Hybrid, E85 and Gasoline Vehicles In Government Fleets

Colorado Department of Public Health and Environment

Air Pollution Control Division

September 2007

The Costs, Benefits And Emissions Reductions Of Three Major Vehicle Types Are Analyzed By The State Of Colorado

Hybrid electric and E85 vehicles are now included in most government fleets as a supplement to the standard internal combustion engine fleet vehicle. Many fleets have purchased E85 vehicles and are using them as an alternative to gasoline-only vehicles, as the availability of E85 allows.

Hybrid vehicles, both in their sedan and mid-sized SUV form, are seen as a small, but important staple of vehicle fleets. As the cost of gasoline has risen and remains high in the last year, the Colorado executive and legislative branches of government have passed legislation and executive orders to increase the number of hybrid and E85 vehicles in the state fleet. The purpose of these actions is to not only reduce fleet management costs, but also to improve energy efficiency, reduce dependence upon gasoline products and to reduce emissions from all pollutants, with an emphasis on climate change emissions.

Both hybrid and E85 vehicles are capable of achieving significant fuel economy and reducing air pollution emissions. In addition to reducing our dependence on oil and improving the environment, these vehicles offer the opportunity for cost savings over the life of the vehicle ownership, when compared to conventional gasoline-powered vehicles.

In addition, the economic impact of Colorado-grown crops, such as corn, mustard seed and switch grass, which produce biofuels, can be very positive on a local and regional level, in both the private and public sectors.

For fleet operators wanting to improve the bottom line for fleet vehicle costs and improve air quality, hybrids are an attractive option. Since fleets account for a significant portion of vehicle manufacturers' sales, governments have the opportunity to shape the future of the vehicle market and to allow advanced technologies to become more widely available for both institutional purchasers and everyday commuters.

Colorado's Greening Government Fleet Executive Order

Governor Bill Ritter introduced Executive Order # D0012 07 on April 16, 2007. The EO sets goals for Colorado state government to reduce energy consumption in state vehicles and buildings. Specifically, the EO requires state fleet management to cut the use of petroleum products in state vehicles by 25 percent by June 30, 2012, by restricting the purchase of four-wheel drive sport utility vehicles, giving priority to replacement of pre-1996 light duty vehicles, that have a city fuel efficiency rating of less than 25 miles per gallon, and acquiring gasoline/electric hybrid vehicles, alternative and flex fuel vehicles and other fuel efficient/low emission vehicles whenever practicable.

Colorado's Fleet

The Colorado Department of Personnel and Administration is the state agency responsible for implementation of the Greening Government Fleet Program initiated and required by Colorado Governor Bill Ritter's 2007 Executive Order #D0012 07. As such, the DPA must conduct, in cooperation with the Colorado Department of Public Health and Environment a "transportation efficiency audit" to evaluate the current amount of state fleet emissions, and then suggest how to increase the average fuel efficiency and use of alternative fuels/vehicles in the state fleet.

Table 1. Colorado Fleet Alternatively Fueled Vehicles in 2007

Vehicle type	E 85	Diesel	Hybrid Electric	Duel fuel propane	Duel fuel CNG	Dedicated CNG	Plug-in Hybrid
Number	573	286	50	24	3	2	1

Source: Colorado Department of Personnel and Administration

Hybrids

Hybrid electric vehicles combine the best features of conventional and electric cars to improve fuel and environmental performance without sacrificing convenience or performance. They get their power from both an internal combustion engine and a battery-powered electric motor, which results in greater fuel efficiency and cleaner emissions than most conventional cars. Hybrids use standard gasoline for refueling and never need to be plugged-in.

Battery power in hybrids is recovered and stored during braking through a process called *regenerative braking.* The battery is also recharged by the engine when it produces more power than is needed to drive the wheels.

Toyota Prius

Because of the extra power the electric motor provides, gasoline engines in hybrids can be built smaller without compromising performance. By allowing the engine to operate more efficiently, *engine downsizing* decreases exhaust emissions and increases the fuel economy of hybrids.

