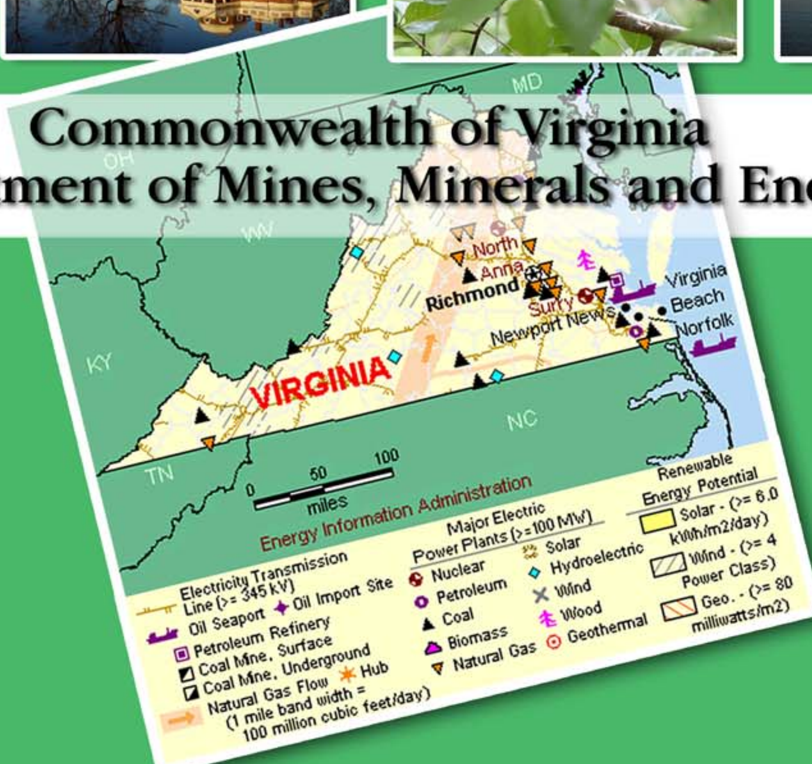
The *Virginia* Energy Plan




Commonwealth of Virginia
Department of Mines, Minerals and Energy



2007

Table of Contents

Chapter 1

The Virginia Energy Plan Executive Summary

The purpose of the Virginia Energy Plan is to chart a path forward that will provide for reliable energy supplies at reasonable rates and increase the use of conservation and efficiency measures in Virginia.

1.0 Introduction

The purpose of the Virginia Energy Plan is to chart a path forward that will provide for reliable energy supplies at reasonable rates and increase the use of conservation and efficiency measures in Virginia. The Plan has been developed in accordance with 2006 legislation (Title 67 of the Code of Virginia; see Appendix B) that set out energy policy statements and objectives and directed the Department of Mines, Minerals and Energy to develop a ten-year state energy plan. The Plan is to be updated every five years.

This Plan was developed using information gathered from the Virginia Energy Plan Advisory Group (see Appendix A for a list of members), which met five times to address the Plan's major components. The Plan is also the product of input received at five public workshops held around the state and from public comments submitted via the Internet. The plan has been reviewed by the Department of Environmental Quality and other state agencies, State Corporation Commission staff, and the Virginia Center for Coal and Energy Research. The research and development recommendations are derived from a study by the Center for Innovative Technology.

The Virginia General Assembly set out energy policy statements and objectives in the Code of Virginia at sections 67-101 and 67-102. These call for Virginia to take a broad range of energy actions, including:

- Ensure the availability of reliable energy at costs that are reasonable and that advance the health, welfare, and safety of Commonwealth residents.
- Establish sufficient energy supply and delivery infrastructure, including that needed to support the availability of natural gas, in the Commonwealth.
- Use energy resources efficiently and facilitate conservation.
- Facilitate development of low-cost energy resources located both within and outside the Commonwealth, including development of clean coal resources.
- Facilitate development of energy sources that are less polluting of the Commonwealth's air and water, and electric generation technologies that do not contribute to greenhouse gases and global warming.
- Ensure the economic viability of Virginia's producers of low-cost energy resources.
- Foster research and development of alternative energy sources that are competitive at market prices.
- Develop energy resources and facilities that do not impose a disproportionately adverse impact on economically disadvantaged or minority communities.
- Increase Virginia's reliance on agricultural-based ethanol and biodiesel from crops grown in the Commonwealth.
- Ensure that energy generation and delivery systems are located in places that minimize impacts to pristine natural areas and other significant onshore natural resources, and that are as near as possible to compatible development.

1.1 Executive Summary

Virginia must overcome market, consumer-education, historical energy-cost, public policy, and institutional barriers in order to meet these energy policies and objectives. Overcoming these barriers will require a mix of public and private investments.

Virginia Energy Plan 2017 Goals

- **Increase energy independence, with an emphasis on conservation and clean fuel technologies, by:**
  - Reducing the rate of growth of energy use by 40 percent. This will reverse the projected growth in per capita energy use and result in a nearly level per capita energy use per year.
  - Increasing Virginia's indigenous energy production by 20 percent.
- **Expand consumer energy education to overcome barriers to implementing energy-efficiency and conservation actions.**
- **Reduce greenhouse gas emissions by 30 percent by 2025, bringing emissions back to 2000 levels.**
- **Capitalize on economic development opportunities through business expansion and increased research and development in areas of strength, including alternate transportation fuels, nuclear technology, coastal energy production, and carbon capture and storage.**

Meeting the goals of this Plan and implementing the energy policy and objectives set out in the 2006 energy policy legislation will require actions by individuals, businesses, and government institutions.

Meeting the goals of this Plan and implementing the energy policy and objectives set out in the 2006 energy policy legislation will require actions by individuals, businesses, and government institutions. Individuals, business, and government will need to work together to increase energy-efficiency and conservation actions, provide for a diverse portfolio of energy supplies including traditional and alternate energy sources, provide the needed infrastructure to deliver conservation services and energy supplies, and provide for focused research, development, and deployment of new energy technologies.

Through these efforts, Virginia will increase the role of energy efficiency and conservation, support existing businesses with reliable low-cost energy supplies, support new job growth, increase energy-education activities, increase energy assistance to low-income Virginians, and increase energy research and development at our universities and businesses. Virginians will see lower energy costs in the short term through energy-efficiency and conservation actions, and have a more secure energy future because of investments in new energy infrastructure, energy research and development, and new energy businesses.

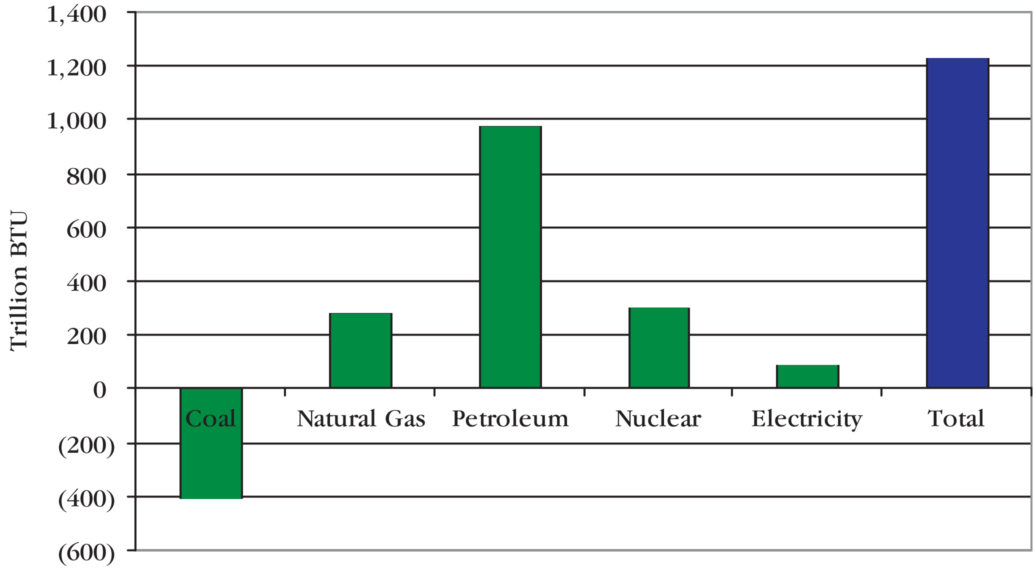
The Commonwealth should ensure that these activities are effective in meeting Virginia's energy goals. The Governor's Energy Policy Advisory Council, with assistance from the Department of Mines, Minerals and Energy and other state agencies and institutions, should evaluate the energy saved, new supplies of energy generated, and value of investments in energy research and development and new business development. The results of the evaluation should be reported to the Governor and the General Assembly to ensure accountability of the proposed energy activities.

1.1.1 Supply and Consumption of Energy in Virginia

Virginia's energy needs are met by a combination of in-state production and imports. Sources include coal, natural gas, uranium, hydropower, petroleum, and renewable sources. The state is a net exporter of coal and produces natural gas in an amount equal to approximately one-third of state consumption. All other fuels are imported from other states and foreign countries (see Figure 1-1).

Transportation is the single largest energy-using sector, accounting for approximately 43 percent of total energy use in the state.

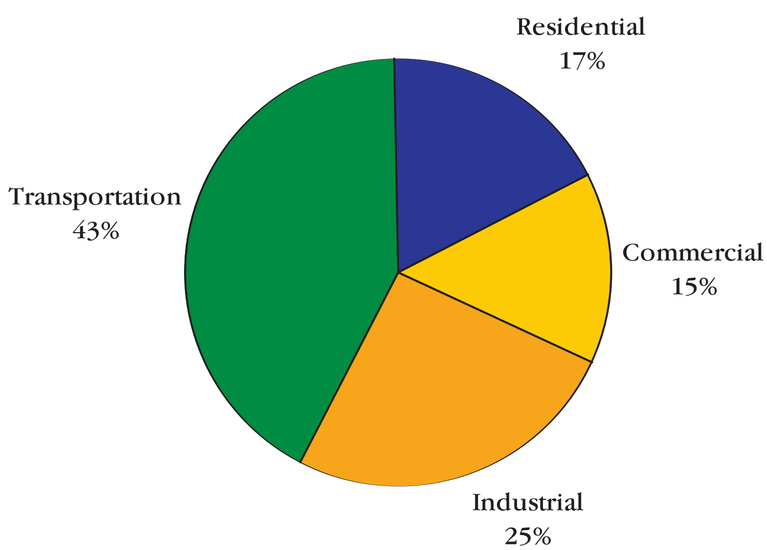
Figure 1-1 Net Imports of Energy into Virginia



Approximately three-quarters of the electricity used in Virginia is produced inside the state from in-state supplies of coal, natural gas, and renewable resources, and from imported uranium, coal, natural gas, and petroleum. The balance of electricity is imported from other states.

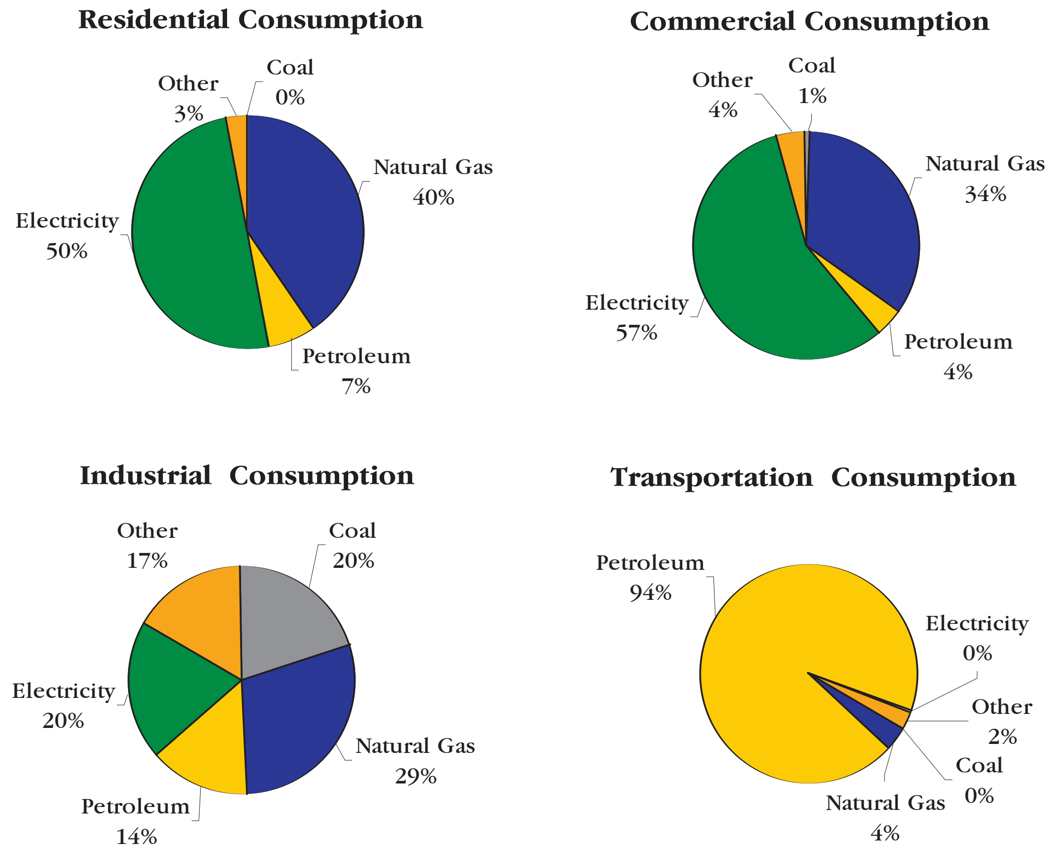
Transportation is the single largest energy-using sector, accounting for approximately 43 percent of total energy use in the state (see Figure 1-2). Virginia's building stock accounts for approximately 57 percent of total energy used. Of that, 17 percent is used in the residential sector, 15 percent in the commercial sector, and 25 percent in the industrial sector.

Figure 1-2 Energy Use in Virginia by Sector, 2003



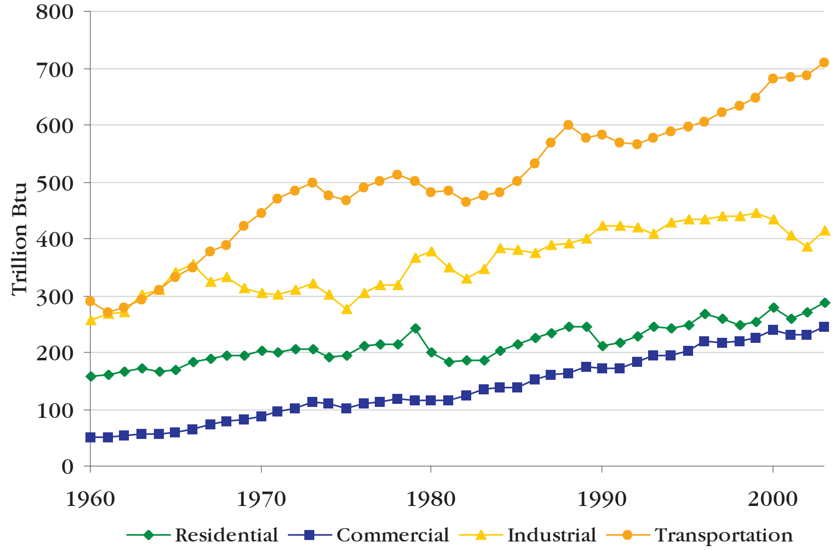
Virginia's residential consumers rely on electricity and natural gas for 90 percent of non-transportation energy use. Commercial consumers rely on electricity and natural gas for 91 percent of energy use. Industrial consumers rely on a more even distribution of energy types. Virginia's transportation energy use relies almost completely, at 94 percent of total, on petroleum. Figure 1-3 illustrates the sources of energy used by these four sectors.

Figure 1-3 Sources of energy for residential, commercial, industrial, and transportation consumption



Since the 1970s, energy efficiency and conservation practices have significantly reduced the amount of energy used in the Commonwealth. Despite these actions, energy demand in Virginia has grown steadily over time, as shown in Figure 1-4. This growth generally follows growth in the state's economy. However, transportation energy use has increased at a faster pace than other sectors as Virginians' vehicle ownership rates and vehicle miles traveled have increased faster than overall economic growth.

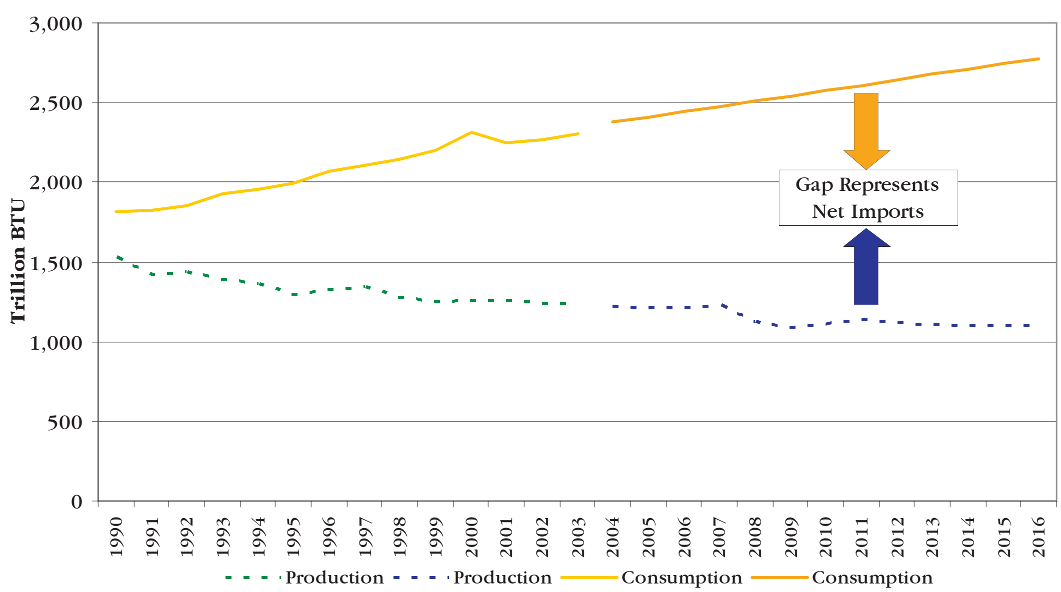
Figure 1-4 Virginia's Energy Use - Growth over Time



Virginia's growing economy will need increasing amounts of energy over the next ten years. As the state's economy moves to include a greater percentage of service jobs and as more computers, electric appliances, and equipment are placed in use, the state will consume more electricity. Constraints in natural gas production, transmission, and distribution infrastructure, combined with conservation by natural gas users in response to recent price increases, will limit growth in natural gas consumption. Some increase in demand for natural gas will come from new natural gas-fired electric generation facilities. Increased use of alternate transportation fuels and increased fuel efficiency will reduce the growth rate for petroleum.

Virginia's energy production is expected to decrease over time as the amount of coal mined in Virginia decreases. This will result in a growing gap between what Virginians use and what the state produces (see Figure 1-5) and will increase the drain on Virginia's economy through increased payments for imported energy.

Figure 1-5 Virginia's Supply and Consumption Gap *(Trillion BTUs)*



Virginia will need a broad mix of energy sources over the next ten years. New technologies should expand the state's energy portfolio, including prudent investments in projects such as the Virginia City Hybrid Energy Center's fluidized bed coal power plant, the Integrated Gasification Combined Cycle (IGCC) power plant proposed to serve Appalachian Power customers, liquid fuel production from agricultural and waste products, wind, and solar. New nuclear power generation, hydrogen, methane hydrates, and ocean power are beyond the ten-year scope of this Plan.

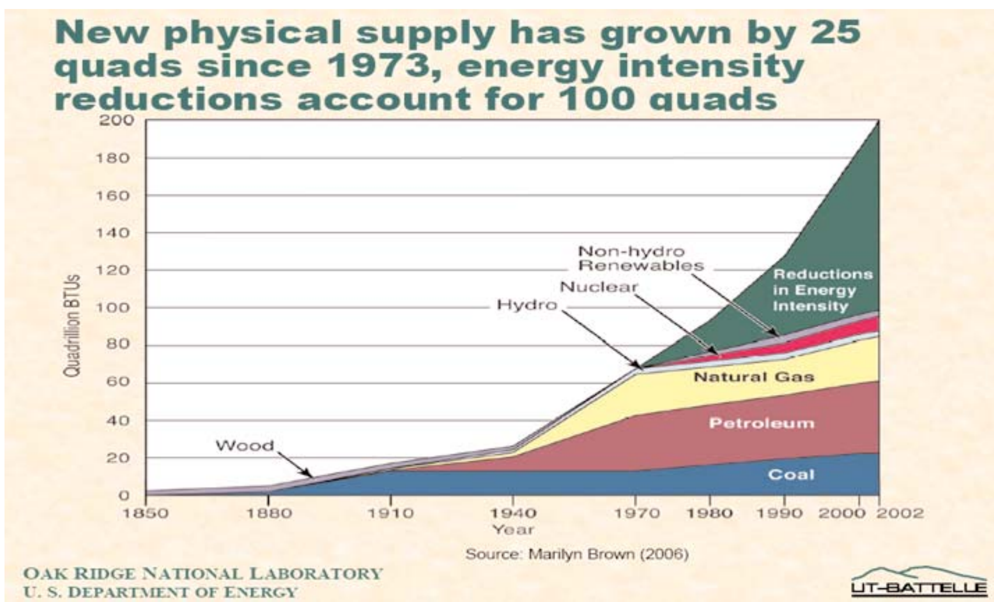
Virginia will need to reduce the energy growth rate through conservation and efficiency and increase its indigenous production of energy, both renewable and conventional, to meet energy growth after efficiency and conservation have been implemented. Specific goals and recommendations addressing energy resources and consumption are set out in other Plan sections addressing energy efficiency and conservation and infrastructure.

Energy efficiency and conservation provide the least costly and most readily deployable energy resource options available to Virginia.

1.1.2 Energy Efficiency and Conservation

Energy efficiency and conservation provide the least costly and most readily deployable energy resource options available to Virginia. As shown in Figure 1-6, analysis by the Oak Ridge National Laboratory shows the United States has made significant strides in energy efficiency and conservation since the 1970s; energy consumption would have doubled without past efficiency and conservation actions.

Figure 1-6 Impact of Energy-Efficiency Efforts on U.S. Energy Intensity, 1973-2002



However, Virginia has invested less in energy efficiency and conservation than some other states and therefore still has significant short and long-term opportunities for efficiency and conservation. Investment has been limited because the relatively low cost of energy has reduced the number of cost-effective options. Utility investments in efficiency and conservation were also limited by the need to reduce costs as Virginia moved to a competitive utility market.

As energy costs increase, Virginia is in a better position to achieve significant cost-effective energy savings.

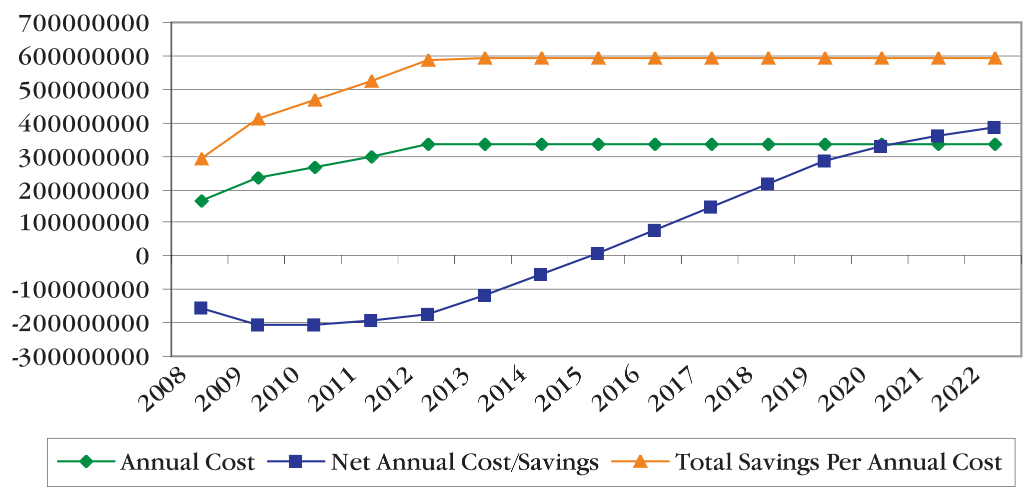
Energy efficiency and conservation opportunities can be classified as having technical potential, achievable potential, and achievable cost effective potential. Calculations based on studies in other states show that Virginia, with a concerted investment in energy efficiency and conservation activities, has an achievable cost effective electric energy reduction potential of 14 percent over the next ten years.

Legislation enacted in 2007 set a goal to reduce 2022 electric use by 10 percent of 2006 retail consumption through conservation and efficiency. Reaching the 10 percent goal would defer or postpone the need for approximately 3,900 megawatts of new electric generation capacity by 2022, equivalent to four or five large generation stations. Virginia consumers would save in the range of $200 to $700 million (net savings after costs) through 2022 (average $15 to $50 million per year), depending on the value assigned to electricity savings. Consumers would receive substantial lifetime savings for their investments in efficiency. Total savings over the lives of the measures would range from $300 to $590 million for each yearly investment in energy-efficiency measures (see Figure 1-7).

Achieving these savings would require a substantial up-front investment. Assuming energy-efficiency measures cost three cents per lifetime-kilowatt-hour-saved[1], utilities and consumers together would have to invest an average of approximately $300 million per year ($100 to $120 million by electric utilities, matched by $180 to $200 million by consumers) over the fifteen-year life of the program. Consumers as a whole would see a net increase in costs because of the investments in efficiency over the first seven or eight years, followed by net savings over the next seven or eight years.

Legislation enacted in 2007 set a goal to reduce 2022 electric use by 10 percent of 2006 retail consumption through conservation and efficiency. Reaching the 10 percent goal would defer or postpone the need for approximately 3,900 megawatts of new electric generation capacity by 2022, equivalent to four or five large generation stations.

Figure 1-7 Electric Energy Efficiency Costs and Savings



Similar calculations show that Virginia could realize, with a concerted investment in efficiency and conservation, natural gas savings of approximately 7.5 percent over the next ten years. This would lower Virginian's natural gas costs by an average of approximately $125 million annually (net savings after program expenses based on 2007 natural gas costs). A national estimate of fuel oil conservation opportunities found that fuel oil use could be reduced 13 percent by 2015 through an aggressive program of conservation and efficiency.

The state should continue its efforts to ensure that affordable energy is available

[1]From the 2006 National Action Plan for Energy Efficiency.

Reducing transportation fuel use by 5 percent through these measures would save 260 million gallons of gasoline per year, equivalent to the energy used by 300,000 cars in Virginia each year.

to low-income and elderly Virginians. The Weatherization Assistance Program is most effective when it receives a consistent level of financial support from year to year. More households can be served with a reliable source of increased funding. Virginia has provided additional funding to the Low-Income Home Energy Assistance Program in times of sharply increased energy costs or particularly cold winters. This support has helped the Commonwealth's most vulnerable households afford needed heat and electricity.

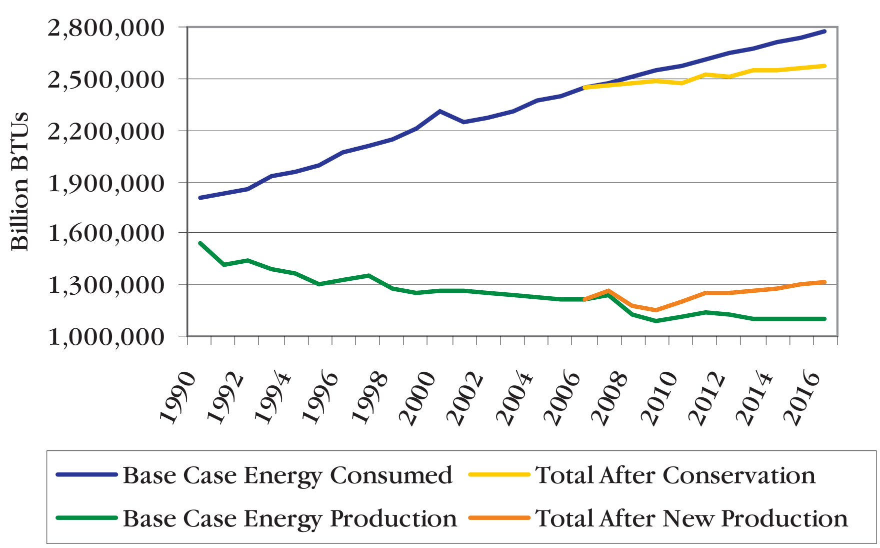
Transportation efficiency improvements have the potential to reduce state energy use. The state can help build the infrastructure to move more long-distance freight from trucks to rail, improve public transit service, implement additional transportation demand-management activities such as telecommuting, ride-sharing, and car-sharing, increase capacity for alternate transportation modes such as bicycling and walking, implement more congestion-mitigation actions, and modify land-development practices. Virginia's statewide 2007 transportation funding package will provide substantial new funding to advance these efforts. For fiscal years 2008-2013, statewide transportation funding will increase 44 percent and rail 40 percent. For public transportation, total funding is around $2 billion.

Energy-based transportation measures should be targeted at reducing vehicle miles traveled, increasing transportation efficiency, and increasing use of alternate transportation fuels. Reducing transportation fuel use by 5 percent through these measures would save 260 million gallons of gasoline per year, equivalent to the energy used by 300,000 cars in Virginia each year.

New technologies should be available within the term of this Plan to help advance energy efficiency. These may include items such as light-emitting diode (LED) lighting, microgeneration systems, cool roofs, computer network controls, and new automobile technologies.

Increased energy efficiency and conservation and new sources of energy will result in a modification of the supply and demand curves. These supply and demand wedges will reduce the gap between supply and demand and reduce the drain on Virginia's economy from energy imports (see Figure 1-8).

Figure 1-8 Virginia Total Energy Produced and Consumed, 1990-2016



Changing consumer behavior and creating demand for energy services and products can have the largest impact on our ability to meet our energy goals.

Goals for Energy Efficiency and Conservation

Reduce by 40 percent the rate of growth in energy use that it would see without the Plan's recommended efficiency and conservation actions. This would reverse the growth in per capita energy use and result, by 2017, in a nearly level per capita energy use per year. Meeting this goal will require a concerted effort in implementing new actions to reduce electric, natural gas, and petroleum product use. This goal also includes weatherizing an additional 700-plus homes of Virginia's low-income families per year through increased investment in the Weatherization Assistance Program.

Increase consumer education about energy use and conservation. Consumers must be educated about energy opportunities if we are to overcome the consumer knowledge market barriers. With clear knowledge, consumers will be comfortable in taking energy-saving actions and making energy-savings investments. Changing consumer behavior and creating demand for energy services and products can have the largest impact on our ability to meet our energy goals.

Recommendations for Energy Efficiency and Conservation

Government policy can support increased use of energy-efficiency and conservation measures and help ensure that energy suppliers can provide needed infrastructure. State, federal, and local governments each have a role in setting energy policy.

Recommendation: ***Virginia should increase incentives for consumer energy efficiency by expanding tax benefits for consumer investments.*** Virginia, contingent on an acceptable revenue impact, should:

- Expand its sales-tax holiday to high-efficiency natural gas, fuel oil, and propane equipment.
- Add a spring sales-tax holiday weekend for Energy Star equipment to provide an incentive for high-efficiency air conditioning and other equipment not covered in the fall Energy Star sales-tax holiday.
- Provide tax incentives for energy efficiency and conservation similar to those provided by the federal government for investments such as energy-efficiency building improvements, high-efficiency equipment, combined heat and power installations, heat recovery, and other technologies.

Recommendation: ***Virginia's utilities should sponsor or offer efficiency and conservation programs for their customers.***

- Subject to the outcome of the 2007 State Corporation Commission energy conservation and demand-control study, the Commonwealth, in cooperation with electric utilities and energy-efficiency service providers, should initiate an aggressive set of actions to expand use of energy efficiency, conservation, and demand management to offset electric demand and use. Energy-efficiency and conservation activities, or program portfolios, should address all customer classes and income levels.
- Any portfolio of electric energy conservation activities should be evaluated for cost effectiveness. Virginia should use a mix of the Total Resource Cost Test, Societal Test, Utility/Program Administrator Test, Participant Test, and Rate Impact Measure Test. No one single tool should be used solely as a go-no go decision mechanism.
- These activities will require incentives to overcome implementation barriers. Based on incentives provided in other states' successful programs, Virginia's electric utilities would have to invest $116 million

per year to reach the 10 percent electric savings goal.

- Energy conservation and demand-control activities should be evaluated for effectiveness through use of measurement and verification protocols. Programs not meeting planned results should be reevaluated to determine if they should be modified or ended.
- Virginia should carefully implement a combination of natural gas local distribution utility revenue decoupling for energy-efficiency and conservation programs.
- Virginia's natural gas utilities and producers also should broadly implement the U.S. Environmental Protection Agency's Natural Gas Star recommendations to conserve natural gas and reduce leakage in production, transmission, and distribution operations.

Recommendation: ***Virginia should expand support for programs that help low-income Virginians reduce their energy use.***

- Virginia should expand the capacity of and funding for the Weatherization Assistance Program to allow additional low-income households to receive energy-efficiency and conservation improvements. Two million dollars per year would allow the program to serve an additional 715 households per year. The weatherization work reduces these households' energy bills and their need for other energy assistance.
- Virginia should provide additional funding to the Low-Income Home Energy Assistance Program in times of sharply increased energy costs or particularly cold winters.

Recommendation: ***Virginia should implement an expanded energy education program.*** This program should be developed by July 2008 based on input from energy and education stakeholders.

- Virginia should implement an energy-conservation consumer-education program to overcome consumer market barriers and allow consumers to be confident in investing in energy-efficiency and conservation improvements. Education efforts should be included as part of utility energy-efficiency and conservation programs. Education efforts should include more widely promoting web-based education resources such as the *Virginia Energy Savers Handbook* to consumers.
- A broad energy-efficiency/green-product-branding effort is needed to provide consumers with a reliable label on energy-using products and energy-efficient materials. One choice is to expand the federal Energy Star designation to all types of energy-using equipment and energy-savings materials. If the federal Energy Star cannot be expanded, then Virginia should support implementation of an independent energy-efficiency label program. This effort should be coordinated with utilities and retail-store communication programs.
- Energy education should include information to help consumers avoid fraudulent claims of energy savings. This should be provided in cooperation with the Office of Consumer Affairs at the Department of Agriculture and Consumer Services.
- Virginia should promote use of educational resources available in federal programs such as Clean Cities, Rebuild America, Climate Leaders, and the U.S. Mayors Climate Protection Agreement (Cool Cities) and Cool Counties.
- Virginia should continue to actively promote recycling.
- An effective, statewide non-utility energy-education program will require $1 million per year to support development and delivery of energy information to consumers.

This consumer-education work would be in addition to, and coordinated with, energy education included in utility-sponsored efficiency and conservation programs.

Recommendation: ***Virginia should implement policies to improve the energy efficiency of its building stock.***

- Virginia should ensure that the energy requirements in the Uniform Statewide Building Code result in the most efficient energy performance that is cost effective. This may require use of energy codes more stringent than those in the model International Building Code.
- Virginia should provide training to building code officials, architects and engineers, and the building community on how to properly meet energy codes and use more energy efficient building standards.
- Virginia should work with its building community to provide additional energy-conservation education to the industry's workforce.
- Virginia should initiate a home energy rating system for new and existing homes.

Recommendation: ***Virginia should support efforts by its industrial and commercial sectors to improve the efficiency of their operations.***

- Virginia should establish energy assessment centers, similar to federally funded industrial energy assessment centers, at its engineering universities or with other providers, to offer energy audits and assessments to small commercial and industrial consumers.
- Virginia should help industrial consumers implement waste-to-energy, heat recovery, and combined heat and power projects.

Recommendation: ***Virginia should support deployment of new energy-conservation technologies.***

- Virginia should monitor new technology development and provide financial support to encourage early adoption of emerging energy technologies.

Recommendation: ***The federal government should expand its efforts in support of energy efficiency and conservation.***

The federal government has a primary role in promoting energy efficiency and development of reliable energy supplies through tax policy and direct financial assistance, research and development, energy data publication, equipment and vehicle standards, and public education. Many of these policies must be implemented on a national or regional basis, as state implementation would introduce dysfunction into markets or lead to duplication and inefficiencies.

- The federal government should continue providing the numerous energy-efficiency and conservation, research and development, energy data, grants, and other services to residential, commercial, industrial, and institutional consumers.
- The federal government should increase its investment in energy efficiency and conservation and alternate energy development, and support state efforts to deliver these services to consumers. These investments should be provided at a stable level over a multiyear period to ensure that partners can efficiently plan and implement new investments.
- The federal government should more broadly implement improved appliance efficiency requirements. If neighboring states set higher appliance standards, Virginia should consider joining them to set a regional appliance efficiency standard in the common market areas.

Corporate Average Fuel Efficiency (CAFE) standards for vehicles should be increased 10 miles per gallon over the next ten years to 37.5 miles per gallon for automobiles and 32.2 miles per gallon for light trucks.

- Corporate Average Fuel Efficiency (CAFE) standards for vehicles should be increased 10 miles per gallon over the next ten years to 37.5 miles per gallon for automobiles and 32.2 miles per gallon for light trucks, with off-ramps for proven technical or safety roadblocks. CAFE standards should be based on actual mileage and should not be adjusted upward based on use of alternate fuels in fleets. CAFE protocols should be periodically adjusted to account for changing driving conditions such as urban/suburban/rural driving patterns, typical congestion delays, and typical speeds driven.

Recommendation: ***Local governments should establish policies to increase the energy efficiency of their citizens.***

A number of early-adopting Virginia localities are taking action to encourage energy-efficiency and conservation action by their citizens. Other Virginia localities should follow their lead and establish policies to encourage additional private energy conservation actions.

- Localities should take advantage of authority granted under 2007 legislation to create a separate real-estate classification and lower tax rate for buildings that are 30 percent more efficient than required by building code.
- Localities should adopt land-use plans that allow higher-density development near mass transit nodes and encourage mixed-use communities, urban redevelopment, and infill development.
- Localities should allow higher-density development for projects meeting Leadership in Energy and Environmental Design (LEED) standards, and streamline permitting and reduce permitting fees for LEED buildings.
- Localities should consider how development and transportation patterns affect energy use when developing their comprehensive plans.
- Localities should assess the use of conservation easements and purchase of development rights as a way to preserve open space and direct development toward areas with mass transportation available.
- Localities should take advantage of authority granted under 2007 legislation to enter into agreements with nonpublic schools to provide student transportation, increasing the efficiency of the overall student transportation system.
- Localities should support development of new renewable energy and distributed energy applications. Localities should use the Virginia Renewable Site Scoring system developed under authority of the Virginia Energy Plan legislation in their local land-use decision-making process.
- Localities should consider sharing landfill tipping fees with projects that convert waste to energy and in turn reduce waste volume and extend the life of the locality's landfill.

Each Virginian affects the state's energy future through day-to-day and long-term lifestyle decisions. There are many easy, small decisions that collectively can make a big difference in energy use. These decisions should be made wisely so that adequate supplies will be available to meet Virginia's future needs. These decisions can be made by Virginia's governments, individuals, and businesses.

Recommendation: ***Government should lead by example and implement all cost-effective conservation opportunities.***

- State government has completed an operational review of energy use to identify other opportunities for energy management and efficiency

Each Virginian affects the state's energy future through day-to-day and long-term lifestyle decisions. There are many easy, small decisions that collectively can make a big difference in energy use.

improvements. State government should implement the actions under Executive Order 48 (2007) and the best practices identified during the operational review to reduce energy use and costs.

- Federal government agencies have taken many actions in Virginia to reduce their energy use and use alternate supplies of energy. The Federal Energy Management Program is a model for an organization's energy management practices. Virginia should pursue opportunities to work together with federal facilities on energy management, through the Virginia Regional Environmental Management System.
- Numerous Virginia localities have taken actions to manage their energy use. All Virginia localities should follow the lead of these local governments and implement cost-effective internal energy-conservation opportunities and establish policies to encourage private energy conservation actions.

Recommendation: ***Individual consumers should make day-to-day and long-term lifestyle choices that save energy.***

- Virginians should take the many simple, daily lifestyle steps to use energy more efficiently, such as using compact fluorescent lightbulbs, ensuring that heating and cooling equipment is properly serviced, lowering water-heater temperature settings, adding insulation to water heaters and pipes located in unheated areas, sealing leaks in homes, turning lights and equipment off when not needed, not overcooling or overheating homes, planning trips, and not driving at excessive speeds. These small steps can add up to big savings.
- Virginians should consider the energy impacts of broader lifestyle decisions such as where to live or what forms of transportation to use. They also can choose to build more efficient houses that meet Energy Star or EarthCraft Home standards. A small initial investment in increasing the energy efficiency of new homes will be returned in lower energy bills, reducing the overall cost of ownership and increasing housing affordability.
- Consumers should reduce energy use and costs through purchasing decisions. For example, Virginians can save considerable energy by purchasing Energy Star and other high-efficiency equipment whenever available.
- Virginians should make fuel efficiency a primary factor in vehicle purchase decisions. All drivers should keep vehicles properly maintained, such as keeping tire pressure at recommended levels and keeping vehicles tuned up.
- Consumers should take actions that, while not saving energy directly, have an indirect effect on energy consumption. This includes actions such as purchasing goods with less extensive packaging and recycling.

For more information on how individuals can use energy wisely, see the *Virginia Energy Savers Handbook* and other consumer information at www.dmme.virginia.gov/DE/ConsumerInfo/consumerinfo.shtml or the U.S. Department of Energy's *Consumer Guide to Energy Efficiency and Renewable Energy* at www.eere.energy.gov/consumer.

Recommendation: ***Commercial businesses should give priority to energy-efficiency and conservation actions.***

Just as individual consumers can affect our energy future, commercial businesses can increase the efficiency of energy use in Virginia.

Energy Management

- Commercial businesses should use best energy management practices such as those in the Energy Star or

Just as individual consumers can affect our energy future, commercial businesses can increase the efficiency of energy use in Virginia.

Energy is the second largest cost after personnel for many industries. Energy cost savings usually improve a company's bottom line.

ANSI/MSE 2000:2005 protocols.

- Commercial businesses should participate in Virginia's Environmental Excellence Program.

Commercial Buildings

- Commercial businesses have a long-term impact on energy use through their design and construction decisions. Constructing high-efficiency buildings, such as those that meet the energy standards for LEED buildings, provides long-term energy and environmental savings. Constructing a LEED building can increase first costs by 2 to 3 percent, but the investment will be returned through lower operating costs in as little as four years.
- Commercial business managers should give priority to energy efficiency when renting space.
- Commercial business owners should invest in all cost-effective efficiency and conservation improvements, or use energy savings performance contractors to implement energy savings improvements.
- Commercial property that has not had a rigorous preventative maintenance program should be recommissioned (like a building tune-up) if the building has been in operation for more than ten years. Commercial businesses should also ensure that new buildings, whether self-built or leased, have been properly commissioned to reduce ongoing energy use and costs.
- Commercial businesses should purchase high-efficiency Energy Star or equivalent equipment.
- Lighting is critical to most retail businesses. Retail businesses should maximize use of daylight to reduce daytime electrical lighting and select the most efficient sources of lighting that provide proper color control for their business needs.

Recommendation: ***Virginia's manufacturers should give priority to energy-efficiency and conservation actions.***

While Virginia's manufacturers have taken many actions to reduce their energy expenditures, many energy-conservation opportunities are still available. Energy is the second largest cost after personnel for many industries. Energy cost savings usually improve a company's bottom line.

Energy Management

- Industrial concerns should follow best energy management practices provided for in the Energy Star or ANSI/MSE 2000:2005 protocols.
- Virginia's industries should avail themselves of energy-conservation tools through the Federal Department of Energy's Industrial Technologies Program

Process Efficiency

- Small manufacturers should use the services of industrial assessment centers to identify and implement cost-effective energy-efficiency process improvements.
- Larger industrial operations should pursue cost-effective opportunities through the federal Industrial Technologies Program for such things as process improvements, use of variable-speed motor drives, development of combined heat and power, waste heat recovery, and waste-to-energy applications.

Recommendation: ***Agricultural and forestry operations should expand use of energy-efficiency and conservation actions.***

There are many practices that Virginia's agricultural and forestry industries can implement to improve energy efficiency and conservation.

- Virginia's forest products industry should follow the practices set out in the Forest Products Industry of the Future program.

Three paths should be followed to reduce the energy impact of transportation in Virginia: reduce vehicle miles traveled, increase the efficiency of our vehicles and fleets, and replace imported petroleum with renewable liquid fuels.

- Virginia's farms and agribusinesses should use the energy management tools provided by the U.S. Department of Agriculture and National Resources Conservation Service.

Recommendation: ***Virginians should increase the energy efficiency of fleets and transportation systems.***

Three paths should be followed to reduce the energy impact of transportation in Virginia: reduce vehicle miles traveled, increase the efficiency of our vehicles and fleets, and replace imported petroleum with renewable liquid fuels.

Reducing Vehicle Miles Traveled

- State and local governments should better integrate land-use and transportation planning. State agencies addressing transportation and energy should monitor performance measures for per capita transportation energy use and vehicle miles traveled as a measure of transportation energy efficiency.
- Virginia should fully implement its portfolio of transportation demand management tools, including providing capital and operating funding to create easy-to-use alternatives to single-occupant vehicle commutes and access to reasonably priced and regularly scheduled mass transit service in both urban and suburban areas.
- Virginia should give priority to congestion-mitigation projects when allocating transportation funding.
- Virginia should continue to support development of new light rail systems in urban areas, such as the proposed Norfolk Light Rail project.
- Virginia should continue to develop its transportation infrastructure to include facilities for no- or low-fuel methods such as walking, bicycling, and small scooters consistent with the Commonwealth Transportation Board's *Policy for Integrating Bicycle and Pedestrian Accommodations*.
- Virginia should review its roadway design standards to evaluate whether changes can be made to facilitate higher-density development in urban areas.
- Virginia state and local policies should encourage land-use patterns that allow for construction of safe and accessible facilities for non-motorized transportation and that reduce the need for long commutes.
- Virginia should continue to expand the availability and use of high-occupancy vehicle (HOV) and high-occupancy tolling (HOT) lanes through expansion of service on I-95, adding HOV/HOT lanes to the Washington, D.C., Beltway, and on other highways as congestion increases.
- The Commonwealth should increase its work to promote the use of alternate methods to single-occupant commutes such as telecommuting, ride-sharing, and car-sharing through consumer education, providing telecommuting centers, and providing convenient locations for car-share parking.
- Virginia should make a concerted effort to move truck freight to rail and barge.

Increasing Fleet Efficiencies

- Individuals and businesses should include fuel efficiency in their decision making when purchasing vehicles and equipment.
- Fleet operators should plan vehicle routes to minimize mileage and minimize travel during highly congested times.
- Vehicle owners should keep vehicles properly maintained, such as keeping tire pressure at recommended levels and keeping vehicles tuned up.
- Virginia has recently restricted use of newly purchased hybrid vehicles in HOV lanes. Use of highly fuel efficient hybrids in HOV lanes can balance the goals of mitigating

Driving smart saves fuel. Using controlled acceleration and deceleration, cruise control, and slowing down can significantly increase fuel efficiencies. Tests of aggressive verses calm driving in cities show up to 25 percent savings using best driving practices. For every 5-mph decrease on the highway, a typical driver will save 5 percent in fuel.

congestion and reducing energy use in transportation. The Commonwealth should evaluate the effect this has on the rate of hybrid vehicle market penetration. If the market penetration rate declines in relation to other states, Virginia should work with the federal government to reconsider the ban for the most fuel-efficient hybrid vehicles. For example, any hybrid with a more than 50-mpg combined mileage rating could still be allowed to obtain clean special vehicle license plates and use the HOV lanes.

- Driving smart saves fuel. Using controlled acceleration and deceleration, cruise control, and slowing down can significantly increase fuel efficiencies. Tests of aggressive verses calm driving in cities show up to 25 percent savings using best driving practices. For every 5-mph decrease on the highway, a typical driver will save 5 percent in fuel.

Using Alternate Transportation Fuels

- The biofuels incentive program should be adequately funded. The Virginia Economic Development Partnership, Department of Agriculture and Consumer Services, and Department of Mines, Minerals and Energy should continue to work with prospective companies to increase the amount of alternate transportation fuels produced in Virginia.
- Virginia should consider mandating use of 10 percent ethanol and 5 percent biodiesel in all retail fuel sales when there are sufficient supplies available from non-food crop sources to support this use. Any mandate should be coupled with incentives for fuel terminals to make the necessary infrastructure improvements to handle the new fuel mixes.
- Virginia should amend its statute and regulations to allow for flexibility in blending conventional and alternate fuels to facilitate increased alternate fuel sales. For example, repealing the ethanol content pump labeling requirements would provide gas-station owners with increased flexibility to sell conventional or reformulated gasoline in areas where reformulated gasoline is not required.
- Virginia should help increase the market availability of E85 and B20 or greater biodiesel by helping retailers add new retail outlets for the fuels.
- The Commonwealth should, consistent with Virginia's hydrogen blueprint, carefully monitor the potential for hydrogen technologies to serve Virginia's energy needs.

Recommendation: *Virginia's higher education institutions should expand efforts to use energy wisely and train the next generation of leaders about energy.*

Virginia's higher education institutions can lead by example by implementing energy-efficiency and conservation actions across their campuses. These actions will not only reduce energy use and lower energy bills but will also help educate future generations of leaders on how to make wise energy decisions.

- Virginia universities should expand involvement in the Greening the College Campus or similar activities to increase energy efficiency of their operations.

1.1.3 Virginia's Energy Infrastructure

Virginia is home to significant electric generation and transmission, natural gas and petroleum pipeline and storage, rail and road, and marine import infrastructure (see Figure 1-9). The state is also home to one medium-sized petroleum refinery.

Virginia will need to add energy infrastructure over the next ten years to continue to provide reliable, low-cost energy to its consumers and decrease the potential risk consumers face from disruptions in energy supplies.

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Figure 1-9 Virginia's Energy Infrastructure

Electric Infrastructure

Virginia is at the southern end of the Mid-Atlantic area which is projected to violate electric reliability standards as early as 2011. With no increase in conservation, Virginia would need to add an additional 5,098 megawatts of capacity through a mix of electric generation or imports coupled with increased transmission capacity. If the 10 percent energy-efficiency and conservation goal set in 2007 legislation is met, the state would still need to add an additional 2,358 megawatts of capacity. Additional electrical infrastructure growth will be needed if any current capacity must be retired. This capacity will need to serve electric growth in the northern Virginia, Hampton Roads, and central Virginia areas.

Natural Gas Infrastructure

Virginia will need new onshore natural gas infrastructure over the next ten years. Virginia is near the end of the natural gas pipelines that bring Gulf of Mexico gas to markets. The state relies on these main transmission pipelines and shorter branch lines to deliver natural gas to users throughout the state.

The highest-priority need for new natural gas infrastructure is a third natural gas pipeline crossing the James River. Other transmission and distribution pipeline projects will be needed to solve local reliability problems and serve new large users such as electric generation plants.

Virginia's natural gas utilities will also need to add additional storage to their systems to meet peak winter and summer demands for natural gas.

The state is an attractive expansion target for liquefied natural gas (LNG) imports. Virginia's utilities would need to add new pipeline transmission capacity if any LNG import facility is located in the state.

Virginia's natural gas producers will continue to need new gathering pipeline and compression capacity to serve new areas where natural gas wells are drilled. These will be needed to serve both expanded coalbed methane production as well as new wells producing from deep shale formations.

Petroleum Infrastructure

The state's petroleum infrastructure will need to adapt over the next ten years to accommodate growth in alternate transportation fuels. New fuels require additional tanks and handling facilities at terminals. Virginia will need to add or retrofit a significant number of retail outlets for E85 and biodiesel fuels. New alternate fuel producers require land, buildings, and rail and road access. Expansion of the petroleum refinery in Yorktown would enhance Virginia's ability to supply reliable gasoline and diesel supplies to end users.

Virginians need to learn more about the extent to which offshore natural gas and petroleum deposits exist before making any final decision regarding offshore production. Current state policy supports natural gas exploration more than 50 miles from the coast. The federal government should work with the offshore oil and natural gas industry to develop geophysical information about the offshore geology and possible deposits. Virginia, working with the federal government and the offshore industry, needs to continue research on the offshore environment, including marine and seafloor life, ground stability, and other relevant matters.

The Minerals Management Service should also revise its offshore administrative boundaries using a more equitable method that does not allocate large areas to states with convex coastlines and small areas to states with concave-shaped coasts.

Renewable Energy Infrastructure

Virginia will need new infrastructure to support its renewable fuels industry. There are limits under Virginia's renewable portfolio standard to the amount of wood that can be used for biomass-based electric generation. There also are limited supplies available for large cellulosic liquid fuel projects. Therefore, Virginia needs to develop new infrastructure for biomass energy use, including facilities to gather, process, and store wood from sources such as land clearing, urban wood waste, and wood residue left after logging.

There may also be a need for additional electrical distribution or transmission lines to serve new alternate electricity generation. This may include onshore wind-powered projects as well as offshore wind- and ocean-powered generation.

Coal Infrastructure

Virginia relies on railroad and highway infrastructure to transport its coal resources. Coal is processed at preparation plants located in Virginia's coalfields. This infrastructure should not need major improvements over the ten-year term of this Plan. There will be a need for new coal haulage roads and public road improvements as mines open and close in order to minimize conflict between routes needed to haul coal and built-up communities. The state's electric consumers would benefit from adding import capacity at one or more coal export facilities along Virginia's coast. This would allow for an increase in competition for coal supplied to electric utilities and would help mitigate future price increases.

Nuclear Infrastructure

New nuclear energy production is not expected to come on-line over the ten-year term of this Plan. However, a new nuclear power plant may be under construction during the term of this Plan and come on-line shortly thereafter.

Although production of uranium is prohibited under state law and legislative action would be needed to lift this moratorium, uranium exploration activities are expected during the term of this Plan. This is in response to the long-term price increases for uranium and the need to supply future new nuclear reactors around the world. Virginia should take steps during the term of this Plan to understand the environmental risks and identify controls needed if uranium mining were to be allowed.

Goals for Energy Infrastructure and Supply

Increase in-state production of energy by 20 percent over what is projected in 2017. To meet this goal, Virginia will need expanded electrical, natural gas, and liquid fuel resources.

- Even after meeting the 10 percent electric savings goal set out in 2007 legislation, Virginia will need to expand its electric generation infrastructure by more than 2,300 megawatts. This new generation will need to be supplied through both conventional and renewable generation. Virginia electric utilities will also need to construct new transmission infrastructure to deliver electricity to growing market areas.
- Virginia's natural gas utilities will need to make ongoing investments in new infrastructure to deliver natural gas to consumers. This includes constructing a third pipeline across the James River between north and south Hampton Roads and constructing new local distribution pipelines and peak storage facilities. Additional upstream natural gas infrastructure is also needed to bring adequate natural gas supplies to Virginia's natural gas consumers.
- Virginia will need to invest in new liquid fuel infrastructure. The energy generation goals in this Plan include increasing the capacity of the petroleum refinery in Yorktown by 40,000 barrels per day and providing 300 million gallons per year of ethanol production and 120 million gallons per year of biodiesel production. This would offset imports needed to fuel 1.2 million of the state's cars and trucks per year.

The General Assembly enacted renewable energy grant programs established in 2006 legislation. Virginia must fund these grants and other efforts to expand use of renewable energy sources if there is to be a significant growth in renewable energy use over the life of this Plan. These efforts will allow renewable energy sources to become self-sustaining in the future.

Recommendations to Improve Virginia's Energy Infrastructure and Supply

Virginia must ensure that there is adequate infrastructure to provide needed energy supplies to Virginia. Adding infrastructure will help decrease energy imports. This will keep funds otherwise spent on energy imports in Virginia's economy and decrease the potential risk consumers face from disruptions to energy supplies.

Recommendation: ***Virginia should support expansion of the state's electric infrastructure needed for the state's growing economy.***

- Virginia's electric utilities should provide sufficient information with their biennial filings to facilitate a wider public understanding of the Commonwealth's future electric demands and plans to meet these demands.
- Developers of conventional electric generation capacity that would serve and be paid for by Virginia electric consumers should be required to show, as part of an application for a Certificate of Public Convenience and Necessity,

that the conventional generation is needed after all cost-effective energy-efficiency and conservation actions have been implemented, and that the conventional generation is less expensive than new renewable generation capacity.

- Virginia should maintain public policies to ensure that the state's electric utilities have access to low-cost capital for prudent investments in needed new generation capacity such as for the Virginia City Hybrid Energy Center, Virginia's share of new coal-fired Integrated Gasification Combined Cycle power plants, and renewable electric generation.
- Virginia should support development of new electrical transmission facilities to serve growing regions of the state, particularly in northern Virginia and Hampton Roads.
- Virginia will continue to need new and upgraded electric distribution systems. This will require an ongoing investment by Virginia's electric utilities to meet growing system needs and ensure reliability of supply.
- Utility companies should take full advantage of the pre-application planning process established by legislation in 2007 to ensure timely review of electric transmission line applications. The applying utility should make complete information available to the public about the need for the line, including options for not building the line, and for possible routes. The decision-making process on the need for new electric infrastructure should also include opportunity for public involvement early in the process.
- Decisions regarding the routing of electric transmission lines should continue to be made at the state level. There should be no federal designation of a National Interest Electric Transmission Corridor in Virginia. If such a corridor designation is made, the prohibition against use of federal eminent domain over state property must include a prohibition against use of federal eminent domain to overturn state-owned conservation easements.
- Virginia should develop a better-coordinated approach among the State Corporation Commission (SCC), Office of the Attorney General, the Governor's energy advisor, and environmental agencies to provide state input into the PJM planning process. The level of coordination or communication among the SCC, Office of the Attorney General, and Governor's Office should recognize that the SCC's role may be limited by the need to avoid prejudging matters that may come before it for approval. The Commonwealth also should actively track the North American Electric Reliability Council's planning process for its effect on the state's electric service requirements.
- PJM should include a broad portfolio of conservation and demand-control programs when assessing future loads.
- The Commonwealth, through the Joint Commission on Technology and Science, should continue its evaluation of the costs and benefits of placing electric transmission lines underground in order to generate accurate information needed to determine when the costs of placing lines underground as compared to aboveground make such construction in the public interest.

Recommendation: ***Virginia should encourage generation of electricity from new renewable sources.***

- Virginia should develop the supply systems needed to allow wood remaining after commercial lumber harvesting, land-clearing debris, and demolition waste to be used as a fuel source for biomass-fired electric generation plants.

- The Virginia Tech/Department of Forestry biomass GIS mapping tools should be expanded to include all potential sources of biomass for energy generation.
- Virginia should support expansion of and development of new waste-to-energy facilities to reduce the need for landfills, reduce environmental impacts of managing animal wastes, and meet growing demands for energy. Localities should consider dedicating a portion of tipping fees to support projects that extend the life of landfills. The state should work with localities to pre-package waste-to-energy and alternate fuel production sites with required zoning, environmental assessments, and infrastructure.
- Community associations should not place unreasonable restrictions on renewable-energy installations such as solar thermal or photovoltaic panels that are integrated into the facility design. Community associations and localities are encouraged to consider the results of the state system to rate a property's suitability for solar and wind development when considering approval of such uses.
- Onshore wind should be developed after receiving local land-use approval and a finding that avian and bat species and critical habitat would not be materially affected. Early projects should include post-construction testing to identify avian and bat impact.
- The Commonwealth should fund the Photovoltaic, Solar, and Wind Energy Utilization Grant and Renewable Electricity Production Grant Programs that were established in the 2006 Virginia Energy Plan legislation. Five million dollars per year is needed over the next five years to generate significant private investments in and installation of new renewable energy systems. To the extent that limited funds are available, they should support the Photovoltaic, Solar, and Wind Energy Utilization Grant Program first. Commercial-scale projects that would be supported by the Renewable Electricity Production Grant Program will be supported under the state's new renewable portfolio standard.
- The Commonwealth should encourage all cost-effective, environmentally responsible development of offshore wind resources. Virginia should work through the Virginia Coastal Energy Research Consortium with the federal Minerals Management Service's Outer Continental Shelf Alternate Energy and Alternate Use Program to more carefully characterize the offshore wind potential and identify potential environmental impacts of such development.

The Commonwealth should encourage all cost-effective, environmentally responsible development of offshore wind resources.

Recommendation: ***Virginia should support expansion of the state's natural gas infrastructure needed to support the state's growing economy.***

- Virginia needs to strengthen its natural gas infrastructure by increasing delivery capacity to the south Hampton Roads area and to areas with new development. This will require both new pipeline and peak storage capacity. State, regional, and local economic development and energy officials should monitor the supplies and demand for natural gas and work with natural gas utilities, pipeline companies, and the State Corporation Commission to ensure that an adequate supply infrastructure is available. Provision of adequate infrastructure may require use of alternate rate plans to ensure that consumers pay fair rates and utilities receive adequate return to provide and maintain the needed infrastructure.
- Local distribution companies should work with localities to designate corridors for natural gas pipelines in advance of need and

avoid conflicts between line extension and local land-use plans.

- Virginia should support projects to diversify natural gas supplies, such as new LNG terminal construction or increased pipeline capacity from southwest Virginia's natural gas fields or other supply areas, to growing areas of Virginia. Such projects should be protective of public safety and high-value environmental resources.
- Any development of offshore natural gas resources should be made consistent with Virginia policy. Both the federal Mineral Management Service (MMS), through leasing actions, and the National Oceanographic and Atmospheric Administration, through the Coastal Zone Management program approvals, should recognize Virginia policy when taking action affecting offshore development. The MMS also should work with the offshore exploration and production industry and East Coast states to determine the extent of offshore natural gas resources and the environmental protections that would be needed if such development were to proceed.

Recommendation: ***Virginia should support the petroleum infrastructure needed to supply petroleum and alternate transportation fuel products to Virginia consumers.***

- State and regional economic development entities should continue to work with the Yorktown petroleum refinery owner to support expansion of the refinery.
- As the marketplace for petroleum products expands to include new products such as low-sulfur fuels and non-petroleum alternate fuels such as ethanol and biodiesel, petroleum terminals must reconfigure their facilities to manage the new products. Local governments should, consistent with public health and safety protection needs, streamline approval of modification plans and provide all available flexibility to terminal operators to make these needed changes.
- Development of alternate fuels such as ethanol and biodiesel will require developing new fuel production and transportation facilities. Other infrastructure will be needed to supply raw-material inputs, such as biomass supplies, to production facilities. Virginia's production incentive for in-state-produced biofuels should be adequately funded. Localities are encouraged to work with state economic development, agriculture, and energy agencies to identify sites providing the necessary infrastructure for new biofuel production facilities.
- Virginia should provide incentives to increase the use of municipal solid waste or agricultural waste for energy generation or alternative liquid fuels.
- Virginia should target the military ground transportation and ship transportation systems as a market for in-state-produced synthetic diesel fuels.
- Any development of offshore petroleum resources should be managed consistent with Virginia policy. No exploration or production of petroleum should be allowed at this time. The federal MMS should work with Virginia, other East Coast states, and the offshore exploration and production industry to evaluate the increased risk and protections that would be needed as part of any leasing of outer continental shelf petroleum deposits.

Recommendation: ***Virginia should ensure that its coal industry can provide needed fuel to provide cost-effective electric supplies and energy for the country's steel industry.***

- The Commonwealth and its coal industry should work together to maintain a viable mining industry that supports the economy in southwest Virginia and provides needed coal resources for electric and steel production at reasonable costs to consumers. This includes maintaining safe conditions for mine workers (e.g., working to implement changes in federal mine safety law related to mine rescue, emergency supplies in mines, underground miner tracking and communication systems, and seals used in underground mines) and controlling effects of coal mining on the environment.

- Local governments in southwest Virginia are encouraged to use local coalfield road-improvement funds to ensure that there are adequate roads to haul coal on routes that minimize conflict with built-up areas.
- Virginia's rail providers must ensure that there is adequate rail-car capacity to carry coal from Virginia's mines to end users and to Virginia's coal export facilities.
- Virginia should support carbon capture and storage projects in unminable coal seams to help support continued markets for Virginia coal.
- While Virginia should not take actions that would diminish the viability of southwest Virginia coal producers, Virginia coal consumers will benefit from the market diversity provided from coal imports. Therefore, state and local approval should be given to infrastructure improvements needed to modify existing coal export facilities to accept coal imports.

Recommendation: ***Virginia should support development of fueling infrastructure as the market develops for hydrogen fuel use, as outlined in Virginia's hydrogen blueprint.***

- Hydrogen can become a larger provider of energy to Virginia. However, it is not expected to be a major provider during the ten-year term of this Plan.

Recommendation: ***Virginia should support industry efforts to ensure that the state's energy infrastructure is secure from natural and human-made disasters.***

- Virginia's energy industry should take the necessary steps to protect the state's energy infrastructure from risk of natural and human-made disasters.
- Energy infrastructure owners should invest in ongoing maintenance of facilities and rights-of-way, update controls and infrastructure to replace aging equipment and facilities, and harden existing facilities where needed for protection. Particular emphasis should be placed on central facilities such as power plants, bulk fuel storage facilities, and transmission infrastructure.
- State, local, and federal public safety and homeland security agencies should maintain clear communication with energy providers to develop and test response plans, and ensure coordinated response to any risks or incidents.

1.1.4 Energy, the Environment, and Climate Change

Energy use and production can affect Virginia's land, air, and water quality as well as wildlife and wildlife habitat. Energy production and consumption are significant factors in Virginia's air quality challenges. Fuel consumption accounts for the overwhelming majority of Virginia's sulfur dioxide, nitrogen oxides, mercury, and carbon emissions to the atmosphere. Emissions from energy production and consumption cause mercury, nutrient, and acid deposition and thermal inputs into Virginia's waters.

Energy consumption is the largest human-made contributor to greenhouse gas emissions. The Intergovernmental Panel on Climate Change's *Fourth Assessment*

Report stated, with an increased confidence level over previous reports, that most of the observed increase in globally averaged temperatures since the mid-twentieth century is "very likely due" to the increased anthropogenic greenhouse gas concentrations.

Carbon dioxide emissions rose in Virginia by approximately 34 percent from 1990 to 2004, a rate nearly twice the national average. This increase results, in part, from growth in Virginia's economy and development patterns that have produced sprawl and long commutes. Virginia ranked in the top ten states with a 30 percent increase in gasoline-powered cars during this period.

Carbon dioxide emissions rose in Virginia by approximately 34 percent from 1990 to 2004, a rate nearly twice the national average. This increase results, in part, from growth in Virginia's economy and development patterns that have produced sprawl and long commutes.

What does climate change mean for Virginia? Over the long term, climate change will affect Virginia's population, wildlife, and economy. The Virginia Institute for Marine Science estimates that the Mid-Atlantic sea level will rise between 4 and 12 inches by 2030, threatening coastal islands and low-lying areas. Air and sea temperature changes would cause more frequent tropical storms, with increased damage to Virginia communities. Chesapeake Bay is particularly susceptible to damage caused by climate change. Changing rain and temperature patterns would disrupt agriculture and forestry.

Carbon dioxide emissions can be reduced by energy efficiency and conservation, using energy from sources that generate less carbon dioxide or are part of a closed carbon cycle, and carbon capture and storage. Methane emissions can be reduced by maximizing production of coalbed methane related to coal mining, by improving gathering, transmission, and distribution pipeline systems to eliminate leaks, and by increasing waste-to-energy development and landfill gas recovery.

Energy production often uses large amounts of water and large tracts of land. Point and non-point discharges from land disturbances for energy production, ranging from construction to agricultural practices growing energy fuels, can add to water quality problems. Electrical generation can affect large tracts of land for fuel storage, rail access, water for cooling, and ash disposal. Wind-power sites, while small around each turbine, are often spread across large areas of land. Surface mineral extraction sites in Virginia can disturb large areas for mines, natural gas well sites, natural gas pipelines, and access roads.

There also is a link between land-use patterns and energy use. Suburban sprawl leads to increased automobile use and decreases use of lower energy-use alternatives such as transit, bicycling, and walking. Sprawl also requires extra investments in new energy infrastructure per household served. More efficient land development, such as that found in new urbanism-style development and high-density development around public transit nodes, will help slow growth of energy use in Virginia.

Energy efficiency and conservation have positive environmental impacts. Energy-efficiency and conservation practices reduce energy use and the resulting environmental impacts from energy generation.

