ALTERNATIVE FUELS
AND
ALTERNATIVE FUEL VEHICLES
IN KENTUCKY

A REVIEW AND ANALYSIS

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LEGISLATIVE RESEARCH COMMISSION

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MEMORANDUM

To: Don Cetrulo, Director
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From: Ginny Wilson, Ph.D.
LRC Chief Economist

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Subject: Research Study on Alternate-Fuel Vehicles

Date: September 3, 1997

SB 88, enacted by the 1996 General Assembly, required a study of alternate-fuel vehicles and refueling properties, and the possibility of using a state income tax credit to promote their development in Kentucky. This research memorandum presents the results of that study.

The conclusions from the study are as follows.

1. The U.S. Department of Energy conducted a study of the prospects for the development of mature markets for alternative motor fuels, and the likelihood that, if developed, those markets could further the two goals of reduced energy dependency and reductions in greenhouse emissions. The authors concluded that, of the fuels considered likely to have the potential to develop mature markets by 2010 (ethanol, methanol, and liquefied petroleum gas or propane) only increased use of ethanol would be expected to result in net 8% - 10% reductions in U.S. energy imports and greenhouse gas emissions. These reductions were only anticipated if ethanol production receives an on-going subsidy of about $5.50 per barrel of gasoline equivalent. Whether the benefits of the expected reductions exceed the costs of a permanent subsidy is a question which has not been resolved.

2. The study by the U.S. Department of Energy concluded that continuing technological limitations would cause vehicles operating on compressed natural gas and electricity to have a relatively high purchase price, short range, and long refueling time, into the foreseeable future. This was expected to limit these fuels to a very small market share, even assuming transition to a mature market for AFV's in general.

3 The purchase of flexible-fuel vehicles leads to reduced consumption of gasoline only if such vehicles operate primarily on alternative fuels. Therefore, if the General Assembly decides to establish an incentive for the purchase of flexible-fuel vehicles, the incentive should be linked to the actual use of an alternative fuel.

4. Automobile manufacturers have announced plans for large-scale production of flexible-fuel vehicles, many of which will have prices similar to equivalent gasoline models. Researchers at the U.S. Department of Energy have concluded that the lack of availability of alternative fuel refueling sites appears to be the greatest impediment to the development of a market for AFV's. Therefore, if the General Assembly decides to invest state resources in providing incentives to expand use of alternative fuels, those incentives would likely be most effective if they are targeted to promotion of the establishment of public refueling sites.

5. The U.S. Department of Energy is currently conducting a detailed study of the government actions which would be most likely to spur development of mature markets for AFV's, and the costs of those actions. That research is expected to be completed in late 1997. The General Assembly may want to have the benefit of those research results before it decides on particular state actions.

6. The rudimentary analysis staff was able to construct tended to support the opinions of several researchers specializing in market research on AFV's that a state the size of Kentucky would have little ability to greatly affect the market for AFV's, even within its own borders. It does not represent a sufficiently large market share so that changes here would substantially affect manufacturing decisions of national producers of vehicles; and fuel availability needs to be established in large geographic areas before consumers are likely to feel comfortable purchasing an AFV. Researchers at the U.S. Department of Energy who are conducting the transition analysis noted above have expressed a willingness to use the estimation model to consider such a question. However, the preliminary conclusion is that only federal action, or coordinated state actions, would be sufficient to effectively spur significant market development in Kentucky.

7. It is estimated that, in the short run, a Kentucky income tax credit of 10% of the additional purchase price of an AFV relative to an equivalent gasoline vehicle and for the establishment of an alternative fuel refueling station would cost the General Fund approximately $200,000 - $700,000 and would result in the purchase of an additional 500 - 1,500 AFV's in the state. It is believed that the long-run effect of state incentives (independent of all other federal and private actions) on the market for AFV's would likely be small, for the reasons noted above. The long-run effect of incentives on the General Fund could be small or large, depending on

whether they apply only to actions taken in response to the state incentive, or whether they might apply to actions caused by federal requirements or incentives which might develop in the private market, such as from technological breakthroughs or from a large long-term increase in the price of gasoline.

Alternative Fuels and Alternative Fuel Vehicles in Kentucky: A Review and Analysis

SB 88, enacted by the 1996 General Assembly, requires the Legislative Research Commission to "conduct a study of clean-fuel vehicles, clean-fuel refueling property, and the possibility of an income tax credit to promote clean-fuel vehicles and clean-fuel vehicle refueling property." This report presents the results of that study.

The report is organized into four major sections. The first section gives a summary of existing federal and state legislation intended to promote the use of alternative-fuel vehicles. The second section presents information on the currently available alternative-fuel vehicles, and how they compare to traditional gasoline vehicles in terms of purchase price, fuel price, fuel efficiency, fuel availability, maintenance costs, and driver satisfaction. The third section addresses the question of whether, given an assumed transition to mature markets, alternative fuels have the long-run potential to displace a significant percentage of the petroleum used in transportation. The fourth section examines the factors most likely to facilitate the transition to these mature markets, and the likely effect of a state tax incentive on that transition.

Legislative Background

The U.S. has recently seen renewed interest in the use of transportation fuels that may replace gasoline and diesel fuel. The current effort has the dual goal of improving air quality and increasing energy security.[1] On the federal level, two major pieces of legislation – the Clean Air Act Amendments of 1990 and the Energy Policy Act of 1992 - have been responsible for directing and promoting the use of alternative fuels and alternative fuel vehicles.

The Clean Air Act and its subsequent amendments in 1990 addressed the issue of air pollution. Under the Clean Air Act, primary and secondary national ambient air quality standards were established for various pollutants. The primary standards are those necessary to protect public health, while the secondary standards are those necessary to protect other publicly valued items, such as flora, fauna, and buildings.[2] The Amendments include provisions requiring the U.S. Environmental Protection Agency (EPA) to classify all regions of the country into attainment or nonattainment areas. Kentucky has two areas that do not meet the sulfur dioxide (SO_2) standard. Boyd County does not meet the primary standards, while Muhlenberg County does not meet the secondary standards.

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[1] Energy Information Administration, "Alternatives to Traditional Transportation Fuels: An Overview", U.S. Department of Energy, Washington, D.C., June 1994.

[2] Hill, Kelly. Alternative Fuel Policies and Programs: A Legislator's Guide, NCSL, Washington, D.C., June 1997.

The Clean Air Act Amendments also specify air quality requirements for the transportation sector. National requirements were set forth, as well as more stringent requirements for those cities and regions that failed to meet the national ambient air quality standards. Some of the regulations include a reduction in tailpipe emissions by vehicle manufacturers beginning in 1994; the use of alternative fuels for fleets in regions with the most serious ozone attainment problems; and the sale and use of oxygenated gasoline in designated carbon monoxide non-attainment areas during the winter months, when the most severe pollution occurs.[3] In addition, the Clean Air Act Amendments require use of reformulated gasoline year-round to reduce ozone and air toxins in those areas with ozone air pollution problems. Boone, Kenton, Campbell, Jefferson, and portions of Bullitt and Oldham counties are nonattainment areas for ozone. Kentucky has chosen to voluntarily participate in the reformulated gasoline program, in order to achieve ozone emission reductions in these ozone nonattainment areas.

Recently, the Louisville and Cincinnati/northern Kentucky areas have registered ozone readings which are in violation of the current ozone compliance levels under the Clean Air Act. Further violations would require the adoption of stricter smog-control measures than those already in place. The situation has become more complicated, however, due to stricter air-quality standards adopted in July 1997 by the U.S Environmental Protection Agency. This means that areas of the state that were in compliance under the old standards may not meet the new air pollution standards for ozone as set by EPA. Until the details of the new smog control program are set forth, it remains unclear what, and where, new ozone control standards will be required. The new rules are scheduled to be phased in over 15 years.[4, 5]

The Energy Policy Act of 1992 (EPACT) primarily addressed the issue of energy security, an issue heightened in the wake of the 1990-1991 Persian Gulf War. One goal of EPACT is to decrease U.S. dependence on imported oil by replacing imported petroleum with domestic sources. The targeted displacement levels are 10 percent of the motor fuels by the year 2000 and 30 percent by 2010.

A key component of EPACT is the mandated use of alternative fuels and alternative fuel vehicles (AFV's) by federal, state, and fuel provider fleets. The Alternative Fuel Transportation Program implements the EPACT provisions for state government and alternative fuel provider fleets. The mandated acquisition (purchase/conversion) of AFV's covers light-duty vehicles only – passenger cars, vans, and pick-up trucks. State government and alternative fuel provider fleets are required to include an increasing percentage of AFV's in their acquisition of new light-duty vehicles beginning with Model Year 1997.[6] Table 1 presents the acquisition schedule. States covered by the rule are those with 50 or more light-duty vehicles, 20 of which are used primarily within a

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[3] Ibid.

