Backgrounder on Flexible Fuel Vehicles and E85

What is a Flexible Fuel Vehicle?

As currently offered to consumers by several automakers, flexible fuel vehicles (FFVs) are designed to operate on any mixture of gasoline and ethanol - with ethanol concentrations of up to 85% by volume (E85).* There is one major difference between an FFV and a conventional gasoline-fueled vehicle – the FFV detects the ethanol/gasoline ratio and makes appropriate adjustments to the engine's ignition timing and air/fuel mixture ratios to account for the ethanol and optimize performance and maintain emissions control. The vehicle must be equipped with an air/fuel ratio map capable of handling the adjustments necessary for optimized performance on both gasoline and E85. Components of the fuel delivery systems on FFVs are also modified and upgraded to be resistant to the corrosive effects of alcohol in the fuel.

Availability and consumer purchase cost of FFVs

FFVs were first introduced in 1993 with a flexible fuel version of the Ford Taurus.† Other auto manufacturers soon followed in the mid-1990s with the production of FFV versions of several popular light truck and van models as well as passenger cars.

The federal government and state governments, along with businesses in the alternative fuel industry, are required to purchase alternative-fueled vehicles by the Energy Policy Act of 1992. In addition, under the Clean Air Act Amendments of 1990, municipal fleets can use alternative fuel vehicles to mitigate air quality problems. Blends of 85% ethanol with 15% gasoline (E85), and 95% ethanol with 5% gasoline (E95) are currently considered alternative fuels by the US Department of Energy.

The Alternative Motor Fuels Act of 1988 provides Corporate Average Fuel Economy (CAFÉ) incentives to the auto industry for producing vehicles capable of operating on alcohol or natural gas fuels either exclusively or in conjunction with gasoline or diesel fuel. The Energy Policy Act of 2005 extends the availability of these CAFÉ credits through 2010 and authorizes NHTSA to consider extending the incentives through 2014.‡ This opportunity to earn CAFÉ credits is likely the reason for the expanded offering of (particularly pickups, vans and sport utility) FFVs in recent years. (1)§

---

* As presented later in this paper, a gasoline/ethanol blend designated as E85 could actually contain hydrocarbons (including denaturant) at levels ranging from 17 to 30% by volume and meet the ASTM Standard specifications.

† The FFVs first produced by Ford in the early 1990s were designed to operate on any mixture of gasoline blended with methanol (M85) up to a maximum of 85 % by volume.

‡ A brief discussion of the procedure for calculating Corporate Average Fuel Economy Credits for FFVs is provided in Appendix A.

§ Numbers in ( ) denote references listed at the end of this paper.

Ford, DaimlerChrysler, General Motors and Nissan currently offer model year 2006 vehicles for sale in the US which include the flexible fuel capability as standard equipment. Examples include the Ford Taurus, Ford F-150 pickup, GM Silverado, Chevy Tahoe, Chevrolet Impala and Dodge Ram pickup. (2, 24) Thirty-Four of the 520 models reported in the DOE/EPA *Model Year 2006 Fuel Economy Guide* are FFVs. (24) According to statements made by the manufacturers the FFVs are being made available at "little to no additional cost to the consumer." (1, 19)

Aside from DaimlerChrysler, General Motors and Ford have been the most aggressive in promoting the availability of FFVs nationwide. (3, 4, 5) Ford and DaimlerChrysler recently announced that they would not certify model year 2006 FFVs for California, and cited compliance concerns with respect to the stricter California LEV II evaporative emissions regulations which are currently being phased in. This has also precluded sales of Ford and DaimlerChrysler FFVs in those northeastern states which have adopted California emissions standards. (6, 7)

Estimates of the total number of FFVs currently in operation vary from 4 to 5 million. (7, 21) This is equivalent to about 2-3 percent of the total fleet of cars, light trucks, SUVs and vans on the road today.

Physical Properties of E85 and Comparison with Gasoline

The properties of E85 are governed by ASTM specifications which are shown in Appendix B.** These specifications were issued in 1999 and may be considered somewhat dated. For instance, they clearly do not reflect the EPA Tier 2/Gasoline Sulfur regulations which require refiners to meet a 30 ppm average gasoline sulfur limit starting in 2006. The ASTM specification for E85 allows for up to 300 ppm sulfur in the mixture. This high level could degrade the performance of catalytic converters that must be on the FFV to meet emission standards.

Pure ethanol differs from conventional gasoline in that it has a constant boiling point temperature, higher octane, lower energy density, and requires more heat for vaporization. (See Appendix C.) (8, 13) Blends containing 85% ethanol by volume have a higher octane value than regular gasoline, but because of the lower energy density of ethanol, an E85 blend contains only about 69 - 74% of the energy of regular gasoline on a Btu/gallon basis. This means that a 35% increase in the capacity of the fuel handling infrastructure (delivery tanks and carriers) would be needed for E85 systems to enable the same level of mobility (total vehicle miles of travel) as that provided by the current gasoline distribution system.

** Note: California has somewhat different requirements for the E85 fuel used for vehicle emissions certification testing. These requirements include specifications that the petroleum portion of the blend shall not exceed 15-21 percent by volume, and the Reid vapor pressure of the petroleum portion of the blend must meet a maximum limit of "8.0-8.5 psi, using common blending components from the gasoline stream." (27)

Neither the ASTM standards nor EPA regulations require deposit control additives to protect the intake valves and fuel injectors of vehicles operated on E85. The engines on FFVs operate like those on gasoline vehicles, but there is little published information available on their deposit formation tendencies. Evaluations of the need for deposit control additives in E85 (and their effectiveness) have not been completed.

Much like gasoline, the volatility of E85 must be adjusted seasonally and by geographic region to assure adequate cold start and drive away performance. This is done by increasing bot the volatility and the amount of gasoline (typically from 15% to 30% by volume) in blends sold during colder months.

Pure ethanol has broader flammability limits than gasoline and burns with lower flame luminosity. When blended with hydrocarbon fuels, the vapor space flammability limits of ethanol approach those of gasoline and luminosity is increased. (13)

With a stoichiometric air-to-fuel ratio of 10 (compared to 14.7 for regular gasoline), E85 needs more fuel per pound of air for optimum combustion; therefore E85 can not be used in conventional vehicles which are designed for no more than E10.

