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PSG
Shaping Your Alternative Fuel Program

TECHNICAL AND ENVIRONMENTAL SUMMARY OF SPECIFIED ALTERNATIVE FUEL OPTIONS

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Introduction

The single most important decision to be made with regard to any clean fleet program is what alternative fuel(s) to deploy for fleet use. On the surface this may seem a fairly obvious question but what is not obvious or simple is making that choice. Fleets interested in moving toward clean modes of transportation must actually ask these questions and realize that several factors must be taken into consideration before any long term change in direction should occur.

<u>These questions are</u>:

1. Is the fuel currently commercially viable?
2. Is the fuel easily adaptable to the existing fleet?
3. Will new infrastructure be required?
    a. At what cost?
    b. At what locations?
4. Is there a variety of OEM vehicles that will run on the new fuel?
5. Is there a long term commitment from the auto and engine manufacturers for this fuel?
6. Are these vehicles/technologies U.S. EPA and/or CARB certified?
7. Is there an existing national user base to support the validity of the specified fuel?
8. What emission reductions can be expected from the fuel?
9. What detrimental factors are associated with the fuel?
10. Are there any federal, state and/or local regulations that will inhibit the fuel's short and/or long term validity?
11. Are there any federal, state and/or local funding opportunities to assist in the fuel's assimilation throughout the fleet?

This report will take a detailed look at the fuels listed below and endeavor to come up with what PSG feels are the best alternative fuel choices for any fleet to make today. PSG has conducted a comprehensive review of all commercially viable fuels for light-, medium-, and heavy-duty applications and submits the following analysis for review.

<u>The fuels contained in this report are</u>:

- Ultra Low Sulfur Diesel (ULSD)
- Ethanol (E85)
- Biodiesel (B20)
- Liquefied Petroleum Gas (LPG)
- Natural Gas (CNG & LNG)
- Hydrogen
- Electricity:
    - Gasoline/Electric Hybrids (LDV, LDT)
    - Diesel/Electric Hybrids (HDT, HHDT)
    - Plug-In Hybrid-Electric Vehicles

(Note: Periodically, reference to various industry vehicle weight classes will be made. They are listed in the table below.)

Vehicle Classification	***Abbreviation***	***GVWR Range***
Light-Duty Vehicle	*LDV*	*Up to 8,500 lbs.*
Light-Duty Truck	*LDT*	*Up to 8,500 lbs.*
Medium-Duty Passenger Vehicle	*MDPV*	*8,501 to 14,000 lbs.*
Heavy-Duty Truck	*HDT*	*14,001 to 32,999 lbs.*
Heavy, Heavy-Duty Truck	*HHDT*	*33,000+ lbs.*

Ultra Low Sulfur Diesel (ULSD)

What Is ULSD?

First, it is important to note that ULSD are NOT alternative fuels. Sulfate particulate and sulfur dioxide (SOx) toxins are emitted in direct proportion to the amount of sulfur in diesel fuel. ULSD has been mandated by the U.S. Environmental Protection Agency as a replacement fuel for low sulfur (500 PPM) diesel. Ultra-low sulfur diesel fuel is a specially refined diesel fuel that has dramatically lower sulfur content than regular on-road diesel.

ULSD has a sulfur content of <15ppm and is an EPA-driven rule that came into effect on June 1, 2006. Beginning on June 1, 2006 the sulfur content of ULSD could not exceed 15 parts per million (ppm) based on EPA mandates. Comparatively, regular #2 diesel has a maximum of 500 parts per million of sulfur. *The lower sulfur content* in ULSD produces fewer sulfate emissions and, most importantly, enables the use of emission-reduction equipment, like particulate traps and NOx emission catalysts, to lower emissions of particles and nitrogen oxides. Use of these systems in combination with ULSD can reduce emissions of fine particulates (PM_{10}, $PM_{2.5}$) by more than 90 percent and emissions of hydrocarbons to nearly undetectable levels.

ULSD Emissions

Pollutant	**Fuel Only**	**w/Add-On Technologies**
Particulate Matter (PM)	13% reduction	20% - 80% reduction
Hydrocarbons (HC)	13% reduction	90% reduction
Carbon Monoxide (CO)	6% reduction	90% reduction
Nitrogen Oxides (NOx)	3% reduction	15% - 20% reduction

(Source: U.S. EPA, CARB, Clean Air Fleets 2007)

Diesel Add-On Technologies at a Glance

Diesel Particulate Filter (DPF)

Diesel particulate filters (DPFs) are one class of emission control technologies that lower PM emissions. By trapping the particulates as the exhaust gas passes through the filter, DPFs are able to achieve PM reductions of 80 – 90 percent. Numerous studies have documented the effectiveness of DPFs in both on- and off-road applications. The systems are relatively easy to maintain, but do require users to monitor their condition and occasionally remove the filter, blowing out the ash and replacing it.

Fuel sulfur content plays a key role in the performance of DPFs since it has a direct impact on the level of particulate matter in the exhaust. Numerous studies have found that DPFs, regardless of their manufacturer, achieve higher PM reductions with the use of ULSD fuel.

PM Filter Type	NOx	PM	HC	CO	Est. Price
Base Metal Oxidizing	N/A	80%	50%	50%	$6.5K - $10K
Highly Oxidizing Precious Metal	0% - 5%	>90%	90%	90%	$6.5K - $10K

Diesel Oxidation Catalysts (DOC)

Diesel oxidation catalysts (DOCs) are a section of the exhaust system coated with metals that trigger chemical reactions which breakdown pollutants (CO, HC, PM) into harmless gases, when engine exhaust passes through it. Since 1995, more than 500,000 trucks and buses have been retrofitted with DOC systems.

On- and off-road applications of DOCs are virtually maintenance free, requiring only periodic inspections. DOCs also work to improve the effectiveness and performance of Diesel Particulate Filters (DPFs), by attracting excess soot from the exhaust before it passes through the filter. The costs of DOC devices range from several hundred to several thousand dollars per device depending on engine size, sales volume, and whether the installation is a muffler replacement or an in-line installation.

Oxidation Catalyst Type	NOx	PM	HC	CO	Est. Price
Base Metal	N/A	10% - 30%	50%	50%	$1K - $2K
Precious Metal	N/A	>20% - 40%	50%	50%	$1K - $3K

NOx Reduction Technologies

The first verified system to reduce NOx and PM is a NOx reduction catalyst. This system combines a NOx catalyst with a particulate filter or oxidation catalyst to provide additional PM reductions. In addition to exhaust gas recirculation (EGR) technology which helps lessen NOx production during the combustion process, post-combustion emission controls for NOx include selective catalytic reduction (SCR) and NOx absorber technologies.

SCR devices have been used for years to control NOx from stationary sources and are now being applied to mobile sources to cut the pollutant by over 70 percent. Unlike DOCs, the SCR system requires the addition of a *"reductant"* (typically urea or ammonia) to convert NOx pollutants to nitrogen and oxygen. Based on the oxidizing metals used in the SCR, additional pollutant reductions can be achieved.

NOx absorber catalyst technology is also undergoing extensive research and development in anticipation of the 2010 on-road, heavy-duty diesel engine regulations. Researchers have demonstrated the ability of NOx absorbers to control up to 90 percent or more of NOx emissions over a broad temperature range.

NOx absorbers act to store NOx emissions during lean engine operation and release the stored NOx by periodically creating a rich exhaust environment by either engine operation or the injection of a reductant in the exhaust stream. While EPA estimates that the technology can cut NOx (as well as HC and CO) by more than 90 percent, it is still largely in the research and development phase for on-road applications.

Crankcase Emission Control

In the majority of turbo-charged diesel engines, the crankcase breather is vented to the atmosphere often using a downward directed draft tube, therefore allowing a substantial amount of PM to be released into the atmosphere. One solution to this emissions problem is the use of a multi-stage filter designed to collect and return the emitted lube oil to the engine's sump or a CCV system (available from Fleetguard).

