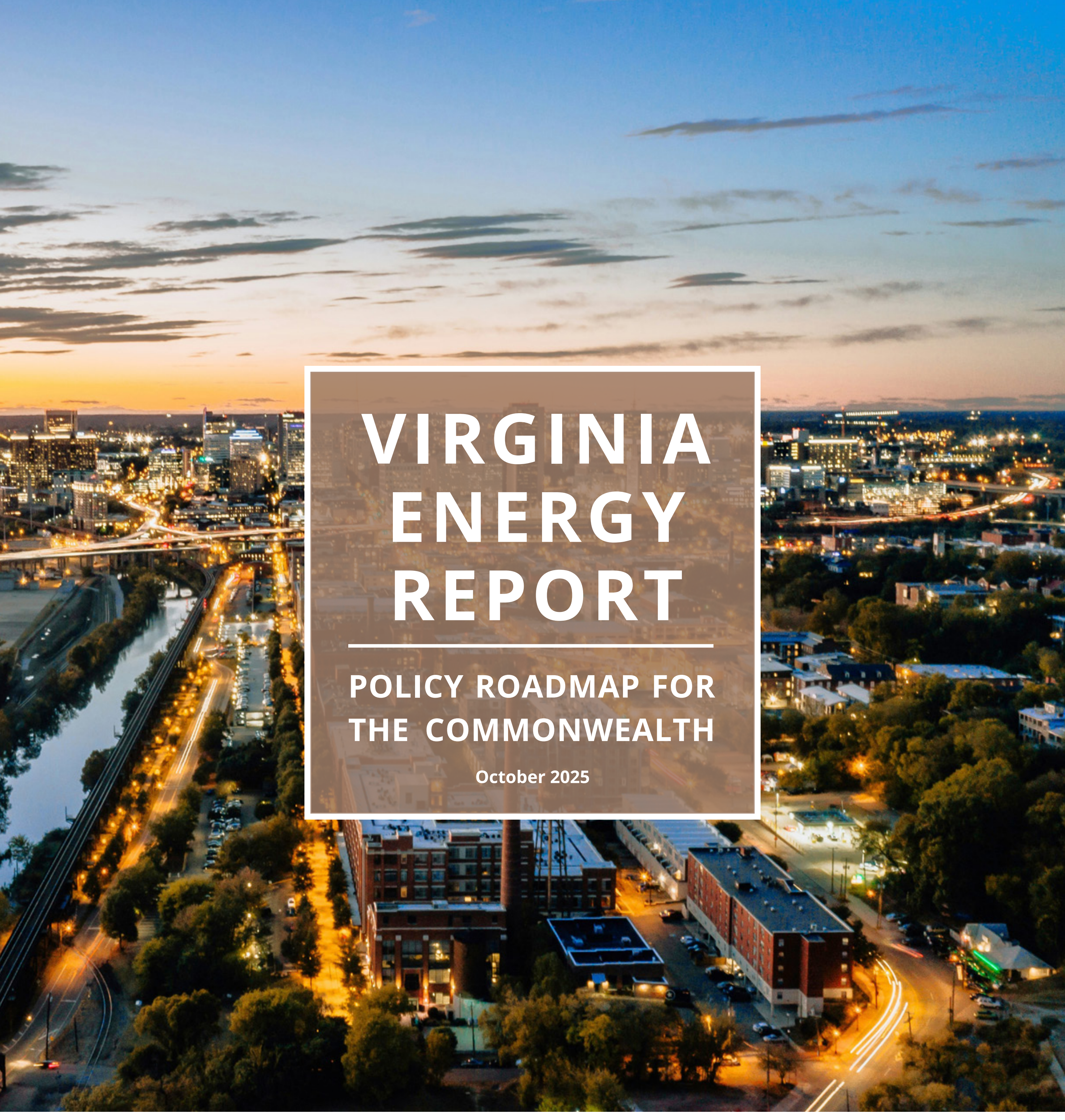


VIRGINIA ENERGY REPORT

POLICY ROADMAP FOR THE COMMONWEALTH

October 2025

The Center for Energy Science and Policy
Schar School of Policy and Government
George Mason University

Lead Author

Paul Bubbosh, J.D.
Adjunct Professor, George Mason University

Principal Co-Authors

Jack Potter
D. Elliot Meyer
Todd Smith
Marcos Rahmeyer-Lara
Schuyler Lynch
Non-Resident and Student Fellows, Center for Energy Science & Policy,
George Mason University

Contributing Authors

Jordan Bertaux, William Barker, Mary Decker, Daniela Romero, Woody Davenport, Dylan Kezele, Dominic Leone

Principal Editor and Report Design

D. Elliot Meyer

Acknowledgement

The authors wish to thank Amb (ret) Richard Kauzlarich, Co-Director of the Center for Science and Policy and Distinguished Visting Professor for all his support and dedication to the mission of the Center and George Mason University. The authors also wish to thank the report's peer review team.

Disclaimers

The analysis and recommendations expressed in this report are the sole work of the individual authors and do not represent the official policy or position of George Mason University, its affiliates, or any other individuals associated with George Mason University.

The recommendations are consistent with current Virginia laws, primarily the Virginia Electric Utility Regulation Act and Virginia Clean Economy Act (VCEA). The VCEA mandates a renewable portfolio standard program to deliver electricity from 100 percent renewable sources by 2045-2050, among other requirements. This report is not an endorsement of any specific energy source. The policy pathways presented are intended to comply with existing state laws.

This report is not intended to lobby for resources for Virginia public colleges and universities. While this report does advocate education, it should not be interpreted as a request for legislative funding.

Report Citation: Paul Bubbosh, Jack Potter, Todd Smith, Marcos Rahmeyer-Lara, Schuyler Lynch, D. Elliot Meyer. (October, 2025). Virginia Energy Report 2025: Policy Roadmap for the Commonwealth. George Mason University. Web.

PREFACE

The energy sector is dynamic. It is influenced by an ever-growing host of factors. Energy analysts used to focus on five major influences: laws, economics, politics, infrastructure, and technology. Over time analysts added more, such as national security, financing, international relations and development, environment and climate change, public health, sustainability, and global commerce and trade. There are probably many more influences because energy systems influence virtually every human activity. In fact, every major public policy area is directly affected by its relationship with energy, and its reach extends to international, national, state, and local interests. Like a spider's web, touch any one of these areas and the reverberations affect everything else. This complexity requires policies that consider all these factors carefully.

As a country, we aspire to achieve energy security: accessible, reliable, and affordable sources of energy. We value domestic development of natural resources and critical materials to meet our energy goals. We continue to lead in energy technology and innovation through robust collaboration between public and private institutions. The core principle in the management of such values and interests is consistent, pragmatic cooperation.

In Virginia, we can control what happens within our borders. We can influence how we achieve the goals identified above, especially on consistency, certainty, and bipartisanship. Virginia, like many states, faces a new and changing energy dynamic, primarily the need to generate more energy because of increased demand from data centers, manufacturing, and electrification of vehicles and buildings. We have not seen the confluence of these events in over a generation. This is all happening at the same time as most Virginians are seeing the real costs of energy increase.

The purpose of this report is to provide practical recommendations for rapidly deploying new clean energy projects, increasing demand-side management programs, and enhancing education throughout Virginia. At such crossroads, coalition-building between top-down leadership and bottom-up grassroots efforts is required. This work strives to provide an objective analysis that adheres to current state law and sensible projections for Virginia's energy leaders and decision-makers. The timeframe for recommendations is between four to ten years – the typical timeframe for policy feedback cycles to mature. Ultimately, we share the collective goal to improve the lives of all Virginians through its energy systems.

Paul Bubbosh

Adjunct Professor
George Mason University

ABBREVIATIONS

AMI	Advanced Metering Infrastructure
BEV	Battery Electric Vehicle
BTU	British Thermal Unit
Bcf/d	Billion Cubic Feet per Day
CO_2	Carbon Dioxide
DR	Demand Response
DERs	Distributed Energy Resources
DG	Distributed Generation
EIA	Energy Information Administration
FERC	Federal Energy Regulatory Commission
GW	Gigawatts
GWh	Gigawatt-hours
H.B.	House Bill
IRA	Inflation Reduction Act
kW	Kilowatts
LCOE	Levelized Cost of Energy
MTRM	Mountain Top Removal Mining
MW	Megawatts
MWh	Megawatt-hours
NERC	North American Electric Reliability Corporation
NOx	Nitrous Oxides
PHEV	Plug-in Hybrid Electric Vehicle
PJM	Pennsylvania, New Jersey, and Maryland (RTO)
$PM_{2.5}$	2.5-micron Particulate Matter
PM_{10}	10-micron Particulate Matter
RECs	Renewable Energy Credits
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable Portfolio Standard
RTO	Regional Transmission Organization
S.B.	Senate Bill

SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCC	Social Cost of Carbon
SO_2	Sulfur Dioxide
TDS	Transmission, Distribution, and Storage
VCEA	Virginia Clean Economy Act
VMT	Vehicle Miles Travelled
VOCs	Volatile Organic Compounds
VPPs	Virtual Power Plants

GLOSSARY OF KEY TERMS

BTU (British Thermal Unit): A measure of energy. Technically, a BTU represents the heat content of fuels or energy sources. It offers a common unit of measurement that can be used to count and compare different energy sources or fuels.

Demand Response (DR) or Demand Side Management (DSM): A strategy used to reduce electricity consumption by consumers in response to peak demand conditions or prices.

Distributed Energy Resources (DER): Small-scale energy systems that generate or store energy and are connected to the grid and/or operated in isolation (e.g., rooftop solar, microgrids).

Distributed Generation (DG): Related to DER, distributed generation often refers to on-site generation resources used to supply power to a large energy consumer.

Energy Efficiency and Energy Intensity: Energy efficiency is about delivering a service with less energy input (doing more with less). Energy intensity is a measure of this reduction of energy but measured as the amount of energy used per dollar of economic activity.

Primary and Secondary Energy: Primary energy is energy in its raw form before conversion to another form. This can be coal, natural gas, or petroleum before conversion in power plants or for use in vehicles. Secondary energy is the conversion of primary energy into a transportable form, such as burning coal in a power plant to produce electricity.

Virginia Energy Market: Virginia's participation in a regional transmission organization (PJM) allows it to operate within a larger, interconnected grid spanning all or part of 13 states and the District of Columbia. This helps ensure the grid's reliability by allowing power to be centrally dispatched and moved across a wide area to meet demand. PJM manages the wholesale electricity market, which is where Virginia utilities purchase most of their power, including imports from other states. While the Commonwealth has two major investor-owned utilities, regulated by the Virginia State Corporation Commission, large businesses can choose their electricity supplier, known as Independent Power Producers.

Watts (W), Kilowatt (kW), Megawatt (MW), Gigawatt (GW): These are all measurements or units of power produced, consumed, or transmitted.

- 1 watt (W) = 1 unit of power. Typically, small electrical appliances like a smartphone charge at 5 W. Thus, the energy it consumes per hour is 5 Watt-hours (or Whs)
- 1 kilowatt (kW) = 1,000 watts. Typically, larger electrical appliances like a water heater rated at 5 kW or 5,000 W.
- 1 megawatt (MW) = 1,000,000 watts (one million watts) or 1,000 kilowatts (kW). Typically, MW is conveniently used for small to medium power plants or large renewable energy installations like solar or wind farms.
- 1 gigawatt (GW) = 1,000 megawatts or 1 billion watts. Typically, GW is a measure of energy for large power plants or national energy grids.

Kilowatt Hour (kWh): Where kW measures power or electricity generated, one kilowatt hour (kWh) measures the total energy used from consuming 1kW continuously for 1 hour, typically used for household billing purposes. One Megawatt-Hour (MWh) is the total energy used from consuming 1 MW of power continuously for 1 hour.

TABLE OF CONTENTS

EXECUTIVE SUMMARY
Recommendations

This list reflects only high-priority recommendations. For the full list of recommmendations and references, see the Part III. Recommendations Section.

I. The Three-Pronged Energy Strategy

To ensure affordable energy prices, resilient and reliable electricity delivery, and a strong economy and job sector, Virginia should focus on three main strategies:

1. First, fast-track cleaner electric generation and efficient transmission to meet growing demand.
2. Second, prioritize demand-side management programs to consume less energy during peak periods.
3. Third, engage with and educate communities about the cost- and health-benefits of cleaner, diversified energy generation and demand efficiency to achieve broad and long-lasting support for these policies.

Virginia should approach this three-pronged strategy using a combined top-down and bottom-up approach, each with broad application, high-level attention, funding, and long-term support.

II. Improve Demand Side Management and Load Forecasting

Virginia should ensure better understanding of energy demand. The available data and reactions to this data from energy experts makes assessing future energy load growth challenging. While this report focuses on cleaner energy generation, demand-side management, and distributed generation, the report is unable to assess with confidence if these tools are sufficient to meet future demand. This uncertainty creates risks. On one hand, if Virginia approves new electricity generation facilities and the expected demand does not materialize, then ratepayers must pay for these stranded physical assets (this does not apply to entities that purchase power from Independent Power Producers). On the other hand, if Virginia relies on demand-side management programs and distributed energy resources, and load growth exceeds these energy management tools, this could risk grid reliability. In short, Virginia needs to get smart on its energy load needs and management tools.

III. Top-Down: Focus Large-Scale Solar Projects in High Energy Demand Areas

The challenges with local siting of utility scale solar projects are significant and attempts to mandate statewide control may reduce public support for large solar projects. Virginia should evaluate the potential of maximizing the deployment of utility scale solar projects and distributed energy resources within Northern Virginia, its largest electricity demand center, or close to large energy consumers. If this is accomplished, then Virginia should consider other alternatives to meet its energy goals, including statewide legislation.

IV. Top-Down: Deploy DERs in State-Owned Buildings and Public Spaces

Virginia should deploy distributed energy resources (DERs) in state-owned public buildings and spaces and form public-private partnerships to represent its leadership on deploying DERs. Compared to utility scale projects, DERs can be deployed more quickly and at lower cost. Replacing federal incentives from the Inflation Reduction Act is not feasible, but using available state-based tools can create incentives to make deploying DERs more economically favorable.

Based on a review of other states, the following incentives and policies are recommended:

- State investment tax credits;
- Rebates for solar PV, battery systems, or energy-efficient generators;
- Grant programs for schools, critical facilities, and community resilience hubs;
- Revolving loan funds for financing projects;
- Legislation to simplify and standardize the permitting processes and installation requirements for DERs at critical facilities (e.g., hospitals, emergency shelters) and high-load demand facilities (e.g., data centers).

V. Top-Down: Increase in Demand Response Programs through Utility Mandates and Assistance

Virginia should mandate and assist its utilities in increasing the marketing, delivery, processing, and participation in demand response programs with its customers. This is critical to ensure the public understands the basis for the recommendations that provide a roadmap for implementing the VCEA. Demand response programs are always less expensive than building new generation. There is a wide array of proven financial tools that should be aggregated and deployed.

Based on a review of other states, the following incentives and policies are recommended:

- Increase rebate offerings and other enrollment incentives.
- Conduct statewide and local outreach about cost savings.
- Create a public recognition program for large customers and municipalities.
- Resolve outstanding data privacy issues with communication devices between customers and utilities.

VI. Top-Down: Establish and Fund a Statewide Energy Education Campaign

Virginia should facilitate an energy education campaign that is comprehensive, state-wide, long-term, and supported with adequate funding. This is critical to ensure the public understands the basis for the recommendations that provide a roadmap for implementing the VCEA.

VII. Bottom-Up: Facilitate a Local Energy Action Planning Initiative

Virginia should facilitate a state-supported, locally driven Local Energy Action Planning Initiative. This initiative, funded by the state, would task public colleges and universities to help every municipality develop a tailored energy action plan as part of its required comprehensive plan update. Energy plans should establish specific goals that reflect the municipality's needs without being tied to statewide targets, although statewide targets can serve as guidance for local goals. This process will serve as the primary vehicle for bottom-up education and stakeholder engagement.

VIII. Bottom-Up: Assess Municipality's Baseline Energy Costs, Emissions, and Community Vulnerabilities to Extreme Weather

The municipality energy plans should assess baseline energy costs, emissions, and community vulnerability to climate-induced events (e.g., flooding, heat waves). Further, energy planning efforts should provide unbiased information about strategies, actions, and policies to address high energy costs, harmful emissions, and community resilience. Most importantly, energy action planning should involve decision making by key community stakeholders and local government officials. One possible consideration is to require municipalities with populations above 50,000 to develop and implement energy plans and make energy planning voluntary for municipalities under this threshold.

EXECUTIVE SUMMARY
Baseline and Projections

I. Energy Consumption[1]

Baseline

Over the past 20 years:

- Virginia's total energy consumption has remained relatively stable. It has consistently ranked in the top 15 states nationally for highest total energy consumption.
- Virginia's energy consumption per economic output (energy intensity) was more efficient than most states (it produces more for less energy). Its per capita consumption was around the national average.
- Virginia's primary energy consumption (the first use of an energy source) shifted from coal to natural gas and renewables. Virginia's secondary energy consumption, by the electric sector, shifted from mostly petroleum and coal to mostly natural gas, biomass, and solar. Petroleum and nuclear energy have maintained steady consumption rates.
- Virginia's highest sector for consumption has been the transportation sector, but in recent years the commercial sector has matched transportation. In 2022, Virginia ranked 6th nationally in commercial energy consumption, behind Texas, California, New York, Florida, and Illinois.

Projections

- Virginia will likely experience an increase in electricity consumption driven primarily by the explosive growth of data centers and, to a lesser extent, transportation and building electrification, and increased manufacturing. Some energy experts project an 8 percent increase by 2030 and a 20 percent increase by 2035.
- Virginia will likely see an increase in vehicle petroleum consumption by over 10 percent by 2035.

1 *All references are found in the correlating sections of the report.*

II. Energy Production

Baseline[2]

Over the past 20 years:

- Virginia's total primary energy production decreased by one-third. Coal and petroleum decreased the most over this period, while natural gas, biomass, and solar energy increased the most. Currently, nuclear energy is the highest source of primary energy production.
- Despite this trend in decreasing energy production, electricity generation has increased significantly. Virginia shifted its reliance from coal to natural gas. Nuclear energy has remained steady as a source of production and its nuclear power plants generate the most power.
- Virginia's energy consumption exceeded its production, thereby making it a net energy importer. In 2023, Virginia was the highest net electricity importer of any state.

Projections

- Virginia's domestic electricity generation capacity will likely decrease by 17 gigawatts (GW). Solar power will likely have the greatest decrease at 16 GW.
- Virginia will likely see a short-term spike in utility-scale solar power and natural gas plants, followed by an increasingly challenging economic outlook for future production.
- Both solar and natural gas power facilities will face supply chain constraints in the near to medium term (3 to 5 years) for different reasons. Natural gas supply chain shortages will result from increased competition for scarce resources, while solar and wind shortages will result from changes

Exterior view of the Virginia City Hybrid Energy Center (610 MW) in the Town of St. Paul, in Wise County, Virginia.

2 *All references are found in the correlating sections of the report.*

in federal incentives and supply chain constraints.

- The backlog in regional transmission interconnections for new generation projects and delays in local siting and permitting of these new projects will likely further complicate the speed and scale of new generation facilities.

III. Energy Prices and Expenditures[3]

Baseline

Over the past 20 years:

- Virginia's total energy prices were in the median range when compared to all other states, ranked 25th among states.
- Virginia's natural gas prices for homeowners peaked in 2007, decreased from 2008 to 2016, and have been on the rise since then and have reached historic highs recently.
- Virginia's natural gas prices for commercial customers reflect U.S. national average prices but have trended lower in recent years. Natural gas prices for industrial customers have consistently been higher than national averages.
- Virginia's electricity prices have been lower than national averages—on average 18 percent lower—across all sectors: residential, commercial, and industrial.
- Virginia's total electricity sales to residential, commercial, and industrial customers are among the 15-highest states nationally, and 70 percent higher than the national average. The commercial sector experienced the largest increase.
- Virginia's per capita energy spending has more than doubled to nearly $5,000 annually, which is 15 percent lower than the national average and ranked 32nd nationally - 31 states have higher per capita spending.
- Virginians spend more on energy as a percentage of income in all end-use sectors (residential, commercial, residential, industrial, and transportation) compared to national averages. Of all end-use sectors, Virginians spend the most on transportation.

3 *All references are found in the correlating sections of the report.*

Projections

- Virginia's retail electricity rates will likely increase for residential, commercial, and industrial consumers. Increases will likely range from $110 to $165 per household annually in 2030, and from $192 to $280 in 2035.
- Petroleum consumption will likely increase gasoline prices by up to 3 percent by 2035.
- Roughly half to two-thirds of projected household energy cost increases stem from higher outlays for mobility fuels (gasoline, diesel) and EV charging in scenarios where EV penetration slows.

