DEPLOYMENT OF ALTERNATIVE FUELS IN TEXAS

IAC A - Task 8b

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DISCLAIMER

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1. INTRODUCTION

"In the absence of alternatives to petroleum products …reliance on foreign producers for oil will increase 30% through 2030, and our transport sector's greenhouse gas emissions will grow by nearly 40%."

- National Biofuels Plan, October 2008
Biomass Research and Development Board

Interest in alternative fuels for transportation increases as the nation looks for solutions to greenhouse gas emissions, air pollution and dependence on foreign oil supplies, and farther in the future, possibly an end of fossil fuel usage as we know it today. Alternative fuels are non-traditional or conventional fuels put to alternative uses. Alternative fuels include renewable fuels such as ethanol and biodiesel as well as those from fossil fuels such as natural gas and propane. Non-petroleum based renewable fuel use reduces greenhouse gases and other pollutants by displacing use of gasoline and diesel. Natural gas and propane sources are domestically prevelant and increase energy security by reducing dependence on foreign oil.

Commonly used alternative fuels include natural gas, propane, ethanol and biodiesel. There is also considerable interest in the use of electricity and hydrogen as a transportation fuel, although they have not yet been sufficiently developed for (highway) transportation and are not covered in depth in this report. Compressed natural gas (CNG) and liquid natural gas (LNG) are a mixture of hydrocarbons, predominantly methane (CH_4) and are used in dedicated or bi-fuel engines. Liquid petroleum gas (LPG), or propane, is a by-product of oil refining and natural gas processing. Ethanol is made from organic vegetative materials such as corn, sugar cane and switch grass. It is commonly found in the fuel supply in low percentages (<10%) as a result of the EPA's renewable fuel standards and as a MTBE replacement. However, flex fueled vehicles (FFV) can use E85, which is 85% ethanol and 15% gasoline. Biodiesel is also a renewable fuel made from vegetable oils or animal fats. Biodiesel is often a blend of organic sources and diesel. Like ethanol, it is commonly referred to by its percentage of renewable matter. B20, which is a blend of 20% biofuel and 80% diesel is common and can be used in any diesel vehicle with only minor modifications, if any.

Alternative fuel availability is a significant barrier to its use. Of federally owned alternative fuel vehicles, over half were waived from using alternative fuels because the fuel was not readily available.[1] Fueling infrastructure is a large component of this unavailability. Only a small fraction of fuel stations offer alternative fuels. In 2006, only 0.7% of stations (1,157 stations) carried E85 and only 0.5%, or 968 stations provided bioidesel.[2]

While there are many barriers to alternative fuel use, this technical memorandum is focused on the deployment of alternative fueling stations. This memorandum assesses the current state of alternative fuel availability in Texas and opportunities for enhanced deployment. The alternative fuels examined in this memorandum primarily include biodiesel, ethanol (E85), CNG, LNG and LPG. Electricity and hydrogen are discussed in the first chapter on alternative fuel usage trends and incentives. However, due to their limited commercial applications, these fuels were not explored in depth. They are still largely in the research and development phase. Each alternative fuel will be examined separately since each of these fuels often serves distinct markets and has unique needs.

Alternative fuel station deployment is based on the following factors:

- The target fleet market served, including:
    - Whether a dedicated engine or conversion is required for the fuel,
    - Whether target vehicles are light, medium or heavy-duty vehicles,
    - Centrally fueled fleets versus non-centrally fueled fleets
    - Highway or non-highway, urban or interstate usage
    - Vehicle ownership- commerical, governmental or individual entities.
- Fuel limitations, opportunities and requirements in Texas (e. g., emissions benefits, available supply, storage and handling issues)
- Locations of current fueling infrastructure

Before covering the details of each individual alternative fuel, this memorandum covers alternative fuel usage trends to provide overall context on non-traditional fuel usage. Alternative fuel incentive programs are also discussed. Many incentive programs cover multiple alternative fuels and serve as an important resource for fuel station deployment strategies.

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[1] DOE, Energy Efficiency and Renewable Energy Office, "Frequently Asked Questions about Federal Fleet Management," http://www1.eere.energy.gov/femp/pdfs/federal_fleet_faq.pdf, accessed June 2009.

[2] Haney, Bryan, Energy Information Administration, presentation at the 2007 EIA Energy Outlook, Modeling, and Data Conference entitled "Major Issues Affecting Biofuel Growth and Development in the U.S." http://www.eia.doe.gov/oiaf/aeo/conf/handouts.html, accessed June 2009.

2. ALTERNATIVE FUEL USAGE AND INCENTIVE PROGRAMS

This section provides the overall context of alternative fuels. Sourced primarily from data provided by the Department of Energy's (DOE) Energy Information Administration (EIA), information on alternative fuel volumes, usage and trends is provided for the alternative fuel industry as a whole. This section also lists current incentive programs for alternative fuels. The information on incentive programs is a current snapshot of programs, which change over time. However, based on the limited information available, there is a brief discussion of the trend for alternative fuel incentive programs.

In this section and throughout this report, fuels are measured in gasoline gallons equivalent (GGE). Measuring by GGE normalizes the different energy densities of fuels. For example, E85 has less energy than gasoline, so a gallon of E85 would not be equivalent to a gallon of gasoline from a usage standpoint. DOE provides conversion factors that reflect these different energy densities, which are provided in Table 1.

Table 1. Alternative Fuel Conversion Factors for GGE Calculations

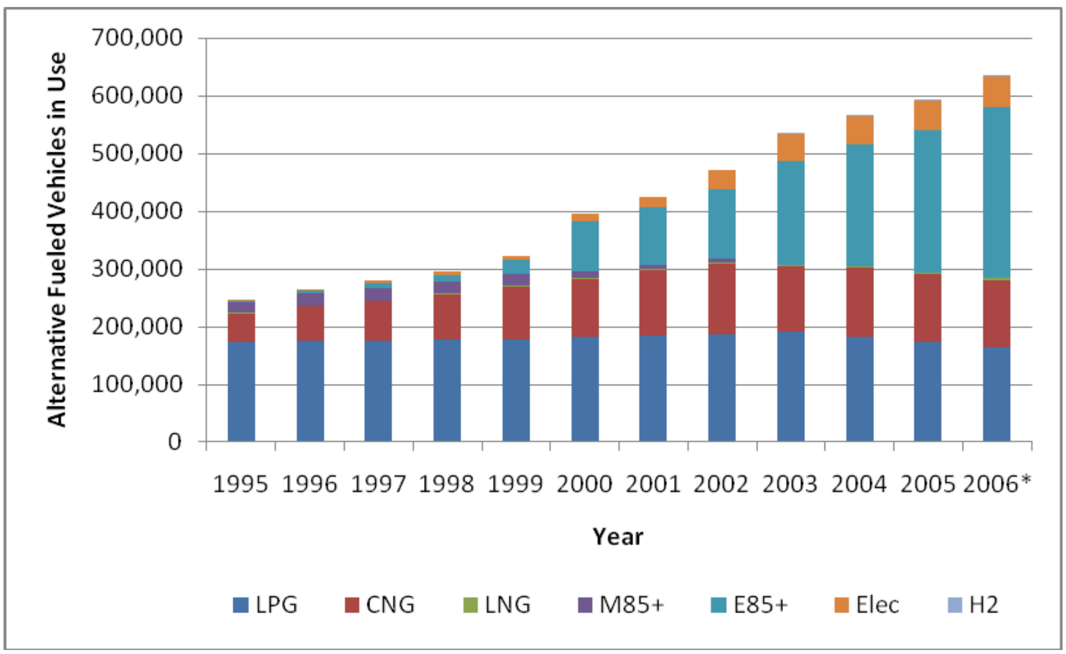
Fuel Type	Fuel Measurment Unit	Conversion Factor
B100	Gallons	1.015
B20	Gallons	1.126
CNG	Gallons at 2400 psi	0.18
CNG	Gallons at 2600 psi	0.27
CNG	Hundred Cubic Feet	0.83
Diesel	Gallons	1.147
E-85	Gallons	0.72
Electric	kWh	0.03
Gasoline	Gallons	No conversion needed.
Hydrogen	Kg	1
LNG	Gallons at 14.7psi and -234°F	0.66
LPG	Gallons	0.74

Source: DOE, "Converting Alternative Fuel Units to Gasoline Gallon Equivalents (GGE)," http://www1.eere.energy.gov/vehiclesandfuels/epact/pdfs/afc_docket/conversion_table.pdf, accessed August 2009.

ALTERNATIVE FUEL USAGE, COMPOSITIONS AND TRENDS

Alternative fuel use is increasing in the United States, both in vehicles and fuel consumption. Figure 1 depicts the number of alternative fueled vehicles in use. E85 vehicles depicted in the table reflect only vehicles that are expected to be using E85 and not all FFVs that are E85 capable. Since lower blends of biodiesel can be used in any diesel vehicles without major modifications, this fuel it is not included in the table. The M85 refers to vehicles that can use a minimum of 85% methanol. Utilization of these vehicles peaked in 1997 and became obsolete by 2003. The largest increase in alternative fueled vehicles is E85 capable vehicles, which doubled in use from 2002 to 2006 from 121,000 to 297,000 vehicles. While small in numbers, vehicles capable of using electricity and hydrogen are increasing steadily. In 1995 less than 3,000 electric vehicles existed and in 2006 there were more than 53,000. Hydrogen vehicles did not appear until 2003 and by 2006 there were an estimated 159 vehicles nationwide. While comparatively plentiful, the numbers of LPG and CNG vehicles in use are slightly decreasing.

Figure 1. Alternative Fueled Vehicles in Use (1995-2006)

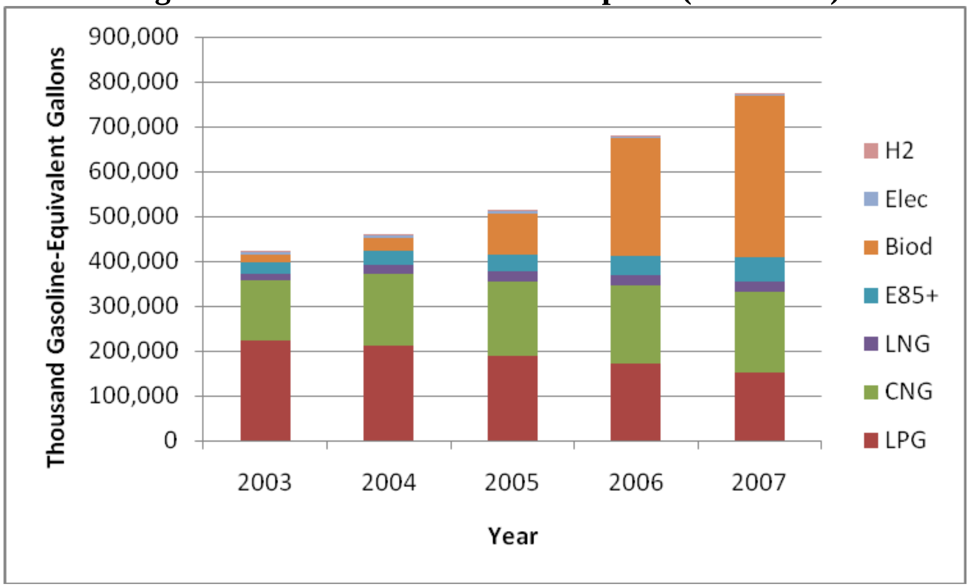


* Data for 2006 is preliminary.
Source: Department of Energy, Alternative Fuel and Data Center, http://www.afdc.energy.gov/afdc/data/vehicles.html, accessed June 2009.

An examination of alternative fuel consumption nationally (shown in Figure 2) shows recent increases for all fuels except propane and a marginal decrease in electricity usage. In pace with the E85 capable vehicles in use, the consumption of E85 doubled from 2003 to 2007. Biodiesel accounts for the most dramatic increase in fuel usage, which almost tripled from 2005 to 2006. Biodiesel is presently the most commonly used alternative fuel. While Figure 1 indicates that the numbers of CNG vehicles are slightly decreasing, the fuel consumption rates for both forms of natural gas are still climbing.

Overall, the percentage of transportation fuel comprised of alternative fuels is increasing. While alternative fuels currently comprise less than 1% of overall fuel consumption, the percentage of these non-traditional fuels increased 75% over the five year period from 2003 to 2007.[3]

Figure 2. Alternative Fuel Consumption (2003-2007)



Source: Department of Energy, Alternative Fuel and Data Center, http://www.afdc.energy.gov/afdc/data/vehicles.html, accessed June 2009.

Texas is second in the nation for alternative fuel use. In 2007, Texas had more than 88,000 alternative fueled vehicles in use and consumed over 49 million gasoline-equivalent gallons of alternative fuel (biodiesel not included).[4] From Figure 3 it is clear that LPG is still the predominent alternative fuel among the non-biodiesel alternative fuel options. More than 58,700 vehicles consumed more than 31.3 million gasoline-equivalent gallons of LPG. The graph also indicates that natural gas vehicles are widely used because their fuel consumption is relatively high compared to the number of vehicles. In contrast, vehicles that are E85 capable did not consume as much ethanol per vehicle as the vehicle population numbers would suggest.

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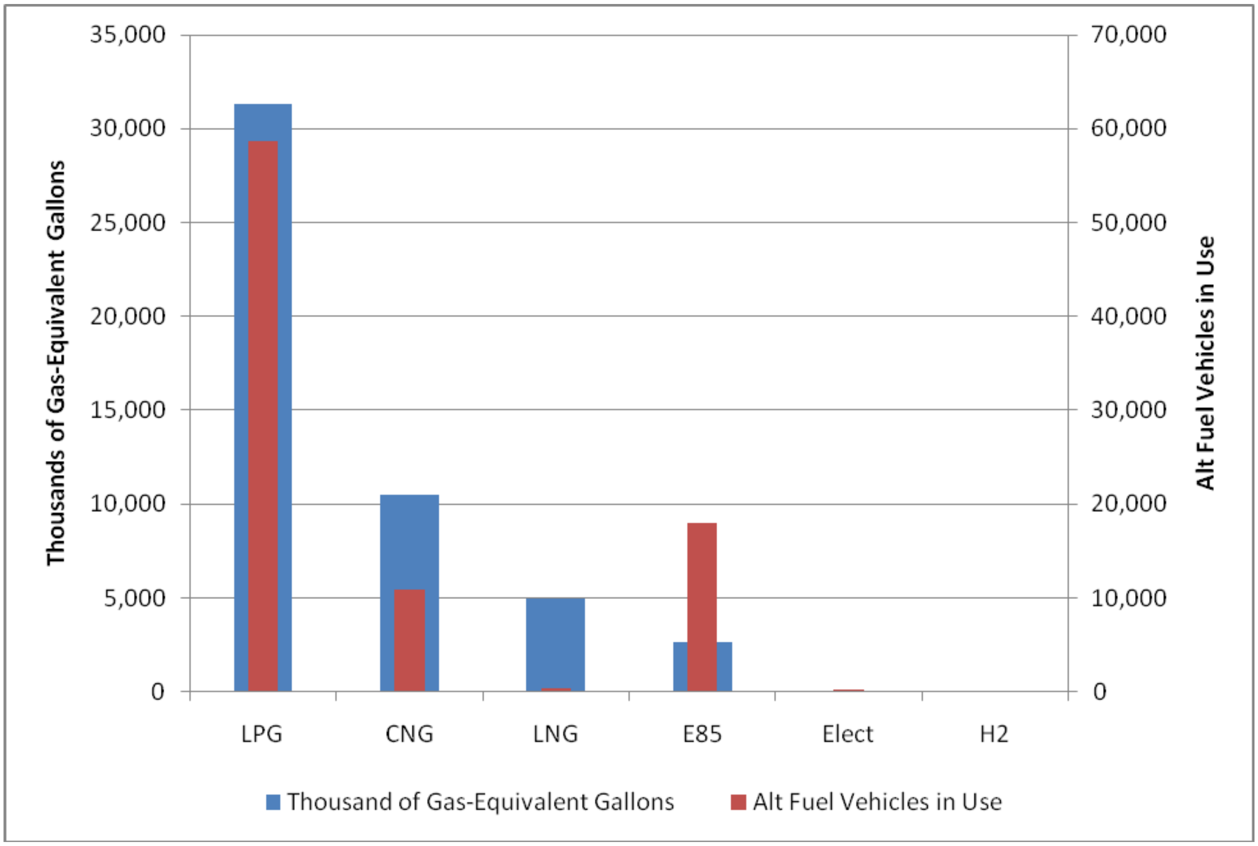
[3] Energy Information Administration, "Estimated Consumption of Vehicle Fuels in the United States, by Fuel Type, 2003-2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed June 2009.

[4] Energy Information Administration, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed June 2009.

However, more than 18,000 of the E85 flex fueled vehicles consumed more than 2.6 million gasoline-equivalent gallons. In 2007, Texas had 173 vehicles capable of using electricity, and approximately 20,000 gasoline-equivalent gallons were consumed from the grid. There are few hydrogen powered vehicles in Texas.

Figure 3. Alternative Fuel Vehicles and Consumption in Texas, 2007



Source: Department of Energy, Alternative Fuel and Data Center, http://www.afdc.energy.gov/afdc/data/vehicles.html, accessed June 2009.

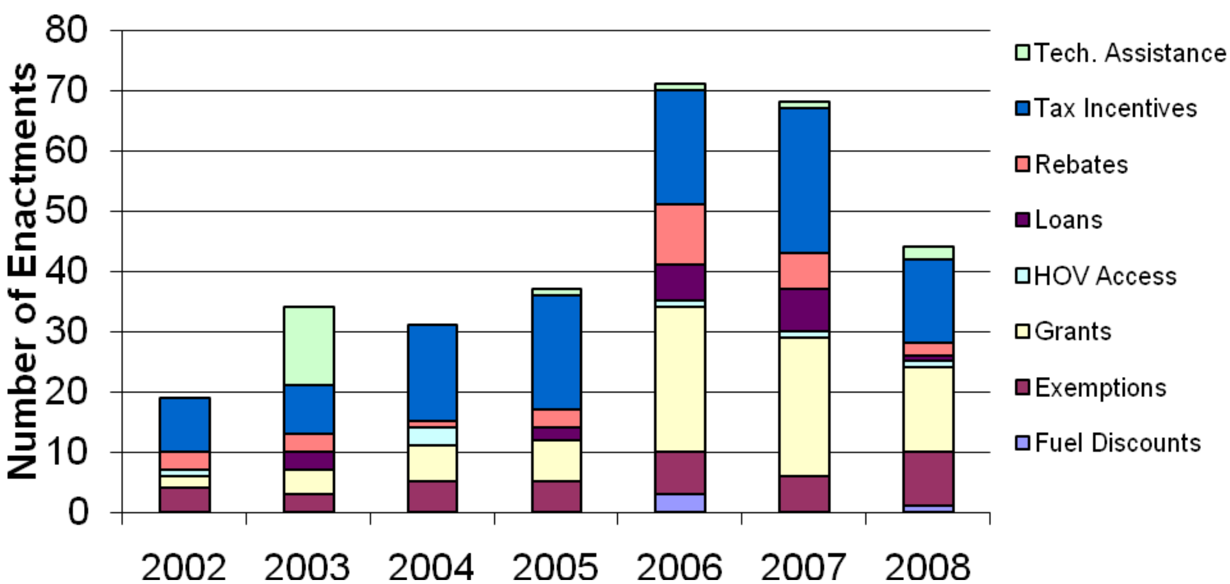
The previous figures suggest that the current picture of alternative fuel use nationally and in Texas is shifting. LPG usage as the dominent alternative fuel is decreasing while ethanol and biodiesel usage are on the rise. Natural gas vehicles are starting to stagnate in number, the fuel consumption data suggests that the vehicles in service are being widely used.

The picture for electric vehicles thus far is mixed nationally, but looks strong in Texas. While the number of electric vehicles in use is increasing, the fuel consumption numbers suggest that the vehicles are not consuming much electricity. However, electric miles are thought to be very fuel efficient, so data based on gasoline-equivalent gallons may appear to underestimate the usage rates of electric vehicles. Texas is also well positioned as a state to adopt hydrogen technology if it becomes more available and affordable. The state's petrochemical industry produces hydrogen as a by-product and the state has nearly 1,000 miles of hydrogen pipelines.[5]

INCENTIVE PROGRAMS FOR ALTERNATIVE FUELS

There are several incentive programs at the state, local and federal level to encourage the use of alternative fuels in Texas and the nation. Incentives may include technical assistance or financial assistance such as tax credits or exemptions, discounts, rebates, loans or grants. Figure 4 lists the number of alternative fuel incentives enacted at the state level for different types of programs. Some incentives may be counted multiple times because they apply to more than one incentive type. The figure depicts an incentive peak during 2006 with a decline in financial incentive programs. Only alternative fuel exemptions from normally applied restrictions, laws or requirements have shown an upward, yet unsteady, trend.

Figure 4. State Level Alternative Fuel Incentive Enactments by Type of Incentive



Source: DOE, Alternative Fuel and Advanced Vehicle Data Center, "Data, Analysis and Trends: Laws and Incentives," http://www.afdc.energy.gov/afdc/data/laws.html, accessed June 2009.

[5] Texas Department of Transportation, "TxDOT Strategic Plan for Hydrogen Vehicles and Fueling Stations," August 2006.

In addition to state leadership, the federal government has played a major role in providing alternative fuel incentives.

Federal Incentive Programs for Alternative Fuels

The federal government has considerable regulatory flexibility in creating vehicle and fuel mandates, and has also enacted a number of tax incentives for alternative fuel activities. The following sections highlight some of the more prominent alternative fuel incentives at various levels of governance.