Renewable energy production that offsets conventional energy production can reduce environmental impacts. Production of cellulosic energy crops can be used to reduce agricultural runoff. Production of algae as an energy feedstock can be used to manage nutrients in Virginia's waterways. Carbon capture and storage can be further developed to reduce the carbon emissions from conventional energy production.

There are several environmental programs that can help increase energy efficiency and renewable energy development. Renewable energy purchases can be used to offset nitrous oxide emissions under Virginia's ozone State Implementation Plan. Virginia's Clean Air Champions program includes driver education material about the importance of keeping vehicles maintained, with attendant air quality and energy impacts. Actions taken through other programs such as the Clean Cities, Cool Cities, Cool Counties, Climate Leaders, and Virginia Environmental Excellence Program all will help reduce energy use.

Typical suburban sprawl in Virginia leads to increased automobile use and decreases use of lower energy-use alternatives such as transit, bicycling, and walking. Sprawl also requires extra investments in new energy infrastructure per household served. More efficient land development, such as that found in new urbanism-style development and high-density development around public transit nodes, will help slow growth of energy use in Virginia.

Goals for Energy, the Environment, and Climate Change

Reduce carbon emissions by 30 percent by 2025, to return to its year 2000 emissions level. Meeting the 10 percent electricity conservation goal and the 12 percent renewable portfolio standard goal for Virginia's investor-owned utilities in the 2007 electric regulation legislation, and achieving a 10 percent reduction in gasoline use in Virginia, would reduce carbon dioxide emissions by nearly 18 million tons per year, or approximately 15 percent of Virginia's total 2005 carbon emissions. Other actions will be needed if Virginia is to meet the 30 percent reduction goal.

This issue should be the subject of national policy because both the causes of, and solutions to, climate change transcend state and local boundaries. But, the magnitude of the problem is such that states can not simply wait for a federal resolution. It is hoped that these recommendations, and similar actions taken by other states and localities, may motivate a comprehensive national approach to this topic. Virginia stands willing to participate in the develop of such an approach and will work to harmonize our efforts with a reasonably aggressive national strategy.

Recommendations for Energy, the Environment, and Climate Change

Recommendation: ***Virginia should create a Commission on Climate Change to make a more comprehensive assessment of greenhouse gas issues and develop a plan for how to reach a greenhouse gas emission reduction goal.***

- Specifically, the Commission would be charged with preparing a Climate Change Action Plan that would (i) calculate the size of and contributors to Virginia's carbon footprint, (ii) address the effects of increasing atmospheric greenhouse gas concentrations on the state, (iii) identify what Virginia needs to do to prepare for the likely consequences of climate change, and (iv) identify what actions are needed to meet goals for reducing greenhouse gas emissions.

Recommendation: ***To help calculate Virginia's carbon footprint, the state should go beyond a voluntary reporting regime and require reporting of greenhouse gas emissions using The Climate Registry protocol.***

Recommendation: ***Decisions on how Virginia will meet its future energy needs should be based on both costs of the energy sources and the need to protect ecosystems, natural resources, and the health and well-being of citizens, including economically disadvantaged and minority communities.***

Recommendation: ***Development should be clustered, and infill and brownfield development should be encouraged to reduce energy impacts.***

- Greenfield development, besides using open space and changing the environment, promotes increased energy use. Government policies should encourage developmen that allows for greater use of mass transportation, requires less new energy infra-structure, and provides for greater energy efficiency in the built environment.

Recommendation: ***Renewable energy production that offsets conventional energy production should be promoted to reduce environmental emissions. Carbon capture and storage should be further developed to reduce the carbon emissions from conventional energy production.***

Virginia's colleges and universities, federal laboratories, and businesses undertake a broad range of world-class energy research and development (R&D). These have the potential to lead to substantial new business activity in Virginia.

Recommendation: *Environmental programs should be leveraged to increase energy efficiency and renewable energy development.*

- This should include actions such as using renewable energy purchases to offset nitrous oxide emissions under Virginia's ozone State Implementation Plan.
- Consumer education should identify the environmental and energy effects of wise resource management.
- Virginia governments, businesses, and individuals should be encouraged to participate in activities under the Clean Cities, Cool Cities, Cool Counties, Climate Leaders, and Virginia Environmental Excellence Programs.

1.1.5 Energy Research and Development

Virginia's colleges and universities, federal laboratories, and businesses undertake a broad range of world-class energy research and development (R&D). These have the potential to lead to substantial new business activity in Virginia. Current university energy R&D strengths include coal use, fuel cells, alternate fuel development such as for cellulosic biofuels, and coastal energy.

Virginia is home to three federal laboratories that complete energy R&D activities. The NASA Langley Research Center conducts research on the impact of aviation on the environment and how alternative vehicles, fuels, and transportation systems can be made more efficient. The Thomas Jefferson National Accelerator Facility is involved in basic science related to atomic nuclei at the quark level. The lab has limited opportunities for applied research. Energy research at the Naval Surface Warfare Center, Dahlgren Division addresses the energy efficiency of weapons and electric guns.

Virginia's businesses undertake a wide range of energy-related research and development. Significant strengths exist in the Areva NP/BWXT nuclear cluster around Lynchburg, at Northrop Grumman Newport News, at private technology businesses (particularly those serving federal clients), and at small businesses that have often spun off from university R&D.

Virginia faces a challenge coordinating these varied energy R&D activities in ways that increase their value to the Commonwealth. The state could create an energy R&D roadmap through which it would be able to better match areas of core strength with the best value proposition for investment in energy R&D and where it can make investments to facilitate competitive bids for federal energy R&D and leverage private investments. Virginia needs a governance structure for coordinating state energy R&D investments and activities.

Goals for Energy Research and Development

Increase investment in energy R&D by $10 million per year, with half from state resources and half from private and federal resources. With this investment, Virginia will be able to attract federal and private investment in energy R&D and the state's businesses will be not left behind in the world marketplaces in which they compete.

Recommendations for Energy Research and Development

Recommendation: *Virginia should provide a consistent funding source for energy R&D and deployment.*

- State funding for energy R&D should be provided through a state energy R&D fund as a subset of the Commonwealth Technology Research Fund. It is estimated that $5 million per year is necessary to build new research capacity and competitively respond to federal R&D grant opportunities.
- Initial priority areas for energy R&D

The Commonwealth should provide start-up financial support to help Virginia become the home of businesses that bring new energy technologies to the marketplace and develop new innovative energy sources and infra-structure.

Energy businesses can add to Virginia's economic vitality.

investment include nuclear energy development associated with the nuclear clusters in the Lynchburg and Hampton Roads areas, alternate liquid fuel production from waste and cellulosic feedstock, coastal energy development from algae and wind, and carbon capture and storage in unminable coal seams.

Recommendation: ***Virginia should establish a public-private governance structure to set priorities for public energy R&D funding.***

- Priorities for funding should be set using a governance system involving university, business, and government stakeholders based on a roadmap identifying the growth areas for energy R&D and areas where Virginia researchers can bring added value to these growth areas.
- The energy R&D governance system should be established as a virtual organization, named the Virginia Energy Research and Development Organization (VERDO), supported by resources within Virginia's energy research and government stakeholder organizations.
- VERDO should be a member of the Association of State Energy Research and Technology Transfer Institutions (ASERTTI).
- VERDO should host energy research showcases to connect technologies developed by Virginia's energy R&D organizations with venture capital firms and businesses with the resources to bring the ideas to market.
- This could be done solely with Virginia entities, but it might be more effective if undertaken jointly with neighboring states to become a Mid-Atlantic energy R&D showcase.

Recommendation: ***Virginia should support development of two to three energy technology parks.***

As discussed below in Section 1.1.6, high-value focus for energy technology parks includes renewable fuels and fossil fuel production/carbon management.

1.1.6 Energy Economic Development

Economic development opportunities can come from energy-efficiency operations, provision of new energy infrastructure, activities to support environmental protection related to energy production and use, and through energy R&D actions.

Goals for Energy Economic Development

Support existing businesses wishing to make substantial new investments in energy activities, such as around the nuclear business cluster in Lynchburg.

Provide start-up financial support to help Virginia become the home of businesses that bring new energy technologies to the market-place and develop new innovative energy sources and infrastructure.

These will provide a basis for new job growth and income to the Commonwealth. This should create an environment where Virginia's businesses are positioned to seize opportunities for innovative energy projects that can prove the viability of leading-edge technologies.

Recommendations for Economic Development

Energy businesses can add to Virginia's economic vitality. Today, coal and natural gas production provide the foundation for southwest Virginia's economy. Virginia's cost-competitive energy supplies provide a natural advantage to business recruitment and retention. Renewable energy supplies provide an opportunity for significant new job growth across the state. There are particularly good opportunities for new alternate liquid fuel-based job growth.

Recommendation: ***Virginia should target its business development***

actions to those energy businesses that produce real employment and capital investment gains.

- Virginia should refine its production grants for renewable energy businesses such as those for solar manufacturers and biofuel producers to ensure that the support meets business needs while providing a positive return on investment to the Commonwealth. This should include assistance needed to take advantage of the U.S. Department of Energy's clean energy loan guarantee and similar programs. Up to $5 million per year is needed to fund these incentives and support other new energy business development.
- Virginia should form a multiagency Tiger Team of state-agency energy and economic development specialists to work with localities and industry partners to identify and package appropriate energy project sites.
- Virginia should increase support for energy research partnerships between its universities and businesses, and pursue opportunities to commercialize new technologies in partnership with Virginia businesses.
- Economic developers should work with the state's electric utilities and the State Corporation Commission to use existing authority to offer an economic development electricity rate for major energy-intensive projects.

Recommendation: ***Virginia should support growth of the state's nuclear industry cluster.***

- Virginia should provide long-term financial support to the Center for Advanced Engineering and Research in Lynchburg. This effort should be designed to help solve the problems of a growing shortage of trained nuclear-industry workers.
- Virginia should assess the business opportunities that will come from decommissioning nuclear Navy ships and support development of the needed businesses to provide these services.
- Virginia should assess the potential value of and regulatory needs for uranium production in Pittsylvania County.

Recommendation: ***Virginia should support development of new energy technology business parks.***

- These parks should have combined heat and power and alternate liquid fuel development as their base tenants and include energy research and development and other energy businesses, providing for a sharing of common infrastructure to reduce overall cost to any single business. One target market for a plant could be alternate liquid fuels produced for military ground and ship transportation. A second high-value center for Virginia might be a fossil-fuel and carbon management center located in southwest Virginia.

Recommendation: ***Virginia should provide workforce services that support development of adequate numbers of trained workers for energy businesses.***

- Virginia's community colleges and economic development officials should work with industries in their area to provide region-specific training programs for energy industry clusters. Examples include coal miner training provided by Southwest Virginia and Mountain Empire Community Colleges and industry-specific training provided through the Center for Advanced Engineering and Research in Lynchburg.
- Efforts to develop vocational training curricula should account for regional needs of energy providers. An example of such a program is the Kentucky Coal Academy's curriculum provided to coalfield high schools in Kentucky.

Recommendation: ***Virginia should address both the potential negative environmental impact and economic value when assessing whether projects impose a disproportionately adverse impact on economically disadvantaged or minority communities.***

1.2 Conclusions

The recommendations of this Plan will help Virginians overcome barriers faced by consumers in making energy-efficiency and conservation improvements, add to Virginia's energy infrastructure, provide new energy supplies, support new business development, and expand research, development, and deployment of new energy technologies. Virginia can attract additional federal grants by providing funds for cost sharing and can attract private investment in energy projects through increased state support.

As discussed in various recommendations, achieving the goals of this Plan will require substantial annual investments by the Commonwealth, private business, and individuals. Estimated costs of these initiatives are summarized below.

- If Virginia is to meet its 10 percent electric savings goal by 2022, the Commonwealth's electric utilities will need to invest in the range of $100 to $120 million per year to support energy conservation programs. This would include costs of incentives, consumer education, and administration of energy-efficiency and conservation programs. Utility customers will have to match this investment with $180 to $200 million per year to cover their share of up-front energy-efficiency costs.
- $5 million per year is needed for energy research and development to foster long-term improvements in how Virginia and the nation can supply and use energy more efficiently. This should be matched with at least an equivalent amount from private and federal sources.
- Renewable energy grant programs established in 2006 legislation and other efforts to expand use of renewable energy sources should be funded with $5 million per year if we are to achieve a significant growth in renewable energy supplies.
- Up to $5 million per year is needed to support energy business incentives, such as the Biofuels Incentive Grant Program; new technologies such as waste, cellulosic, and coal-based liquid fuel production, solar panel and wind turbine manufacturing; and development of innovative energy sources and infrastructure such as combined heat and power projects and ethanol fueling stations.
- $2 million per year is needed to expand the number of elderly and low-income families served by the Weatherization Assistance Program.
- $1 million per year is needed for energy education to supplement utility-based consumer education programs and other smaller-scale energy projects.

Taken together, these recommendations will result in a substantial investment in new energy activities in Virginia. By heeding these calls to action, government, individual citizens, and businesses will use energy more wisely, have increased security from energy-driven disruptions, help ensure the availability of needed energy supplies to support the state's economy, and reduce the future impacts of climate change.

Virginia can attract additional federal grants by providing funds for cost sharing and can attract private investment in energy projects through increased state support.

By heeding these calls to action, government, individual citizens, and businesses will use energy more wisely, have increased security from energy-driven disruptions, help ensure the availability of needed energy supplies to support the state's economy, and reduce the future impacts of climate change.

Chapter 2
Virginia Energy Resources and Consumption

This Plan sets a goal to increase the in-state production of energy by 20 percent by 2017 over what is projected in the base case. Increasing in-state production of energy will keep funds otherwise spent on energy imports in Virginia's economy and decrease the potential risk Virginia consumers face from disruptions in energy supplies.

2.0 Virginia Energy Resources and Consumption

Electricity, natural gas, propane, and other fuels used in our homes and buildings and gasoline and diesel fuel used for transportation are supplied to Virginia consumers from in-state production of coal, natural gas, and renewable fuels, from in-state generation of electricity, and from imports of petroleum, electricity (and uranium used to generate electricity), natural gas, coal, propane, and other fuels. The difference between the amount of energy produced in a state and the amount consumed is called its net energy balance. Virginia's net energy balance is negative as most energy used in Virginia comes from imports.

Energy consumption typically increases with population growth and rising household incomes, which allow for more disposable income to purchase larger homes and energy-consuming devices. Therefore, as Virginia's population and income have grown, energy consumption has grown. This growth in consumption has happened at the same time that in-state production of energy has decreased, so Virginia's negative net energy balance has been growing.

Virginia's 2005 population of 7.5 million was the twelfth highest of the fifty states. Average annual growth in population was nearly 1.4 percent between 1995 and 2005, slightly higher than the national average of 1.2 percent. The population is projected to increase at an annual average rate of 1.1 percent over the next twenty years, compared with 0.8 percent for the United States as a whole.[2]

Virginia's median household income in 2005 was $54,240, more than 17 percent higher than the national median income. Similarly, the average per capita income of $29,148 was more than 16 percent higher than the national average. Approximately 7 percent of Virginia's families live below the poverty level, compared with a national average of just over 10 percent.

While Virginia's in-state production of energy has declined since 1990, Virginia must increase the amount of energy it produces to help meet the growing energy demand of its citizens and businesses. This Plan sets a goal to increase the in-state production of energy by 20 percent by 2017 over what is projected in the base case. Increasing in-state production of energy will keep funds otherwise spent on energy imports in Virginia's economy and decrease the potential risk Virginia consumers face from disruptions in energy supplies.

2.1 Energy Production

Energy production in Virginia consists primarily of coal, electricity, and natural gas. Petroleum and renewable and alternative fuel sources produce only a small percentage of energy used in the state.

2.1.1 Coal Production

Driven by industry expansion in western states, U.S. coal production increased steadily over the last twenty years, while Appalachia's share of total coal production decreased. Virginia's coal production declined from a peak of 46.5 million tons in 1990 to 31.7 million tons in 2006. Costs associated with mining the relatively thin seams found in Virginia's underground mining operations have led to this decline. Much of western coal production comes from less costly surface mines.

Historically, Virginia ranks among the top ten coal-producing states. In 2006, it ranked tenth. Wyoming (444.9 million short tons), West Virginia (151 million), and Kentucky (119.6 million) are the top three coal-producing states. Virginia mines coal in the Central Appalachian Basin in the seven southwestern counties of Lee, Scott, Wise, Buchanan, Dickenson, Russell, and Tazewell.

Virginia's coal industry consists predominately of small operations that develop remnant or finite above-drainage reserves using the room and pillar mining method. These small operations comprise approximately 70 percent of Virginia's mining activities. Although a typical small operator employs fewer than thirty-six people, together these operators have a significant

[2] Source: U.S. Census Bureau, Population Division, Interim State Population Projections, 2005.

Chapter 2

Virginia Energy Resources and Consumption

continued

Coal will continue to be an attractive fuel source for the electric utility industry as clean-coal technologies advance.

employment and economic impact on the rural communities of southwest Virginia. Virginia is home to a small number of larger mines. One large underground mine producing coal from a longwall mining operation in Buchanan County employs more than 300 people and produces more than 2 million tons per year.

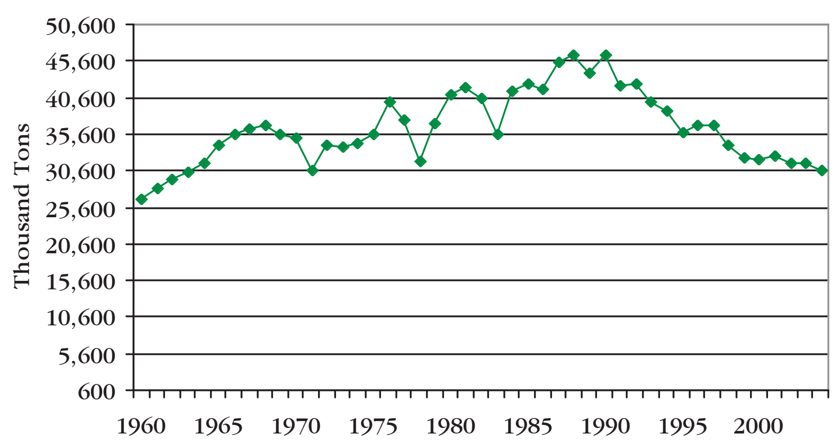
Since 1980, modern equipment, improved miner training, and better mine designs have allowed miner productivity to more than double while the number of licensed mines has declined by half. In the early 1980s, Virginia had more than 10,000 coal-production employees. Today that figure fluctuates between 4,500 and 5,000.

The majority of Virginia's future coal production will come from small underground operations augmented by surface contour and high-wall mining operations. This future capacity depends on the ability of small coal operators to remain productive and competitive.

Mining disasters in 2006 prompted new federal legislation known as the Mine Improvement and New Emergency Response Act of 2006, or MINER Act. The Act requires improvements in miner training, emergency oxygen supplies, communication, and mine rescue services. The new law will increase safety in underground coal mines but may cause some small mines to close.

Coal production contributes substantially to the state's economy. A 1995 study conducted by the Virginia Center for Coal and Energy Research concluded that each mining job supported three non-mining jobs. Severance taxes paid by the coal industry support local and state government and contribute to economic diversification of the coalfield region through the Virginia Coalfield Economic Development Authority.

Figure 2-1 Virginia Coal Production, 1960-2004

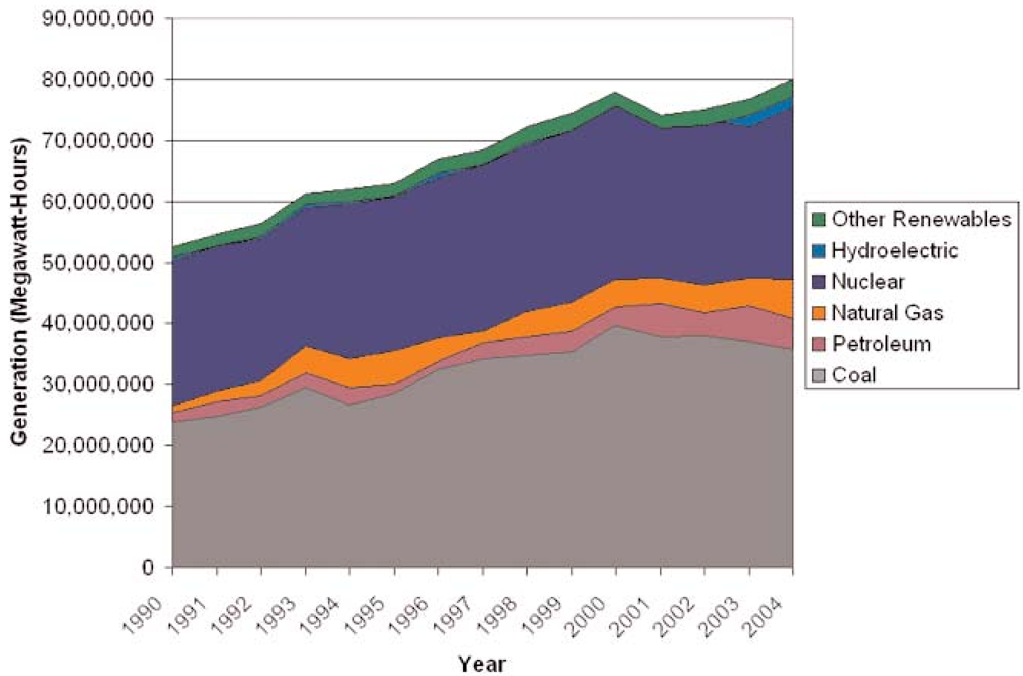


Future coal production rates in Virginia should be more stable. Coal will continue to be an attractive fuel source for the electric utility industry as clean-coal technologies advance. Several next-generation alternative-fuel technologies are targeting carbon-rich materials, including coal and waste coal, as the feedstock of choice. Many of these technologies use new processes that limit greenhouse gas releases, making the use of coal an easier choice. Carbon-to-liquids represents a new industry for Virginia. Jobs associated with this industry would be centered near locations of feedstock and production. The coalfields offer attractive production sites and a ready workforce.

2.1.2 Electricity Production

Electric generating plants in Virginia produced 78,900 gigawatt-hours of electricity in 2004. Electricity production in Virginia increased by an average of 2.4 percent, or 1,685 gigawatt-hours per year, from 1994 through 2004. In 2004, 45 percent of the electricity generated in Virginia came from coal and 36 percent from nuclear power plants. The remaining production came from hydro, natural gas, petroleum, and renewable sources. Approximately half of the coal burned in the state's coal-fired power plants is from Virginia mines. Most of the remaining coal is imported from West Virginia and Kentucky. Figure 2-2 provides a breakdown of electric generation in Virginia by fuel type for 1990 to 2004.[3]

Figure 2-2 Virginia's Electric Energy Net Generation by Fuel Type, 1990-2004



Emissions from electrical production in Virginia are less than what would be expected from just looking at the state's generation capacity. In 2004, Virginia had a net summer generating capability of 22.5 gigawatt-hours, the sixteenth highest in the nation. In terms of emission rates, it ranked eighteenth in the nation in sulfur dioxide, thirty-third in nitrogen oxides, and twenty-ninth in carbon dioxide (see Table 2-1).[4] These emissions are better than the national average because of the high proportion of nuclear and hydroelectric power Virginia produces.

Table 2-1 Virginia Electric Generation Emissions, 2004

Chemical	Amount (lbs/MWh)	U.S. Rank*
Sulfur Dioxide	6.1	18
Nitrogen Dioxide	1.9	33
Carbon Dioxide	1,309	29

** A rank of 1 means the highest production of emissions.*

[3]Source: Virginia Energy Patterns and Trends.
[4]Source: Energy Information Administration.

Chapter 2

Virginia Energy Resources and Consumption

continued

Virginia's electric sector is well positioned to respond to future growth. Recent utility legislation provides both a focus on conservation and incentives for new power plants.

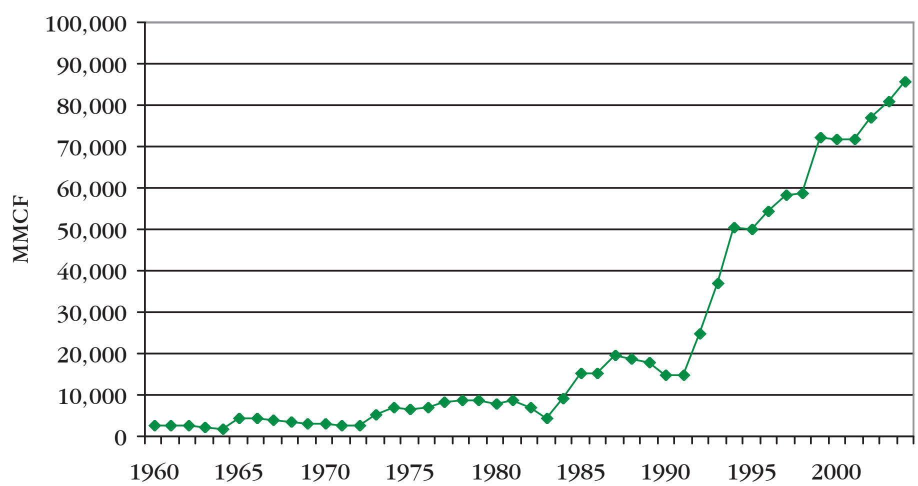
Virginia's electric sector is well positioned to respond to future growth. Recent utility legislation provides both a focus on conservation and incentives for new power plants. Virginia's electric generators also have the potential to sell excess off-peak generation in the northeast PJM markets where capacity margins are slim and prices are higher. There also are opportunities associated with developing renewable energy options and retiring old generation capacity in favor of newer, more efficient, and cleaner plants.

The opportunity to balance the need for increased supply by placing more emphasis on efficiency gains, conservation, and demand-side management is addressed in Chapter 3.

2.1.3 Natural Gas Production

Virginia's natural gas production has experienced rapid growth since the early 1990s, exceeding 5 percent annually. In 2005, Virginia produced 88.6 billion cubic feet (MMCF) of gas. This is equivalent to 32 percent of the state's annual demand across all end users, more than the entire residential demand.[5] Natural gas production in 2004 represented 7 percent of total primary energy production in the state.[6] Most of the increase in natural gas production has been from expanded extraction in Buchanan and Dickenson Counties.[7] Natural gas production and development activities contribute substantially to the local economy in southwest Virginia's gas-producing counties. Figure 2-3 presents annual natural gas production data in Virginia for 1960-2004.

Figure 2-3 Natural Gas Production in Virginia, 1960-2004



Coalbed methane is the most common source of natural gas produced in Virginia. Its extraction produces a marketable product from what used to be a troublesome by-product of coal mining.

Natural gas is fed from the well where it is produced into a system of gathering lines, which connect to facilities that compress the gas into a pipeline-quality product. After processing, the gas is fed into the interstate pipeline network where it is consumed in Virginia and other eastern states.

While natural gas production in the coalfield region will continue to rise incrementally, long-term sustained increases are limited by depleting reserves. In December 2005, Virginia's natural gas reserves were estimated to be 2,018 billion cubic feet.[8] Given current removal rates, this reserve would last about twenty-five years.[9] New discoveries and changing technologies may extend Virginia's reserve base and allow production to be maintained at high levels for a longer period of time.

[5] www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_072.pdf.
[6] Virginia Energy Patterns and Trends, Statewide Energy Overview Table.
[7] Virginia Energy Patterns and Trends.
[8] Energy Information Administration, Advance Summary: U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves, 2005 Annual Report.
[9] This annual natural gas removal rate shown is based on a three-year average rate of production for the years 2002-2004.

Chapter 2

Virginia Energy Resources and Consumption

continued

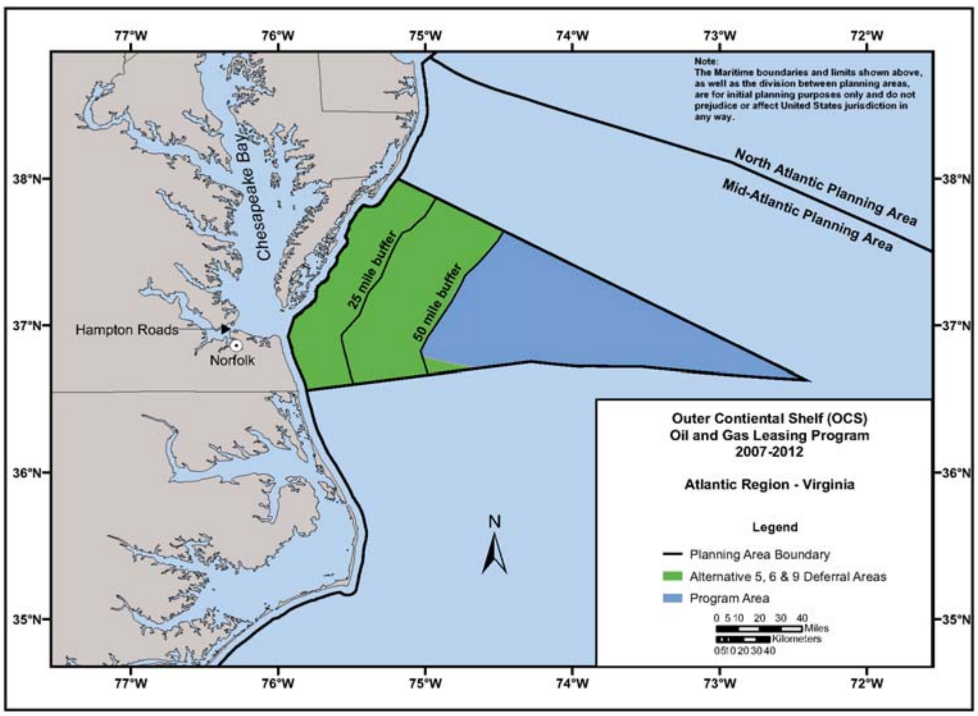
Virginia's natural gas utilities, marketers, and some large businesses purchase natural gas during summer months when it is cheaper and store it for use in winter when it is more expensive. Natural formations suitable for such storage are being used in Smyth County near Saltville and in Scott and Washington Counties near Bristol.

While natural gas deposits may be available from Atlantic offshore areas, there is a congressional moratorium on producing oil or natural gas from new areas of the outer continental shelf and a presidential withdrawal of offshore lands from consideration for oil and gas leasing. With the recent rise in natural gas prices, there has been new interest in producing these offshore resources. The Department of Interior's Minerals Management Service (MMS) has revised its 2007-2012 Outer Continental Shelf Oil and Gas Leasing Program to include a possible lease sale off the Virginia coast in 2011.

Figure 2-4 shows this lease sale area.[10] The area excludes a buffer to 50 miles from Virginia's coastline and at the mouth of Chesapeake Bay.

While natural gas production in the coalfield region will continue to rise incrementally, long-term sustained increases are limited by depleting reserves.

Figure 2-4: Mid-Atlantic OCS Lease Area Proposed by MMS off Virginia



The MMS estimates that the conventionally recoverable fossil fuel resource in the proposed lease area is 56 million barrels of oil and 327 billion cubic feet of natural gas. It further estimates that forty years would be required to lease, explore, develop, and produce these resources.

Virginia has established as its policy on development of these offshore resources that only offshore exploration of natural gas no closer than 50 miles to the shore should be approved at this time.[11] The Commonwealth needs more information about the potential size of the resource before it can make final decisions regarding the approval of production.

Several milestones would have to be met before any drilling could begin, including:

- Congress would have to lift its moratorium on coastal exploration and production.
- The president would have to lift the executive order prohibiting exploratory and leasing activities.

[10]Source: U.S. Department of the Interior, MMS, Proposed Final Program of the Outer Continent Oil and Gas Leasing Program, 2007-2012, April 2007, map 9, p. 68.
[11]See the Code of Virginia, Section 67-300.

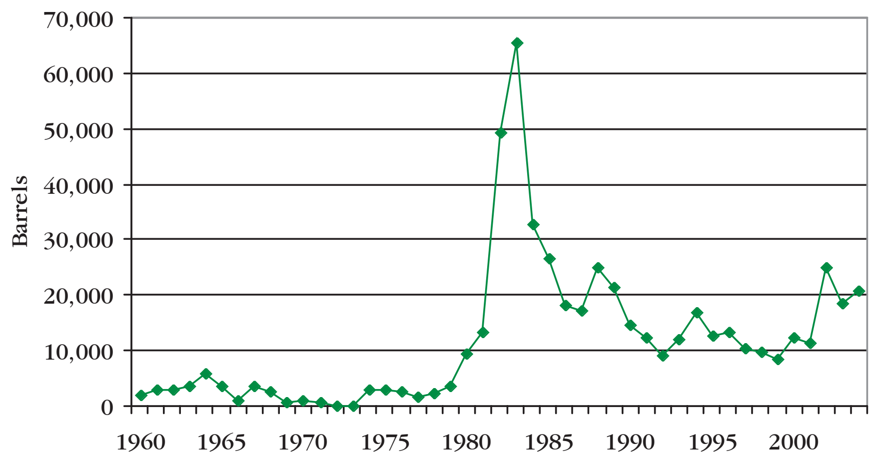
- Industry would have to demonstrate sufficient interest in federal waters off Virginia's coast.
- Proposed exploratory plans would have to go through both a federal environmental assessment and a state review for consistency with Virginia's coastal management regulations.

The MMS established state administrative boundaries in outer continental shelf waters using an equidistance methodology for the purpose of managing offshore resources. The equidistance methodology expands the areas attributable to states with convex coastlines and decreases the areas attributable to states, such as Virginia, with concave-shaped coastlines. Use of equidistant boundaries reduces the Commonwealth's ability to influence decisions about offshore resource development. This will affect not only natural gas extraction but also sand, other minerals, and renewable energy resources. The MMS should revise the administrative boundaries to more equitably reflect coastal states' interests.

2.1.4 Petroleum Production

Virginia is a very small petroleum producer. In-state production represents only one one-hundredth of 1 percent of total state energy production and occurs only in Lee and Wise Counties. Figure 2-5 shows Virginia's petroleum production for the years 1960-2004.

Figure 2-5 Petroleum Production in Virginia, 1960-2004



2.1.5 Renewable Energy Production

Renewable energy production in Virginia comes from hydroelectric power, landfill gas, geothermal energy, solar and photovoltaic energy, wind energy, biomass, and waste energy. Renewable energy production in Virginia (largely hydroelectric) remained relatively stable from 1990 to 2004 (see Figure 2-6), representing less than one tenth of 1 percent of total energy produced in the state. This amount would be greater if energy from non-metered sources, such as solar hot water heating, passive solar, hot springs, and other small-scale on-site renewable energy systems, could be counted.

Virginia has significant untapped renewable energy resources, including wind, tidal, solar, biomass, municipal solid waste, and others. Advanced technology and manufacturing, along with strong university research and development capability, put Virginia in a good position to capitalize on these forms of energy.

[2]http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_072.pdf

[3]Virginia Energy Patterns and Trends, "Statewide Energy Overview Table".

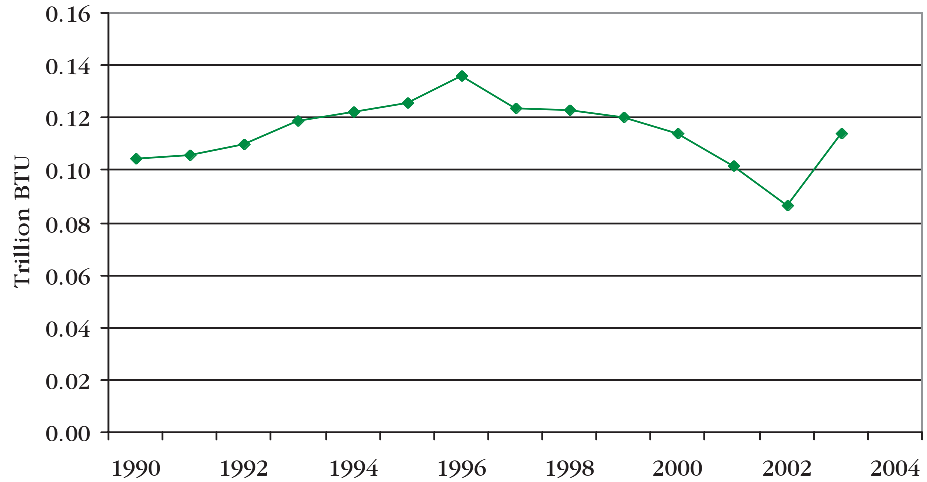
[4]Virginia Energy Patterns and Trends.

[5]Energy Information Administration, Advance Summary - U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves, 2005 Annual Report.

[6]The annual natural gas removal rate shown here is based upon a three-year average rate of production for the years 2002 to 2004.

Virginia has significant untapped renewable energy resources, including wind, tidal, solar, biomass, municipal solid waste, and others. Advanced technology and manufacturing, along with strong university research and development capability, put Virginia in a good position to capitalize on these forms of energy.

Figure 2-6 Renewable Energy Production in Virginia, 1990-2004*



**Source: Energy Information Administration*

The demand for renewable resources is expected to escalate due to the growing public concern regarding global warming and reducing greenhouse gas emissions coupled with the rising cost of environmental compliance for conventional energy sources. Technology advancements are making renewable sources increasingly competitive. The renewable portfolio standard incentives included in the 2007 electric utility legislation provide a platform for Virginia's utilities to further diversify their generation mix with renewable sources.

Virginia currently has about 580 megawatts (MW) of operational non-hydro renewable energy capacity. There is technical potential to develop nearly 44,000 megawatts.[12] The largest technical potential is from wind energy and solar photovoltaic (PV) electricity, followed by biomass combustion and landfill gas (see Table 2-2). However, reaching this potential is probably beyond the ten-year horizon addressed in this Plan. Advancements in technology and reductions in cost are needed for Virginia to reach this goal.

Table 2-2 Virginia's Technical Renewable Energy Potential Generating Capacity

Renewable Energy Resource	2002 Installed Capacity in Virginia (MW)	Virginia Potential Installed New Capacity (MW)	Capacity Factor
Land-based wind	0.01	1,950	30-45%
Offshore wind	0	28,100	35-40%
Solar PV	0.22	11,000 - 13,000	14%-20%
Biomass combustion	415	760	83%
MSW/Landfill gas	168	30	90%
TOTAL	**583.23**	**41,840 - 43,840**	

[12]There may be less usable production from these sources because of low capacity factors for some renewable sources, particularly solar- and wind-powered projects.

2.2 Energy Imports and Exports

Virginia must import energy to fill the gap between in-state production and use. Except for coal, energy consumption for each type of fuel far exceeds in-state production. Figure 2-7 and Table 2-3 show the net imports and exports of each fuel source in 2004. Figure 2-8 shows how the net amounts have changed over time. A negative figure indicates net exports. Supply-side additions, demand-side management, and conservation could alter the net import ratio. Closing this gap between imports and in-state production could be a significant economic opportunity for Virginia.

Virginia must import energy to fill the gap between in-state production and use. Except for coal, energy consumption for each type of fuel far exceeds in-state production.

Closing this gap between imports and in-state production could be a significant economic opportunity for Virginia.

Figure 2-7 Virginia's Net Energy Imports/(Exports), 2004

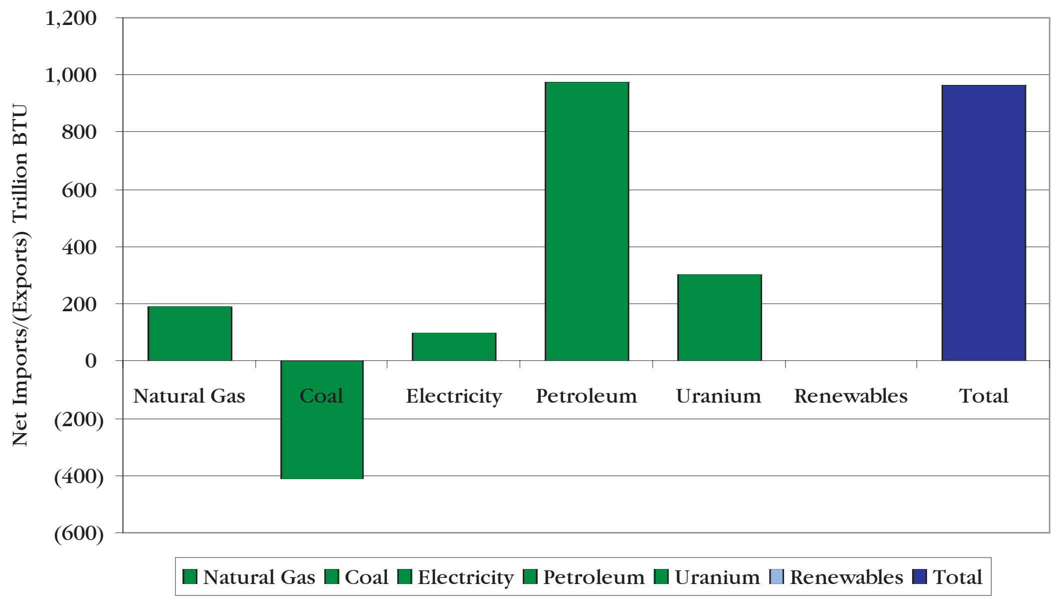
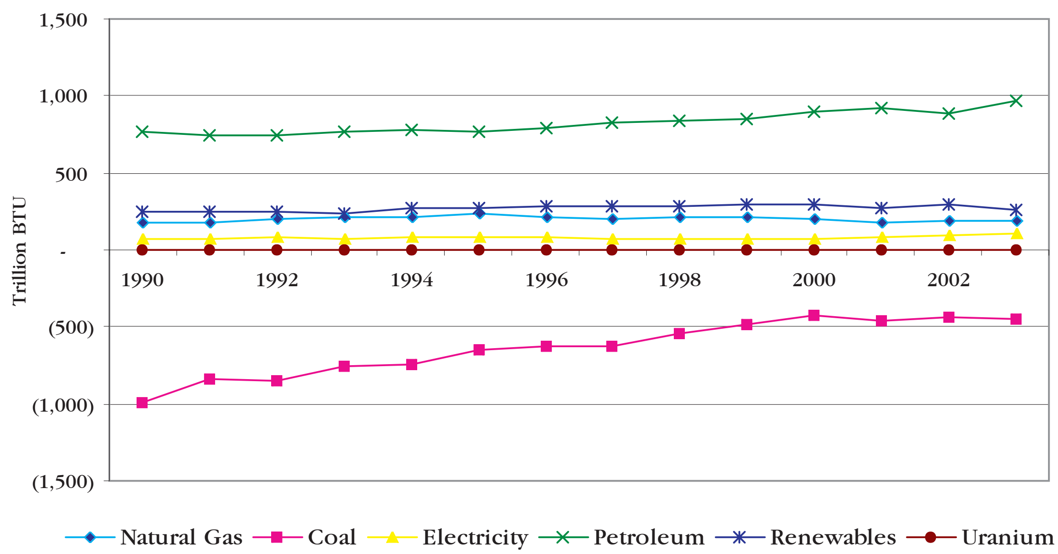


Table 2-3 Virginia's Net Energy Imports/(Exports), 2004

Fuel	Production	Consumption	Net Imp/(Exp)	% of Consumption
Coal	881.0	469.6	-411.4	187.60%
Electricity	253.8	353.8	100.0	28.30%
Natural Gas	88.2	277.7	189.4	68.20%
Petroleum	0.1	975.6	975.5	100.00%
Uranium	0.0	300.8	300.8	100.00%
Renewables	0.1	0.1	0.0	0.00%
Total	1,223.3	2,377.6	1,154.3	48.60%

Figure 2-8 Virginia's Net Energy Imports/(Exports) by Fuel, 1990-2003



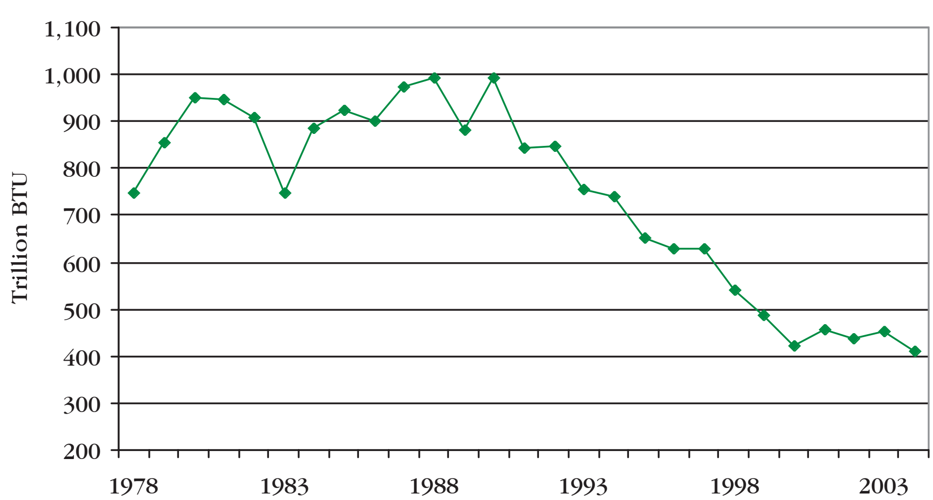
The following subsections look at each fuel type in more detail.

2.2.1 Coal Exports

Virginia continues to be a net exporter of coal, shipping 411.4 trillion BTUs, or 47 percent of 2004 coal production, out of the state. As indicated in Figure 2-9, there has been a decline in coal exports since the late 1980s.

Coal production is expected to decline by an average rate of 3 percent per year from 2006 to 2016, after which time it is expected to reach a more stable level. Conversely, coal consumption is expected to increase by 1.9 percent per year. The increase will come from the proposed Virginia City Hybrid Energy Center and increased use of existing coal-fired power plants. No growth has been projected for

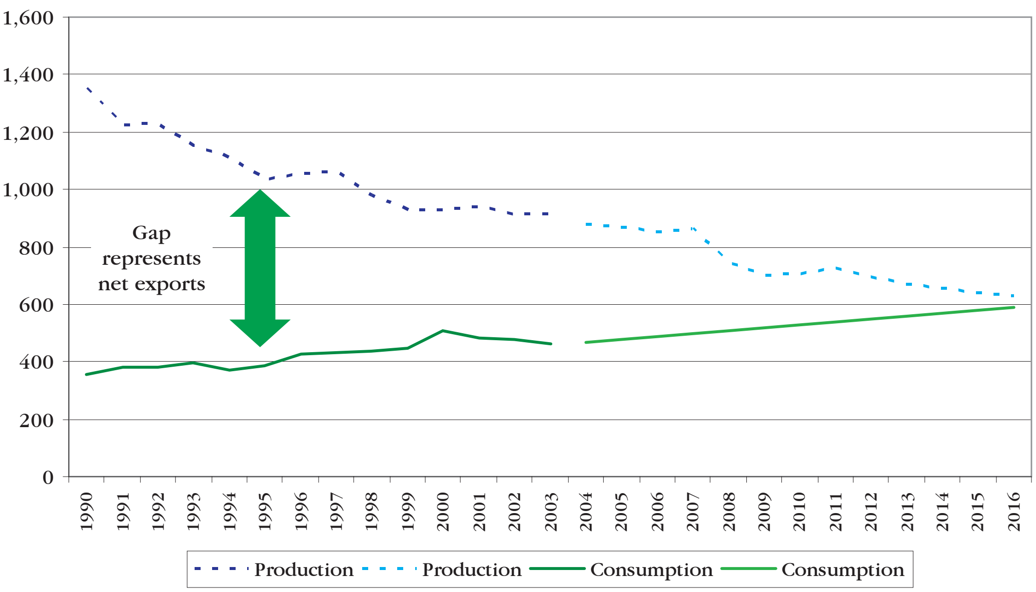
Figure 2-9 Virginia's Net Coal Exports



coal-to-liquid plants. Any plants coming on-line in Virginia would increase the state's coal consumption.

If the production and consumption trends continue, Virginia could become a net coal importer as early as 2018 (see Figure 2-10). However, external forces affecting Virginia's coal markets and production may change this projection.

Figure 2-10 Virginia's Coal Production-Consumption Gap, 1990-2017 *(Trillion BTUs)*

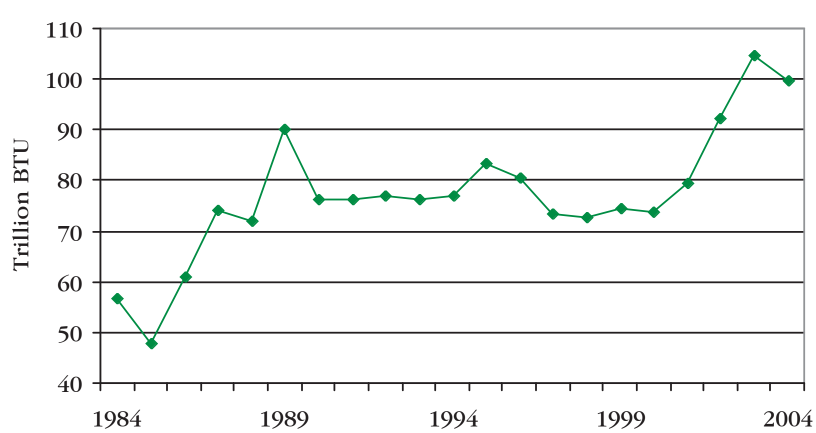


2.2.2 Electricity Imports

Virginia imported nearly one-third of its electricity in 2004. Imports of electricity have been growing over time, ranging from 22 percent of total use in 1990 up to just below 30 percent in 2005. Figure 2-11 shows the growth in net electricity imports over time.

Some of Virginia's electricity imports come from the Mount Storm electric generating station which is 100 percent committed to serving Virginia consumers. Other imports come from facilities, such as those operated by Appalachian Power and Allegheny Power, dedicated to serving an individual utility's consumers in its Virginia and non-Virginia service territories. A third group of imports comes from economic purchases through bilateral sales or through PJM markets.

Figure 2-11 Virginia's Net Electricity Imports, 1984-2004



Virginia can close its electricity import gap with a combination of energy efficiency, demand-side management, and electric generation additions. A variety of production, conservation, and import scenarios (see Table 2-4) were developed to illustrate this potential. The total demand growth over the next ten years is projected to be 7,224 megawatts without any new energy efficiency or demand-side management. Virginia would need to add approximately 5,100 megawatts of generation capacity by 2016 in order to maintain a 30 percent import ratio.[13] If Virginia can reduce its electricity use by 14 percent (see Chapter 3 for a discussion of conservation potential) while holding its import ratio stable, then the state would only need 1,220 megawatts of new power generation capacity by 2016. A 10 percent reduction would result in Virginia needing an additional 2,358 megawatts of new generation capacity. Lowering the electricity import ratio would require production of more power from in-state facilities. Any increase in electricity imports would require increases in high-voltage transmission capacity.

Virginia can close its electricity import gap with a combination of energy efficiency, demand-side management, and electric generation additions.

Table 2-4 Electricity Import Scenarios for Virginia

Scenario	Year	Peak Electrical Demand for Virginia (MW)	Conservation & Energy Efficiency Savings	Conservation & Energy Efficiency (MW)	Net Summer Generation Capacity (MW)	Net Generation Change (MW)	Electricity Imports (% of Total Capacity)
Base Case	2005	32,026	0%	0	22,599		29.4%
1	2016	39,250	0%	0	22,599	0	42.4%
2	2016	39,250	0%	0	27,697	5,098	29.4%
3	2016	33,755	14%	5,495	22,599	0	33.0%
4	2016	33,755	14%	5,495	23,819	1,220	29.4%
5	2016	33,755	14%	5,495	33,755	11,156	0%

	Scenario
	Base historical year - 2005
1	No conservation and efficiency impacts, No new production
2	No conservation and efficiency impacts, new generation added at a rate needed to maintain base-year import proportion
3	14% conservation and efficiency impacts, no new production
4	14% conservation and efficiency impacts, new generation added at a rate needed to maintain base-year import proportion
5	14% conservation and efficiency impacts, new generation added at a rate needed to reduce imports to zero

These trends and forecasts are based on net imports and exports for the entire state and do not break out new infrastructure needs in areas where growth rates are highest or in areas otherwise affected by constraint or congestion.

[13]Based on the incremental energy consumption by 2016 and the relationship between Virginia's summer capacity and annual energy consumption in 2004.

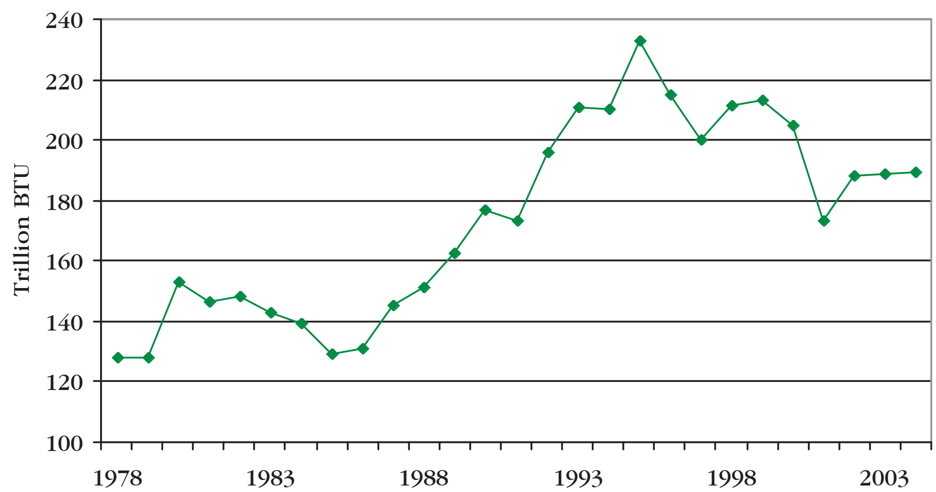
2.2.3 Natural Gas Imports

Approximately two-thirds of the natural gas consumed in Virginia comes from imports. Net imports of natural gas rose sharply from 1985 through 1995 and then fell after 1995 as in-state production increased (see Figure 2-12).

Future natural gas load, and therefore net imports, will be affected by changes in use of natural gas for electric generation and increased use in response to economic growth. Net natural gas imports could be reduced through increased efficiency and conservation. Reducing the peak electricity loads that rely on natural gas generation could also help reduce the need for natural gas imports. These options are discussed in Chapter 3.

A gallon of gas not used domestically eliminates nearly 2 gallons of oil being imported from abroad.

Figure 2-12 Virginia's Net Natural Gas Imports, 1978-2003



2.2.4 Petroleum Imports

Nearly all of the petroleum Virginia consumes is imported (see Figure 2-13). Petroleum consumption grew by approximately 2.3 percent per year from 1994 to 2004. This caused net imports to increase at the same rate.

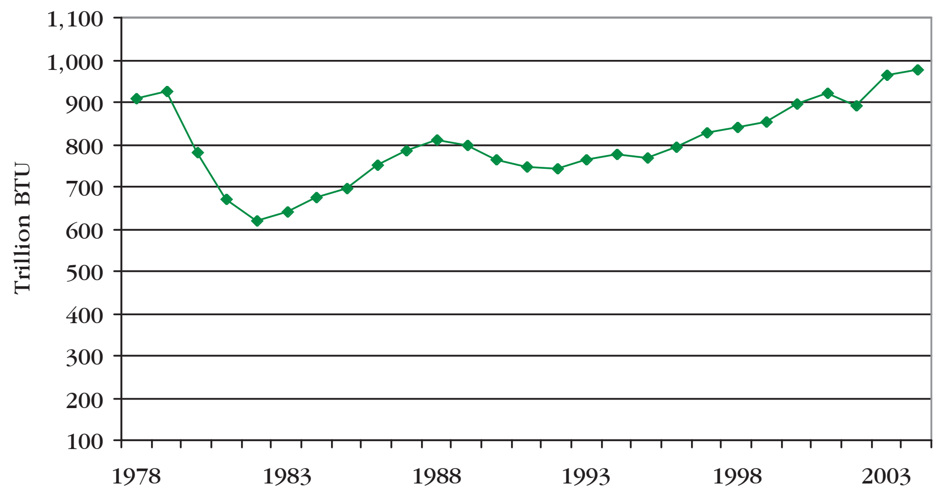
Reducing consumption of conventional petroleum products and offsetting petroleum with Virginia-derived alternative fuels could reduce imports. For example, a gallon of gas not used domestically eliminates nearly 2 gallons of oil being imported from abroad.[14] According to information from the Governors' Ethanol Coalition, for every 100 million gallons of local ethanol produced (the annual capacity of a typical plant), more than 168 million gallons (4 million barrels) of imported oil would be offset and more than $200 million would be reduced from the trade deficit.

Reducing consumption, and thereby imports, can occur with different mechanisms and initiatives. The transportation sector represents the largest area of opportunity as it uses 75 percent of Virginia's petroleum.[15] These options are discussed in Chapter 3.

[14]See www.auto.howstuffworks.com/question417.htm. This website states that a barrel of oil (which contains 42 gallons, or 159 liters) will yield 19 or 20 gallons (75 liters) of gasoline, depending on the refinery.
[15]Virginia Energy Patterns and Trends.

Chapter 2
Virginia Energy Resources and Consumption
continued

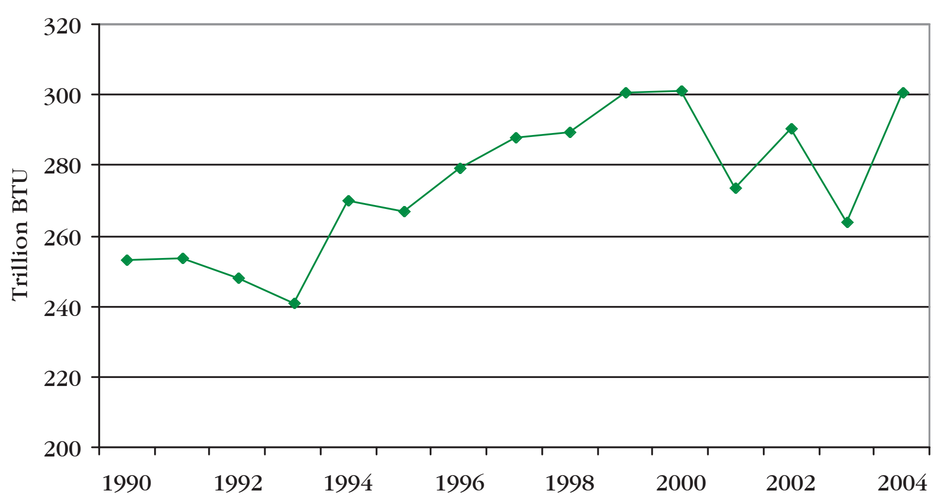
Figure 2-13 Virginia's Net Petroleum Imports,1978-2003



2.2.5 Uranium Imports

All of the uranium used to fuel Virginia's North Anna and Surry nuclear power plants is imported (see Figure 2-14). Virginia consumes around 1.6 million pounds of uranium per year.[16] An expansion of the North Anna power plant would result in increased uranium imports. The potential to mine Virginia uranium is therefore strategically important and warrants careful analysis.

Figure 2-14 Virginia's Net Uranium Imports, 1990-2004



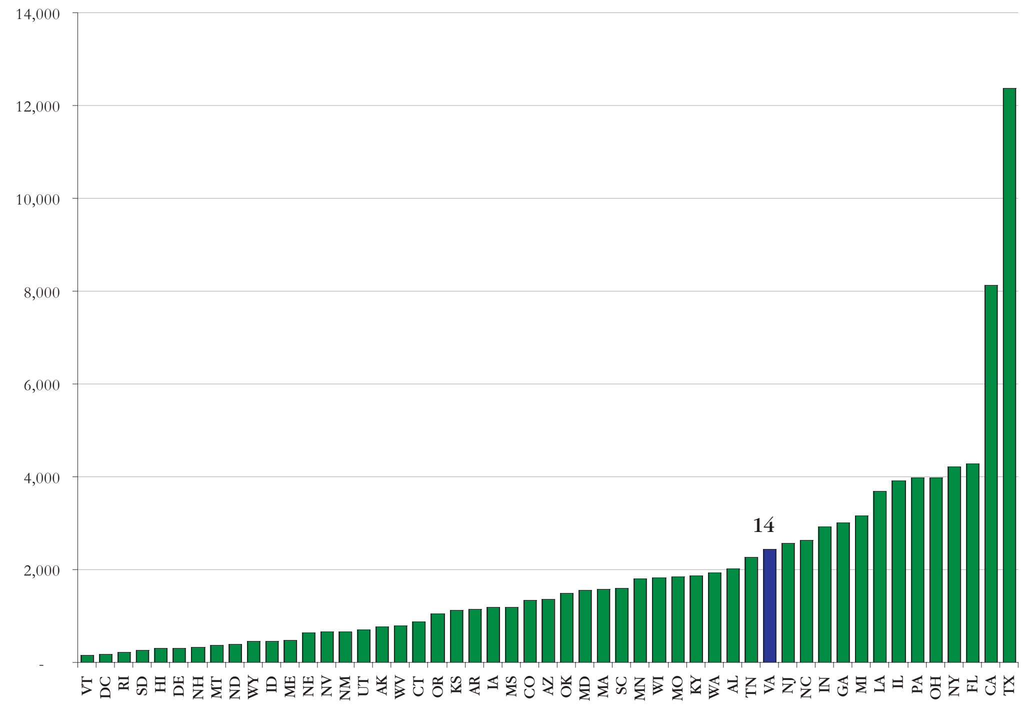
[16]According to Mr. Hink Barker, manager of nuclear fuel procurement for the North Anna and Surry facilities, these two plants use approximately 1.6 million pounds of unenriched uranium each year. This number is based on a range of 1.3 to 1.9 million pounds per year, depending on how many units are refueled in any given year. The input uranium is natural uranium at 0.7% U235. It needs to be enriched up to the 4.2 to 4.7% level. The enrichment process creates many pounds of waste during the conversion to enriched nuclear fuel. The final amount of enriched (higher U235 percent) uranium that actually goes into the reactor core is about 30 metric tons (approximately 66,000 pounds) per year for the type of reactors in Virginia.

2.3 Energy Consumption

Virginia ranks fourteenth in the nation in total energy consumption (see Figure 2-15). This is slightly lower than its twelfth-place population ranking. Virginia ranks tenth in commercial energy consumption, twelfth in both residential and transportation, and seventeenth in industrial. The state ranks twenty-fourth in total consumption per capita, because of the relatively higher urban population percentage and lower industrial intensity of the state's economy.

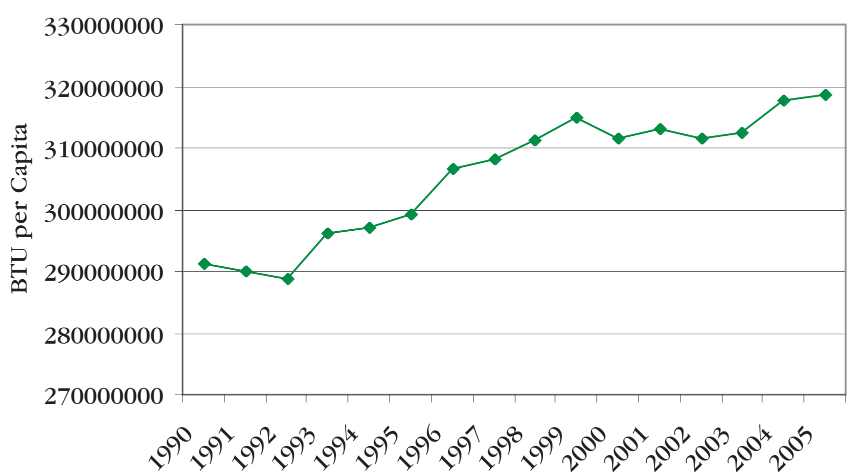
Virginia ranks fourteenth in the nation in total energy consumption. This is slightly lower than its twelfth-place population ranking.

Figure 2-15 State Rankings of Total Energy Consumption



Another useful way to look at energy use is to consider the amount used by each person in Virginia. Energy use per capita in the state grew from 291 million BTUs in 1990 to 319 by 2005 (see Figure 2-16). This is equivalent to an average growth rate of approximately six tenths of 1 percent per year.

Figure 2-16 Virginia's Per Capita Energy Use, 1990-2005



[10]Based on Energy Information Administration data with the exception of uranium, which is estimated by applying the 2004 heat rates for the two nuclear facilities to electricity generated.

2.3.1 Energy Consumption by Sector

Figure 2-17 shows Virginia's growth in energy consumption by sector for 1960 through 2003.[17] Figure 2-18 shows a snapshot of this data for 2003.

Energy use for transportation has grown at the fastest rate. The commercial sector has experienced the smallest growth. Energy use in other sectors has fluctuated but exhibited overall upward trends. Figure 2-19 presents Virginia's energy consumption by sector for 1960 and 2003.

Figure 2-20 shows the breakout of energy use by source for each sector.[18] Because of its growth rate, the transportation sector is now the state's single largest energy-using sector, accounting for approximately 43 percent of total energy use (measured at the end-use point, i.e., the meter or pump). Of the remaining 57 percent, 17 percent is used in the residential sector, 15 percent in the commercial sector, and 25 percent in the industrial sector.

Figure 2-17 Virginia's Total Energy Consumption by Sector, 1960-2003

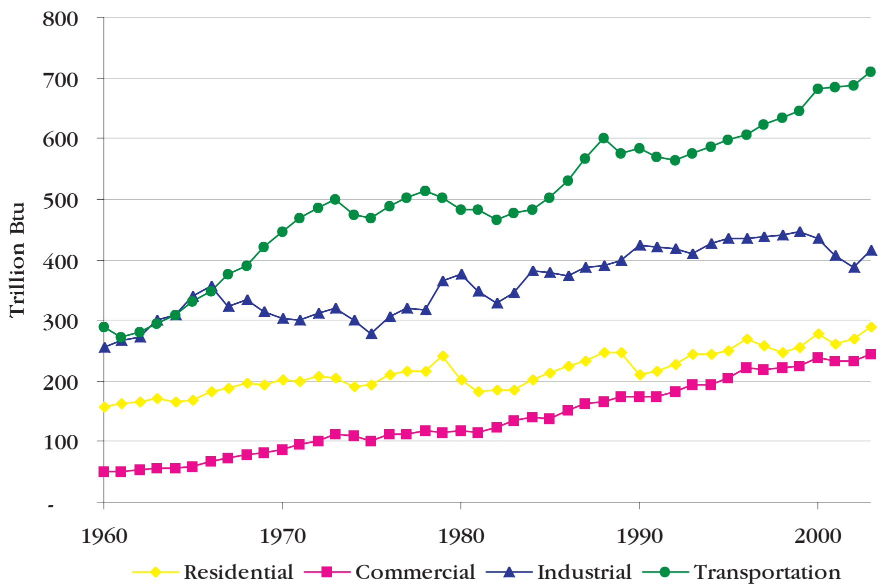
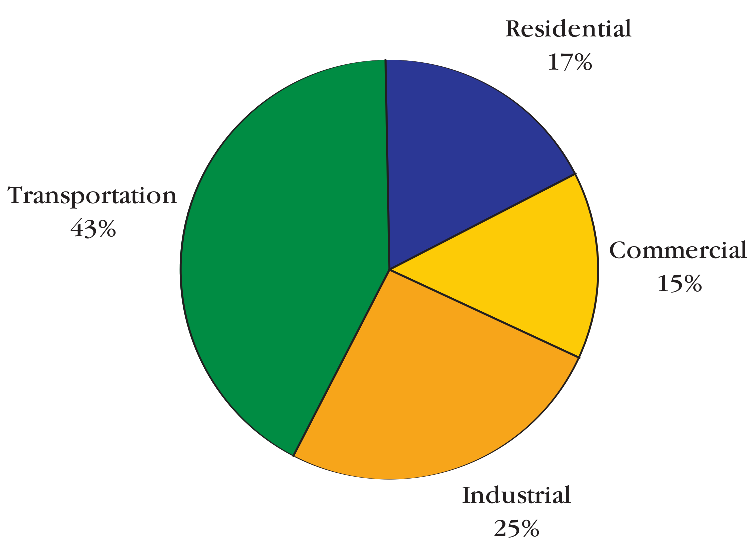


Figure 2-18 Virginia's Total Energy Consumption by Sector, 2003



[17]Data show the energy used at the point of consumption (site data) and do not include the energy used to produce or deliver the electricity, petroleum, natural gas, and other energy to the end users (source data). If electric generation and transmission losses are included in the calculations, transportation energy use decreases to approximately 33% of total energy use.