These systems allow filtered gases to return to the intake system, balancing the differential pressures involved and allowing the systems to eliminate crankcase emissions. In addition to some closed crankcase filtration systems' ability to lower crankcase emissions, it also reduces PM emissions by 25% – 32% and CO by 14% – 18%, according to U.S. EPA.

Additional Emission Reduction Technologies

- Hydraulic Launch Assist – A truck equipped with a hydraulic launch assist (HLA) system recovers energy normally lost during deceleration and converts it to hydraulic pressure in an accumulator, where it is later used as a source of energy during the vehicles next acceleration. The HLA system consists of a reversible hydraulic pump/motor coupled to the drive shaft through a clutch and two accumulators. As the driver steps on the brake, the pump/motor forces hydraulic fluid out of a low-pressure accumulator and into a high pressure accumulator, increasing the pressure of nitrogen gas stored there to 5,000 psi.

  During acceleration, the HLA system switches from the pump mode to the motor mode, the nitrogen gas forces the hydraulic fluid back into the low-pressure accumulator, and the pump/motor applies torque to the driveshaft through the clutch. Unfortunately, HLA systems are limited in their commercial applications because the technology is simply too complex, too expensive and can create too many continuing maintenance issues/costs.

- Electric Launch Assist – Much like its hydraulic counterpart, an electric launch assist (ELA) recovers energy during deceleration by means of regenerative braking. The difference between the two technologies is that an ELA stores the recovered energy in on board batteries and then uses the stored energy to power an electric motor. The motor interfaces with the vehicle's drive shaft and assists the diesel engine during acceleration. Conventional ELAs have proven to be more cost effective and more reliable than HLAs but they have also shown a drop off in power and available torque.

- Improved Diesel Particulate Filters – With conventional particulate traps exhaust gases continuously pass through the trap in one direction. This causes hot exhaust gases to heat the filter trap and cooler exhaust gases to cool the filter trap. A continuous filter temperature of 600° C is required to systematically oxidize soot, but at idle or during the typical city duty cycle, the engine exhaust temperature going into the trap will average around 100° C rendering the trap virtually ineffective. In this mode, the trap accumulates carbon because the internal heat is insufficient for oxidization to occur. A unidirectional flow diesel catalytic converter filter trap remains effective at low power and at idle, only if significant fuel is added to the converter before it cools. This allows the equipment to maintain the particulate oxidation temperature by continuously oxidizing fuel, but is very wasteful and uneconomical.

  The Smart Muffler™ by SmartMuffler International will trap and destroy diesel exhaust smoke or soot, complex hydrocarbons and carbon monoxide but, unlike standard DPTs, it will do so with a significantly reduced fuel penalty. It incorporates an automatic overheat protection which allows it to continuously burn off PM, thus eliminating buildup and the threat of thermal runaway. There is no loss of horsepower due to excessive build up of soot or ash (competitive systems experience decreasing horsepower and increased fuel consumption as soot accumulates between regeneration events). No over-fueling of the engine is required in order to dump increased fuel into the after-treatment to increase soot oxidation. With the Smart Muffler™ there is no costly servicing of traps & filters, (estimated to be 2-3 cents per liter or 5% of fuel costs with PM traps on the market today).

Ethanol (E85)

What Is E85?

E85 is the term for motor fuel blends of 85 percent ethanol and just 15 percent gasoline. E85 is an alternative fuel as defined by the U.S. Department of Energy. E85 has the highest oxygen content of any transportation fuel available today, making it burn cleaner than gasoline. E85 also reduces greenhouse gas emissions such as carbon dioxide, the main contributor to global warming, as much as 39 to 46 percent compared to gasoline. This is of main concern of most municipal light- and medium-duty fleets throughout the United States.

In many ways ethanol could be considered an ideal transportation fuel. It's better for the environment than petroleum, it is domestically produced, and its use supports farmers and rural economies. Currently, a small amount of ethanol (10% by volume; E10*) is added to much of the gasoline we put in our vehicles in order to fulfill federal oxygenate requirements, add octane, and extend the petroleum fuel supply. E10 is a widely available vehicle fuel and is used for oxygenated fuel programs such as those in operation during the winter in Denver and Las Vegas, and in reformulated gasoline programs.

(Note: Alcohol fuel blends are designated by E for ethanol or M for methanol, followed by a number representing the percentage of alcohol (by volume) in the blend. The ethanol used in fuel blends is denatured ("poisoned" to prevent human consumption) and can contain up to 5% hydrocarbons (gasoline or gasoline-like additives) before blending. Additional gasoline is added to the ethanol to make up the desired percentage in the blend. The fuel E85, commonly called fuel ethanol, is made of 85% denatured ethanol blended with 15 % gasoline; and E100 is 100% denatured ethanol.)

Automakers have developed vehicles called flexible fuel vehicles (FFVs) that can operate on almost any blend of ethanol and gasoline. Ethanol FFVs are similar to gasoline vehicles and their true strength lies in their ability to empower fleets with the option of progressively building up their FFV fleet without having to immediately install E85 infrastructure. Infrastructure can be installed after a minimum threshold inventory has been reached. Although FFVs can operate on E85 or straight gasoline, to avoid drivability harshness as the system recognizes the new fuel, it is recommended to:

- ✓ Switch between fuels when the fuel gauge is above ¼ full
- ✓ Always add more than five gallons of the new fuel type at each fill-up
- ✓ Operate the vehicle for five minutes immediately after refueling

2010 FFV Availability:

Make	Model	Engine
Dodge	Dakota	4.7L V6
Dodge	Ram 1500	4.7L V6
Dodge	Grand Caravan	3.3L V6
Dodge	Avenger	2.7L V6
Chrysler	Seabring Convertible	2.7L V6
Chrysler	Seabring Sedan	2.7L V6
Chrysler	Town & Country	3.3L V6
Ford	Crown Victoria (incl. Taxi & Police)	4.6L V8
Ford	Fusion	3.0L V6
Ford	Escape	3.0L V6
Ford	Expedition/Expedition EL	5.4L 3V V8
Ford	F-150	5.4L 3V V8
Ford	E-Series Commercial Van	4.6L & 5.4L V8
Lincoln	Navigator/Navigator L	5.4L 3V V8
Lincoln	Town Car	4.6L V8
Mercury	Milan	3.0L V6
Mercury	Gran Marquis	4.6L V8
Mercury	Mariner	3.0L V6
Buick	Lucerne	3.9L V6
Chevrolet	Tahoe/Tahoe Police Pkg.	5.3L & 6.2L V8
Chevrolet	HHR	2.2L & 2.4L 4-cylinder
Chevrolet	Malibu	2.4L 4-cylinder & 3.5L V6
Chevrolet	Avalanche & Silverado	4.8L V8
Chevrolet	Express Van	4.8L V8/5.3L V8/6.0L V8
Chevrolet	Impala/Impala Police Pkg.	3.5L & 3.9L V6
Chevrolet	Suburban	5.3L V8
GMC	Yukon/Yukon Denali	5.3L & 6.2L V8
GMC	Sierra/Sierra Denali	4.8L V8/5.3L & 6.2L V8
Cadillac	Escalade/Escalade ESV & EXT	6.2L V8
Nissan	Armada	5.6L V8
Nissan	Titan	5.6L V8
Mercedez Benz	C300 (luxury & sport sedan)	3.0L V6
Toyota	Sequoia	5.7L V8
Toyota	Tundra	5.7L V8

What About Cost?

Currently E85 is undergoing a tremendous growth in popularity across the United States. Oil refineries are buying it in bulk to replace the toxic gasoline additive MTBE (methyl tertiary-butyl ether). MTBE has been used in U.S. gasoline at low levels since 1979 to replace lead as an octane enhancer (helps prevent the engine from "knocking"). Since 1992, MTBE has been used at higher concentrations in some gasoline to fulfill the oxygenate requirements set by Congress in the 1990 Clean Air Act Amendments. Oxygen helps gasoline burn more completely, reducing harmful tailpipe emissions from motor vehicles.