[4]Melnykovych, Andrew, *"U.S. Rules Will Force More Cities to Cut Smog"*, The Courier-Journal, July 17, 1997.

[5]The Kentucky Division for Air Quality has identified 15 counties which may be unable to comply with the new federal standards: Boone, Bullitt, Campbell, Daviess, Fayette, Greenup, Hancock, Hardin, Henderson, Kenton, Jefferson, Livingston, McLean, Oldham, and Scott counties. The projections are based on ozone readings from 1994 through 1996. Melnykovych, Andrew, *"Tougher Ozone Rules Will Be Felt in the State"*, The Courier-Journal, July 21, 1997.

[6] A model year is defined as the period from September 1 of the previous calendar year to August 31 of the current year.

Metropolitan Statistical Area (MSA) with a 1980 population of 250,000 or more and capable of being centrally fueled.[7] Alternative fuel providers include gas and nonfederal electric utilities, providers of alternative fuels, and those who produce or import more than 50,000 barrels of petroleum per day.

Table 1. EPACT Mandated Acquisition Schedule for State Government and Alternative Fuel Providers

Model Year	State Government	Alternative Fuel Providers
1997	10%	30%
1998	15%	50%
1999	25%	70%
2000	50%	90%
2001+	75%	90%

Source: U.S. Department of Energy, Alternative Fuels Data Center.

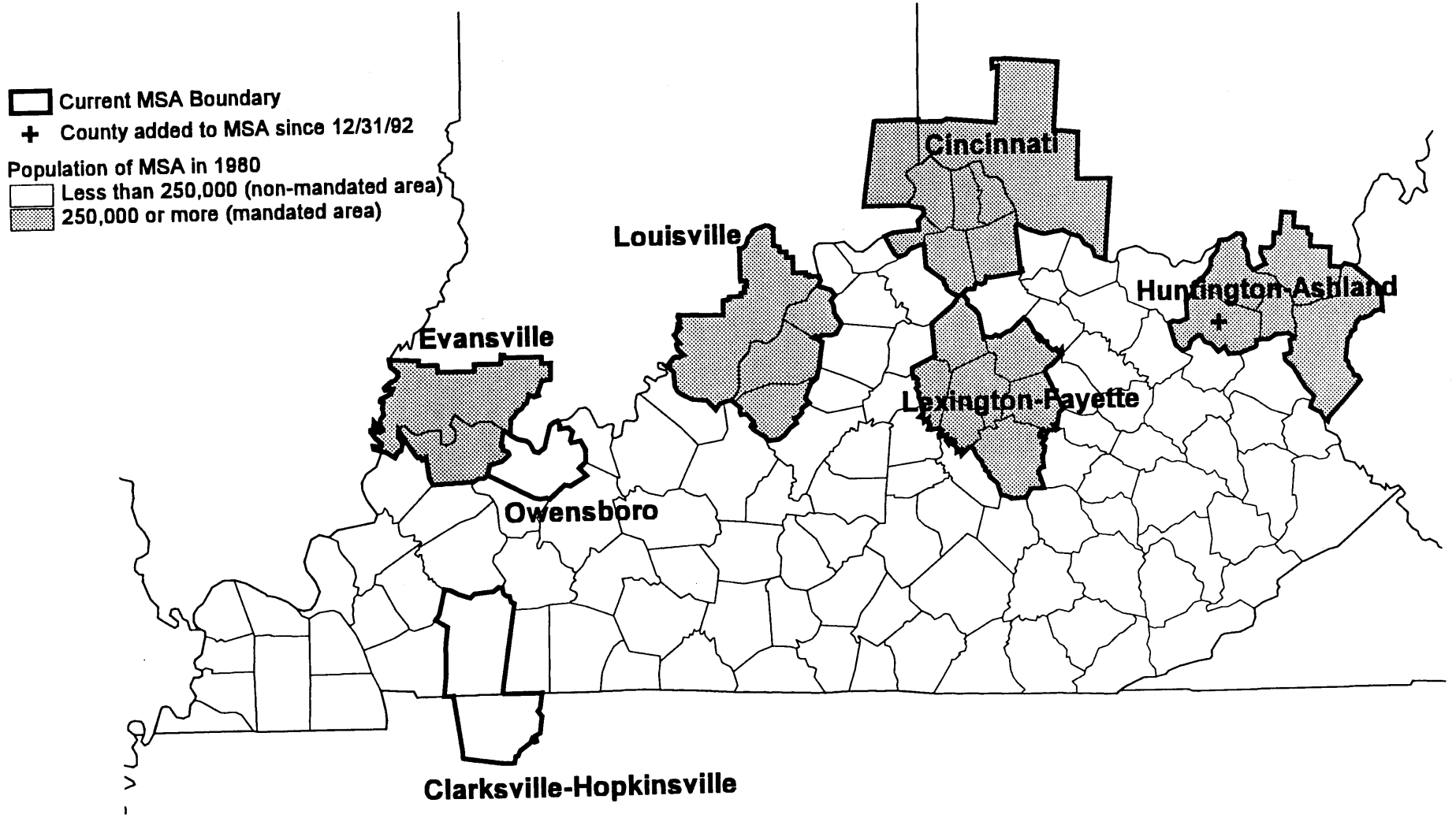
As defined under EPACT, a fleet is 20 or more light-duty vehicles, used primarily in an MSA with a 1980 population over 250,000, which are capable of being centrally fueled. Because Franklin County is not in an MSA, Kentucky state vehicles that operate primarily in Frankfort are not covered by the EPACT mandate; however, Kentucky state government does currently operate 178 AFV's - 10 compressed natural gas and 175 ethanol.

Map 1 displays Kentucky's Metropolitan Statistical Areas (MSAs). The gray areas are those that meet the criteria of having a population of 250,000 or more in 1980. The final ruling from the Department of Energy states that the list of mandated areas is based on all MSAs and Consolidated MSAs, as defined by the Office of Management and Budget as of December 31, 1992, and listed in the *Statistical Abstract of the United States 1993* as having a population of over 250,000 in 1980. The ruling further states that the list of MSAs will not be updated. It is not clear from the ruling whether counties that are subsequently added to or dropped from MSAs will change their mandate status. In Kentucky's case, as seen in the map, Carter County has again been included in the Huntington-Ashland MSA, subsequent to December 31, 1992.

AFV mandates are not in effect for local governments, private firms (other than alternative fuel providers), or individuals. The Department of Energy (DOE) is required to undertake a staged rulemaking process to determine whether AFV mandates should also be applied to other private fleets and local government fleets starting no earlier than model year 1999. The deadline for an "early rule" was December 15, 1996, which the DOE did not meet. The rulemaking process now falls under the "late rule" deadline, which is January 1, 2000. If the mandates were applied to local government and private fleets, these fleet owners would be required to include an increasing percentage of AFV's in their acquisition of new light-duty vehicles beginning with model year 2002.

[7] U.S. Department of Energy, Alternative Fueled Vehicles for State Government and Fuel Provider Fleets: A Guide for meeting EPACT 1992 Requirements, Washington, D.C., February 1996.

Map 1
Kentucky's Metropolitan Statistical Areas
As They Relate to EPACT



Source: MSA Boundaries determined by Office of Management and Budget

Based on data from the Automated Vehicle Information System, it is estimated that, in 1996, there were about 15,860 vehicles operated in fleets of size 50 or more in Kentucky MSA's. Alternative fuel providers accounted for 11.8% of those fleet vehicles, local governments for 4.7%, and private fleets for 83.5%. As discussed above, a certain percentage of new fleet vehicles acquired by alternative fuel providers must be AFV's. If, on average, 10% of fleet vehicles were replaced each year, then alternative fuel providers would have to replace a total of 186 vehicles, of which 30%, or 56 vehicles, would have to be AFV's.[8] If the mandates were applied to local government and private fleets as proposed, then 20% of their new fleet vehicle purchases must be AFV's. Again, with a replacement factor of 10%, local governments would have to acquire 15 AFV's, while private fleets would have to acquire 265 AFV's.

In addition to the mandates for fleets to accelerate the introduction of AFV's, tax incentives for using certain alternative fuels have been offered. Ethanol, in particular, has received considerable assistance. Currently, the federal government pays ethanol distributors 54 cents per gallon of ethanol in the form of a highway tax credit. Without this subsidy, little ethanol would be used as automotive fuel, because the costs of production are too high to make ethanol competitive with other alternative fuels. The General Accounting Office estimates that the partial exemption for alcohol fuels reduced federal motor fuels excise tax revenues by about $7.1 billion from fiscal years 1979 to 1995, and without the exemption, an additional $617 million of revenue would have been allocated to the Highway Trust Fund for fiscal year 1995.[9]

State governments also have enacted a variety of mandates and incentives to promote AFV's. These are shown in Appendix A, Table A1.

