SECTION 8 – ENERGY INFRASTRUCTURE

EXISTING AND IMPROVING ENERGY INFRASTRUCTURE

Introduction

As illustrated in previous Sections of the Energy Plan, a dynamic and diverse infrastructure is needed to provide Virginia's businesses and residents with the energy they need. The existing infrastructure includes:

- Electricity generation, transmission and distribution
- Coal mining, transportation and export
- Nuclear power, spent fuel storage and training
- Natural gas production, transmission and storage
- Renewables, including wood/biomass production and transportation, solar, geothermal, hydroelectric, landfill gas capture and wind
- Petroleum and propane production, refining, transportation and distribution
- Alternative Fuels and Advanced Vehicle Technology

Other sections of the Energy Plan have detailed individual energy sources and their production, generation, distribution, demand and future trends. Some of that information is summarized here to reiterate the importance of maintaining and growing the infrastructure in order to continue to provide affordable energy to Virginians.

Electricity

With the numerous energy sources and vast infrastructure in Virginia, the utilities do not own in-state generation capacity sufficient to meet their territories' peak loads plus the reserves required by the Federal Energy Regulatory Commission.

- In 2010, 35.9 percent of the electricity consumed was purchased on the wholesale market pursuant to existing contracts[1].

- Up to 45 percent of Virginia's electric supply comes from power generated out of state. Most imports come from coal-fired plants located west and north of Virginia. A small amount of imports come from renewable projects such as wind projects in West Virginia, Illinois, and Indiana. According to the State Corporation Commission (SCC), however, between 85 and 90 percent of the total supply of electricity to Virginia's Investor Owned Utilities is produced from facilities owned by the utilities that serve Virginia and are under SCC rate setting jurisdiction.

- All three of Virginia's investor-owned utilities own out-of-state generation facilities dedicated to serving their Virginia customers.

[1] EIA. State Electric Profiles, Virginia, http://www.eia.doe.gov/cneaf/electricity/st_profiles/virginia.html

Transmission and Distribution of Electricity
Within the electric system, transmission lines carry bulk power from power stations to substations. Dominion Virginia Power, Appalachian Power, Delmarva Power, and Allegheny Power own and maintain transmission and distribution facilities in Virginia. The Virginia State Corporation Commission (SCC) must certify the need for and approve the location of proposed new electric transmission lines. Substations "step-down" voltages from the very high voltages used in the bulk power system to lower voltages needed to serve retail customers. Distribution lines carry power from substations to individual homes and businesses. These lines include main lines and smaller "tap" lines. Since the early 1990s most neighborhood tap lines have been placed underground as a matter of course to improve reliability. In 2014, the Virginia General Assembly approved legislation that allows utilities to place up to 20 percent of the worst performing neighborhood lines underground, in order to reduce the frequency and duration of electricity outages in neighborhoods served by overhead distribution lines.

Transmission is regulated by the Federal Energy Regulatory Commission, pursuant to federal law. FERC, together with the Regional Transmission Organizations, in Virginia the RTO is PJM, review and approve proposed new transmission projects and set rates of recovery for those projected developments.

PJM Interconnection
PJM is an independent service operator (ISO); as such it has been designated by the FERC as a regional transmission organization that manages the interstate high voltage electric delivery system, as well as coordinating and creating a forward pricing market for electric power within its region.

PJM works closely with other ISOs, such as the Midwest, New York, and New England ISOs to provide enhanced reliability for the electricity transmission system in the entire Mid-Atlantic and northeastern United States. PJM also sets market rules related to the purchase of wholesale power, and has emergency management protocols and capacity retention tools.

PJM is charged with the responsibility of assuring the reliability of the transmission grid in its territory. PJM publishes annually a Regional Transmission Expansion Plan (RTEP) to identify the need for new transmission resources.[2] The RTEP process involves a 15 year planning window to address transmission investments to ensure grid reliability and improve economic efficiency. PJM continues to assess the ongoing reliability of transmission facilities throughout the Commonwealth.

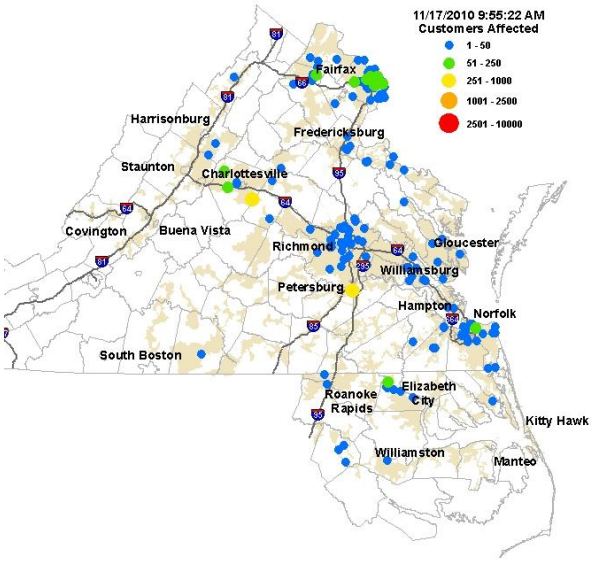
Virginia Electric Utility Companies
Three regulated investor-owned electric power companies serve Virginia: Dominion Virginia Power, Appalachian Power, and Kentucky Utilities/Old Dominion Power.

[2] PJM Fact Sheet, http://www.pjm.com/documents/~/media/about-pjm/newsroom/fact-sheets/rtep-fact-sheet.ashx.

Dominion Virginia Power
Dominion Virginia Power is the largest electricity provider in the Commonwealth. The parent company operates in several states where it sells both electricity and natural gas, and owns extensive critical energy assets. System-wide, these assets include 5,000 miles of electricity transmission lines; 12,000 miles of natural gas transmission, storage, and gathering pipelines; and 925 Billion cubic feet (Bcf) of natural gas storage capacity. Within Virginia, the company serves 2.4 million electricity customers, principally in the eastern half of the State: 42 percent residential, 34 percent commercial, 11 percent governmental, and 8 percent industrial. Figure 8-1 shows a typical weather-related outage map that encompasses Dominion's service territory in the Commonwealth.

The map also includes the company's service area in North Carolina.

Figure 8-1. Dominion Virginia Power Service Territory

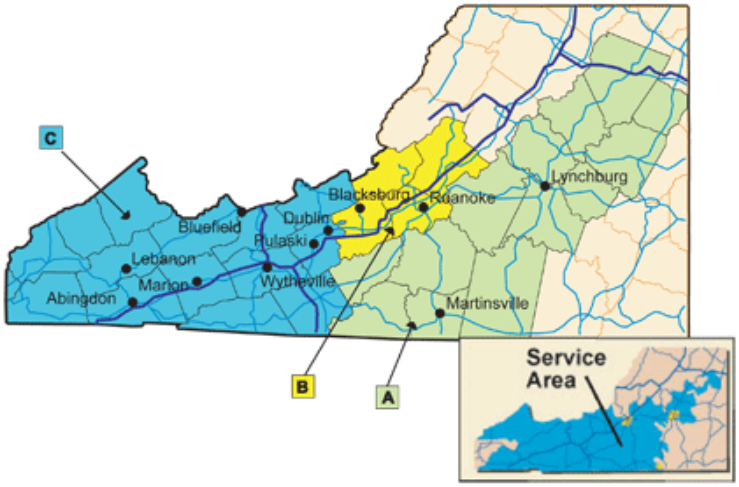


Source: Dominion, https://www.dom.com/storm-center/dominion-electric-outage-map.jsp.

Dominion Virginia Power has 29 electric power generating plants representing 61 percent of total generation capacity within Virginia. Two of the generating plants are nuclear plants, eleven burn coal, ten burn natural gas, five burn oil, and one is pumped storage hydroelectric.

American Electric Power
AEP is a large, multi-State electric power generator that owns the nation's largest electricity transmission system. Appalachian Power, a subsidiary of AEP, serves about one million customers in its three-state operating area that includes Virginia, West Virginia, and Tennessee. The utility owns nearly seven percent of Virginia's total generation capacity and over 2,000 miles of electric transmission lines. The company serves Virginia customers west of a line that runs approximately from Lynchburg to Martinsville. Figure 8-2 depicts the service territory and the location of external affairs offices in Virginia.

Figure 8-2. Appalachian Power Territory and External Affairs Offices

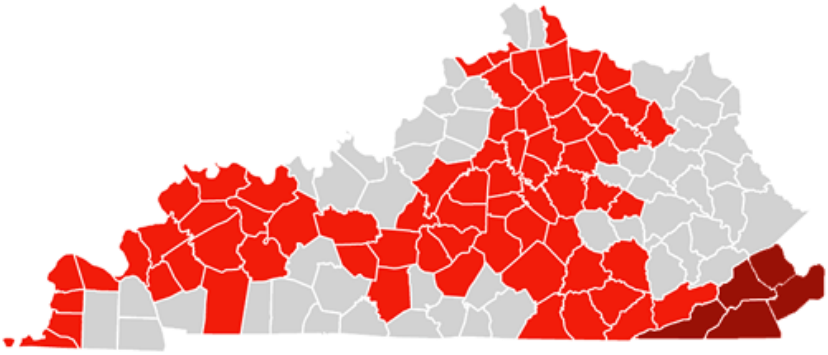


Source: Appalachian Power, External Affairs, https://www.appalachianpower.com/account/bills/rates/RatesAndTariffs.aspx.

Kentucky Utilities

Kentucky Utilities, headquartered in Lexington, Kentucky, is known in Virginia as Old Dominion Power. In 2010, Kentucky Utilities was acquired by PPL Corporation of Allentown, Pennsylvania. It has a total generation capacity of 4,570 MW. All four of its generating plants are located in Kentucky: Ghent in Carroll County, Tyrone in Woodford County, E.W. Brown in Mercer County, and Green River in Muhlenberg County. Kentucky Utilities serves five counties and 29,000 customers in the southwestern tip of Virginia. Figure 8-3 depicts the utility's entire service area, which is mostly in Kentucky; the darker-shaded region on the lower right side of the map includes the southwestern tip of Virginia served by Old Dominion Power.

Figure 8-3. Kentucky/Old Dominion Service Territory



Source: LGE/KU Service Territories, http:// www.lge-ku.com/service_territory.asp.