In the past, most refiners chose to use MTBE over other oxygenates primarily for economic reasons. It is cheap but has been shown to cause cancer. So, although MTBE is not officially banned in all 50 states, oil companies are switching to ethanol to avoid possible lawsuits. Typically, E85 is priced to be $0.30 - $0.40 below 87-octane gasoline. E85 has a higher octane (104), but lower energy content per unit of volume. Consequently, E85 fuel economy is less than 87-octane gasoline, and vehicles operating on E85 may experience slightly reduced range. The lower price of E85 and improved engine technology easily make up for any fuel economy discrepancy between FFVs and vehicles running on 100% gasoline. As cellulosic ethanol production becomes more commonplace, the price of E85 will drop even further. There are currently more than twenty (20) cellulosic ethanol plants under construction in the U.S.

Besides its superior performance characteristics, ethanol burns cleaner than gasoline; it is a completely renewable, domestic, environmentally friendly fuel that enhances the nation's economy and energy security. Government tests have shown that E85 vehicles reduce harmful hydrocarbon and benzene emissions when compared to vehicles running on gasoline. E85 vehicles also reduce carbon dioxide (CO_2), a harmful greenhouse gas (GHG) and a major contributor to global warming. GHG reductions using corn-based E85 range from 18-29%. E85 produced by cellulosic material yields GHG reductions of up to 86%. Ethanol also degrades quickly in water and, therefore, poses much less risk to the environment than an oil or gasoline spill.

Infrastructure

New E85 refueling infrastructure will be required in order for fleets to take advantage of this fuel. Owning its own refueling infrastructure and blending E85 on site via blending dispenser(s) will empower a fleet to take advantage of the federal tax credit of $0.435 per gallon ($0.51 x 85%) dispensed (minus any applicable federal excise tax). A less expensive way to acquire immediate E85 fueling would be to incorporate a 10,000 gallon, skid-mounted fueling system. This system would require the city provide only a concrete slab, power and Internet access and would cost approximately $85,000.

E85 Emissions

Pollutant	Fuel Only	w/Add-On Technologies
Particulate Matter (PM)	20% reduction	- N/A -
Hydrocarbons (HC)	5% reduction	- N/A -
Carbon Monoxide (CO)	17% reduction	- N/A -
Carbon Dioxide (CO_2)	40% reduction	- N/A -
Nitrogen Oxides (NOx)	10% reduction	- N/A -

(Source: U.S. EPA Fact Sheet EPA420-F-00-035, Clean Air Fleets - 2007)

Note: According to studies by Argonne National Laboratory, use of cellulosic-produced E85 would achieve an 86% reduction in greenhouse gas emissions, a 70% reduction in petroleum use and a 70-79% reduction in fossil energy use.

Biodiesel (B20)

What Is Biodiesel?

Biodiesel is a clean-burning fuel containing no sulfur or aromatic compounds. It is produced from a number of renewable sources including soybean oil, rapeseed oil, and animal fats. These sources can be obtained from agricultural feedstocks or by recycling used oil, such as cooking grease. The most common form of biodiesel found in the United States is derived from soybean oil.

Biodiesel can be used in its pure form, B100 ("neat biodiesel"), or blended with conventional diesel and/or ULSD. The most common blend is B20, which contains 20 percent biodiesel blended with 80 percent petroleum diesel. The major advantage of B20 when compared to other alternative fuels is that it can be used in any diesel engine with little or no modification to the engine or fuel system.

Most Original Engine Manufacturers (OEM) have issued statements that support the use of biodiesel in a 5% concentration (B5). When biodiesel fuels are used in older vehicles the condition of seals, hoses, gaskets, and wire coatings should be monitored regularly. According to the National Biodiesel Board's experience, there is no impact on these components when using a B5 blend or lower. OEMs are switching to components suitable for use with ULSD and biodiesel fuel combination.

Environmental Advantages of Biodiesel (B100)

- ✓ Does not contain aromatics or sulfur
- ✓ Naturally high cetane levels (above TxLED standard)
- ✓ Reduces hydrocarbon emissions by 20%
- ✓ Reduces hazardous air pollutants (HAPs), PM & VOCs
- ✓ Biodiesel production & use acts as a "Carbon Sink" which reduces the "Greenhouse Effect" by absorbing more carbon dioxide than is emitted (3.2 energy units generated per 1 used)
- ✓ Up to 40% improved efficiency relative to gasoline equivalents
- ✓ NOx neutral according to recent studies (B20)

The benefits of B20 include enhanced lubricity, fuel system cleaning properties, and environmental benefits. Changes in diesel fuel, primarily the reduction of sulfur and aromatic levels (ULSD and TxLED), and the process used to reduce these pollutants have reduced the lubricity of diesel fuel. However, the addition of biodiesel, even in smaller quantities than B20, increases fuel lubricity. This increased lubricity can increase the life of heavy-duty engines. In addition to enhanced lubricity, biodiesel acts as a solvent and cleans engine systems. This can cause fuel filter clogs when biodiesel is first introduced so fuel filters should be monitored closely during the first six months of use.

Potential drawbacks with biodiesel use include cost, cold flow properties, fuel economy, and shelf life. The average cost to add a percentage point of biodiesel to conventional diesel is $0.01. Therefore, the additional cost to add up to 20 percent biodiesel, B20, to conventional diesel fuel can run as high as $0.20. Also, in the state of Texas biodiesel blends of 20% or higher must also use a NOx reduction additive from Oryxe. This can add up to an additional $0.04 per gallon to the cost of biodiesel.

Another potential drawback of B20 is its cold flow property. This cold flow problem arises when diesel fuel, including both biodiesel and petroleum diesel fuels, are used in very cold temperatures. According to the United States Department of Agriculture, the cold filter plugging point of B20 is approximately 7 degrees warmer than with conventional diesel. However, this small increase in the temperature at which B20 starts to freeze compared to conventional diesel does not present problems for most Texas users.

As is the case with all other alternative fuels, conventional diesel contains more energy content, and therefore provides higher fuel economy than biodiesel. According to the U.S. EPA, plant-based B20 contains more energy content than animal-based B20. This energy content has a direct relation on fuel economy with plant-based biodiesel providing better fuel economy than animal-based biodiesel. The U.S. EPA estimates that the fuel economy penalty for B20 is between 1.6% (plant-based biodiesel) - 2.15% (animal-based biodiesel). However, B20 has a higher cetane number than conventional diesel, which increases the engine's performance to balance some of the energy loss.

A final potential issue with B20 is shelf life. The current industry standard is that biodiesel should be used within six months. Most fuel is used long before six months so this should not present a problem unless an operator is storing fuel for a long period of time.

Does Biodiesel Increase NOx?

No other alternative fuel has experienced such a wealth of misinformation and mistaken emission testing as has biodiesel. In 2002, the U.S. EPA issued *A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions, Draft Technical Report*. In it, the EPA stated that B20 could raise NOx emissions by as much as 2% and B100 could raise NOx emissions by as much as 10%. This has made biodiesel an unacceptable alternative to diesel fuel in areas that were in NOx non-attainment. However, this report was based solely on the review of literature and contained no actual laboratory or field testing.

Studies by the U.S. DOE/NREL, Texas A&M University, and North Carolina State University and the Department of Transportation refute this claim. It is important to note that, unlike the 2002 EPA report, all three studies incorporated real-world, on-road data.

Study Findings:

- 2005 - North Carolina State/US DOT study concludes that B20 *reduces* NOx by an average of 10% (using Portable Emission Monitors [PEMs]).
- 2006 - Navy PEMs study concludes biodiesel is NOx neutral & supports B20 roll-out in Navy vehicles.
- September 2006 – Texas A&M (CAPCOG-funded) School Bus Study finds NOx neutrality from B20 blends (the only study to ever directly compare ULSD to blend of ULSD and biodiesel) (TCEQ additive tests are not direct)
- October 2006 – DOE/NREL Study just released is the most comprehensive documentation of NOx emissions from biodiesel ever developed to date:
    - *"Based on newer data for more than 43 different engines, we conclude that B20 derived from soy-biodiesel has, on average, no impact on emissions of NOx"* TCEQ ruled the studies were "inconclusive" and "contradictory".