Current Alternative-Fuel Technology[10]

Alternative fuels, or clean fuels, are considered to be cleaner than conventional gasoline.[11] EPACT designates the following as alternative fuels:

- 100 percent methanol, denatured ethanol, and other alcohols;
- mixtures containing 85 percent or more by volume, denatured ethanol, or other alcohols with gasoline or other fuels – more commonly known as M85 and E85;
- compressed natural gas (CNG) and liquefied natural gas (LNG);
- liquefied petroleum gas (propane) - or, LPG;

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[8]The average replacement rate for state vehicles is about 10%.

[9] U.S. General Accounting Office, "Tax Policy: Effects of the Alcohol Fuels Tax Incentives", Report to the Chairman, Committee on Ways and Means, House of Representatives, GGD-97-41, March 1997.

[10]Even as demand for larger and more powerful vehicles is causing U.S. gasoline consumption to increase, significant research is being done on development of vehicles that use much less energy and produce much less pollution than those discussed below. Development of these "supercars" incorporates attempts to improve all aspects of vehicle design, including aerodynamic styling, fuel type and efficiency, tire configuration, braking system, and computer control systems. These efforts hold great promise for advancing the goals of energy independence and reduced emissions; however, because they are still in the early stages of design, and because they involve much more than the use of alternative fuels, consideration of "supercars" was judged to be beyond the scope of the research directed by SB 88.

[11] Environmental Protection Agency, "Clean Fuels: An Overview", EPA 400-F-92-008, Fact Sheet OMS-6.

- electricity (including electricity from solar energy);
- hydrogen;
- coal-derived fuels;
- fuels (other than alcohol) derived from biological materials, including neat biodiesel.

Reformulated gasoline (RFG), diesel, and biodiesel blends do not qualify as alternative fuels under EPACT. Currently, three types of alternative fuels are available in Kentucky – CNG, LPG, and E85. The following sections compare various features of vehicles fueled by alternative fuels with those fueled by gasoline.

Vehicle Price. Alternative fuel vehicles may be either original equipment manufacturer's vehicles (OEM) built with the capability to burn a clean fuel, or conventional vehicles converted to burn clean fuels. Flexible-fuel vehicles (FFVs) are manufactured with the capability to burn either an alternative fuel or conventional gasoline. The incremental costs for AFV's range from $0 to over $5,000. The U.S. Department of Energy's National Renewable Energy Laboratory collected cost data on the Federal AFV fleet.[12] They found that AFV's initially can cost up to 25% more than gasoline vehicles. CNG vehicles are at the high end, while manufacturers have offered the alcohol fuel vehicles for the same price (or close to it) as the gasoline version. Table 2 provides prices for alternative fuel vehicles and the base price for the gasoline version.

Table 2. Incremental Costs for Alternative Fuel Vehicles – Model Year 1997

Fuel Type	Vehicle	Incremental Cost	Vehicle Base Price	Incremental Cost as % of Base Price
M85	Ford Taurus	-$345	$17,995 - $21,610	-2%
E85	Ford Taurus	-$345	$17,995 - $21,610	-2%
CNG	Ford Contour	$5,115	$14,285	36%
	Ford Crown Victoria	$3,255	$21,575-$23,295	14%
	Ford Econoline Van	$1,130	$19,180-$22,800	5%
	Ford F-250 Truck	$3,580	$17,515	20%
	GMC Sierra 2500 Truck	$5,800	$18,337	32%
Electricity	GM EV1	$33,995 vehicle $1,995 charger	-	-
	Honda EV	$18,337 vehicle $795 charger	-	-

Sources: Vehicle manufacturers; U.S. Department of Energy, National Alternative Fuels Hotline, Light-Duty Vehicle Resource Guide; Automotive Information Center; National Automobile Bankers Associates/Vehicle Information Services.

Recently, both Chrysler and Ford have announced plans to increase their output of flexible-fuel vehicles. In the next three or four years, Ford will begin annual production of 250,000 cars, mini-

[12] Whalen, Peg, et al., "Alternative Fuel Light-Duty Vehicles: Summary of Results from the National Renewable Energy Laboratory's Vehicle Evaluation Data Collection Efforts", U.S. Department of Energy Washington, D.C., May 1996.

vans, and pick-up trucks that can burn either ethanol or gasoline.[13] Chrysler plans to equip more than one-third of its mini-vans with engines that run on both ethanol and gasoline, beginning with the 1998 model year.[14] Chrysler's flexible-fuel mini-vans will be offered at no incremental cost over the conventional gasoline model.

While both manufacturers have characterized their plans as part of a corporate commitment to clean air and an effort to push the commercialization of alternative fuel vehicles, auto industry observers note that the major goal may be compliance with federal fuel-economy standards. Rising sales of pick-up trucks, sport-utility vehicles, and vans, which are highly profitable but have low fuel-economy ratings, have pushed the companies out of compliance with the federal corporate average fuel-economy standards. Depending on sales volume, the alternative-fuel vehicles can help the auto manufacturers in federal fuel-economy calculations. Under an exception in the law, the fuel economy of vehicles that run on fuels made up of less than 15 percent gasoline can be multiplied by 6.66 when calculating an auto maker's corporate average fuel economy rating, regardless of whether the vehicles are actually fueled by an alternative fuel or not. Auto manufacturers are subject to heavy fines if they do not meet the federal fuel-economy requirements.

Electric vehicles continue to be the least popular alternative-fuel vehicle, due to their limited range and costliness. Both General Motors and Honda offer an electric vehicle. Toyota recently announced plans to offer a new electric sport utility vehicle for about $42,000, or $499 per month on lease.

As mentioned earlier, another method to acquire an AFV is to convert a conventional gasoline vehicle to run on an alternative fuel. Conversion costs of light-duty vehicles depend on the alternative fuel, the level of conversion technology, and the number and size of the fuel tanks.[15] Conversion kits for methanol and ethanol are unavailable, due to lack of manufacturers in the case of ethanol, and lack of certification of the conversion kits in the case of methanol. Estimates of conversion costs for CNG range from $2,700 to $4,500; for LPG, from $1,000 to $3,700; and for converting to an electric vehicle, from $4,000 to $5,000.

Fuel Price. The National Renewable Energy Laboratory reports that in early 1996, retail prices were approximately $1.62 to $1.72 per gallon of E85; $1.73 to $2.69 per gallon of M85; $0.58 to $1.05 per gallon of CNG; and $1.06 to $1.18 for regular unleaded gasoline.[16] All prices are reported in gallons of gasoline equivalent (GGE), which is the amount of fuel with the same energy content as one gallon of gasoline. Table A2 in the appendix lists the energy content in British thermal units (Btu) and the conversion factor of each fuel. Similar data on fuel retail prices for Kentucky are shown in Table 3.

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[13] Bradsher, Keith, "Ford to Hike Output of Vehicles Using Ethanol", New York Times, June 4, 1997.
[14] Reitman, Valerie and Nichole M. Christian, "Chrysler Plans on Minivans Using Ethanol", Wall Street Journal, June 10, 1997.
[15] Whalen, Peg, et al.
[16] Whalen, Peg, et al.

Fuel Efficiency. The National Renewable Energy Laboratory also evaluated the fuel economy of AFV's in the federal fleet. Two sources of fuel economy data were analyzed: fuel economy obtained during emissions testing, and in-use fuel economy, as gathered from refueling records. Flexible-fuel vehicles running on ethanol and methanol, and dedicated CNG vehicles, were compared to a similar control vehicle running on reformulated gasoline. On the whole, the National Renewable Energy Laboratory found that, on an equivalent energy basis, the vehicles operating on alternative fuels achieved fuel economy levels similar to the standard gasoline vehicles tested.

Table 3. Fuel Costs

Fuel Type	U.S.	Kentucky
M85	$1.73-$2.69/gal. Avg. price: $2.00/GGE	Not available in KY
E85	$1.62-$1.72/gal. Avg. price: $1.66/GGE	$1.269/GGE (Louisville – June 1997)
CNG	$0.58-$1.05/gal. Avg. price: $0.86/GGE	$0.79/GGE (Frankfort – June 1997) $0.899/GGE (Florence – June 1997)
LPG	$0.64/gal (does not include taxes)	$0.94/GGE; $0.89/GGE with fill-up rate discount (Frankfort – June 1997)
Electricity	Cost per mile: $0.15-$0.104	Electric vehicles not available in KY
Gasoline	$1.06-$1.18/gal. - Regular Unleaded	1.213/gal. – Regular Unleaded 1.296/gal. – Mid-grade Unleaded 1.366/gal. – Premium Unleaded (KY statewide average – Jan. to May 1997)

Sources: U.S. Department of Energy; California Energy Commission; American Automobile Association, Energy Information Administration.

The indices in Table 4 provide a useful means of comparing the fuel economy of the AFV's and the control vehicles obtained in the emissions testing. All values are indexed to gasoline, which has a value of 1.0. Depending on the vehicle model, the fuel economy for the AFV's ranged from half that of a standard gasoline vehicle to slightly better in the emissions testing. The in-use fuel economy results ranged from a low of .38 for M85 fueled vehicles to 1.33 for CNG fueled vehicles.