Cooperative Utilities
The SCC regulates 13 distribution electric cooperatives; all are members of the Virginia/Maryland/District Association of Electric Cooperatives (VMDAEC), an association of 16 member cooperatives in Virginia, Maryland and Delaware. The Virginia cooperatives serve over 600,000 retail customers. The Virginia cooperatives are listed here with URL linkage:

A&N Electric Cooperative
B-A-R-C Electric Cooperative
Central Virginia Electric Cooperative
Community Electric Cooperative
Craig-Botetourt Electric Cooperative
Mecklenburg Electric Cooperative
Northern Neck Electric Cooperative
Northern Virginia Electric Cooperative
Prince George Electric Cooperative
Rappahannock Electric Cooperative
Shenandoah Valley Electric Cooperative
Southside Electric Cooperative
Powell Valley Electric Cooperative

The VMDAEC assists the Commonwealth and member cooperatives with mitigation of electricity problems and restoration of service. In addition to monitoring federal and State policy issues, the Association has training programs that help workers at member cooperatives maintain and upgrade their professional skills and the members ensure compliance with applicable federal and state safety regulations.

Old Dominion Electric Cooperative
Old Dominion Electric Cooperative (ODEC), headquartered in Glen Allen, Virginia, is a generation and transmission cooperative that serves wholesale and retail electricity customers in Virginia, Delaware, Maryland and North Carolina. The nine Virginia member cooperatives are A&N, BARC, Community, Mecklenburg, Northern Neck, Prince George, Rappahannock, Shenandoah, and Southside.

ODEC generates power from five power plants in Virginia and Maryland. ODEC has purchased undivided shares in:

- North Anna Nuclear Plant, Louisa County – 11.6 percent of 1,800 MW
- Clover Power Station (coal-fired), Halifax County – 50 percent of 850 MW
- Three combustion turbine peaking plants:
  - Marsh Run Station, near Remington in Fauquier County
  - Louisa Power Station, near Gordonsville, Virginia
  - Rock Springs in Cecil County, Maryland

In 2010, ODEC acquired interests in hydro, landfill gas and wind power facilities. In addition, ODEC owns transmission lines and delivers electricity via power lines that Dominion Virginia Power, Appalachian Power and Delmarva Power operate in Delaware, and Allegheny Power Company operates in Maryland, respectively. Four other Virginia cooperatives purchase power via bilateral contracts with various providers, such as IOUs or non-utility generators.

Municipal Utilities
There are 16 municipal electric utilities serving approximately 161,000 retail customers Virginia customers. The Municipal Electric Power Association of Virginia (MEPAV) represents them. MEPAV's president, vice president, and three other individuals constitute an executive committee. MEPAV does not have a separate office or executive director; however, MEPAV retains a legislative consultant who monitors electricity policy matters on behalf of the membership. When the need arises, MEPAV can be contacted through the Virginia Municipal League or by contacting any of the member municipalities for the contact information.

The members of MEPAV are:

- City of Bedford
- Town of Blackstone
- City of Bristol
- Town of Culpeper
- City of Danville
- Town of Elkton
- City of Franklin
- Town of Front Royal
- Harrisonburg Electric Commission
- City of Manassas
- City of Martinsville
- City of Radford
- Town of Richlands
- City of Salem
- Virginia Polytechnic Institute & State University
- Town of Wakefield

Coal Mining, Transportation, and Exports
Coal is one of the top three sources used to generate electricity, along with nuclear and natural gas, and accounts for about 20 percent of Virginia's total energy generation. Virginia supplied 25 percent of the coal while the rest came from Kentucky and West Virginia based on availability and cost.

Virginia's mining companies produce nearly 4.5 percent of U.S. coal east of the Mississippi River from underground and surface mines in Southwest Virginia. It is mined in the Southwest Virginia Coalfield, part of the Appalachian Coal Basin which extends from Pennsylvania to Alabama, where to this day almost all of Virginia's coal is produced. In 2013 there were 51 Virginia mining companies which produced 17 million tons of coal. Of the 51 companies, 2 produced 8 million tons (45 percent of the 2013 production).
While Virginia is 14th in the nation in terms of coal production, over the past 10 years production has begun to decrease. The easily mined coal seams have been depleted and the number of producing mines has decreased by 10 percent making it more challenging to continue to produce at the same level. The majority of the coal comes from underground mines.

Coal is transported by rail throughout Virginia and beyond. On a tonnage basis, coal accounts for more than two-thirds of all Virginia rail freight traffic. Coal is shipped from the Southwest Virginia Coalfield via Norfolk-Southern and CSX railroads via each company's primary coal corridor lines.

Not all of the coal produced in Virginia is used to produce energy in the state. Much of the coal that is produced in the state is sold in the European and Asian markets for steel and manufacturing or electric generation. In a typical year, 25-30 percent of the coal is sold domestically for manufacturing steel or making industrial steam. Only a small amount is sold for institutional, commercial and residential heating.

Nuclear Power

Dominion operates four nuclear units at its two Virginia nuclear power plants. In 2012, these plants provided 36.4 percent of the electricity generated in Virginia. All of the plants were started in the 1970s and 1980s and currently have operating licenses which extend to 2030-2040. Operating capacity for the four reactors in Virginia in 2013 ranged from 77.7 to 96.9 percent with an average of 90.1 percent[3].

Two units are located at the North Anna Power Station in Louisa County and two are located at the Surry Power Station in Surry County.

- Dominion owns an 88.4 percent share of the North Anna station. The Old Dominion Electric Cooperative owns the remaining 11.6 percent share.
- Dominion owns 100 percent of the Surry Station.
- The Nuclear Regulatory Commission (NRC) extended both Surry's and North Anna's operating licenses in 2003. Generally, the NRC issues licenses for reactors to operate for up to 40 years. These licenses can be renewed for up to an additional 20 years, which is the case for both North Anna and Surry.[4]
- Surry currently employs 965 employees and North Anna employs 960 employees at an average salary (exclusive of benefits) of more than $80,000 per year.

[3] Energy Information Administration, Sources & Uses, Total Energy, Monthly Energy Review, Nuclear Energy, Table 8.1 Nuclear Energy Overview.
[4] National Regulatory Commission, Nuclear Reactors, License Renewal, Overview.

In addition to its nuclear generation plants at Surry and North Anna, Virginia hosts a number of nuclear powered naval vessels, including aircraft carriers, other surface vessels, and attack and ballistic missile submarines.

Dominion has made operating and capital improvements to the plants that have reduced down time for refueling and repairs and increased plant efficiency as well as upgrades that have increased their generating capacity.

Spent Fuel Management
Nuclear fuel is currently stored on the North Anna and Surry sites in spent fuel pools and dry storage casks. Dominion customers have been paying a fee of one-tenth of one cent/kilowatt hour ($.001/kWh) generated by nuclear power plants into the federal Nuclear Waste Fund to finance a permanent spent nuclear fuel storage facility.

Nuclear Plant Siting and Construction
Nuclear power plant siting is largely regulated through the licensing process of the Nuclear Regulatory Commission (NRC). Licensing requirements have been streamlined since plants were licensed in the 1960s and 1970s. Nuclear utilities now can receive an early site permit followed by a combined construction-operating permit.

Dominion has received its early site permit for the proposed third North Anna unit and the combined construction-operating permit application is pending before the NRC. Nuclear plant permitting and construction can take up to 8-10 years. Nuclear plants are major construction projects, involving thousands of construction workers. North Anna 3 would be one of the largest construction projects in Virginia history.

Uranium Mining
Currently, more than 90 percent of uranium used in commercial nuclear reactors in the United States is imported.[5] Virginia has a uranium oxide resource in Pittsylvania County, estimated at 119 million pounds (at 0.025 percent uranium oxide cutoff). There is currently a moratorium on uranium mining in Virginia, with no change expected.

Nuclear Industry Workforce Development
Construction of the North Anna 3 plant would provide thousands of construction jobs in addition to the growing reactor manufacturing in Newport News. US customer needs are met by Mitsubishi Nuclear Energy Systems (MNES) headquarters based in Arlington, VA, which supports existing power plants, as well as new facilities, through the introduction of the US Advanced Pressurized Water Reactor technology.

Virginia is a leader in design, construction, and maintenance of nuclear power plants through AREVA, B&W, Dominion, and Northrop Grumman.

- AREVA, B&W, and Northrop Grumman have an ongoing need for nuclear and other engineers and service technicians
- Northrop Grumman employs thousands of workers at its Newport News shipyard constructing nuclear powered ships

[5] EIA, http://www.eia.gov/todayinenergy/detail.cfm?id=2150, July 11, 2011

- Dominion's current nuclear workforce is nearing retirement age and trained technicians and engineers are needed to replace those leaving
- Dominion will also need additional nuclear plant operation, engineering, maintenance, and other workers if it adds the third unit to the North Anna power station

Furthermore, both Virginia Tech and Virginia Commonwealth University have nuclear-related teaching and research capacity to serve the industry.

Natural Gas Production, Transmission, and Storage

Most of Virginia's natural gas production comes from coal bed methane fields, two of which (Nora and Oakwood fields) are among the 100 largest natural gas fields in the United States. Virginia ranked 4th among the states in coal bed methane proved reserves at the end of 2011. Virginia produces the equivalent of approximately 50 percent of the natural gas the state consumes. According to the U.S. Energy Information Administration (EIA), Virginia ranked 16th in the nation among all States that produced natural gas in 2012. Coal bed methane accounted for roughly 82 percent of the total production (about 121 bcf) and conventional gas accounted for about 18 percent (about 26 bcf).

> Virginia ranked 16th in the nation among all States that produced natural gas in 2012.

Natural gas is produced in Southwest Virginia, in Buchanan, Dickenson, Russell, Lee, Scott, Tazewell and Wise counties. Coal bed methane (CBM) is also produced in Buchanan, Dickenson, Russell, Tazewell and Wise counties. Virginia natural gas and coal-bed methane wells have produced 1.63 trillion cubic feet of gas since 1950.

In 2012, Virginia consumers used 392.2 billion cubic feet (BCF) of natural gas. An additional 17.8 billion cubic feet was consumed in the operation of pipelines, primarily in compressors, and in well, field, and lease operations, such as drilling operations, heaters, dehydrators, and field compressors.[6] The total amount of natural gas consumed in Virginia in 2012 by all sectors was 410.1 billion cubic feet. Natural gas use increased by 58 percent over the last decade primarily attributable to new customer growth and use of natural gas for electric generation requiring additional infrastructure to distribute the gas to consumers.

