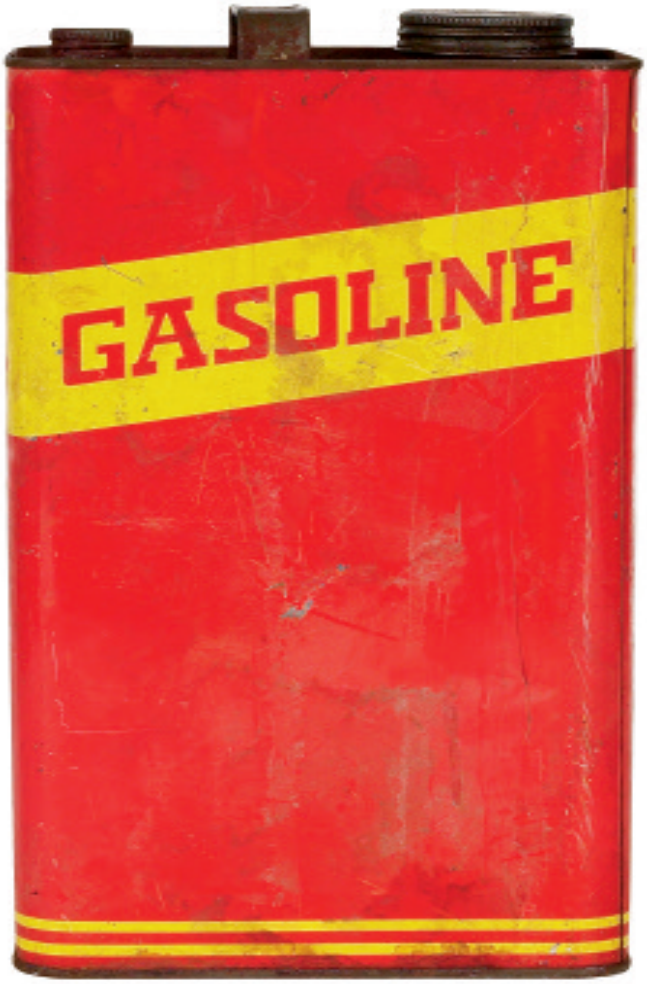
Transportation, Energy, and the Environment in North Carolina

Anne Tazewell

More than a billion dollars a day goes to line the pockets of nations that "do not particularly like us," as President George W. Bush puts it. In 2005, North Carolina ranked tenth in the United States in expenditures on gasoline—$9.9 billion.[1] Add to that the more than $2 billion that North Carolinians are spending for diesel fuel, and the state is edging up to expenditures of $12 billion annually on fuels that it neither produces nor refines. Along with increasing fuel prices, per capita vehicle miles traveled are expected to surpass the state's projected growth in population, so what North Carolinians spend for transportation-related fuels probably will continue to increase exponentially. Whereas stationary power sources have diversified into natural gas, coal, uranium, and, more recently, renewable energy sources such as the sun and wind, the U.S. transportation sector (cars and trucks) is still 96 percent reliant on petroleum.

The reliance would not be such a problem if oil were to remain cheap, stay in U.S. control, and be environmentally preferable to the alternatives. But none of these prospects are likely. When world oil production peaks—and reasonable evidence indicates that the world is in the midst of this peak now—oil will increasingly go up in value as the remaining supply becomes more difficult to extract and get to market. As it is now, Americans are consuming three barrels of oil for every new barrel that is discovered, putting the world in the position of depleting known reserves at an alarming rate, given how dependent the world is on oil. U.S. oil production peaked in 1970, forcing the nation to

The author is manager of the Transportation Program at the North Carolina Solar Center. Contact her at anne_tazewell@ncsu.edu.



rely more on imported oil, much of it from unstable parts of the world. The disturbing fact is that with just 5 percent of the world's population, the United States consumes more than 25 percent of the world's oil production. This is not a good position for North Carolina or the United States to be in. But as Saudi Arabia's former Minister of Oil, Ahmed Saki Yamani, said in 2000, "The Stone Age came to an end not for a lack of stones, and the oil age will end, but not for a lack of oil."

Climate change and air-quality concerns are equally important drivers for a new age of transportation energy alternatives. One-quarter of North Carolina counties do not meet national air-quality standards for either ozone or particulate matter. This number will expand next year as the U.S. Environmental Protection Agency (EPA) ratchets down the acceptable level of emissions to protect human health better.

Currently, twenty-four of North Carolina's counties do not meet national standards for air quality.

A greater challenge, however, could be emissions that are currently unregulated in the United States. Carbon dioxide, created primarily through the burning of fossil fuel, is the primary culprit of the greenhouse effect and all its attendant problems.

For transportation decision makers, there are more opportunities and more reasons than ever before to exercise freedom of choice. With the rise in availability of alternative fuels and advanced transportation technologies, North Carolina governments have a choice of actions that they can take to support the four E's: emission reductions, environmental enhancement, energy diversity, and economic development.

This article explores the alternative fuels available today, such as biodiesel, ethanol, natural gas, propane, and electricity, and it offers guidelines for deciding which to choose, depending on the intended application. Further, the article discusses retrofitting of existing vehicles, and hybrid-electric vehicles, two advanced transportation technologies that also can help reduce critical emissions. The article then offers examples of innovations in North Carolina's own backyard. Finally, it describes national and state incentives, policies, and programs, and discusses some conservation measures, all of which suggest ways in which North Carolina governments can chart the course ahead.

Alternative Fuels Available Today

Biofuels such as biodiesel and ethanol hold tremendous promise for North Carolina and have gained a lot of trac-

tion recently because of the potential to produce and use them in state. Although the state has no petroleum refineries or oil wells, biofuels must still be compared with petroleum because they are blended with and used as a replacement for petroleum. Low-carbon fuels such as natural gas and propane reduce emissions and can help stabilize budgets because they cost less than conventional transportation fuels. Although they are fossil fuels, natural gas and propane are cleaner and more abundant in the United States than petroleum is. These biofuels and low-carbon fuels offer opportunities for fuel diversity that North Carolina government fleets can incorporate today.