Federal Alternative Fuel Mandates

The federal government's mandatory programs for promoting alternative fuels involve a sweeping renewable fuel standard affecting the entire nation and then a few requirements targeted primarily at public fleets. Alternative fueled vehicles must meet the same emissions requirements of petroleum fueled vehicles. However, at the fuel production level, producers are required to incorporate a certain percentage of renewable fuels annually, which primarily compromise ethanol and a smaller amount of biodiesel. The Renewable Fuels Standard (RFS) was born in the 2005 Energy Policy Act (EPAct) and was expanded in the Energy Independence and Security Act of 2007 (EISA 2007). The percentage of renewable fuels incorporated into the national fuel supply is to increase annually to 36 billion gallons by 2022. These provisions are largely invisible to average consumers who fill up their gas tanks with fuel that contains a small percentage of ethanol regularly.

Fleets serving federal and state institutions, along with alternative fuel providers are also subject to alternative fuel fleet mandates for new vehicle purchases. Energy Policy Act (EPAct) of 1992 requires federal and state agencies to make 75% of all new light duty fleet acquisitions capable of running on alternative fuels. Alternative fuel providers must also comply with a similar provision.

Federal fleets have been subject to other alternative fuel requirements. Most recently, EISA 2007 and Executive Order 13423 set out several requirements to boost alternative fuel use and decrease the use of petroleum in transportation. Federal agencies must reduce petroleum consumption by 20% by 2015 from a 2005 baseline, including a 2% minimum annual reduction. Federal agencies are also expected to increase alternative fuel consumption by 10% annually. These more recent requirements build off of previous mandates. EPAct 2005 requires federal fleets to use alternative fuels with vehicles that have dual fuel capabilities. Absent this requirement, federal fleets would be able to acquire duel fuel vehicles, but continue to use petroleum fuel without increasing renewable fuel consumption. Federal fleets can acquire a waiver from alternative fuel usage requirements if the alternative fuel is not available within five miles or 15 minutes of the garaged location of the vehicles. Most of the E85 waivers submitted to DOE from federal agencies operating in Texas came from the state's metropolitan areas of Dallas, Houston and Austin. The U.S. Postal Service applied for the most E85 waivers in Texas, followed by the U.S. Army.[6] While waiver data would normally provide important information on where to concentrate fuel availability efforts, there is an EISA 2007 provision that will enhance the availability of renewable fuels in all federal agencies. Starting in 2010, federal entities will be required to install at least one renewable fuel pump at each federal fleet fueling center.

Federal Alternative Fuel Tax Credits

Federal tax credits encouraging the use of alternative fuels can be applied at several different levels. Table 1 lists the tax credits for purchasers of alternative fueled vehicles while Table 2 lists tax incentives for fuel producers and blenders. While these tables provide an overview of the incentives available, many important details regarding these tax incentives are omitted.

The Alternative Fuel Infrastructure Tax Credit is the single tax credit for all qualifying alternative fuel infrastructure. Fueling infrastructure for natural gas, LPG, liquified hydrogen, electricity, E85, or diesel fuel blends containing a minimum of 20% biodiesel (B20) can qualify for various incentive amounts depending on when the equipment comes into service and whether the infrastructure is commercial or residental. For equipment in service after January 1, 2009, the credit amount for commercial entities is up to 50%, with a maximum $50,000. Hydrogen fueling infrastructure can not exceed $200,000. For residential units put in service after January 1, 2009, the credit can be up to $2,000.

[6] DOE, Alternative Fuels and Advance Vehicles Data Center, "Data, Analysis and Trends: Federal Fleets," http://www.afdc.energy.gov/afdc/data/fleets.html, accessed June 2009.

Table 2. Federal Tax Credits for Alternative Fueled Vehicles

Title	Alternative Fuels or Activities Covered	Amount of Credit
Fuel Cell Motor Vehicle Tax Credit	Fuel cell vehicles	Up to $8,000
Heavy-Duty Hybrid Electric Vehicle (HEV) Tax Credit	Qualified heavy-duty HEVs	Up to $18,000
Light-Duty Hybrid Electric Vehicle (HEV) and Advanced Lean Burn Vehicle Tax Credit	Qualified light-duty HEVs and advanced lean burn technology vehicles	Up to $3,000 for 2009 vehicles.
Qualified Alternative Fuel Motor Vehicle (QAFMV) Tax Credit	Vehicles powered by natural gas, LPG, hydrogen, and fuel containing at least 85% methanol.	Varies by vehicle. Can be $32,000 for some natural gas vehicles.
Qualified Plug-In Electric Drive Motor Vehicle Tax Credit	Qualified plug-in electric drive motor vehicle	$2,500 - $7,500

Source: DOE, Alternative Fuels & Advanced Vehicles Data Center, State and Federal Incentives and Laws, http://www.afdc.energy.gov/afdc/progs/fed_summary.php/afdc/US/0 , accessed June 2009.

Table 3. Federal Alternative Fuel Tax Incentives

Title	Alternative Fuels or Activities Covered	Applicable for	Amount of Credit
Alternative Fuel Excise Tax Credit	CNG, LNG, LPG, biomass fuels, P-Series fuel, Fischer-Tropsch fuels.	Entities that report and pay federal excise taxes.	$0.50 per gallon
Alternative Fuel Mixture Excise Tax Credit	CNG, LNG, LPG, biomass fuels, P-Series fuel, Fischer-Tropsch fuels.	Registered alternative fuel blenders	$0.50 per gallon of alternative fuel used
Biodiesel Income Tax Credit	B100 (meeting ASTM D6751 specs)	A taxpayer that delivers (for their own use or anothers) B100	$1.00 per gallon
Biodiesel Mixture Excise Tax Credit	biodiesel (meeting ASTM D6751 specs)	Registered biodiesel blenders	$1.00 per gallon of biodiesel
Cellulosic Biofuel Producer Tax Credit	Cellulosic biofuel	Registered producers	Up to $1.01 per gallon of cellulosic biofuel
Small Agri-Biodiesel Producer Tax Credit	Agri-biodiesel (diesel fuel derived solely from virgin oils)	Small agri-biodiesel producers	$0.10 per gallon of agri-biodiesel
Small Ethanol Producer Tax Credit	Ethanol	Small ethanol producers	$0.10 per gallon of ethanol
Volumetric Ethanol Excise Tax Credit (VEETC)	Ethanol	Registered ethanol blenders	$0.45 per gallon of pure ethanol blended with gasoline

Source: DOE, Alternative Fuels & Advanced Vehicles Data Center, State and Federal Incentives and Laws, http://www.afdc.energy.gov/afdc/progs/fed_summary.php/afdc/US/0 , accessed June 2009.

Federal Grant and Loan Programs for Alternative Fuels

Federal grant and loan programs for alternative fuels have decreased since their height in 2006, as depicted previously in Figure 4. Rather than have their own dedicated sources of funding, many federal grant and loan programs are not specific to alternative fuels and promote activities like air quality, energy projects and rural development generally. While the Clean Fuels Grant program is dedicated to transit related alternative fuels or other emissions reducing activites, the program is inconsistently funded by Congress. Table 3 lists current federal programs that can provide funds for alternative fuel activities.

Table 4. Federal Grants and Loans for Activities that Include Alternative Fuels

Title	Agency	Fuel and Activities Funded	Eligible Entities
Clean Fuels Grant Program	Federal Transit Administration	Grants to assist transit agencies with the purchase of alternative fuel or low-emission vehicles or alternative fuel activities.	Transit agencies in ozone and carbon monoxide air quality nonattainment and maintenance areas.
Congestion Mitigation and Air Quality (CMAQ) Improvement Program	Federal Highway Administration directs funds to state DOTs or MPOs	Funding for activities that reduce transportation-related emissions. Alternative fuel infrastructure projects are largely eligible. Funding is competitive. Stand alone alternative fuel purchases are not eligible.	Public-private partnerships are eligible. Project must be in the MPO's tranportation plan and TIP/STIP.
Improved Energy Technology Loan Program	Department of Energy	Provides loan guarantees for the commercial use of advanced technologies, including alternative fuel vehicles and biofuels. Research and development projects are not eligible.	Broad eligibility, including private, non-federal governmental institutions, individuals or other entities.
National Clean Diesel Campaign (NCDC)	U.S. Environmental Protection Agency	Grant funding for projects that reduce diesel emissions from the existing diesel fleet. Biodiesel and alternative fuel replacements are eligible. Fuel infrastructure is not eligible.	State, regional and local governments and nonprofit entites that include transportation or air quality activites.
Renewable Energy Systems and Energy Efficiency Improvements Grants	U.S. Department of Agriculture	Renewable energy systems and energy improvements. Eligible activities include biofuels, hydrogen and energy efficiency improvements.	Agricultural producers and small rural businesses.
Value-Added Producer Grants (VAPG)	U.S. Department of Agriculture	VAPG grants are for planning activities and working capital for agricultural products and farm-based renewable energy.	Producers and producer groups, agricultural cooperatives and majority-controlled producer-based business ventures
Voluntary Airport Low Emission (VALE) Program	Federal Aviation Administration	Funds for reducing emissions at airports through the purchase of low-emission vehicles, development of fueling and recharging stations, use of gate electrification, and other projects.	Airports located in designated air quality nonattainment and maintenance areas.

Source: DOE, Alternative Fuels & Advanced Vehicles Data Center, State and Federal Incentives and Laws, http://www.afdc.energy.gov/afdc/progs/fed_summary.php/afdc/US/0 , accessed June 2009.

Texas Alternative Fuel Incentives

Texas has a combination of grant programs, technical assistance and a tax exception to support the use of alternative fuels. Technical assistance and support is provided by the Texas General Land Office, the Texas Railroad Commission, the Texas State Energy Conservation Office and the Texas Commission on Environmental Quality. For example, the Texas Railroad Commission provides free safety and maintenance training for propane vehicles.

Texas Financial Incentives

Texas provides a tax exemption for the renewable fuel portion of biodiesel and ethanol.[7] State gasoline and diesel taxes for conventional fuels are $0.20 per gallon. The State's taxation method for LPG, CNG and LNG are difficult to directly compare with gasoline and diesel. For out-of-state vehicles, the fuels are taxed $0.15 per gallon. However, Texas vehicles pay on a pre-paid basis. LPG and natural gas vehicles purchase a decal for tax pre-payment that is based on vehicle weight and miles traveled. For example, a Class A (less than 4,000lbs) vehicle traveling between 10,000 to 14,999 miles annually can pay between $0.006 and $0.009 per mile in state tax. For a Class F vehicle (43,501 lbs or more), the rate can vary between $0.037 and $0.055 for 10,000 to 14,999 miles annually. Transit buses pay a flat fee of $444.00 annually.[8]

Texas also has a number of state grant programs for alternative fuel activities are listed in Table 4.

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[7] Texas Comptroller of Public Accounts, "Fuel Tax Index" http://www.cpa.state.tx.us/taxinfo/fuels/ , accessed June 2009.

[8] See bottom table on Form 06-215 from the Texas Comptroller of Public Accounts for pre-paid LPG, LNG, CNG tax rates based on weight class and mileage. Available at: http://www.window.state.tx.us/taxinfo/taxforms/06-215.pdf, accessed August 2009.

Table 5. Texas State Grant Programs for Alternative Fuel Projects

Title	Administrating Agency	Fuel and Activities Funded	Eligible Entities
Heavy-Duty Natural Gas Vehicle (NGV) Grants	Texas General Land Office	Diesel vehicle replacements with NGVs.	Public entities
Liquefied Petroleum Gas (LPG) Vehicle Incentives	Texas Railroad Commmission	Replacement of diesel school buses, delivery vehicles and forklifts with cleaner propane models.	Owners of diesel fleets
New Technology Research and Development (NTRD) Program	Texas Commission on Environmental Quality	Research, development, and commercialization of technologies that reduce NOx, including alternative fuels.	Academic/research organizations, national laboratories and for-profit firms
Transportation Efficiency Program	Texas State Energy Conservation Office	Provides 11 million for alternative fuel projects, including vehicles and refueling equipment. Part of the State Energy Plan funded with federal economic recovery funds.	Governmental entities
Texas Clean Fleet Program	Texas Commission on Environmental Quality	Grants for replacing diesel vehicles with alternative fuel or hybrid vehicles.	Commercial entities with at least 100 vehicles. Some local governments may be eligible
Texas Emissions Reduction Plan (TERP) Emission Reduction Grants	Texas Commission on Environmental Quality	Replacement of diesel vehicles with alternatively fueled models. Funds other activities that reduce nitrogen oxide (NOx) from diesel engines.	Owners of diesel fleets

Source: DOE, Alternative Fuels & Advanced Vehicles Data Center, Texas Incentives and Laws, www.afdc.energy.gov/afdc/progs/state_summary.php/TX , accessed June 2009.

The 2009 Texas legislative session made several changes to the state's TERP and NTRD programs that will take place on September 1, 2009. HB 1796 expands TERP program eligibility to stationary projects and fewer funds are allocated for the grant programs that mainly support mobile source emission reduction projects. This could increase competition for TERP project funding for all types of projects, including alternative fuels. Since TERP funds are used for the General Land Office's natural gas vehicle grants and the Texas Railroad Commission's propane vehicle grants, these programs could be affected by the new changes to the TERP program.

House Bill 1796 also extends NTRD funding eligibilty to stationary projects and field validations of innovative technologies. Funding for the NTRD program is modestly reduced. The program could remain a source of funds for fuel technologies, but funding may be more competitive. The house bill also transfers management of the program from the Houston

Advanced Research Center to TCEQ. TCEQ may contract with a nonprofit organization or institution of higher education to adminster the program.

The 2009 Legislative session also created a new set aside of TERP funds for alternative fueled projects. Senate Bill 1759 allocates 5% of TERP funds for the Texas Clean Fleets Program to fund the incremental costs of replacing diesel vehicles with alternative fuel or hybrid models. Many of the usual TERP provisions for replacement projects must be met, such as a requirement to reduce nitrogen oxide (NOx) emissions by a minimum of 25%. However, replacement projects are not tied to nonattainment areas. Grant amounts pay for a portion of the incremental costs for a qualifying vehicle on a sliding scale. Older diesel vehicles replaced qualify for 80% of the incremental replacement cost, while the replacement of newer vehicles may only qualify for 50% of the incremental cost. Electricity, natural gas, hydrogen, propane and methanol are listed as alternative fuels, but biodiesel is not explicitly included, presumeably because biodiesel does not require a dedicated engine. The bill also contains language requiring TCEQ to study the emissions impact of alternative fuel fueling facilities in nonattainment areas and seek EPA approval for State Implementation Plan credits for activities tied to alternative fuel fueling facilities.

Texas State Agency Fleet Mandates

House Bill 432 strengthens the requirements on state agencies for alternative fuel vehicle requirements. Most state agency fleets are required to purchase alternative fuel vehicles unless a waiver is obtained from the TCEQ on the grounds of fuel supply and cost limitations. State agencies are also limited in size and horsepower for purchases of vehicles used primarily for the transportation of individuals unless the vehicle utilizes alternative fuels. HB 432's language alters the pre-existing requirements from vehicles that are "capable for using alternative fuels" to vehicles that "use" alternative fuels at least 80% of the time. This limits the ability of state fleets to operate dual fuel vehicles on primarily conventional fuels. The bill also expanded the list of alternative fuels from natural gas, propane, methanol and ethanol fuels to include biodiesel (B20 or more) and electricity for plug-in hybrid vehicles. By September 30, 2010, most state agencies are required to use alternative fuels in 50% of the fleet.

Local and Private Programs

Clean Cities is a federal DOE program that supports local initiatives that reduce the use of petroleum. The program provides technical assistance, education and outreach and fosters partnerships. Through public/private partnerships, Clean Cities promotes alternative fuels and other strategies. Typically administered in councils of governments, Texas has had six Clean Cities locations in Texas which cover San Antonio (Alamo Area Council of Governments), Austin (Central Texas Clean Cities), Dallas-Fort Worth (North Central Texas Council of Governments), East Texas (North Texas Air Care), Houston-Galveston (Houston-Galveston Area Council) and Beaumont-Port Arthur (South East Texas Regional Planning Commission). However, not all Clean Cities coalitions in less populated areas are consistently active. Nonetheless, these coalitions have helped secure alternative fueling infrastructure and have provided grant funds for alternative fueled vehicles. For example, the Houston Clean Vehicles Program provides funds to private and government fleets for alternatively fueled vehicles and conversions as well as alternative fueling infrastructure. The Houston-Galveston Area Council also has a Clean School Bus program that will replace older buses with alternative fuel models. The Dallas-Fort Worth program is currently offering $2,500 rebates toward the purchase of a commercial propane lawnmower.

Funding for alternative fuel projects can occasionally come from private entities. Gas utilities have a vested interest in natural gas vehicles and fueling infrastructures and electric utilities can provide support for plug-in vehicle projects. For example, the Texas Gas Service provides rebates for Austin area customers and businesses for the purchase of a natural gas vehicle or conversion of a gasoline vehicle. Vehicle rebates are from $1,000 - $3,000. The company also provides a $1,500 rebate for refueling infrastructure.

CONCLUSIONS ABOUT ALTERNATIVE FUEL TRENDS AND INCENTIVE PROGRAMS

While alternative fuel use has increased, recent trends suggest that there are winners and losers among alternative fuels. Methanol use is practically obsolete, although the fuel is still listed as an eligible activity in many financial incentive programs. The vehicles and usage of LPG has steadily decreased since 2003. Compressed natural gas has decreased in the number of vehicles using the fuel, but the fuel usage in existing vehicles remains strong. This suggests that investments in future CNG as a transporation fuel may start to wane, but existing investments are still being heavily utilized. Unlike CNG, LNG is increasing in the number of vehicles and the amount of fuel being utilized. Hydrogen and electricity usage as transportation fuel is still small in scale and developing.

Ethanol and particularly biodiesel are the big growth sectors for alternative fuels. While E85 fuel usage has grown an average of 20% from 2003-2007, biodiesel growth peaked at 224% in 2005 and has dropped to a still impressive growth rate of 37% in 2007. These trends suggest that the renewable fuels account for a large share of the promising trends showing increased popularity of alternative fuels.

While it is common for alternative fuel incentives to encourage the deployment of all types of alternative fuels, ethanol and biodiesel are often set apart in many programs. Since they are renewable fuels, the renewable fuel standard mandates a certain amount of growth in fuel usage annually. Federal tax credits are more generous for biodiesel and ethanol. At the state level, only these fuels are fully exempted from state fuel taxes. The developing use of hydrogen and electricity are also given unique incentive programs.

While incentive programs for alternative fuels at the state level have shown a marked decrease (see Figure 4), there are indicators that government incentives for alternative fuels are still strong. For example, fleet mandates at both the state and federal level have been strengthened. While previous requirements allowed the use of alternative fuel “capable” vehicles, recent changes to requirements specify actual use of alternative fuels. Fleet managers will not be able to take credit for activities that involve using conventional fuels in dual fuel vehicles.

For Texas, the incentives provided at the state level remain robust despite some decreased opportunities. While there will be a decrease in state funding for TERP, funding set asides for alternative fuel fuels may result in more TERP funded alternative fuel projects. Before the funding set aside put in place by Texas Senate Bill 1759, alternative fuel projects had difficulty competing with conventionally fueled replacements for TERP funds. Of the more than 5,000 TERP projects to date involving almost $700 million in grant funding, alternative fuel projects account for less than 25 projects and $7 million of the grant funds.[9] With dedicated funding available for all areas of the state, there is a greater probability of these funds actually increasing the use of alternative fuels.

In addition, the federal economic stimulus funds provided through the American Recovery and Reinvestment Act of 2009 provide $11 million for alternative fuel projects in Texas. Managed by the Texas State Energy Conservation Office, governmental entities are eligible to apply for grants that pay for alternative refueling equipment or the incremental cost of alternative fuel vehicles.

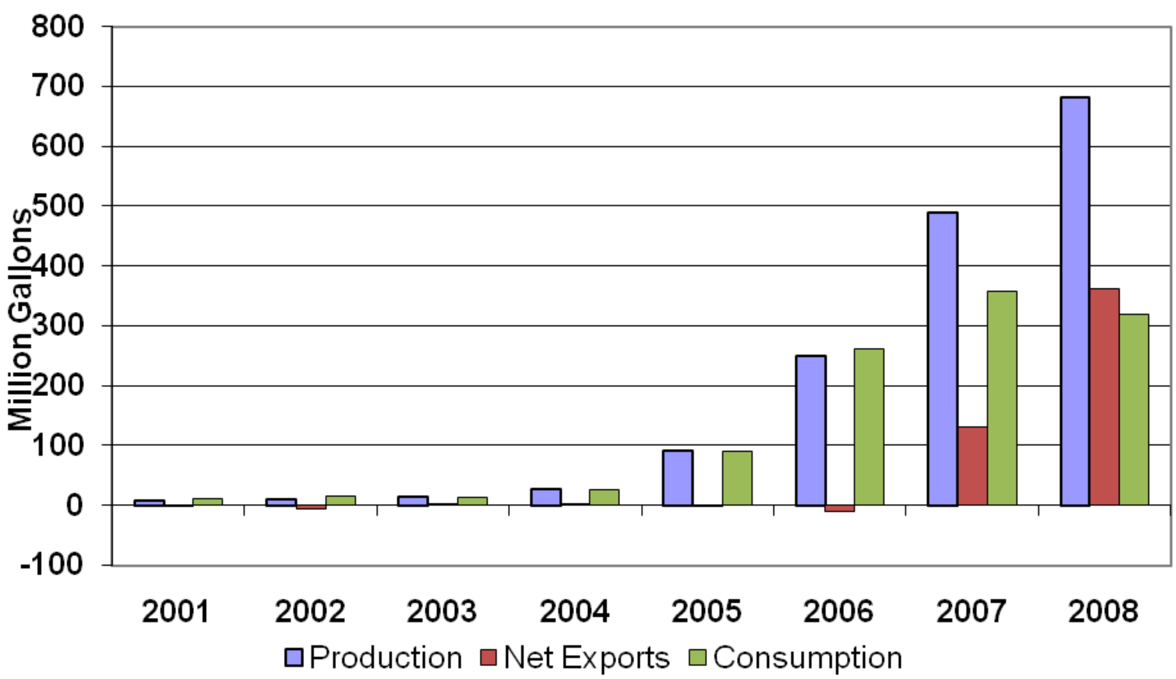
Given the difference in alternative fuel usage, trends and incentives, each type of nonconventional fuel is examined separately in the subsequent chapters. These chapters also include a statewide examination at where the alternative fuel infrastructure is currently located.