Local Distribution Companies

Natural gas transmission companies move natural gas from production areas to population centers through transmission pipelines. Local Distribution Companies (LDCs), which are utilities regulated by the SCC, then distribute the gas to end users. LDCs primarily sell gas to the residential and commercial markets. A total of 10 natural gas LDCs serve Virginia customers in assigned territories; seven are investor owned LDCs, and the remaining three are municipal LDCs. Virginia's investor-owned LDCs are:

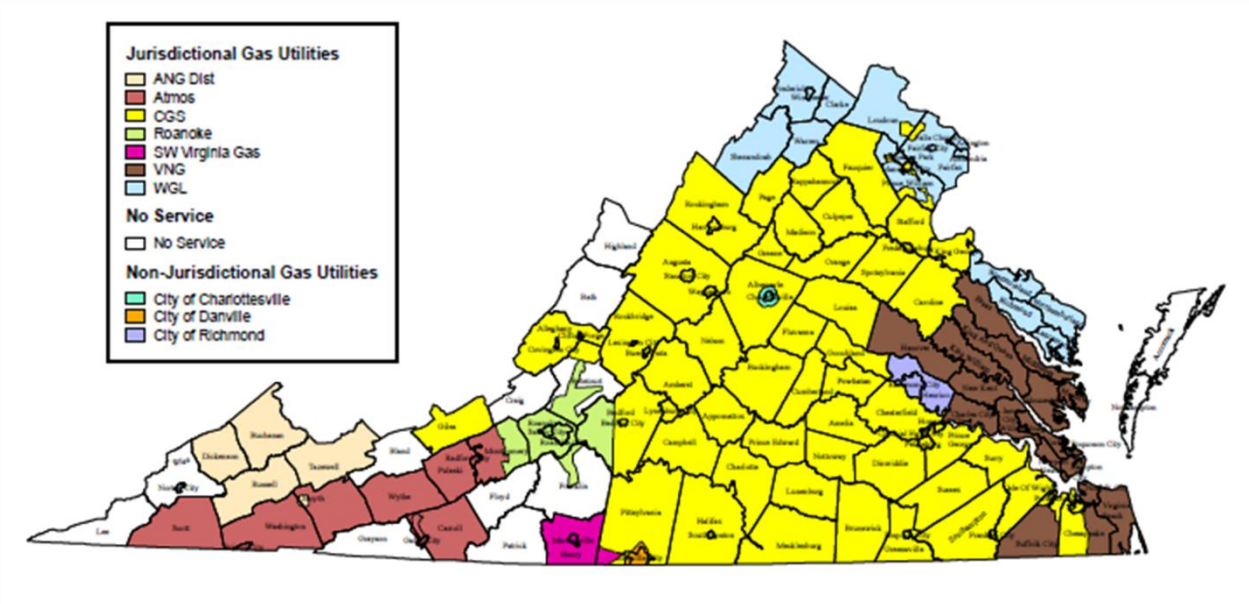
- Columbia Gas of Virginia
- Washington Gas
- Virginia Natural Gas
- Roanoke Gas

[6] EIA. Natural Gas Navigator. http://www.eia.doe.gov/dnav/ng/ng_http://www.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_SVA_a.htm.sum_lsum_dcu_SVA, July 31, 2014

- Atmos Energy
- Appalachian Natural Gas Distribution Company
- Southwestern Virginia Gas Company

The municipal LDCs are in the Cities of Richmond, Charlottesville, and Danville. Figure 8-4 shows the territory of each LDC in Virginia.

Figure 8-4: Service Areas of Virginia Natural Gas Distribution Companies[7]



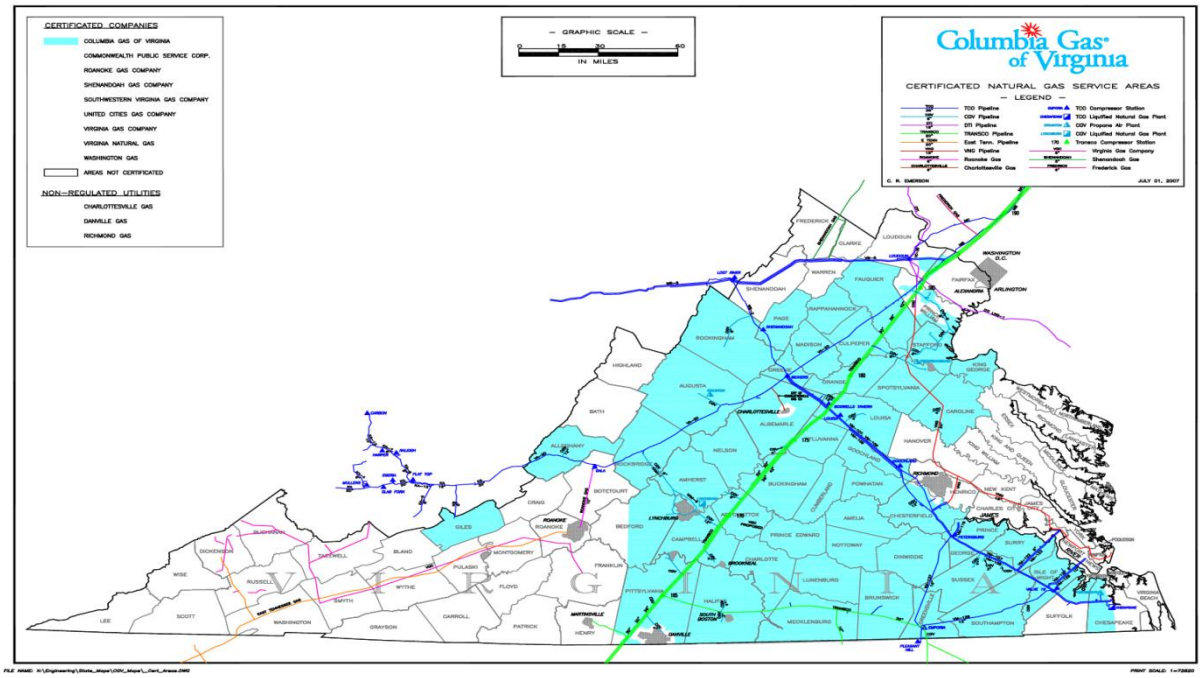
Appalachian Natural Gas Distribution Company
Headquartered in Abingdon, Virginia, Appalachian Natural Gas serves customers in southwest Virginia with natural gas that includes gas produced within the Commonwealth. Virginia counties served include Buchanan, Dickenson, Russell, and Tazewell.

Atmos Energy
Atmos Energy Corporation, headquartered in Dallas, Texas, is a natural gas distributor, serving customers in 12 states. The company serves consumers in western Virginia, (to the south of the West Virginia border) with its 650 miles of distribution pipelines. Atmos also has extensive non-utility operations related to natural gas.

Columbia Gas of Virginia
Columbia Gas of Virginia is a NiSource company. NiSource, headquartered in Merrillville, Indiana, is multistate gas transmission and distribution company, with operations stretching from New England to Texas, and west to Oklahoma, Missouri, Illinois, and Michigan. CGV, headquartered in Chester, Virginia, serves 240,000 customers in the Commonwealth, with nearly 5,000 miles of distribution and 61 miles of transmission pipelines. The LDC provides natural gas to 81 communities in Chesapeake, Chesterfield County, Fairfax County, Fredericksburg, Harrisonburg, Lexington, Lynchburg, Petersburg, Portsmouth, Prince William County, and Staunton. Figure 8-5 shows CGV's service area.

[7] State Corporation Commission, http://www.scc.virginia.gov/pue/gas/map.aspx. June 23, 2010.

Figure 8-5. CGS Service Area

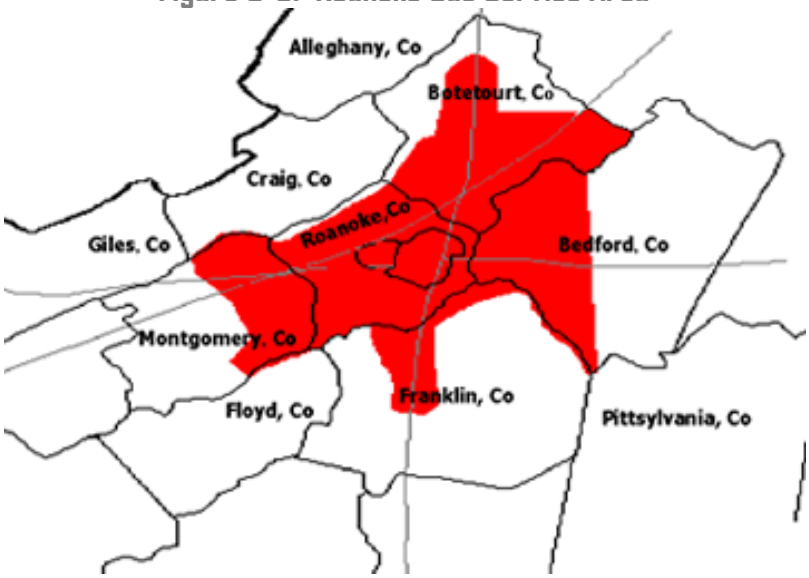


Source: Columbia Gas of Virginia, <http://www.columbiagasva.com/about-us>.

Roanoke Gas Company

A holding company, RGC Resources, owns Roanoke Gas. The company services over 51,000 accounts in its five county metropolitan service area with over 1,000 miles of distribution and 66 miles of transmission pipelines. Figure 8-6 depicts this company's service area.

Figure 8-6. Roanoke Gas Service Area

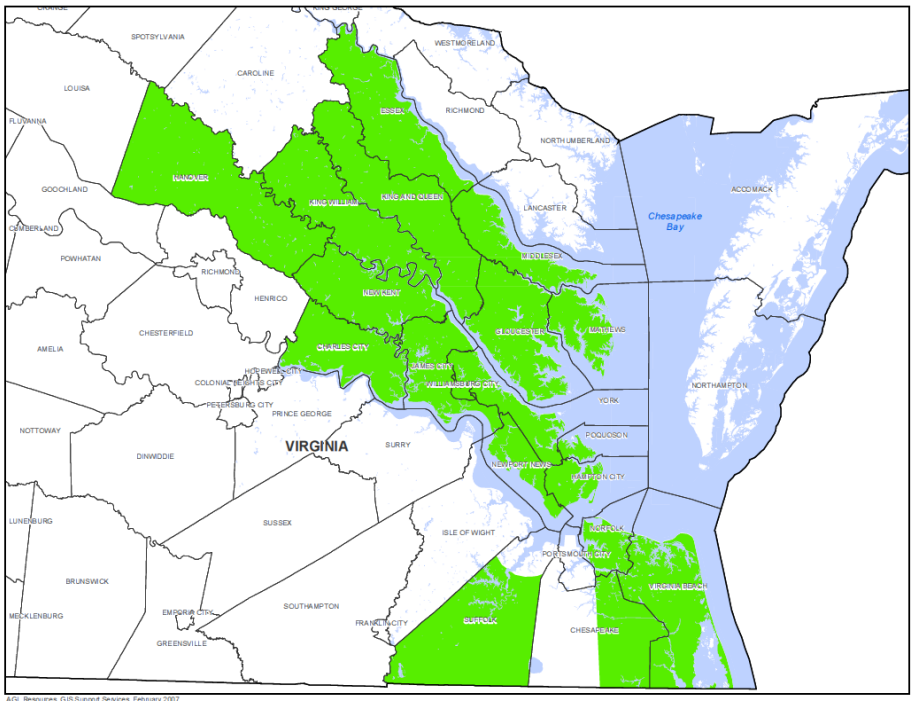


Source: RGC Resources, http://www.roanokegas.com/aboutus/servicearea.html

Southwestern Virginia Gas Company
Southwestern Virginia Gas Company is located in Martinsville, Virginia, and serves 4,600 accounts. The company's customers reside in Henry County and parts of Pittsylvania County.