Biodiesel Emissions

Pollutant	Fuel Only	w/Add-On Technologies
Particulate Matter (PM)	10% reduction	20% - 80%
Hydrocarbons (HC)	20% reduction	75% - 90%
Carbon Monoxide (CO)	16% reduction	75% - 90%
Nitrogen Oxides (NOx)	± 2% reduction	15% - 20%

(Source: U.S. EPA, CARB, Clean Air Fleets - 2007)

Do Biofuels Harm Agricultural Supplies and Prices?

The great promise behind alternative fuels like ethanol and biodiesel is that they are renewable. In other words, they offer the United States the option of growing our fuel instead of importing it. Efforts to substitute alternative fuels for petroleum are gaining attention in a world threatened by climate change, rural economic decline, and instability in major oil-producing countries. Biofuel crops take in carbon dioxide from the atmosphere while they are growing, offsetting the greenhouse gases released when the fuel is subsequently burned. Replacing petroleum with biofuel can reduce air pollution, including emissions of fine particulates and carbon monoxide. Biofuel production also can improve rural economies by creating new jobs and raising farm incomes. As a locally produced, renewable fuel, ethanol and biodiesel have the potential to diversify energy portfolios, lower dependence on foreign oil, and improve trade balances in oil-importing nations.

Although ethanol's popularity is growing, today's inefficient production methods and conversion technologies mean that this fuel will only produce modest, short-term environmental and economic benefits. The largest obstacle to biofuel production is land availability. Expanding cropland for energy production will likely worsen the already intense competition for land between agriculture, forests, and urban sprawl. With temperatures rising and water tables falling worldwide, global food supply and demand are precariously balanced.

Placing greater emphasis on land efficiency – that is, maximizing energy yield per acre – will be essential to making the best use of biofuels. Though corn has broad political support as an ethanol feedstock in the United States, it is one of the least efficient sources of ethanol. For example, ethanol yields per acre for French sugar beets and Brazilian sugarcane are roughly double those for American corn. And even though only 1/6 of the nation's corn crop in 2007 was used for fuel production, for biofuels to become a major part of the world fuel supply, their primary source will not be grains or even sugar crops. It will be more abundant and land-efficient cellulosic feedstocks, such as agricultural and forest residues, grasses, and fast-growing trees. Promising new technologies are already being developed that use enzymes to break down cellulose and release the plants' sugars for fermentation into ethanol. A demonstration plant using this technology opened in Canada last year, and large-scale production is expected to be commercially viable by 2015.

Agricultural residues, such as corn stalks, wheat straw, and rice stalks, are normally left on the field, plowed under, or burned. Collecting just a third of these for biofuel production would allow farmers to reap a sort of second harvest, increasing farm income while leaving enough organic matter to maintain soil health and prevent erosion. The agricultural residues that could be harvested sustainably in the United States today, for example, could yield 14.5 billion gallons of ethanol—four times the current output—with no additional land demands.

"Energy crops," such as hardy grasses and fast-growing trees, have higher ethanol yields and better energy balances than conventional starch crops. One likely candidate is Switchgrass, a tall perennial grass used by farmers to protect land from erosion. It requires minimal irrigation, fertilizer, or herbicides but yields 2-3 times more ethanol per acre than corn does. Such crops could potentially be harvested on marginal land, avoiding the conversion of healthy cropland or forests to energy-crop production. One of the most recent developments in harvesting biofuel feed stocks is acquiring biodiesel oil and ethanol cellulosic material from algae. The Office of Fuels Development, a division of the Department of Energy, funded a program from 1978 through 1996 under the National Renewable Energy Laboratory (NREL) known as the "*Aquatic Species Program*". The focus of this program was to investigate different species of high-oil algae that could be grown specifically for the purpose of wide scale biodiesel production. The research began as a project looking into using quick-growing algae to sequester carbon in CO_2 emissions from coal power plants. Noticing that some algae have very high oil content, the project shifted its focus to growing algae for another purpose - producing biodiesel. Some species of algae are ideally suited to biodiesel production due to their high oil content (some well over 50% oil), and extremely fast growth rates. Once the algae has been harvested, dried and had its oil extracted, it can then be used as a wonderful source of cellulosic feedstock for ethanol production.

Increasing the role of ethanol and biodiesel in meeting fuel demand will require ongoing research and development to improve biomass conversion technologies, along with consistent legislative support for biofuel production and greater fuel efficiency in the automotive industry. Shifting government energy subsidies, such as from oil exploration to biofuel development, is a clear choice as new oil fields prove increasingly elusive. With improved vehicle fuel economy and the use of more-efficient cellulosic feed stocks, biofuel has the potential to supply a substantial share of the world's automotive fuel without negatively impacting agriculture supply and/or pricing.

Liquefied Propane Gas (LPG)

Liquefied Petroleum Gas (LPG) has been used as a transportation fuel since the 1940s. According to the Gas Processors Association HD5 specification for LPG as a transportation fuel, LPG must consist of 90% propane, no more than 5% propylene, and 5% other, which is primarily butane and butylene. It is produced as a by-product of natural gas processing and petroleum refining. The components of LPG are gases at normal temperatures and pressures. Most vehicles that use this fuel are dual-use vehicles in that they can switch between gasoline or propane fuel. The benefits of propane-fueled vehicles include cost and emissions reductions. The cost of propane, depending on market factors, is usually less than gasoline. Depending upon vehicle calibration, propane can provide significant carbon monoxide and hydrocarbon emissions reductions.

Propane vehicles can produce fewer ozone-forming emissions than vehicles powered by reformulated gasoline. In addition, tests on light-duty, bi-fuel vehicles have demonstrated a 98% reduction in the emissions of toxics, including benzene, butadiene, formaldehyde, and acetaldehyde, when the vehicles were running on propane rather than gasoline. Approximately 85% of all propane used in this country comes from domestic sources, so driving a propane vehicle can dramatically help reduce U.S. dependence on imported oil and strengthen national energy security.

<u>What About Cost?</u>

Currently, the cost of a gallon of LPG to a municipal fleet is averaging around $1.40 per GGE. So, driving a propane vehicle can save the city a considerable amount of money. In addition, propane is the most accessible of all alternative fuels. In the United States approximately 3,000 publicly accessible facilities offer propane.

The primary drawbacks with propane vehicles are the cost of the vehicle, slightly reduced fuel economy and lack of significant presence in heavy-duty configurations. But, with increasing additions to both light- and medium-duty vehicle configurations, this deterrent is steadily decreasing. Overall, the cost of LPG-fueled vehicles is $3,000 to $5,000 higher than light duty gasoline-fueled vehicles with medium duty vehicle conversions averaging $12,000 more than standard gasoline-fueled vehicles. Additionally, these vehicles get slightly reduced fuel economy compared to gasoline-powered vehicles. However, LPG does qualify for the $0.50 per gallon federal credit (minus any applicable federal excise tax).

2010 LPG Vehicle/Engine Availability:

Make	Model	Engine
Roush Ford	F250	5.4L V8
Roush Ford	F350	5.4L V8
BlueBird	*Vision School Bus	8.1L
GM (CFUSA)	*C4500 – C8500	8.1L
GM (CFUSA)	*G4500 (cut van chassis)	6.0L
GM (CFUSA)	*Workhorse (W42 chassis)	6.0L
GM (CFUSA)	*G3500 (cut van chassis)	6.0L
GM (CFUSA)	*C2500/3500 (cab chassis)	6.0L

Note: Vehicle uses the patented LPI System from CleanFUEL USA. The LPI system utilizes patented Icom JTG Technology manufactured by Icom North America. Benefits of the CleanFUEL/Icom system include:

- *Fully integrated, dedicated engine system designed in complete harmony with the gasoline engine,*
- *Engineered to maximize the design benefits of the gasoline engine and utilizes the OEM engine computer, specifically calibrated for propane. This allows for optimal fuel economy, performance and low emissions, while leaving the OEM-developed diagnostics intact.*

Propane Emissions

Pollutant	Fuel Only	w/Add-On Technologies
Particulate Matter (PM)	80% reduction	- N/A -
Hydrocarbons (HC)	18% reduction	- N/A -
Carbon Monoxide (CO)	60% reduction	- N/A -
Nitrogen Oxides (NOx)	20% reduction	- N/A -

(Source: U.S. EPA, CARB, Clean Air Fleets - 2007)

Natural Gas (CNG/LNG)

Natural gas is mostly methane (about 95 percent). The other 5 percent is made up of various gases along with small amounts of water vapor. These other gases include butane, propane, ethane and other trace gases. Methane is a hydrocarbon, meaning its molecules are made up of hydrogen and carbon atoms.

