E85, Flex-Fuel Vehicles, and AB 1493

Integrating biofuels into California's vehicular greenhouse gas regulations

A report to the California Air Resources Board
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Abbreviations Used

ACM	Alternative Compliance Mechanism
AFV	Alternative Fuel Vehicle
ARB	California Air Resources Board
BUR	Biofuels Use Rate
CalEPA	California Environmental Protection Agency
CARFG	California Reformulated Gasoline
CDF	California Department of Forestry and Fire Protection
CDFA	California Department of Food and Agriculture
CEC	California Energy Commission,
DGS	Department of General Services
DoE	U.S. Department of Energy
DOT	U.S. Department of Transportation
E85	85% ethanol, 15% gasoline fuel
EPA	U.S. Environmental Protection Agency
EV	Equivalence Value
FAF	Fuel Adjustment Factor
FFV	Flexible-fuel vehicle
FY	Financial year
GHG	Greenhouse gas
I/M	Inspection and maintenance
ISOR	Initial Statement of Reasons
IWMB	Integrated Waste Management Board
LDT1	Light-duty truck with a loaded vehicle weight of 0-3750 pounds
LDT2	Light-duty truck with a loaded vehicle weight of 3751 pounds to a gross vehicle weight of 8500 pounds.
LPG	Liquefied Petroleum Gas
MPG	Miles per gallon
MPEG	Miles per gasoline-gallon-equivalent
MY	Model year
NG	Natural gas
OBD	Onboard diagnostic
PC	Passenger car
POS	Point-of-sale
PUC	Public Utilities Commission
RIN	Renewable Identification Number
RFS	Renewable Fuels Standard
VMT	Vehicle miles traveled
WRCB	Water Resources Control Board
WTP	Willingness-to-pay

Executive Summary

The California Exhaust Emission Standards and Test Procedures (Part I(E) 2.5.2.1.5), commonly known as the AB 1493 regulations, aim to reduce greenhouse gas (GHG) emissions from motor vehicles by setting limits on the permissible per-mile GHG emissions of new vehicles sold in the state. The regulations' Optional Alternative Compliance Mechanism (ACM) allows automakers to claim GHG reductions from the use of biofuels in flexible-fuel vehicles (FFVs), to the extent automakers can assure biofuels use in these vehicles. This analysis focuses specifically on the use of E85 (85% ethanol, 15% gasoline) fuel, though it is often applicable to all biofuels, and finds large potential for AB 1493 compliance through FFVs and biofuels use.

Current and future policies mandate alternative fuels and vehicles, increasing cost-effectiveness of FFV-based AB1493 compliance

AB 1493 regulations (and the ACM) are situated in a context of state, federal, and international policies that independently support biofuels and FFVs. For example:

- Current and future state and federal mandates create large supply and demand for FFVs
- Current and future policies increase the percentage of biofuels, predominantly ethanol in the near term, that will be sold as part of the overall fuel supply
- Future policies are likely to increase the number of retail E85 dispensers in the state

Flex-fuel technology itself is very inexpensive to deploy in automakers' current model types. Thus the interaction of the above policies makes FFVs significantly cost-effective as a strategy for meeting GHG requirements under AB 1493. As long as automakers can demonstrate *any* biofuels use rate, it is advantageous for them to use FFVs as a compliance strategy.

Consumer cost-effectiveness depends critically on consumer willingness-to-pay for E85 fuel relative to gasoline. Biofuel prices are impossible to predict, but supply trends suggest long-term price-competitiveness. Moreover, willingness-to-pay for non-petroleum fuels can be high for many fleets and many general consumers. Thus, technological and market conditions are likely to increase the cost-effectiveness of the ACM for consumers as well.

Biofuels use rates (BUR) can be documented by a wide range of fleets

Current AB 1493 regulations only allow automakers to count flex-fuel vehicles (FFVs) as using biofuels if those FFVs are sold to fleets that can demonstrate their biofuels use rate (BUR) by fueling vehicles onsite. However, there are many fleet applications that could demonstrate their BUR. Modern purchasing-card- or card-lock-based fuel management programs increasingly allow for accurate tracking of alternative fuel use in a variety of off-site fueling systems. These methods are applicable to a large number of fleets, including government agencies, corporate fleets, and commercial fleets, and so have a large penetration potential of 20,000 to 80,000 new vehicles per year in California.

In addition, on-board diagnostic (OBD) systems are capable of detecting the biofuel content of fuels consumed and could be made capable of recording this information. This would allow auto manufacturers to demonstrate BUR for diverse vehicle fleets, including the substantial rental vehicle market of 200,000 new vehicles annually.

An average biofuels use rate can and should be calculated for all FFVs

In addition to fleet-specific biofuels use rates, a default BUR can and should be calculated and applied to all FFVs sold in the state, using an FAF based on the aggregate level of high-blend biofuels sold in the state and the number of FFVs in service (not including fuels and vehicles counted under a fleet-specific BUR). This method could lead to very significant penetration of FFVs as a compliance mechanism, up to virtually the entire sales of 2 million new vehicles each year in California.

Fuel adjustment factor (FAF) should be based on a transparent model and frequently revised

The fuel adjustment factor (FAF) is the ratio of biofuel GHG emissions to those of gasoline. The FAF is used as a multiplier to the "tailpipe" emissions of FFVs running on biofuels to account for the reduced GHG in the "upstream" phases of the fuel lifecycle. This analysis finds that:

- biofuels from different production processes produce widely variant GHG emissions,
- the GHG-intensity of gasoline will also vary over time,
- there is persistent uncertainty in lifecycle GHG emissions,
- therefore the average relative GHG performance of biofuels should be frequently calculated using a publicly-accessible, peer-reviewed model

Accessibility, transparency, and peer-review help ensure the accuracy, currency, and credibility of the model. The average GHG intensity of the range of biofuels and petroleum fuels in use in California should be calculated as frequently as feasible to reflect the quickly evolving industry, and to robustly manage the uncertainty inherent in both the basic physical processes and correct accounting of fuels production impacts.

The FAF may conflict with future fuel-sector GHG regulation – But using biofuels in FFVs would likely show some GHG reduction even without FAF

Unlike other tailpipe emission regulations, AB1493 considers the "upstream" emissions of biofuels relative to gasoline, and so implicates fuel-sector GHG emissions. However, future GHG policy, such as AB 32 regulations, may address upstream GHG emissions of transportation fuels in a fuel-sector-specific regulatory structure, in which case the FAF should be revised or eliminated. However, small but significant GHG reductions (5% or more) in vehicle *tailpipe* emissions result from the use of E85 in FFVs, and so demonstrating the use of biofuels in FFVs is likely to be beneficial even without an FAF.

Introduction

AB 1493 was introduced by Assemblymember Fran Pavley in 2001 and was signed by Governor Davis on July 22, 2002. The legislation is intended to address and reduce the approximately 40 percent of California's greenhouse gas emissions in the state emitted by passenger vehicles. Since the bill's passage, ten other states have adopted or are in the process of adopting the regulations as well, potentially affecting 33% of the U.S. new vehicle market.[1]

The bill delegated to the California Air Resources Board (ARB) authority for promulgating regulations to achieve the bill's purposes. ARB conducted regulatory rulemaking throughout 2003 and 2004, and issued final regulations September 15, 2005. The regulations set quantitative limits on the quantity of greenhouse gases emitted per mile by passenger vehicles, in a structure similar to existing limits on Clean Air Act "criteria" pollutants. The regulations will apply to 2009 and later model year vehicles and the full standard will be phased in over eight model years. When fully phased in the mid-term (2013-2016) standards will result in about a 30 percent reduction.

The legislation required (rather contradictorily) that the regulations be designed to achieve the maximum feasible GHG reduction, while allowing automakers to meet the standards at the lowest cost and maximum flexibility that maintains the goals of the program. Allowing for the use of E85 in FFVs is one aspect of this flexibility.

Flex-fuel vehicles can utilize either gasoline or ethanol-gasoline blends up to 85% ethanol (E85). Flex-fuel vehicles cost very little more to produce than an identical gasoline vehicle, needing only more corrosion-resistant materials throughout the fuel system and a system for sensing the percentage of alcohol in the fuel and adjusting the fuel injection appropriately. Although FFVs are not expensive to produce, E85 can be more expensive than gasoline, either by volume or by mileage potential.[2] Thus the "cost-effectiveness" of FFV/E85 as an AB1493 compliance mechanism is highly dependent on the price of E85, and hence its status an "alternative" mechanism.

More than 250,000 FFVs already operate in California, a number that is growing at a rate of 45,000 to 50,000 each year.[3] One major reason for the sale of FFVs in California to date is a provision of the federal Corporate Average Fuel Economy (CAFE) regulations that award automakers an additional mileage credit for FFVs. But this provision makes no requirement that these vehicles use alternative fuel, and the overwhelming majority does not. To avoid a similar "regulatory slippage" result, the AB 1493 regulations require documentation of E85 use in FFVs in order to claim the resulting GHG credit.

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[1] (Freeman 2006, Federal Highway Administration 2004, NADA 2006)

[2] Because FFVs obtain worse fuel economy on E85 than on gasoline (between 70-80%), it is more expensive than gasoline unless its price is 20-30% less per gallon. For instance, ARB estimated the price of E85 in its rulemaking analysis as 101% of gasoline on a per-gallon basis, which is about 35% more expensive than gasoline for the same mileage.

[3] (California Energy Commission 2005), citing California Energy Commission's Joint Agency Department of Motor Vehicles Data Project, in cooperation with the Department of Motor Vehicles.

The basic structure of the ACM involves three unique concepts:

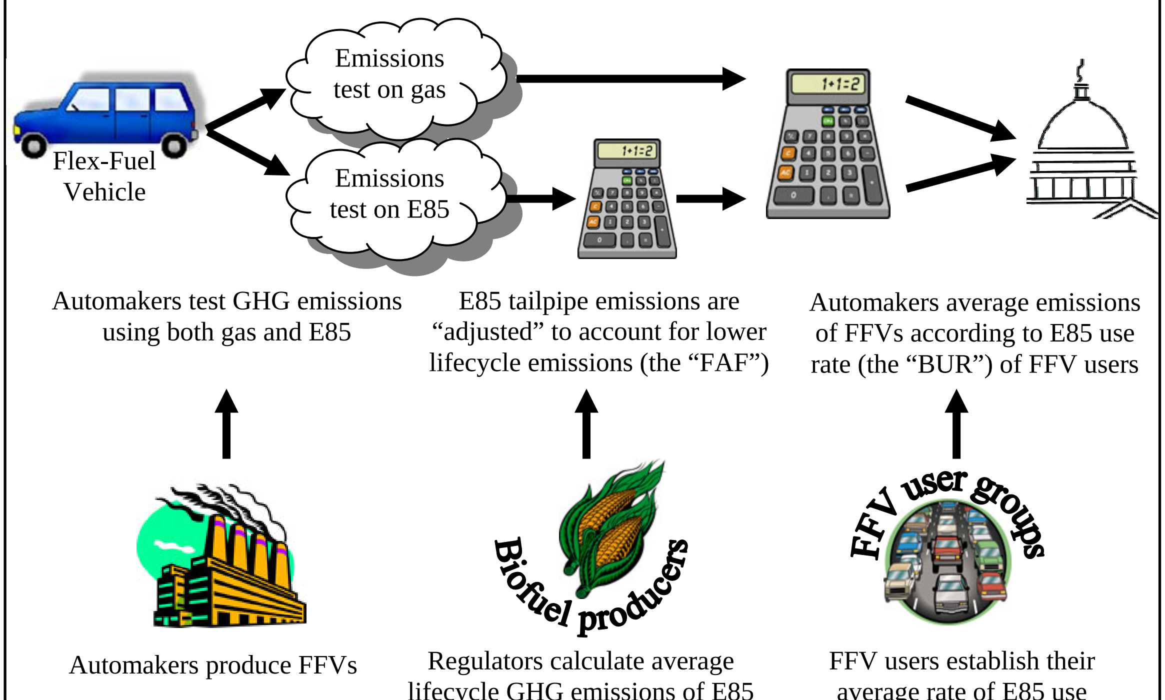
- FFV User Group: A conceptually and statistically separable group of FFV owners/users. This could be a specific fleet, owners of all FFVs sold by a particular manufacturer, or owners of all FFVs in service. The user group is the functional unit for determining the BUR and automakers can only claim the test emissions and FAF for FFVs sold to a user group with a demonstrated BUR.

> **AB1493 ACM Text**
> (Section 1961.1(a)(1)(B)2.a.) *"Optional Alternative Compliance Mechanisms.* Beginning with the 2010 model year, a manufacturer that demonstrates that a bi-fuel, fuel-flexible, dual-fuel, or grid-connected hybrid electric GHG vehicle test group will be operated in use in California on the alternative fuel shall be eligible to certify those vehicles using this optional alternative compliance procedure, upon approval of the Executive Officer."

- Biofuels Use Rate (BUR): The percentage of miles traveled by all FFVs in a user group using the relevant biofuel. The BUR establishes the proportion of estimated lifetime vehicle miles traveled for which the automaker can use the biofuel test emissions and FAF.

- Fuel Adjustment Factor (FAF): A multiplier applied to the test emissions of a vehicle running on biofuels to account for the 'lifecycle' emissions of the biofuel relative to gasoline. The FAF is based on lifecycle analysis of biofuel and petroleum fuel production.

FFV/E85 Alternative Compliance Mechanism Schematic



Part 1: Policy universe

1.1 California Policy

The ACM falls into a constellation of public policy in California surrounding the issues of climate change, criteria pollutant reduction, and energy diversification that bear on the technical issues of automobile technology, fuel infrastructure, and consumer choice.

1.1.1 2005 Integrated Energy Policy Report[4]

The State's biennial comprehensive energy plan includes multiple objectives related to the use of biofuels in FFVs. The report, and by implication its cooperating agencies and stakeholders, recognize increased use of high-blend ethanol in FFVs as part of an overall "transition to an efficient, multi-fuel transportation market."

The Report calls for specific State actions in regards to promoting E85 and FFVs, including:

- Developing and certifying E-85-compatible fuel dispensing systems.
- Implementing a process to expedite the permitting of E-85 stations.
- Investigating the feasibility of requiring all or a portion of new cars sold in California to be FFVs.
- Establishing a collaborative state/industry working group to prepare a strategic plan to exploit opportunities to incorporate E-85 into the existing retail fueling system.
- Sponsoring a consumer notification and education program promoting the availability of FFVs and E-85 fuel.
- Amending California's clean fuels regulations (discussed below) to incorporate broader emission and/or petroleum reduction criteria in the clean fuels outlet "trigger" provision and examine its authority to require automakers to produce as many FFVs as possible for the California market.

Moreover, in the Report's discussion of climate change policy, the Report finds:

- Emission performance standards and fuel or carbon performance standards are the most direct approach to reducing greenhouse gas emissions from motor vehicles.
- Market-based incentives should complement standards to increase low- and no-emission strategies for the transportation sector.
- State policies should empower consumer choices of low- or no-emission fuels, vehicles, and transportation options.