Biofuels

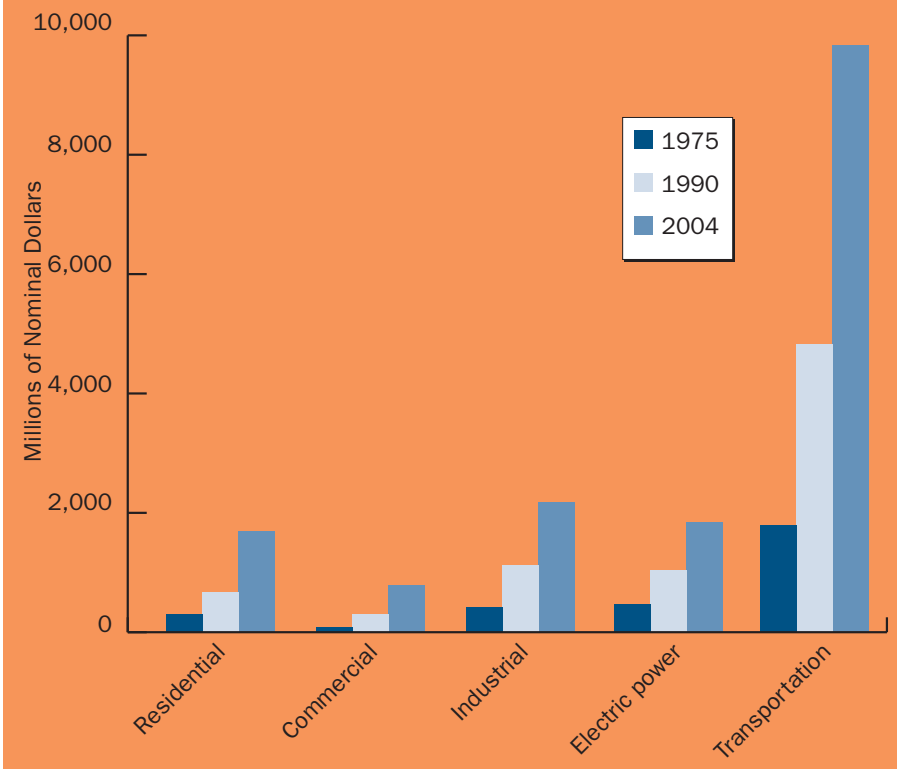
Biodiesel

Few people had heard of biodiesel in 1999, when the North Carolina Department of Transportation began sending its tanker trucks to Florida to pick up the renewable fuel. Now the state has multiple production facilities and commercial service stations, and municipalities from Asheville to Wilmington are using it. North Carolina has seen a great expansion in the use of biodiesel, in part because it is a "pour and go" technology. That is, if a car has a diesel engine, it can use biodiesel. Unlike other alternative fuels, biodiesel does not require any special

Aspects of Energy Use and Capacity in North Carolina

Dennis Grady and Jason Hoyle

Chart 9. **Total Expenditures on Primary Energy, by Sector, 1975, 1990, and 2004**



Expenditures on primary energy have risen consistently for the past several decades. These are expenditures for fuels such as coal, petroleum, and natural gas. Neither renewable energy sources, such as wind or sun, nor electricity is included. Following the trend in energy consumption, the commercial sector has shown the largest increase, with an annual growth rate of 7.7 percent from 1975 through 2004. However, it remains the smallest sector in total expenditures on primary energy. For the most part, each sector's share of state expenditures remained relatively constant from 1975 through 2004. Transportation expenditures represented the majority of expenditures throughout the period, with about a 60 percent share.

Source: Data from U.S. Department of Energy, Energy Information Administration, "State Energy Consumption, Price, and Expenditure Estimates," www.eia.doe.gov/emeu/states/_seds.html.

Biodiesel Producers and Plant Capacity

Blue Ridge Biofuels
109 Roberts Street
Asheville, NC 28801
828.253.1034
1–2 million gallons per year

Evans Biodiesel
2301 Industrial Park Drive
Wilson, NC 27894
252.237.1898
4 million gallons per year

Foothills Bio-Energies
815-D Virginia Street S.W.
Lenoir, NC 28645
828.759.7101
5 million gallons per year

Gortman Biofuel
617 Waughtown Street,
Building 200, Bay 25
Winston-Salem, NC 27107
336.731.2599
100,000 gallons per year

North Carolina BioFuels
1607 Chase Circle
Roanoke Rapids, NC 27870
252.589.8280
1.5 million gallons per year

Patriot Biodiesel (formerly Oak Biodiesel, High Point)
Greensboro
336.209.0728
(not in production yet at new location)

Piedmont Biofuels
P.O. Box 661
Pittsboro, NC 27312
919.321.8260
1 million gallons per year

refueling equipment. It can be used in place of conventional petroleum diesel as 100 percent biodiesel—B100—or in any blend from B2 (2 percent biodiesel/98 percent petroleum diesel) up, with little or no modification to existing vehicles or infrastructure.

In low blends, such as B2, biodiesel acts as a lubricant for ultra-low sulfur diesel (ULSD). ULSD was widely introduced in fall 2006 to help trucks meet more stringent federal emission standards that went into effect with model year 2007 vehicles. Sulfur contaminates the catalysts used in the large filters that remove most of the particulate matter in diesel exhaust. So the amount of sulfur in diesel was reduced significantly in ULSD. However, when sulfur is removed, diesel loses its "lubricity," its capacity for reducing friction. So an additive is necessary. Adding B2 to ULSD restores the lubricity, helping the fuel perform better in new engines.

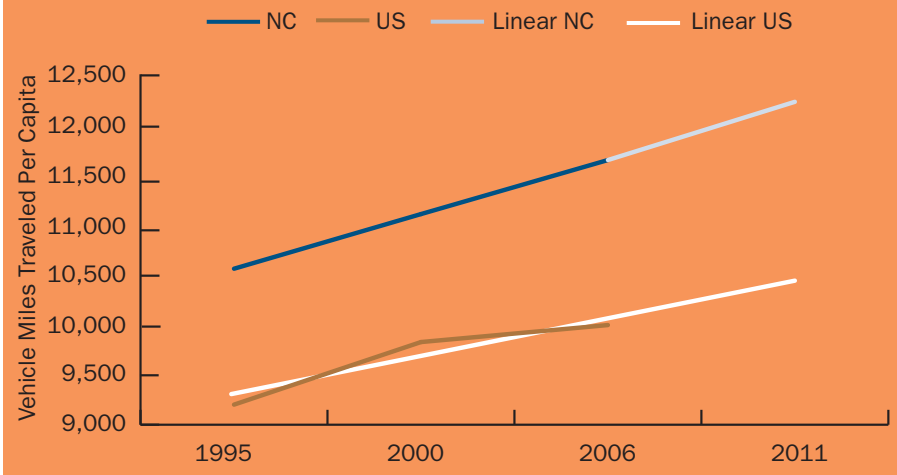
Biodiesel is not to be confused with straight vegetable oil. Biodiesel is pro-

Data collected between July 2007 and April 2008 indicate that Chapel Hill Transit is realizing, on average, a 51 percent increase in fuel economy with its hybrid-electric buses, as compared with its conventional diesel buses.