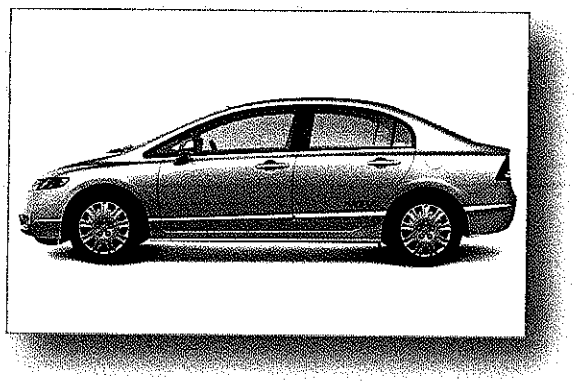
Natural gas is one of the most common forms of energy used today. Compressed natural gas (CNG) is used in thousands of vehicles worldwide primarily due to its lower cost and the fact it generates fewer exhaust and greenhouse gas emissions than gasoline- or diesel-powered vehicles.

Overall, the benefits of using CNG include lower fuel costs, increased performance, and dramatic emissions reductions. The cost for one gallon of CNG runs between 30% – 40% less than gasoline or diesel fuel. In conjunction with the increased performance experienced by CNG vehicles, operators get a longer lasting, lower operating cost vehicle. In on-road, heavy-duty trucks, refuse vehicles and transit buses, CNG is the most prominent and widely used alternative to conventional diesel fuel.

Widespread acceptability of CNG fell short in the light-duty sector because of a serious lack of public accessible refueling infrastructure. This was because refueling stations average $1,500,000 to $2,000,000+ to construct. This made wide-spread construction of CNG stations economically prohibitive for private CNG suppliers.

This situation, in turn, spurred a modern-day "Catch22" scenario where there weren't enough CNG fueling stations because there weren't enough light-duty CNG vehicles because there weren't enough CNG fueling stations. This frustrating scenario prompted all light-duty auto manufacturers except Honda (Civic GX) to get out of the CNG business. Regrettably, some end-users have taken this action as a sign that CNG is not a viable alternative fuel. There could be nothing further from the truth.

The Honda Civic GX has been consistently recognized by the U.S. Environmental Protection Agency as the cleanest light-duty, internal-combustion vehicles available. The California Air Resources Board (CARB) gave the GX an AT-PZEV (Advanced Technology Partial Zero- Emission Vehicle) emissions rating.



***2010 Honda Civic GX Emissions*:**

- NOx – 0.02 g/mile
- CO – 2.1 g/mile
- PM – 0.01 g/mile

*** Estimated 24 mpg city / 36 hwy**

OEM Natural Gas Engines:

At this time, the only commercially viable fuel options for heavy duty applications are diesel, TxLED, biodiesel and natural gas. Of these choices, natural gas is the only fuel that cannot run in a diesel engine and so natural gas engines are the only true alternatives to be discussed in this portion of the report.

As per EPA and CARB certifications, there is no cleaner commercially viable fuel for heavy-duty applications than natural gas. Many experts believe that the only engines that will be able to meet the stringent 2010 standard of 0.2 g/bhp-hr are natural gas engines. Cummins Westport has been the leader in clean engine development with their current and future NG heavy duty engines.

Cummins/Westport NG Engine Options:

Engine	Model	Rated Power (kW)	Peak Torque (lb-ft)	EPA Emission Std.
CW ISL-G	**320**	**239 @ 2,000 RPM**	**1,356 @ 1,300 RPM**	**0.2 g/bhp-hr NOx**
CW ISL	**300**	**224 @ 2,100 RPM**	**1,166 @ 1,300 RPM**	**0.2 g/bhp-hr NOx**
CW ISL	**280**	**209 @ 2,000 RPM**	**1,220 @ 1,300 RPM**	**0.2 g/bhp-hr NOx**
CW ISL	**260**	**194 @ 2,200 RPM**	**895 @ 1,300 RPM**	**0.2 g/bhp-hr NOx**
CW ISL	**250**	**186 @ 2,200 RPM**	**990 @ 1,300 RPM**	**0.2 g/bhp-hr NOx**

Engine Maintenance Intervals:

- Oil & Filters – 7,500 miles / 500 hours / 6 months
- Fuel Filter – 15,000 miles / 1,000 hours / 12 months
- Coolant Filter – 7,500 miles / 500 hours / 6 months
- Spark Plugs – 22,500 miles / 1,500 hours / 18 months
- Change Coolant – 30,000 miles / 2,000 hours / 24 months
- Valve Adjustment – 30,000 miles / 2,000 hours / 24 months

Infrastructure & Service Enhancements:

CNG infrastructure is expensive. For example, a station that contains a fast-fill dispenser with two hoses, adequate storage and 12 – 16 time-fill posts will cost in the neighborhood of $1,750,000 to 2,000,000. However, this cost can quickly be recovered by building up the number of CNG heavy, heavy-duty trucks and buses and taking full advantage of the cheaper fuel (over $1.00 per gallon less than diesel), all applicable grants and federal rebates/incentives.

There will also be some cost involved in upgrading the city's service center with the necessary detection, ventilation and safety measures. This can run anywhere between and $100,000 to $750,000 and is solely dependent on the local Fire Marshal and Plano's accepted safety requirements.

Natural Gas OEM Heavy-Duty Replacement Engine Option:

There is one EPA and CARB certified replacement engine option available in the market today. This is the Phoenix engine from Emission Solutions, Inc. (ESI). The ESI Phoenix NG 7.6L is a dedicated natural gas OEM engine that utilizes a very reliable and popular diesel engine as its base platform (**Detroit Diesel – DT466 and DT466E**). ESI manufactures and re-designs the older diesel engine utilizing patented technology, cryogenically treated components, an Electronic Control Unit (ECU) and a fly-by-wire electronic throttle body for improved performance and durability. The ECU provides ignition, fuel control and employs "look-ahead" adaptive learn technology to optimize engine performance across the full spectrum of load conditions. The engine with CNG storage cost around $65,000.

Phoenix NG 7.6L Specifications:

- ✓ 175 – 265 hp
- ✓ 460 – 280 lb-ft torque
- ✓ Four cycle, In-Line six
- ✓ 2-year parts and labor warranty

For the same reasons that natural gas suffered in the light-duty market, it is flourishing in the heavy-duty sector. These large trucks and buses use enough CNG/LNG to make it economically feasible to build convenient, on-site infrastructure. There are also some powerful federal tax incentives and rebates for fuel use, new equipment purchases and infrastructure support. (*Note: More information on these two programs is provided in the "Federal Incentives for the Use of Alternative Fuels" section of this report*).

All heavy-duty engines must now meet the federal emission standard of 0.2 g/bhp-hr NOx. This law has forced diesel engine manufacturers to aggressively change the standard configurations of their engines as well as form alliances with add-on technologies that enable these large engines to fall into compliance with the stringent regulation. In most cases, the combination of revamped engine technology and add-on emission control devices like *Particulate Traps* (PTs), *Exhaust Gas Re-circulators* (EGRs), and *Selective Catalytic Reducers* (SCRs) will enable fleets to meet the 2007 standard. But in less than two (2) years this criterion will be lowered to 0.2 g/bhp-hr NOx. Diesel engines are struggling to meet this lower standard, no matter what add-on technology is used.

So, decisions must be made today that will do more than bring a fleet closer to U.S. EPA compliance. Fleet-appropriate alternative fuels and technologies must be chosen that are sound and have clearly defined roadmaps for the future. The companies behind them must be financially sound and have a proven track record of product development success.