1.1.2 Bioenergy Action Plan[5]

Requested by the Governor in August 2005, the Plan was issued in final form in July 2006. The Plan was jointly developed by California Energy Commission (CEC), CARB, California Environmental Protection Agency (CalEPA), California Department of Forestry and Fire Protection (CDF), Department of General Services (DGS), California

[4] (California Energy Commission 2005)
[5] (Bioenergy Interagency Working Group 2006)

Department of Food and Agriculture (CDFA), Integrated Waste Management Board (IWMB), Public Utilities Commission (PUC), and Water Resources Control Board (WRCB). Addressing biomass energy utilization for electricity generation and natural gas and petroleum substitution, the Plan made the following recommendations relevant to E85 and FFVs:

- In preparing the State Alternative Fuels Plan (AB 1007) CEC will identify actions and incentives to increase the production and use of biofuels and to develop an extensive and convenient E-85 network in new and retrofitted service stations in California.
- The ARB will evaluate the suitability of using available regulatory levers (presumably including the Clean Fuels Program "outlet trigger") to encourage the establishment of E-85 stations in California by June 30, 2007.
- The State Department of General Services will develop an annual statewide vehicle asset plan by December 31, 2006, that will:
  - Include FFVs in the state's vehicle procurement program.
  - Require state agencies (for light duty, non-public safety applications, and other applications as practical) to purchase FFVs, increasing to 50 percent of total new vehicles purchased by 2010.
- ARB will consider a requirement increasing the percentage of E85-compatible vehicles sold in the state.

1.1.3 California Clean Fuels Program[6]

The California Clean Fuels Program includes a provision referred to as the "Clean Fuels outlet trigger." This provision requires retail fuel outlets to provide alternative fuel at their stations when the number of vehicles statewide capable of using the fuel reaches 20,000. This number of vehicles is discounted for fleet vehicles according to their likelihood of refueling onsite versus at private outlets. The Executive Officer of the ARB is charged with making the determination of whether the trigger is activated, and determining the number of outlets required by the regulation.

1.1.4 AB 2076: Reducing California's Petroleum Dependence[7]

Assembly Bill 2076 (Shelley), passed by the Legislature in 2000, required the California Energy Commission and California Air Resources Board to develop and adopt recommendations for the Governor and the Legislature on a California strategy to reduce petroleum dependence. The joint agency report, issued in August 2003, recommended that the Governor and Legislature adopt a statewide goal of reducing demand for on-road gasoline and diesel to 15 percent below the 2003 demand level by 2020 and maintaining that level for the foreseeable future.

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[6] (CCR Title 13, §§2300-2317 (1999))
[7] (California Energy Commission and California Air Resources Board 2003)

The report recommended that the Governor and Legislature should adopt a goal establishing a minimum fraction of on-road transportation fuel that is derived from non-petroleum sources. To be consistent with the overall petroleum reduction goal of 15% below 2003 petroleum demand, the agencies recommended an additional goal of 20 percent use of non-petroleum fuels by the year 2020 and 30 percent by 2030.

1.1.5 AB 1007: The Alternative Fuels Plan[8]

AB 1007 (Pavley) was signed into law in September 2005. Essentially a planning mandate, the law requires the California Energy Commission (CEC), in consultation with other state agencies, to develop a state plan to increase the use of alternative transportation fuels. The plan will set goals for increased alternative fuel use for the years 2012, 2017, and 2022 and the plan will recommend policies to attain these fuel goals, including:

- standards for transportation fuels and vehicles;
- mechanisms to ensure that FFVs use alternative fuels to the maximum extent feasible;
- and mechanisms to ensure that alternative fuel fueling stations are available.

1.1.6 AB 32: Global Warming Act of 2006[9]

AB 32 (Nuñez and Pavley) requires ARB to implement regulations to reduce statewide GHG emissions to 1990 levels by 2020. AB 32 was signed into law on Sept. 27, 2006, and regulations will not be developed for some time. The statute requires ARB to identify “sources or categories of sources” whose emissions are at “a level of significance that its participation in the program… will… effectively reduce greenhouse gas emissions.” ARB is also required to take into account the “relative contribution” of each source or category of sources. At 40% of California’s emissions, it is likely that the personal and light-duty vehicles sector will be identified as one or more sources, and prioritized in the sequence of regulation.

How AB 32 will interact with AB 1493 regulations is unclear. The ARB is required to promote consistency between AB 32 programs and existing and proposed international, federal, and state GHG reporting systems, and the statute specifies that it will not limit the ability of existing regulations to control GHG emissions. The statute also specifies that if AB 1493 regulations do not remain in effect, equivalent mobile source GHG regulations may be promulgated under AB 32. Thus, AB 32 is likely to be compatible with AB 1493 in regulating “tailpipe” emissions from the transportation sector, but there may be an opportunity for AB 32 to create a different regulatory system to address the “upstream” emissions of transportation fuels.

[8] (Division 26, California Health and Safety Code, Article 6.5)
[9] (Division 25.5, California Health and Safety Code)

1.2 Federal Policy

1.2.1 Alternative Motor Fuels Act of 1988 (AMFA)[10]

AMFA provides Corporate Average Fuel Economy (CAFE) credit for the manufacture of vehicles that are capable of using alcohol or natural gas fuels. The CAFE treatment of FFVs is very favorable, given that the vehicles are assumed to consume only 15% of a gallon of gasoline for every gallon of E85 consumed[11] and they are assumed to operate on E85 50% of the time.[12] Thus the credit can inflate FFVs' fuel economy by as much as 74%. The maximum CAFE credit that can be applied to the manufacturer's aggregate fleet value from the addition of FFVs is limited to 1.2 mpg for model years 1993 through 2010.

Most alternative-fuel vehicles produced in response to AMFA have been flexible-fuel vehicles designed to operate on E85. Perversely, because these vehicles overwhelmingly operate on gasoline fuels, multiple researchers have found that the credit serves to increase overall fuel consumption.[13] In their 2002 review of the AMFA CAFE credits, the Department of Transportation, Department of Energy, and Environmental Protection Agency recommended that Congress, "Examine alternatives to the current dual-fuel vehicle CAFE credit program structure, such as linking the CAFE credit to actual alternative fuel used."

1.2.2 Energy Policy Act of 1992[14]

The Energy Policy Act (EPAct) of 1992 established a national goal of reducing petroleum use by 30% by 2010. As one mechanism to achieve this goal, the legislation directed the Department of Energy (DoE) to promulgate regulations to require alternative fuel vehicle (including FFV) acquisitions by fleets of various types. DoE has promulgated these mandates for federal government, state government, and alternative fuel provider fleets that have more than 50 light-duty vehicles (LDVs) overall, with at least 20 vehicles in one of 125 designated metropolitan statistical areas. EPAct required that 75 percent of all covered light-duty vehicles acquired for fleets in FY 1999 and beyond must be AFVs.

The DoE's 2004 long-delayed decision not to promulgate a similar AFV acquisition mandate for local government and private fleets was vacated by court order in March of 2006. DoE will have until early 2008 to determine again whether a rule is necessary. In

[10] (Public Law 100-494)
[11] This is regardless of the actual blend level. In fact, because of denaturant in 'pure' ethanol and variance allowed in ASTM fuel standards for E85, E85 fuel can contain as little as 70-79% ethanol. (National Renewable Energy Laboratory and National Ethanol Vehicle Coalition 2006)
[12] The estimated 4 million FFVs in service in 2004 (MacDonald 2005) consumed an estimated 31 million gallons of E85 in 2004 (EIA 2004, Table 10), and so operated on E85 less than 1% of the time.
[13] DOT/DoE/EPA estimate that the AMFA credit increased the credited vehicles' petroleum consumption by 1% more than if they had not been awarded the FFV credit. (U.S. Department of Transportation et al. 2002)
[14] (Public Law 102-486)

September 2006, DoE issued a Notice of Proposed Rulemaking to redefine the EPAct petroleum reduction goal to 30% by *2030*. It is unclear what effect this redefinition would have on existing AFV acquisition mandates or the prospect for the local and private fleet rule. It is possible that this development increases the chance of an expanded mandate.

1.2.3 Executive Order 13149[15]

E.O. 13149, "Greening the Government through Federal Fleet and Transportation Efficiency," signed in 2000, reinforced the AFV acquisition goal of EPAct for federal fleets, extending the requirement to all fleets composed of 20 or more vehicles, requiring that FFVs operate on the alternate fuel the majority of the time, and requiring agencies to reduce petroleum consumption by 20% relative to 1999 by 2005 and thereafter.

1.2.4 Energy Policy Act 2005[16]

EPAct 2005 included several provisions relevant to E85 and FFVs:

- Section 701: Requires federal fleets to use alternative fuels in dual-fuel vehicles and FFVs, unless a waiver is granted.
- Section 702: Requires the U.S. General Services Administration (and other federal agencies that procure vehicles for fleets) to spread the incremental vehicle costs of AFVs among all vehicles.
- Section 772: Extended the current AMFA CAFE credits for FFVs through 2010. It also authorizes DoT to consider extending the incentives through 2014.
- Section 1342: Provides a tax credit for developing new private alternative fuel refueling stations equal to 30% of the cost, up to $30,000 for business property.
- Section 1501: creates the Renewable Fuels Standard (RFS). The RFS requires that gasoline sold by refiners, importers and blenders must contain an increasing amount of renewable fuel, such as ethanol or biodiesel, starting at 4 billion gallons in 2006, increasing each year by 700 million gallons, and reaching a level of 7.5 billion gallons in 2012. After 2012, renewable fuel production must grow at least the same rate as gasoline production. This quantity is somewhat complicated by the provision that under the RFS, one gallon of cellulosic[17] or waste-derived ethanol counts as 2.5 gallons through 2012. After that, the ratio no longer applies and 250 million gallons of cellulosic biomass ethanol must be included in the nation's annual fuel mix.

[15] (Executive Order 13149, 2000)
[16] (Public Law 109-58)
[17] "Cellulosic" ethanol refers to ethanol fermented from the more complex sugars contained in plant cellulose and hemi-cellulose. Unlike starch-based ethanol, such as corn- or sugar-derived ethanol, cellulosic ethanol may be made from almost any plant-based biomass, including agricultural residues such as rice straw or corn stalks, or purpose-grown energy crops such as switchgrass or poplar trees. The cellulosic ethanol process is considerably less fossil fuel- and GHG-intensive than corn ethanol (see discussion in Section 3), but it is currently more expensive and no commercial production facilities exist. Considerable research and policy efforts are directed at commercializing cellulosic ethanol.

1.2.5 Renewable Fuels Standard proposed regulations[18]

EPA released its Notice of Proposed Rulemaking (NOPR) for the Renewable Fuels Standard Program for 2007 and Beyond on September 7, 2006. These regulations set forth the mechanism for setting volumetric obligations of individual fuel refiners, blenders, and importers and of tracking compliance. The Renewable Identification Number and Equivalence Value mechanisms are of particular interest for the future of FFV/E85 systems.

- Renewable Identification Numbers (RINs) and Equivalence Value (EV): The EPA proposes that the regulated entities (fuel producers, blenders, or importers) will demonstrate compliance with their renewable fuel obligation by submitting Renewable Identification Numbers (RINs). RINs will function as compliance credits and can be bought, sold, traded, saved, and borrowed. RINs will be generated by renewable fuel producers with each batch of biofuels that is produced, or by importers by each batch imported (and RINs will be "destroyed" if biofuels are exported). Generally, each RIN will correspond with a volumetric gallon of ethanol that is produced and consumed. However, for fuels that are either statutorily defined to count for more than their volume, or that have significantly higher energy content than ethanol, an Equivalence Value (EV) will be applied to generate additional RINs. Thus, the EV for cellulosic ethanol will be 2.5 and biodiesel will have an EV of 1.5, meaning that 2.5 RINs will be generated per gallon of cellulosic ethanol, and 1.5 RINs per gallon of biodiesel. The EV will be included as a 2-digit code within the RIN.

1.3 Analysis of policy universe

1.3.1 Influence on FFVs and alternative fuel use

The policies, statutes, and regulations reviewed in this section all have bearing on the feasibility of the ACM to provide a significant strategy for automakers to meet AB 1493 GHG reduction targets. Each measure is oriented toward increasing the availability of FFVs and E85 fuel.

The largest driver of FFV production to date has been the CAFE fuel economy bonus credit awarded to automakers' FFV models. As this credit was extended in EPAct 2005, there will likely continue to be a strong incentive for automakers to produce FFVs at a level to at least maximize this credit.

The strongest driver in FFV acquisition has arguably been the fleet AFV requirements of EPAct 1992 and 2005 and further state fleet mandates suggested in the California Bioenergy Action Plan that create sizable markets for FFVs in California independent of AB 1493. Recent court decisions have even revived the potential of extending the AFV requirements to municipal and private fleets. Because of fuel use mandates (e.g. EO 13149 and EPAct 2005 §701) and centralized fuel management, these markets have

[18] (U.S. Environmental Protection Agency 2006)

potential to establish high biofuels use rates (BUR) and to generate the data necessary to claim fuel adjustment factor (FAF) credit under AB 1493 requirements (see discussion of the fleet BUR method, Section 2.2).

State policies also indicate momentum toward FFVs and biofuels among the general vehicle population. AB 1007 and the Bioenergy Action Plan suggest future state mandates for minimum percentage sales of FFVs among all cars sold in the state, and suggest that the Clean Fuels Program outlet requirements to increase the number of E85 pumps at retail fuel stations may be triggered as more FFVs come online.

1.3.2 Policy context and FFV cost-effectiveness for auto manufacturers

The combination of these policies creates both sizable supply of FFVs and biofuels by automakers and fuel providers and significant demand for FFVs and biofuels by several consumer segments in California, independent of the provisions for FFVs under AB 1493. At the same time, FFV technology incurs very little production cost premium to manufacturers,[19] and does not negatively affect vehicle performance. Thus, as long as *any* BUR can be established for some or all FFVs, the cost-effectiveness of FFVs as an AB 1493 compliance technology is relatively high from an auto manufacturers' perspective.

For instance, using E85 in FFVs can result in a GHG reduction of roughly 30%, calculated using the current AB 1493 regulation's "fuel adjustment factor" (FAF) for E85[20] (though the actual relative emissions can vary tremendously[21]). Thus 100% E85 use in FFVs would result in GHG reductions roughly equal to the total GHG reductions required for the "average" vehicle by the end of the medium-term (2016) phase-in of the AB 1493 regulations. ARB staff calculated the average per-vehicle cost of "primary compliance" technologies required to meet these regulations as $539 for passenger cars and light-duty vehicles and $851 for medium-duty vehicles. Because FFV's don't incur these up-front costs, there is an implicit value $400 - $850 in avoided costs per vehicle sold to a fleet that is able to document 100% biofuels use. By extension, achieving *any* level of state-wide biofuels use rate that can be used as an estimate for biofuels use in new FFVs has an implicit value of $5.14 per medium-duty FFV sold for each percent

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[19] While automakers have been reluctant to reveal cost data, in their response to questions for the 2002 DOT/DoE/EPA Report to Congress on the AMFA FFV CAFE credit (U.S. Department of Transportation et al. 2002), GM, Ford, DaimlerChrysler, and the Alliance of Automobile Manufacturers reported cost or price differentials between $0 and $125 per vehicle for flex-fuel capability. In the AB 1493 ISOR (California Air Resources Board 2004), the ARB estimated a $0 incremental cost to manufacturers for producing flex-fuel capable models. Rubin and Leiby (2000) estimated in 1999 that producing FFVs created positive value for automakers because the AMFA CAFE credit avoided $550 – $1100 in terms of CAFE penalties.