[18]Fuel sources have different properties which affect how much they are used in any sector. Fuel suppliers often compete against each other based on fuel properties such as ease of use, cost, carbon footprint, safety, and other factors. Ultimate efficiencies and environmental impacts of energy use by each source depend on factors, many of which are not measured with a great degree of rigor, related to production, processing, and transportation of the energy to end users.

Figure 2-19 Virginia's Total Energy Consumption Profile by Sector, 1960 and 2003

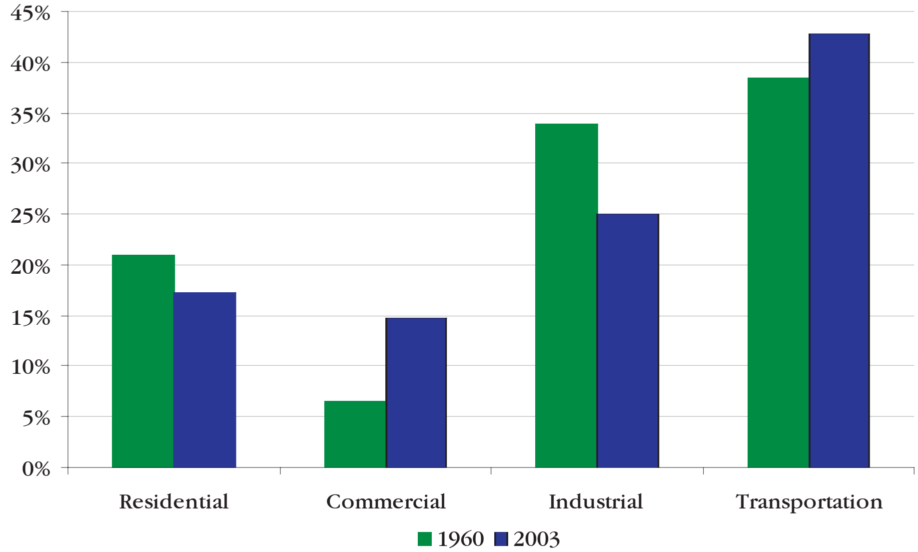
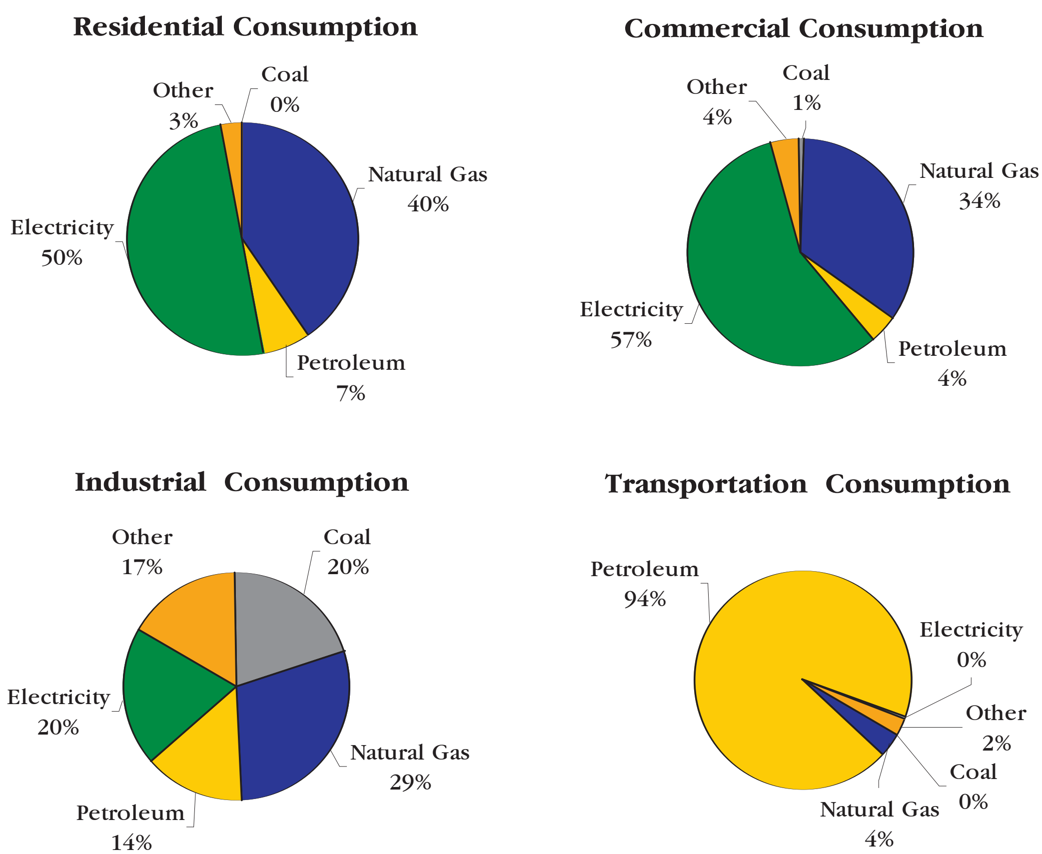


Figure 2-20 Virginia's Energy Consumption by Sector, 2003



Residential Consumption

The condition of a state's housing stock has a significant effect on energy use. Virginia housing stock is younger, larger, and higher in value than the national average. This causes Virginia's housing stock to be more efficient on a per-square-foot basis than the national average, but greater in energy use because of the larger size and higher presence of energy-using equipment in higher value housing.

Table 2-5 summarizes and compares the primary heating fuels for homes in Virginia and the nation. Natural gas is not available in many of the rural and mountainous regions of Virginia; therefore, relative to the country as a whole, Virginia homes use a much higher proportion of electricity as their primary heating fuel.

Table 2-5 Virginia Heating Fuel Market Share

House Heating Fuel Market Share	Virginia	U.S.
Utility gas	35.2%	50.5%
Bottled, tank, or LP gas	5.3%	6.0%
Electricity	45.6%	32.5%
Fuel oil, kerosene, etc.	10.6%	8.0%
Coal or coke	0.1%	0.1%
Wood	2.4%	1.7%
Solar energy	0.0%	0.0%
Other fuel	0.4%	0.4%
No fuel used	0.3%	0.8%

Commercial Consumption

Commercial energy use is heavily electric. Most is used to light, heat, and cool commercial spaces, refrigerate goods, and power computers. Electric use has grown as more information technology and other electric equipment have been added.

Industrial Consumption

Industrial energy use is more evenly distributed among fuel types. Industrial energy use is primarily driven by process needs. Energy is used to drive motors, to handle materials, as a feedstock to industrial processes, and as a thermal input to manufacturing.

Transportation Consumption

Transportation is almost totally fueled by petroleum. Most transportation energy use is for moving automobiles, trucks, and aircraft. Transportation energy use will remain heavily dependent on petroleum until non-petroleum alternate sources, such as ethanol, biodiesel, and coal-to-liquids, are developed.

Chapter 2

Virginia Energy Resources and Consumption

continued

2.4 Energy Production and Consumption Forecasts

Historical trends and industry data were used to project energy production and consumption trends in Virginia. The difference between energy production and consumption is Virginia's energy balance and reflects its net energy imports and exports. Table 2-6 shows Virginia's total energy production and consumption base case forecasts.

Table 2-6 Energy Production and Consumption Forecasts for Virginia *(Billion BTUs)*

Year (a)	Amount Produced (b)	Growth (c)	Percent Growth (d)	Amount Consumed (e)	Growth (f)	Percent Growth (g)	Net Imported/ (Exported) (h)	Growth (i)	Percent Growth (j)
1990	1,536,048.0			1,811,416.1			275,368.1		
1991	1,417,819.9	(118,228.1)	-7.7%	1,826,877.6	15,461.5	0.9%	409,057.7	133,689.6	48.5%
1992	1,436,762.3	18,942.3	1.3%	1,852,395.2	25,517.6	1.4%	415,633.0	6,575.2	1.6%
1993	1,393,331.8	(43,430.5)	-3.0%	1,927,796.1	75,400.9	4.1%	534,464.3	118,831.3	28.6%
1994	1,367,985.1	(25,346.7)	-1.8%	1,959,115.0	31,319.0	1.6%	591,129.9	56,665.7	10.6%
1995	1,296,980.7	(71,004.4)	-5.2%	1,996,636.3	37,521.2	1.9%	699,655.6	108,525.7	18.4%
1996	1,330,417.8	33,437.1	2.6%	2,070,035.6	73,399.3	3.7%	739,617.8	39,962.2	5.7%
1997	1,346,573.8	16,156.1	1.2%	2,105,239.1	35,203.5	1.7%	758,665.3	19,047.4	2.6%
1998	1,276,797.0	(69,776.8)	-5.2%	2,147,401.7	42,162.6	2.0%	870,604.7	111,939.4	14.8%
1999	1,247,525.2	(29,271.9)	-2.3%	2,203,962.9	56,561.2	2.6%	956,437.8	85,833.0	9.9%
2000	1,258,281.4	10,756.2	0.9%	2,312,418.9	108,455.9	4.9%	1,054,137.5	97,699.7	10.2%
2001	1,263,185.9	4,904.5	0.4%	2,252,304.1	(60,114.8)	-2.6%	989,118.2	(65,019.3)	-6.2%
2002	1,245,569.4	(17,616.5)	-1.4%	2,269,029.3	16,725.3	0.7%	1,023,460.0	34,341.8	3.5%
2003	1,238,495.8	(7,073.6)	-0.6%	2,307,218.2	38,188.8	1.7%	1,068,722.4	45,262.4	4.4%
2004	1,223,247.3	(15,248.5)	-1.2%	2,377,552.0	70,333.8	3.0%	1,154,304.7	85,582.3	8.0%
2005	1,214,006.5	(9,240.8)	-0.8%	2,410,705.4	33,153.4	1.4%	1,196,698.9	42,394.2	3.7%
2006	1,210,208.5	(3,798.0)	-0.3%	2,443,858.8	33,153.4	1.4%	1,233,650.3	36,951.4	3.1%
2007	1,234,311.0	24,102.5	2.0%	2,477,012.2	33,153.4	1.4%	1,242,701.1	9,050.9	0.7%
2008	1,130,256.4	(104,054.7)	-8.4%	2,510,165.6	33,153.4	1.3%	1,379,909.2	137,208.1	11.0%
2009	1,091,638.6	(38,617.8)	-3.4%	2,543,319.0	33,153.4	1.3%	1,451,680.4	71,771.2	5.2%
2010	1,112,831.0	21,192.4	1.9%	2,576,472.4	33,153.4	1.3%	1,463,641.4	11,961.0	0.8%
2011	1,141,107.5	28,276.5	2.5%	2,609,625.8	33,153.4	1.3%	1,468,518.3	4,876.9	0.3%
2012	1,122,109.9	(18,997.6)	-1.7%	2,642,779.2	33,153.4	1.3%	1,520,669.3	52,151.0	3.6%
2013	1,106,721.1	(15,388.8)	-1.4%	2,675,932.6	33,153.4	1.3%	1,569,211.5	48,542.2	3.2%
2014	1,104,684.4	(2,036.6)	-0.2%	2,709,086.0	33,153.4	1.2%	1,604,401.6	35,190.0	2.2%
2015	1,102,647.8	(2,036.6)	-0.2%	2,742,239.4	33,153.4	1.2%	1,639,591.6	35,190.0	2.2%
2016	1,100,611.2	(2,036.6)	-0.2%	2,775,392.8	33,153.4	1.2%	1,674,781.7	35,190.0	2.1%

COMPOUND GROWTH RATES

	Amount Produced	Amount Consumed	Net Imported/ (Exported)
1993-1998	-1.7%	2.2%	10.3%
1998-2003	-0.6%	1.4%	4.2%
2003-2008	-1.8%	1.7%	5.2%
2008-2013	-0.4%	1.3%	2.6%
2003-2016	-0.9%	1.4%	3.5%

Figure 2-21 presents Virginia's net energy imports and exports for the years 2004 and 2016. Even with a decline in coal production, Virginia is expected to continue to be a coal exporter through the ten-year window of this Plan. The state is expected to continue being a net importer of natural gas, petroleum, nuclear, and electricity.

Figure 2-21 Virginia's Net Energy Imports/(Exports), 2004 and 2016

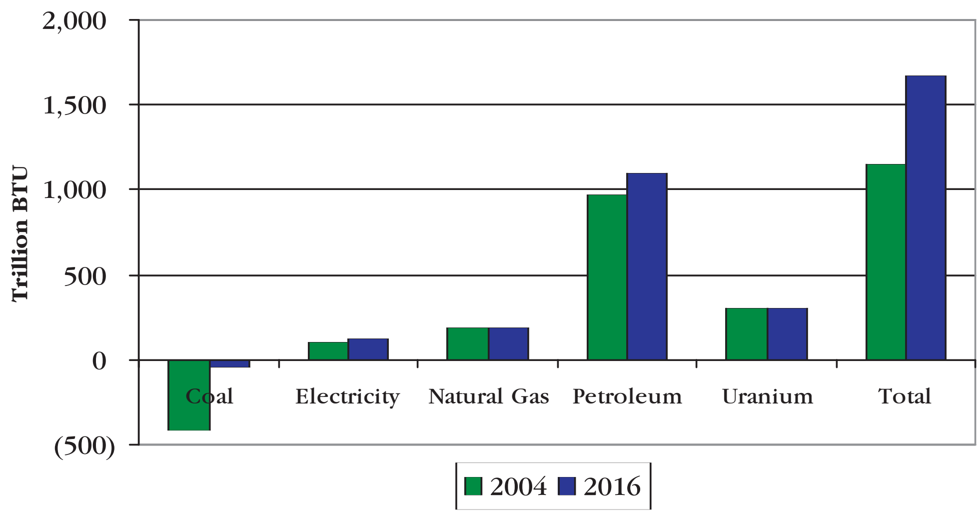
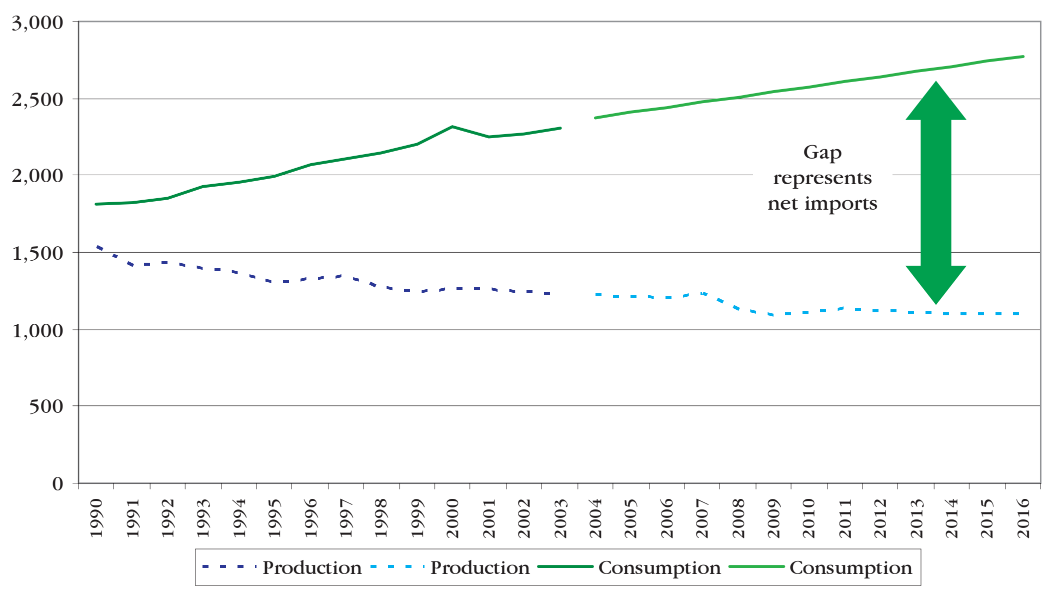


Figure 2-22 presents the historical and projected (base case) energy production and consumption ratio for the years 1990 to 2016. With no new supply- or demand-side measures, the gap between energy consumed and produced in Virginia is expected to increase from 1,154 trillion BTUs in 2004 to 1,639 trillion BTUs in 2016. The 2004 gap had a market value of $9.3 billion. The gap in 2016 would be $15.9 billion in today's prices, an increase of 4.6 percent per year from 2004 through 2016.

Figure 2-22 Virginia's Energy Supply and Demand Gap *(Trillion BTUs)*



Virginia can choose to actively pursue early commercial use of new technologies. Near-term generation options include clean coal, solar, wind, nuclear, and waste and biomass. Longer-term options, available ten or more years from now, include tidal/in-stream water, high-temperature geothermal energy, hydrogen, and methane hydrates.

2.5 Impact of Utility Regulation and Restructuring

Over the last decade, Virginia opened the door to electric utility deregulation. A fully developed marketplace would have promoted competition and resulted in efficient and low-cost electric service. However, the competition once envisioned has not materialized. Therefore, the Virginia General Assembly directed the State Corporation Commission (SCC) to continue regulatory oversight.[19]

Instead of returning to the traditional system of utility regulation, the legislation established a hybrid mechanism for regulating the rates of investor-owned electric utilities. The new process prescribes utility rates of return, while recognizing the impact that utility regulation has on financing needed infrastructure improvements. In addition, each utility may seek rate-adjustment clauses to recover:

- Costs for services provided by PJM under Federal Regulatory Energy Commission approved demand-response programs.
- Costs of authorized deferred environmental and reliability improvements.
- Costs of authorized demand-management, conservation, energy-efficiency, and load-management programs.
- Costs of participation in the new renewable portfolio standard.
- Costs of projects that the SCC finds to be necessary to comply with state or federal environmental laws or regulations applicable to generation facilities used to serve the utility's native load obligations.

If the SCC reviews rates and determines that a utility earned less than its authorized rate of return, rates will be increased to a level that allows rate of return. If the SCC determines that a utility earned more than its established rate of return, the SCC is required to direct that 60 percent of overearnings be credited to customers' bills.

The Commonwealth has made the renewable portfolio standard available to electric utilities that show a reasonable expectation of achieving 12 percent of base-year electric energy sales from renewable energy sources by 2022. Under the voluntary program, a utility that meets renewable energy goals can earn an increased rate of return. The utility also can earn an enhanced rate of return on the construction costs of generation facilities used to provide the renewable energy. Double production credits are provided for energy from solar or wind sources.

The legislation provides that customers with an electrical demand of more than 5 megawatts, but less than 1 percent of the utility's load, may shop for power. Nonresidential customers may aggregate their demand to meet the 5-megawatt threshold. Municipalities are allowed to aggregate the electric load of their governmental operations to negotiate rates and terms of service.

The legislation provides incentives for construction of new base-load generation to protect consumers from high-cost, volatile wholesale electricity markets.

The legislation is intended to provide an outlet for competition while protecting those consumers who cannot competitively shop for electricity. Predicted outcomes include improved utility infrastructure, rate increases less than those in neighboring states, increased use of renewables, and increased efficiency and conservation.

2.6 Role of New Technologies

As new technologies advance and become competitive, they will naturally come to market. Virginia can choose to actively pursue early commercial use of new technologies. Near-term generation options include clean coal, solar, wind, nuclear, and waste and biomass. Longer-term options, available ten or more years from now, include tidal/in-stream water, high-temperature geothermal energy, hydrogen, and methane hydrates. New conservation technologies are addressed in Chapter 3.

Virginia's businesses and institutions are

[19]http://leg1.state.va.us/cgi-bin/legp504.exe?071+ful+HB3068ER+pdf.

conducting research on many of these potential longer-term energy solutions. While the commercial use of many of these products may be beyond the ten-year term of this Plan, returns on research and development of these products can begin sooner. Chapter 6 contains further information about these energy research and development activities.

2.6.1 Near-Term Technologies

Clean Coal

Advanced circulating fluidized bed technology is a proven clean-coal technology that can produce power with reduced emissions. This flexible technology can be used with run-of-mine coal, waste coal, and renewable energy sources such as wood waste. The Virginia City Hybrid Energy Center is being engineered for 20 percent co-firing of renewable or waste fuel.

Integrated Gasification Combined Cycle (IGCC) plants uses gasified coal to fuel a conventional combined cycle power plant. This is another near-term technology that can produce power with reduced emissions. There are currently two coal-based IGCC plants in the United States, in Florida and Indiana.[20] They represent the cleanest coal-based technology operating today. American Electric Power has proposed building two IGCC plants, one of which will serve Appalachian Power customers.

Coal (or other carbon)-to-liquids is an emerging technology that offers promise. Rapid advancements may bring projects to Virginia in less than five years.

Virginia has the opportunity to sequester carbon in unminable coal seams. A recent report from the Virginia Center for Coal and Energy Research (VCCER) provides detailed information on this opportunity.[21] Preliminary conclusions indicate that coal in the Central Appalachian Basin has significant sequestration potential, particularly in Buchanan, Dickenson, and Wise Counties. An estimated 7.33 trillion cubic feet of carbon dioxide storage capacity is available in the unminable Lee and Pocahontas formation coals in southwest Virginia. There is an estimated 4.94 trillion cubic feet of technically feasible storage capacity of areas currently developed for coalbed methane production. An additional 0.9 trillion cubic feet of coalbed methane may be produced due to the enhanced recovery resulting from carbon dioxide injection.

Nuclear

Nuclear power plant design has evolved since the first-generation prototypes were built in the 1950s and 1960s. Generation III+ reactors are under development and likely to be deployed by 2010. These include the Economic Simplified Boiling Water Reactor, which Dominion has identified as the reactor of choice in its North Anna plant siting license applications. Other companies, including Areva NP in Lynchburg, offer competing designs. Pebble bed reactors are being developed in South Africa and Asia.

While operational costs of nuclear power plants are the lowest of any type of generation except for hydroelectric, wind, and solar, nuclear power's high capital cost is a deterrent to its construction. Additionally, the United States needs to find a permanent solution to nuclear fuel disposal. However, fossil-fueled plants continue to incur costs to control emissions. With future carbon taxes or emissions trading requirements, nuclear power generation is expected to grow.

Uranium Production

There is a renewed interest in uranium exploration and mining due to rising uranium prices. Wyoming (the largest U.S. producer of uranium with the largest reserve base, according to the National Mining Association), Utah, and Colorado are states with the greatest potential for additional extraction.

Federal law and regulations control many uranium mining activities, including the Uranium Mill Tailings Radiation Control Act of 1978, the Safe Drinking Water Act, the Underground Injection Control Program, and the National Emission Standards for Hazardous Air Pollutants. The federal government controls the licensing of uranium-processing mills and

[20] ConocoPhillips and Cinergy jointly operate the Wabash River Generating Station in West Terre Haute, IN. This facility is a repowering of an existing coal plant with 262 megawatts of capacity. It became operational in 1995 and was a DOE demonstration project, receiving 50% of the total project funding from DOE during a four-year demonstration phase. The Polk Power Station is an IGCC facility run by Tampa Electric Company in southern Florida. The plant has 250 megawatts of capacity and was also a part of the DOE's demonstration program, receiving $120 million in federal funds. The project was placed in commercial operation in 1996 and continues to operate commercially for Tampa Electric Company today.

[21] In May 2004, DOE commissioned VCCER and Marshall Miller & Associates, Inc. to conduct an assessment of the carbon sequestration potential of the Pennsylvanian-age coalbeds in the Central Appalachian Basin.

disposal of the associated mill tailings. Beyond the general environmental protection programs, there is no federal program that regulates mine operation, reclamation, and closure. Some states (e.g., Wyoming, Colorado, and Texas) have developed uranium mining standards

Uranium deposits were discovered about thirty-five years ago at Coles Hill in Pittsylvania County, but uranium has never been mined from the site. According to a 1983 report by Marline Uranium Corporation, a deposit estimated at 30 million tons could yield a potential annual extraction rate of approximately 2 million pounds per year. Applying the March 2007 price of $85 per ton[22] equals a market value of $170 million per year.

The prospect of uranium mining in Virginia was extensively studied by the Virginia Coal and Energy Commission in the early 1980s. At the conclusion of these studies, the commission issued Senate Document 15 (1985) which recommended that a Virginia uranium industry be allowed to develop within a specific and detailed legislative framework designed to protect the public health and environment. Following this report, Virginia prohibited uranium mining but established a regulatory program for uranium exploration. The Commonwealth would need to develop operational and reclamation requirements for uranium mining and milling before the moratorium on extraction could be lifted.

For every one million pounds of uranium oxide produced per year, an estimated 200 direct jobs would be created. Marline estimated in 1983 that during thirteen years of operations at the Swanson mine and mill, approximately 2.3 million pounds of uranium oxide would be produced each year and about 453 direct jobs created. Marline estimated that the project would create an additional 312 indirect jobs statewide. It also indicated that with more exploration, additional uranium might be discovered in Pittsylvania and adjacent counties. Production at the mine and mill could be expanded to accommodate the increased reserves.

Initial environmental and land-use studies that evaluated the impact of the project found that surface and groundwater impact would be minimal. No significant deep, regional aquifers were identified in the area of the deposit. Any development would have to be carefully designed, developed, and monitored to ensure that the operation would not affect surface and groundwater.

The proposed Marline uranium mine would have used 1,265 acres, with the mine pit affecting 135 acres, waste rock and mill tailings disposal areas covering 930 acres, the mill covering 25 acres, and support area covering 175 acres.

Significant opportunities existing in other areas of the nuclear industry are addressed later in this Plan. They include research, development, construction, and operation of new generation reactors (see Chapter 4), fuel processing, servicing the nuclear navy, and providing high-tech workforce training.

Municipal Solid Waste

Virginia is the nation's second largest importer of municipal solid waste.[23] Decomposing solid waste creates methane, which when captured at landfill sites can be used to generate electricity. Biomass generation facilities may also be located at landfill sites.

Virginia has more than seventy landfills with active projects at nineteen of these sites. The U.S. Environmental Protection Agency's Landfill Methane Outreach Program identifies approximately fifteen more sites as attractive candidates for landfill gas projects, with many of the remaining forty considered project "potential."

Virginia has several plants that convert waste and biomass into energy (see Chapter 4). Covanta's I-95 Energy/Resource Recovery Facility processes 3,000 tons a day of municipal solid waste and has a generating capacity of 79 megawatts of electricity, and its Alexandria/Arlington Resource Recovery Facility processes 975 tons of solid waste a day and has a generating capacity of 23

[22]Ux Consulting Company, March 5, 2007, U3O8 spot price.
[23]Department of Environmental Quality, Office of Policy and Legislation, "Report on the Management of Municipal Solid Waste in the Commonwealth of Virginia: A Historical Review," November 1998, available at www.deq.state.va.us.

megawatts. Another example includes the Southeast Public Service Authority, which operates a municipal solid waste plant in Portsmouth. The plant is designed to process 1,500 tons per day. It produces process steam and electricity for the Norfolk Naval Shipyard and sells excess electricity to Dominion.

In addition, Virginia is following technologies that convert solid waste into alternative liquid fuels. Several technologies are in advanced stages, with one that uses a bio-catalytic conversion process leading the way. This process can convert any low-moisture carbon feedstock, including coal and waste coal. The process also allows for easy capture of excess carbon gas and significantly reduces greenhouse gas emissions inherent in landfill operations.

Animal Waste

The Virginia Waste Solutions Forum, a grassroots, multidisciplinary group of researchers, farmers, economic development interests, state government, and others, focuses on innovative solutions and strategies to improve water quality by dealing with excess nutrients generated by animal agriculture in the Shenandoah Valley. One promising option under consideration and study by the forum is to use agricultural waste as a feedstock for energy production.

Biomass

The Virginia Center for Coal and Energy Research estimates there is a potential for 760 megawatts of new electrical generation in Virginia from biomass. Forest residues could potentially support about 530 megawatts of electric generation. Other biomass resources include urban wood residues (180 megawatts), unused mill residues (14.5 megawatts), crop residues (32.8 megawatts), and animal manure (12.3 megawatts).

Several energy plants use wood or wood wastes as fuel sources. The largest is in Pittsylvania County and is owned and operated by Dominion. Consisting of three boilers and one 80-megawatt turbine unit, it consumes about 750,000 tons of wood per year.

See Chapter 4 for a more in-depth discussion of biomass.

Wind

Virginia has significant land-based and offshore wind energy resources. The potential installed capacity of land-based wind power in available Class 4 and higher resource areas within 20 miles of existing transmission lines is a little over 600 megawatts. An additional 750 megawatts could be installed if and when Class 3 land-based wind resources become economical. Class 3+ sites more than 20 miles from existing transmission lines could account for an additional generation capacity of nearly 600 megawatts. This yields a total potential land-based wind generation capacity of 1,950 megawatts.[24]

Offshore wind power located beyond the horizon of Virginia's Atlantic Coast, in Class 6 winds and in water depths less than 20 meters, could be economically feasible today. The potential installed capacity is about 740 megawatts. Harnessing Class 5 and 6 offshore winds in water depths less than 40 meters within 50 miles of the coast requires either monopile or truss-work foundations, both of which have been installed in European waters. The potential generation in this area is 28,100 megawatts.[25]

Wind power data produced by AWS TrueWind Solutions characterized Virginia's wind energy resource and produced an area breakdown based on wind class and type of land ownership. In March 2006, Virginia asked the National Renewable Energy Laboratory (NREL) wind-mapping group for a GIS analysis of near-shore wind data as an extension of AWS's work. Table 2-7 shows the area estimates for the distribution of Virginia's wind resources among different types of lands and waters.

[24]Actual production may be less because of lands unsuitable for wind development and low capacity factors of wind systems.
[25]National Renewable Energy Laboratory, "A Study of Increased Use of Renewable Energy Resources in Virginia," Appendix A, pp. A-3-A-4, November 11, 2005.

Solar-powered electricity is attractive as it is emissions free and there is an ample solar resource.

Table 2-7 Virginia's Wind Energy Resource Areas *(km²)**

Type of Area	Class 3	Class 4	Class 5	Class 6
Fish and Wildlife Service	80	7	0	0
National Park Service	119	67	35	29
USDA Forest Service	598	291	145	102
Department of Defense	33	0	0	0
Private	844	265	61	38
All other lands	12	4	2	2
All Land-Based	**1,686**	**634**	**243**	**171**
Inland waterways	50	46	0	0
Chesapeake Bay	923	3,018	181	0
Atlantic Ocean (to 3 n.mi.)	277	823	566	0
All State Waters	**1,250**	**3,887**	**747**	**0**
3 to 6 n.mi. offshore			824	0
6 to 20 n.mi. offshore			3,205	2,111
20 to 50 n.mi. offshore			8	10,668
All Federal Waters			**4,037**	**12,779**
TOTAL ALL AREAS	**2,936**	**4,521**	**5,027**	**12,950**

*Estimates for land-based and state waters from AWS Truewind. Area estimates for federal waters based on NREL analysis, out to 50 nautical miles, Class 5 and 6 areas only.

Adjustments to this table must be made to exclude sensitive areas unsuitable for development when calculating the actual wind potential. This would exclude turbines out to 6 nautical miles and in most of the waters of Chesapeake Bay, and include only 67 percent from 6 to 20 nautical miles offshore and 33 percent from 20 to 50 nautical miles offshore because of potential ocean use conflicts.

Achievable capacity will depend on advancements in technology, reductions in cost, capacity of suppliers and installers to meet market demands, and ability to move sites through legal approval and community acceptance.

Solar

There are many developed technologies to take advantage of solar energy, among them passive solar heating, daylighting, solar hot water, and photovoltaic (PV) systems.

Many low-tech solar options are available to Virginia now. Passive solar is the most basic form of solar energy. Buildings that use passive solar and other green design concepts are less expensive to operate and maintain, provide a healthier environment for occupants, and increase worker productivity. Passive solar for light and heat generally does not increase the cost of new construction.

Market barriers for passive solar buildings include construction techniques that are different from standard practices and building appearances that do not always conform to what the community or customer expects.

A typical residential solar water heating system for a family of four delivers 4 kilowatts of electrical equivalent thermal power under full-sun conditions. For every solar hot water heating system installed, an average of 0.5 kilowatts of peak demand is offset from a utility's load.[26]

Solar-powered electricity is attractive as it is emissions free and there is an ample solar resource. Solar PV cells are made of semiconducting materials similar to those used in computer chips. When these

[26]Solar Thermal Collector Energy Production Produced by the Solar Rating and Certification Corporation, www.solar-rating.org.

materials absorb sunlight, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. PV cells can be either crystalline silicon (single crystal or polycrystalline) or thin film using materials such as amorphous silicon, cadmium telluride, or copper indium gallium diselenide. Most recently, nanotechnology has entered the field with materials that can be sprayed or printed onto a variety of substrates. These have the potential to reduce costs when compared with conventional crystalline and thin film technologies. However, PV costs are still high today and do not compete well financially with conventional sources and other renewables.

While direct costs of solar PV power are high, there may be indirect benefits to utilities when solar PV power is deployed in their service territories. In Texas, the City of Austin's municipal electric utility reports that the value of distributed PV power is in the range of 11 to 12 cents per kilowatt hour. The cost per kilowatt ranged from $1,983 to $2,938.[27] While conditions differ in Virginia and the state's electric utilities would not receive the same level of benefit, this study shows the potential value of solar PV production to the state's electric utilities.

Local governments have the authority to exempt solar energy property for property tax purposes. Only a minority of Virginia localities have implemented this option.

The Virginia Center for Coal and Energy Research reports that Virginia has the technical potential for 11,000 megawatts if using horizontal, roof-integrated panels and 13,000 megawatts if using tilted arrays on existing rooftops. Forty percent would be installed on commercial buildings and 60 percent on residences.

These systems, integrated into the electric grid, could support local distribution systems during peak demand, provide reactive power control, support disaster recovery, provide a hedge against fuel-cost uncertainties, and provide other benefits. Solar electric is especially valuable in offsetting peak demand in summer, the best time for solar energy generation.

Solar PV manufacturing offers great potential for economic development in the coming years. The *PV Roadmap*, an industry-led effort to assess the best mix of research and market development, predicts that with a reasonable set of incentives, the solar PV market in the United States could grow more than 30 percent a year over the next twenty years, increasing from 340 megawatts of installed capacity to 9,600 megawatts in 2015. *PV Roadmap* also predicts that the average installed cost in 2015 could be $3.68 per watt ($2.91 for manufacturing and $0.77 for construction and installation). This would require a $27 billion investment in manufacturing and $7 billion investment in construction and installation. Direct employment could increase from 20,000 jobs today to 62,000 jobs by 2015. The report ranked Virginia fifteenth in the nation in potential investment and job creation (640 jobs and $550 million investment) if the predicted trend is reached.

Virginia has been host to two PV manufacturers, one of which ceased operations in 2002. Virginia offers the Solar Manufacturing Incentive Grant Program, which awards up to $4.5 million a year for the sale of Virginia-manufactured PV panels. However, this grant no longer has been able to attract new solar panel manufacturing. Over the past year, eight PV manufacturers have expressed interest in locating manufacturing plants in Virginia, but none have committed. One of the companies expanded in Germany, where it received a combined package of direct incentives, coupled with significant end-user incentives such as a generous feed-in tariff for solar-generated electricity. A second, Midwest company decided the Virginia grant alone was not worth disrupting its current workforce and instead expanded operations in its home state. A third company told Virginia economic development representatives that the grant incentive, originally developed to support a less-than-10-megawatt facility in the 1990s, is not sufficient to attract the current required investment by modern

[27] Thomas E. Hoff, Richard Perez, Gerry Braun, Michael Kuhn, and Benjamin Norris, "The Value of Distributed Photovoltaics to Austin Energy and the City of Austin," prepared by Clean Power Research, L.L.C., March 17, 2006.

PV manufacturers. The program could be updated to attract investments in a different market from when the program was originally introduced.

2.6.2 Long-term Technologies

Geothermal Energy

The term "geothermal energy" is popularly associated with bubbling hot springs and geysers, where volcanic activity produces temperatures above the boiling point of water near the earth's surface. Such high-temperature geothermal reservoirs do not exist in the eastern United States. There are two low-temperature reservoirs in Virginia.

Virginia's western low-temperature reservoir is associated with aquifers that circulate and heat groundwater, then return it to the surface to hot springs clustered around Highland and Bath Counties, with water temperatures typically ranging from 70 to 105°F. In the Warm Springs area, there is considerable lower-temperature water available. This resource is used for space heating at The Homestead resort complex.

Virginia also has an eastern low-grade geothermal reservoir around Chesapeake Bay, where groundwater temperatures of 75 to 80°F are found about 1,000 feet below the surface. The heat comes from granite bodies that contain relatively high concentrations of radioactive isotopes. These granite intrusions are overlain by a thick layer of Coastal Plain sediments, which act as an insulating blanket, allowing the heat to build up and create a relatively high geothermal gradient. This formation is a candidate for a longer-term geothermal conversion technology known as hot dry rock, which uses the hot temperatures of underground granite rock layers.

Tidal/In-Stream Water

Tidal changes in sea level can be used to generate electricity. Dams can be constructed across coastal bays or estuaries that have large differences between low and high tides. The changing water levels create pressure that can drive turbines to make electricity. However, any tidal power development would have to address serious environmental impacts from constructing impoundments across coastal bays or estuaries.

Offshore turbines function similarly to an underwater wind farm. They are much cheaper to build and do not have the environmental problems of tidal barriers. Water is denser than wind; therefore, fewer and smaller offshore turbines are needed to produce the same amount of electricity as wind turbines.

Wave-based generation systems are also being tested for future use. It is not known whether these would be applicable for Virginia waters.

Hydrogen

Developing hydrogen is a current federal government priority. Drawbacks are high production costs and lack of storage and transport infrastructure. To succeed in the commercial marketplace, hydrogen transportation costs must be competitive with conventional fuels and technologies. Automotive fuel cells are advancing, but key technical challenges remain. Goals include lowering the cost of automotive fuel cells to be competitive with the internal combustion engine, increasing durability to 5,000 hours to achieve parity with conventional automobiles, and creating the on-vehicle safe storage of enough hydrogen to allow a 300-mile cruising range.

The Virginia Hydrogen Economy Roundtable Forum published in 2006 a state hydrogen plan and vision titled *Building a Hydrogen Economy in Virginia, Suggested Strategies*. The forum was established in 2002 and includes representatives from more than thirty energy- and transportation-related industries, federal and state government agencies, Virginia academic institutions, and nongovernmental organizations. Five priorities were recommended.

- Educate Virginia's future workforce, focusing on K-12 education.

Marketing Virginia's core strengths – research and development, nuclear, proximity to markets, resources, and conservation and efficiency opportunities – could have a significant impact on economic development in the energy sector.

- Leverage the research and development potential of Virginia's academic institutions.
- Invest in hydrogen demonstration projects with high visibility.
- Foster partnership building.
- Coordinate policies and incentives to drive the building of a hydrogen economy in Virginia.

The plan includes a range of options for each of the first four action items, several possible approaches for policy development, and an incentives strategy. The 2007 General Assembly approved funding for a pilot K-12 education program.

Methane Hydrates

A methane hydrate is a form of natural gas where the molecules of methane are trapped inside a lattice of ice. Hydrate deposits may be several hundred meters thick. Methane hydrates usually form either in permafrost regions on land or beneath the ocean floor. Methane hydrate occurs around most continental margins. Virginia's coastal regions may offer methane hydrate resources.

If just 1 percent of the nation's hydrate resources were commercially developed, it would more than double the nation's proven gas reserves. Although commercial extraction is at least ten years off, methane hydrate merits research.

2.7 Opportunities and Challenges

Transmission Constraints - Electricity

Virginia, especially northern Virginia and the Delmarva Peninsula, is faced with electric transmission constraints. The electric transmission network must be expanded to provide efficient and reliable delivery to areas of high growth.

Electrical demand in northern Virginia has grown by approximately 40 percent over the last decade. PJM recently cited Dominion as having the fastest growing demand for electricity at peak times among any of the PJM regions across thirteen states. PJM compared the increase in demand on the Dominion system to adding approximately a million new houses over the next five years. PJM's analysis shows that without increases in transmission infrastructure to keep the northern Virginia portion of the system stable, northern Virginia electric consumers face an increasing risk of rolling blackouts as early as summer 2011.

Transmission Constraints - Natural Gas

Tidewater is sensitive to natural gas constraints. Virginia Natural Gas is developing a Hampton Roads Crossing project, which will add a third pipeline across the James River and alleviate some of the Tidewater constraint by providing additional capacity to transport natural gas through the region. Other regions in Virginia may become sensitive to natural gas constraints as the state's economy grows.

Priority

Marketing Virginia's core strengths–research and development, nuclear, proximity to markets, resources, and conservation and efficiency opportunities–could have a significant impact on economic development in the energy sector. This could be accomplished through improved coordination of Virginia's research institutions and technology sector (see Chapter 6) and through coordinated efforts of Virginia's economic development offices and interests (Virginia Economic Development Partnership, local and regional economic development offices, industrial development authorities, and private developers).

Potential

By matching its strengths and resources, Virginia has the opportunity to improve its ratio between imports and production. Efficiency and conservation opportunities (Chapter 3) reduce the need for imports. New production can supplement and replace older, less efficient generation sources. Each 1 percent shift from producing more energy or using less can have a significant impact on Virginia's economy (see Table 2-8). For example, data show that a 1 percent shift in petroleum use to

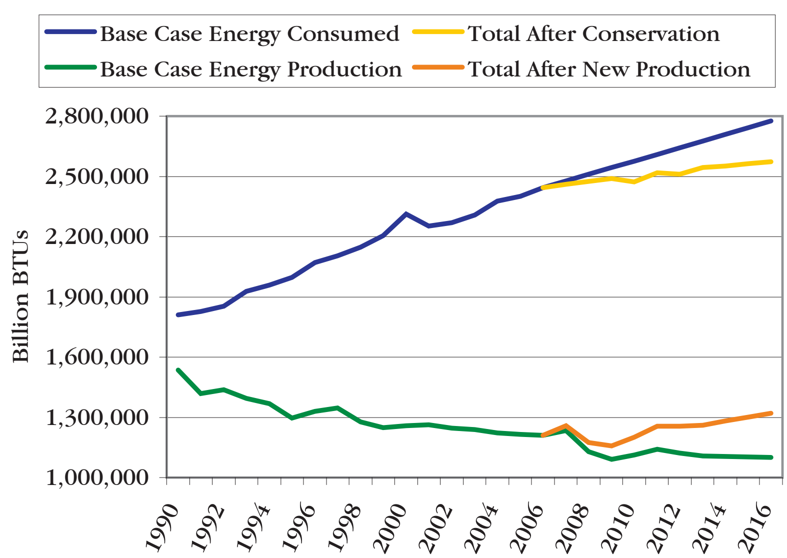
Virginia sources would retain over $100 million in Virginia's economy. A similar shift of electrical generation would keep $20 million in the state's economy and in natural gas production would keep over $12 million in the state's economy.

Table 2-8 Impact of 1 Percent Change in Virginia's Energy Imports/Exports

CHANGE IN NET IMPORTS					
Fuel	2007 Net Imports (Billion BTUs)	1% of Net Imports (Billion BTUs)	Equivalent Amount	Units	Market Value ($Million)
Natural Gas	190,399	1,904	1,851,420	MCF	$12.8
Petroleum	1,006,590	10,066	1,728,051	BBS	$114.1
Electricity	109,472	1,095	320,750	MWh	$20.1
Uranium (U235)	300,850	3,009	14,329	lb	$0.7
CHANGE IN NET EXPORTS					
Fuel	2007 Net Exports (Billion BTUs)	1% of Net Exports (Billion BTUs)	Equivalent Amount	Units	Market Value ($Million)
Coal	364,609	3,646	136,227	Tons	$6.8
THERMAL CONVERSION FACTORS					
1 cubic foot of Natural Gas = 1,028.4 BTUs					
1 barrel of Petroleum = 5.825 Million BTUs					
1 kWh Electricity = 3,413 BTUs					
1 pound U235 = 210 Million BTUs					
1 pound of coal = 12,867.4 BTUs					

These actions will result in a modification of the energy supply and demand curves (see Figure 2-23). These supply and demand wedges will reduce the gap between supply and demand and reduce the drain on Virginia's economy from energy imports.

Figure 2-23 Virginia Total Energy Produced and Consumed, 1990-2016



Chapter 3

Energy Efficiency and Conservation

Energy efficiency and conservation offer Virginia the most cost-effective and most readily deployable method to manage its energy future.

[28]These workshops were held in fall 2006 in the cities of Abingdon, Annandale, Lexington, Williamsburg, and Virginia Beach.

3.0 Energy Efficiency and Conservation

Energy efficiency and conservation offer Virginia the most cost-effective and most readily deployable method to manage its energy future. They should be the first actions consumers take to address future energy needs. Government also has a significant role to play to increase implementation of energy-efficiency and conservation measures by providing incentives, broadening public awareness, and through its role as a regulator of utility-service pricing.

Energy-efficiency opportunities are physical, long-lasting changes that reduce energy use while maintaining or improving performance (e.g., high-efficiency lighting, Energy Star appliances, fuel-efficient cars). Energy conservation is achieved when consumers limit or reduce their use of energy-consuming devices (e.g., turn off lights, drive fewer miles).

It is important to maintain a comfortable margin between the highest point of energy demand and the supply system's capacity in order to avoid events such as electric-grid blackouts, transmission constraints, and price volatility. For example, electric-grid system operators calculate and maintain reserve margins to account for real-time supply-and-demand fluctuations caused by events such as sudden loss of generation or severe weather. As reserve margins shrink, markets are at increased risk for disruptions and price spikes. Sustainable demand reductions based on conservation and energy efficiency improve reserve margins and reduce supply-side needs and long-term capacity increases.

This chapter presents information on the amount of achievable energy efficiency and conservation in Virginia; identifies cost-effective energy-efficiency and conservation measures that could significantly reduce energy demand; and discusses ways in which Virginia can take a leadership role in setting energy-efficiency and conservation policy.

This Plan sets an overall goal to reduce the rate of growth of energy use over the base case by 40 percent. To reach this level, the Plan sets fuel-specific goals to reduce "electric use by 10 percent by 2022 as called for in the 2007 electric re-regulation legislation, to reduce natural gas consumption by more than 7 percent, to reduce non-transportation petroleum use by 10 percent, and to reduce transportation energy use by 5 percent.

3.1 Improving Energy Efficiency and Conservation in Virginia

Virginia's energy policy objectives call for using energy resources more efficiently and facilitating conservation. Virginia has a history of relatively low energy costs compared with other states-which means financial returns and payback from implementing efficiency and conservation measures have been limited. States with historically high costs have established a range of programs that can serve as models for Virginia.

Energy-efficiency and conservation programs can include many strategies. A few of the most important are:

- Consumer education.
- Training for service and design professionals.
- Financial incentives that influence consumers' decisions.
- Increasing energy-efficiency building and equipment standards.
- Utility rates and programs (time-of-use rates, demand response, etc.).
- Research and development programs.
- Transportation improvements and mass transit incentives.

The Virginia Energy Plan Advisory Group provided input on the Plan at five public workshops.[28] The advisory group agreed that Virginia should develop and implement a full range of cost-effective energy-efficiency and conservation programs.

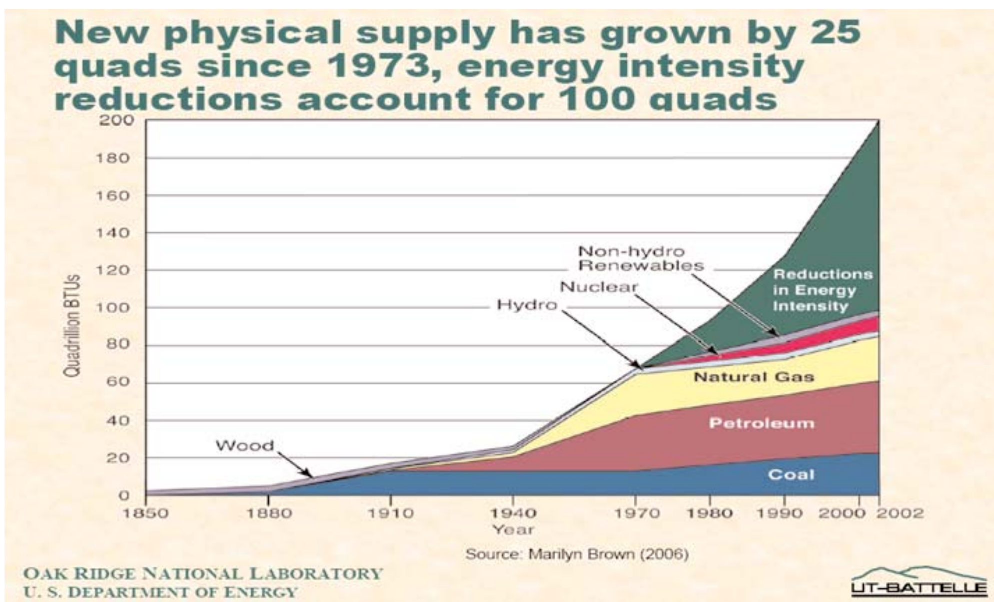
Placing a high priority on energy efficiency and conservation is compatible with the findings of the Appalachian Regional Commission (ARC) Energy Blueprint, the

2005 National Energy Policy Act, and Virginia's 2006 Economic Development Strategic Plan.[29] Strategic objective #1 in the ARC report, "Energizing Appalachia: A Regional Blueprint for Economic and Energy Development" is to "promote energy efficiency in Appalachia to enhance the Region's economic competitiveness."[30] The 2006 National Action Plan for Energy Efficiency, developed by more than fifty leading government, utility, non-profit, industry, and business organizations, notes that "improving the energy efficiency of our homes, businesses, schools, governments, and industries-which consume more than 70 percent of the natural gas and electricity used in the country-is one of the most constructive, cost-effective ways to address these challenges. Increased investment in energy efficiency in our homes, buildings, and industries can lower energy bills, reduce demand for fossil fuels, help stabilize energy prices, enhance electric and natural gas system reliability, and help reduce emissions of air pollutants and greenhouse gases."[31] The Virginia Energy Plan uses concepts from the National Action Plan for Energy Efficiency and complements this national effort.

Energy-efficiency efforts have already had a significant impact on energy use (see Figure 3-1). Without them, the nation's energy use would have more than doubled between 1973 and 2002.

Energy-efficiency efforts have already had a significant impact on energy use. Without them, the nation's energy use would have more than doubled between 1973 and 2002.

Figure 3-1 Impact of Energy-Efficiency Efforts on U.S. Energy Intensity, 1973-2002



[29]State of Virginia, "Virginia Leading the Way, Governor Kaine's Economic Development Strategic Plan," 2006, p. 15.
[30]ARC, "Energizing Appalachia: A Regional Blueprint for Economic and Energy Development," October 2006, p. 1.
[31]U.S. Department of Energy and U.S. Environmental Protection Agency, National Action Plan for Energy Efficiency, July 2006.

Virginia should not wait for the rate increase "creep" to cause an unmanageable burden. Virginia can obtain significant savings and environmental benefits through increased investments in energy efficiency and conservation.

3.2 History of Energy-Efficiency Savings and Spending by Electric Utilities in Virginia

The U.S. Department of Energy's Energy Information Administration (EIA) collects annual energy-efficiency spending and savings data from U.S. electric utilities. Virginia ranks low on energy-efficiency savings originating from utility programs. Of a hundred investor-owned utilities that provided information to EIA on energy-efficiency savings, the highest-performing Virginia utility ranked sixty-fourth. Western Massachusetts Electric Company (WMECO) ranked first, but Massachusetts had the second-highest electric rates of the fifty states. WMECO began implementing energy-efficiency programs in the 1970s and has already saved more than 15 percent of total annual kilowatt-hour sales as a result.

Electricity prices are likely to increase in Virginia because of increased fuel costs and the need for infrastructure improvements. While these increases may create an economic burden, they also make efficiency upgrades financially more attractive to consumers and utilities. Higher electric rates mean shorter paybacks on efficiency investments. Virginia should not wait for the rate increase "creep" to cause an unmanageable burden. Virginia can obtain significant savings and environmental benefits through increased investments in energy efficiency and conservation.

The top twenty electric utilities with energy-efficiency programs spend an average of 2.75 percent of annual electric-utility revenues on energy-efficiency programs. These same utilities have already saved an average of 12 percent of their total electric sales through the end of 2005. Typically, every $1 spent by these utilities on energy efficiency saves consumers $3 to $4.

The 2006 National Action Plan for Energy Efficiency reports that utilities are operating energy-efficiency programs at a program cost of about $0.02 to $0.03 per lifetime-kilowatt-hour-saved and $1.30 to $2.00 per lifetime-million-BTUs-saved.[32]

Efficiency and conservation can defer the need for new power generation facilities. Energy-efficiency programs reduce the demand for electricity, reduce emissions from conventional power plants, and provide a more diversified energy-resource mix.

3.3 Opportunities and Challenges with Energy Efficiency and Conservation

Virginia has several opportunities that will help with the development of new energy-efficiency and conservation programs:

- There is a significant amount of cost-effective energy-efficiency savings potential in Virginia. According to data from the U.S. Department of Energy's Energy Information Administration, penetration of energy-efficiency measures is still low for Energy Star appliances and energy-efficient lighting.
- Virginia has a diverse inventory of energy-service companies available to help design and implement aggressive energy-efficiency and conservation programs.
- Virginia has several educational institutions that can train workers for the energy-service industries.
- Virginia has several local "champions" of energy-efficiency programs (e.g., Arlington, Fairfax, and Loudoun Counties) that have established momentum and can serve as models in designing and implementing new energy-efficiency and conservation programs.
- Virginia has kept its energy-related building codes up to date with model codes, resulting in substantial savings in new building energy use.

Virginia's challenges in energy efficiency and conservation include:

- Because few formal energy-efficiency, conservation, and demand-control programs have been in place in Virginia, a significant transition will be needed for energy-efficiency programs to be fully implemented and recognized by consumers. Effecting

[32]U.S. Department of Energy and U.S. Environmental Protection Agency, National Action Plan for Energy Efficiency, July 2006, p. 1-6.

Virginia has no established funding source for energy-efficiency and conservation programs. Most states with a successful history of efficiency programs provide significant funding resources.

change in consumer behavior will require a significant shift in attitudes and awareness.

- The State Corporation Commission has historically given different weights to financial tests when considering the cost effectiveness of energy-efficiency programs. It historically has used the Rate Impact Measure Test as the primary test of cost effectiveness. The Total Resource Cost Test indicates whether an energy-efficiency measure or program has a cost per lifetime-kilowatt-hour-saved less than the avoided cost of electric generation, transmission, and distribution. The Societal Test assesses costs not directly attributed to utility services. A 2004 study found that twenty-eight states used either the Total Resource Cost or Societal Test as the main determinate of the cost effectiveness of energy-efficiency programs or measures. Virginia should use a mix of the Total Resource Cost Test, Societal Test, Utility/Program Administrator Test, Participant Test, and Rate Impact Measure Test. No one tool should be used solely as a go-no go decision point.
- Model energy codes may not optimize the energy-savings potential in new building construction. Using standards such as Energy Star or Leadership in Energy and Environmental Design (LEED) may offer opportunities for long-term energy savings.
- Virginia has no established funding source for energy-efficiency and conservation programs. Most states with a successful history of efficiency programs provide significant funding resources.
- The largest single piece of Virginia's energy-consumption "pie" is transportation fuel. Strategies such as mitigating traffic congestion, converting truck freight to rail or barge, and improving vehicle miles per gallon represent significant implementation challenges. See Section 3.5.3, Petroleum Energy-Efficiency Potential, for a discussion of transportation fuel efficiency and conservation.
- Energy-conservation and demand-control activities should be evaluated for effectiveness through use of measurement and verification protocols. Programs not meeting planned results should be reevaluated to determine if they should be modified or ended.

3.4 The Case for Energy Efficiency and Conservation

Developing and implementing aggressive energy-efficiency and conservation programs make good business sense for Virginia.

- Numerous energy-efficiency measures have a cost per lifetime-kilowatt-hour-saved[33] that is less than the cost per kilowatt-hour for electric generation from new power plants. As shown in Table 3-1, the cost of many residential energy-efficiency measures is lower than 5 cents per lifetime-kilowatt-hour-saved (5 cents per kilowatt-hour is the approximate cost of generation provided by a new coal-fired power plant).
- Cost-effective energy-efficiency and conservation programs can reduce emissions of nitrous oxide, sulfur dioxide, carbon dioxide, and particulates.
- Energy-efficiency and conservation programs can be viewed as an energy resource in energy planning. Many energy-efficiency and conservation measures can be deployed to reduce demand much more rapidly and less expensively than supply-side options can increase production.
- As Virginia's population, business community, and energy needs continue to grow, energy efficiency and conservation can defer the need for new energy-supply facilities and the associated environmental burdens they place on land, water, and air resources.
- Energy efficiency and conservation can make businesses (and homes) more comfortable and more productive by improving lighting levels and reducing glare.
- Energy efficiency and conservation can help businesses reduce operating costs, thus making businesses more efficient and increasing profits that can be reinvested. The Wisconsin Focus on Energy program, for example,

[33]The cost of energy-efficiency measures is calculated over their entire useful life, not just one year. For example, a typical compact fluorescent lightbulb lasts seven years, and the levelized cost per lifetime-kWh-saved reflects the entire useful life of the bulb, not just the first year.

reported that forty-six new full-time jobs are created in the state for every $1 million invested in energy-efficiency programs.[34]

Other measures will not save significant amounts of energy but can reduce the peak demand for electricity. For example, the Northern Virginia Electric Cooperative has installed devices for a substantial percent of its customers which allows the co-op to change air-conditioning and hot water heater cycling during peak hours with significant peak savings. Many peak demand control savings are now cost effective due to the availability of smart metering and time-of-usage electricity rates.

Energy-efficiency and conservation programs tend to relieve supply and demand pressure without the cost, environmental impact, and time delays associated with constructing new infrastructure (e.g., large power plants).

Table 3-1 Examples of Residential Energy-Efficiency Measures Costing Less than $.05 per Lifetime-Kilowatt-Hour-Saved

Energy-Efficiency Measure	Levelized Cost per Lifetime-kWh-Saved
Energy Star dehumidifier	$0.000
Compact fluorescent lightbulb	$0.003
Low-flow shower head	$0.008
Programmable thermostat	$0.008
Water-heater blanket	$0.008
Low-flow faucet aerator	$0.018
Efficient oil furnace fan motor	$0.021
Efficient natural gas furnace fan motor	$0.021
Efficient propane furnace fan motor	$0.021
Standby power	$0.023
Insulation and weatherization	$0.024
Energy Star windows	$0.033
Energy-efficient water heating	$0.035
Energy Star single-room air conditioner	$0.036
Energy Star-compliant, side-by-side refrigerator	$0.045
Energy Star-compliant, bottom-mount freezer-refrigerator	$0.049
Low-income insulation and weatherization	$0.049

Energy-efficiency and conservation programs provide a variety of environmental benefits.[35] The potential for carbon regulation and nuclear waste disposal costs creates a risk that Virginia's low-cost generation resources may cost more in the future. Adding energy efficiency and conservation to the mix reduces this risk. Energy-efficiency and conservation programs tend to relieve supply and demand pressure without the cost, environmental impact, and time delays associated with constructing new infrastructure (e.g., large power plants). Utilities and their consumers face less technical and financial risk if there is less need to construct new facilities.

[34] Data obtained from Wisconsin Focus on Energy program evaluation report, available at www.focusonenergy.com.
[35] "The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest," prepared for the Hewlett Foundation Energy Series by the Southwest Energy Efficiency Project, November 2002. See Chapter 5 for more discussion about energy and the environment.

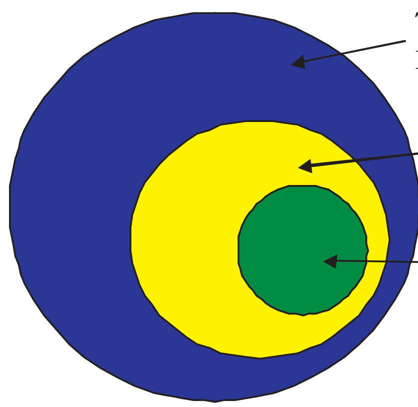
3.5 Energy-Efficiency and Conservation Potential in Virginia

It is standard practice, when preparing an assessment of energy savings in a state or region, to develop three levels of savings potential: technical, achievable, and achievable cost effective.

- Technical potential is the complete penetration of all energy-efficiency measures that are technically feasible from an engineering perspective, regardless of cost.
- Achievable potential is the market penetration that can be achieved with a concerted, sustained campaign that requires programmatic support levels beyond what can be justified on a strictly economic basis.
- Achievable cost effective potential is the potential for the realistic penetration of energy-efficient measures based on a cost-effectiveness evaluation. High levels of support are required, but measured results should exceed associated program costs.

Figure 3-2 depicts the relationship between these three categories (this diagram is for illustrative purposes only and does not reflect the scale of savings for Virginia). To develop the achievable cost effective potential, only those efficiency measures that have a levelized cost per lifetime-million-BTUs-saved lower than the cost of energy supply (i.e., electricity, natural gas, fuel oil, etc.) are considered. The analyses provided in this Plan rely on several studies to estimate cost-effective energy-efficiency and conservation opportunities in other states. Estimated efficiency savings from these studies were applied to develop a forecast of Virginia's potential.

Figure 3-2 Venn Diagram of the Stages of Energy Savings Potential



3.5.1 Electricity Energy-Efficiency Potential

Table 3-2 presents the results of fifteen electricity energy-efficiency potential studies completed for other states and regions. Connecticut, Georgia, North Carolina, and Vermont have a total achievable cost effective electricity savings potential of 13, 9, 14, and 19 percent, respectively, over the next decade. Table 3-2 also shows the incentive-level assumptions (for incentives paid to program participants) for these studies. Incentives range from a low of 15 percent to a high of 100 percent of energy-efficiency-measure costs.

Table 3-2: Comparison of Potential Electricity Savings from Studies in Other States

Percent of Total Electricity (MWh) Sales														
Sector	Conn. *2012 [1]	California 2016 [2]	Florida 2017 [3]	Georgia 2015 [4]	Big Rivers (KY) 2015 [5]	Mass. 2007 [6]	North Carolina 2016 [7]	New York 2012 [8]	NY/NJ/PA 2011 [9]	Oregon 2013 [10]	Puget Sound (WA) 2023 [11]	Southwest 2020 [12]	Texas 2017 [13]	Vermont 2015 [14]
Technical Potential														
Residential	21%	39%		33%	26%		40%	37%		28%		26%		40%
Commercial	25%	27%		33%			32%	41%		32%		37%		40%
Industrial	20%	18%		17%	11%		24%	22%		35%		33%		21%
Total	***24%***	***30%***		***29%***			***33%***	***37%***		***31%***		***33%***		***35%***
Achievable Potential														
Residential	17%			21%	18%		20%	26%	35%		17%			26%
Commercial	17%			22%			22%	38%			7%			24%
Industrial	17%			15%	9%		18%	16%	41%		0%			15%
Total	***17%***			***20%***			***20%***	***30%***			***12%***			***22%***
Achievable Cost Effective Potential														
Residential	13%	13%		9%	16%	31%	17%				7%			21%
Commercial	14%	6%		10%	10%	21%	12%				6%			21%
Industrial	13%	10%		7%	9%	21%	12%				0%			15%
Total	***13%***	***10%***	***10%***	***9%***	***12%***	***24%***	***14%***				***6%***		***12%***	***19%***
Incentive Level as a Percent of Incremental Cost														
¥Percentage	51–70%	Average between 2004 incentives and full incremental cost		25, 50, 100%	50%	N/A	50%	20–50%		N/A		15–25%		50%
£Source Page	p. 30	p. ES-2		p. 2-11			p. 3	p. 3-7				p. 5-10		

* Represents the year by which the percentage savings will be achieved.

¥ Reports the assumptions used in each study relating to the level of financial incentives paid to consumers who purchase high-efficiency equipment. In a few of the studies, more than one level of financial incentives was considered.

£ Indicates where the incentive-level assumption can be found in each study.

1. GDS Associates, "Independent Assessment of Conservation and Energy Efficiency Potential for Connecticut and the Southwest Connecticut Region, Appendix B," June 2004.
2. Itron et al., "California Energy Efficiency Potential Study," vol. 1, May 2006. Achievable cost effective potential is defined as a market potential scenario where incentives are the average between 2004 incentive levels and full measure cost.
3. R. Neal Elliott et al., "Potential for Energy Efficiency and Renewable Energy to Meet Florida's Growing Electricity Needs," ACEEE report E072, February 2007.
4. Georgia Environmental Facilities Authority, "Assessment of Energy Efficiency Potential in Georgia - Final Report," prepared by ICF Consulting, May 5, 2005.
5. "The Maximum Achievable Cost Effective Potential for Electric Energy Efficiency In the Service Territory of the Big Rivers Electric Corporation," prepared for Big Rivers Electric Cooperative by GDS Associates, November 2005.
6. "Remaining Electric Energy Efficiency Opportunities in Massachusetts: Final Report," prepared for program administrators and Massachusetts Division of Energy Resources by RLW Analytics, Inc. and Shel Feldman Management Consulting, June 7, 2001.
7. GDS Associates, "A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina," December 2006.
8. New York State Energy Research and Development Authority, "Energy Efficiency and Renewable Energy Resource Development Potential in New York State - Final Report," prepared by Optimal Energy, Inc., August, 2003.
9. ACEEE, "Energy Efficiency and Economic Development in New York, New Jersey, and Pennsylvania," 1997.
10. "Energy Efficiency and Conservation Measure Resource Assessment for the Residential, Commercial, Industrial, and Agricultural Sectors," prepared for the Energy Trust of Oregon by Ecotope, Inc., ACEEE, and the Tellus Institute, January 2003.
11. "Assessment of Long-Term Electricity and Natural Gas Conservation Potential in Puget Sound Energy Service Area 2003–2024," prepared for Puget Sound Energy by KEMA-XENERGY/Quantec, August 2003.
12. "The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest," prepared for Hewlett Foundation Energy Series by Southwest Energy Efficiency Project, November 2002.
13. ACEEE, "Potential for Energy Efficiency, Demand Response, and Onsite Renewable Energy to Meet Texas' Growing Electricity Needs," ACEEE report E073, March 2007.
14. Vermont Department of Public Service, "Vermont Electric Energy Efficiency Potential Study, Final Report," prepared and submitted by GDS Associates, Inc., January 2007. This study includes fuel shifting programs to shift residential customers away from electric space- and water-heating appliances and from electric clothes dryers.
15. Energy Center of Wisconsin, "Energy Efficiency & Customer-Sited Renewable Energy: Achievable Potential in Wisconsin: 2006–2015," November 2005. Wisconsin reported combined results for commercial and industrial sectors as C&I.

Electricity Savings in Virginia in Five and Ten Years

Tables 3-3 and 3-4 present estimates of technical and achievable cost effective potential savings for Virginia in five and ten years for electricity by sector. Because no Virginia-specific study has been performed, forecast estimates have been derived from the average of the savings found in Connecticut, Georgia, North Carolina, and Vermont.

Cumulative annual achievable cost effective savings potential in Virginia is estimated to be 8,868 gigawatt-hours (GWh) in five years and 19,355 gigawatt-hours in ten years. The savings represent the total electricity savings in the fifth and tenth years, respectively, from the energy-efficiency measures examined in this study. The cumulative annual achievable cost effective potential across all sectors over ten years is estimated to be 14 percent.

Table 3-3 Electric Energy Savings Potential in Five Years for Virginia

Level of Potential Savings	Cumulative Annual Savings Potential in Five Years (GWh)	% of Five-Year GWh Consumption Forecast
Residential Sector		
Technical Potential	17,268	34%
Achievable Cost Effective	3,542	8%
Commercial Sector		
Technical Potential	16,794	33%
Achievable Cost Effective	3,907	8%
Industrial Sector		
Technical Potential	5,403	21%
Achievable Cost Effective	1,419	6%
Total - All Sectors		
Technical Potential	39,465	30%
Achievable Cost Effective	8,868	7%

Note: The five-year electricity savings potential estimate for Virginia is the average of Connecticut, Georgia, North Carolina, and Vermont, which are shown in Table 3-2.