Aspects of Energy Use and Capacity in North Carolina

Dennis Grady and Jason Hoyle

Chart 10. **Historical and Projected Vehicle Miles Traveled Per Capita, North Carolina and the United States, 1995–2011**



The average North Carolinian drives more than the average American. The overall rate of vehicle miles traveled in the United States has been leveling, but North Carolina's trajectory has changed little in the past decade.

Sources: Data from U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: Federal Highway Administration, 1995, 2000, 2006); U.S. Census Bureau, *Statistical Abstract of the United States 2006* (Washington, DC: U.S. Census Bureau, 2006), www.census.gov/compendia/statab/. "Linear" means the trendline as calculated by Excel.

Chapel Hill Transit

duced when a fat such as soy oil, animal renderings, or waste vegetable oil is catalyzed and mixed with methanol. The process removes glycerin (which can gunk up fuel lines and engines) and yields biodiesel. Biodiesel can be used in any diesel engine without modification, whereas a diesel vehicle running on straight vegetable oil must have an additional fuel tank and/or preheat the oil so that it will flow smoothly through the system. Also, biodiesel is recognized by the federal government as an alternative fuel, whereas straight vegetable oil is not.

Biodiesel is the only fuel to have passed EPA's rigorous health-effect testing. It is nontoxic and safe to handle, and has a much higher flashpoint than petroleum diesel—260 degrees versus 117 degrees. Finally, it burns more cleanly than petroleum diesel, reducing sulfur associated with acid rain, particulate matter linked to heart and respiratory diseases, and other emissions of concern.

With all these benefits, why is biodiesel not more widely used? The two main reasons are (1) concerns about vehicle warranties and (2) price. Warranties are a source of confusion for many would-be biodiesel users. They should not be. Although engine manufacturers may recommend that certain fuel be used in particular engines, they do not warranty fuel use. So if an automobile owner has a fuel-related problem from using B20 (or ULSD, for that matter), he or she should go back to the supplier of the bad fuel, not to the vehicle manufacturer. A federal law, the Magnuson-Moss Warranty Act, prohibits a manufacturer from voiding a warranty for use of an additive, which biodiesel is considered to be.[2] So even though any complications with biodiesel would not be covered by the engine warranty, fueling with biodiesel will not void the engine warranty.

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Biodiesel is not widely used because of its price and concerns about vehicle warranties.

Still, fleet managers are concerned and with good reason. Poor-quality biodiesel is a primary concern of the industry. Biodiesel users must have confidence that the fuel they are supplied meets the American Society of Testing Materials D6751 standard. The standard ensures the quality of B100 that is mixed with petroleum diesel. If a quality issue arises with biodiesel, a reputable supplier will stand by its product and assist the customer in identifying and correcting the problem.

The cost of biodiesel can vary widely, depending on the price of the feedstocks that went into making it and the transportation costs required to get it from the producer to the user. For governmental entities, B20 is available in all one hundred of North Carolina's counties on a statewide purchasing contract. Also, fleets can purchase B100 directly from seven small production facilities in North Carolina and "splash-blend" it in a fuel tanker with petroleum diesel to make B20, the blend most commonly used (for a list of these facilities, see the sidebar on page 29). To do this, one would load a 7,500-gallon tanker with 6,000 gallons of diesel at the petroleum terminal and 1,500 gallons of B100 (20 percent of a 7,500-gallon tanker) at a biodiesel production facility. The B100 will mix sufficiently with the diesel en route to the fuel storage tank. From there, it can be used directly in on- and off-road equipment.

Most operations that use biodiesel do not install any additional infrastructure. Rather, they switch to a biodiesel blend using existing equipment.

Because biodiesel is relatively easy to make and handle, "home brewers" across the state are making it in garages and back yards. In 2007 the state gave them more reason to do so by passing legislation that removed the motor fuels

tax on biodiesel made by an individual for use in his or her own noncommercial vehicle.[3]

Although B100 will not harm the environment if it is accidently spilled (it is considered an "insignificant" aquatic toxin by the National Institute of Occupational Safety and Health), biodiesel production is a chemical process that requires the handling of explosive and caustic materials. Safety standards and procedures are vitally important for large- and small-scale production, including proper storage of methanol and catalysts such as sodium hydroxide, proper disposal or recycling of water used in washing biodiesel, and a plan for use of the glycerin byproduct. With biodiesel production soaring across the United States, finding more valuable uses for glycerin is an important consideration for production facilities. Researchers at North Carolina State University's College of Engineering are refining crude glycerin with catalysts and enzymes to find more value-added products from biodiesel production. One of the state's commercial production facilities, Blue Ridge Biofuels in Asheville, is experimenting with glycerin as a fuel in a boiler application, and another, Piedmont Biofuels, is selling glycerin for use in a wastewater treatment facility.

By supporting use, distribution, and production of biodiesel, local governments in North Carolina are helping the biodiesel industry gain experience and secure biodiesel's future as a viable transportation fuel. Since the North Carolina Department of Transportation began using biodiesel in 1999, there has been a wide expansion of its use. In 2006, more than a dozen municipalities, multiple state agencies, three school systems, two transit agencies, and more than forty service stations used 2.5 million gallons of B100.[4]

Ethanol

Like biodiesel, ethanol is a renewable fuel made from organic materials, biodiesel from oils, and ethanol from sugar. The United States produces most of its ethanol from corn. North Carolina is a net importer of corn to feed its livestock industry, so the long-term viability of an ethanol industry in this state depends on developing high-yield, high-sugar crops, such as sweet potatoes, and on freeing up sugars from the cell walls of wood waste and crops such as switch grass to produce "cellulosic ethanol."