[20] This 30% is the product of both the 26% upstream GHG reduction implicit in the current FAF of .74 and the "tailpipe" emissions reduction of 4-6% that has consistently been reported for FFVs using E85 relative to the same vehicle using gasoline (discussed in Section 3.2)

[21] Depending on the actual ethanol and gasoline production processes, the total lifecycle GHG emissions of biofuels relative to gasoline can vary significantly, with current production processes representing a range of 0% to -50% difference with gasoline, with even greater variation possible in the future. This variance is described in more detail in Section 3.

BUR in 2009 and $11.55 in 2016 (Table 1.1). Because these are average estimated technology costs across all manufacturers, the avoided costs for some manufacturers may be much higher.

Table 1.1 Avoided technology costs

Model Year	Vehicle Type	Required % GHG reduction	Estimated cost of GHG reduction via "primary compliance" technology	Estimated cost per 1% GHG reduction	Value of "avoided technology" with 1% BUR and FAF = .74
2009	PC/LDT1	-1.3%	$16	-$12.31	-$3.69
	LDT2	-2.1%	$36	-$17.14	-$5.14
2012	PC/LDT1	-24.9%	$292	-$11.73	-$3.52
	LDT2	-18.3%	$308	-$16.83	-$5.05
2016	PC/LDT1	-33.9%	$626	-$18.47	-$5.54
	LDT2	-24.8%	$955	-$38.51	-$11.55

1.3.3 Fuel cost and consumer welfare

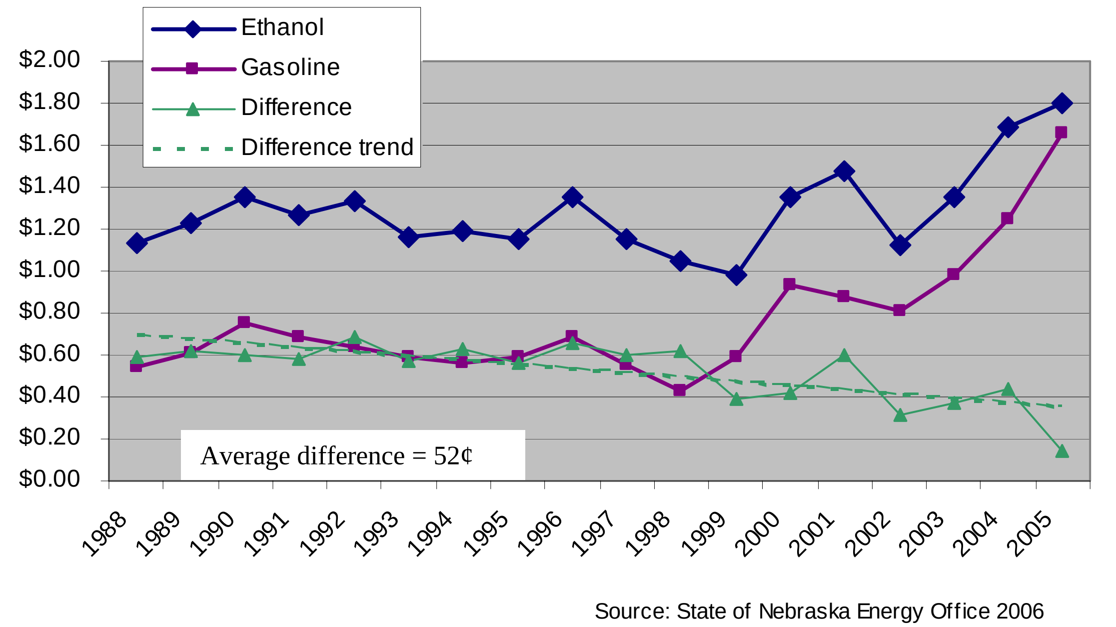
The language of AB 1493 defines the cost-effectiveness of the regulation as the maximum technologically-feasible GHG reduction that is, "economical to an owner or operator of a vehicle, taking into account the full life-cycle costs of a vehicle." ARB rejected FFVs and E85 use as a primary compliance strategy because, in addition to difficulty in assuring biofuels use, the assumption of a higher price of E85 relative to gasoline would entail a high cost to consumers. This assumption results in a negative net present value for consumers, and a significantly lower cost-effectiveness than other technologies, in meeting AB 1493 goals, from an individual consumer's perspective.[22]

Because the technology cost of FFVs is low, fuel cost is the major determinant of the cost-effectiveness of E85/FFV use both as a GHG abatement strategy and as an AB 1493 compliance strategy. When the cost of E85 is roughly equivalent to gasoline on a per-mile basis (that is, the cost per gallon of E85, multiplied by the ratio of MPG_{E85} to $MPG_{Gasoline}$, is commensurate with the gasoline price per gallon[23]), then there is a positive net present value for consumers of the FFV/E85 technology.

Thus the price of E85 is critical. Predicting or estimating the cost of E85 is a complex task. Its supply and demand are changing radically and rapidly and it is both contradictory and variable in its economic relationship to other transportation fuels. Historically, the price of ethanol has roughly mirrored the cost of gasoline, with a 51-cent average price premium (since 1990) matching the federal fuel subsidy, so that retail

[22] The ISOR calculated a negative net present value of -$4023 for FFV technology, based on the increased cost of fuel (relative to fuel economy) to consumers over an average 16 year vehicle service life.
[23] This MPG ratio in contemporary FFVs ranges from 72-80%, meaning that the nominal price of a gallon of E85 should be 72-80% that of gasoline to be cost-competitive. ARB used a ratio of 17.6/24.8 (71%) for the MPG difference between an FFV using E85 and a baseline gasoline vehicle.

Figure 1.1: Nebraska wholesale ethanol and gasoline prices 1988-2005



prices are roughly equal on a per-gallon basis.[24] This price differential may be narrowing over time (Figure 1.1). The AB 1493 ISOR used a price for CARFG of $1.74 per gallon while E85 was assumed to sell for $1.76 for a nominal gallon (roughly $2.38 on a mileage-equivalent basis).

Ethanol has economic status as both a complement (as an oxygenate and/or octane enhancer) and a substitute (as E85) to gasoline. It is likely that the higher ethanol prices are driven by demand for the fuel as a complement.[25] Under this theory, E85 prices will only fall (and hence be an effective mass-market gasoline substitute) when the oxygenate market is satisfied.

Ethanol supply continues to expand rapidly (Figure 1.2). Since 1996, domestic ethanol production has increased at a 15% average annual growth rate.[26] Since 2002, the domestic production has grown at a 21% annual rate, and anecdotal evidence indicates this trend is increasing further with recent explosion in investment in ethanol production, both domestically and abroad. New ethanol technologies such as cellulosic ethanol or in-state production from municipal or agricultural waste resources may promise further production supply increase and cost decreases. On the other hand, if and as more states pass mandates for minimum ethanol blends in gasoline, the fuel additive market may continue to soak up the supply of ethanol, keeping prices generally high. In short, it is very hard to predict where E85 prices will develop in comparison to gasoline prices.

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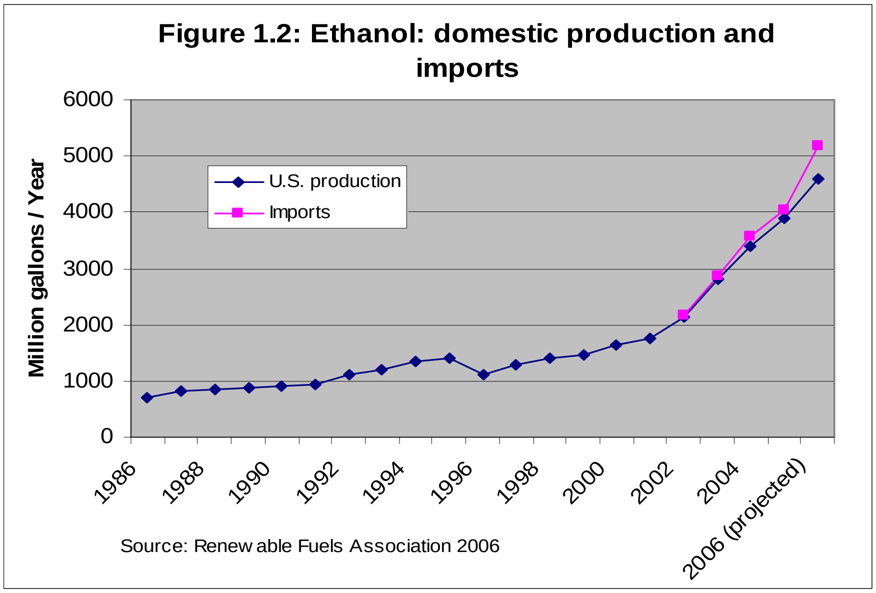
[24] (State of Nebraska Energy Office 2006)

[25] This effect was especially noticeable in the wake of MTBE bans, when as the first summer oxygenate season began without MTBE, prices spiked (briefly) at more than $4 per gallon wholesale in July 2006 (California terminal prices from Oxy-Fuel News, provided by (California Energy Commission 2006)

[26] (Energy Information Administration 2006, Renewable Fuels Association 2006)

However, it is important to note that what matters for consumer welfare is consumer willingness-to-pay (WTP). Theoretical[27] and empirical evidence would indicate that consumers exhibit a higher WTP for alternative fuels (including E85) than for petroleum fuels. One of the best empirical datasets supporting this observation is the State of Minnesota's E85 sales records.[28] Minnesota has demonstrated an extraordinary biofuels use rate, with an 8% monthly growth in E85 use over the last 4 years (200% annually between 2004 and 2006), and an average statewide BUR of nearly 18% presently. This remarkable use has occurred where the price of E85 has cost an average of $0.32 more on a mileage-equivalent basis (on a per-gallon basis, E85 ranged from $0.08 more expensive to $0.45 less expensive.) Minnesota admittedly has an extremely high social premium on the locally-produced ethanol fuels, but California also contains many market segments that display extraordinary dedication to social/environmental criteria. Alternatively, as E85 averaged $0.27 less than gasoline on a per-gallon basis, the growth in sales may also reflect an inability or unwillingness of many consumers to calculate mileage-equivalent cost.



Moreover, the willingness-to-pay for E85 in fleet applications (where mandate or institutional commitments require AFVs and alternative fuel use) is likely much higher still. Public fleets, especially, that are mandated to use alternative fuels in AFVs in their fleets should not be thought to incur any increased cost to achieve GHG reductions through these actions that are otherwise required. In these cases, the only incremental cost to E85 in FFVs for AB 1493 compliance occurs in the data collection necessary to document these fleets' biofuels use rate (BUR).

[27] (Sperling et al 1995) found that 85% respondents to a contingent valuation survey would be willing to pay at least 2¢ more per gallon for methanol fuel with a suggested but unspecified air quality benefit, while 25% would be willing to pay as much as 45¢ more. (Interestingly this research also found significant WTP for increased octane and power in fuels, qualities that ethanol blends also offer).
[28] (Trudeau, 2006)

1.3.4 Alternative Compliance Mechanism and the future of GHG policy

AB 1493, like other vehicular air pollution regulations, is generally concerned with the "tailpipe" emissions of vehicles; the regulation establishes exact limits on the mass of greenhouse gas pollutants that may be emitted by motor vehicles in use. However, the Alternative Compliance Mechanism that credits alternative fuels with their lower upstream emissions relative to gasoline is potentially unique in that it implicates additional sectors, including fuels and agriculture, in a vehicle regulation.

This conflation of sectors may become increasingly problematic as additional GHG regulations come into force in California, the nation, and internationally. The primary critique is that fuel- and agricultural-sector emissions should be regulated directly. Auto manufacturers have no direct authority over fuel producers, and much less over agricultural producers, and yet the Fuel Adjustment Factor provision of AB 1493 gives automakers responsibility (without authority) over emissions in these sectors.

Future regulatory structures, including those to be developed according to AB 32, may seek to establish fuel-sector specific regulation. Such regulation could capture the "well-to-pump" emissions of each volume of fuel. Then vehicles would only be responsible for the carbon released from the fuel in combustion, the "pump-to-wheels" emissions.

Three possible future regulatory structures include:

- "Point source" regulation, including cap-and-trade: Each GHG-emitting 'technology' in the "fuel-and-vehicle" system would be treated as a point source. AB 1493's primary mechanisms do this with vehicles, by requiring precise GHG emission limits at vehicle tailpipes. A complete set of point source regulations would similarly regulate all "tailpipes" in the fuel production cycle - including freight trucks, tractors, and trains, as well as traditional "smokestacks," and including oil wells, refineries, and biorefineries. The remaining traditional non-point source, agricultural fields, would need creative regulation to also be treated as a point – through regulation of inputs, or treated with a regulatory "bubble" covering each producer's total field operations.

  Carbon released at the tailpipe (or smokestack) that was 'recently' absorbed from the atmosphere would need to be excluded. Thus this system would not require lifecycle analysis (and so would not require the application of a fuel adjustment factor (FAF), discussed in Section 3), but would require applying a biofuels use rate (BUR) (discussed in Section 2).

- A GHG-intensity standard for fuels. A maximum "upstream" emissions level can be set for fuels, with trading to allow the use of a range of fuels of different intensities. Biofuel lifecycle emissions would be calculated, but would be regulated at the fuel blender/distributor/importer point. The RIN and EV mechanisms proposed by EPA to implement the Renewable Fuels Standard lay the foundation for just such a program. Thus a FAF would not be necessary for automakers under AB 1493 (though a BUR would still be necessary to claim the tailpipe emissions of using biofuels in FFVs).

- Carbon charge: A carbon charge (GHG tax) would create monetary charges for all products containing fossil carbon, or that release other GHGs in use. Thus all fuels, including gasoline and biofuels, would be taxed according to the fossil (i.e. fixed from the atmosphere more than 100 years ago) carbon contained in the fuel. Any GHGs released in the making of the biofuels, including N_2O emissions from agriculture and energy use in the biorefinery, would be charged to the farmer and biofuel producer, respectively. Because all GHG emissions would be accounted for by the time a consumer purchased fuels at the pump, neither a BUR nor FAF calculation would be necessary.

In the absence of any of these more comprehensive regulatory structures, the alternative compliance mechanism of AB1493 provides an appropriate partial and temporary strategy for incorporating the lifecycle impact of fuels. But future GHG regulation, including AB 32, may implement more direct regulation of the fuels sector. When such regulation is created, the 'fuel adjustment' provisions of AB 1493 should be eliminated.

Part 2: Biofuel Use Rate

2.1 Summary

AB 1493's ACM requires automakers to demonstrate the use of alternative fuels in bi-fuel and flexible-fuel vehicles. The intention behind this provision is to prevent the type of regulatory slippage that has occurred in the FFV CAFE-credit provision in AMFA.[29] Thus the feasibility of demonstrating a biofuel use rate (BUR) for specific sets of FFV users becomes central to the ability of automakers to meet AB 1493 goals through the sale of FFVs. The language of the regulation (see Box 2.1) focuses on one method for documenting BURs: data collection by centrally-fueled fleets. However, the regulation reserves significant discretion to the Executive Officer of ARB to accept alternative BUR methods. This section examines the potential of additional markets to document biofuels use in FFVs, including:

- More expansive fleet-based documentation
- General population biofuel use

This section also examines several technical means to gather sufficient documentation, including:

- Card-lock or purchase-card data
- Onboard diagnostic data
- Average statewide biofuel sales

2.2 Use of the Biofuels Use Rate (BUR)

The "Optional Alternative Compliance Mechanisms" (see text in Introduction) identified in the regulation indicates that the purpose of the Biofuel Use Rate is to demonstrate the percentage of the vehicle's operation that is operated on the biofuel so that the appropriate GHG emissions test results and fuel adjustment factor are used.