IV. Economic Development and Jobs[4]

Baseline

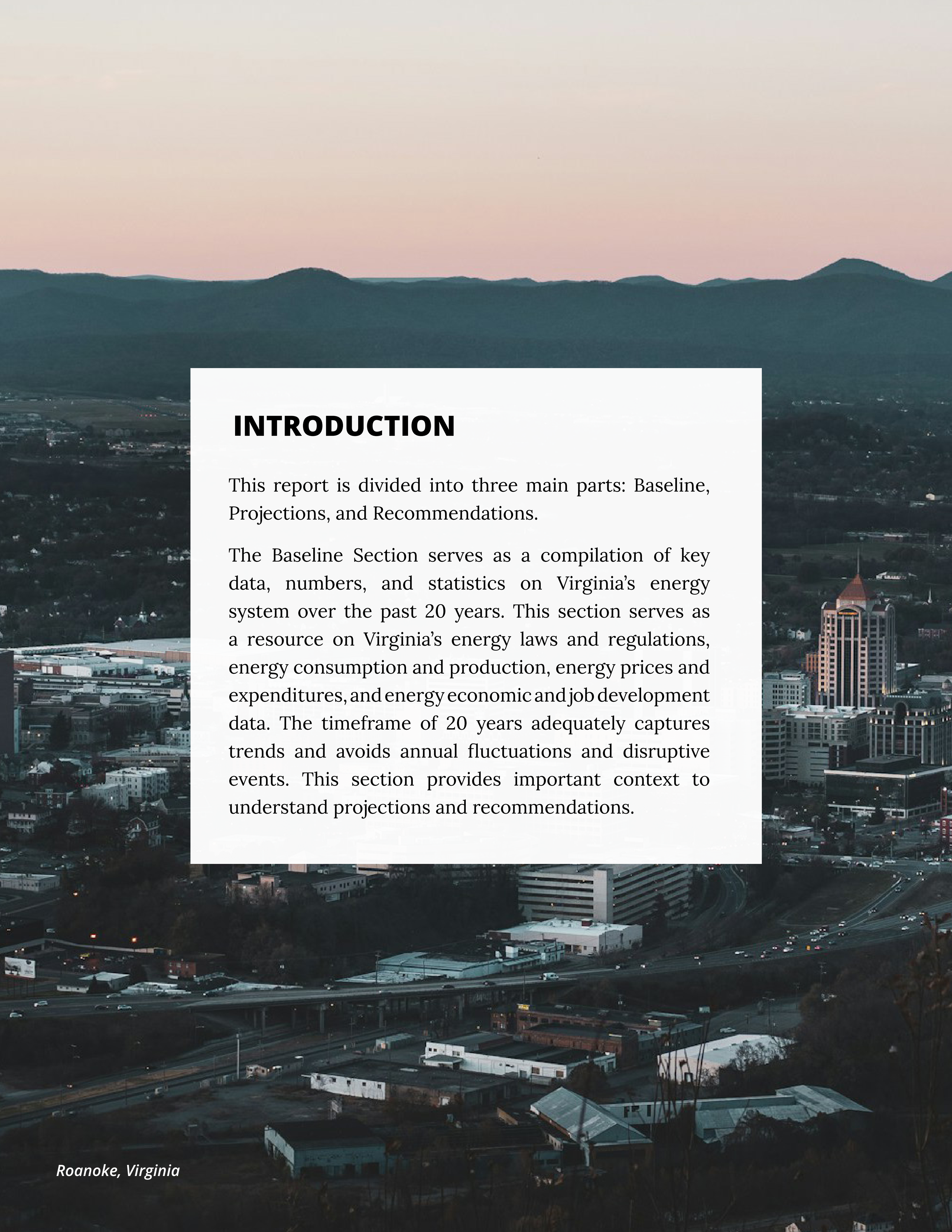
- In 2022, Virginia's energy sector employed approximately 187,000 workers, which represents almost 5 percent of Virginia's total civilian labor workforce.
- In 2022, Virginia's energy efficiency sector comprised 40 percent of its total energy workforce. Virginia ranks in the top 10 states for energy efficiency employment.
- In 2022, Virginia's solar industry employed the most people in the electricity sector, over 5,000.
- In 2022, Virginia's electric vehicle and energy efficiency sectors contributed the most to GDP - adding $3.8 billion in economic activity.
- Since 2010, Virginia's coal jobs have decreased by 70 percent.
- During Virginia's participation in the Regional Greenhouse Gas Initiative, from 2021 to 2023, the program generated approximately $200M per year in revenue, which was distributed to flood preparedness and energy efficiency programs.

Projections

- Virginia's GDP could decrease by $1.8 billion by 2030 and $3.1 billion by 2035, although government estimates vary.
- Virginia could lose 11,000 energy-related jobs by 2030 and 17,000 energy-related jobs by 2035.

---

4 *All references are found in the correlating sections of the report.*



INTRODUCTION

This report is divided into three main parts: Baseline, Projections, and Recommendations.

The Baseline Section serves as a compilation of key data, numbers, and statistics on Virginia's energy system over the past 20 years. This section serves as a resource on Virginia's energy laws and regulations, energy consumption and production, energy prices and expenditures, and energy economic and job development data. The timeframe of 20 years adequately captures trends and avoids annual fluctuations and disruptive events. This section provides important context to understand projections and recommendations.

Roanoke, Virginia

The Projections Section has been significantly shaped and altered by the recent U.S. Congressional reconciliation bill and federal policies. These recent actions raise important issues for Virginia, especially in terms of its own state law on clean and renewable energy. The report's projections pivot based on these recent changes, which also influence the report's recommendations. The projections section focuses on preliminary outlooks over the next four years according to experts and how it could impact Virginia specifically. This has resulted in a truncated section, but one that focuses on how to respond to current shifts in federal incentives and policies.

The report concludes with the Recommendations Section which represent the culmination of examining Virginia's energy past and projections about its energy future. This is the heart of the report, and it presents the bottom-line upfront. This part offers a menu of policy choices and actions for state government leadership to consider in the short term.

The recommendations are designed to meet two goals: First, present a practical, realistic, and cost-effective roadmap to implement the VCEA's goals. The recommendations included here are well within the capability of the target audience and implementable in the short term. Some of these recommendations can be challenging and controversial in tight fiscal conditions and politically partisan environments. On that point, the report presents balanced recommendations that will hopefully assuage political and economic challenges. Second, ensure that recommendations will ultimately improve the lives of Virginians in terms of energy affordability, human health, and community well-being. These recommendations are presented with respect to the spectrum of community, culture, and resources amongst Virginians across the Commonwealth.

There are more areas to consider, including influences on infrastructure and technology, environment and public health, security and emergency preparedness, and transportation. To address and ensure coverage of these other areas, these topics are included in appendices.

Finally, the report includes a section on methodology. The analysis and recommendations were developed using structured analytic techniques. The robust nature of these techniques reflects the complexity of the topic and yields carefully considered recommendations.

PART I: BASELINE

Section 1. Laws and Governance

Section 2. Consumption

Section 3. Energy Production

Section 4. Energy Prices and Expenditures

Section 5. Economic Development and Job Creation

Section 1
LAWS AND GOVERNANCE

Summary

The future direction of Virginia's energy sector is guided primarily by the 2020 Virginia Clean Economy Act. This law established the framework for energy in the state by mandating renewable energy targets for the electric grid and fossil-fuel plant retirements. It also sets standards for utility-based energy efficiency programs, energy storage facilities, and net metering for solar projects. Recent changes to this legislation include the state's withdrawal from a regional cap-and-trade greenhouse gas program and California clean car standards. Some local municipalities have aggressively pursued this clean energy transition by seeking grants and enacting local policies, while others have restricted or prohibited renewable energy projects.

This section explains the key components of the Virginia Clean Economy Act, current compliance status with these components, and multi-state policies. Note, this report does not opine on the potential outcomes of federal and state legal disputes involving some of these policies and regulations.

Key Takeaways

- Virginia law mandates a pathway to a decarbonized economy.
- Virginia's two main utilities are making progress on meeting most of the legal requirements.
- Virginia's largest utility faces challenges meeting energy efficiency targets.
- Local resistance to solar projects and the withdrawal from multi-state climate policies complicates compliance with legal frameworks.

I. Virginia's Regulatory Context

Virginia's present energy laws and governance is contextualized by a substantial shift in regulatory energy structures over the past two decades. In the wake of national trends towards deregulating electricity markets, increasing competition, and allowing consumer choice for certain electric services, Virginia passed the Virginia Electric Utility Restructuring Act in 1999, a bipartisan legislative effort to modernize the Commonwealth's energy marketplace. This law was similar to others enacted in adjacent PJM mid-Atlantic states. This law created a competitive electricity generation market for Virginia residents and large industrial consumers. It phased in customer choice for electricity providers and capped retail rates at 1999 levels through 2010.[1] By design, the increase in market competition would lower rates, spur innovation and energy investment, and improve consumer's energy decision-making.[2]

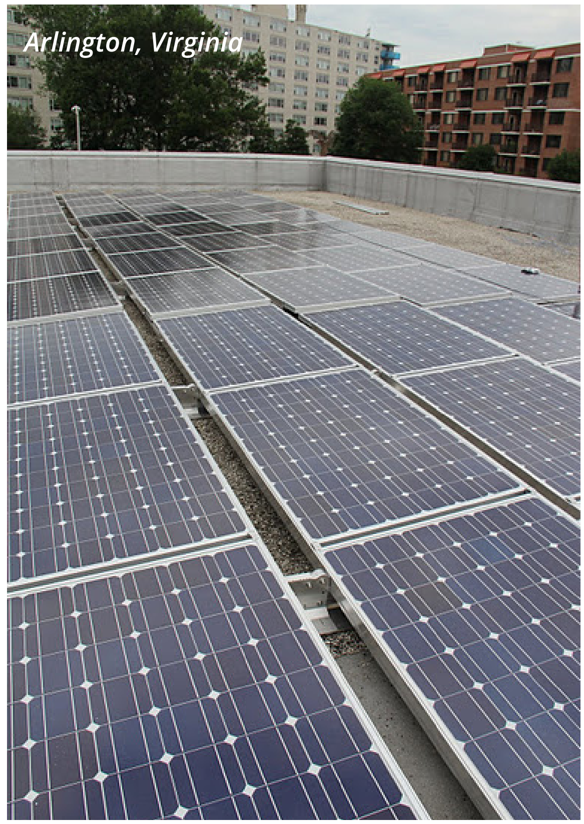
However, after an initial pilot program and phased rollout for consumer choice, competition did not materialize. Unlike neighboring states, particularly Pennsylvania, that saw strong increases in marketplace competitive and positive policy feedback,[3] Virginia saw little change in customer choice. As a result, existing incumbent utilities and cooperatives maintained a captured market.[4] With the lack of competition at point of retail, competition for energy generation also failed to materialize. Lawmakers grew concerned that entrenched energy companies could wield extraordinary market power in the absence of competition and increase prices for profit-gauging without rate regulation by the State Corporation Commission.[5]

In 2007, the General Assembly "re-regulated" Virginia's energy market by passing the Virginia Electric Utility Regulation Act.[6] Although the law restored SCC's regulation of retail rates and reestablished vertically integrated utility models, the Re-Regulation Act was a novel hybrid model. The Act established triennial review rate cases for Phase I and II utility companies (Dominion Energy and Appalachian Power), new procedures for increasing or decreasing rates, and numerous financial incentives for utilities, including rate adjustment clauses (RACs), voluntary renewable portfolio goals (RPS),[1] and bonuses for fossil and renewable generation.[7]

The 2007 regulatory overhaul set the conditions for Virginia's energy market to begin substantially diversifying its energy generation portfolio and incentivize distributed energy in the following decade. This coincided with major energy market trends - detailed throughout this report – notably the increasingly competitive levelized cost of energy for

1 Target for 12% renewable generation by 2022.

newer generation technologies (e.g. combined cycle gas turbine (CCGT), monocrystalline photovoltaic solar panels, and low-specific power offshore wind turbines). As a result, Virginia's regulatory landscape set a strong foundation for lawmakers and the SCC to incentivize investment in a diversity of generation assets and flexibility to changing energy priorities for the public. The Virginia Electric Utility Regulation Act serves as the foundation for how the state's electric utilities operate. It created a framework for regulation, rate structures, and overall energy policy.[8]


Arlington, Virginia

II. Virginia Clean Economy Act

In 2020 the Commonwealth enacted the Virginia Clean Economy Act (VCEA. This legislation introduced a comprehensive plan to transition Virginia's energy landscape toward a cleaner, renewable-based grid, by embedding carbon reduction mandates into the state's existing utility regulations.[9] Therefore, the dissection of this law is paramount in guiding this report.

The VCEA has four major provisions. First, the law establishes specific targets for reducing carbon emissions. It accomplishes this through a Renewable Portfolio Standard which sets incremental benchmarks for utilities to meet in their shift toward 100 percent carbon-free electricity generation for the largest utilities - Dominion Energy and Appalachian Power. This includes offshore wind as a key component of Virginia's energy future. Second, it sets targets for retiring fossil fuel plants. Third, it sets a target for energy storage capacity to ensure a resilient electric grid. Finally, it implements a series of provisions intended to increase energy efficiency and distributed energy resources. This is accomplished primarily through an Energy Efficiency Resource Standard and net metering. The law contains other local and regional provisions, such as allowing municipalities to impose revenue sharing for solar projects, adjusting local property tax exemptions for solar projects, and requiring creation of a community solar sharing program.

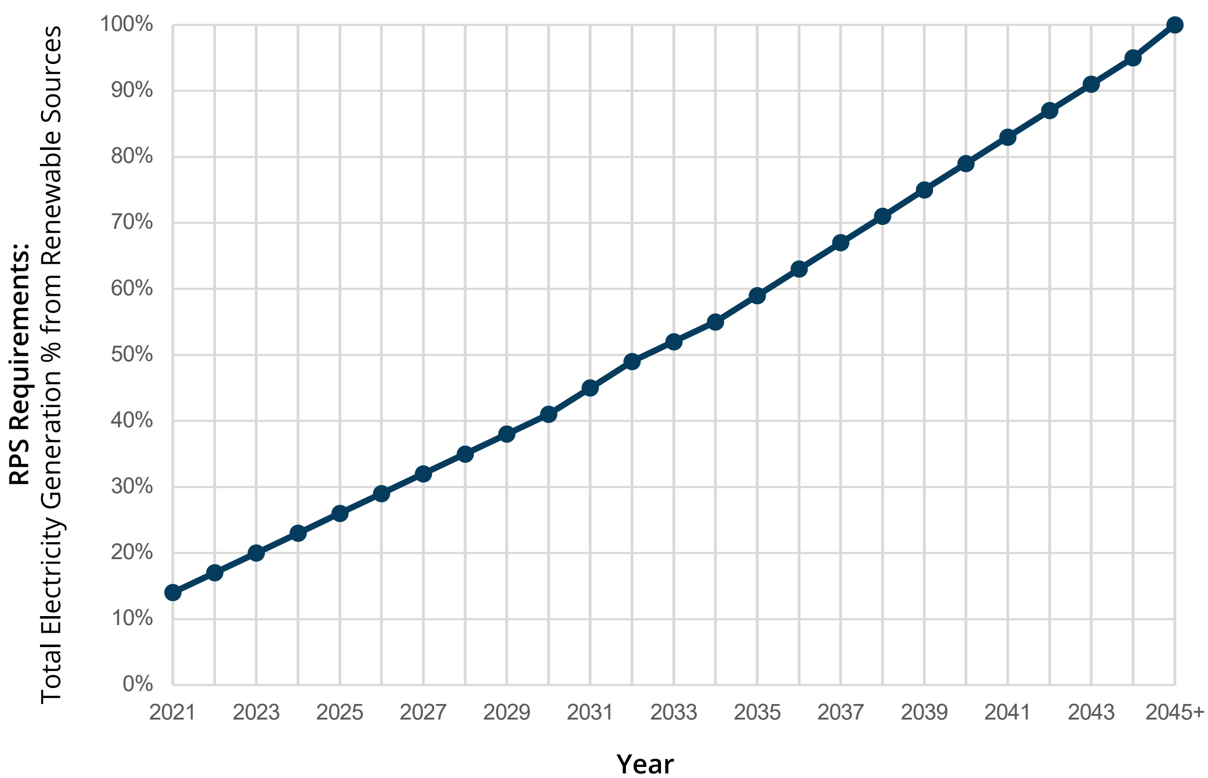
III. Renewable Portfolio Standard

The VCEA established a mandatory Renewable Portfolio Standard (RPS) to transition the state's electricity generation to 100 percent renewable energy.[10] The RPS seeks to accomplish this goal by outlining specific targets and timelines for electricity providers, primarily focusing on the state's largest providers: Dominion Energy and Appalachian Power. The VCEA requires an increase in new solar and onshore wind generating power, from 5,000 megawatts (MW) to 16,000 MW. It also requires 5,200 MW from offshore wind.[11]

Dominion Energy, classified as a Phase II utility, is required to produce electricity from 100 percent renewable sources by 2045 (see Figure 1). In 2024, Dominion Energy reported progress towards this goal.[12]

In 2024, Dominion Energy petitioned the Virginia State Corporation Commission (state regulator of public utilities) for approval to construct or purchase approximately 3,600 MW of solar and onshore wind capacity, with 49 percent company-owned and 51 percent acquired through power purchase agreements (a contract between electricity generator and utility), according to state reporting.[13] This development aligns with the VCEA's requirement for Dominion Energy to

Figure 1: Renewable Portfolio Standard Requirements, Dominion Energy



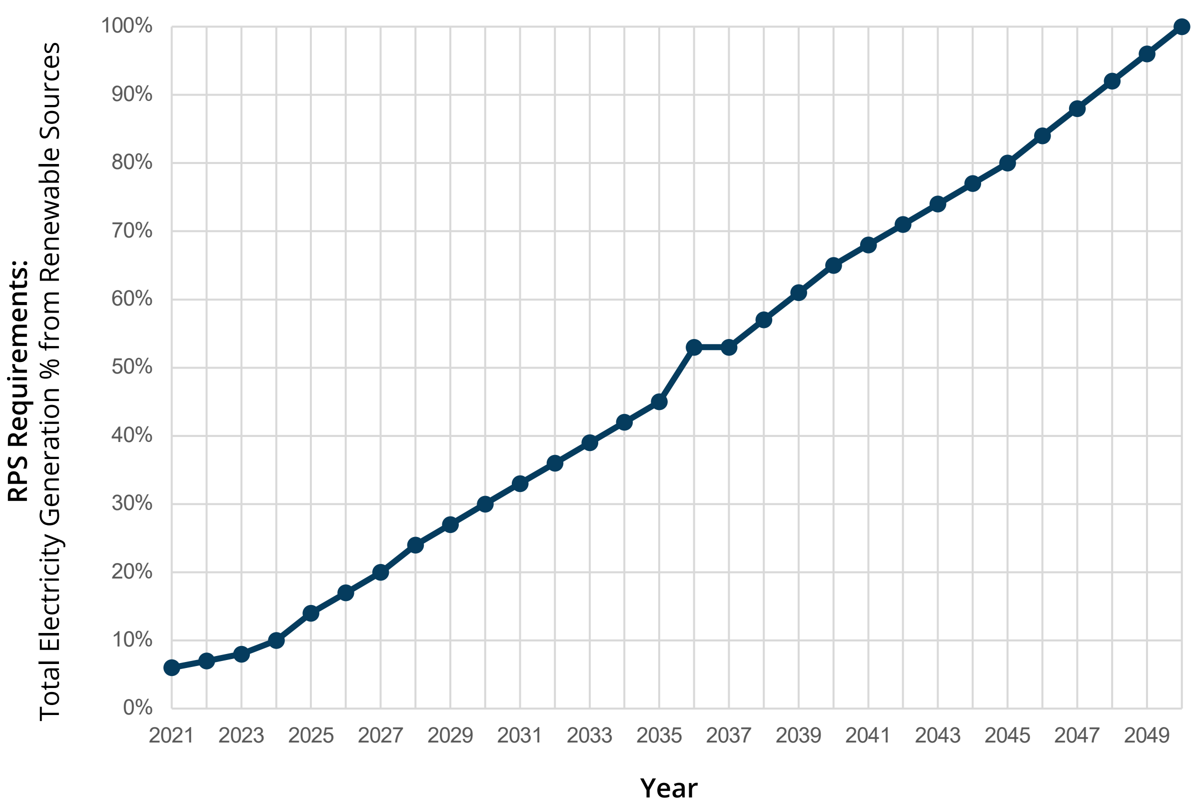
petition for at least 3,000 MW of such capacity by 2024.[14]

Dominion Energy's 2024 RPS Development Plan also includes requests for certificates of public convenience and necessity to construct two utility-scale solar projects totaling approximately 208 MW and to implement 24 power purchase agreements for solar and energy storage resources totaling 588 MW of solar and 377 MW of energy storage, according to state data.[15] In March 2024, Dominion petitioned the state for new base and fuel rates, effectively increasing rates by $21.43 for a typical residential customer, phased in between mid-2025 and 2027, according to the utility.[16]

Appalachian Power, a Phase I utility, is required to produce electricity from 100 percent renewable sources by 2050 (see Figure 2). Their 2024 RPS Development Plan outlines strategies to meet these goals, including the procurement of renewable energy credits and investments in renewable infrastructure.[17]

In 2024, Appalachian Power filed its annual RPS Development Plan, outlining five

Figure 2: Renewable Portfolio Standard Requirements, Appalachian Power



alternative modeling scenarios to meet the VCEA's renewable energy procurement requirements. The plan includes requests for cost recovery for certain solar projects and anticipates a residential cost increase of approximately $0.05 per month per 1,000 kilowatts, according to state data.[18] Previously, the State Corporation Commission approved Appalachian Power's acquisition of 493 MW of new renewable capacity through a combination of company-owned assets and power purchase agreements. This includes 289 MW of solar and 204 MW of wind power to be acquired over a three-year period.