<u>FFV Performance, Energy Use and Emissions</u>

As noted above, E85 has a higher octane rating compared to regular gasoline. This could allow for improved performance (e.g., higher speed, acceleration due to a 3-5% increase in horsepower) if an FFV engine is designed to take advantage of the higher octane fuel. Given the limited availability of E85, it is questionable as to whether the manufacturers have in fact designed FFVs sold in the US to do so. In Europe, on the other hand, some FFV models (such as the Saab 9-5 model equipped with the flex-fuel 2.0 liter turbo engine) have clearly been designed to optimize performance on the higher octane in E85. (26)

Based on the heating value data shown in Appendix C, E85 contains about 69 - 74% of the energy of gasoline on a gallon basis. Therefore fuel economy (miles/gallon) on FFVs is substantially reduced when operated on E85. The extent of the decrease depends upon the reduction of heating value due to the presence of the ethanol in fuel, and the vehicle response. Analysis of the gasoline and E85 city/highway fuel economy ratings for the 33 model year 2006 FFVs (12 passenger cars and 21 pickups, vans and sport utility vehicles) listed in the DOE/EPA *Fuel Economy Guide* (and reproduced in Appendix E) indicates that the fuel economy penalty for E85 averages about 26% with a range between 24% and 34%.(24)

Given the above cited average fuel economy penalty of 26% for a model year 2006 FFV operated on E85, this means that on a cents/mile basis, the retail price of a gallon of E85 would have to be at least 60 cents <u>less than</u> the current average retail price of gasoline†† in order for the fuel operating costs on E85 to be comparable with those on gasoline.

---

†† The national average retail price of gasoline was 229.8 cents/gallon (including taxes) as of 2/27/06 according to the US Energy Information Administration, *Weekly Retail Gasoline and Diesel Prices* survey. (29)

There is limited published information available on the emissions characteristics of modern technology FFVs operated on E85. The available data relate to tests performed on FFVs produced in the early and mid-1990s and standard EPA emissions certification tests. (28) Measurements made by the Auto/Oil Air Quality Improvement Research Program (AQIRP) program showed that the effects of E85 on CO and NMHC emissions were mixed across the 3 mid-1990s FFVs tested. NOx emissions decreased and acetaldehyde emissions increased across the three vehicles evaluated. (12, 13) These data are generally consistent with the results of similar tests that have been reported by the US Department of Energy. (14)

There is even less published information available on the in-use durability of FFV engines and emissions control systems operated on E85.

E85 has a lower concentration of volatile components compared to typical gasoline, so one would expect evaporative emissions from an FFV fueled with E85 to be lower than for conventional gasoline. However, there is little published data on the comparison of evaporative emissions from FFVs fueled with E85 versus gasoline and some manufacturers have stated that the ability to comply with stringent evaporative emissions requirements in California will be a barrier to the sale of model year 2007 and later FFVs in that state. (6, 7) Furthermore, when consumers commingle E85 and non-oxygenated gasoline (or a low oxygenate gasoline blend) in the vehicle fuel tank (as might happen, for instance, upon consecutive refueling), the resulting nonlinear increase in the volatility of the mixture may elevate the FFV evaporative emissions. There is little, if any, information available on the emissions effects associated with commingling and more testing may be required.

Arguments regarding a criteria air quality benefit (or detriment) attributable to the operation of E85 FFVs have (or will) likely become moot in the near future as both FFVs and gasoline-fueled models must be certified to the same stringent emissions standards and as these vehicles increasingly dominate the on-road fleet. As expected, a review of the certified emissions levels for several 2005 – 2007 model year FFVs sold in California reveals relatively minor differences between E85 versus gasoline with respect to mass emissions of non-methane organic gases, nitrogen oxides and carbon monoxide, with values generally at or well below the standards on either fuel. (See Appendix D.) (23)

Performance of Non-FFVs on E85

The operation of non-FFVs on E85 can incur significant risk to the vehicle and/or its emissions. Fuel system delivery components that have not been modified to be tolerant of ethanol may be at increased risk of corrosion. In addition, the use of E85 in recent model non-FFVs could result in improper engine operating conditions which would cause the "check engine" light to illuminate. Furthermore, this could lead to emission control system malfunction or failure if allowed to persist. (8) If a non-FFV is fueled with E85, the engine will operate (if at all) outside of the air/fuel calibration window set by the manufacturer. Because of the oxygen present in the E85 fuel, the engine will be operating in a lean mode, which will degrade performance. Manufacturers of non-FFVs warn customers not to fuel with gasoline containing more than 10% ethanol (E10) and may void the customer's vehicle warranty if they do.

Ethanol Lifecycle Energy Use and Greenhouse Gas Emissions

Various studies have indicated that it takes approximately 73,500 Btu to produce a gallon of ethanol (mostly from fossil fuels). Given that combustion of ethanol generates 76,000 Btu per gallon, and allowing for co-product credits, implies that the net energy balance of ethanol is approximately 15,000 Btu per gallon. Hence, the size of the potential energy savings from ethanol use (on a well to wheels basis) is relatively small. (9)

A number of studies have concluded that the use of ethanol in FFVs will reduce greenhouse gas (GHG) emissions relative to petroleum fuels on a wells-to-wheels basis. However, these studies suggest that the lifecycle GHG impact associated with corn-based ethanol (the most likely source of this fuel in the near term) is expected to be moderate (~13-16 %) at best. (10, 11)

Potential Ground Water Issues Associated With Ethanol Fuels

Multi-media evaluations: In a 1999 report on the investigation of clean air and clean water issues associated with oxygenates in reformulated gasoline, one of the principal recommendations offered by an independent blue ribbon panel of experts (convened by US EPA) on this subject (and repeated below) was the need to conduct multi-media assessments of "…any new, broadly used, product:"

> "The introduction of reformulated gasoline has had substantial air quality benefits, but has at the same time raised significant issues about the questions that should be asked before widespread introduction of a new, broadly-used product. The unanticipated effects of RFG on groundwater highlight the importance of exploring the potential for adverse effects in all media (air, soil, and water), and on human and ecosystem health, before widespread introduction of any new, broadly-used, product." (40)

While E85 was not the specific focus of this panel recommendation in 1999, it does fall within the realm of the definition of "…any new, broadly used, product."

Groundwater: Releases of ethanol fuels to groundwater could occur from the following sources: underground or aboveground storage tank systems (USTs/ASTs), and tanker truck or railcar accidents (32). In addition, small releases may occur from motor vehicle accidents where the fuel tank is damaged. Release from storage facilities (USTs/ASTs) can be either single events (large or small releases) or chronic small releases over time.

Because of the substantial improvements to release prevention, detection and corrective action technologies for both USTs and ASTs, the frequency of occurrence of releases is expected to far less than it was 5 or 10 years ago. The size of releases is also expected to be smaller, and the time to detection much shorter, so the potential for such releases to migrate off-site is also much less likely. If releases do occur, it is expected that they will be detected soon and appropriate corrective actions will be undertaken.