Hybrids with *engine idle off* capability can turn their gasoline engine off when stopped. This reduces emissions, which are dirtier when idling, and improves fuel efficiency. Idling off makes vehicles especially efficient and quiet in city, stop-and-go traffic.

Some hybrids have *electric-only drive*, powering the car with the battery alone at speeds up to 10-15 miles per hour. This provides significant fuel savings and emissions reductions because combustion engines operate least efficiently at low speeds.

E85 Vehicles

A flex-fuel E85 vehicle, or FFV, is a vehicle that is capable of running on either gasoline or E85, which is a blend of 85-percent ethanol and 15-percent gasoline. Ethanol can be manufactured from various sources, but "corn is king." A bushel of field corn can be processed into at least 2.7 gallons of ethanol. Partly motivated by fuel-economy credits from the federal government, automakers have decided to make certain engines of specific car models operational on both fuel types as a no-cost option.

Ethanol advocates emphasize that using E85 results in decreased reliance on imported oil, reduced environmental pollution, and a lower negative impact on the public's health. Ethanol is 100-percent renewable and non-carcinogenic. At the same time, production is 100-percent domestic.

E85 has a substantially higher octane rating than today's gasoline, which means improved performance by way of greater horsepower. E85 has the *highest* oxygen content of all available fuels, so it burns more fully. Its use can result in a nearly 30-percent reduction of greenhouse gas emissions according to many ethanol manufacturing sources. However, the EPA takes a more moderate approach claiming that while making the switch from gasoline to ethanol blends can lower the environment's carbon monoxide levels by as much as 40 percent, but greenhouse gas emissions are likely to be cut by only 15 to 20 percent.

Ethanol has a noticeably *lower* energy content than gasoline—exactly how much lower seems to be a matter of some controversy and numerous opinions. For instance, some industry sources say this decreased energy content rating translates to roughly a *12- to 20-percent reduction in fuel mileage*. However, John Howell, product director for Cadillac, states there is a *"15- to 25-percent* difference in the level of energy by liquid measure." EPA states fuel-economy estimates for flex-fuel models using ethanol reveal that E85 reduces gas mileage *by 21 to 31 percent* during city driving and *20 to 34 percent* while on the highway.

Currently, E85 is sold at only about 640 filling stations nationwide, and more than two-thirds are in the upper Midwest, meaning availability is proving to be a large obstacle. Although the number of E85 stations doubled last year from the previous year, the total number of stations is still tiny, especially when compared to the 170,000 stations that dispense conventional gasoline.


Chevy Impala Flex-fuel

Section A.
Cost/Benefit Analysis of Hybrid-E85-Gasoline Vehicle Types

Methodology

The cost/benefit analysis that follows is both quantitative and qualitative. The quantitative analysis provides a comparison of key economic variables associated with hybrid and E85 vehicles and their conventional gasoline counterparts. It is recognized that hybrid and some makes of E85 vehicles are new to the marketplace and that technology and costs are rapidly changing. Therefore, a quantitative analysis alone may not fully capture the economic conditions observed within a government fleet. For this reason, interviews with state and local fleet managers and additional research are also conducted.

Economic variables used in the cost/benefit analysis include the following:

- **Initial Purchase Price:** The initial purchase prices are based on 2007 Colorado State acquisition prices. When state acquisition prices are not available, the manufacturer's suggested retail price is reduced by 30 percent. A 30 percent reduction is consistent with the reductions received for similar vehicles in 2007.
- **Residual Value:** Residual value performance measures the ability of a product to hold its value over time and is considered a key indicator of a product's long-term desirability. A strong residual value results in less depreciation over time, reducing the cost of ownership. For the purposes of this analysis, residual value represents the value of the vehicle at the end of a 60-month (5-year) lifecycle. Residual values for conventional gasoline vehicles are

based upon data supplied by the Automotive Lease Guide in 2007. Local hybrid dealers provide residual values for hybrid vehicles.