Table 3-4 Electric Energy Savings Potential in Ten Years for Virginia

Level of Potential Savings	Cumulative Annual Savings Potential in Ten Years (GWh)	% of Ten-Year GWh Consumption Forecast
Residential Sector		
Technical Potential	17,268	34%
Achievable Cost Effective	7,732	15%
Commercial Sector		
Technical Potential	16,794	33%
Achievable Cost Effective	8,526	17%
Industrial Sector		
Technical Potential	5,403	21%
Achievable Cost Effective	3,097	12%
Total - All Sectors		
Technical Potential	39,465	30%
Achievable Cost Effective	19,355	14%

Note: The ten-year electricity savings potential estimate for Virginia is the average of Connecticut, Georgia, North Carolina, and Vermont, which are shown in Table 3-2.

In summary, if Virginia were to invest significantly in energy efficiency and conservation and to reach the 14 percent achievable cost effective savings level, it could defer or postpone the need for 5,495 megawatts of new electric generating capacity within ten years. Meeting this goal will require a combination of government, utility, non-profit, industry, and business efforts. Needed actions include:

- Financial incentives to utility customers.
- Marketing.
- Administration.
- Planning.
- Program evaluation and metrics.

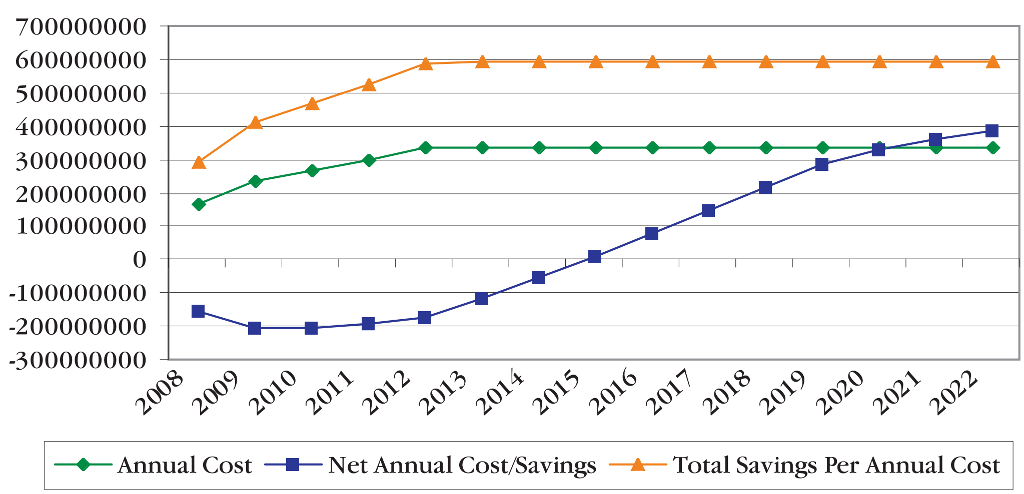
A January 2005 report from the American Council for an Energy Efficient Economy (ACEEE), based on research from leading energy-efficiency states, documents that a portfolio of electric energy-efficiency programs can save electricity at 3 cents per lifetime-kilowatt-hour-saved.[36] Using this figure, the present value of total costs to achieve Virginia's 14 percent electricity savings would be approximately $4.6 billion over ten years. The present value of program electricity savings would be approximately $13.8 billion.[37]

Legislation enacted in 2007 set a goal to reduce 2022 electric use by 10 percent of 2006 retail consumption through conservation and efficiency. Reaching the 10 percent goal would defer or postpone the need for approximately 3,900 megawatts of new electric generation capacity by 2022, equivalent to four or five large generation stations.

Virginia consumers would save in the range of $200 to $700 million (net savings after costs) through 2022 (average $15 to $50 million per year), depending on the value assigned to electricity savings. Consumers would receive substantial lifetime savings for their investments in efficiency. Total savings over the lives of the measures would range from $300 to $590 million for each yearly investment in energy-efficiency measures.

Achieving these savings would require a substantial up-front investment. Using the 3 cents cost per lifetime-kilowatt-hour-saved discussed above, utilities and consumers together would have to invest an average of approximately $300 million per year over the fifteen-year life of the program ($100 to $120 million by electric utilities, matched by $180 to $200 million by consumers). Consumers as a whole would see a net increase in costs because of the investments in efficiency over the first seven or eight years, followed by net savings over the next seven or eight years. These costs and savings are illustrated in Figure 3-3.

Figure 3-3 Costs and Savings from Electric Efficiency Programs



[36] ACEEE, "Examining the Potential for Energy Efficiency to Help Address the Natural Gas Crisis in the Midwest," ACEEE report UO51, January 2005, p. 33. The estimates for Virginia are extrapolations from other state studies. No specific cost and savings study has been completed for Virginia. Therefore, the projected costs and savings should be treated as rough estimates. See also the 2006 National Action Plan for Energy Efficiency.

[37] For example, according to the 2006 Annual Report to the Maine Legislature, Efficiency Maine programs saved 75 gigawatt-hours in fiscal year 2006, and the overall benefit/cost ratio for all Efficiency Maine programs in FY 2006 was 3 to 1.

3.5.2 Natural Gas Energy-Efficiency Potential

Table 3-5 presents the results of recent natural gas energy-efficiency potential studies for nine states, the Midwest, and the nation as a whole. The technical potential for natural gas savings ranged from 20 to 38 percent in the seven states for which that figure was calculated. An ACEEE study concluded that the national technical potential for gas energy efficiency is 41 percent of annual national gas sales.[38] The total achievable cost effective potential for natural gas savings ranged from 4 to 28 percent.

Table 3-5: Comparison of Potential Natural Gas Savings from Recent Studies in Other States

Percent of Total Natural Gas Sales										
Sector	California 2016 [1]	Utah 2013 [2]	Oregon & Washington 2013 [3]	New Mexico 2014 [4]	New York 2012 [5]	Georgia 2010 [6]	New Jersey 2020 [7]	Wisconsin 2015 [8]	Midwest 2015 [9]	National 2013 [10]
Technical Potential										
Residential	28%	46%	24%	62%		31%	46%			48%
Commercial	14%	29%	18%	17%		28%	15%			20%
Industrial	13%	-	5%	8%		4%	15%			
Total	***21%***	***38%***	***20%***	***36%***		***19%***	***32%***			***41%***
Achievable Cost Effective Potential										
Residential	4%	26%	5%	17%	27%	5%		3%	7%	9%
Commercial	3%	11%	5%	10%	33%	10%		3%	6%	8%
Industrial	4%		2%	6%	22%	5%		3%	7%	
Total	***4%***	***20%***	***5%***	***12%***	***28%***	***6%***	***9%***	***5%***	***7%***	***9%***
Incentive Level as a Percent of Incremental Cost										
¥Percentage	Average b/w 2004 incentives and full incremental cost	50%	100%	50%	50%	100%	80%			
£Page Source	pg ES-2		pg 2-4		5-16 : 5-24	pg 2-11	pg 2-7			

Notes

* Represents the year by which the percentage savings will be achieved.

¥ Reports the assumptions used in each study relating to the level of financial incentives paid to consumers who purchase high-efficiency equipment. In a few of the studies, more than one level of financial incentives was considered.

£ Indicates where the incentive-level assumption can be found in each study.

1. Itron et al. "California Energy Efficiency Potential Study," Vol. 1, May 2006. Achievable Cost Effective Potential is defined as a market potential scenario where incentives are the average between 2004 incentive levels and full measure cost
2. GDS Associates, Inc. "The Maximum Achievable Cost Effective Potential for Gas DSM in Utah for the Questar Gas Company Service Area" June 2004.
3. "Assessment of Long Term Electricity and Natural Gas Conservation Potential in Puget Sound Energy Service Area 2003-2024," prepared for Puget Sound Energy by KEMA-XENERGY/Quantec, August 2003. The published study is for twenty years. Numbers reported in this table are half of published numbers.
4. GDS Associates, Inc. "The Maximum Achievable Cost Effective Potential for Natural Gas Energy Efficiency in the Service Territory of PNM," May 2005.
5. Optimal Energy et al. "Natural Gas Energy Efficiency Resource Development Potential in New York State," October 2006.
6. Georgia Environmental Facilities Authority, "Assessment of Energy Efficiency Potential in Georgia - Final Report" prepared by ICF Consulting, May 5, 2005.
7 KEMA, Inc. "New Jersey Energy Efficiency and Distributed Generation Market Assessment," final report to Rutgers University Center for Energy, Economic and Environmental Policy, November 2004. Potential is calculated as Gas Savings in 2020 as a % of 2004 Sales.
8. Energy Center of Wisconsin. "Energy Efficiency & Customer-Sited Renewable Energy: Achievable Potential in Wisconsin: 2006-2015, November 2005. Wisconsin reported combined results for commercial and industrial sectors as C&I.
9. ACEEE. "Examining the Potential for Energy Efficiency to Help Address the Natural Gas Crisis in the Mid-West. Report UO51, January 2005.
10. ACEEE. " The Technical, Economic, and Achievable Potential for Energy Efficiency in the United States: A Meta-Analysis of Recent Studies." Proceedings from the 2004 Buildings Summer Study. August 2004.

[38] ACEEE, "The Technical, Economic, and Achievable Potential for Energy Efficiency in the United States: A Meta-Analysis of Recent Studies: Proceedings from the 2004 Buildings Summer Study," 2004.

Natural Gas Savings in Virginia in Five and Ten Years

Tables 3-6 and 3-7 present estimates of cumulative annual technical and achievable cost effective potential savings for Virginia in five and ten years for natural gas by sector. As no Virginia-specific study has been performed, the figures in these two tables were derived from results listed for seven of the studies in Table 3-5 (Utah, New Mexico, New Jersey, Oregon and Washington, Georgia, Wisconsin, and the Midwest).[39]

The cumulative annual technical savings potential for all sectors is estimated to be 64 trillion BTUs (MMBTUs).[40] The cumulative annual achievable cost effective savings potential is estimated to be 9.3 trillion BTUs in five years and 21.1 trillion BTUs in ten years. The savings numbers in the two tables represent the total natural gas savings across the entire fifth and tenth years, respectively, from the energy-efficiency measures examined in this study.

Table 3-6 Natural Gas Energy Savings Potential in Five Years for Virginia

Level of Potential Savings	Cumulative Annual Savings Potential in Five Years (MMBTUs)	% of Five-Year MMBTU Consumption Forecast
Residential Sector		
Technical Potential	41,107,818	42.0%
Achievable Cost Effective	4,502,900	5.0%
Commercial Sector		
Technical Potential	16,611,319	21.0%
Achievable Cost Effective	2,911,334	4.0%
Industrial Sector		
Technical Potential	6,072,901	6.0%
Achievable Cost Effective	1,862,611	2.0%
Total - All Sectors		
Technical Potential	63,792,039	22%
Achievable Cost Effective	9,276,845	3.5%

Note: The five-year natural gas savings potential estimate for Virginia is the average of of Utah, New Mexico, New Jersey, Oregon and Washington, Georgia, Wisconsin, and the Midwest, which are shown in Table 3-5.

Table 3-7 Natural Gas Energy Savings Potential in Ten Years for Virginia

Level of Potential Savings	Cumulative Annual Savings Potential in Ten Years (MMBTUs)	% of Ten-Year MMBTU Consumption Forecast
Residential Sector		
Technical Potential	41,107,818	42.0%
Achievable Cost Effective	9,787,576	10.0%
Commercial Sector		
Technical Potential	16,611,319	21.0%
Achievable Cost Effective	6,328,122	8.0%
Industrial Sector		
Technical Potential	6,072,901	6.0%
Achievable Cost Effective	5,060,751	5.0%
Total - All Sectors		
Technical Potential	63,792,039	22.2%
Achievable Cost Effective	21,176,448	7.4%

Note: The ten-year natural gas savings potential estimate for Virginia is the average of of Utah, New Mexico, New Jersey, Oregon and Washington, Georgia, Wisconsin, and the Midwest, which are shown in Table 3-5.

[39] The estimates for Virginia are extrapolations from other state studies. No specific cost and savings study has been completed for Virginia. Therefore, the projected costs and savings should be treated as rough estimates. The calculations omit the results of the studies from California and New York because they are significant outliers (either too low or too high).

[40] The 64 million MMBTU figure represents the full technical potential for cumulative annual natural gas savings if all technically feasible natural gas energy-efficiency measures were implemented. The estimates of cumulative annual MMBTU savings for the achievable cost effective potential represent what could be saved after screening measures for cost effectiveness, and after adjusting for consumer acceptance of energy-efficiency measures.

According to recent studies in other states, $1 invested in natural gas energy-efficiency programs results in approximately $3 of natural gas savings.

Transportation changes will have the largest effect on petroleum use in Virginia. Options to reduce energy use for transportation include reducing vehicle miles traveled and increasing fleet efficiencies.

[41]Federal Transit Administration, National Transit Database 2004.
[42]HDR/HLB Decision Economics, Inc., Virginia Department of Rail and Public Transit Benefit Cost Analysis, 1997.
[43]Environmental Protection Agency, Emission Facts (EPA420-F-05-001), 2005.

In summary, if Virginia were to invest in programs to reach achievable cost effective goals, natural gas reductions of approximately 7.4 percent, or 21.2 trillion BTUs, are predicted within ten years. At a current retail cost in Virginia in 2007 of $12.08 per thousand cubic feet, this would translate to retail savings for customers of $257 million annually. According to recent studies in other states, $1 invested in natural gas energy-efficiency programs results in approximately $3 of natural gas savings.

As with electricity efficiency and conservation, implementation of natural gas efficiency and conservation programs will require up-front investment by natural gas utilities and consumers to overcome barriers to consumer implementation. Natural gas ratemaking policies, such as those addressing rate decoupling, must be carefully crafted to provide both protection to consumers and adequate recovery of utilities' program costs and local distribution infrastructure costs.

3.5.3 Petroleum Energy-Efficiency Potential

Transportation changes will have the largest effect on petroleum use in Virginia. Options to reduce energy use for transportation include reducing vehicle miles traveled and increasing fleet efficiencies.

Vehicle miles traveled can be reduced through demand management, moving freight from truck to rail or barge, increasing use of mass transit and other alternatives to automobile use, and increasing use of high-occupancy vehicle and high-occupancy tolling lanes.

Transportation Demand Management - Using alternative methods (e.g., telecommuting, flex-time variable work schedule, ride-sharing, and car-sharing) for the daily commute.

Transportation demand-management programs can reduce fuel consumption by reducing automobile use and increasing occupancy of automobiles. A 2001 Department of Rail and Public Transportation study found that the average telecommuter in the Fredericksburg area made 2.86 fewer trips weekly than the average non-telecommuter. This resulted in an individual annual fuel savings of 486 gallons and a reduction in carbon dioxide emissions of 4.7 tons annually per individual.[41] As the number of people who telecommute increases, these benefits will grow. Flex-time variable work schedules allow employees to travel outside times of high congestion.

Hurdles to successful implementation of transportation demand-management programs include the lack of public and business training and education, competing funding priorities, user flexibility, and limited availability of broadband in some areas of the state. Additionally, some of these programs require initial large-scale investment and supporting infrastructure.

Secondary effects of telecommuting include expanded demand on the broadband infrastructure and more opportunities for midday trips. Ride- and car-sharing could result in decreased automobile ownership and use, reduced user mobility, and reduced carbon dioxide emissions.

Truck Freight to Rail or Barge - Moving freight from diesel trucks onto existing rail infrastructure or barge.[42]

The majority of Virginia's freight moves by trucks on the state highway system. However, it is more fuel efficient to move freight by rail than by truck; rail uses 0.002 gallons of fuel per ton-mile, compared with 0.0175 gallons for the average truck.

Virginia is working with other states and rail companies to develop the Heartland Corridor Project. This project is designed to create a double-decker rail freight line from Hampton Roads to the Midwest. When fully operational, it will remove approximately 150,000 trucks from highways annually and move the containers to rail. This will result in annual fuel savings of 7.6 million gallons of fuel and could potentially reduce carbon dioxide emissions by 84,360 tons annually.[43] The Heartland Corridor Project is receiving financial support through the Department of Rail and Public Transit's Rail

Public transportation consumes less fuel per passenger-mile than automobiles. In 2004, the average bus in the United States used a gallon of gasoline equivalent per 34.9 passenger-miles, whereas a single-occupant automobile uses a gallon of gasoline equivalent per 19.6 passenger-miles. In 2004, the Virginia Railway Express achieved even greater efficiency, with 74.3 passenger-miles per gallon of gasoline equivalent.

Enhancement Program, which has made energy efficiency an explicit goal.

Another potential project is the James River Barge Line. According to reports, a Hampton Roads maritime enterprise has asked the federal government for $500,000 to help initiate a project that would take some of the growing volume of cargo containers off I-64 and U.S. 460 between Hampton Roads and Richmond. Beginning as a weekly service, the line would move barges laden with containers and guided by tugboats about 80 miles up the James River to the Port of Richmond. The service would move at least 5,000 containers in the first year. By 2015, the goal is to transport about 250,000 containers annually with two large barges making trips twice a week.[44]

Other opportunities are being developed to move freight from truck to rail. For example, the Department of Rail and Public Transportation is completing a 2007 study of the feasibility and cost of diverting I-81 freight from truck to rail.

Virginia provided for substantial new investment in rail under the 2007 transportation package. The statewide funding package includes $13 million per year in new funding for the Rail Enhancement Fund.

Hurdles associated with moving truck freight to rail include additional capital investment and infrastructure (including capacity of existing rail corridors, facilities, routes, and rolling stock and equipment), reliability, timeliness and predictability of service, funding priorities, and business perceptions.

Increased freight traffic could cause conflicts with existing passenger rail service because of limited rail capacity.

Secondary effects of moving truck freight to rail include reducing roadway congestion, reducing accidents (accident rates per ton-mile are considerably lower for rail than for trucks), and reducing heavy-truck roadway damage. There is a potential for additional reduction in emissions from converting locomotives to a clean-burning fuel. An increase in the amount of freight moved by rail could displace jobs in the trucking industry and could disrupt passenger rail service because of additional freight rail traffic.

Transit - Improved public transportation for citizens

Virginia is home to fifty-six bus, subway, intercity rail (AMTRAK), and commuter rail (Virginia Railway Express) systems. There is one proposed light rail system, in Norfolk.

Public transportation consumes less fuel per passenger-mile than automobiles. In 2004, the average bus in the United States used a gallon of gasoline equivalent per 34.9 passenger-miles, whereas a single-occupant automobile uses a gallon of gasoline equivalent per 19.6 passenger-miles.[45] In 2004, the Virginia Railway Express achieved even greater efficiency, with 74.3 passenger-miles per gallon of gasoline equivalent.

The average automobile releases 989.8 pounds of carbon dioxide for each 1,000 passenger miles, compared with 555.9 pounds for the average bus and 261.1 pounds for rail.[46] Promoting the use of public transportation will reduce greenhouse gas emissions and lead to improved air quality.

Virginia's 2007 transportation package included a substantial increase in funds to be used for public transit improvements. The statewide package included $60 million funding for transit system capital improvements and $45 million for transit system operations. A substantial amount of the regional transportation funding in the 2007 package also will be allocated to public transportation. For example, Alexandria, Falls Church, and Arlington will use 50 percent of their new revenues on public transportation. The Washington Metropolitan Area Transit Authority and Virginia Railway Express may receive additional funds if revenue raised under the Northern Virginia Transportation Authority exceeds that needed to pay debt service on transportation bonds.

Hurdles to transit use in Virginia include low-density land-development patterns that leave public transit unavailable to many, high capital and operating costs of

[44] "Barge project appears feasible: Hampton Roads firm seeks money to set up service to Richmond," Richmond Times Dispatch, May 8, 2007.
[45] Federal Transit Administration, National Transit Database, 2004.
[46] Environmental Protection Agency, Emission Facts (EPA420-F-05-001), 2005.

Walking and bicycling are the most fuel-efficient forms of transportation. If more people regularly walked and cycled, fuel would be saved, air pollution would be reduced, and less energy would be needed to create, operate, and maintain roadway lane miles and parking facilities.

transit systems, public perception that transit is a lower-quality source of travel, limited frequency of service, funding priorities, and capacity constraints if transit use increases quickly. Increased passenger rail service could cause conflicts with freight traffic in corridors with limited rail capacity.

Secondary effects of transit improvements include potential reduction of roadway congestion, reduction of the number of new lane miles necessary, and possible reduction of highway maintenance expenditures.

Alternative Modes - Using low-fuel methods such as bicycling, walking, or small electric vehicles for individual daily commutes.

Walking and bicycling are the most fuel-efficient forms of transportation. If more people regularly walked and cycled, fuel would be saved, air pollution would be reduced, and less energy would be needed to create, operate, and maintain roadway lane miles and parking facilities. In 2004, the Commonwealth Transportation Board adopted a policy to promote the provision of bicycle and pedestrian accommodations (Policy for Integrating Bicycle and Pedestrian Accommodations).

Significant hurdles stand in the way of increased use of alternate transportation modes. Current low-density land-development patterns discourage nonmotorized transportation by separating residential areas from workplaces, shopping, and other attractions. Walking and bicycling are often perceived by the public as auxiliary activities rather than viable travel modes. Citizens repeatedly cite the lack of safe, convenient facilities for walking and cycling as obstacles to increased use of these modes.

Provision of safe and accessible facilities as well as more compact land use would promote walking and bicycling as viable transportation modes. In many European countries, at least 25 percent of urban trips are by walking or cycling, and in a few countries (e.g., Denmark and The Netherlands), more than 40 percent of these trips are nonmotorized.[47]

High-Occupancy Vehicle (HOV) and High-Occupancy Toll (HOT) Lanes

High-occupancy vehicle (HOV) and high-occupancy toll (HOT) lanes provide the driving public with a new choice: premium and predictable travel conditions on corridors where conditions are otherwise congested. At the same time, they maximize the use of managed lanes (including HOV lanes) without causing traffic service to fall below desired levels.[48]

Traffic volumes on HOT lanes are managed to ensure superior, consistent, and reliable travel times, particularly during peak travel periods. HOT lanes allow HOV and paying non-HOV motorists to travel at higher speeds than vehicles on congested general-purpose lanes. The addition of HOT options to an existing HOV facility may provide traffic-service improvements on congested general-purpose highway lanes. These improvements also have the potential to draw vehicles off other parallel routes and improve traffic efficiency in the corridor. HOT lanes may provide an opportunity to improve the efficiency of existing HOV lanes by filling available "excess capacity" that otherwise would not be used.

Energy savings can be realized through HOV and HOT lanes in several ways. Vehicles operating at constant speeds are more fuel efficient than those traveling in stop-and-go traffic. Secondly, as more riders share vehicles, less energy is used to transport the same number of people. The average vehicle occupancy in the HOV 3+ lanes on the I-95 corridor is 2.54 compared with 1.04 for the general-purpose lanes. The average HOV commuter in those lanes uses only 42 percent of the fuel required to transport a single passenger in the general-purpose lanes.

An important factor in the success of an HOV system is the favorable travel times for drivers in the HOV lanes as compared with those in the general-purpose lanes. In northern Virginia, recent traffic counts document the considerable time savings from use of HOV lanes (see Table 3-8).

[47]Pucher and Dijstra, "Making Walking and Cycling Safer: Lessons from Europe," Transportation Quarterly, 2000.
[48]U.S. Department of Transportation, Federal Highway Administration, "A Guide for HOT Lane Development," March 2003.

Table 3-8 Travel Times for Northern Virginia Drivers in HOV Lanes vs. General-Purpose Lanes

Type of Lane	Route Traveled		
	I-95/395	I-66	Dulles Toll Road
General-purpose	58 min.	69 min.	56 min.
HOV	27 min.	41 min.	31 min.

Fixing a serious maintenance problem, such as a faulty oxygen sensor, can improve mileage by as much as 40 percent.

For every 5-mph decrease on the highway, a typical driver will save 5 percent in fuel.

HOT lanes can provide an additional source of revenue to support transportation improvements such as additional transit service and construction and operation of additional lanes, or to address corridor transit needs or other local demand-management strategies. Some transportation improvements might not be possible without the additional revenue provided by HOT lanes.

With the proposed HOT lanes, bus service on I-95 and 495 would be able to use the new lanes. HOT-lane revenues could be used to double bus service on I-95 and provide the first-ever bus service on the Beltway.

Hurdles to increased HOV and HOT lane use include the substantial capital needs and construction disruption for new lanes.

Increasing transportation efficiency can be accomplished by increasing fleet efficiencies and improving driver habits.

Increasing Fleet Efficiencies

Individuals and businesses should look carefully at fuel efficiency when selecting vehicles and equipment. There are many fuel-efficient options that will meet transportation needs. Consumers should look for higher-efficiency vehicles, hybrid gas-electric vehicles, flex-fuel vehicles that can use gasoline or E85, and new clean-burning diesel vehicles. Virginia should look at opportunities to promote use of new vehicle technologies such as plug-in hybrids.

Savings to consumers can be substantial. Driving a vehicle 12,000 miles per year at 38 miles per gallon versus 28 miles per gallon, at $2.50 per gallon, saves 113 gallons of gasoline and $282.50 per year. This is a 26 percent reduction in gasoline use. Using a very efficient vehicle such as a hybrid electric at 50 miles per gallon would increase savings to 189 gallons and $472.50, a 44 percent decrease in gasoline use. If you own your car for seven years, you would save 791 gallons of gasoline and $1,977.50. Over the seventeen-year average life of a car, this totals a savings of over 1,900 gallons of gasoline and over $4,800 for the energy-efficient car. This would save over 3,200 gallons and $8,000 for the hybrid electric car, equivalent to being rebated almost one-third of the cost of a hybrid car.

Overall fleet efficiencies also can be improved through increasing the Corporate Average Fuel Efficiency (CAFE) standards.

Driving Habits

Vehicle owners should keep vehicles properly maintained. The most important maintenance practices include keeping tire pressures at recommended levels and keeping vehicles properly tuned up. Fixing a car that is noticeably out of tune or has failed an emissions test can improve its gas mileage by an average of 4 percent, though results vary based on the kind of repair and how well it is done. Fixing a serious maintenance problem, such as a faulty oxygen sensor, can improve mileage by as much as 40 percent. More information is available through the Commonwealth's Driver Education Core Curriculum.

Virginians should drive smart to save fuel. Steady acceleration and deceleration, using cruise control, and slowing down can significantly increase fleet efficiencies. Studies show a 5 to 15 percent savings can be achieved by reducing highway speeds 10 miles per hour and by using cruise control. Tests of aggressive verses calm driving in cities show up to 25 percent savings using best driving practices. For every 5-mph decrease on the highway, a typical driver will save 5 percent in fuel.

Drivers also can plan trips to combine stops. This reduces the total number of trips and reduces vehicle miles traveled and energy use.

For every 5 percent per year reduction in gasoline use in Virginia, we would save 260 million gallons of gasoline, save more than $500 million, and reduce carbon dioxide emissions by nearly 2 million tons per year, or approximately 1.5 percent of Virginia's total carbon emissions.

In 2001 the United States recycled only 5.5 percent of discarded plastics products, compared with 57 percent in Germany.[50] If the United States could achieve the plastics recycling rate of Germany, it could save 600,000 barrels of petroleum a day.[51]

Other Fuel Oil Savings

In 2006, the American Council for an Energy Efficient Economy (ACEEE) completed a study of the technical and achievable potential for saving fuel oil with energy-efficiency measures and practices.[49] The study examined numerous technologies that can save oil in the buildings sector and reported that an aggressive program of energy efficiency could reduce fuel oil consumption nationally 13 percent by 2015 and 21 percent by 2020.

Increased recycling of plastic products also presents significant opportunities for reducing petroleum use. In 2001 the United States recycled only 5.5 percent of discarded plastics products, compared with 57 percent in Germany.[50] If the United States could achieve the plastics recycling rate of Germany, it could save 600,000 barrels of petroleum a day.[51]

3.5.4 Energy Conservation for Low-Income Virginians

The number of Virginia families living in poverty has increased to 795,000 as of mid-2007. More than 370,000 of these households have incomes at or below 130 percent of the federal poverty level and are eligible for low-income energy assistance. These low-income Virginians pay a higher percentage of their income for energy than other Virginians. With little to no discretionary income, they are seriously affected by energy-cost increases. The state operates two programs to assist them.

The Weatherization Assistance Program funds improvements to eligible households, including repairing and replacing heating and cooling equipment, sealing air leaks, and insulating buildings, ducts, and hot water heaters. The average expenditure per home is about $2,800. Approximately 2,000 homes are weatherized each year. Evaluation of the program shows that weatherization can reduce heating and cooling bills by 30 percent or more. In Virginia, participating household energy costs are reduced by approximately $300 per year.

The program targets households that include the elderly, individuals with disabilities, or children, and those households receiving assistance from the Department of Social Services. Because of the need to maintain crews and equipment, this program works most efficiently with a stable flow of funds from year to year; it does not readily react to one-time infusions.

The Low-Income Home Energy Assistance Program (LIHEAP), administered by the Virginia Department of Social Services, helps low-income Virginians-particularly those with the lowest incomes that pay a high proportion of household income for home energy-pay their energy bills. The program also provides crisis assistance and cooling assistance funding. The average recipient household receives $250 through this program, which typically covers about 25 percent of winter energy costs. Approximately 60 percent of households served by this program have annual family incomes of less than $10,000, well below the federal poverty level. These families have little room in their budgets to absorb even modest increases in energy costs, making the need for energy-assistance services even more critical than in previous years. Without increased appropriations, LIHEAP will cover a smaller percentage of households' winter energy costs as energy costs rise, or alternatively will have to further restrict the number of families it can serve.

[49]ACEEE, "Reducing Oil Use Through Energy Efficiency, Opportunities Beyond Cars and Light Trucks," ACEEE report E061, January 2006.
[50]Amory B. Lovins, E. Kyle Datta, Odd-Even Bustnes, Jonathan G. Koomey, and Nathan J. Glasgow, Winning the Oil Endgame: Innovation for Profits, Jobs, and Security (Snowmass, CO: Rocky Mountain Institute, 2004), p. 95.
[51]Ibid.

Low-income Virginians pay a higher percentage of their income for energy than other Virginians. With little to no discretionary income, they are seriously affected by energy-cost increases.

Beginning in 2007, Virginia has put in place a sales-tax holiday for Energy Star products.

A portion of LIHEAP funding is transferred to the Weatherization Assistance Program to pay for energy-efficiency and conservation improvements to households receiving financial assistance.

Primary funding for the program comes from the federal Low-Income Home Energy Assistance Program grant. Virginia has provided additional funding to the program, both from the general fund and Temporary Assistance for Needy Families funds, during times of sharply rising energy costs. Electric and natural gas utilities and faith-based organizations also provide assistance to households that cannot pay their energy bills and face service shut-off.

In an effort to serve as many households as possible and coordinate services, the Virginia Department of Social Services partners with other major energy-assistance programs offered by state agencies and utilities such as Dominion's EnergyShare Program, American Electric Power's Neighbor to Neighbor Program, the Virginia Department for the Aging's Fan Care Program, the Department of Housing and Community Development's Weatherization Programs, and most recently, Citizens Energy Oil Heat Program.

Other states have implemented programs that reduce low-income consumers' energy costs. Examples include utility disconnect moratoriums, discounted rates, and waivers on reconnection fees.

3.5.5 Role of Incentives

Many states, energy-efficiency organizations, and electric and gas utilities offer financial incentives for consumers to purchase energy-efficient products. Beginning in 2007, Virginia has put in place a sales-tax holiday for Energy Star products. In many instances, a high-efficiency product costs more than a standard-efficiency product. The purpose of the incentive is to reduce or eliminate this extra cost. This is particularly important in Virginia because of its history of low electricity prices. Up-front transaction costs for businesses to convert or upgrade to energy-efficient equipment and the inability for customers to justify the cost of an energy-efficient purchase are primary barriers to making a large-scale transition to more efficient products. Tax incentives, grants, rebates, and energy-efficiency mortgages are all proven mechanisms that could be deployed in Virginia.

3.5.6 Role of Consumer Education

Recent market research has shown that lack of information about energy-efficient equipment and building practices is a major barrier that prevents consumers from practicing energy efficiency. Ensuring that Virginians have up-to-date and accurate information on energy-efficient equipment and practices will increase adoption and implementation of energy-efficiency and conservation measures on a large scale.

The National Action Plan for Energy Efficiency recognizes the importance of consumer education and addresses the need to communicate the benefits of and opportunities for energy efficiency. Programs need to document and market the benefits to:

- Customers - based on reduced energy bills, energy cost savings, and return on investment.
- Utilities - based on improved business health, including return on equity, earnings per share, and debt coverage ratios being unaffected.
- Policy makers - based on how a well-designed approach to energy efficiency can have significant societal benefits to the economy, environment, and energy security. Effort is also necessary to educate decision makers that although energy efficiency can be viewed as an important low-cost resource, it does require funding, just as a new supply-side infrastructure requires funding.

Consumers face many types of energy-efficiency and conservation advertising. The federal government provides the Energy Star label. Some states provide a state energy-efficiency or green-product label. Appliances are required to have the yellow Energy Guide label. Many commercial companies provide their own energy labeling system, and make energy-efficiency or savings claims for their products. While many of these claims are verifiable, the Federal Trade Commission and consumer watchdogs have found others to be false (in part because some companies report only best-case projections). These many advertising sources often confuse and overwhelm consumers. In short, there is no single, unbiased source of energy-product labeling-similar to the Underwriters Laboratory (UL) seal for safety-on which consumers can rely.

There should be a uniform energy-efficiency brand label for all types of products and materials.

There should be a uniform energy-efficiency brand label for all types of products and materials. Virginia should support a national program to extend the Energy Star label beyond appliances, office equipment, and buildings. If this cannot be accomplished, Virginia could help establish and support an independently administered, multistate branding effort that verifies efficiency and an extensive advertising campaign to build brand recognition.

Any consumer-education program should also provide information consumers need to avoid energy-related scams. This consumer-education activity should be coordinated with the consumer protection programs at the Department of Agriculture and Consumer Services and Office of the Attorney General.

Providing home owners, renters, and businesses with energy audits should be part of a consumer energy-education program. Both electronic and field audits, with proper quality control over recommendations, should be provided to help consumers identify cost-effective opportunities to reduce energy use in their homes and businesses.

3.5.7 Role of State Government - Leading by Example

A firm commitment to improving the energy efficiency of state government will show that the state can lead by example.

Substantial potential exists for saving energy in government sector operations. A firm commitment to improving the energy efficiency of state government will show that the state can lead by example. Lastly, reducing energy consumption will help improve the state's environmental quality.

Energy is one of several cross-cutting areas determined to have a significant impact on the cost of state government. Operational reviews of these areas have focused on implementing best management practices across state government in order to capture the full potential of increased efficiency. A team of decision makers and subject-matter experts from the Commonwealth of Virginia and private industry worked together with members of the General Assembly to conduct the review and provide a final analysis of recommendations. The review assessed energy best practices being used by private business, Virginia agencies, other states, the federal government, and the provisions of state energy management Executive Order 48 (2007) issued by Governor Kaine.

Executive Order 48, Energy Efficiency in State Government, incorporates several operational review best practices. These include requiring an Agency Energy Manager for those agencies with energy costs exceeding $1 million; design and construction consistent with the energy performance standards of the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system or the federal Energy Star rating; maximizing the use of biodiesel and ethanol in state fleet vehicles; leasing space within a quarter-mile of a bus, trolley, Metro, or commuter rail stop; and purchasing Energy Star-rated appliances.

Additional best practices in state government operations focus on the following areas.

- **Centralized energy procurement.** At present each agency procures energy and energy-related services by issuing a purchase order using a statewide contract. With natural gas, the contract allows the use of various hedging mechanisms, including storage, futures, and cap and slide. Because each agency is procuring a relatively small quantity of gas, it can only spend a limited amount of time procuring gas and often does not get the best deal. When larger blocks of energy are procured, the decision to buy must be approved by a committee that may not meet for several days, sometimes missing the opportunity to lock in the best price. With centralized procurement, a specialist could develop and implement a procurement plan whereby all agencies could meet their budget requirements, lower their risk, ensure adequate supply, and get the best deal possible. Purchasing in blocks of 10,000 decatherms would offer additional savings that are not available to agencies under the present structure.

- **Building energy audits and upgrades through performance contracting.** State agencies could benefit from a building energy audit program that provides a consistent benchmark for evaluating facilities. These audits could identify low-cost savings opportunities that would lead to immediate savings. Agencies would use the audit to determine where to spend energy-efficiency dollars to gain the greatest savings. Audits would provide justification for building and equipment upgrades. State agencies could then issue requests for proposals for installation and servicing of high-efficiency equipment. The cost of the equipment and its installation could be paid through savings on future energy bills.
- **Placing a priority on energy management, and establishing a best practice center to set and initiate actions and initiatives.** Developing consistent standards and practices for state agencies is key to implementing best practices statewide. Virginia could establish a Virginia Energy Management Program using a model similar to that of the Federal Energy Management Program.
- **Building commissioning/recommissioning.** The largest opportunity for energy savings is in the inventory of state-owned buildings. Commissioning is equivalent to a building "tune-up" in which equipment and systems are evaluated, cleaned, and adjusted to restore to peak performance. Studies have shown that the payback to commission an existing building can be as low as 8.4 months.

3.6 Emerging Energy-Efficiency Technologies and Practices

Several energy-efficient products on the horizon should contribute even greater energy-savings potential as they are integrated into the current market. In this Plan, "emerging technologies" refer to those measures that are either not yet commercially available or that are available but have penetrated only a small percentage of the marketplace. Examples include light-emitting diode (LED) lighting, microgeneration systems, and cool roofs.

According to a U.S. Department of Energy study, by 2020 solid-state lighting devices such as LEDs could cut electricity used for illumination by 50 percent.

According to a U.S. Department of Energy study, by 2020 solid-state lighting devices such as LEDs could cut electricity used for illumination by 50 percent. Current market penetration of LEDs is small, but commercial availability should increase substantially in the near future.[52]

Cogeneration systems in the residential sector can produce both useful thermal energy and electricity from a single source of fuel such as oil or natural gas. This complete system is more than 85 percent efficient in converting fuel energy into useful heat and electric power. Residential-scale cogeneration technologies are still in their infancy, and the potential for energy and emissions savings is yet to be firmly established.

Cool roofs consist of materials that reflect the sun's energy from the roof surface, reducing its temperature by up to 100°F and thereby reducing the heat transferred into the building below.[53]

Snap Duct technology is a system of mechanically fastened fittings for flex and hard ducts that snap together to create a long-lasting seal. Testing shows that these fittings can eliminate about 90 percent of the leakage within a duct system, saving up to 21 percent of a heating, ventilating, and air conditioning system's annual energy output.[54]

Networked computer management software, though commercially available, still faces both technical and human interface

[52]David Pescovitz, "LED There Be Light," Berkeley Engineering Lab Notes vol. 2 (8), 2002.
[53]Consumer Energy Center, "Cool Roofs," accessed April 2006 at www.consumerenergycenter.org.
[54]ACEEE, "Emerging Energy-Saving Technologies and Practices for the Buildings Sector," ACEEE report AO42, October 2004.

problems. Companies often disable the energy-efficient controls because of network security concerns. When used appropriately, this software can work with security protocols and save up to 40 percent of a terminal's annual output.[55]

Innovative techniques, technologies, and practices are also penetrating the utility marketplace. New demand-control technologies can be combined with practices such as demand-response programs, time-of-use rates, load aggregating, and curtailment. Demand response and time-of-use rates are designed to reward customers who reduce energy consumption when demand for electricity is high. Rate decoupling allows utilities to adequately capture fixed cost of service without being incentivized to sell more units of energy. Load aggregating promotes economies of scale and allows a group of small customers to purchase as a single entity with increased buying power. Consolidating peaks, improving load factor, and curtailing block load are options that can improve system efficiencies and reduce costs.

Water and materials recycling are integral to the energy equation. Considerable energy goes into treating water to potable quality only to have it used for irrigation or cooling. Collecting and using gray water for purposes such as flushing toilets or for industrial inputs are growing practices. Large amounts of energy can be saved by recycling and reusing materials instead of using virgin products.

Considerable energy goes into treating water to potable quality only to have it used for irrigation or cooling. Collecting and using gray water for purposes such as flushing toilets or for industrial inputs are growing practices.

[55]Ibid.

Chapter 4

Energy Infrastructure

4.0 Energy Infrastructure

A robust infrastructure is needed to deliver affordable, reliable energy supplies. Virginia's energy infrastructure (see Figure 4-1) includes facilities required for:

- Electricity generation, transmission, and distribution.
- Natural gas supply, transmission, and storage.
- Petroleum production, refining, transportation, and distribution.
- Coal mining, transportation, and export.
- Propane supply, transportation, and distribution.
- Wood/biomass supply and transportation.

The electric infrastructure is the most widespread energy system in the state.

Figure 4-1 Virginia's Energy Infrastructure

Emerging infrastructure issues and opportunities include the need for new electrical transmission and generation, natural gas pipeline improvements, utility-scale wind siting, alternative fuels production, and uranium mining.

The electric infrastructure is the most widespread energy system in the state. PJM, the power pool of which Virginia is a member, reports that the electric supply infrastructure in northern Virginia will need to be expanded by 2011. Studies also show the need for additional electric-system capacity to serve the Tidewater region. Conservation and demand-control actions may delay the need for expansion, but they will not eliminate it. This Plan includes the goal to meet the need for electric generating capacity by adding over 2,300 megawatts of capacity.

Virginia's natural gas infrastructure supports a wide array of users. Although the infrastructure has been adequate, there have been constraints in south Hampton Roads, where several options have been proposed to increase infrastructure capacity. This includes construction of a third pipeline crossing the James River between north and south Hampton Roads and construction of new local distribution pipelines and peak storage facilities.

Virginia receives gasoline, diesel fuel, fuel oils, and aviation fuel from two petroleum-product pipelines originating in the Gulf of Mexico region, the oil refinery in Yorktown, and ship and barge deliveries to terminals on Virginia's coast. Virginia's alternative fuel production is currently limited to several small (generally 5 million gallons per year or less) biodiesel facilities.

Developers of large-capacity biofuel plants (100-million-gallon and greater range) have shown considerable interest in locating in Virginia because of the state's proximity to end-use fuel markets and feedstock potential (barley, switchgrass, agricultural waste, solid waste, and algae). Virginia is expected to have several such plants come on-line in the next five years. Advancing technologies for cellulosic, waste-to-fuel, and algae-based processes could set the stage for significant long-term growth of the alternatives fuels production industry in Virginia.

This Plan includes goals to increase the capacity of the petroleum refinery in Yorktown by 40,000 barrels per day (approximately a 45 percent increase) and to provide 300 million gallons per year of ethanol production and 120 million gallons per year of biofuels production. These increases would offset gasoline and diesel fuel imports needed to fuel 1.2 million of the state's cars and trucks per year.

Virginia relies on rail and highway infrastructure to transport coal. A congested and constrained rail system represents the biggest challenge, but road infrastructures for coal are generally adequate.

Siting of utility-scale wind turbines in Virginia has been a topic of much public debate, with a proposed land-based wind farm in Highland County having received the most attention. While the benefits of renewable energy are clear, there are environmental and community-related challenges. If environmental concerns can be overcome, the debate comes down to community acceptance. Virginia's biggest opportunity in this area lies in offshore wind (see Chapter 2).

Virginia's energy industries need a supply of trained workers to construct and maintain the state's energy infrastructure and provided needed energy supplies. Many energy industries need workers with specialized skills in areas such as power plant operations, mining, and propane delivery. Many energy industry workers also will be retiring during the ten-year term of this Plan.

The Virginia Community College System, working with area economic development organizations and businesses, can play a vital role in providing training to energy business workers. This may take the form of basic technical and work skills training and specialized training related to a particular energy industry. Examples include coal-miner training provided by Southwest Virginia and Mountain Empire Community Colleges and nuclear-industry training provided through the Center for Advanced Engineering and Research in Lynchburg. Colleges and universities also must train the next generation of engineers and scientists needed by the state's energy businesses. Efforts to develop vocational-training curricula should account for regional needs of energy providers. An example of such a program is the Kentucky Coal Academy's curriculum provided to coalfield high schools in Kentucky.

A significant challenge that faces the entire energy industry is preparedness and risk management. Virginia's energy industry must take steps to protect the state's energy infrastructure from natural and human-made disasters. This includes performing ongoing maintenance of facilities and rights-of-way, updating controls and infrastructure to replace aging equipment and facilities, and where needed, hardening existing facilities for protection. The industry must also make improvements to ensure the safety of the energy infrastructure. Particular emphasis should be placed on central facilities such as power plants, bulk fuel storage facilities, and transmission infrastructure. Virginia and federal public safety and homeland security agencies should maintain clear communication with energy providers to develop, test, and coordinate response plans to any risks or incidents.

State and local governments must also be diligent in preparing for energy emergencies. Emergency response requires a robust and uninterruptible energy supply. Installing generators at critical facilities designated for response or shelter is an important step in improving readiness and response. At a minimum, critical facilities should be retrofitted to facilitate hook-up of generators in a disaster. Historical evidence shows that many localities have contracts with fuel vendors that do not have the infrastructure or equipment to maintain supplies during times of disaster. State agencies and local governments should have both primary and back-up fuel contracts that will ensure fuel delivery during a disaster.

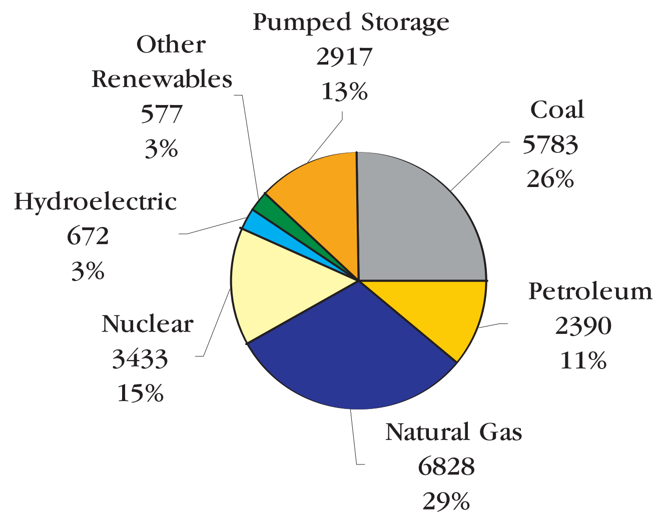
4.1 Electrical Generation, Transmission, and Distribution

4.1.1 Existing Generating Infrastructure

An understanding of how electric demand will grow is essential for resource planning. Virginia's investor-owned electric utilities will be required to file, coincident with their biennial rate filings before the State Corporation Commission, plans for projected generation and transmission requirements to serve their native load for the next ten years. These plans must show how the utilities will provide for and pay for the needed resources.

Virginia electric utilities operate electrical generating facilities throughout the state. Their total summer net generation capacity in 2005 was 22,599 megawatts, sixteenth highest among the fifty states.[56] (Texas ranked first, with 101,046 megawatts.) A large portion of Virginia's electric energy generation capacity comes from coal-fired and nuclear plants (26 and 15 percent, respectively). The electric utilities also operate several oil-fired, gas-fired, and hydroelectric generation facilities to supplement power from coal, nuclear units, and interstate power transfers when needed. Figure 4-2 shows Virginia's electric generating capability (in megawatts) by fuel type for the year 2005.[57] Table 4-1 lists the state's ten largest electric generating plants in 2005.[58] The largest one is a pumped storage plant in Bath County.

Figure 4-2 Virginia Electric Generating Capability (MW) by Fuel Type, 2005



[56]U.S. Department of Energy, Energy Information Administration (EIA), Individual State Electricity Profiles (www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html).
[57]EIA, State Electricity Profiles-Virginia, Table 4: Electric Power Industry Capability by Primary Energy Source, 1990 through 2005 (www.eia.doe.gov/cneaf/electricity/st_profiles/sept04va.xls).
[58]EIA, State Electricity Profiles-Virginia, Table 2: Ten Largest Plants by Generating Capability, 2004 (www.eia.doe.gov/cneaf/electricity/st_profiles/sept02va.xls).

Table 4-1 Ten Largest Plants in Virginia by Generating Capability, 2005

Plant	Energy Sources	Operating Company	Net Summer Capability (MW)
1. Bath County	Pumped Storage	Dominion Virginia Power	2,679
2. North Anna	Nuclear	Dominion Virginia Power	1,835
3. Possum Point	Gas	Dominion Virginia Power	1,706
4. Chesterfield	Coal	Dominion Virginia Power	1,631
5. Surry	Nuclear	Dominion Virginia Power	1,598
6. Yorktown	Coal	Dominion Virginia Power	1,141
7. Tenaska Virginia Generating Station	Gas	Tenaska Virginia Partners LP	910
8. Clover	Coal	Dominion Virginia Power	865
9. Doswell Energy Center	Gas	Doswell Ltd Partnership	820
10. Chesapeake	Coal	Dominion Virginia Power	710

Virginia's demand for electricity varies on both a daily and seasonal basis. The large coal-fired and nuclear generators, as well as some of the hydroelectric plants, serve the base load, while oil and gas-fired electric generation plants generally operate to produce power during periods of high electricity demand.

The state's two major electric utilities provide the largest part of state electric supply from coal-fired power plants. American Electric Power operates the Clinch River plant in Russell County and the Glen Lyn plant on the New River in Giles County, near the West Virginia border. Dominion operates nine coal-fired plants in eastern Virginia, including the Clover plant on the Roanoke River in Halifax County. Owned in partnership with Old Dominion Electric Cooperative, this is among the nation's newest and most modern coal-fired generating plants.

Virginia has two large commercial nuclear power plants, North Anna in Louisa County and Surry in Surry County. Dominion built and operates both plants. North Anna consists of two reactors that came on-line in 1978 and 1980 and are capable of producing a total of 1,842 megawatts of electricity. Surry consists of two reactors that came on-line in 1972 and 1973 and are capable of producing a total of 1,598 megawatts.

Virginia's demand for electricity varies on both a daily and seasonal basis. The large coal-fired and nuclear generators, as well as some of the hydroelectric plants, serve the base load, while oil and gas-fired electric generation plants generally operate to produce power during periods of high electricity demand.

4.1.2 Adequacy of Electric Generation Infrastructure

Virginia imports approximately 29 percent of its electrical requirements and has experienced rapid load growth over the past ten years. According to the trend forecast of 1.85 percent growth per year, demand will increase 6,568 megawatts over the next decade (see Table 4-2).[59,60] Note that the need for new generation capacity may be reduced by successful conservation and efficiency (Chapter 3).

[59]The latest PJM electric summer peak demand forecast for the Dominion load zone shows a similar projected annual growth rate, 1.88% per year for the 2006-2016 time period. See Section 5.0 of the PJM 2007 Regional Transmission Expansion Plan, Figure 5-3.
[60]The electric load forecast for Virginia presented in this table was developed by GDS Associates and is described in more detail in Chapter 2.

Virginia enacted a voluntary renewable portfolio standard in its 2007 electric utility regulation legislation.[63] This calls for Virginia's participating investor-owned electric utilities to generate 4 percent or more of their electricity from renewable sources by 2012, 7 percent or more by 2017, and 12 percent or more by 2022.

Table 4-2 Forecast of Peak Electric Demand in Virginia

Year	Base Case Forecast for Peak Electric Demand in Virginia (MW)	Cumulative Growth in MW Demand From 2005 Base Year	Virginia Capacity Needed to Maintain Current Electricity Imports Ratio of 29.4%
2005	32,026	0	22,599
2006	32,683	657	23,063
2007	33,340	1,314	23,526
2008	33,997	1,971	23,990
2009	34,653	2,627	24,453
2010	35,310	3,284	24,916
2011	35,967	3,941	25,380
2012	36,623	4,597	25,843
2013	37,280	5,254	26,307
2014	37,937	5,911	26,770
2015	38,594	6,568	27,233
2016	39,250	7,224	27,697
Source: GDS Associates, Inc. , June 2007			

Significant demand growth has occurred in northern Virginia, where the population has increased by 66 percent since 1990. Loudoun and Prince William Counties consistently rank among the fastest growing counties in the United States.[61] Virginia consequently faces a growing gap between population growth in certain regions and available electricity to serve those regions. Electric demand in northern Virginia is expected to increase by approximately 2 percent a year, requiring an additional 4,000 megawatts of supply over the next decade.[62] Because of the limited ability to build new central power plants in this region, the most probable solution is a combination of conservation and efficiency, distributed generation, and new transmission.

Some of this capacity could be met with new renewable energy (see Chapter 2). Virginia enacted a voluntary renewable portfolio standard in its 2007 electric utility regulation legislation.[63] This calls for Virginia's participating investor-owned electric utilities to generate 4 percent or more of their electricity from renewable sources by 2012, 7 percent or more by 2017, and 12 percent or more by 2022. Meeting this would require generating more than 7.75 million megawatt-hours of power from renewable sources. Dominion, American Electric Power, and private developers are working on plans to develop new renewable-power generation.

Some of these renewable projects and other distributed generation can be located in built-up areas, closer to electric loads. This can reduce the need for new long-distance electric transmission.

Virginia has established a target of meeting 10 percent of its 2006 electric demands through conservation by 2022. Prorating this target over the next ten years, the state should be able to meet 6 to 7 percent of this goal, or nearly 1,500 megawatts, by 2016.

4.1.3 Planned Electric Generation Facilities

Several electric generation plants are being planned or considered for construction in Virginia (see Table 4-3). The largest is the nuclear reactor at the North Anna power station. Dominion has already requested an early site permit for two new reactors at the site. The Nuclear Regulatory Commission (NRC) held public hearings on the application for the permit

[61]Dominion Power, "Dominion: Meeting Northern Virginia's Growing Demand for Electricity," 2007 (www.dom.com/about/elec-transmission/powerline/meadowbrook/ppt/newline.ppt).
[62]C. Flores, "Dominion Searches for Ways to Meet Demand," Daily Press [Newport News, VA], January 16, 2007.
[63]See chapters 933 and 888 of the 2007 Virginia Acts of Assembly (http://leg1.state.va.us).

in April 2007. While the NRC had not issued the permit as of June 2007, it has issued its final environmental impact statement, which stated that construction would have minimal adverse effect on land use, air quality, and the local ecology. The NRC is expected to decide whether to issue the early site permit later in 2007.

Dominion has selected a reclaimed surface coal mine in Wise County as a site for a new coal-fired power plant. The Virginia City Hybrid Energy Center is projected to be operational by 2012, with an estimated capacity of 585 megawatts. If constructed, the station will use Virginia coal, coal waste, and biomass in an advanced circulating fluidized bed boiler. The site has adequate local fuel and water supplies, available electrical transmission, and is expected to have minimal environmental impact.[64] Dominion officials say it would bring $3.5 to $4 million in tax revenue per year and would create more than 1,000 construction jobs, 250 mining jobs, and 75 to 100 permanent jobs at the plant. Dominion hopes to start construction in 2008 but still needs several permit approvals.[65]

Competitive Power Ventures of Silver Springs, Maryland, plans to construct a new natural gas-fired electric power plant in Warren County. The firm received a certificate from the State Corporation Commission (SCC) in 2003 and a permit from the Department of Environmental Quality in 2004. Competitive Power Ventures said the plant will pay about $1.9 million per year in property taxes to Warren County and will employ twenty people with an average annual salary of $55,000.[66]

Highland New Wind Development has announced plans to construct twenty-two wind towers west of Monterey. More information on the project is provided below in Section 4.7, Renewable Energy Infrastructure-Wind Power.

Dominion filed an application with the SCC on April 19, 2007, to install two gas-/oil-fired turbine generators at its existing Ladysmith power plant in Caroline County. If approved, the two 150-megawatt peak power units are expected to be in operation by August 2008.

American Electric Power plans to develop two Integrated Gasification Combined Cycle (IGCC) power plants, with a total capacity of about 1,200 megawatts, in West Virginia and Ohio. Some of this power would serve Appalachian Power customers in Virginia.

Virginia has established a target of meeting 10 percent of its 2006 electric demands through conservation by 2022. Prorating this target over the next ten years, the state should be able to meet 6 to 7 percent of this goal, or nearly 1,500 megawatts, by 2016.

Table 4-3 Electric Generation Facilities Planned in Virginia

Owner Name	Plant Name	Unit	County in Virginia	Primary Fuel	Nameplate Capacity (MW)	Estimated Commercial Online Date
Feasibility Stage (Planned new generator undergoing feasibility study)						
Hydro Matrix LP	Flannagan Hydroelectric Project	1	Dickenson	Water	5	Not available
Virginia Electric & Power	North Anna	NB3	Louisa	Uranium	917	January 1, 2050
Proposed (New generator planned for installation)						
Ameresco, Inc.	Rappahannock Landfill Project	IC1 2	Stafford	Landfill gas	2.14	December 31, 2007
Fauquier Landfill Gas LLC	Fauquier Landfill	IC3	Fauquier	Landfill gas	1	Not available
Virginia Electric & Power	Virginia City Hybrid Energy Center	ST1	Wise	Coal	500	June 1, 2012
Application Pending (Application filed for permits, regulatory approval pending)						
CPV Warren LLC	CPV Warren Power Generating	CC1	Warren	Natural Gas	520	June 1, 2010
Highland New Wind Development LLC	Highland County Wind	WT1 19	Highland	Wind	38	December 31, 2008
Virginia Electric & Power	Ladysmith Generation Facility		Caroline	Natural Gas/Fuel Oil	300	August 2008

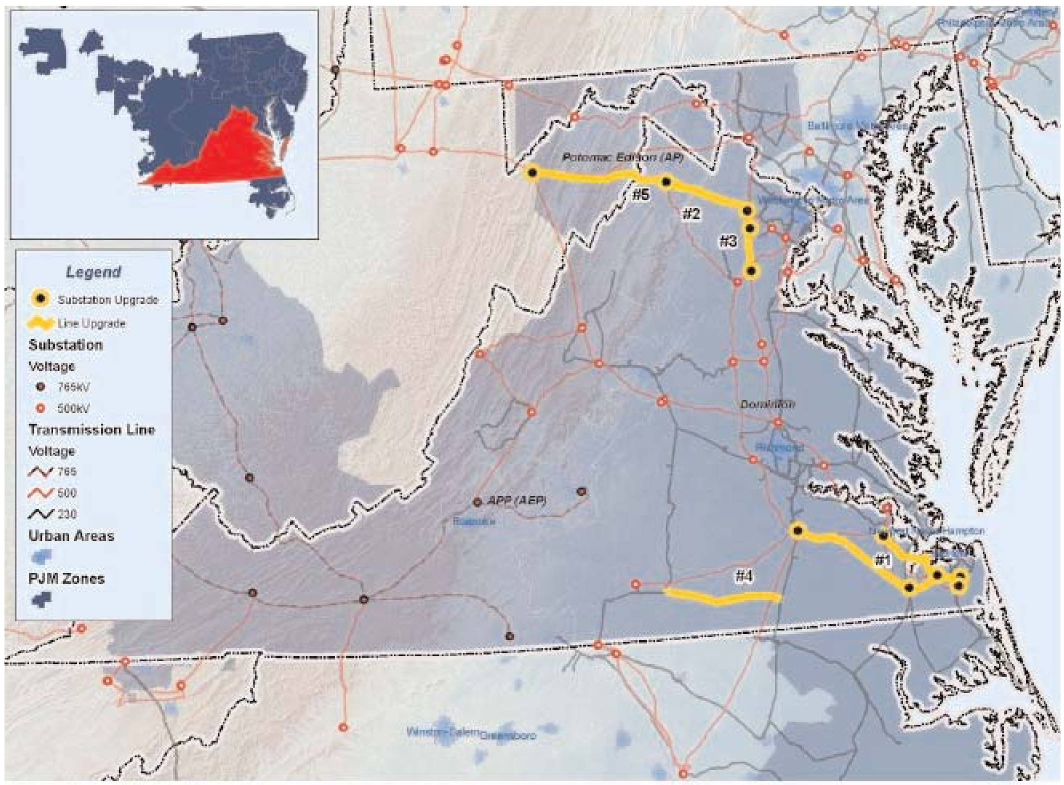
[64]"Wise County Site Chosen for Final Evaluation of Future Clean Coal Power Station in Virginia," Dominion Electric Power Company, news release, May 11, 2006 (www.dom.com/news/elec2006/pr0511.jsp).
[65]Bristol Herald Courier, March 27, 2007.
[66]Greg Edwards, "Gas-fired power plant for Warren Co.," Richmond Times Dispatch, March 15, 2007.

4.1.4 Existing Electric Transmission System

Electric power is distributed in Virginia through 500- and 765-kilovolt transmission lines. An intricate network of smaller, lower-voltage lines moves power from these high-voltage lines to consumers (see Figure 4-3).

Virginia's electrical network is an integral component of the regional network managed by PJM. PJM serves several important functions, including providing a regional power market for electric providers and maintaining the integrity and reliability of the grid. PJM ensures the reliability of the largest centrally dispatched electric grid in the world by coordinating the movement of electricity in thirteen states. PJM manages a regional planning process for generation and transmission expansion to ensure future electric reliability. It also facilitates a collaborative process for planning future transmission facilities for the region. Stakeholders include participants who produce, buy, sell, move, and regulate electricity.

Figure 4-3 Major Electric Transmission Line Systems in Virginia



Source: PJM.

The North American Electric Reliability Council, using information provided by eight regional reliability organizations, prepared its 2006 Long-Term Reliability Assessment for the period through 2015. Key findings in the 2006 report indicate that:

- Capacity margins continue to decline in most regions.
- Construction of new transmission facilities is slow and continues to face obstacles.
- Fuel supply and delivery are critical to reliability and must be evaluated.
- An aging design workforce and electric operations will challenge future reliability.

A U.S. Department of Energy (DOE) study of the nation's electric supplies found potential shortages in the eastern portion of the Mid-Atlantic region. The study also found there is excess generation capacity west of this region, leading the DOE to propose the area from West Virginia and western Pennsylvania north to New York and south to northern Virginia as a National Interest Electric Transmission Corridor, or NIETC. The DOE states that in making such a designation it does not suggest that transmission is the only method for responding to the shortage; the intention of the designation is to make it easier to locate electric transmission facilities in the region. Virginia believes that the designation of a portion of Virginia as part of an NIETC could lengthen the decision-making process and would not meet the intent of the National Energy Policy Act of 2005.

Virginia has taken several actions since the federal DOE completed its congestion study on which it based the draft designation. The state enacted legislation in 2007 that includes incentives for construction of new generation facilities and provisions for recovery of federally approved transmission costs. The state also has enacted a new coordination process for projects requiring certification by both the State Corporation Commission (SCC) and Virginia's environmental agencies. This pre-application review process will provide for timely consideration of permitting and certification issues. Through these actions, Virginia will be able to implement policies that are most responsive to the needs of its electric consumers and consider the optimal mix of conservation, new generation, and new transmission facilities.

There is limited opportunity to construct new fossil-fueled generation in northern Virginia. The area is designated as non-compliance for ozone, and any new electric generation would have to be coupled with offsets of emissions from other sources in the region. Additionally, there are pressures to close older generating plants in the greater Washington, D.C., area. This would add to the supply deficit and result in the need for new transmission infrastructure in the region.

Studies of the capacity of Virginia's electric transmission system are undertaken as part of PJM's adequacy planning process. This process includes multiple stakeholders, among them electric utilities, consumers, public interest groups, and states and localities. PJM standards for system adequacy are based on North American Electricity Reliability Council standards. Virginia state government is represented by the SCC and the Consumer Assistance Division of the Office of the Attorney General. PJM has identified the need for greater involvement of state executive branch officials in the process. This Plan recommends that Virginia develop a coordinated approach among the SCC, the Office of the Attorney General, and the executive branch energy policy and environmental agencies to provide state input into PJM's planning process.

There is ongoing debate on whether new electric transmission lines should be constructed on overhead towers or placed underground. While there is general agreement that constructing transmission lines underground significantly increases the life-cycle costs of long-length transmission lines, it has been found to be cost effective in high-density population areas because of conflicts with other land uses. The Joint Commission on Technology and Science is evaluating aboveground verses underground placement of transmission lines. Today, localities in Virginia may set up a special taxing district to pay for the increased costs of placing electric transmission lines underground. However, there is considerable debate whether residents of the areas through which lines pass or users of the power from the lines should pay for these costs.

4.1.5 Planned Transmission System Additions

Several issues regarding Virginia's transmission system will need to be addressed over the next several years to maintain the reliability of the high-voltage system, meet load growth in critical areas, replace aging infrastructure, and facilitate new generator interconnections. Without the addition of high-voltage projects, reliability and supply will reach a critical point by 2011.

As part of its ongoing responsibilities, PJM annually prepares a plan to address regional transmission needs. The 2006 Regional Transmission Expansion Plan recommends upgrades to address near-term needs within five years and assesses long-term needs that require a planning horizon of fifteen years or more. The plan also provides data on major upgrade plans approved prior to and during 2006. Allegheny Power and Dominion plan to construct 500- and 230-kilovolt facilities in Virginia (see below). Allegheny Power committed to the addition of a fourth 500- to 138-kilovolt autotransformer at its Meadowbrook station, scheduled to be installed in May 2008. Dominion proposed $14.8 million in transmission line and substation additions to be in service by June 2009 and identified an additional $698 million in 500- and 115-kilovolt projects to address voltage criteria violations in the Norfolk and Virginia Beach areas, along with various overloads on the 500-kilovolt system. A list of specific projects is available on the PJM website.

As noted above, Allegheny Power and Dominion have proposed building a high-voltage transmission line in Virginia as part of a 240-mile, 500-kilovolt line from southwest Pennsylvania. In proceedings before the SCC, Dominion noted that under normal load conditions the Purcellville load area would nearly exceed the capacity of the distribution circuits by summer 2011. With the loss of one of the four available circuits, the load will nearly exceed the capacity of the remaining three circuits by summer 2007 and will exceed it by 2008.

Dominion has stated that such overloads can be avoided only with increased transmission-line investment in the region or mandatory load curtailment actions such as rolling blackouts. PJM has concurred and asserts that without additional transmission capability, the urban load center that includes northern Virginia will become overloaded by 2011 and will be in violation of North American Electric Reliability Council and PJM reliability and planning criteria. Dominion has stated that if the new transmission line is not built, it may need to shed as much as 1,100 megawatts of load through rolling blackouts during peak periods in summer 2011, and as much as 1,700 megawatts in summer 2013. The company has proposed using a route along existing transmission corridors. The SCC has ultimate responsibility for certifying the need for increased electric transmission capacity and for approving the route. It will make a final decision on the proposed route for this new transmission line later in 2007 or 2008.[67]

Table 4-4 shows the estimated transmission system expenditures by year for 2009-2011 for Dominion and Allegheny Power.[68]

Table 4-4 Projected Transmission System Expenditures

Year	Dominion Virginia Power ($ in Millions)	Allegheny Power Company ($ in Millions)
2009	$39	
2010	$30	
2011	$300	$342

[67]Virginia SCC, case no. PUE-2005-00018, Commission Order Remanding for Further Proceedings, February 21, 2007.
[68]Ibid.

4.1.6 Opportunities and Challenges

Virginia will continue to need new and upgraded electric distribution systems. This will require an ongoing investment by the state's electric utilities to meet growing system needs and ensure reliability of supply.

Obtaining the necessary permits and licenses to build new electric generation and transmission facilities can be a lengthy and expensive process. At the workshops held in 2006 to develop this energy plan, many of the participants identified this as an area that needs improving. Virginia's recently enacted legislation, effective on July 1, 2007, creates a coordinated process for reviewing applications for new energy facilities such as power plants and codifies recommendations from the SCC and Secretary of Natural Resources report on how to streamline the permitting process.

While Virginia recognizes that electric-supply issues cross state lines and require assessment across a multistate region, decisions regarding the routing of transmission lines should continue to be made at the state level.

Virginia has the potential for renewable electric generation from solar, onshore and offshore wind, run-of-stream hydropower, and waste- or biomass-fired facilities. There has been considerable debate about the appropriateness of onshore wind development in Virginia and other states. Localities should consider both the potential value to increasing the diversity of their electric supply and the visual and community effects of such projects. Community associations and localities are encouraged to consider the results of the state system to rate a property's suitability for solar and wind development when considering approval of such uses. Local governments and community associations also should provide property owners with a clear set of guidelines for renewable energy projects and should allow for the installation of solar thermal or photovoltaic panels that are integrated into a facility's design.

Virginia authorized two grant programs in 2006 to support development of alternate energy supplies, but the programs have not been funded. The Renewable Electricity Production Grant Program was designed to support utility-scale generation of electric power from renewable sources. The Photovoltaic, Solar, and Wind Energy Utilization Grant Program would support small generators. Since small generators would not receive any financial incentive from Virginia's renewable portfolio standard (see Chapter 2 for a discussion of Virginia's renewable portfolio standard), the state should first, to the extent resources are available, fund the Photovoltaic, Solar, and Wind Energy Utilization Grant Program.