There are no known published case histories of groundwater impacts from E85 releases from the approximately 600 facilities currently selling that fuel. The present understanding is based on limited documentation of large releases of E95 (denatured, fuel grade ethanol), laboratory studies and computer modeling analyses. Concern with subsurface releases is mostly focused on the potential for migration of contaminants off site and/or to nearby drinking water wells. Of interest is whether ethanol itself can migrate very far from the source, or if ethanol might affect the transport of any of the gasoline components present (e.g., benzene).

Ethanol is known to be completely soluble in water and rapidly biodegraded in groundwater under most conditions (33, 34). It would be expected that most small releases (e.g., 10's – 100's of gallons) should not persist for more than a few weeks or months, and would in most cases not travel far from the spill location (35, 36, 37). If large amounts of E85 are released to subsurface (e.g., 1000's gallons), or possibly for the case of chronic, infrequent small releases, it is possible that even with rapid biodegradation, ethanol may persist for much longer periods of time in groundwater and migrate offsite. Also, the rapid anaerobic biodegradation of large releases of ethanol is likely to generate methane gas, and so there may be safety concerns that would need to be addressed for any nearby structures (37). Finally, the intensive biodegradation that is probable when ethanol is released to ground water is also likely to substantially alter the geochemistry and quality of the impacted water, including changes in water pH, dissolved metals, etc., which could impart disagreeable taste and odor characteristics to the water.

Because there is relatively little gasoline (15% by volume) present in E85, the total mass of gasoline components of concern, like benzene, is very small compared to conventional gasoline releases. However, it is likely that the presence of high concentrations of ethanol will cause enhanced dissolution of the gasoline compounds into ground water (32, 37). It is also likely that the rapid biodegradation of ethanol may result in an inhibition of the biodegradation of benzene or other gasoline compounds, which might allow those compounds to migrate farther off-site (32, 33, 34). The distance that ethanol or gasoline compounds will travel in ground water will be highly dependent upon the characteristics of the spill (e.g., the volume and rate of the release) and the local hydrogeology (e.g., ground water depth, velocity, geochemistry, etc.) and any corrective action undertaken.

Large releases of E85 might occur at sites where there have been previous releases of gasoline or diesel fuel and where those fuels are still present at the water table. At these sites there would be added potential for enhanced dissolution or mobilization of the residual gasoline or diesel fuel as the E85 came in contact with the older releases (37, 38).

Because of the limited number of lab and field studies documenting the behavior of E85 in the ground water environment, research is continuing so as to provide a more complete understanding of this type of motor fuel release, and to identify the most appropriate corrective action technologies.

<u>Other Environmental Issues Associated with E85</u>

There is widespread consensus that the overwhelming majority of new ethanol production to comply with the recently enacted renewable fuels standard will be corn-based, at least over the next decade. A recently completed study by Global Insight showed that higher levels of ethanol production lead to a greater degree of continuous corn planting, resulting in a greater need for weed control, more insect problems, and additional nitrogen fertilizer and insecticide use. (9) Significantly higher fertilizer and pesticide use associated with higher corn crop-induced ethanol production levels will increase the likelihood of additional nutrient run-off and increased adverse environmental impacts on water resources.

Increased Ethanol Production Creates Major Economic Disbenefits
Global Insight recently completed a study which evaluated the major winners and losers from increased ethanol production. (9) The study drew the following conclusions:

- Increased ethanol production would divert more of the nation's corn crop away from food production, which would significantly increase food prices. For example, under a scenario of 8 billion gallons of ethanol usage, corn acreage is estimated to increase by 7.24 million acres. This would increase the share of corn production devoted to ethanol from an estimated current level of 12% up to 23%. Also, 8 billion gallons of ethanol usage is estimated to cost consumers $10 billion per year in additional food expenditures, as measured by the change in the Consumer Price Index for "All Food".

- Cow-calf producers, representing 42% of all farms, would suffer profit declines due to increased feed costs.

- Most of the economic benefit to the agriculture sector due to increased ethanol production would be limited to the producers of corn and soybeans, most of who operate in Nebraska, South Dakota, Minnesota, Wisconsin, Missouri, Indiana, Illinois and Ohio. Grain corn farmers represent about 16% of all farmers.

- Consumers abroad, especially poor countries, would also be worse off. Not only would they need to pay more for primary grains, but also there would likely be reduced food aid and other food donations as grain prices rise.

E85 Supply and Infrastructure Issues
According to the US Department of Energy, as of March 21, 2006 there were 592 retail outlets in 36 states across the US which offered E85 fuel. This is equivalent to less than one half of one percent of the total (~169,000) gasoline retail outlets nationwide. (15)

Most of the E85 retail outlets currently in operation are located in the Midwest (Minnesota, Illinois, Nebraska and the Dakotas). There are only a handful of E85 outlets in the West and in the Northeast. (The entire state of California, for instance, has only one retail outlet available to individual consumers and a handful available for government- and privately-owned fleets of FFVs.) (15)

GM and Ford recently have been aggressive in publicly promoting partnerships with various oil companies and state agencies designed to demonstrate the use of E85 and expand the availability of E85 retail outlets. For instance, key objectives of the California-sponsored E85 demonstration program are to assess vehicle performance (mileage, emissions, effect of various climatic conditions, maintenance needs, driver feedback) and investigate commercial feasibility (blending, transportation, storage, dispensing). (16, 17, 18, 20, 22)

As with gasoline, E85 fuel will require certified Stage I and Stage II vapor recovery systems. Currently there is no certified vapor recovery system for dispensing E85. However, the California Air Resources Board has allowed 5 research and development (R&D) facilities in California to operate without certification and collect E85 fueling information. Two E85 stations will operate under a joint demonstration program (GM, Chevron, Pacific Ethanol and Cal-Trans) for which one of the purposes is to generate data that can be used to support a certification application. Manufacturers of vapor recovery equipment have expressed concern about the risk of investing large amounts of resources in developing certified E85 dispensing equipment when the market and demand for E85 is uncertain. (22)

As with automobile fuel system components, there are potential compatibility issues with using fuel storage tanks and pumps that have not been designed to withstand the corrosive (and hygroscopic) properties associated with ethanol. (8, 13, 30) E85 has significantly different chemical properties than both straight petroleum gasoline and E10 gasoline (a blend of 10% ethanol and 90% gasoline). The chemical properties of E85 make it corrosive to the gasoline station equipment. For example, when "aluminum come[s] in [to] contact with ethanol, [it] may dissolve in the fuel, which may damage engine parts and result in poor vehicle drive-ability." This equipment can be modified or replaced to allow the storage and dispensing of E-85, however, it would require significant changes to the existing underground storage tank (UST) infrastructure. (8)

The language of the policies and practices relating to brand protection varies among the owners of the different gasoline brands. Generally, however, a dealer and/ or distributor (jobber) is not prohibited from installing unbranded E85 tanks and pumps on service station property. Retrofitting a gasoline station to host E85 will depend on the age of the system and the market for the fuel. Adding a new E85 UST system with dispenser could cost as much as $240,000. (25) If a station owner decided, based on market demand, to convert a compatible tank to E85, the cost could be substantially less to change out the dispenser and other equipment.