Virginia Natural Gas
Virginia Natural Gas (VNG) is located in Norfolk, Virginia. VNG is a subsidiary of AGL Resources, headquartered in Atlanta, Georgia. AGL covers nine southeastern States. VNG serves over 264,000 customers in southeastern Virginia with over 5,000 miles of distribution and 156 miles of transmission pipelines. Figure 8-7 shows the company's service territory in detail.

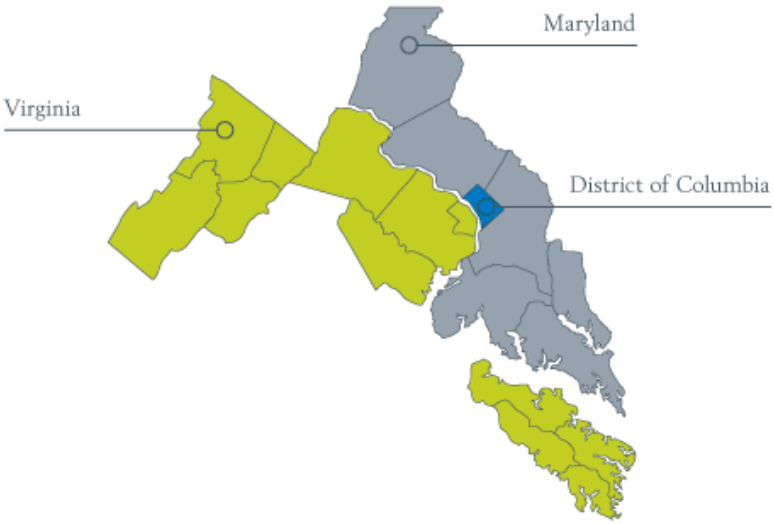
Figure 8-7. VNG Service Territory



Source: Virginia Natural Gas, About Us, Areas We Serve, http://www.virginianaturalgas.com/Universal/AboutUs.aspx.

Washington Gas Light (Including Shenandoah Division)
Washington Gas Light or Washington Gas headquartered in Washington, DC serves customers in the Washington Metropolitan Council of Governments (WMCOG) area. The service territory includes southern areas of Maryland, DC, Northern Virginia, and the Shenandoah area. The Shenandoah division is located in Winchester, Virginia, and the Washington Gas & Light division is located in Herndon, Virginia. Utilizing its 5,500 miles of distribution and 81 miles of transmission pipeline, the company serves over one million customers throughout its service territory with approximately 480,000 end-users in Virginia. Figure 8-8 illustrates the company's service areas.

Figure 8-8. WGL Service Territory



Source: WGL Holdings, About WGL Holdings, Service Territory, http://www.wglholdings.com/territory.cfm.

Municipal Natural Gas Utilities
In Virginia, three municipal natural gas utilities are governed by their local jurisdictions as authorized by Virginia Code. The three utilities are Charlottesville Gas, Danville Utilities, and Richmond City Gas.

Charlottesville Gas
The City of Charlottesville operates its municipal gas distribution as Charlottesville Gas, within the city's Department of Public Works, Public Utilities Division. The city serves 18,300 gas customers, purchasing and reselling wholesale natural gas through a variety of rate schedules, including firm and interruptible tariffs. The service area for Charlottesville Gas includes the City of Charlottesville and parts of Albemarle County.

Danville Utilities
Danville provides electricity and natural gas to its city residents, serving some 16,500 customers. The city purchases gas on a firm contract from the Transcontinental Gas Pipeline Corporation (TRANSCO) as well as other major producers.

Richmond City Gas Utility
The City of Richmond Department of Public Utilities (DPU) operates five utilities including natural gas. The DPU serves more than 500,000 residential and commercial customers in Richmond and the surrounding metropolitan region including Chesterfield and Henrico counties.

Natural Gas Pipelines
Natural gas produced in Virginia is collected in gathering pipeline systems. These systems include low pressure pipelines from wells to compression facilities where the gas is cleaned and

compressed. After being compressed, the gas is fed into the interstate pipeline network where it is delivered to customers.

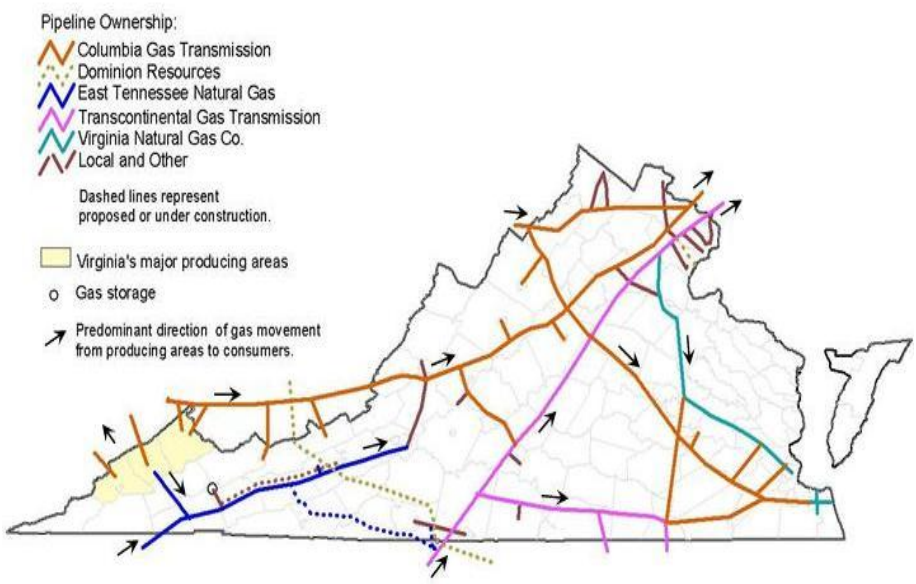
Natural gas produced in Virginia is sold in Tennessee, Southwestern Virginia, and in Northeastern states because there is limited pipeline capacity to deliver gas from Southwestern Virginia to the Central and Eastern Virginia markets. However, the capacity to deliver Virginia produced natural gas to the Northern, Central, and Hampton Roads regions of Virginia increased with the connection of the Spectra Patriot Pipeline to the Transco interstate pipeline.

Natural gas consumed in Virginia comes from three main sources:

- The Gulf of Mexico and other southern supply sources through the Transco natural gas transmission pipeline
- Virginia and other Appalachian natural gas production through the Spectra pipeline system in Southwest Virginia and the Columbia Gas Transmission pipeline system through West Virginia to Northern Virginia
- The Cove Point Liquefied Natural Gas (LNG) import facility in Maryland through the Dominion/Virginia Natural Gas pipeline serving Eastern Virginia. Dominion Cove Point received authorization on October 7, 2011, from the Department of Energy to enter into contracts to export liquefied natural gas to countries that have free trade agreements with the United States. Dominion is permitted to enter into multi-year contracts up to 25 years long with companies wishing to export natural gas to countries with free trade agreements. The authorization is for up to 1 billion cubic feet per day

There are approximately 2,950 miles of natural gas transmission pipelines in Virginia as shown in Figure 8-9 below.

Figure 8-9: Major Natural Gas Transmission Pipelines in Virginia[8]



[8] Modified from VEPT. Major Natural Gas Pipelines. http://www.energy.vt.edu/vept/naturalgas/NG_pipelines.asp. June 28, 2011

Table 8-1: Principal Natural Gas Pipeline Companies Serving Virginia[9]

Pipeline Name	Principal Supply Source(s)
Interstate & Importing Pipelines	
Columbia Gas Transmission Co	Southwest, Appalachia
Dominion Cove Point LNG LP	Northeast
Dominion Transmission Corp	Southwest, Appalachia
East Tennessee Natural Gas Co	Interstate System
NORA Gas Transmission Co	Southeast
Transcontinental Gas Pipeline Co	Southwest
*Intrastate Pipelines***	
Virginia Natural Gas Co	Interstate System

Natural gas companies have added new pipeline capacity across the state in recent years, including:

- Virginia Natural Gas' HRX pipeline that provides a third pipeline water crossing in Hampton Roads[10]
- Spectra's East Tennessee Line to Southside Virginia and North Carolina[11]
- Spectra's Jewell Ridge Pipeline to deliver natural gas from Southwest Virginia's gas production areas to the East Tennessee line and Saltville natural gas storage facility[12]

Storage facilities

Virginia is home to two underground natural gas storage facilities, the Spectra salt cavern storage facility in Saltville and the Early Grove underground storage field in Scott and Washington Counties.[13] Other underground natural gas storage services available to Virginia utilities and consumers are located in West Virginia, Pennsylvania, and Ohio. Dominion is one of the largest operators of these underground natural gas storage facilities. The locations of the facilities are illustrated in figure 8-10 below.