Table 4. Fuel Economy Indices
(Gasoline = 1.0)

Fuel Type	Lab Index	In-Use Index
CNG	.86-.93	.70-1.33
E85	1.03-1.06	.52-1.04
M85	.52-1.02	.38-1.07

Source: Whalen, Peg, et al, *Alternative Fuel Light-Duty Vehicles: Summary of Results from the National Renewable Energy Laboratory's Vehicle Evaluation Data Collection Efforts*, May 1996.

Alternative Fuel Emissions. As discussed earlier, one of the policy goals of the current focus on alternative fuels is cleaner air. The National Renewable Energy Laboratory conducted an extensive study of AFV emissions.[17] The study focused primarily on original equipment manufactured (OEM) alternative fuel vehicles, but also looked at emissions from converted vehicles. Table 5 summarizes the results. The data on emissions from LPG fueled vehicles and electric vehicles was gathered from the Energy Information Administration (EIA).

Table 5. Emission Test Results for Alternative Fuels - Compared to Gasoline

Emissions	Alcohol Fuels (M50, M85, E50, E85)	CNG	LPG[18]	Electricity[18]
Carbon Monoxide (CO)	Equal/Less	Less	Less	Less
Nitrogen Oxides (NOx)	Equal/Less	Less	Equal	Uncertain[19]
Hydrocarbons (HC)	Equal/Less	Less	NA	NA
Non-methane Hydrocarbons (NMHC)	Equal/Less	Less	NA	NA
Carbon Dioxide	Less	Less	Less	Uncertain[19]
Ozone Precursors	Less	Less	Less	Less
Particulate Matter[18]	None/Less[20]	None	Less	More
Hydrocarbon Profile				
Benzene	Less	Less		
1,3 butadiene	Less	Less		
Formaldehyde	Equal/More[21]	Less		
Acetaldehyde	Equal/More[22]	Less		

Source: Whalen, Peg, et al, *Alternative Fuel Light-Duty Vehicles: Summary of Results from the National Renewable Energy Laboratory's Vehicle Evaluation Data Collection Efforts*, May 1996; Energy Information Administration, *Alternatives to Traditional Transportation Fuels: An Overview*, June 1994.

In general, alcohol fueled vehicles (M85 and E85) had equivalent or lower regulated emissions compared to reformulated gasoline. CNG vehicles showed lower emissions. The studies conducted by Energy Information Administration indicate that, for the most part, emissions for LPG fueled vehicles are less than for gasoline. Emissions from electric vehicles also are, in general, lower; however, this is dependent on the energy source used to generate the electricity. For example, the California Energy Commission reports that electric powered vehicles may be up to 97 to 98 percent cleaner than gasoline powered vehicles, depending on the type of emission, even when California and out of state power plants are figured into the air pollution. Emission from electric powered vehicles in other states may not be as low as in California, where most of the electricity is provided by clean-burning natural gas and from renewable energy sources.[23]

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[17] Whalen, Peg, et al.

[18] Data source for LPG, electricity, and particulate matter emissions: "Alternatives to Traditional Transportation Fuels: An Overview", June 1994, Energy Information Administration, U.S. Department of Energy.

[19] Results are uncertain because of the wide variation in emissions, due to the engine's compression, temperature, and fuel/oxygen mix.

[20] Less particulate matter emissions are reported for E50 and E85. No particulate matter emissions are reported for M85. Results on particulate matter emissions for M50 are reported.

[21] Increase noted for methanol.

[22] Increase noted for ethanol.

[23] California Energy Commission, *The ABCs of AFVs: A Guide to Alternative Fuel Vehicles*, April 1996.

In related research it was determined that the toxicity and smog-forming potential of the various constituent compounds of the alternative fuels tested in the study (E85, M85, CNG) and reformulated gasoline were very different. Hydrocarbon toxins such as benzene and 1,3-butadiene were lower for the alcohol and CNG fuel tests. However, formaldehyde emissions were increased for methanol, while acetaldehyde emissions were increased for ethanol. Both formaldehyde and acetaldehyde emissions were generally lower for CNG. The analysis of hydrocarbons also allows an evaluation of the ozone-forming, or smog, potential of the fuels. The results indicated that the smog forming potential of the alcohol fuels and CNG was lower than for vehicles running on RFG. The study also found that these alternative fuels produced fewer carbon dioxide emissions.

Some limited emissions testing was conducted on gasoline vehicles converted to operate on CNG and LPG. The results from the emissions tests on vehicles that had undergone aftermarket conversions were not promising. In many cases, emissions from converted AFV's were higher than before conversion. Table 6 presents the emissions test results from CNG conversions.

Table 6. Emissions Test Results from CNG Conversions Compared to Gasoline[24]

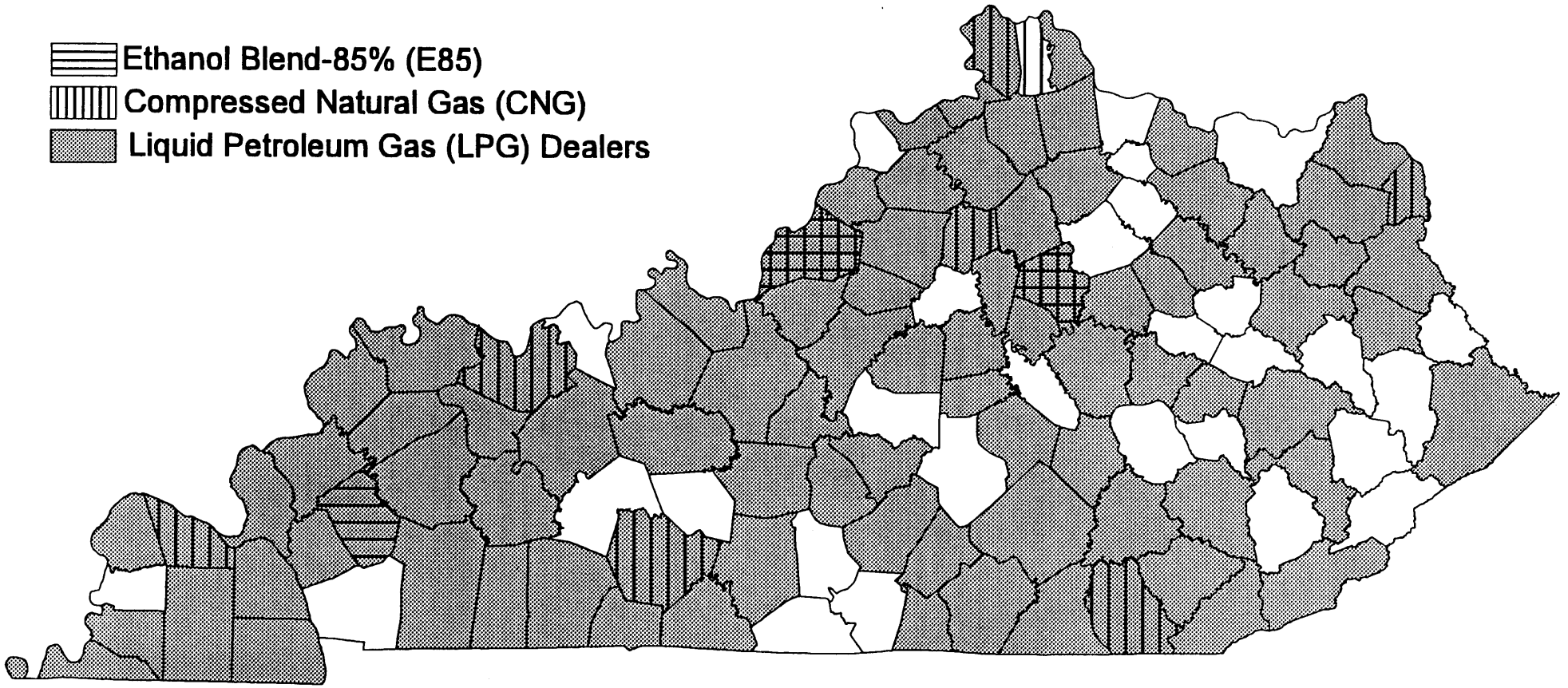
Vehicle Model	Model Year	Emissions After Conversion		
		Nitrogen Oxide	Carbon Monoxide	Non-methane Hydrocarbons
Acclaim	1992	Large increase	Large decrease	Large decrease
Acclaim	1992	Large increase	Moderate decrease	Moderate decrease
Astro	1992	Moderate decrease	Large increase	Moderate decrease
Caravan	1992	Large increase	Large increase	Moderate decrease
Caravan	1992	Large increase	Large increase	Moderate decrease
Safari	1993	Moderate decrease	No Change	Large decrease
Safari	1993	Moderate decrease	Moderate decrease	Large decrease
Taurus	1994	Large increase	Large increase	No Change
Taurus	1994	Large increase	Large increase	No Change
B250 Truck	1994	Moderate decrease	Moderate increase	Large decrease
B250 Truck	1994	Moderate decrease	Large increase	Large decrease
C1500 Truck	1994	Moderate decrease	Large increase	Large decrease
C1500 Truck	1994	Moderate decrease	Large increase	Large decrease

Source: Whalen, Peg, et al, *Alternative Fuel Light-Duty Vehicles: Summary of Results from the National Renewable Energy Laboratory's Vehicle Evaluation Data Collection Efforts*, May 1996.