[9] Examined all TERP project funded before December 31, 2008. Detailed project listing was provided by the Texas Commission on Environmental Quality. General list of projects can be found at: http://www.tceq.state.tx.us/implementation/air/terp/

3. BIODIESEL

Biodiesel is a renewable fuel that can be manufactured from new and used vegetable oils or animal fats. It is typically made from soybean oil. The fuel is domestically produced, non-toxic, biodegradable and, compared to conventional diesel fuel, reduces particulate matter (PM), carbon monoxide (CO), hydrocarbons (HC) and air toxics. Biodiesel is typically blended with petroleum diesel. Two common biodiesel blends are B20 (20 percent biodiesel and 80 percent petroleum diesel) and B2 (2 percent biodiesel and 98 percent petroleum diesel). Biodiesel production, export and consumption have increased dramatically in the last few years, as is shown in Figure 5.

Figure 5. U.S. Biodiesel Production, Exports, and Consumption



Source: DOE, Energy Information Administration, "Alternatives to Traditional Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html#consumption, accessed July 2009.

BIODIESEL LIMITATIONS AND OPPORTUNITIES

Of alternative fuels, biodiesel is one of the easiest to deploy without a significant capital investment. Lower blends of biodiesel (B2, B5 and often B20) can be used by any diesel vehicle with few, if any, modifications and the fuel's storage modifications are not much more demanding that those for traditional fuels. Fuel quality was an early concern with biodiesel, but this can be mitigated by specifying that biodiesel to meet the ASTM D6751 standard for B100 (discussed below). Biodiesel reduces most key emissions and its use is encouraged, mandated and incentivized by many of the programs outlined in the previous chapter.

There are some disadvantages to biodiesel. One is the fuel's intolerance to cold weather. TxDOT experienced this problem firsthand when none of its Houston vehicles in one location would start one cold morning.[10] EPA has determined that there is likely a slight increase in nitrogen oxide emissions (NOx) from biodiesel.[11] Currently, the Dallas-Fort Worth, Houston-Galveston and Beaumont-Port Arthur areas are in nonattainment for the ozone standard, making any increase in NOx emissions a concern for those areas. Lastly, biodiesel does result in slight decreases in fuel economy.

Ease of Use with Limited, if any, Vehicle Modifications

B20 and lower blends of biodiesel are often compatible with most petroleum diesel engines, and few, if any, modifications are required for the engine or fuel system. Maintenance issues with biodiesel are typically minor. Biodiesel blends can soften and degrade elastomers and natural rubber materials used in system components like gaskets, hoses, and seal compounds. These materials are typically found on older vehicles and will often have to be replaced with a more compatible material. Vehicle owners may also have to replace the fuel filter after using the first tank of biodiesel. The fuel can have a cleaning affect on fuel tanks and pipes by releasing accumulated deposits.[12] However, biodiesel also has lubricity advantages, which can reduce overall maintenance costs and extend engine life.[13] Most original engine manufactures will accept biodiesel blends up to B20 before there are any concerns about warranties. The National Biodiesl Board maintains a clearinghouse of original equipment manufacturer (OEM) statements

[10] Lewis, Don, TxDOT Fleet Manager, personal communication on July 23, 2009.

[11] U.S. EPA. "Regulatory Impact Analysis: Renewable Fuel Standard Program" p. 161

[12] U.S. EPA, "SmartWay Grow and Go: Biodiesel," http://www.epa.gov/smartway/growandgo/documents/factsheet-biodiesel.htm, accessed June 2009.

[13] Radich, Anthony, DOE, Energy Information Administration, "Biodiesel Performance, Cost and Use," http://www.eia.doe.gov/oiaf/analysispaper/biodiesel/ , accessed June 2009.

regarding biodiesel usage.[14] Vehicle owners are encouraged to consult their OEM's recommendations prior to biodiesel usage.

Fuel Quality

Biodiesel can be produced from several sources. The quality of the fuel can vary depending on the feedstock, production processes, storage, blending, shipping and distribution of the fuel. The ASTM D6751 fuel standard, termed the *Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels* from the American Society for Testing and Materials, sets the bar for a high quality, dependable fuel. The limitation of the ASTM D6751 standard is that it applies only to B100 fuels. While the specification is often used as a guide for lower biodiesel blends, it may not address all the unique issues of blended biodiesel fuels, such as gell points and cold weather performance.

The National Biodiesel Board has a certification program for producers, marketers and labs that include the ASTM standard and additional requirements on storage, distribution and other practices that can affect the quality of fuel. Entities that pass independent audits can receive the BQ-9000 designation that indicates that the fuel meets certain standards. However, the lack of an ASTM standard for biodiesel blends other than B100 is still a limitation for ensuring fuel quality for non-B100 fuels. However, it is commonly recommended for vehicle owners to use suppliers that are BQ-9000 certified and confirm whether the biodiesel provided meets ASTM D6751 specifications.

Storage

The infrastructure cost associated with introducing biodiesel to fueling stations is similar to diesel fuel and can be stored similarly. Biodiesel can be stored in old diesel tanks once cleaned and dried at a low cost. One exception is concrete-lined tanks. Acceptable storage tank materials include aluminum, steel, fluorinated polyethylene, fluorinated polypropylene and

[14] National Biodiesel Board, "Automakers' and Engine Manufacturers' Positions of Support for Biodiesel Blends," http://www.biodiesel.org/resources/oems/default.aspx, accessed June 2009.

teflon. Biodiesel fuel should not be stored for more than six months, which is not typically a problem for fuel storage and can be solved with additives.[15]

Cold Weather Concerns

There are cold weather concerns with biodiesel because the fuel can gel at low temperatures and clog fuel lines and filters. The cloud and pour points of biodiesel is lower than regular diesel and will vary by blend, feedstock and other factors. Cloud point refers to the temperature at which crystals first begin to appear and pour point refers to the temperature at which the fuel will no longer continue to flow. The fuel should be stored at least 4-5 ºF above the cloud point and temperatures of 40º to 45ºF (4º to 7ºC) will typically be sufficent for B100. Lower biodiesel blends can handle lower temperatures. Additives can also help lower the cloud and pour points of fuel.[16]

Less Energy per Gallon

Biodiesel does have marginally less energy per gallon. Compared with #2 diesel, biodiesel has 8% less energy per gallon. For B20, this will translate into a 1-2% decrease in fuel economy. However, the energy content of biodiesel can vary from by season and suppliers.[17]

Emissions Reductions

Biodiesel is a renewable fuel that reduces greenhouse gas (GHG) emissions by displacing diesel fuel. EPA estimates that B100 reduces lifecycle GHG emissions by at least 50% and B20 results in at least a 10% reduction.[18] Biodiesel also reduces particulate matter (PM), carbon monoxide (CO) and hydrocarbons (HC) emissions. Emissions reductions depend on the

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[15] National Biodiesel Board, "Regulated Fleets Use Biodiesel," http://www.biodiesel.org/pdf_files/fuelfactsheets/RegulatedFleet_QA.pdf , accessed June 2009.

[16] DOE, "Biodiesel Handling and Use Guidelines," January 2009, http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/43672.pdf , accessed June 2009.

[17] DOE, "Biodiesel Handling and Use Guidelines," January 2009, http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/43672.pdf , accessed June 2009.

[18] U.S. EPA, "SmartWay Grow and Go: Biodiesel," http://www.epa.gov/smartway/growandgo/documents/factsheet-biodiesel.htm, accessed June 2009.

feedstock and percentage of biodiesel blended with diesel. Some studies have shown a slight increase in nitrogen oxide (NOx) emissions with biodiesel. B100 has shown a 10% NOx increase and B20 has shown a 2% increase.[19] While this NOx increase can be a concern in Texas nonattainment areas, TCEQ has approved 5% biodiesel blends with TxLED for nonattainment areas.[20]

TARGET FLEET

Since biodiesel is a diesel replacement fuel, it is commonly used in work vehicles such as light-duty trucks and heavy-duty diesel vehicles. Biodiesel operates in diesel engines similar to petroleum diesel, allowing a variety of diesel vehicles, from light to heavy-duty, to use biodiesel as a diesel fuel alternative without noticeable performance issues. This makes biodiesel a popular choice for federal and state fleets that are subject to alternative fuel fleet mandates. The National Biodiesel Board commissioned a survey of biodiesel users in 2004 and found that B20 was a common choice for large federal, state and local, utility and commercial fleets with vehicles using biodiesel commonly in the gross vehicle weight ratings (GVWR) 2-5 categories. Of those surveyed, approximately half of these large fleets had used biodiesel.[21]

While commercial class 8b trucks are not frequently cited as users of biodiesel, the fuel is the only alternative fuel that can be easily used for these non-centrally fueled fleets. For the low profit margin trucking industry, biodiesel's higher price can be a powerful deterrent to using the fuel. However, when diesel prices are significantly high, lower biodiesel blends can actually be cheaper than conventional diesel. In early 2007 to mid- 2008, B2-B5 was often \$0.01 - \$0.12 per gasoline gallon equivalent (GGE) cheaper than diesel.[22] If biodiesel prices become competitive

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[19] U.S. EPA. "Regulatory Impact Analysis: Renewable Fuel Standard Program" p. 161

[20] TCEQ, "Texas Low Emission Diesel (TxLED) Program," http://www.tceq.state.tx.us/implementation/air/sip/cleandiesel.html, accessed June 2009.

[21] National Biodiesel Board, "Biodiesel End-User Survey: Implications for Industry Growth," http://www.biodiesel.org/resources/reportsdatabase/reports/fle/20040202_fle-029.pdf , accessed July 2009.

[22] DOE, Energy, Efficiency and Renewable Energy, "Data, Analysis and Trends: Fuel," http://www.afdc.energy.gov/afdc/data/fuels.html , accessed July 2009.

with diesel, then this renewable fuel might be the industry's singular option for cleaner fuels if large capital investments are to be avoided.

TEXAS BIODIESEL FUELING STATIONS

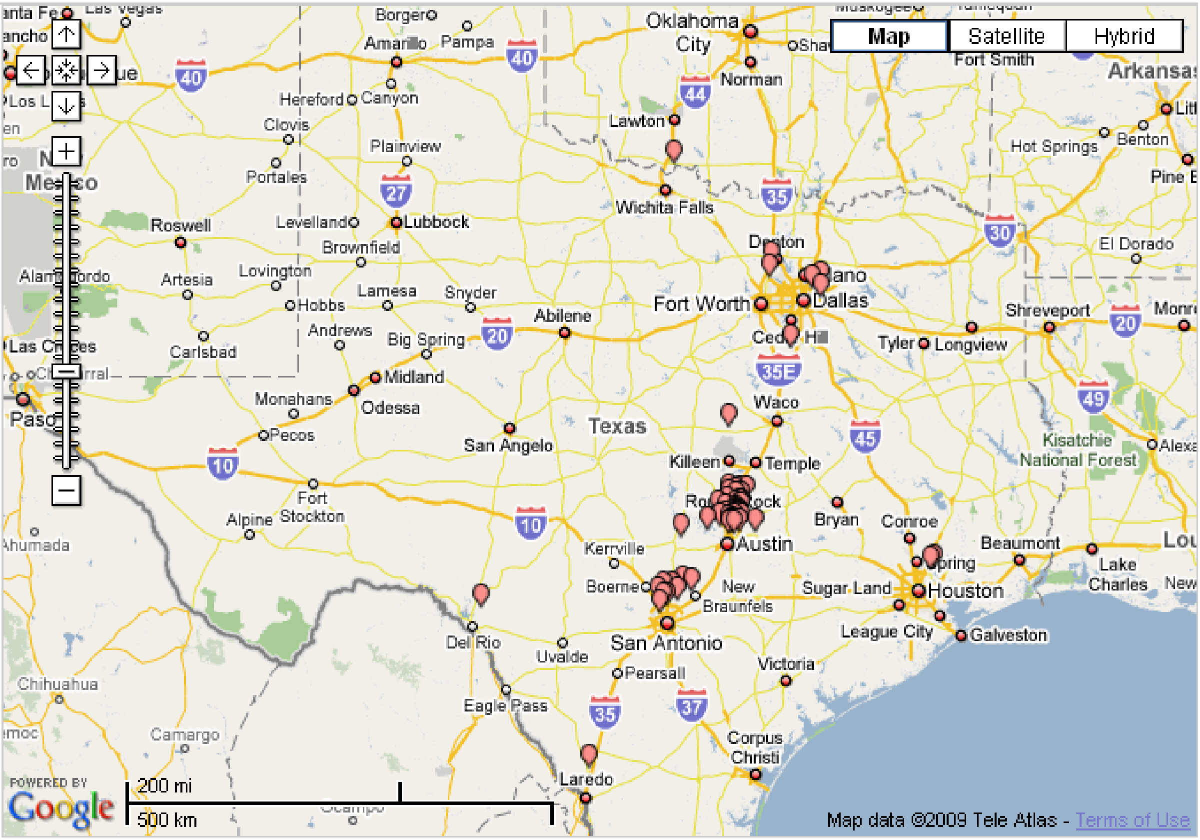
Currently, there are 56 biodiesel fueling stations on record in Texas, as shown by area and type in Table 5 and in Figure 6. Most of these stations are available to the public and most are located in the Austin region. Of the seven stations that serve only private fleets, five of them serve air force bases.

Table 6. Biodiesel Stations in Texas

Metro Area	Available to Public	Private Fleets Only	Planned
Austin	34		
Dallas-Fort Worth	4	1	
Houston	1	1	
San Antonio	6	3	
Rural or Other	2 (Blanco, Laredo)	2	2 (one public, one private)
Total	**47**	**7**	**2**

Source: Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/stations/advanced.php. Data current as of April 8, 2009.

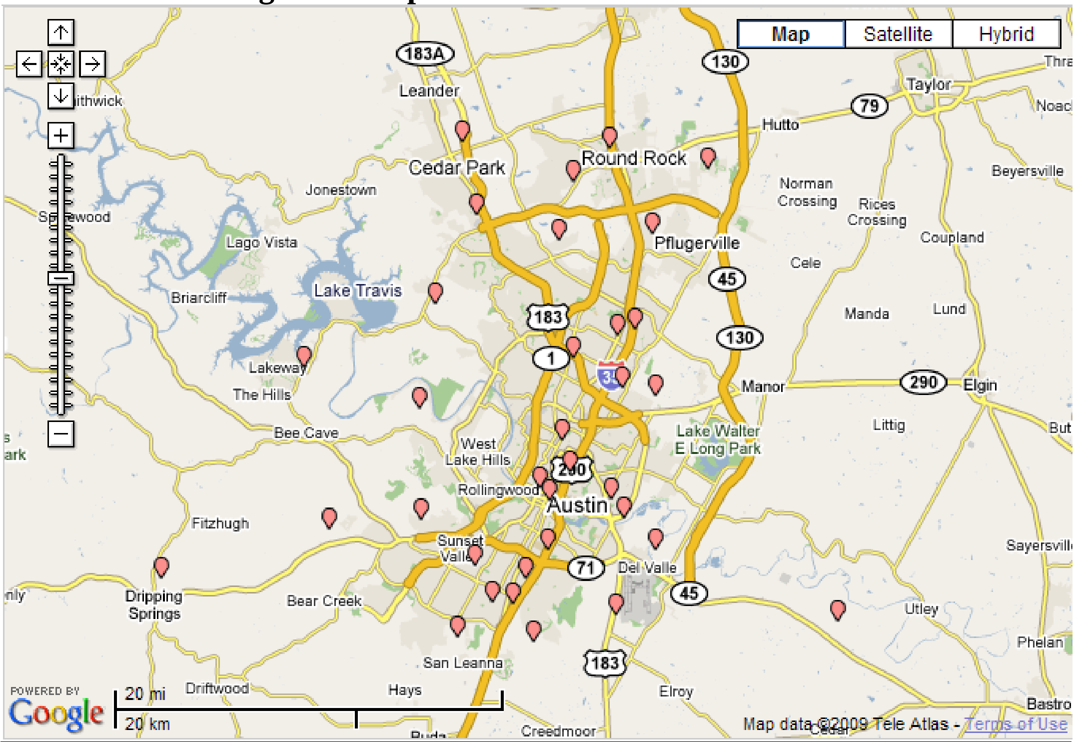
Figure 6. Map of Biodiesel Stations in Texas



Source: Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/stations/advanced.php. Data current as of April 8, 2009.

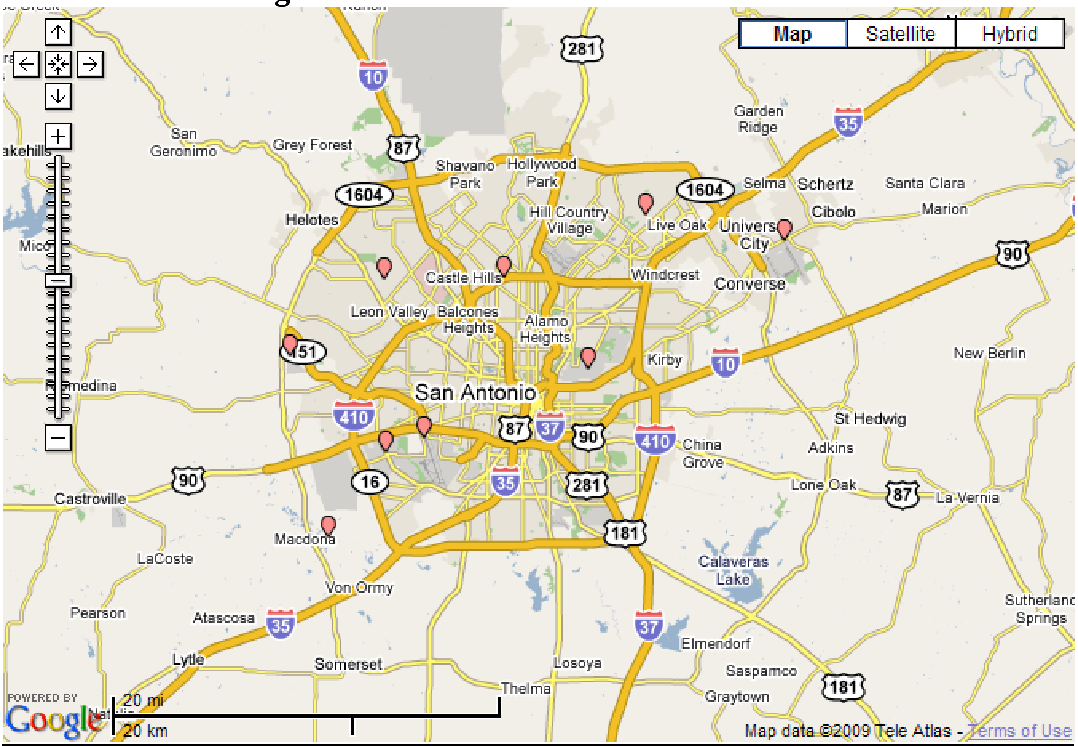
Austin has more biodiesel fueling stations than any other city in the nation. Locations are depicted in Figure 7. These stations are well dispersed throughout the populated areas of the city and many are along the I-35 interstate. San Antonio has nine biodiesel stations located primarily in the northern parts of the city, as depicted in Figure 8.

Figure 7. Map of Biodiesel Stations in Austin



Source: Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/stations/advanced.php. Data current as of April 9, 2009.

Figure 8. Biodiesel Stations in San Antonio



Source: Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/stations/advanced.php. Data current as of April 9, 2009.

BIODIESEL STATION DEPLOYMENT STRATEGY

Biodiesel is commonly used by centrally-fueled government fleets, but its use could be expanded to additional municipalities and fleets, especially in less urbanized areas of the state. These areas would be less affected by the modest potential impact on NOx emissions from biodiesel use. The fuel could also be used for interstate and regional travel by transportation haulers if the price was competitive the regular diesel.

For long and regional haul trucking needs, the I-35 corridor is nearly sufficient for the large heavy duty trucks that need to fill up approximately every 1,000 miles. Assuming that a medium or heavy-duty fleet operator would not mind deviating a few miles from I-35, they could fill up in Laredo or Dallas-Fort Worth at one end of the state and travel with more than enough fuel to make it to the Austin or San Antonio stations located right next to the highway.

Lacking in the state is the fueling infrastructure for east-west long haul travel along I-10 or I-20. El Paso is currently developing a biodiesel plant that will be a resource for regional west Texas and long haul travel.[23] However, the western supply of biodiesel could be augmented by additional resources along I-10 or 1-20 such as the Abilene or Fort Stockton areas. The panhandle is also lacking in biodiesel supply and could benefit from some stations along 1-27, such as in Amarillo or Lubbock.