While Virginia recognizes that electric-supply issues cross state lines and require assessment across a multistate region, decisions regarding the routing of transmission lines should continue to be made at the state level. Federal eminent domain should not be used to locate an electric transmission line. Additionally, it should be clarified that the prohibition against using federal eminent domain over state property includes a prohibition against overturning state-owned conservation easements.

An electric transmission-line developer may apply to the Federal Energy Regulatory Commission for approval to construct a line in a designated National Interest Electric Transmission Corridor if Virginia or neighboring states fail to approve the construction of a line within twelve months of submitting a complete application to the state. Virginia will be challenged to complete its review of any transmission-line application within twelve months, particularly with complex or long-distance projects. Companies applying for approval to construct a transmission line should complete sufficient pre-application work to address the full range of possible issues associated with their application. Applicants should take full advantage of the pre-application planning process established by 2007 state legislation.[69] This will narrow the issues to be considered and increase the likelihood of completing the permit review within the one-year limit.

PJM is responsible for ensuring that adequate electric supplies are available to meet future electric demand consistent with North American Electric Reliability

[69] For information, see Senate Document 22, 2006, Coordinating the Review of Energy Facilities (http://leg2.state.va.us/DLS/H&SDocs.NSF/4d54200d7e28716385256ec1004f3130/1eb821c475a805868525715b0048201b?OpenDocument) and §56-46.1.H of the Code of Virginia.

Council requirements. It considers conservation and demand-control activities as reliable and guaranteed only if they are under binding contract to utilities in the region. PJM should investigate the reliability of accepting a broad portfolio of conservation and demand-control program portfolios when assessing future loads. Further analysis should help determine the reliability of conservation and demand-control programs when calculating load forecasts.

Virginia can better coordinate among the SCC, Office of the Attorney General, and executive branch energy and environmental agencies how to provide state input into the PJM and North American Electric Reliability Council planning processes.

Virginia, through the Joint Commission on Technology and Science, is evaluating aboveground verses underground placement of transmission lines. Use of underground verses overhead electric transmission lines raises many questions regarding cost of constructing and operating the lines, who benefits, who should pay for any increased costs, and reliability. Through this process, Virginia stakeholders can reach agreement when the costs of placing lines underground rather than aboveground are in the public interest.

In 2007 Virginia enacted amendments to its electric utility regulation laws. The new legislation includes investment recovery mechanisms for new plant and infrastructure construction, incentives for using renewable sources, and a goal for electric conservation and demand-reduction programs. Under the new law, a utility will be permitted to earn a rate-of-return bonus for developing new base-load capacity. The law also provides for a rate-of-return bonus for nuclear, carbon-capture compatible, clean-coal, and renewable projects. If a utility does not offer a 100 percent renewable energy retail product to its customers by the end of the rate-cap period, a licensed retailer can offer such a product to all classes of customers.

In 2007 Virginia enacted amendments to its electric utility regulation laws. The new legislation includes investment recovery mechanisms for new plant and infrastructure construction, incentives for using renewable sources, and a goal for electric conservation and demand-reduction programs.

4.2 Natural Gas

4.2.1 Existing Infrastructure

Natural gas is a versatile fuel that adapts to a wide range of uses and helps meet the energy needs of residential, commercial, and industrial customers. Virginia's natural gas utilities serve more than a million residential (approximately 37 percent of households) and 90,000 commercial natural gas customers. The state produces about 85 billion cubic feet of natural gas per year and has a demand of approximately three times that amount.[70] With increasing demand from homes and businesses, as well as from new gas-fired power plants, new supplies will be needed over the next decade.

Virginia's natural gas is supplied through three primary routes: pipelines from the Gulf of Mexico region, liquefied natural gas (LNG) imports through Cove Point, Maryland, and natural gas produced or stored in southwest Virginia. Natural formations suitable for natural gas storage are being used in Smyth County near Saltville and in Washington and Scott Counties.

Virginia also is home to local natural gas storage facilities designed to serve peak load. These hold natural gas, propane, or LNG in tanks or underground caverns for delivery into the local distribution pipeline system to meet peak natural gas demand.

Industrial customers and gas-distribution utilities withdraw gas from the interstate pipeline network and storage facilities to supply their factories, homes and businesses within local service areas.

Virginia's infrastructure for distributing and transporting natural gas consists of more than 1,200 miles of interstate gas pipelines and 22,000 miles of other natural gas pipelines (see Figure 4-4).[71]

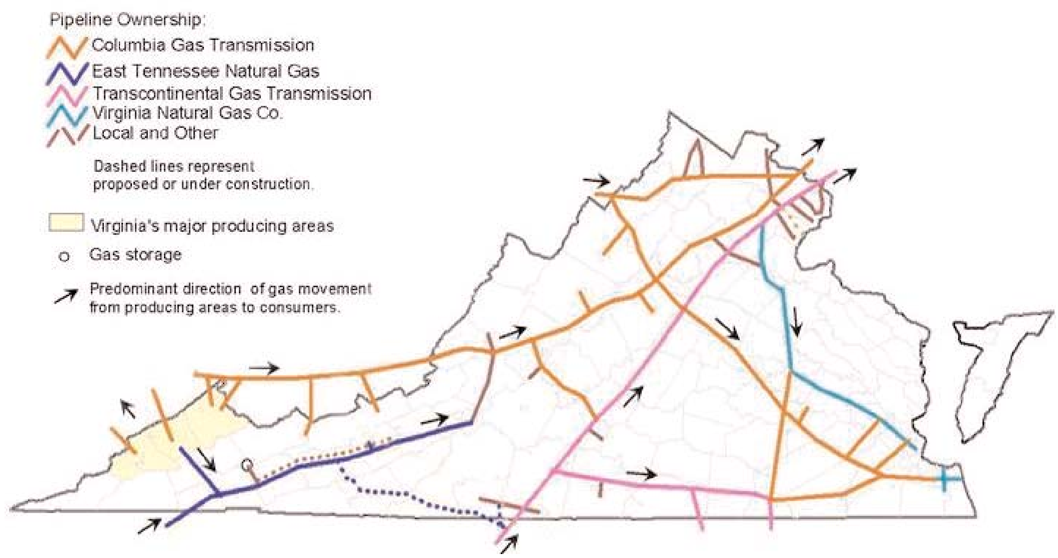
[70]"Virginia's Natural Gas Infrastructure Needs," presentation by James Kibler to the State of Virginia DMME Energy Plan Working Group, September 11, 2006.

[71]Virginia Energy Patterns and Trends: Major Natural Gas Pipelines (www.energy.vt.edu/vept/naturalgas/NG_pipelines.asp). More detailed statistics on natural gas pipelines in Virginia are available on the website of the Office of Pipeline Safety Program of the U.S. Department of Transportation.

Virginia's natural gas utilities serve more than a million residential (approximately 37 percent of house-holds) and 90,000 commercial natural gas customers.

Virginia's infra-structure for distributing and transporting natural gas consists of more than 1,200 miles of interstate gas pipelines and 22,000 miles of other natural gas pipelines (see Figure 4-4).

Figure 4-4 Major Natural Gas Pipelines In Virginia



Because of pipeline system limits, the Cove Point, Maryland, LNG import facility has primarily served northern Virginia and the Virginia peninsula. Ongoing expansion at Cove Point has increased its capacity to serve other Virginia markets. The recent construction of the natural gas pipeline from southwest Virginia's coalfields to the Duke Energy/East Tennessee Natural Gas pipeline near Saltville has increased the ability to supply Virginia-produced natural gas to the Roanoke area and other localities along the Virginia-Tennessee border.

4.2.2 Adequacy of Natural Gas System Infrastructure

As a result of the growth in demand for natural gas both nationally and in Virginia since the late 1990s, new infrastructure is needed. Current market conditions show there is an imbalance between natural gas demand and the supplies needed to support Virginia's and the nation's economy. For example, demand for natural gas has grown 30 percent over the past ten years in the Virginia Natural Gas service area-twice the national average. Pipeline system reliability is also crucial to military facilities in the Virginia Natural Gas service area, among them the Norfolk Naval Station, Oceana Naval Air Station, Little Creek Amphibious Base, Dam Neck Naval Training Station, and Fort Story. Other infrastructure improvements will be needed in other regions of Virginia as the state's economy and natural gas use grows.

New pipeline projects are difficult to develop. Pipeline developers need to have contracts for a substantial amount of a proposed pipeline's capacity before committing to construction. This was seen in the difficulties in developing and termination of the Homestead, Tidewater, and Greenbrier pipeline projects. This can result in some natural gas transmission constraints being unsolved.

Natural gas service in Virginia is also affected by upstream constraints that increase natural gas costs to consumers and lessen reliability. This was illustrated by the problems in natural gas markets after the 2005 Gulf of Mexico hurricanes. These upstream constraints must be addressed to reduce the risk of future natural gas supply problems in Virginia.

4.2.3 Planned Natural Gas Facilities

Several new natural gas pipelines have been proposed or are under construction in Virginia. Duke Energy is constructing the Patriot pipeline upgrade from Tennessee toward Roanoke and extension from Henry County into North Carolina.

In August 2006 the State Corporation Commission directed Virginia Natural Gas to construct a pipeline under the Hampton Roads harbor from Newport News to Norfolk to connect its northern and southern gas distribution systems. The Hampton Roads Crossing (HRX) pipeline will ensure a reliable and competitively priced supply to meet the rapid population growth in the region and the resulting demand for natural gas. Virginia Natural Gas currently estimates that the project will cost between $48 and $60 million to serve its service territory, and more if it is expanded to serve additional natural gas utilities.

The HRX pipeline will include construction of approximately 10 miles of onshore pipeline, and 10 miles crossing the Hampton Roads harbor. It will also include upstream pipeline compression facilities in Hanover and Charles City Counties, and a city gate station at the termination point in Norfolk.

Scheduled to be completed with initial deliveries of gas into Norfolk by late 2009, the project is designed to transport up to 100,000 decatherms per day of additional capacity into the Virginia Natural Gas distribution system, as well as additional capacity to industrial users and neighboring distribution companies.

Dominion has received approval from the Federal Energy Regulatory Commission to further expand its facilities at the Cove Point LNG terminal.

At Saltville, the storage field capacity that began service in August 2003 has increased substantially since 2004. Working gas storage capacity has grown from 2.1 billion cubic feet to 5.8; daily injection capacity has increased from 104 million cubic feet to 220; and daily withdrawal capacity has increased from 208 million cubic feet to 486.[72] The Saltville natural gas storage facility operator signed an agreement in June 2007 with a salt mining company to develop additional storage capacity in the future.

Virginia's natural gas local distribution utilities regularly need to build additional local distribution network pipes to serve newly developed areas. The local distribution companies also periodically need to build new peak storage facilities to serve expanding loads.

4.2.4 Opportunities and Challenges

Virginia should carefully consider support for projects to diversify its natural gas supplies, such as new LNG terminals and increasing pipeline capacity.

Additional capacity improvements to gas pipelines across the southeastern portion of the state could be added, or additional storage for peak use could be added. State and regional energy and economic development entities should monitor natural gas supply and demand and work with local utilities and pipelines to ensure that an adequate supply infrastructure is maintained.

Virginia has the geography and the market to make the Hampton Roads area an attractive expansion target for both new LNG storage and import. LNG supply, storage, and distribution would itself represent a major industry expansion and would bring new gas supplies to this area for industrial use.

Virginia's natural gas utilities must replace old infrastructure, such as old pipe, fittings, valves, and other equipment, to maintain reliable service. This requires ongoing investments that must be recovered from ratepayers.

One possible source for diversifying Virginia's natural gas supplies is offshore natural gas production. The U.S. Minerals Management Service (MMS) has included the potential for one special lease sale in waters at least 50 miles off Virginia's coast.

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The Virginia legislature has recently examined opportunities for drilling for new oil and natural gas supplies on the outer continental shelf.[73] Virginia's off-shore areas have been subject to limited federal, state, and industry resource

[72]Source: www.ferc.gov/industries/gas/indus-act/storage/certificated-for-expansion.pdf.
[73]See http://leg2.state.va.us/dls/h&sdocs.nsf/4d54200d7e28716385256ec1004f3130/314f8feb1408441285256fcd004e4d6d?OpenDocument.

Chapter 4
Energy Infrastructure
continued

assessments. These studies show the geology in this area to be gas prone, although the presence of economically recoverable supplies is not assured. In addition, the presence of oil cannot be ruled out. Further geophysical exploration and drilling will be necessary to determine whether economically recoverable natural gas or oil exists. The federal government estimates there may be 33.3 trillion cubic feet of natural gas and 3.5 billion barrels of oil in the Atlantic outer continental shelf. On a pro rata basis, this would total about 11.7 trillion cubic feet of gas and 1.2 billion barrels of oil in the Mid-Atlantic area. Royalty estimates depend on the amount of resources recoverable and the cost of gas or oil. There could be from zero to more than $10 billion in total value of natural gas in Virginia offshore administrative boundary areas.

Any development of this resource should be made consistent with Virginia policy. This policy states that the federal government should only proceed with exploration of natural gas more than 50 miles from the state's shoreline. Both the MMS, through its five-year offshore plans, and the National Oceanographic and Atmospheric Administration, through the Coastal Zone Management program, should recognize this policy when taking action affecting offshore development. The MMS should also work with the offshore exploration and production industry and the state to determine the extent of offshore natural gas resources and the environmental protections that would be needed for such development.

4.3 Petroleum

4.3.1 Existing Infrastructure

Gasoline, diesel, and other petroleum products are distributed through a network of pipelines and terminals located in and around Virginia and neighboring states. As the marketplace for fuels expands to include new products such as low-sulfur fuels and non-petroleum alternate fuels, petroleum terminals must reconfigure their facilities to manage the new products.

Developing alternate fuels such as ethanol and biodiesel will require developing new fuel production and transportation facilities. Other infrastructure will be needed to supply raw material inputs, such as biomass supplies. Virginia has a production incentive grant for in-state produced biofuels (see Section 4.8, Alternative Fuels Production, below).

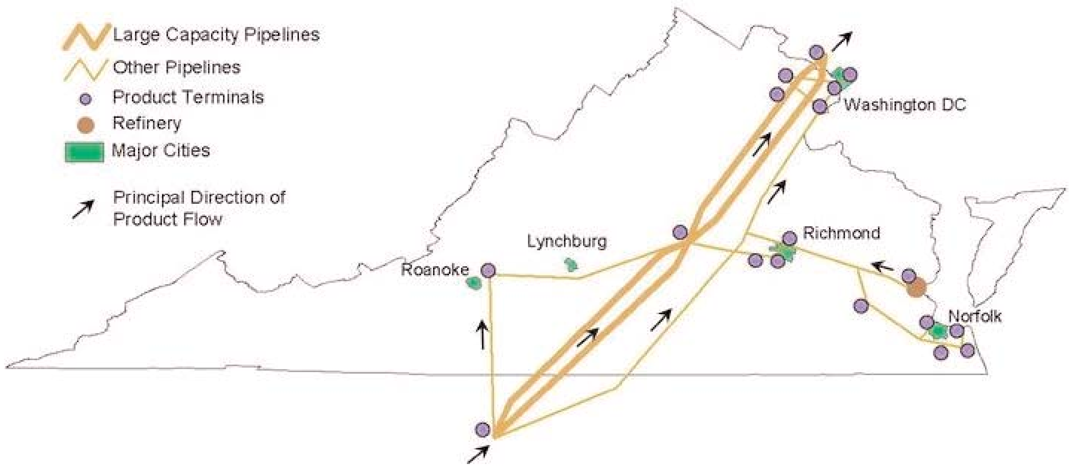
Although Virginia does produce oil and petroleum products, in-state production accounts for only a small portion of the state's consumption. All of the oil production occurs in Lee and Wise Counties. Oil production is primarily a byproduct of natural gas extraction efforts from deep geological reservoirs containing both natural gas deposits and small amounts of crude oil. Virginia's one oil refinery, at Yorktown, has a production capacity of 58,600 barrels of petroleum products per calendar day, which ranks 89th out of 144 U.S. refineries.

4.3.2 Distribution Network: Oil Pipelines

Virginia imports nearly all of its petroleum products (gasoline, diesel, and heating and jet fuels), primarily from refineries in the Gulf Coast, through the Colonial and Plantation pipelines. The Plantation pipeline ends at Reagan Washington National Airport in Arlington County, whereas the Colonial pipeline stretches north into northern New Jersey (see Figure 4-5).[74]

[74]Virginia Energy Patterns and Trends: Major Petroleum Product Pipelines (www.energy.vt.edu/vept/petroleum/oil_pipeline.asp).

Figure 4-5 Major Petroleum Pipelines and Terminals in Virginia



Petroleum products also arrive in Virginia via ocean tanker and barge. The ships and barges primarily serve the petroleum terminals in Chesapeake.

Pipelines, barges, and ocean tankers can transport many different types of petroleum products. Once they bring petroleum into Virginia, it is stored in bulk storage at terminals. Large bulk storage terminals for petroleum products are located in Richmond, Chesapeake, the Roanoke area, and northern Virginia. Petroleum jobbers have smaller storage sites throughout the state. Local dealers often have some limited on-site storage capacity. There is also a large break-out tank farm in Cumberland County along the major pipeline corridor that serves to balance supplies and make up pipeline supply deficiencies in Virginia and points northward.

Some products cannot be transported via pipeline. Ethanol, for example, is transported via barge, rail, or tanker truck and must be stored in separate, dedicated tanks. Ethanol is mixed with pipeline product (referred to as reformulated gasoline blendstock for oxygen blending, or RBOB) at a terminal to make reformulated gasoline.[75] As summer approaches, distributors switch to products that are specially blended for summer weather conditions. When making this switch, it is necessary to have a completely empty storage tank before filling with the summer blend product.

Petroleum products are distributed from a terminal to retailers by tanker truck. Transport companies are either retailer operated or independent trucking firms specializing in liquid fuels. In Virginia, retailers of petroleum products include convenience-store chains owned by refiner and distributor companies, and small independently owned businesses.

4.3.3 Adequacy of Petroleum Infrastructure

The large amount and diverse array of petroleum products imported into the state are constrained by the number of terminals and their storage capacity. There are few options for building new terminals or refineries because the Virginia coastline is already well developed, and new port sites and land for refineries near ports do not exist. There is, however, potential for building new tanks at existing terminals and for expanding the existing refinery. Several factors complicate such growth, however, including public concerns about locating new industrial facilities, the number of different fuels needed, and associated tank requirements.

[75]RBOB is a petroleum product that conforms to industry standards for reformulated regular gasoline blendstock for blending with 10% denatured fuel ethanol (92% purity). It is a wholesale non-oxygenated blendstock ready for the addition of 10% ethanol at the truck rack.

Virginia has the potential to develop an alternative fuels industry. Virginia-derived alternative fuels could reduce demand for conventional petroleum products and alleviate a portion of import needs and supply challenges

4.3.4 Opportunities and Challenges

The primary supply improvement available is expansion of the Yorktown refinery. Virginia made permanent the sales-tax exemption to supplies and equipment for this refinery to help its owner obtain financing for an expansion project. State and regional economic development entities should continue to work with the owner to provide all cost-justified assistance to this expansion.

Terminal expansion and modifications are required as a result of new fuel standards and products. Additionally, as alternative fuel markets develop, new storage and distribution infrastructure will be required. Local governments should, consistent with public health and safety protection needs, streamline approval of modification plans and provide all available flexibility to terminal operators to make these needed changes.

Virginia has not supported exploration and development of offshore oil. Although drilling may be the only way to determine if offshore oil resources are present, developing these resources exposes Virginia's world-class coastal resources to greater risk than natural gas development. If offshore oil deposits are found, Virginia and the federal government should work with stakeholders to evaluate the increased risk and protections that would be needed before any further development is approved.

Virginia has the potential to develop an alternative fuels industry. Virginia-derived alternative fuels could reduce demand for conventional petroleum products and alleviate a portion of import needs and supply challenges (see Section 4.8 below).

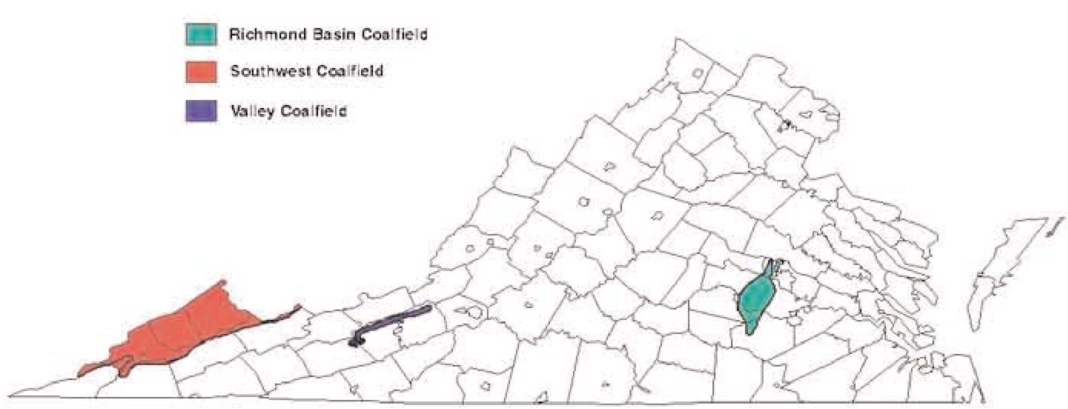
4.4 Coal Mining

4.4.1 Existing Infrastructure

Coal Mines

All Virginia coal is produced today in southwest Virginia (see Figure 4-6).[76] Production peaked in 1990 at 46.5 million tons and since then has decreased by 42 percent. By 2006, production had declined to approximately 32 million tons. Virginia's coal mining industry employed more than 4,700 people in 2005. Table 4-5 provides data on production and employment trends from 1996 to 2005.[77]

Figure 4-6 Virginia's Coalfields



[76]Virginia Energy Patterns and Trends: Existing Coal Fields (www.energy.vt.edu/vept/coal/basins.asp).
[77]Virginia Energy Patterns and Trends: Production and Employment Data by Mine Size (Coal) (www.energy.vt.edu/vept/coal/minesize.asp).

Table 4-5 Coal Mine Trends, 1996-2005

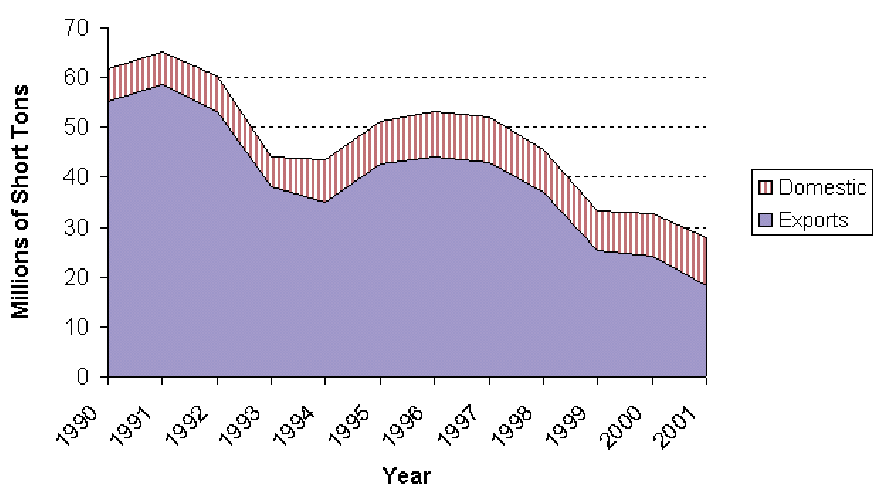
Year	Number of Mines	Short Tons Produced	Number of Employees
1996	325	36,725,571	6,089
1997	355	36,889,161	6,534
1998	352	34,001,907	5,802
1999	361	32,253,994	5,456
2000	341	33,210,226	4,926
2001	327	32,600,564	5,261
2002	323	31,746,140	4,956
2003	295	31,445,858	4,353
2004	292	30,486,961	4,501
2005	265	26,937,574	4,764

The Commonwealth and Virginia's coal industry should work together to maintain a viable mining industry that supports the economy in southwest Virginia and provides needed coal resources for electric and steel production at reasonable costs to consumers. This includes maintaining safe conditions for mine workers (e.g., working to implement changes in federal mine safety law related to mine rescue, emergency supplies in mines, underground miner tracking and communication systems, and seals used in underground mines) and controlling effects of coal mining on the environment.

Distribution Network

The vast majority of Virginia coal is shipped from mine to market and ports by rail. The Port of Hampton Roads, at the mouth of Chesapeake Bay, can load more than 65 million tons annually and is one of the largest and most efficient coal-shipping facilities in the world. The facilities handle coal mined in Virginia, West Virginia, and Kentucky. The markets for this coal include electric generators located close to East Coast shipping lanes and overseas purchasers. Figure 4-7 shows trends for coal shipments from the Port of Hampton Roads from 1990 to 2001.[78]

Figure 4-7 Coal Shipments from Port of Hampton Roads, 1990-2001



[78]Virginia Energy Patterns and Trends: Coal Shipments from the Port of Hampton Roads (www.energy.vt.edu/vept/coal/basins.asp).

There have been conflicts between utilities, coal producers, and coal-hauling railroads about transporting coal. Utilities and coal producers have complained about the lack of competition due to being captive shippers, resulting in high shipping costs. There have periodically been problems with availability of coal cars for moving coal from mine to markets. Rail shipping rates are governed by the federal government. The Federal Railroad Commission should ensure that coal transportation rates are fair to users while providing an adequate return to railroad companies to ensure adequate investment in infrastructure.

4.4.2 Adequacy of Infrastructure

The coal-related road and rail infrastructure is generally adequate. The biggest infrastructure challenge is a congested and constrained rail system and the growing competition for rail. The demand for rail will continue to grow as efforts to move truck freight to rail increase.

According to 2005 data from the Energy Information Administration, municipal solid waste plants generated more than 1 million megawatt-hours of energy, and landfill gas plants approximately 97,500 megawatt-hours.

4.4.3 Opportunities and Challenges

Virginia has the opportunity to import coal from sources such as South America to provide the lowest-possible-cost coal supplies to utility and industrial users. While Virginia should not take actions that would diminish the viability of southwest Virginia coal producers, Virginia utility consumers will benefit from the market diversity provided from coal imports. Virginia should therefore provide the approvals necessary to modify existing coal-export facilities to accept coal imports.

Local governments in southwest Virginia are encouraged to continue using local coalfield road improvement funds to ensure that there are adequate roads to haul coal on routes that minimize conflict with built-up areas. Virginia's rail providers are encouraged to continue efforts to supply adequate rail-car capacity to carry coal from Virginia's mines to end-users and Virginia's coal-export ports.

4.5 Propane

4.5.1 Existing Infrastructure

Consumers in Virginia used approximately 229 million gallons of propane in 2004, the latest year for which propane consumption data are available.[79] The 2000 U.S. Census reports that 5.1 percent of households in Virginia use propane or bottled gas for space heating. Propane consumption in Virginia has remained fairly flat for several years.

The majority of Virginia's propane gas is supplied by an interstate propane pipeline that terminates in Apex, North Carolina. Tanker trucks fill up at the terminal in Apex and then bring the supplies to Virginia. Propane also is delivered via railroad cars, barges, and tankers. Propane gas supply is generally stored in large aboveground tanks at distribution facilities. There are fifty-three Virginia-based distributors and eight multistate distributors serving the state.

4.5.2 Planned Propane Facilities

The Virginia Propane Gas Association reports that Virginia's propane supply capacity is on the increase. Many members of the association are adding extra 30,000-gallon storage tanks to their current bulk storage facilities. Several are even adding new bulk plants.[80]

In 2007 the National Propane Gas Association began charging membership dues based on the number of bulk propane storage tanks per company, rather than on the number of office locations. Accordingly, up-to-date data on the total number of bulk storage plants in Virginia will be readily available beginning in 2008.

4.6 Biomass/Waste

4.6.1 Existing Infrastructure

Virginia has several plants that convert waste and biomass into energy. The largest is Covanta's I-95 Energy/Resource Recovery Facility which began operation in 1990. It processes 3,000 tons per day of

[79] Source: American Petroleum Institute.
[80] E-mail from Mary Howell of the Virginia Propane Gas Association, May 14, 2007.

municipal solid waste and has a generating capacity of 79 megawatts of electricity. This renewable energy is distributed through Dominion and provides enough energy to meet the needs of 75,000 homes. Covanta's Alexandria/Arlington Resource Recovery Facility in northern Virginia processes 975 tons of waste per day and has a generating capacity of 23 megawatts. The Southeast Public Service Authority operates a municipal solid waste plant in Portsmouth that is designed to process 1,500 tons per day. It produces process steam and electricity for the Norfolk Naval Shipyard and sells excess electricity to Dominion. Other waste-to-energy plants operate in Harrisonburg, Salem, and Hampton.

Significant resources exist to support additional biomass or waste-to-energy infrastructure projects. With the potential to grow energy crops on farmland, coupled with resources that include more than fifty operating landfills and 16 million acres of forestland, Virginia clearly has adequate resources.

Other plants extract landfill gas/methane (the primary molecular component in natural gas) from in-situ waste to drive electric generators or to fuel nearby public and industrial facilities. According to data from the Environmental Protection Agency's Landfill Methane Outreach Program, Virginia has nineteen operational landfill gas projects. Ten of these use methane for generating electricity and have a combined capacity of more than 30 megawatts. Two are under construction with a 7-megawatt capacity. The remaining nine burn methane to drive thermal energy processes.

According to 2005 data from the Energy Information Administration, municipal solid waste plants generated more than 1 million megawatt-hours of energy, and landfill gas plants approximately 97,500 megawatt-hours.[81]

Several energy plants use wood or wood wastes as fuel sources. The largest such facility is in Pittsylvania County and is owned and operated by Dominion. It consists of three boilers and one 80-megawatt turbine unit and consumes about 750,000 tons of wood per year.

4.6.2 Adequacy of Biomass/Waste Resources

Significant resources exist to support additional biomass or waste-to-energy infrastructure projects. With the potential to grow energy crops on farmland, coupled with resources that include more than fifty operating landfills and 16 million acres of forestland, Virginia clearly has adequate resources.

In October 2006, Virginia Tech's Department of Wood Science and Forest Products published the Assessment of Virginia's Bio-Energy Resources, Wood Residues Using GIS to evaluate Virginia's "types, quantities, and location of wood residues and other woody materials that could be available for use as bio-energy or other applications." The study found that primary manufacturers produced an estimated 7.5 million tons of Virginia biomass residues in 2003, approximately 90 percent of which came from sawmills. Secondary manufacturers produced an estimated 570,000 tons of Virginia's biomass residues in 2003. Nottoway, Pittsylvania, Rockbridge, Augusta, and Caroline were the state's top five residue-producing counties. This research indicated that responding Virginia landfill facilities received approximately 10.8 million tons of waste in 2003, of which 1.2 million tons were solid wood.

The total estimated forest residue production from Virginia in 2003 was 756,000 tons.

4.6.3 Planned Biomass/Waste Facilities

The 585-megawatt Virginia City Hybrid Energy Center proposed in Wise County is being designed to co-fire as much as 20 percent from biomass.

Biomass and waste are potential feedstock for the alternative liquid fuel industry. More information on this is provided below in Section 4.8.

4.6.4 Opportunities and Challenges

Virginia electric utility re-regulation legislation enacted in 2007 includes incentives for renewable generation, including firing or co-firing of biomass. It is anticipated that much of the capacity required to meet the goals of the legisla-

[81]EIA Form 960 Annual Data Files.

Virginia electric utility re-regulation legislation enacted in 2007 includes incentives for renewable generation, including firing or co-firing of biomass. It is anticipated that much of the capacity required to meet the goals of the legislation will, at least initially, come through biomass-fired generation. This will create a demand for fuel and will result in new markets for one of Virginia's greatest resources.

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Virginia is rich in biomass resources, including forestry products, waste wood from construction and wood products production, animal manures, energy crops such as switchgrass and soybeans, among others. The Virginia Biomass Energy Group, a collaboration of farmers, government officials, university researchers, businesses, and other stakeholders, is currently working to identify and quantify the state's biomass resources and to develop environmentally and economically viable strategies for increasing their use.

A December 2005 report prepared by the Virginia Center for Coal and Energy Research found there is a technical potential for energy from biomass of about 760 megawatts of electrical generation, with more than 500 megawatts coming from forest residues. Other biomass sources include urban wood residues (180 megawatts), unused mill residues (14.5 megawatts), crop residues (32.8 megawatts), and animal manure (12.3 megawatts). The study states that while landfill gas generators are among the lowest-cost renewables, Virginia has limited resources to develop, with only about 30 megawatts of additional potential generation capacity in existing landfills.

4.7 Renewable Energy Infrastructure–Wind Power

A predominant issue associated with renewable energy infrastructure is the siting of utility-scale wind turbines. There is no current utility-scale wind infrastructure in Virginia. While individual site assessments will be required for individual projects, adequate sites in high-wind-resource areas exist, both land based and offshore (see Chapter 2) to support utility-scale wind power use in Virginia.

4.7.1 Planned Wind Facilities

Highland New Wind Development LLC has proposed building up to twenty 2-megawatt turbines in western Highland County. The facility would be rated at just under 40-megawatt capacity and would be Virginia's first commercial wind project, producing more than 100 million kilowatt-hours annually (based on a 30 percent capacity factor).

James Madison University is conducting a feasibility study to determine whether a small number of utility-scale wind turbines are a viable option to meet a significant portion of electrical load at Tangier Island and export the excess wind power produced to the mainland. Power to the island is fed via a submerged cable from Accomack County on the eastern shore. This cable continues on to Smith Island, north of Tangier. The output from a community-scale wind power project could serve one or both islands, or could be sold to a third party such as a federal facility or manufacturer interested in procuring green power. This could provide a model for a small community co-op that others could learn from and replicate.

Several wind developers are exploring potential projects in the western and southwestern sections of the state.

4.7.2 Opportunities and Challenges

The application process to construct the Highland wind farm began in late 2005. In 2006, a Highland County District Court judge ruled that the Highland County Board of Supervisors followed proper procedure when it issued a conditional-use permit for the 400-foot-tall turbines. The judge also ruled that the project complies with the county's height ordinance and comprehensive plan. The Virginia Supreme Court will hear an appeal of the District Court decision, with a ruling anticipated in September 2007.

The wind farm also must receive a Certificate of Public Convenience and Necessity from the State Corporation Commission (SCC). In April 2007 the SCC judges sent the case back to the hearing examiner to reexamine the environmental

Initial reviews find Virginia has substantial potential for developing offshore wind resources beyond the normally visible horizon.

impact of the proposed turbines on various bird species. The order remanding the case noted that the wind farm would provide economic benefits and not harm grid reliability or competition, but that more analysis is needed to determine what, if any, mitigation might be required regarding the project's impact on bats and birds.

Virginia is implementing a Virginia Renewables Scoring System for siting Virginia renewable energy resources. This system ascribes numerical scores to parcels of real property based on the suitability of a wind or solar energy facility. The scoring system considers wind characteristics, proximity to electric power transmission systems, impacts to natural and historic resources and to economically disadvantaged or minority communities, and compatibility with local land-use plans. The scoring system uses GIS data sets that include wildlife, cultural, historical, economic, technical, and other aspects of the landscape.

Local governments also can adopt a local wind ordinance. Rockingham County has adopted a model local wind-energy ordinance developed with the Virginia Wind Energy Collaborative. The federal Department of Energy's Wind Powering America program has identified Virginia as a priority state and is supporting the Virginia collaborative.

In response to authority in the federal Energy Policy Act of 2005, the Minerals Management Service (MMS) is implementing an Outer Continental Shelf Alternative Energy and Alternate Use Program. The program is focused on those alternative energy technologies, including offshore wind, wave, and ocean current capture technologies, and offshore areas that industry has expressed an interest in developing in the 2007-2014 timeframe. The program will address the environmental impacts by including stipulations for data collection, facility siting, mitigation, and ongoing impact evaluation and will provide a roadmap for developers to follow during the permitting process, facilitating faster development of the alternative energy industry on the outer continental shelf.[82] The MMS anticipates receiving applications for development of these technologies over the next five to seven years.

It is Virginia's policy to support federal efforts to examine the feasibility of offshore wind energy being used in an environmentally responsible fashion. Initial reviews find Virginia has substantial potential for developing offshore wind resources beyond the normally visible horizon. Virginia is providing initial support for analysis through the Virginia Coastal Energy Research Consortium. This study will be undertaken jointly with the state's research universities, the wind power industry, and Virginia's electric utilities.

Virginia-based wind developments could increase the likelihood of wind-based business expansion in Virginia. General Electric has a facility in Salem that makes turbine components. The state could attract new wind-related businesses with a commitment to the industry and a local market for wind-energy products.

4.8 Alternative Fuels Production

Through rapidly advancing conversion technologies, biomass products, coal, and waste can be used to manufacture alternative liquid fuels.

Alternative fuels help meet goals associated with reducing environmental impacts. An alternative fuels industry would add diversity to a transportation sector that is completely dominated by petroleum. Supply diversity reduces risk and enhances energy security.

As part of its effort to reduce reliance on petroleum, improve the environment, and bring economic development to the coalfields and agricultural communities, Virginia can work to develop an alternative liquid fuel industry. Virginia's strategic advantages include proximity to markets and population centers, natural and waste resources for feedstock, Department of Defense presence and its eagerness to develop military-specification synthetic

[82]See http://ocsenergy.anl.gov/documents/dpeis/Alt_Energy_DPEIS_Executive_Summary.pdf.

fuels, and related research and development capacity (see Chapter 6).

4.8.1 Existing Infrastructure

Virginia currently is home to several small biodiesel refineries. Three produce biodiesel from soy, and a few others produce biodiesel from waste grease and oils.

4.8.2 Planned Alternative Fuels Facilities

The Virginia Economic Development Partnership, Department of Agriculture and Consumer Services, and Department of Mines, Minerals and Energy have been working together with prospects interested in locating large-scale production plants in Virginia. As of May 2007, no plans had been finalized.

4.8.3 Opportunities and Challenges

In 2006, Virginia legislation established a Biofuels Production Fund and Grant Incentive Program to provide a 10-cent-per-gallon incentive for locating a plant in Virginia.

In 2006, Virginia legislation established a Biofuels Production Fund and Grant Incentive Program to provide a 10-cent-per-gallon incentive for locating a plant in Virginia. Large-scale plants are now being developed in the 100-million-gallon-per-year or larger range. Virginia may need to consider incentives to spur initial capital investment in these large plants, such as loan guarantees or tax credits to secure investment. Another option would be to give assurance that a plant would receive a guaranteed benefit from the Biofuels Grant.

Virginia needs to expand its retail alternate fuel infrastructure if there are to be significant new uses of the fuels. The Virginia E85 Fueling Infrastructure Project is establishing three sites for government-owned vehicles to refuel. The project also will support development of twelve to fifteen retail locations on the I-95 and I-64 corridors. These efforts help drive market transition and provide justification for large-scale biofuel production in the state.

University-level research is continually advancing in the areas of alternative energy and fuels. Bioengineering of future energy crops and improvement of feedstock-to-fuel conversion technologies are examples. Momentum is building in developing demonstrations and pilot plants. Switchgrass and barley are examples of potential energy crops and represent an area of opportunity for Virginia farmers. Some of the stakeholders in current efforts include the Tobacco Commission, the Institute for Advanced Learning and Research in Danville, state universities, farm owners, and private industry. Virginia should expand and empower partnerships that demonstrate the potential of alternative fuel advancements with an eye to commercial-scale production.

The U.S. Department of Energy is developing rules for a clean energy loan guarantee program authorized in the Energy Policy Act of 2005. The program is intended to spur investment in projects that employ new, clean-energy technologies. A primary program focus is alternative liquid fuels projects. Projects will help sustain economic growth, yield environmental benefits, and allow for a more stable and secure energy supply. Congress provided the Department of Energy with authority to issue guarantees for up to $4 billion in loans. Virginia should promote and use this tool and devise strategies to capture its share of the offering.

Several emerging technologies involve gasification of feedstock. In this process, coal, waste, or wood/biomass residue is converted to gas and the gas then converted to liquid. A major advantage of gasification systems is that the gases they produce contain less particulate matter. It is easier to remove or capture harmful materials such as sulfur and carbon dioxide during gasification processes. However, capital costs can be significantly higher than for conventional combustion systems.

The Department of Defense uses more aviation fuel than any other type of energy. It also uses a substantial amount of liquid fuels for ground and water transportation. Virginia government, research institutions, and industry have an opportunity to work with the Defense Department to help supply fuel-replacement needs. Virginia should first focus on ground- and water-transportation fuel, then aviation.

Local governments that operate landfills should consider dedicating a portion of their tipping fees to support projects that convert waste to energy and which, in turn, extend the life of landfills.

One of the biggest barriers to landing an alternate fuel project has been finding an appropriate site. State and local governments could consider pre-packaging alternative fuel production plant sites with required zoning and infrastructure (e.g., energy, rail or barge, and water). This could be done in conjunction with demonstrating and commercializing emerging technologies. (See Chapter 6 for a description of developing state-supported, technology-centric sites that offer common, basic infrastructure such as shell space, bulk transport, energy, water/wastewater, by-product/waste handling, clean rooms, etc.)

While there is considerable speculation around the timing of hydrogen technologies, the potential of hydrogen should not be overlooked. Hydrogen could become the prime mover for future automotive and other transportation applications. As provided for in Virginia's hydrogen blueprint, the state should support developing fueling infrastructure as the market develops for hydrogen fuel use.

4.9 Uranium/Nuclear Energy

Virginia has unique attributes within the nuclear industry that provide an opportunity for it to be the leader in nuclear energy.

Virginia has unique attributes within the nuclear industry that provide an opportunity for it to be the leader in nuclear energy. They include the following:

- Energy companies could be as close as a year away from deciding to build the first new nuclear reactors in the United States since the 1970s. Dominion could be one of the earliest, given its consideration of new reactors at its North Anna plant.
- As discussed in Chapter 2, Virginia has a uranium oxide resource in Pittsylvania County that presents options for a uranium mining industry.
- The Lynchburg region is home to BWXT and Areva NP, which design, service, and build nuclear components for the civil and military markets.
- There is a significant Navy presence in Tidewater, and Northrop Grumman Newport News is a primary contractor in the building and servicing of U.S. Navy nuclear vessels.
- Virginia institutions of higher education and their research and development capacity provide an excellent support mechanism that can provide both technical assistance and future workforce training.

4.9.1 Existing Infrastructure

Resources exist to support a uranium mining industry in Virginia (see Chapter 2). Dominion operates two nuclear plants in Virginia, one in Louisa County and one in Surry County (see Section 4.1.1, Existing Generating Infrastructure, above).

4.9.2 Planned Nuclear Facilities

Dominion has asked the Nuclear Regulatory Commission to approve a site for new nuclear reactors at its North Anna Power Station. The company expects to receive a permit for the site late in 2007 and is considering applying for a license to build and operate a third reactor at the plant. Only after a permit is approved, expected around 2010, will it decide whether to build the reactor. However, the company placed early orders for critical nuclear plant components to ensure their availability should the project go ahead.

4.9.3 Opportunities and Challenges-Developing Virginia's Nuclear Cluster

New Reactors

In 2007 Virginia electric utility restructuring legislation provided incentives for new nuclear generation by providing for an enhanced rate of return-twice that of a conventional generating plant and equal to that of renewable energy sources or plants that incorporate carbon capture and clean-coal technologies. The advantages of nuclear generators are that, *Virginia needs to develop strategies that combine the strengths of its university system, in both research assistance and future workforce training, with the needs of its industry partners.*

A future opportunity for Virginia is the forthcoming decommissioning of nuclear navy ships. Virginia's unique infrastructure in building these vessels and the major navy presence offer a distinct advantage. Virginia should assist the industry in pursuing and capturing business opportunities associated with nuclear decommissioning.

once built, the facilities operate steady-state at near capacity for decades and provide electricity with near-zero air emissions.

The National Energy Policy Act of 2005 promised financial incentives to companies that propose new reactors. Regulators expect to receive about twenty applications for new plants in the next three years, with at least thirty new reactors. Dominion plans to make its decision on proceeding with the North Anna plant in time to be eligible for the federal incentives. If Dominion decides to proceed with this reactor construction, then there will be opportunities for Virginia businesses to support this construction. Any plant would not likely be completed during the term of this Plan.

Virginia-based Nuclear Energy Businesses

The Lynchburg region is home to BWXT and Areva NP, international nuclear energy firms with significant potential for expansion. Areva specializes in providing equipment and supplies to the energy industry. The company is committed to making sustainable development the focal point of its industrial market business strategy. Areva's manufacturing facility in Lynchburg manufactures process control instruments, inorganic chemicals, measurement and control devices, and pumps and pumping equipment. According to Areva, it had 230 job openings during the first quarter of 2007 and expected a need for 800 jobs over the next five years, with 400 of those being in Lynchburg. If Virginia can help solve the labor problem, Virginia will be the clear number-one expansion target, as no other state is addressing this issue. Virginia needs to develop strategies that combine the strengths of its university system, in both research assistance and future work-force training, with the needs of its industry partners.

If BWXT were to expand in the commercial nuclear market, the Lynchburg area would be an attractive location. Such a move would increase the pool of talented workers within the sector. Increased expertise in the region, along with expanded training programs, could encourage ancillary companies to move to Virginia. Benefits to the sector and to Virginia would include increased customer/supplier relationships, further diversification of the sectors, enhanced training programs, and increased revenue streams for the state and the localities.

Virginia's Uranium Resources

There are sufficient resources to support a uranium mining industry in Pittsylvania County with enough to meet the fuel needs of Virginia's current generation (see Chapter 2). Significant work to assess the risk from mining and need for regulatory controls must be completed before any decision can be made whether such mining should take place.

Navy Presence and Northrop Grumman Newport News

Northrop Grumman Newport News designs, builds, overhauls, and repairs a wide variety of ships for the U.S. Navy and commercial customers. Northrop Grumman is currently the nation's sole designer, builder, and refueler of nuclear-powered aircraft carriers and one of only two companies capable of designing and building nuclear-powered submarines. The largest industrial employer in Virginia, the Northrop Grumman Newport News shipyard is located on more than 550 acres along the James River in Newport News and employs about 19,000 people. The shipyard is home to the Western Hemisphere's largest dry dock and crane. Northrop Grumman is the largest non-governmental provider of fleet maintenance services to the Navy. It also provides after-market services for a wide array of navy vessels.

A future opportunity for Virginia is the forthcoming decommissioning of nuclear navy ships. Virginia's unique infrastructure in building these vessels and the major navy presence offer a distinct advantage. Virginia should assist the industry in pursuing and capturing business opportunities associated with nuclear decommissioning.

Chapter 5

Energy and the Environment

Decisions on meeting future energy needs should no longer be based only on traditional economic models; they can also incorporate protection of ecosystems, natural resources, and the health and well-being of citizens.

5.0 Energy and the Environment

Virginia citizens rely on energy to power their homes and businesses, fuel their mobility, and support their quality of life. However, pollution caused by the combustion of fossil fuels has detrimental effects on Virginia's climate and air and water quality, and can affect the health of its citizens and wildlife. Mineral extraction and the development of utility infrastructure can also impose an environmental burden by altering Virginia's rural landscapes and aquatic habitats. Virginia's energy policy recognizes the imperative to constantly strive for an appropriate balance between the environmental costs of energy production and use and the benefits to our economy and our way of life.

Decisions on meeting future energy needs should no longer be based only on traditional economic models; they can also incorporate protection of ecosystems, natural resources, and the health and well-being of citizens. By using materials and water more efficiently and employing reuse and recycling, we can reduce the energy required to produce and process materials and to treat water.

Virginia can join in the transition to a greener energy future by pursuing emerging energy production technologies, increasing conservation and the use of renewable resources, and improving energy efficiency.

Energy production practices can have a positive effect on the environment by reducing energy use and the resulting environmental impacts. Biofuel production can provide a new market for farmers who make agricultural uses of land more economically sustainable and could be a source of revenue to implement water-quality best management practices. Production of cellulosic energy crops may produce less agricultural runoff than other crops. Production of algae as an energy feedstock can be used to reduce nutrients in Virginia's waterways. Renewable energy production that offsets conventional energy production can reduce pollution as compared with traditional energy sources. Carbon capture and storage need to be further developed to reduce the carbon emissions from conventional energy production.

5.1 Impacts of Energy Use on Climate Change

Strong evidence exists that increasing emissions of carbon dioxide and other greenhouse gases are affecting Earth's climate. The Intergovernmental Panel on Climate Change's *Fourth Assessment Report* stated, with an increased confidence level over previous reports, that most of the observed increase in globally averaged temperatures since the mid-twentieth century is "very likely due" to the increased anthropogenic greenhouse gas concentrations.[83]

Carbon dioxide emissions rose in Virginia by approximately 34 percent from 1990 to 2004, a rate nearly twice the national average. This increase results, in part, from growth in Virginia's economy and development patterns that have produced sprawl and long commutes. A 30 percent increase in gasoline-powered cars during this period ranked Virginia in the top ten states. The current science suggests that many changes can be expected from the cumulative effects of human-related emissions of carbon dioxide and other greenhouse gases affecting weather patterns, wildlife habitat, food production, and water supplies.[84]

What does climate change mean for Virginia? Over the long term, climate change will affect Virginia's people, wildlife, and economy. The Virginia Institute for Marine Science estimates that the Mid-Atlantic sea level will rise between 4 and 12 inches by 2030, threatening coastal islands and low-lying areas. Air and sea temperature changes would cause more frequent tropical storms, with increased damage to Virginia communities. Changing rain and temperature patterns would disrupt agriculture and forestry.

Carbon dioxide emissions can be reduced

[83]See the EPA website www.epa.gov/climatechange/science/stateofknowledge.html; report from the Greenhouse Gas Working Group of the State Advisory Board on Air Pollution, January 5, 2007 (www.deq.virginia.gov/air/sab/GHGreport.doc); and Intergovernmental Panel on Climate Change, "Climate Change 2007: The Physical Science Basis; Summary for Policymakers" (www.ipcc.ch/SPM2feb07.pdf)

[84]The six primary greenhouse gases listed in the Kyoto Protocol are carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydroflurocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF6) (http://europa.eu/scadplus/leg/en/lvb/l28060.htm).

Methane is a major source of greenhouse gases. According to the U.S. Environmental Protection Agency (EPA), methane is more than twenty times more effective at trapping heat in the atmosphere than carbon dioxide over a hundred-year period.

by increasing energy efficiency and conservation and using energy from sources that generate less carbon dioxide such as nuclear, hydropower, solar, wind, and biomass energy with a closed carbon cycle. Future technologies may permit widespread, cost-effective capture and storage of carbon.

A January 2007 report from the Greenhouse Gas Working Group of the State Advisory Board on Air Pollution provided an overview of greenhouse gases, including their sources and emissions in Virginia. The report listed policy options but did not make specific recommendations. The report noted that (i) the principal greenhouse gas from human activities is carbon dioxide, largely because these emissions are many times greater than any other greenhouse gas; (ii) the United States is responsible for about 25 percent of global carbon dioxide emissions; (iii) burning fossil fuels accounts for about 80 percent of U.S. greenhouse gas emissions; (iv) reducing greenhouse gas emissions and carbon capture and storage are two ways to address the problem of global warming caused by greenhouse gases; and (v) because transportation accounts for 40 percent of carbon dioxide emissions, the transportation sector is one of the most promising areas for carbon dioxide emissions reductions.

One technology that may be available in the near term is advanced coal gasification with carbon capture. Carbon may also be removed from the atmosphere by biological means in forests and grasslands. Replanting and conservation of forestland and grassland is one of the options open to Virginia to capture and store carbon.

Methane is another major source of greenhouse gases. According to the U.S. Environmental Protection Agency (EPA), methane is more than twenty times more effective at trapping heat in the atmosphere than carbon dioxide over a hundred-year period. The EPA states that methane's relatively short atmospheric lifetime, coupled with its potency as a greenhouse gas, makes it a candidate for mitigating global warming over the near term. Virginia has been a leader in reducing emissions of methane from coal-mining operations. Approximately 80 billion cubic feet of methane were capture from coal seams in 2006. This is nearly enough to provide natural gas to all residential users in the state. Methane emissions have also been reduced through local natural gas utility pipeline repair programs and increased recovery of landfill gas.

Methane emissions also can be reduced through waste management practices. Increasing waste-to-energy development keeps waste out of landfills and reduces methane formation. Implementing new landfill gas to energy projects will capture methane otherwise vented to the atmosphere or burned in flairs, creating useful energy out of this wasted resource.

The Energy Policy Act of 2005 is the most recent major federal legislation that, in part, should lead to decreased greenhouse gas emissions. The act requires use of cleaner burning alternative fuels, federal purchases of renewable electricity, and higher efficiency standards for selected energy-using products. It provides tax incentives to promote alternative fuels, efficient vehicles, renewable and nuclear electricity, efficient buildings, and clean-coal technologies.

A growing number of states are adopting policies aimed at reducing greenhouse gas emissions, among them renewable portfolio standards for electric generation, fiscal incentives (tax benefits, rebates, grants, and loans) for energy-efficiency and renewable-energy measures, enhanced building energy standards, greenhouse gas inventory and registry activities, carbon cap and trade programs, and other measures.

Virginia has begun to address greenhouse gas emissions, but it has the potential to do more. Virginia adopted a voluntary renewable portfolio standard early in 2007. Additionally, on May 22, 2007, Governor Kaine announced that Virginia had joined The Climate Registry. With a membership of more than thirty states and several tribes, The Climate Registry is the

On May 22, 2007, Governor Kaine announced that Virginia had joined The Climate Registry. With a membership of more than thirty states and several tribes, The Climate Registry is the nation's only state-sponsored initiative to standardize methodologies to record and measure greenhouse gas emissions such as carbon dioxide, methane, and nitrous oxides.

nation's only state-sponsored initiative to standardize methodologies to record and measure greenhouse gas emissions such as carbon dioxide, methane, and nitrous oxides. The Climate Registry is intended to provide "an accurate, complete, consistent, transparent and verified set of greenhouse gas emissions data from reporting entities, supported by a robust accounting and verification infrastructure."[85]

Implementation of 2007 electric utility legislation will also result in reduced greenhouse gas emissions. Meeting the 10 percent electric conservation goal in the 2007 electric legislation would be equivalent to reducing more than 7 million metric tons of carbon dioxide emissions, or approximately 5.5 percent of the estimated 130 metric million tons of 2005 total carbon dioxide emissions. Meeting the 12 percent renewable portfolio standard goals for Virginia's investor-owned utilities would result in a similar reduction in carbon dioxide emissions. A 10 percent reduction in gasoline use in Virginia would reduce carbon dioxide emissions by nearly 4 million metric tons per year, or approximately 3 percent of Virginia's total 2005 carbon emissions.

The recommended actions in this Plan for increased energy efficiency, methane emission reductions, and switches to lower-carbon fuels are a start toward controlling greenhouse gas emissions. However, these actions alone will not solve the problem of increasing carbon dioxide emissions.

Virginia can join other states in setting an aggressive goal to reduce greenhouse gas emissions by 30 percent by 2025. This will bring Virginia's greenhouse gas emissions back to 2000 levels. The question of how Virginia will reach this goal requires exploration that is beyond the scope of this Plan. Therefore, the Commonwealth should create a Commission on Climate Change. The commission could be asked to make a more comprehensive assessment of greenhouse gas issues and develop a plan for how to reach this greenhouse gas emission reduction goal. Specifically, the commission could be charged with preparing a Climate Change Action Plan that would (i) calculate the size of and contributors to Virginia's carbon footprint, (ii) address the effects of increasing atmospheric greenhouse gas concentrations on the state, (iii) identify what Virginia needs to do to prepare for the likely consequences of climate change, and (iv) identify what actions are needed to meet goals for reducing greenhouse gas emissions.

To help calculate the size of Virginia's carbon footprint, the state could go beyond voluntary participation and require reporting of greenhouse gas emissions through The Climate Registry. This would establish hard data needed to look at specific areas where carbon is emitted and help identify where reductions are possible.

This issue should be the subject of national policy because both the causes of, and solutions to, climate change transcend state and local boundaries. But, the magnitude of the problem is such that states can not simply wait for a federal resolution. It is hoped that these recommendations, and similar actions taken by other states and localities, may motivate a comprehensive national approach to this topic. Virginia stands willing to participate in the develop of such an approach and will work to harmonize our efforts with a reasonably aggressive national strategy.

5.2 Impacts of Energy Use on Air Quality

Energy production and consumption are significant factors in Virginia's air quality challenges. Burning fossil fuels to generate electricity and to power transportation systems is the predominant contributor of pollutants to the atmosphere. In 2005, fuel combustion accounted for the overwhelming majority of the 291,635 metric tons of sulfur dioxide, 125,189 metric tons of nitrous oxides, and 1 metric ton of mercury emitted by Virginia utilities and industry. It also accounted for a substantial percentage of particulate matter, volatile organic compounds, and hazardous air pollutants.

[85]The Climate Registry, www.theclimateregistry.org.

Emission of these pollutants is regulated by the state under the federal Clean Air Act. Air quality permits are issued to industries and facilities that emit regulated pollutants to ensure that these emissions do not harm public health or cause significant deterioration in areas that have clean air. As part of this regulatory regime, Virginia adopted the Clean Air Interstate Rule and mercury rules capping emissions of sulfur dioxide, nitrous oxides, and mercury. Any new sources of these pollutants must be offset so there will be no net increase in the emissions.

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The three population centers of northern Virginia, Richmond, and Hampton Roads are most affected by air pollution nonattainment designations. As of July 2007, nine full or partial counties were designated as nonattainment for the federal fine particulate matter standard. Until May 29, 2007, sixteen full or partial counties in Virginia were designated as nonattainment areas for the federal eight-hour ozone air-quality standard.[86] On that date, the U.S. Environmental Protection Agency announced that air quality in Richmond and Hampton Roads meets the federal standard to protect people's health from ozone pollution. The federal agency took the action after determining that air quality in the two areas has improved since the initial nonattainment designation.

Current and projected population growth and industry expansion suggest that Virginia faces challenges in balancing energy demands with environmental concerns. Issues associated with global warming have led governments, businesses, and individuals to examine ways to alter policies, strategies, and lifestyles to reduce emissions of greenhouse gases. Approaches such as renewable-energy use, energy efficiency and conservation, mixed use/high-density land-use planning, mass transit, recycling/waste-stream reuse, telecommuting, and driving hybrid and other fuel-efficient vehicles are all becoming mainstream and will play a key role in addressing the challenge.

5.3 Impacts of Energy Use on Water Quality and Water Supplies

The energy-use impacts on water quality and supply that are of greatest concern in Virginia are mercury, nutrient, and acid deposition and water heating and evaporation. Energy extraction and production also affect water quality and availability of water supplies. The Department of Environmental Quality (DEQ) and Department of Mines, Minerals and Energy regulate most of these impacts through their permitting processes and by setting limits to protect water quality and quantity. Energy production also can affect aquatic water habitat by altering flow regimes, obstructing fish migration and causing sedimentation.

5.3.1 Mercury Deposition

Mercury from power plant emissions can be deposited into rivers and streams by rain and ultimately accumulates in fish. Mercury accounts for a large percentage of all Virginia state advisories on reduced fish consumption. As of December 31, 2005, there were twelve mercury-impaired waters in Virginia.[87] In all but two,[88] air deposition is suspected as a significant or the sole source of the contamination. The Virginia Department of Health has issued mercury-based fish-consumption advisories for portions of all ten of Virginia's river basins, based on fish-tissue monitoring.[89] The U.S. Environmental Protection Agency (EPA) and the Food and Drug Administration have issued seafood-consumption advisories because of mercury levels found in certain marine species.

Recognizing that mercury emissions are transported long distances, the EPA issued the Clean Air Mercury Rule to reduce emissions from coal-fired utilities and to help states meet their water-quality goals. States were required to submit a rule by fall 2006 to implement the federal reductions. The State Air Pollution Control Board adopted these rules in January 2007. The rules capped mercury

[86]Virginia Ambient Air Monitoring 2005 Data Report, Virginia DEQ, p. 69.
[87]Virginia Water Quality Assessment 305(b)/303(d) Integrated Report, September 2006, pp. 3.1-9-3.2-54.
[88]Mercury impairments in the North Fork of the Holston River in southwest Virginia and in the Shenandoah/South Rivers in the valley region are due to legacy point source from industrial activities.
[89]Virginia Water Quality Assessment 305(b)/303(d) Integrated Report, September 2006, p. 2.4-12.

Major portions of Chesapeake Bay and its tributaries are listed under the Clean Water Act as "impaired" because of such factors as low dissolved-oxygen levels, poor water clarity, and algae blooms. Caused by excess nitrogen and phosphorus loads, these conditions severely stress the bay's ecosystem and hinder commercial fishing, recreational use, and aesthetic enjoyment of the bay and its tributaries.

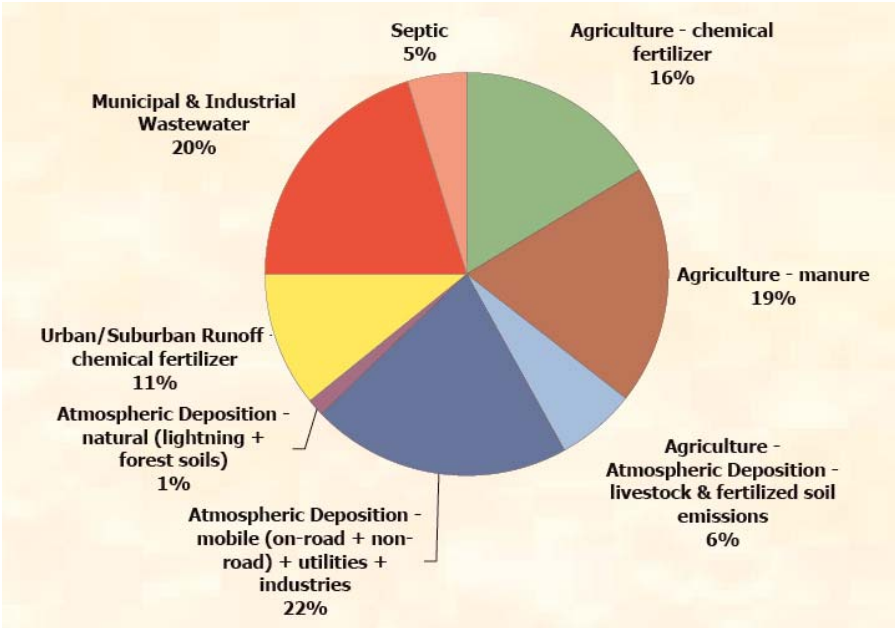
emissions so new emissions must be offset, and restricted trading allowances more than the minimum required under the federal Clean Air Mercury Rule. The DEQ is conducting a study, scheduled for completion by fall 2008, to determine the effects and sources of mercury deposition in state waters and whether or not additional controls are needed.

5.3.2 Nutrient Deposition

Major portions of Chesapeake Bay and its tributaries are listed under the Clean Water Act as "impaired" because of such factors as low dissolved-oxygen levels, poor water clarity, and algae blooms. Caused by excess nitrogen and phosphorus loads, these conditions severely stress the bay's ecosystem and hinder commercial fishing, recreational use, and aesthetic enjoyment of the bay and its tributaries. The EPA's Chesapeake Bay Program Office estimates that in 2005, 22 percent of the nitrogen load in the bay and its tributaries came from air deposition from mobile source, industrial, and electric utility emissions (see Figure 5-1). The remainder came from point sources such as discharges from wastewater treatment plants and industrial facilities and non-point sources such as urban, suburban, and agricultural runoff.

The State Air Pollution Control Board has recently adopted regulations to implement the federal Clean Air Interstate Rule that will cap and eventually reduce nitrous oxide emissions and impacts from power generation. Virginia has also instituted regulatory controls on point-source dischargers and has invested hundreds of millions of dollars to reduce point-source and non-point-source nutrient discharges to the Chesapeake Bay and its tributaries. Additional nutrient-reduction measures, especially for non-point sources, will be needed to achieve restoration of the bay and its tributaries.

Figure 5-1 Sources of Nitrogen Loads to Chesapeake Bay, 2005



Total Nitrogen Loads to the Bay in 2005 = 266 million lbs./year

5.3.3 Acid Deposition

Acidic compounds are formed in the atmosphere when sulfur dioxide and nitrous oxide pollutants, released primarily from burning fossil fuels, react with other substances in the atmosphere. These compounds can be deposited on land and water by rain, fog, snow, or dust. Acidification of soil and vegetation damages forests and crops by making them more susceptible to disease. Acid

[90]See the EPA's website: www.epa.gov/region7/programs/artd/air/acidrain/acidrn2.htm.

deposition contributes to the deterioration of buildings and monuments. Acidic aerosols are known to worsen asthma and other lung ailments and to impair visibility in many regions, including the scenic vistas of our national parks.[90]

Increased water acidity and metals leached from acidified soil can impair the ability of certain types of fish and aquatic plants to reproduce, grow, and survive. Streams in the Appalachian Mountain region have lost trout and other aquatic life because of acid deposition.

In the preamble to the Clean Air Interstate Rule in the Federal Register (2005), the EPA stated that activities to reduce sulfur dioxide and nitrous oxide emissions from coal-fired utilities will result in environmental benefits, such as reducing nutrient deposition that leads to excessive aquatic plant growth and eutrophication and reducing acidification of lakes, streams, and forests. Preventing pollution, reducing tailpipe emissions, and reducing emissions from power generation and industrial processes are the recommended actions for curbing acid deposition.

Virginia has several specific initiatives to control acid deposition, including:

- Title IV utility controls (Phase II) – Large Virginia power plants were required to reduce sulfur dioxide and nitrous oxide emissions beginning in 2000 and to participate in a federal sulfur dioxide trading program.
- Low-sulfur gasoline and diesel fuel – Phased in for on-road and off-road vehicles starting in 2006.
- Clean Air Interstate Rule – Additional large sulfur dioxide reductions from power plants are expected in 2009 and 2010.
- New federal emission regulations for off-road vehicles, trains, and marine engines will be phased in over the next five to ten years. Some regulations have been adopted and some are currently proposed.

5.3.4 Water Heating and Evaporation

Power generation and energy use contribute to water-supply challenges in Virginia, where population and economic growth are increasingly stressing a finite fresh water supply. Steam generation and cooling processes in power plants use billions of gallons of water each year from Virginia's surface waters and groundwater. Although most of this water is returned to surface waters, a significant portion is lost to evaporation.

Water resources are very limited in most of Virginia for any type of intensive water-consuming project. The pressures of a growing population and expanding industrial operations will continue to tighten water supplies in more regions of the state, reducing the water available for energy production. Emerging technologies and alternative energy sources can help reduce these impacts. For example, the Virginia City Hybrid Energy Center being developed in Wise County will use air-cooling technologies to significantly reduce water use.

5.4 Land Use and Energy Consumption

Electrical generating facilities require large tracts of land. They also require rail, barge, and pipeline infrastructure for fuel delivery, transmission lines, and waste storage and disposal facilities. As demand for electricity continues to grow, so does the challenge of finding appropriate sites and acquiring rights-of-way.

Extraction of coal, oil, and natural gas also has an effect on Virginia's landscape. The most significant impacts are those associated with surface coal mining. Surface mining operations in Virginia are expected to decline over the term of this Plan; projections suggest most future production will come from underground operations.

Transportation is Virginia's largest energy-consuming sector. Land use and transportation are integrally linked. The typical suburban sprawl that characterizes much of Virginia's urban crescent increases the demand for new roads and highways. This style of development intensifies automobile use and discourages the use of less polluting alternatives such as public

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[91]Southern Environmental Law Center, "Where Are We Growing? Land Use and Transportation in Virginia," based on original data from U.S. Census Bureau, USDA Natural Resources Inventory, and Federal Highway Administration, 2002 (www.selcva.org/publications/va_growth_report.pdf)

From 1980 to 2000, Virginia's population grew 33 percent, while vehicle miles traveled grew 99 percent.

High-density, mixed-use "new urbanism"-style developments are gaining popularity. These communities offer live-work-play lifestyles where walking or biking to work or to shop is easy, convenient, and safe.

transit, bicycling, or walking.