Fuel Availability. One barrier to the wider introduction of AFV's has been the lack of infrastructure to support the vehicles. A key component of this infrastructure is refueling stations. Map 2 indicates the availability of E85, CNG, and LPG throughout Kentucky. E85 is only publicly available in Jefferson County. In Fayette and Caldwell Counties, E85 is only available in private facilities owned by the University of Kentucky. CNG is available at 13 sites in Kentucky. Of the ten CNG refueling stations for which access information was known, three were available to the public during limited business hours; four were available to the public but restricted by card

[24]"Large" indicates a change of more than 50%, "moderate" indicates a change of 10% - 50%, and "no change" indicates a change of less than 10%.

Map 2
Location of Alternative Fuel Stations



Source: Derived from separate lists produced by Kentucky Clean Fuels Coalition, DOE's Alternative Fuels Data Center (http://www.afdc.nrel.gov/newrefuel/search.html), and Kentucky Department of Agriculture Division of Regulation and Inspection

or other means; and three were privately held facilities. The shaded counties represent those in which an LPG dealer is located. In most cases, an LPG dealer facility will supply fuel to vehicles on an as-needed basis. However, there may be a few counties shaded in the map in which the dealer sells for non-vehicle uses and does not have the capacity to fuel motor vehicles.

The startup costs for alternative fuel refueling stations vary by the type of fuel as well as other factors, such as the size of the tank.[25] Costs for refueling stations for dispensing M85, E85, and LPG are generally $40,000 or less, which is comparable to costs for a new gasoline station.[26] Installation costs for a CNG station ranged from $300,000 to $500,000 in estimates provided by companies operating refueling stations in Kentucky. The cost for a CNG refueling system to be used with a single vehicle in a private home is about $2,500.

Maintenance. Research on the federal fleet also examined maintenance costs associated with AFV's. Researchers concluded that maintenance costs for AFV's were expected to be somewhat higher than for gasoline vehicles. A number of factors contributed to these higher costs. First, the cost of replacement parts is higher for vehicles in limited production, such as AFV's. Second, some maintenance problems, and their associated costs, are unique to AFV's. The researchers cite the problems encountered with fuel pumps and injectors in the early AFV models. Finally, scheduled maintenance costs, particularly for oil changes, were expected to be higher for alcohol fueled vehicles because of the more frequent recommended oil change schedule.

The analysis of the available maintenance data focused on CNG and methanol fueled vehicles due to the lack of data on ethanol vehicles. Repair trends for CNG and M85 vehicles indicated that unscheduled maintenance had decreased with the newer models. These trends, coupled with the growing experience with AFV's, led the National Renewable Energy Laboratory researchers to conclude that, in the long-term, maintenance costs for AFV's should approach the levels for gasoline vehicles.[27]

Driver Satisfaction. Driver comments on performance-related problems while driving the study vehicles were collected and analyzed as well.[28] Some of the performance-related problems included hard starting, lighting of the "check engine" light, poor idle quality, hesitation, lack of power, engine ping, and vehicle stalling. Researchers compared driver-reported complaints on all the vehicles during their first 100,000 miles of service. Driver complaints were found to be more common for the earlier model AFV's.

CNG vehicles received the most complaints per vehicle during the 1992-94 model years. Drivers complained of poor idling and hesitation most frequently. Limited range continued to be a concern throughout the program. Some drivers reported that they limited their use of CNG

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[25] The cost of the real estate for the facilities also is a major cost item. However, for the purpose of this study, the cost of the real estate was not included.

[26] The costs may be considerably higher for a state-of-the-art facility with numerous pumps. Estimates were gathered for a comparable facility to that used for alternative fuels. Most of the facilities for alternative fuels have fewer pumps and a simpler set up than most commercial gasoline fueling locations.

[27] It is estimated that U.S. households spend an average of $653 a year on vehicle maintenance. Wellner, Alison Stein, "Keeping Old Cars on the Road", American Demographics, July 1997.

[28] Whalen, et al.

vehicles for fear of running out of fuel. Drivers of methanol vehicles also reported poor idling and hesitation, but these complaints also showed a decrease with the later models. The number of driver complaints for ethanol vehicles was closer to that of gasoline.

Long-Run Market Prospects

It is apparent from the comparisons shown above that, at this time, currently available alternative-fuel vehicles do not generally have the technical and economic characteristics to compete effectively with traditional gasoline vehicles as consumers make purchasing decisions. The purpose of federal and state mandates and incentives is to facilitate the development of mature markets for AFV's, with the objective of displacing 10% of the petroleum used in light-duty vehicles by the year 2000, and 30% by the year 2010. As noted above, the stated goals of this level of displacement are to reduce U.S. dependence on foreign energy supplies and to reduce emissions from motor vehicles.

The first important question is whether, even given mature markets, AFV's can meet the objectives of petroleum displacement in order to achieve the policy goals of reduced energy dependence and a cleaner environment. This question was addressed in a study conducted by the U.S. Department of Energy.[29] In the initial phase of the study the authors ignored the question of what hurdles would need to be overcome for the development of mature markets for AFV's, and focused only on the likely long-run operation of mature markets. The study used a linked model of the U.S. and world fuel markets to evaluate whether alternative fuels could claim a substantial share of the U.S. light-duty transportation market. A major advantage of using the model for the analysis is that it was designed to take account of subsequent changes in fuel markets after the initial change. This allowed researchers to assess the net effects of all changes in fuel consumption, not just those related to changes in motor vehicle fuel consumption.

Two major scenarios were evaluated. The "equal-tax" case makes the assumption that all motor fuels are subject to equal federal and state fuel taxes, on a Btu-equivalent basis. The "current-tax" case assumes that the 1994 federal and state fuel tax structure is maintained, whereby "ethanol is subsidized, CNG is taxed at a lower rate than gasoline on a Btu-equivalent basis, and methanol and LPG are taxed at higher rates."[30]

The major conclusions of the Department of Energy (DOE) study are as follows.

- 10% displacement of gasoline motor fuel by the year 2000 appears likely with existing government policies. Virtually all of that displacement is expected to come from current gasoline production practices and oxygenates requirements mandated under the Clean Air Act. Only 0.5% of the displacement would come from alternative fuels. (Note: Even that estimate may be high because the study assumed that the imposition of mandates on private fleets and local government fleets would begin in 1999, rather than in 2002 or later.)

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[29] U.S. Department of Energy, *Assessment of Costs and Benefits of Flexible and Alternative Fuel Use in the U.S. Transportation Sector: Market Potential and Impacts of Alternative Fuel Use in Light-Duty Vehicles: A 2000/2010 Analysis, Technical Report Fourteen,* January, 1996.

[30] U.S. Department of Energy, *Assessment of Costs and Benefits*, p. 7.

- In the absence of mature markets for alternate fuels, only about 12% of motor fuel used in light-duty vehicles will be displaced, mostly by oxygenates in reformulated gasoline.

- Given the assumption of mature markets, it is feasible that alternative fuels could displace more than 30% of gasoline used in light-duty vehicles by 2010; however, to achieve that level of displacement most of the demand for AFV's will have to come from private non-fleet consumers.

- Under the equal tax scenario, the primary alternate fuels in use would be LPG and methanol; with a continuation of current fuel tax structures, LPG and ethanol would dominate the alternative fuel market. Because of the higher price of corn, it is expected that all ethanol would be made from cellulosic-based feedstock (most likely hardwoods.)

- Neither CNG nor electricity capture a significant share of the AFV market under any scenario considered reasonable. It was estimated that CNG might capture 3 - 5% of the motor fuel market, while electric vehicles might capture 1%. The market share for both fuels was expected to remain very small, even assuming transition to mature markets, because of expected continuation of technological limitations that result in relatively high vehicle purchase costs, long refueling times, and frequent refueling requirements, compared to gasoline and to other alternative fuels.

- If LPG and methanol are the primary alternate fuels used (equal-tax case), it is estimated that imports of foreign oil would decrease; however, there would be virtually no change in total fuel imports, because methanol, and much of the propane, would likely be imported from the Middle East. If ethanol replaces methanol as a primary alternate fuel (current-tax case) total energy imports would be expected to decline by about 8 percent.

- Similarly, dominance of the AFV market by LPG and methanol (equal-tax case) would not result in a significant change in the total level of greenhouse gas emissions from light-duty vehicles. Replacement of methanol with cellulosic ethanol (current-tax case) would reduce the total level of greenhouse gas emissions by 10 percent.