For inter-city usage by light duty diesel vehicles, Austin is the only city with convenient coverage. As with other centrally-fueled fleets, biodiesel could be expanded beyond the capital area to other municipalities. Centrally fueled fleets in west Texas and the panhandle, along with Corpus Christi and Victoria might be options for infrastructure deployment.

Ensuring good fuel quality can also help promote the use of biodiesel and foster user acceptance. Producers can be educated and encouraged to partcipate in the BQ-9000 program and users of biodiesel should be educated on the questions they should be asking their fuel biodiesel, such as the fuel meets ASTM 6751 fuel standards and if the vendor is BQ-9000 accredited.

[23] Kolenc, Vic. "Biodiesel Age Dawns in El Paso," El Paso Times, June 28, 2008.

4. COMPRESSED NATURAL GAS

Compressed natural gas (CNG) is a pressurized form of natural gas which remains clear, odorless, and non-corrosive. Natural gas is compressed to pressures above 3,600 pounds per square inch (psi) and is primarily composed of methane (CH_4). Although vehicles can use natural gas as either a liquid or a gas, most vehicles use the gaseous form. A majority of natural gas comes from three types of wells: natural gas-and-condensate wells, oil wells, and coal bed methane wells. Before well-extracted natural gas can be used in vehicles, it must undergo a cleaning process.[24]

Using CNG as a transportation fuel requires an investment in specialized vehicles capable of using CNG. In 2007, there were more than 10,800 CNG vehicles in use in Texas consuming more than 10.5 million gasoline gallons equivent (GGE).[25] Nationally, the number of CNG vehicles in use has decreased from its height of popularity in 2004, when an estimated 118,500 vehicles were in use. In 2007, the number of vehicles had dropped to almost 114,400. CNG vehicles have been introduced in a wide variety of commercial applications. Taxis, trucks, delivery vehicles, transit and school buses are common types of CNG vehicles. Often government agencies use CNG in their fleets and for public transportation.[26]

While the number of CNG vehicles has peaked and been slowly declining for the last few years, the consumption of CNG fuel continues to rise. On a GGE basis, CNG fuel consumption nationally has increased 34% from 2003 to 2007.[27] The proportion of CNG vehicles in the heavy-duty weight classes has increased, which may account for a portion of the fuel usage increase. Another possibility is that entities that own CNG vehicles on average are using them more.

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[24] California Energy Commission, "Consumer Energy Center: Compressed Natural Gas as a Transportation Fuel," http://www.consumerenergycenter.org/transportation/afvs/cng.html, accessed April, 2009.

[25] DOE, Energy Information Agency, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed July, 2009.

[26] California Energy Commission, "Consumer Energy Center: Compressed Natural Gas as a Transportation Fuel," http://www.consumerenergycenter.org/transportation/afvs/cng.html, accessed April, 2009.

[27] DOE, Energy Information Agency, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed July, 2009.

CNG vehicles either have dedicated engines that use only CNG or they have a bi-fuel, also known as dual fuel, vehicle that can run both on CNG and a conventional fuel. Gasoline and diesel vehicles can be converted to a dual fuel CNG vehicle. These vehicles can operate with either the conventional fuel tank or from a separate CNG cylinder typically placed in the trunk or on the roof. The driver can select what fuel to burn by simply flipping a switch on the dashboard. This conversion has the advantage of not requiring as much change to the engine as a dedicated CNG conversion.[28]

CNG LIMITATIONS AND OPPORTUNITIES

The use of CNG as a transportation fuel requires an upfront capital expenditure in CNG capable vehicles and fueling infrastructure. This capital commitment often limits the fuel to commercial usage. The fuel is primarily suited for centrally fueled fleets or those that are used in a predictable local and regional travel patterns. However, once the invenstment is made, CNG typically costs less to operate and enhances the nation's energy security. The fuel is also seen as a stepping stone to hydrogen.

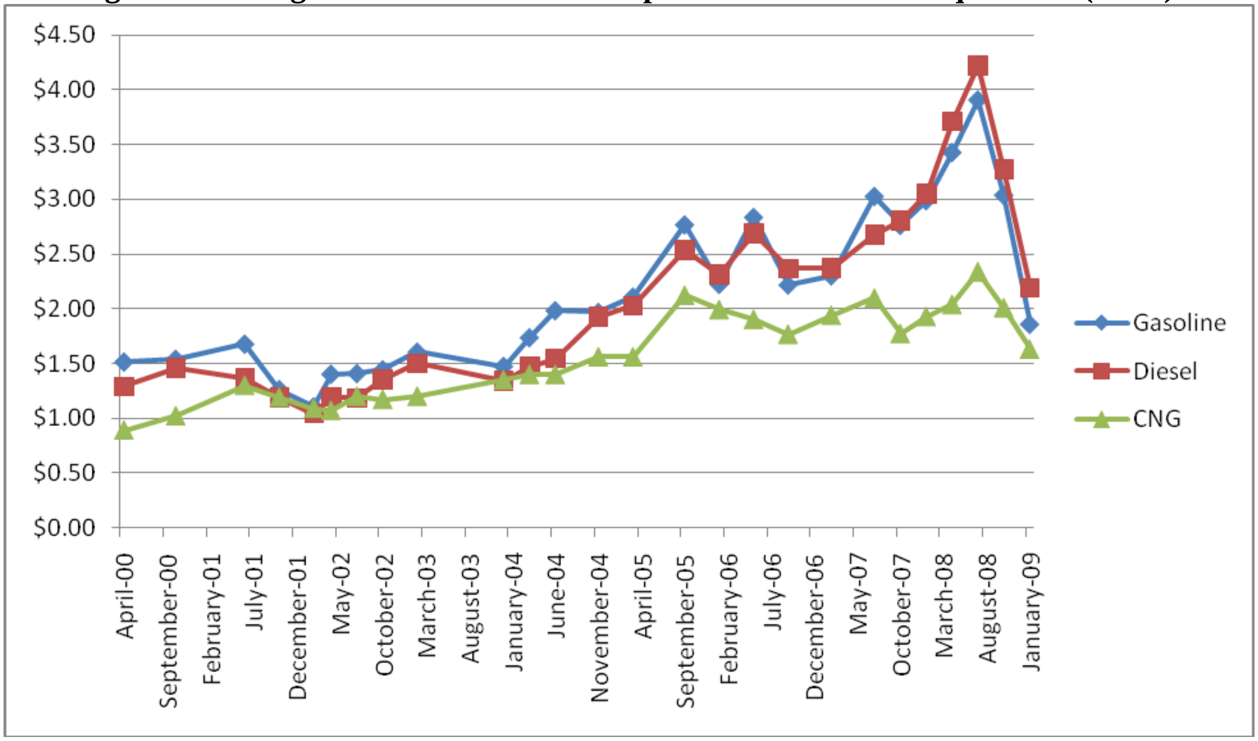
CNG Costs Less per GGE

Once an investment has been made to use CNG fuel and vehicles, the cost of CNG per gasoline gallons equivent (GGE) is less than traditional fuels, as seen in Figure 9. This indicates that CNG may be more attractive for heavily used vehicles with high fuel usage. However, when traditional petroleum fuels are cheap and natural gas prices have risen, then the cost savings of CNG shrinks. Recent data suggests that the price advantage for CNG is narrowing. However, in January of 2009, CNG was still $0.23 per GGE cheaper than gasoline and $0.56 less expensive than diesel. [29]

[28] Co-generation Technologies, "Renewable Energy Technologies," http://www.cogeneration.net/liquefied_natural_gas.htm, accessed July, 2009.

[29] DOE, Energy Information Agency, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed July, 2009.

Figure 9. Average U.S. Retail Fuel Prices per Gasoline Gallon Equivalent (GGE)



Source: DOE, Energy Information Administration, "Alternatives to Traditional Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html#consumption, accessed July 2009.

CNG and Energy Security

Most natural gas used in the United States is domestically produced or comes from politically stable countries such as Canada. Approximately, 60% of the nation's petroleum is imported.[30] In contrast, only 16% of natural gas was imported in 2007.[31] For this reason, natural gas is seen as a near-term solution to energy security.

CNG: the Bridge to Hydrogen

CNG may facilitate the transition to hydrogen as a transportation fuel. Natural gas has high amounts of hydrogen than can be used as a fuel source. The existing network of natural gas pipelines and refueling stations could be used to supply hydrogen from the gas and lessons learned from using CNG as a gaseous fuel can be applied to hydrogen. DOE and others are

[30] DOE, Energy Efficiency and Renewable Energy, "Natural Gas Benefits," http://www.afdc.energy.gov/afdc/fuels/natural_gas_benefits.html, accessed July 2009.

[31] Energy Information Agency, "Annual Energy Outlook 2009," http://www.eia.doe.gov/oiaf/aeo/gas.html , accessed July 2009.

developing vehicles that use both types of fuel with hydrogen-natural gas blends (HCNG). These HCNG vehicles are aimed to bridge the transition from natural gas to hydrogen as a transportation fuel.[32]

CNG and Emissions

CNG has traditionally been touted as a way to reduce emissions. Trade associations claim reductions in carbon monoxide, nitrogen oxides, particulate matter and carbon dioxide.[33] Alternatively fueled vehicles must meet the same emissions standards as petroleum powered vehicles and CNG claims of superior emissions had more validity before engine emissions standards were strengthened. In 2002, the California Air Resources Board released a study comparing the emissions of diesel and CNG buses. Buses retrofitted with a diesel particulate filter emitted lower levels of particulate matter, carbon monoxide, hydrocarbons and many air toxics than CNG buses without a catalyst. The results suggest that catalysts are important even for CNG buses. However, CNG buses without a catalyst emitted less nitrogen oxides (NOx), nitrogen dioxide (NO_2) and carbon dioxide (CO_2) emissions than retrofitted diesel buses.[34]

CNG emits less CO_2 emissions than conventional fuels. The fuel is composed primarily of methane, which is a potent greenhouse gas with more than 20 times the heat trapping effectiveness of CO_2.[35] However, EPA's evaluation of the trade off between these two pollutants indicates that CNG does have a GHG emissions benefit. Compared to gasoline on a btu basis, CNG reduces GHGs emissions by 28.5%.[36]

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[32] DOE, Alternative Fuels and Advanced Vehicles Data Center, "Hydrogen/Natural Gas (HCNG) Fuel Blends," http://www.afdc.energy.gov/afdc/fuels/natural_gas_blends.html, accessed July, 2009.

[33] Natural Gas Vehicles for America, http://www.ngvc.org/about_ngv/index.html, accessed July 2009.

[34] Ayala, Alberto, N. Kato, R. Okamoto, et al. "CNG and Diesel Transit Bus Emissions in Review," Presentation at the 9th Diesel Engine Emissions Reduction Conference, August 24 - 28, 2003, Newport, Rhode Island, http://www1.eere.energy.gov/vehiclesandfuels/pdfs/deer_2003/session5/deer_2003_ayala.pdf, accessed July 2009.

[35] EPA, "Climate Change: Methane," http://www.epa.gov/methane, accessed July 2009.

[36] EPA, "Greenhouse Gas Impacts of Expanded Renewable and Alternative Fuels Use," http://www.epa.gov/OMS/renewablefuels/420f07035.pdf, accessed July 2009.

Storage and Infrastructure

Many CNG vehicle fueling stations in the United States are owned and operated by private companies and local governments. CNG is stored and distributed in thick-walled cylinders of steel, aluminum, or composite tanks built to last more than 20 years.[37] The infrastructure cost to add CNG to a fueling station varies greatly depending on the amount of CNG fuel required, the amount of fuel stored and the site conditions. CNG stations often require more space than conventional gas stations. [38]

There are three different types of CNG fueling stations. Slow fill CNG stations, which are also called "time fill" stations, usually require eight or more hours for refueling and are used by centrally fueled fleets that return to the yard for multiple hours or overnight. A cascade fast fill system can refuel CNG vehicles in a 30-90 minute period from stored gas. For large vehicle applications, a buffered fast fill has the same filling times as a cascade fast fill, but can refuel large vehicles on a continual basis. The costs for these systems increases from time fill to fast fill and from cascade to buffered systems. Home refueling stations are often time fill and users typically refuel their vehicle overnight. It may take up to 12 hours to get a full tank. These residential or small scale systems can often cost up to $4,000.[39]

Less Distance on a Fuel Tank

A CNG fueled vehicle gets roughly the same fuel economy as a conventional gasoline vehicle on a gasoline gallon equivalent (GGE) basis. A GGE is the amount of alternative fuel that contains the same amount of energy as a gallon of gasoline. However, due to CNG's large tank size, fewer GGEs can fit on a vehicle. This limits the driving range of CNG vehicles when compared to their gasoline and diesel counterparts. Different conversions and dedicated CNG

[37] California Energy Commission, "Consumer Energy Center: Compressed Natural Gas as a Transportation Fuel," http://www.consumerenergycenter.org/transportation/afvs/cng.html, accessed April, 2009.

[38] Gas Equipment Systems, Inc, http://www.cngfuelsystems.com/faqs.asp, accessed July, 2009.

[39] Greencar.com, "Five Things You Need to Know about Natural Gas Stations," http://www.greencar.com/articles/5-things-need-natural-gas-stations.php, accessed July 2009.

vehicles will have different fuel economy ranges. [40] As an example, the driving range of the dedicated CNG 2009 Honda Civic GX sedan is less than 250 miles.[41]

Tank technology improvements are increasing the distance vehicles can run on CNG. Tanks made with kevlar are lighter than those made from steel. With lighter tanks, more of them can be fit on vehicle roofs, therefore increasing the amount of miles a vehicle can travel before refueling. The lighter tanks are one of the main reasons that El Paso's transit agency, Sun Metro, is switching its LNG buses to CNG.[42]

CNG Vehicle Costs and Availability

CNG vehicles cost more than traditionally fueled vehicles. A light-duty CNG vehicle can be $1,500 to $6,000 more than a gasoline vehicle. Currently, the Honda Civic GX sedan is the only manufactured light duty CNG vehicle available. Heavy-duty trucks and buses can cost $30,000 to $50,000 more than a diesel vehicle. [43]

It is possible to retrofit or convert some vehicles to run on CNG. Currently, a limited number of U.S. vehicles and companies are certified for CNG conversions. Each conversion must meet stringent Environmental Protection Agency (EPA) standards and/or California Air Resources Board (CARB) requirements. The cost of converting a vehicle to run on natural gas includes the emissions performance data, electronics, fuel tanks, tubing/brackets, and the installation. The type of conversion and the fuel capacity needed can significantly influence the cost since CNG cylinders are expensive. These costs plus receiving the certifications can cost up to $50,000. [44]

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[40] DOE, Energy Efficiency and Renewable Energy, "Alternative and Advanced Fuels: CNG and LNG," http://www.afdc.energy.gov/afdc/fuels/natural_gas_cng_lng.html, accessed July, 2009.

[41] Automedia.com, "Review of the 2009 Honda Civic GX," http://www.automedia.com/2009_Honda_Civic_GX/rts20090401hc/1 , accessed July, 2009.

[42] Bunce, Kevin, Fleet Manager, Sun Metro, personal communication, July 9, 2009.

[43] Maryland Energy Administration, "Straight Answers on Alternative Fuels," October, 2006, http://www.energy.maryland.gov/incentives/transportation/factsheets/Natural_Gas.pdf, accessed July 2009.

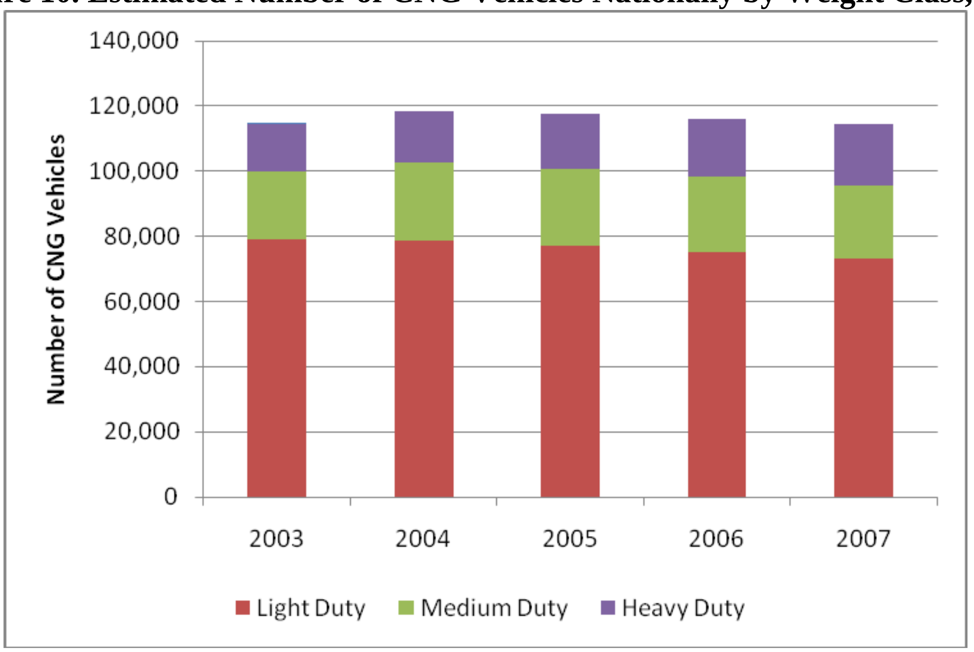
[44] Natural Gas Vehicles for America, "Frequently Asked Questions About Converting Vehicles to Operate on Natural Gas," http://www.ngvamerica.org/pdfs/FAQs_Converting_to_NGVs.pdf, accessed July 2009.

TARGET FLEET

As depicted in Figure 10, most CNG vehicles are light duty. In 2007, light-duty models compromised almost 64% of the national CNG fleet, while medium and heavy-duty percentages were 20% and 14% respectively. Since 2003, the percentage of light duty CNG vehicles has declined slightly while the proportion of heavy-duty vehicles has marginally increased. Pick up trucks, followed by compact cars, compromise the largest portion of light-duty models. Buses account for the largest share of heavy-duty CNG vehicles. CNG buses are common among transit agencies.

From a fuel consumption standpoint, transit and school buses dominate the proportion CNG fuel consumed from heavy-duty vehicles. In 2007, these buses accounted for 73% of all CNG fuel consumption used in heavy-duty applications, which account for most CNG usage. The entire light-duty CNG market accounted for only 15% of its CNG fuel consumption. [45]

Figure 10. Estimated Number of CNG Vehicles Nationally by Weight Class, 2003-2007



Source: DOE, Energy Information Agency, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed July, 2009.

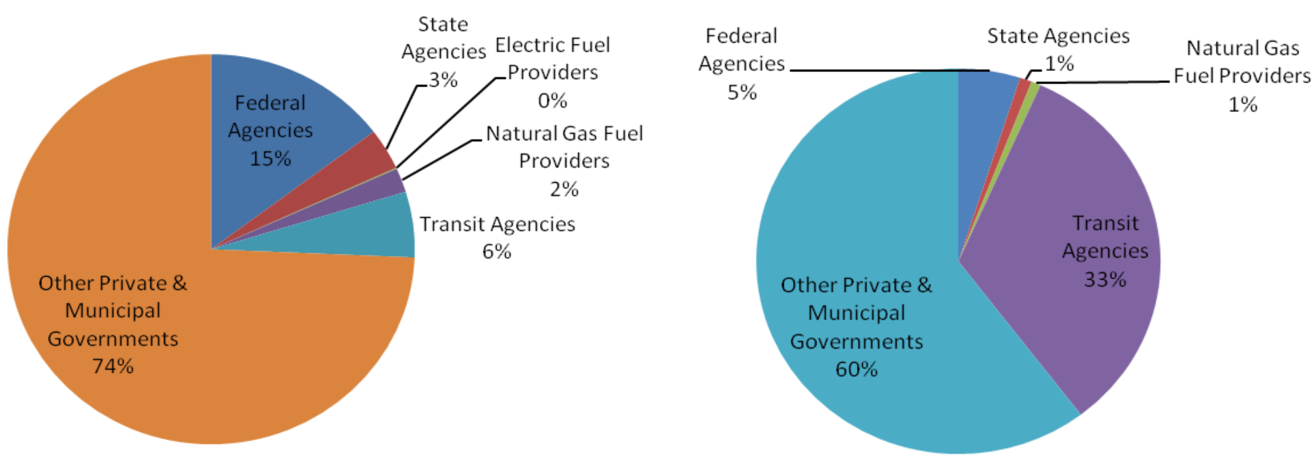
[45] DOE, Energy Information Agency, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed July, 2009.

Most CNG vehicle users are either local government agencies or private businesses, which accounted for 68% of CNG vehicles used in 2007. Nationally, federal and state agencies compromised approximately 16% of the CNG vehicles in use and transit agencies accounted for only 8%. However, fuel consumption for transit far outweighs its small CNG vehicle inventory. U.S. transit agencies used more than half of all CNG fuel in GGE. Municpal and private entities consumed only a third of the national CNG consumption in 2007.

In Texas, local government agencies and private businesses compromise a larger percentage of CNG vehicles in use than at the national level. Figure 11, shows the percentage of CNG vehicles in use and CNG fuel consumption by user group in Texas. Federal and state agencies compromise 18% of the CNG vehicles in use, but use only 6% of the CNG fuel. While transit compromises only 6% of the CNG vehicles in use, the fleet consumes a disproportionately large percentage of CNG at 33% of the Texas consumption. [46] Presumeably, the CNG transit buses are then better able to take advantage of CNG's low cost per GGE and optimize their capital investments in CNG vehicles and fueling infrastructure.