When establishing the tailpipe emissions of flex-fuel vehicles, automakers and regulators test FFVs separately using gasoline and E85. The gasoline emission profile is the assumed default emissions. The biofuel tailpipe emissions are "adjusted" using the FAF and are used for the proportion of lifetime emissions established by the BUR.[30] Thus the average emissions for a FFV (sold to a user group with an established BUR) is determined as the BUR-weighted average of the gasoline and 'adjusted' biofuel emissions profiles.

2.2.1 Identifying User Groups

Because AB 1493 regulations rely on the *predicted* emissions of vehicles, calculated at the time those vehicles are sold, the alternative fuel use rate of that vehicle over its lifetime is also be predicted in advance. Because the biofuels use rate is a function of the

[29] Several studies have shown that the FFV "CAFE loophole" has either not achieved its goal of petroleum displacement (U.S. Department of Transportation et al. 2002) or has done so at a relatively high cost (Rubin and Leiby 2000), primarily because there is no guarantee of actual alternative fuel use.
[30] FFV tailpipe emissions and the FAF are discussed in Section 3

vehicle user's choices, the BUR prediction must in turn be based on a prediction of a specific FFV user (or user group) behavior.

Thus, the ACM requires specific, segregatable groups of FFV users, about which some estimate can be made of their biofuel use rate over the lifetime of vehicles that are sold to them. Only then can automakers use the tested emissions and FAF of an FFV operating on biofuel, and only for the percentage of vehicle operation established by the BUR, and only for the number of vehicles sold to that specific group of users.

The current regulation envisions that these conditions can only be established for fleets of vehicles operated by an institution that actually provides fuel on-site. This implicitly assumes that all other FFVs will operate on biofuels 0% of the time. Thus, the regulation could miss substantial biofuel use in the future, and disadvantage FFVs within the state's emerging universe of vehicular GHG reduction strategies.

Instead, it is possible to assign an average biofuels use rate to each of several sets of FFV user groups, including multiple types of fleets, as well as a "catch-all" group encompassing all other FFVs in service. A minimum level of data and data quality is all that is required. Many fleets are able to collect adequate data, not only through on-site fueling but also through fleet-management systems. In addition, a default "general vehicle" percentage can be applied as a default value based on the level of biofuels use achieved by all FFVs in service. In the future, OBD systems may be able to provide additional BUR, such as for rental cars.

2.1.3 Type of data required

The language of the regulation (see Box 2.1) specifies that the data necessary to demonstrate alternative fuel use include, "the percentage of total vehicle miles traveled by the…vehicles…using the alternative fuel and using gasoline." Read literally, the only way to accurately capture these data is through comprehensive fuel-stream and mileage monitoring through onboard diagnostics systems. In all other cases, this percentage can only be estimated using some number of assumptions. The data necessary to estimate this statistic are:

- gross consumption of both alternative fuel and gasoline, <u>or</u>
- consumption of gasoline <u>or</u> alternative fuel <u>and</u> total miles traveled

and

- published fuel economy of the vehicle when operating on each fuel
- average number of years in this application

Calculating this statistic is more problematic than the regulatory language suggests, because the data most likely to be known, fuel consumption, are related to miles traveled by fuel economy, which is a problematic average to begin with[31] that further varies by the fuel used.

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[31] EPA fuel economy ratings are based on laboratory dynamometer tests of prototype vehicles with reduced functionality. These tests poorly represent real-world driving conditions, let alone seasonal, regional, and

2.1.4 BUR will vary over life of vehicle

The length of time in service in the application is necessary to calculate the lifetime BUR. The BUR and FAF credit awarded for biofuel use occurs at only one point in time, when the vehicle is first produced, but is intended to represent the proportion of biofuels use consumed over the vehicle's lifetime. Thus by definition, the ACM requires an assumption as to the lifetime use of the alternative fuel. But biofuels use patterns are likely to vary over a vehicle lifetime, especially when ownership or market conditions change.

The method outlined in the regulation for calculating the GHG emissions of current model year FFVs is especially prone to distortion, as it is based on the relative use of the alternative fuel by the *previous model year* FFVs. That is, the biofuels usage demonstrated *for one year* by the previous model year's FFVs is assumed to represent the biofuels use that the current model year FFVs will achieve throughout their lifespan. This approach is prone to inaccuracy in two ways. In the first instance, auto manufacturers could inflate their GHG savings achieved by FFVs by creating incentives for biofuels use in the first year of operation that disappear, along with biofuels use, after the first year's data have been collected. In the second instance, fleets that utilize FFVs and on-site biofuels use for a relatively short length of service may then release vehicles to the general population that then cease or decrease biofuels use.

According to Bobit Fleet Fact Book,[32] 65% of fleet vehicles that were "remarketed" in 2004 were MY 2001 or newer, and only 22% were MY 1999 or older. The Energy Information Agency assumes that automobiles are kept an average of 35 months by business fleets, 68 months by utilities, and 81 months by government. Light trucks are kept an average of 56, 60, and 82 months by business, utilities, and government, respectively.[33] These statistics indicate that the potential for "slippage" from using one year's data for a estimating the biofuels use over an 8- to 16-year vehicle lifespan is high. Instead, such a vehicle's estimated lifetime biofuels use rate should be calculated using the fleet rate for the number of years it is likely to be in the fleet, averaged with "general public" biofuels rate for the remainder of the vehicle lifetime. Generically, this would be calculated as:

$$BUR = \frac{\sum_{i=1}^{N}(BUR_i \times T_i)}{\sum T_i}$$

where i = each user group, up to N such groups, and T_i = years in service in each user group.

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fuel specification differences. EPA applies correction factors to the city and highway ratings to capture some of this difference, but these factors were last updated in 1984. Recent analysis of user-reported MPG results compared to EPA's ratings reveal a broad correspondence at the aggregate level, but significant variation in individual experience (Greene et al. 2005).

[32] (Bobit Publishing 2005)

[33] (Energy Information Administration 2006)

In addition to the fact that this one-year data restriction is distortionary, the following discussion of BUR documentation methods demonstrates that it is not necessary (except, of course, in the first years of a BUR-demonstration program). All BUR methods discussed below can and should use longer-term data to calculate the BUR.

2.2 Fleet-based BUR

Box 2.1: AB1493 text of fleet-based BUR

(Section 1961.1(a)(1)(B)2.a.i.): "To demonstrate that bi-fuel, fuel-flexible, dual-fuel, or grid-connected hybrid electric vehicles within a GHG vehicle test group will be operated in use in California on the alternative fuel, the manufacturer shall provide data that shows the previous model year sales of such vehicles to fleets that provide the alternative fuel on-site... This [sic] data shall include both the total number of vehicles sales that were made to such fleets or end users... and as the percentage of total GHG vehicle test group sales. The manufacturer shall also provide data demonstrating the percentage of total vehicle miles traveled by the bi-fuel, fuel-flexible, dual-fuel, or grid-connected hybrid electric vehicles sold to each fleet... in the previous model year using the alternative fuel and using gasoline."

The mechanism is nominally limited to those fleets capable of fueling FFVs from onsite E85 tanks and dispensers (see Box 2.1). However, many fleets that utilize off-site refueling could also be capable of collecting appropriate data. This study therefore examines both on-site and off-site refueling scenarios.

"Fleets" have an ambiguous definition, but are generally understood in this context to indicate a group of vehicles owned and/or operated by a single entity. What is important is that the fleet entity have logistical or administrative benefits of scale in instituting a FFV/E85 program and of collecting and reporting data from the program. Entities that operate such fleets in California include the state and federal governments, local governments and special districts, and private companies. These fleets span a wide array of applications, from agency staff transportation to taxis and rental cars. These fleets may also have other cost, logistical, and administrative advantages in that many fleets are otherwise mandated to purchase AFVs and to use alternative fuel, as discussed in Section 1.3.1.

2.2.3 On-site fueling

The scenario envisioned by the ACM regulation focuses on the centrally-fueled fleet, such as the Lawrence Berkeley National Laboratory case discussed in Box 2.2. These fleets are presumed to have the greatest ability to document the use of E85 use. Certainly, on-site fueling at federal facilities has demonstrated the highest BUR among federal agencies struggling to comply with E.O. 13149.[34] In addition, these fleets may be able to accurately secure and track specific biofuel supplies with unique upstream emissions, so that specific FAF may be awarded. Therefore, on-site fueled fleets may be an excellent application to demonstrate high BUR and even individual FAF.

[34] (Putsche 2006)

Box 2.2: Case Study: Lawrence Berkeley National Laboratory

LBNL implemented E85 vehicle and fueling infrastructure in 2004. The program has been in response to the federal Executive Order 13149: "Greening the Government through Federal Fleet and Transportation Efficiency " which as a Department of Energy facility the Lab is obliged to follow. Its success makes it one of the very few federal facilities to meet EO 13149 fuel use targets.

LBNL currently operates 86 FFVs, including sedans and light- and medium-duty pickups, out of a fleet of 270 vehicles. A 4,000-gallon tank and dedicated E85 pump have been installed for the FFVs. The process of establishing on-site refueling capacity has been an ongoing challenge because of logistical, technical, and regulatory hurdles. The total cost of infrastructure is estimated at $130,000.

Fueling data are collected by OPW fuel management software running on PetroVend fuel control equipment. Fuel supply is provided on a Department of Defense Energy Support Center contract with Western Biofuels Company, and is priced at a fixed premium over the wholesale spot price of ethanol occurring on the day of delivery. Each FFV has an associated fuel card which only activates the E85 pump.

The program has recorded the overall E85 and gasoline fuel use of the fleet. In FY2005, the fleet as a whole consumed 54,000 gallons of gasoline and 11,000 gallons of E85 (the E85 pump was offline for 7 months of the year). In FY2006, LBNL used 23,500 gallons of E85 and 40,150 gallons of gasoline. LBNL does not currently segregate FFV fuel management data from non-FFVs, so a BUR cannot be calculated from these data. However, according to fleet manager Bill Llewellyn, collecting and reporting these data to dealers or manufacturers would not require significant alteration of procedures.

LBNL leases its FFVs through the U.S. General Services Administration. GSA tracks the warranty maintenance schedules and warranty maintenance is performed by the dealer. If alcohol fuel data were collected by the OBD system, this centralized maintenance would provide ample opportunity to collect these data.

Source: (Thorson 2005, Llewellyn 2006)

According to the California Energy Commission's database of fueling facilities in the state, updated through 2001-2002, there are over 400 federal, 500 state, 1500 "utility", 2300 local, and nearly 6000 "private" (not retail) fueling facilities in the state.[35] These numbers overstate actual fuel outlets to a large but unknown extent because some locations have multiple entries in the database according to their number of storage tanks, and some entries represent storage sites that have no refueling capability. Further, of course, these sites may be low-fuel-throughput and may serve only a few vehicles, or they may serve heavy-duty vehicles or otherwise not serve vehicles covered by AB 1493.

[35] (California Energy Commission 2002)

Nevertheless, these data suggest that there are many fleet fueling outlets in the state that may be appropriate loci for "on-site" BUR.

2.2.4 Off-site fueling

Central fueling is not necessary for the fleet-based BUR to produce high-quality biofuel use data. Fleets may utilize one of several types of off-site fueling systems that could also function to document alternative fuel use. These include:

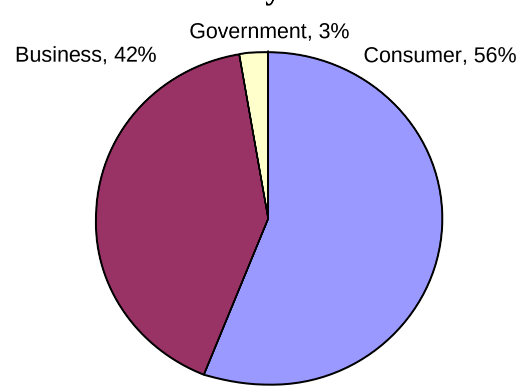
- Public (government) or utility company multi-fleet fueling stations
- Card-lock private fueling stations
- Purchase-card tracking of retail fuel purchases

The key to data collection in each of these instances is accurate and comprehensive tracking of fuel use in specific fleets, through fuel management software in dispensers that distinguishes fuel types and tracks purchases to specific vehicles. Where these conditions obtain, these mechanisms are theoretically just as valid as centrally-fueled fleet scenarios.

Increasing numbers of fleets have instituted sophisticated fuel data management programs. While private companies have instituted these programs to control costs, the federal and California state governments have instituted fuel tracking programs to monitor compliance with AFV and petroleum reduction goals.[36] All these methods rely on card-based data capture, discussed in Section 2.4.3.

2.2.5 Calculation of Potential Penetration

Figure 2.1: Share of New Vehicle Sales by Sector



Source: BTS National Transportation Statistics 2004 Table 1-18

The potential market for FFV in fleets in California is quite large. Government agencies alone maintain nearly 500,000 vehicles in the state. Nationwide, public and private fleet sales account 45% of all new vehicle sales. Centralized fleets of 20 or more vehicles are over 17% of all new passenger and light truck registrations.[37] Applying this percentage to the roughly 2 million annual new passenger vehicle sales in California yields an estimate of nearly 350,000 vehicles sold to fleets annually in the state. A bottom-up estimate derived from numerous published sources detailed in Table 2.1 results in an estimate of nearly 300,000 vehicles sold to fleets in California per year.

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[36] The federal government, each state, and "alternative fuel providers" (including most power utilities) track AFV/FFV acquisitions and alternative fuel use, in order to demonstrate compliance with EPAct and E.O. 13149 obligations (EERE 2001-2006). California also tracks state fleet alternative fuel vehicle inventory and acquisitions and alternative fuel use in compliance with SB 552 (California Department of General Services 2006).

[37] (Bobit Publishing 2005)

These fleet sales are extremely concentrated among a few manufacturers and a few models. American-based manufacturers compose 83% of fleet sales. Between these manufacturers, five models in each class accounted for more than 50% of all fleet registrations (46% of SUVs, 50% of cars, and 90% of light trucks) in MY 2004.[38]

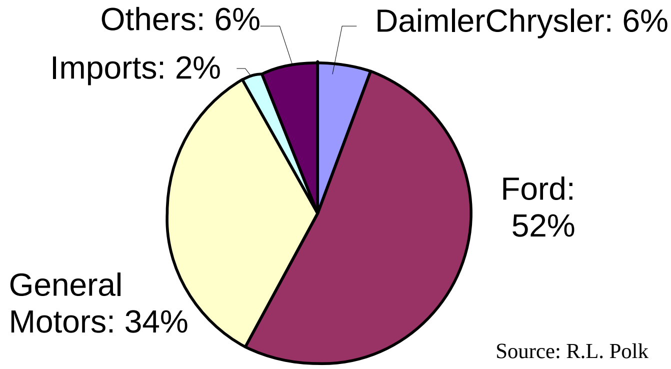
Table 2.1 illustrates the number of vehicles in fleets of different types nationwide and in California. There are several different types of fleet that have different BUR potential. Government and utility fleets, because of their responsibility to comply with various AFV and alternative use mandates and their centralized fuel control, are a primary market. But corporate and commercial fleets also have potential for centralized fuel data management and policies to encourage biofuels use. Finally, rental car fleets are a very large new vehicle purchaser and may in the future have some ability to demonstrate BUR.