Range Fuel, a Georgia plant that broke ground in November 2007, uses a two-step thermochemical process to convert wood waste and forest residues into ethanol. It is not yet clear when the process will be profitable enough to be widely adopted, but the race is on, particularly in the Southeast, an area abundant in cellulosic materials. Spurred by federal grants and incentives from the federal 2005 Energy Policy Act, researchers are working aggressively to bring costs down so that cellulosic ethanol can be competitive with ethanol derived from corn.

Researchers are working hard to make cellulosic ethanol competitive in price with corn-based ethanol.

Ethanol is widely used across the United States in two blends, E10 and E85. E10 (10 percent ethanol/90 percent regular unleaded gasoline) can be used in any gasoline-powered vehicle. In many states that require reformulated gasoline, E10 is used as an oxygenate in place of methyl tertiary-butyl ether, a proven groundwater contaminant and a probable carcinogen. "Reformulated gasoline," known as RFG, is gasoline blended to reduce smog-forming and toxic pollutants of the air. The federal Clean Air Act requires that RFG be used in the cities with the worst smog pollution to reduce harmful emissions that cause ground-level ozone. The law also specifies that RFG contain oxygen (2 percent by weight). Methyl tertiary-butyl ether and ethanol are the two most commonly used substances that add oxygen to gasoline.

Marketers in North Carolina are voluntarily using E10, which is nontoxic, because its 113 octane rating allows it to be blended with regular gasoline to make a premium fuel. Moreover, there is a 51-cent federal tax credit for blending ethanol and gasoline. Consequently, marketers that provide an E10 blend can claim a 5.1-cent tax credit for every gallon used.

Ethanol also is used in E85-capable flex fuel vehicles (FFVs). FFVs run on either E85 (70–85 percent ethanol/30–15 percent gasoline, depending on the season) or straight gasoline. Fuel sensors adjust the input to the vehicle.

Currently, six million-plus FFVs are operating in the United States, more than 120,000 of them in North Carolina. In model year 2008, U.S. auto manufacturers are offering about thirty FFVs at no extra cost to consumers. A first for this year is three FFVs that often are used in law enforcement: the Ford Crown Victoria with a 4.6-liter engine, the Chevy Impala with a 3.9-liter engine, and the Chevy Tahoe with a 5.3-liter engine.

Manufacturers of FFVs receive credits to offset fines that they would otherwise receive for low rates of fuel economy. So the automotive industry has some inherent incentives to continue expanding its FFV offerings.

Although FFVs do not cost any more than gasoline-only vehicles, they require more fuel to go the same distance that vehicles operating on gasoline can go, because ethanol has about 30 percent less energy per gallon than gasoline does. This differential can result in, on average, a 20 percent loss in fuel economy. However, experts say that if manufacturers developed vehicles to run only on E85, or if they engineered FFVs to run more efficiently when burning E85 than when burning gasoline, they could eliminate much of this loss.

In the meantime, ethanol prices and federal tax credits are making E85 less expensive than regular unleaded gasoline at the state's eleven commercial stations. The need to refuel more often with E85 can be somewhat offset by its lower cost. In addition, a new statewide contract makes E85 available in all one hundred counties.

Although fuel prices are subject to volatility and predicting the future is anything but safe, fall 2007 prices on the state contract for E85 ran 40 cents less than the price of gasoline, and prices are expected to stay lower for the foreseeable future. However, with California and Florida talking about starting to use E10 and with distributors generally

Refueling Stations in North Carolina for CNG Vehicles

Station Name	Address	City	Contact Phone	Customers	Payment
City of Asheville	45 McCormick Pl.	Asheville	828.259.5700 or 828.259.5702	GP	PK/CC
NC–CNG	2618 Hendersonville Rd.	Arden	828.210.8146	GP	CC
Butner Federal Prison	Old Hwy. #75	Butner	919.575.5000, ext.1207	SO	I
Town of Chapel Hill	6850 Millhouse Rd	Chapel Hill	919.969.5142	SL	I
Piedmont Natural Gas	4301 Yancey Rd.	Charlotte	704.364.3120, ext. 4392, or 704.525.5585	GP	I
Town of Garner	610 Rand Mill Rd.	Garner	919.772.7600, ext. 31 or 32	SL/GP	GP = Cash SL = I
PSNC Energy	800 Gaston Dr.	Gastonia	704.810.3282	GP	PK
Piedmont Natural Gas			*Station Being Moved*		
City of Hickory	1441 9th Ave. NE	Hickory	828.323.7574	GP	CC
Orange County Public Works	680 NC 86 North	Hillsborough	919.245.2628	GP	CC
Davidson County Garage	925 N. Main St.	Lexington	336.242.2250	GP	CC
PSNC Energy	600 W. Cabarrus St.	Raleigh	919.836.2428	GP	PK
City of Raleigh	4120 New Bern Ave.	Raleigh	919.250.2733	GP	PK/CC
City of Winston-Salem	650 Stadium Dr.	Winston-Salem	336.727.2507	GP	I
Dept. of Transportation	300 Craft Dr.	Winston-Salem	336.896.7021	SL	PK

Source: North Carolina Department of Environment and Natural Resources, Division of Air Quality, "You Must Plan Your Trip When Driving a CNG Vehicle," http://daq.state.nc.us/motor/cng/refuel.shtml. Customers: GP = general public; SL = state and local government only; SO = state only. Payment: C = cash; CC = credit card; I = invoice; PK = Pro-Kee (a key system).

beginning to use more E10 and E85, supplies are tightening. Further, corn prices are going up. Consequently, the United States will start importing more Brazilian ethanol, and that will help stabilize prices. New U.S. plants, including cellulose-based plants, also will help increase supply.

One of the challenges with ethanol is that it cannot be shipped through a pipeline because of its water-loving nature. With no production yet in North Carolina, ethanol is coming in by rail and truck, slowing expansion into the marketplace. This situation is likely to change soon because at least two companies plan to begin producing ethanol in North Carolina in 2008.

Further, there is talk of expanding the capacity to store and distribute ethanol at North Carolina petroleum terminals.