Natural Gas OEM Light-Duty Up-Fit Technologies:

Although there is a small variety of up-fit CNG technologies available to fleets, their cost often make them difficult to justify inclusion into any clean-fleet initiative. However, in the right circumstances they do make sense. So, those products that have been EPA/CARB verified are listed below:

- **BAF Technologies, Inc.** – BAF is a small volume manufacturer of vehicles that operate on Compressed Natural Gas (CNG). They work with fleet managers and dealers to convert new vehicles to run on CNG. This conversion work can be done at their headquarters in Dallas, Texas or at one of its partner facilities nationwide. All of the engine families BAF converts have been approved by the California Air Resources Board (CARB) and/or the Environmental Protection Agency (U.S. EPA). This is a crucial difference in their systems and converted vehicles over other "kits" which in the market that do not meet state and federal legal requirements. BAF' line of CNG conversions cover the following platforms
  - ✓ **Ford Crown Victoria/Lincoln Town Car**
  - ✓ **Ford F-150/F-250/F-350 pickups**
  - ✓ **Ford E-350 van**
  - ✓ **Ford E-450 shuttle**

- **Clean Fuel CNG Conversions** – Clean Fuel converts and uplifts fleet and personal vehicles to operate on Compressed Natural Gas (CNG) instead of gasoline. Their specialty is sedans and light-duty pickup trucks and vans. Based in Austin, Texas, they are licensed by the Texas Railroad Commission and the Oklahoma DCS Alternative Fuels Division to install and maintain automotive CNG fuel systems. Their technicians are ASE Certified for CNG vehicles and we also have a CSA certified CNG Fuel System Inspector on staff and can provide the required 36 month inspections. Their dedicated CNG platforms are below:

Dedicated CNG Platforms:

Model Year	Make / Model	Engine	Engine Family	Fuel Capacity	Availability	Conversion Price
2008	Ford Focus	2.0L	8FMXV02.0VD4	9.1 GGE	Now	$9,900
2008	Ford Focus	2.0L	8FMXV02.0VD4	6.7 GGE	Now	$9,400
2009	Ford Focus	2.0L	9FMXV02.0VD4	9.1 GGE	Now	$9,900
2009	Ford Focus	2.0L	9FMXV02.0VD4	6.7 GGE	Now	$9,400
2010	Ford Focus	2.0L	TBD	9.1 GGE	4th Qtr 2009	$9,900
2010	Ford Focus	2.0L	TBD	6.7 GGE	4th Qtr 2009	$9,400
2008	Ford Fusion / Mercury Milan	2.3L	8FMXV02.3VEX	9.1 GGE	Now	$10,400
2009	Ford Fusion / Mercury Milan	2.3L	9FMXV02.3VEX	9.1 GGE	Now	$10,400
2010	Ford Fusion / Mercury Milan	2.5L	TBD	9.1 GGE	4th Qtr 2009	$10,400
2008	Chevrolet Impala	3.5L / 3.9L	8GMXV03.9052	10.4 GGE	Now	$12,300
2008	Chevrolet Impala	3.5L / 3.9L	8GMXV03.9052	13 GGE	Now	$13,300
2009	Chevrolet Impala	3.5L / 3.9L	9GMXV03.9052	10.4 GGE	Now	$12,300
2009	Chevrolet Impala	3.5L / 3.9L	9GMXV03.9052	13 GGE	Now	$13,300
2010	Ford Transit Connect	2.0L	9FMXV02.0VD4	12.6 GGE	4th Qtr 2009	$12,400
2008	Hummer H3 / H3T	5.3L	8GMXT05.3377	21 GGE	Now	$13,800
2009	Ford F-150	4.6L 3V	TBD	12.6 GGE	1st Qtr 2010	$11,800
2009	Ford F-150	4.6L 3V	TBD	21.2 GGE	1st Qtr 2010	$12,800
2010	Ford F-150	4.6L 3V	TBD	12.6 GGE	1st Qtr 2010	$11,800
2010	Ford F-150	4.6L 3V	TBD	21.2 GGE	1st Qtr 2010	$12,800
2008	Chevrolet Silverado / Avalanche	5.3L	8GMXT05.3381	12.6 GGE	Now	$9,900
2008	Chevrolet Silverado / Avalanche	5.3L	8GMXT05.3381	21.2 GGE	Now	$11,500
2008	GMC Sierra	5.3L	8GMXT05.3381	21.2 GGE	Now	$11,500
2008	Chevrolet Tahoe / Suburban	5.3L	8GMXT05.3381	16 GGE *	Now	$11,500
2008	GMC Yukon	5.3L	8GMXT05.3381	16 GGE *	Now	$11,500
2009	Chevrolet Silverado / Avalanche	5.3L	9GMXT05.3373	12.6 GGE	Now	$9,900
2009	Chevrolet Silverado / Avalanche	5.3L	9GMXT05.3373	21.2 GGE	Now	$11,500
2009	GMC Sierra	5.3L	9GMXT05.3373	12.6 GGE	Now	$9,900
2009	Chevrolet Tahoe / Suburban	5.3L	9GMXT05.3373	16 GGE *	Now	$11,500
2009	GMC Yukon	5.3L	9GMXT05.3373	16 GGE *	Now	$11,500
2009	Chevy Silverado / GMC Sierra	6.0L	9GMXK06.0396	12.6 GGE	Now	$9,900
2009	Chevrolet Express / G Van	6.0L	9GMXK06.0396	16 GGE *	Now	$11,500
2009	GMC Savana	6.0L	9GMXK06.0396	16 GGE *	Now	$11,500
2010	Ford F-250, F-350	5.4L	TBD	12.6 GGE	Depends on demand	$11,800
2010	Ford F-250, F-350	5.4L	TBD	21.2 GGE	Depends on demand	$12,800

Natural Gas Emissions

Pollutant	Fuel Only	w/Add-On Technologies
Particulate Matter (PM)	67% - 94% reduction	90+% reduction
Hydrocarbons (HC)	50% - 75%% reduction	90+% reduction
Carbon Monoxide (CO)	90% reduction	90% reduction
Carbon Dioxide (CO_2)	24% reduction	90% reduction
Nitrogen Oxides (NOx)	35% - 60% reduction	57% - 90% reduction

(Source: U.S. EPA, CARB, Clean Air Fleets - 2007)

Hydrogen

In his 2003 State of the Union address, President Bush announced a $1.2 billion hydrogen fuel initiative to reverse America's growing dependence on foreign oil by developing the technology for commercially viable hydrogen-powered fuel cells to power cars, trucks, homes and businesses with no pollution or greenhouse gases. The hydrogen fuel initiative included $720 million in new funding over five years to develop the technologies and infrastructure to produce, store, and distribute hydrogen for use in fuel cell vehicles and electricity generation. Combined with the FreedomCAR (Cooperative Automotive Research) initiative, $1.7 billion was set aside to assist in the development of hydrogen-powered fuel cells, hydrogen infrastructure and advanced automotive technologies. Unfortunately, there are still many problems that need to be overcome before hydrogen can be seriously considered as a viable alternative fuel.

The first, and most obvious, is that hydrogen gas is extremely explosive. To make matters worse, it has a very low energy density so massive amounts of Hydrogen must be used. Therefore, Hydrogen gas has to be compressed down to 10,000 psi and stored in tanks that are constructed of rust-proof materials to prevent long-term tank degradation and potentially fatal leaks.

Diesel fuel has an energy density of 1,058 kBtu/cu.ft. Biodiesel has an energy density of 950 kBtu/cu.ft, and hydrogen stored at 3,626 psi (250 times atmospheric pressure) only has an energy density of 68 kBtu/cu.ft. So, pressurized to 250 atmospheres, hydrogen's volumetric energy density is only 6.4% that of diesel. This means that with similar efficiencies of converting that stored chemical energy into motion (as diesel engines and fuel cells have), a hydrogen vehicle would need a fuel tank more than 15 times as large as conventional diesel storage to yield the same driving range as a diesel powered vehicle. Dedicating that much space to fuel storage would drastically reduce how much cargo trucks could carry. Additionally, the cost of the high pressure, corrosion resistant storage tanks to carry that much fuel is still astronomical. To help address this problem, again, hydrogen would need to be stored at 10,000 psi but developing the technology needed to safely support any gas stored at this incredibly high pressure is in itself cost prohibitive. To make matters worse, hydrogen is a colorless, odorless gas that burns clear.