2.2.5.1 Government Fleets

The federal government purchases between 50,000 and 70,000 vehicles a year (65,000 in FY2004 and FY2005).[39] 45,000 of those are in centralized fleets that qualify under the AFV requirements of EPAct and EO 13149.[40] Under this mandate, federal agencies purchased 17,000 FFVs in 2005. Assuming California accounts for roughly 10% of these, roughly 1,700 FFVs could be purchased by federal agencies in California per year.

The State of California purchases nearly 5,000 vehicles a year. In 2003, California state E85 FFVs numbered 1185.[41] New FFV purchases by state fleets were 736 in1999-00, 326 in 2000-01, and 106 in 2001-02. This decline represents recent rule changes by the Department of General Services; state fleets may only purchase AFVs for which fuels are available in California. This effectively precludes new FFV purchases unless and until E85 fuel becomes available to the purchasing agency. However, more recent policy seems to be reversing this decision. The Bioenergy Action Plan (discussed in Section 1.1.2) calls for a state policy requiring 50% of state fleet acquisitions to be FFVs by 2010. Also, California has recently initiated a new FFV adoption experiment with the cooperation of GM, Chevron, and Pacific Ethanol in establishing E85 fueling stations. At a 50% FFV acquisition rate, the State could purchase more than 2,500 FFVs per year.

Figure 2.2: Share of MY2004 Government Fleet Sales by Manufacturer



Source: R.L. Polk

[38] (Bobit Publishing 2005)
[39] (U.S. General Services Administration 2006)
[40] (EERE 2001-2006)
[41] (California Energy Commission et al. 2003)

Table 2.1: Actual and estimated fleet vehicles						
Currently inventory						
	Nationwide			**California**		
Sector	**All Vehicles**	**AFVs**	**FFVs**	**All Vehicles**	**AFVs**	**FFVs**
Federal	**590,000** [b,2]; **380,000** [a,3]	**96,000** [2]	**83,000** [2]	**61,000** [6]	**9,700** [4]	**7,000** [4,b]
State	*500,000* [B,a,3]	**58,000** [b,8]	**33,000** [b,8]	**38,000** [7]	**5,300** [7]	**1,800** [b,12]
Local	*1,900,000* [B,a,3]	**77,000** [b,8]	**8,100** [b,8]	**390,000** [B,6]		**3,600** [b,12]
Utilities	**320,000** [9]	**33,000** [b,8]	**3,500** [b,8]	*32,000* [G]		
Private	**3,200,000** [a, 3]	**320,000** [b,8]	**45,000** [b,8]	*320,000* [G]		**28,350** [b,12]
Rental	**2,100,000** [a, 3]			*210,000* [G]		**28,350** [b,12]
Taxi	**160,000** [a, 3]			*16,000* [G]		
Total	*8,800,000*		*>170,000*	*1,100,000*		**69,000** [b,12]
Annual acquisitions						
	Nationwide			**California**		
Sector	**All Vehicles**	**AFVs**	**FFVs**	**All vehicles**	**AFVs**	**FFVs**
Federal	**45,000** [1]; **65,000** [2]	**17,000** [1,2]	**17,000** [1,2]	*6,500* [G]	*1,700* [E,4]	*1,300* [E,4]
State	*30,000* [A,a,3]	**6,400** [5]	**5000** [5]	**4,900** [7]	**300** [7]	**100** [b,10]
Local	*120,000* [A,a,3]			*12,000* [G]		
Utilities	*63,000* [F]	**1,500** [5]	**600** [5]	*6,300* [G]		
Private	**680,000** [3]			*68,000* [G]		
Rental	**1,900,000** [3]			*190,000* [G]		
Taxi	*31,000* [F]			*3,100* [G]		
Total	*2,900,000*			*290,000*		**6,800** [b,11]

Notes:

- Bold = reported data,
  Italics = estimated data
  a = Vehicles in “Fleets” with 15+ inventory and/or 5+ acquisitions/year;
  b = all vehicles
- 1 = (EERE 2001-2006)
  2 = (U.S. General Services Administration 2006)
  3 = (Automotive Fleet 2005)
  4 = (Sirk 2006)
  5 = (EERE 2005)
  6 = (Federal Highway Administration 2005)
  7 = (California Department of General Services 2006)
  8 = (Energy Information Administration 2004, 2005)
  9 = (Bureau of Transportation Statistics 2005)
  10 = (California Energy Commission et al. 2003)
  11 = (California Air Resources Board 2004)
  12 = (California Energy Commission 2005)
- A: 215,202 total government MY2004 registrations (from source 3) minus 64,613 Federal acquisitions, divided 80/20 local/state;
  B: 2,434,00 "State, County, and Local" fleet vehicles (from source 3) divided 80/20 local/state;
  C: Source (5) lists 5,404 FFVs were acquired by S&FP, with states having a much higher proportion as FFVs. The breakdown between these is a guesstimate based on these facts.
  D: Estimated FFVs in use in state from (8), minus federal and state numbers
  E: Average change in number of vehicles FY 2000 - FY 2005
  F: Assume 20% replacement rate
  G: Assume CA accounts for 10% of national inventory or acquisitions

The Federal Highway Administration reports that in 2004 there were approximately 430,000 vehicles in use by state, county, and municipal entities in California. Subtracting State and Federal vehicles, a rough estimate of 390,000 vehicles may be calculated for county, municipal and special district fleets. Assuming a conservative 6% replacement rate, local governments may be purchasing 24,000 vehicles a year. The bottom-up estimates in Table 2.1 yield a lower estimate of 12,000 annual local government acquisitions.

2.2.5.2 Corporate Fleets

Private fleet vehicles are also a large potential source of sales and BUR documentation. According to the Automotive Fleet Fact Book 2005, as of June 2005 there were roughly 3,200,000 passenger vehicles in service in private fleets (of more than 15 vehicles) nationwide. An additional 1.3 million cars are estimated to be in private and commercial fleets of 5-14 vehicles. Corporate fleets purchased 680,000 new vehicles in MY2004 (a 21% replacement rate). If 10% were purchased in California (a conservative estimate, considering the relative size of California in the nation's economy) then nearly 70,000 vehicles are sold to corporate fleets each year.

Figure 2.3: Share of Fleet Sales by Segment

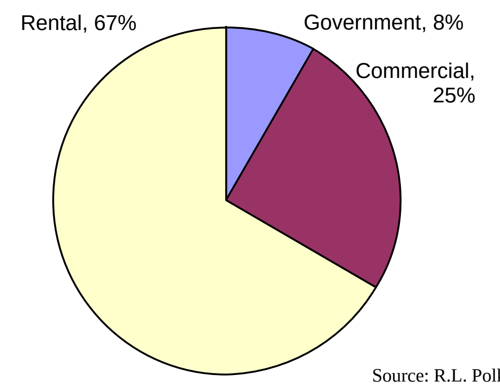


Table 2.2: 2004 Top 5 Companies' Fleet Management and Leasing Company Inventories

Company	Vehicles	% Market
G.E. Commercial Finance	760,000	28%
PHH Arval	548,000	20%
LeasePlan USA	400,000	15%
ARI	384,900	14%
Wheels	250,300	9%
Total	**2,300,000**	**85%**

Source: Automotive Fleet Fact Book 2005

These fleets often have centralized vehicle and fuel management and are capable of collecting fuel usage data sufficient to estimate a FFV BUR. Many companies lease vehicles, or contract fleet management, from one of a few large fleet management companies. These centralized fleet management companies have high potential to implement practices to collect BUR data. Table 2.2 illustrates that the top five fleet management companies make up 85% of the outsourced fleet management market with over 2 million vehicles. GE Commercial Finance Fleet Services alone leased or managed 760,000 vehicles nationwide.

Rental car fleets are a very significant source of new vehicle sales, selling perhaps as much as 200,000 vehicles in California per year. However, these fleets have much less opportunity to achieve significant biofuels use, or to track this use if there were fuel available to the rental customers. However, if automakers were to make available OBD-based BUR data collection (discussed in Section 2.4.3), rental car fleets would be an ideal application. The centralized service of these vehicles means that data collection could occur without relying on state I/M programs. And because, as Table 2.3 illustrates, the top five rental car companies compose 83% of the market, economies of scale in policy, administration, and technology could achieve significant penetration of FFVs and documented BUR.

Table 2.3: 2005 Top 5 Companies' Rental Car Market Share

Company	Vehicles	% Market
Enterprise Rent-A-Car	592,426	35%
Hertz	315,000	18%
Vanguard Car Rental USA	209,400	12%
Avis Rent A Car System Inc	200,000	12%
Budget Rent A Car	105,000	6%
Top 5 total share	**1,400,000**	**83%**

Source: Auto Rental News 2006

2.3 General population (default) BUR

This BUR-demonstration method is based on attributing all biofuels use in the state (not accounted for by any fleet-based BUR) to all FFVs in service. The calculation of this average rate is feasible, and would generally capture the GHG-reductions provided by FFVs using E85 in general use. This system also allows for automakers to benefit from general increases in biofuels utilization and provides incentives for automakers to help in increasing the availability and utilization of E85 fueling stations and increasing consumer awareness.

2.3.3 General population BUR as default

Although there is currently very little “general population” use of E85 (primarily because of a lack of fueling stations), the range of policies discussed in Section 1, and other industry momentum, may increase this use. As this occurs, automakers selling FFVs into the general population should receive the benefit of the associated GHG reductions. The current regulatory treatment of FFVs under AB 1493 is incomplete in that it only allows for E85 assessment for vehicles sold to fleets that can establish a fleet-based BUR. Instead, any “unaccounted for” E85 sales in the state should be estimated to have been consumed equally by all “unaccounted for” FFVs in service, and so establish a default BUR for those vehicles sold into general circulation.

Allowing for automakers to claim the average biofuels use of existing FFVs for future FFVs allows these vehicles to be credited with some level of GHG reductions even in the absence of the detailed data necessary to establish user-specific biofuels use. This default rate should also be applied to vehicles sold to fleets for the portion of their predicted service life after they are remarketed from fleet service.

The accuracy of the data may initially be low for any individual vehicle or model year, or manufacturer’s fleet, as it is based on estimated fuel economy and VMT. But over time the shifting average applied to each successive model year as a lifetime BUR estimate would approach the actual rate achieved over all model years.

2.3.4 Calculation of potential penetration

Flex-fuel capability technology is low-cost and can be applied to many or most of the entire fleet of vehicles currently in production. Flex-fuel *capability* in itself does not affect any vehicle performance attributes and does not typically entail a vehicle price premium, so there are few barriers to consumer acceptance of the capability. Because supply and demand for the majority of models is not affected by flex-fuel capability,[42] the penetration potential of FFVs is not meaningfully limited. Approximately five million FFVs are estimated to be in service in the U.S. 300,000 of these are estimated to be on the roads in California, with 50,000 additional vehicles sold each year.[43] 73% of these vehicles are thought to be sold into the general population.[44]

Instead, the penetration potential of E85 use in FFVs in the general population is thus limited by consumer acceptance and adoption of E85. The consumer barrier of price is discussed in some detail in Section 1.3.3. In discussing consumer acceptance of E85 fuel, however (as distinct from consumer welfare), it is important to note that consumers do not make fuel use decisions based solely on a rational and mathematically accurate calculation of gasoline-mileage-equivalent fuel prices. Consumers may be unaware or unmotivated to make the necessary mathematical conversions to compare fuel prices on a mileage basis, or they may be motivated by additional personal factors (e.g. environmental, agricultural, or energy security concerns) besides price. This is evidenced by the success of E85 sales where the fuel is available, even in the presence of unfavorable price ratios.

For instance, Minnesota's 108,000 FFV drivers consumed 2.6 million gallons of E85 in 2004 from 101 service stations.[45] In 2006, drivers had consumed nearly 12 million gallons of E85 through the month of August (average of 1.5 million gallons per month) from 280 fueling stations.[46] Assuming 150,000 FFVs currently in circulation, a 15 MPG E85 fuel economy, and 15,000 average vehicle miles traveled,[47] this usage is roughly equivalent to an 18% BUR. The average price difference during these months was $0.40 (in favor of E85) on a per-gallon basis, but E85 was approximately *$0.34 more expensive* on a gasoline-mileage-equivalent basis. In other words, E85 was 11% cheaper per gallon, but approximately 19% more expensive on a mileage basis.

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[42] Indeed, to the extent that E85 is a meaningful substitute to gasoline (in price, availability, and performance), the flex-fuel capability would theoretically function as a positive attribute in that it enhances flexibility and adaptability of consumers to fuel price uncertainty and personal environmental/political motivations.
[43] (Herwick 2005)
[44] (MacDonald 2005)
[45] (MacDonald 2005) quoting Ralph Groschen, MN State Energy Office
[46] (Trudeau 2006)
[47] These data assumptions are based on (Bromiley and Dobrovlny 2005). They used a MN Department of Motor Vehicles registration search in March 2005 that reported 108,000 private FFVs, the most common model of which is a 2003 Dodge Caravan (with 14.8 E85 MPG).

As discussed in Section 1.3.2, implicit value would be created in avoided alternative technology costs by selling FFVs that can be expected to achieve a documented statewide E85 use. Based on the ARB's calculation of the cost of alternative GHG-reducing technology, increasing the BUR of general population FFVs would avoid costs of $5-$12 per vehicle for every one percent biofuels use rate. If California's current FFV sales rate of 50,000 vehicles were expected to achieve a BUR comparable to Minnesota's 18%, then between $4.6 and $10.3 million in avoided technology costs would be saved annually. These savings could be used to offset the cost of fuel and infrastructure necessary to achieve (and increase) this BUR.

2.3.4.1 Automaker efforts to increase E85 use

Research has indicated that one of the major barriers to E85 use by FFV owners is lack of familiarity with the fuel, its uses or benefits, and of course fueling locations.[48] Increasing this familiarity among the general population, in concert with expanding actual access to fuel, could have dramatic effects on E85 adoption that should be recognized under AB 1493. Automakers can participate in programs that increase the general rate of E85 utilization by FFV owners. One type of such programs is an educational campaign, such as the "Live Green, Go Yellow" campaign initiated by GM in January 2006. This program aims to make FFV owners aware, through advertising, yellow gas caps on FFVs, and targeted fuel subsidies of the capability of their vehicles, and to increase the general public's awareness of FFVs

Box 2.3: GM E85 Fuel Card Programs

GM experimented with a version of the fuel card program envisioned under this mechanism in 2003 with a program in the Chicago Metropolitan Statistical Area. Cards were issued to every GM FFV owner registered in the program area worth $50 of E85. There was reportedly good response to the program. (Herwick 2006).

In May 2006 GM announced an expanded version of the program, with $1000 fuel cards offered to purchasers of new GM FFVs in two Midwest markets: Chicago and Minneapolis. The program has reportedly had substantial marketing impact, with FFV sales in the targeted markets doubling over the term of the promotion, and May FFV sales exhibiting a 222% increase over May 2005 (2,238 units compared to 695 the year before).