Renewable fuels such as biodiesel and ethanol help diversify the state's fuel supplies, putting it on a path to less dependence on imported oil. Without oil production and refineries, the $10–$15 billion that North Carolina spends annually on petroleum does not yield the economic benefit that biofuel refineries do, even if some of the feedstocks for these refineries are imported from other states or nations. Although soy and corn—the current dominant feedstocks for biodiesel and ethanol—clearly will not be able to replace petroleum significantly, they will help carry North Carolina to a future in which additional feedstocks will offer better yields for less energy inputs.

Some opponents of biofuels argue that crops grown for fuel are taking food out of people's mouths and that this redirection of resources is the primary cause of rising food prices. This food-versus-fuel argument, although a potential concern for the future, is misleading. Many factors are responsible for the rise in food prices. One of them is the increase in oil prices.

Rising corn prices are good for farmers. A primary threat to U.S. agriculture today is the loss of farmland to development. One of the reasons farmland is being lost is that crop prices have been too low, and development pressures too high, for farmers to stay in agriculture. To address concerns that corn used to feed the ethanol boom is contributing to the world hunger problem, one could argue that the low prices for U.S. agricultural products overseas are making it more difficult for the world's hungry. Less developed countries find it hard to compete on the world market with subsidized (and therefore cheap) American grain.[5] As the largest U.S. agricultural crop, corn is generally in surplus, requiring government price supports. Therefore, to the extent that ethanol supports corn prices, costs to taxpayers are reduced.

Furthermore, most grain grown in the United States is used not to feed people but to feed animals that humans then eat. It takes seven to nine pounds of grain to make one pound of meat. The corn used in ethanol production is "field corn" used to feed livestock, not sweet corn, which humans eat. Moreover, the argument is not food versus fuel because the production of corn-based ethanol uses only the starch, leaving distillers grain, a valuable co-product that is suitable for animal feed. Studies conducted by university researchers for the National Corn Growers Association indicate that 10–15 percent of poultry feed and 20–50 percent of swine feed could be replaced with distillers grain.[6]

Burning one gallon of gasoline creates nineteen pounds of carbon dioxide.

Another valuable co-product, this one produced through soy farming, spurred investment in biodiesel production. Soy farmers invested heavily in launching the biodiesel market in the United States because of a chronic glut of soy oil resulting from much of the meal going to animal feed.

The state cannot grow its way out of its overreliance on petroleum. However, biofuels coupled with conservation can make a significant dent in the ten million barrels of oil imported daily into the United States.[7]

Biofuels and Petroleum: A Comparison

The costs of biofuels must be compared critically with the costs of what they are replacing—petroleum. There are commodity price supports for corn and soy, as well as tax credits for blending biofuels with petroleum, but there also are many hidden and not-so-hidden subsidies for petroleum. This subsidization hurts the economy and puts the United States in a vulnerable position. An October 2003 paper (updated in 2006) published by the National Defense Council Foundation thoroughly lays out some of the costs and concludes that Americans pay far more for petroleum than the price at the pump.[8] Even with government help, biofuels will never be able to compete on a level playing field because of the tremendous capital investment that already has been sunk into making the petroleum industry the most powerful in the world.

Another important reason to consider using biofuels is climate change. Burning one gallon of gasoline creates nineteen pounds of carbon dioxide. Being plant based, biodiesel and ethanol absorb carbon dioxide during the growing process, and that absorption offsets the carbon that they release through combustion. A National Renewable Energy Lab study of B100 in urban transit buses concludes that biodiesel can reduce carbon dioxide emissions by 78 percent, as compared with petroleum diesel, when using life-cycle analysis. "Life-cycle analysis" takes into consideration all the factors in fuel production. Petroleum does not have the same life-cycle benefits as plant-based fuels because its combustion releases carbon into the atmosphere that has been underground for millions of years.[9] Research also has shown that using full-life-cycle analysis, corn-based ethanol results in carbon dioxide reductions of 18–29 percent, and cellulosic ethanol, up to 86 percent.[10] Not only are greenhouse gases directly linked to fuel combustion, but the amount of fossil fuel energy used to process and transport the fuel to the end user is an important consideration in developing the means to reduce greenhouse gases.

Biodiesel has the highest "energy balance ratio"—the ratio of the energy used to create a fuel, to the energy created by it—of any fuel widely used in the United States. For every unit of fossil fuel energy used to grow and process soybeans into biodiesel, 3.2 units of energy are created to use in a diesel vehicle. Every unit of fossil fuel energy used to extract and refine crude oil into petroleum diesel yields only 0.83 units of energy—a negative energy balance. Ethanol's energy balance is not quite as stellar as biodiesel's, but it is better than gasoline's. For corn-based ethanol, 1.34 units of energy are created for every unit of fossil fuel input, compared with 0.81 units for gasoline.[11]

Low-Carbon Fuels: Natural Gas and Propane

Not all fossil fuels are created equal. Fossil fuels are compounds that contain carbon atoms and hydrogen atoms, with

energy embedded in the bonds between the atoms. The carbon-to-hydrogen ratio affects a fuel's properties, the amount of impurities (other elements such as sulfur) it contains, and the amount of carbon it releases in combustion. Two fossil fuels with low carbon-to-hydrogen ratios are natural gas and propane.

Natural Gas

With one carbon atom and four hydrogen atoms, natural gas is the cleanest fossil fuel, with almost no impurities. Because it is gaseous, though, it must be compressed for use in vehicles. The Honda Civic GX, a "dedicated natural gas" vehicle (meaning a vehicle that operates only on natural gas), produces almost no emissions. In fact, the EPA has repeatedly ranked the GX as the "cleanest internal combustion vehicle" on the road today. Unfortunately, it also is the only light-duty compressed natural gas (CNG) vehicle being offered directly from the factory by an auto manufacturer.

Through vehicle retrofitters, other CNG vehicles are available as dedicated or "bi-fuel" (meaning that they have two fuel systems and can switch from one to the other). Many light- and medium-duty vehicles such as sedans, pickups, and vans can be retrofitted to operate on natural gas by companies that have certification from the EPA to adapt specific makes and models. TransEco Energy Corp., recently opened in Asheville, is one such company. Adapting a gasoline vehicle is not unlike adding a custom moon roof. Arrangements are made through the dealer where the vehicle is purchased, and the CNG fuel system carries a warranty just as any new vehicle does.