The US Department of Energy has issued guidelines for storing, handling and dispensing E85, which state the following:

> "Many underground fiberglass tanks that meet EPA standards may also be used to store E85. However, fiberglass storage tanks manufactured prior to 1992 MAY NOT (emphasis not added) be able to handle E85. If you wish to use an existing fiberglass underground storage tank that was manufactured prior to 1992 to store E85, contact the National Ethanol Vehicle Coalition for additional information" (8).

Other sources indicate that "[p]recautions must be taken with the storage of E-blend fuels [greater than 10% ethanol] in single-walled fiberglass tank systems fabricated prior to

January 1, 1984, as these tanks may not be compatible with ethanol…Lined tanks will not be approved for E85" (31).

Terminals may have to retrofit to accommodate increased throughput of ethanol. This could include new tank capacity (in areas where ethanol is already used as an oxygenate the existing storage tanks might be adequate), modifying the rack to accommodate E85, and adding hardware to blend the fuel.

- In the near term, it is likely that most of the projected increase in shipments in ethanol to terminals will be handled by tanker truck and rail tank car as opposed to pipelines. Except for a few proprietary pipelines, the common carriers generally do not ship ethanol in their systems. The increased risk of corrosion and potential for water contamination associated with ethanol are key factors limiting its transport via pipeline.

- Many terminals in the Midwestern US are currently designed to deliver gasoline blended with ethanol at 10 percent by volume. Practically all California terminals are currently designed to blend gasoline containing 5.7 percent ethanol by volume. Depending upon the current facility design, the incorporation of E85 into the terminal product slate may entail a change as simple as modification of a computer program for controlling in-line product blending. Alternatively, the terminal facility may have to make significant equipment changes that could be very expensive.

- The largest concern is for terminals that are configured to receive ethanol via truck. At present, for every 10 trucks leaving such a terminal with gasoline containing ethanol blended at 10 volume %, there is one truck coming in to the terminal with a load of ethanol. To distribute E85 fuel would entail 8.5 incoming truckloads of ethanol for every 10 trucks leaving the terminal. Demand for high volumes of E85 would require significant modifications to the terminal to handle the additional truck traffic, build new areas for unloading the ethanol, and likely require the addition of new tanks. Terminals receiving product via marine barge/ship or railroad may only need to install additional storage tanks.

Labeling Requirements and Misfueling Issues

When the retail price of E85 is lower than that of other gasoline grades, there is greater incentive – and potential – to misfuel by owners of non-FFVs who are not aware of the performance issues with operating on E85. To address this issue, fuel providers and state and federal regulatory agencies have been cooperating in the development of criteria and standards for the proper signage for – and labeling of – E85 tanks and dispensing equipment.

The US Department of Energy has summarized the existing requirements regarding the labeling for tanks containing ethanol fuel. (8) A bronze pentagon decal...with "E85" in black must label the fillbox and fillbox cover." In addition, each state, along with the US Department of Transportation, has developed certain signage to place at refueling stations. Also, the Federal Trade Commission requires a small sticker to be placed on the face of the fuel dispenser as close as possible to the price per unit of fuel. The sticker should have a black background with orange text." The text on the label reads, E85, Minimum 85% ethanol. (8) Product meeting ASTM standards for E85 will not meet an 85% minimum ethanol content as prescribed by the label. Consumer information in this regard remains un-reconciled. E85 blends will actually contain from 17 to 30 % hydrocarbon and aliphatic ethers.

Federal Tax Incentives for E85

The federal tax treatment of E85 depends on the alcohol component of the fuel:

- **Agricultural E85.** In this case, the 85% ethanol component is produced from agricultural products such as corn or grain. The E85 is taxed under Section 4081 of the Internal Revenue Code at the full gasoline rate of 18.4 cents per gallon. There is a corresponding tax credit of 51 cents/gallon of ethanol used to produce the E85. Put another way, there is a tax credit of 43.35 cents/gallon of E85. The person who is entitled to the credit is the person who produces the E85 mixture. If the E85 producer does not have excise tax liabilities against which to apply the credit, he may apply for an excise tax refund instead. The Agricultural E85 producer may take an income tax credit under Section 40(a), but he cannot "double dip" … he must adjust the income tax credit to take into account the benefit of any prior excise tax credit or refund he claimed.

- **Coal/Peat E85.** The 85% ethanol component is produced from coal including peat. This type of E85 is taxed at the retail level under Section 4041(b)(2) of the Internal Revenue Code at a rate of 13.25 cents/gallon. The gasoline component is taxed under Section 4081 at a rate of 18.4 cents/gallon when it is removed from the terminal. The person who paid the tax on the gasoline (i.e., the supplier) may file a refund claim for the 18.4 cents/gallon that was paid on the gasoline portion of the blend.

- **Natural Gas E85.** The 85% ethanol component is produced from natural gas. This type of E85 is taxed at the retail level under Section 4041(m) of the Internal Revenue Code at a rate of 11.4 cents/gallon for ethanol fuel and 9.25 cents/gallon for methanol fuel. The gasoline component is taxed under Section 4081 at a rate of 18.4 cents/gallon when it is removed from the terminal. The person who paid the tax (i.e., the supplier) may file a refund claim for the 18.4 cents/gallon that was paid on the gasoline portion of the blend.

Federal Tax Incentives for E85 Infrastructure

The Energy Policy Act of 2005 added new Internal Revenue Code section 30C pursuant to which taxpayers may claim a 30% income tax credit for the cost of installing clean-fuel (including E85) vehicle refueling property for use in a trade or business or at the principal residence of the taxpayer after 2005. In the case of retail clean-fuel vehicle refueling property, the credit may not exceed $30,000. In the case of residential clean-fuel vehicle refueling property, the credit may not exceed $1,000. This E85-related credit expires at the end of 2009.