From 1980 to 2000, Virginia's population grew 33 percent, while vehicle miles traveled grew 99 percent. From 1992 to 1997, a 7 percent population increase in Virginia was accompanied by a 15 percent increase in land development.[91] Virginia's trend toward sprawl and demand for transportation of people and freight is projected to grow at a similar pace for at least the next decade.

Sprawl impacts land, water, and air through increased utility infrastructure, energy use, and traffic. Policies aimed at changing land-use patterns would reduce energy use and the need for new electric and natural gas infrastructure, including power plants, transmission lines, and pipelines. Long-term land-use changes aimed at creating denser, mixed-use settlements offer considerable energy-saving opportunities. Focusing developers' attention on pedestrian and bicycle accommodations and public transit is also important.

Virginia's 2007 transportation legislation included measures that build on the previous reforms in transportation and land-use planning by expanding the scope and application of transportation impact fees for by-right commercial and residential development in communities with growing populations. This will promote more energy-efficient development by helping check unfettered sprawl and promote infill development. Other legislation enacted in 2007 strengthened standards for accepting subdivision streets into the state system by increasing connectivity standards for roads and subdivisions, enhancing the overall capacity and efficiency of the transportation network. Other legislation promoted traffic flow and interconnectivity on the state's road system, ensuring that new and existing roadways are not degraded by the creation of too many and poorly spaced intersections, turn lanes, median breaks, and other impediments and allowed Virginia Department of Transportation vehicles to participate in clearing cars and restoring traffic flow after an accident, improving response time. These traffic flow enhancements will reduce fuel use due to highway congestion.

High-density, mixed-use "new urbanism"-style developments are gaining popularity. These communities offer live-work-play lifestyles where walking or biking to work or to shop is easy, convenient, and safe. Many of the developments are incorporating a range of sustainability initiatives, from high-efficiency building-construction standards to water, wastewater, and solid waste handling and use. More recently, developers and property owners are showing an interest in community-based power generation where small, distributed units would be co-located with or sited close to a community to provide power to residents and businesses or to be sold back to the grid. This also provides for an attractive market for renewable-energy applications. In Virginia, examples include Haymount in Caroline County, Rocketts Landing in Richmond, and New Town in Williamsburg. Plans for the Town of Haymount, for example call for approximately 12,000 people, 4,000 homes (which will use green building products), 250,000 square feet of retail space, 500,000 square feet of commercial and light industrial space, churches, parks, schools, and an organic farm. Only a third of the land will be developed, with the rest remaining in forests, wetlands, and farming areas.

Although not a new urban development, Tangier Island is an example of a self-sufficient community. The community is considering installing utility-scale wind turbines to supplement and replace much of the power purchased from the mainland or coming from on-island diesel generator sets. If implemented, this would provide a model for a small community co-op that others could learn from and replicate.

Redevelopment of urban brownfield properties and inner-city districts can have the same positive impacts on energy and the environment while also creating jobs, revitalizing neighborhoods, increasing property- and sales-tax revenues, decreasing sprawl, and reducing health risks to the local community. Redevelopment can be

Chapter 5

Energy and the Environment

continued

A January 2007 report prepared by the State Advisory Board on Air Pollution states that energy efficiency can slow the growth in electric demand and moderate the associated price volatility, energy security concerns, and environmental impacts.[93] The report notes that the United States now saves "more energy each year from energy efficiency than we get from any single energy source."[94]

[92]American Council for an Energy Efficient Economy, "Consumer Guide to Energy Savings," 8th ed., 2003, www.aceee.org/consumer-guide/index.htm.
[93]State of Virginia, "Report from the Greenhouse Gas Working Group of the State Advisory Board on Air Pollution," January 5, 2007, p. 46.
[94]Ibid.
[95]www.chesapeakebay.net/pubs/blueribbon/Blue_Ribbon_fullreport.pdf.

transit oriented by developing around transit stops and including retail and commercial so that people can meet daily needs by foot, bicycle, or public transportation. Arlington County's land-use plans along metro routes in the county are a good example of compact, transit-oriented urban development.

5.5 The Environmental Case for Energy Efficiency and Renewable Energy

5.5.1 Energy Efficiency

Using energy more efficiently, whether through more efficient end uses or generation, reduces the amount of fuel required to produce a unit of energy. This in turn reduces emissions of greenhouse gases and other pollutants.

Efficiency measures can also save substantial amounts of water in electrical generation and in homes, offices, and industrial facilities. For example, a new high-efficiency clothes washer uses 4,500 gallons less water a year than a standard-efficiency washer.[92]

A January 2007 report prepared by the State Advisory Board on Air Pollution states that energy efficiency can slow the growth in electric demand and moderate the associated price volatility, energy security concerns, and environmental impacts.[93] The report notes that the United States now saves "more energy each year from energy efficiency than we get from any single energy source."[94] An added advantage of energy-efficiency improvements is that they typically can be implemented quickly.

5.5.2 Biofuels Production

According to the June 2004 Chesapeake Bay Watershed Blue Ribbon Finance Panel, "virtually all of the [Chesapeake Bay] basin's more than 87,000 farms will need to implement additional best management practices (BMPs)-well beyond those now in place-to meet current goals for reducing nutrient and sediment loadings to the Bay and its tributaries….Nitrogen originates from both inorganic fertilizer and manure and is a particular concern in corn, wheat and soybean production due to inefficient nitrogen uptake in those large-scale crop operations."[95] Increased acreage of row crops such as corn or soybeans planted in response to ethanol or biodiesel demand can make this problem worse. It is also possible that farm acres currently devoted to implementing conservation practices could be converted to corn production. Growing other biofuel crops, such as hull-less barley or cellulosic crops, can, with best management practices, reduce nutrient runoff. Best management practices should be followed on any lands used to produce energy crops to avoid harming water quality.

Best management practices also could include capturing nutrients and using them as a catalyst to breed new biomass alternative fuel feedstock. The Virginia Coastal Energy Research Center is researching algae biomass-to-energy technologies. Algae can be cultivated using nutrients from manure digesters or through photo-bioreactors that harvest nutrients from irrigation runoff.

Algae species can be selected to make a variety of products, including lipids for biodiesel, proteins for feed, and carbohydrate biomass for fuels. Lipid-rich algae, for instance, can be pressed to extract oil for conversion to biodiesel in a manner similar to that used for soy-based biodiesel production. The resulting protein- and carbohydrate-rich meal has animal feed potential. If cellulosic ethanol production advances, algae can also serve as a feedstock for ethanol fuel. Virginia has a favorable climate for algae production, with a long photoperiod, ample sun, warm temperatures, and nutrient-rich waters that could be intercepted from critical points in key watersheds with strategically placed photo-bioreactors. It may be possible to use new tax revenues from an alternative fuels industry to help fund nutrient-reduction best management practices.

Biofuel production in Virginia offers additional positive environmental impacts. Virginia production would result in the increased end-use of these products, thus replacing higher polluting conventional fuels. Production plants would also need agricultural feedstock, creating potential new markets for Virginia farmers, which could preserve our rural heritage by providing an economic alternative to converting farmland to development.

5.5.3 Renewable Electricity Production

Electricity from renewable resources such as solar, geothermal, and wind technologies generally does not contribute to global climate change or local air pollution since no fuels are combusted in these processes.[96] Such low-emission renewable resources emit few or no pollutants and require little or no water for system operation. Biomass use does entail air pollution releases such as sulfur dioxide, but they are reduced relative to other energy sources. Biomass can be carbon neutral if grown to absorb at least as much carbon dioxide during growth as is released by combustion.

State-based standardized calculations that relate electricity production and use to emission rates have been developed based on the generation mix for each state. For every kilowatt-hour saved through efficiency or displaced by an emission-free renewable source, a considerable amount of emissions can be offset. Table 5-1 provides the factors calculated for Virginia per kilowatt-hour (kWh) and megawatt-hour (MWh).[97] These are average factors because different electrical generating units with different rates of emissions are operated at different times based on customer power demand and economic and technical considerations.

A renewable portfolio standard is a policy tool that requires or encourages retail sellers of electricity to provide a minimum portion of their electricity from renewable resources.

Table 5-1 Average Factors for Virginia Electricity Emissions, 2002

CO_2			CH_4	N_2O
lbs/kWh	**short tons/MWh**	**metric tons/MWh**	**lbs/MWh**	**lbs/MWh**
1.16	0.582	0.528	0.0137	0.0192

5.6 Incentives for Renewable Energy

5.6.1 Renewable Portfolio Standard

Many states have programs to provide financial and policy incentives for developing renewable resources. A renewable portfolio standard is a policy tool that requires or encourages retail sellers of electricity to provide a minimum portion of their electricity from renewable resources. Renewable portfolio standard requirements are typically denoted as a percentage of electricity sold to retail customers and are achieved by phased-in increases in the target percentage over time.

Although Congress has considered requiring a federal renewable portfolio standard, to date all enacted such standards have been adopted at the state or local level by state legislation or regulatory initiative. As a result, the resources eligible for renewable portfolio standard vary from state to state. More than twenty states have now passed a standard or similar requirement, with each state developing rules customized to its own regulatory and market environment.

Electric utility restructuring legislation passed in the 2007 Virginia General Assembly established a voluntary Virginia renewable portfolio standard. The standard is available for electric utilities that show a reasonable expectation of achieving 12 percent of base-year electric energy sales from renewable energy sources by 2022. Under the program, a utility that meets renewable energy goals earns an incentive that increases the established rate of return. It also earns an enhanced rate of return on the construction costs of renewable energy generation

[96]EPA, Clean Energy-Environment Guide to Action, April 2006, p. 50 (www.epa.gov/cleanenergy/pdf/gta/guide_action_full.pdf).
[97]Source: Voluntary Reporting of Greenhouse Gases Program, Energy Information Administration.

facilities used to provide the renewable energy. Electricity generated from solar or wind is given double credit toward the goal.

5.6.2 Other Incentives

In 2006, Virginia created a Photovoltaic, Solar, and Wind Energy Utilization Grant Program. The program would grant up to 15 percent of the cost of eligible systems, up to $2,000 for photovoltaic systems, or $1,000 for solar water heating or wind-power systems. Legislation also included a Renewable Electricity Production Grant Program that would grant up to 0.85 cents for each kilowatt-hour of electricity produced from approved renewable energy generators. Both of these programs are subject to appropriation and as of summer 2007 had not received funding.

Electric utility restructuring legislation established a voluntary Virginia renewable portfolio standard available for electric utilities that show a reasonable expectation of achieving 12 percent of base-year electric energy sales from renewable energy sources by 2022.

Virginia offers several incentives to help overcome cost barriers to the use of renewable energy. Counties and localities have been given the authority to exempt, or partly exempt, the cost of solar energy equipment from the property taxes paid by homeowners each year.

Virginia also provides for "net metering," which allows customers to generate their own electricity (such as through the use of solar panels) and receive the full retail value for their excess electricity at times when their renewable energy system is producing more electricity than their building is consuming.

Localities may also establish a separate classification of real estate for properties that are at least 30 percent or more energy efficient than required by building code. The localities may then set a lower real-estate tax rate as an incentive to construct these energy-efficient structures.

A different type of incentive for energy efficiency and renewable energy (EERE) is provided in Virginia's implementation of the Clean Air Interstate Rule. The Virginia rule caps total nitrous oxide emissions from the state's electrical generating plants of at least 25-megawatt capacity. Such plants are allocated tradable allowances, each representing a ton of nitrous oxide that can be bought and sold, allowing flexibility in how electrical generators will achieve required statewide nitrous oxide reductions.

As enacted by the State Air Pollution Control Board, the rule incorporates a set-aside of allowances for new facilities as well as a special energy efficiency and renewable energy set-aside. Projects that displace at least a ton of nitrous oxide emissions can obtain such allowances, which can then be credited in air pollution State Implementation Plans or other air-quality regulatory processes.

Scenarios for use of energy efficiency and renewable energy allowances could include northern Virginia localities buying wind power or implementing energy-efficiency measures that are allocated nitrous oxide allowances, which can be retired and then recognized by the Environmental Protection Agency as evidence of the localities achieving creditable nitrous oxide reductions.

5.7 Carbon Capture and Storage

Carbon capture and storage is a topic that is generating considerable interest and has significant potential. The U.S. Department of Energy's Office of Fossil Energy supports carbon sequestration activities and identifies sources of emissions and suitable sites for storage, with a goal of reducing carbon dioxide emissions and preventing a projected one-third increase in U.S. emissions from 2005 to 2030. Developers of new technologies for power generation and alternative fuels are including carbon capture as prerequisites to their research and development platforms and in their plans for commercialization.

Aviation fuel for the Department of Defense represents the largest single market area for liquid fuels. The Department of Defense is actively pursuing synthetic replacements to JP-8 aviation fuel; and U.S. Air Force representatives have noted that for replacement fuels to be considered, carbon capture or carbon-free production processes will be required.

Significant carbon sequestration research has been conducted under the Regional Carbon Sequestration Partnership program, which draws from seven regions in the United States and Canada and consists of more than four hundred organizations in forty states, four Canadian provinces, and three Indian nations. In March 2007, the partnership released the results of a survey that identified stationary sources (including power plants) that produce 3.8 billion tons of carbon dioxide each year, as well as sites with the potential to store more than 3,500 billion tons of carbon dioxide. Carbon sequestration involves capturing and storing carbon dioxide that would otherwise remain in the atmosphere for long periods of time. The carbon dioxide is stored in geologic formations, soils, and vegetation or other environmentally friendly forms.

Although diversifying energy production and transitioning to cleaner alternatives will take time and money, energy conservation and efficiency can start now.

Virginia Tech, a partner in the Southeast Regional Carbon Sequestration Partnership (SECARB), has researched and developed data on Virginia's potential and is testing carbon capture and storage technology in Virginia's coal seams. The project has the potential to implement a ten-year pilot to capture a million tons of carbon dioxide per year in Virginia. It also could increase the production of coalbed methane from the coal seams, increasing the efficiency of these operations (see Chapter 6).

5.8 Environmental Programs Affecting Energy Use

Changes in current patterns of producing and using energy can greatly reduce a variety of environmental problems, including emissions of greenhouse gases, conventional pollutants, and hazardous air emissions. Such changes can also reduce water use and water pollution.

Energy recovery can also address environmental concerns. For instance, energy recovery from gases generated in landfills, from sewage treatment, and in certain industrial processes can reduce air pollution, odor, greenhouse gas emissions, and explosive hazard. In such industries as agriculture and food production, treatment of wastes through energy recovery can yield useful energy, reduce disposal costs and nuisance from odor and other impacts, and perhaps derive concentrated nutrients or other saleable products.

Energy conservation and efficiency provide the least costly and most readily deployable energy-resource options and provide an immediate strategy to reduce the adverse impacts of energy production. Although diversifying energy production and transitioning to cleaner alternatives will take time and money, energy conservation and efficiency can start now. Carbon capture and storage technologies, clean-energy technologies, and efforts that reduce the environmental burden created by new energy infrastructure, current land-use patterns, and growing traffic-load trends represent longer-term approaches that can have significant positive energy and environmental impacts.

The Virginia Environmental Excellence Program (VEEP) is a voluntary program offering membership to government and non-government members. The program recognizes environmental achievements and encourages superior performance through environmental management systems and pollution prevention. It is closely aligned with the National Environmental Performance Track program, a voluntary partnership program run by the Environmental Protection Agency that recognizes top environmental performance among participating U.S. facilities. The program stresses continual environmental improvement through the use of environmental management systems, performance measures, and public outreach. Energy efficiency improvements should be an integral part of the VEEP actions.

On the local level, the Arlington Initiative to Reduce Emissions is a collaborative effort between the county government, businesses, organizations, and individuals that calls for a commitment to reduce greenhouse gas emissions by 10 percent by 2012.[98] As of July 2007, seven Virginia

[98]See www.arlingtonva.us/portals/topics/Climate.aspx.

mayors were participating in the U.S. Mayors Climate Protection Agreement. Fairfax County has been a leader in developing the Cool Counties Climate Stabilization Declaration.

Voluntary organizations, such as the Chicago Climate Exchange and the U.S. Climate Action Partnership (which includes major companies and environmental organizations), support and administer emission reduction plans.

5.8.1 Virginia Programs

Virginia Clean Air Interstate Rule

Numerous counties and cities in Virginia have been designated as nonattainment areas for the National Ambient Air Quality Standard for ozone and for fine particulate matter. In late 2006, the Virginia Air Pollution Control Board adopted regulations to implement the federal Clean Air Interstate Rule. These regulations reduce future emissions from power plants of sulfur dioxide and nitrous oxides-precursors to ground-level ozone and particulate matter-to a greater extent than the minimums required under federal rules. As described previously, these regulations also provide a new mechanism to reduce emissions by allocating nitrous oxide allowances to spur energy efficiency and renewable energy projects and requiring that such allowances be retired.

EERE Measures in the Virginia State Implementation Plan

Under the Clean Air Act, Virginia is required by June 2007 to submit additional control measures to help bring its air quality into attainment with the 8-hour ozone standard. As part of this Plan, municipalities in northern Virginia, including Arlington, Fairfax, and Prince William Counties and the Alexandria City School District, have proposed quadrupling the wind-energy purchases included in Virginia's 2004 ozone State Implementation Plan. They have also included energy-efficiency measures for the first time, including retrofitting traffic signals with high-efficiency light-emitting diode (LED) bulbs.

High Electric Demand Day Initiative

On March 2, 2007, the Ozone Transport Commission-an organization of state environmental commissioners in the Northeast and Mid-Atlantic States, including Virginia-adopted a resolution endorsing energy-efficiency and clean-energy strategies to combat high levels of ozone in the Northeast and Mid-Atlantic States. The goal is to intensify efforts among state air and energy agencies and utility regulators to adopt policies that reduce peak levels of electric power demand. Accomplishing this goal will not only improve air quality and public health but also will moderate electric price increases and improve reliability of the electric grid.

Clean Air Champions

The Department of Environmental Quality, in partnership with the American Lung Association, has developed a marketing campaign and curriculum to educate Virginians on the importance of keeping vehicles well maintained in order to protect air quality. This material has been incorporated in the Drivers Education Core Curriculum that is provided to approximately 80,000 students every year.

One of the challenges Virginia municipalities face with many of these efforts is the need to develop, refine, and implement methods to improve the quantification of energy savings and emissions reductions that result from energy-savings measures. This work is necessary to gain maximum benefits from the use of the new tools in the Virginia Clean Air Interstate Rule and to implement the governor's 2007 executive order requiring the calculation of greenhouse gas emission reductions resulting from energy-savings measures in public buildings. This work can be best accomplished through a collaborative effort among state environmental and energy agencies and the State Corporation Commission, with support from relevant federal agencies.

State Advisory Board on Air Pollution

The 2007 report from the Greenhouse Gas Working Group included a list of policy options that address energy. This list includes recommendations in energy

Many communities are taking action to reduce the environmental and energy burdens created by current land-use and development trends. Policies that promote smart growth and coordination of land use with transportation primarily involve planning, modeling, and regulatory tools that support local government efforts.

efficiency, transportation, industry, and energy production, many of which are reflected in this Plan.

5.8.2 Other Approaches and Options

Many communities are taking action to reduce the environmental and energy burdens created by current land-use and development trends. Policies that promote smart growth and coordination of land use with transportation primarily involve planning, modeling, and regulatory tools that support local government efforts. They include tax measures, impact fees, new zoning ordinances, and regional or statewide growth management planning. State-supported investments in roads, public buildings, and other local development-related costs could be leveraged in order to make progress toward smart-growth communities. Using open-space protection programs, policies can discourage sprawl and greenfield development. Typical actions include:

- Localities and planning commissions addressing energy effects of land-use plans.
- Local planning and zoning commissions adopting measures such as transportation and infrastructure planning, transit-oriented development, and housing diversity.
- Statewide policies supporting land conservation, regional mass transit, property-tax reform, and building energy codes.

Several programs already exist in Virginia. Expanding the state's role and increasing the level of participation by local governments and businesses is a low-cost option.

For local governments:

- Clean Cities (offered in Virginia through the Hampton Roads Clean Cities Coalition).
- Rebuild America (offered in Virginia through the Virginia Sustainable Building Network).
- U.S. Mayors Climate Protection Agreement.
- Cool Counties Climate Stabilization Declaration.

For business and industry:

- U.S. Climate Action Partnership (industry and environmental group partnership).
- Climate Leaders and Climate Wise (EPA).
- U.S. Department of Energy's voluntary Reporting of Greenhouse Gas and Emission Reductions Program.
- Industrial Technologies Program (DOE).
- Energy Star (EPA).
- Virginia Environmental Excellence Program (Virginia DEQ).
- SF6 Reduction Program (EPA and electric power industry collaborative).
- AgStar, Gas Star, Combined Heat & Power Partnership, Landfill Methane Outreach Program, Coalbed Methane Outreach Program, Methane-to-Markets (EPA and various business sectors).
- Industry-specific partnerships such as The PowerTree Carbon Company, LLC.

Promoting a green campus initiative with colleges, universities, and secondary schools can minimize environmental impact and create learning labs for sustainability. This program would develop and support an effective process to promote energy and environmental sustainability with educational institutions, while introducing and educating future decision makers and social pioneers on energy and sustainability issues.

Tree planting is a primary means of enhancing total carbon sink capacity. Programs encouraging tree planting can be effective in both rural and urban settings. Existing programs address a range of goals, such as habitat conservation, scenic values, and wildlife corridors. Afforestation and urban tree planting programs can yield low-cost carbon sequestration.

A branding program can increase consumer preferences for products and services that decrease greenhouse gas emissions and/or mitigate climate change impact. The federal government could expand the Energy Star brand to include more products. Alternatively, Virginia could partner with the private sector to promote environmentally preferable products, recycled content, and other green goods and services. Retailers such as Home Depot, through its Eco Options program, are already offering such products.

Another way to address emissions from mobile sources would be to create a feebate program. Such a program would charge a fee on purchases for vehicles that are below specified fuel-efficiency and emission-performance criteria and offer a rebate on vehicles that exceed the criteria. The program could be designed in several different ways, taking into account the classes of vehicle to be covered and the manner in which the fees and rebates are calculated, collected, and disbursed. A feebate system can also be designed to either generate revenue or to be revenue neutral.

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Chapter 6

Energy Research and Development

Virginia is home to a world-class university research and development (R&D) system where there is extensive energy-related activity. The state is also home to a robust technology sector, with an impressive inventory of energy capacity.

6.0 Energy Research and Development

Advancing new energy technologies is critical if the United States is ever to reach energy independence and security. Virginia is home to a world-class university research and development (R&D) system where there is extensive energy-related activity. The state is also home to a robust technology sector, with an impressive inventory of energy capacity. This chapter investigates opportunities for Virginia to be an R&D leader in energy and environmental technologies. The chapter sets out a goal to increase energy R&D by $10 million per year, with half from state resources and half from private and federal resources.

Virginia's Department of Mines, Minerals and Energy partnered with the Center for Innovative Technology to perform a study on energy-related R&D. The objectives were to:

- Identify and describe Virginia's institutional strengths in energy R&D.
- Identify Virginia energy R&D activities that are currently or could become national or international leaders.
- Assess best practices for energy R&D facilitation and coordination and how they can be applied in Virginia.
- Provide an initial analysis of the potential benefits to Virginia from coordinated energy R&D.

Numerous reports were reviewed, and the Center for Innovative Technology visited or interviewed representatives at eleven Virginia colleges and universities, several private companies, and three federal laboratories in the state. The study concentrated on institutions with the most activity and expertise. It also investigated energy R&D performed by a few large private companies and Small Business Innovation Research award recipients. Several other states were examined to establish best practices, with special attention given to those that could enhance coordination of energy R&D activities among universities, federal laboratories, and industry in Virginia. The findings of the study are incorporated in this chapter.

Energy-related research in Virginia's colleges and universities, federal laboratories, and industry focuses on several areas: long-standing interests in fossil fuels (coal and natural gas) and nuclear energy, as well as recent and increasing interest in renewable energy sources such as biomass, geothermal, solar, wind, and coastal energy. There is also research in fuel cells and hydrogen, energy efficiency and conservation, energy and the environment, energy economics, and energy policy. Several of these areas-among them nuclear energy, alternative liquid fuels, coastal energy, and carbon capture and storage-could be leveraged into positions of national leadership.

Virginia's federal research laboratories, including the U.S. Department of Energy's Thomas Jefferson National Accelerator Facility in Newport News and NASA Langley Research Center, are engaged in energy research relevant to their core missions.

Significant energy research is being conducted by industry in Virginia, including nuclear energy stalwarts Areva NP and BWXT in Lynchburg, Siemens and Northrop Grumman Newport News on the peninsula, major electricity utilities such as Dominion Virginia Power, and a growing number of early-stage companies developing innovative energy-related technologies, often supported by federal Small Business Innovation Research and Small Business Technology Transfer Program awards.

The academic, federal, and industry sectors have overlapping research strengths in carbon sequestration, energy crops, alternative fuels, coastal/wind energy, energy efficiency and conservation, and nuclear technologies. Universities and industry have common research strengths in technologies for clean use of coal, while fuel cells are a common research area of several universities and NASA Langley.

Research leaders in Virginia's universities, federal laboratories, and industry identified lessons learned and suggested how the state could better facilitate energy-related

Potential benefits of coordinated energy R&D include increases in research funding and productivity; company creation, growth, and attraction; job creation and retention; advances in technology development and deployment; and environmental improvements.

R&D. Six best practices were identified through investigation of the energy R&D programs of six other states and one regional collaborative. Together these suggestions provide guidance for developing a statewide program to facilitate energy R&D in Virginia. Key components of such a program include the following:

- Develop a state Energy R&D Roadmap with milestones, and track results.
- Provide a cost-sharing commitment fund to enable competitive bids for large federal projects/awards and strategic recruiting opportunities.
- Fund a state-level initiative to coordinate and build Virginia's energy research, development, demonstration, and deployment capacity and spur its economic impact.

Potential benefits of coordinated energy R&D include increases in research funding and productivity; company creation, growth, and attraction; job creation and retention; advances in technology development and deployment; and environmental improvements.

6.1 Energy R&D at Virginia Colleges and Universities

The most comprehensive portfolio of energy-related R&D is found at Virginia Tech, which supports research activities in every energy arena identified for this Plan. The College of William and Mary, the Institute for Advanced Learning and Research, James Madison University, Norfolk State University, Old Dominion University, the University of Virginia, Virginia Commonwealth University, and Virginia State University also have research programs relating to energy resources, production, conservation, use, and in some cases, energy/environment issues and energy policy. George Mason University and Virginia Military Institute have interests in energy policy.

At least two state universities are making energy research a significant part of their strategic plans. In August 2006, Virginia Tech announced the creation of a Deans' Energy Task Force to play a key role in implementing the university's strategic initiative dealing with energy, materials, and environment. The task force, supported within Virginia Tech's Office of the Vice President for Research, has completed a detailed survey of Virginia Tech's breadth of research, education, and outreach activities related to energy.[99]

At the University of Virginia, Energy, Conservation and the Environment is a priority initiative within the office of the Vice President for Research and will be included in the university's ten-year academic plan currently in development. This initiative is being coordinated through a faculty steering committee comprising representatives from its schools of architecture, business, education, engineering, law, and arts and sciences. The university sees the three areas of energy, conservation, and the environment as equally important and is striving for a balanced program of research and education.[100]

Table 6-1 summarizes the types of energy-related R&D performed in Virginia's colleges and universities. The Center for Innovative Technology assessed the current or potential national prominence of Virginia energy research and expertise based on criteria that included founding and/or leading national-scale research consortia; winning, or placing as a finalist, in national centers; ranking among top U.S. programs by size, research funding, or distinctiveness; national-level recognition/ awards to faculty or research projects; perceived critical mass of capabilities across several Virginia institutions; and geographic/resource advantage.

[99] www.research.vt.edu/energy/index.html.
[100] Phil Parrish, personal communication, September 22, 2006.

Chapter 6

Energy Research and Development

continued

Table 6-1 Energy R&D at Virginia Universities and Colleges

Virginia College or University	Coal, Oil, Gas	Nuclear	Fuel Cells/ H2	Alternative Fuels: Waste- or Bio-derived	Geothermal	Hydroelectric	Solar/Photovoltaics	Wind	Coastal (Wind/Tidal/ Current/Wave)	Energy Storage	Efficiency/Conservation	Buildings/Environment	Energy Policy/ Economics
	Energy Generation/Sources									Energy Use/ Impact			Energy Policy
				Alternative Fuels	Other Renewables								
College of William and Mary		•					•		•				•
George Mason University													•
Institute for Advanced Learning & Research				•									
James Madison University			•	•				•	•		•		•
Norfolk State University							•		•				
Old Dominion University				•			•	•	•				
University of Virginia	•	•	•	•			•			•	•	•	•
Virginia Commonwealth University			•	•			•			•	•		
Virginia Military Institute													•
Virginia Tech	•	•	•	•	•	•	•	•	•	•	•	•	•
Virginia State University				•									

Virginia research areas with current or potential national prominence are carbon sequestration (VT), advanced separation technologies (VT), fuel cells and hydrogen (VT, UVA, VCU), alternative fuels (JMU, UVA, VSU, VT/IALR), coastal energy, including wind (CWM, JMU, NSU, ODU, VT), energy efficiency and conservation (JMU, UVA, VCU, VT) and green building design (UVA, VT). Faculty researchers in several Virginia institutions are studying nuclear power (CWM, UVA, VT), photovoltaics (CWM, NSU, ODU, UVA, VCU, VT), and energy policy (CWM, GMU, JMU, UVA, VMI, VT).

A verified figure for academic expenditures in energy-related R&D in Virginia is not available. Since "energy" is not among the National Science Foundation's (NSF's) defined list of science and engineering fields that universities and colleges use to track their R&D expenditures, there is no historical tracking of energy-related R&D. Energy-related research may therefore fall within many NSF classifications, including environmental sciences, life sciences, math and computer sciences, physical sciences, and sciences, not elsewhere classified.

Virginia universities also maintain working relationships with federal laboratories involved in energy research. The University of Virginia and Virginia Tech are among the core universities with seats on the governing board of the federal Oak Ridge National Laboratory, and they continue to be University Partners of the laboratory.[101] Several Virginia universities collaborate with the Thomas Jefferson National Accelerator Facility in Newport News, supported in part by the state through the Southeastern Universities Research Association. The association offers professorships at Virginia universities and distinguished scientist awards to assist in attracting talent and leadership to the lab.

Key energy-related research activities and expertise in Virginia colleges and universities are presented in Sections 6.1.1 through 6.1.3, organized by research category.

[101] www.ornl.gov/ornlhome/university_partners.shtml.

6.1.1 Energy Generation and Sources

Fossil Fuels (Coal, Oil, Natural Gas)

Two centers associated with Virginia Tech lead Virginia coal-related research. The Virginia Center for Coal and Energy Research (VCCER) at Virginia Tech is an interdisciplinary research and information resource, created by Virginia's General Assembly in 1977.[102] The VCCER conducts and coordinates research for the Virginia General Assembly, state utilities, and other corporate, government, and academic sponsors. Areas of study include:

- Energy statistics and modeling.
- Socioeconomic effects of energy and coal development.
- Environmental impacts of coal and energy.
- Sustainable development of energy and mineral resources.
- Carbon management and sequestration.
- Optimization of mining systems.
- Energy-efficiency studies.
- Coalbed methane extraction and use.
- Energy infrastructure studies.

The VCCER addresses global energy development, greenhouse gas emissions, and deregulation of the electric utility industry.

The VCCER also is leading an interdisciplinary coalition comprising universities, industry, and state agencies to identify potential carbon sequestration sinks in central Appalachia, as part of the Southeast Regional Carbon Sequestration Partnership (SECARB), one of seven partnerships created by the federal Department of Energy (DOE) to determine optimum approaches for capturing and storing carbon dioxide.

Under Phase I of the carbon sequestration program, the central Appalachian coal seam research team, led by the VCCER, conducted regional characterization of the coalbeds, located favorable areas to sequester carbon dioxide, and quantified the carbon dioxide storage capacity and associated enhanced coalbed methane recovery potential in southwest Virginia. Carbon dioxide's attraction to coal is approximately twice that of methane. Carbon sequestration has the potential to increase methane production from coal seams by displacing methane that otherwise might not be produced. Theoretically, carbon dioxide molecules will be preferentially absorbed onto the coal surface, thereby releasing methane gas and boosting coalbed methane production. The cost of implementing carbon dioxide sequestration technologies could be offset by enhanced coalbed methane recovery. Carbon dioxide sequestration capacity values for coal seams have been calculated by processing and assimilating net coal thickness, coal rank, coal isotherm, and related coal-reservoir data. Factors such as historical deep mining and currently permitted deep mine areas have been taken into account in the calculations, as carbon dioxide cannot be effectively sequestered in mined locations.

The primary objectives in Phase II of this program are to continue refining the geologic characterization, expand the study area to contiguous West Virginia and Kentucky counties, and verify the sequestration capacity and performance of mature coalbed methane reservoirs through two field validation test sites. Research has identified ideal areas for sequestration in mature coalbed methane production areas in Buchanan, Dickenson, Russell, Tazewell, and Wise Counties in Virginia and in Fayette, McDowell, Raleigh, and Wyoming Counties in West Virginia (see Figure 6-1). The coal seams in the Central Appalachian Basin could store from 398 to 1,341 million tons of carbon dioxide and a corresponding enhanced coalbed methane recovery of 0.79 to 2.49 trillion cubic feet of natural gas. If these technologies prove successful, the economic development potential of enhanced coalbed methane recovery and the greenhouse gas mitigation potential of storing carbon dioxide are significant.

The Phase II sequestration testing will be conducted in actively producing coalbed methane wells in southwest Virginia's Central Appalachian Basin and in the

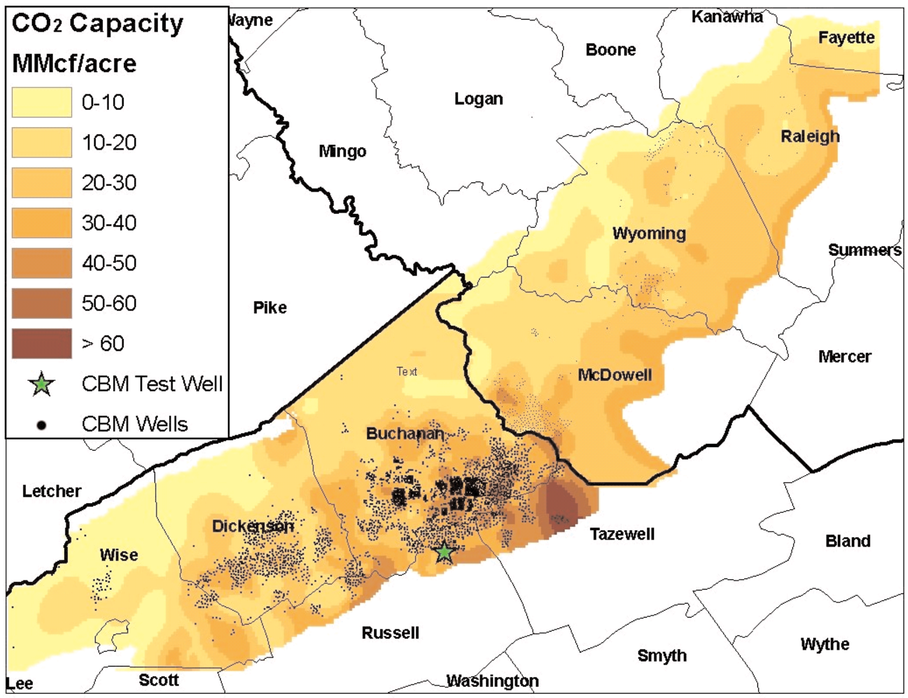
[102] www.energy.vt.edu/index.html.

Black Warrior Basin in Alabama. About 1,000 tons of carbon dioxide will be injected into donated wells in each site. Both surface and subsurface monitoring programs will measure and verify the location of the injected carbon dioxide. Throughout this program, vigorous public outreach and technology transfer activities will be conducted.

The DOE has provided $14.3 million to SECARB for Phase II of this project. The program has dedicated $3.4 million to demonstrate carbon sequestration potential in unmineable coal seams in both the Central Appalachian and Black Warrior Basins. An additional 20 percent of the total project funding is from cost sharing and contributions from the twenty industrial partners participating in the project.

Phase III of the carbon sequestration program, in which there will be large-scale sequestration testing, will be implemented during the term of this Plan. This research could be housed in a Fossil Fuel and Carbon Management Center operated by the VCCER in Abington and Dickenson County.

Figure 6-1 Carbon Capture Potential in Virginia and West Virginia



The Center for Advanced Separation Technologies (CAST) is a national consortium of seven universities formed in 2001 under the auspices of the federal DOE.[103] Its mission is to conduct fundamental and applied research to develop technologies that can be used to produce coal and mineral concentrates in an efficient and environmentally acceptable manner. The center is led by Virginia Tech's Dr. Roe-Hoan Yoon, who formerly headed Virginia Tech's Center for Coal and Minerals Processing. In March 2005, the center received a $12 million grant from the National Energy Technology Laboratory to advance separation technologies used by mining industries.

In 2004, the U.S. mining industry produced a total of $63.9 billion in raw materials (second only to China), $19.9 billion of it from coal and $44 billion from minerals. CAST is the only center in the United States devoted to separations research as applied to the mining industry.

[103]www.cast.org.vt.edu.

Virginia has significant research strength in the areas of fuel cells and hydrogen. Worldwide government spending for fuel-cell and hydrogen infra-structure approached $1.5 billion in 2004, and it is estimated that world markets for fuel cells in systems will grow more than tenfold, reaching $12.6 billion per year by 2012.[109]

[104]Roe-Hoan Yoon, personal communication, September 26, 2006.
[105]Ken Ball, Eugene Brown, Mark Pierson, personal communication, September 26, 2006.
[106]Ibid.
[107]Phil Parrish, personal communication, September 22, 2006.
[108]Dennis Manos, personal communication, September 22, 2006.
[109]From "Why Fuel Cell Research?" provided by VT fuel cell research cluster faculty, September 2006.
[110]From chart "Potential Fuel Cell Markets," A. Scott, Chemical Week (www.chemweek.com), November 3, 2004.
[111]From "Why Fuel Cell Research?" provided by VT fuel cell research cluster faculty, September 2006.

"The NETL award will allow CAST to develop and transfer additional advanced separation technologies to remove impurities from coal, including mercury, sulfur dioxide, and nitrogen oxides, in an environmentally acceptable manner-and to clean up waste impoundments created in the past and acid mine water," says Dr. Yoon.

Dr. Yoon also notes that the Department of Mining Engineering at Virginia Tech is the largest such department in the nation and has one of the few mining engineering research programs.[104] With 40 percent of the mining engineers in the nation over many years having graduated from Virginia Tech, several of the leaders in this field are VT graduates. Dr. Yoon notes that coal production is down in the eastern United States, in part because of a decline in funds for mining engineering technology. To realize the full production of U.S. coal reserves from mining, methods for recovering coal from deep, thin seams must improve.

Nuclear

Virginia Tech (Eugene Brown, Mechanical Engineering, and Mark Pierson, Research Division) is working with the new Center for Advanced Engineering and Research in Lynchburg to enhance technical capabilities of the nuclear industries in Region 2000.[105] Ken Ball (Mechanical Engineering) is proposing a collaborative certificate program in nuclear and radiation engineering and science to encompass the areas of nuclear power generation, nondestructive evaluation, materials science, and nuclear medicine.[106]

The University of Virginia once had a strong nuclear engineering program, but the two nuclear reactors at the university were decommissioned (in 1988 and 1998) and the program ceased in 1999. UVA still maintains faculty expertise in nuclear containment systems based on amorphous materials resistant to corrosion (Scully, Kelly, Stoner, Materials Science).[107]

College of William and Mary researchers have interests in accelerator-based waste disposal, advanced radiation shielding, and low-level waste handling, as well as plasma-wall interactions in magnetic confinement fusion.[108]

Fuel Cells and Hydrogen

Virginia has significant research strength in the areas of fuel cells and hydrogen. Worldwide government spending for fuel-cell and hydrogen infrastructure approached $1.5 billion in 2004, and it is estimated that world markets for fuel cells in systems will grow more than tenfold, reaching $12.6 billion per year by 2012.[109] Including stationary, portable, and vehicle-based fuel cells, potential markets are estimated to exceed $45 billion by 2013.[110] Many U.S. industries are at a critical point in their need to implement fuel-cell technology in a commercially viable way. General Motors, for example, is investing $3 billion in fuel-cell technology and plans to launch a commercial fuel-cell vehicle line in 2010.[111] The federal government proposed a five-year, $1.2 billion Hydrogen Fuel Initiative, including a FY 2007 request of $289.5 million. Most of this funding is designated for the DOE's Energy and Efficiency and Renewable Energy program, with other funding designated for the Office of Science, the Fossil Energy program, the Nuclear Energy program, and a relatively small amount for the Department of Transportation.

Virginia Tech has a strong cluster of researchers focused on improving fuel-cell performance. Key researchers include James McGrath (PEMs and MEAs), Dave Dillard (fuel-cell durability/sealants), Scott Case and Jack Lesko (composite systems, durability modeling), and several others (e.g., Michael Ellis, Doug Nelson, and Michael von Spakovsky) involved in integration and performance analysis of fuel cells in systems such as buildings and automobiles. Nelson directs the Virginia Tech Center for Automotive Fuel Cell Systems, and von Spakovsky directs the Center for Energy Systems Research, both of which have received long-term funding from the federal DOE. Recent interests include development of fuel cells powered by biological processes (N. Love, M. Ellis, and I. Puri), hydrogen production from sugars (Percival Zhang) and from water by solar catalysis (K. Brewer), and hydrogen storage in carbon nanostructures (I. Puri).[112]

In January 2006, DOE Secretary Samuel Bodman announced that Virginia Tech was among twelve teams sharing $19 million for polymer membrane research for hydrogen fuel systems. The polymer membrane is an integral part of a hydrogen fuel-cell system that creates electricity to power a vehicle. The goal of the research is to advance membrane durability and extend its shelf life, while simultaneously bringing down the cost. Virginia Tech's James McGrath, University Distinguished Professor of Chemistry, was the recipient of a 2004 R&D 100 award for his development of novel, low-cost, high-temperature polymer membranes for hydrogen fuel cells. In 2004, McGrath and Virginia Tech's provost Mark McNamee were awarded a two-year, $600,000 NSF Partnership for Innovation grant to support a program called "Bridging the Gap Between New Materials, Fuel Cell Devices and Products." Virginia Tech's partners included Battelle, Los Alamos National Laboratory, the Center for Innovative Technology, several companies, and Virginia Commonwealth University.

The Virginia Tech fuel cell cluster is working to build its recognition to a national level. Research expenditures in the group have increased from $600,000 to more than $1 million in 2006.

The Virginia Tech fuel cell cluster is working to build its recognition to a national level. Research expenditures in the group have increased from $600,000 to more than $1 million in 2006. The VT group recently teamed with several other universities on a proposal for a five-year, $20 million NSF Engineering Research Center award. The proposal was among 9 finalists from 126 applications. Although it was not selected for one of the five awards, the team may reapply. The cluster faculty noted that a cost-sharing investment by the state would be critical for the group to receive the high-visibility NSF award and Energy Research Center designation. The group is developing a strategy to increase recognition of Virginia Tech's fuel-cell research in order to build on an NSF Research Experiences for Undergraduates award to engage top undergraduates and grow the pipeline of graduate students.[113]

Virginia Commonwealth University faculty in the departments of Mechanical Engineering (Muammer Koç) and Chemical and Life Sciences Engineering (Ken Wynne) are focused on design and manufacturability of fuel-cell systems, developing novel micromanufacturing processes to make fuel-cell components cheaper and more durable. Dr. Pura Jena (Physics) announced in July 2006 the computer-modeled design of a lithium-coated "buckyball" nanoparticle that can theoretically store hydrogen molecules at densities exceeding industry targets. Jena is currently collaborating with scientists who will conduct experiments to prove that hydrogen can be stored in the lithium buckyballs. Jena's research, supported by the DOE, is in collaboration with researchers at Richmond's Philip Morris Research Center.[114]

Several University of Virginia researchers are focused in the non-hydrogen fuel-cell arena. Steven McIntosh is working to develop high-performance anode materials for versatile high-temperature solid oxide fuel cells that can use a variety of combustible fuels, including gasoline and biodiesel, to produce both heat and electricity while minimizing carbon release. On a more fundamental level, Ian Harrison (Chemistry) and Matthew Neurock (Chemical Engineering) are working on optimizing catalytic materials for yield, selectivity, or minimized energy use. Harrison is focusing on the reactivity of methane, which with the right catalysts and conditions could potentially be harnessed at the well-head as a reliable source of easily transportable methanol for powering fuel cells.[115]

Alternative Liquid Fuels

Virginia has significant strengths in research to develop efficient methods for generating energy from renewable waste and bio-based resources. Plants, plant-derived materials, and agricultural wastes provide domestic and sustainable resources to provide power, fuel, and chemical needs. Biofuel feedstocks include animal and vegetable oil wastes.

[112] Information provided by VT fuel cell research cluster faculty, September 26, 2006.
[113] Ibid.
[114] www.news.vcu.edu/news.aspx?v=detail&nid=1466.
[115] "Research Highlights from the University of Virginia," UVA Explorations, Fall 2006.

Biomass feedstocks include agricultural and forestry/mill residues, dedicated energy crops, urban wood wastes, municipal solid wastes, and landfill gas. A 2005 study found that nearly 1.4 billion dry tons of biomass could be available for large-scale bioenergy and biorefinery industries by the middle of this century while still meeting demands for forestry products, food, and fiber.[116] In June 2006 the federal DOE released an ambitious research agenda for overcoming the challenges to the large-scale production of cellulosic ethanol as part of its goal of displacing 30 percent of the 2004 U.S. transportation-fuel consumption with biofuels by 2030.[117]

Virginia has significant strengths in research to develop efficient methods for generating energy from renewable waste and bio-based resources.

Virginia Tech has extensive expertise in bioenergy and bioproducts at its main campus in Blacksburg as well as through Virginia Tech faculty affiliated with the Institute for Advanced Learning and Research in Danville. The Virginia Tech Energy Task Force lists several large categories of bioenergy/bioproducts research:[118]

- Bioenergy Adoption/Use - including feedstock and logistics issues of establishing bioenergy facilities (J. Cundiff, D. Parrish, R. Visser), economic/environmental impact assessments (G. Amacher, R. Visser, B. Smith), and orchestration with regional stakeholders such as existing energy producers and users, and local/state government entities (R. Bush, J. Waldon).
- Use in Transportation - including optimizing vehicle design for bio-based fuels (D. Nelson) and environmental and socioeconomic impacts of adopting biofuels (L. Schweitzer).
- Biomass: Sources, Creation, and Enhancement - including genetic engineering of species such as switchgrass and poplar trees for optimizing their use as bioenergy and bioproducts feedstocks (E. Beers, A. Brunner, J. Burger, J. Fike, B. Flinn [IALR], T. Fox, C. Griffey, J. Iqbal, J. Nowak, D. Parrish, J. Seiler, W. Thomason).
- Biomass Conversion, Ethanol Production - including research to optimize conversion of agricultural waste, livestock manure, and bioenergy crops into ethanol and other liquid fuels (F. Agblevor, J. S. Chen, J. Fan, C. Griffey, S. Renneckar, Y.-H. P. Zhang). One project is using animal/seafood waste for biogas production (Z. Wen).
- Products and Byproducts - including direct use of ethanol in fuel cells (M. Ellis), small-scale production of charcoal (T. Hammett and P. Radtke), fortified fuel pellets (R. Moffit [IALR], J. Nowak), and biodiesel by-product glycerol as a food source for algae rich in omega-3 polyunsaturated fatty acids (Z. Wen).

Biodiesel

The Virginia Coastal Energy Research Consortium, lead by Old Dominion University, is researching production of algae from nutrient-rich waters to serve as a feedstock for biodiesel. Led by Patrick Hatcher, the group is installing a test facility at a Hampton Roads Sanitation District waste plant that will include algae growing trays and a biodiesel reactor.

One of the four program foci of James Madison University's Center for Energy and Environmental Sustainability is alternative fuels, led by Dr. Chris Bachmann. James Madison University works closely with the City of Harrisonburg to promote the adoption of biodiesel both on campus (2% biodiesel, with a goal of 20%) and in the city's transit and school-bus fleet. This collaboration was recognized as exemplary by President Bush in summer 2005. The center is also investigating the use of engineered single-cell microalgae in a photo-bioreactor as a promising alternative feedstock for producing biodiesel. These algae, some of the fastest growing plants known, can remove waste carbon dioxide from traditional power plant emissions and can contain as much as 60 percent oil by weight. Theoretically, algae farms could produce four hundred times as much oil on a pounds-per-acre basis as soybeans, and therefore meet the nation's transportation energy demands while using less than 1 percent of the total U.S. land mass.[119]

[116]R. D. Perlack et. al., "Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply," DOE/GO-102005-2135, Oak Ridge National Laboratory, Oak Ridge, TN, April 2005 (http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf).
[117]U.S. DOE, "Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda," DOE/SC-0095, U.S. DOE Office of Science and Office of Energy Efficiency and Renewable Energy, June 2006 (www.doegenomestolife.org/biofuels).
[118]See www.research.vt.edu/energy/resbio.html.
[119]www.cisat.jmu.edu/biodiesel.

Theoretically, algae farms could produce four hundred times as much oil on a pounds-per-acre basis as soybeans, and therefore meet the nation's transportation energy demands while using less than 1 percent of the total U.S. land mass.

At the University of Virginia, Robert Davis and Giorgio Carta (Chemical Engineering) are working on reusable, highly porous solid catalysts for converting heavy fats and oils into renewable biodiesel fuel additives (providing lubrication) as well as aqueous solution catalysts for converting the by-product glycerol into feedstock for high-value chemicals. Combinations of such catalyzed processes are necessary to enable a fully integrated biorefinery.[120]

Virginia Commonwealth University's Stephen Fong (Chemical and Life Sciences Engineering) takes a systems biology approach to rational metabolic engineering for improving bioreactors. His research includes using computational modeling with molecular genetics to predict, design, and characterize bacterial strains engineered to produce specific chemicals.[121]

Similarly, Virginia Tech's Julia Fan (Biological Systems Engineering) is developing biocatalysts through enzyme engineering and microbial strain development. These biocatalysts are used in developing and optimizing processes (e.g., pyrolysis, gasification, biodiesel production) to convert renewable resources (e.g., paper sludge, biomass, starch) to value-added products in an economically viable and environmentally sound manner.[122]

Biomass to Fuels/Products

It has been estimated that Virginia could produce 297,986 dry tons of agricultural residue biomass at $40 per ton and an additional 1.2 million dry tons of dedicated energy crops at $40 per dry ton. Urban wood waste could contribute more than 865,757 dry tons at $30 per ton.[123]

Use of agriculture and forestry-based feedstocks for energy and novel products generation/development can significantly contribute to diversification of the tobacco-based economy of Southside and southwest Virginia and open competitive opportunities for developing new industries in this region.[124] In response to this opportunity, Virginia Tech has assembled a multidisciplinary research and technology development cluster targeting small-scale (community-based) energy and novel products development, based on the sustainable cultivation of biomass in the vicinity of the processing plants. Led by Jerzy Nowak of Virginia Tech Horticulture, the team proposes establishing the Bio-Based Energy and Products Research Center with operations in Blacksburg, the Institute of Sustainable and Renewable Resources at the Institute for Advanced Learning and Research in Danville, and Windy Acres Nursery in Gretna. The center is proposed to serve as the R&D/implementation base for using short-rotation wood (hybrid poplar and loblolly pine) and herbaceous biomass (switchgrass, miscanthus, alfalfa, and clover) as feedstocks for generating bioenergy (electricity, heat, bio-oil/diesel), bio-oil extracts, and wood-based potting media, as well as high-energy wood/grass pellets integrating high-energy recyclables (in collaboration with the Institute for Advanced Learning and Research, Advanced and Applied Polymer Processing Institute). Successful research from the center would support development of a renewable resource processing center and spin-off enterprises.[125]

Percival Zhang (Biological Systems Engineering) has developed a cost-effective, low-temperature pretreatment process for efficient fractionation to separate lignin and hemicellulose from the ethanol-precursor cellulose. He also is genetically engineering enzymatic pathways for the production of hydrogen from natural sugars.[126]

The University of Virginia recently hired metabolic engineer Michael Raab, creator of GreenGenes™ technology, on which he founded the company Agrivida. Agrivida is developing an engineered seed designed for ethanol production. The technology is a biological "switch" that enables producers to activate a desired enzyme on demand to break down the biomass into basic sugars for ethanol processing. This is expected to substantially reduce the costs of ethanol production while yielding waste biomass for electricity generation. There also exists the long-term opportunity for photobiological production of hydrogen.[127]

[120]Robert Davis, UVA, presentation to statewide meeting on DOE GTL bioenergy solicitation, September 5, 2006.
[121]www.engineering.vcu.edu/fong-lab/metabolicenginee.html.
[122]www.bse.vt.edu/06/department/faculty.php#ZhiliangFan.
[123]Marie E. Walsh et al, "Biomass Feedstock Availability in the United States: 1999 State Level Analysis," DOE, April 30, 1999, updated January 2000 (http://bioenergy.ornl.gov/resourcedata/index.html).
[124]Jerzy Nowak, VT, 2006, Model Bio-Products Development System: Rural Economic Development and Environmental Benefits.
[125]Ibid.
[126]http://filebox.vt.edu/users/ypzhang/research.htm.
[127]See www.masstech.org/IS/reports/clusterreport11405.pdf.

Virginia State University's Harbans Bhardwaj focuses on improving crop species to increase yield, quality, and other traits. In the energy/environment arena, he is developing canola and white lupin as new crops in Virginia. Both crops have industrial uses: canola as a source of biodiesel, and lupin as a source of alkaloids and as a green manure crop to reduce or eliminate use of nitrogen fertilizers in a sustainable crop-production system.[128]

James Madison University's Center for Energy and Environmental Sustainability is developing an ethanol production facility that will investigate the ethanol potential of a variety of alternative-fuel feedstocks, including the giant sea kelp, *Macrocystis pyrifera*. This is one of the fastest growing plants known (it can grow more than a foot a day) and can be harvested from the ocean by large-scale commercial vessels. This seaweed is low in oil, storing much of its energy as starches and sugars. While not ideal for making biodiesel, it is well suited for ethanol production.[129]

Waste to Energy

Virginia currently has nineteen landfills producing methane for energy, and fifteen more are identified as potential sites.[130] In northern Virginia, the Alexandria/ Arlington Resource Recovery Facility processes more than 975 tons of solid waste each day, generating more than 78.4 million BTUs (23,000 kilowatt-hours) of electricity. The electricity is distributed by Dominion Power and supplies more than 300,000 residents.[131] Atlantic Waste Disposal's 373-acre landfill in Waverly now provides 15 percent of the natural gas required of Honeywell's Hopewell plant and is expected to provide as much as 50 percent in ten to fifteen years. This project has the potential to save Honeywell $50 million in energy costs while significantly reducing greenhouse gas emissions from landfill wastes.[132]

The partnership of James Madison University's Center for Energy and Environmental Sustainability with the City of Harrisonburg includes work to develop an integrated waste-to-energy facility integrating multiple systems, including use of city municipal solid waste to produce heat and electricity; use of campus, city restaurant, and school waste vegetable oils in a biodiesel refinery; and biomass processing of campus waste paper, construction and landscaping waste, and area agricultural and forestry wastes.[133]

A team of Virginia Tech researchers led by F. Agblevor (Biological Systems Engineering) is working on rapid pyrolysis reactor methods for efficient conversion of poultry litter, switchgrass, and woods into bio-oils and other products. Dr. Agblevor also invented a process to convert cotton-gin waste and recycled paper sludge into ethanol.[134]

Geothermal

Virginia Tech's Department of Geological Sciences developed the southeastern United States Geothermal Data website, hosting data on terrestrial heat flow, practical applications of low-temperature geothermal energy, and a temperature versus depth database. This site is frequently updated to include temperature data, rock thermal conductivity, and heat flow values from New Jersey to Georgia.[135]

Solar/Photovoltaics

At Norfolk State University, Sam-Shajing Sun is a recognized leader in polymer materials research for solar cell applications. Sun's research expertise includes the design, synthesis, processing, characterization, and modeling of novel organic and polymeric solid-state supra-molecular and nanostructured materials and thin films devices for electronic, photonic, magnetic, and energy conversion applications. Current research projects funded by NASA and the Air Force Research Labs include development of novel supra-molecular and nanostructured conjugated block copolymer systems for potential photo detector and solar energy conversion (solar cell) applications. In 2002, NASA awarded a Center for Research and Education in Advanced Materials, or

[128]www.vsu.edu/pages/3016.asp.
[129]www.isat.jmu.edu/AFP/fuels.html.
[130]U.S. EPA Landfill Methane Outreach Program Active Program Map, July 13, 2006 (www.epa.gov/lmop/docs/map.pdf) (quote from Southeastern SunGrant Center Virginia Biomass/Bioenergy Overview, 2006).
[131]Biomass Research and Development Initiative, 2003, Virginia Biobased Fuels, Power and Products State Fact Sheet (http://sungrant.tennessee.edu/factsheets/virginia.pdf).
[132]John Reid Blackwell, "Honeywell Finds a Solution to its Gas Needs," Greater Richmond Catalyst, November 16, 2006, at www.richmondcatalyst.com/Issue11_Honeywell2.asp (originally published April 24, 2006, in Richmond Times-Dispatch).
[133]Ron Kander, JMU, presentation to statewide meeting on DOE GTL bioenergy solicitation, September 5, 2006.
[134]www.research.vt.edu/energy/resbio.html.
[135]http://geothermal.geol.vt.edu.

CREAM, to Norfolk State University under Sun's leadership. A Norfolk State spin-off company (Sun Macromolecular Corporation) is leading an industrial partnership bid to the U.S. DOE's Solar America Initiative to commercialize the polymer solar cells.[136]

Old Dominion University has several groups researching photovoltaic materials, including Electrical and Computer Engineering faculty Hani Elsayed-Ali (thin films and physical electronics), Helmut Baumgart (atomic layer deposition for electronic thin films), and Sacharia Albin (photonics), as well as Richard Gregory in Chemistry (organic conductive polymers) and Julie Hao in Mechanical Engineering.[137]

University of Virginia's Mool Gupta at the National Institute of Aerospace in Hampton (laser applications for advanced manufacturing)[138] and Petra Reinke in Materials Science (nanoscale molecular electronics)[139] also are working on photovoltaic materials.

At Virginia Commonwealth University, James McLeskey's research interests include novel energy conversion systems, traditional power generation, nanoparticle entrainment, and engineering education. Current research revolves around optical studies of photovoltaics (solar cells) made from organic polymers and quantum dots (nanoscale particles such as carbon nanotubes or titanium dioxide).[140]

The University of Virginia and Virginia Tech have competed successfully in the federal DOE's national Solar Decathlon in Washington, D.C. (see Buildings/ Environment in Section 6.1.2, below).

Wind

Several Mid-Atlantic states have begun installing grid-connected wind energy projects in the size range of 5 to 50 megawatts, to generate electricity that can be sold as a green alternative to conventionally generated power. In Virginia, the Virginia Wind Energy Collaborative (VWEC)[141] was created as a partnership of the Virginia Tech Advanced Research Institute's Center for Energy and the Global Environment (CEAGE), James Madison University's Center for Energy and Environmental Sustainability, the Environmental Resources Trust, the George Washington University Law School, and Old Mill Power Company. Supporting agencies are the Virginia Department of Mines, Minerals and Energy and the federal Wind Powering America program. The VWEC's mission is to educate the public, inform decision makers about wind energy, and facilitate its development in the state in support of the need for reliable and affordable energy, environmental quality, and economic development. Collaborative partners provide technical support in several ways, including analysis of wind data and answering questions from developers about the feasibility of wind energy projects; support of local, state, and federal agencies in exploring potential wind energy applications on their lands; and to inform counties and cities about bulk power purchase opportunities from wind energy projects as a cost-effective means of improving air quality and complying with federal ground-level ozone standards.

Among the VWEC's activities are the technical research and analyses necessary to determine the potential for developing large, utility-scale wind systems to reclaim defunct coalfields in southwest Virginia. Virginia Tech's CEAGE, in conjunction with the Department of Mines, Minerals and Energy, is pioneering this effort.[142] CAEGE provides technical research support to wind developers and to local, state, federal, and private agencies.

A Virginia-based partnership led by James Madison University responded in November 2006 to a National Renewable Energy Laboratory Cooperative Research and Development Agreement opportunity to design, construct, and assist in operating a wind turbine test facility capable of testing blades exceeding 70 meters in length. Virginia was not successful in receiving a grant award but is investigating partnership opportunities.

[136]Adebisi Oladipupo, NSU, personal communication, October 25, 2006.
[137]Mohammad Karim, ODU, personal communication, November 6, 2006.
[138]www.seas.virginia.edu/news/gupta.php.
[139]www.virginia.edu/ms/faculty/reinke.html#research.
[140]www.egr.vcu.edu/me/faculty/me-faculty_mcleskey.html.
[141]http://vwec.cisat.jmu.edu/index.htm.
[142]Ibid.

Coastal Energy (Wind/Tidal/Current/Wave)

The 2006 General Assembly established the Virginia Coastal Energy Research Consortium (VCERC) to serve as an interdisciplinary study, research, and information resource on coastal energy issues, including wave or tidal action, currents, offshore winds, thermal differences, and methane hydrates.[143] The consortium's academic partners include Old Dominion University, the Virginia Institute of Marine Science, Virginia Tech's Advanced Research Institute, James Madison University, Norfolk State University, the University of Virginia, and Virginia Commonwealth University.[144] Science Applications International Corporation's Maritime Operations division has collaborated in developing the consortium and will serve as a lead systems integrator for marine industry support of the consortium.[145] Old Dominion University has established a working group for the consortium led by Dr. Patrick Hatcher, a geochemist focused on origin and chemical transformations of plant-derived biopolymers in natural systems. It is likely that the consortium will be able to use offshore wind and current data collected through the Center for Innovative Technology's Coastal Observation project, which is sponsored by NASA.

Offshore wind energy is the most commercially mature of several marine renewable energy sources being studied, with Denmark, Germany, and the United Kingdom particularly active in deployment. Nearly thirty offshore wind projects are under development in the United Kingdom and could supply more than 8 percent of the United Kingdom's annual electricity demand within the decade.[146] Virginia is uniquely positioned to benefit from offshore and coastal energy resources: it has 110 miles of coastline along the Atlantic Ocean, federal R&D facilities (e.g., NASA Langley Research Center and Wallops Flight Facility on the Eastern Shore), Norfolk Naval Base and Northrop Grumman Newport News Shipbuilding, repair facilities, and an integrated transportation system that includes direct ocean access. Most of Chesapeake Bay and the near-shore areas feature Class 4 winds or higher. A VWEC project led by James Madison University's Jonathan Miles studied the technical, environmental, and economic feasibility of wind turbines at NASA's Wallops Island facilities. The results provide guidance for other federal agencies in siting wind turbines.[147] Virginia Tech researchers led by George Hagerman are quantifying the potential energy and economic benefits of offshore wind energy development in Virginia, as well as identifying opportunities for the state's maritime industry and manufacturers to develop fabrication materials and methods for marine renewable energy structures.[148]

Virginia Tech's Center for Energy and the Global Environment is collaborating with the Electric Power Research Institute, utilities, and state and provincial governments to plan and develop the first North American demonstration projects for tidal current energy in San Francisco and Nova Scotia. The center is also conducting research for Verdant Power, a tidal turbine developer based in Arlington.[149]

Power generation turbine research at Virginia Commonwealth University (James McLeskey) may be relevant to these efforts (see Energy Efficiency and Conservation in Section 6.1.2, below).

6.1.2 Energy Use and Impacts

Energy Storage

Virginia Tech's Department of Electrical and Computer Engineering is engaged in the research of energy storage to, among other applications, prevent power system blackouts. The work is supported by the National Science Foundation (NSF), the Electric Power Research Institute, and the Tennessee Valley Authority.[150]

Researchers at the Virginia Tech and University of Virginia's Rotating Machinery and Controls group research modeling and control of magnetic bearing systems used in high-speed energy storage flywheels. Uninterruptible power supplies, consistent power quality, and hybrid

[143] http://leg1.state.va.us/cgi-bin/legp504.exe?000+cod+67-601.
[144] http://leg1.state.va.us/cgi-bin/legp504.exe?000+cod+67-600.
[145] Neil Rondorf, "A Virginia-Based Marine Renewable Energy Technologies," presentation to VCERC, September 19, 2006 (www.cit.org/vrtac/2006/06-09-19-VCERC-Presentation.ppt#256,1).
[146] VT CEAGE, "Marine Renewable Energy" pdf from G. Hagerman, September 28, 2006.
[147] http://vwec.cisat.jmu.edu/programs.htm.
148www.ceage.vt.edu/2DOC/IEEE_Richmond_07Sep06.pdf.
[149] VT CEAGE, "Marine Renewable Energy" pdf from G. Hagerman, September 28, 2006.
[150] Virginia Tech Research, Summer 2006 (www.research.vt.edu/resmag/2006Summer/index.html).

vehicles are among the applications.

Virginia Commonwealth University's Pura Jena is working on hydrogen storage in nanoparticles, as mentioned earlier under Fuel Cells and Hydrogen in Section 6.1.1.

Energy Efficiency and Conservation

Research in efficient energy use and resource conservation is a strength at several Virginia universities. Virginia Tech faculty, staff, and students received seven patents in 2005–including two that received R&D 100 awards from *R&D Magazine*–for technologies that use energy more efficiently and safeguard electric grid and oil resources. Five of the patents were developed at the Center for Power Electronic Systems (CPES), an NSF Engineering Research Center led by Virginia Tech that leverages more than $10 million in annual support from the NSF, industry, and university funds.[151] One is an efficient and cost-effective bidirectional DC/DC converter that reduces switch voltage stress; the technology has been adopted by Ballard Power Systems, the largest fuel-cell company in the world. The CPES has 32 faculty, 146 students, and 10 research staff, with 80 industry partners and 18 research sponsors funding more than $7 million in research annually. CPES faculty focus on improving power conversion by integrating power and load management actions. They estimate that using power management electronics available today could achieve a 3 percent savings in electricity-corresponding to 2.3 billion barrels of oil annually-by 2010 and that advancements in power electronics technology can produce 27 percent total savings in electricity and transportation energy by 2025.[152]

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Other efficiency/conservation research areas in the Virginia Tech College of Engineering include novel materials for heat exchange in next-generation refrigeration systems, materials selection for reducing energy consumption, drag reduction in turbulent flows in pipelines, and screening tools for heating, ventilation, and air conditioning systems.

At Virginia Commonwealth University, James McLeskey directs the Energy Conservation Systems Laboratory. His funded projects include developing computer-modeling tools for the power generation industry-specifically, tools for calculating heat transfer and mechanical stresses in large turbo-generator rotors.[153]

In the area of conservation related to transportation energy use, the University of Virginia's Smart Travel Lab is a joint effort between the Department of Civil Engineering and the Virginia Transportation Research Council. The lab is connected to traffic management systems operated by the Virginia Department of Transportation (DOT), providing researchers with direct access to current Intelligent Transportation System (ITS) data. This allows the lab to help the DOT's Smart Travel Program reduce traffic congestion in the heavily populated areas of northern Virginia and Hampton Roads. The Smart Travel Lab is part of the University of Virginia's Center for Transportation Studies, which also is studying intermodal transportation systems.[154]

The Virginia Tech Transportation Institute (VTTI) conducts research focused on modeling, evaluation, and integration of ITS and non-ITS traffic engineering applications, including development of energy and emissions models responsive to those applications. The VTTI also operates Smart Road, a unique state-of-the-art, full-scale research facility for pavement research and evaluation of ITS concepts, technologies, and products.[155]

Buildings/Environment

As noted above, the University of Virginia's energy R&D is part of its Energy, Conservation and the Environment initiative. The university believes it is important from the outset to coordinate research on efficient use, conservation, sustainability, and environmental impacts with the development of alternate energy technologies.

The University of Virginia's architecture school is home to John Quale, a nationally recognized expert in sustainable building

[151]www.cpes.vt.edu.
[152]Charts from CPES faculty, September 26, 2006.
[153]www.engineering.vcu.edu/ecsl/index.html.
[154]cts.virginia.edu/stl_index.htm.
[155]www.vtti.vt.edu.