Utilities that fail to meet the standards and timelines outlined by the RPS requirements must make deficiency payments to the state. A portion of these payments are reallocated into job training programs in historically economically disadvantaged communities, helping to ensure that the transition to renewable energy also supports equity in development and economic opportunity for all.[19]

IV. RPS Renewable Energy Credit

The law allows the two major utilities to purchase renewable energy credits (RECs) from approved sources, which include:

- Solar or wind facilities in Virginia, off Virginia's Atlantic shoreline (or in federal waters and connected to Virginia), or in the PJM region.
- Hydroelectric facilities that are utility-owned or contracted (or small non-utility owned hydroelectric plants), located in Virginia or within the PJM region.
- Waste-to-energy or landfill gas-fired generating facilities in Virginia (except for those that use waste heat from fossil fuel combustion or biomass).
- Biomass-fired facilities in Virginia (only if capped at 10 to 15 percent of generation or total useful energy).

Note, the law requires that after 2024 a minimum of 75 percent of RECs must come from sources in Virginia.

V. Carbon Plant Retirements

The VCEA mandates the systematic retirement of carbon-emitting power plants over three phases. This initiative is central to VCEA's goal of achieving a 100 percent carbon-free electricity supply by 2050. The law outlines specific retirement deadlines for coal-fired, oil-fired, and natural gas-fired plants.

The first phase concluded in 2024 and required retirement of all large petroleum-based power plants and all coal-fired power plants. This first phase exempted coal plants owned by electric cooperatives and any coal plants in the Appalachia region that co-fire with biomass. The second phase, 2025 to 2028, requires retirement of all biomass-fired electric generating units that do not co-fire with coal, which would have closed 3 of the 4 biomass plants owned by Dominion Energy. In 2023, the Virginia General Assembly amended this part of the VCEA to keep biomass facilities open. The change was supported by industry and environmental groups upon an agreement to study the future of biomass in the state, according to a press report.[20] The final phase, 2029 to 2045, requires retirement of all other electric generating units located in Virginia owned by Dominion Energy and Appalachian Power that emit carbon as a by-product of combusting fuel to generate electricity. The law contains an emergency provision whereby utilities can petition the Virginia State Corporation Commission for an exemption if closure would endanger electric supply reliability or security.[21]

VI. Recent Plant Retirements in Virginia

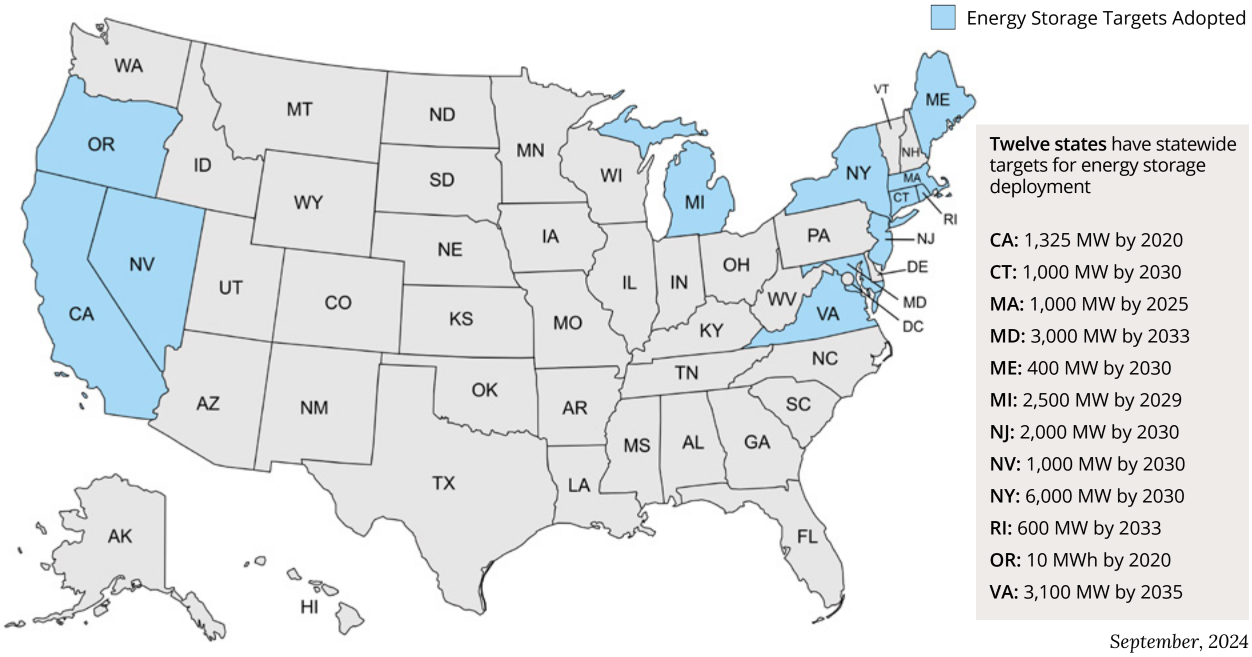
To assess the progress toward these mandates, the Virginia Department of Energy provides a list of carbon-emitting facilities subject to retirement (see Table 1).[22]

Table 1: Carbon Plant Retirements

Plant Name	County	Fuel Type	Capacity (MW)	Operator	Year Closed
Birchwood Power	King George	Coal	258.3	Birchwood Power Partners LP	2021
Buchanan Generation LLC	Buchanan	Natural Gas	88.0	Buchanan Generation LLC	2023
Chesterfield (Units 5 & 6)*	Chesterfield	Coal	1,499.5	Dominion Energy	2023
Gravel Neck 1**	Surry	Natural Gas / Petroleum	407.7	Dominion Energy	2020
Low Moor CT***	Alleghany	Petroleum Liquids	82.8	Dominion Energy	2022
Possum Point 5****	Prince William	Natural Gas / Petroleum	709.0	Dominion Energy	2021
Yorktown Unit 3*****	York	Heavy Oil	882.0	Dominion Energy	2023

**Only Units 5 & 6 at Chesterfield (coal-fired) were mandated to retire by 2024 under VCEA.*
***Closure confirmed in Dominion's 2020 Integrated Resource Plan (IRP).*
**** Listed in Dominion's IRP as anticipated for 2022 retirement.*
***** IRP indicated June 2021 closure for Unit 5; CTs were anticipated to retire in 2022.*
****** Only Unit 3 at Yorktown was oil-fired and subject to 2024 mandate.*

Figure 3: State Energy Storage Targets



September, 2024
Graphic adapted from DSIRE-NC Clean Technology Center

VII. Storage Capacity

The VCEA set forth requirements for Phase I and II utilities to develop (construct or acquire) substantial storage solutions, which recognizes the critical role of energy storage in the transition of Virginia's power sector.[23]

- Phase I Utilities (i.e. Appalachian Power): Tasked with deploying at least 400 MW of energy storage capacity by 2035.
- Phase II Utilities (i.e. Dominion Energy): Tasked with deploying at least 2,700 MW of energy storage capacity by 2035.

VCEA's storage capacity targets were developed to support renewable energy from intermittent sources, like wind and solar, which will ensure a more reliable and resilient electric power supply. Virginia has the third highest storage capacity target in the country behind Oregon and New York, according to a public service center (see Figure 3).[24]

Virginia is making progress toward its energy storage targets established under VCEA. In 2024, Dominion Energy petitioned the Virginia State Corporation Commission for 547 MW of energy storage capacity, with 16 percent as company-owned and 84 percent through power purchase agreements. This includes the deployment of three battery energy storage systems totaling over 300 megawatt-hours (MWh), scheduled for commissioning in 2025 and 2026.[25]

VIII. Energy Efficiency

The VCEA establishes an energy efficiency standard under which Dominion Energy and Appalachian Power are required to achieve incremental annual energy efficiency savings. This program reduces costs for consumers by reducing the demand for energy statewide. The VCEA sets forth these requirements for total annual energy savings through energy efficiency programs, using 2019 as a baseline year.[26]

- Phase I Utilities (i.e. Appalachian Power): Must achieve 2 percent reduction in energy consumption by 2025.
- Phase II Utilities (i.e. Dominion Energy): Must achieve 5 percent reduction in energy consumption by 2025.

After 2025, and every three years thereafter, the Virginia State Corporation Commission will establish new targets for energy efficiency and thoroughly consider the feasibility and success of the programs.[27] Ultimately, these benchmarks encourage utilities across Virginia to implement energy efficiency programs, such as appliance rebates and home weatherization assistance programs, with a particular focus on aiding low-income and historically underserved households and communities.

In 2022, Dominion Energy achieved 1.23 percent energy efficiency, short of its interim target of 1.25 percent. In 2023, it achieved 1.8 percent, also short of its interim target of 2.5 percent, according to state reporting.[28] Dominion estimates its energy efficiency savings in 2024 and 2025 will also not meet VCEA goals, according to the utility.[29]

In contrast, Appalachian Power exceeded its 2022 goal of 0.5 percent interim target by achieving 1.52 percent and exceeded its 2023 goal of 1 percent by achieving 2.41 percent, according to state data.[30]

Dominion Energy offers various energy efficiency programs, including the Income and Age Qualifying Residential Bundle Program, which provides free in-home energy assessments and installations of energy-saving products for eligible customers. Appalachian Power provides energy efficiency initiatives through its TakeCharge VA programs, offering resources like energy efficiency kits and rebates to help customers reduce energy consumption.

Of note, the law contains a provision that prohibits approval of new construction of utility-owned generating facilities that emit carbon unless the utility has already met its energy savings goals. There are exemptions; for example, the state must find that supply-side resources are more cost-effective than demand-side or energy storage resources and there is an escape hatch for endangerment to electric reliability or service security.

IX. Offshore Wind

Dominion Energy anticipates that offshore wind will contribute significantly to its portfolio transition over the next 25 years.[31] Virginia maintains considerable offshore wind capability off its coastline, which positions the state as a leader in utilizing and expanding this renewable energy source to meet growing electricity demands, according to state reporting.[32] The VCEA established requirements for offshore wind to meet the goals outlined in the law. This requirement sets a goal of 5,200 MW of offshore wind generation by 2035. To meet this goal, Dominion Energy developed its Coastal Virginia Offshore Wind Project.

The Coastal Virginia Offshore Wind (CVOW) project commenced onshore construction for transmission infrastructure in late 2023, and offshore construction commenced in early 2024. As of 2025, the project has achieved significant milestones, including the completion of two pilot turbines and ongoing construction activities. The U.S. Bureau of Ocean Energy Management has granted key federal approvals, with full operations expected by the end of 2026. Once completed, the CVOW project will generate enough energy to power up to 660,000 homes, according to utility reporting.[33]

The VCEA also requires that offshore wind projects maximize local economic benefits and prioritize jobs for historically disadvantaged workers and Virginia residents. Dominion Energy has partnered with local authorities and organizations to recruit and train workers for the CVOW project. The project is expected to support approximately 900 jobs annually during construction and 1,100 jobs during operation, according to utility data.[34]

Seven states in the Mid-Atlantic and Northeast have statewide targets for offshore wind development. In planned offshore wind development, Virginia's targets are less ambitious than New York, New Jersey, Maryland, Massachusetts, and North Carolina, but more ambitious than Connecticut, Rhode Island, and Maine, according to a public service center (see Figure 4).[35]

Figure 4: State Offshore Wind Targets

Seven states have statewide targets for offshore wind energy deployment.
Three states have goals.

CT: 2,000 MW by 2030
MA: 5,600 MW by 2027
MD: 1,200 MW by 2030
(Goal) 8,500 MW by 2031
ME: 3,000 MW by 2040
NC: (Goal) 8,000 MW by 2040
NJ: (Goal) 11,000 MW by 2040
NY: 9,000 MW by 2035
RI: 600-1,000 MW by 2022
VA: 5,200 MW by 2032

June, 2024
Graphic adapted from DSIRE-NC Clean Technology Center

X. Net Metering Caps

The VCEA includes significant enhancements to net metering, which is a utility billing practice of recording the excess energy generated by solar installation and applying it to the customer's bill as credit. The law increases the system-wide cap on the total amount of renewable energy that can be net metered in a utility's service territory from 1 to 6 percent (5 percent available to all customers and 1 percent carved-out for low-income utility customers). The following is from the VCEA:[36]

Increased Capacity Limits

- Increases qualifying residential systems from 20 kilowatts (kW) to 25 kW.
- Increases non-residential qualifying systems from 1 MW to 3 MW.

Agricultural Net Metering

- The law allows agricultural businesses to aggregate electricity consumption across multiple meters on contiguous properties.

Compensation for Excess Generation

- Customers who generate more electricity than they consume over a 12-month period can sell the excess to their utility via a power purchase agreement.
- The price for excess electricity is set by the State Corporation Commission.

XI. Utility-Scale Solar Development and Local Governance

Virginia's governance structure for energy policy operates primarily at the state level, with localities having limited authority due to the Dillon Rule, which restricts local governments to powers explicitly granted by the state. This limitation has made clean energy development at the local level more challenging.

Local governments have influenced utility-scale solar project deployments through zoning regulations and land use planning decisions. For instance, in April 2025, Mecklenburg County voted unanimously to remove utility-scale solar as a future allowed land use countywide, effectively halting large solar project development in the area, according to a press report.[37] This decision reflects a broader trend of local resistance to utility-scale solar projects, prompting discussions about the balance between state energy goals and local land use authority.

The VCEA authorizes localities to include reasonable regulations and provisions in its zoning ordinance for a special exception for any solar project. This allows the local governing body to impose conditions, such as cash payments for, or construction of, public improvements.[38]

The crux of the issue involves increasing state control over local land use siting decisions on utility scale solar projects. A substantial number of utility-scale solar projects are built in the Southside and Tidewater regions, and 90% are built on forested, crop, and pasture lands. In 2025, a legislative bill failed in committee that would have imposed a model ordinance and created a state review board to recommend approval or denial of solar project proposals before localities.[39]

XII. Virginia's Role in Multi-State Climate Policies

Virginia's participation in multi-state environmental programs and initiatives, such as the Regional Greenhouse Gas Initiative, the Social Cost of Carbon, and California's vehicle emissions standards, reflects the state's commitment to addressing climate change and reducing greenhouse gas emissions.

Regional Greenhouse Gas Initiative

The Clean Energy and Community Flood Preparedness Act required that Virginia design, implement, and regulate a carbon dioxide (CO_2) allowance auction program consistent with the Regional Greenhouse Gas Initiative (RGGI).[40] Becoming the first southern state to do so, Virginia joined RGGI in 2021, joining Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont in the program. RGGI is a cooperative market-based and multi-state program within the Northeast and Mid-Atlantic regions that is aimed at reducing CO_2 emissions from the power sector. Functioning as a type of cap-and-trade system, RGGI sets a regional limit on emissions from power plants while allowing them to also buy and sell allowances based on their total emissions level. Each state uses the revenue generated from their participation in RGGI in a different way, but generally revenue goes towards funding energy efficiency programs, renewable energy expansion, and climate adaptation measures.[41]

Virginia's participation in RGGI has been politically contentious. In 2022, Governor Glenn Youngkin and Republican legislators lobbied to withdraw the state from RGGI, arguing that the program was a type of "carbon tax" on consumers that would increase their electricity bills. The Virginia Air Pollution Control Board then voted in 2023 to repeal the state's participation in RGGI, following an executive order from the Governor directing a withdrawal. Environmental groups and state Democratic lawmakers challenged the move from the Youngkin administration, and in November 2024, the Circuit Court of Floyd County ruled that the action was unlawful and that the "only body with the authority to repeal the RGGI Regulation would be the General Assembly . . . because a statute, the RGGI Act, requires the RGGI Regulation to exist," according to reporting from an environmental association.[42] The Youngkin administration subsequently filed an appeal against the ruling, which is still ongoing.

Social Cost of Carbon

The social cost of carbon (SCC) is an economic metric used to estimate the damage associated with an increase in carbon dioxide (CO_2) emissions. Following the passage of the VCEA and Virginia's participation in RGGI, the SCC has been incorporated into the state's energy and environmental policy framework. The Virginia State Corporation Commission utilizes the SCC, which is based on the best available science and economics, including the 2016 Interagency Working Group technical support document.

In January 2025, President Donald Trump issued Executive Order 14154, titled "Unleashing American Energy," which disbanded the Interagency Working Group (IWG) on the Social Cost of Greenhouse Gases.[43] This action rescinded prior federal estimates for the social cost of carbon, methane, and nitrous oxide, and directed agencies to use the 2003 Office of Management and Budget's Circular A-4 for regulatory analyses, effectively lowering the estimated costs associated with greenhouse gas emissions.

The disbanding of the IWG and the withdrawal of its guidance documents has introduced uncertainty into state-level climate policies, including those in Virginia. Without standardized federal estimates for the social cost of carbon, Virginia may face challenges in incorporating these metrics into their energy and environmental policy frameworks, potentially affecting the evaluation of the economic risks and benefits of policy proposals aimed at reducing carbon emissions, according to academic reporting.[44]

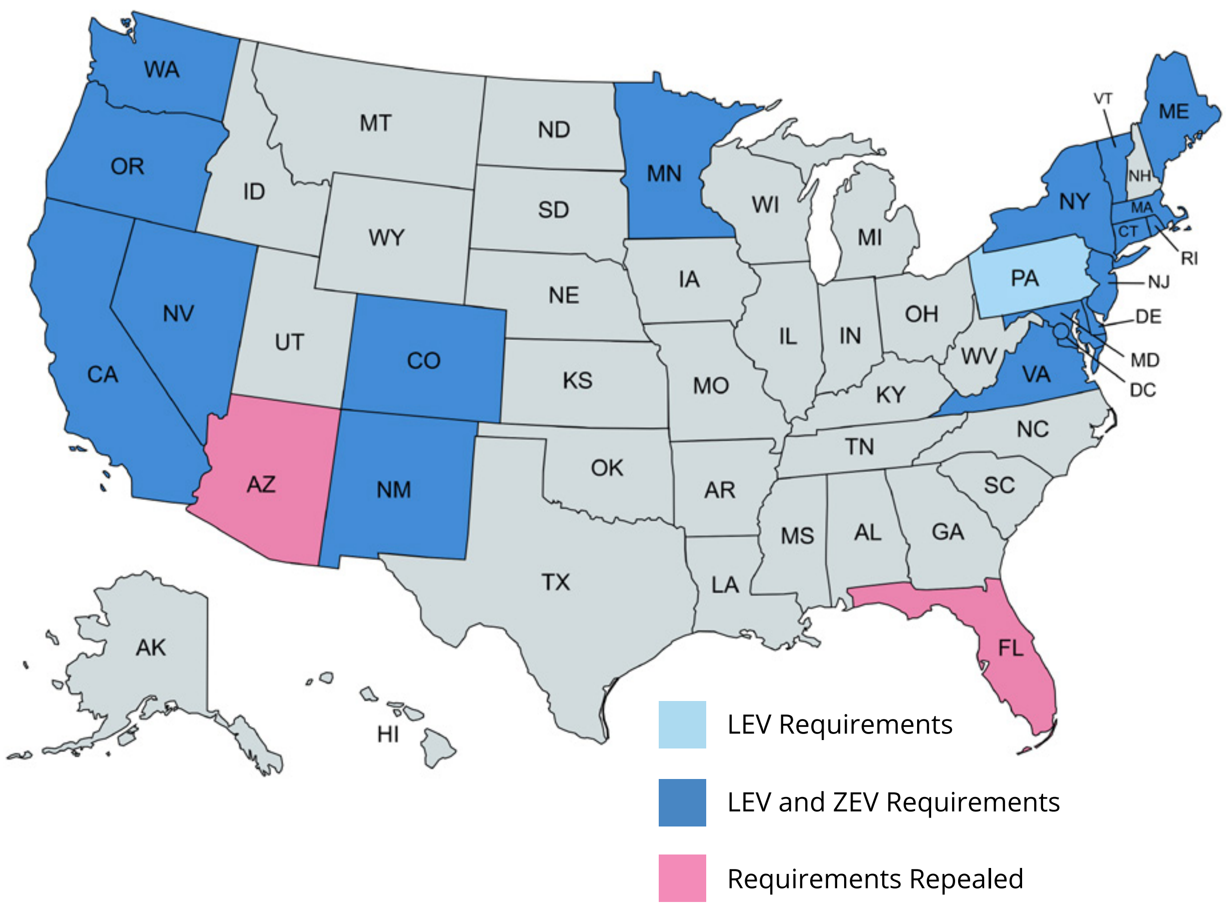
California's Vehicle Emissions Standards

California has long set the nation's most stringent vehicle emissions standards, going beyond federal regulations set under the Clean Air Act, which allows states to adopt California's stricter standards instead of the federal ones.[45] The regulations include lower tailpipe emission, stricter standards for fuel efficiency, and a mandate for zero-emission vehicle adoption. In 2021, Virginia become one of over a dozen states to adopt the standards set by California, according to a public service center.[46] As of 2025, 17 states and Washington, DC have adopted California's Zero-Emission Vehicle Standards.