[9] The pipeline table data is taken from http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/MajorInterstatesTable.html, from http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/interstate.html "Interstate Pipeline Capacity on a State-to-State Level, and http://www.eia.gov/state/state-energy-profiles-data.cfm?sid=VA#Distribution. The pipeline figure is taken from EIA., "About US Natural Gas Pipelines" http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/northeast.html. June 28, 2011

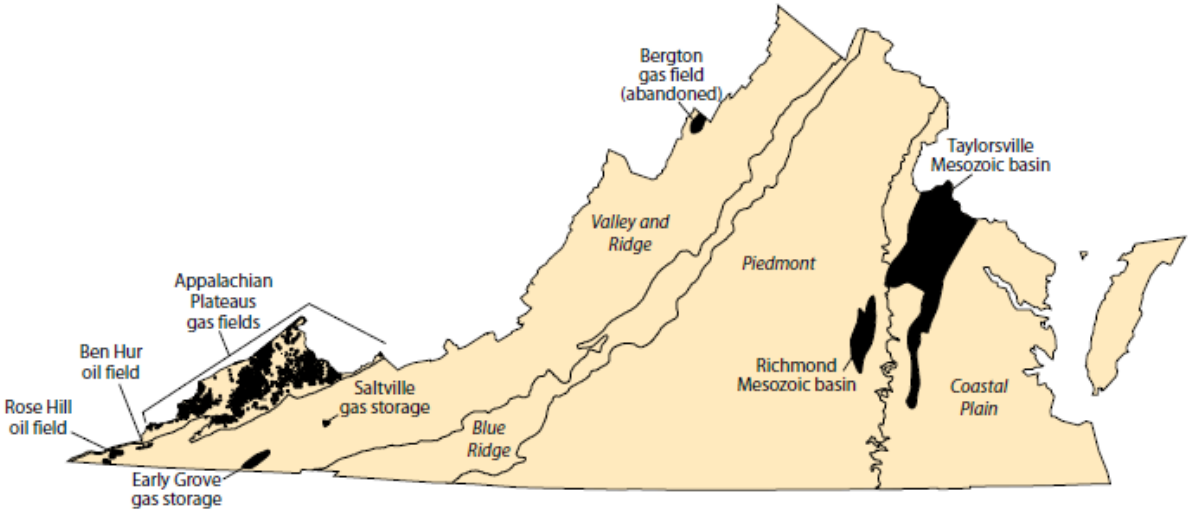
[10] Virginia Natural Gas, "Hampton Roads Crossing Pipeline","http://www.virginianaturalgas.com/Universal/AboutUs/InOurCommunity/HamptonRoadsCrossingPipeline.aspx, June 29, 2011

[11] http://www.spectraenergy.com/Operations/US- Natural-Gas-Pipelines/East-Tennessee-Natural-Gas/

[12] Ibid.

[13] Storage/Saltville-Gas-Storage/

Figure 8-10: Underground Natural Gas Storage Facilities



Virginia LDCs operate peaking natural gas storage facilities near their local distribution networks. These facilities include compressed natural gas tanks, liquefied natural gas tanks, and one underground propane storage cavern. Companies store gas in these facilities when demand is low and inject gas into the pipeline system during times of peak demand.

Renewables:
Virginia's viable renewable resources include:

- Biomass
- Waste to energy and landfill gas
- Wind, both offshore and on-shore
- Hydroelectric, not including pumped storage
- Low temperature geothermal
- Solar

In 2013 these resources provided about 6 percent of the electricity capacity in Virginia and about 5 percent of the electricity generated.[14] Virginia is ranked number 26 in the nation for renewable capacity, with just under 1.5 gigawatts of net summer renewable generating capacity.[15]

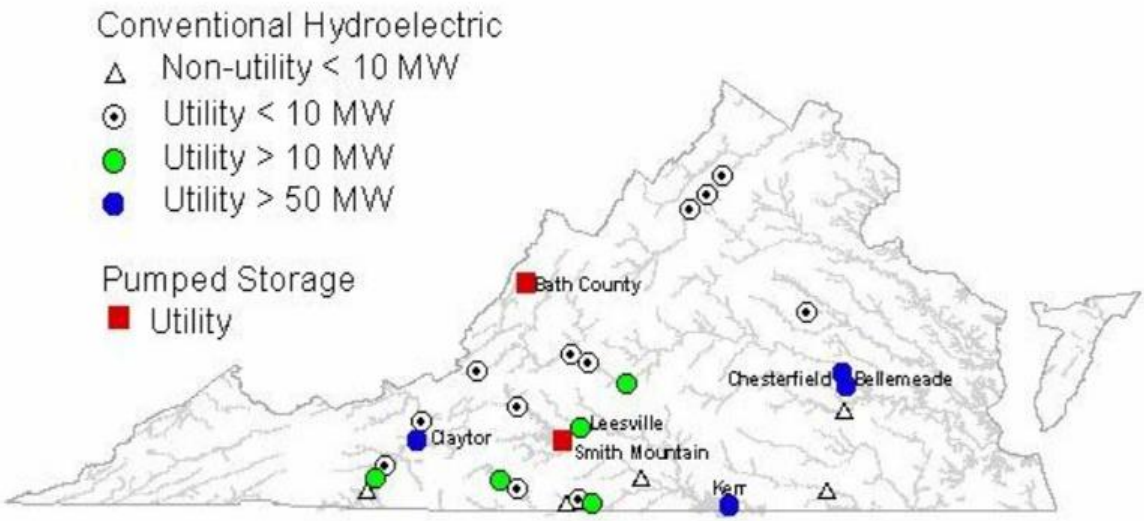
[14] Energy Information Administration Virginia Renewable Energy Profile 2010 http://www.eia.gov/renewable/state/virginia
[15] Energy Information Administration, State Renewable Electricity Profiles: http://www.eia.gov/renewable/state

Electricity generated from renewables in Virginia is used in several ways.

- The primary use of renewable electricity has been on-site distributed generation using primarily grid connected solar photovoltaic or small wind systems. While exact counts are not available, a small number of off-grid homes use solar and/or small wind systems coupled with battery storage. Typically, however, even systems with battery storage are grid connected and the batteries add a measure of energy security in the event of power outages.
- Virginia's electric utilities own renewable generation assets and operate them to meet their service obligation and renewable energy portfolio goals.
- Independent renewable generation projects contract to provide their power to investor-owned or cooperative utilities, or sell their power on the wholesale market.

Hydroelectric Power
Virginia is home to 24 conventional hydropower facilities with a combined capacity of 439 megawatts, and two pumped storage facilities with a combined capacity of 3659 megawatts. The Bath County pumped storage facility, jointly owned by Dominion and the operating companies of the Allegheny Power System, make up the bulk of Virginia's pumped storage, and is the second largest pumped storage facility in the world.

Figure 8-11.



Solar Power
Sunlight can be used to generate electricity or to directly heat water or air for homes and businesses. Solar generating capacity grew significantly in the past several years because of declining solar equipment costs, which fell between 70 and 80 percent between 2007 and 2010[16].

As of March 2014, the total net metered capacity of solar photovoltaic systems in Virginia was just under 12 megawatts, with additional non-net metered solar totaling approximately four megawatts (mostly on military installations).

[16] http://reneweconomy.com.au/2014/solar-pv-continues-shoot-cost-curve-42386

Legislation enacted in 2011 allows for the creation of utility distributed solar generation demonstration programs.

Pursuant to that legislation, Dominion plans to install up to 30 megawatts of company-owned distributed solar generation on leased commercial rooftops in strategically located areas of its service territory. This project will allow the utility to learn how to manage a larger scale intermittent resource and include such assets in its generation and reliability planning.

Because Virginia is a regulated monopoly utility state, Virginia law does not allow a third party to install and own a renewable energy facility on a utility customer's property and sell the utility customer the renewable output of the renewable energy system. In 2013 the Legislature enacted legislation that would allow for a pilot program within Dominion Virginia Power service territory to enable third party power purchase agreements (PPAs) for systems as large as one megawatt, up to an aggregate of 50 megawatts system wide.

Geothermal

Geothermal energy can provide heating and cooling through use of geothermal heat pumps. These can be found on both residential homes and commercial businesses. Geothermal technology has been available for more than 30 years. There has been an increase in systems installed due to state and federal tax incentives.

York County Schools have geothermal systems operating wells in nine school facilities. Energy costs for a typical York County geothermal school were reduced by approximately $60,000 per year. There are limited low-temperature geothermal resources in Bath County that are suitable for water and space heating.

Onshore Wind Power in Virginia

To date, the only onshore wind power project to receive regulatory approval is the 39 megawatt Highland New Wind project in Highland County. It received final approval to begin construction in 2008, but has not constructed the project. A number of developers, including Dominion, have been exploring projects in several Virginia counties.

Dominion Virginia Power currently operates two wind power generation facilities that serve Virginia load, including a 50 percent interest in the 264 megawatt Ned Power Mount Storm facility in Grant County, West Virginia, and a 50 percent interest in the 300 megawatt Fowler Ridge I facility located in Benton County, Indiana.[17]

Appalachian Power Company purchases 75 megawatts worth of renewable energy certificates from the Camp Grove wind facility in Illinois and 100 megawatts from the Fowler Ridge II project in Indiana.[18]

To support the development of wind power in Virginia, James Madison University (JMU) operates several programs to assist landowners and local officials in assessing the suitability of sites for land-based residential and utility-scale wind projects.

[17] http://www.dom.com/about/environment/report/renewable-energy-and-green-power.jsp

[18] Commonwealth of Virginia State Corporation Commission, "Report to the Commission on Electric Utility Regulation of the Virginia General Assembly", http://www.scc.virginia.gov/comm/reports/2010_veur.pdf, September 1, 2010

The Virginia Center for Wind Energy at JMU provides wind related services to local governments, state agencies, landowners, academia, non-governmental organizations, and businesses. These services include wind resource measurements, economic modeling, education and outreach, energy policy analysis, assessment of technical specifications, Geographic Information Systems analysis, and the strategic deployment of wind power within the Commonwealth and beyond.

Offshore Wind Power

Offshore wind has the potential to provide the largest, scalable renewable energy resource for Virginia. The state currently does not have any utility-scale wind power in operation.
Virginia is unique with a shallow continental shelf that extends out 30 miles. With its proximity to load centers, supply chain infrastructure, a trained work force and best in class ports, offshore wind can provide substantial benefits to the state.
In 2013, Dominion Virginia Power won a federal lease for 112,800 acres off the Virginia coast to develop offshore wind power with the potential to generate up to 2000 megawatts, or enough to electricity to power 500,000 homes.

Waste-to-Energy and Landfill Gas

Virginia currently has 33 landfills that are capturing, converting and using landfill gas (LFG) as an energy source. Twenty-five of these landfills are generating electricity and have a combined capacity of 94.5 megawatts. Three LFG projects are under construction and 38 landfills are either candidates or potential sites for projects. LFG projects are operational, under construction or planned in 54 counties from Eastern Shore to Southwest Virginia.

Wood/Biomass Production and Transportation

Biomass is a broad term used to describe organic materials of a biological origin that can be used as a source of energy. These may include agricultural and forestry residues, the organic component of municipal solid wastes, and terrestrial and aquatic crops, such as switch grass or algae, grown solely for energy purposes. Biomass can be used to generate electricity by burning it in place of fossil fuels in steam turbines. It can also be converted to methane through anaerobic digestion, or to liquid fuels, also called biofuels, such as ethanol or biodiesel, primarily for transportation.

Virginia has multiple waste-to-energy projects listed below which are part of the overall energy infrastructure of the state.