- **Fuel Miles per Gallon:** Based on EPA's Fuel Economy city/highway estimates. The EPA recently applied new testing procedures to, which cause a fuel economy estimate drop of an average of 12 percent for city driving and 8 percent for highway driving on most 2008 model year vehicles. These estimates are intended to be more realistic and to include factors such as use of air conditioning and winter driving. Estimates in this study were adjusted to reflect this change and give a more realistic picture of fuel efficiency.

- **Fuel Cost:** Estimated at $3.10 per gallon for gasoline and hybrid models based on the Energy Information Administration petroleum product prices for Colorado, May 2007, unleaded regular gasoline. Cost adjusted to $2.68 to reflect state discount of approximately $0.42. Fuel cost for E85 vehicles estimated at $2.39 per gallon based on local prices as of May 2007. Cost adjusted to $1.97 to reflect state discount of $0.42.

- **Inflation:** Inflation represents the increase in costs over time. The rate of inflation used in this analysis is based on the Denver-Boulder-Greeley CMSA inflation rate of 3.5% as forecasted by the State of Colorado General Assembly for 2007. Cost variables were compounded at 3.5% per year to account for rising costs associated with inflation.

- **Discount Factor:** Discounting is the process of finding the present value of an amount of money at a future date. Discount rates are applied to all cost variables.

- **Maintenance Costs:** Data provided by the Colorado State Fleet and local dealers indicates no difference in general maintenance costs between hybrid and E85 vehicles and their gasoline counter parts. As a result, maintenance costs are not factored into this cost/benefit analysis.

- **Vehicle Models/Classes:** Vehicle models used in this analysis were chosen to represent the state fleet and include the Toyota Prius (Hybrid), Chevy Impala (E85 and Gasoline), and Ford Escape (Hybrid and Gasoline).

Analysis of Ownership Costs

Table 1: Total Ownership Cost

	Hybrid Sedan	E85 Sedan	Gasoline Sedan	Small Hybrid SUV	Small Gasoline SUV[4]
Purchase Price	$21,403	$15,238	$15,238	$24,019	$17,867
Residual Value[1 & 2]	($6,344)	($4,867)	($4,867)	($7,318)	($5,228)
Net Price	$15,059	$10,371	$10,371	$16,701	$12,639
Fuel Miles Per Gallon (city/hwy)	48/45	14/21	18/28	31/29	17/21
Fuel Miles Per Gallon Combined	46 (43)[3]	17 (26)[3]	22	30	19
Fuel Cost[1]	$6,007	$11,949	$12,561	$9,211	$14,554
Total Ownership Cost	$21,066	$22,320	$22,932	$25,912	$27,193

Notes: Calculations reflect values over the life cycle of the vehicle. The life cycle for all vehicles in the analysis is assumed to be 8 years/100,000 miles in accordance with Colorado State Fleet Management average vehicle replacement schedule; Vehicles that are leased require the payment of a financial rate (similar to the interest rate that would be paid for a loan). Data provided by the State indicated that additional financing charges for hybrid vehicles are not substantial and would not alter the outcome of the analysis.

[1] Residual Value and Fuel Cost are discounted and compounded to account for the rising costs associated with inflation.

[2] Residual Value based on a *5 year, 60-month projection* – more distant projections are not available.

[3] Numbers in ( ) reflect Colorado State Fleet combined unverified mpg, which differ from EPA mpg.

[4] State purchase price for this vehicle/model was not available – reduced MSRP by 30 percent, which reflects the discounts received in 2007 State price agreements for similar models.

As Table 1 shows, higher resale values and lower fuel costs compensate for the higher initial purchase price associated with a hybrid vehicle, reducing the cost of ownership over the lifecycle of the vehicle. The difference in total ownership costs between the hybrid and gasoline SUV reflects the fact that the state purchases 6-cylinder gasoline SUVs and 4-cylinder hybrid SUVs. Manufacturer reductions in purchase price, give gasoline vehicles an advantage, an issue that is discussed further in the section that follows.