The legislation, signed by then Governor Ralph Northam, argued that the stricter emissions rules would reduce air pollution, improve public health, and accelerate the transition to electric vehicles (see Figure 5).

Virginia's adoption of California standards has been politically contentious. Governor Youngkin has argued that the standards and mandates limit consumer choice, increase vehicle costs, and that Virginia lacks adequate electric vehicle infrastructure. Republicans in the state legislature have, on numerous occasions, tried to reverse the 2021 law that tied Virginia to those regulations. However, in June 2024, Governor Youngkin announced that the state would no longer adhere to the standards on January 1, 2025.[47] Although the standards at the time were to expire in California on that date, they were being replaced by another set of rules that the Youngkin administration claimed were not a part of the 2021 Virginia legislation tying the state to them. The decision swiftly garnered opposition from Democratic lawmakers, and lawsuits are pending on the decision.

Figure 5: California Vehicle Emission Standard Adoption, May 2024



Section 2
CONSUMPTION

Summary

Over the past 20 years, Virginia's total energy consumption only increased slightly, despite the Commonwealth's population increasing by over one million residents and GDP by more than 50 percent. This tracks with national trends. Virginia's energy consumption is still well above the national average – 13th highest nationally. Most significantly, over this period, Virginia has shifted its source of primary energy consumption – from coal to natural gas and solar energy.

This section examines Virginia's energy consumption trends over a 20-year period, from 2002 to 2022, analyzing changes across different sectors, and Virginia's position relative to other Mid-Atlantic states. Understanding these trends serves as the foundation upon which to assess future projections and recommendations.

In this section, all data, tables, and graphics are sourced from the U.S. Energy Information Administration, unless otherwise noted.

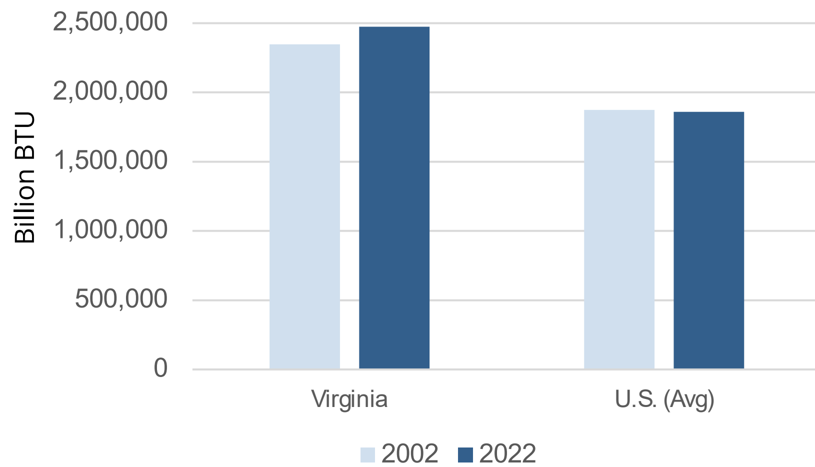
Key Takeaways

- Nationally, Virginia is consistently **in the top-15 states for highest total energy consumption.**
- **Virginia produces more with less:** energy consumption per economic output (energy intensity) is more efficient than most states.
- Since 2002, Virginia's **primary energy consumption has shifted from coal to natural gas, solar, and biomass.** Petroleum and nuclear energy have remained relatively constant.
- The transportation sector has traditionally been Virginia's largest energy consumer by sector.
- In 2022, Virginia's **commerical sector matched transportation in highest total energy consumption,** largely due to data center expansion.
- Virginia now **ranks 6th nationally in commercial energy consumption**, behind Texas, California, New York, Florida, and Illinois.

I. Total Energy Consumed

Over a 20-year period, Virginia's total energy consumption remained stable with 3.5 percent growth in energy consumption (2.3 to 2.4 billion British Thermal Unit or "BTU") which placed Virginia as the 13th highest ranked state for energy consumption (see Figure 6). During this same period, Virginia's GDP increased by almost 50 percent, and the population grew by 1.3 million.[48]

Figure 6: Total Energy Consumption, 2002-2022



II. Virginia's Rank Among PJM Mid-Atlantic States

Virginia is a member of the Regional Transmission Organization known as "Pennsylvania, New Jersey, and Maryland," or "PJM." The PJM comprises 13 states. For comparison purposes, this report examines a subset of the PJM—the states in the Mid-Atlantic region: Delaware, Maryland, New Jersey, Pennsylvania, Virginia, and West Virginia (see Table 2 for comparisons).

In 2022, Virginia's total energy consumption exceeded its Mid-Atlantic neighbors – Delaware, Maryland, New Jersey, and West Virginia (see Figure 7). Only Pennsylvania consumed more (3.7 billion BTU).[49]

Figure 7: PJM Mid-Atlantic States Total Energy Consumption, 2002-2022

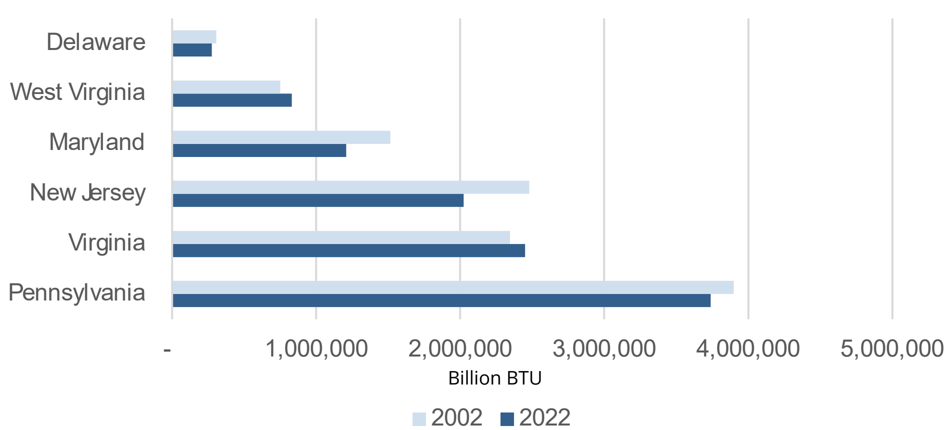


Table 2: 2024 PJM (Mid-Atlantic) State Indicators and Energy Consumption

State (PJM-RTO)	Total Population	2022 Real GDP[1]	Per Capita Income	2022 Total Energy Consumption (Billion BTU)	2022 Total Energy Intensity
Delaware	1.1M	$77,149	$65,392	275,185	3.57
Maryland	6.3M	$416,406	$73,849	1,207,626	2.90
New Jersey	9.5M	$650,236	$80,724	2,024,328	3.11
Pennsylvania	13.1M	$779,361	$67,839	3,738,924	4.80
Virginia	8.8M	$580,475	$72,855	2,449,868	4.22
West Virginia	1.8M	$77,188	$52,585	829,676	10.75

1. *Real gross domestic product (GDP), million chained (2017) dollars*

III. Virginia's Energy Intensity

Energy intensity refers to energy consumption per real dollar of gross domestic product (GDP). This is the ratio of energy used to the total value of a state's economic output and indicates the amount of energy used to support economic and social activity. A lower ratio means less energy is used to produce a unit of economic output, which is a measure of state-wide energy efficiency.

In 2002, Virginia's energy intensity was 6,000 BTU per real dollar of GDP.[50] By 2022, energy intensity had decreased to 4,000 thousand BTU per real dollar of GDP - ranked 32nd nationally in energy intensity (same ranking in 2002).

IV. Primary Consumption by Energy Source

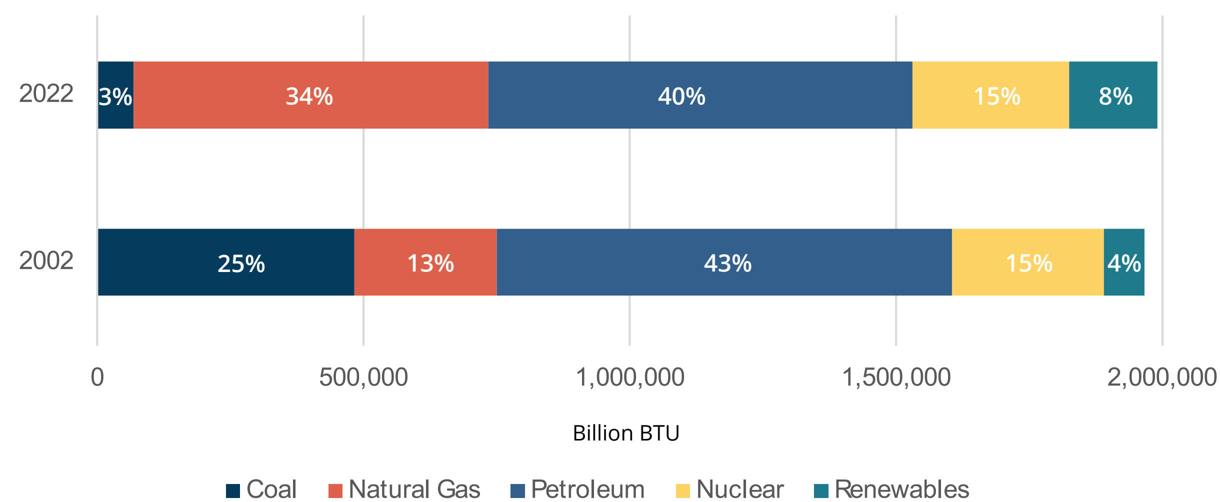
Primary energy is the total amount of energy used directly from natural sources to meet the state's energy needs, organized by the source of energy: fossil fuels (oil, natural gas, and coal), nuclear energy, and renewable energy (wind, solar).[51] Primary energy consumption is calculated by adding all energy inputs to the economy, including production, and imports, and subtracting exports.

Virginia's primary energy consumption has experienced significant shifts in its use of fossil fuels and renewable energy (see Table 3). The following looks at primary consumption trends from 2002 to 2022. Currently, Virginia's primary energy consumption is dominated by petroleum (40 percent) and natural gas (34 percent) (see Figure 8).

Table 3: Change in Primary Consumption by Energy Source, 2002-2022

Percent Change	Energy Source	2022 BTUs	2002 BTUs	Difference	2022 U.S. Rank (20-yr. change)
-85%	Coal	68 B	483 B	-415 B	31st (-15)
+150%	Natural Gas	666 B	267 B	399 B	16th (+7)
-8%	Petroleum	797 B	855 B	-58 B	12th (+1)
+3%	Nuclear	294 B	285 B	9 B	12th (+3)
+117%	Renewables	165 B	76 B	89 B	18th (+1)

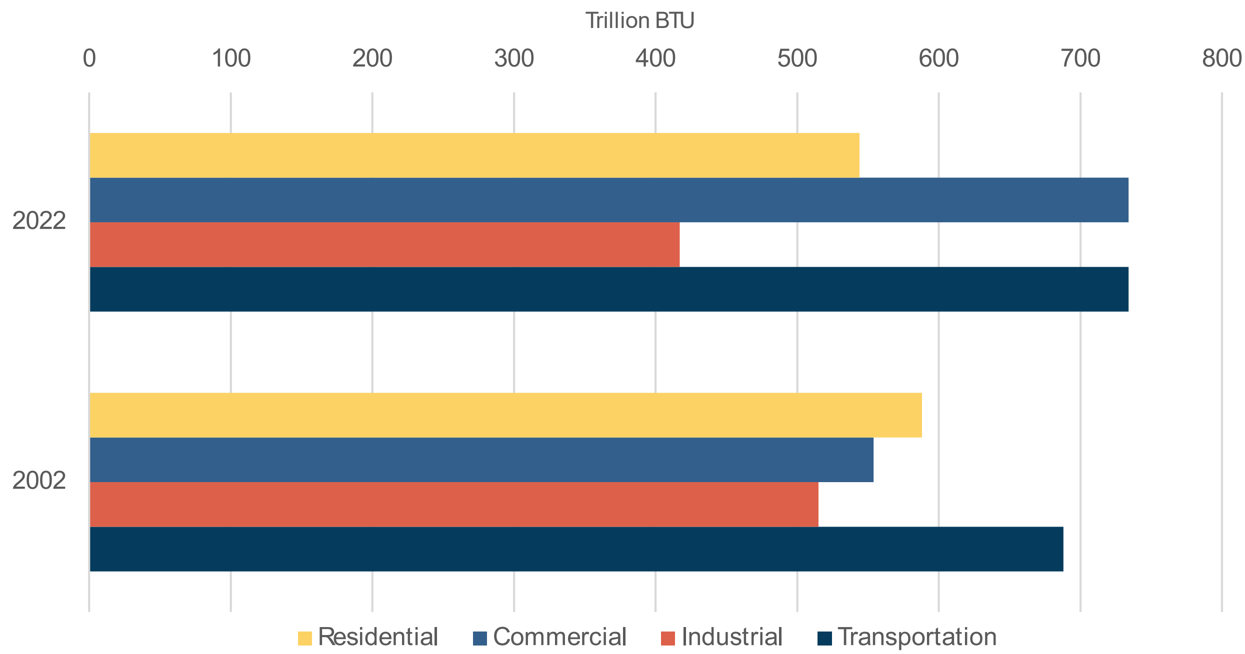
Figure 8: Primary Energy Consumption by Source and BTU, 2002-2022



V. Energy Consumption by End Use Sector

In 2002, the transportation sector accounted for most of energy end use consumption (29 percent). By 2022, the commercial sector experienced the largest growth at 33 percent, and now accounts for 30 percent of end use consumption (see Figures 9).[52] In 2022, Virginia ranked 6th nationally in commercial energy consumption, behind Texas, California, New York, Florida, and Illinois – states with larger populations. During this same period, the residential and industrial sector consumption decreased.

Figure 9: Virginia Consumption by End Use Sector, 2002-2022



VI. Energy Consumption by End Use Sector: Mid-Atlantic State Comparisons

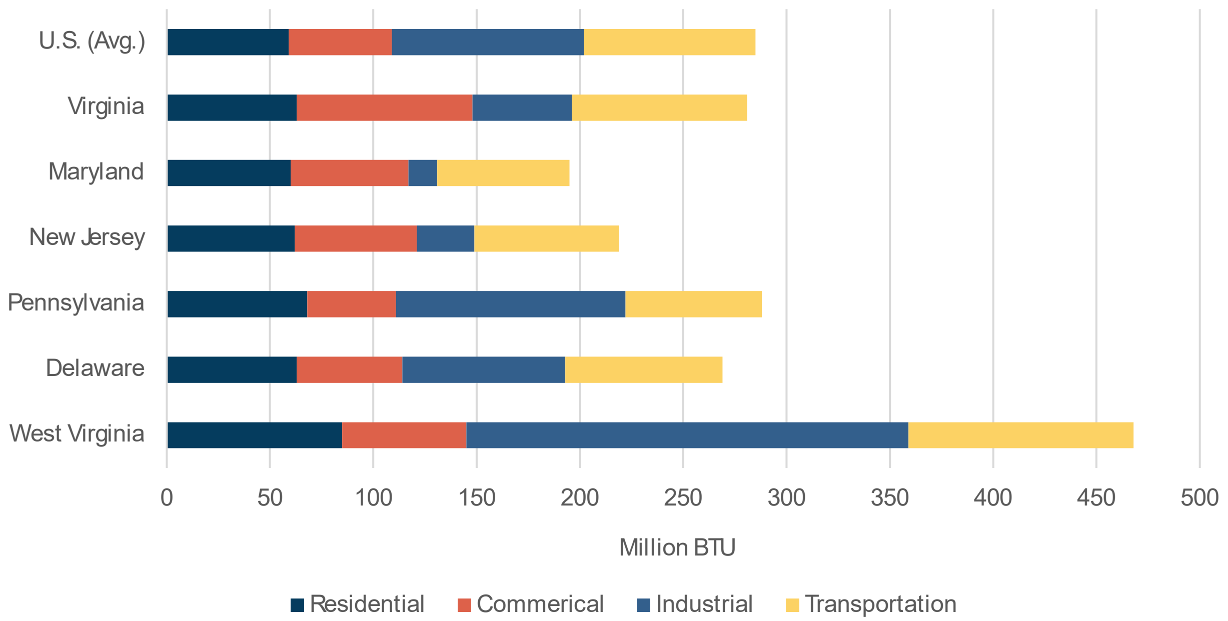
Commercial: Virginia consumes more total energy in the commercial sector than the other five Mid-Atlantic states, 27 percent higher.

Industrial: Virginia consumes the second most total energy in the industrial sector – exceeded by Pennsylvania.

Transportation: Virginia consumes the second most total energy in the transportation sector – exceeded by Pennsylvania.

Residential: Virginia consumes more energy in the residential sector than Maryland, West Virginia, and Delaware, but less than Pennsylvania and New Jersey.[53]

Figure 10: PJM Mid-Atlantic Per Capita Energy Consumption by End Use Sector, 2022



VII. Per Capita Energy Consumption

On a per capita basis, Virginia's total energy consumption is around the national average of 280 million BTU. From 2002 to 2022, Virginia's per capita energy consumption decreased by 11 percent while its population increased by 19 percent.[54]

By end-use sector (residential, commercial, industrial, electric), Virginia's per capita consumption in the commercial sector is the 4th highest in the U.S – 84 million BTU per capita (see Figure 10).[55] This represents a significant increase over the 10-year period beginning in 2012 when Virginia was ranked 46th nationally in per capita commercial energy consumption. Per capita energy consumption in the residential and transportation sectors hover around the national average, while the industrial sector is ranked 36th nationally.

VIII. Electricity Consumption

Over the past 20 years, Virginia's electric power sector consumption by energy sources experienced a significant decrease in coal and petroleum and a significant increase in natural gas, biomass, and solar. During this same period, nuclear and hydropower maintained consistent electricity consumption (see Figures 11.1 and 11.2).[56] Note, these sources do not account for all the demand. Much of Virginia's electricity comes from out of state.

