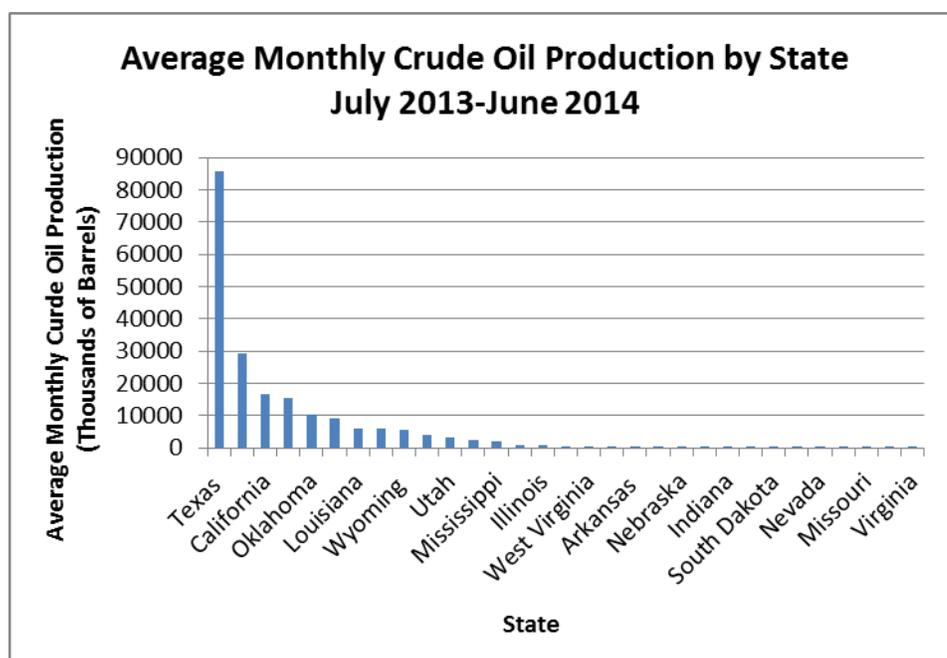


SECTION 11 – ADVANCED VEHICLE TECHNOLOGY AND ALTERNATIVE FUELS

Transportation Energy Alternatives Overview

Virginia is a state with almost no current petroleum production and with a near total dependence on oil for motor fuel imported from other states and countries, as shown in Figure 11-1. There are ample fuel alternatives available, and by considering alternative fuel vehicles, there are significant economic, environmental, and energy security opportunities for the Commonwealth.

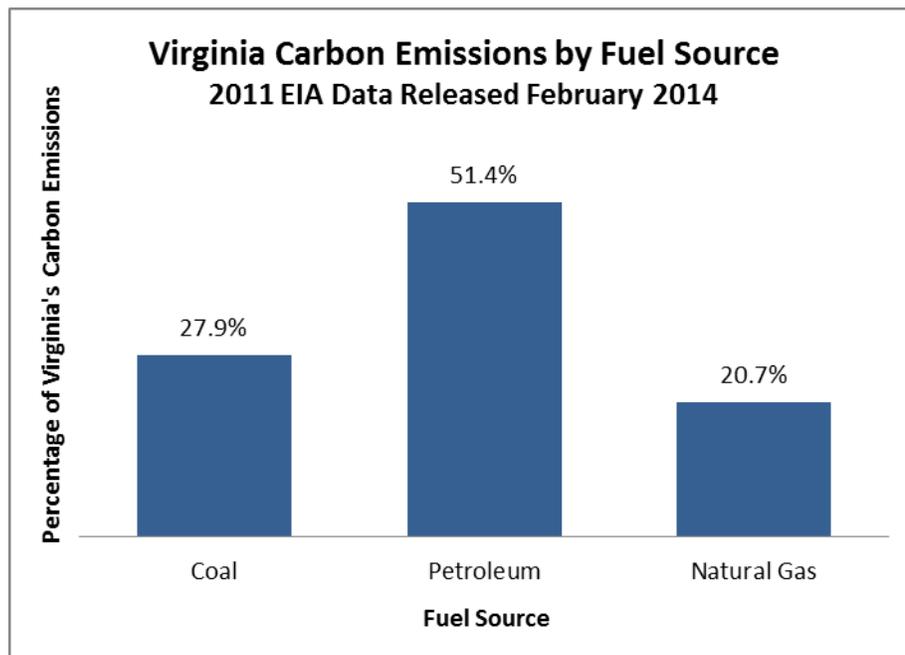
Figure 11-1: Average Monthly Crude Oil Production by State: July 2013-June 2014¹



Oil use causes the majority of the State's emissions impact, as shown in Figure 11-2. This issue is important for climate change considerations. The Commonwealth has formed a U.S. Department of Energy-designated partnership called Virginia Clean Cities, hosted at James Madison University, which works to advance these energy, economic, and environmental opportunities for vehicle fleets and individual consumers in Virginia.

¹ Crude Oil Production, U.S. Energy Information Administration, Monthly Production Averaged for July 2013-June 2014, Data Released September 2, 2014. Data Accessed September 3, 2014. http://www.eia.gov/dnav/pet/pet_crd_crdpn_adc_mbbbl_m.htm Method: Follow link, Download Series History, Average July 2013-June 2014 Monthly Oil Production, Remove PADD averages, and create chart from highest to lowest production.

Figure 11-2: Virginia Carbon Emissions by Fuel Source²



Commonwealth's Alternative Fuel Vehicle Initiative

The Commonwealth of Virginia takes an “all-of-the-above” approach to achieving energy security and recognizes the need to replace imported fuels with cleaner domestic energy for vehicles. In 2011, the Virginia General Assembly unanimously approved legislation directing the establishment of a plan to replace state-owned vehicles that operate using gasoline or diesel fuel, with vehicles that operate using natural gas, electricity, or other alternative fuels³. Alternative fuels also include ethanol, propane, biodiesel, hydrogen, and others defined by alternative fuel providers or submitting entities.

In order to implement a successful and cost-effective strategy to replace state-owned vehicles, resources available in the private sector have been leveraged. In this effort, private sector natural gas and propane infrastructure and vehicle partners have been selected and approved on a state contract to deploy alternative fuel vehicles and stations that can service the state fleet. These partnerships help expand the alternative fuels and vehicles markets, support the expansion of private sector businesses, and create jobs in Virginia.

This initiative will continue to gain momentum as more public and private decision makers are brought together to discuss vehicle options for fleets across the State.

² Virginia State CO₂ Emissions, U.S. Energy Information Administration, Release Date: February 25, 2014, Data from: 2011, http://www.eia.gov/environment/emissions/state/state_emissions.cfm Method: Download Virginia Emissions data, Use Fuel Totals to create percentage shares of total carbon emissions

³ VA HB 2282, 2011, Regular Session (2011, April 06). Virginia Information System. Retrieved September 1, 2014, from <http://leg1.state.va.us/cgi-bin/legp504.exe?111+sum+HB2282>

Transportation Infrastructure

Virginia's alternative fuel infrastructure is varied and growing. By the end of 2013⁴, Virginia had 369 public and private alternate fuel stations throughout the Commonwealth. Virginia gained 83 new stations in 2013, mainly due to the large boost in electric vehicle charging stations. The most readily available of these fueling stations include electric, biodiesel, and propane (LPG). Table 11-1 shows the growth and changes in the total number of public and private alternative fuel stations in the Commonwealth, by individual fuels between 2005 and 2013, and Figure 11-3 shows a map of Virginia's Alternative Fuel Stations.