In general, E85 vehicles lack the fuel efficiencies and higher resale values associated with hybrid technology, which results in the higher ownership cost reported in Table 1.

Interviews with State and Local Fleet Managers

The Colorado State Fleet Manager indicated that hybrid vehicles are not yet an economically competitive option for the state fleet because the higher purchase price is difficult to recover. In large part this is a result of the discount in purchase price the state receives from local dealers for gasoline and E85 vehicles (can be up to 50 percent off of the initial purchase price). The state has also found that some of its fleet E85 vehicles achieve better fuel efficiencies than reported by the EPA (26 mpg as compared to 17 mpg), but this number is not verified. A fuel economy rating of 26 mpg would result in a total ownership cost of $21,079, slightly more than the hybrid. Although an E85 vehicle does not retain its value as well as a hybrid vehicle, the higher fuel economy would make E85 vehicles a more competitive option.

Local fleet managers indicated that Alternative Fuel Vehicles (AFVs) have worked well in their fleets and have been a competitive option. Boulder and Denver continue to purchase AFVs and Denver is looking to expand the fleet to include heavy-duty electric and hydraulic boost systems for the city's trash truck fleet.

Battery replacement is a concern for fleet managers, especially as it relates to resale value. The City of Denver is pursuing the possibility of selling their hybrid vehicles while their resale value remains high and replacing them with new models. The City of Boulder is considering replacing the battery before sale. They plan to sell their first Prius in 2008 or 2009 and are fairly confident that they will sell due to the popularity of the Prius in the community.

The lack of manufacturer reductions for the cost of hybrid vehicles was cited as a major barrier to the inclusion of greater numbers of hybrids in the fleet. If manufacturers were more aggressively involved in providing cost reductions, hybrids would be more competitive. One way this could be achieved is through the revision of federal policy (e.g., Energy Policy Act) to bridge the gap in price between hybrids and their gasoline/E 85 counterparts. Limited fuel sources (e.g., Compressed Natural Gas, Liquefied Natural Gas, & E-85) and AFV models to choose from was also sited as a constraint. The City of Boulder indicated that manufacturer availability was the only barrier to including more AFVs in their fleet. They are especially interested in a wider variety of pick-up models.

Additional Considerations

Since hybrid vehicles are somewhat new to the marketplace and the technology is rapidly changing, it is difficult to accurately predict what resale values will be several years in the future. For example, the presence of the hybrid-specific battery raises questions, since it is not known how many years beyond the current warranty (8 years or 100,000 miles for most hybrids) the battery will last and how the presence of a battery near or at the end of its warranty will affect resale value. Currently, resale of hybrids is particularly strong, in light of the short supply of new models (Kelley Blue Book, 2007).

Hybrid battery packs are designed to last for the lifetime of the vehicle, somewhere between 150,000 and 200,000 miles. There is no definitive word on the actual cost of battery replacement, in part because batteries have not yet had to be replaced. The cost of battery replacement is generally estimated at about $3,000 for the Toyota Prius. It is important to consider that the cost of the battery is expected to decline (and has been declining) as technology and production becomes more efficient, reducing the initial cost of a hybrid vehicle.

A rebate is available from the Colorado Department of Revenue for the purchase of an alternative fuel vehicle or for the conversion of a vehicle to operate using an alternative fuel. Vehicles must be owned by the State of Colorado, a political subdivision of the state, or a tax-exempt organization, and be used in connection with the official activities of the entity. The rebate is a percentage of the incremental cost if used toward purchasing a new alternative fuel vehicle, or is a percentage of the conversion cost if used towards the cost of converting a vehicle to operate using an alternative fuel. Each qualified entity is limited to $350,000 per state fiscal year in total rebates paid. Mild hybrids (e.g., Chevy Silverado) do not qualify. Rebates are available through 2011.

Conclusion

Higher resale values, lower fuel costs, strong warranties, and federal rebates compensate for the higher initial purchase price associated with a hybrid vehicle, reducing the cost of ownership over the lifecycle of the vehicle. However, manufacturer reductions in purchase price make gasoline vehicles a more attractive option.