Although the cards allowed for the purchase of either gasoline or E85, data was not collected as to the actual purchase breakdown of each fuel.

The program did require the creation of unique arrangements with MasterCard to ensure the credits were only used for fuel purchases, and enhancing relationships with E85 fuel retailers. Moreover, the program has reportedly had a positive impact on other fuel retailers, with an increase in interest in installing E85 pumps. (Minneapolis Star-Tribune 2006, Green Car Congress 2006)

[48] (Greene 1997) found through statistical regression on household survey data that low station availability imposes costs on consumers equivalent to an additional $0.35/gallon when E85 availability is available at 1% of retail stations, falling to $0.02 at 50% availability.

and E85. GM has added E85 stations to the database of information that is available to customers for navigation services through the OnStar technology – in other words, GM's OnStar will help FFV drivers find the nearest E85 station.

Another strategy is that which increases the availability of E85 refueling stations. GM announced in January 2006 plans to partner with Chevron, Pacific Ethanol, and the State of California to equip Caltrans with FFV vehicles and to develop multiple E85 refueling stations. In February, GM announced a partnership with Shell Oil and VeraSun Energy to add 26 E85 pumps in the Chicago area. Ford announced a similar collaboration with VeraSun aimed at developing an "Ethanol Corridor" along Interstates 50 and 75 in Illinois and Missouri, allowing for travel between Chicago and Kansas City, Missouri entirely on E85.

Another option is a direct subsidy of E85 fuel in order to increase consumer acceptance and adoption of E85 fuel as well as seeding consumer demand pull to incentivize the development of additional fueling stations. Fuel card-based subsidies have been used to positive effect to increase FFV sales and E85 use (see Box 2.3).

However, fuel card redemption in itself could not reliably be used to estimate a BUR because the data produced is not adequate and the use established cannot be assumed to continue after the promotion ends. Drivers could be consuming an unknown amount of other fuels. This could not be corrected by assuming the biofuels use represents part of average vehicle miles traveled because the introduction of subsidized fuel would introduce distortions to this average, such as an incentive on drivers to drive more, or a selection bias as higher-mileage drivers would be more likely to use the subsidized fuel. Another difficulty concerns matching fuel use with specific vehicles. The redemption of E85 card credits would not correspond with the fuels usage in the vehicle with which the card was issued. That is, the card may be used to purchase E85 fuel for a vehicle other than the one with which the card was issued.[49]

2.4 Data Collection Systems

2.4.3 Card-based data capture

Many fleet managers use card-based systems for authorizing, managing, and tracking fuel purchases. Fleets with on-site fueling may issue cards to FFV users that only activate the E85 pump. Off-site card-lock systems also issue cards restricted to specific fuel dispensers. Public multi-fleet fueling stations and private card-lock systems use vehicle-linked card systems to track fuel usage for specific vehicles. All these systems can have

[49] From a State perspective, the upstream GHG savings achieved by the use of a biofuel does not vary with the FFV in which it is used. However, the crediting of those upstream emissions to an auto manufacturer does matter if, for instance, a fuel card issued with a GM car is used to fill a Chrysler vehicle. Also, the tailpipe emissions from FFVs running on biofuels may vary by vehicle, so that using a biofuel in another vehicle will result in a different aggregate GHG savings relative to baseline. Lastly, there is the possibility that E85 could end up in non-FFVs, in which case evaporative and permeation emissions could be higher and damage to fuel systems could result in erosion of emissions controls.

a high level of accuracy in tracking fuel use because they comprehensively track the relative fuel consumption of each vehicle.

Most public and corporate fleets issue purchasing cards. These credit-card-like systems, in conjunction with retail point-of-sale (POS) technology and credit card data processing companies, are capable of capturing various data about fuel purchases. The degree of detail that these systems are capable of capturing is dependent on the capability of the POS device, the retailer's data systems, card issuers and intermediate data processors, and the final data users. This data capability is described by industry conventions as "data levels" (see Box 2.4). Level II may provide sufficiently detailed data to estimate fleet BUR, or the more detailed Level III data may be necessary, depending on the POS system, data processor, and card issuer capabilities.

Box 2.4: Levels of card-based data collection

Credit- and purchase-card processing systems are described within the industry by 'levels' of increasingly complete data capture capability:

Level I

- Merchant name, location, and Merchant Category Code
- Transaction amount and date

Level II

- Vehicle or driver ID number
- Perhaps: Fuel type and quantity

Level III

- Odometer reading
- Additional driver / vehicle identification
- Additional line item information (fuel RIN?)

Source: (Avery 2005, Frontline Processing 2006, Visa USA 2006)

So far, the diffusion of Level II and III capability has been slow. The federal government has sought to collect these data in order to demonstrate alternative fuel use compliance with EPAct / E.O. 13149.[50] The data collected from credit card purchases to date has been unsatisfactory, and has included both false negatives (showing gasoline or "miscellaneous fuel" purchases where E85 was purchased), and false positives (showing E85 where gasoline or other fuel was purchased). According to experts in this issue,[51] these difficulties are not symptomatic of any fundamental barrier, but rather occur because of insufficient diffusion of both technical capacity and managerial initiative. Both of these issues are likely to improve in time. Policy drivers and private sector demand (including automobile sector demand for BUR data) can help accelerate this process.

2.4.4 Onboard diagnostic fuel monitor-based data collection

Onboard diagnostic (OBD) systems provide a possible method of collecting very specific and accurate BUR data. OBD systems have been integrated into all major manufacturers' vehicles sold in California since the 1988 model year. The original OBD merely monitored emissions control systems and alerted vehicle operators with malfunction

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[50] DoE has been pursuing the issue for some time and has active programs to identify and resolve the associated issues (Miller 2006).

[51] (McConahy 2006)

indicator light, but data offtake systems and protocols were not standardized. OBD-II systems, required by ARB beginning in MY1996, increased the monitoring capability and standardized data protocols and equipment. The capabilities of a possible future OBD-III standard are the subject of much speculation.[52]

The fuel composition sensor, also called the flex-fuel sensor, is a standard component on gasoline-powered and flex-fuel vehicles that uses differences in the electrical conductivity of gasoline and alcohol fuels to calculate the amount of alcohol in the fuel and adjust combustion (most especially the fuel /air ratio and ignition timing) accordingly to maintain emissions standards and optimize fuel efficiency. Reportedly, the fuel composition sensor can also be used to reliably identify the percentage of biodiesel in diesel fuel blends.[53]

It is technically feasible to merge the capabilities of the flex-fuel sensor and OBD systems to record and report the amount of alcohol fuel used. These data could be recorded over time and downloaded during regular maintenance, mandated inspection and maintenance (I/M) programs, or even remotely transmitted from the vehicle to central processors via transponder or wireless telecommunications technology. Introducing this technology would require relatively minor technical modification to OBD systems to allocate memory and transmission codes, though more advanced data communication such as remote transmission for all vehicles would require extensive technical and institutional innovation.

In order to be useful in meeting regulatory requirements, the data on biofuel use must be collected and transmitted to auto manufacturers. Possible means to accomplish this are discussed below and include:

- Automatic transmittal
- I/M program (Smog Check)
- Maintenance

2.4.4.1 Baseline

One technical accounting difficulty presented by the use of OBD data is differentiating the biofuel content of the reference fuel (e.g. CARFG) from higher-blend biofuel such as E85. For example, current CARFG contains 5.7% ethanol, while E85 mixed in a vehicle's fuel tank would contain anywhere from 5.7 – 85% ethanol. Thus, OBD-obtained BUR data

Box 2.5: GM OnStar

OnStar is a vehicle diagnostic and communication technology developed by GM, and installed in vehicles from many automotive manufacturers including Acura, Audi, General Motors, Isuzu, Subaru and Volkswagen.

OnStar monitors standard vehicle operation and the status of safety and emission control equipment. Moreover, the system uses cellular communication to contact central assistance centers to transmit data and receive assistance. If GM were to add biofuel sensing data to the monitoring capability of OnStar, the company could gather sufficient data to develop a GM-specific general BUR.

[52] (CARB 2004, Wikipedia 2006)
[53] (Tat and Gerpen 2001)

should deduct 5.7% of detected ethanol. This deduction should be done after the data is retrieved, so that over time, as the baseline percentage of biofuel in reference fuel changes, the amount of OBD-detected biofuel deducted can change to reflect this baseline.

2.4.4.2 Automatic transmittal

The first method, automatic transmittal, would utilize a radio transponder or wireless telecom capability installed in vehicles that would transmit OBD fuel sensor information to a central authority. GM's OnStar technology is an example of such a system (see Box 2.5).

A new OBD standard, OBD III, is reportedly being considered at both the state and federal levels, and there is considerable interest in including a transponder, cellular, or satellite data reporting capability. This method has strengths in that it is accurate, comprehensive, resistant to manipulation, and timely. Its disadvantages lie in consumer acceptance of a technology that many see as an intrusion on users' privacy. Little information is available as to the status of OBD III regulatory development.

If such a technology were to be deployed, it could be well-suited to use in establishing BUR. This method would not need full vehicle identification (and so could mitigate the privacy concerns of OBD-III critics), but would only require the portions of the Vehicle Identification Number (VIN) code unique to each manufacturer. Data as to the proportion of biofuel consumed would be very accurate and specific as to manufacturer and model.

2.4.4.3 Collection during Smog Check

OBD-based BUR data could be collected during Smog Check[54] to provide the basis for estimating an accurate general population BUR. Moreover, these data could be used in conjunction with other characteristics of vehicles to determine whether more specific subsets of general population BUR could be established. For instance, analysis of Smog Check OBD data could reveal that certain manufacturers or models attain higher BUR than others, or that certain geographic areas attain higher rates.

The deficiency of Smog Check data collection lies in the fact that the requirement is not binding during the first six years of a vehicle lifespan, and so the data collected in this way would always be missing a major part of the FFV population. Whether this would significantly skew the resulting estimates, however, is unclear. Moreover, if a new OBD III standard does come online with remote transmission capability, the Smog Check program may eventually be discontinued.

[54] Smog Check is the State of California's primary Inspection and Maintenance (I/M) program for private vehicles. Owners of vehicles older than six years are required to submit proof of Smog Check certification in order to register their vehicle.

Alternatively, it may be that data on alcohol fuel usage gathered during Smog Check would be useful in calibrating the BUR estimation from other data sources.

2.4.4.4 Collection during maintenance

Perhaps the simplest way to fulfill the needs of fuel usage documentation lies in OBD data collection during warranty maintenance. This option has an advantage in that auto manufacturers have a large degree of control over the program, and yet consumer participation is voluntary. However, this method would probably not capture a significant amount of users (in inverse proportion to participation in warranty maintenance and the degree of participation of maintenance facilities in reporting data).

However, where specific groups of users, such as fleets, maintain regular maintenance practices over time, OBD data collected during maintenance could provide accurate and comprehensive BUR data for that fleet. Much fleet vehicle maintenance is performed by dealers under warranty,[55] and so can provide a good opportunity for automakers to ensure data collection and transmittal.

2.4.5 Aggregate average biofuel use rate estimation

Calculating the average general population BUR discussed in Section 2.3 could be accomplished using currently available data. Calculation of an average lifetime biofuels use statistic would not be simple and would require several assumptions, but a tolerably robust statistic could be estimated to represent the lifetime proportion of alternative fuel use. The calculation basically calculates the energy of biofuels sold as a fraction of the total energy demand of all vehicles in circulation.

Several data can be accurately calculated using available sources. Fuel use in California is reported to the State Board of Equalization for Use Fuel Tax purposes. These data can be used to calculate the annual biofuels use in the state. FFVs can be identified through unique code sequences in their Vehicle Identification Number (VIN) and so the total population of FFVs in the state, and the model year distribution of these vehicles, can be calculated with Department of Motor Vehicle vehicle registration data.

Average annual vehicle miles traveled (VMT) data can be calculated using mileage accrual rates from odometer readings taken during Smog Check and reported by the Bureau of Automotive Repair, as per ARB's current AB 1493 methodology. These should be calculated for each MY in the inventory. Average fuel economy, when operating on both biofuels and conventional fuels, should be assigned per MY based on either EPA or ARB data. Of course, vehicles and fuels used in calculating BUR in other contexts (i.e. fleet-based BUR) must be deducted from this calculation.

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[55] Actual data on frequency of warranty maintenance of vehicles per manufacturer, if it exists, appears to be proprietary, and is not published. Fleet level warranty maintenance rates, however, are likely to be high. For instance, U.S. General Services Administration, the largest federal fleet lessor, directs client fleets to have all warranty maintenance performed by dealers (Miller 2006).

Box 2.6: Estimating aggregate average biofuel use

The object is to calculate *Q*, the percentage of an FFV's energy consumption that is consumed as alternative fuel. An average fuel economy (denominated in miles per megajoule (*MPMJ*) can be defined for each MY using EPA fuel economy (for both alternative and conventional fuels expressed on an energy basis) for each model in that model year (based on the distribution of models per MY in DMV registration records), and defined using the variable *Q*:

$$MPMJ^{MY} = (MPMJ^{MY}_{Alt} * Q) + (MPMJ^{MY}_{conv} * 1 - Q)$$

This average energy economy per model year can be used with the estimated VMT per MY to calculate an aggregate energy needed to fuel all FFVs in the inventory for the past year:

$$MJ_{Total} = \sum_{MY} \frac{VMT^{MY}}{MPMJ^{MY}}$$

Finally, the total energy of the alternative fuel sold in the past year can be expressed as a fraction of the total estimated energy consumed by FFVs to yield the percentage of total energy that was supplied by the alternative fuel:

$$Q = MJ_{Alt} / MJ_{Total}$$

This, then, is the average percentage of energy consumed as alternative fuel by existing FFVs, and can be taken as approximately equal to the average percentage of miles traveled on the alternative fuel by all existing FFVs.

An equation using all these data can be constructed that can be solved for the average percentage of miles traveled using the alternative fuel. The basic form of this equation is given in Box 2.6.

This calculation simplifies regulatory treatment by assuming that the percentage of alternative fuel to total fuel energy consumed per vehicle is the same across all models in each model years. It is not known whether this treatment would significantly distort actual general population biofuels use (for instance if drivers of certain manufacturers' vehicles are more likely to use biofuels). The collection of OBD-based data could help to determine whether such differences exist, and would provide an alternative method for manufacturers if the aggregate average method was unsatisfactory.

2.4.5.1 Geographically-differentiated average BUR

It may be advantageous to develop geographically-differentiated average BUR, where FFVs sold into geographically-defined markets are credited with the BUR of FFVs operating in that market. Although this would not change the fundamental mathematical sum, it may alter behavior and lead to higher totals overall. This is because of the high network and agglomeration efficiencies of "clustering" in introducing new fuels and FFVs.[56] FFVs in localities with a high density of E85 retail stations are likely to achieve much higher BUR, and vehicle markets are also typically highly segmented

[56] (Winebrake and Farrell 1997; Welch 2006)

geographically so that vehicles sold into a metropolitan market have a high likelihood to be used in that market. Thus if the aggregate average biofuels use calculation described here could be statistically segregated geographically, the dynamics of adoption could be self-reinforcing. Concentrating FFV sales lead to higher E85 station coverage, higher biofuels use, and higher FFV adoption, and so on.