Table 11-1: Alternative Fuel Stations in Virginia⁵

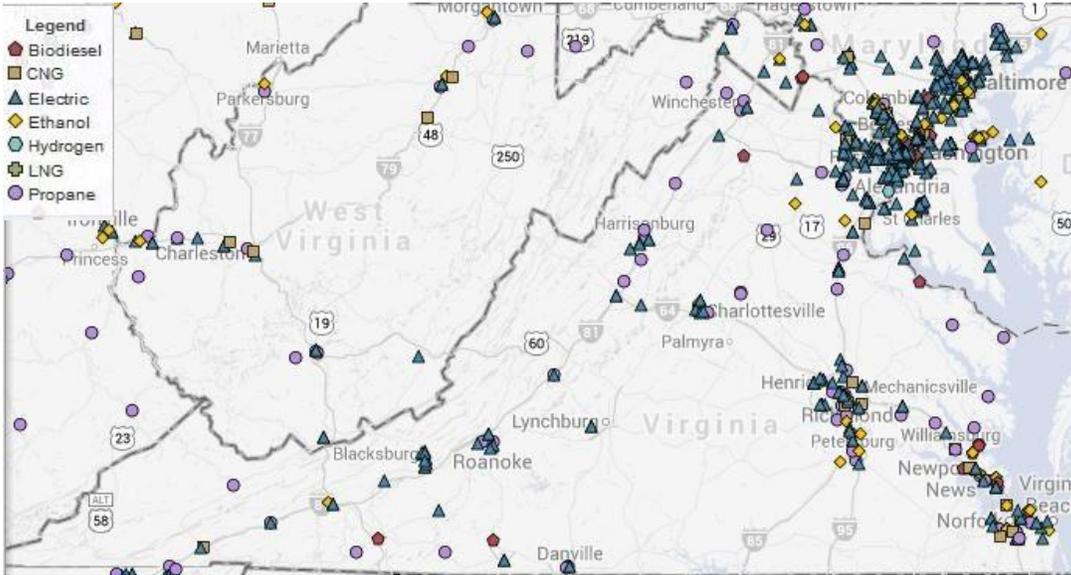
	Bio die sel	C N G	E 8 5	Hyd rog en	LP G Pr op an e	L N G	El ec tri c	Tot al Alt Fu el Sta tio ns
2 0 0 5	32	1 2	4	0	26	-	-	74
2 0 0 6	39	1 2	4	1	26	-	-	82
2 0 0 7	39	1 2	4	1	26	-	-	82
2 0 0 8	40	1 2	4	1	26	-	-	83
2 0 0 9	38	1 1	8	1	27	-	1	86
2 0 1 0	44	1 4	1 1	1	49	-	4	12 3
2 0 1 0	48	1 2	1 5	1	66	-	47	18 9

⁴ Virginia Clean Cities, Alternative Fuels Inventory Report, June 2014. Submitted to the Virginia Department of Mines, Minerals and Energy, Energy Division (2014, July 5).

⁵ Virginia Clean Cities, Alternative Fuels Inventory Report, June 2014.

1								
1								
2								
0								
1			1	1			14	28
2	36	7	9	2	70	2	0	6
2								
0								
1		2	2				21	36
3	33	1	1	2	71	2	9	9
2								
0								
1		2	2				24	41
4	33	4	0	2	82	2	7	0

Figure 11-3: Virginia Alternative Fuel Stations Map⁶



⁶ Virginia Alternative Fueling Station Locator, Alternative Fuels Data Center, U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy. Retrieved July 7, 2014 from <http://www.afdc.energy.gov/afdc/locator/stations/state>.

Market Trends

Production

Virginia's alternative fuels production is largely in natural gas, propane, (which is a byproduct of natural gas processing), biodiesel, and ethanol. In 2012, Virginia produced 146.4 trillion cubic feet of natural gas⁷, of which the vast majority came from coal bed wells. In 2013, Virginia produced 3.3 million gallons of biodiesel at two active biodiesel refineries and 1 million gallons of ethanol from one active refinery, for a combined biofuel production of 4.3 million gallons.⁸ This is the largest biofuels production output in the State over the past six years; and producers reported a potential production capacity of 17.5 million gallons.⁹ Virginia's biofuels (biodiesel and ethanol) production from 2008 through 2013 is shown in Figure 11-4 and biofuels producing facilities located around the State are shown in Figure 11-5.

Figure 11-4: Gallons of Biofuel Produced in Virginia, 2008-2013¹⁰

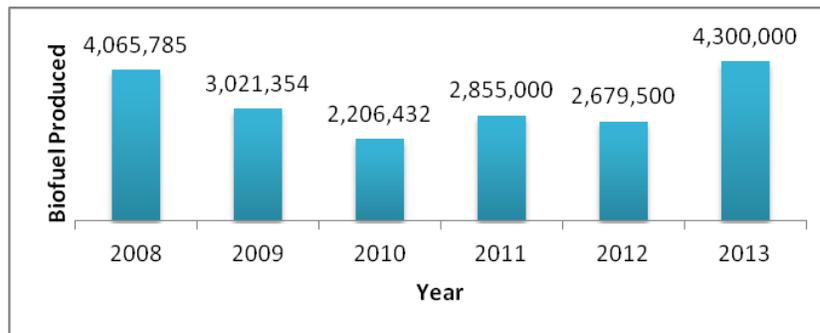
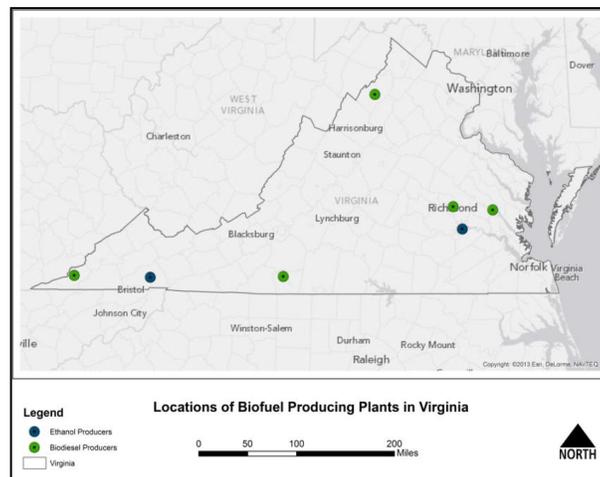


Figure 11-5: Biofuels Producing Plants in Virginia: January 2014¹¹



⁷ U.S. Energy Information Administration, Virginia Natural Gas Summary, http://www.eia.gov/dnav/ng/ng_sum_lsum_dc_u_sva_a.htm

⁸ Virginia Clean Cities, Virginia Alternate Fuels Report, January 2014. <http://www.vacleancities.org/wp-content/uploads/Alt-Fuels-Report-Q4-2013-Final.pdf>

⁹ Ibid.

¹⁰ Ibid.

¹¹ Virginia Clean Cities, Virginia Alternate Fuels Report, January 2014. <http://www.vacleancities.org/wp-content/uploads/Alt-Fuels-Report-Q4-2013-Final.pdf> (Production plant location data was collected directly from production plants).

Consumption

Virginia has significant alternative fuels usage in government and private fleets. The growth of alternative fuel vehicles and conventional fuel vehicles in Virginia's green fleets are shown in Figure 11-6. Within these fleets, E85 and biodiesel represent the largest level of alternative fuel consumption in the Commonwealth, despite a recent decline in the use of biodiesel. In 2013, Virginia fleets reported using E85 in over 8,500 vehicles and biodiesel in over 4,300 vehicles.¹²