Figure 11. Texas Percentage of CNG Vehicles and Consumption by User Group, 2007

Percentage of CNG Vehicles in Use ***Percentage of CNG Fuel Consumption by GGE***



Source: DOE, Energy Information Agency, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed July, 2009

[46] DOE, Energy Information Agency, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed July, 2009.

Approximately 60% of the national CNG fleet is comprised of non-dedicated engines. However, these dual fuel vehicles account for merely 16% of CNG fuel consumed (by GGE). Most CNG trucks and automobiles have non-dedicated engines. In 2007, more than 90% of CNG buses were dedicated. Since CNG buses account for a large percentage of CNG fuel consumption, more than 84% of CNG fuel use was accounted for by dedicated engines. [47]

CNG FUELING STATIONS IN TEXAS

There are currently 18 compressed natural gas fueling stations in Texas. Stations are listed by location in Table 6, and Figure 12 depicts the statewide locations. While most CNG stations are listed as public, they are set up primarily to serve government fleets and are frequently located at government facilities. More than half are operated by Clean Energy, a private company.

Most fueling stations are located in and around the Dallas-Fort Worth area. Figure 13 shows a detailed map of stations in the area. Both airports (DFW and Love Field) have a CNG station along with the City of Irving, and Fort Worth Transportation Authority. Dallas is also home to BAF Technologies which converts vehicles to CNG. The City of Dallas has a fleet of approximately 173 CNG vehicles. Despite reports that the City has experienced some issues with their vehicles, they ordered more light-duty CNG vehicles in 2008.[48]

Table 7. CNG Fueling Stations in Texas

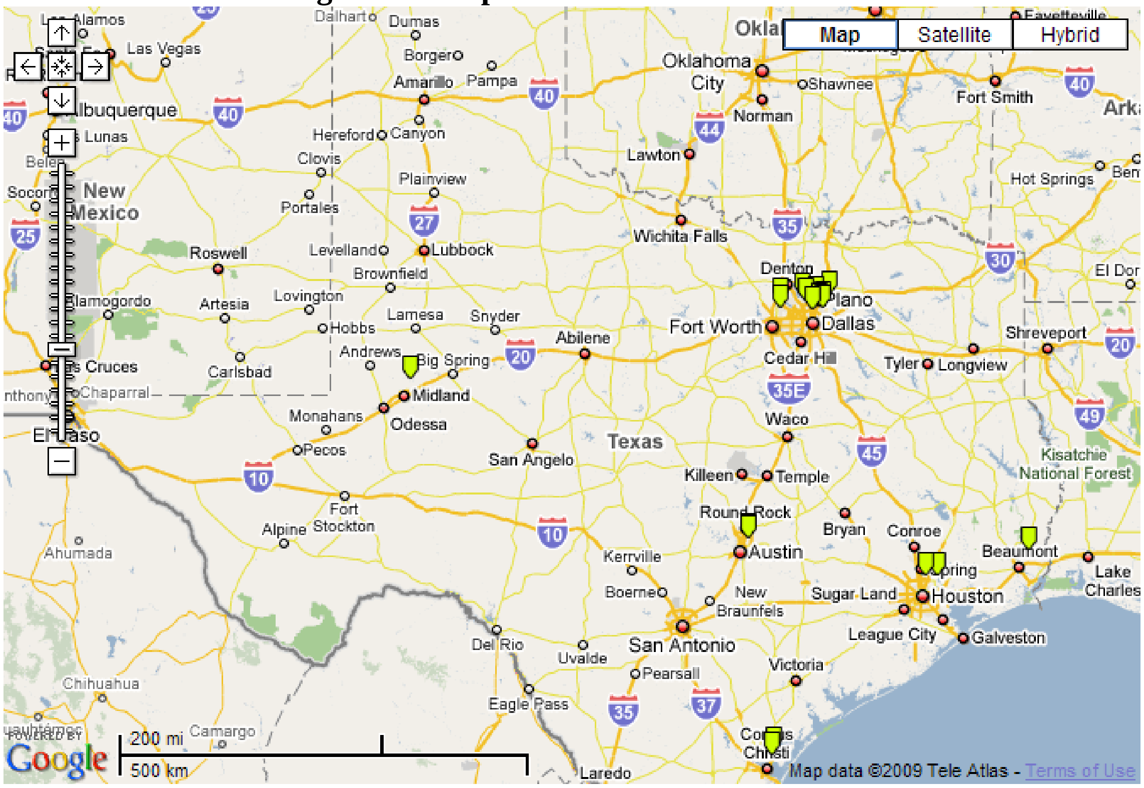
Metro Area	Available to Public	Private Fleets Only	Planned
Austin	1	1	
Beaumont	1		
Corpus Christi	1		1
Dallas-Fort Worth	9	1	
Houston	2		
Midland	1		
Total	**15**	**2**	**1**

Source: Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/stations/advanced.php. Data current as of April 8, 2009.

[47] DOE, Energy Information Agency, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed July, 2009.

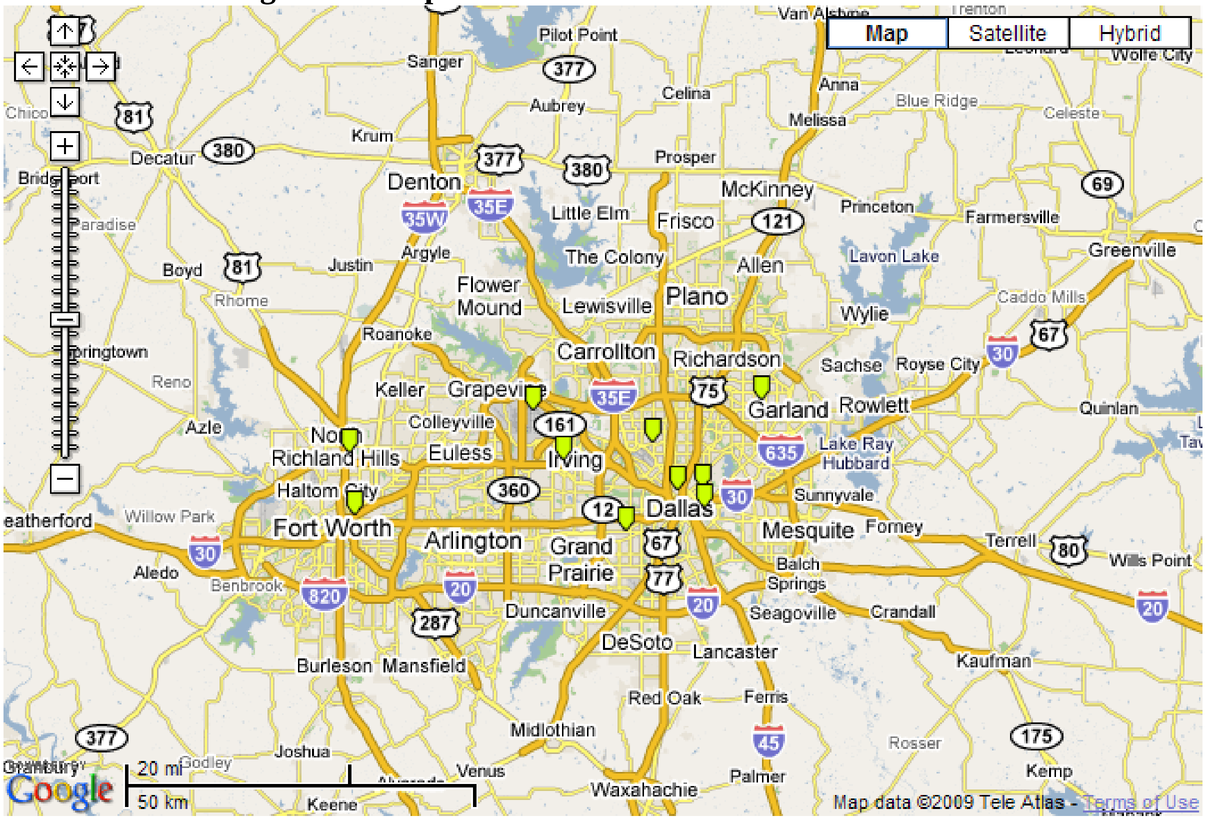
[48] Stevens, Barry, "The Time is Right for Compressed Natural Gas Vehicles," Dallas Business Journal, July 25, 2008.

Figure 12. Map of CNG Stations in Texas



Source: Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/stations/advanced.php. Data current as of April 9, 2009.

Figure 13. Map of CNG Stations in Dallas-Fort Worth



Source: Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/stations/advanced.php. Data current as of April 9, 2009.

CNG STATION DEPLOYMENT STRATEGY

CNG works best with a centrally fueled fleet where longer refueling times at set locations do not pose a problem. Transit agencies have a good history with CNG, although some transit agencies have turned to other environmental fuels or approaches. Houston's METRO is using hybrid buses and San Antonio's VIA Metropolitan Transit system is using propane. Nonetheless, El Paso's Sun Metro transit system is transitioning its LNG buses to CNG. The primary reason for the switch is that CNG is cheaper to run and newer, lightweight CNG tanks allow the buses to carry more fuel.

The Houston area has a large number of short-haul fleets serving the Port of Houston, distribution centers and area businesses. The area has a well-known business leader using CNG in their vehicles. Price, reliability, maintenance benefit and positive image are some of the reasons that Silver Eagle Distributors have touted CNG as a transportation fuel. The company is the largest distributor for Anheuser-Busch. Silver Eagle completed an 18 month evaluation of CNG converted trucks and plans to expand CNG usage, subject to grant funding.[49]

While the city boasts two fueling centers, an economic and market study could determine if Houston could be a promising location for further deployment of CNG fueling stations. A study could assess whether the capital cost barriers to CNG can be overcome with incentives for certain industries and how many CNG vehicles could be necessary to support fueling station. Grant funds can be an important motivator for CNG usage and a market study could help determine the strategic usage of funds for spurring more CNG usage in Houston.

While CNG fueling stations are currently located in urban areas close to large fleets, the location of future fueling sites may change with advancements in bio-methane. With more development, landfills, sewage and agricultural waste could become economical and reliable sources of fuel for CNG vehicles. These renewable fuel sources are typically outside urban centers and could either serve local fleets or be transported at a greater expense to other areas.

[49] Corson, Stan. Fleet Manager, Silver Eagle Distributors, presentation to the Alamo Area Council of Governments Advancing the Choice event, August 12, 2008, http://www.aacog.com/cleancities/program/advancingthechoice.asp, accessed July 2009.

5. ETHANOL (E85)

Ethanol is a renewable fuel produced from crops such as corn, sugar-cane, sorghum, wheat, or even cornstalks. Ethanol is mixed with gasoline at various levels because its low volatility can make cold starts difficult.[50] Low level blends contain up to 10% ethanol, or E10. These low levels of ethanol are added to almost half the nation's gasoline in order to boost octane levels, decrease carbon monoxide emissions and comply with the renewable fuel standard. No vehicle modifications are needed for gasoline vehicles to use E10 or less. The EPA is currently assessing whether intermediate blends of ethanol, E15 to E20, should be approved for standard motor vehicles.[51] Low levels of ethanol are not classified as an alternative fuel under the Energy Policy Act of 1992.

Fuel blends with 85% ethanol, called E85, are classified as an alternative fuel. Vehicles must be designated and designed a Flexible Fueled Vehicle (FFV) to use E85. An estimated eight million FFVs are in operation, but many owners may not be aware that they own one. FFV are primarily light duty vehicles and are available in most vehicle classes, although American made SUVs, trucks and minivans seem to the most common FFVs available. Vehicle owners can look up whether their vehicle is a FFV on DOE's website or check the label inside the fuel door. [52]

National E85 usage and the number of FFVs in use have steadily increased in recent years. As depicted in Figure 14, E85 consumption and the number of FFVs in use are closely linked and have more than doubled in the five year period. It should be noted that the number of FFVs in the figure reflect the number of vehicles using E85 and not all of vehicles that are capable of using the fuel. In 2007, Texas consumed more than 2.6 million GGEs of E85 and used the fuel in more than 18,000 FFVs. While Texas E85 and FFV usage accounted for almost

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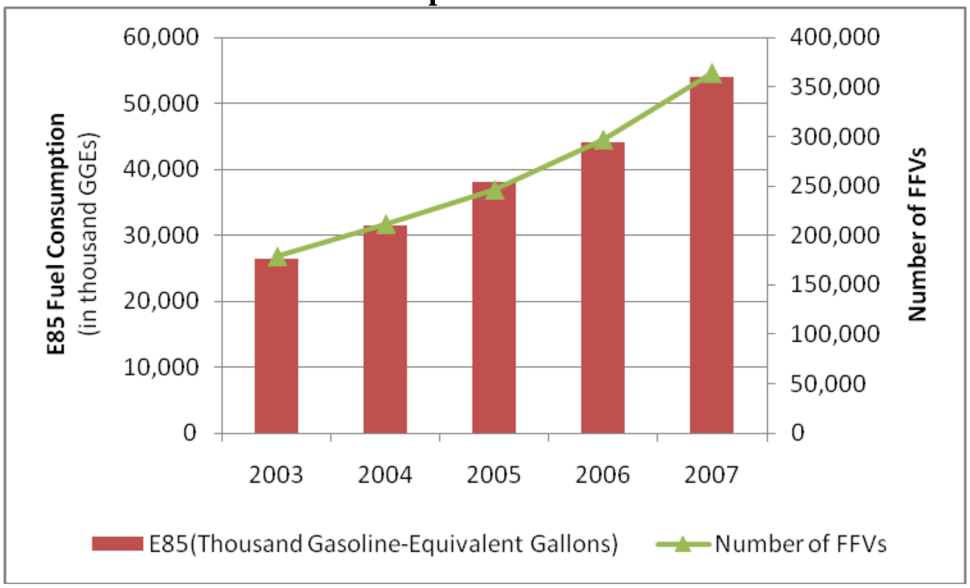
[50] Growth Energy, "E85: Frequently Asked Questions," http://www.e85fuel.com/e85101/questions.php, accessed July, 2009.

[51] DOE, Alternative Fuels and Advanced Vehicles Data Center, "Ethanol Blends," http://www.afdc.energy.gov/afdc/ethanol/blends.html, accessed July 2009.

[52] DOE, Alternative Fuels and Advanced Vehicles Data Center, "Flexible Fuel Vehicles," http://www.afdc.energy.gov/afdc/vehicles/flexible_fuel.html, accessed July 2009.

5% of national usage, the state only had 32 stations or less than 3% of all E85 stations nationwide.[53]

Figure 14. National E85 Fuel Consumption and Flexible Fuel Vehicles in Use



Source: DOE, Energy Efficiency and Renewable Energy, "Data, Analysis and Fuels, 2007," http://www.afdc.energy.gov/afdc/data/#www.afdc.energy.gov/afdc/data/ , accessed July, 2009.

E85 LIMITATIONS AND OPPORTUNITIES

Ethanol has several advantages over other alternative fuels. Flex fuel vehicles are easily available. Government mandates encourage E85 production and use and the fuel provides a largely domestically grown energy source for reducing greenhouse gas emissions. The downside of the fuel is that it contains less energy per gallon and costs more than gasoline when compared on a gasoline equivalent basis.

E85 Vehicles

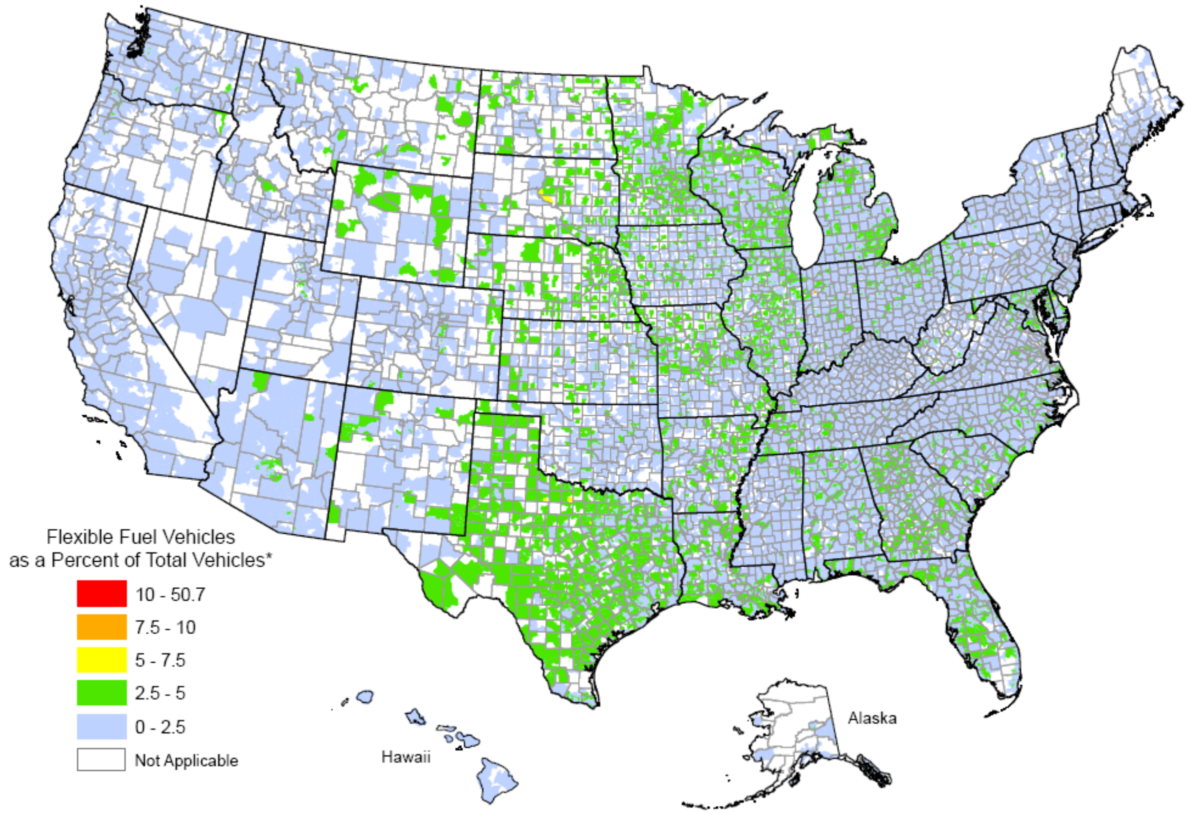
For the light duty market, there are more vehicles capable of using E85 than any other alternative fuel. Often there is no extra cost for the flexible fuel capability. As previously stated, more than 8 million FFVs are on the road today, but only a fraction of these vehicles actually use the fuel. Often education and fuel availability are the barriers to E85 usage. Many vehicle

[53] DOE, Energy Efficiency and Renewable Energy, "Data, Analysis and Fuels, 2007," http://www.afdc.energy.gov/afdc/data/#www.afdc.energy.gov/afdc/data/ , accessed July, 2009.

owners with FFVs may not even know their vehicle is capable of using the fuel or where to buy the fuel.

Texas has a large percentage of FFVs. Figure 15 shows the percentage of FFVs from the total number of non-diesel vehicles by zip code. As shown by the green color, many areas in the state have approximately 2.5 to 5% FFVs in their gasoline vehicle fleet.

Figure 15. Flexible Fuel Vehicle Registrations by Zip Code, 2006



Source: National Renewable Energy Lab, November 2006, http://www.afdc.energy.gov/afdc/pdfs/ffv_zip.pdf, accessed July 2009.

Energy Balance and Imported Oil

There has been much debate about whether the energy required to produce ethanol is greater than the energy it provides as a transportation fuel. The DOE maintains that ethanol has a positive energy balance and that ethanol provides a third or more energy than what is required to produce it.[54] Per btu provided at the pump, corn ethanol uses 0.74 btu from fossil fuels in the

[54] DOE, Energy Efficiency and Renewable Energy, "Ethanol Myths and Facts," http://www1.eere.energy.gov/biomass/ethanol_myths_facts.html, accessed July 2009.

production of the fuel. Cellulosic ethanol is much more efficient and consumes less than 0.10 btu from fossil sources per btu available at the pump. [55]

Ethanol is largely domestically produced and can therefore help displace imported oil. For example, a full-size FFV truck using E85 for 11,000 miles would save approximately 477 gallons of gaoline annually.[56] Most of the ethanol used domestically comes from corn crops. The U.S. is the largest ethanol producer in the world.[57]

E85 Emissions

In general, E85 either reduces or does not increase most pollutants. FFVs must meet the same emissions standards as their gasoline counterparts so there is no increase in emissions for criteria pollutants. E85 is known to reduce greenhouse gas (GHG) emissions, carbon monoxide emissions and benzene, which is an air toxic and known human carcinogen. Ethanol's emissions are impacted by the feedstock used to create the fuel and production processes. For example, compared to gasoline on a btu basis, the EPA found that corn ethanol reduces GHG emissions by 21.8%, sugar ethanol has a 56% reduction and cellulosic ethanol reduces these emissions by 90.9%.[58] There is also evidence that E85 reduces NOx, PM, and 1, 3 butadiene, which is also an air toxic. Since E85 is less volatile than gasoline, evaporative emissions from fuel tanks and fuel lines are also reduced. However, use of E85 does pose a pollutant trade off for methane and some air toxics. Formaldehyde, acetaldehyde and methane emissions have all increased with E85 usage.[59]

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[55] DOE, Energy Efficiency and Renewable Energy, "Handbook for Handling, Storing and Dispensing E85," April 2008, http://www.afdc.energy.gov/afdc/pdfs/41853.pdf**,** accessed July 2009.

[56] DOE, Energy Efficiency and Renewable Energy, "Handbook for Handling, Storing and Dispensing E85," April 2008, http://www.afdc.energy.gov/afdc/pdfs/41853.pdf**,** accessed July 2009.