While the DOE study answers one important question – with mature markets, alternative fuels could replace 30% of light-duty motor fuel consumption – it leaves several others. The first major policy question, of course, is whether additional investments should be made in promoting methanol and LPG use, since their displacement of gasoline may not achieve the stated policy goals of net reductions in energy dependence and greenhouse gas emissions. It should be noted that the DOE results do not provide complete information to answer this question. Although total energy imports are not expected to decline, there would be somewhat greater diversity in the number of countries from which energy is purchased. This could provide some lessening of the risk that U.S. energy imports would be disrupted for political reasons.

Also, the science of estimating changes in greenhouse gas emissions is extremely complex. For example, some recent research indicates that vehicles converted to use alternative fuels may have a higher level of emissions than identical vehicles so equipped in the original manufacturing process, and may even have a higher level of emissions than traditional gasoline vehicles.[31, 32] Thus, assumptions about the mix of AFV types can have significant effects on the results. A study of the potential of AFV's to reduce air pollutants and, thereby, reduce health costs, in the South Coast Air Basin of California concluded that such benefits could be achieved.[33] However, the two primary fuels modeled in the study were electricity and CNG, which, in the DOE study, were not shown to be likely to develop mature national markets by 2010.

While increased use of cellulosic ethanol might reduce both net energy imports and greenhouse gas emissions by roughly 10%, these reductions are only possible through long-run government subsidies (on the order of $5.50 per barrel of gasoline equivalent), because of that fuel's higher price.[34] Thus, the second policy question is whether the cost of long-term subsidies for ethanol, plus the costs associated with stimulating the development of a mature market for AFV's, exceeds the benefits associated with the projected reductions in energy dependence and emissions.

If a determination is made that promotion of AFV's is a desired public strategy, then the third policy question would be concerned with what particular set of government actions would be most likely to stimulate the development of mature markets, and what costs those policies might entail. Assessment of the first two questions is left to the consideration of policy makers. Information pertinent to the third question is presented in the following section.

Market Transition Issues

It is estimated that, in 1997, there are approximately 386,000 AFV's in use in the U.S. This represents about two tenths of a percent of all vehicles. Approximately 68% of AFV's are owned by private entities, 22% are owned by state and local governments, and 10% are owned by the federal government.[35] The number of AFV's would need to increase to about 50 million by 2010 to capture 30% of the motor fuel market share.

There are two production changes which can make AFV's more economically competitive with traditional vehicles. First is that technological breakthroughs in design can make production and operation less costly. An explicit assumption of the DOE research summarized above is that the technology for vehicles which can use LPG, M85, and E85 is quickly maturing, so that additional technical improvements are not expected to yield significant reductions in production or refueling

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[31] Blazek, C.F., P. Freeman Rowley, J.W. Grimes, *Evaluation of Aftermarket CNG Conversion Kits in Light-Duty Vehicle Applications,* National Renewable Energy Laboratory, July, 1995.
[32] Kelly, K.J., *New Alternative Fuel Vehicle Emissions Data,* National Renewable Energy Laboratory, Center for Transportation Technologies and Systems, June, 1997.
[33] Kazimi, C., Evaluating the Environmental Impact of Alternative-Fuel Vehicles, Journal of Environmental Economics and Management, 33 (1997), 163-185.
[34] U.S. Department of Energy, *Analyzing the Transition to Alternative Fuel Vehicles,* May 22, 1997.
[35] Energy Information Administration, *Alternatives to Traditional Transportation Fuels 1995, Volume 1,* December, 1996.

costs in the next two decades, compared to traditional vehicles. Conversely, DOE assumed that the same period will not yield technical improvements that would make vehicles which use CNG or electricity viable competitors. However, the nature and timing of technological breakthroughs are unpredictable. A great deal of technical work is being done not only on alternative fuels, but on improvements in vehicle materials, engine design, and traffic control. A breakthrough in any of these areas could change the relative costs of vehicle types and, therefore, the conclusions of the DOE study.

The second means by which production costs can be reduced is through economies of scale. Generally, the average cost per unit tends to decline as more units are produced (to a point). The DOE results are based on the assumption that, given known technologies, mature markets for AFV's which use LPG, M85, and E85 could develop if enough are produced to allow economies of scale to make vehicle and fuel prices more competitive.[36]

The effect of economies of scale on the premiums paid for AFV's and alternative fuels, relative to gasoline vehicles and fuels, is shown in Table 7. As more vehicles are produced, and more refueling stations are established, it becomes more likely that AFV's could be competitive with gasoline vehicles. The question is how to spur the increased production to achieve necessary economies of scale.

As outlined above, there are two basic strategies governments are using to spur demand for AFV's – mandates and incentives. Both mandates and incentives can be targeted to purchasers or to sellers, to spur their use of particular vehicles or of particular fuels; or they can be targeted to achieve reductions in particular types of emissions. All of these combinations of mandates and incentives currently exist in state or federal policies.

An important question is which particular set of targeted policies is most likely to significantly increase the market for AFV's. This question is currently under study by DOE as a follow-up to the study of the mature market potentials summarized above. While the work is still in progress, the authors have published results of a preliminary analysis. Their initial findings are as follows.

- **Without government intervention, mature markets for AFV's won't develop.** The private market is not likely to overcome the initial hurdle of high costs due to small production runs and sparse fuel availability.

- **The major impediment to the development of mature markets for AFV's is the lack of wide availability of public refueling stations.** Even at this early stage, the cost differences for purchase of AFV's is quickly declining and their availability is improving. On the other hand, estimates shown in Table 7 indicate that lack of fuel availability adds an effective cost of $1.84 to the regular retail purchase price of an alternative fuel. (This amount is not an actual dollar cost. The assumption is that having the fuel available at only 1% of retail stations has the same effect on demand as would this amount added to the pump price of the

[36] Leiby, P. and J. Rubin, The Transitional Alternative Fuels and Vehicles Model, Oak Ridge National Laboratory, March 12, 1997.

fuel.) Obviously, few consumers would be willing to regularly use an alternative fuel under these conditions.

- **Mandates and incentives are only effective if they result in increased use of alternative fuels.** EPACT mandates that a certain percentage of public and private fleet purchases be AFV's. Federal corporate average fuel economy regulations impose a stiff penalty on vehicle manufacturers if the average fuel economy of all of their vehicle models sold exceed certain levels. Both of these mandates were intended to increase use of alternative fuels. However, the actuality is that manufacturers are producing flexible-fuel vehicles in larger numbers to increase their calculated corporate average fuel economy, and purchasers are buying flexible-fuel vehicles to satisfy mandates and take advantage of incentives, but the bulk of these vehicles are likely powered by gasoline.

- **Mandates and incentives are only effective if they result in increased purchase of new and used AFV's by private non-fleet consumers.** Private non-fleet consumers ultimately purchase nearly all light-duty vehicles. Fleet managers make purchasing decisions on the basis of their ability to eventually sell older vehicles into the private market. If used AFV's are not attractive to the private market, they are less likely to be purchased by fleet owners. By themselves, fleet owners do not represent a large enough share of the light-duty vehicle market to generate sufficient demand to create a mature market for AFV's.

Table 7. Estimates of Economies of Scale in Production of AFV's

1. Additional Vehicle Production Costs Compared to Gasoline Vehicle				
		Number Produced		
	Additional Costs	**2,500**	**25,000**	**100,000**
	Dedicated Alcohol Vehicle	$2,209	$344	$189
	Flexible Fuel Vehicle	$1,909	$375	$247
2. Fuel Retailing Costs ($/Gallon Gasoline Equivalent)				
		Proportion of Pumps Offering the Fuel		
		1/6	**1/3**	**All**
	Gasoline	$0.09	$0.08	$0.07
	M85	$0.13	$0.12	$0.10
	E85	$0.13	$0.12	$0.10
3. Estimate of Effective Additional Cost from Limited Availability of Alternative Fuel Compared to Gasoline ($/Gallon Gasoline Equivalent)				
	Percent of Stations Offering the Alternative Fuel			
	1%	**5%**	**10%**	**20%**
Additional Cost	$1.84	$0.38	$0.20	$0.11

Source: Leiby, P., and Jonathan Rubin, The Transitional Alternative Fuels and Vehicles Model, Oak Ridge National Laboratory, March 12, 1997.

Effect of a Kentucky Income Tax Credit

SB 88 mandated a specific analysis of the likely effect of a Kentucky income tax credit for purchase of AFV's and establishment of refueling stations. This section gives the results of that analysis.