Figure 11-6: Alternative Fuel Fleets and Vehicles in Virginia's Green Fleets

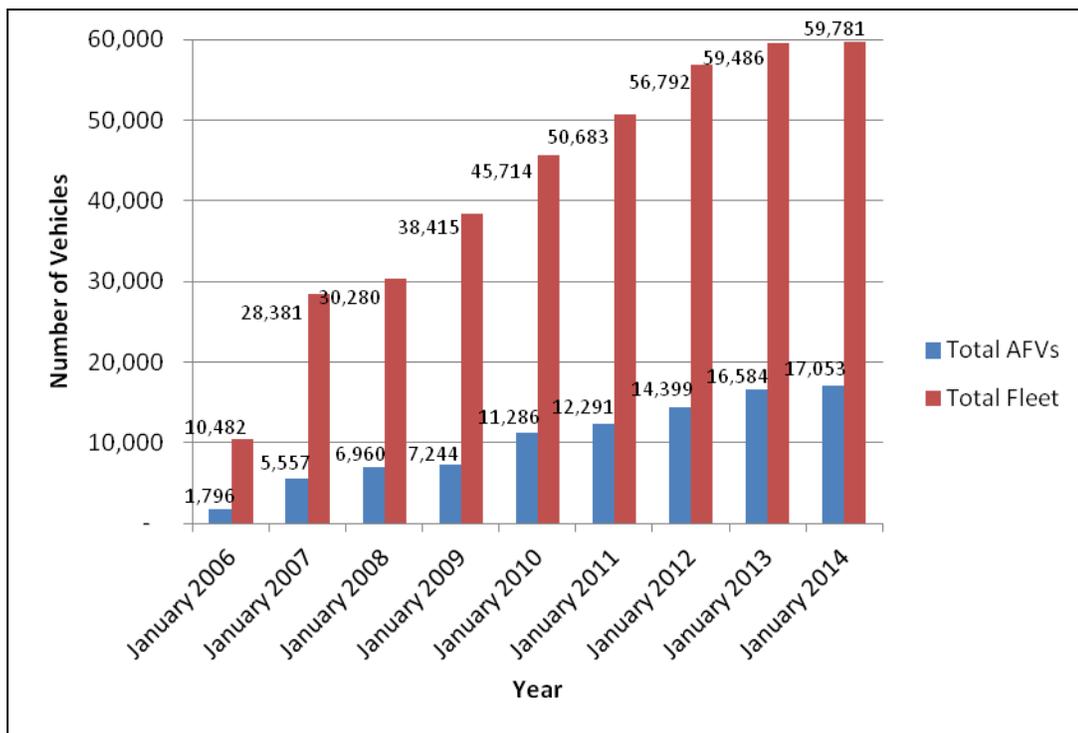
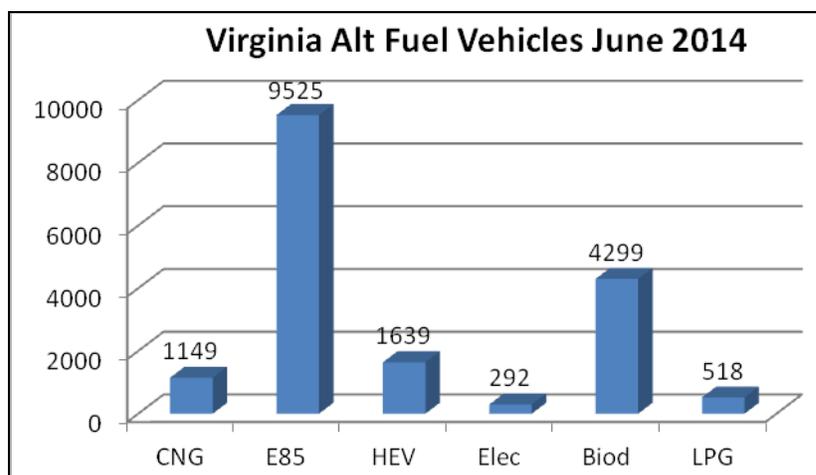


Figure 11-7 shows the total number of alternative-fuel vehicles in fleets in the Commonwealth, as of June 2014. Natural gas has become a growing alternative for heavy duty vehicles, and in 2013, Virginia consumed 217 million cubic feet of natural gas for vehicle fuel¹³. Electric vehicles are also growing quickly in fleet use despite their low overall numbers.

¹² Ibid.

¹³ Virginia Clean Cities, Alternative Fuels Inventory Report, June 2014.

Figure 11-7: 2014 Alternative Fuel Fleet Vehicles in Virginia¹⁴



Fuel Prices

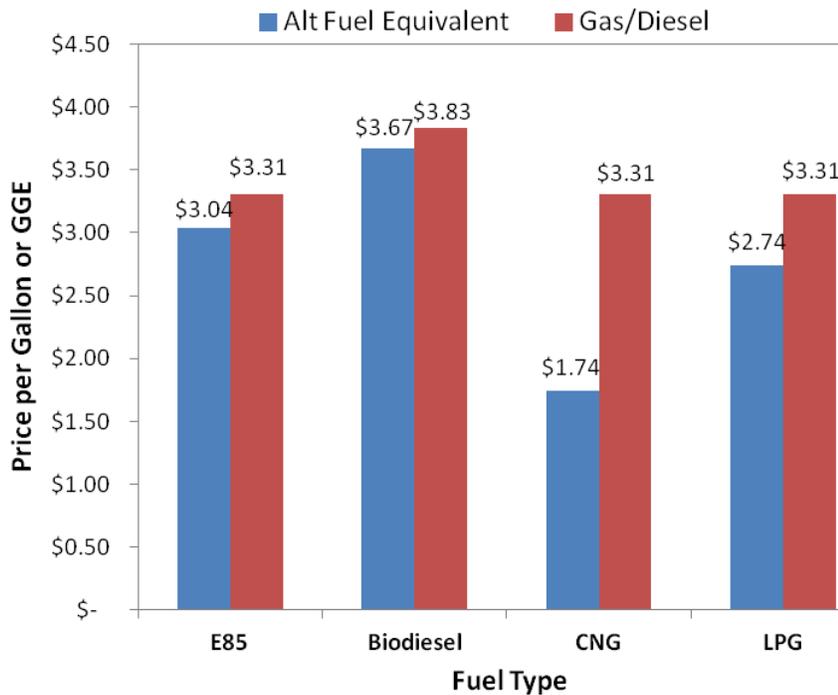
Figure 11-8 compares Virginia's average petroleum prices with alternative fuel equivalent prices collected in the Spring of 2014 by Virginia Clean Cities' alternative fuel price report.¹⁵ Of note, several alternative fuel equivalents are often lower than their gasoline or diesel equivalent. Fleet pricing for alternative fuels is consistently and significantly lower than many public prices for gasoline and diesel in Virginia energy equivalents. Electricity is not included because Virginia electricity has no stable fuel retail price per kilowatt (KW), but at current utility rates electricity is available for less than \$1.00 gallon equivalent at homes and workplaces.



¹⁴ Ibid.

¹⁵ Virginia Clean Cities, Alternative Fuel Price Report, April 2014. Submitted to the U.S. Department of Energy on 2014, April 15.

Figure 11-8: Virginia Alternative Fuel and Petroleum Prices: Spring 2014¹⁶



Alternative Fuels

Biodiesel

Biodiesel is a liquid fuel made up of fatty acid alkyl esters, fatty acid methyl esters, or long-chain mono alkyl esters. It is produced from renewable sources such as new and used vegetable oils, animal fats, and recycled restaurant grease (yellow grease). It is a nontoxic, biodegradable, and cleaner burning replacement for petroleum-based diesel fuel.¹⁷

Biodiesel in Virginia is produced at several facilities, which collect waste grease or vegetable oils and process them into biodiesel fuel. In Virginia, 3.5 million gallons of biodiesel are produced each year, facilitating jobs and economic impact while reducing emissions.¹⁸

Biodiesel is distributed from the point of production via truck, train, or barge. Pipeline distribution of biodiesel, which would be the most economical option, is still in the experimental phase. It is distributed to retail fueling stations and directly to end users such as large vehicle fleets, and can be easily dispensed through fueling equipment that is similar to regular diesel dispensers. Many stations throughout the Commonwealth offer biodiesel at the pump at various blend levels.

Biodiesel performs similarly to traditional diesel, though B100 (100 percent biodiesel) may result in minimal power loss and a slight reduction in fuel economy due to its having lower energy content

¹⁶ Ibid.

