walking, biking, busing or carpooling to work.
- Maintain cars well so that they achieve higher fuel economy.
- Purchase smaller, more fuel-efficient cars or scooters/mopeds (available now with electric motors or gas motors).
- If a new full-size car is required, purchase a hybrid or flex-fuel vehicle. Assuming 15,000 vehicle miles traveled per year, a hybrid vehicle that averages 45 mpg vs. the current fleet average of about 22 mpg will save approximately 330 gallons of gasoline per year,[41] or about $1,000 per year at today's prices. Similarly, an E85 flex-fuel vehicle that is fueled entirely with E85 will displace approximately 500 gallons of gasoline per year.[42]
- Meet/communicate with local, state and federal elected officials to promote policies consistent with the Fossil Free by '33 program and a reduction in petroleum use.

---

[40] Reuters, "Bank of America, Others Warm to Hybrid Car Rebates," http://www.planetark.com/dailynewsstory.cfm/newsid/36710/story.htm

[41] Assumes California gasoline is 5.6% ethanol by volume.

[42] E85 is 85% ethanol by volume, but this ethanol typically contains 5% gasoline as a denaturant. Therefore E85 fuel is 80.75% ethanol by volume. Ethanol also contains about 1/3 less energy per gallon than gasoline. Furthermore, analysis by Argonne National Laboratory conducted in the development of its GREET model (taken from version 1.7 of the GREET model, which is available at http://www.transportation.anl.gov/software/GREET/index.html), which analyzes so-called *well-to-wheels* energy use and emissions of different fuel chains, shows that E85 vehicles obtain slightly better overall fuel economy than regular gasoline vehicles. As a result of all these factors, it is estimated that an E85 vehicle displaces approximately 75% of the gasoline consumed in a conventional vehicle, if it were fueled entirely with E85.

## Case Studies

**San Francisco, CA**

In 1999, with the help of the San Francisco Clean Cities Coalition, the City established a Healthy Air and Smog Prevention ordinance requiring City fleets to purchase vehicles using alternative fuels or energy-efficient vehicles with low emissions. (Chapter 85 of the San Francisco Municipal Code) This municipal legislation also provided funding for research and development to establish infrastructure to support Alternative Fuel Vehicles (AFVs).

By 2006, the City of San Francisco reported that it had integrated more than 800 alternative fuel vehicles into its fleets. In addition, several City departments and agencies use B20 (a blend of 20% biodiesel and 80% petroleum diesel) including San Francisco Airport, DPW, Municipal Buses and the San Francisco Zoo.

In early 2006, Mayor Gavin Newsom issued an Executive Directive designed to increase the pace of municipal use of biodiesel. The Directive states that all Departments currently using diesel shall begin using a B20 bio-diesel as soon as practicable with the following incremental goals for implementation:

- Initiate and complete a biodiesel pilot project by Dec 31, 2006
- Use B20 biodiesel in 25% of vehicles and equipment by March 31, 2007; and
- Use B20 biodiesel in 100% of vehicles and equipment by December 31, 2007

In response to the directive, the San Francisco Fire Department announced a six month pilot program to test and monitor the use of B20 in two fire trucks, six engines and one ambulance.

**Seattle, WA**

In 2003, the Mayor and City Council of Seattle set a long term goal of having a 100% "clean and green fleet" of vehicles. The Clean Green Fleet Action Plan called for half of all compact cars purchased by the City to use cleaner-burning alternative fuels and emphasized the use of biodiesel and ultra-low sulfur diesel in city vehicles.

As a result of the "clean and green" initiative, the City's fleet of over 3,000 vehicles has steadily transitioned to alternative fuel vehicles (AFVs) and more climate-friendly fuels. The City has purchased hundreds of hybrid electric cars and boasts an entire diesel fleet that runs on biodiesel and ultra low sulfur diesel. The incorporation of AFVs combined with substantial fleet downsizing has made the Green Fleet Program a model for other jurisdictions.