In general, E85 vehicles lack the fuel efficiencies and higher resale values associated with hybrid technology, which results in a higher ownership cost when compared to their hybrid and gasoline counterparts. However, the state has found that E85 vehicles achieve better fuel efficiencies in some of its E85 vehicles than reported by the EPA, which would make them a more competitive option.

Denver and Boulder fleet managers have found hybrid and E85 vehicles economically competitive options and are expanding the use of AFVs in their fleets. In addition to the limited availability of alternative fuel sources and AFV models to choose from, the lack of manufacturer reductions for the cost of hybrid vehicles appears to be a major barrier to the inclusion of greater numbers of hybrids in government fleets. Overcoming this barrier would likely require the revision of federal policy so as to bridge the gap in initial purchase price between hybrids and their gasoline/E85 counterparts.


Toyota Highlander Hybrid

Contacts

In addition to local dealerships and maintenance departments, the following individuals provided information for this report:

- Nancy Kuhn, City of Denver Public Works Department
- Jim Arnold, City of Boulder Fleet Maintenance Supervisor
- Bill Boyes, City of Boulder Facilities and Fleet Manager
- Art Hale, Colorado State Fleet Manager
- Luke Walch, Boulder Toyota
- Rick Borselari, Champion Ford

Data Sources

- Automotive Lease Guide (http://www.alg.com)
- Colorado General Assembly, 2007. *Focus Colorado: Economic and Revenue Forecast, 2007-2011*.
- Colorado Revised Statutes 39-33-101 through 39-33-106
- Kelly Blue Book (http://www.kbb.com)
- U.S. Department of Energy. Energy Efficiency and Renewable Energy Program (http://www.eere.energy.gov/cleancities/about.html)
- U.S. Environmental Protection Agency. Model Year 2007 Fuel Economy Guide (www.fueleconomy.gov)

Section B. Emissions Calculations

Discussion

Consideration of greenhouse gas emissions entails looking at the fuel type, amount of fuel used and a number of externalities related to fuel production, transportation and distribution.

Thus, emissions of greenhouse gases are reflected not just as a *tailpipe emission* normally associated with vehicle use, but also as a *life cycle emissions*.

Converting to greenhouse gas emissions equivalents take into account carbon dioxide, nitrous oxide and methane. This analysis uses a comprehensive comparison considering a lifecycle approach, taking into account the energy used to produce and deliver the fuel.

There are no adjustments to remove government subsidies from the cost calculations since the final fuel costs include taxes, and to some extent, built in subsidies. This last point is considerably more complex than the superficial $0.51 cents per gallon rebate fuel producers receive for each gallon of ethanol blended into the fuel stream. If one were to consider all the external costs, subsidies to agricultural producers, as well as oil exploration and development would have to be factored in. Assuming these costs are somehow reflected in the 'at the pump' cost, it is probably the safest approach for this analysis, since it really is what the State would pay for fuel at retail, or even wholesale price.

A state operated vehicle may have sufficient choices to be fueled on E85 in the Denver metro area, but if it were used in travel outside metropolitan areas, it could be expected to use 100% gasoline fuel. Added to this issue is the high degree of flux in the cost of fuels. When making five-year projections of costs one has little ability to speculate what gasoline or ethanol will cost.

While numerous models appear to be available for such a comparison, this analysis focused on using output from the Argonne National Labs GREET model, one of the newest and most vetted models available for such analysis.

A simple measurement based upon the dollars spent on fuel use as a ratio of the emissions could be developed. For instance, looking at the Toyota Prius over the 100,000-mile span of the analysis, the fuel cost would be $6,987 and 26.7 tons of greenhouse gasses would be emitted. A cost per ton might be reflected by the final ownership cost estimated at $21,066 per 26.7 tons or $789 per ton. Comparing this to the $415/ton of dollars per ton related to the gasoline Chevy Impala, or $515 for the E85 Chevy Impala would make the cost per ton for the gasoline Impala seem favorable. However, the goal is to emit the fewest tons of emissions for a given dollar so, unlike the typical analysis for a power plant, here we look at the normalized cost comparing the standard vehicle overall cost and emissions against the alternative cost and emissions within the same class. In Table 1, using the Chevrolet Impala as the base, we compare its over all cost and emissions against the Toyota Prius and E-85 sedans.