¹⁷ Biodiesel Fuel Basics, Alternative Fuels Data Center, U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, http://www.afdc.energy.gov/fuels/biodiesel_basics.html

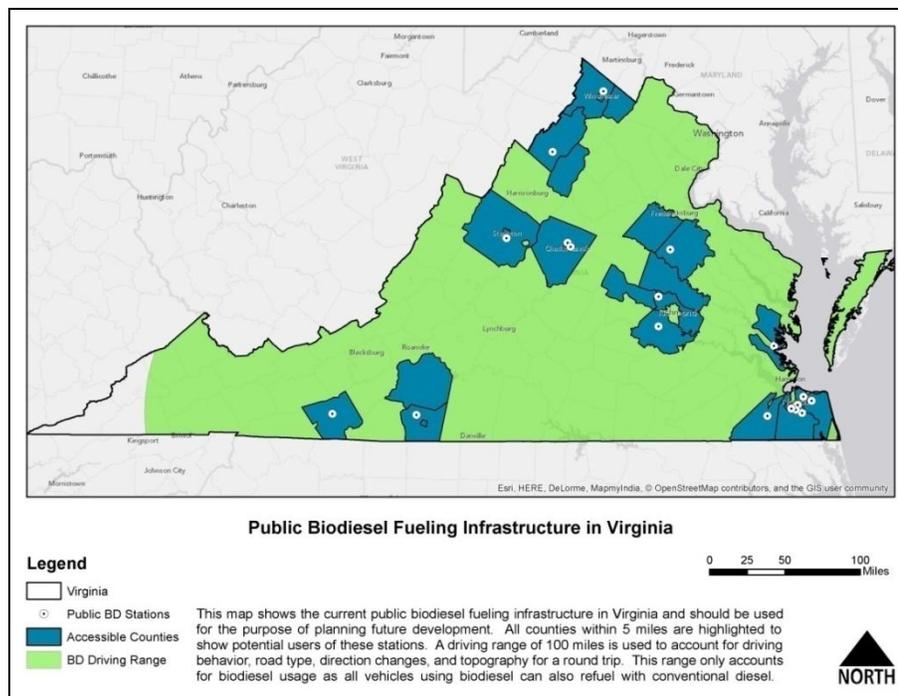
¹⁸ Virginia Clean Cities, Alternative Fuel Production Inventory, January 2014

than petroleum diesel. Because biodiesel acts as a lubricant, it reduces wear and tear on the engine, reducing maintenance costs and extending engine life. Biodiesel also results in significantly lower emissions of particulate matter, carbon monoxide, toxic contaminants, sulfur dioxide, hydrocarbons, visible smoke, and noxious odors as compared to petroleum diesel emissions.¹⁹ The production of biodiesel has a 1-to-5.54 energy balance ratio, which means that for every 1 unit of energy that goes into production, 5.54 units of energy are produced.²⁰

Numerous fleets in Virginia have used biodiesel including: school systems in Williamsburg-James City County, Gloucester County, and Virginia Beach; local government and school fleets in the Counties of Chesterfield, Arlington, Westmoreland, and Northumberland and the Cities of Newport News, Staunton, Blacksburg, Roanoke, and Waynesboro; U.S. military fleets for the Army, Navy, and Air Force; Woodfin Oil; SuperValu; the University of Virginia and Virginia Tech; and more.

Biodiesel can be used in almost any diesel vehicle without modification, except older vehicles that need rubber materials replaced because biodiesel is a powerful solvent. Figure 11-9²¹ shows the locations of current public biodiesel fueling infrastructure in Virginia. Public stations are presented as white dots and all counties within 5 miles of the stations are highlighted in blue to show the potential users of these stations.

Figure 11-9: Public Biodiesel Fueling Infrastructure in Virginia: June 2014



¹⁹ Biodiesel Vehicle Emissions, Alternative Fuels Data Center, U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, http://www.afdc.energy.gov/vehicles/diesels_emissions.html

²⁰ Pradham, A. et al. Energy Life-Cycle Assessment of Soybean Biodiesel Revisited, 2011 American Society of Agricultural and Biological Engineers: <http://www.usda.gov/oce/reports/energy/EnergyLifeCycleSoybeanBiodiesel6-11.pdf>

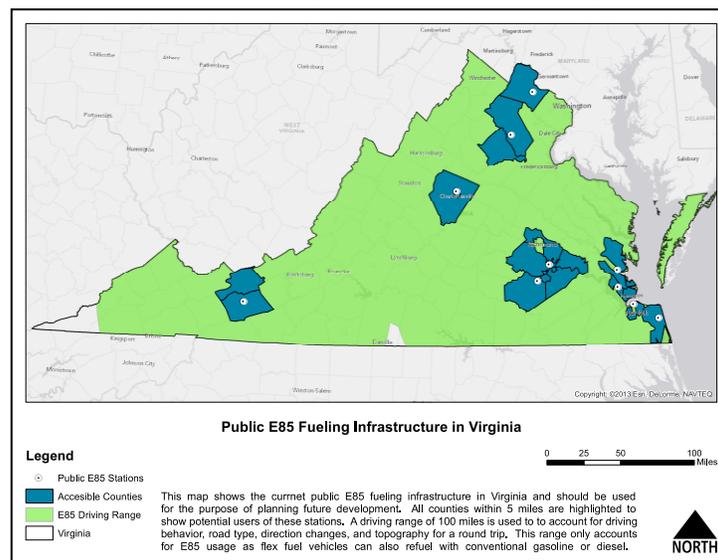
²¹ Virginia Clean Cities, Virginia Alternative Fuel Maps: A GIS Based Analysis of Virginia's Alternative Fuel Infrastructure. June 2014, <http://www.vcleancities.org/wp-content/uploads/Virginia-Alt-Fuel-Report.pdf>

Ethanol

Ethanol is a renewable fuel made from various plant materials, which collectively are called "biomass." This includes corn, barley, wheat, and cellulose feedstocks such as corn stalks, rice straw, sugar cane bagasse, pulpwood, switch grass, and municipal solid waste.²² As a motor fuel, ethanol is produced in a similar process as alcohol, and it is blended with gasoline for use in vehicles.

There are currently several blends of ethanol fuel on the market. E10 is a blend of 10 percent ethanol and 90 percent gasoline.²³ More than 70 percent of American gas stations now sell E10, but as newer vehicles are manufactured, the industry may shift to raise the standard to more E15 use. E15 is a blend of 15 percent ethanol and 85 percent gasoline.²⁴ This is a new, higher octane blend that has been approved by the U.S. Environmental Protection Agency (EPA) for use in vehicles year 2001 and newer. The Mid-Level Blends, or E20, E30, and E40 are blended between 10 percent and 85 percent ethanol.²⁵ All flex-fuel vehicles (FFVs) on the road are manufactured to operate on gasoline and up to 85 percent ethanol, so mid-level blends can be dispensed at stations that have blender pump infrastructure. There are 300,000 FFVs in Virginia today.²⁶ The most common ethanol fuel mixture and standard fuel for FFVs is E85, a blend of 85 percent denatured ethanol and 15 percent gasoline.²⁷ Finally, E100 is pure ethanol fuel and is not commonly sold in the United States.²⁸ Figure 11-10²⁹ shows the locations of current public ethanol fueling infrastructure in Virginia.

Figure 11-10: Ethanol Fueling Infrastructure in Virginia: June 2014



²² Ethanol Fuel Basics, Alternative Fuels Data Center, U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, http://www.afdc.energy.gov/fuels/ethanol_fuel_basics.html

²³ Ethanol Blends, Alternative Fuels Data Center, U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy http://www.afdc.energy.gov/fuels/ethanol_blends.html

²⁴ Ibid.

²⁵ Ibid.

²⁶ Virginia Clean Cities, 2013 Transportation Technology Deployment Annual Report, March 2014. <http://www.vacleancities.org/wp-content/uploads/Approved-Annual-Report.pdf>

²⁷ Ethanol Blends, Alternative Fuels Data Center, U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, http://www.afdc.energy.gov/fuels/ethanol_blends.html

²⁸ Ibid.