[57] U.S. EPA, SmartWay Grow and Go, "E85 and Flex Fueled Vehicles," http://www.epa.gov/smartway/growandgo/documents/factsheet-e85.htm, accessed July 2009.

[58] EPA, "Greenhouse Gas Impacts of Expanded Renewable and Alternative Fuels Use," http://www.epa.gov/OMS/renewablefuels/420f07035.pdf, accessed July 2009.

[59] DOE, Energy Efficiency and Renewable Energy, "E85 Emissions," http://www.afdc.energy.gov/afdc/vehicles/emissions_e85.html, accessed July 2009.

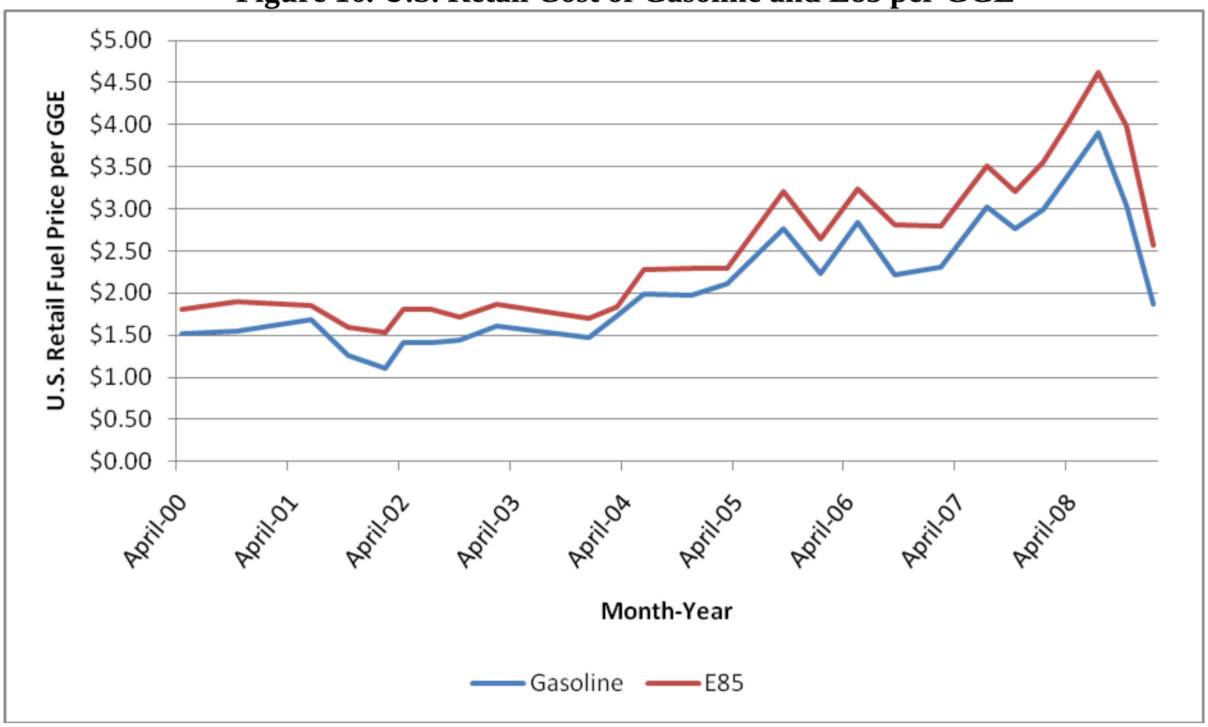
Less Distance per Gallon

E85 has less energy than gasoline and reduce fuel economy by 20-30%. This means that users of E85 must refuel more often, which affects the fuel's cost per gallon.[60]

Cost of E85

At the retail level, E85 is often priced similarly or lower than gasoline on a per gallon basis. However, E85 reduces fuel economy by 20-30%, so it is difficult for customers to compare the true cost of E85 on a btu or gasoline equivalent basis. While the price is often lower, on a GGE basis, E85 usually costs more, as depicted in Figure 16.

Figure 16. U.S. Retail Cost of Gasoline and E85 per GGE



Source: DOE, Energy Efficiency and Renewable Energy, "Data, Analysis and Fuels, 2007," http://www.afdc.energy.gov/afdc/data/#www.afdc.energy.gov/afdc/data/ , accessed July, 2009

Storage and Infrastructure

Several key barriers to storage, use and infrastructure have been removed in the past five years. In 2006, EPA clarified when Stage II gasoline vapor recovery equipment would be required for new E85 pumps. The next year, Underwriters Laboratory, Inc. established

[60] DOE, Energy Efficiency and Renewable Energy, "Handbook for Handling, Storing and Dispensing E85," April 2008, http://www.afdc.energy.gov/afdc/pdfs/41853.pdf, accessed July 2009.

standardized testing procedures for E85 dispensors, which further provided confidence that the risks associated with selling E85 could be overcome. Lastly, several federal incentives were established to mitigate some of the initial capital costs required.[61]

Getting E85 to the fueling structure cost effectively is often a challenge for ethanol. Ethanol is often grown and produced in the midwest region of the nation and then is trucked, barged or shipped by rail to where it is consumed. Pipelines are the cheapest form of transport but are largely unavailable for E85. Current pipelines are incompatibly located for ethanol's needs and the fuel can corrode pipes and affect fuel quality by releasing accumulated deposits from pipeline walls.[62] Texas has several ethanol plants located in the panhandle that minimize the extensive transport needs to get the fuel to refueling stations.[63]

Unlike nonrenewable alternative fuels, E85 fuel dispensing stations only require minor modifications to accommodate E85 fuel. Gasoline and diesel fuel storage and dispensing equipment is similar to the equipment used for alcohol-based fuels. However, certain types of materials that are commonly used with gasoline should be avoided for E85. For example, soft metals such as zinc, brass, lead, aluminum should be avoided and only E85-compatible materials should be used in ethanol storage and dispensing systems. For this reason, the ease of retrofitting existing fuel infrastructure for E85 use will vary on the specific existing equipment. Tanks previously used for storing other types of fuel may be used for E85 if the tank is properly cleaned. Any remaining debris will result in contaminated fuel.

For ozone nonattainment areas classified as serious, severe, or extreme, fuel dispensers for E85 must contain Stage II vapor recovery systems. For Texas, only Houston-Galveston-Brazoria meets this classification.

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[61] DOE, Energy Efficiency and Renewable Energy, "Handbook for Handling, Storing and Dispensing E85," April 2008, http://www.afdc.energy.gov/afdc/pdfs/41853.pdf, accessed July 2009.

[62] DOE, Energy Efficiency and Renewable Energy, "Ethanol Distribution," http://www.afdc.energy.gov/afdc/ethanol/distribution.html, accessed July 2009.

[63] Renewable Fuels Assocation, "Biorefinery Locations," http://www.ethanolrfa.org/industry/locations/, accessed July 2009.

E85 has different fire safety practices than those used for gasoline. The techniques used to control an ethanol fire are different than those used for gasoline. For this reason, local fire marshals should be notified and consulted when new fueling stations are being developed.[64]

E85 TARGET FLEET

E85 is used primarily in light-duty or medium-duty vehicles. While the proportion of medium duty vehicles is growing among FFVs, in 2007 approximately 96% of FFVs in use were light duty vehicles. With one lone exception, all E85 vehicles are dual fuel or capable of running on traditional fuels. A few flex-fuel diesel vehicles are capable of using E95 (a blend of 95% fuel ethanol and 5% gasoline), but these fuels are incapable of using E85. E95 flex fuel vehicles are very rare.

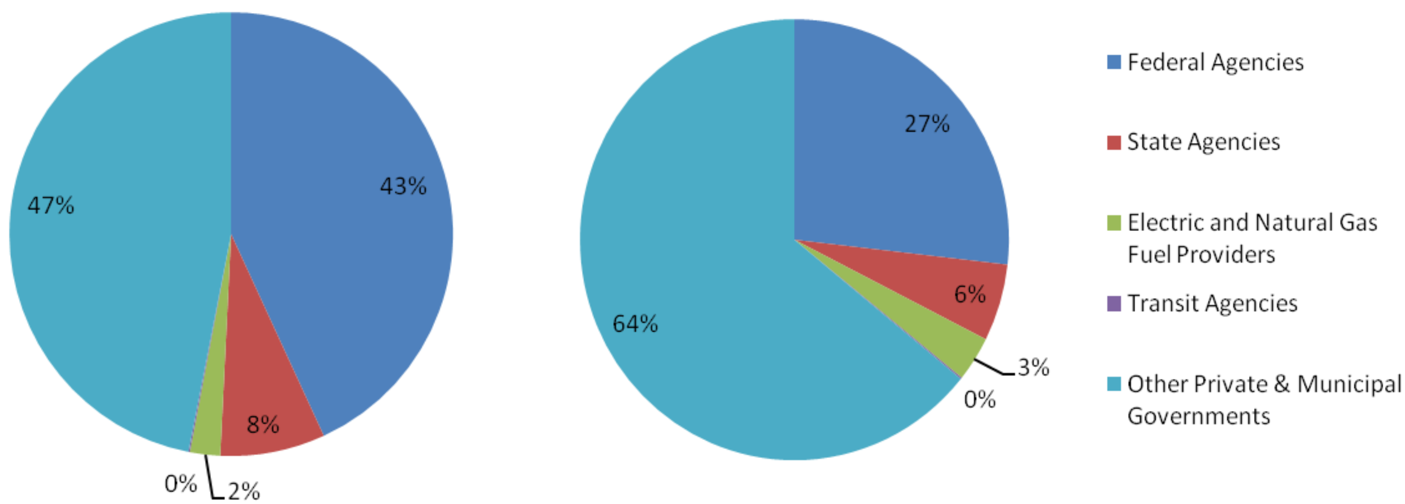
Virturally all FFVs are originally manufactured vehicles. Converting existing vehicles to run on E85 requires an extensive process and is very costly. Modifications to fuel system materials and components, such as the fuel pump, fuel injectors and electronic engine control system make conversions complicated and extremely costly. All conversions must also be tested and approved by EPA. There are no FFV converters listed on DOE's website.

FFVs using E85 are owned and operated primarily by private companies and municipal governments. Figure 17. depicts the proportion of FFVs using E85 and E85 fuel consumption by user group in Texas during 2007. Almost half of all FFVs using E85 are owned by municipalities and private businesses. While they account for 47% of the vehicles, they consumed approximately 64% of the fuel. In contrast, federal entities owned 43% of the FFVs using E85 but only consumed 27% of the fuel. This chart does not include public consumption of E85.

[64] DOE, Energy Efficiency and Renewable Energy, "Handbook for Handling, Storing and Dispensing E85," April 2008, http://www.afdc.energy.gov/afdc/pdfs/41853.pdf**,** accessed July 2009.

Figure 17. Texas Percentage of FFVs Using E85 and Consumption by User Group, 2007

Percentage of FFVs Using E85 *Percentage of E85 Consumption by GGE*



Source: DOE, Energy Efficiency and Renewable Energy, "Data, Analysis and Fuels, 2007," http://www.afdc.energy.gov/afdc/data/#www.afdc.energy.gov/afdc/data/ , accessed July, 2009

E85 FUELING STATIONS IN TEXAS

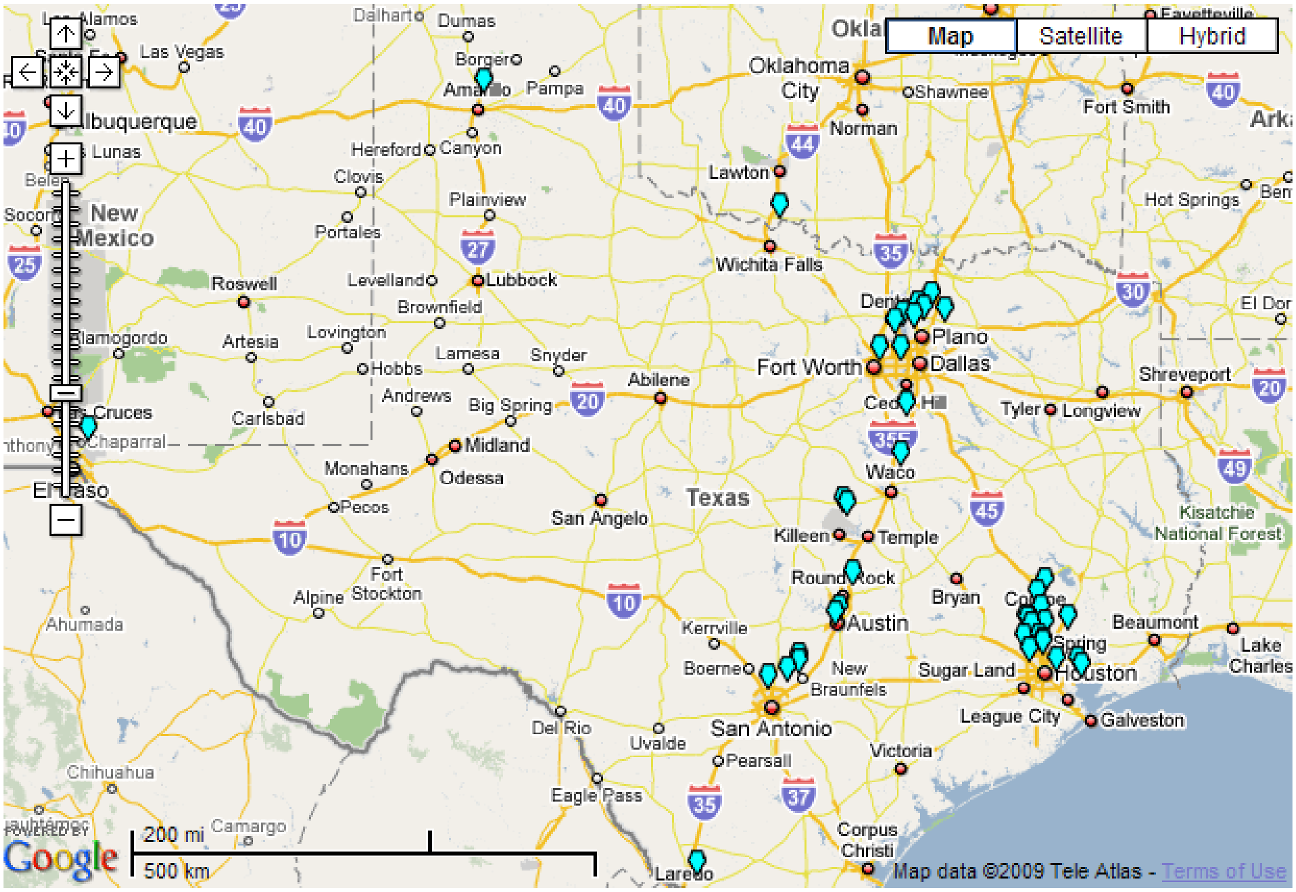
There are 39 ethanol fueling stations in Texas and two that are in the planning stages. Most of these stations (33) are open to the public. Half of the private fueling stations are operated for air force bases and the other three are for Fort Bliss, Johnson Space Center and the Pantex plant in Amarillo. Table 7 lists the locations of stations and Figure 18 maps their locations.

Table 8. Ethanol E85 Stations in Texas

Metro Area	Available to Public	Private Fleets Only	Planned
Austin	3		
Dallas-Fort Worth	9		
Houston	12	1	
San Antonio	2	2	
Rural or Other	7	3	2 (Fort Hood, Hillsboro)
Total	**33**	**6**	**2**

Source: Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/stations/advanced.php. Data current as of April 9, 2009.

Figure 18. Ethanol E85 Stations in Texas



Source: Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/stations/advanced.php. Data current as of April 9, 2009.

E85 STATION DEPLOYMENT STRATEGY

The ethanol industry has been hurt lately by high corn prices, low oil prices and the economic downturn. Several corn ethanol plants have become bankrupt in the last few years.[65] However, all alternative fuels are affected by shrinking budgets and E85 as an alternative fuel has several key advantages. E85 is bolstered by the renewable fuel standard and alternative fuel fleet mandates. Mandates on government fleets have strengthened by focusing on fuel usage and performance measures, and these fleets are often looking for viable options for alternative fuel options. E85 FFVs offers many advantages over other alternative fuels in that they are readily

[65] Weaver, Michael, "Ethanol Industry Financing Challenges Continue," August 2009, Ethanol Producer Magazine, http://ethanolproducer.com/article.jsp?article_id=5822, accessed July 2009

available, do not cost much more than non-FFVs and have the flexibility to use gasoline when E85 is not available. For this reason, government fleets subject to alternative fuel mandates often see E85 as an attractive option. However, with only 41 stations statewide, E85 fueling infrastructure likely is not sufficient for the supply. For example, TxDOT has approximately 1,100 E85 FFVs, but often cannot use the fuel because of refueling availability.[66]

One promising sign indicating E85 stability is its transition into the mainstream retail fuel market. Unlike many other alternative fuels that are often owned by either a government entity or a company providing the fuel, E85 stations in Texas are often owned by grocery stores such as Kroger and HEB. All but one E85 station in the Dallas-Fort Worth area is located at a Kroger store. All public stations in Houston are located at a major grocery store.

There are several Texas locations noticeably lacking in E85 fueling options. DOE fuel waiver data for Texas shows that Austin, Dallas and Houston are areas where federal fuel waivers are commonly sought for E85.[67] Major metropolitan markets and transporation corridors have few, if any options. San Antonio has only two public stations and El Paso has none. Austin, which is an environmental market, has only three stations. While the I-35 corridor has some stations, other highways have few, if any options.

The I-10 corridor would be a good target for providing the fuel to the western parts of the state. The Clean Cities Program is looking at ways to make I-10 a clean corridor where alternative fuels and idle reduction technologies are available. The expected growth in automobile and truck travel is expected to reach 62% and 118% respectibly along the corridor.[68] E85 stations along I-10 would help make that vision a reality. Since the panhandle has several ethanol plants, I-27 from Amarillo to Lubbock may be another good option.

Growth in E85 stations should also be complemented with public outreach and education. Many owners of FFVs may not know they can use the fuel or know where to find a station. TxDOT played an important role in preventing litter through its nationally recognized "Don't

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[66] Lewis, Don, TxDOT Fleet Manager, personal communication on July 23, 2009.

[67] DOE, Alternative Fuels and Advance Vehicles Data Center, "Data, Analysis and Trends: Federal Fleets," http://www.afdc.energy.gov/afdc/data/fleets.html, accessed June 2009.

[68] Hudgins, Andrew, Clean Cities Transportation Coordinator, "Clean Cities Spotlight: The I-10 Clean Corridor Project," Presentation to the Advancing the Choice event, June 18, 2008, http://www.houston-cleancities.org/ATC_08/Andrew%20Hudgins,%20San%20Antonio%20Clean%20Cities.pdf, accessed July 2009.

Mess with Texas" campaign. The agency could play a similar role in educating consumers about the advantages and proper use of E85 fuel. Fuel providers are also an important audience for spurring more E85 stations. There are several good resources for retailers provided by DOE on how to assess whether a fuel station is a good candidat for the inclusion of E85 capabilities.[69]

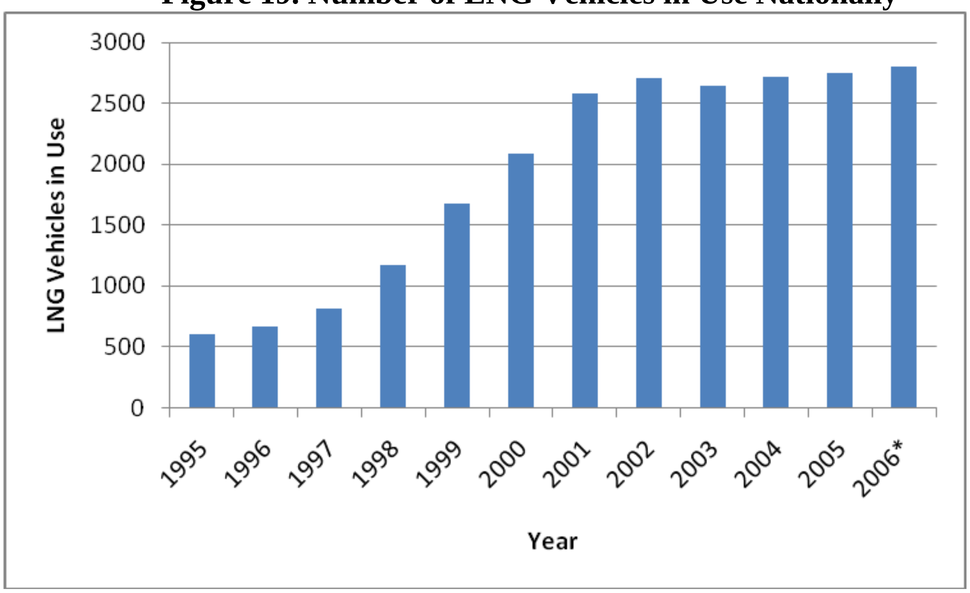
[69] Johnson, C. and M. Melendez, National Renewable Energy Laboratory, "E85 Retail Business Case: When and Why to Sell E85," December 2007, http://www.afdc.energy.gov/afdc/pdfs/41590.pdf, accessed July 2009.