So, the safety issues alone make hydrogen a very risky and very expensive alternative to diesel and gasoline. There are two main options for producing hydrogen - generating it from water, and extracting it from other fuels. With each case, the energy efficiency is well below 100% (i.e. you have to put more energy into separating the hydrogen than the chemical energy the hydrogen itself has). Currently, most hydrogen used industrially is extracted from natural gas through steam reformation. Both of these processes are time consuming and very expensive. It is hoped that through partnerships with the private sector, the hydrogen fuel initiative and FreedomCAR will make it practical and cost-effective for large numbers of Americans to choose to use clean, hydrogen fuel cell vehicles by 2020.

Electricity

Gasoline/Electric Hybrids (LDV/LDT) – The strength behind Hybrid vehicles is their capability to ***reduce*** fuel use. These vehicles still use gasoline as their primary fuel but by incorporating advanced engine technologies and the benefits of an on board electric motor, hybrid cars, SUVs and trucks can consume less gasoline (*note: some hybrid systems are primarily designed to increase power, not improve fuel efficiency*).

The key to a hybrid car is that the gasoline engine can be much smaller than the one in a conventional car and therefore more efficient. Most cars require a relatively big engine to produce enough power to accelerate the car quickly. In a small engine, however, the efficiency can be improved by using smaller, lighter parts, by reducing the number of cylinders and by operating the engine closer to its maximum load. There are several reasons why smaller engines are more efficient than bigger ones:

- The big engine is heavier than the small engine, so the car uses extra energy every time it accelerates or drives up a hill.
- The pistons and other internal components are heavier, requiring more energy each time they go up and down in the cylinder.
- The displacement of the cylinders is larger, so more fuel is required by each cylinder.
- Bigger engines usually have more cylinders, and each cylinder uses fuel every time the engine fires, even if the car isn't moving.

The gas engine on a conventional car is sized for the peak power requirement (those few times when the accelerator pedal is "floored"). In fact, most drivers use the peak power of their engines less than one percent of the time. The hybrid car uses a much smaller engine, one that is sized closer to the average power requirement than to the peak power.

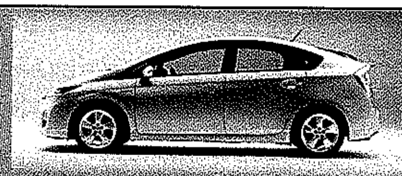
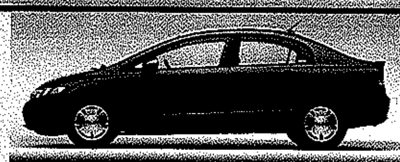
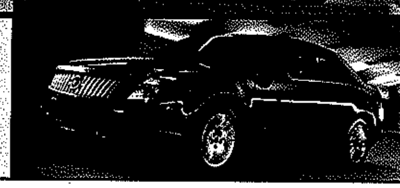
Besides a smaller, more efficient engine, today's hybrids use many other tactics to increase fuel efficiency. To draw every mile out of a gallon of gasoline, a hybrid car can:

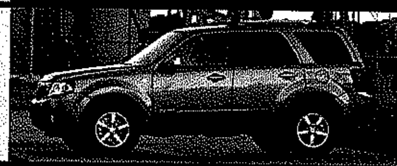
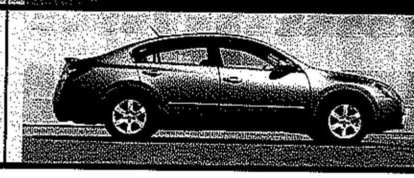
1. **Recover energy and store it in the battery** - Whenever you step on the brake pedal in your car, you are removing energy from the car. The faster a car is going, the more kinetic energy it has. The brakes of a car remove this energy and dissipate it in the form of heat. A hybrid car can capture some of this energy and store it in the battery to use later. It does this by using "regenerative braking." That is, instead of just using the brakes to stop the car, the electric motor that drives the hybrid can also slow the car. In this mode, the electric motor acts as a generator and charges the batteries while the car is slowing down.
2. **Sometimes shut off the engine** - A hybrid car does not need to rely on the gasoline engine all of the time because it has an alternate power source – the electric motor and batteries. So, the hybrid car can sometimes turn off the gasoline engine, for example when the vehicle is stopped at a red light.
3. **Use advanced aerodynamics to reduce drag** - When driving on the freeway, most of the work for an engine goes into pushing the car through the air. This force is known as aerodynamic drag. This drag force can be reduced by reducing the frontal area of the car. Reducing disturbances around objects that stick out from the car or eliminating them altogether can also help to improve the aerodynamics.

4. **Use low-rolling resistance tires** - The tires on most cars are optimized to give a smooth ride, minimize noise, and provide good traction in a variety of weather conditions. But they are rarely optimized for efficiency. In fact, the tires cause a surprising amount of drag while you are driving. Hybrid cars use special tires that are both stiffer and inflated to a higher pressure than conventional tires. The result is that they cause about half the drag of regular tires.

5. **Use lightweight materials** - Reducing the overall weight of a car is another way to increase the mileage. A lighter vehicle uses less energy each time you accelerate or drive up a hill. Composite materials like carbon fiber or lightweight metals like aluminum and magnesium can be used to reduce weight.

2010 Hybrid Electric Vehicles:

Make	Model	Picture	Cost	Est. MPG (city/hwy.)
Toyota	Prius		$22,400	51/48
Honda	Civic		$22,600	40/45
Honda	Insight		$19,800	40/43
Ford	Fusion		$27,300	41/36
Ford	Escape		$29,300	34/31
Mercury	Milan		$27,500	41/36

Mercury	Mariner		$29,800	34/30
Mazda	Tribute		$29,900	34/30
Chevrolet	Malibu		$22,800	34/26
Chevrolet	Tahoe		$50,500	21/22
Chevrolet	Silverado (pickup)		$39,000	21/22
Nissan	Altima		$26,800	35/33

**(Source: http://www.hybridcars.com. Cars listed are those that are ready for purchase at the time of this report.)*

Three areas of concern with gasoline/electric hybrids are that: 1) they rely on gasoline as their main source of fuel and, 2) there is a significant price differential between them and regular gasoline and/or flex fuel vehicles and, 3) the safe disposal of their used or defective batteries. It is important to calculate fuel savings for the estimated miles the car will travel over its city-determined lifecycle to ensure the price increase over conventional gasoline and flex fuel vehicles can be compensated through fuel savings. Another consideration is that their batteries do not have a limitless life, creating the need to replace them. However, most do last throughout the warranty period with some manufacturers.

There are currently more than one million hybrid gas-electric vehicles on American roads. Some environmentalists are concerned about trading one problem for another. They worry that a hybrid utopia might turn into a toxic nightmare when the nickel metal hydride batteries being used in most of today's HEVs end up in landfills.

The need for more robust battery technologies to power vehicles and their accessories prompted *Environmental Defense* to conduct a three-month research effort in 2007 to examine environmental impacts related to the extraction, manufacture, use, and disposal of nickel metal hydride batteries, as well as lithium ion—which many consider to be the battery of choice in the next five years.

Environmental Defense then compared those impacts to lead acid. Their initial conclusion was that lead batteries are the worst, nickel is next, and lithium is the least harmful.

While not nearly as dangerous as lead, nickel is not without some environmental risks, and is considered a probable carcinogen. There are also concerns about the environmental impacts of nickel mining, and apparent challenges with fully recycling the nickel used in hybrid batteries. Toyota and Honda place decals with a toll-free number on their hybrid battery packs. Toyota offers a $200 bounty to ensure that every battery comes back to the company. In a press release, Toyota stated, "Every part of the battery, from the precious metals to the plastic, plates, steel case and the wiring, is recycled." Conversely, Honda arranges for the collection of the battery and then transfers it to a preferred recycler to follow their prescribed process: disassembling and sorting the materials; shredding the plastic material; recovering and processing the metal; and neutralizing the alkaline material before sending it to a landfill.