²⁹ Virginia Clean Cities, Virginia Alternative Fuel Maps: A GIS Based Analysis of Virginia's Alternative Fuel Infrastructure. June 2014. <http://www.vacleancities.org/wp-content/uploads/Virginia-Alt-Fuel-Report.pdf>

Most ethanol is produced in the grain-growing states of the mid-western United States, but there are several producers within the Commonwealth. Vireol Ltd. opened an ethanol plant in Hopewell, in 2014, that has a capacity to produce 62 million gallons of bioethanol a year.³⁰ The plant produces ethanol from corn, barley, and other small grains. One major byproduct of production is dried distiller grains, a high protein feed ingredient used in poultry and livestock industries. MXI Environment Services, LLC, is a leading national supplier of ethanol recycling. MXI has an Ethanol Recycling Facility in Abingdon, that takes in waste containing alcohol and recaptures the ethanol using distillation, then processes it into fuel grade ethanol with a molecular sieve.³¹ Fiberight LLC has a pilot plant in southern Virginia that turns garbage, corn stalks, and wheat straw into biofuel ethanol by pressure cooking materials into pulp composed of cellulose, which can be broken down into sugar and turned into ethanol in the right conditions.³² Finally, at the time of this writing, Tyton BioEnergy Systems, a Virginia company, has announced plans to facilitate ethanol production in North Carolina using tobacco as a primary feedstock, which will create 79 jobs and will be a \$36 million investment in the State.³³

Propane

Propane, also known as liquefied petroleum gas (LPG or LP-gas), or auto gas, is a three-carbon alkane gas (C_3H_8)³⁴. Stored in puncture-resistant tanks at 300 psi, propane turns into a colorless, odorless liquid. As pressure is released, the liquid propane vaporizes and turns into gas that is used for combustion. An odorant, ethyl mercaptan, is added to all propane for leak detection. Propane has a high octane rating and excellent properties for spark-ignited internal combustion engines. It is also non-toxic and presents no threat to soil, surface water, or groundwater.³⁵

Propane, also known as liquefied petroleum gas (LPG or LP-gas), or auto gas, is a three-carbon alkane gas (C_3H_8)!

The interest in propane as an alternative transportation fuel stems mainly from its domestic availability, high energy density, clean-burning qualities, and low costs at the volumes used for motor fuel application. It is the most commonly used alternative transportation fuel and the third most used vehicle fuel, behind gasoline and diesel. Propane is considered an alternative fuel under the Energy Policy Act of 1992.

There are two types of propane vehicles: dedicated and bi-fuel. Dedicated propane vehicles are designed to run only on propane, while bi-fuel propane vehicles have two separate fueling systems that enable the vehicle to use either propane or gasoline. Currently, no light-duty propane vehicles are available for sale by automotive original equipment manufacturers (OEMs); however, other certified installers can economically and reliably retrofit many light-duty vehicles for propane operation. Light- and medium-duty options for vehicles powered by propane include the Ford F-250, F-350, E-450 cutaway, F-450, F-550, F-650, and cargo and passenger vans. Propane engines and fueling systems are readily available for medium- and heavy-duty vehicles such as school

³⁰ British company plans to open Hopewell ethanol plant, WWBT-TV NBC 12, Richmond, VA, 2014, January 10, <http://goo.gl/8IKJ6p>.

³¹ Ethanol Disposal & Recycling, MXI Environmental Services, LLC, <http://www.ethanolrecycling.com/>

³² Business Overview, Fiberight, <http://fiberight.com/investor-relations/>

³³ \$1.8 M Fed Grant Helps Bring \$200M NC Biofuel Plant, North Carolina Biotechnology Center, 2014, June 18, <http://www.ncbiotech.org/article/18m-fed-grant-helps-bring-nc-cellulosic-ethanol-plant/15636>.

³⁴ Propane Fuel Basics, Alternative Fuels Data Center, U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, http://www.afdc.energy.gov/fuels/propane_basics.html.

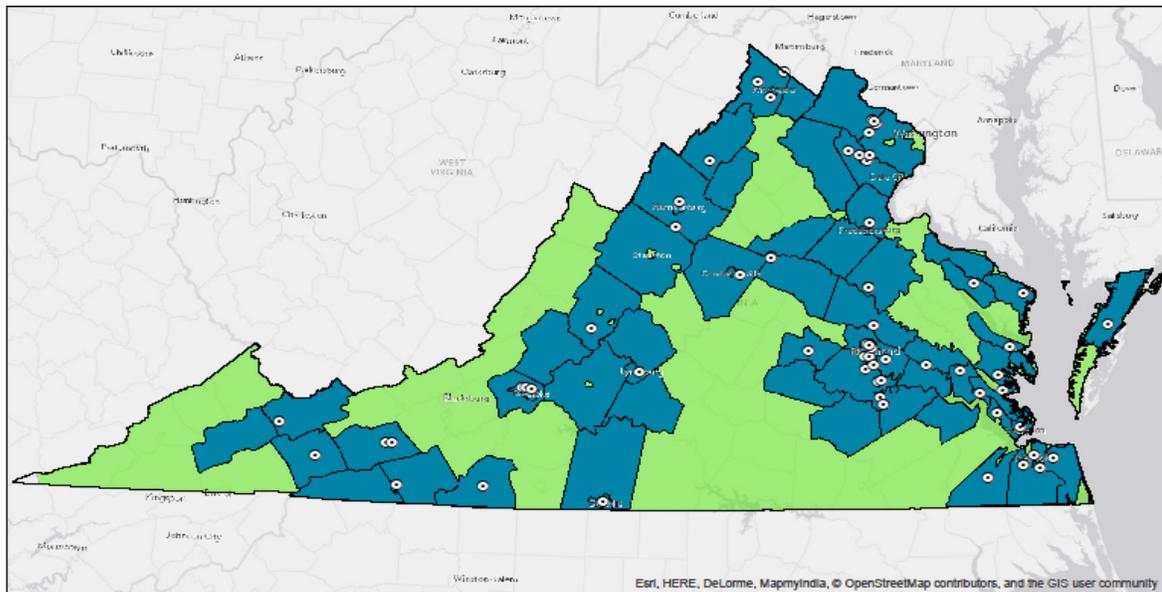
³⁵ Ibid.

buses and street sweepers, including some from OEMs. Currently, over 500 vehicles are operating on this fuel in Virginia.³⁶

Transportation vehicle conversions in the United States require U.S. Environmental Protection Agency (EPA) certification and a skilled propane conversion technician. The upfront costs to convert fleet vehicles to propane can be offset by lower fuel, operating, and maintenance costs over the lifespan of the vehicles. Conversion to a dedicated propane or bi-fuel propane vehicle can be attractive when fueling infrastructure is in place and volume fuel discounts are available. This fueling infrastructure is inexpensive and there are over 80 public and fleet stations in Virginia.³⁷ The payback period depends on the average distance traveled by these fleet vehicles. Fleet vehicles typically are high-mileage, high fuel consumption vehicles operating in a limited area, so the payback period on propane fleet vehicles can be very reasonable.

Figure 11-11³⁸ shows the locations of public propane fueling infrastructure in Virginia. Public stations are presented as white dots and all counties within 5 miles of the stations are highlighted in blue to show the potential users of these stations. A 100-mile driving radius was input for each station, accounting for driving behavior, road type, direction changes, and topography for a round trip. The driving range for Virginia public stations is highlighted in green.

Figure 11-11: Public LPG Fueling Infrastructure in Virginia: June 2014



Public LPG Fueling Infrastructure in Virginia

Legend

- Virginia
- Public LPG Stations
- Accessible Counties
- LPG Driving Range

This map shows the current public LPG fueling infrastructure in Virginia and should be used for the purpose of planning future development. All counties within 5 miles are highlighted to show potential users of these stations. A driving range of 100 miles is used to account for driving behavior, road type, direction changes, and topography for a round trip. This range only accounts for LPG usage as bifuel vehicles can also refuel with conventional gasoline or diesel.