State Incentives for E85 Infrastructure

Several states, particularly those in the Midwest (such as Iowa, Minnesota and Indiana), have adopted programs that offer grants, loans or tax breaks for organizations converting existing fueling facilities, or building new ones, to include ethanol blends such as E85 or biodiesel in plans for storage and handling systems. For instance, the Indiana Alternative Fuels Grant Program, funded through grant money from the U.S. Department of Energy, can pay for 50 percent of the cost of installing an E85 pump, up to $50,000. (39) For a fairly comprehensive summary listing of state incentives for alternative fuels and alternative fuel vehicles including E85 and FFVs, the reader is encouraged to visit the "Alternative Fuels Data Center" website maintained by the US Department of Energy. (41)

REFERENCES

1. US Department of Transportation, US Department of Energy, and US Environmental Protection Agency, *Report to Congress, Effects of the Alternative Motor Fuels Act CAFÉ Incentives Policy*, March 2002

2. US Department of Energy, *Model Year 2006: Alternative Fuel and Advanced Technology Vehicles*, http://www.eere.energy.gov/afdc/pdfs/my2006_afv_atv.pdf

3. Wall Street Journal, *Ford, GM Push to Promote 'Flex Fuel' Vehicles*, January 10, 2006

4. General Motors, http://www.gm.com/automotive/innovations/altfuel/

5. Ford Motor Company, *Using Corn for Power*, http://www.ford.com/en/innovation/technology/usingCornForPower.htm

6. NewFuelsandVehicles.com, *Ford, Daimler Decide to Restrict Availability of Ethanol Vehicles*, January 20, 2006

7. National Ethanol Vehicle Coalition, 2006 *Purchasing Guide for Flexible Fuel Vehicles*, http://www.e85fuel.com

8. US Department of Energy, National Renewable Energy Laboratory, *Handbook for Handling Storing, and Dispensing E85*, Report No. DOE/GO-102002-1596, April 1, 2002

9. Global Insight, *Winners and Losers of Ethanol Mandates*, May 2005

10. Farrell, A.E. et al., *Ethanol Can Contribute to Energy and Environmental Goals*, Science, 27 January 2006, vol 311

11. Wang, M. et al, General Motors Corp, Argonne National Laboratory, BP, ExxonMobil, Shell, *Well-to-Wheel Energy Use and Greenhouse Gas Emissions of Advanced Fuel/Vehicle Systems – North American Analysis*, June 2001

12. Auto/Oil Air Quality Improvement Research Program, *Program Final Report*, January 1997

13. American Petroleum Institute, *Alcohols and Ethers: a Technical Assessment of Their Application as Fuels and Fuel Components*, API Publication 4261, Third edition, June 2001

14. Kelly, K.J., et al, National Renewable Energy Laboratory, *Federal Test Procedure Emissions Test Results from Ethanol Variable-Fuel Vehicle Chevrolet Luminas*, paper presented at Society of Automotive Engineers, May 1996

15. US Department of Energy, http://www.eere.energy.gov/afdc/infrastructure/station_counts.html

16. Ford Motor Company, *Ford and Verasun Announce Partnership to Drive Ethanol Infrastructure*, press release, November 4, 2005

17. General Motors, *General Motors Promotes Greater E85 Consumer Awareness, Use*, press release, February 9, 2006

18. General Motors Corp, *GM Joins State of California, Chevron Technology Ventures LLC, and Pacific Ethanol to Help Investigate Ethanol as Alternative, Renewable Fuel*, press release, January 5, 2006, http://biz.yahoo.com/prnews/060105/deth005a.html?.v=2

19. National Ethanol Vehicle Coalition, *Frequently Asked Questions*, http://www.e85fuel.com/e85101/faqs/cost.php

20. GreenBiz.com, *GM Launches Public Campaign to Promote E85 'Flex-Fuel' Vehicle*, February 9, 2006, http://www.greenbiz.com/news/news_third.cfm?NewsID=30357

21. US Energy Information Administration, *Annual Energy Outlook 2006*, Supplemental Table 45, February 2006, http://www.eia.doe.gov/oiaf/aeo/supplement/index.html

22. California Environmental Protection Agency, Air Resources Board, *Meeting to Discuss Vapor Recovery for Facilities that Dispense E85*, February 2, 2006, http://www.arb.ca.gov/vapor/vapor.htm

23. California Environmental Protection Agency, Air Resources Board, *On-Road New Vehicle and Engine Certification Program, Executive Orders*, http://www.arb.ca.gov/msprog/onroad/cert/cert.php

24. US Environmental Protection Agency, *Model Year 2006 Fuel Economy Guide*, http://www.fueleconomy.gov/feg/FEG2006.pdf

25. Truett, Richard, *Ethanol Gains Momentum but Needs More Pumps*, Automotive News February 20, 2006

26. Green Car Congress, *Saab Flex-Fuel Vehicle for '05*, 29 August 2004, http://www.greencarcongress.com/2004/08/saab_flex_fuel_.html

27. California Environmental Protection Agency, Air Resources Board, *California Exhaust Emission Standards and Test Procedures for 2001 and Subsequent Model*

Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, as amended August 4, 2005, http://www.arb.ca.gov/msprog/onroad/cert/cert.php#2

28. US Environmental Protection Agency, *Annual Certification Test Results and Data*, http://www.epa.gov/otaq/crttst.htm

29. US Energy Information Administration, *Weekly Retail Gasoline and Diesel Prices*, http://tonto.eia.doe.gov/dnav/pet/pet_pri_gnd_dcus_nus_w.htm

30. Renewable Fuels Association, Fuel Ethanol – Industry Guidelines, Specifications, and Procedures (Publication #960501), Revised October 2005, www.ethanolrfa.org

31. Wisconsin Department of Commerce, Ethanol Motor Fuel Storage Overview, Revised September 2005, www.commerce.state.wi.us

32. The Subsurface Fate of Ethanol: A Look at the Emerging Oxygenate Alternative to MTBE. 2003. LUSTLine #36. http://www.epa.gov/OUST/oxygenat/LL36ETH.pdf

33. Lawrence Livermore National Laboratory. 2001. Use of Ethanol as a Fuel Oxygenate: Subsurface Fate and Transport of Gasoline Containing Ethanol. http://www-erd.llnl.gov/ethanol/etohdocII/index.html

34. NESCAUM. 2001. The "Health, Environmental, and Economic Impacts of Adding Ethanol to Gasoline in the Northeast States" Volume 3: Water Resources and Associated Health Impacts. http://www.nescaum.org/committees/ethanol-report.html

35. Dakhel N, Pasteris G, Werner D, Hohener P.Environ Sci Technol. 2003. Small-volume releases of gasoline in the vadose zone: impact of the additives MTBE and ethanol on groundwater quality. 15; 37(10):2127-33.