6. LIQUEFIED NATURAL GAS

Liquefied natural gas (LNG) is created by cooling natural gas to -260 degrees Fahrenheit to a clear, colorless, and odorless liquid. The liquefaction process removes most of the water vapor, butane, propane, and other trace gases, that are included in ordinary natural gas. The resulting LNG is usually more than 98% pure methane (CH_4) with only small amounts of other hydrocarbons. The liquid form is denser than natural gas or CNG and requires much less space for the same amount of energy. Natural gas travels overseas in LNG form due to its economical storage space needs.[70]

LNG is considerably less prevalent as a transportation fuel than CNG. In 2006, national estimates of LNG vehicles in use were slightly less than 2,800 vehicles consuming 23 million gasoline gallons equivent (GGE). As depicted in Figure 19, the number of LNG vehicles in use rose dramtically in the late 1990's and have plateaued since 2001. In 2007, Texas had an estimated 411 LNG vehicles consuming almost 5 million GGE.

Figure 19. Number of LNG Vehicles in Use Nationally



*2006 numbers are prelimary.
Source: DOE, Energy Information Agency, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed July, 2009.

[70] California Energy Commission, "Frequently Asked Questions about LNG," http://www.energy.ca.gov/lng/faq.html, accesed July, 2009.

Similar to CNG, LNG vehicles require a specialized engine but can also be dual fuel. Dual-fuel vehicles allow users to take advantage of the availability of gasoline/diesel when LNG is not accessible option. Since LNG is stored in specialized fuel tanks, dual-fuel vehicles require two separate fueling systems, similar to CNG's bi-fuel conversion.[71]

LNG LIMITATIONS AND OPPORTUNITIES

LNG shares many of the same opportunities and limitations as CNG. LNG vehicles cost more, approximately $3,500 to $7,000 more than traditional gasoline vehicles. Although conversion kits are available for light-duty vehicles, it is usually not economically feasible.[72] Similar to CNG, LNG can also be seen as a bridge to hydrogen technologies. LNG has a slightly diminished greenhouse gas benefit when compared to CNG, but is still significant at 22.6% when compared with gasoline on an energy equivalent basis.[73]

LNG also shares with CNG the propensity to get less mileage per tank of fuel. The GGE equals about 1.5 gallons of LNG.[74] The driving range of LNG vehicles depends on type of vehicle and conversion. Bi-fuel LNG offers a driving range closer to that of gasoline vehicles. Dedicated vehicles have a much shorter driving range than gasoline.[75] However, Kenworth states their LNG-powered trucks have about the same or greater travel distance on natural gas as their diesel trucks at a comparable diesel fuel amount.[76]

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[71] Co-generation Technologies, "Renewable Energy Technologies," http://www.cogeneration.net/liquefied_natural_gas.htm, accessed July, 2009.

[72] Santa Cruz County Regional Transportation Commission, "Natural Gas Vehicle Factsheet," http://www.commutesolutions.org/ngv.html, accessed July, 2009.

[73] EPA, "Greenhouse Gas Impacts of Expanded Renewable and Alternative Fuels Use," http://www.epa.gov/OMS/renewablefuels/420f07035.pdf, accessed July 2009.

[74] DOE, Energy Efficiency and Renewable Energy, "Alternative and Advanced Fuels: CNG and LNG," http://www.afdc.energy.gov/afdc/fuels/natural_gas_cng_lng.html, accessed July, 2009.

[75] Co-generation Technologies, "Renewable Energy Technologies," http://www.cogeneration.net/liquefied_natural_gas.htm, accessed July, 2009.

[76] Kenworth, "New Kenworth T800 LNG Trucks Help Drayage Fleet with Clean Air Efforts in L os Angeles, Long Beach," http://www.kenworth.com/newspics/T800%20LNG%20TTSI.pdf, accessed July, 2009.

While there are key similarities between CNG and LNG, there are also some key differences in cost per GGE, storage, infrastructure and energy security. These differences often pose additional challenges to LNG projects.

LNG Costs per GGE

LNG costs may differ from CNG depending on the transport of the fuel. CNG can often be provided from utilities through a pipeline. In contrast, LNG often must be trucked to the location or run through a liquefication process at added costs. Sun Metro systems commissioned a study of the cost comparisons between LNG and CNG and found that CNG was the cheaper option for their particular situation.[77]

LNG and Energy Security

Since LNG requires less space per unit than CNG, it is easier to ship and therefore import. LNG imports are expected to increase from 2007-2030, according to the Energy Information Administration.[78] Nonetheless, LNG can also be produced from domestic natural gas through a liquefication process.

Frequent Vehicle Usage

LNG may not be a good fit for vehicles that are not used frequently or regularly. Fuel stored in the vehicle's tank can turn to vapor as the fuel is heated to ambient temperatures. If left in the tank too long, the pressure from gasification can pop off the fuel cap and the vaporized LNG can escape. The same issue can occur during storage.

Storage and Infrastructure

LNG is either trucked to a fueling center or is converted from CNG through a liquefication process. LNG tanks use double-wall construction with insulation between the walls made especially for LNG storage. Large tanks have a low height to width ratio and are

[77] Pasternak, Scott, Principal and Senior Director, R.W. Beck, "Cost-Benefit Analysis for Sun Metro CNG/LNG Supply," April 2009, http://www.elpasotexas.gov/sunmetro/agenda/06-02-09/06020911D.pdf, accessed July 2009.

[78] EIA, "Natural Gas Supply, Disposition and Prices," http://www.eia.doe.gov/oiaf/forecasting.html, accessed July 2009.

cylindrical in design with a domed roof. Smaller tanks are stored in either horizontal or vertical pressure vessels. LNG tanks can be found both above and underground to keep the liquid at a low temperature. Once the gas is at a liquefied state, it must be kept cold (at least below -117 degrees Fahrenheit) or it will revert to a gas. These temperature requirements increase the cost of LNG cylinders.[79] These high storage and infrastructure costs have prevented widespread use of LNG in commercial applications. LNG refueling stations can cost $350,000 to more than $1 million.[80]

LNG TARGET FLEET

LNG fuel systems are typically used in heavy-duty vehicles.[81] In 2007, approximately 88% of LNG vehicles were heavy-duty. This sector also consumed 99% of all LNG fuel. LNG buses alone accounted for 86% of all LNG fuel consumed in 2007.[82]

In Texas, transit agencies, municipalities and private business account for virtually all LNG vehicles and fuel usage in 2007. Noticeably absent both nationally and within the state are LNG usage among state and federal entities. Although transit agencies owned just over half of the state's LNG vehicles, their fuel usage accounted for 63% of the state's share in 2007. CNG useage among transit agencies nationwide exhibited a similar, but more dramatic pattern.[83]

LNG FUELING STATIONS IN TEXAS

Currently there are 4 liquefied natural gas fueling stations located in Texas, as depicted in Figure 20. This is down from seven stations in 2002, but has rebounded from merely two

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[79] Co-generation Technologies, "Renewable Energy Technologies," http://www.cogeneration.net/liquefied_natural_gas.htm, accessed July, 2009.

[80] Idaho National Laboratory, "Natural Gas Technologies: Low-Cost Refueling Station," September 2005, http://www.inl.gov/lng/projects/refuelingstation.shtml, accessed July, 2009.

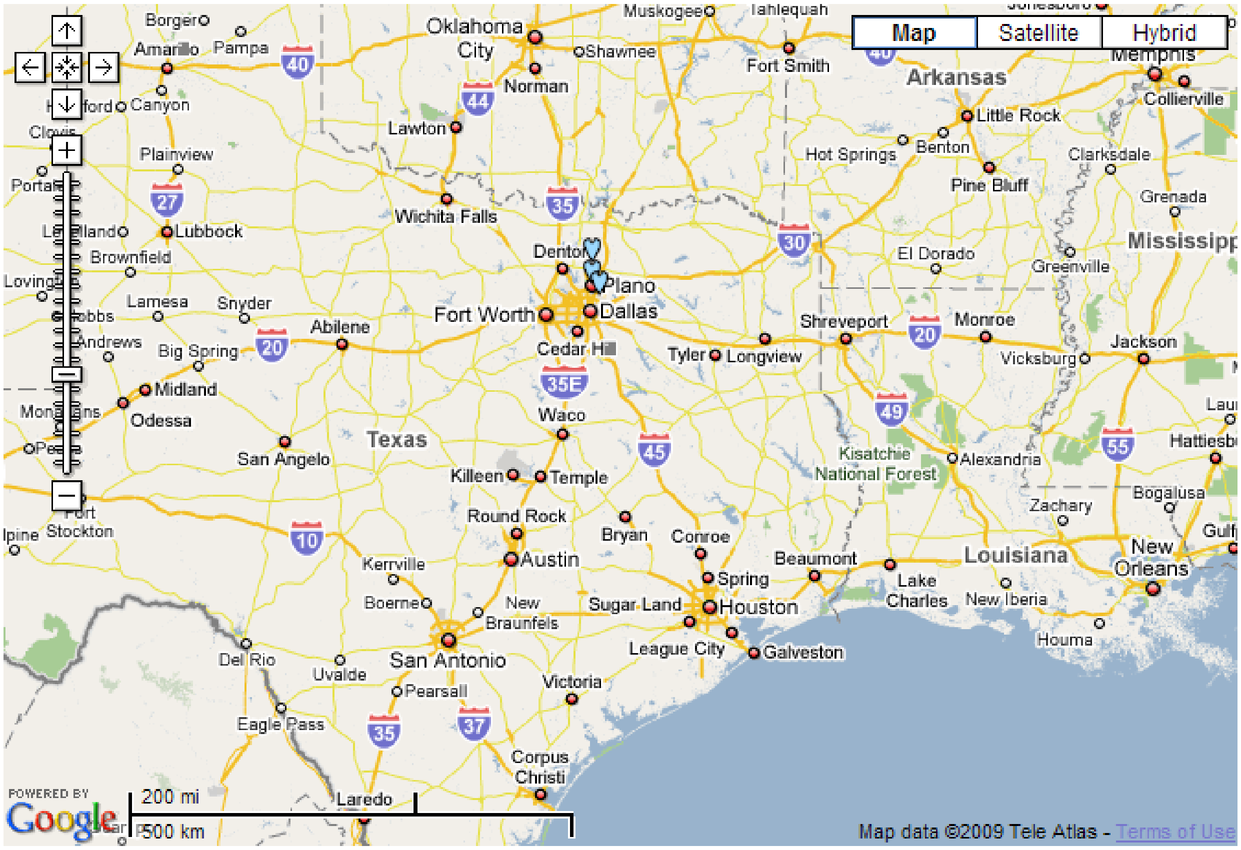
[81] DOE, Energy Efficiency and Renewable Energy, "Alternative and Advanced Fuels: CNG and LNG," http://www.afdc.energy.gov/afdc/fuels/natural_gas_cng_lng.html, accessed July, 2009.

[82] DOE, Energy Information Agency, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed July, 2009.

[83] DOE, Energy Information Agency, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed July, 2009.

stations in 2005. All LNG stations in Texas are privately owned. Three of the four stations are located around Dallas/Fort Worth. These LNG stations are used by the Dallas Area Rapid Transit and Sysco Food Service. There is one LNG station in Houston that is used by HEB.

Figure 20. LNG Stations in Texas



Source: Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/stations/advanced.php. Data current as of April 9, 2009.

LNG STATION DEPLOYMENT STRATEGY

LNG may have few opportunities for Texas when compared to CNG. Transport costs are a major factor that determines the economics of LNG because often the fuel must be produced at a plant and trucked to the location.[84] Texas has one LNG plant in Freeport, Texas and the Port

[84] Yborra, Stephe, Director of Market Analysis, Education & Communications, NGV America, "The Compelling Case for NGVs," presentation to the Alamo Area Council of Governments' Advancing the Choice event, August 12, 2008, http://www.aacog.com/cleancities/program/advancingthechoice.asp, accessed July 2009.

of Houston has LNG onsite to fuel LNG vessels.[85,86] While the Port has the fuel easily available, the fuel may not be option due to the fuel's possible emissions impact. Emissions testing conducted on LNG terminal tractors operating at the Port of Long Beach found that they emitted approximately 21% more NOx than their diesel counterparts. Since Houston is in a nonattainment area for ozone, LNG yard hostlers are not recommended. Given these concerns, it recommended to let the market control the deployment of LNG stations.

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[85] Federal Energy Regulatory Commission, "North American Existing LNG Plants as of May 29, 2009," http://www.ferc.gov/industries/lng/indus-act/terminals/lng-existing.pdf, accessed July 2009.

[86] Professional Mariner, "LNG Work Brings New Tractor Tugs to Texas Seaports," Issue 105, 2007, http://www.professionalmariner.com/, accessed July 2009.

7. PROPANE/LIQUEFIED PETROLEUM GAS

Liquefied petroleum gas (LPG) is often referred to as propane because it is the main component of the fuel. LPG consists of a mixture of propane and other similar hydrocarbon gases. Different batches of LPG have slightly different mixtures of gases. These hydrocarbons are gases at room temperature, but turn to liquid when they are compressed. For this reason, LPG is stored in liquid form under 300 psi of pressure. LPG is a by-product of natural gas processing and crude oil refining, with each compromising roughly half of production. Less than 2% of propane consumption is used for transportation.[87]

LPG consumption has decreased in recent years. Until 2007 when it was eclipsed by CNG, it was the most prevelent alternative fuel. Howver from 2003 to 2007, the consumption of LPG nationally dropped 32%. This drop is mirrored in the number of Texas fueling stations shown in Figure 21. There have been several reasons cited for the decrease in using propane as a transportation fuel: the cost of vehicle conversions and lack of manufactured propane models, the fluctuations in propane prices and the lack of service technicians.[88] Similar to natural gas vehicle, the use of LPG in a vehicle requires either a dedicated or bi-fuel engine.

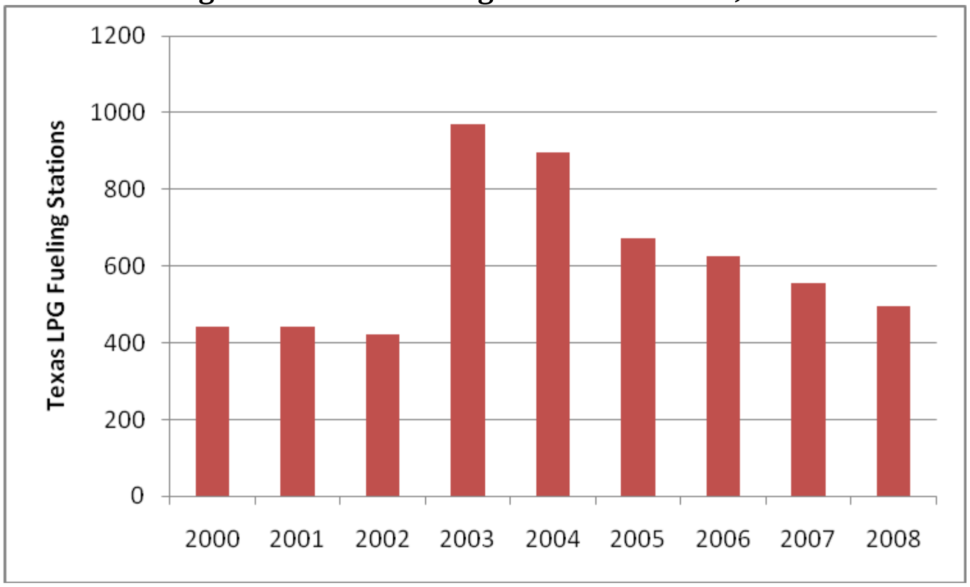
Despite the decrease in LPG as a transportation fuel, Texas is a big user of LPG, presumeably because of the state's refining activities. In 2008, approximately 23% of all LPG fueling stations nationally were in Texas. In 2007, Texas accounted for 20% of national LPG consumption, or more than 31 million gasoline equivalent gallons (GGE).[89] Texas was also home to more than 58,700 LPG vehicles in use in 2007. The state had approximately 37% of the nation's share of LPG vehicles.

[87] DOE, Alternative Fuels and Advanced Vehicles Data Center, "Alternative and Advanced Fuels: Propane," http://www.afdc.energy.gov/afdc/fuels/propane_what_is.html, accessed July 2009.

[88] Propane Education and Research Council, "Propane: Engine Fuel Roadmap," September 2005, http://www.propanecouncil.org/uploadedFiles/propanecouncil/Resources/Industry/Engine_Fuel_Roadmap.pdf, accessed July 2009.

[89] DOE, Energy Information Agency, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed July, 2009

Figure 21. LPG Fueling Stations in Texas, 2000-2008



Source: DOE, Energy Information Agency, "Alternatives to Traditional Transportation Fuels 2007," http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html, accessed July, 2009.

LPG LIMITATIONS AND OPPORTUNITIES

LPG's primary advantage over other alternative fuels is its fueling infrastructure. While decreasing in number, LPG has more fueling stations than any other alternative fuel. Like natural gas and biodiesel, the fuel is primarily domestically produced with some emissions advantages. The fuel has a greater distance per gallon than natural gas, but is similarly affected by challenges with vehicle and conversion costs. Propane is unique among alternative fuels in that it often- but does not always- closely track petroleum or natural gas prices, thereby increasing the unpredictability of its fuel prices. The number of originally manufactured LPG vehicles and conversion kits for sale are also increasingly more limited than for most other alternative fuels.

Distance per Gallon

Propane has one of the highest energy densities of all alternative fuels. However, a gallon of propane has about 25% less energy than a gallon of gasoline.[90]

[90] DOE, Alternative Fuels and Advanced Vehicles Data Center, "Alternative and Advanced Fuels: Propane," http://www.afdc.energy.gov/afdc/fuels/propane_alternative.html, accessed July 2009.

Energy Security

Most LPG is produced domestically, thereby reducing the dependence on foreign oil. Only about 10% of propane is imported into the U.S. [91]

LPG Vehicle Availability

There are no originally manufactured light-duty propane vehicles in the market today. However, aftermarket coversions, such as the Ford F-250 and F-350 propane trucks produced by Roush, are available. Conversions require EPA approval and a licensed propane conversion technician. Vehicles can be equipped to operate on a dedicated conversion (solely on propane) or dual-fuel conversion (switch between propane and gasoline). Propane tanks fit compactly into car trunks. In trucks and vans, propane tanks replace gasoline tanks and often fit under the body of the vehicle. The average cost of conversion of a light-duty vehicle from gasoline to dedicated propane fuel ranges from $4,000 to $12,000. These costs can be paid for over time through lower operating and maintenance costs.[92]

Medium and heavy duty LPG vehicles are available as originally manufactured vehicles or from conversions. Commonly available vehicles include school buses, delivery trucks, street cars and street sweepers.

Price per Gallon

With few exceptions, propane prices are more expensive than traditional fuels and natural gas fuels on a GGE basis. Since 2001, propane has become one of the most expensive alternative fuels, with the occasional exceptions of B100 and E85.

Propane's price fluctuations are also harder to predict. Unlike other alternative fuels, it does not consistently follow gasoline or diesel prices, as can be seen in Figure 22. Propane is a traded commodity that is often benchmarked by the Mont Belvieu propane swap (OPIS on the New York Mercantile Exchange).[93] Propane prices are influenced by crude oil and natural gas

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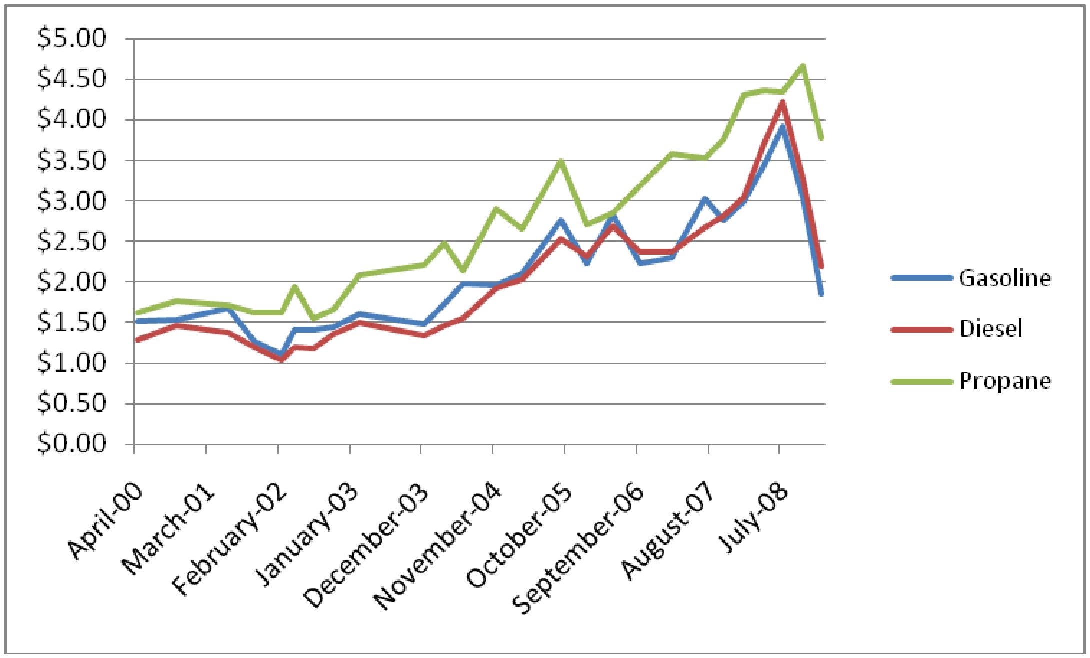
[91] EIA, "Propane Prices: What Consumers Should Know," http://www.eia.doe.gov/bookshelf/brochures/propane/, accessed July 2009.

[92] DOE, Alternative Fuels and Advanced Vehicles Data Center, "Alternative and Advanced Fuels: Propane Vehicle Availability," http://www.afdc.energy.gov/afdc/vehicles/propane_availability.html , accessed July 2009.