³⁶ Virginia Clean Cities, Virginia Alternate Fuels Report, January 2014. <http://www.vacleancities.org/wp-content/uploads/Alt-Fuels-Report-Q4-2013-Final.pdf>

³⁷ Virginia Clean Cities, Alternative Fuel Production Inventory, June 2014,

³⁸ Virginia Clean Cities, Virginia Alternative Fuel Maps: A GIS Based Analysis of Virginia's Alternative Fuel Infrastructure. June 2014, <http://www.vacleancities.org/wp-content/uploads/Virginia-Alt-Fuel-Report.pdf>,

Natural Gas

Natural gas is a mixture of hydrocarbons, predominantly methane, and also contains ethane, propane, and other gases such as nitrogen, helium, carbon dioxide, hydrogen sulfide, and water vapor.³⁹ It is one of the cleanest burning alternative fuels available and offers a number of advantages over gasoline.

Most natural gas used in the U.S. is produced domestically from gas wells or as a result of crude oil production. Natural gas can also be mined from subsurface porous rock reservoirs through extraction processes, such as hydraulic fracturing. In addition, natural gas can come from decaying organic materials, such as waste from plants, landfill gas and water/sewage, and livestock.⁴⁰ Processing is required to separate the gas from petroleum liquids and to remove contaminants.

The difference in tailpipe emissions between conventional and natural gas vehicles has narrowed because more stringent emissions regulations have been applied to conventional vehicles and modern emissions controls have been deployed⁴¹. In light-duty applications, the emissions from natural gas vehicles are similar to conventional gasoline vehicles with modern emissions controls. However, CNG vehicles do see a reduction of 50 percent in evaporative volatile organic compounds and a 10 percent reduction in carbon monoxide.⁴² Currently, the primary applications for compressed natural gas vehicles are heavy haulers, public transit bus fleets, and waste hauling trucks; however, there are effective vehicle options as small as compact passenger vehicles.



Natural gas vehicles can be fueled at public stations or private, on-site stations. Currently, there are 6 public and 18 private CNG stations, and 2 LNG stations in Virginia.⁴³ Station development is an expensive and time-consuming process that requires working through local permitting agencies, acquiring land near an adequate pipeline, and obtaining long-term contracts and customers for the fuel. Growing worldwide demand for natural gas will also put pressure on suppliers and potentially increase the price per gallon, thereby reducing the financial incentive to invest in expensive refueling stations.

Natural gas vehicles can easily be fueled at public stations or take advantage of on-site refueling. Individual home compressors use a slow-fill system for overnight refueling. In heavy-duty applications, the cost of a high capacity fast-fill private or public station could be anywhere from

³⁹ Natural Gas Fuel Basics, Alternative Fuels Data Center, U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, http://www.afdc.energy.gov/fuels/natural_gas_basics.html

⁴⁰ Ibid.

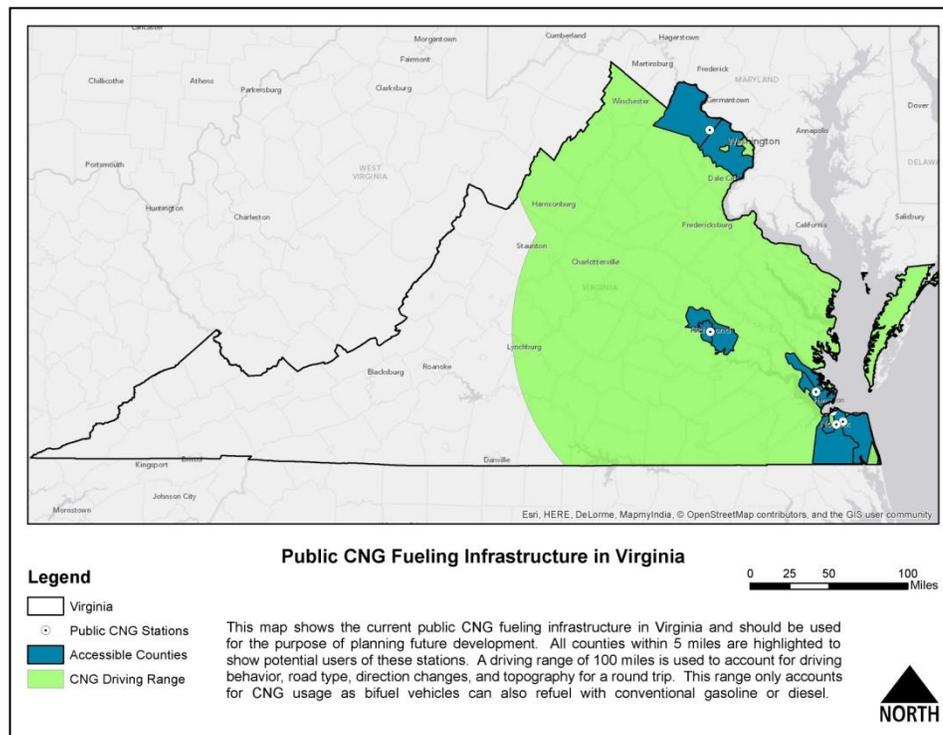
⁴¹ Natural Gas Vehicle Emissions, Alternative Fuels Data Center, U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, http://www.afdc.energy.gov/vehicles/natural_gas_emissions.html

⁴² GREET Fleet Carbon and Petroleum Footprint Calculator, Argonne National Laboratory, 2012 https://greet.es.anl.gov/fleet_footprint_calculator

⁴³ Virginia Clean Cities, Alternative Fuels Inventory Report, June 2014

\$200,000 to as much as \$3 million, but often ranges around \$1 million. Wider availability of this inexpensive fuel could lead to much wider adoption. Figure 11-12⁴⁴ shows the locations of public CNG fueling infrastructure in Virginia.

Figure 11-12: Public CNG Fueling Infrastructure in Virginia: June 2014



Electric Vehicles

Adoption of electric vehicles (EVs) is becoming a reality in the Commonwealth of Virginia. Electricity represents a less expensive, cleaner, and locally generated energy source that also contributes to new economic advantages. The energy industry research group, PRTM Management Consultants, has estimated that vehicle electrification could represent more than \$250 billion in economic development opportunities, worldwide, by 2020.⁴⁵ This estimate considers growth in electricity generation and distribution, grid and infrastructure investments, batteries and their components, vehicle sales, and associated advertising and marketing services.

Although electricity production may contribute to air pollution, EVs are considered zero-emissions vehicles because their motors produce no exhaust or emissions. There are several types and models of electric vehicles that are on the market today from all auto manufacturers. An all-electric vehicle runs solely on electricity with no internal combustion engine. Hybrid electric vehicles combine the benefits of high fuel economy and low emissions with the power and range of

⁴⁴ Virginia Clean Cities, Virginia Alternative Fuel Maps: A GIS Based Analysis of Virginia's Alternative Fuel Infrastructure. June 2014. <http://www.vcleancities.org/wp-content/uploads/Virginia-Alt-Fuel-Report.pdf>

⁴⁵ Virginia Clean Cities, Richmond Electric Vehicle Initiative (REVI) Electric Vehicle Readiness Plan, March 2013, <http://www.vcleancities.org/wp-content/uploads/Final-REVI-Plan-Email-low-res.pdf>

conventional gasoline fueling. Hybrid technologies also have potential to be combined with alternative fuels and fuel cells to provide additional benefits. Plug-in hybrids are plug-in electric vehicles that carry a small conventional combustion engine. The combustion engine is engaged once the battery is exhausted, at which point the car operates as a conventional hybrid. This combination allows for longer trips.