Figure 11.1: Virginia Electricity Consumption by Energy Source, 2002-2022

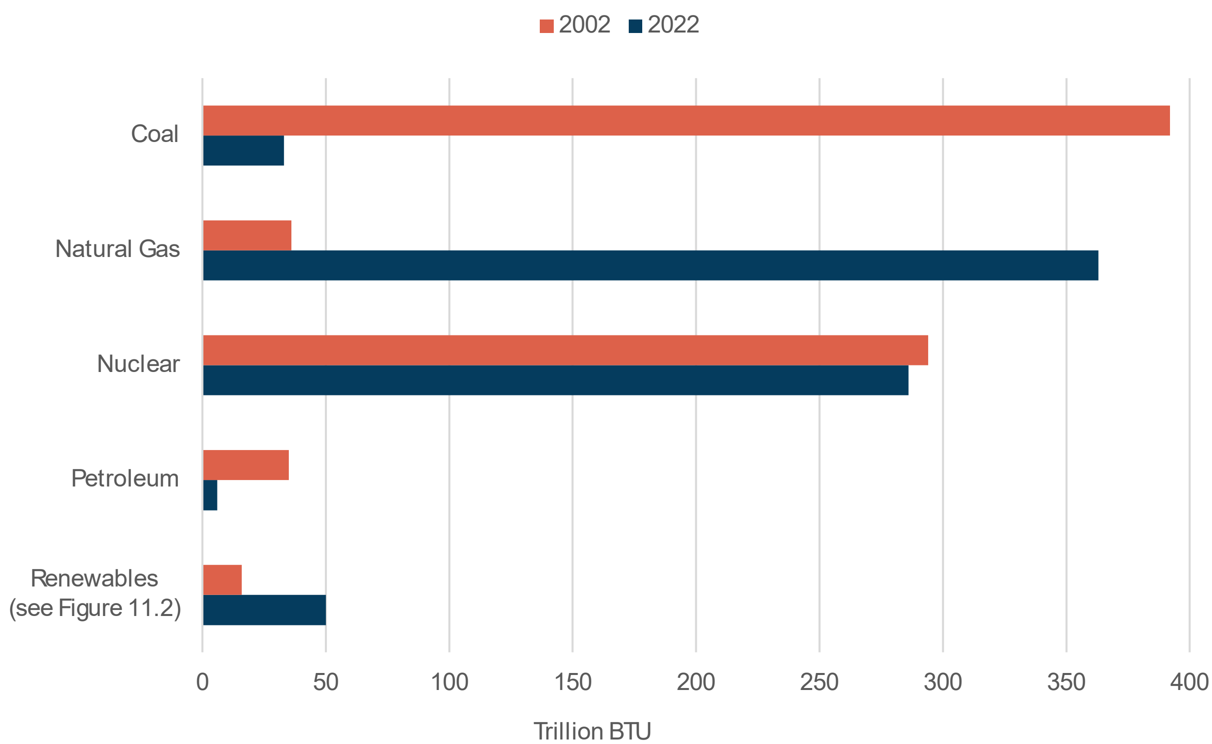
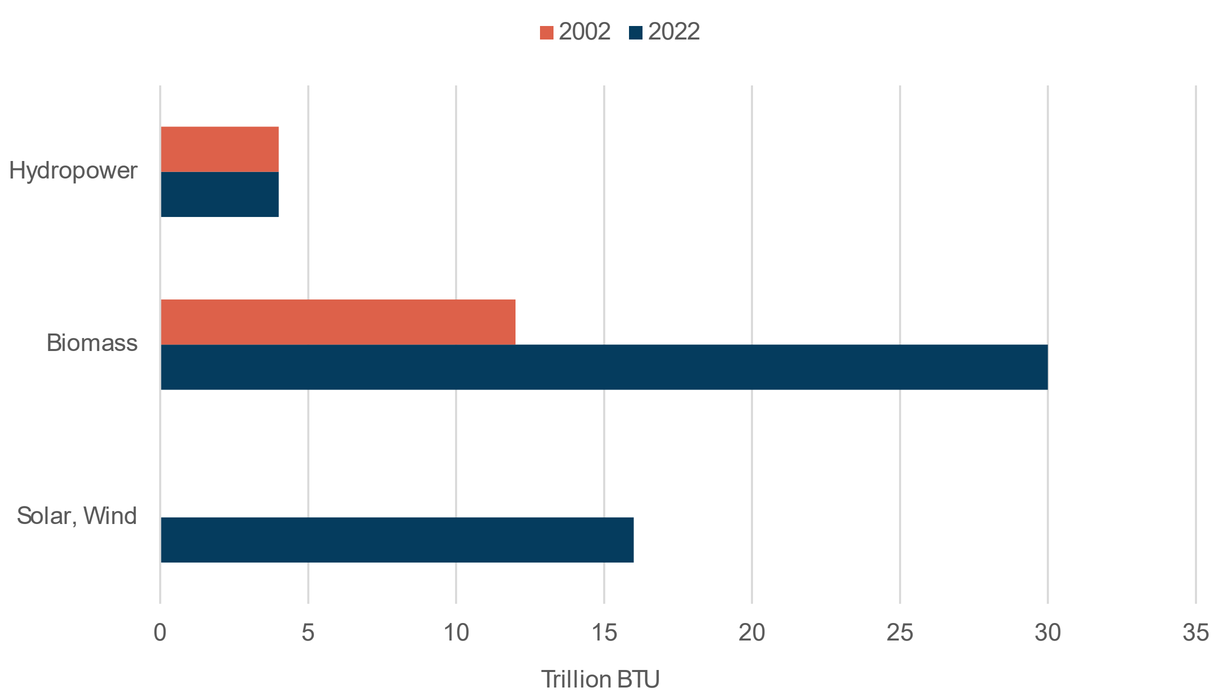


Figure 11.2: Virginia Electricity Consumption by Renewables, 2002-2022



Section 3
ENERGY PRODUCTION

Summary

Over the past two decades, Virginia's primary energy production declined but has remained in the same ranking nationally over the past 20 years. The greatest declines were in coal and petroleum production, while natural gas, biomass (wood), and solar production increased the most. When it comes to electricity generation, Virginia's mix of sources has increased and shifted from coal to natural gas. Since Virginia's production has decreased while its consumption increased, this makes Virginia a net importer of electricity.

This section examines Virginia's primary and secondary energy production trends over a 20-year period, the largest power plants and geographic locations, and energy imports and exports. Understanding this information serves as the foundation upon which to assess future projections and recommendations.

In this section, all data, tables, and graphics are sourced from the U.S. Energy Information Administration, unless otherwise noted.

Key Takeaways

- Virginia's primary energy production decreased by one-third. Coal and petroleum decreased the most. Nuclear power is the highest source of primary energy production. Natural gas, biomass, and solar energy increased the most.
- Despite this trend of decreasing energy production, electricity generation has increased significantly. Virginia shifted its reliance from coal to natural gas. Nuclear energy has remained steady as a source of production. Per facility, Virginia's nuclear power plants generate the most power.
- Virginia's energy consumption exceeded its production, thereby making it a net energy importer. In 2023, Virginia was the highest net electricity importer of any state.

I. Primary Energy Production

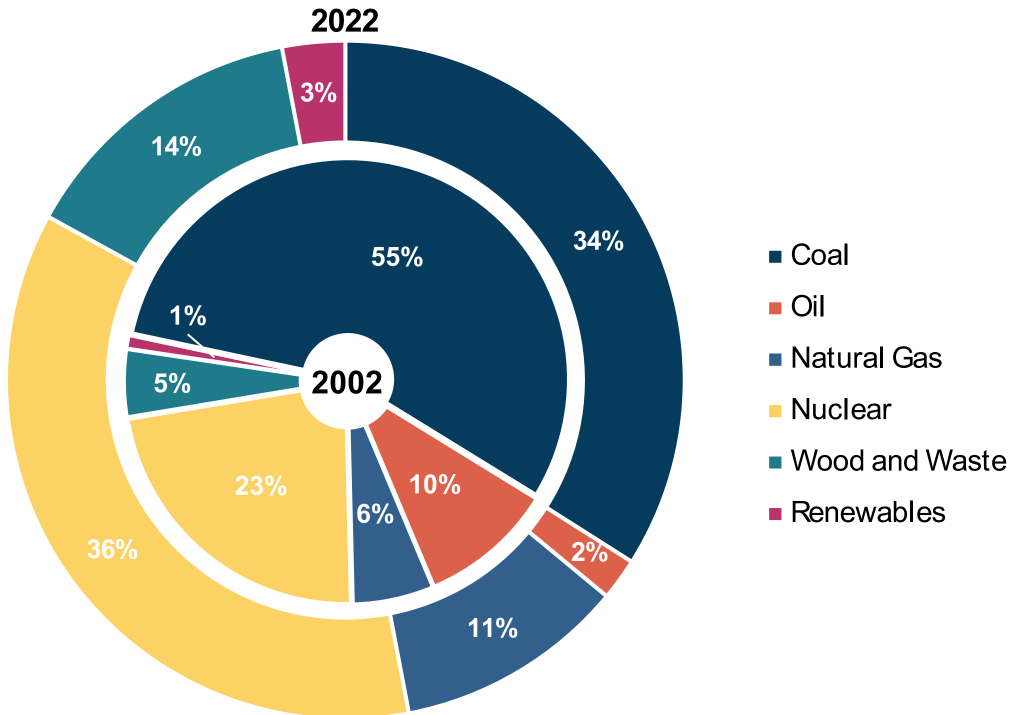
Over the past 20 years, Virginia's primary energy production – energy produced before any transformation to secondary or tertiary forms of energy – declined by 34 percent. In 2002, Virginia produced 1.2 trillion BTU from all energy sources. By 2022, production declined to 808 trillion BTU. Virginia's is ranked 17th in total primary energy production nationally, a position it has held for the past two decades (see Table 4 and Figure 12).[57]

Table 4: Primary Energy Production Trends, 2002-2022

20-Yr Trend	Energy Source	Changes
-65%	Coal	In 2002, Virginia produced 793 trillion BTU of coal. By 2022, coal production had decreased by 65 percent to 279 trillion BTU. In 2002, Virginia had 141 coal mines. By 2023, the number of coal mines decreased to 41. Of the 21 states that still produce coal, Virginia is in the top ten, a ranking that has not changed in 20 years. Virginia's coal production represents 2 percent of U.S. coal production and 1 percent of U.S. recoverable coal reserves[1] (141 million short tons).[60]
+9%	Nuclear	In 2002, Virginia produced 285.5 trillion BTU of nuclear power. By 2022, nuclear production had increased by about 9 percent to 310 trillion BTU.[61]
+18%	Natural Gas	In 2002, Virginia produced 79 trillion BTU of natural gas at 3,400 wells. By 2022, production increased by 18 percent (to 93 trillion BTU) and the number of wells expanded to 8,000. Of the 34 states that produce natural gas, Virginia is ranked 18th – a slight increase in state position (it was 20th in 2002). Most of Virginia's natural gas is found in coalbed methane reserves, of which Virginia contains one-fifth of U.S. proved reserves. This is the third-largest amount of any state.[62]
-90%	Petroleum	In 2002, Virginia produced 25,000 barrels of crude oil. In 2022, crude oil production decreased almost 90 percent (to 3,000 barrels/year). Virginia's crude oil production peaked in 1983 at 65,000 barrels.[63]
+75%	Biomass	In 2002, Virginia produced 67 trillion BTU of biomass (wood and waste), placing Virginia 15th nationally. By 2022, Virginia had increased production by 75 percent (to 118 trillion BTU) and moved the state to the 6th position nationally. Virginia has 7 biomass production plants.[64]
638%	Other Renewables	Over the past 20 years, renewables increased 6-fold (from 3.6 to 23 trillion BTU in 2020). Virginia produces renewable energy from hydropower and solar. Over the past 20 years, renewables increased 5-fold (from 3.6 to 23 trillion BTU in 2020). Currently, Virginia has over 100 utility-scale solar plants (>1MW), 25 conventional hydropower plants, and 2 unconventional (pumped storage) hydropower plants, according to U.S. government data.[65]

[1] *The U.S. government classifies "recoverable coal reserves" as the quantity of coal that can be recovered from existing coal reserves at producing mines.*

Figure 12: Virginia Primary Energy Production, 2002-2022



II. Electricity Generation

In 2002, Virginia's electricity sector generated 75,000-megawatt hours (MWh), and relied primarily on coal (49 percent) and nuclear energy (42 percent). By 2022, electricity generation increased 19 percent (to 89,000 MWh) and relies primarily on natural gas (55 percent) and nuclear energy (32 percent). Virginia's largest electric power plants (generation facilities) are nuclear and natural gas plants (see Appendix E).

III. Virginia's Electricity Imports

Virginia's electricity consumption exceeds its production, therefore Virginia imports electricity from other states in the Eastern Regional grid. In 2002, Virginia's net import of electricity was 37 million MWh.[1] By 2022, imports increased 35 percent to 50 million MWh. This represents the highest net electricity importer of any state in 2023 (see Figures 13-14).[58]

IV. Virginia Primary Energy Imports and Exports

Coal: Virginia exports more coal than it imports. The Norfolk Customs District exports about one-third of the nation's coal exports, the largest share handled by

[1] U.S. Energy Information Administration defines Net Interstate Trade as the Total Supply – (Total Electric Industry Sales + Direct Use + Total International Exports + Estimated Losses).

Figure 13: Virginia Net Electricity Imports, 2002-2022

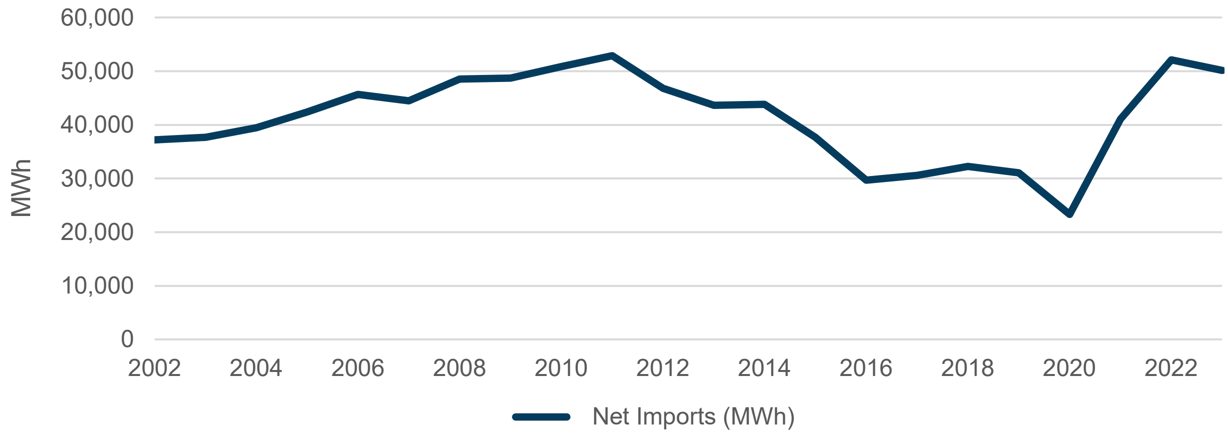
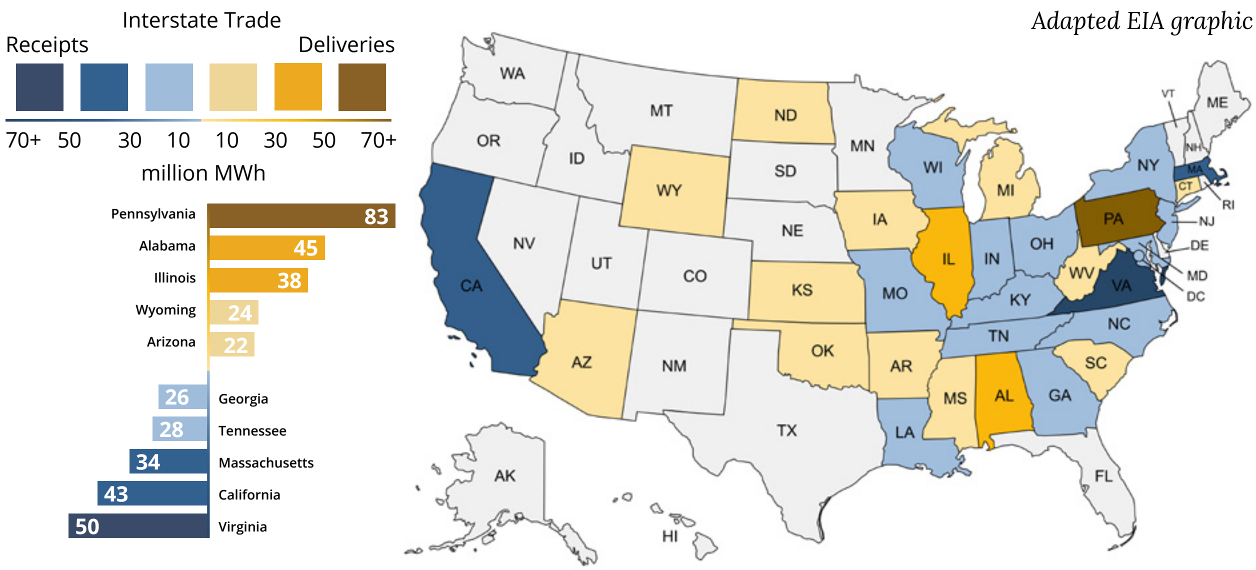


Figure 14: U.S. Net Electricity Interstate Trade, 2023



any U.S. port. The U.S. exports its coal to over 70 countries. The top five countries in 2023 are India (19 percent), The Netherlands (14 percent), Japan (9 percent), Brazil (7 percent), and South Korea (6 percent).[59]

Natural Gas: Virginia imports natural gas from other U.S. states, such as Maryland and West Virginia, as part of a pipeline distribution network that reaches other states, such as North Carolina, Tennessee, and Washington D.C.

Petroleum: Virginia maintains minor crude oil reserves but does not have any operating refineries and does not export petroleum products.

Primary Energy Production Comparisons - PJM Mid-Atlantic States: Of the six PJM Mid-Atlantic states (VA, MD, PA, NJ, WV, and DE), Virginia produces more primary energy than all the states except for Pennsylvania and West Virginia.

Section 4
ENERGY PRICES AND EXPENDITURES

Summary

Virginia has had moderate energy prices over the past two decades. Currently, Virginia's overall energy prices are comparable to the national average when considering all energy sources and end-use sectors (residential, commercial, industrial, electric). However, price points differ depending on the end-use sector. Electricity prices are lower in all sectors (residential, commercial, industrial) compared to national averages, but electricity sales are among the highest in the country, especially in the commercial sector.

On energy expenditures, Virginia spends the 12th highest amount on electricity nationally, well above the national average. On a per capita basis, Virginians spend less than the national average. Finally, transportation expenditures far exceed those of all the other sectors.

In this section, all data, tables, and graphics are sourced from the U.S. Energy Information Administration, unless otherwise noted.

Key Takeaways

- Virginia's natural gas prices for homeowners peaked in 2007, decreased from 2008 to 2016, and have been on the rise since then and have reached historic highs recently.
- Virginia's natural gas prices for commercial customers reflect U.S. national average prices but have trended lower in recent years. Natural gas prices for industrial customers have consistently been higher than national averages.
- Virginia's electricity prices have been lower than national averages—on average 18 percent lower—across all sectors (residential, commercial, and industrial).

Key Takeaways (*continued*)

- Virginia's total electricity sales to residential, commercial, industrial customers are among the 15-highest states nationally, and 70 percent higher than the national average. The commercial sector experienced the largest increase.
- Virginia's per capita energy spending has more than doubled to nearly $5,000 annually, which is 15 percent lower than the national average and ranked 32nd nationally (31 states have higher per capita spending).
- Virginians spend more money on energy in all end-use sectors (residential, commercial, residential, industrial, and transportation) compared to national averages. Of all end-use sectors, Virginians spend the most on transportation.

I. Total Energy Prices

Over the past 20 years, Virginia's total energy prices have increased by nearly 150 percent, which is consistent with average state increases across the country during this period. This is largely a consequence of higher fuel prices and demand. Other factors can also influence prices, such as weather, global supply chain issues, and grid infrastructure. Since 2002, Virginia's total energy prices have increased from $11 to $26 per million BTU.[66]

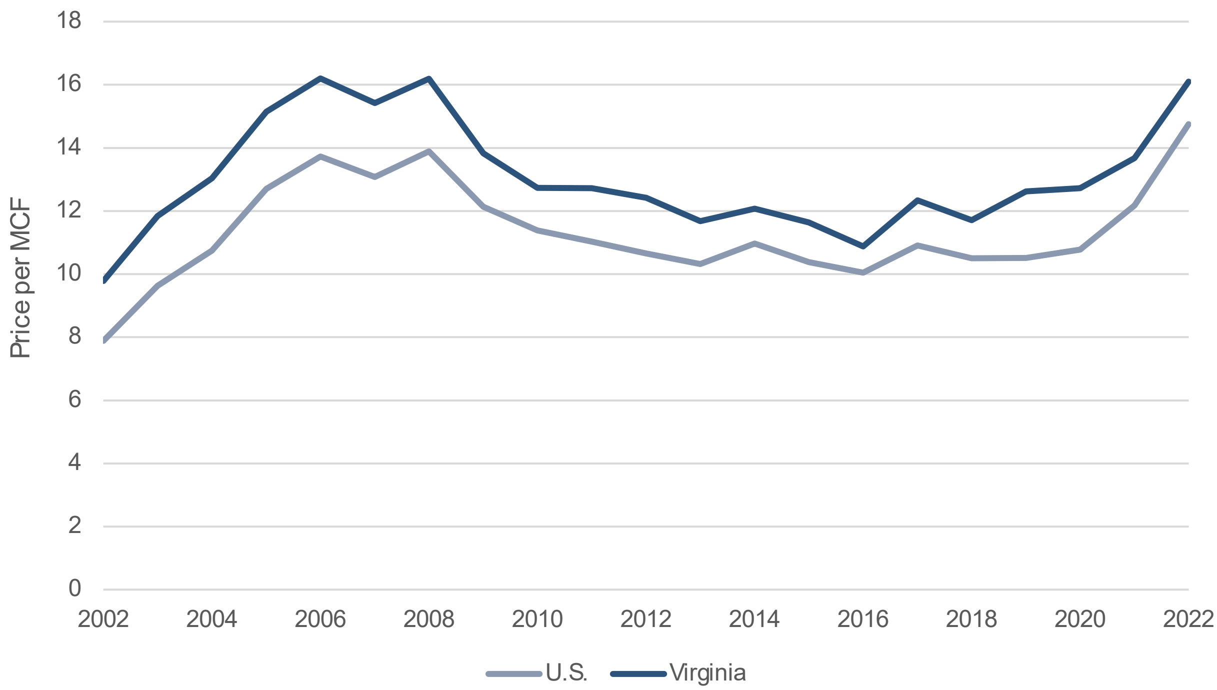
In 2022, Virginia's energy prices were in the median range when compared to all other states, ranked 25th nationally.