North Carolina has fifteen CNG stations operated by a wide range of local, state, federal, and utility providers (see the sidebar on page 33). At least eleven are open to the public, but only six of these accept credit cards. At others, users pay by invoice or use a key system.

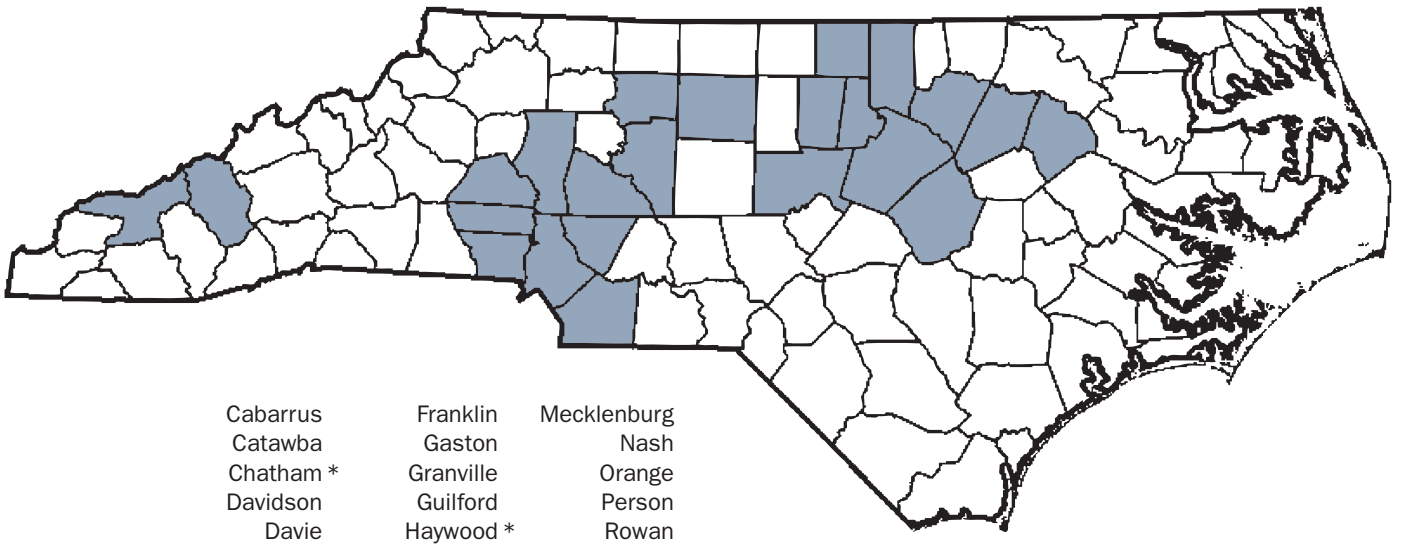
Fueling with natural gas may be done either as a fast fill, which takes 3–5 minutes (much as fueling with gasoline does), or as a time-fill, which takes 6–8 hours and is typically employed by fleets that park their vehicles overnight in a specific location.

Developing refueling infrastructure for CNG does not have to be an expensive undertaking. It can begin with a small refueling appliance manufactured by FuelMaker, which costs $35,000 and can time-fill two to five vehicles at a time. FuelMakers are easy to site and install because they are rated as appliances. In California and New York, FuelMaker has introduced the Phill, a home refueling appliance. For about $4,000, vehicle owners who have natural gas at their homes now can fuel their vehicles overnight with a small apparatus mounted in their garage.

Propane

Often referred to as propane, liquefied petroleum gas (LPG) is a byproduct of natural gas and crude oil refining. LPG shares many of the clean-burning characteristics of natural gas. However, being liquefied, it does not have to be compressed. Thus its refueling infrastructure is similar to that for petroleum

Figure 1. **North Carolina Counties Not Meeting National Standards for Ambient Air Quality**



Cabarrus	Franklin	Mecklenburg
Catawba	Gaston	Nash
Chatham *	Granville	Orange
Davidson	Guilford	Person
Davie	Haywood *	Rowan
Durham	Iredell *	Swain *
Edgecombe	Johnston	Union
Forsyth	Lincoln	Wake

*Represents partial counties. The nonattainment portions of both Chatham and Iredell counties are defined by townships from the Census: in Chatham County, Baldwin, Williams, New Hope, and Center; in Iredell County, Davidson and Coddle Creek. The nonattainment portions of Haywood and Swain counties are the Great Smoky Mountains National Park boundary. For information about the standards, see North Carolina Solar Center, Clean Fuel Advanced Technology, *Mobile Emissions and the Environment: An Overview and What We Can Do Now* (Raleigh, NC: Clean Fuel Advanced Technology, North Carolina Solar Center, n.d.), www.engr.ncsu.edu/ncsc/transportation/docs/Factsheets/Mobile_Emissions_Environment.pdf.

fuels. Many of the companies that adapt vehicles to use CNG convert vehicles to operate on propane. Worldwide, more than 14 million vehicles run on CNG or LPG. Ironically, although the Cummins Consolidated Diesel Company in Rocky Mount, North Carolina, manufactures a very clean-burning CNG engine for use in heavy-duty vehicles such as large trucks and buses, CNG sales for such vehicles are almost nonexistent in the state. The market for the engines is surging in other parts of the world, such as China and India, where many of the engines are shipped.

There are many reasons to take a second look at CNG and LPG for North Carolina. Besides the benefit in cleaner air, the costs of these low-carbon fuels consistently track lower than those of gasoline and diesel. Moreover, large fleets can lock into long-term contracts that assure them of prices lower than those for conventional petroleum fuels and, if volume is significant enough, offer them refueling infrastructure for no cost.

A good example of a company making a business decision to use alternative fuels is Schwan's, of Marshall, Minnesota. Schwan's delivers frozen foods in almost all fifty states, including North Carolina. The company has relied on propane to fuel its fleet of delivery trucks for more than twenty-two years. Today, 7,000 of the 7,500 vehicles in its fleet are dedicated propane medium-duty trucks.

Schwan's, a national purveyor of frozen foods, has used propane to fuel its delivery trucks for more than twenty-two years.