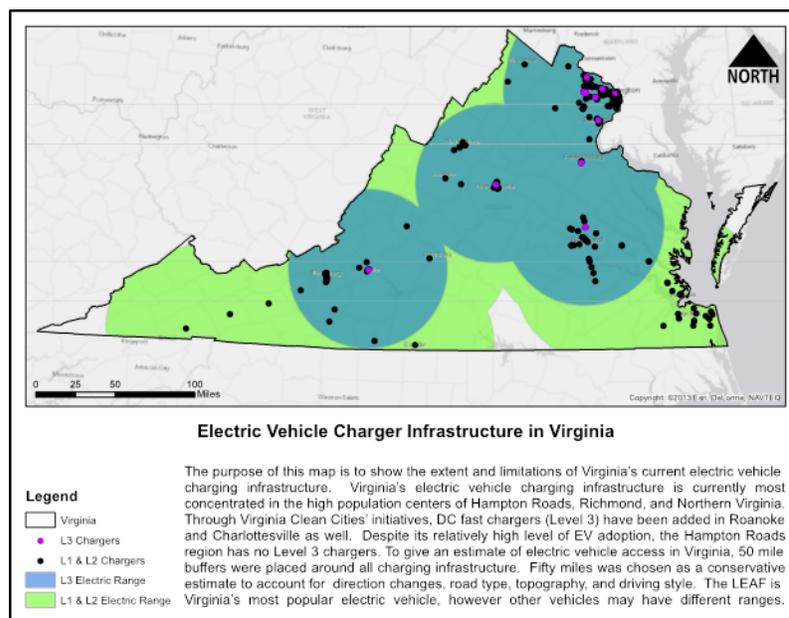
The Commonwealth of Virginia has seen extensive growth in electric vehicle deployment in recent years. Based on information from the Virginia Department of Motor Vehicles, there were 3,078 electric vehicles in Virginia as of May 2014.⁴⁶ This is an increase of over one thousand percent over 2012.

Electric Vehicle Charging

Electric vehicle recharging facilities are being installed at individual consumers' facilities and increasingly at multi-family, commercial, and government buildings across Virginia. Electric vehicles can be recharged from any outlet at home or at work, but Virginia drivers and owners often install a 240-volt charger similar in power use as a dryer, and as such are inexpensive or free to permit. A third level of charging is provided by Fast Chargers which are more like traditional gas station rapid charging. In Virginia, businesses and individuals can sell electricity for electric vehicle fuel use and not be considered a utility.

According to Virginia Clean Cities, there are currently 247 electric vehicle charging stations in Virginia. There are also current efforts across the Commonwealth to develop a network of DC Fast Chargers in key development areas. Figure 11-13⁴⁷ shows Virginia's current electric vehicle charging infrastructure.

Figure 11-13: Electric Vehicle Charging Infrastructure in Virginia: June 2014

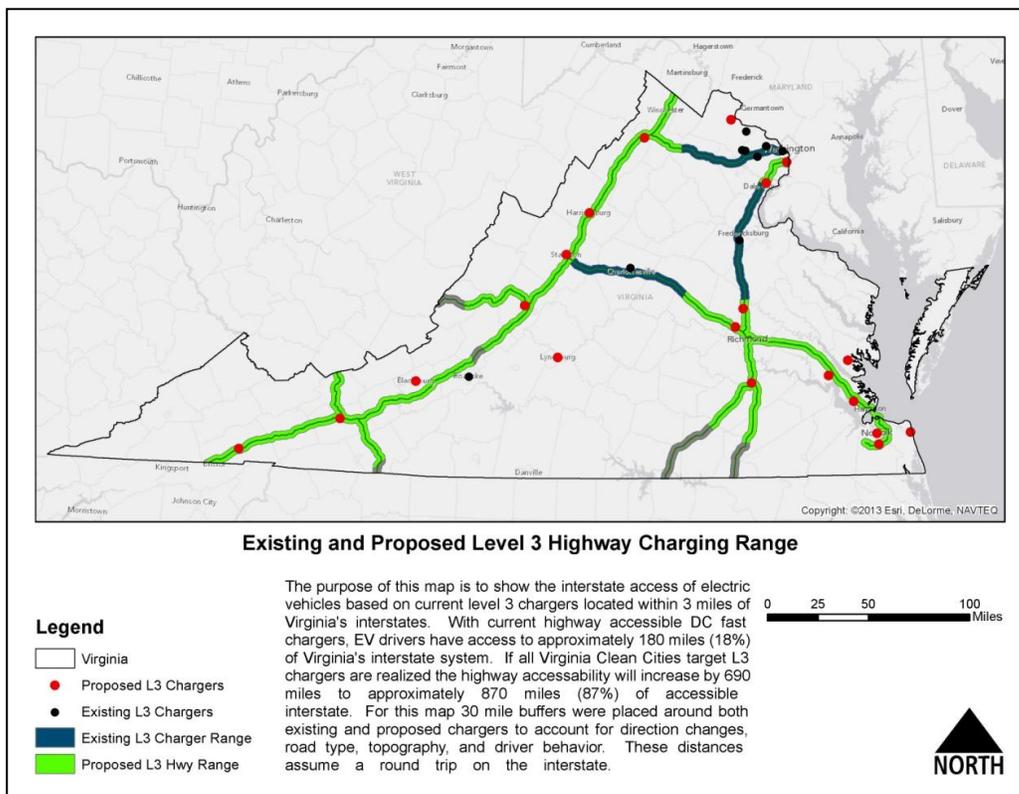


⁴⁶ Virginia Department of Motor Vehicles, proprietary information request, 2014

⁴⁷ Virginia Clean Cities, Virginia Alternative Fuel Maps: A GIS Based Analysis of Virginia's Alternative Fuel Infrastructure, June 2014, <http://www.vcleancities.org/wp-content/uploads/Virginia-Alt-Fuel-Report.pdf>

Figure 11-14⁴⁸ shows the current interstate access for electric vehicles based on current Level 3 chargers, within 3 miles of Virginia's major interstates. The map's black dots represent existing chargers and the blue lines represent the existing range. With the existing infrastructure, EV drivers can only access 18 percent of Virginia's interstate system.

Figure 11-14: Existing and Proposed Level 3 Highway Charging Range: June 2014



Hydrogen Fuel Cells

Hydrogen has been recognized as an alternative fuel under the Energy Policy Act⁴⁹ (EPAct 1992) since 1992 and currently qualifies for several federal motor vehicle and fuel tax credits, as well as infrastructure incentives.⁵⁰ Fuel cell electric vehicles powered by hydrogen are two to three times more efficient than conventional vehicles and produce no harmful tail pipe emissions. Numerous vehicle manufacturers have tested hydrogen fuel cell technology, and in 2015, several different platforms will become available in the American market. As of 2014, the market trend is to offer hydrogen fuel cell vehicles under a 3-year leasing program where the cost of the fuel is included in the lease price. The majority of hydrogen vehicles are expected in California where infrastructure

⁴⁸ Virginia Clean Cities, Virginia Alternative Fuel Maps: A GIS Based Analysis of Virginia's Alternative Fuel Infrastructure, June 2014, <http://www.vcleancities.org/wp-content/uploads/Virginia-Alt-Fuel-Report.pdf>

⁴⁹ Energy Policy Act of 1992. Public Law 102-486. Enacted October 24, 2002 by 102nd Congress, http://www.afdc.energy.gov/laws/key_legislation#epact92

⁵⁰ Federal Laws and Incentives for Hydrogen, Alternative Fuels Data Center, U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, <http://www.afdc.energy.gov/fuels/laws/HY/US>

and state incentives are available, but with technology and range advancement, additional states like Virginia will begin to adopt this technology for transportation.

Like battery electric vehicles, fuel cell electric vehicles use electricity to power a motor located near the vehicle's wheels. In contrast to other electric vehicles, fuel cell vehicles produce their primary electricity using a fuel cell powered by hydrogen, rather than a battery. Hydrogen is stored at 10,000 psi or in a cryogenic liquid tank and is passed through a proton exchange membrane in the presence of oxygen. This creates the electric current that powers the vehicle, along with water vapor as waste product. During the vehicle design process, the vehicle manufacturer controls the power of the vehicle by changing the fuel cell size and controls the amount of energy stored on board by changing the fuel tank size. This is different than a battery electric vehicle where the amount of power and energy available are both closely tied to the battery size.

Hydrogen can be produced using diverse, domestic resources including fossil fuels, such as natural gas and coal (with carbon sequestration), nuclear, and biomass as well as other renewable energy technologies, such as wind, solar, geothermal, or hydro-electric power. One common way to produce hydrogen is through electrolysis, which separates water into hydrogen and oxygen; and hydrogen is also a waste product of certain nuclear power industry activities.