Since 2002 both the University of Virginia and Virginia Tech have competed in the federal Department of Energy's highly competitive national Solar Decathlon in Washington, D.C. In 2002, the University of Virginia's solar house placed second overall, and in 2005 Virginia Tech's entry won the Architecture and Dwelling contest.

design, as well as experts in landscape and remediation technology (Julie Bargmann) and environmental planning and sustainable communities (Timothy Beatley). Additional expertise in conservation and sustainability resides in Civil Engineering (Teresa Culver, Michael Demetsky, Lester Hoel, Nick Garber, Brian Smith, Brian Park, Julie Zimmerman) and the Darden School of Business (Andrea Larson and Richard Brownlee). The university's Environmental Sciences Department has expertise in atmospheric chemistry (Jim Galloway), plant-atmosphere flux (José Fuentes), coastal ecology (Jay Zieman), contaminant hydrology (Todd Scanlon), organic tracers (Steve Macko), and groundwater (Janet Herman and George Hornberger).[156] Dr. Hornberger was named to the U.S. Nuclear Waste Technical Review Board by President Bush in 2004. The board provides independent scientific and technical oversight of the U.S. program for managing and disposing of spent nuclear fuel from civilian nuclear power plants.[157]

Virginia Tech has several researchers working in the "energy and built environment" arena within its College of Architecture and Urban Studies (CAUS). Energy-efficient green building design, systems and construction methods, facility energy management, and related energy policy are among the research areas of faculty in the Schools of Architecture and Design (Robert Dunay, Michael Erman, Jim Jones, Robert Schubert, Joe Wheeler), Construction (Yvan Beliveau, Annie Pearce, George Reichard), and Public and International Affairs (John Randolph).[158]

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6.1.3 Energy Policy

Virginia's energy R&D includes considerable expertise in energy/environment/economic policy that can help guide successful deployment of novel energy solutions in an economically and environmentally sustainable manner.

Virginia Tech's Center for Energy and the Global Environment (CEAGE) examines issues related to energy and its role in the global environment.[159] Its mission is to promote cooperation among diverse groups interested in sustainable energy development and to act as a catalyst for developing solutions to environmental problems in many regions of the world. CEAGE is led by the Advanced Research Institute's director, Dr. Saifur Rahman. Since its creation in 1994, it has made links with industry groups and universities in more than thirty nations, making it one of the most internationally active research organizations of its kind at Virginia Tech. Among many research programs, CEAGE is working with multiple stakeholders (e.g., local, state, and federal governments, U.S. Navy, Minerals Management Service) to identify and address issues related to development of coastal energy resources.

A major CEAGE initiative is the Critical Infrastructure Modeling and Assessment Program, which provides policymakers, legislators, and researchers' with long-term perspectives and guidance on various issues affecting the planning, commissioning, and operating of critical infrastructures.

Virginia Tech has several faculty addressing law, regulation/deregulation, and policy issues related to energy and society. Research interests include energy implications for environmental quality, state incentives for use of green power, forest management, energy conservation in landscape design, housing technology, hydrogen-based energy conversion, policies promoting safe and effective distributed energy generation and storage, and nuclear energy regulation.[160]

[156]Phil Parrish and Lisa Friedersdorf, UVA, personal communication, September 22, 2006.
[157]www.virginia.edu/researchandpublicservice/expertise/honors.html.
[158]Robert Schubert, CAUS, September 26, 2006; VT Energy Portfolio-9-20-06 (from J. Lesko).
[159]www.ceage.vt.edu.
[160]VT Energy Portfolio-9-20-06 (from J. Lesko).

Economist Irene Leech is studying consumer issues related to energy such as affordability, reliability, security, consumer understanding, impact on consumer of market forces versus regulation, and environmental impacts of consumer choices. She is also a member of a multidisciplinary team from several Virginia Tech departments that is completing an NSF project on energy security.[161]

James Madison University faculty are engaged in informing state energy policy in a variety of ways. Jonathan Miles and Maria Papadakis, working through the Virginia Wind Energy Collaborative, actively provide local, state, and federal policymakers with information on wind resources and options for efficiently harnessing wind energy, as well as zoning development model language, now applied in several counties statewide, which provides a special-use permitting for small wind systems.[162] Chris Bachmann and C. J. Brodrick of James Madison University are working with Virginia Tech's Lisa Schweitzer, an urban planning specialist working on environmental justice and community/bioregional energy issues, to look at the socioeconomic impacts and justice aspects of implementing alternative fuels.[163]

George Mason University's Center for Transportation Policy, Operations and Logistics is a partner with the University of Virginia and Virginia Tech in the National Center for ITS Implementation Research, one of thirty-three University Transportation Centers funded by the U.S. Department of Transportation and one of only two devoted exclusively to Intelligent Transportation Systems.[164]

The College of William and Mary's public policy program addresses questions related to adopting new energy technologies, such as structuring incentives for contractors to use photovoltaics and LEED (Leadership in Energy and Environmental Design program of the U.S. Green Building Council) standards in their buildings.[165]

Virginia Military Institute's energy policy research involves working with varied stakeholders (producers, commercial providers and users, regulatory) to determine the optimum combinations of policies and new technologies to make Virginia's energy-grid system work most efficiently as new alternative energy sources are brought on line with conventional sources. Virginia Military Institute offers itself as a "neutral ground" for Virginia stakeholders to meet and technical and policy issues, and to that end hosted the inaugural Energy Virginia Conference in October 2006.[166]

6.2 Energy R&D at Federal Labs in Virginia

Virginia is home to three federal research laboratories conducting energy research: the U.S. Department of Energy's Thomas Jefferson National Accelerator Facility, NASA Langley Research Center, and the Naval Surface Warfare Center in Dahlgren.

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[161]Irene Leech, VT, personal communication, September 26, 2006.
[162]Jonathan Miles, JMU, personal communication, November 7, 2006.
[163]Lisa Schweitzer, VT, personal communication, September 26, 2006.
[164]http://policy.gmu.edu/research/research_tpl.html.
[165]Dennis Manos, CWM, personal communication, September 22, 2006.
[166]Ron Erchul, VMI, personal communication, October 31, 2006.

Table 6-2 Energy R&D at Federal Laboratories in Virginia

	Energy Generation/Sources									Energy Use/ Impact			Energy Policy
				Alternative Fuels	Other Renewables								
Virginia Federal Lab	Coal, Oil, Gas	Nuclear	Fuel Cells/H2	Alternative Fuels: Waste- or Bio-derived	Geothermal	Hydroelectric	Solar/Photovoltaics	Wind	Coastal (Wind/Tidal/ Current/Wave)	Energy Storage	Efficiency/Conservation	Buildings/Environment	Energy Policy/ Economics
Thomas Jefferson National Accelerator Facility (DOE)		•					•	•					
NASA Langley Research Center		•	•	•				•		•	•	•	
Naval Surface Warfare Center - Dahlgren Division											•		

6.2.1 Thomas Jefferson National Accelerator Facility (Jefferson Lab)

Jefferson Lab is a federally funded facility with a primary mission to conduct basic science research on atomic nuclei at the quark level. Applied research is a derivative mission, wherein Jefferson Lab, with industry and university partners, develops uses for the lab's free electron laser (FEL). Energy-related FEL research includes work on photovoltaics and on hardened materials for severe environments such as turbine blades. The accelerator technology at the lab could be used for transmutation of nuclear waste if Los Alamos proceeds on the technology.[167]

6.2.2 NASA Langley Research Center

NASA Langley Research Center has three main areas of expertise: systems analysis, materials and structures, and aerodynamics. It has primary systems analysis responsibility within NASA labs. For many years, NASA Langley has focused on the impact of aviation on the environment. More recently this has expanded to a systems-level approach, looking at how alternative vehicles, fuels, and transportation systems can be most efficient and reduce harmful emissions.[168] Research includes work on energy sources for aircraft, including hydrogen-fueled combustion, hydrogen fuel-cell electric propulsion, lithium-air fuel-cell electric propulsion, nuclear hybrid systems, and aluminum powder combustion. In many cases, the studies are conducted to develop "zero emissions" aircraft propulsion systems.[169]

In the area of materials and structures, NASA Langley focuses on high-temperature materials to enable more efficient combustion, lightweight design, and non-destructive evaluation methods. The lab's long experience in aerodynamics and wind tunnels is being applied not only to aircraft but also to reducing drag on trucks and even NASCAR race cars.

6.2.3 Naval Surface Warfare Center, Dahlgren Division

The Naval Surface Warfare Center, Dahlgren Division's main focus is weapons/combat systems. Its main energy-related work is on energy efficiency of weapons and electric guns.[170]

6.3 Energy R&D at Virginia Industries

6.3.1 Energy R&D at Selected Virginia Companies

Several Virginia companies were interviewed to determine their general energy R&D interests. Table 6-3 summarizes the findings.

[167]Fred Dylla, personal communication, September 26, 2006.
[168]Rich Antcliff, NASA Langley Research Center, personal communication, November 3, 2006.
[169]Lesa Roe, NASA Langley Research Center, communication to VRTAC Univ/Fed Lab Subcommittee, August 2006.
[170]Larry Triola, personal communication, September 18, 2006.

Table 6-3 Energy R&D at Selected Virginia Companies

	Energy Generation/Sources									Energy Use/ Impact			Energy Policy
				Alternative Fuels	Other Renewables								
Virginia Company	Coal, Oil, Gas	Nuclear	Fuel Cells/H2	Alternative Fuels: Waste- or Bio-derived	Geothermal	Hydroelectric	Solar/Photovoltaics	Wind	Coastal (Wind/Tidal/ Current/Wave)	Energy Storage	Efficiency/Conservation	Buildings/Environment	Energy Policy/ Economics
Afton Chemical, Richmond											•		
Areva NP, Lynchburg		•											
BWXT, Lynchburg		•											
Consutech, Richmond				•									
Delta T, Williamsburg				•									
Dominion Power	•	•					•	•			•	•	•
GE Energy, Salem	•	•					•	•			•		
Northrop Grumman Newport News	•			•						•			
SAIC, Virginia Beach						•		•	•				•
Siemens, Newport News											•		
Verdant Power, Arlington						•			•				
SBIR/STTR Companies	•	•		•	•		•				•		

In general, the companies interviewed are currently working with, or seeking partnerships with, Virginia research universities. The companies did not provide information on their energy R&D expenditures.

In addition to companies working on the technical aspects of energy generation and use, there are numerous firms in the state and region (e.g., Science Applications International Corporation, Sentech, Cadmus) studying energy policy and economics.

Virginia's coal industry has supported the Virginia Tech Center for Advanced Separation Technologies' research to improve mining engineering and coal separations technologies.

Afton Chemical of Richmond is a global petroleum additives supplier, created from Ethyl Corporation in 2004. Afton sells lubricant and fuel additives to reduce wear in engine parts and improve fuel performance while reducing emissions. It is committed to innovative technology and world-class research, with dedicated state-of-the-art research facilities in Richmond.[171]

Areva NP has operations in Lynchburg and has expertise and active involvement in every sector of the nuclear power industry, including the nuclear fuel cycle, reactors, instrumentation, nuclear measurement systems, and engineering. Areva's three largest activities in Virginia are Nuclear Regulatory Commission certification for its EPR (European Pressurized Reactor) design, fuel design/development and manufacturing, and R&D for methods to service existing power reactors. Areva is exploring research with Virginia Tech in several areas, including non-destructive evaluation methods. Areva recently provided a list of R&D topics of interest to the new Center for Advanced Engineering and Research in Lynchburg, which is seeking to enhance the technical capabilities of the nuclear industries in the Region 2000 area. Areva is interested in engaging with research institutions, both to work on innovative solutions to problems in its industry as well as to create a pipeline of prospective employees for the company.[172]

BWXT, headquartered in Lynchburg, has more than 11,300 employees in eleven

[171]www.aftonchemical.com/Regions/North+America/Products/index.htm.

states and is a subsidiary of McDermott International, Inc., a leading worldwide energy services company. BWXT has a long history in nuclear manufacturing and operations, including unparalleled experience in nuclear safeguards and security, both with U.S. government and commercial clients and at its unique, highly secure, privately owned and operated nuclear manufacturing and laboratory facilities. BWXT has significant team member roles in nuclear operations at many national labs, including those at Argonne, Oak Ridge, Idaho, Los Alamos, and Savannah River.[173]

Consutech Systems, LLC of Richmond designs and manufactures waste combustion and air quality control equipment.[174] Its CONSUMAT waste disposal technology is also being used as the initial gasification step in an organic waste-to-fuel process developed by BRI Energy of Arkansas.[175]

Delta-T Corporation in Williamsburg is a world-class designer of high-efficiency ethanol production facilities, providing alcohol production, dehydration, and purification technology solutions to more than 115 clients worldwide in fuel, beverage, industrial, and pharmaceutical alcohol markets. Delta-T's ongoing research pipeline for "Precision Ethanol" focuses on innovation in its core technologies for high-efficiency integrated ethanol distillation/dehydration/evaporation systems as well as cellulose conversion to ethanol, flexible plants able to process multiple feedstocks for adapting to market conditions, and biorefinery options to broaden the product portfolio of ethanol makers.[176]

Dominion Power supports R&D activities directed toward improving the reliability and efficiency of its service to customers. The company was a founding member of the Electric Power Research Institute (EPRI), formed by the electric utility industry to pool assets and conduct research into technologies expected to contribute to its goals. During the 1980s and 1990s the company supported and participated in a variety of R&D projects, such as evaluation of a fuel cell installed at Old Dominion University, assessment of the potential of high-temperature superconductivity (in conjunction with the Center for Innovative Technology), and demonstration of electric vehicles and innovative recharging technology. As the structure of the electric business changed and Dominion merged with Consolidated Natural Gas and acquired an oil and gas exploration and production business, the company's R&D efforts evolved to address these broader needs. Dominion's R&D activities are now decentralized, reflecting the "unbundling" of the electric business and the company's diversification. More recent R&D activities include carbon sequestration research via the Virginia Center for Coal and Energy Research, assessment of wind power potential at selected sites, assessment of new nuclear reactor designs and clean coal technologies, and collaborative research with the EPRI to improve nuclear generation and electric transmission.[177]

General Electric's Salem facility is active in energy technology development, with expertise in control and power electronics. In addition to manufacturing capabilities, GE Salem is heavily involved in engineering new products, primarily for other GE business units. Application areas include wind energy (power converters, grid stability, control systems, and technology), coal gasification (control software and hardware development, control strategies, and optimization), oil and gas (15-megawatt electric drives for compressor motors), gas/steam turbines (new sensors/circuitry for measurements needed for performance optimization), solar energy (3-kilowatt inverter), and nuclear energy (plant simulation and performance optimization, some funded through the DOE and the Nustart Nuclear program). GE Salem is not currently funding research projects with Virginia universities, but it hires many Virginia Tech students. Although the company is interested in collaborating with local businesses and institutions, coordination with other institutions has not been a critical factor for its product-oriented environment.[178]

Northrop Grumman Newport News (NGNN)

[173] www.bwxt.com/news/news_maint.asp?news_ID=56.
[174] www.consutech.com.
[175] http://brienergy.com.
[176] deltatcorp.com/deltatcorp/index.asp?section=History.
[177] Herbert Wheary, Dominion Power, personal communication, October 2, 2006.
[178] James Maughan, GE Salem general manager, personal communication, November 17, 2006.

manages the Virginia Advanced Shipbuilding Integration Center established by the state in 1998. The center's purpose is to enhance and promote the quality and competitiveness of Virginia's shipbuilding industry and to promote the general welfare of Virginia citizens. The center, along with electronic-system and software suppliers, U.S. Navy laboratories and program representatives, and Virginia institutions of higher learning, develops and integrates new technologies for aircraft carriers and advanced shipbuilding. It also participates on the steering committee of the Virginia Hydrogen Roundtable, exploring installation of a hydrogen power park to provide both critical shipyard electric loads as well as fuel for its fleet vehicles. NGNN is also pursuing coal-to-liquid concepts and synthetic fuel technologies in order to develop a modular design for sea-based fuel production. NGNN's synthetic fuel concepts, developed with its Idaho National Laboratory partner, are being received with interest by the Department of Defense, DOE, the Defense Logistics Agency, and others.[179]

Science Applications International Corporation, as mentioned earlier under Coastal Energy in Section 6.1.1, collaborated in developing the Virginia Coastal Energy Research Consortium and will serve as lead systems integrator for marine-industry support of the consortium.[180]

Siemens Automotive in Newport News has performed research on its fuel injector systems to improve fuel economy. Much of that work is now being done in Europe, while the Virginia group currently focuses more on controlling emissions using after-exhaust treatment to remove particulates. As alternative fuel use increases in the United States, the U.S. group may refocus on optimizing injectors for use with the new fuels. Siemens collaborated with Old Dominion University and the Applied Research Center in the past on direct injection research.[181]

Verdant Power, one of three leading tidal turbine manufacturers, is headquartered in Arlington and is producing underwater turbines for deployment in a tidal stream demonstration project in New York City's East River.[182]

6.3.2 SBIR/STTR Energy Research in Virginia

The Center for Innovative Technology identified thirteen Virginia companies that have received federal energy-related Small Business Innovative Research (SBIR) or Small Technology Transfer (STTR) awards in the last five years. These companies and their research areas are:

- Advanced Resources International, Inc., Arlington - carbon dioxide sequestration.
- Airak Engineering, Manassas - power converters for distributed energy.
- AMAC International, Inc., Newport News - power couplers for high RF power applications, such as nuclear physics accelerators.
- DDL OMNI Engineering, McLean - solid-state joining processes for alloys used in first wall/blanket applications for fusion power systems.
- Defense Life Sciences, LLC, McLean - biomass/waste conversion to fuel.
- Edenspace Systems Corporation, Chantilly - transgenic crops engineered for post-harvest self-hydrolysis of biomass to cellulose for fuel production. Edenspace recently won a $1.9 million award from DOE to lead an Energy Corn Consortium to develop corn hybrids optimized for cellulosic ethanol production.[183]
- Luna Innovations, Inc., Blacksburg - sensors for high-temperature power turbines; thin-film fullerene-polymer photovoltaic materials.
- Materials Modification, Inc., Fairfax - nanostructured electrodes for solar cells; nano-catalysts for efficient carbon-dioxide-to-methanol conversion.
- NanoSonic, Inc., Christiansburg - ink-jet electrostatic self-assembly of polymer thin-film solar cells on flexible, lightweight substrates.
- New Generation Motors Corporation, Ashburn - propulsion technology.
- PhotoSonic, Inc., Blacksburg - high-temperature geothermal well logging tools.

[179] Peter Diakun, NGNN, personal communication, September 22, 2006.
[180] Neil Rondorf, "A Virginia-Based Marine Renewable Energy Technologies," presentation to VCERC, September 19, 2006 (www.cit.org/vrtac/2006/06-09-19-VCERC-Presentation.ppt#256,1).
[181] Sean Nally, Siemens Newport News, personal communication, November 2, 2006.
[182] www.verdantpower.com/initiatives/currentinit.html.
[183] www.edenspace.com/10-25-2006.html.

- Prime Research, LC, Blacksburg - photonic sensors for geothermal wells.
- Zimmerman Associates, Inc., Fairfax - carbon dioxide monitoring and verification.

Four of these companies are spin-offs from university or federal laboratory research: Luna Innovations, NanoSonic, and Prime Research near Virginia Tech in Blacksburg, and AMAC near the Thomas Jefferson National Accelerator Facility in Newport News.

6.4 State Best Practices for Facilitating Energy R&D

The Center for Innovative Technology investigated the energy R&D efforts of other states, looking for geographically distributed programs with established track records and measurable success. Specifically, the Center examined California's Public Interest Energy Research (PIER) program,[184] the Connecticut Clean Energy Fund (CCEF),[185] the Massachusetts Renewable Energy Trust (RET),[186] Minnesota's Xcel Renewable Development Fund (XERDF),[187] the New York State Energy Research and Development Authority (NYSERDA),[188] the Ohio Coal Development Office (OCDO),[189] and the Northwest Energy Technology Collaborative (NWETC),[190] a major initiative coordinated through the Washington Technology Center. An analysis of these programs suggests several best practices that Virginia may wish to adopt in a program to support its own energy R&D.

Engage a broad stakeholder base in governance. NYSERDA's board is a good example of this. It includes the heads of state government offices in Transportation, Environmental Conservation, Public Service Commission, and the N.Y. Power Authority as well as nine others, who must include an engineer/research scientist, economist, environmentalist, consumer advocate, gas utility officer, electric utility officer, and three at-large members.

Provide for a consistent and substantial funding base. California's PIER collects about $62 million annually directly from state electricity users to fund public interest energy research. NYSERDA derives its research revenues from a combination of state appropriations, a System Benefit Charge (SBC) assessment on the intrastate sales of New York State's investor-owned electric and gas utilities; funding is augmented by voluntary contributions by the N.Y. and Long Island Power Authorities. The Massachusetts RET is also funded through an SBC, which amounts to about 50 cents a month for residential customers. Minnesota's XERDF is supported by settlements paid by the Xcel Energy Corporation for storage of spent nuclear fuel.

Define a market-driven research roadmap. NYSERDA hosts regular meetings with all stakeholders to develop a roadmap for research areas that reflect state energy issues and solutions. The roadmap then directs solicitation areas and facilitates R&D cooperation.

Set funding by program topic areas and allocate among best projects proposed. Topic areas should accommodate a variety of technologies and be directed toward the roadmap-identified needs. Solicitations should allow proposals from private, public, and nonprofit institutions and should encourage research consortia (including federal research labs). Decisions should be based on recommendations of a combination of external experts and an internal program manager.

Provide maximum flexibility for financing instruments to support R&D and innovative companies. The board of directors of the Massachusetts Technology Collaborative, administrator for the state's RET, by law has the ability to expend funds to make grants, contracts, loans, equity investments, energy production credits, bill credits, or rebates, and provide financial or debt-service assistance. Connecticut's CCEF Company Investment initiative invests via equity, convertible debt, debt, and debt-like financial vehicles. Repayments should be reinvested in R&D funding programs.

[184] www.energy.ca.gov/pier/index.html.
[185] www.ctcleanenergy.com.
[186] www.mtpc.org/renewableenergy/index.htm.
[187] www.xcelenergy.com/XLWEB/CDA/0,3080,1-1-1_11824_11838-801-0_0_0-0,00.html.
[188] www.powernaturally.org.
[189] www.ohioairquality.org/ocdo/ocdo.asp.
[190] www.nwetc.com/index.php.

Require "skin-in-the-game." Nearly all competitive funding programs require projects to have significant cost sharing from private sector, universities, and/or other non-state project partners.

Facilitate "real-world" demonstration opportunities. NWETC's Test Bed demonstration engages "test bed host" utilities, industry customers, and government institutions to screen applications from energy technology ventures and provide feedback to all applicants, and place selected participants' technology in appropriate field-testing sites.[191] The Connecticut CCEF Operational Demonstration Program makes funds available to early-stage clean-energy projects making innovative use of renewable energy resources or technologies, including wind, solar, fuel cells, wave power, biomass, landfill gas, and certain types of hydropower.[192]

Showcase companies with proven novel solutions. Events like the Northwest Energy Technology Showcase [193] created by NWETC provide companies that have novel energy solutions an opportunity to present their solutions to potential customers, investors, and public-sector decision makers. The companies and technologies should be carefully chosen to be sure they offer high-quality, proven solutions.

Track effectiveness of research in developing useful products and services to demonstrate the return on investment by the state. NYSERDA states that "Since 1990, NSYERDA has successfully developed and brought into use more than 170 innovative, energy-efficient, and environmentally beneficial products, processes, and services. These contributions to the State's economic growth and environmental protection are made at a cost of about $0.70 per New York resident per year."[194]

Join ASERTTI. Virginia is not a member of the Association of State Energy Research and Technology Transfer Institutions (ASERTTI). This nonprofit organization of states, federal agencies, universities, companies, and other research institutions promotes research development and deployment of advanced energy technologies that can contribute to economic growth, environmental quality, and energy security and reliability in the United States. Though not all members are state research development and deployment organizations, ASERTTI's focus is state-level public-interest energy research, development, demonstration, and deployment (RDD&D) needs. Collaboration and the development of working relationships to serve the public interest in energy are the main focus of ASERTTI's work.[195]

Nearly all competitive funding programs require projects to have significant cost sharing from private sector, universities, and/or other non-state project partners.

Benefits of membership in ASERTTI include:[196]

- Ability to share and receive information regarding new energy programs and emerging technologies to promote energy efficiency, demand-side management, renewables, distributed generation, and other clean-energy systems.
- Development of working relationships with other states, the federal government, and other national energy research, development, and deployment institutions.
- Ease of collaborating with state and national organizations to leverage funds and other resources to conduct joint research, development, and deployment projects and to reach common goals.

The annual ASERTTI membership fee is on a sliding scale, with most organizations being at $1,000, though there is some flexibility with new members. ASERTTI's executive director noted that one of the most important benefits is the willingness of some of the better-funded members to provide both opportunities (such as solicitations, cost-shared funds for external proposals) and advice in the design and operation of programs.[197]

191www.nwetc.com/cs_testbed.php.
192www.ctinnovations.com/funding/ccef/demo_project.php.
193www.nwetc.com/nets.php.
194www.nyserda.org/About/default.asp.
195www.asertti.org.
196www.asertti.org/join.htm.
197David Terry, Executive Director, ASERTTI, personal communication.

6.5 Opportunities for Improving Virginia Coordination of Energy R&D

6.5.1 Needs

Several important themes emerged from discussions with research leaders across the state concerning how Virginia could better facilitate and coordinate energy-related R&D. Among them were the following.

True leaders in their field have a history of focusing on what they do best, building consensus and capacity, and placing a high priority on their agenda so as to avoid resource competition.

Research leaders agreed that state support for R&D should serve sectors important to Virginia's economy, such as agriculture, mining, transportation, and the military.

Need to identify areas of core strength and strategic advantage. States that have been successful in establishing a reputation as a national leader do so through a combination of:

- Natural resources.
- Demographics and geography.
- Past success and track record.
- Research capacity.
- Partnerships.
- Agenda priority and financial commitment.

True leaders in their field have a history of focusing on what they do best, building consensus and capacity, and placing a high priority on their agenda so as to avoid resource competition.

Need to serve key customer bases in the state. Research leaders agreed that state support for R&D should serve sectors important to Virginia's economy, such as agriculture, mining, transportation, and the military. Examples include:

- Movement of the Southside Virginia economy away from tobacco coincides with an opportunity afforded by the need for renewable bio-based fuels.
- Poultry/agriculture wastes can be turned from regional/industry liabilities to energy resources.
- Coastal energy research and deployment can provide opportunities for collaboration with the maritime industries and the military in Hampton Roads.
- Lessons learned from implementation of efficiency/conservation criteria in government buildings can be used by policymakers to provide effective guidelines for commercial real estate construction, with much broader impact on energy demand.

Need for an integrated, system-level approach for sustainable energy generation. Another significant theme was the need to take a holistic approach to energy R&D, optimizing the balance of energy/economic/environmental issues involved in energy production. Examples include:

- Improving the economic viability of biodiesel production by R&D, leading to the ability to use the glycerol by-products in an integrated biorefinery to produce high-value chemicals.
- Coordinating research on fuel cells that can be used in homes with environmentally green building design to reduce the demand for centralized power.
- Siting offshore wind power towers to optimize the balance of power generation, access to market demand, construction and maintenance costs, and environmental impact.

Need for demonstration "reduction-to-practice" projects. Reduction-to-practice projects test promising research results in a "real-world" context, collaborating with industry and communities. James Madison University's work with the City of Harrisonburg and its own on-campus facilities management group to develop integrated waste-to-energy facilities and processes provides a systems-level model for R&D structured to serve a community's needs. James Madison University researchers work closely with the university's facilities management, using campus facilities as an initial test bed/physical lab for reducing to practice sustainable energy and conservation technologies.[198] As these capabilities are developed on campus, they are coordinated with Harrisonburg's efforts in energy conservation and waste reuse to create a real-world demonstration that fosters continued development and hastened deployment of the technologies. The proposed Bio-Based Energy and Products Development partnership among Virginia Tech, the Institute for Advanced Learning and Research, regional communities, and industry envisions a similar research-to-

[198]Ron Kander, JMU, personal communication, October 2, 2006

Virginia's ability to develop its energy R&D capacity in areas of significant interest to the state is handicapped by the geographic distribution of research strengths, and the lack of a process and staff to coordinate those activities and enable state-level responses to large federal opportunities.

demonstration and deployment transition. Providing problem-based funding to collaborative teams of localities, school systems, and businesses can engage faculty and students across disciplines to develop solutions to real-life problems of specific industry sectors (e.g., disposition of hog/poultry waste, new agriculture crop base for Southside, military need for secure, domestic sources of fuel and energy). Demonstration projects can also define specific issues for further research that have a focused market-need application, and may engage more research funding from the private sector.

Need for state cost-sharing commitments to enable competitive bids for large federal projects and awards. Several leading university research faculty and administrators, as well as industry respondents, noted that Virginia has lost opportunities to win large-scale federal R&D awards. Such awards are crucial to establishing national prominence in the sector. Although the proposals were competitive on a science/technology basis, they could not offer cost-sharing commitments from the state. For example, the Virginia Center for Coal and Energy Research's Director Michael Karmis noted that while Virginia has sites that could qualify for the $1 billion federal FutureGen initiative,[199] the state did not provide a cost-sharing commitment (approximately $5 million would have been required)[200] and lost any opportunity to host the FutureGen plant.

Likewise, as previously noted, the Virginia Tech fuel cell cluster was one of nine finalists for the National Science Foundation Engineering Research Center award ($20 million over five years). The solicitation required 30 percent cost sharing; the successful bid involved teams of industry (Westinghouse and General Electric) and universities providing cost sharing, such as shared facilities.[201]

Need increased funding of centers created by the Commonwealth. The Virginia General Assembly has recognized the importance of energy research by legislatively designating two state entities: the Virginia Center for Coal and Energy Research (VCCER) and the new Virginia Coastal Energy Research Consortium (VCERC). However, the state's low financial support has limited the effectiveness of these entities. Virginia's budgetary support of the VCCER ($141,750 and 2 FTE positions in the current biennium-more than a 50 percent reduction from 1980s' levels) is significantly less than what equivalent centers in West Virginia ($2.7 million, 33 FTE faculty/staff) and Kentucky ($5 million, 69 FTE faculty/staff) receive from their states. West Virginia's National Research Center for Coal and Energy receives significant funding from the federal DOE, reducing the need for state resources. Both West Virginia and Kentucky have committed close to an additional $5 million per year in recent years to promote programs such as carbon sequestration and coal-to-liquids.[202] The VCCER's status as a Commonwealth resource was reinforced in the 2006 legislation mandating the Virginia Energy Plan, with emphasis on its role in administering the Clean Coal Technology Research Fund. However, no monies were appropriated to the fund.

The creation of the VCERC as an "interdisciplinary study, research, and information resource for the Commonwealth on coastal energy issues" makes clear that coastal energy research (as defined in the legislation) falls under its purview. The state has designated $1.5 million in funding for the VCERC. Virginia Tech's George Hagerman pointed out that state support for graduate student and post-doctoral candidates is critically needed to allow existing research to continue while freeing senior research faculty to work with stakeholder agencies addressing issues key to offshore energy development.[203]

Need for state-level process and resources to coordinate collaboration and development of research capacity. Virginia's ability to develop its energy R&D capacity in areas of significant interest to the state is handicapped by the geographic distribution of research strengths, and the lack of a process and staff to coordinate those activities and enable state-level

[199] FutureGen is a ten-year, $1-billion public-private partnership project in concert with the international FutureGen Industrial Alliance to build the world's first zero-emissions, integrated carbon sequestration and hydrogen production research power plant. See www.fossil.energy.gov/programs/powersystems/futuregen.
[200] Michael Karmis, personal communication, September 26, 2006.
[201] Michael Karmis and Fuel Cell Cluster faculty communications, September 26, 2006.
[202] Michael Karmis, personal communication, October 20, 2006.
[203] George Hagerman, personal communication, September 28, 2006.

Funding to recruit and retain needed research and support staff, as well as support for recruitment, tuition, and stipends for graduate students and fellowships for postdoctoral researchers, is needed to attract the brightest and best to Virginia's research institutions.

responses to large federal opportunities. In some cases, funding for recruiting nationally prominent researchers is needed to make state-level responses competitive. Funding to recruit and retain needed research and support staff, as well as support for recruitment, tuition, and stipends for graduate students and fellowships for postdoctoral researchers, is also needed to attract the brightest and best to Virginia's research institutions. Such shortcomings have constrained Virginia's ability to mount a strong and competitive state-level response to, for instance, the DOE's program solicitation for two $125 million biofuels research centers.

In some cases, researchers from different institutions collaborate when their expertise is complementary and cooperation may better leverage outside funding. State university and college leaders, as well as industry representatives interviewed, generally support and encourage such mutually beneficial collaborations. Experience suggests that the best collaborations develop from the "bottom up," with complementary expertise finding a common problem of interest to solve and a source of funding to support the research. The model other states have adopted, with a state-level energy R&D initiative facilitating multidisciplinary, multi-institutional projects, should foster successful Virginia collaborations and alliances at the grassroots level.

6.5.2 Guidance for Virginia Facilitation of Energy R&D

The needs and suggestions identified above, along with the best practices from other states, provided the following guidance for developing a statewide program to facilitate energy R&D.

Develop a state Energy R&D Roadmap with milestones, and track results. One industry respondent noted that opportunities exist for collaboration with state universities but that industry requires there be a defined roadmap with milestones. Another noted that until there is consensus on the goals for energy R&D, it is difficult to design a specific, targeted strategy with measurable results that can be tracked and reported to the General Assembly.

These inputs support adopting practices of state programs such as NYSERDA that meet regularly with a broad base of stakeholders to develop a market-driven roadmap reflecting state energy issues and needed solutions. The roadmap guides solicitation areas and facilitates R&D cooperation. It should include goals that are measurable and regularly tracked.

Provide a cost-sharing commitment fund to enable competitive bids for large federal project or awards and strategic recruiting opportunities. The ability to make such cost-sharing commitments available in a timely manner is crucial to Virginia research groups being competitive for large-scale federal awards. Readily available funds also are important in responding to strategic opportunities on a smaller scale. Both types of awards serve to attract key researchers and enhance corporate partnerships, and can bolster Virginia's competitiveness in energy research. The Commonwealth Technology Research Fund is one potential vehicle to administer such funding. In both the national-level proposals as well as strategic recruiting opportunities, participating institutions would be required to demonstrate "skin-in-the-game" by providing financial commitments.

Fund a state-level initiative to coordinate and build Virginia's energy R&D capacity and spur its economic impact. The Virginia Research and Technology Advisory Council's (VRTAC's) University/Federal Lab Subcommittee has drafted a proposal for a five-year R&D initiative focused on thematic areas including "Energy, Conservation and Environment." The recommended management strategy is establishment and financial support of a consortium of universities, industry, and federal laboratories, reporting to a governor's panel. The consortium would determine core strengths and manage projects with the objectives of establishing a framework to help build research capacity in core areas at Virginia universities and providing support for collaborative research, development, and pilot-scale projects involving universities, industry, and federal labs. In order to foster job creation and economic revitalization, at least one project in the area of Energy, Conservation and Environment would be in economically deprived areas of Virginia. An example of a collaborative development project could be a biofuels program established to build research capacity which then leads to a bioreactor scale-up project in an economically deprived area, which would prove that the technology works and lead to new jobs in a short time frame.[204]

6.5.3 Benefits to Virginia from Coordinating Energy R&D

A state-level, integrated program that promotes energy R&D, addresses needs of key economic sectors, and provides staffing and cost-sharing funds to increase competitiveness for high-profile federal awards could have significant benefits for Virginia.

Data from the U.S. Bureau of Economic Analysis suggest that R&D accounted for a substantial share of the resurgence in U.S. economic growth in recent years. Using data from the National Science Foundation's annual surveys of government, academic, industry, and nonprofit R&D expenditures, the Bureau of Economic Analysis determined that R&D contributed 6.5 percent to economic growth between 1995 and 2002.[205]

A state-level, integrated program that promotes energy R&D, addresses needs of key economic sectors, and provides staffing and cost-sharing funds to increase competitiveness for high-profile federal awards could have significant benefits for Virginia. Potential outcomes include:

- Increased federal and other research funding, thus enhancing capabilities and expertise at Virginia institutions and companies.
- Attraction of high-profile researchers and premier students and post-doctoral candidates.
- New company creation, company attraction, and existing company growth.
- Job creation and retention.
- Technology development and deployment.
- Environmental benefits.

Research Funding and Productivity

Providing sufficient staffing and cost-sharing funds should give groups that are already technically competitive an added ability to win large federal projects such as a National Science Foundation Engineering Research Center. Where Virginia has provided sufficient initial funding for focused research areas, the returns have been impressive. For example, the creation of the Virginia Bioinformatics Institute in 2000, provided for by $12.3 million in initial state funds (from the Tobacco Commission), has led to a thriving, nationally recognized research center with 18 faculty and more than 200 employees managing nearly $50 million in external research support in a new 130,000-square-foot facility on the Virginia Tech campus.[206]

Attraction of Best Researchers, Students, and Postdoctoral Candidates

A state commitment to energy R&D, attracting increased federal and industrial support for research, will further the ability of institutions to attract high-profile faculty as well as the best and brightest students and postdoctoral research fellows.

Existing and New Company Growth; Company Attraction

Large company representatives interviewed noted they will support some R&D at a low level as "good citizens." However, industry is more likely to engage in university and regional research projects when state or federal funding is provided and the projects address relevant market needs. When industry is engaged in these projects, there is increased likelihood that students will gain expertise relevant to the corporate sponsors and that more students will be employed in Virginia companies. A state program facilitating energy R&D in areas where the state has recognized research strengths should also help attract companies and develop industry clusters in those areas.

A state program providing funding for energy innovation to solve market needs will also drive entrepreneurial investments in energy R&D, as is the case with

[204] Draft recommendation from VRTAC University/Federal Lab Subcommittee, December 2006.
[205] www.bea.gov/bea/newsrelarchive/2006/rdspend06.htm.
[206] www.vbi.vt.edu/about.

the federal SBIR/STTR programs supporting early-stage energy research. Other state energy programs (i.e., CCEF's Company Investment program[207] and NWETC's Energy Venture NW and Northwest Energy Angels™)[208] include investment funds supporting innovative energy companies.

Job Creation and Growth

A number of studies have looked at the economic impacts, including job creation, of deploying renewable energy. The following are examples:

- Daniel Kammen, an energy policy expert at the University of California, Berkeley, compared job creation from three scenarios with varying mixes of renewable energy sources (biomass, wind, solar) for providing 20 percent of electricity in the United States by 2020. His study predicted between 170,000 and nearly 250,000 new jobs related to energy.[209]
- A 2004 report from the Union of Concerned Scientists estimated that the 20 percent Renewable Energy Standard would create more than 355,000 new jobs in manufacturing, construction, operation, maintenance, and other industries-a net increase of nearly 157,500 jobs by 2020.[210]
- A 2004 report from the National Renewable Energy Laboratory noted that achieving the goals of the Department of Energy's Wind Powering America program during the next twenty years will create $60 billion in capital investment in rural America, provide $1.2 billion in new income for farmers and rural landowners, and create 80,000 new jobs.[211]

Technology Development, Demonstration, and Deployment

A prime metric for evaluating the success of Virginia's energy R&D facilitation program should be its ability to yield practical applications that provide for the state's energy needs in cleaner, cheaper, and/or more efficient ways. A 2005 report from California's PIER program states that from its inception in 1998 through 2003, "33 products were placed into use in their intended markets and are expected to produce ratepayer benefits between $320 million and $822 million over their lifetimes. Based on PIER program disbursements of approximately $200 million through 2003, the benefit-to-cost ratio was between 1.6 to 1 and 4.1 to 1. The range of benefits reflects uncertainties in the performance and in the sales projections for the products…the PIER benefit-to-cost ratio is quite comparable to results reported by other organizations with similar mandates, such as the Gas Research Institute, the Electric Power Research Institute, the NYSERDA, and the United States Department of Energy."[212]

Environmental Benefits

Advances in conservation and efficiency, new carbon management and sequestration technologies, and growth in alternative energy source production and use can have a significant impact on reducing energy use and air pollution. The 2005 California PIER report noted that the thirty-three products developed during the 1998-2003 period would over their lifetime save 5.6 gigawatt-hours of electricity and 8.8 billion cubic feet of natural gas, avoid 730 megawatts of capacity construction, and reduce emissions of sulfur dioxide (2,000 tons), nitrous oxides (2,700 tons), and carbon dioxide (1.8 million tons).[213]

[207]www.ctcleanenergy.com/investment/renewable_company.html.
208www.nwetc.com/nweangels.php.
[209]Daniel M. Kammen, "Business Unusual: Methods to Develop a Clean Energy Economy," presentation to NREL, September 20, 2004, Washington, D.C. (www.nrel.gov/analysis/seminar/docs/2004/ea_seminar_sept_20.ppt, Slide 30).
[210]Union of Concerned Scientists, "Renewing America's Economy: A 20 Percent National Renewable Electricity Standard Will Create Jobs and Save Consumers Money," September 2004 (www.energyfuturecoalition.org/pubs/Economic%20Growth%20Opportunities.doc).
[211]NREL, "Wind Energy for Rural Economic Development", June 2004 (www.nrel.gov/docs/fy04osti/33590.pdf).
[212]California Energy Commission, "2004 Annual Review of the PIER Program Volume 1-Commercial Successes and Benefits" (www.energy.ca.gov/2005publications/CEC-500-2005-055/CEC-500-2005-055-V1.PDF).
[213]Ibid.

Chapter 7

Recommendations

7.0 Recommendations

Virginia's energy path forward will require actions by each of us individually, in our businesses and industries, and by our government institutions. The recommendations set out actions that will help secure Virginia's energy future and implement the energy policy and objectives set out as the Energy Policy of the Commonwealth, Chapter 1 of Title 67 of the Code of Virginia (see Appendix B).

Virginia must overcome market, consumer-education, historical energy-cost, public-policy, and institutional barriers to meet these energy policies and objectives. Overcoming these barriers will require a mix of public and private investments in energy actions.

This Plan sets a goal to increase energy independence in Virginia with an emphasis on conservation and efficiency and clean-fuel technologies.

- Expanded conservation and efficiency actions aim to reduce by 40 percent the rate of growth in energy use that Virginia would see without the Plan's recommended actions (base case). This will require a concerted effort in implementing new actions to reduce use of electric, natural gas, and petroleum products. The Plan's energy-savings goal is based on the following:
  - Virginia has set its goal to reduce electric use by 10 percent of 2006 electric use by 2022 through energy-efficiency, conservation, and demand-management activities. This would reduce our electric demand by nearly 3,900 megawatts, equivalent to four times the capacity of the proposed Virginia City Hybrid Energy Center. This would reduce Virginians' electric costs by $200 to $700 million through 2022 (net savings after cost of measures). Total savings over the life of measures would total between $300 and $590 million for each yearly investment in energy-efficiency measures
  - Natural gas use in Virginia can be reduced more than 7 percent through the cost-effective, achievable strategies identified in this Plan. This would reduce Virginians' natural gas costs by more than $125 million per year (net savings after cost of measures).
  - Consumption of petroleum products used to heat our homes and businesses can be reduced 10 percent through the actions identified in this Plan. Transportation fuel use can be cut 5 percent through the recommendations in this Plan.
  - The 40 percent conservation goal of this Plan also includes weatherizing an additional 700 homes of low-income Virginia families per year through increased investment in the Weatherization Assistance Program.
- Virginia utilities will need to make substantial investments in new energy production and infrastructure. This Plan sets the goal to increase in-state generation of energy by 20 percent over what is projected in the 2017 base case.
  - To meet this goal and maintain the same rate of electricity imported into Virginia as was imported in 2006 (even after meeting the 10% electric savings goal), Virginia must expand its electric generation infrastructure by more than 2,300 megawatts. This should include Virginia's electric utilities making full progress toward meeting the 12 percent renewable energy supply goal provided for in the state's new renewable portfolio standard. Virginia electric utilities also will need to construct new electric transmission infrastructure to deliver needed electricity to growing market areas. Proposed new plants include the 585-megawatt coal- and biomass-fired Virginia City Hybrid Energy Center, the 520-megawatt natural gas-fired power plant in Warren County, and the 300-megawatt natural gas peak power plant expansion in Caroline County. (See Chapter 4 for more information on infrastructure.)
  - Virginia's natural gas utilities will need to make ongoing investments in new infrastructure to deliver needed natural gas to consumers. This includes constructing a third

pipeline across the James River between north and south Hampton Roads and constructing new local distribution pipelines and peak storage facilities. Other pipeline and peak storage projects will be needed in growing areas such as northern Virginia.
    - Virginia will need to invest in new transportation fuel infrastructure. The energy generation goals in this Plan include increasing the capacity of the petroleum refinery in Yorktown by 40,000 barrels per day and providing 300 million gallons per year of ethanol production and 120 million gallons per year of biodiesel production.
- Consumers must be educated about energy opportunities if we are to overcome the consumer knowledge market barriers. With clear knowledge, consumers will be comfortable in taking energy-saving actions and making energy-savings investments. Changing consumer behavior and creating demand for energy services and products can have the largest impact on our ability to meet our energy goals. Virginia must expand the delivery of energy-efficiency and demand-control information to its citizens to meet this Plan's consumer education goal.
- Virginia also must reduce greenhouse gas emissions. This Plan sets a goal to reduce greenhouse gas emissions back to 2000 levels by 2025. This will require 2005 levels to be 30 percent lower than projected levels with no action.
    - Implementing the energy-efficiency and renewable-energy recommendations of this Plan will allow Virginia to meet a goal of reducing its greenhouse gas emissions by approximately 15 percent, or 18 million metric tons per year.
    - Energy-efficiency and conservation actions alone will not be sufficient to reach this goal. Therefore, Virginia should establish a Commission on Climate Change to make a comprehensive assessment of greenhouse gas issues and develop a plan for how Virginia can reach this greenhouse gas emission reduction goal.
- Virginia should provide long-term support for energy research and development (R&D) to foster long-term improvements in how Virginia and the nation produce and use energy. This Plan sets out the goal to increase energy R&D by $10 million per year from state, private, and federal resources. Without this investment, Virginia will be unable to attract federal and private investment in energy R&D and the state's businesses will be left behind in the world marketplaces in which they compete.
- The General Assembly enacted energy business incentives such as the Biofuels Incentive Grant and the Solar Photovoltaic Manufacturing Incentive Grant programs. Virginia must invest in these incentives if they are to be effective in bringing these energy-based jobs to the state. Virginia needs to support existing businesses wishing to make substantial new investments in energy activities, such as around the nuclear business cluster in Lynchburg. Start-up financial support is needed if Virginia is to be the home of businesses that bring new energy technologies to the marketplace and develop new innovative energy sources and infrastructure. These will provide a basis for new job growth and income to the Commonwealth.
- There are opportunities for smaller-scale energy projects that can prove the viability of leading-edge technologies, creating new opportunities for consumers and Virginia businesses.

The Commonwealth should ensure that these activities are effective in meeting Virginia's energy goals. The Governor's Energy Policy Advisory Council, with assistance from the Department of Mines, Minerals and Energy and other state agencies, should evaluate the energy saved, new supplies of energy generated, and value of investments in energy R&D and new business development. The results of the evaluation should be reported to the Governor and the General Assembly to ensure accountability of the proposed energy activities.

Through these efforts, Virginia will increase the role of energy efficiency and conservation, support existing businesses with reliable low-cost energy supplies, support new job growth, increase energy-education activities, increase energy assistance to low-income Virginians, and increase energy R&D at our universities and businesses. Virginians will see lower energy costs in the short term because of efficiency and conservation actions, and have a more secure energy future because of investments in new energy infrastructure, energy R&D, and new energy businesses.

7.1 Energy Efficiency and Conservation

Energy efficiency and conservation is the first area where we should take actions for a secure energy future.

As described in the 2006 National Action Plan for Energy Efficiency, energy efficiency and conservation can:

- Lower consumers' energy bills.
- Give consumers greater control over energy-use decisions.
- Cost less than developing many types of new energy sources.
- Be deployed in smaller increments and more quickly than large supply projects.
- Reduce the environmental impact of expanding energy use.
- Support economic development through jobs delivering energy conservation services and decreasing export of funds outside Virginia for energy imports.
- Reduce the level of energy imports, lessening the vulnerability of our economy to price and supply disruptions.

This Plan sets out a goal to reduce future growth in energy use by 40 percent below what would happen without the recommendations of this Plan (see Figure 7-1). This would reverse Virginia's per capita energy consumption growth rate and provide for nearly level per capita energy use per year by the end of the term of this Plan (see Figure 7-2).

Figure 7-1 Virginia Total Energy Consumption Trends

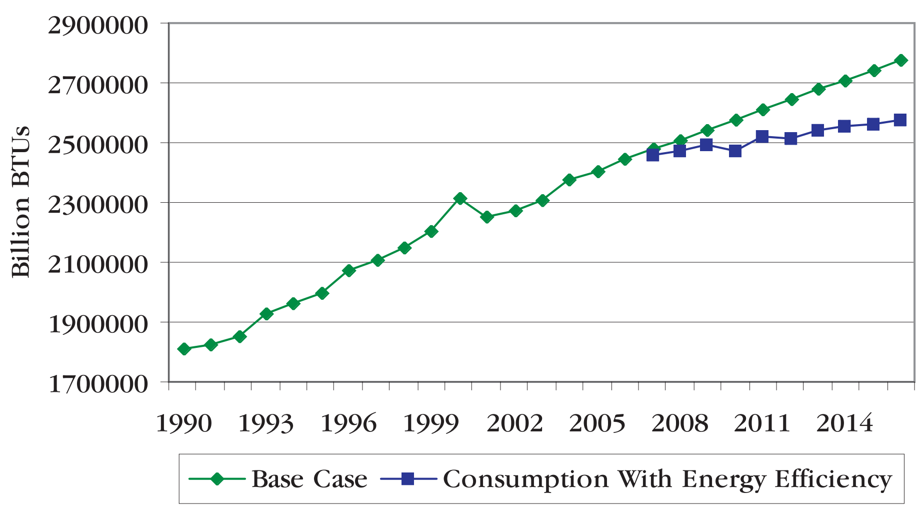
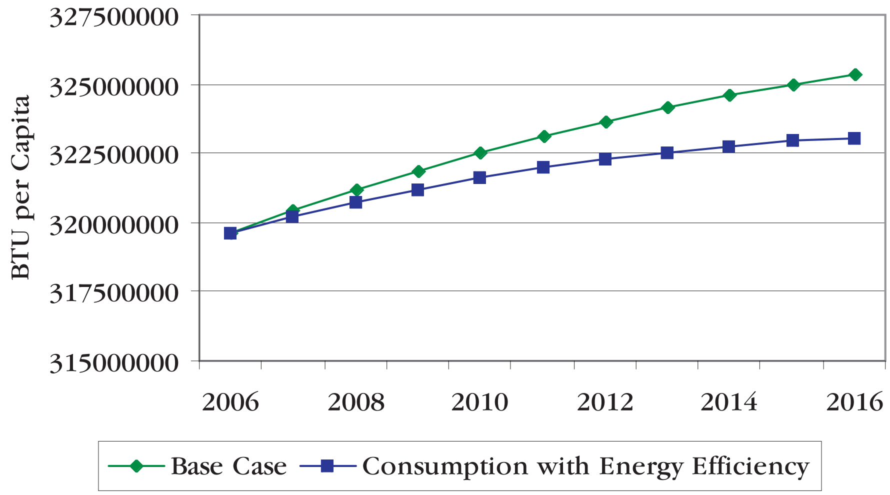


Figure 7-2 Virginia Per Capita Energy Consumption Trends



7.1.1 State Policies for Energy Efficiency and Conservation

With increasing energy costs and public attention to energy issues, Virginia has the opportunity to set state government policies and implement programs that will increase the use of energy conservation strategies in the state.

Consumer Energy Efficiency

Virginia should, contingent on an acceptable revenue impact, expand its sales-tax holiday to include energy-savings natural gas, fuel oil, and propane-fueled equipment. Virginia established the October sales-tax holiday for Energy Star electrically powered equipment. There are substantial efficiency and conservation improvements available with other types of equipment. Expanding the sales-tax holiday to these types of equipment will offer the savings to consumers using other than electric equipment.

Virginia should also consider adding a spring sales-tax holiday for Energy Star and other high-efficiency equipment. This will offer the sales-tax holiday at the time that consumers are making decisions about air conditioning and other types of equipment not on the market during the fall sales-tax holiday. A spring sales-tax holiday will help Virginia reduce its summer electric demand peak and overall electricity costs.

The Commonwealth should also work with equipment and product suppliers, retailers, and utilities to publicize the Energy Star tax holiday and promote the Energy Conservation Awareness Week.

While having a larger revenue impact, Virginia could provide tax incentives for energy efficiency and conservation similar to those provided by the federal government for investments such as energy-efficiency building improvements, high-efficiency equipment, combined heat and power installations, heat recovery, and other technologies. These would include tax credits and accelerated depreciation for investments in energy efficiency and conservation.

Utility Conservation Programs

Virginia has an opportunity to reduce its electric consumption over the next ten years. Analysis provided for this Plan shows that Virginia should be able to cost effectively achieve a 14 percent reduction in electric energy use. The General Assembly established a goal that 10 percent of electric use by retail customers

(2006 base year) should be offset by conservation and efficiency by 2022. It directed the State Corporation Commission (SCC) to convene a proceeding to determine if the 10 percent goal can be cost effectively achieved, to identify the mix of programs to be used to achieve the goal, and to develop an implementation plan that identifies the entities that could most effectively implement the programs and that estimates the cost of attaining the goal.

These activities can be undertaken by utilities or by governmental and non-governmental stakeholders. The final mix of types of activities, costs, and providers should be determined through the 2007 SCC proceeding on electric utility conservation programs.

Analysis completed for this Plan shows that Virginia electric utilities would have to invest in the range of $100 to $120 million per year between 2008 and 2022 to meet the 10 percent electric savings goal. This would have to be matched by $180 to $200 million per year by electric consumers.

These investments would lead to increased total costs to electric consumers over the first seven years, followed by savings over the next eight years until 2022. Total net consumers savings would be between $200 and $700 million after paying for the investments. Total savings over the lives of the measures would range from $300 to $590 million for each yearly investment in energy-efficiency measures.

Energy-efficiency and conservation activities should address all customer classes and income levels. This will minimize the risk of cross-subsidization among customer groups. A broad spectrum of stakeholders, including utilities, consumers, and environmental interest groups, should actively participate in the SCC's energy-efficiency proceeding.

Proposed utility-based energy-conservation activities should be assessed for cost effectiveness. There are several tools available to assess cost effectiveness of the programs. They include the Total Resource Cost Test, Societal Test, Utility/Program Administrator Test, Participant Test, and Rate Impact Measure Test. A measure of the cost per kilowatt hour of conserved energy also may be used to evaluate activities. Each evaluative tool will measure a component of cost effectiveness. Utility energy-efficiency and conservation activities should be measured using the full set of evaluative tools. No single energy-efficiency program assessment tool should be used solely as a go-no go decision mechanism.

After being implemented, utility energy-efficiency and conservation activities should be evaluated for effectiveness through use of measurement and verification protocols. Standardized measurement and verification protocols that have been used in other states should be used in Virginia. Programs not meeting planned results should be reevaluated to determine if they should be modified or ended. This evaluation should be completed on an annual basis.

Virginia's electric energy conservation portfolio should include programs that have proven successful in other states. Specific utility actions found to be effective in other states include:

- Promotion of the Energy Star sales-tax holiday.
- Residential and non-residential energy assessments to help consumers identify how to use energy efficiently.
- Provision of real-time rates and advanced metering for customers with the ability to control electric use in peak demand periods. This could include the ability to aggregate demand among customers to participate in the PJM demand-response program.
- Financial incentives for replacing old, less efficient appliances and equipment with high-efficiency models (including documentation of recycling of old equipment). This should be targeted at residential equipment such as furnaces/boilers, air conditioners, heat pumps, refrigerators, washing machines, and hot water heaters, and commercial and industrial equipment such as motors and electric process equipment.

- Expand use of ground-source heat pumps in lieu of air-source heat pumps.
- Air conditioning equipment and hot water heater cycling in peak demand periods.
- Financial incentives for upgrading lighting to more efficient units.
- Demonstration programs for emerging technologies, such as light-emitting diode (LED) lighting, infrared heating/drying, ultraviolet light sterilization, and others.
- Education and unbiased, non-commercial information to consumers on cost-effective energy-efficiency actions.

New technologies such as smart grid improvements also may provide opportunities to improve the efficiency of the utility network.

In 2007 Virginia removed a disincentive to electric utilities investing in these activities when it changed how these utilities are regulated. Utilities will no longer be permanently penalized for reductions in sales due to energy-efficiency improvements. Utility revenues will be reviewed on a two-year cycle, with the ability to adjust rates for any under-recovery of return on equity. Additionally, Virginia's electric utilities are authorized to recover direct costs of energy-efficiency program expenses. With these disincentives removed, Virginia's investor-owned electric utilities should invest in all cost-effective energy-efficiency activities. Virginia's electric cooperatives and municipally owned electric utilities should also maximize cost-effective investments that result in a total cost reduction to their members or residents.

These activities will require incentives to overcome consumer-implementation barriers. Based on the level of incentives in successful programs in other states, $100 to $120 million per year is needed to reach the 10 percent electric savings goal.

Virginia's retail electric sales totaled 108.9 billion kilowatt-hours in 2005. Meeting the 10 percent goal based on 2005 sales would have reduced electricity sales by 10.9 billion kilowatt-hours. This would be equivalent to a reduction of 7.2 million metric tons of carbon dioxide emissions, or approximately 5.5 percent of the estimated 130 million metric tons of total carbon dioxide emissions in 2005 in Virginia.

Virginia also should take additional policy actions targeted at reducing consumption of other fuels. For example, natural gas utilities have a disincentive to promote energy efficiency. Distribution rates for non-industrial consumers are closely tied to the customers' use of gas. This provides an incentive for local distribution utilities to promote higher usage in order to recover the fixed costs of their distribution systems and maximize profits. Natural gas utilities in a stable or declining market have a reduced ability to recover their fixed costs if sales are reduced by conservation activities.

This market barrier can be overcome through careful use of revenue decoupling. Revenue decoupling, combined with strategies to promote energy conservation by natural gas users, can provide benefits to direct program participants through lower natural gas bills as well as benefits to other consumers through utility cost savings in peak natural gas purchases, purchases of firm and interruptible pipeline capacity, and balancing services. These savings can offset cross-subsidization of participating customers by non-participants.

Use of revenue decoupling for reasons other than energy-efficiency and conservation actions must be implemented carefully. Many factors affect natural gas sales, such as year-to-year changes in weather and economic activity in a utility's service territory. Where daily consumption rates are trending lower, utilities should be able to recover investments needed to maintain existing networks and add capacity to meet peak-day loads. Revenue decoupling can serve as a variable tool to encourage infrastructure investment in an environment where average daily use is declining. However, revenue decoupling should provide protection against excessive recoveries due to increases in sales from weather and economic expansion.

Natural gas energy-conservation activities should include financial incentives and educational support for replacing old, less efficient natural gas space and hot water heating and process equipment with high-efficiency furnaces, hot water heaters and process equipment, tankless water heaters, radiant heaters, and more efficient commercial cooking and baking equipment.

Virginia's natural gas producers, transmission pipelines, and local distribution utilities should broadly implement the Gas Star recommendations to conserve natural gas by reducing leakage in production, transmission, and distribution operations. Some activities are ongoing today. For example, some Virginia natural gas local distribution utilities have been upgrading old underground piping systems to eliminate leaks. The SCC has supported these efforts through its prompt consideration of cost recovery for these efforts. Virginia's natural gas utilities and the SCC should be commended for this effort. Both Virginia's public and municipal natural gas utilities should continue with these efforts to conserve natural gas resources through reducing leaks.

Energy Conservation for Low-Income Virginians

The Weatherization Assistance Program funds improvements to eligible low-income households. These include repairing and replacing heating and cooling equipment, sealing air leaks, and insulating buildings, ducts, and hot water heaters. This program works most efficiently with a stable flow of funds from year to year because of the need to maintain crews and equipment. It does not readily react to one-time infusions of funds. Virginia should expand the capacity of the Weatherization Assistance Program, using a reliable, long-term source of funds to serve a greater percentage of eligible households per year. Two million dollars per year would allow the program to serve an additional 715 households per year. Other housing programs that assist low-income families should also incorporate energy efficiency into their efforts. Through these activities, households' energy bills and need for other energy assistance can be reduced.

Low-income Virginians receive assistance paying their energy bills through the Low-Income Home Energy Assistance Program (LIHEAP). Primary funding for LIHEAP comes from the federal Low-Income Home Energy Assistance Program grant. Virginia has provided additional funding to LIHEAP, both from the general fund and Temporary Assistance to Needy Families funds, during times of sharply rising and high-cost energy. Virginia should continue to provide increased LIHEAP funding at such times and should improve coordination among public and private energy assistance programs.

Options to reduce the need for energy assistance, such as utility disconnect moratoriums, discounted "lifeline" rates, and waivers on reconnection fees, should be examined for applicability in Virginia.

Energy Education

Virginia should implement an energy-conservation public education program to overcome consumer market barriers and make consumers confident in making energy -efficiency improvements. Information should be seen as coming from an unbiased source. Consumer education should be targeted toward:

- Homeowners and renters, addressing the use of energy-efficient appliances, equipment, and daily practices. Special emphasis should be made with low-income households as they typically reside in less energy efficient housing stock.
- Commercial building owners and business managers, addressing the values of more energy efficient construction such as Leadership for Energy and Environmental Design (LEED) and Energy Star. This also should include benchmarking energy use, guidance on use of performance contracting, and similar topics. Business-related education also should promote participation in federal programs such as the Green Lodging program.
- Primary and secondary school students,

incorporating energy efficiency into Standards of Learning requirements. This should include providing the necessary tools and training to teachers to incorporate energy efficiency into their lessons.

As part of this program, Virginia should encourage development of a green/ energy-efficient product and material label, and be an early adopter as one is developed. For example, the Energy Star label could be expanded to include materials and equipment beyond appliances, office equipment, and buildings. If the federal Energy Star labeling program cannot be expanded, Virginia should support implementation of an independent, energy-efficiency label program. This effort should be coordinated with utility and retail store communication programs.

Virginia should more widely promote web-based education resources, such as the *Virginia Energy Savers Handbook*, to consumers. The state can expand distribution of information on and from the handbook, including direct distribution of copies to high-value audiences, flyers and other advertising on how to find energy-conservation information on the Virginia state government Internet pages, and expanded distribution through Virginia's cooperative extension offices.

There are numerous governmental programs that can provide energy-efficiency best practices and education to consumers. These include programs such as Clean Cities, Rebuild America, Climate Leaders, Cool Cities, and others. Virginia should promote use of the educational materials available through these programs.

An effective, statewide energy-education program will require $1 million per year to support development and delivery of energy information to consumers.

Virginia should continue to actively promote recycling. Many Virginia localities already recycle a substantial portion of their wastes. Reuse and recycling programs result in less energy expended to make new products from raw materials.

Building Efficiency and Conservation

Virginia uses the International Building Code as the basis for the Uniform Statewide Building Code. The International Building Code's energy code is updated on a three-year cycle to reflect updated technology and building practices. Virginia has regularly updated the Uniform Statewide Building Code to incorporate the updates to the International Building Code. This has kept Virginia's minimum construction practices up to date with the current minimum requirements.

Incorporating additional cost-effective energy improvements into new construction can help improve housing affordability by reducing total cost of home ownership and by reducing the amount of energy used in the state's institutional, commercial, and industrial buildings. The Commonwealth should ensure that the energy requirements in the Uniform Statewide Building Code result in the most efficient energy performance that is cost effective. This may require use of energy codes more stringent than those in the model International Building Code.

Virginia should provide training to building code officials, architects and engineers, and the building community about how to properly meet energy codes and use more energy-efficient building standards such as LEED, Energy Star, and EarthCraft Homes. These efforts would increase the number of design professionals and builders certified under these programs. This effort should be targeted to both the commercial and residential markets.

Virginia should work with its building community to provide additional energy-conservation education to the industry's workforce. This should include training on proper sizing and installation of energy -using equipment, proper construction practices, and operations and maintenance training. These efforts could be provided through the Virginia Community College System or targeted workshops offered across the state.

Virginia should initiate a home energy-rating system for new and existing homes using an existing rating system such as that provided by the Residential Energy Services Network.

Industrial Efficiency and Conservation

Virginia should create energy assessment centers, similar to those provided under the U.S. Department of Energy's industrial energy assessment center program, to provide energy audits and assessments to commercial and small industrial consumers. This could be managed through Virginia's university engineering and science programs or through non-governmental organizations such as chambers of commerce or regional planning districts. The program could use engineering students and professors and retired engineers to provide the assessments and tools from the numerous federal energy efficiency programs such as Energy Star, Industries of the Future, steam and motor efficiency programs, and GreenLights.

Virginia should assist industrial consumers to implement waste-to-energy, heat recovery, and combined heat and power projects. These projects represent the largest opportunities to replace higher-cost conventional energy sources, using energy sources and materials that typically are wasted.

New Technologies

New technologies are regularly being introduced into the marketplace that can use less energy to perform needed tasks. Virginia should monitor new technology development and provide financial support to encourage early adoption of emerging energy technologies. Current examples of such technology include residential and commercial LED lighting, fiber-optic daylighting, microgeneration systems, cool roofs, computer network controls, and new automobile technologies.

7.1.2 Federal Policies for Energy Efficiency and Conservation

The federal government plays a leading role in promoting energy efficiency and development of reliable energy supplies through tax policy and direct financial assistance, research and development (R&D), energy data publication, equipment and vehicle standards, and public education.

The federal government should continue providing the numerous energy efficiency and conservation, R&D, energy data, grants, and other services to residential, commercial, industrial, and institutional consumers. As part of this work, the federal government should increase its investment in energy efficiency and conservation and alternate energy development, and support state efforts to deliver these services to energy consumers. These investments should be provided at a reliable level over a multiyear period to ensure that partners can efficiently plan and implement new investments.

The federal government also should provide sufficient funding for energy development activities to reach a critical mass and bring new technologies to deployment.

Many energy policies should be implemented on a national or regional basis, as state implementation can introduce dysfunction into markets or lead to duplication and inefficiencies. For example, northern Virginia's appliance markets overlap with those in Maryland and the District of Columbia, and the southwest Virginia appliance market overlaps with the Tennessee Tri-Cities market. Limiting sales to only high-efficiency models in the Virginia portion of these markets might drive consumers across state lines to purchase lower first cost units, taking the economic activity away from Virginia and negating any energy savings from more efficient equipment. Virginia encourages the federal government to more broadly implement improved appliance efficiency requirements. If neighboring jurisdictions set higher appliance standards, Virginia should consider setting regional appliance efficiency standards in the common market areas.

Transportation is the single largest energy-using sector, but saving energy in transportation has proven difficult. To improve energy efficiency in transportation, the Corporate Average Fuel Efficiency (CAFE) standards for vehicles should be increased by 10 miles per gallon over the next ten years, to 37.5 miles per gallon for automobiles and 32.2 miles per gallon for light trucks, with off-ramps for proven technical or safety roadblocks. CAFE standards should be based on actual mileage and should not be adjusted upward based on use of alternate fuels in fleets.

CAFE protocols should be periodically adjusted to account for changing driving conditions, such as urban/suburban/rural driving patterns, typical congestion delays, and typical speeds driven. This will help CAFE standards better approximate actual driving experiences and lead to more accurate vehicle-mile-per-gallon estimates.

While market drivers such as tax credits will help increase transportation fuel efficiency, a mandatory increase in CAFE standards will be more effective in conserving gasoline and other transportation fuels.

7.1.3 Local Government Policies for Energy Efficiency and Conservation

Several early-adopting Virginia localities are implementing policy decisions to encourage private energy-efficiency and conservation actions in their localities. Additional Virginia localities should follow their lead in adopting policies to encourage additional private energy conservation actions. These policies can take the form of tax policy, as well as land use and zoning, transportation, and operational decision making.

Localities should take advantage of authority granted under 2007 legislation and create a separate real-estate classification and lower tax rate for buildings that are 30 percent more efficient than required by building code.