The following technical bulletins are available to download at: http://api-ep.api.org/environment/index.cfm?objectid=3874DD32-D87D-4AF3-875DB513BFC5446A&method=display_body&er=1&bitmask=002008008000000000

36. *Evaluation of Small-Volume Releases of Ethanol-Blended Gasoline at UST Sites* American Petroleum Institute, Soil and Groundwater Research Bulletin No. 19 October 2000

37. *Answers to Frequently Asked Questions About Ethanol Impacts to Groundwater*. December 2003. American Petroleum Institute, Soil and Groundwater Research Bulletin No. 20

38. *The Impact of Gasohol and Fuel-Grade Ethanol on BTX and Other Hydrocarbons in Ground Water: Effect on Concentrations Near a Source*. American Petroleum Institute, Soil and Groundwater Research Bulletin 23 December 2005.

39. STI/SPFA, *Indiana Boosts Alternative Fuel Infrastructure Through Grants*, Tank Talk, Volume 21, Number 1, March 2006

40. US Environmental Protection Agency, *Achieving Clean Air and Clean Water: The Report of the Blue Ribbon Panel on Oxygenates in Gasoline*, September 15, 1999

41. US Department of Energy, *Alternative Fuels Data Center, http://www.eere.energy.gov/afdc/progs/all_state_summary.cgi?afdc/0r*

APPENDIX A

Calculation of Corporate Average Fuel Economy (CAFE) Credits for Flexible-Fuel Vehicles

Section 6 of the Alternative Motor Fuels Act (AMFA) of 1988 contains provisions that allow for special treatment of vehicle CAFE calculations for "dedicated" and "dual-fuel"(also referred to as "flexible-fuel") methanol, ethanol and natural gas alternative fuel vehicles. Vehicles that operate exclusively on a 70 percent or greater methanol or ethanol concentration, or only on compressed or liquefied natural gas are recognized by AMFA to be "dedicated" alternative fuel vehicles. Those that have the capability to operate on either conventional gasoline or diesel fuel, or a mixture of the fuel and gasoline or diesel fuel, or only on the alternative fuel, without modification to the vehicle, are considered as "dual-fuel" or "flexible-fuel" vehicles.

Beginning in MY 1993, manufacturers of FFVs and other so-called “dedicated” and “dual-fuel” vehicles defined in AMFA could qualify for special treatment in the calculation of their CAFE by computing the weighted average of the fuel economy while operating on gasoline or diesel fuel and when operating on the alcohol after dividing the alcohol fuel economy by a factor of 0.15. For FFVs, an assumption is made that the vehicles would operate 50% of the time on the alternative fuel and 50% of the time on conventional fuel, resulting in a fuel economy that is based on a harmonic average of alternative fuel and conventional fuel. The fuel economy for an FFV model is calculated by dividing 1.0 by the sum of 0.5 divided by the fuel economy as measured on the conventional fuel and 0.5 divided by the fuel economy as measured on the alternative fuel, using the 0.15 volumetric conversion factor. For example, for an FFV that achieves 15 miles per gallon operating on an alcohol fuel and 25 mpg on the conventional fuel, the resulting CAFE would be:

$$FE = 1/[(0.5/25) + (0.5/(1/0.15)(15))] = 40 \text{ miles per gallon}$$

The fuel economy calculation and testing procedures for alternative fuel vehicles were codified by the EPA in 1994 (59 FR 39638; August 3, 1994).

AMFA also limits the extent to which these special considerations can improve a manufacturer's average fuel economy to a maximum of 1.2 mpg for any given model year for each category of automobiles (domestic and import passenger car fleets; light truck fleets). The incentive program was extended through model year 2008 by the 2005 Energy Act. In the event that the Secretary of Transportation reduces the current CAFE requirement from 27.5 mpg for any model year, any increase of CAFE resulting from the AMFA calculation amount will be reduced by the CAFE standard, but may not be reduced to yield less than 0.7 mpg (49 U.S.C. §32906(b)).

The CAFE credits that automakers received for offering flexible-fuel vehicles in 2004 are shown in the table below, followed by their fleet averages for those categories and the standards they had to meet.

	Credit	Fleet avg.	Standard
General Motors light trucks	1.2 mpg	21.2	20.7
Ford domestic cars	0.6 mpg	26.5*	27.5
Ford light trucks	1.2 mpg	21.1	20.7
DaimlerChrysler domestic cars	0.5 mpg	29.7	27.5
DaimlerChrysler imported cars	0.5 mpg	26.6*	27.5

*Carmakers that fail to meet standards in a given year can make up for the shortfall with credits from past or future years

Source: National Highway Traffic Safety Administration

APPENDIX B

ASTM D5798-99 Standard Specification for Fuel Ethanol (Ed75Ed85) For Automotive Spark-Ignition Engines

Property	Value for Class			Test Method
ASTM volatility class	1	2	3	N/A
Ethanol, plus higher alcohols (minimum volume %)	79	74	70	ASTM D5501
Hydrocarbons (including denaturant) (volume %)	17-21	17-26	17-30	ASTM D4815
Vapor pressure at 37.8°C				
kPa	38-59	48-65	66-83	ASTM D4953, D5190, D5191
psi	5.5-8.5	7.0-9.5	9.5-12.0	
Lead (maximum, mg/L)	2.6	2.6	3.9	ASTM D5059
Phosphorus (maximum, mg/L)	0.3	0.3	0.4	ASTM D3231
Sulfur (maximum, mg/kg)	210	260	300	ASTM D3120, D1266, D2622
Methanol (maximum, volume %)		0.5	N/A	
Higher aliphatic alcohols, C3-C8 (maximum volume %)		2		N/A
Water (maximum, mass %)		1.0		ASTM E203
Acidity as acetic acid (maximum, mg/kg)		50		ASTM D1613
Inorganic chloride (maximum, mg/kg)		1		ASTM D512, D7988
Total chlorine as chlorides (maximum, mg/kg)		2		ASTM D4929
Gum, unwashed (Maximum, mg/100 mL)		20		ASTM D381
Gum, solvent-washed (maximum, mg/100 mL)		5.0		ASTM D381
Copper (maximum, mg/100 mL)		0.07		ASTM D1688
Appearance		Product shall be visibly free of suspended or precipitated contaminants (shall be clear and bright).		Appearance determined at ambient temperature or 21°C (70°F), whichever is higher.

N/A = Not applicable

Note: Fuel ethanol today does not have a maximum sulfate specification. It is currently being balloted at ASTM as a maximum of 4 ppm, but has not yet passed. High levels of sulfate can compromise vehicle performance either through fuel filter plugging, fuel injector sticking or flow reduction, or valve deposition.