However, gathering accurate data at a sub-state geographic level would be difficult and the necessary calculations would require several more assumptions. This report does not suggest a method for accomplishing these calculations. Over time, however, automakers and ARB should pursue this metric along with other strategies to harvest the benefits of clustering FFV adoption and E85 station development.

Part 3: Fuel Adjustment Factor

3.1 Summary

The Fuel Adjustment Factor (FAF) is a mechanism intended to account for differences, relative to gasoline, in the GHG emissions from the production of alternative fuels that are used in vehicles. One FAF is defined in the regulation for each type of fuel (E85, natural gas, and LPG), based on the results of a proprietary lifecycle emissions model. This section examines the FAF for E85 and concludes that:

- both ethanol production and gasoline production will have varying production emissions, therefore
- the relative emissions of E85 should be frequently revised using a publicly-accessible, peer-reviewed method, and
- in some cases, specific FAF could be calculated for individual biofuels

3.1.1 Lifecycle Assessment

Lifecycle analysis is the practice of analyzing costs or impacts created by all processes associated with the manufacture, use, and disposal of a product. Lifecycle GHG assessment of fuels computes the GHG emissions in feedstock production (e.g. fossil fuel extraction or biomass agriculture), refining, distribution, consumption in the vehicle, and "disposal" in the atmosphere. The emissions from each of these stages can differ according to feedstock, production processes used, types of materials and energy used, and vehicle technology.

The majority of AB 1493 regulations, like the rest of the California Exhaust Emission Standards and Test Procedures, focus on the testing of the downstream or "tailpipe" emissions of vehicles. While tailpipe emissions of GHG

Box 3.1: Lifecycle GHG Accounting for Biofuels

GHG emissions (or credits) from:

"Up-stream":

- Feedstock production
  - CO_2 absorption by biomass (credit)
  - Manufacture and application of seed, fertilizers, pesticides, etc.
  - Energy use in field operations, crop drying
  - In-field emissions from fertilizers
  - Change in stock of 'soil organic carbon'
  - Portion of process attributed to "co-products" (credit)
  - Transportation to biorefinery
- Biorefinery
  - Energy for heat and power
  - Portion of process attributed to "co-products" (credit)
  - Transportation to blenders, distributors

"Downstream":

- Vehicle
  - Evaporative emissions
  - Combustion emissions

from gasoline versus E85 combusted in the same FFV can vary by a small but significant amount, the well-to-tank emissions of the two fuels are likely to be very different. The primary difference lies in the fact that production of biomass for biofuels includes the absorption of carbon from the atmosphere during photosynthesis. The Fuel Adjustment Factor (FAF) is the regulatory mechanism designed to capture this upstream difference.

3.1.2 Calculating the FAF

The FAF represents the ratio of the lifecycle GHG emissions of biofuels to the lifecycle emissions of gasoline. It is used as a multiplier for the tailpipe emissions of a vehicle operating on biofuels. Thus the FAF answers the question, "Each gram of tailpipe emissions (from an FFV operating on biofuels) is associated with a how much *lifecycle* GHG emissions, *relative to gasoline*?" The FAF of CARFG is necessarily one, while the FAF for fuels that are less GHG-intensive in their lifecycle than gasoline is less than one.

The calculation for the FAF uses "average" upstream and downstream emissions from both biofuels and California Reformulated Gasoline (CARFG). The FAF first requires the "fuel cycle emissions ratio," that is, the ratio of upstream emissions to downstream emissions for each fuel. This ratio represents "how many grams of GHG were released upstream for every gram released downstream." This ratio is then used to create the "fuel cycle factor," calculated as 1 + the fuel cycle emissions ratio, and representing the total lifecycle emissions associated with one unit of tailpipe emissions. Finally, the FAF is calculated as the ratio of biofuels' fuel cycle factor to that of CARFG. The equation below illustrates this relationship:

Table 3.1: FAF Calculations[57]	**E85: Current FAF**	**Gasoline: Current CARFG FAF**
Fuel Cycle Emissions (g/mi)	-12.7	117
Tailpipe Emissions (g/mi)	356.9	377.4
Fuel Cycle Emission Ratio	-0.04	0.31
Fuel Cycle Factor	0.96	1.31
Fuel Adjustment Factor	0.74	1.00

$$FAF = \frac{1 + \dfrac{E85FuelCycleEmissions}{E85TailpipeEmissions}}{1 + \dfrac{GasolineFuelCycleEmissions}{GasolineTailpipeEmissions}}$$

3.2 Tailpipe GHGs

The BUR is used to establish the fraction of a vehicle's emissions that should be computed using the appropriate biofuels emissions factors, as distinct from the vehicle's gasoline-powered emissions. There are two components to the biofuels emissions factors: the tailpipe emissions and the Fuel Adjustment Factor. Flex-fuel vehicle tailpipe emissions are tested separately using gasoline and E85. The gasoline emission profile is unadjusted and is the assumed default fuel. The biofuel tailpipe emissions are "adjusted" using the FAF and are used for the proportion of lifetime vehicle miles traveled (VMT)

[57] (California Air Resources Board 2004; Unnasch 2006)

established by the BUR. Thus the average emissions for a FFV (sold to a user group with an established BUR) is determined as the BUR-weighted average of the gasoline and 'adjusted' biofuel emissions profiles.

In addition to the FAF, the tailpipe GHG emissions of a FFV using E85 differ from those of the same vehicle running on gasoline. A tailpipe emissions reduction of 5-6% has consistently been reported for FFVs using E85 relative to the same vehicle using gasoline (Kelly et al. 1996, EERE 1998, Kelly et al. 1999, Levelton Engineering Ltd. 2000, Lucon et al. 2005). Some portion (0-5%) of this difference is due to the lower carbon-to-energy ratio of E85 (more energy derived from hydrogen oxidization), and the other part of the difference is due to a higher energy-efficiency of vehicles operating on E85. Together, these effects mean that on average FFVs physically emit less GHG per mile when operated on E85.

The higher energy efficiency of FFVs running on E85 is in turn due to the higher power delivery potential of E85, based on higher octane and charge cooling. The 1990s-era FFVs tested by Kelly et al showed miles-per-gasoline-equivalent (MPEG) fuel economy using E85 approximately 2-3% higher than when operating on gasoline. According to FuelEconomy.gov, the 34 MY 2007 FFVs available show a MPEG 0-10% higher on E85, with an average 3% improvement in miles per energy unit. The 49 FFVs listed for MY 2006 and the 43 FFVs in MY2005 also showed an average 3% efficiency gain.[58] If FFVs are optimized to take advantage of the higher octane and other properties of E85, fuel efficiencies can improve further, meaning correspondingly low GHG emissions per mile. Saab's BioPower FFV in the European market reportedly achieves 15% efficiency gains over gasoline (Green Car Congress 2004). Current research is developing dedicated ethanol vehicle technology to take advantage of ethanol's higher octane and use high compression ratios (19.5:1) to approach or surpass the actual volumetric fuel economy of gasoline engines (Brusstar and Bakenhus 2005).

The implication of these findings is that the GHG reduction benefits of using E85 in FFVs are not only a result of applying the FAF. Establishing a BUR that allows some portion of the vehicle's emissions to be counted at the E85 test results will likely offer small but robust results regardless of the magnitude, or even existence, of the FAF.

3.3 Variation in GHG emissions from different production pathways

The FAF suffers from being a single static ratio of quantities that are in fact diverse and dynamic. Each major fuel type (e.g. ethanol, CNG, electricity, and including CARFG gasoline) has one default value representing the fuel's average lifecycle emissions, and the FAF normalizes these relative to the CARFG lifecycle emissions. Because these

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[58] The exact amount of this change is uncertain because of variance in the chemical composition and hence energy content of the test fuels. While volumetric fuel economy can be accurately measured, the associated energy consumption cannot be known precisely. But there is a clear trend over the data available to indicate a small increase in energy efficiency.

values were reportedly based on those calculated in GREET (version 1.6)[59], they represent the average biofuel industry performance, as reported by USDA in 2001. Because of the rapidly changing nature of the ethanol industry,[60] these values are not likely to represent the actual average GHG performance of fuel ethanol. Moreover, they are even less likely to reflect the average GHG emissions of ethanol used in California, as California is more likely to use ethanol from natural gas-fired biorefineries partially integrated with feedlot or dairy operations in-state (e.g. Pacific Ethanol), or to import ethanol from Brazil or China.

Large differences in lifecycle GHG emissions occur among types of ethanol produced from different feedstocks or in different "biorefineries." As Table 3.2 and Figure 3.1 illustrate, the upstream GHG emissions of a "GHG-intensive" ethanol production scenario (involving inefficiently-produced corn shipped to a distant coal-fired biorefinery) can differ substantially from those of "average" corn ethanol, and these emissions profiles in turn differ substantially from that of either Brazilian sugarcane or "cellulosic" ethanol scenarios.

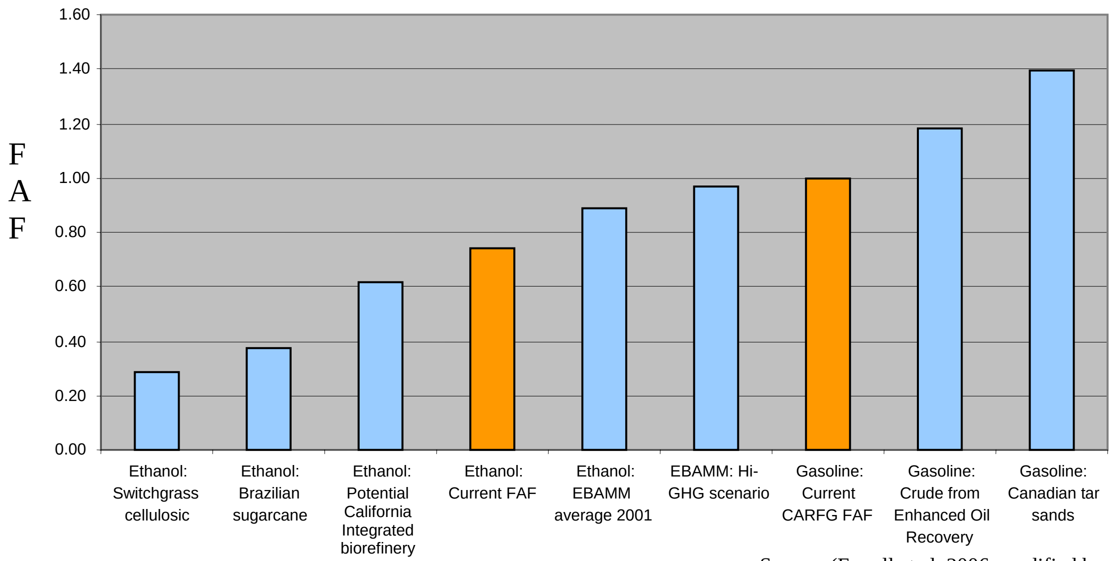
Table 3.2: Sample Fuel Adjustment Factor Calculations

Fuel Type and Production Pathway Scenarios	**Ethanol: "Cellulosic" from switchgrass**	**Ethanol: Brazilian sugarcane**	**Ethanol: Current FAF**	**Ethanol: EBAMM average today**	**EBAMM: Hi-GHG scenario**	**Gasoline: Current CARFG FAF**	**Gasoline: Crude from Canadian tar sands**
Units	g GHG per MJ	g GHG per MJ	g GHG per *mile*	g GHG per MJ	g GHG per MJ	g GHG per MJ	g GHG per MJ
Feedstock Production	-62.36	-54.89	n/r	-34.46	-27.34	5.12	42.31
Fuel Production	0.87	4.14	n/r	39.04	46.01	16.10	15.40
Fuel Cycle	-45.61	-36.93	-12.70	7.78	19.16	21.22	57.71
Vehicle Emissions	66.03	66.03	356.90	66.03	66.03	69.50	69.50
Fuel Cycle Emission Ratio	-0.69	-0.56	-0.04	0.12	0.29	0.31	0.83
Fuel Cycle Factor	0.31	0.44	0.96	1.12	1.29	1.31	1.83
Fuel Adjustment Factor	0.24	0.34	0.74	0.86	0.99	1.00	1.40

[59] The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model, produced by Argonne National Laboratory (primarily Dr. Michael Wang) is a voluminous and detailed lifecycle analysis model of a wide range of transportation fuels and propulsion technologies. It is available for public use at http://www.transportation.anl.gov/software/GREET/index.html. (Wang 2005)

[60] U.S. ethanol production capacity has increased 150% since January 2001, according to the Renewable Fuels Association, and an additional 55% capacity increase is under construction. The GHG intensity of this additional capacity is unknown, with reports of both high-GHG-intensity coal-fired plants as well as low-GHG biomass-powered plants and highly efficient plants integrated with electrical power plants and/or livestock operations. There are also at least 5 demonstration-scale cellulosic ethanol plants in operation or construction, and 2 or more waste-to-ethanol facilities. Finally, ethanol imports have tripled between 2002 and 2005.(Renewable Fuels Association 2006)

Figure 3.1: Fuel Adjustment Factors for different biofuel and gasoline production pathways



Source: (Farrell et al. 2006, modified by author)

In addition, the gasoline industry is changing as well, with more Enhanced Oil Recovery (EOR) and nonconventional (e.g. Canadian tar sands) crude oil sources coming online, which have very different GHG profiles.[61] An increasing GHG-intensity of the gasoline baseline would also suggest a need to revise the FAFs over time. As illustrated in Figure 3.1, the upstream GHG emissions of gasoline varies with the crude oil source, and even the 'average' CARFG emissions profile will vary over time as the sources of crude change.

Calculating average FAFs based on out-of-date GHG values for these fuels is not representative of actual GHG savings using E85, and the use of average values loses any incentive for regulated entities to seek out lower-than-average GHG-intensive fuels, and so removes incentives for producers to produce those fuels.

3.3.1 Uncertainty in GHG emissions

In addition to variance in the known emissions from different biofuel production pathways, several parameters of GHG accounting are subject to uncertainty in specific dynamics.[62] There are several major types and sources of uncertainty in the GHG impacts of biofuels. Several of the basic chemical fate and transport processes in agriculture are subject to both aleatory and epistemic uncertainty, especially in-soil carbon and nitrogen

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[61] EOR oil is estimated to have a GHG-intensity between 102 to 119% of conventional oil, while SynCrude from the Alberta tar sands is estimated to have a GHG-intensity between 114 and 140% of conventional. (Brandt and Farrell 2006)

[62] The primary complexities of the accounting process are: 1) basic uncertainty in some physical GHG-emitting processes, 2) data quality issues, 3) choice of system boundaries, including how to account for co-products, and 4) blend level variance

processes. The science is not fully developed, data are inadequate, and stochastic influences are high.[63]

This uncertainty can be managed by using consensus expert judgments on the state-of-the-science at any given time, and updating the model as science improves understanding. Maintaining transparency and accessibility of the model is key to soliciting expert opinion and facilitating consensus. Maintaining transparency and peer-review of the FAF model and performing frequent revisions of the model, its parameters, and variable data as the science improves is the best strategy for managing the uncertainty associated with lifecycle GHG analysis.