Localities should adopt land-use plans that allow higher density development near mass transit nodes and encourage mixed-use communities, urban redevelopment, and infill development.

Localities should allow higher density development for projects meeting LEED standards and streamline and reduce permitting fees for LEED buildings.

Localities should consider how development and transportation patterns affect energy use when developing their comprehensive plans. Localities also should assess the use of conservation easements and purchase of development rights as a way to preserve open space and direct development toward areas with mass transportation available.

Localities should take advantage of authority granted under 2007 legislation to enter into agreements with nonpublic schools to provide student transportation, increasing the efficiency of the overall student transportation system.

Localities should support development of new renewable energy and distributed energy applications. Localities should use the Virginia Renewable Site Scoring system developed under authority of 2006 Senate Bill 262 in their local land-use decision-making process.

Localities should consider sharing landfill tipping fees with projects that convert waste to energy and which, in turn, reduce waste volume and extend the life of the locality's landfill.

7.1.4 Energy-Efficiency and Conservation Actions in Government

State Government

Government should lead by example and implement all cost-effective conservation opportunities.

State government energy-conservation goals have been set out in Executive Order 48, issued on April 5, 2007, calling for Virginia state agencies and institutions to reduce conventional energy expenditures by 20 percent between 2007 and 2010. The executive order also directs state agencies and institutions to:

- Use certified energy managers to support energy management activities if their energy bills exceed $1 million per year.
- Construct new buildings over 5,000 square feet in size and complete renovations valued over 50 percent of a building's assessed value using the energy components of the Leadership for Energy and Environmental Design (LEED) certification or Energy Star standards.
- Lease space in metropolitan areas near public transit, and at sites that are pedestrian and bicycle friendly and give a lease preference to LEED- or Energy Star-rated buildings.
- Minimize vehicle miles traveled related to state operations, implement transit and ride-sharing programs, maximize use of E85 and B20 fuels, and include fuel efficiency and emissions in vehicle purchase decisions.
- Purchase Energy Star equipment whenever a classification exists for the equipment, purchase all recycled paper-compatible copiers, printers, and related office equipment, and purchase recycled paper except where equipment limitations precludes its use.

State government also has completed an operational review of energy use to identify other opportunities for energy management and efficiency improvements. This review identified additional best practices that state agencies and institutions should use.

- Create a Virginia Energy Management Program to provide for more coordinated management of energy issues, training for and communication among state energy managers, and evaluation of new technologies and processes.
- Purchase natural gas from centralized contracts, using underground gas storage, price locks, futures, and pipeline transportation contract tools to minimize natural gas purchase costs.
- Pilot recommissioning of state buildings to ensure that their energy-using systems work as designed.
- Integrate centralized management of utility billing with the new state enterprise management system.
- Coordinate a multiagency participation in the PJM demand-response program.
- Encourage broader participation in the Department of Environmental Quality's Environmental Excellence Program.
- Consider a central fund for energy-efficiency improvements to replace third-party funding in energy savings performance contracts to allow the Commonwealth to retain a higher percentage of savings.

Federal Government

Federal government agencies have taken many actions to reduce their energy use and use alternate supplies of energy. The Federal Energy Management Program is a model for energy management. The Commonwealth should pursue opportunities to work with federal facilities on energy management through the Virginia Regional Environmental Management System.

Local Governments

Several Virginia's localities are implementing actions to manage energy use. For example, the Cities of Alexandria, Charlottesville, Portsmouth, Richmond, Roanoke, Virginia Beach, and Williamsburg and the Town of Blacksburg have signed the U.S. Mayors Climate Protection Agreement under the Cool Cities program. They have pledged to take significant local actions to conserve energy use in their operations and among their citizens. Arlington County has instituted numerous energy-savings actions in its operations, including use of hybrid vehicles in its fleet and reductions in energy use in facilities.

All Virginia localities should follow the lead of these early-adopting local governments and implement all cost-effective, internal energy conservation opportunities.

7.1.5 Individual Consumer Energy-Efficiency and Conservation Actions

Each Virginian affects the state's energy future through day-to-day actions and long-term lifestyle decisions. Many small decisions collectively can make a big difference in state energy use. In making these decisions, people should use energy conservatively so that supplies will continue to be available to meet our needs.

There are many easy day-to-day choices people can make to use energy more efficiently.

- Virginians should follow the advice of their mothers and fathers to turn lights, televisions, and equipment off when not needed.
- How Virginians drive affects energy use. Plan trips to reduce the total miles driven. Simple acts such as combining trips, walking, bicycling, and using transit all add up to save energy in transportation and reduce emissions. Avoid overly fast stops and starts and traveling at excessive speeds.
- Consumers have similar opportunities to conserve energy in other motorized equipment such as lawn mowers and boats. Keep equipment properly maintained, and don't unnecessarily leave equipment or motors idling. Operating boats at recommended speeds saves fuel. For example, if a boat travels 24 miles per hour (20 knots) at 5,000 rpm versus 22 miles per hour (18 knots) at 4,000 rpm, it will burn considerably more fuel with only a very small gain in speed.
- Dress appropriately for the season, and set thermostats on heating or air conditioning units only as high or low as needed for comfort.

Virginians should also consider the energy impacts of longer-term lifestyle decisions such as where we live or how we use transportation.

The largest financial decision most people make is in purchasing a home. This decision will have a long-term impact on the amount of energy use.

- Purchasing a home where you can walk or use transit to work, shop, and go to school, and using school buses for travel to and from school instead of individual cars, will reduce your total energy footprint.
- Make sure your home is insulated and leakfree to reduce energy use and energy bills over its life. This can be done by purchasing a highly efficient new home, such as one from an EarthCraft homebuilder or an Energy Star home. A list of Virginia's EarthCraft homebuilders is available on the Internet at www.southface.org. Homeowners may also be eligible for special loans for energy-efficient houses. These mortgages recognize that homeowners pay less of their income for energy so more is available for mortgage costs. Homeowners may be eligible for a higher debt-to-income ratio on such mortgages.
- In existing homes, seal cracks, add insulation and proper ventilation, repair or replace leaky windows, and replace old, inefficient equipment. There are energy audit providers who can provide home-specific recommendations through physical inspections and use of thermographics, blower doors, and other assessment tools. Energy-savings improvements in existing houses readily lend themselves to do-it-yourself projects. Many building material suppliers offer how-to clinics on simple energy-savings improvements.
- Other recommended actions to improve the efficiency of homes are available in the *Virginia Energy Savers Handbook*, available on-line at www.dmme.virginia.gov/DE/ConsumerInfo/consumerinfo.shtml .

Virginians can reduce energy use and costs through purchasing decisions.

- Participate in activities such as Energy Star's Change a Light, Change the World program, through which consumers exchange incandescent lightbulbs for compact fluorescent lightbulbs, and the Cool Your World Campaign, which encourages consumers to use Energy Star-qualified cooling products, seal leaks that let out cool air, and get annual air-conditioner or heat-pump service.

- Consumers use appliances, equipment, and vehicles for many years. Purchasing high-efficiency units results in long-lasting savings. Always purchase Energy Star items when available. For example, one of the largest energy-using appliances in many homes is the refrigerator. A new Energy Star-rated refrigerator uses 40 percent less energy than conventional models sold as recently as 2001. Also, if you purchase a new refrigerator, don't just hook up the old, inefficient unit in your garage or basement. This just increases your electric use. Dispose of your old refrigerator at your local center that recycles white goods.
- Virginians should also purchase higher efficiency appliances and equipment fueled by natural gas, propane, or fuel oil that are not rated under the Energy Star program. A high-efficiency natural gas water heater can save approximately $50 per year over a standard model based on typical 2007 Virginia natural gas prices. Installing low-flow showerheads uses less hot water, sewer, and energy.
- Use of ground-source heat pumps is another option that works well in Virginia. Our climate creates demands for heating and cooling. A ground-source heat pump works more efficiently during both seasons, increasing the cost effectiveness of the equipment. A ground-source heat pump used in Virginia is typically about 25 percent more efficient than a standard air-source heat pump.

One of the largest users of energy is vehicles. While individuals have many reasons to choose a particular vehicle make and model to meet their needs, each of us should make fuel efficiency a primary factor in our vehicle purchase decisions. See the recommendations in Section 7.1.9, Energy Efficiency in Fleets/Transportation, for more information.

There are many actions we can take that, while not directly saving energy, have an indirect effect on energy conservation. For example, purchasing goods with less packaging reduces the energy used to create the packaging and ship the products. Purchasing locally grown produce reduces energy used for transporting the products to market. Reusing and recycling materials saves the energy used to produce new goods from raw materials. Many jurisdictions in Virginia offer recycling for paper, metal, glass, and plastics. Used motor oils can be taken to collection centers. Appliances and other white goods can often be recycled at local waste transfer stations or landfills. Many areas offer special collections for electronic and chemical wastes. Many homeowners can use yard wastes for compost or separate them for separate yard-waste collections.

For more information on what you can do to use energy wisely, see the *Virginia Energy Savers Handbook* and other consumer information at www.dmme.virginia.gov/DE/ConsumerInfo/consumer-info.shtml or the U.S. Department of Energy's (DOE's) C*onsumer Guide to Energy Efficiency and Renewable Energy* at www.eere.energy.gov/consumer.

7.1.6 Commercial Business Energy-Efficiency and Conservation Actions

Just as individual consumers can change our energy future, commercial business can take actions to increase the efficiency of energy use in Virginia.

Since most businesses' first priority is to serve customers and not manage their energy use, energy will often go unattended without specific responsibility being assigned. The first action businesses should take is to assign a person or team to be responsible for energy management. This is consistent with the Energy Star program's recommendations (see www.energystar.gov/index.cfm?c=guidelines.guidelines_index) or the ANSI/MSE 2000:2005 energy management system (see http://innovate.gatech.edu/Default.aspx?tabid=2008). Businesses also can receive energy management assistance from trade groups or their local utilities.

Businesses also should participate in the Virginia Environmental Excellence Program. This can provide a framework to integrate energy and environmental actions into one coordinated effort.

Information is available at www.deq.virginia.gov/veep.

Using these tools, businesses can use benchmarks, such as the Energy Star Portfolio Manager, to measure how efficiently they are managing energy. If a business finds it is using more than best practice benchmark standards, it should use an automated auditing tool or an outside professional energy auditor to determine opportunities to reduce energy use.

Businesses should take advantage of programs designed to help specific types of commercial operations. For example, Energy Star has specific information for auto dealers, grocery and convenience stores, home-based businesses, lodging, and restaurants.

Commercial businesses have a long-term impact on energy use through their construction and rental decisions. Constructing high-efficiency buildings, such as meeting the energy standards for LEED buildings, can increase first costs by 2 to 3 percent, but the investment will be returned through lower operating costs in as little as four years. While location is critical for many commercial buildings, commercial business managers should give priority to energy efficiency when renting space. Commercial businesses should consider locating near public transit whenever possible, making businesses more accessible to both customers and employees.

If a business owns an inefficient building, the business owner should consider investing in efficiency improvements or use energy savings performance contractors to implement energy-savings improvements.

Recommissioning, which is like a building tune-up, can offer many businesses a high return on costs. Many older commercial buildings are not operating as designed. Equipment may be improperly calibrated, leading to excessive run time. Filters may be dirty, resulting in increased power to move air or liquids. Control sequences may no longer match equipment or space needs. Studies have found that building recommissioning can often have a less than a one-year payback. Commercial property that has not had a rigorous preventative maintenance program should be recommissioned if the building has been in operation for more than ten years. Commercial businesses should also be sure that new buildings, whether self-built or leased, have been properly commissioned to reduce ongoing energy use and costs. See the Energy Star guide to building recommissioning at www.energystar.gov/ia/business/BUM_recommissioning.pdf.

Commercial businesses should reduce their energy bills through purchase and use of high-efficiency equipment. Businesses should always purchase Energy Star equipment when available.

High-quality lighting is critical to most retail businesses. Retail businesses should maximize use of daylight to reduce daytime electrical lighting and should select the most efficient sources of lighting that provide proper color control for their business needs.

Many commercial businesses operate service or delivery fleets. Businesses should carefully consider fuel efficiency when purchasing vehicles for their fleets. Businesses should also ensure that their fleets are properly maintained, that drivers are trained on energy-efficient driving techniques, and that routes are planned to minimize wasted driving and congestion. Additional transportation energy savings recommendations are found in Section 7.1.9 of this chapter.

7.1.7 Industrial Energy-Efficiency and Conservation Actions

While Virginia industries have many of the same energy-conservation opportunities as commercial businesses, manufacturers have the extra opportunity to conserve energy in their processes. Energy is the second largest cost after personnel for many industries. Energy cost savings typically directly improve a company's bottom line.

Industrial concerns should follow best practice energy management models such as the Energy Star or ANSI/MSE 2000:2005 protocols for managing energy use. They should include energy efficiency in their building and purchasing decisions and fleet management.

Virginia industries can find more information through the federal Energy Star program (see www.energystar.gov/index.cfm?c=manuf_res.pt_manuf) and the DOE's Industrial Technology Program (see www1.eere.energy.gov/industry/bestpractices/systems.html). These programs provide best practices to address energy-using areas such as motors, pumps, and fans, process heating, steam, and compressed air.

Technical and financial assistance in identifying energy-savings opportunities is available to small, medium, and large industries. Small industrial concerns within 150 miles of a federal DOE Industrial Assessment Center, such as those located at North Carolina State or West Virginia University, can receive energy audits by a team of engineering students and faculty (see www.iac.rutgers.edu). On average, savings from assessment recommendations total $55,000 per year. The Industrial Assessment Center website also has a database of more than 11,000 recommendations made during business assessments.

Mid-sized industrial concerns can receive financial support for a plantwide energy assessment (see www1.eere.energy.gov/industry/bestpractices/plant_wide_assessments.html).

Large industrial sites should use federal Energy Savings Assessments to help reduce energy use and intensity (see www1.eere.energy.gov/industry/saveenergynow/assessments.html).

Large industrial operations should pursue cost-effective opportunities to use combined heat and power applications. Industries can generate power from high-pressure steam and use the resulting lower pressure steam to operate processes. This can result in a highly efficient use of energy and in cost savings. More information is available from the Virginia Department of Environmental Quality (see www.deq.virginia.gov/innovtech/der1.html).

Many industrial businesses operate motorized equipment and delivery fleets. Businesses should look carefully at fuel efficiency when selecting vehicles and equipment. Industries should also ensure that their fleets are properly maintained, that drivers minimize equipment idling and are trained on energy-efficient driving techniques, and that routes are planned to minimize wasted driving and congestion. Additional transportation energy savings recommendations are found in Section 7.1.9 of this chapter.

7.1.8 Agricultural and Forestry Energy-Efficiency and Conservation Actions

Many resources are available to help Virginia's agricultural and forestry industries improve their energy efficiency.

The U.S. Department of Agriculture offers energy programs and recommendations for farms and agricultural businesses (see www.usda.gov/wps/portal/!ut/p/_s.7_0_A/7_0_1OB?navid=ENERGY&navtype=MS). Additional information on energy efficiency in agricultural operations is available from the National Resources Conservation Service (see www.nrcs.usda.gov/technical/energy).

Virginia's forest products industry should implement the recommendations in the U.S. DOE's Forest Products Industry of the Future Program (see www.eere.energy.gov/industry/forest/partnerships.html).

7.1.9 Energy Efficiency in Fleets/Transportation

Three paths should be followed to reduce energy impact from transportation.

- Reduce the amount of energy used by reducing vehicle miles traveled, increasing the use of higher-efficiency forms of transportation, implementing congestion-mitigation actions, and increasing availability and use of high-occupancy vehicle (HOV) and high occupancy toll (HOT) lanes.
- Increase the efficiency of vehicles and

fleets.

- Replace imported petroleum with renewable liquid fuels.

Many transportation energy problems are better implemented through national action. However, there are numerous transportation improvements available at the state level.

Reducing Vehicle Miles Traveled

Virginia should implement a portfolio of transportation demand-management tools. This should include providing adequate capital and operating funding to create easy alternatives to daily single-occupant vehicle commutes. These options should include providing state support, in conjunction with local actions, to ensure that Virginians have access to reasonably priced and regularly scheduled mass transit service in our urban and suburban areas. These services should be tied to park-and-ride facilities for rural residents traveling into urban areas and should include support for Virginia's fifty-six bus, commuter rail, and intercity rail systems. Virginia should also support development of new light rail systems such as the proposed Norfolk Light Rail project.

Commercial and industrial fleet operators should plan vehicle routes and schedules to minimize mileage and travel during highly congested times.

Significant land-use barriers stand in the way of improved transportation energy use. Current land-development patterns often discourage non-motorized transportation by separating residences from workplaces, shopping, and other attractions. State and local governments should better integrate land-use and transportation planning. They can encourage land-use patterns that allow for construction of safe and accessible facilities for non-motorized transportation. Developers should include facilities for no- or low-fuel methods such as walking, bicycling, and small scooters consistent with the Commonwealth Transportation Board's *Policy for Integrating Bicycle and Pedestrian Accommodations*. State agencies addressing transportation and energy should monitor performance measures for per capita transportation energy use and vehicle miles traveled as a measure of transportation energy efficiency.

Some roadway design standards can deter higher density development similar to those found in older urban communities. For example, wide minimum road widths may prohibit some compact land-use designs. Virginia should review its roadway design standards to evaluate whether changes can be made to facilitate higher density development in urban areas.

Virginia should expand the use of HOV and HOT lanes. These provide the driving public with premium and predictable travel conditions when conditions are often congested. They also increase the through-put of vehicles, reduce congestion, and save energy. Energy savings come from increased vehicle efficiency due to operating at constant speeds, increased occupancy in HOV lanes, and reduced traffic backups. Additionally, buses using HOV and HOT lanes can provide more efficient service to transit users. HOV and HOT lanes should be actively considered in regional transportation plans for Virginia's major urban areas. Virginia should give high priority to other congestion-mitigation projects in allocating its transportation funding. Specific projects that should be pursued include providing HOV/HOT lanes farther south on I-95 and on the Capital Beltway, and as transportation density increases, on highways in the Hampton Roads and Richmond areas.

The Commonwealth should continue to promote use of alternate methods to the daily commute such as telecommuting, ride-sharing, and car-sharing. These activities should be promoted through increased public education, increased availability of broadband infrastructure, and provision of regional telecommuting centers. Localities should be flexible in providing priority locations for car-sharing services.

Virginia should make concerted actions to move truck freight to rail and barge. Barriers to increased rail freight use include the needed capital investment in infrastructure to improve rail corridors and truck-to-rail-to-truck facilities; reliability, timeliness, and predictability of service; and business perspectives. To overcome these barriers, Virginia should continue to implement the Heartland Corridor Project and include, as part of I-81 improvements, facilities to move freight from truck to rail. Virginia should also continue to provide incentives for business access to rail in its economic development programs.

Increasing Fleet Efficiencies

Individuals and businesses should look carefully at fuel efficiency when selecting vehicles and equipment. There are many fuel-efficient options that will meet transportation needs. Consumers should look for higher efficiency vehicles, hybrid gas-electric vehicles, flex-fuel vehicles that can use gasoline or E85, and new clean-burning diesel vehicles.

Driving a vehicle 12,000 miles per year that gets 38 rather than 28 miles per gallon, at $2.50 per gallon, saves 113 gallons of gasoline and $282.50 per year. This is a 26 percent reduction in gasoline use. Using a very efficient vehicle such as a hybrid electric at 50 miles per gallon would increase savings to 189 gallons and $472.50, a 44 percent decrease in gasoline use. If you own your car for seven years, you would save 791 gallons of gasoline and $1,977.50. Over the seventeen-year average life of a car, this totals a savings of over 1,900 gallons of gasoline and over $4,800 for the energy-efficient car and over 3,200 gallons and $8,000 for the hybrid electric car.

Vehicle owners should keep vehicles properly maintained. The most important maintenance practices include keeping tire pressures at recommended levels and keeping vehicles properly tuned up. Fixing a car that is noticeably out of tune or has failed an emissions test can improve its gas mileage by an average of 4 percent, though results vary based on the kind of repair and how well it is done. Fixing a serious maintenance problem, such as a faulty oxygen sensor, can improve mileage by as much as 40 percent. More information is available through the Commonwealth's Driver Education Core Curriculum.

Virginians should drive smart to save fuel. Steady acceleration and deceleration, using cruise control, and slowing down can significantly increase fleet efficiencies. Tests of aggressive verses calm driving in cities show up to 25 percent savings using best driving practices. For every 5-mph decrease on the highway, a typical driver will save 5 percent in fuel.

Virginia has historically been a leading state for gasoline-electric hybrid vehicle use. Demand in northern Virginia has been driven by the ability of hybrid cars to use HOV lanes. However, Virginia has recently restricted use of newly purchased hybrid vehicles on HOV lanes. Use of highly fuel efficient hybrids on HOV lanes can balance HOV goals of mitigating congestion and reducing energy use in transportation.

The Commonwealth should carefully evaluate the effect this has on the rate of hybrid vehicle market penetration. If the market penetration rate declines in relation to other states, Virginia should work with the federal government to reconsider the ban for the most fuel efficient hybrid vehicles. For example, any hybrid with over a 50-mpg combined EPA mileage rating could still be allowed to obtain clean special vehicle license plates and use the HOV lanes.

For every 5 percent per year reduction in gasoline use in Virginia, we would save 260 million gallons of gasoline, save more than $500 million, and reduce carbon dioxide emissions by nearly 2 million tons per year, or approximately 1.5 percent of Virginia's total carbon emissions.

Using Alternate Transportation Fuels

Virginia has instituted efforts to increase the use of alternate transportation fuels. The Biofuels Incentive Program provides a 10-cent-per-gallon incentive for production of biofuels from domestic feedstock. This program should be fully funded. Additionally, the Virginia Economic Development Partnership, Department of

Agriculture and Consumer Services, and Department of Mines, Minerals and Energy should continue to work with prospective companies to increase the amount of alternate transportation fuels produced in Virginia.

Virginia should consider mandating use of 10 percent ethanol and 5 percent biodiesel in all retail fuel sales when there are sufficient supplies available from non-food crop sources to support this use. Any mandate should be coupled with incentives for fuel terminals to make the necessary infrastructure improvements to handle the new fuel mixes.

Virginia should also assist with increasing the market availability of E85 and B20 or greater biodiesel. This should include assistance in locating more alternate fuel retail stations through incentives for biofuel islands in our urban centers and no more than every 75 miles along the Commonwealth's interstate highways.

Virginia should implement a highway signage program directing motorists to E85 and biodiesel retail outlets. This should be done in conjunction with neighboring states and the District of Columbia to provide a uniform sign format.

Virginia should amend its statute and regulations to allow for flexibility in blending conventional and alternate fuels to facilitate increased alternate fuel sales. For example, Virginia gas-station owners must post signs on pumps providing 10 percent ethanol reformulated gasoline. These signs were first put in place when older cars would have been harmed by the ethanol mix. Today, all cars are designed to accept the 10 percent ethanol mix.

This signage requirement restricts the ability of owners of stations outside areas requiring use of reformulated gasoline from using the 10 percent ethanol product when it is cost effective to do so. Virginia should repeal the ethanol content pump labeling requirements to provide gas-station owners with increased flexibility to use conventional or reformulated gasoline in areas where reformulated gasoline is not required.

Virginia would benefit by increased use of hydrogen as a transportation fuel. Virginia's hydrogen fuel stakeholders have produced the blueprint for Virginia's hydrogen future. The Commonwealth should, consistent with this blueprint, carefully monitor the potential for hydrogen technologies to serve Virginians' energy needs.

Virginia also should facilitate education about hydrogen fuels. Hydrogen should be addressed in the state's higher education engineering curriculum. The Commonwealth should continue to incorporate hydrogen education in its primary and secondary education through expanded use of the National Energy Education Development Program hydrogen curriculum.

7.1.10 Higher Education Energy-Efficiency and Conservation Actions

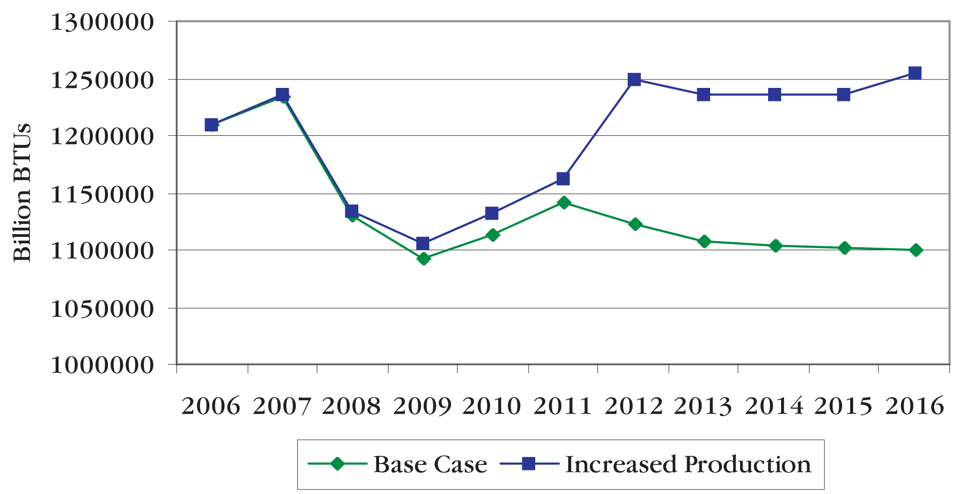
Virginia's higher education institutions can lead by example by implementing energy-efficiency actions across their campuses. These actions will not only reduce energy use and lower energy bills but will also help educate our next generation of leaders on how to manage energy wisely in their lives.

Virginia universities should expand involvement in the Greening the College Campus or similar activities to increase the energy efficiency of university operations.

7.2 Virginia's Energy Infrastructure and Supplies

Virginia must ensure that there is an adequate infrastructure to provide needed energy supplies to Virginia. The Commonwealth will need to address electric supply, natural gas, petroleum, and coal infrastructure, as well as how this infrastructure is protected from security risks. This Plan sets out a goal to produce 20 percent more energy in state than would be produced without the actions recommended in this plan (see Figure 7-3). Meeting this goal will require increased in-state electric and liquid fuel production, and a stabilization of coal production.

Figure 7-3 Virginia Energy Production Trends



7.2.1 Electric Supply Infrastructure

The electric infrastructure is the most widespread energy system in the state. It is critical to understand how electric demand will grow in order to adequately plan how resources will be provided. In particular, PJM has stated that Virginia's electric supply infrastructure in northern Virginia will need expansion by 2011. Studies also show the need for additional electric system capacity to serve the Tidewater region.

While conservation and demand control may delay when any expansion of Virginia's electric infrastructure is needed, analysis cited in this Plan has shown that growth in electric use will overtake the generation and transmission system's capacity, resulting in the need for new infrastructure. If Virginia is to reduce its reliance on imported electricity, this would add to the stress on the state's generation and transmission system.

Virginia's investor-owned utilities will be required to file, coincident with their biennial rate filings before the State Corporation Commission (SCC), plans for projected generation and transmission requirements to serve their native load for the next ten years. Virginia's utilities should provide sufficient information with this filing for the public to understand the assumptions used to make these estimates. A broad public understanding of the Commonwealth's future electric demands and plans to meet these demands should help reduce the contention over new electric infrastructure development.

Growing electric demand can be met through new conventional and renewable electric generation, reducing demand through efficiency and conservation, or importing electricity over transmission wires from remote generation plants. Virginia should require developers of conventional electric generation capacity to be paid for by Virginia's utility consumers to show, as a condition of receiving a Certificate of Public Convenience and Necessity, that the proposed conventional generation is needed after all cost-effective energy-efficiency and conservation actions have been implemented and that the conventional generation is less expensive than new renewable generation capacity.

Providing the new electrical infrastructure needed to meet growing demand will require billions of dollars of investment in new facilities. For example, as of the release of this Plan, Virginia's utilities are working to develop the Virginia City Hybrid Energy Center, Integrated Gasification Combined Cycle (IGCC) plants, increased gas-fired peaking capacity, new nuclear power plant capacity, and renewable energy capacity. Virginia should ensure that its electric utilities have access to low-cost capital for investments needed for this new capacity.

The federal DOE has proposed to designate the area from West Virginia and western Pennsylvania to the New York City to northern Virginia areas as a National Interest Electric Transmission Corridor (NIETC). This designation means that a transmission line developer may apply to the Federal Energy Regulatory Commission for approval to construct a line if Virginia or neighboring states fail to approve the construction of a line within twelve months of submittal of a complete application to the state.

To ensure timely review of electric transmission line applications, utility companies should complete sufficient pre-application work to address the full range of issues in their applications and take full advantage of the pre-application planning process established by legislation in 2007. The applying utility should make complete information available to the public about the need for the line, including options for not building the line, and for possible routes. This will narrow the issues to be considered by the SCC and increase the likelihood of completing the permit review within the twelve-month limit of federal law.

While Virginia recognizes that electric supply issues cross state lines and require assessment across a multistate region, decisions regarding the routing of these lines should continue to be made at the state level.

If an NIETC designation is made in Virginia, the prohibition against use of federal eminent domain over state property must include a prohibition against use of federal eminent domain to overturn state-owned conservation easements.

Studies of the capacity of the electric transmission system in Virginia are undertaken as part of the PJM adequacy planning process. This process is designed to include participation from multiple stakeholders, including electric utilities, consumers, public interest groups, states, and localities. The SCC and the Consumer Assistance Division of the Office of the Attorney General represent Virginia state government in the process. PJM has identified the need for greater involvement of executive branch officials in the process. Virginia should develop a better coordinated approach among the SCC, Office of the Attorney General, and the executive branch energy policy and environmental agencies to provide state input into PJM's and the North American Electric Reliability Council's planning processes. The level of coordination or communication among the SCC, Office of the Attorney General and Governor's Office should recognize that the SCC's role may be limited by the need to avoid pre-judging matters that may come before the SCC for approval. This might limit the level of coordination possible with the SCC on some matters.

PJM has the responsibility to ensure that adequate electric supplies are available to meet future electric needs. PJM only counts conservation and demand-control activities that are under binding contract to utilities in the region when assessing future loads. PJM should include the effects of a broad portfolio of conservation and demand-control programs. This should reduce the risk that the load will still be on-line during peak times. Further research should be undertaken to determine an acceptable capacity factor to use for conservation and demand-control programs.

There is ongoing debate whether new electric transmission lines should be constructed on overhead towers or placed underground. The Commonwealth, through the Joint Commission on Technology and Science, is evaluating issues regarding aboveground verses underground placement of transmission lines. Virginia should continue its evaluation of the costs and benefits of placing electric transmission lines underground in order to generate accurate information needed to determine when the costs of placing lines underground make such construction in the public interest.

7.2.2 Renewable Electric Generation

Virginia enacted a voluntary renewable portfolio standard in its 2007 electric utility regulation legislation. This calls for Virginia's participating investor-owned electric utilities to generate 4 percent or more of their electricity from renewable sources by 2012, 7 percent or more by 2017, and 12 percent or more by 2022. Meeting this would require generation of over 7.75 million megawatt-hours of power from renewable sources. Existing renewable generation will be able to meet approximately 2 percent of this load. Both Dominion Virginia Power and Appalachian Power are working on plans to develop new renewable-power generation from wind and other sources to meet these goals.

Biomass-fired electric generation should not compete with the lumber and wood products industry for wood fiber. These industries provide a higher value product from Virginia's forests. Virginia should develop the supply systems needed to make wood remaining after commercial lumber harvesting, land-clearing debris, and demolition waste available as a fuel for biomass-fired electric generation plants.

Virginia Tech, working with the Department of Forestry, has a GIS mapping tool to identify locations of wood resources. This tool should be expanded to include all potential sources of biomass for energy generation.

Property owners can integrate small-scale electrical generation into their homes and buildings. Some community associations and localities place limits on installation of energy-generating property. Property owners should not face unreasonable limits to add renewable power sources. For example, community associations should not place unreasonable restrictions on installation of solar thermal or photovoltaic panels that are integrated into the facility design. Community associations and localities are encouraged to use the state system to rate a property's suitability for solar and wind development when considering approval of such uses. Additional localities should exercise their authority to exempt solar systems from property taxes to eliminate any property-tax penalty from system installations.

There has been considerable debate about the appropriateness of onshore wind development in Virginia and other states. Onshore wind development should be approved upon local land-use acceptance and a finding of no significant mortality of avian and bat species. Early projects should include post-construction monitoring to identify avian and bat impact. Localities should consider both the potential value to increasing electric supply diversity in their areas and the potential visual and community effects of proposed projects.

The General Assembly authorized two grant programs in 2006 to support development of alternate energy supplies. The programs have not been funded, however. The Renewable Electricity Production Grant Program was designed to support generation of electric power from renewable sources. Large-scale renewable electricity production now will be supported through implementation of the state's renewable portfolio standard. Small generators would be supported through the Photovoltaic, Solar, and Wind Energy Utilization Grant Program. These small generators would not receive support under the renewable portfolio standard. Therefore, the Commonwealth should first, to the extent resources are available, provide financial support to the Photovoltaic, Solar, and Wind Energy Utilization Grant Program before funding the Renewable Electricity Production Grant Program.

It is the state's policy to support federal efforts that examine the feasibility of offshore wind energy being used in an environmentally responsible fashion. Initial reviews find that Virginia has substantial potential for development of offshore wind resources beyond the normally visible horizon. The Commonwealth should encourage all cost-effective, environmentally responsible development of its offshore wind resources. Virginia should work with the federal Minerals Management Service's Outer Continental Shelf Alternate Energy and Alternate Use Program to more carefully characterize the offshore wind potential and identify potential environmental impacts of such development.

Virginia will continue to need new and upgraded electric distribution systems. This will require an ongoing investment by Virginia's electric utilities to meet growing system needs and ensure reliability of supply.

7.2.3 Natural Gas Infrastructure

Virginia's natural gas infrastructure supports a wide array of natural gas users. While the natural gas infrastructure has generally been adequate to serve these users, there have been transmission constraints to south Hampton Roads. The planned third pipeline crossing of the James River should help reduce this problem. State, regional, and local economic development officials should monitor the supply and demand for natural gas and work with the local natural gas utilities, pipeline companies, and the State Corporation Commission to ensure that an adequate supply infrastructure is maintained.

Virginia's natural gas is supplied through three primary routes: natural gas pipelines from the Gulf of Mexico region, natural gas imported through the Cove Point, Maryland, liquefied natural gas (LNG) terminal, and natural gas produced in southwest Virginia's natural gas fields. Because of pipeline system limits, the Cove Point imports serve primarily the northern Virginia and Virginia peninsula regions and the southwest Virginia gas fields serve primarily southwest Virginia markets.

Virginia remains largely dependent on supplies from the Gulf of Mexico region. As seen in 2005, disruption of supplies from this region causes substantial price increases to Virginia consumers and exacerbates the price differential paid by Virginia consumers compared with most other regions of the country. Virginia should carefully consider projects to diversify its natural gas supplies, such as new LNG terminal construction or increased pipeline capacity from southwest Virginia's natural gas fields to eastern Virginia. Such projects should be protective of public safety and high-value environmental resources.

Developing new sources of supply will require new investments. Virginia needs to carefully consider how its regulatory structure and rates affect companies' access to low-cost capital needed for these investments.

One potential source to diversify Virginia's natural gas supplies is from offshore natural gas production. Any development of offshore natural gas should be made consistent with Virginia policy. Both the federal Mineral Management Service (MMS), through its leasing actions, and the National Oceanographic and Atmospheric Administration, through Coastal Zone Management program approvals, should recognize Virginia policy when taking action affecting offshore development. The MMS also should work together with the offshore exploration and production industry and East Coast states to determine the extent of offshore natural gas resources and the environmental protections that would be needed if such development were to proceed.

The MMS established state administrative boundaries in outer continental shelf waters using an equidistance methodology for the purpose of managing offshore resources. The equidistance methodology expands the areas attributable to states with convex coastlines and decreases the areas attributable to states, such as Virginia, with concave-shaped coastlines. Use of equidistant boundaries reduces the Commonwealth's ability to influence decisions about offshore resource development. This will affect not only natural gas extraction but also sand, other minerals, and renewable energy resources. The MMS should revise the administrative boundaries to more equitably reflect coastal states' interests.

7.2.4 Petroleum Infrastructure

Virginia consumers receive gasoline, diesel fuel, fuel oils, and aviation fuel from three primary sources: two petroleum-product pipelines from the Gulf of Mexico region, the oil refinery in Yorktown, and by ship and barge delivered to terminals on Virginia's east coast.

Virginia made permanent the sales-tax exemption to supplies and equipment for the Yorktown refinery to help the refinery owner obtain financing for an expansion project. State and regional economic development entities should continue to work with the refinery owner to provide all cost-justified assistance to this expansion.

Gasoline, diesel, and other petroleum products are distributed through a network of terminals located in and around Virginia. As the marketplace for petroleum products expands to include new products such as low-sulfur fuels, ethanol, and biodiesel, petroleum terminals must reconfigure their facilities to manage the new products. Local governments should, consistent with public health and safety protection, streamline approval of modification plans and provide flexibility to terminal operators to make these needed changes.

Development of alternate fuels such as ethanol and biodiesel will require development of new fuel production and transportation facilities. Other infrastructure will be needed to supply raw-material inputs, such as biomass supplies, to production facilities. Virginia's production incentive for in-state-produced biofuels should be funded to provide sufficient incentive for producers to locate new plants in Virginia. Localities are encouraged to work with state economic development, agriculture, and energy agencies to identify sites that provide the necessary infrastructure for new biofuel production facilities.

Virginia has substantial municipal solid waste and agriculture waste that could be a feedstock to alternate fuel production. Virginia should provide incentives to increase the use of municipal solid waste or agricultural waste for energy generation or alternative liquid transportation fuels.

The U.S. military has set goals to replace petroleum fuels with alternates. Virginia should target the military ground transportation and ship transportation systems as a market for in-state-produced synthetic diesel fuels.

7.2.5 Coal Production Infrastructure

The Commonwealth and Virginia's coal industry should work together to maintain a viable mining industry. Virginia's coal industry is the backbone of the economy in southwest Virginia and provides needed coal resources for electric and steel production at reasonable costs to consumers. The state and industry should continue efforts to provide safe working conditions for mine workers, including working to implement provisions of changes in federal mine safety law related to mine rescue, emergency supplies in mines, underground miner tracking and communication systems, and seals used in underground mines. The state and industry should also continue work to control deleterious effects of coal mining on the environment and neighboring communities.

Virginia relies on railroad and highway infrastructure for transportation of its coal resources. Coal-related road and rail infrastructure are generally adequate. Local governments in southwest Virginia should use local coalfield road improvement funds to ensure that there are adequate roads to haul coal on routes that minimize conflict with built-up areas. Virginia's rail providers must ensure that adequate rail-car capacity remains available to carry coal from Virginia's mines to end users and export facilities.

Virginia will need to invest in new infrastructure to support carbon capture and storage in unminable coal seams. Virginia is positioned to be a leader in developing this technology. Investments are needed in facilities to collect carbon from generating sources, transport it to the areas with available coal seams, and inject it into the unminable coal seams. Additional investment is needed in the research facilities needed to develop this technology. This research could be housed in a Fossil Fuel and Carbon Management Center operated by the Virginia Center for Coal and Energy Research in Abington and Dickenson County.

Virginia has the opportunity to import coal from sources such as South America to provide the lowest-possible-cost coal to utility and industrial users. While Virginia should not take actions that would diminish the viability of southwest Virginia coal producers, Virginia coal consumers will benefit from the market diversity provided from coal imports. Therefore, Virginia should provide necessary approvals needed to modify existing coal export facilities to accept coal imports.

7.2.6 Hydrogen Industry Infrastructure Development

Hydrogen may meet increasing amounts of Virginia's energy needs over the next ten years. As provided for in Virginia's hydrogen blueprint, the state should support development of fueling infrastructure as the market develops for hydrogen fuel use.

7.2.7 Energy Infrastructure Security

Virginia's energy industry must take necessary steps to protect the state's energy infrastructure from natural and human-made disasters. This includes performing ongoing maintenance of facilities and rights-of-way, updating controls and infrastructure to replace aging equipment and facilities, and hardening existing facilities where needed for protection. Particular emphasis should be placed on central facilities such as power plants, bulk fuel storage facilities, and transmission infrastructure.

State, local, and federal public safety and homeland security agencies should maintain clear communication with energy providers to plan for, test response plans for, and ensure coordinated response to any risks or incidents.

Virginia's emergency response facilities must have energy to operate during and after natural or human-made disasters. Virginia and its localities should ensure that their emergency operations centers have adequate emergency electric generation backup. Fuel supply contracts for emergency generators and emergency response vehicles should require delivery of alternate sources if primary sources are unavailable because of emergency. Renewable energy sources, such as solar photovoltaic systems, can be used to provide localized electric service at locations, such as gas stations, to maintain essential services after a disaster.

7.3 Energy, the Environment, and Climate Change

Decisions on how Virginia will meet its future energy needs should be based on analysis of both costs of the energy sources and the need to protect ecosystems, natural resources, and the health and well-being of citizens, including economically disadvantaged and minority communities.

Energy consumption is the largest contributor to greenhouse gas emissions. The Intergovernmental Panel on Climate Change's (IPCC's) *Fourth Assessment Report* stated, with an increased confidence level over previous reports, that most of the observed increase in globally averaged temperatures since the mid-twentieth century is "very likely due" to the increased anthropogenic greenhouse gas concentrations. The third IPCC report had labeled increased temperature "likely" due to increased greenhouse gas concentrations.

Carbon dioxide emissions rose in Virginia by approximately 34 percent from 1990 to 2004, a rate nearly twice the national average. This increase results, in part, from growth in Virginia's economy and development patterns that have produced sprawl and long commutes. Vehicle ownership rates also increased during this period, in which Virginia ranked in the top ten states with a 30 percent increase in gasoline-powered cars.

What does climate change mean for Virginia? Over the long term, climate change will affect Virginia's population, wildlife, and economy. The Virginia Institute for Marine Science estimates that the Mid-Atlantic sea level will rise between 4 and 12 inches by 2030, threatening coastal islands and low-lying areas. Air and sea temperature changes would cause more frequent tropical storms, with increased damage to Virginia coastal communities. Chesapeake Bay is particularly susceptible to damage caused by increasing ocean levels due to climate change. There would also be increased flooding to inland communities from more intensive storms caused by climate change. Changing rain and temperature patterns would disrupt agriculture and forestry.

To meet the challenges of climate change, Virginia should reduce carbon emissions by 30 percent by 2025, to return to its year 2000 greenhouse gas emission level.

Carbon dioxide emissions can be reduced by energy efficiency and conservation, using energy from sources that generate less carbon dioxide or are part of a closed carbon cycle, and carbon capture and storage. Methane emissions can be reduced by maximizing production of coalbed methane related to coal mining, improving gathering, transmission, and distribution pipeline systems to eliminate leaks, and by increasing waste-to-energy development and landfill gas recovery. Meeting the 10 percent electricity conservation goal and the 12 percent renewable portfolio standard goal for Virginia's investor-owned utilities in the 2007 electric regulation legislation, and achieving a 10 percent reduction in gasoline use in Virginia, would reduce carbon dioxide emissions by nearly 18 million tons per year, or approximately 15 percent of Virginia's total 2005 carbon emissions.

While energy-efficiency actions will help reduce carbon emissions, other actions will be needed if Virginia is to meet the 30 percent reduction goal. Insufficient information is available to determine how to meet the full 30 percent goal. Therefore, Virginia should create a Commission on Climate Change to make a more comprehensive assessment of greenhouse gas issues and develop a plan for how to reach a greenhouse gas emission reduction goal.

Specifically, the Commission would be charged with preparing a Climate Change Action Plan that would (i) calculate the size of and contributors to Virginia's carbon footprint, (ii) address the effects of increasing atmospheric greenhouse gas concentrations on the state, (iii) identify what Virginia needs to do to prepare for the likely consequences of climate change, and (iv) identify what actions are needed to meet goals for reducing greenhouse gas emissions.

To help this effort, Virginia should go beyond a voluntary reporting regime and require reporting of greenhouse gas emissions using The Climate Registry protocol. This will provide the necessary data to calculate the size of Virginia's carbon footprint and allow the Commonwealth to better assess what steps are needed to reduce greenhouse gas emissions.

This issue should be the subject of national policy because both the causes of, and solutions to, climate change transcend state and local boundaries. But, the magnitude of the problem is such that states can not simply wait for a federal resolution. It is hoped that these recommendations, and similar actions taken by other states and localities, may motivate a comprehensive national approach to this topic. Virginia stands willing to participate in the develop of such an approach and will work to harmonize our efforts with a reasonably aggressive national strategy.

Greenfield development, besides using open space and changing the environment at the site, promotes increased energy use. Development should be clustered and infill and brownfield development should be encouraged to reduce energy impacts. Government policies should be put in place to encourage development that allows for greater use of transportation, requires less new energy infrastructure, and provides for greater energy efficiency in the built environment.

Renewable energy production that offsets conventional energy production should be promoted to reduce environmental emissions. Carbon capture and storage should be further developed to reduce the carbon emissions from conventional energy production.

Environmental programs should be leveraged to increase energy efficiency and renewable energy development, such as using renewable energy purchases to offset nitrous oxide emissions under Virginia's ozone State Implementation Plan. Consumer education should identify the co-environmental and energy effects of wise resource management. Virginia governments, businesses, and individuals should be encouraged to participate in activities under programs such as Clean Cities, Cool Cities, Cool Counties, Climate Leaders, and the Virginia Environmental Excellence Program.

As energy is consumed economy-wide, actions to control carbon emissions should take an economy-wide approach. Reducing energy use through efficiency and conservation improvements, constructing more efficient new buildings, improving industrial process energy efficiency, reducing vehicle miles traveled, and increasing vehicle fuel economy, as well as increasing use of carbon-neutral fuels, should all be used to reduce greenhouse gas emissions.

7.4 Energy R&D

Virginia has a strong foundation of energy research and development (R&D). The state's universities and businesses have leading research activities in areas such as biofuels, fuel processing, nuclear level physics, carbon capture and storage, wind, and coastal energy resources. Numerous small businesses, often spun off from university and federal laboratory research, are involved in energy R&D. However, there are weaknesses in coordination among research activities and in making consistent funding available for matching federal R&D funding and for multiyear research efforts.

Energy R&D in Virginia should be strengthened by providing a consistent funding source and using a governance system involving university, business, and government stakeholders to set energy R&D priorities. This governance system should set out a roadmap identifying the growth areas for energy R&D, the areas where Virginia researchers can bring added value to these growth areas, and recommend projects for state support. Based on analysis completed for this Plan, Virginia has strategic opportunities for energy R&D related to nuclear power development, cellulosic and waste-based biofuels, coastal energy, and carbon capture and storage in unminable coal seams.

This energy R&D governance system should be established as a virtual organization, named the Virginia Energy Research and Development Organization (VERDO). VERDO should join the Association of State Energy Research and Technology Transfer Institutions (ASERTTI).

The energy R&D fund should be available to match federal energy R&D projects, provide funding to build state energy R&D capacity, and provide funding for reduction to practice projects that help new technologies bridge the "valley of death" between research and commercialization. Organizations receiving funding should be required to provide internal funds to their projects. This is often referred to as "having skin in the game."

VERDO should host energy research showcases to bridge technologies developed by Virginia's energy R&D organizations to the venture capital and businesses with the resources to bring the ideas to commercialization. This could be done solely in Virginia but might be more effective if undertaken jointly with neighboring states to become a Mid-Atlantic energy R&D showcase.

Virginia should support development of two or three energy technology parks. Each park should have one or more key energy tenants to anchor it, with room for energy start-ups and research facilities. The energy technology parks could be centered around a particular technology such as biofuels, wind technologies, coal, or natural gas exploration and production.

7.5 Energy Economic Development

Energy businesses can add to Virginia's economic vitality. Today, coal and natural gas production provide the foundation for southwest Virginia's economy. Virginia's cost-competitive energy supplies provide a natural advantage to business recruitment and retention. Renewable energy supplies provide an opportunity for new job growth across the state. There are particularly good opportunities for new alternate liquid fuel-based job growth.

Virginia should target its business development actions to those energy businesses that produce employment and capital investment gains. Energy investments should be evaluated for their return on investment to Virginia and its localities.

Virginia should refine its production grants for renewable energy businesses, such as those for solar manufacturers and biofuel producers, to ensure that the support meets business needs while providing a positive return on investment to the Commonwealth. Virginia should consider combining economic development incentives with other actions that would help develop markets for the alternate energy businesses. This should include assistance needed to take advantage of the U.S. Department of Energy's clean energy loan guarantee and similar programs. Up to $5 million per year is needed to fund these incentives and support other new energy business development.

Virginia should form a multiagency Tiger Team of state agency energy and economic development specialists to work with localities and industry partners to identify and package appropriate energy project sites.

Virginia should increase support for energy research partnerships between its universities and businesses. This is further spelled out in Chapter 6 and in Section 7.3 above.

Economic developers should work with the state's electric utilities and the State Corporation Commission to use existing authority and offer an economic development electricity package as part of the state's incentive package for major energy-intensive projects. Virginia's electric rates historically have been very competitive compared with those in other states, especially those with whom we normally compete. Virginia should work with its electric utilities to create a not-to-exceed price structure for energy-intensive companies with greater than a 20-megawatt load and who have a high capital investment and high electrical load factor. The rate should only be available after energy-conserving measures have been implemented so that the industry would be among the most efficient in its class. The economic development rate should be based on an analysis showing that the new industry's load profile, cost of service, and proposed rate would not lead to cross-subsidization from other customers. This would not only provide an incentive for large-scale industrial development but would increase the market for energy technology companies offering energy-efficiency services to Virginia's manufacturers.

Virginia should increase activities to further develop the state's nuclear industry cluster. The Lynchburg area offers unique opportunities, being home to Areva NP and BXWT, companies that design, service, and build nuclear components for the civil and military markets. This, coupled with the Norfolk Naval Base and Northrop Grumman Newport News Shipbuilding in Hampton Roads and closeness to Washington, D.C., with its nuclear regulatory bodies, provides Virginia with a strategic advantage. Virginia should help provide this industry with trained labor needed to fill its highly technical jobs through providing long-term financial support to the Center for Advanced Engineering and Research in Lynchburg. This work is particularly timely during the term of this Plan as the nuclear industry will be growing to respond to the upcoming market cycle for new nuclear generating plants.

Virginia should assess the business opportunities that will come from decommissioning nuclear Navy ships and support development of businesses needed to provide these services. Virginia's existing nuclear business infrastructure is well positioned to take a lead in this upcoming market.

Virginia should assess the potential value of and regulatory needs for uranium production in Pittsylvania County.

Virginia should support development of new energy technology business parks. As discussed above in Section 7.3, energy technology parks could have one or more key energy tenants to anchor them, with room for energy start-ups and research facilities. These parks could be centered around a particular technology, and they should be located where high-quality rail and utility service could be provided to tenants. Funds from sources such as the Tobacco Revitalization Commission or Virginia Coalfields Economic Development Authority can be used to provide the needed infrastructure for such parks in Southside or Southwest Virginia. One target market for a plant could be alternate liquid fuels produced for military ground and ship transportation. A second high-value center for Virginia might be a fossil-fuel and carbon management center located in Southwest Virginia.

Virginia should provide workforce services that support development of adequate numbers of trained workers for energy businesses. Virginia's community colleges and economic development officials should work with industries in their area to provide region-specific training programs for energy industry clusters. Examples include coal miner training provided by Southwest Virginia and Mountain Empire Community Colleges and industry-specific training provided through the Center for Advanced Engineering and Research in Lynchburg. Efforts to develop vocational training curricula should account for regional needs of energy providers. An example of such a program is the Kentucky Coal Academy's curriculum provided to coal-field high schools in Kentucky.

Virginia should, when assessing whether projects impose a disproportionately adverse impact on economically disadvantaged or minority communities, address both the potential for negative environmental impacts and positive economic value.

7.6 Implementing the Recommendations

Many of the recommendations of this Plan will require financial support to implement. Financial support is needed to overcome barriers faced by individual consumers and businesses in making cost-effective investments in energy efficiency, infrastructure, new energy supplies, new business development, and research, development, and deployment. Virginia can attract additional federal funds through providing non-federal cost-sharing. Virginia also can attract additional private investment in energy projects through state support. New public education activities will require new financial support.

Virginia has not been able to attract some energy investments because of a lack of funds to support new projects. In two recent examples, Virginia unsuccessfully proposed to host the National Energy Technology Laboratory's new offshore wind turbine blade test facility. Virginia's proposal was ranked below those from Massachusetts and Texas primarily because it included less financial support. Virginia also had limited ability to compete for the U.S. Department of Energy's (DOE's) Bioenergy Research Centers.

There will be ongoing opportunities for Virginia to compete for new federal funding for energy activities. For example, the U.S. DOE is proposing to fund additional carbon capture and storage projects. Virginia is positioned to develop a coal-seam carbon capture and storage project if it can develop a technology and cost-competitive project. The U.S. DOE continues to fund biofuels development research, development, and deployment activities. Virginia universities have the research experience and can compete for these resources given a source of non-federal funds to match grants.

Tax benefits are an effective means to overcome barriers to private investment in energy-conservation and development activities. Tax credits, tax holidays, and accelerated depreciation can be used to raise awareness of and provide financial support for energy investments. Virginia is implementing a sales-tax holiday for certain Energy Star-rated appliances and equipment. Virginia should monitor this sales-tax holiday to better understand the revenue impact of this action. This data can be used to estimate the revenue impact of any expansion of the sales-tax holiday.

The federal government provides income-tax credits and accelerated depreciation for private investments in energy production and energy efficiency. Virginia could consider providing state tax treatment for energy-efficiency investments similar to federal tax benefits to provide additional incentives for energy-conservation activities.

Direct incentives in energy conservation and alternative energy development are necessary to overcome barriers to investment in these areas. To be effective, funding should be reliably available over a multiyear period. Short-term or start-and-stop investments lead to inefficient management of activities.

As discussed above under the individual recommendations, achieving the goals of this Plan will require substantial new annual investments by the Commonwealth, private business, and individuals. Estimated costs of these initiatives are summarized below.

- If Virginia is to meet its 10 percent electric savings goal by 2022, the Commonwealth's electric utilities will need to invest in the range of $100 to $120 million per year to support energy-conservation programs. This would include costs of incentives, consumer education, and administration of energy-efficiency and conservation programs. Utility consumers would have to match this investment with $180 to $200 million per year to cover their share of up-front energy-efficiency costs.
- $5 million per year is needed for energy R&D to foster long-term improvements to how Virginia and the nation can supply and use energy more efficiently. This should be matched with at least an equivalent

amount from private and federal sources.

- Renewable energy grant programs established in the 2006 legislation and other efforts to expand use of renewable energy sources should be funded $5 million per year if we are to achieve a significant growth in renewable energy supplies.
- Up to $5 million per year is needed to support energy businesses incentives, such as the Biofuels Incentive Grant Program, and for new technologies such as waste, cellulosic, and coal-based liquid fuel production, solar panel and wind turbine manufacturing, and development of innovative energy sources and infrastructure such as combined heat and power projects and ethanol fueling stations.
- $2 million per year is needed to expand the number of elderly and low-income families served through the Weatherization Assistance Program.
- $1 million per year is needed for energy education to supplement utility-based consumer-education programs and other smaller-scale energy projects.

The Governor's Energy Policy Advisory Council, with assistance from the Department of Mines, Minerals and Energy and other agencies, should be charged with evaluating the energy saved, new supplies of energy generated, and value of investments in energy R&D and new business development resulting from this Plan. The results of the evaluation would be reported back to the Governor and the General Assembly to ensure accountability of the proposed energy activities.

Taken together, these recommendations will result in a substantial investment in new energy activities in Virginia. By heeding these calls to action, government, individual citizens, and businesses will use energy more wisely, have increased security from energy-driven disruptions, and help ensure the availability of needed energy supplies to support the state's economy and reduce the future impacts of climate change.

Appendix A
Virginia Energy Plan Advisory Group Members

Conveners:
- The Honorable L. Preston Bryant, Jr., Secretary of Natural Resources
- The Honorable Patrick O. Gottschalk, Secretary of Commerce and Trade

Members:
- Robert M. Blue, Vice President, State and Federal Affairs, Dominion Virginia Power
- J. Lynwood Butner, Vice President, Easter Associates, representing the Virginia Propane Gas Association
- R. Daniel Carson, Jr., Vice President, Appalachian Power
- Al Christopher, Executive Director, Virginia Clean Cities. Also representing the Virginia Hydrogen Roundtable
- Diana Dascalu-Joffe, Senior Campaign Director, Chesapeake Climate Action Network
- Suzette Denslow, Deputy Director, Virginia Municipal League
- Theo DeWolff, Managing Director, PPM Atlantic Renewable
- Judy Dunscomb, Senior Conservation Scientist, The Nature Conservancy
- Mike Edwards, Deputy Director for Legislative Affairs, Virginia Association of Counties
- Amy Hewett, Director of Government Affairs and Public Relations, Virginia Chamber of Commerce
- Dan Holmes, Special Projects Coordinator, Piedmont Environmental Council
- W. Thomas Hudson, President, Virginia Coal Association
- Jim Kibler, Vice President, Governmental Relations, Virginia Natural Gas/AGL Resources. Also representing the Virginia Oil and Gas Association
- Mitchel A. King, Old Mill Power and Virginia Representative, Board of Directors, MDV Solar Energy Industries Association
- Matt LaRocque, Manager, Legislative and Regulatory Affairs, Southern Region, PJM Interconnection
- Dale Lee, Vice President, RGC Resources/Roanoke Gas
- Irene E. Leech, President, Virginia Citizens Consumer Council
- W. Scott McGeary, Area Manager, Public Affairs, Washington Gas
- Linda McMinimy, Executive Director, Virginia Transit Association
- Louis R. Monacell, Christian & Barton, representing the Virginia/Old Dominion Committees on Fair Utility Rates
- Hugh E. Montgomery, Jr., Executive Director, Institute for Defense and Homeland Security, representing the Center for Innovative Technology
- David Muchow, President and CEO, SkyBuilt Power
- Michael J. O'Connor, President, Virginia Petroleum Convenience and Grocery Association
- Annette Osso, Executive Director, Virginia Sustainable Building Network
- Michael J. Quillen, President and CEO, Alpha Natural Resources
- Susan Rubin, Assistant Vice President, Government Affairs, Old Dominion Electric Cooperative
- Andrew W. Smith, Senior Assistant Director of Governmental Relations, Virginia Farm Bureau
- Mary E. Spruill, State Programs Director, National Energy Education Development (NEED)

Appendix A

Virginia Energy Plan Advisory Group Members

continued

- Mike Town, Director, Virginia Chapter, Sierra Club
- Mark Tubbs, Director of Regulatory and Governmental Policy, Columbia Gas of Virginia
- Brett Vassey, President, Virginia Manufacturing Association
- August Wallmeyer, Executive Director, Virginia Independent Power Producers, Inc. and Virginia Energy Providers Association
- Michael D. Ward, Executive Director, Virginia Petroleum Council
- Aldie Warnock, Vice President, External Affairs, Alleghany Power
- Billy Weitzenfeld, Executive Director, Virginia Association of Energy Conservation Professionals

Appendix B

Code of Virginia Language

Appendix B
Code of Virginia Language Establishing The Virginia Energy Plan

Chapter 1
Energy Policy of the Commonwealth

§ 67-100. Legislative findings.

The General Assembly hereby finds that:

1. Energy is essential to the health, safety, and welfare of the people of this Commonwealth and to the Commonwealth's economy;
2. The state government should facilitate the availability and delivery of reliable and adequate supplies of energy to industrial, commercial, and residential users at reasonable costs such that these users and the Commonwealth's economy are able to be productive; and
3. The Commonwealth would benefit from articulating clear objectives pertaining to energy issues, adopting an energy policy that advances these objectives, and establishing a procedure for measuring the implementation of these policies.

§ 67-101. Energy objectives.

The Commonwealth recognizes each of the following objectives pertaining to energy issues will advance the health, welfare, and safety of the residents of the Commonwealth:

1. Ensuring the availability of reliable energy at costs that are reasonable and in quantities that will support the Commonwealth's economy;
2. Managing the rate of consumption of existing energy resources in relation to economic growth;
3. Establishing sufficient supply and delivery infrastructure to maintain reliable energy availability in the event of a disruption occurring to a portion of the Commonwealth's energy matrix;
4. Using energy resources more efficiently;
5. Facilitating conservation;
6. Optimizing intrastate and interstate use of energy supply and delivery to maximize energy availability, reliability, and price opportunities to the benefit of all user classes and the Commonwealth's economy as stated in subdivision 2 of § 67-100;
7. Increasing Virginia's reliance on sources of energy that, compared to traditional energy resources, are less polluting of the Commonwealth's air and waters;
8. Researching the efficacy, cost, and benefits of reducing, avoiding, or sequestering the emissions of greenhouse gases produced in connection with the generation of energy;
9. Removing impediments to the use of abundant low-cost energy resources located within and outside the Commonwealth and ensuring the economic viability of the producers, especially those in the Commonwealth, of such resources;
10. Developing energy resources and facilities in a manner that does not impose a disproportionate adverse impact on economically disadvantaged or minority communities;
11. Recognizing the need to foster those economically developable alternative sources of energy that can be provided at market prices as vital components of a diversified portfolio of energy resources; and
12. Increasing Virginia's reliance on biodiesel and ethanol produced from corn, soybeans,

hulless barley, and other suitable crops grown in the Commonwealth that will create jobs and income, produce clean-burning fuels that will help to improve air quality, and provide the new markets for Virginia's agricultural products needed to preserve farm employment, conserve farmland, and help pay for agricultural best management practices to protect water quality.

Nothing in this section shall be deemed to abrogate or modify in any way the provisions of the Virginia Electric Utility Restructuring Act (§ 56-576 et seq.).

§ 67-102. Commonwealth Energy Policy.

A. To achieve the objectives enumerated in § 67-101, it shall be the policy of the Commonwealth to:

1. Support research and development of, and promote the use of, renewable energy sources;
2. Ensure that the combination of energy supplies and energy-saving systems are sufficient to support the demands of economic growth;
3. Promote research and development of clean coal technologies, including but not limited to integrated gasification combined cycle systems;
4. Promote cost-effective conservation of energy and fuel supplies;
5. Ensure the availability of affordable natural gas throughout the Commonwealth by expanding Virginia's natural gas distribution and transmission pipeline infrastructure; developing coalbed methane gas resources and methane hydrate resources; encouraging the productive use of landfill gas; and siting one or more liquefied natural gas terminals;
6. Promote the generation of electricity through technologies that do not contribute to greenhouse gases and global warming;
7. Facilitate the development of new, and the expansion of existing, petroleum refining facilities within the Commonwealth;
8. Promote the use of motor vehicles that utilize alternate fuels and are highly energy efficient;
9. Support efforts to reduce the demand for imported petroleum by developing alternative technologies, including but not limited to the production of synthetic and hydrogen-based fuels, and the infrastructure required for the widespread implementation of such technologies;
10. Promote the use of biodiesel and ethanol produced from agricultural crops grown in the Commonwealth;
11. Ensure that development of new, or expansion of existing, energy resources or facilities does not have a disproportionate adverse impact on economically disadvantaged or minority communities; and
12. Ensure that energy generation and delivery systems that may be approved for development in the Commonwealth, including liquefied natural gas and related delivery and storage systems, should be located so as to minimize impacts to pristine natural areas and other significant onshore natural resources, and as near to compatible development as possible.

B. The elements of the policy set forth in subsection A shall be referred to collectively in this title as the Commonwealth Energy Policy.

C. All agencies and political subdivisions of the Commonwealth, in taking discretionary action with regard to energy issues, shall recognize the elements of the Commonwealth Energy Policy and where appropriate, shall act in a manner consistent therewith.

D. The Commonwealth Energy Policy is intended to provide guidance to the agencies and political subdivisions of the Commonwealth in taking discretionary action with regard to energy issues, and shall not be construed to amend, repeal, or override any contrary provision of applicable law. The failure or refusal of any person to recognize the elements of the Commonwealth Energy Policy, to act in a manner consistent with the Commonwealth Energy Policy, or to take any other action whatsoever, shall not create any right, action, or cause of action or provide standing for any person to challenge the action of the Commonwealth or any of its agencies or political subdivisions.

Chapter 2
Virginia Energy Plan

§ 67-200. Definitions.

As used in this title:

"**Division**" means the Division of Energy of the Department of Mines, Minerals and Energy.

"**Plan**" means the Virginia Energy Plan prepared pursuant to this chapter, including any updates thereto.

§ 67-201. Development of the Virginia Energy Plan.

A. The Division, in consultation with the State Corporation Commission, the Department of Environmental Quality, and the Center for Coal and Energy Research, shall prepare a comprehensive Virginia Energy Plan covering a 10-year period. The Plan shall propose actions, consistent with the objectives enumerated in § 67-101, that will implement the Commonwealth Energy Policy set forth in § 67-102.

B. In addition, the Plan shall include:

1. Projections of energy consumption in the Commonwealth, including but not limited to the use of fuel sources and costs of electricity, natural gas, gasoline, coal, renewable resources, and other forms of energy resources used in the Commonwealth;
2. An analysis of the adequacy of electricity generation, transmission, and distribution resources in the Commonwealth for the natural gas and electric industries, and how regional generation, transmission, and distribution resources affect the Commonwealth;
3. An analysis of siting requirements for electric generation resources and natural gas and electric transmission and distribution resources;
4. An analysis of fuel diversity for electricity generation, recognizing the importance of flexibility in meeting future capacity needs;
5. An analysis of the efficient use of energy resources and conservation initiatives;
6. An analysis of how these Virginia-specific issues relate to regional initiatives to assure the adequacy of fuel production, generation, transmission, and distribution assets;
7. An analysis of siting of energy resource development, refining or transmission facilities to identify any disproportionate adverse impact of such activities on economically disadvantaged or minority communities; and
8. Recommendations, based on the analyses completed under subdivisions 1 through 7, for legislative, regulatory, and other public and private actions to implement the elements of the Commonwealth Energy Policy.

C. In preparing the Plan, the Division and other agencies involved in the planning process shall utilize state geographic information systems, to the extent deemed practicable, to assess how recommendations in the plan may affect pristine natural areas and other significant onshore natural resources.

D. In preparing the Plan, the Division and other agencies involved in the planning process shall develop a system for ascribing numerical scores to parcels of real property based on the extent to which the parcels are suitable for the siting of a wind energy facility or solar energy facility. For wind energy facilities, the scoring system shall address the wind velocity, sustained velocity, turbulence, proximity to electric power transmission systems, potential impacts to natural and historic resources and to economically disadvantaged or minority communities, and compatibility with the local land use plan. For solar energy facilities, the scoring system shall address the parcel's proximity to electric power transmission lines, potential impacts of such a facility to natural and historic resources and to economically disadvantaged or minority communities, and compatibility with the local land use plan. The system developed pursuant to this section shall allow the suitability of the parcel for the siting of a wind energy facility or solar energy facility to be compared to the suitability of other parcels so scored, and shall be based on a scale that allows the suitability of the parcel for the siting of a such an energy facility to be measured against the hypothetical score of an ideal location for such a facility.

E. After July 1, 2007, upon receipt by the Division of a recommendation from the Department of General Services, a local governing body, or the parcel's owner that a parcel of real property is a potentially suitable location for a wind energy facility or solar energy facility, the Division shall analyze the suitability of the parcel for the location of such a facility. In conducting its analysis, the Division shall ascribe a numerical score to the parcel using the scoring system developed pursuant to subsection D.

§ 67-202. Schedule.

A. The Division shall complete the Plan by July 1, 2007.

B. Prior to completion of the Plan, the Division shall present drafts to, and consult with, the Coal and Energy Commission and the Commission on Electric Utility Restructuring.

C. The Plan shall be updated by the Division no less frequently than every five years.

§ 67-203. Submission of Plan.

Upon completion, the Division shall submit the Plan, including periodic updates thereto, to the Governor, the Commissioners of the State Corporation Commission, and the General Assembly. The Plan shall be submitted as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents. The Plan's executive summary shall be posted on the General Assembly's website.

The Department of Mines, Minerals and Energy would like to thank Dick Spellman and his team at DGS Associates, Inc. for their assistance in developing the Virginia Energy Plan. Mr. Spellman may be reached at:

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