APPENDIX C

Comparison of Fuel Properties

Comparison of Fuel Properties			
Property	**Ethanol**	**Gasoline**	**E85**
Chemical Formula	C_2H5OH	C_4 to C_{12} chains	*
Main constituents (% by weight)	52C, 13 H, 35 O	85-88 C, 12-15 H	57 C, 13 H, 30 O
Octane (R+M)/2	98-100	86-94	96
Lower heating value (Btu/gal @ 60°F)	76,000	109,000-119,000	80,950 – 82,450**
Boiling Temperature, °F	173	80-437	*
Latent heat of Vaporization (Btu/gal @ 60°F)	2,378	~900	*
Miles per gallon Compared to gasoline	70%	-	72%
Relative tank size to Yield (driving range equivalent to gasoline)	Tank is 1.5 times larger	1	Tank is 1.4 times larger
Reid vapor pressure (psi)	2.3	6.5-15	5.5-12
Ignition point **Fuel in air (%)** **Temperature (approx.) (°F)**	 3-19 850	 1-8 495	 * *
Specific Gravity (60/65°F)	0.794	0.72 – 0.78	0.78
Flash point, °F	55	-45	*
Flammability Limits, vol %	4.3 – 19	1.4 – 7.6	*
Electrical Conductivity (mhos/cm)	1.35×10^{-9}	1×10^{-14}	*
Vehicle Power	5% power increase	Standard	3%-5% power increase
Stoichiometric air/fuel ratio (by weight)	9	14.7	10

*Depends on percentage and type of the hydrocarbon fraction
**Calculated assuming 15 vol % ethanol and 85 vol % gasoline and the range of lower heating values shown for these (ethanol and gasoline) components

Sources: References 8, 13

APPENDIX D

Exhaust Emissions Certification Test Values for California FFVs
(grams per mile @ useful life)

2007 FFVs Certified to California Light Duty Truck (3,751-5,750 lbs ALVW) LEV2 ULEV Standards				
Vehicle Model	**Fuel**	**NOx (std=0.04)**	**NMOG (std=0.070)**	**CO (std=2.1)**
Chevrolet Tahoe & GMC Yukon	E85	0.04	0.062	1.0
	Gasoline	0.02	0.065	0.9
2006 FFVs Certified to California Medium Duty Vehicle (3,751-5,750 lbs ALVW) SULEV1 Standards				
Vehicle Model	**Fuel**	**NOx (std=0.20)**	**NMOG (std=0.156)**	**CO (std=4.2)**
Chevrolet Tahoe & GMC Yukon	E85	0.06	0.091	1.0
	Gasoline	0.07	0.054	1.2
2006 FFVs Certified to California Passenger Car LEV2 LEV Standards				
Vehicle Model	**Fuel**	**NOx (std=0.07**	**NMOG (std=0.090)**	**CO (std=4.2)**
Chevrolet Impala & Monte Carlo	E85	0.02	0.052	0.8
	Gasoline	0.01	0.054	1.0
2005 FFVs Certified to California Passenger Car LEV1 ULEV Standards				
Vehicle Model	**Fuel**	**NOx (std=0.20**	**NMOG (std=0.125)**	**CO (std=4.2)**
Ford Taurus & Mercury Sable	E85	0.05	0.060	0.8
	Gasoline	0.03	0.061	1.1
Mercedes-Benz C 240 & C320	E85	0.01	0.051	0.2
	Gasoline	0.05	0.034	0.4
Dodge Stratus & Chrysler Sebring	E85	0.05	0.045	0.5
	Gasoline	0.06	0.058	1.0
2005 FFVs Certified to California Light Duty Truck (3,751-5,750 lbs LVW) LEV1 ULEV Standards				
Vehicle Model	**Fuel**	**NOx (std=0.30**	**NMOG (std=0.156)**	**CO (std=4.2)**
Ford Explorer & Mercury Mountaineer	E85	0.20	0.083	1.8
	Gasoline	0.20	0.063	2.2
2005 FFVs Certified to California Medium Duty Vehicle (3,751-5,750 lbs ALVW) LEV Standards				
Vehicle Model	**Fuel**	**NOx (std=0.6)**	**NMOG (std=0.230)**	**CO (std=6.4)**
Chevrolet Tahoe & Silverado & GMC Sierra	E85	0.20	0.135	1.0
	Gasoline	0.20	0.070	1.2

Source: Reference 23

Evaporative Emissions Certification Test Values for California FFVs

2007 FFVs Certified to California Light Duty Truck (3,751-5,750 lbs ALVW) LEV2 ULEV Standards					
Vehicle Model	**Evap Family**	**3-D (std=0.90)**	**2-D (std=1.15**	**RL (std=0.05)**	**ORVR (std=0.20)**
Chevrolet Tahoe & GMC Yukon	7GMXR0176820	0.55	0.38	0.00	(0.03)*
	7GMXR0223840	0.53	0.32	0.00	(0.09)*
2006 FFVs Certified to California Medium Duty Vehicle (3,751-5,750 lbs ALVW) SULEV1 Standards					
Vehicle Model	**Evap Family**	**3-D (std=0.90)**	**2-D (std=1.15**	**RL (std=0.05)**	**ORVR (std=0.20)**
Chevrolet Tahoe & GMC Yukon	6GMXR0176820	0.47	0.56	0.00	0.03
	6GMXR0223840	0.59	0.73	0.00	0.09
2006 FFVs Certified to California Passenger Car LEV2 LEV Standards					
Vehicle Model	**Evap Family**	**3-D (std=0.50**	**2-D (std=0.65)**	**RL (std=0.05)**	**ORVR (std=0.20)**
Chevrolet Impala & Monte Carlo	6GMXR0133810	0.25	0.30	0.00	0.01
	6GMXR0133880	0.35	0.40	0.00	0.01
2005 FFVs Certified to California Passenger Car LEV1 ULEV Standards					
Vehicle Model	**Evap Family**	**3-D (std=2.0)**	**2-D (std=2.5)**	**RL (std=0.05)**	**ORVR (std=0.20)**
Ford Taurus & Mercury Sable	5MXR0185GAE	1.0	1.2	0.01	0.04
Mercedes-Benz C 240 & C320	5MBXR0155LFZ	0.7	2.2	0.004	0.02
Dodge Stratus & Chrysler Sebring	5CRX0130XBA	1.6	0.8	0.000	0.11
2005 FFVs Certified to California Light Duty Truck (3,751-5,750 lbs LVW) LEV1 ULEV Standards					
Vehicle Model	**Evap Family**	**3-D (std=2.0)**	**2-D (std=2.5)**	**RL (std=0.05)**	**ORVR (std=0.20)**
Ford Explorer & Mercury Mountaineer	5MXR0220GFE	0.9	0.7	0.002	0.02
	5MXR0200GBV	0.8	0.6	0.04	0.00