Staff could identify no previous studies of how state tax incentives affect the demand for AFV's. General research on the demand for AFV's indicates that fuel availability and range between refuelings, if either is significantly less than that for gasoline, are both critical issues affecting consumer demand.[37] Previous research also indicates that fewer consumers will choose to purchase an AFV if the price is $1,000 less than an identical gasoline vehicle, than would choose to purchase a gasoline vehicle if the AFV is $1,000 more, even holding other factors constant.[38] This means there is some consumer resistance to purchase of AFV's that is not completely responsive to price. An evaluation of the effects of federal alcohol fuels tax incentives by the U.S. General Accounting Office concluded that they had done little to spur the development of ethanol production.[39]

Table 8 shows estimates of the number of AFV's by state for the years 1995 - 1997, along with the total number of vehicles registered in each state in 1994 (the most recent data available.) The estimates are that there were 3,739 AFV's in Kentucky in 1995, 3,990 in 1996, and that there are 4,125 in 1997. This represents 0.15% of the total number of vehicles in the state in 1994.

To estimate how this percentage might change in the presence of state incentives, states were categorized according to whether they offer AFV incentives to all private purchasers, whether they offer incentives only to local government and other public purchasers, or whether they offer no incentives (including KY). The weighted average numbers of 1997 AFV's as a percent of 1994 vehicle stocks were compared for the states offering incentives to all purchasers and the states offering no incentives. (See Appendix A, Table A1 for state incentives.) The average percentage of total vehicle stock made up of AFV's among states offering incentives was 0.22%, compared to 0.16% among states offering no incentives (and 0.15% in KY.) Even in Oklahoma, the state with the highest concentration, AFV's accounted for less than one half of one percent of the total vehicle stock.

If Kentucky had incentives in place that raised its concentration of AFV's to the average of all states with incentives, then the state would be expected to have an additional 500 - 1,500 AFV's. Table 9 contains estimates of the distribution of AFV's and refueling stations by fuel type, and shows an estimate of the average number of AFV's of a particular fuel type per refueling station of that type. These numbers were used to estimate possible costs of an income tax credit. If the credit were 10% of the additional cost of an AFV over the cost of an equivalent gasoline vehicle, and 10% of the cost of a refueling station (both as proposed in HB 534), then the loss to the

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[37]Bunch, D.S., M. Bradley, T.P. Golob, R. Kitamura, and G.P. Occhuzzo, "Demand for Clean-Fuel Vehicles in California: A Discrete-Choice Stated Preference Pilot Project", *Transportation Research*, 27A:3, 1993, 237-253.
[38]Energy Information Administration, *Describing Current and Potential Markets for Alternative-Fuel Vehicles*, March, 1996.
[39]U.S. General Accounting Office, *Effects of the Alcohol Fuels Tax Incentives*, March, 1997.

General Fund would be between $200,000 and $700,000. Note that these are short-term estimates.

An additional point in the consideration of state tax credits is that, if the intent of the credit is to spur demand for AFV's, it should not apply to vehicles used to meet existing federal mandates. If mandated vehicles are eligible for the tax credit, the state will have given up revenue without having caused a change in the desired behavior.[40] It is estimated that more than two thirds of the additional AFV purchases between now and the year 2000 will be in response to EPACT mandates.[41]

Conclusions

Based on the research mandated by SB 88, the following conclusions are offered.

1. The U.S. Department of Energy conducted a study of the prospects for the development of mature markets for alternative motor fuels, and the likelihood that, if developed, those markets could further the two goals of reduced energy dependency and reductions in greenhouse emissions. The authors concluded that, of the fuels considered likely to have the potential to develop mature markets by 2010 (ethanol, methanol, and LPG) only increased use of ethanol would be expected to result in net 8% - 10% reductions in U.S. energy imports and greenhouse gas emissions. These reductions were only anticipated if ethanol production receives an on-going subsidy of about $5.50 per barrel of gasoline equivalent. Whether the benefits of the expected reductions exceed the costs of a permanent subsidy is a question which has not been resolved.

2. The study by the U.S. Department of Energy concluded that continuing technological limitations would cause vehicles operating on CNG and electricity to have a relatively high purchase price, short range, and long refueling time, into the foreseeable future. This was expected to limit these fuels to a very small market share, even assuming transition to a mature market for AFV's in general.

3 The purchase of flexible-fuel vehicles leads to reduced consumption of gasoline only if such vehicles operate primarily on alternative fuels. Therefore, if the General Assembly decides to establish an incentive for the purchase of flexible-fuel vehicles, the incentive should be linked to the actual use of an alternative fuel.

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[40]The point has been raised that a state incentive might encourage a mandated purchaser to select an AFV which burns a more desirable type of fuel from the standpoint of fuel efficiency or emissions, but which may have a higher purchase price. However, the current policy debate has largely centered on the question of offering incentives to AFV's relative to gasoline vehicles and has not yet extended to a discussion of offering incentives for purchase of a vehicle that burns one alternative fuel relative to another.

[41]Energy Information Administration, unpublished supplementary tables from National Energy Modeling System used in preparing the Annual Energy Outlook 1997, available on Internet, ftp://ftp.eia.doe.gov/pub/forecasting/aeo97/tables/sup97d.pdf, Table 40.

4. Automobile manufactures have announced plans for large-scale production of flexible-fuel vehicles, many of which will have prices similar to equivalent gasoline models. Researchers at the U.S. Department of Energy have concluded that the lack of availability of alternative fuel refueling sites appears to be the greatest impediment to the development of a market for AFV's. Therefore, if the General Assembly decides to invest state resources in providing incentives to expand use of alternative fuels, those incentives would likely be most effective if they are targeted to promotion of the establishment of public refueling sites.

5. The U.S. Department of Energy is currently conducting a detailed study of the government actions which would be most likely to spur development of mature markets for AFV's, and the costs of those actions. That research is expected to be completed in late 1997. The General Assembly may want to have the benefit of those research results before it decides on particular state actions.

6. The rudimentary analysis staff was able to construct tended to support the opinions of several researchers specializing in market research on AFV's that a state the size of Kentucky would have little ability to greatly affect the market for AFV's, even within its own borders. It does not represent a sufficiently large market share so that changes here would substantially affect manufacturing decisions of national producers of vehicles; and fuel availability needs to be established in large geographic areas before consumers are likely to feel comfortable purchasing an AFV. Researchers at the U.S. Department of Energy who are conducting the transition analysis noted above have expressed a willingness to use the estimation model to consider such a question. However, the preliminary conclusion is that only federal action, or coordinated state actions, would be sufficient to effectively spur significant market development in Kentucky.

7. It is estimated that, in the short run, a Kentucky income tax credit of 10% of the additional purchase price of an AFV relative to an equivalent gasoline vehicle and for the establishment of an alternative fuel refueling station would cost the General Fund approximately $200,000 - $700,000 and would result in the purchase of an additional 500 - 1,500 AFV's in the state. It is believed that the long-run effect of state incentives (independent of all other federal and private actions) on the market for AFV's would likely be small, for the reasons noted above. The long-run effect of incentives on the General Fund could be small or large, depending on whether they apply only to actions taken in response to the state incentive, or whether they might apply to actions caused by federal requirements or incentives which might develop in the private market, such as from technological breakthroughs or from a large long-term increase in the price of gasoline.

Table 8. Estimated Number of Alternative Fuel Vehicles and Total Vehicles

State	Estimated Number of Alternative Fuel Vehicles 1995	1996	1997	Total Number of Vehicles 1994	AFV's as % of Total Vehicles
Alabama	3,355	3,604	3,985	3,177,000	0.13%
Alaska	170	197	462	533,000	0.09%
Arizona	4,963	5,917	7,000	2,813,000	0.25%
Arkansas	1,663	1,754	1,852	1,567,000	0.12%
California	51,745	57,396	63,413	22,339,000	0.28%
Colorado	5,783	6,376	6,768	2,750,000	0.25%
Connecticut	2,044	2,254	2,787	2,599,000	0.11%
Delaware	327	352	432	578,000	0.07%
Florida	9,716	10,380	10,630	10,252,000	0.10%
Georgia	9,260	10,036	11,047	5,990,000	0.18%
Hawaii	469	514	518	779,000	0.07%
Idaho	1,686	1,775	1,812	1,035,000	0.18%
Illinois	17,125	18,050	19,113	8,698,000	0.22%
Indiana	8,214	8,775	9,421	4,889,000	0.19%
Iowa	5,145	5,535	5,842	2,766,000	0.21%
Kansas	4,455	4,611	4,780	2,083,000	0.23%
Kentucky	3,739	3,990	4,125	2,666,000	0.15%
Louisiana	4,411	4,629	5,692	3,426,000	0.17%
Maine	648	666	680	946,000	0.07%
Maryland	3,973	4,228	4,442	3,640,000	0.12%
Massachusetts	3,625	3,785	3,964	4,027,000	0.10%
Michigan	15,192	15,828	17,049	7,574,000	0.23%
Minnesota	2,274	2,580	2,926	4,057,000	0.07%
Mississippi	6,303	6,465	6,622	2,063,000	0.32%
Missouri	3,842	4,375	4,950	4,208,000	0.12%
Montana	1,461	1,539	1,777	950,000	0.19%
Nebraska	2,675	2,851	3,201	1,458,000	0.22%
Nevada	2,220	2,546	2,814	985,000	0.29%
New Hampshire	353	365	385	992,000	0.04%
New Jersey	5,117	5,842	6,424	5,839,000	0.11%
New Mexico	3,966	4,268	4,549	1,422,000	0.32%
New York	12,982	13,684	14,682	10,196,000	0.14%
North Carolina	8,268	8,498	8,824	5,443,000	0.16%
North Dakota	1,168	1,268	1,216	685,000	0.18%
Ohio	16,825	17,847	20,514	9,664,000	0.21%
Oklahoma	12,063	12,615	13,272	2,806,000	0.47%
Oregon	6,711	6,958	7,148	2,753,000	0.26%
Pennsylvania	12,585	12,756	13,420	8,482,000	0.16%
Rhode Island	632	668	977	699,000	0.14%
South Carolina	4,152	4,260	4,431	2,743,000	0.16%
South Dakota	1,194	1,256	1,393	769,000	0.18%
Tennessee	7,328	7,558	7,845	5,059,000	0.16%
Texas	32,307	34,465	36,009	13,626,000	0.26%
Utah	3,383	3,815	4,463	1,415,000	0.32%
Vermont	303	310	325	489,000	0.07%
Virginia	6,390	6,987	8,483	5,507,000	0.15%
Washington	6,712	7,000	6,906	4,465,000	0.15%
West Virginia	1,332	1,575	1,816	1,462,000	0.12%
Wisconsin	10,622	11,255	12,058	3,926,000	0.31%
Wyoming	1,146	1,179	1,257	508,000	0.25%
Total	332,022	355,437	384,501	197,798,000	0.19%