U.S. auto manufacturers do not produce vehicles that operate solely on these tried-and-true low-carbon fuels because traditional petroleum fuels have been inexpensive enough that fleet managers and consumers alike have not generated sufficient demand. As air quality and fuel diversity become more important priorities, CNG and LPG gain in viability.

North Carolina currently has twenty-four counties that do not meet national ambient air-quality standards (see Figure 1). Furthermore, the North Carolina Division of Air Quality estimates that by 2009 the greatest source of oxides of nitrogen—a primary component of ground-level ozone—will be cars and trucks. Ozone, a lung irritant, is created when oxides of nitrogen and volatile organic compounds mix in the presence of sunlight. CNG and LPG vehicles reduce oxides of nitrogen by 50–85 percent, compared with gasoline-powered vehicles.

Retrofitting of Existing Vehicles

It is starting to happen: less dirty black smoke billowing from trucks and buses. New federal standards for heavy-duty diesels require a startling reduction in emissions by 2010. Specifically, allowable emissions for oxides of nitrogen must be reduced by 92 percent of 2004 levels, and allowable emissions for particulate matter, by 90 percent. Three technologies are available to help meet the standard for particulate matter: diesel particulate filters, diesel oxidation catalysts, and diesel multi-stage filters.

Starting with model year 2007, all new heavy-duty trucks come with "diesel particulate filters" (DPFs), ceramic devices that collect particulate matter in the exhaust stream. The high temperature of the exhaust heats the ceramic structure and allows the particles inside to break down (or oxidize) into less harmful components. This technology can be retrofitted on North Carolina's "legacy fleet," its diesel workhorses that can serve for up to thirty years before being retired.

DPFs require annual maintenance because the particulate matter accumulates on a honeycomb-like inner structure that must be cleaned. As fleets add new trucks and this technology becomes more commonplace, larger municipalities may invest in their own cleaners. Now technology providers will take dirty filters for off-site cleaning, so it is

important to have a "swing filter" on hand to keep the vehicle on the road while the dirty one is being cleaned. Other options are possible for fleets that do not want to deal with annual maintenance and the cost of DPFs, which can run from $5,000 to $10,000 each. However, DPFs are the "gold standard" for reducing particular matter emissions on 1994–2006 engines. Up to 90 percent of particulate matter is removed, including the solid carbon core.

"Diesel oxidation catalysts" (DOCs) use a chemical process to break down pollutants in the exhaust stream into less harmful components. These devices are rated by the EPA as removing between 25 percent and 40 percent of particulate matter. DOCs remove only the soluble organic fraction of a typical particle, not the elemental carbon that is increasingly being linked to heart and lung diseases. However, DOCs are relatively inexpensive at $600–$1,000 each and require no maintenance. They also are good choices for off-road equipment because, unlike DPFs, they do not require ULSD.

"Diesel multi-stage filters" (DMFs) might be a good compromise between DPFs and DOCs in certain applications. DMFs use a two-stage metallic filter to trap and reduce particulate matter. Each stage consists of alternating layers of corrugated and fleece-like metal that is coated with a catalyst. At a lower cost than DPFs, DMFs remove up to 50 percent of particulate matter, can be used in 1991–2002 engines, and require the use of ULSD, but do not require any maintenance.

In government fleet operations, school buses are a primary target for diesel retrofitting. Children's lungs are not fully developed, making the impact of breathing dirty air greater. With asthma as the number one cause of absence from school and with schools' federal funding based on attendance, cleaning up school bus exhaust makes both environmental and economic sense.[12] A bill that passed the General Assembly in 2007 will provide $2.5 million to help retrofit school buses in the twenty-four North Carolina counties that do not meet federal air-quality standards. The program, to be launched by the North Carolina Division of Air Quality in fall 2008, will provide funding to install retrofit technologies that remove the greatest amount of emissions.

All the retrofit technologies can be coupled with crank-case ventilation systems (CCVs). A CCV reduces emissions of hydrocarbons and particulate matter produced from the engine crankcase or the oil pan area, and this reduction dramatically improves in-cab air quality. CCVs are not installed alone but coupled with other technologies such as DPFs and DOCs. For an approximate add-on cost of $500 each, CCVs can significantly enhance emission reductions and should be used whenever other technologies are used, particularly on school buses.

Hybrid-Electric and All-Electric Vehicles

Hybrid-vehicle technologies have captured the attention of the automotive industry, with cumulative sales in the United States rising from just 9,300 in 2000 to more than 350,000 through 2007.[13] A "hybrid-electric vehicle" uses both an electric motor and an internal combustion engine to propel itself. Hybrids capture energy that is normally lost through braking and coasting to recharge batteries, which in turn power the electric motor without the need for plugging in. Hybrids have the potential to use electricity to power onboard accessories or to provide outlets to plug in appliances or tools.

Currently, fourteen hybrid models are available, ranging from sedans to luxury vehicles. All have the potential to achieve greater fuel economy and lower emissions than conventional gasoline-engine vehicles.

The newer additions to the hybrid lineup have been larger, more expensive vehicles. Hybrids cost more—on average, about $6,000 more than conventional vehicles. This incremental cost is more easily absorbed in higher-priced vehicles.

However, by hybridizing larger vehicles, the automobile industry loses some fuel-economy benefits. For example, a five-passenger Toyota Prius averages 50–55 miles per gallon, compared with a typical passenger vehicle on the road today, which gets half that. On the other hand, a seven-passenger Toyota Highlander hybrid gets 25–27 miles per gallon, just a few more than the gasoline-powered Highlander, which gets 18–24 miles per gallon.

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Among the possible transportation-related strategies to mitigate the effects of climate change, improving fuel economy is the single greatest step that the United States can take today.[14] With the transportation sector responsible for more than 30 percent of U.S. greenhouse gas emissions, matching vehicles to the tasks they must perform can conserve considerable fuel.

Plug-in hybrids are a promising avenue for the future of passenger vehicles, but at present they are available only through a retrofit that voids the original warranty. Nonetheless, owners of hybrid vehicles like the Toyota Prius are buying kits that allow them to replace their car's existing battery with an array of batteries and then use plug-in technology to charge the batteries

and get more mileage in the all-electric mode. Moreover, by charging the battery overnight with off-peak electricity, they can help even demand for electric power.