3.3.2 Importance of accessible, peer-reviewed, updated accounting method

Accurately accounting for lifecycle GHG emissions is a complicated but feasible task. There are a number of inputs and processes that must be documented, but the number is finite and the data are generally available. The task requires a quantitative model to estimate the emissions from various stages in the production chain.

The greenhouse gas accounting model currently used under the regulation was developed by TIAX Inc. based on Argonne National Laboratory's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model. While the GREET model is a publicly-available Excel-spreadsheet-based model with extensive documentation, the TIAX model is proprietary and has not been released to the public. This inaccessibility has negative consequences in term of both the accuracy and integrity of the model. Accuracy of the model would be improved by making the assumptions and calculations subject to expert review, critique, and correction, and integrity would benefit by from the perception of such "peer review," a bedrock principle of scientific credibility. Further, allowing frequent review and updating of model variables and values is key to appropriately managing uncertainty, and change, in biofuels' lifecycle emissions.

Another benefit of a public model is the ability of current or prospective ethanol producers to calculate the GHG intensity of their products and investigate methods of reducing their emissions. Producers can use the model to calculate the cost-effectiveness of GHG reducing technologies.

Because the GREET model is a public product, available to researchers for performing calculations or modifications for specific purposes, it can be used to build a public FAF

[63] Particularly significant examples of uncertainty occur in agricultural GHG emissions, especially the influence of nitrogen, agricultural lime, and tillage practices. Nitrogenous fertilizer (a major input to corn production) transforms into N_2O, a powerful greenhouse gas, through several processes that are dependent on the utilization efficiency of the crop (in turn dependent on the farmer's application, weather, and other influences), the soil chemistry and consistency, and prevailing climate and weather over several days. Agricultural limestone (applied infrequently but in large amounts to some fields to correct soil acidity), may either release carbon or bind carbon dioxide from the atmosphere (i.e. it can be either a GHG source or sink), depending on soil chemistry and weather. Lastly, the response of soil organic carbon stocks to differences in cropping patterns or tillage practices, such as no-till agriculture, is a subject of active scientific inquiry but is largely unknown.

model. A simplified, derivative model of the GREET model could be used to specifically model the variety of ethanol production pathways, as discussed in Section 3.4.1 below. One such simplified model is the ERG Biofuels Analysis Meta-Model (EBAMM), produced by the Energy and Resources Group (ERG) at the University of California at Berkeley.[64]

The EBAMM model was originally used to investigate the "energy balance" of ethanol by comparing the published energy-intensity data from a sample of prominent analyses of ethanol production. The model was extended to investigate GHG- and fossil fuel-intensity of ethanol by applying standard GHG and fossil fuel factors (derived from GREET) to the energy and material inputs reported by researchers.

Table 3.3: Example EBAMM-Based Feedstock Emissions Calculation	**Cellulosic**	**Brazil-sugarcane**	**California integrated biorefinery**	**Corn 2001**	**CO2 Intensive**
Agricultural phase					
Nitrogen fertilizer emissions (kg CO2e/ha)	547	638	1,638	1,638	1,616
Phosphorus (kg CO2e/ha)	3.4	59.0	102.4	102	63
Potassium (kg CO2e/ha)	2.4	71.2	70.4	70	17
Lime (kg CO2e/ha)	-	186.6	228.2	228	228
Herbicide (kg CO2e/ha)	10.4	46.4	69.5	69	56
Insecticide (kg CO2e/ha)	-	3.9	5.4	5.4	4.7
Seed (kg CO2e/ha)	-	-	-	-	-
Transport emissions (kg CO2e/ha)	3	128	39	39	34
Gasoline (kg CO2e/ha)	-	-	114	114	70
Diesel (kg CO2e/ha)	341	788	248	248	449
Nat Gas (kg CO2e/ha)	-	-	46	46	181
LPG (kg CO2e/ha)	-	-	61	61	73
Electricity (kg CO2e/ha)	42	-	56	56	256
Energy used in irrigation (kg CO2e/ha)	-	-	4	4	24
Labor transportation (kg CO2e/ha)	-	-	-	-	-
Farm machinery (kg CO2e/ha)	21	131	21	21	21
CO2 from land use change (kg/ha)	-	-	-	-	-
Total agricultural phase (kg CO2e /ha)	**971**	**2,052**	**2,703**	**2,703**	**3,094**
Biorefinery phase					
Transport of feedstock to biorefinery (g CO2e/L)	51	228	594	49	198
Primary energy (g CO2e/L)	-	7	-	-	-
Diesel (g CO2e/L)	5	-	-	-	-
Coal (g CO2e/L)	-	-	-	885	1,398
NG (g CO2e/L)	-	-	356	365	-
Electricity (g CO2e/L)	-	-	144	-	-
Biomass (g CO2e/L)	-	-	-	-	-
Capital (plant and equipment) (g CO2e/L)	29	33	9	8.8	8.8
Process water (g CO2e/L)	19	-	-	25	25
Effluent restoration (BOD at PWTPs) (g CO2e/L)	20	-	-	20	20
Transportation to blenders/retailers	n/r	n/r	n/r	n/r	n/r
Totals					
Crop yield (kg/ha)	13,450	68,700	8,746	8,746	8,389
Biorefinery yield (L/kg corn)	0.38	0.09	0.45	0.40	0.40
Gross agricultural phase (g CO2e/L)	189	347	685	780	931
Absorption Credit (g CO2e/L)	-1,511	-1,511	-1,511	-1,511	-1,511
Net Ag Emissions (g/MJ)	**-62**	**-55**	**-39**	**-34**	**-27**
gross biorefinery phase (g CO2e/L)	124	267	1,103	1,353	1,649
Coproduct credits (g CO2e/L)	(106)	(179)	(525)	(525)	(525)
Reported HV of ethanol (MJ/L)	21	21	21	21	21
Net Biorefinery emissions (g/MJ)	**1**	**4**	**27**	**39**	**53**
Net feedstock emissions (g CO2e/L)	**-61**	**-51**	**-12**	**5**	**26**

Source: (Farrell et al. 2006, modified by author)
Data presented are illustrative and are not meant as actual lifecycle analysis results

[64] (Farrell et al. 2006)Available at http://rael.berkeley.edu/EBAMM/

This example of a simplified model (or in fact the EBAMM model itself) should be adopted and adapted by ARB for creating a FAF model. Under such a scheme, the inputs into the fuel production process would be reported by producers or estimated by regulators, and associated GHG emission factors would be developed through expert input and public review and applied to the reported inputs. An example of the results of such a process (based on EBAMM) is presented in Table 3.3.

3.3.3 GHG accounting and cost effectiveness

Assuring the most accurate FAF calculation maximizes the cost-effectiveness of GHG abatement and AB 1493 compliance through the use of biofuels in FFVs. Biofuel production costs do not necessarily track GHG abatement costs. Hence lower-cost biofuels (such as those produced from feedstocks using substantial nitrogenous fertilizers and processed using coal) may have a higher cost-per-GHG-reduction than biofuels that have a slightly higher financial cost but much lower GHG profile. Without accurate incentives in the regulation to capture the actual GHG performance of biofuels, the cost of GHG abatement is likely to be higher, and the actual GHG reduction achieved lower, than necessary. Capturing the correct GHG reduction potential of biofuels increases the cost-effectiveness of GHG reduction, and creates the correct incentives for driving down the GHG-intensity of biofuels over time.

3.4 Options for GHG accounting

Because of the difference in GHG emissions of biofuels produced from different processes, and the effect these differences have on the cost-effectiveness of GHG abatement from using biofuels, it is important that a regulatory system designed to give credit for GHG emissions take account of these differences. Despite the promulgation of one static FAF in the AB 1493 regulations, the regulatory language and history appears to reserve discretion to the Executive Officer to determine a new FAF if it can be demonstrated that the fuel used by FFVs in general, or in specific applications, are produced with significantly lower lifecycle emissions.[65]

3.4.1 Periodic Updating

Periodic updating of default values through some averaging of the biofuels sector increases the representativeness of the default values. Acquiring data to accomplish a specific and exact industry average is unlikely given the 140-and-counting domestic plants currently in operation or under construction, as well as foreign producers. However, estimating GHG intensity of a small set of representative production methods and calculating rough percentages of total supply produced from each process is probably

[65] The regulation states in reference to hydrogen and electricity upstream emission factors, "The Executive Officer may approve use of a lower upstream emissions factor if a manufacturer demonstrates the appropriateness of the lower value by providing information that includes, but is not limited to the percentage of hydrogen fuel or the percentage of electricity produced for sale in California using a "renewable energy resource." (California Air Resources Board 2005)(Part I (E)(2.5.2.1.5)) CARB staff have stated that with appropriate evidence, a new FAF for E85 could be calculated. (Evashank 2006)

a feasible goal. For instance, the FAF model should include separate calculations for "Brazilian sugarcane ethanol," "Midwestern corn, coal-fired biorefinery," "Midwestern corn, biomass-fired biorefinery," "California corn, NG-fired," etc. and determine the percentage of the state's ethanol obtained from each source. The average GHG intensity thus obtained would be more representative of current practice.

The EPA's proposal for the Renewable Fuels Standard that relies on RINs may create a strong foundation for this accurate average updating. Because refiners, blenders, or importers must obtain sufficient RINs to satisfy their renewable fuels obligation under the RFS, and each RIN is associated with a specific gallon of a specific biofuel batch, this system may provide useful data to California regulators to estimate the source of biofuels used in California.[66]

A deficiency of this method is that it does little to communicate incentives to fuel producers for improving GHG performance. This is because individual biofuels users and, in turn, producers receive no individual benefit from improvements in aggregate performance, while producers using financially cheaper but higher-GHG processes or feedstocks gain individual cost savings while suffering only a small fraction of any value diminution caused by an unfavorable aggregate adjustment. Such a policy essentially sets the average FAF as a common property resource with the standard "tragic" results. This is another argument for transitioning to fuel-sector-specific GHG regulation in the future, as discussed in Section 1.3.4.

3.4.2 Tracking individual FAF

It is attractive to hope that the FAF system could be used to award differential GHG-reduction credit for the use of different biofuels. Unfortunately it seems unlikely that this goal could be accomplished using the AB 1493 ACM. The FAF (like the BUR) is applied to new vehicles at the point of their sale in California. It is based on an *estimate* of the lifetime use of biofuels by FFVs. Therefore, in order to apply different FAF based on the use of a biofuel from a specific production pathway, regulators would have to have a reliable reasonable assurance that a specific vehicle would consume biofuel from only one type of producer. In other words, automakers would have to demonstrate that a given vehicle would only ever operate on Brand X biofuel.

This is only likely to be feasible given two conditions:

- Tracking of the GHG-intensity of specific fuels becomes feasible
- Specific institutional users commit to purchasing specific GHG-intensity fuel.

It is quite possible that in the future a "green biofuels" accounting methodology will be established, either through voluntary industry- or NGO-certification[67] or through

[66] These data would be far from conclusive for purposes of tracking specific biofuels, however. Because RINs are easily separable from physical volumes of fuel in order to be used as credits, there is no guarantee that RINs from certain biofuel producers are associated with the actual biofuels sold by a refiner, blender, or importer presenting the RIN. Further, there will be no mechanism to determine which biofuels are used in high-blends (E85) and which are used in the additive market. However, once established, the RIN structure may evolve to allow more detailed tracking.

[67] In the mold of sustainable forestry or organic agriculture certification

government mandate through fuel-sector GHG regulation. Were this to occur, fuels may carry a GHG-rating much as they carry octane ratings,[68] and so government agencies or institutional fleets could commit to purchase only a certain standard. Based on these users' ability to document their unique BUR, automakers selling to these fleets could also claim a unique FAF. However, not all problems would be solved; for instance, OBD-based BUR (discussed in Section 2.4.3) could not reveal the GHG-intensity of the fuel used.

3.4.3 Recommended approach: updated default values, optional certification

This analysis suggests a "default +" approach, in which E85 is awarded a default value based on the average GHG profile of the bulk pool fuels in the industry, and individual automakers can apply for different treatment when they can demonstrate a trackable supply chain from a biofuels producer with significantly different GHG profile to specific users. Default values, updated periodically to represent changes in the industry average GHG performance of both biofuels and the reference gasoline, strike the most feasible balance between accuracy and workability in the calculation of FAFs for fuels sold in most circumstances.

Certain producer/user combinations are likely to exist that could certify the GHG performance of their specific fuel and demonstrate its use in eligible vehicles. This situation may be possible in the near term in fleet applications. Because fleets usually have supply contracts with specific suppliers, who in turn may be able to track the origin of their ethanol fuels, data from these applications may be able to demonstrate the necessary reliable use of specific fuel. Alternatively, institutional fleet operators may commit to a voluntary "sustainable biofuels" standard and so would produce sufficient data to demonstrate the GHG-intensity of the fuels they use.

[68] Of course, this is not an equivalent rating as octane is an attribute inherent in the fuel that can be revealed by chemical analysis, whereas GHG-intensity is imputed to the fuel and relies on historical and ancillary data.

Conclusion

The market conditions for FFVs and E85 are changing rapidly in California and the nation. These changes together create favorable conditions for FFVs to make a significant contribution to meeting AB 1493 requirements. These dynamics are:

- Existing and future mandates and incentives create substantial market supply and demand for FFVs independent of AB 1493.
- The technology requirements for producing FFVs are low-cost and consumer acceptance of FFVs is high.
- Ethanol fuel supply is increasing rapidly and current and future mandates require minimum ethanol consumption.

These factors make FFVs a cost-effective compliance strategy for manufacturers if *any* level of biofuels use can be demonstrated. Cost-effectiveness of biofuels use for consumers, in turn, is entirely dependent on fuel cost. While it is impossible to predict the price trajectory of ethanol in the future, historical evidence indicates that the calculations used by ARB in rulemaking were unnecessarily pessimistic, and ignored the willingness of consumers to pay a premium for non-petroleum fuels.

The current construction of the ACM, specifying that a biofuels use rate can only be documented by centrally-fueled fleets, is overly restrictive. E85 use can be demonstrated in a variety of fleets, using either purchasing card data or (in the future) onboard-diagnostic systems. The potential penetration of FFVs and E85 use in these contexts is substantial. Fleets that could use card-based data to document their biofuels use purchase as many as 20,000 to 80,000 vehicles per year. Including the number of vehicles in fleets that could use OBD data to establish their BUR (such as rental cars) brings the potential annual acquisition to 300,000 vehicles.

Automakers should also be allowed to calculate an average BUR for all FFVs sold into the general public vehicle population. The potential penetration of FFVs sales under this mechanism is not meaningfully limited, and could accommodate a large portion of the total vehicle sales in the state (i.e. up to 1 or 2 million vehicles per year). Crediting FFVs with this average rate and, especially, differentiating the average BUR rates by major metropolitan markets of the state, would add extra incentives for automakers to participate in developing E85 infrastructure, retail stations, and adoption.

The GHG-intensity of ethanol and gasoline is not static, nor is all ethanol the same. The methodology for evaluating fuel GHG-intensity should be based on a publicly-accessible, robust modeling framework, allowing public review and adaptation to uncertainty, as well as providing a guide for producers in testing the GHG-intensity of production alternatives. The FAF should be periodically updated to reflect changes in average GHG performance for both gasoline and ethanol. In the future, GHG accounting and tracking of biofuels may become more common, and CARB should be prepared to award different FAFs for users that can track fuels from source to user.

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