II. Natural Gas Prices (Residential)

In 2022, Virginia's residential natural gas prices reached a 16-year high not seen since its peak in 2008, right before the Great Recession. The price drop between 2007 to 2013 was largely due to economic conditions and technological advances (fracking), which led to a 25 percent increase in production.

Virginia's natural gas prices for residents are consistently higher than national

Figure 15: U.S. and Virginia Natural Gas Prices (Residential)



averages (see Figure 15) and is ranked 10th highest in the country.[67] In the PJM Mid-Atlantic states, Virginia's natural gas prices for residents are higher than all states, except for Maryland.[68]

III. Natural Gas Prices (Commercial and Industrial)

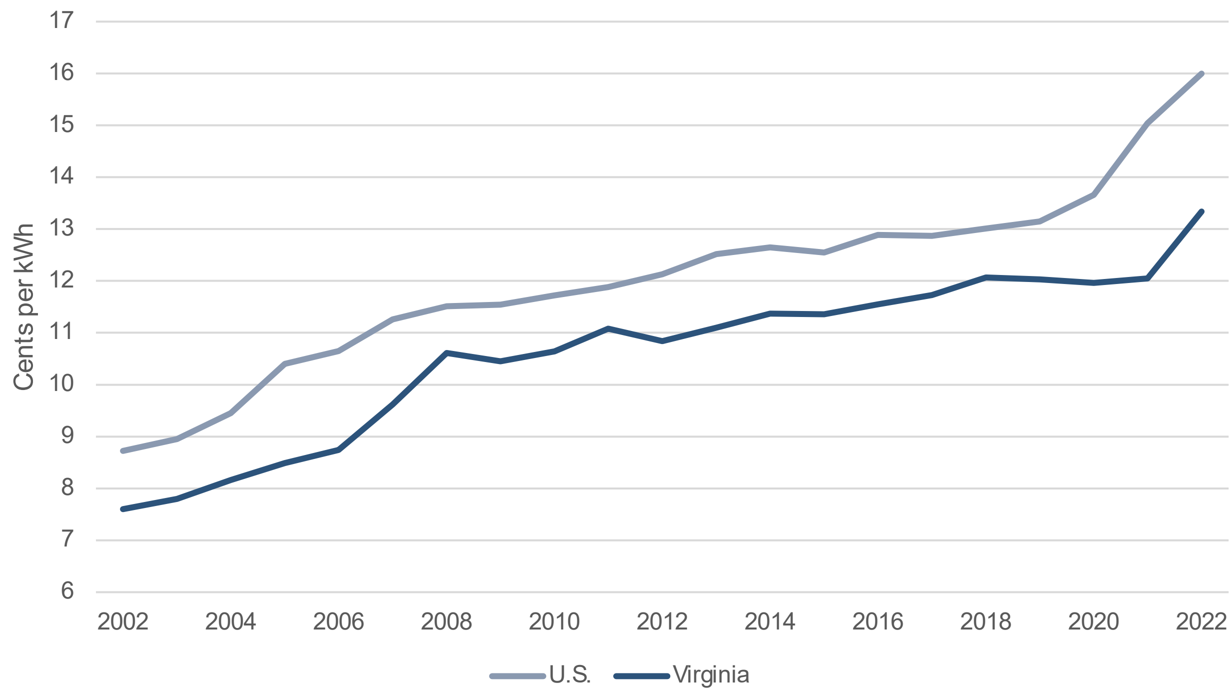
In the commercial sector, U.S. natural gas prices have fluctuated from a high in 2008 of $12.23 per thousand cubic feet (cu ft) to the most current price of $10.14/thousand cu ft. Virginia's commercial gas prices largely track that trajectory, with a high in 2008 of $12.81/thousand cu ft to a current price of $9.40/thousand cu ft, lower than the national average.[69]

In the industrial sector, U.S. natural gas prices have fluctuated from a high in 2008 of $9.65 per thousand cu ft to the most current price of $3.93/thousand cu ft. Virginia's industrial gas prices posted a high in 2008 of $11.49/thousand cu ft, well above the national average, to a current price of $4.34/thousand cu ft, also above the national average.

III. Electricity Prices (Residential)

Over the past 20 years, Virginia's residential electricity prices have increased by

Figure 16: U.S. and Virginia Average Electricity Prices (Residential)



over 70 percent, reflecting national trends. Historically, Virginia has had lower average electricity prices—on average 18 percent lower—than the national average (see Figure 16).[70] Currently, Virginia's electricity price is ranked 32nd nationally, therefore less than 31 other states.

In the PJM Mid-Atlantic states, Virginia's most current electricity price ($13.34 per kilowatt hour or "kWh") is lower than the other states, which range from $14.82 per kWh (West Virginia) to $19.70 per kWh (New Jersey).[71]

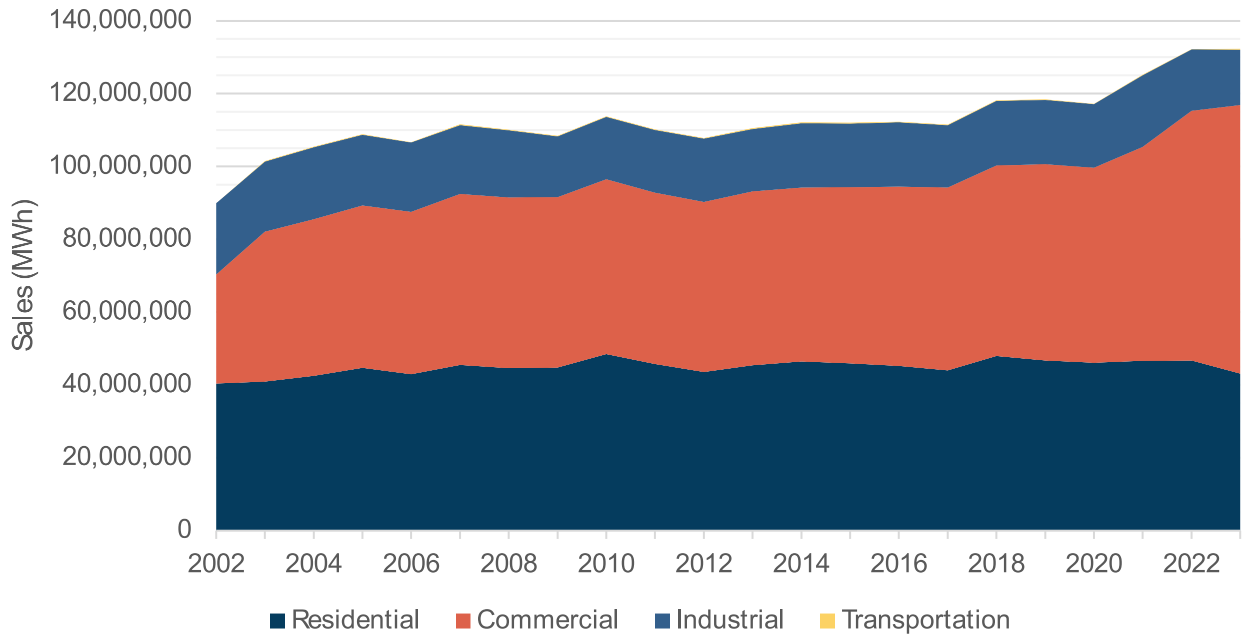
IV. Electricity Prices (Commercial and Industrial)

In the commercial sector, over a 20-year period, Virginia's electricity prices increased by 64 percent (to $0.0966 per kWh), but is still less than the national average ($0.1259 per kWh).

Likewise, in the industrial sector, over a 20-year period, electricity prices increased by 93 percent (to $0.0799 per kWh), but is also less than the national average ($0.0804 per kWh).

Overall, Virginia's average electricity prices across all sectors are below the national average (Virginia—$0.1079 per kWh; U.S. average—$0.1320 per kWh).[72]

Figure 17: Virginia Electricity Sales by Sector, 2002-2023



V. Total Electricity Sales (kWh)

From 2002 to 2022, Virginia's total electricity sales (per million kWh) to customers increased by 52 percent, while during this period population increased by 1.3 million and GDP grew by $200 billion. As of 2022, Virginia's total electricity sales (residential, commercial, industrial) are among the 10-highest ranked states nationally and 70 percent higher than the national average.

The commercial sector represented the largest increase, growing over 100 percent, while the residential sector experienced modest growth at 27 percent, and the industrial sector experienced a decline of 10 percent (see Figure 17).[73]

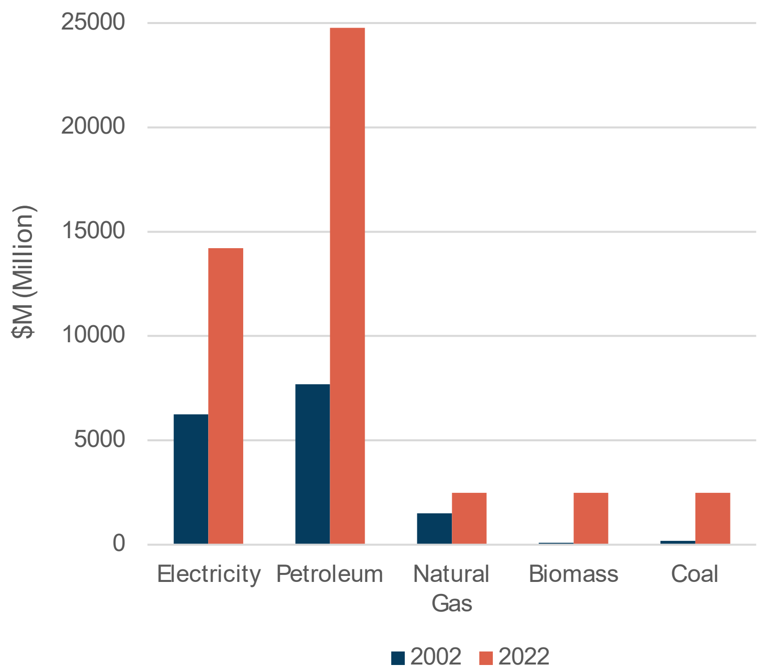
In the PJM Mid-Atlantic states, Virginia sells more electricity than all other states except for Pennsylvania. As of 2025, Virginia's commercial sector had the highest sales (approximately 6,000 MWh) compared to the other states.[74]

VI. Total Energy Expenditures

Since 2002, the amount of money Virginians spent on energy for both primary and electricity sources increased 170 percent ($15.6 million in 2002 to $42.4 million in 2022).[75] As of 2022, Virginia's energy expenditures were 12th highest in the country, roughly 25 percent higher than the national average of $34 million.

All energy sources had increased expenditures over this period, with primary energy sources (coal, petroleum, and natural gas) increasing the most at over 200 percent, followed by biomass at 197 percent, electricity at 127 percent, and nuclear at 32 percent (see Figure 18).[76]

Figure 18: Change in Energy Expenditures, 2002-2022



VII. Per Capita Expenditures

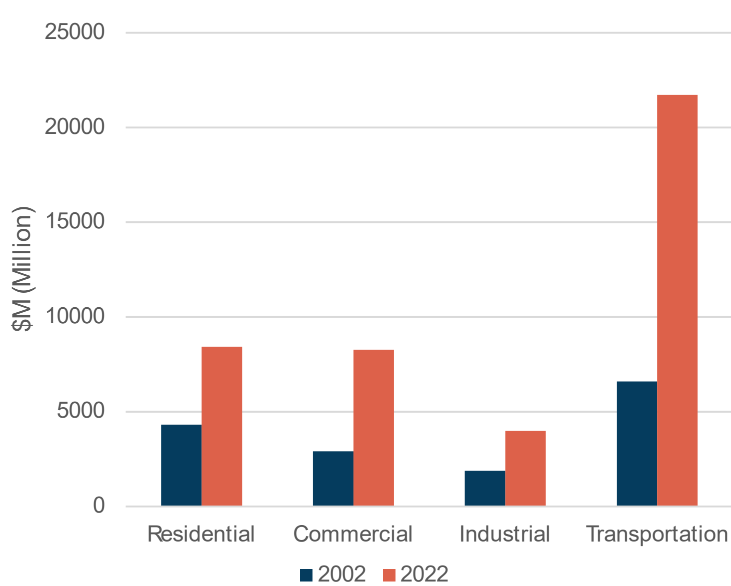
In 2002, Virginia's energy expenditure per capita was about $2,000 annually.[77] In 2022, it more than doubled to nearly $5,000 annually, which is 15 percent lower than the national average and 32nd nationally.[78]

In the PJM Mid-Atlantic states, Virginia's current per capita expenditures are lower than West Virginia ($6,219), but higher than Pennsylvania ($4,848), Delaware ($4,725), and New Jersey ($4,321).[79]

VIII. Total Energy Expenditures by End-Use Sector

Since 2002, all end-use sectors have increased energy expenditures by over 100 percent, with transportation expenditures higher than all other sectors combined (see Figure 19). Virginia's current energy end-use expenditures are higher than the national averages for commercial (74 percent higher), residential (30 percent higher), and transportation (29 percent higher), but less than the national average for industrial (29 percent lower).

Figure 19: Change in Total Expenditures per End Use Sector, 2002-2022



Section 5

ECONOMIC DEVELOPMENT AND JOB CREATION

Summary

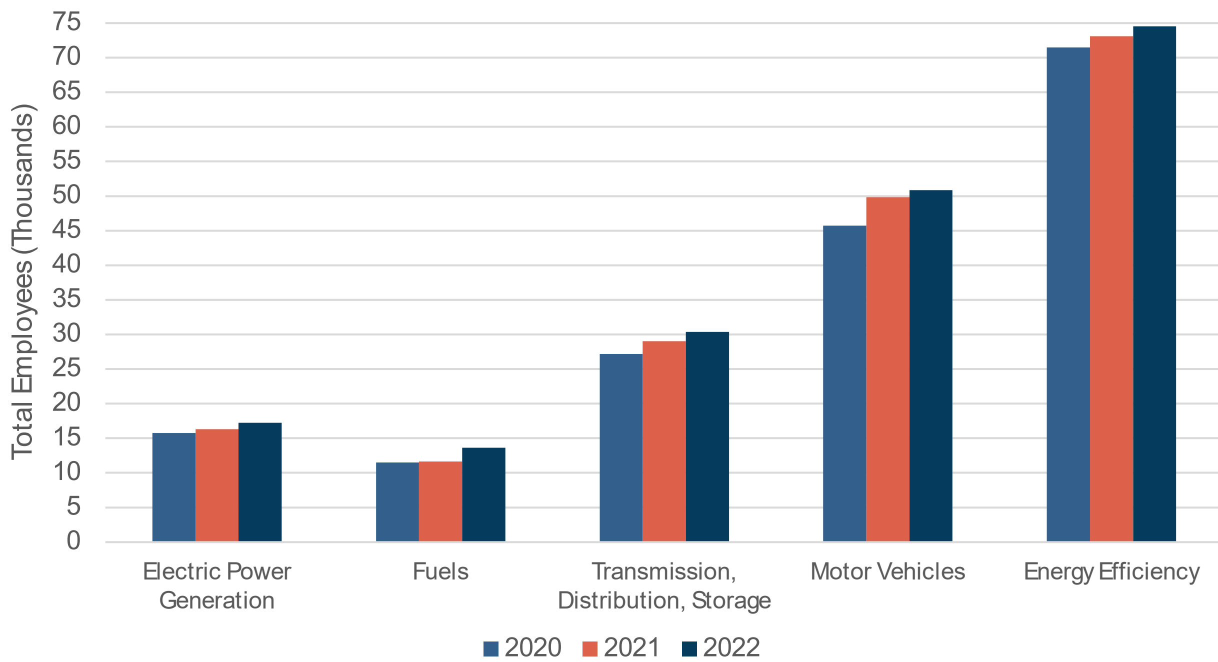
The energy sector has had a crucial role in Virginia's economic development, shaping job creation, infrastructure investments, and overall GDP contributions. As Virginia transitions to cleaner energy sources, economic shifts are evident in employment distribution, investment trends, and technological advancements. The energy efficiency sector represents the area of highest employment growth, followed by electric vehicles. Electric vehicle infrastructure represents the greatest contribution to state economic activity and GDP growth. While every municipality in Virginia saw increases in energy jobs, the Northern and Central regions saw the greatest growth.

This section explores Virginia's employment trends across several sectors and identifies the geographic locations for these trends. It also delves into the economic benefits of certain state and national policy and regulatory decisions, such the Regional Greenhouse Gas Initiative and the Inflation Reduction Act. Finally, the section details how energy has contributed to Virginia's GDP.

Key Takeaways

- In 2022, Virginia's energy sector employed approximately 187,000 workers, which represents almost 5 percent of Virginia's total civilian labor workforce.
- In 2022, Virginia's energy efficiency sector comprised 40 percent of its total energy workforce. Virginia ranks in the top 10 states for energy efficiency employment.
- In 2022, Virginia's solar industry employed the most people in the electricity sector (over 5,000).
- In 2022, Virginia's electric vehicle and energy efficiency sectors contributed the most to GDP—adding $3.8 billion in economic activity.
- Since 2010, Virginia's coal jobs have decreased by 70 percent.
- During Virginia's participation in the Regional Greenhouse Gas Initiative (2021-2023), the program generated approximately $200M per year in revenue, which was distributed to flood preparedness and energy efficiency programs.

Figure 20: Virginia Energy Section Employment Distribution, 2020-2022



I. Energy Sector Employment Trends

As of 2022, Virginia's energy sector employed approximately 187,000 workers, accounting for 2.3 percent of the national energy workforce, according to U.S. Department of Energy (DOE).[80] This represents almost 5 percent of Virginia's total civilian labor workforce.[81]

From 2020 to 2023, Virginia's energy sector expanded its workforce by an average ofx 10 percent. Energy sector employment is distributed across five major sectors (see Figure 20):

- Energy Efficiency: 74,516 workers
- Motor Vehicles: 50,871 workers
- Transmission, Distribution, and Storage: 30,350 workers
- Electric Power Generation: 17,246 workers
- Fuels: 13,642 workers

II. Energy Efficiency Sector

The energy efficiency sector comprises 40 percent of Virginia's total energy workforce, according to DOE.[82] This mirrors national trends, where energy efficiency jobs outpace other sectors, including fossil fuel-based jobs. Virginia ranks in the top

10 states for energy efficiency jobs. The top ten states for energy efficiency jobs are as follows: California (310,433), Texas (154,565), New York (117,339), Florida (112,620), Illinois (86,916), Massachusetts (84,556), Michigan (84,052), North Carolina (84,020), Ohio (79,653), and Virginia (74,516), according to the DOE.[83]

Within the energy efficiency sector, Energy Star and efficient lighting jobs employ the most people. This is followed by traditional HVAC (heating, ventilation, and cooling) jobs, and then high efficiency/renewable HVAC jobs, and finally, materials and insulation jobs (see Figure 21). The type of work conducted in this sector is mostly construction (60 percent). Every municipality in Virginia employs people in energy efficiency, according to DOE.[84] The top ten municipalities for Energy Star and efficient lighting jobs are listed in Table 5.