Table 1. Emissions Comparison Hybrid – E85 – Gasoline Vehicle Types

	Fuel Miles Per gallon[1]	Gallons of fuel used/100,000 miles[2]	Tons of Greenhouse gas emissions tons/100,000 miles[3]	Fuel cost per 100,000 miles based on DOE GREET model[4]	Fuel cost per 100,000 miles based on Contractor analysis[5]	Total ownership cost based on Contractor analysis[6]
Hybrid Sedan (Toyota Prius)	46	2174	26.7	$6,987	$6,007	$21,066
Gasoline Sedan (Chevy Impala)	22	4545	55.3	$14,653	$12,561	$22,932
Small Hybrid SUV 4WD-4cyl, automatic (Ford Escape)	28	3571	44	$11,493	$9,211	$25,912
E85 Sedan (Chevy Impala)	17	5882	43.3	$12,347	$11,949	$22,320
Small Gasoline SUV 4WD- 6cyl (Ford Escape)	19	5263	64	$16,099	$14,554	$27,193

[1]Fuel use based on 'new' EPA estimates (e.g. 2007 new EPA calculation process)
[2]Based on 15,000 miles per year, adjusted times 6.7 to equal 100,000 miles
[3]Emissions based on DOE/Argonne National Labs GREET model
[4]Fuel cost estimates 45% highway, 55% city, $2.68 per gallon gasoline and $1.97 per gallon E85
[5]Contractor fuel costs based on State contract fuel costs
[6]Includes purchase price, residual value, net price, fuel use and fuel cost

Table 2. Energy Efficiency of Hybrid – E85 – Gasoline Vehicle Types

	Efficiency Ratio Percent[1] $100 \times (E_0 - E_c)/ E_0$	Pounds saved (per 100,000 mile driven) dollar spent $(E_0 - E_c)/TOC$ [2]
Gasoline Sedan vs. Hybrid Sedan	52%	2.49 lbs saved /dollar spent
Gasoline Sedan vs. E85 Sedan	22%	1.07 lbs saved /dollar spent
Gasoline SUV versus hybrid SUV	32%	1.54 lbs saved/dollar spent

1 E_0 = Emissions of standard gasoline vehicle for this class based on GREET model at 100,000 miles
2 E_c = Emissions of controlled vehicle (hybrid, E85, etc.). Relative to gasoline base vehicle for this class of vehicle, TOC = Total Ownership Cost from

Table 3. Five Vehicle Type Cost and Emissions Rankings

1 = Best ----- 5 = Worst

	Prius	E85 Sedan	Gasoline Sedan	Hybrid Mid-SUV	Gasoline Mid-SUV
MPG	1	3	4	2	5
Gallons of fuel used	1	2	4	3	5
Fuel cost @ 100,000 miles	1	3	4	2	5
GHG emissions @ 100,000 miles	1	2	4	3	5
Total Ownership Cost	1	2	3	4	5

Table 4. Five Vehicle Type Cost and Emissions Values

	Prius	E85 Sedan	Gasoline Sedan	Hybrid Mid-SUV	Gasoline Mid-SUV
MPG	46	17	22	28	19
Gallons of fuel used	2174	5882	4545	3571	5263
Fuel cost @ 100,000 miles	$6,327	$11,587	$12,180	$9,570	$14,104
GHG emissions @ 100,000 miles	26.7	43.3	55.3	44	64
Total ownership cost	$21,066	$22,320	$22,932	$25,912	$27,913

Conclusion

Both hybrid and E85 vehicles can be a competitive option for government fleets. Higher resale values, lower fuel costs, strong warranties, and federal rebates compensate for the higher purchase price associated with hybrid vehicles. Although an E85 vehicle does not retain its value as well as a hybrid vehicle, manufacturer discounted purchase prices and lower fuel costs can make E85 vehicles a more economical option than both gasoline and hybrid vehicles. The lack of manufacturer reductions for the cost of hybrid vehicles appears to be a major barrier to the inclusion of greater numbers of hybrids in government fleets. Overcoming this barrier would likely require the revision of federal policy so as to bridge the gap in initial purchase price between hybrids and their gasoline/E85 counterparts.