Table 8-2: Biomass and Waste-to-Energy Projects[19]

Project	Energy Produced
Fairfax County Covanta WTE plant	124 MW of electricity
Alexandria/Arlington Covanta WTE plant	29 MW of electricity
SPSA WTE plant	60 MW plus steam
Harrisonburg WTE plant	2.5 MW plus steam
Dominion Multitrade (sawdust and wood chips)	80 MW of electricity and steam

[19] Virginia Cooperative Extension, "Preliminary Residual Biomass Inventory for the Commonwealth of Virginia: Geographic Information System Based Multi-Feedstock Bioresidue Assessment"

Dominion Altivista (wood chips co-fired with coal)	2 MW electricity
21 Landfill Gas generating plants	20.6 MW electricity
Sussex County Landfill	Process gas for Honeywell in Hopewell
Wood pellet manufacturing plants	Wood pellets for domestic/export markets
Six industrial CHP (wood, wood waste, black liquor)	182 MW electricity and steam
Institutional boilers such as Piedmont Geriatric Hospital and Longwood University	Steam
Piedmont Bioproducts	Green diesel
Five in-state biodiesel producers	Biodiesel
Five commercial biodiesel plants (soy, canola, waste greases)	Biodiesel
Farm and coop biodiesel operations (unknown number)	Biodiesel; filtered vegetable oil
Louisa County pellet plant	Wood pellets

Virginia has substantial biomass resources. Below are some individual biomass resource assessments which have been completed.

Table 8-3: Biomass Waste Inventories

Type of Biomass	Amount of Resource
Forest slash	2,253,244 dry tons
Sawdust and sawmill waste	2,538,140 dry tons
Crop residues	750,137 dry tons
Animal wastes	1,045,946 dry tons
Municipal solid waste	2,016,587 tons
Landfill gas	66 landfills; 21 operational projects; 11 candidate landfills
Construction debris	593,211 tons
Food processing waste	763,022 tons

Stand-alone power generation with woody biomass can meet base load demand, providing constant, steady power to the grid. Dominion has been generating electricity with woody biomass at their 83-megawatt Pittsylvania Power Station in Hurt, Virginia since 1994. Dominion received approval from the Virginia State Corporation Commission to convert three 63-megawatt coal-fired power stations at Altavista, Hopewell and Southampton to 51-megawatt woody biomass plants, one of which, Altavista, went online in 2013. Dominion also began co-firing woody biomass with coal at their new 600-megawatt Virginia City Hybrid Energy Center in 2012. The Hybrid Energy Center is designed to burn up to 20 percent woody biomass, generating 117 megawatts of biomass energy. Co-firing with woody biomass diversifies their fuel supply and reduces sulfur and nitrogen oxide emissions. The Northern Virginia Electric Cooperative's 49.9-megawatt Halifax County Biomass Plant also began commercial operations in 2013, utilizing forest residues harvested within 75 miles of their South Boston location.

The use of biomass for stand-alone power generation has become a source of contention, however. Overall efficiencies of stand-alone power generation are around 30 percent and the waste heat is by definition not utilized. Concerns have been raised about the "carbon debt" of

biomass power generation and the recent release of the EPA's proposed Clean Power Plan to regulate carbon dioxide under section 111(d) of the Clean Air Act requires clarification on how biogenic (biomass) carbon emissions will be handled.

Petroleum Production, Refining, Transportation and Distribution

Petroleum is used mainly for transportation but also heating oil, and propane. Heating oil was the second largest use, with smaller amounts used for aviation, residual fuel oil, and propane. Use in Virginia grew through 1998 but has stabilized since 1999 as vehicle miles traveled stabilized and the oldest, less fuel-efficient vehicles were replaced by more efficient models. The majority of Virginia's propane gas is supplied by the interstate propane pipeline terminating in Apex, North Carolina, and the water-based terminal in Chesapeake, Virginia. Some propane is produced in the Lee, Wise and Russell Counties' wells. It is equivalent to less than one percent of the state's annual consumption. The propane produced is typically shipped to refineries in Kentucky for processing.

Petroleum is supplied to Virginia through a network of refineries, pipelines, port facilities, terminals, and retail outlets. All of the petroleum production in Virginia occurs in Lee and Wise Counties. The volumes are small so collection tanks are placed at each wellhead. Collection trucks transport the collected crude to a central location periodically for shipping.

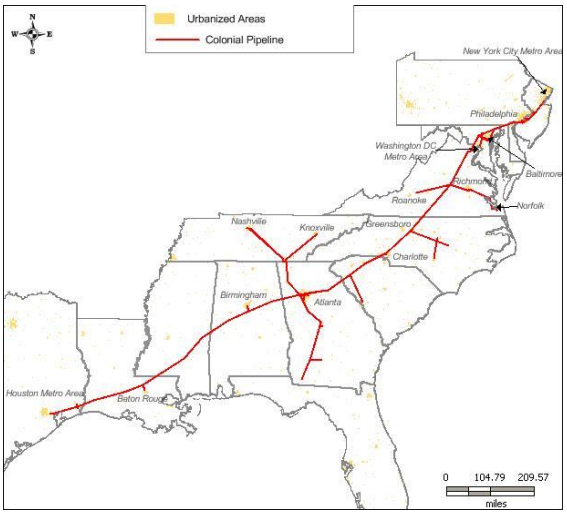
Pipelines and Ports

Because more of the petroleum is supplied from other states, the pipelines and their companies and the ports are critical for the Commonwealth's petroleum product supply. The different pipelines that serve Virginia are outlined below:

The Colonial Pipeline

The Colonial Pipeline (Colonial) headquartered in Avenel, New Jersey, operates an office in Fairfax, Virginia. Colonial is a major supplier for the Commonwealth and surrounding states delivering refined petroleum products from the Gulf Coast, as far north as New Jersey. The liquid products Colonial carries vary seasonally and according to demand, but included among the most important are: distillates such as diesel, home heating oil, and jet fuel and motor gasoline. Colonial ships product in batches and then offloads the product at terminals for sale to end-users. The Colonial Pipeline system is shown in Figure 8-12.

Figure 8-12. The Colonial Pipeline system.



Source: www.colpipe.com/home/about-colonial/system-map

Plantation Pipeline

Kinder Morgan, a major natural gas and petroleum pipeline and energy storage company in the U.S., owns the Plantation Pipeline. Like the Colonial Pipeline, the Plantation Pipeline delivers petroleum products from the Gulf Coast area along the Eastern Seaboard. The pipeline terminates in Washington, DC. Industry sources informally estimate that a batch of product requires approximately 20 days to reach the DC and Virginia area. The Plantation Pipeline is shown in Figure 8-13.

Figure 8-13. Plantation Pipeline Owned by Kinder Morgan

Source: Kinder Morgan, http://www.kindermorgan.com/asset_map/

Dixie Pipeline and Chesapeake Port/Terminal
The Dixie Pipeline does not enter Virginia. However, it is a major source of propane for the Commonwealth. Dixie is a subsidiary of Enterprise Products Partners, L.P. of Houston, Texas. LPG is trucked from the Apex Terminal near the intersection of U.S. Route 1 and Route 55 in Apex, North Carolina, to bulk distributing retailers in Virginia. Enterprise also offloads LPG from vessels to a terminal at the Port of Norfolk, located in Chesapeake, Virginia.

Port of Norfolk
The Port of Norfolk both receives and ships petroleum products. The port classifies petroleum products as "mineral fuel, oil, etc." This classification constituted the largest cargo shipments in 2012, with 65,050,050 short tons exported and 9,160,010 short tons imported.[20] The percentage of fuel and oil comprising these volumes (versus minerals and coal) is unclear

Terminals

Terminals are the major infrastructure elements between supply from pipeline or port and distribution to service stations and end-use customers. Distribution terminals in Fairfax, Richmond, Montvale/ Roanoke, and Chesapeake receive petroleum from the Colonial and Plantation underground pipelines which receive product from refineries in the Gulf of Mexico region. Additionally tankers and barges deliver product to coastal petroleum distribution terminals in Chesapeake and Richmond. Virginia consumers are also regularly supplied from out-of-state petroleum terminals in Baltimore, MD; Greensboro, NC; and Knoxville, TN.

Refined products received at Virginia terminals are offloaded to large (8,000 or 16,000 gallon) tanker trucks owned and operated by local distribution companies or wholesale marketers (jobbers) for delivery to local retail locations. Motor gasoline and diesel fuel are delivered to service stations in this way. Heating oil and propane are picked up by local wholesaler/retailers and transferred to smaller trucks for delivery to the tanks of individual customers (usually 250 to 500 gallon). As of September 2010, there were 45 petroleum terminals in Virginia. These 45 terminals are operated by 23 companies. The companies with multiple terminals are:

- Kinder Morgan: 7
- TransMontaigne: 7
- Motiva: 4
- BP: 3
- CITGO: 2
- Magellan: 2
- NuStar: 2
- Quarles: 2
- Richmond: 2

Refining
The only oil refinery in Virginia was closed in 2010 and is in the process of being converted into a storage hub and transportation hub as a link in the East Coast Chain. Petroleum products will pass through the former refinery by water and rail. (http://hamptonroads.com/2012/12/virginias-only-oil-refinery-becoming-storage-facility)

[20] Virginia Port Authority, *Comprehensive Annual Financial Report*, June 30, 20132009, pp 91.

Industry Organizations
There are several umbrella or industry organizations that represent the interests of the petroleum industry in the state.

1. ***The Virginia Petroleum, Convenience, and Grocery Association (VPCGA*):** The VPCGA has 650 member retail dealers who operate over 4,500 locations throughout the Commonwealth. These retail dealers sell motor gasoline, diesel, and/or heating oil. VPCGA provides liaison with governmental policy makers and offers training on safety and business practices for its members. The VPCGA headquarters is located in Richmond, Virginia.
2. ***The Virginia Petroleum Council*:** The Virginia Petroleum Council represents the interests of the major petroleum suppliers that do business in the Commonwealth. The Council is a division of the American Petroleum Institute (API), and is located in Richmond.
3. ***The Virginia Propane Gas Association (VAPGA):*** VAPGA represents the business interests of member companies in the Commonwealth. Its basic operations are similar to VPCGA, representing member interests before governmental bodies and offering training for member employees. VAPGA is headquartered in Charlottesville, Virginia.

Natural gas, propane, biodiesel and ethanol are the most produced alternative fuels in the state

Alternative Fuels and Advanced Vehicle Technology

Virginia produces very little petroleum and therefore currently must rely almost entirely for oil and motor fuel on imports from other states and countries. There is a push by the state to move towards alternative fuels, at least for state-owned vehicles, to reduce emissions and the dependence on foreign oil. Alternative fuels include ethanol, propane, biodiesel, hydrogen and others.