Table 5: Employment by Locality - Energy Star and Efficiency Lighting, 2023

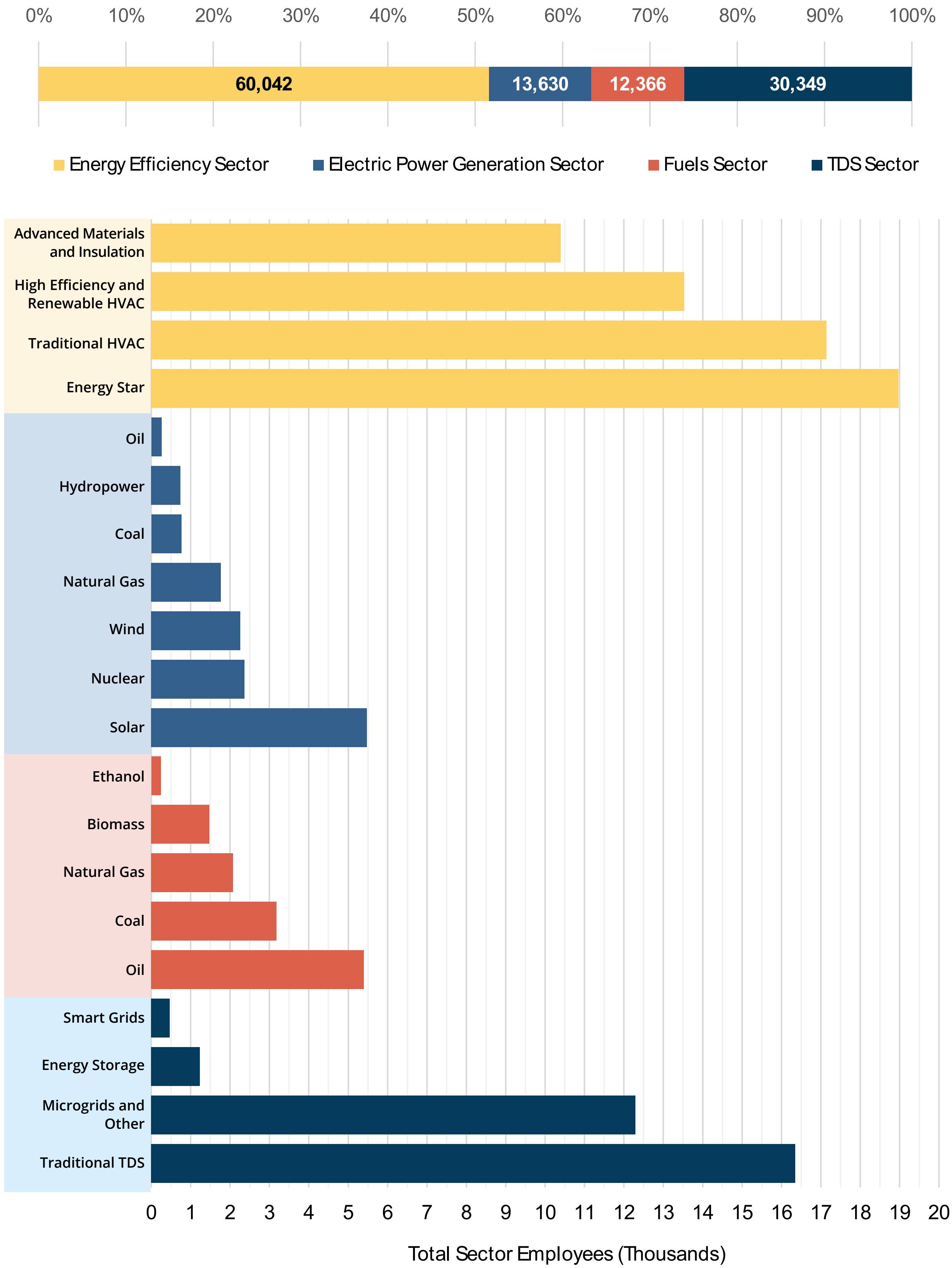
Municipality	Numbered Employed
Fairfax County	4,101
Loudoun County	1,041
Virginia Beach	888
Henrico County	869
Prince William County	836
City of Richmond	777
Chesterfield County	707
City of Chesapeake	633
City of Alexandria	528

Based on the American Council for an Energy-Efficient Economy (ACEEE) 2025 State Energy Efficiency Scorecard, Virginia ranked 20th out of 50 states and the District of Columbia. This is a tie with New Mexico. This ranking represents a slight improvement from the 2020 scorecard, where Virginia ranked 25th. The state's progress has been attributed to its adoption of a clean energy standard, an energy efficiency resource standard, and participation in the Regional Greenhouse Gas Initiative (RGGI).[85]

III. Electric Power Sector

In the Electric Power Generation sector, solar employed the most people in 2022, by far; followed by nuclear, wind, natural gas, coal, hydroelectric, and oil (See Figure 21). Within this sector, most of the work is construction and professional services (66 percent) (e.g., engineering solutions, third-party reviews, construction oversight, and post-modification testing and commissioning).

Figure 21: Virginia Total Employment by Energy Sector and Sub-sector, 2022



Distribution of Electricity Jobs by Energy Source

- Solar employs people in every region except for the Southwest region. Most solar workers are based in the Northern (45 percent) and Central (34 percent) regions.
- Nuclear employs people near Virginia's two nuclear facilities, in Louisa County (Central region) and Surry County (Eastern region).
- Wind employs people in the Northern (46 percent), Central (27 percent), and Eastern (22 percent) regions. There were no wind sector employees in Southside, Southwest, and the Valley.
- Natural gas employs people in the Northern (30 percent), West Central (20 percent), Eastern (19 percent), and Southside (15 percent) regions. Every region employs people in the natural gas sector.
- Coal employes people in the Central region (52 percent).
- Hydropower employes people in the West Central (33 percent), Northern (21 percent), and Southside (19 percent) regions. Every region employs people in the hydropower sector, according to DOE.[86]

IV. Fuels Sector

In the Fuels Sector, oil and petroleum employed the most people in 2022, followed by coal, natural gas, biomass, and ethanol (see Figure 21). The most popular type of job in this sector is professional services (62 percent) (e.g., consulting, marketing, public relations, and advisory services).

V. Transmission, Distribution, and Storage (TDS) Sector

In the Transmission, Distribution, and Storage sector, this work is mostly construction and utility-type jobs at substations, electricity delivery, and balancing supply and demand (60 percent) (see Figure 21).

VI. Comparative Job Growth and Decline

Virginia's energy workforce has seen a net increase in jobs in most of the sectors, with the highest number of added jobs in energy efficiency and fuels sectors, according to DOE.[87] Key trends include:

- Energy Efficiency: Gained 3,000 jobs from 2020 to 2022 supporting Virginia's climate goals (4.2 percent growth).

- Electric Power Generation: Gained 1,500 jobs from 2020 to 2022, driven by solar and offshore wind investments (9.6 percent growth).
- Fuels: Gained 2,160 jobs from 2020 to 2022, primarily from biofuels and natural gas (18.8 percent growth).
- Transmission, Distribution, Storage: Gained 3,190 jobs from 2020 to 2022 supporting energy demand needs (11.7 percent growth).
- Coal-Related Jobs: Declined by 28 percent since 2020, following the shift away from coal-fired generation.

VII. Sector Job Losses

Since 2010, Virginia's coal jobs have decreased by 70 percent. From 2022 to 2023, Virginia added about 200 coal jobs, for a total of 2,530 - still at historic lows. Since 2002, Virginia's coal power plants have decreased production by 95 percent (38,000 MWh to 1,972 MWh), with 3 coal power plants remaining in operation.

VIII. Comparisons with PJM Mid-Atlantic States

In the energy efficiency sector, Virginia saw an increase in jobs from 2022 to 2023 (1,381 jobs added). Delaware, Maryland, New Jersey, Pennsylvania, and West Virginia also saw gains in energy efficiency jobs during this period. The energy efficiency sector was the highest ranked sector for total number of energy jobs in Delaware, Maryland, and Virginia; and the second highest ranked sector in New Jersey and Pennsylvania (behind motor vehicles). Only West Virginia had the energy efficiency sector in the 4th position (out of 5), according to DOE.[88]

IX. Benefits of the Inflation Reduction Act

Nationally, the Inflation Reduction Act (IRA) spurred the creation of more than 2,000 new facilities in clean energy manufacturing across the country. The IRA's tax incentives generated more than $289 billion in privately led investments in the U.S. clean energy supply chain, and another $524 billion in future investments. These investments have resulted in more than 340,000 manufacturing jobs across the country. Many of these advantages have accrued to rural communities and areas that have been economically disadvantaged due to failing manufacturing or fossil fuel-related jobs, according to Congressional reporting.[89]

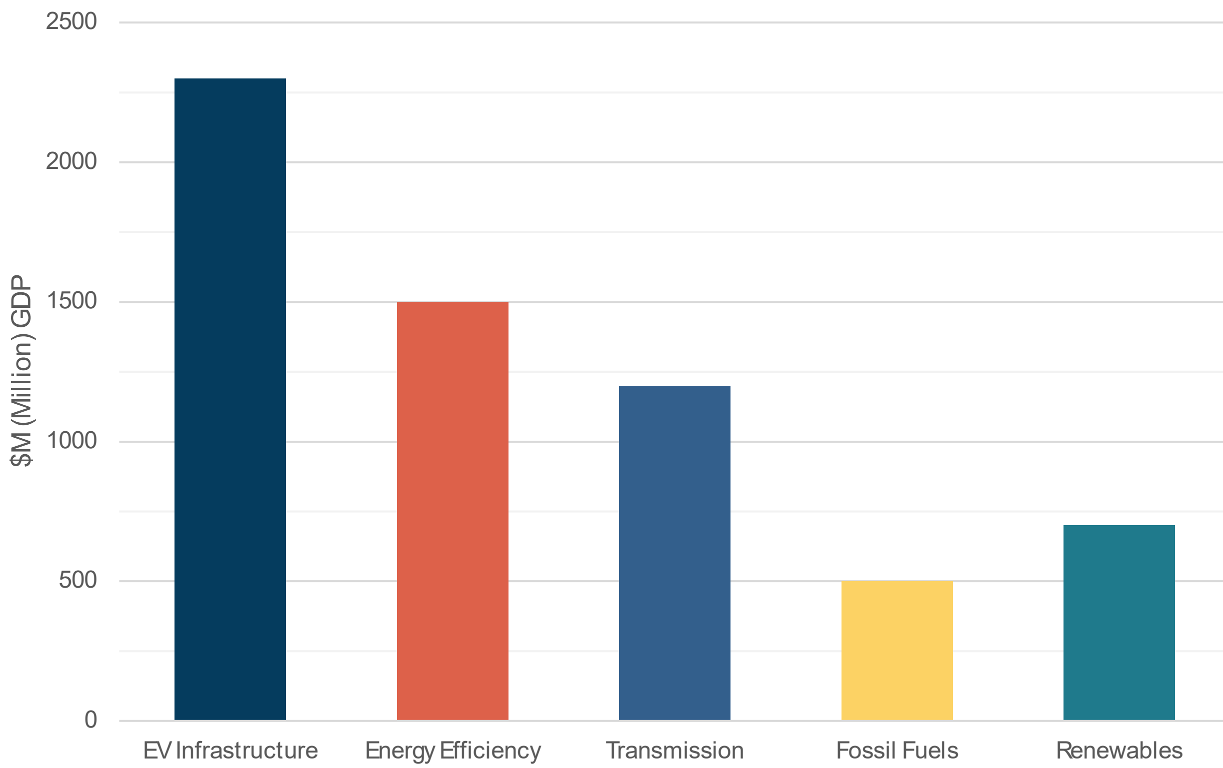
Virginia is in the top 20 states with the highest number of new jobs announced since the passage of the IRA, with over 21,000 new jobs added. Virginia ranks 16th in the country in this category.[90]

X. Benefits of the Regional Greenhouse Gas Initiative

Virginia joined RGGI in 2021 and withdrew in 2023. In this three-year period, Virginia's total revenue earned was over $650 million. These funds were earmarked for low-income energy efficiency programs (50 percent), community flood resilience projects (45 percent), and administrative costs (5 percent), according to a Virginia energy efficiency association.[91] Upon leaving RGGI, this revenue stream ended.

Governor Youngkin's administration argued that RGGI increased electricity costs by passing carbon compliance costs to ratepayers. Dominion Energy estimated the cost to ratepayers at slightly over $2 per month per household, according to press reporting.[92]

Figure 22: GDP Contribution by Energy Sector in Virginia, 2023



XI. GDP Contribution by Energy Sector

The energy industry significantly contributed to Virginia's GDP, with sectoral impacts varying based on market demand, technological adoption, and state incentives.[93] EV infrastructure and energy efficiency contribute to the majority of energy sector GDP (see Figure 22).

- Electric Vehicles and Automotive Industry: Virginia's EV legislation, coupled with its existing automotive manufacturing sector, added $2.3 billion in economic activity, supporting supply chains and infrastructure development.
- Energy Efficiency: Generated an estimated $1.5 billion in economic impact.
- Renewable Energy Growth: With solar energy installations growing, solar-related businesses contributed over $700 million annually to revenue and job creation.
- Fossil Fuels & Decline in Coal: Virginia's coal production and related GDP have declined, contributing to less than $500 million annually, down from $1.2 billion in 2010.[94]

Haymarket, Virginia

PART II: PROJECTIONS

Projections are based on review and summary of publicly available statements by recognized energy expert in academia, think tanks, consultancies, government, and other entities. Although attention is given to recent changes in federal laws and policies, there are a confluence of factors behind projections. While the authors attempt to include wide array of views, this is not an exhaustive list.

Hugh Kenny,
Piedmont Environmental Council

Summary

Virginia needs to generate more energy to meeting growing demand, but it will be challenged to build low-cost electricity projects, such as solar and wind, due to increasing project costs. Likewise, energy prices will rise, and clean energy jobs will diminish, thereby negatively impacting Virginia's economy and employment.

It is important to point out that Virginia operates in a wholesale energy market, as part of its participation in the PJM regional transmission organization. This allows it to operate within a larger, interconnected grid spanning all or part of 12 states and the District of Columbia. In fact, Virginia already inputs much of its electricity which helps ensure the grid's reliability by allowing power to be centrally dispatched and moved across a wide area to meet demand. However, importing electricity can cost more than domestic energy production.

Energy Consumption

Energy consumption will almost certainly increase due to greater energy demand, primarily from large load centers such as data centers powering AI and cloud infrastructure. However, the extent of the increase is uncertain. Many utilities state that increased load growth and lack of adequate and timely new generation will create vulnerabilities to grid reliability. Other experts disagree with this assessment by pointing out inaccuracies in modeling, rampant duplicative and speculative proposals, general uncertainties surrounding data center load needs, and enhanced opportunities with energy efficiencies and other technologies.

- Dominion Energy projects a 5.5 percent annual increase in power demand over the next 15 years, according to its 2024 Integrated Resource Plan.[95] According to the utility, this growth is attributable to increases in data center load growth and electric vehicle load projections. Dominion cites confidence in its short-term load projections of data centers because it uses historical consumption data, includes existing contracts, requires financial deposits prior to project evaluation, and imposes short timeframes to move from project evaluation to construction.[96]

- However, according to a grid optimization company, interconnection requests by data centers far exceed the actual number connected and are largely speculative at this time.[97] An energy management company also states that many utility estimates of data center energy are inflated.[98] Finally, a Department of Energy laboratory study that compared load forecasts and actual growth for 12 Western U.S. utilities found most overestimated future demand.[99]

- According to an electric industry association, a survey of 25 large utilities found that most utilities were skeptical that proposed data center load estimates would materialize.[100] A national industry association representing businesses found that Virginia utilities could do more on energy efficiency, demand response, and virtual power plants in their modeling.[101] The Chinese AI company, DeepSeek, released a model that uses one-tenth of computing power and energy consumption while performing as well as U.S. competitors.[102]

- According to the Data Center Coalition, utilities build load forecasts differently and these differences are not clearly understood. A Virginia utility might use one method, while American Electric Power in Ohio and Commonwealth Edison in Illinois use entirely different methods. Data centers seek standardization, greater transparency, and identified best practices.[103] A representative from Google reinforced the view that utilities lack standardization in communicating load forecast adjustments to PJM.[104] Finally, the Southeastern Electric Reliability Corporation reports that its organization does not have the right load models to adequately study the unique impacts or operating behavior of these projected new data center loads.[105]

- According to a former commissioner at the Texas Public Utility Commission, data center developers are adept at playing utilities off one another to manufacture price elasticity, which results in "phantom" data centers. This happens because the cost of getting in a queue is lower than the weighted likelihood that the data center will use their position.[106]
    - In June of 2025, Texas passed SB 6 which mandates the disclosure of duplicative interconnection requests. The law also gives its grid operator authority to require new electricity users of 75 MW or more to curtail or switch to backup power during grid emergencies.[107]
- According to an academic energy analyst, many data centers do not operate on 24/7/365 near maximum demand but rather operate at closer to 50 percent capacity utilization rate. The misperception stems from conflating "load factor" versus "capacity utilization," as well as real-world constraints, inconsistent workloads, overbuilt redundancy, and hardware maintenance.[108]

Energy Production

Virginia will likely experience a short-term spike in utility-scale solar and natural gas plants already under construction or able to connect to the grid within the next short term (3 years), before facing economic headwinds for new builds beyond this timeframe. Overall, the pipeline for solar and wind project approvals through the regional, state, and local levels have been plagued by delays and uncertainty.

- According to the most recent federal budget reconciliation bill, clean energy investment and production tax credits will terminate for solar and wind facilities that (i) begin construction 12 months after enactment (i.e., July 4, 2026) and if (ii) placed in service after December 31, 2027. In other words, a wind or solar project that begins construction on or before July 4, 2026, is not subject to the statutory end-of-2027 termination date while wind and solar projects beginning construction after July 4, 2026, would in all cases need to be placed in service by the end of 2027.[109]

  - Further, the law prohibits any tax credits that would benefit a Foreign Entity of Concern, which includes China, the world's largest manufacturer of low cost solar and wind technology.[110] Executive branch agencies will issue regulations and guidance on Foreign Entity of Concern.
  - Recent guidance on identifying when a project begins construction changed from demonstrating that 5 percent or more of the total cost of the project has been paid to an opaque requirement: "Construction of an applicable wind or solar facility begins when physical work of a significant nature begins."[111]

- The non-partisan energy and climate policy think tank, Energy Innovation, forecasts that by 2035 Virginia will decrease its electricity generation capacity by 17 gigawatts due to the recent federal law. Utility-scale solar represents the bulk of this decrease - 15 GW.[112] Nationwide, by 2029, the impacts of the federal reconciliation bill will likely lead to a decrease in cumulative new generation capacity additions by 167 GW and increase new natural gas capacity additions by 23 GW, according to an economic consultancy.[113]
- Princeton University's ZERO lab projects reduced U.S. investments in cumulative new solar capacity additions by ~29 gigawatts and wind capacity by ~43 gigawatts from 2025 to 2030, and then a further drop of investments of ~140 gigawatts for solar and ~160 gigawatts for wind through 2035.[114]
  - Princeton estimates that reduced investments will lead to a decrease in clean electricity generation in 2035 by more than 820 terawatt-hours—more than the entire contribution of nuclear or coal to U.S. electricity supply today.[115]
- The raw materials for gas turbines (e.g. super alloy, nickel, and chromium) and the manufacturing of component parts (e.g., blades) will likely face supply chain delays due to global competition from electric utilities, oil and

gas industry, and aerospace industry, according to industry experts.[116] The current waiting time for new gas turbine orders is 3 to 5 years. This global competition will also increase prices for new gas turbines.[117]

  - From 2024 to 2025, the increase in prices for natural gas turbines from planning to procurement stage was over 40 percent in the PJM region, according to an independent, non-partisan organization.[118] In addition to delays for gas turbines, the need to expand natural gas pipelines to accommodate greater flows could take 3 to 5 years to complete per pipeline.[119]

- The PJM interconnection queue has faced a historic backlog of projects awaiting approval, which is filled primarily with solar and wind projects. While processing time has improved, the waiting times for many solar and wind projects will likely fail to meet federally imposed deadlines for tax credits. At the local level, utility-scale solar projects will continue to face delays due to local permitting and siting procedures, supply chain issues, and local government and community opposition.

  - According to the PJM regional transmission organization (Virginia and 12 other states), approximately 44,500 megawatts of proposed projects have interconnection agreements which could move on to construction within the next couple of years. Of these, 88 percent (approximately 39,000 megawatts) are solar, wind, or energy storage.[120]

  - According to the PJM, another 63,000 megawatts of projects remain in the interconnection queue without an agreement. These could be processed by the end of 2026, but many of the solar and wind projects will face challenges connecting to the grid by the federal deadline of December 31, 2027, to receive tax credits.[121] Energy storage projects have until 2033 to take advantage of IRA tax benefits, so those projects will be able to move forward.

    - From 2014 to 2023, only 20 percent of projects in the PJM queue became operational. The remaining 80 percent withdrew or were in some state of flux. The high number of withdrawals and uncertainty results from challenges in determining project economics, which depend on PJM's evaluation of project costs. Once PJM completes its study, primarily the costs of connecting to the grid, project developers can move forward or withdraw. Therefore, entering the queue early helps determine ultimate costs for connection; however, this leads to a long queue of project proposals.