Early in 2006, the Port of Seattle and SSA Marine, the Port's largest maritime customer, made the commitment to use biodiesel in maintenance vehicles and container handling equipment. The Port of Seattle and SSA Marine are charter members of the Biofuels Business Collaborative. The Collaborative is a group of Washington businesses, farmers, investors and fuel consumers that promote the advancement of the state's biofuels industry.

Regional efforts are also supported by the Puget Sound Clean Cities Coalition (PSCC). The PSCC is a public/private partnership that promotes the use of alternative fuels and vehicles, fuel blends, fuel

economy, hybrid electric vehicles and idle reduction. The PSCC is a member of the DOE's Clean Cities Program and supports its mission by providing education, technical assistance, access to grant funds and other services.

The City of Seattle has been continually updating the Green Fleet program since its inception. The goal of 100 % clean and green fleet is a long term goal that it intends to achieve some day. The City has used B20 for a number of years and converted to ultra low sulfur diesel in 2001 along with the use of particulate traps and oxidation catalysts. It has reduced the amount of petroleum fuel used by 12 % compared to the amount the City was using in 2003, mostly due to the biofuels. Seattle also uses electric vehicles in some settings, Segways in campus type environments, CNG vehicles, about 240 hybrids, etc. Seattle is hoping that E85 will become more available for vehicles that are equipped properly for using ethanol.

The City's electric utility has also achieved carbon neutrality for all of its energy usage, through a combination of renewable energy, biofuels and carbon offsets.[43]

**City of Austin, TX / Austin Energy**

In 2006, under the direction of the Austin City Council, the City of Austin and Austin Energy launched the Plug-In Partners campaign to demonstrate to automakers that a market exists today for plug-in hybrid electric vehicles (PHEVs). The campaign is national in scope and its goal is to recruit the support of American cities and public utilities to help demonstrate the market viability for PHEV use by fleets and private consumers. Almost a dozen cities have already joined the campaign as partners including Baltimore, Denver, Los Angeles and Seattle.

The campaign is advancing its goals by pursuing three strategic initiatives:

- Garnering support in the form of online petitions and endorsements by cities across the country
- Procuring "soft" fleet orders
- Developing rebates and incentives

The campaign has developed a template petition form and tracks signatures accumulated from programs across the country through the Plug-In Partners website. A template form for "soft" fleet orders has also been developed and the campaign plans to track vehicle commitments through a Reporting option soon to be added to their website. The goal is to present automakers with this information to demonstrate market interest by presenting "soft" orders for sedans, vans, SUVs and other vehicles by specific governmental and business entities. Finally, the campaign seeks to promote financial incentives in the form of Electric Utility Rebates for Consumers, Local Governments, Businesses and Organizations. Austin Energy is leading the way by setting aside $1 million for PHEV rebates for Austin Energy customers when PHEVs are made available.

The campaign reports that, as of July 2006, it has already obtained 6,000 soft orders for purchases of plug-in hybrids by city agencies and private partners, as well as 11,000 signatures by residents endorsing the idea.[44]

[43] "Seattle City Light reduces net greenhouse-gas emissions to zero," Seattle Times, Nov. 10, 2005.
[44] www.pluginpartners.org.