*Measured on gasoline

Source: Reference No. 23

Notes: 3-D = 3-day diurnal losses (gms/test)
2-D = 2-day diurnal losses (gms/test)
RL = Running losses (gms/test)
ORVR = Refueling losses (gms/test)

APPENDIX E

EPA Fuel Economy Ratings For Model Year 2006 FFVs

	Engine Size (L)/ # Cylinders	Transmission Type	EPA Combined MPG	Fuel
COMPACT CARS				
CHRYSLER				
SEBRING CONVERTIBLE	2.7/8/6	Auto(L4)	20.29	E85
			27.58	Gas
SEBRING CONVERTIBLE (2-mode)	2.7/6	Auto(L4)	20.29	E85
			27.58	Gas
MIDSIZE CARS				
CHEVROLET				
MONTE CARLO	3.5/6	Auto(L4)	22.00	E85
			29.02	Gas
CHRYSLER				
SEBRING 4-DR	2.7/6	Auto(L4)	20.29	E85
			27.58	Gas
SEBRING 4-DR (2-mode)	2.7/6	Auto(L4)	20.29	E85
			27.58	Gas
DODGE				
STRATUS 4-DR	2.7/6	Auto(L4)	20.29	E85
			27.58	Gas
STRATUS 4-DR (2-mode)	2.7/6	Auto(L4)	20.29	E85
			27.58	Gas
LARGE CARS				
CHEVROLET				
IMPALA	3.5/6	Auto(L4)	21.62	E85
			28.47	Gas
FORD				
CROWN VICTORIA	4.6/8	Auto(L4)	23.09	Gas
			16.87	E85
TAURUS	3.0/6	Auto(L4)	19.59	E85
			26.00	Gas
MERCURY				
GRAND MARQUIS	4.6/8	Auto(L4)	16.87	E85
			23.01	Gas
LINCOLN				
TOWN CAR	4.6/8	Auto(L4)	16.87	E85
			23.01	Gas

	Engine Size (L)/ # Cylinders	Transmission Type	EPA Combined MPG	Fuel
STANDARD PICKUP TRUCKS 2WD				
CHEVROLET				
C1500 SILVERADO 2WD	5.3/8	Auto(L4)	15.89	E85
			21.00	Gas
DODGE				
RAM 1500 PICKUP 2WD	4.7/8	Auto(L5)	11.50	E85
			15.95	Gas
GMC				
C1500 SIERRA 2WD	5.3/8	Auto(L4)	15.85	E85
			20.87	Gas
NISSAN				
TITAN 2WD	5.6/8	Auto(L5)	13.56	E85
			18.52	Gas
STANDARD PICKUP TRUCKS 4WD				
CHEVROLET				
K1500 SILVERADO 4WD	5.3/8	Auto(L4)	14.82	E85
			19.63	Gas
DODGE				
RAM 1500 PICKUP 4WD	4.7/8	Auto(L5)	11.50	E85
			15.95	Gas
GMC				
K1500 SIERRA 4WD	5.3/8	Auto(L4)	14.75	E85
			19.13	Gas
NISSAN				
TITAN 4WD	5.6/8	Auto(L5)	12.98	E85
			17.92	Gas
MINIVAN 2WD				
DODGE				
CARAVAN 2WD	3.3/6	Auto(L4)	16.84	E85
			25.64	Gas

EPA Fuel Economy Ratings For Model Year 2006 FFVs

	Engine Size (L)/ # Cylinders	Transmission Type	EPA Combined MPG	Fuel
SPORT UTILITY VEHICLES 2WD				
CHEVROLET				
C1500 AVALANCHE 2WD	5.3/8	Auto(L4)	13.96	E85
			18.59	Gas
C1500 SUBURBAN 2WD	5.3/8	Auto(L4)	13.96	E85
			18.59	Gas
C1500 TAHOE 2WD	5.3/8	Auto(L4)	15.12	E85
			20.03	Gas
DODGE				
DURANGO 2WD	4.7/8	Auto(L5)	11.50	E85
			15.95	Gas
GMC				
C1500 YUKON 2WD	5.3/8	Auto(L4)	15.12	E85
			20.03	Gas
C1500 YUKON XL 2WD	5.3/8	Auto(L4)	13.96	E85
			18.59	Gas
SPORT UTILITY VEHICLES 4WD				
CHEVROLET				
K1500 AVALANCHE 4WD	5.3/8	Auto(L4)	13.88	E85
			18.48	Gas
K1500 SUBURBAN 4WD	5.3	Auto(L4)	13.88	E85
			18.48	Gas
K1500 TAHOE 4WD	5.3/8	Auto(L4)	13.88	E85
			18.48	Gas
DODGE				
DURANGO 4WD	4.7/8	Auto(L5)	11.50	E85
			15.95	Gas
GMC				
K1500 YUKON 4WD	5.3/8	Auto(L4)	13.88	E85
			18.48	Gas
K1500 YUKON XL 4WD	5.3/8	Auto(L4)	13.88	E85
			18.48	Gas

Source: Reference 24

APPENDIX F

Useful Links For Additional Information

Auto Industry Links:
Auto Alliance: http://autoalliance.org/archives/alternativefuel.pdf
General Motors: http://www.gm.com/company/onlygm/livegreengoyellow/index.html
Ford Motor Co:
http://www.ford.com/en/vehicles/specialtyVehicles/environmental/ethanol.htm

DOE Links:
US DOE, Alternative Fuels Data Center:
http://www.eere.energy.gov/afdc/altfuel/ethanol.html
US DOE E85 Toolkit: http://www.eere.energy.gov/afdc/e85toolkit/

Ethanol Industry Trade Groups
Renewable Fuels Association: http://www.ethanolrfa.org/
National Ethanol Vehicle Coalition: http://www.e85fuel.com/index.php
American Coalition for Ethanol: http://www.ethanol.org/e85.html
Nebraska Ethanol Board: http://www.ne-ethanol.org/

Other Organizations:
American Lung Association of Minnesota – Clean Air Choice:
http://www.alamn.org/outdoor/

E85 Fuel Economy
DOE/EPA Fuel Economy Website: http://www.fueleconomy.gov/feg/byfueltype.htm

Ethanol Research
National Renewable Energy Laboratory: http://www.nrel.gov/
Oak Ridge National Laboratory: http://www.ornl.gov/
Argonne National Laboratory: http://www.anl.gov/