Natural gas, propane, biodiesel and ethanol are the most produced alternative fuels in the state. In 2013, mines in Southwest Virginia produced 146.4 trillion cubic feet of natural gas. Biodiesel is produced at 2 active refineries and in 2013, 3.3 million gallons were produced. Around 1 million gallons of ethanol was produced at one active refinery. Virginia biofuel producers report the existing potential to produce 17.5 million gallons of biofuel annually which means currently the state is only producing 25 percent of its current capacity with the existing infrastructure.

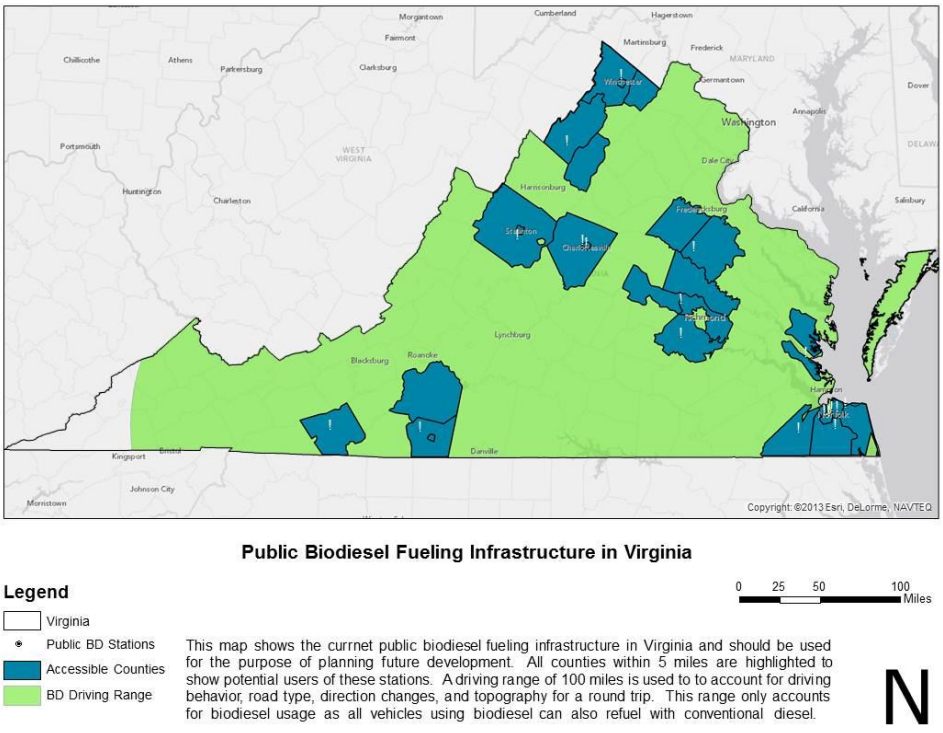
The alternative fuel infrastructure is growing, supported by public-private partnerships to increase the use of alternative fuels. By the end of 2013, Virginia had 364 public and private alternative fuel stations throughout the Commonwealth. In 2013 alone, 78 electric fueling stations were added making electric, biodiesel and propane stations the most readily available in the state.

Most of the alternative fuel is utilized by government and private fleet vehicles with the largest consumption of fuel being E85 and biodiesel. In 2013, Virginia fleets reported using E85 in over 8,500 vehicles and biodiesel in over 4,300 vehicles. The heavy duty vehicles primarily use natural gas and in 2013 Virginia consumed 217 million cubic feet for fuel. Although currently a very small portion of existing fleets, electric vehicle use is growing. 78 additional electric fueling stations built in 2013.

Biodiesel

Biodiesel in Virginia is produced at several facilities that collect waste grease and vegetable oils to process into biodiesel. The map below shows the existing biodiesel infrastructure.

Figure 8-14. Biodiesel in Virginia



Public Biodiesel Fueling Infrastructure in Virginia

Legend

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

0 25 50 100 Miles

This map shows the currnet public biodiesel 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 to account for driving behavior, road type, direction changes, and topography for a round trip. This range only accounts for biodiesel usage as all vehicles using biodiesel can also refuel with conventional diesel.

N

In Virginia 3.5 million gallons of biodiesel is produced a year. There are two large producers: Reco Biodiesel in Richmond and Virginia Biodiesel in West Point. However, there are many small producers including farmers exploring production as well. The biodiesel is currently distributed from these sites via truck, train and barge. It is distributed directly to retail fueling stations and directly to large scale end users with vehicle fleets. It is dispensed through equipment similar to regular diesel dispensers making existing infrastructure easily adaptable for biodiesel distribution. Therefore numerous existing vehicle fleets utilize biodiesel, such as but not limited to the following:

- Williamsburg-James City County Schools
- Virginia Beach Public Schools
- Arlington County and Arlington Schools
- US Army
- US Navy
- US Air Force
- Gloucester County Schools
- Woodfin Oil
- Newport News
- SuperValu
- Staunton
- Waynesboro
- The University of Virginia
- Chesterfield County
- WestmorelandCounty
- Northumberland County
- Roanoke and Roanoke Schools
- Virginia Tech
- Blacksburg

Ethanol

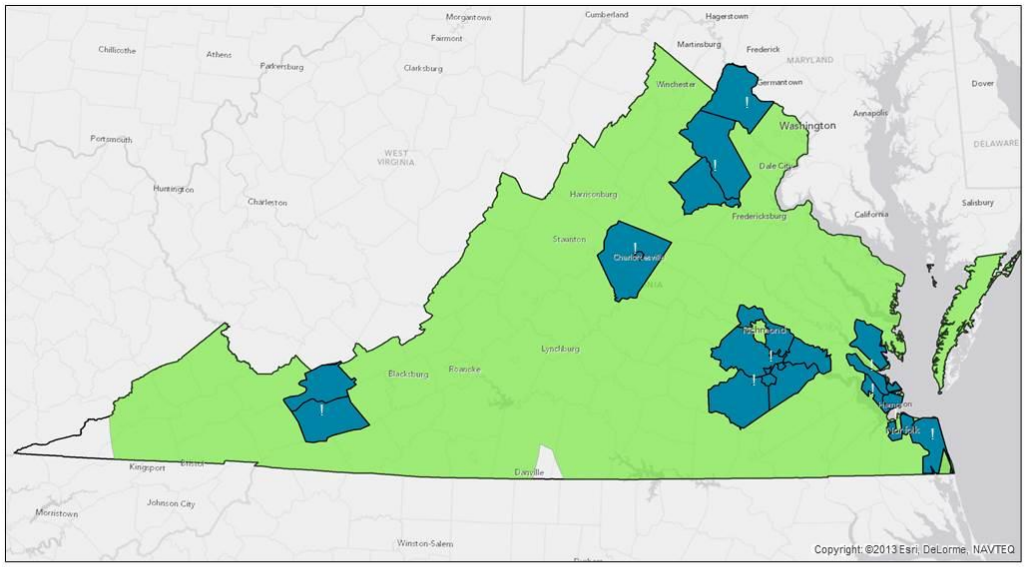
Ethanol is a renewable fuel made from various plant materials and is blended with gasoline. The blends are from 10 percent ethanol up to 85 percent ethanol and can be dispensed at existing fueling stations as long as the stations have blender pump infrastructure. The mid-level blends utilizing 85 percent ethanol with 15 percent gasoline (E85) are used in flex-fuel vehicles of which there are 300,000 in Virginia today. Currently there are over 90 vehicle models with flex fuel options based on 2014 models making the technology readily available to the average consumer. The E85 fueling equipment is slightly different than the petroleum fueling equipment, but the costs are similar and it is possible to convert the equipment with little cost.

Virginia currently has several ethanol producers in the state.

- Vireol Ltd opened an ethanol plant in Hopewell in 2014 and has the capacity to produce 62 million gallons of bioethanol a year. The ethanol is produced from corn, barley and other small grains. The byproduct, dried distiller grains, is used in poultry and livestock industries. MXI Environment Services, LLC recycles the grains and has a facility in Abingdon, VA.
- Fiberight LLC has a pilot plant in Southern Virginia that turns garbage, corn stalks and wheat straw into biofuel ethanol.

There are several other companies with plans to build ethanol plants in the near future. The map below shows the existing E85 fueling infrastructure in the state.

Figure 8-15. E85 Fueling Infrastructure



Public E85 Fueling Infrastructure in Virginia

Legend

- Public E85 Stations
- Accesible Counties
- E85 Driving Range
- Virginia

0 25 50 100 Miles

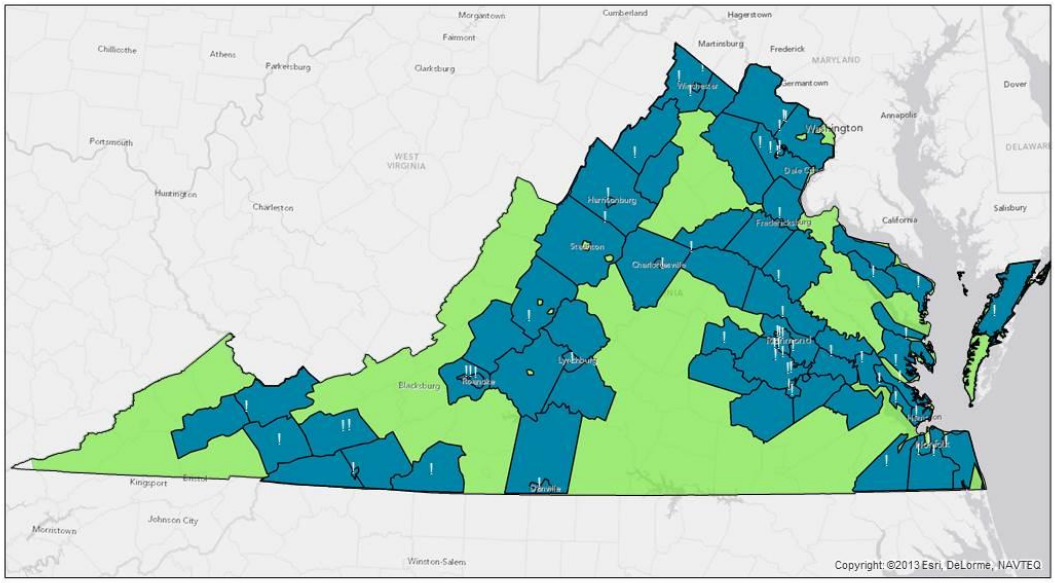
This map shows the curmet public E85 fueling infrastructure in Virginia and should be used for the purpose of planning future development. All counties within 5 miles are highlighted to show potential users of these stations. A driving range of 100 miles is used to to account for driving behavior, road type, direction changes, and topography for a round trip. This range only accounts for E85 usage as flex fuel vehicles can also refuel with conventional gasoline or diesel.