NAVIGANT CONSULTING

## Appendix – Biofuels Incentives & Programs

| Federal Biofuels Incentives | | | | | | |
|---|---|---|---|---|---|---|
| **Name & Responsible Agency** | **Type** | **Description** | **Effective Dates** | **Legislation** | **US Code Reference** | **Comments** |
| Volumetric Ethanol Excise Tax Credit (VEETC) **(IRS) – aka "blender's tax credit"** | Excise tax credit | MIXED: Biodiesel - $0.50 / gallon; Agri-biodiesel $1/gallon; Alcohol (non-ethanol) $0.60 / gallon; Alcohol (other) $0.51 / gallon | Biodiesel - 12/31/2008; Alcohols - 12/31/2010 | JOBS Bill (HR4520) Sec. 301 ; EPACT 2005 Sec. 1344 | 26 U.S.C. 6427 (Chp 65 Subchp B, Section 6427)) | Alcohol: includes methanol and ethanol but does not include—<br>(i) alcohol produced from petroleum, natural gas, or coal (including peat), or<br>(ii) alcohol with a proof of less than 190 (determined without regard to any added denaturants).<br>Such term also includes an alcohol gallon equivalent of ethyl tertiary butyl ether or other ethers produced from such alcohol;<br>Alcohol Fuel Mixture: a mixture of alcohol and a taxable fuel which—<br>(A) is sold by the taxpayer producing such mixture to any person for use as a fuel, or<br>(B) is used as a fuel by the taxpayer producing such mixture. |

| Federal Biofuels Incentives | | | | | | |
|---|---|---|---|---|---|---|
| **Name & Responsible Agency** | **Type** | **Description** | **Effective Dates** | **Legislation** | **US Code Reference** | **Comments** |
| Volumetric Ethanol Income Tax Credit **(IRS)** | Income tax credit | STRAIGHT: Alcohol, Regular - $0.51 / gallon; Alcohol, Low Proof - $0.3778 / gallon; Biodiesel - $0.50 / gallon; (Agri-Biodiesel - $1.00 / gallon); and Renewable Diesel - $1.00 / gallon; MIXED: Alcohol, Regular - $0.51 / gallon; Alcohol, Low Proof - $0.3778 / gallon; Biodiesel - $0.50 / gallon; (Agri-Biodiesel - $1.00 / gallon); Renewable Diesel - $1.00 / gallon | Other - 12/31/2008; Alcohols - 12/31/2010* | JOBS Bill Sec. 302; EPACT 2005 Sec. 1344 | 26 U.S.C. 40 and 40A (Chp1, Subchp A, Part IV, Subpart D, Sections 40 and 40A) | Part of the Business Credit against income, 24 U.S.C. 38, which has its own limitations as a package of individual incentives. Provision provides an election to pass through to farer owners via a cooperative. * Does not apply for periods before 1/1/2011 during which the rates of tax under section 4081(a)(2)(A) are $0.043 / gallon. "Renewable Diesel" provisions can be found in Sec. 1346, and provide identical treatment as biodiesel, but at $1/gal instead of $0.50/gal. |
| Small Ethanol (and Biodiesel) Producer Credit **(IRS)** | Income tax credit | $0.10 / gallon up to 15 million gallons/yr (less than 60 million gallons total capacity) | 12/31/2010 | JOBS Sec. 313, EPACT 2005 Sec. 1347 | 26 U.S.C. 40A (Chp1, Subchp A, Part IV, Subpart D, Section 40A) | EPACT 2005 increased producer size limit from 30 to 60 million gallons. |

| Federal Biofuels Incentives | | | | | | |
|---|---|---|---|---|---|---|
| **Name & Responsible Agency** | **Type** | **Description** | **Effective Dates** | **Legislation** | **US Code Reference** | **Comments** |
| Renewable Fuels Standard **(EPA)** | Mandate | • Gasoline sold/ dispensed must contain the applicable volume (billion gallons) of renewable fuel (on annual avg basis)<br>• 2006 - 4.0; 2007 - 4.7; 2008 - 5.4; 2009 - 6.1; 2010 - 6.8; 2011 - 7.4; 2012 - 7.5;<br>• 1 gallon cellulosic biomass or waste derived ethanol = 2.5 gallons of renewable fuel<br>• 2013 onwards – applicable volume determined by EPA; shall have a min of 250 million gallons from cellulosic biomass (specific calculation given); and 2.5-to-1 ratio no longer applies<br>• If EPA does not issue regs. by 8/2006, applicable amount shall be 2.78% renewable fuel | See "description" | EPACT 2005, Sec. 1501 | 42 U.S.C. 7545 | In 1/2006 EPA released their Notice of Proposed Rulemaking for the implementation of the Renewable Fuel Standard for 2006. Details are:<br>• EPA says they are not likely to meet the 8/2006 deadline given the complexity of the RFS and the fuels industry, need for stakeholder input, and the fact that the EPAct was vague on implementation (e.g., who are the obligated parties? refiners, producers marketers, etc...)<br>• Thus, the default provisions given in EPAct will apply in 2006, i.e., that gasoline contain, on average 2.78% renewable fuel, or about 4 billion gallons.<br>• Given the lack of final rules, the EPA will apply collective responsibility, i.e., as long as the average for gasoline is at least 2.78% in 2006, it will be assumed that all obligations have been met. If the industry falls short, then the shortfall will be carried forward to the 2007 requirement.<br>• EPA expects the industry to exceed the 2.78% target, so "no harm done" in taking more time to get the rules right.<br>• EPA will develop rules such that credit trading will enable fuels not mixed with gasoline to participate in the RFS. |