The entire auto industry is pumping millions of dollars into research regarding lithium ion (LiIon) batteries for tomorrow's cars. Their primary motivation is to reduce the cost and increase the potency of hybrid batteries. Fortunately, supplanting lead and nickel batteries with rechargeable lithium batteries is also promising from an environmental perspective.

<u>New Developments</u>

- **Stop/Start** – Stop/Start hybrids are not *true* hybrids since electricity from the battery is not used to propel the vehicle. However, the Stop/Start feature is an important, energy-saving building block used in hybrid vehicles. Stop/Start technology conserves energy by shutting off the gasoline engine when the vehicle is at rest, such as at a traffic light, and automatically re-starting it when the driver pushes the gas pedal to go forward.

  The gasoline engine in a Stop/Start hybrid is much like those in conventional vehicles. Unlike other hybrids that use an electric motor to help power the vehicle, the engine in a Stop/Start vehicle is usually not smaller in size. The battery in a Stop/Start hybrid is used to store energy generated from the gasoline engine or, during regenerative braking, from the electric motor. These batteries are only used to power the generator that starts the gasoline engine and to power accessories. The only car currently available to U.S. consumers that employs Start/Stop technology is the Chevrolet Malibu Hybrid.

- **Battery Lease Program** – The goal of a Battery Lease Program is to assuage consumer worries about getting stung with the high cost of replacing an electric car battery if it fails or loses too much capability over the course of years. In actuality this practice will effectively be splitting the car payment for an HEV or PHEV in two. As with all things concerning hybrids, the success or failure of this "new" idea will be largely dependent on the individual driving patterns and vehicle use of the owner. The money saved with using electricity will help offset what could be a $4,000 - $5,000 worth of battery lease payments. Currently, Nissan is the largest vehicle manufacturer considering using a battery lease program for its 2010 "Leaf" and hybrid "Altima".

Diesel/Electric Hybrids (HDT/HHDT) – Whereas hybrid electric vehicles can be (under the right circumstances) an acceptable, cost effective form of alternative transportation in the light-duty sector, for the majority of heavy-duty and/or heavy, heavy-duty applications the shear cost of the vehicle makes this impossible. As the price of ULSD and new diesel engines continues to rise it will become increasingly difficult to cost justify this technology.

The true benefit of any electric hybrid is its ability to reduce consumption of fossil fuels. The constant stop-and-start nature of route-based vehicles forces diesel engines to operate at their most inefficient range. Consequently, they burn more fuel and emit more toxins into the atmosphere than any other diesel vehicle. By reducing the amount of diesel fuel expended during the stop-and-start portion of a route-based vehicle, less fuel will be burned and fewer pollutants will be emitted.

To date, the most accepted use of diesel/electric hybrids has been in the transit industry within bus routes that incorporate stop-and-start driving. Energy is stored in a complex system of batteries and released upon initial startup to power an electric motor instead of the buses diesel engine. Though effective, this technology is, again, exorbitantly expensive and thus impractical for all but a very few heavy-duty applications.

Plug-In Hybrid Electric Vehicles (PHEV) – The majority of current plug-In electric vehicles are outfitted with battery packs sufficient to power the vehicles for 35 miles or more on battery power alone. The cars are recharged by plugging into a standard electrical outlet. The cost of an "electric" gallon of gas is estimated to be less than $1.00. This does shift the concern of emissions from the tailpipe to emissions from the power plant creating the electricity. This creates new issues such as determining if the power plant is in a non-attainment area, more specifically, in the area of use and secondly what is the feedstock for the power plant, coal, nuclear or natural gas.

There's been a lot of excitement lately about hybrid vehicles and whether they really deliver the kind of high fuel economy numbers touted by the vehicle manufacturers. EPA mileage estimates are determined under controlled conditions and obviously vary with driving style and traffic conditions. But another issue that has received less attention isn't fuel economy, it is the risk of being shocked or electrocuted while working on these vehicles or coming upon them after they have been in an accident.

<u>Electric Vehicle Concerns</u>

1. All hybrid-electric vehicles (HEVs & PHEVs) use high voltage batteries and electric motors to achieve their fuel economy gains. Their batteries packs quite a wallop, 144 volts on a Honda Insight or Civic, 201 volts on a second-generation Toyota *Prius* (which is bumped up to 500 volts by the power inverter at the electric motors), 275 volts on a first-generation Toyota *Prius* (2001-03), 288 volts on a Lexus RX400H and Toyota Highlander, and 330 volts on a Ford Escape Hybrid. **This is more than enough electricity to kill anyone who accidentally comes into contact with the high voltage battery, wiring or power train components.**

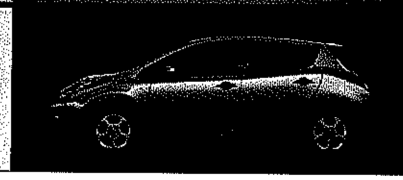
   High voltage direct current (DC) is especially dangerous because it typically causes continuous muscular contractions that prevent the victim from "letting go." This increases the likelihood of deep tissue burns, organ damage and death. Alternating current (AC), by comparison, is more like to cause heart fibrillations that may result in death. The threshold voltage where DC becomes dangerous can be as low as 55 to 60 volts, compared to 110 volts for AC. Ordinary 12 volt DC car batteries and electrical systems pose no danger.

2. Rechargeable batteries tend to die much faster if they are constantly discharged until empty. Factory hybrid systems use a conventional engine to charge the battery before it discharges too much, but PHEVs are specifically intended to run longer on battery power, and thus result in higher rates of battery failure. Research and development has improved battery technology and thus extended the driving range of some of these vehicles to near 100 miles per charge. This exciting breakthrough has lead to passenger vehicles.

3. HEV and PHEV batteries are extremely expensive. It will take high-volumes of HEV/PHEV sales before the price of batteries will begin to decrease.

4. Producing the extra power that would be needed should hybrids continue to grow in popularity will place additional burden on our nation's electric grids and, potentially, add to toxic air emissions (ex: coal powered grids).

2010 Plug-In Hybrid Electric Vehicles:

Make	Model	Picture	Cost	Est. Miles/Charge
Chevrolet	Volt		$40,000	40
Nissan	Leaf		$32,780	100

**(Source: http://www.hybridcars.com. Cars listed are those that are ready for purchase at the time of this report.)*

2011/2012 PHEV Introductions:

- GM Crossover
- Volvo V70
- Cadillac Converj
- Ford Escape
- Toyota Prius
- Mitsubishi PX-MiEV

Idle Reduction

Not all options to be considered when developing a clean-fleet initiative fall into the category of *Alternative Fuel*. Idle reduction technology has advanced beyond that which can typically be found at a highway truck stop. Today, every city is faced with the challenge of finding inventive ways of reducing their fuel consumption while not sacrificing any of the productivity of their various repair crews. Idle reduction can be a very powerful way of doing this. Every twenty (20) minutes a car spends idling provides the same emissions as that same car driving 320 miles. Additionally, just one idling hour produces more than twenty (20) pounds of CO_2.

Normally, most road and bridge repairs are conducted with the aid of generators and/or inverters that are powered by the repair vehicle's own engine. Either way, thousands of gallons of fuel are wasted each year and untold amounts of harmful emissions are released into the air. But, there has been a recent development with regard to safe, reliable electric replacement power for mobile applications.

An average truck idling approximately 1,500 hrs/yr will reduce more than 1.5 tons of NOx over a 10-year lifecycle utilizing Energy Xtreme technology. This same vehicle could also save over 1,000 gallons of fuel annually. The three most popular configurations of power cell technology are: 1) Service Body Box - $5,995, 2) Power Plus Tool Box - $7,495, and 3) Professional Tool Box - $5,995.