State Incentives

Notable incentives and regulations for Virginia from the Alternative Fuels and Advanced Vehicles Data Center (AFDC) are listed below.⁵¹

Biodiesel Production Tax Credit

Qualified biodiesel and green diesel producers are eligible for a tax credit of \$0.01 per gallon of biodiesel or green diesel fuels produced. This credit is available for producers who generate up to two million gallons of biodiesel or green diesel fuel per year. The annual credit may not exceed \$5,000, and producers are only eligible for the credit for the first three years of production. The Virginia Department of Mines, Minerals and Energy must certify qualified producers.

Biofuels Production Grants

The Biofuels Production Incentive Grant Program provides grants to producers of neat advanced biofuels, which include fuels derived from any cellulose, hemicelluloses, or lignin from renewable biomass or algae, and producers of neat biofuels, which include biofuels derived from cereal grains. The grant for neat advanced biofuels or neat biofuels produced in the Commonwealth is as follows: 2014 Calendar Year - \$0.04 per gallon, 2015 Calendar Year - \$0.03 per gallon, and Calendar Year 2016 through June 2017 - \$0.025 per gallon. To qualify, a producer must have begun selling neat biofuels on or after January 1, 2014. A qualified producer must produce a minimum of one million gallons of biofuels, annually, in the Commonwealth, with feedstocks originating in the United States. Beginning January 1, 2016, grants will not be awarded for corn-derived biofuels. The Virginia Department of Mines, Minerals and Energy may not approve more than \$1.5 million in grants for each fiscal year between 2014 and 2017. This program expires June 30, 2017.

⁵¹ Virginia Laws and Incentives, Alternative Fuels and Advanced Vehicles Data Center, <http://www.afdc.energy.gov/laws/laws/VA>

Clean Energy Manufacturing Grants

The Clean Energy Manufacturing Incentive Grant Program provides financial incentives to clean energy manufacturers, including biofuel producers. A producer is eligible for a grant if it commences or expands operations in Virginia on or after July 1, 2011. Producers must make a capital investment greater than \$50 million and create at least 200 full-time jobs that pay at least the prevailing wage.

Agriculture and Forestry Biofuel Production Grants

The Agriculture and Forestry Industries Development (AFID) Fund provides grants to promote and develop the agriculture and forestry industry in Virginia and create or expand value-add facilities, including qualified biofuel production facilities. Individual grants may not exceed \$250,000 or 25 percent of qualified capital expenditures, and are awarded at the Governor's discretion. The grants are awarded to local governments and other Virginia political subdivisions working with qualified businesses. Terms and conditions apply, including the use of a minimum percentage of Virginia grown products, matching funds, and performance requirements.

Clean Transportation Technology Investment Funding

The Commonwealth Energy Fund (CEF), administered through the Center for Innovative Technology, provides early-stage investment funds for Virginia-based companies that provide clean energy products or services. Eligible clean transportation technologies may include vehicles, components, batteries, and fuel cells, in addition to biofuels.

Alternative Fuels Grants and Loans

The Alternative Fuels Revolving Fund is used to distribute loans and grants to municipal, county, and Commonwealth government agencies to support alternative fuel vehicle (AFV) programs; pay for AFV maintenance, operation, evaluation, or testing; pay for vehicle conversions; or improve alternative fuel infrastructure. Eligible alternative fuels include electricity, hydrogen, and natural gas. Projects with a funding match are given priority in the evaluation process.

High-Occupancy Vehicle (HOV) Lane Exemption

Alternative fuel vehicles (AFVs) displaying the Virginia Clean Special Fuel license plate may use Virginia HOV lanes, regardless of the number of occupants. For HOV lanes serving the I-95/I-395 corridor, only registered vehicles displaying Clean Special Fuel license plates issued before July 1, 2006, are exempt from HOV lane requirements. For HOV lanes serving the I-66 corridor, only registered vehicles displaying Clean Special Fuel license plates issued before July 1, 2011, are exempt from HOV lane requirements. Eligible vehicles include dedicated AFVs and some hybrid electric vehicles. The annual fee for Clean Special Fuel license plates is \$25 in addition to the prescribed fee for the Commonwealth's license plates.

Alternative Fuel Job Creation Tax Credit

Businesses involved in alternative fuel vehicle (AFV) and component manufacturing, alternative fueling equipment component manufacturing, AFV conversions, and advanced biofuels production are eligible for a job creation tax credit of up to \$700 per full-time employee. The credit is allowed in the taxable year in which the job is created and in each of the two succeeding years in which the job is continued. Qualified AFVs include vehicles that operate using natural gas, propane, hydrogen, electricity, or advanced biofuels. This credit is effective for taxable years through December 31, 2014.

Green Jobs Tax Credit

Qualified employers are eligible for a \$500 tax credit for each new green job created that offers a salary of at least \$50,000, for up to 350 jobs per employer. The credit is allowed for the first five years that the job is continuously filled. For the purposes of this tax credit, a green job is defined as employment in industries relating to renewable or alternative energy, including hydrogen and fuel cell technology, landfill gas, and biofuels. The tax credit expires on January 1, 2015.

Alternative Fuel Vehicle (AFV) and Fueling Infrastructure Loans

The Virginia Board of Education may use funding from the Literary Fund to provide loans to school boards that convert school buses to operate on alternative fuels or construct alternative fueling stations.

Ethanol Production Equipment Tax Exemption

A county, city, or town may exempt, partially exempt, or set a lower tax rate for qualified equipment used by farmers or farm cooperatives to produce ethanol, provided that the ethanol feedstock consists primarily of farm products.

Biofuel Feedstock Registration Exemption

Individuals that transport waste kitchen grease for conversion to biofuel are exempt from both the Virginia Department of Health registration and the associated annual application fee. This exemption only applies if the individual transports the waste kitchen grease in a container with a capacity of less than 275 gallons and possesses no more than 1,320 gallons of waste kitchen grease, biofuel feedstock derived from kitchen grease, or biofuel at any one time, excluding biofuel contained in vehicle fuel tanks. Other restrictions apply.

Alternative Fuel and Hybrid Electric Vehicle (HEV) Emissions Testing Exemption

The Virginia emissions inspection program, which requires biennial inspections of motor vehicles, does not apply to vehicles exclusively powered by compressed or liquefied natural gas, liquefied petroleum gas (propane), hydrogen, a combination of compressed natural gas and hydrogen, or electricity. Qualified HEVs with U.S. Environmental Protection Agency fuel economy ratings of at least 50 miles per gallon (city) are also exempt from the emissions inspection program unless remote sensing devices indicate the HEV may not meet current emissions standards.

Idle Reduction and Natural Gas Vehicle (NGV) Weight Exemption

Any motor vehicle equipped with an auxiliary power unit or other idle reduction technology may exceed the gross, single axle, tandem axle, or bridge formula weight limits by up to 550 pounds to compensate for the added weight of the idle reduction technology. Furthermore, any NGV may exceed the limits by up to 2,000 pounds.

Alternative Fuel Tax Exemption

Alternative fuel is exempt from taxes if it is sold to a government entity for its exclusive use, sold to a nonprofit charitable organization for the purpose of providing charitable services for low-income medical patients, or produced by an agricultural operator and used exclusively for farm use or vehicles of that operator.

Plug-In Electric Vehicle (PEV) Charging Rate Reduction - Virginia Dominion Power

Virginia Dominion Power offers two rates for residential customers who own qualified PEVs, the Electric Vehicle Pricing Plan and the Electric Vehicle + Home Pricing Plan. The Electric Vehicle Pricing plan allows PEV owners to take advantage of lower rates during off-peak hours. Under this plan, customers must install an additional meter specifically for their electric vehicle supply equipment (EVSE); and Dominion will provide this meter at no charge. The Electric Vehicle + Home Pricing Plan is a whole-house pricing plan in which the customer's EVSE is treated as another appliance. Dominion will provide a new meter at no charge, to record energy usage in 30-minute intervals. This allows Dominion to apply pricing based on time-of-day and encourages customers to charge their PEV during off-peak hours, as hours much as possible. PEV pricing plans are expected to expire on November 30, 2014.