Source: Estimates of AFV's are from Energy Information Administration, *Alternatives to Traditional Transportation Fuels, 1995, Volume 1,* December, 1996. Estimates of the total number of vehicles are from *Statistical Abstract of the United States 1996*, CD-ROM, Bureau of the Census, Table 1000, page 622.

Table 9. U.S. Estimated Number of Alternative Fuel Vehicles and Refueling Stations - 1997

Fuel	Number of AFV's	% of Total	Number of Refueling Stations	# AFV's per Refueling Station
LPG	273,000	71%	3,298	83
CNG	82,702	21%	1,241	67
Methanol	19,917	5%	86	231
Ethanol	6,200	2%	41	151
Electricity	3,925	1%	34	115
Total	**385,744**	**100%**	**4,700**	**82**

Source: Energy Information Administration, *Alternatives to Traditional Transportation Fuels 1995, Volume 1*, December, 1996.

APPENDIX A

Table A1. State Incentives for Alternative Fueled Vehicles

State	State Incentives
Alabama	The state provides assistance of up to $250,000 per project for conversion of public fleet vehicles.
Alaska	The state provides no incentives.
Arizona	The state provides income tax reductions, vehicle license tax reductions, and fuel tax reductions for the purchase and use of AFV's.
Arkansas	The state provides a 50 percent rebate for the conversion costs of AFV's.
California	California Energy Commission offers incentives of $1,000 for certified low emission vehicles and $1,500 for certified ultra-low emission vehicles. The state offers an income tax credit equal to 55 percent of incremental or conversion cost of certified low emission vehicles.
Colorado	The state provides rebates of $1,500 to $6,000 per AFV. The state also offers a 5 percent tax credit to vehicle owners for conversion to or purchase of an AFV.
Connecticut	Corporations are eligible for tax credits for 50 percent of conversion costs to CNG vehicles, LPG vehicles, LNG vehicles, electric vehicles, or AFV fueling stations. A 10 percent tax credit is available for the incremental cost of natural gas or electric vehicles.
Delaware	The state provides financing for conversion or purchase of AFV's for public fleets.
District of Columbia	The district provides no incentives.
Florida	The state provides tax exemption for privately owned electric vehicles and offers financing for conversion to or purchase of AFV's for public fleets.
Georgia	The state offers grants to fund the conversion to or purchase of AFV's for public fleets.
Hawaii	The state offers income tax deductions for the conversion to or purchase of AFV's and for the installation of alternative fuel refueling stations.
Idaho	The state provides no incentives.
Illinois	The state offers a rebate of 80 percent of conversion or incremental cost of AFV's, up to $4,000 per vehicle.
Indiana	The state provides no incentives.
Iowa	The state provides financing for AFV conversions for public fleets.
Kansas	The state offers tax credits to fleets of 10 or more vehicles and grants of up to $1,500 per vehicle for AFV conversions or purchases.
Kentucky	The state provides no incentives for AFV's.
Louisiana	The state offers tax credit for 20 percent of the incremental or conversion costs for AFV's or refueling stations. The state also offers zero percent interest loans for the conversion of public fleets and school buses to AFV's.
Maine	The state provides no incentives.
Maryland	The state offers income tax credits for the cost of converting or purchasing AFV's. Refueling or recharging equipment for AFV's is exempt from property tax. Electric vehicles are exempt from motor fuel tax and the conversion costs for clean fuel vehicles are exempt from sales tax.
Massachusetts	The state provides no incentives.
Michigan	The state provides no incentives.
Minnesota	The state provides no incentives.
Mississippi	The state provides no incentives.
Missouri	The state provides no incentives.
Montana	The state provides an income tax credit of 50 percent for the conversion cost of AFV's.
Nebraska	The state offers no cost and low cost loans for the conversion costs of public fleets, incremental cost factory equipped AFV's, and installation costs for refueling stations.

Nevada	The state pays for all but $1,500 per vehicle for the conversion to natural gas of up to two vehicles per private fleet.
New Hampshire	The state has mandates requiring public and private entities to purchase a percentage of inherently low emission vehicles.
New Jersey	The state provides no incentives.
New Mexico	The state provides grants on a competitive basis for projects, including AFV conversion projects.
New York	The state provides several tax exemptions for AFV's and funds AFV projects on a case-by-case basis.
North Carolina	The state provides no incentives.
North Dakota	The state provides a tax credit of $200 to $500 per vehicle on conversions to alternate fuels.
Ohio	The state provides no incentives.
Oklahoma	The state provides an income tax credit of up to 50 percent of the cost of AFV conversions and 10 percent of the total OEM AFV cost, up to $1,500. The state also has a loan fund for conversion of public fleets to AFV's.
Oregon	The state provides a 35 percent tax credit for AFV's and AFV refueling stations.
Pennsylvania	The state provides tax and registration fee exemptions for electric vehicles. The alternative fuels incentives grants offer to pay 50 percent of the costs for conversions and purchases of AFV's, and installations of refueling stations for AFV's.
Rhode Island	The state provides no incentives.
South Carolina	Legislation is pending for tax incentives for AFV's.
South Dakota	The state provides no incentives.
Tennessee	The state provides no incentives.
Texas	The state provides low interest loans for the conversion of public fleets to AFV's.
Utah	The state provides a 20 percent tax credit, up to $500, for each new dedicated AFV registered in Utah, and a 20 percent tax credit, up to $400, for the conversion costs of CNG, LPG, and electric vehicles. Utah also offers low interest loan programs for the construction of refueling facilities for AFV's.
Vermont	Legislation is pending for tax incentives for AFV's.
Virginia	The state provides a licensing fee exemption and exemption from the high occupancy vehicle lane use restrictions for AFV's. Virginia also provides a 10 percent tax deduction to the federal clean fuel tax, a 1.5 percent sales tax reduction for AFV's, and an AFV fuel tax reduction. The state offers loans for the conversion of public fleets to AFV's.
Washington	The state provides no incentives.
West Virginia	The state provides grants, up to $1,000, for the conversion of public fleets to AFV's.
Wisconsin	The state offers municipalities the competitive cost-sharing grants for the added costs of AFV's. The maximum grant is $2,500 per auto and $10,000 per truck. Each municipality is limited to $50,000.
Wyoming	The state provides no incentives.

Source: Energy Information Administration, *Alternatives to Traditional Transportation Fuels 1995*, Volume 1, December, 1996.

Table A2. Fuel Energy Content and Conversion Factors

Fuel	Energy Content Lower Heating Value (Btu/gal)	Gallon of Gasoline Equivalent (GGE)[1]
Gasoline	115,400	1
Ethanol (E85)	81,500	1.42
Methanol (M85)	65,100	1.77
	Btu/lb[2]	
CNG	20,356	N/A

Source: Peg Whalen, et al, *Alternative Fuel Light-Duty Vehicles: Summary of Results from the National Renewable Energy Laboratory's Vehicle Evaluation Data Collection Efforts*, May 1996.

[1]Gallons of fuel should be multiplied by this factor to get GGE.

[2]Because CNG is a gas and cannot be directly related to the Btu/gal measure for gasoline, the energy content for CNG is listed in Btu/lb.