| Federal Biofuels Incentives | | | | | | |
|---|---|---|---|---|---|---|
| **Name & Responsible Agency** | **Type** | **Description** | **Effective Dates** | **Legislation** | **US Code Reference** | **Comments** |
| Production Incentives for Cellulosic Biofuels **(DOE in consultation with USDA, DOD and EPA)** | Direct Payment | Secretary to determine per gallon incentive for first 100 million gallons of annual production (or after 3 years). Subsequent incentive determined by "reverse auction" | Recipients get incentive for first 6 years of operation | EPACT 2005, Sec. 942 | N/A | Sets goal of achieving 1 billion gallons of cellulosic biofuels (NOT just ethanol) annual production by 2015. |
| Credit for Installing alternative fuel refueling equipment **(IRS)** | Tax credit | 30% up to 30,000 credit | Through 12/31/2009 and 12/31/2014 for hydrogen | EPAct 2005, Sec 1342 | N/A | |

| Other Biomass Energy Related Incentives and Programs | | | | | | |
|---|---|---|---|---|---|---|
| **Name & Responsible Agency** | **Type** | **Description** | **Effective Dates** | **Legislation** | **US Code Reference** | **Comments** |
| Qualifying Gasification Project Credit **(IRS)** | Tax credit | Tax credit equal to 20% of the qualified investment. $350MM cap on credit in total | Tax benefit for one year. Program runs for the 10-year period after October 1, 2005 | EPAct 2005, Sec. 1307 | N/A | Project must be financially viable without any other Federal funding. Includes biomass gasification and black liquor gasification. The qualified investment refers to eligible property that is part of a gasification project and is "necessary for the gasification technology of such project." |

| Other Biomass Energy Related Incentives and Programs | | | | | | |
|---|---|---|---|---|---|---|
| **Name & Responsible Agency** | **Type** | **Description** | **Effective Dates** | **Legislation** | **US Code Reference** | **Comments** |
| Grants for Beneficial use of Biomass from Fuel treatment projects **(DOE)** | Grant | Grants of up to $20/green ton, with a $500,000 limit per grant. Up to $50MM each year is authorized from 2006-2016. | 2006-2016 | EPACT 2005. Sec. 210 | N/A | |
| EPACT 2005 RD&D & Commercialization Program **(DOE)** | RD&D grants | Bioenergy Program ($MM)<br>$213 - 2007<br>$251 - 2008<br>$274 - 2009<br>Of which:<br>Bioerefinery Demo (sec. 932(d)):<br>$100 - 2007<br>$125 - 2008<br>$150 - 2009 | Request for proposals begin in early 2006. | Title IX, Sec. 931 & 932 | | • Sec. 932 (d) is for Integrated Biorefinery Demonstration Projects.<br>• Up to $100 M for a single biorefinery demo project. To be eligible, project must demonstrate commercial profitability, once initial construction costs are paid. |