Ford Escape Hybrid

Production of corn ethanol can actually increase net greenhouse gases by 4% if the milling process is powered by coal. Currently, corn is the source of 95 percent of ethanol in the United States. This production requires good land and petroleum-intensive cultivation and fertilization. Other sources of biofuel, such as sugarcane ethanol, cellulistic ethanol (switchgrass and others), and soybean biodiesel should be examined, since these provide better energy efficiency and reduce emissions over the life of a vehicle than ethanol currently does.

Toyota Camry Hybrid

One might expect that by using E85, net carbon dioxide emissions would be almost zero. The crops used to make the ethanol absorb CO2 from the atmosphere during their growth, and then this CO2 is put back into the atmosphere when the ethanol is burned in an automobile engine. In reality, this cycle is overly simplistic because it fails to recognize other greenhouse gas emissions that occur during the cultivation and production of ethanol. Modern farming, for example, relies heavily on diesel-powered equipment that emits greenhouse gases. Distilling ethanol is also an energy-intensive process that often uses electricity generated from coal, another source of greenhouse emissions.

Table 5. U.S. Biofuels Comparison

	What It Cost	How Much Are We Making 2007 U.S. Production in Gallons	How Much Land Would It Take To replace 5% of gasoline consumption	What's Good About It	What's Bad About It
Gasoline And Petroleum Diesel	$3.10 gasoline[1] $2.79 diesel	136 Billion - Gasoline 63 Billion -Diesel	142 Billion Gallons of Gasoline Consumed in U.S. in 2006	Large supplies for the moment. Massive industrial infrastructure in place.	Releases ancient carbon into atmosphere. Non-renewable. Diesel soot is major pollutant.
Corn Ethanol	$2.39 E85[2]	5.7 Billion	117 million Acres	Homegrown, so promotes energy independence. Some infrastructure in place. Politically popular.	All ethanols yield about a third less power than gasoline. Production can degrade soil. Requires extensive water and fertilizer.
Sugarcane Ethanol	$1.00 In Brazil[3]	4.2 Billion in Brazil	41 Million Acres	Most energy efficient of all biofuels.	Smoke from cane burning creates pollution
Cellulistic Ethanol (switchgrass, slash, and agricultural byproducts)	Not commercially available	Unknown	35 Million Acres if Switchgrass	Major greenhouse gas reductions.	Wide scale utilization may displace native plants and wildlife.
Soybean Biodiesel	$2.53 B20 $3.31 B100	292 Million Estimate	138 Million Acres	Biodiesel burns more cleanly than petroleum diesel by 50%.	Clearing forests for production could increase C02.

U.S. average cost. Colorado state fleet discount cost is $2.68/gallon.
U.S. average cost. Colorado state fleet discount cost is $1.97/gallon.
Not produced in U.S.
Source: Sierra Club. August 2007.

Researchers at the University of California at Berkeley recently examined six major studies of ethanol production and concluded that using ethanol made from corn instead of gasoline would lead to a moderate 13 percent reduction in greenhouse emissions. However, the researchers note that **more dramatic reductions are possible if technology advances make it economical to make ethanol from cellulosic materials** such as switchgrass, a crop currently grown by some U.S. farmers to control erosion on idle fields. Using cellulistic ethanol, they project, could result in 88 percent less greenhouse gas emissions.