[93] Delay, Dale, "A Little Relief," in LP Gas: The Propane Industry's Pricing Pipeline, August 23, 2004, http://www.lpgasmagazine.com/lpgas/article/articleDetail.jsp?id=128666, accessed August, 2009.

prices, seasonal residential demand, petrochemical buying behavior and distance from supply.[94] This fluctuation and unpredictability can deter fleet managers looking for more stable or predictable fuel prices. However, the fuel can compensate for its higher price through engine life and maintenance.[95]

Figure 22. Average U.S. Retail Fuel Prices for LPG, Gasoline and Diesel per GGE



Source: DOE, Energy Efficiency and Renewable Energy, "Data, Analysis and Fuels, 2007," http://www.afdc.energy.gov/afdc/data/#www.afdc.energy.gov/afdc/data/ , accessed July, 2009.

Storage and Infrastructure

LPG is stored in special tanks that keep it under a small amount of pressure (300 psi), so it stays a liquid. The capital structure needed for production, storage, and bulk distribution of propane for traditional uses already exists. The majority of incremental infrastructure costs however, relates primarily to the expansion of the existing network. Existing service station infrastructure used for conventional fuels can be modified to dispense propane. The additional

94 EIA, "Propane Prices: What Consumers Should Know," http://www.eia.doe.gov/bookshelf/brochures/propane/, accessed July 2009.

95 DOE, Alternative Fuels and Advanced Vehicles Data Center, "Alternative and Advanced Fuels: What is a Propane Vehicle," http://www.afdc.energy.gov/afdc/vehicles/propane_what_is.html, accessed July 2009.

cost of adapting a station for propane use is low compared to the requirements for other alternative fuels, such as CNG.[96]

LPG Emissions

LPG emissions are complex and vary among vehicles. While LPG emissions are thought to be cleaner than conventional gasoline, the reductions vary among converted vehicles and manufactured propane vehicles. Generally, manufactured LPG vehicles are thought to be cleaner than converted propane vehicles. Table 8 shows the result of a study conducted by Argonne National Laboratory taking into account emissions from the full fuel cycle. A report from the Alternative Fuels Group found even greater emissions reductions.[97]

Table 9. Lifecycle Emissions of Converted Propane Light-duty Vehicles

Pollutant	Percent Reduced from Gasoline Vehicle
Volatile Organic Compounds (VOC)	0%
Carbon Monoxide (CO)	20% to 40%
Oxides of Nitrogen (NO_x)	0%
Particulate Matter (PM)	80%
Methane	10% increase

Source: Argonne National Laboratory, "A Full Fuel-Cycle Analysis of Energy Emissions Impacts of Transportation Fuels Produced from Natural Gas," December 1999.

While Table 8 indicates no increase in VOC emissions, the California Energy Commission found elevated VOCs in propane vehicles from vehicle storage tanks venting fuel.[98] LPG engines can be tweaked to produce less of some emissions at the expense of others. It has been found that LPG engines can be calibrated to reduce NOx, but this action will increase CO and nonmethane hydrocarbons. LPG has been found to reduce greenhouse gas emissions by 19.9% when compared with gasoline on a btu basis.[99]

[96] DOE, Alternative Fuels and Advanced Vehicles Data Center, "Alternative and Advanced Fuels: Propane Infrastructure,"http://www.afdc.energy.gov/afdc/fuels/propane_infrastructure.html, accessed July 2009.

[97] Alternative Fuels Group, "The Report of Alternative Fuels Group of the Cleaner Vehicles Task Force," January 2000, http://www.cleanairnet.org/infopool/1411/articles-35613_assessment_emission.pdf, accesed July 2009.

[98] DOE, Alternative Fuels and Advanced Vehicles Data Center, "Alternative and Advanced Fuels: Propane Emissions," http://www.afdc.energy.gov/afdc/vehicles/emissions_propane.html, accessed July 2009.

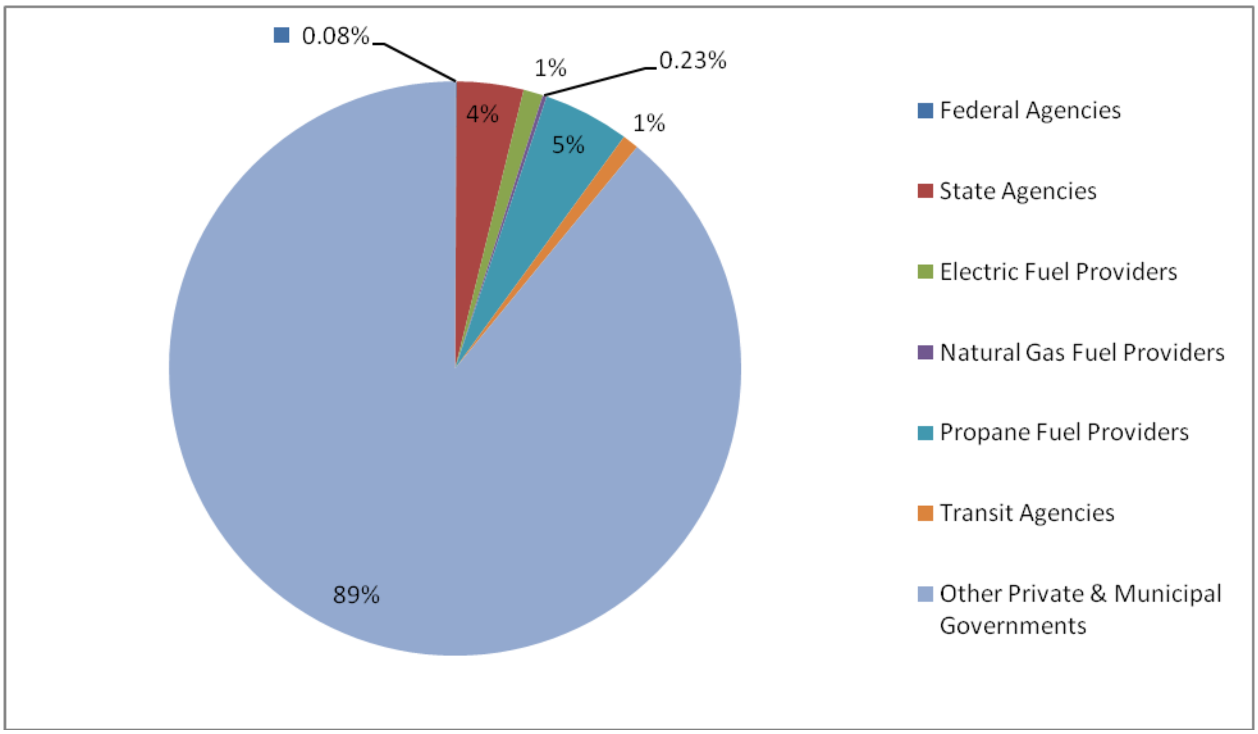
[99] EPA, "Greenhouse Gas Impacts of Expanded Renewable and Alternative Fuels Use," http://www.epa.gov/OMS/renewablefuels/420f07035.pdf, accessed July 2009.

LPG TARGET FLEET

Most LPG vehicles are light-duty. However, the vehicle mix of LPG vehicles is shifting slowly toward medium and heavy-duty fleets. In 2003, approximately 60% of LPG vehicles were light duty. That percentage fell to less than 57% in 2007. The remaining market is split among medium and heavy duty vehicles, with their perentages totaling 20% and 24% respectively in 2007. Most light duty cars, vans and pick up trucks have non-dedicated engines that operate more than one fuel. However, medium and heavy duty vehicles are more likely to have dedicated engines. In 2007, 72% of buses and 78% of SUVs, medium and heavy duty trucks had dedicated LPG engine.

The vast majority of LPG vehicles in use in Texas are owned by private or municipal entities, encompassing approximately 90% of vehicles. Texas state agencies operated more than 4,700 vehicles or 8% of the state's LPG vehices in 2007. Figure 23 shows the amount of LPG by user group in 2007 for Texas.

Figure 23. Texas LPG Fuel Consumption by User Group, 2007



Source: DOE, Energy EfSource: DOE, Efficiency and Renewable Energy, "Data, Analysis and Fuels, 2007," http://www.afdc.energy.gov/afdc/data/#www.afdc.energy.gov/afdc/data/ , accessed July, 2009.

One popular category that is not included in the vehicle totals is propane forklifts, which are ubitquitous in the marketplace. Their low carbon monoxide emissions enable them to be used indoors and the engines are considered durable and easy to maintain. In 2005, more than 670,000 propane forklifts operated in the United States.[100] The Texas Railroad Commission runs a grant program to increase the proportion of propane forklifts in Texas.[101]

LPG FUELING STATIONS IN TEXAS

There are 485 propane/liquefied petroleum gas fueling stations in Texas. Most of them are public and only three are designated as private. Unlike other alternative fuel stations that are primarily in urban areas, most LPG fueling centers are rural. Table 9 shows that 403 stations are in areas outside most of the major population centers. Farm use accounts for 5% of total propane market demand and is the third largest retail sector for propane.[102] TxDOT has found that the number and location of LPG stations have often not met their needs because the hours are not reliable and the volumes are not sufficient. Instead, the agency has had to put in their own LPG fueling infrastructure.[103]

Figure 24 shows the map of fueling stations. The state is well covered along the I-35 corridor as well as throughout the eastern portions of the state. The Dallas-Fort Worth area has a fairly even distribution of fueling centers as can be seen in Figure 25.

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[100] Propane Education and Research Council, "Propane: Engine Fuel Roadmap," September 2005, http://www.propanecouncil.org/uploadedFiles/propanecouncil/Resources/Industry/Engine_Fuel_Roadmap.pdf, accessed July 2009.

[101] Texas Railroad Commission, "Low Emissions Propane Forklift Initiative Program," http://www.propane.tx.gov/rebate_program/forklift.php, accessed July 2009.

[102] Doggett, Tom, "U.S. June propane inventories highest in 27 years: EIA," Rueters, July 8, 2009, http://www.reuters.com, accessed July 2009.

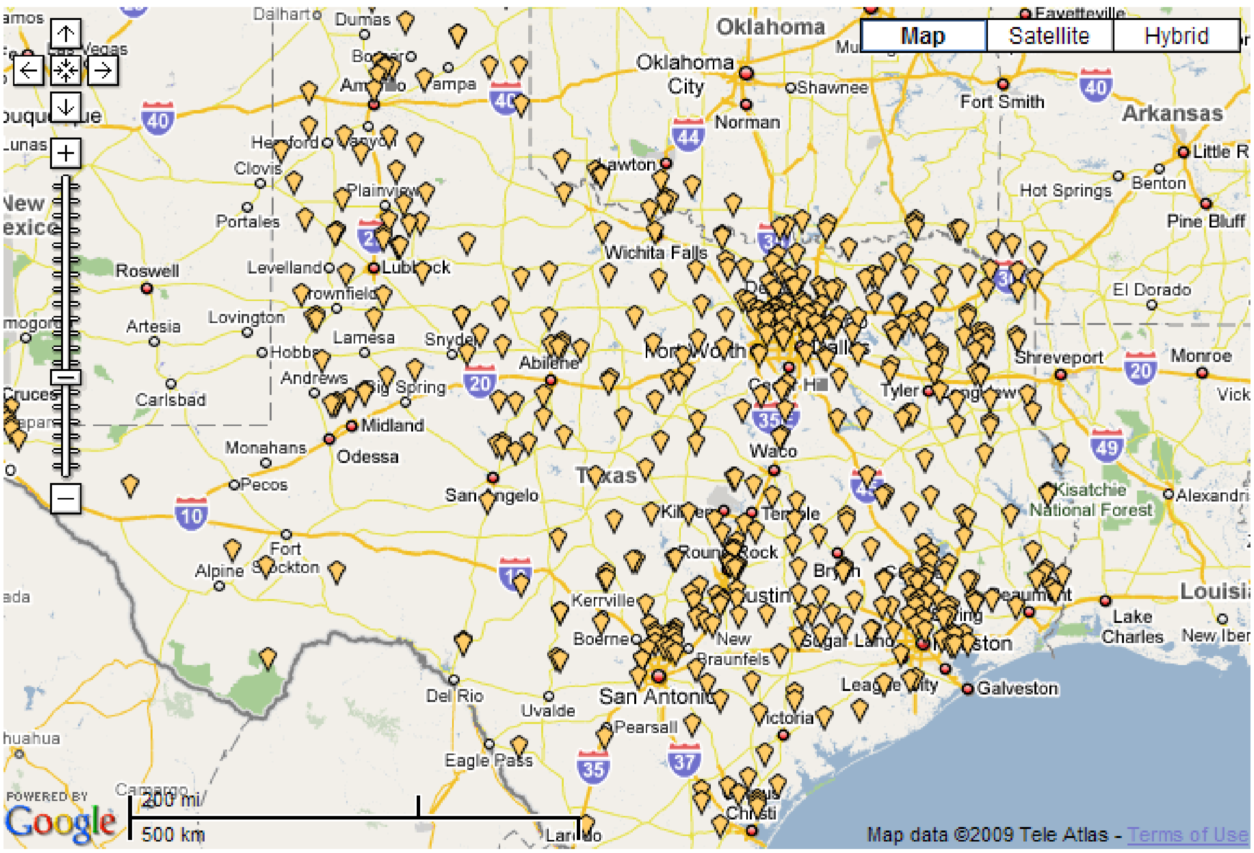
[103] Lewis, Don, TxDOT Fleet Manager, personal communication on July 23, 2009.

Table 10. Propane/Liquefied Petroleum Gas Stations in Texas

Metro Area	Available to Public	Private Fleets Only	Planned
Austin	12	1	
Dallas-Fort Worth	29		
Houston	22		
San Antonio	16		
Rural or Other	403	2	
Total	**482**	**3**	**0**

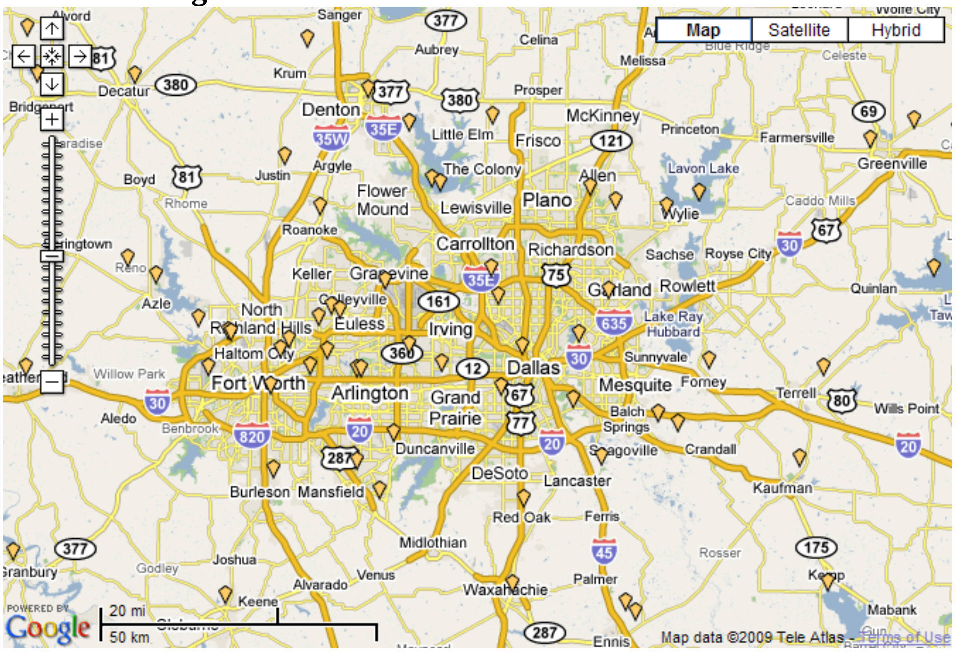
Source: Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/stations/advanced.php. Data current as of April 9, 2009.

Figure 24. LPG Stations in Texas



Source: Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/stations/advanced.php. Data current as of April 9, 2009.

Figure 25. LPG Stations in Dallas-Fort Worth



Source: Department of Energy, Alternative Fuels and Advanced Vehicles Data Center, http://www.afdc.energy.gov/afdc/stations/advanced.php. Data current as of April 9, 2009.

LPG STATION DEPLOYMENT STRATEGY

LPG's declining trend makes it a risk for investing in more fueling stations. The vehicle availability for LPG is shrinking while the fuel's fluctation and cost makes it less competitive with other alternative fuels. The fuel is also not shown to consistently reduce NOx emissions, which is a prime concern for the urban areas within the state.

However, if there was an effort to expand LPG fueling options, the locations without current competition appear to be in the southwestern portions of Texas and specifically along I-10 west of San Antonio. These areas are largely unconcerned with NOx emissions, with the exception of El Paso. However, a market study or analysis would need to be performed beforehand to assess whether there would be enough demand or a fleet willing to use LPG.

8. CONCLUSIONS

While detailed recommendations on deployment strategies are provided in the previous chapters, taken together a theme emerges. There is no silver bullet solution that catapults the use of one alternative fuel over all others. Each fuel has its own advantages and limitations.

Deployment Considerations

There are several factors that influence selection of alternative fuels for a given application or vehicle type. Among these are:

- OEM availability or cost and availability of retrofits
- Storage and infrastructure requirements
- Energy density of fuel
- Fuel efficiency
- Range per tank of fuel
- Available method to transport fuel to market
- Cost per gasoline gallon equivalent
- Emission rates

Potential Deployment Strategies

No one alternative fuel ranks best in all categories and alternative fuels often have a market segment that meets the needs of a particular type of fleet. Table 10 shows the target markets and deployment strategies that could be used to expand alternative fuels deployment for each individual type of alternative fuel. Since vehicle availability, emissions characteristics, and net cost are all critical, the following observations provide some direction.

Table 11. Potential Strategies For Alternative Fuels Deployment

Alternative Fuel	Target Fleet	Priority Fuel Station Locations	Likely Sector For Implementation	Most Needed Fuel Station Locations and Other Comments
Biodiesel	Light duty trucks, heavy duty vehicles	Highways, urban areas	Private sector	East-west interstate and other high volume highways; major metropolitan areas beyond Austin. Highest potential for widespread use.
CNG	Light duty vehicles, transit and school buses	Urban areas	Fleet operators, Private sector	Urban areas with centrally fueled fleets. Vehicle population slightly declining.
Ethanol (E85)	Light and medium duty vehicles	Highways, urban areas	Private sector	Austin, Dallas, El Paso, Houston, San Antonio; I-10 corridor, highest potential for widespread use.
LNG	Transit buses; other heavy duty vehicles	Transit and fleet operators	Fleet operators, centrally fueled fleets	Few vehicles outside transit fleets; not increasing.
LPG	Light duty conversions from gasoline power	Urban fringe, highways	Private sector	No OEM light duty vehicles; total number of vehicles declining; fuel stations generally plentiful.

Some alternative fuels are common in niche markets (such as CNG transit buses); others are only sparsely available. For alternative fuels that are used on heavy vehicles (e.g., buses and heavy trucks), refueling stations are needed within metropolitan areas and at intervals along interstate and similar freeways. For fuels to be attractive for light duty vehicle use, they would need to be available first in population centers, starting with larger metropolitan areas and work toward smaller ones, in addition to intervals along primary highways. LPG usage has been the one exception because it is more prevelent in the rural areas. However, this rural use of the fuel is largely attributable to its non-transportation related uses and is a unique feature of the fuel.

Whether the private sector retailers will be able to finance enough additional refueling stations is a matter of economics. In cases where users are single or a few public agencies, the agencies may have to construct or contract for exclusive/limited use facilities. Where more widespread use exists, private companies may be able to justify investments in new stations (more so if incentives exist), such as in high vehicle usage areas. The locational considerations displayed in Table 10 can provide general guidance, but more detailed locational information would require a study focused on a particular location.

Potentially Most Advantageous Alternative Fuels

If an entity had to choose exclusively among alternative fuels for fueling station deployment, the renewable fuels have advantages over the other alternative fueling options. E85 vehicles are prevalent and most diesel vehicles can use lower biodiesel blends without major modifications. This ease of use at no or low capital costs for the individual consumers enhances the probability that the fuels'usage can become more mainstream.

Many industries have a tipping point where reaching a certain quantity threshold catapults a product into widespread usage. While it is unknown whether alternative fuels have tipping points, the availability of vehicles capable of using the fuels increases the possibility of reaching a critical mass of commonplace usage. The advantage of greater public use is increased economies of scale, greater knowledge and experience with the renewable fuels, reduced emissions and decreased overall costs.

Renewable fuels are also eligible for more incentive programs than other alternative fuels. For example, federal agencies are required to have at least one renewable fuel pump at each fleet facility. One recommendation for capitalizing on this opportunity is to work with federal agencies to see if any new fueling facilities planned can be open to the public and used for other nearby fleets.

Compared to other alternative fuel options, the costs associated with renewable fueling infrastructure are relatively modest. LPG is the one exception. Often existing fueling infrastructure can be retrofitted to include E85 or biodiesel. However, a complete market analysis would be needed for individual fueling stations to assess the economics of including renewable fuels.

Economic and Market Considerations

While this study looked at alternative fueling options, usage, trends and locations, it did not cover the economic and market implications for alternative fueling stations. This is a major consideration for alternative fueling deployment that is outside the scope of this project. Specific locations of fueling infrastructure will largely depend on local market demand and individual economics.

A future effort could help guide potential retailers on the process and resources for conducting a market and cost benefit analysis. Such a study could also assess the economic experience of existing private sector retailers selling E85 and biodiesel in Texas and what factors make a difference in profitability. These findings could be used by other fuel retailers considering renewable fuels and help guide them to a choice that makes economic sense.