Plug-in hybrids already have made inroads in the school bus market through the initiative of Advanced Energy, a Raleigh-based nonprofit organization that launched a national consortium to bring the first hybrid school buses to market in 2006. These first-generation buses are expected nearly to double the fuel economy of diesel-powered buses, from 6.5 miles per gallon to 12 miles per gallon, and to reduce emissions significantly. Only twenty have been produced so far. Potential consumers hope that the incremental cost will drop substantially from the more than $140,000 premium being paid now.

Unlike hybrid school buses, all-electric and hybrid-electric transit buses have been in production for several years by multiple manufacturers. North Carolina transit agencies in Chapel Hill, Charlotte, and Winston-Salem are gaining experience with them, and those agencies' counterpart in Durham plans to join the market soon.

North Carolina stands to gain from the increasing interest in hybrids when Design Line, an international bus company currently manufacturing in New Zealand, starts making hybrid buses in a state-of-the-art factory near Charlotte. Charlotte Douglas International Airport has two Design Line hybrid buses in operation already. However, the industry as a whole is hampered by the significant price tag for the increased fuel economy and reduced emissions that hybrids offer.

As the steep cost for new technologies depresses their adoption rate, neighborhood electric vehicles (NEVs) are moving ahead in popularity among North Carolina municipalities, universities, and parks because they can cost less than a new gasoline vehicle. NEVs have zero tailpipe emissions and are plugged into a standard 110-volt outlet. They must be licensed and are legal to drive on roads zoned up to 35 miles per hour, making them an excellent choice for campus and downtown uses. Beginning at less than $7,000, these vehicles can, in some cases, replace a gasoline-powered vehicle at less cost.

For More Information

For fact sheets on biofuel retail locations and distributors, green fleet policies, and fleet assessments, visit the website of the North Carolina Solar Center's Clean Transportation program, www.cleantransportation.org, and click on Transportation Home/Fact Sheets.

The University of North Carolina at Charlotte is an NEV success story. It currently operates fifty-six NEVS serving a variety of functions on campus, including groundskeeping, maintenance, parking-services ticketing, parking-lot management, student services, housekeeping, and construction. Not only is the university saving the environment, but it is saving money—an estimated $3,800 per vehicle—by eliminating fuel costs and reducing maintenance.

UNC at Charlotte is a success story for neighborhood electric vehicles.

Incentives, Policies, and Programs

North Carolina is fortunate to have a handful of incentives, programs, and policies in place to lead the way to a more sustainable future.

The North Carolina Division of Air Quality provides about $800,000 annually through the Mobile Source Emission Reduction Grant Program for projects that directly reduce transportation-related emissions. An annual call for proposals is held from October through December, with awards made the following spring.

With $2 million in funding from the North Carolina Department of Transportation, the State Energy Office, and the North Carolina Division of Air Quality, the Clean Fuel Advanced Technology project also provides direct funding for transportation-related projects to reduce emissions in the state's twenty-four counties that do not meet air-quality standards. A three-year initiative administered by the North Carolina Solar Center at North Carolina State University, the project supports education and outreach as well.

A third program of direct funding was recently launched with $1 million provided by the 2007 General Assembly to the North Carolina Department of Commerce for green-business grants. Spurred by the Lieutenant Governor's Office, the program seeks to expand access to biofuels by North Carolina fleets and individuals, and to expand energy-efficient and environmentally friendly construction businesses.

Government managers and elected officials can map their course by getting involved with Clean Cities coalitions in the Asheville, Charlotte, and Triangle regions. Sponsored by the U.S. Department of Energy, these coalitions of public and private stakeholders seek to expand the use of alternative fuels to reduce the nation's dependence on imported oil.[15] Through regular meetings of stakeholders, they provide a wealth of opportunity for networking and information exchange. With more than ninety coalitions nationwide, Clean Cities also serves as a gateway to activities on the national scene.

The Clean Transportation Program at the North Carolina Solar Center hosts North Carolina Mobile CARE (Clean Air Renewable Energy), an initiative to recognize exemplary efforts at expanding the use of alternative fuels and advanced technologies in North Carolina. Through fleet surveys and individual consultations, Mobile CARE also provides local governments with an opportunity to take stock of where they stand and receive technical assistance on charting a path to reduced emissions and increased energy diversity.

There are other initiatives as well. The Cool Cities campaign, led by the Sierra Club, is enlisting municipalities across the state in reducing greenhouse gas emissions.[16]

All fleets can benefit from examining the paths outlined in this article, bearing in mind that small steps will eventually add up to a big difference.

The state is leading by example with a requirement that vehicles in fleets larger than ten displace petroleum use by 20 percent by 2010. Attaining the goal of displacing approximately 5 million gallons of petroleum use began by establishing a baseline of fuel use in fiscal year 2004–5. The next step is to incorporate alternative fuels into the mix. Examples include the use of E10 instead of regular gasoline at all North Carolina Department of Transportation fuel sites (at least one in every county) and, by the end of 2008, the use of a mix of B20 and conventional diesel instead of 100 percent conventional diesel at these sites.

Conservation and energy efficiency also are playing a role. By reducing the amount of time spend idling, the North Carolina Department of Environment and Natural Resources' fleet of trucks in the Soil and Water Conservation program has cut fuel consumption by 43 percent. Conservation, whenever possible, always makes dollars and sense. Along with alternative fuels and advanced technologies, energy efficiency will carry North Carolina and the nation down the road to a more secure economy and an enhanced environment.

Conclusion

Rising fuel costs, increased concern for the environment due to climate change, and interest in providing clean air for the next generation—all are compelling reasons to consider alternative fuels, advanced transportation technologies, and practices to promote conservation. There is no perfect solution or one-size-fits-all answer, and there may never be. Nonetheless, there are tremendous opportunities now to introduce fuel and technology diversity into the transportation arena that will enhance the economy and the environment (for resources, see the sidebar on page 38). It is important to get started by exploring the options, developing a plan, and sharing the results with others. By beginning with fuel conservation—downsizing vehicles to the smallest vehicle suitable for the job, planning trips, and reducing idling time—North Carolinians can save money, which can then be devoted to exploring the options outlined in this article. Biofuels, low-carbon fuels, and advanced vehicle technologies such as all-electric cars, hybrid-electric cars, and diesel retrofits all are here now and can serve the state for years to come.

Notes

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