The UC Berkeley study also contradicts a common criticism of ethanol: that it takes more energy to produce it than it delivers as a motor fuel. The study concludes that ethanol made from corn does indeed have **a positive "net energy balance,"** particularly if you consider that other valuable products, such as corn oil, are byproducts of the ethanol-making process.

E85 may be better for the environment and the American farmer, but it has some drawbacks.

- The first is price: **ethanol can be more expensive than gasoline**, depending on where you live. Data on fuel prices from the DOE shows that in the Midwest (where much of the country's ethanol is produced) E85 sells for nearly 30 cents less per gallon than

conventional gasoline. However, on the West Coast, filling up with ethanol would cost a driver 35 cents more per gallon. In the Mid-Atlantic States, E85 had an even higher premium: 44 cents per gallon.

- The higher price of E85 in many areas is made worse by ethanol's second drawback: **ethanol, regardless of the price you pay for it, contains less energy than gasoline**. This means that your car won't go as far on a gallon of E85, and your fuel economy will decrease by 20-30 percent. This is bad news for consumers because even if the price of E85 at the pump is cheaper than gasoline, using ethanol may not be less expensive in the end.

The most fuel-efficient flexible-fuel vehicle available this year is the Chevrolet Impala. Using gasoline, it is rated at 21 mpg in the city and 31 mpg on the highway. By using E85, rated mileage drops to 16 mpg city and 23 mpg highway. If you fill up the Impala's 17-gallon tank at a station in the Midwest, you'll save $5.10 by using E85. However, you can't drive as far on E85 and will have to refuel sooner than if you had purchased conventional gasoline. In fact, your cost per mile is higher using E85: 9.7 cents/mile vs. 8.4 cents/mile for regular gas. A 1.3 cent per mile difference may not seem like much, but over the course of a year's driving it adds almost $200 to your fuel costs.

- Another other issue is that **E85 is widely available only in the Midwest**. The DOE lists more than 600 E85 stations in the United States, but nearly half of those are in two states: Minnesota and Illinois. Other areas, even populous ones, have little E85 infrastructure. For example, New York, California, Texas and Florida have just 15 E85 stations combined, only two of which allow sales to the general public.

To put things in perspective, there are more than 170,000 stations nationwide selling gasoline. While all of them may not need to offer E85, it is clear that wider distribution is needed before E85 can begin to displace gasoline sales.

Section C. Recommendation

Given the cost/benefit and emissions data contained in this report, a staggered approach to replacing gasoline vehicles in the state fleet is advised. Currently, hybrid vehicles are the easiest alternative vehicle type to incorporate into the state fleet from an operations point of view. Hybrids are available for purchase now and do not require an extensive investment in infrastructure, as does the use of ethanol flex fuel. Once again, without a major investment in ethanol fueling infrastructure, there is the constant need outside a few select urban areas to fuel flex fuel vehicles with gasoline, thereby increasing greenhouse gases rather than reducing these with this vehicle technology. While there are barriers to government purchasing hybrids at a discount from manufacturers, the Colorado Governor's Energy Office is examining methods for all levels of government in the state to purchase hybrids in bulk at a discount.

In the near future of 5-10 years, as other types of biofuels that are more effective at reducing greenhouse gas emissions become more available and infrastructure to provide these fuels become more prevalent, flex fuel vehicles will be a competitive and important alternative vehicle choice for fleets. Also, plug-in hybrids and the newest generation of all electric vehicles, as well as advanced engine diesel vehicles, could be highly competitive, on a cost and operations basis, as alternatively sourced vehicles for fleets. In addition, plug-in electric and hybrid electric/gas vehicles that have the ability to plug into a common 110V household outlet and then travel 250-400 miles on a charge may be a viable option in this timeframe. Many vehicle manufacturers claim they will offer a substantial number of gasoline-only powered vehicles that achieve substantially improved gas mileage in the 35-45 mpg range. These should also be considered for purchase and inclusion in the state fleet.

Lastly, in the future of 10 years or more, many new vehicle types, such as fuel cell powered vehicles and super clean diesel vehicles may be an important addition to the state fleet.