N

Propane

There is significant interest in propane as a domestic vehicle fuel because of high energy density, clean-burning qualities, and low costs at the volumes utilized. It is the most commonly alternative transportation fuel and the third most used vehicle fuel, behind gasoline and diesel. Propane engines are largely used in medium and heavy duty vehicles such as street sweepers and school buses. Currently 500 vehicles are operating on this fuel in Virginia. Conversions to propane fuel are complicated and require EPA certification. However,,; the upfront cost can be offset by the lower fuel cost, operating and maintenance expenses over time. Below is a map of the current LPG fueling infrastructure in the state.

Figure 8-16. LPG Fueling Infrastructure



Public LPG Fueling Infrastructure in Virginia

Legend

- Virginia
- LPG_stations
- LPG_5_counties
- LPG_100_range

0 25 50 100 Miles

This map shows the currnet 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 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.

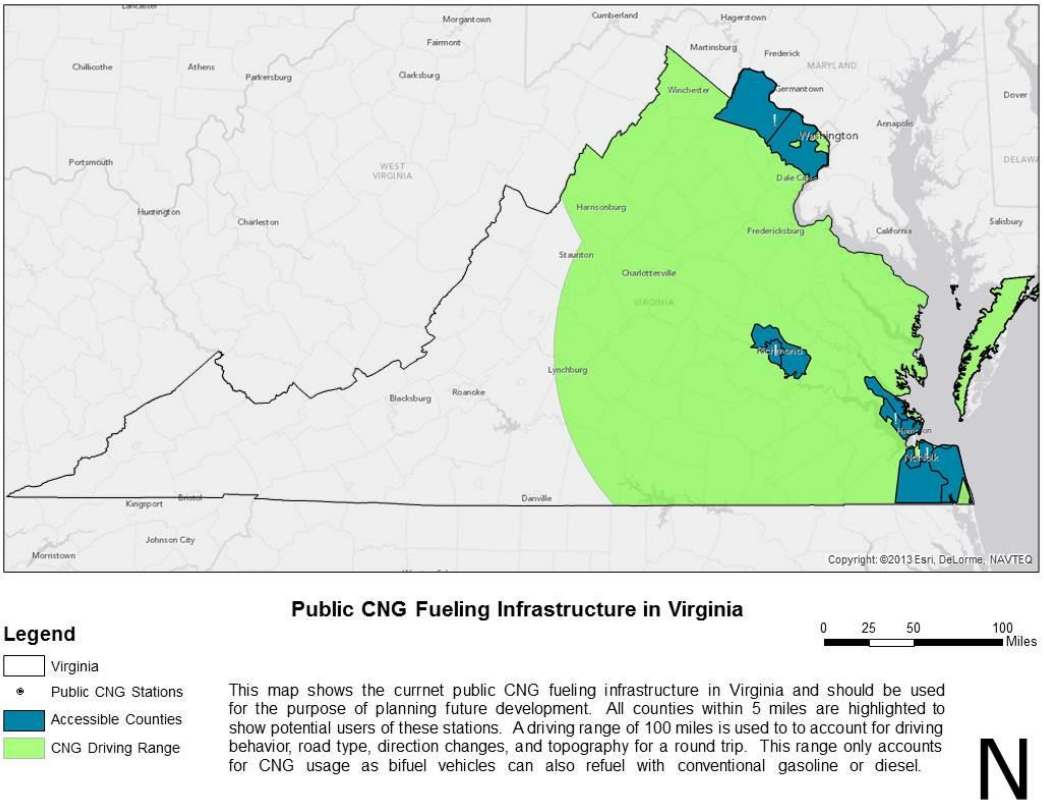
N

Natural Gas

Natural Gas is one of the cleanest burning alternative fuels available and Virginia has significant production, making it an attractive option. Because of the gaseous nature, it must be stored on the vehicle either at 3600 psi as compressed natural gas (CNG) or in a liquefied state (LNG). The primary applications for CNG are heavy haulers, public transit bus fleets, and waste hauling trucks, but small passenger vehicles are becoming more popular.

The vehicles may be fueled at public stations or private filling stations. Station development is expensive and time-consuming due to local permitting processes and locating near existing natural gas pipelines, in addition to finding adequate customers for the fuel to justify the effort. Below is a map of the current natural gas fueling infrastructure.

Figure 8-17. Natural Gas Fueling Infrastructure



Public CNG Fueling Infrastructure in Virginia

Legend

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

0 25 50 100 Miles

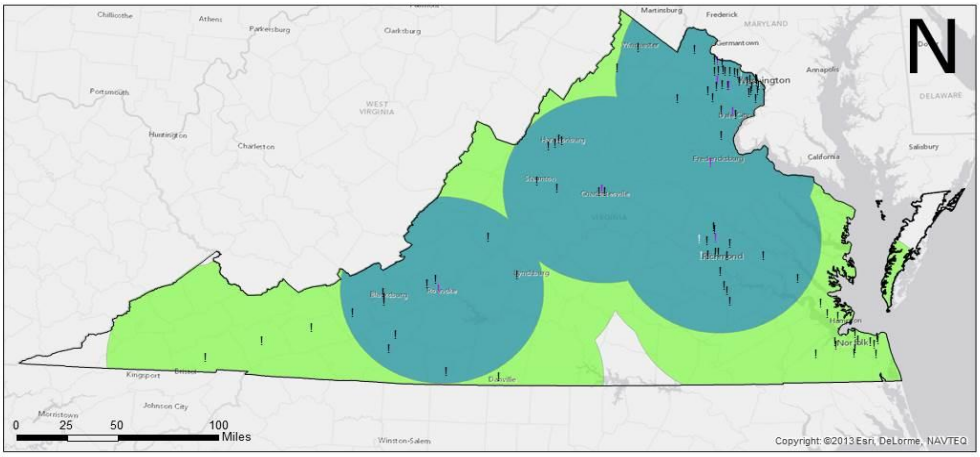
This map shows the currnet public CNG fueling infrastructure in Virginia and should be used for the purpose of planning future development. All counties within 5 miles are highlighted to show potential users of these stations. A driving range of 100 miles is used to to account for driving behavior, road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

N

Electric Vehicles

An Electric Vehicle (EV) stores electricity from the grid on-board to power the motor. Some have on-board chargers while others plug into a charger located outside of the vehicle. There are several models of EVs offered and on the road today. Some are 100 percent electric and some have small combustion engines on board and operate as traditional hybrid cars once the battery power is exhausted, allowing for greater flexibility in travel. As of October 2013, based on information from the Virginia Department of Motor Vehicles, there were 2,521 electric vehicles on the road in Virginia, an increase of over 1000 percent since 2012. According to Virginia Clean Cities there are currently 249 electric charging stations across Virginia to support the growing number of EVs on the road today. The maps below show both the existing electric vehicle charging stations and the plan for additional stations along highways in the future.

Figure 8-18. Existing and Future Electric Vehicle Charging Stations



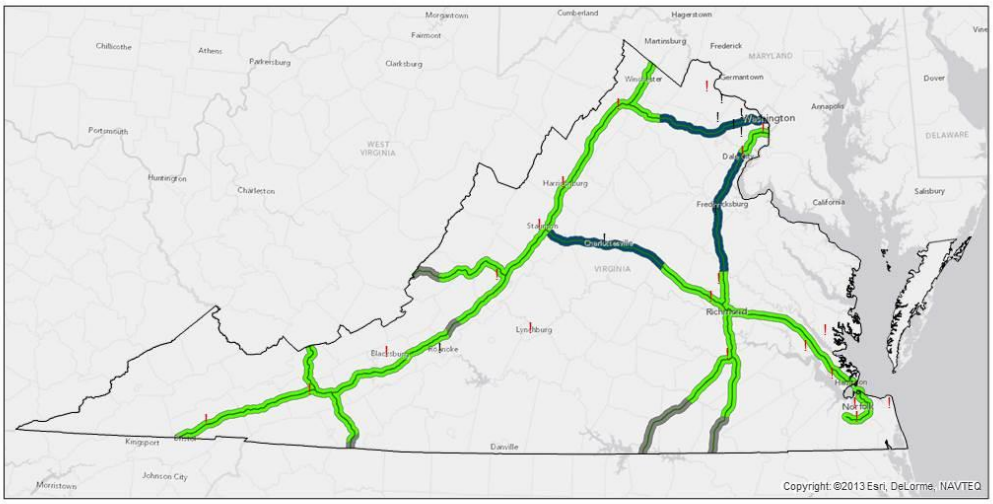
Electric Vehicle Charger Infrastructure in Virginia

Legend

- Virginia
- L3 Chargers
- L1 & L2 Chargers
- L3 Electric Range
- L1 & L2 Electric Range

The purpose of this map is to show the extent and limitations of Virginia's current electric vehicle charging infrastructure. Virginia's electric vehicle charging infrastructure is currently most concentrated in the high population centers of Hampton Roads, Richmond, and Northern Virginia. Through Virginia Clean Cities' initiatives, DC fast chargers (Level 3) have been added in Roanoke and Charlottesville as well. Despite its relatively high level of EV adoption, the Hampton Roads region has no Level 3 chargers. To give an estimate of electric vehicle access in Virginia, 50 mile buffers were placed around all charging infrastructure. Fifty miles was chosen as a conservative estimate to account for direction changes, road type, topography, and driving style. The LEAF is Virginia's most popular electric vehicle, however other vehicles may have different ranges.

Figure 8-19. Existing and Proposed Level 3 Highway Charging Range



Existing and Proposed Level 3 Highway Charging Range

Legend

- Virginia
- Proposed L3 Chargers
- Existing L3 Chargers
- Existing L3 Charger Range
- Proposed L3 Hwy Range

The purpose of this map is to show the interstate access of electric vehicles based on current level 3 chargers located within 3 miles of Virginia's interstates. With current highway accessible DC fast chargers, EV drivers have access to approximately 180 miles (18%) of Virginia's interstate system. If all Virginia Clean Cities target L3 chargers are realized the highway accessability will increase by 690 miles to approximately 870 miles (87%) of accessible interstate. For this map 30 mile buffers were placed around both existing and proposed chargers to account for direction changes, road type, topography, and driver behavior. These distances assume a round trip on the interstate.

0 25 50 100 Miles

N