  - Prior to 2008, wait times for new grid interconnection was two years. In 2023, the wait time had increased to five to seven years for the PJM region, according to a U.S. government laboratory.[122] PJM has implemented interconnection reforms since then and cites a 1-to-2-year processing period.[123] Recent reforms have shifted the priority from first-come/first served to first-ready[to deploy]/first-served. Finally, PJM has partnered with Google and Tapestry (an Alphabet incubator) to use AI to streamline integrating new energy resources into the grid.[124]
  - Nine governors from PJM states (Virginia, Maryland, Michigan, New Jersey, Pennsylvania, Tennessee, Delaware, Illinois, Kentucky) have expressed a lack of confidence in PJM's ability to efficiently connect new generation to the grid and engage in effective long-term transmission planning, thereby risking investments and jobs.[125]

- PJM points to delays in local siting and permitting solar and wind projects, as well as supply chain issues for transmission equipment (e.g., transformers), as the main reason for interconnection delays, which, in some cases, can take over two years at the local level. Further, PJM views policy-driven fossil-fuel plant retirements, such as those mandated by the Virginia Clean Economy Act, as contributing to the overall problem. PJM prefers to fast-track natural gas plants because it scores this source higher on reliability and capacity compared to solar and wind.[126]
  - The 100 MW Sadler solar project in Greensville County took one year to complete, the 1.5 MW Merck solar project in Rockingham County took 2 years to complete, and the 120 MW Maplewood solar project in Pittsylvania County took about three years.[127]
  - Currently, 57 counties and cities in Virginia have either banned or severely restricted utility-scale solar development, according to a renewable energy coalition. [128]
- Dominion Energy's Coastal Virginia Offshore Wind project (CVOW) will likely not be affected by the recent federal reconciliation bill because it is nearing completion of construction. However, the development of new wind

resources is unlikely in the future due to the law's removal of tax credits and policies to restrict federal permits.[129]

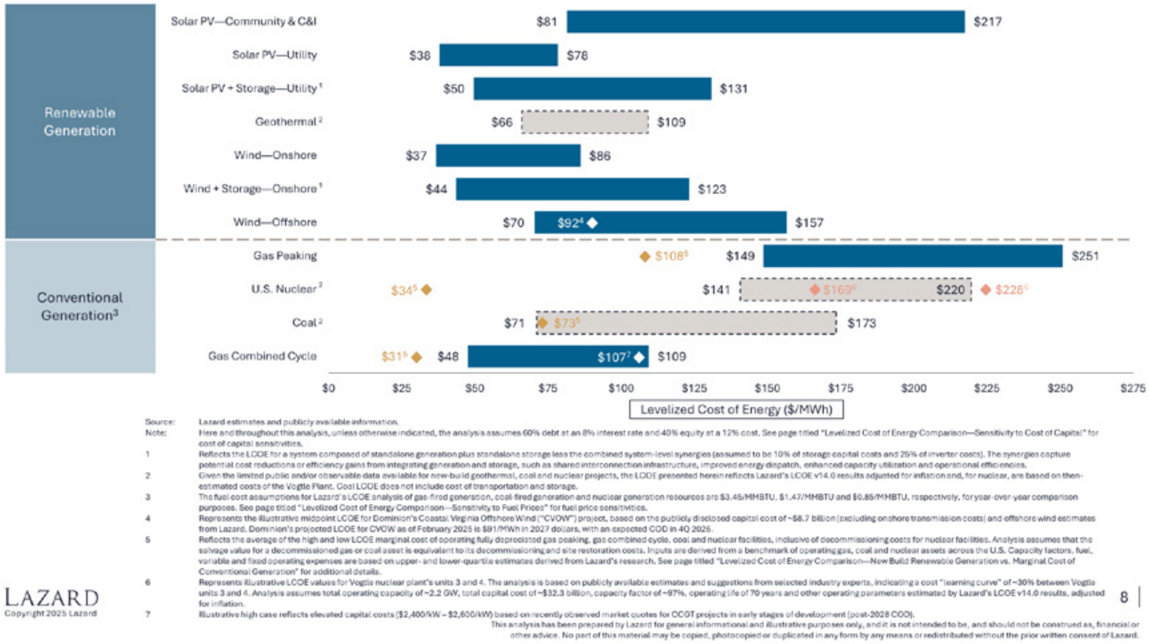
- Most states share control with local governments over siting, permitting, and design of solar and wind facilities based on the size of the project. Generally, projects that are larger in size are controlled by the state.[130]

Energy Prices

The recent passage of the federal reconciliation bill and other administrative policies, among other reasons, will almost certainly result in higher electricity prices for Virginians. Note, not all projected increases are attributable to federal actions. The legal and policy changes remove financial incentives to invest in and build lower cost utility-scale solar and wind projects. Therefore, new generation sources may include more expensive fossil fuel-sourced projects in the medium term (4 to 7 years) and continuation of coal-fired power plants beyond scheduled retirement dates.

- The non-partisan energy and climate policy think tank, Energy Innovation, forecasts that Virginia's retail electricity rates will likely increase by 9 to 14 percent for residential, commercial, and industrial consumers, amounting to $110 annual increase in household energy bills by 2030 and $250 by 2035.[131]
- Princeton University's ZERO lab projects even higher energy costs: $165 per household by 2030 and over $280 dollars by 2035 for the average U.S. household.[132]
- The independent research consultancy, Rhodium Group, estimates that national average household energy bills will increase by $192 annually by 2035, and total industrial energy expenditures will increase from $7 to $11 billion in 2035.
    - Rhodium Group estimates that total industrial energy expenditures will increase by $7 to $11 billion in 2035. Princeton projects energy expenditures for U.S. household and business at over $50 billion dollars in 2035.[133]
- On an unsubsidized $/MWh basis, renewable energy has been the most cost-competitive form of generation, according to a nationally recognized financial advisory and asset management firm (see Figure 23).[134]
- The levelized cost of energy (LCOE) for solar and wind projects may change as

Figure 23: Lazard's Levelized Cost of Energy Comparison, Unsubsidized



federal legislation and executive branch policies make solar and wind projects more expensive by removing tax credits, prohibiting lower-cost foreign products, and adding additional layers of federal reviews, thereby reducing investor interest in funding projects.[135]

- While current utility scale solar projects may be less expensive than fossil-fuel sources, these projects will require battery storage or natural gas backup to ensure reliability. This additional energy infrastructure will likely increase costs on par with natural gas combined cycle plants.[136]
- The federal reconciliation bill eliminates the 30 percent residential clean energy credit on December 31, 2025. This credit applies to solar panels, battery storage technology, solar water heaters, geothermal heat pumps, small wind energy projects, and fuel cell property. Further, the law terminates the energy efficient home improvement credit which provides a 30 percent tax credit for improvements on doors and windows, and purchases of qualifying heat pumps, water heaters, biomass stoves or biomass boilers.[137]
- PJM's "capacity costs" (fees paid to power plants to reserve generation capacity in the future), which can comprise less than 5 percent of electricity bill, have increased significantly in the region. For the most recent auction for the 2026-2027 capacity period, the clearing price reached the maximum price cap negotiated between several states and PJM.[138]

Economic Development

The recent federal reconciliation bill and administrative policies could decrease the Commonwealth's GDP and job growth as investors seek more favorable projects. This represents a sharp reversal of Virginia's GDP and job growth trajectory in the energy sector under the Inflation Reduction Act. However, continued interest from corporations with net zero carbon goals may increase pressure on Virginia to maintain its course on its renewable portfolio standard.

- The Congressional Budget Office's dynamic score finds that the OBBBA would increase real gross domestic product (real GDP) by 0.5 percent over the 2025–2034 period; however, analysts point out that this increase would be offset by the fiscal costs of the bill.[139]
- According to the nonpartisan energy and climate policy think tank, Energy Innovation, Virginia's GDP will likely decrease by $1.8 billion by 2030 and $3.1 billion by 2035.[140]
- Energy Innovation projects that Virginia will lose 11,000 energy jobs by 2030 and 17,000 energy jobs in 2035.
- Amazon, Google, and Microsoft have committed resources to Virginia to support its operations and sustainability goals, including over $2 billion in new energy investments in solar facilities. The corporate expansion of data centers supports over 5,000 direct jobs in construction and maintenance, in addition to indirect employment in IT and cybersecurity.
    - This corporate investment also increases revenue from property taxes. For example, the Town of Leesburg increased its property tax revenues by $1.5 million, according to local reporting.[141] Leesburg's Council leadership plans to use data center revenue on stormwater management system upgrades.

Laws

Some PJM states have taken, and others will likely advance, legislation to streamline siting and permitting at the state level to support policy goals of more renewables. Most states have created a legal construct whereby both the state and municipalities share control over siting and permitting based on the size of the project.

- In Pennsylvania, the governor proposed legislation, which its legislature is now considering (HB 502), that would create a state energy siting board to fast-track energy projects. The plan would also fund new projects through a manufacturing tax credit (up to $100 million per facility for three years). Pennsylvania states that its energy plan will save its customers $664 million by 2040, generate $11.4 billion in renewable energy investments, and create nearly 15,000 energy jobs.[142]

- In Maryland, a new law was recently passed that gives state agencies the authority to develop standardized land use requirements for siting solar energy generating stations over 1 MW. The legislation preempts local zoning requirements prohibiting the construction or operation of solar energy generating stations and energy storage devices.[143]
- In Virginia, the General Assembly introduced a bill in the 2025 session that would have established the Virginia Energy Facility Review Board (HB 2126/SB 1190). This review board would have conducted critical interconnection reviews, analyses, and evaluations of policy options on regional and local energy plans, including facilitating the responsible siting of utility-scale solar and storage facilities, through model local ordinances. If the model local ordinance was not adopted by the local government, the board could impose the model legislation for the locality. The bill failed to pass.[144]
- In New Jersey, the public utility commission will directly procure 1 GW of transmission-scale energy storage over the next year, including standalone storage, additions to existing solar, and solar-plus-storage resources. The funding comes from the New Jersey Clean Energy Program budget, which receives funding from a long-running utility bill surcharge, and will not increase costs for ratepayers.[145] The New Jersey legislature passed a bill that would create a fund to award incentives to storage system developers—at least $60 million a year starting in 2028.[146]
- Twenty-eight states use a combined state and local siting and permitting authority for utility scale solar and wind projects based on the size of the project. Only 12 states empower full decision-making authority to local governments and only 5 states confer this authority to state-level control, according to U.S. government data.[147]

Energy Security

The number of natural gas power plants will likely increase. However, natural gas plants may not result in reliability improvements. Diversification of energy supply, distributed energy resources, and demand response programs can provide greater reliability for the electric grid and at lower cost than adding dispatched generation (including long term storage).

- Winter storms Uri (February 2021), Elliott (December 2022), and Heather (January 2024) caused significant disruptions of natural gas supplies. Interrupted weekly U.S. natural gas production was more than 15 billion cubic feet per day (Bcf/d) during these storms. During winter storm Elliott, 91 GW went offline, while grid operators instituted rolling blackouts totaling 5,400 MW. Approximately 70 percent of the unplanned outages during Elliott were at natural gas plants.[148]
- Grid experts and operators credit "virtual" or distributed power plants for reducing the load need during the 2025 summer heat dome affecting most of the East Coast. Increased energy demand during this period, which came close to exceeding historic energy consumption, could have exhausted reserve margins. Companies like Sunrun, EnergyHub, and Uplight were able to dispatch about 350 MW from customer-sized batteries per day or shed over 900 MW through millions of connected devices (including thermostats, EVs, and batteries).[149]

Public Health and the Environment

The sustained demand for global coal will likely result in continuing emissions of harmful pollutants from coal-fired power plants, such as carbon dioxide, sulfur dioxide, nitrogen oxides, particulate matter, and mercury.

- The recently passed federal reconciliation bill classifies "metallurgical coal" as a "critical" mineral, making it eligible for the Section 45X tax credit equal to 2.5 percent for the manufacturer. This tax credit expires in 2029.[150]
- The International Energy Administration and Wood Mackenzie consultancy have revised their estimates on coal demand, finding continued strong use for several more years. This is largely driven by China and India's reliance on coal for the power sector.[151]
- Current federal policies have incentivized the continuation of coal power plant operations beyond their scheduled retirement date. The actions to accomplish this include emergency rationale, granting waivers or extending deadlines to comply with clean air rules, working to rescind clean air rules,

and providing loan guarantees to coal plants.[152]

Transportation

The recently passed federal reconciliation bill will almost certainly reduce purchases of electric vehicles (EV) due to the expiration of federal tax credits, as well as slow the build-out of public EV charging infrastructure. A small spike in EV purchases is likely in 2025.

- Electric vehicle tax credits will expire on September 30, 2025 ($7,500 federal tax credit for new EVs and $4,000 credit for used EVs). Tax credits for installing charging stations at a residence or business will expire on June 30, 2026.
- Analysts project up to 70 million fewer EVs in the light-duty vehicle stock in 2035, which represents up to a 65 percent reduction from the baseline. This baseline also includes rollbacks of EPA vehicle standards and Congress nullifying EPA's waiver to California, enabling the state to establish its own vehicle standards.[153]
- EVs will be more expensive for consumers absent state or company financial incentives. Many states offer a state-level EV incentive program in the form of grants, rebates or state level tax credit, but many other states offer none.[154]

PART III: RECOMMENDATIONS

Our recommendations reflect three pillars:

1. Fast-track new, cleaner, and low-cost energy generation

2. Consume less energy wherever possible

3. Engage with and educate communities about the benefits of cleaner generation and energy savings.

Louisa, Virginia

Recommendation 1

VIRGINIA MUST BUILD MORE NEW AND CLEAN ELECTRIC GENERATION

1.1. High Priority. To ensure affordable energy prices, resilient and reliable electric delivery, and a strong economy and job sector, Virginia and its regional transmission organization (PJM) should first build cleaner electric generation to meet rapidly growing demand. Second, Virginia should prioritize demand response programs to consume less energy during peak periods. And third, Virginia should facilitate community education about energy affordability, human health, and community well-being through municipal energy plans.

1.2. High Priority. Virginia should approach this 3-prong strategy using a combined top-down and bottom-up approach, each with broad application, high-level attention, funding, and long-term support.

1.3. *Top-Down.* The challenges with local siting of utility scale solar projects are significant and attempts to mandate state-wide control will likely only reduce public support for large solar projects. Virginia should evaluate the potential of maximizing the deployment of utility scale solar projects and distributed energy resources within Northern Virginia, its largest electricity demand center, or nearby the largest energy consumers. If this is accomplished, then Virginia should consider other alternatives to meet its energy goals, including state-wide legislation.

1.4. *Top-Down.* Virginia needs to better understand its future energy demand because of uncertainties within Virginia and throughout its regional transmission organization (PJM). Virginia should be careful about approving the building of large new electricity generation facilities by its major utilities. While most energy experts agree that electricity demand is increasing, the extent of this increase is uncertain. The risk is that if Virginia approves large new generation facilities by its utilities and the expected demand does not materialize, then ratepayers must pay for these stranded assets (this does not apply to Independent Power Producers). Therefore, Virginia should focus on demand side management, distributed energy resources, and on-site generation, particularly for large load centers. But even these tools present uncertainties, especially in terms of how much is needed to meet demand.

1.5. High Priority. *Top-Down.* Virginia should deploy distributed energy resources (DERs) in state-owned public buildings and spaces and form public-private partnerships to deploy DERs so it demonstrates its leadership. Regarding its two main utilities, Virginia should require a more forceful mandate to deploy more DERs. Compared to utility scale projects, DERs can be deployed more quickly and at lower cost. Replacing federal incentives from the Inflation Reduction Act is not feasible, but using available state-based tools can create some incentives to make deploying DERs more economically favorable. Based on a review of other states, we recommend the following incentives and policies.

a. State investment tax credits.
b. Rebates for solar PV, battery systems, or energy-efficient generators.
c. Grant programs for schools, critical facilities, or community resilience hubs.
d. Revolving loan funds for financing projects.
e. Legislation to simplify and standardize the permitting processes and installation requirements for DERs at critical facilities (e.g., hospitals, emergency shelters) and high-load demand facilities (e.g., data centers).

1.6: *Top-Down.* Virginia should identify any state or regional permitting impediments to the rapid deployment of new clean energy projects, and reduce, eliminate, or temporarily suspend these impediments. This is easier for state-based requirements but will be equally important for regional (PJM) requirements. Virginia should institute minimal government oversight and processing for new generation project permitting. Based on a review of other states, we recommend the following incentives and policies:

a. Streamline all forms;
b. Create project exemptions for small projects or pre-approval of projects that meet specific environmental and technical criteria;
c. Create a state review board that uses standardized procedures and deadlines for project approvals;
d. Ensure early engagement with affected communities, use conflict mediation facilitators, provide public databases and dashboard, and educate.

1.7: *Top-Down.* Virginia should require demand flexibility for large-load interconnection agreements (e.g., data centers), including compensating for curtailment, shifting energy demand from the grid to on-site generating sources during peak-load periods, and shifting loads to times when renewable energy is plentiful or power prices are low. Similarly, Virginia should encourage "energy parks" which co-locate solar, wind, and energy storage with large load centers. As an incentive, Virginia should expedite the evaluation and connection process.

1.8. *Top-Down.* Virginia should require utilities to publicly disclose duplicative interconnection requests and standardize load forecasting methodologies across all large load applicants, adopting the best practices established by other states (e.g., Texas S.B. 6), to reduce speculation and uncertainties in forecasting load. For PJM requests, Virginia should work with its member states to ensure reforms are implemented.

1.9. *Top-Down.* Virginia should create and target incentive programs to attract manufacturers that will facilitate new, clean energy generation as well as IT companies that can aggregate load demand for demand response programs. The incentives should focus on advanced manufacturing tax credits, R&D grants, site readiness support, and reduced government "red tape" to attract domestic and international manufacturers of critical clean energy components.

Recommendation 2

VIRGINIA SHOULD IMPLEMENT MORE MEASURES AND CONTROLS TO IMPROVE DEMAND-SIDE MANAGEMENT

2.1. High Priority. Virginia should mandate and assist its utilities in increasing the marketing, delivery, processing, and participation of demand response programs with its customers. Demand response programs include hourly pricing dynamics and utility control over participants' energy use during peak demand periods (upon customer consent). Based on a review of other states, we recommend the following incentives and policies.

a. Increase rebate offerings and other enrollment incentives.

b. Conduct statewide and local outreach about cost savings.

c. Create a public recognition program for large customers and municipalities.

d. Resolve outstanding data privacy issues with communication devices between customers and utilities.

2.2. Virginia should encourage the use of more energy efficiency programs, including energy audits, weatherization, higher-efficiency appliances, and electric appliances. Virginia should re-enter the Regional Greenhouse Gas Initiative and use its revenue (per the original legislation) to support energy efficiency programs.

2.3. Virginia should consider adopting stretch codes for public buildings and data centers to achieve higher efficiency standards, such as the New Buildings Institute Model Stretch codes. These codes address building components such as envelope, mechanical, water heating, lighting and plug loads. Virginia should also provide technical support and funding so municipalities can enforce codes more effectively.

2.4. Virginia should mandate its major utilities advance its pilot Virtual Power Plant (VPP) project by developing and approving a permanent, open-access tariff that would allow both utilities and third-party aggregators to buy and sell grid services from VPPs in a standardized manner. Virginia should also set long-term procurement targets for VPPs, like it has for renewables and energy efficiency. The target should meet a significant portion of projected peak load growth. Finally, Virginia should consider creating a voluntary “VPP Ready” certification for new residential and commercial construction to encourage the pre-installation of VPP-compatible devices and infrastructure

2.5. Virginia should offer a rebate for the purchase of battery electric vehicles and plug-in hybrid electric vehicles. The rebate should apply to vehicles priced at or below $30,000 to send a price signal to manufacturers. The qualifying battery electric vehicle should have a range of at least 120 miles, and the plug-in hybrid electric vehicles should have a range of at least 25 miles. The rebate is calculated at $25 per mile of electric range, up to a maximum of $5,000. This rebate program should be funded through Virginia’s re-entry into the Regional Greenhouse Gas Initiative (RGGI) or through a dedicated appropriation in the state budget.

2.6. Virginia should direct its State Corporation Commission and regulated utilities to coordinate on the development and approval of transportation electrification plans, which would include the expansion of charging infrastructure and rate design.

2.7. Virginia should enact a law that phases in bidirectional electric vehicle charging. The law would require the Virginia State Corporation Commission to create program that allows EVs to both draw power from and supply power to the electric grid.

Recommendation 3

VIRGINIA SHOULD EMBARK UPON COMMUNITY-BASED EDUCATION ON THE MERITS OF NEW AND CLEANER GENERATION AND REDUCING ENERGY USE

3.1. High Priority. *Bottom-Up.* Virginia should implement a state-supported, Local Energy Action Planning Initiative. This initiative, funded by the Commonwealth, would task public colleges and universities to help every municipality develop a tailored energy action plan as part of its required comprehensive plan update. This process will serve as the primary vehicle for bottom-up education and stakeholder engagement.

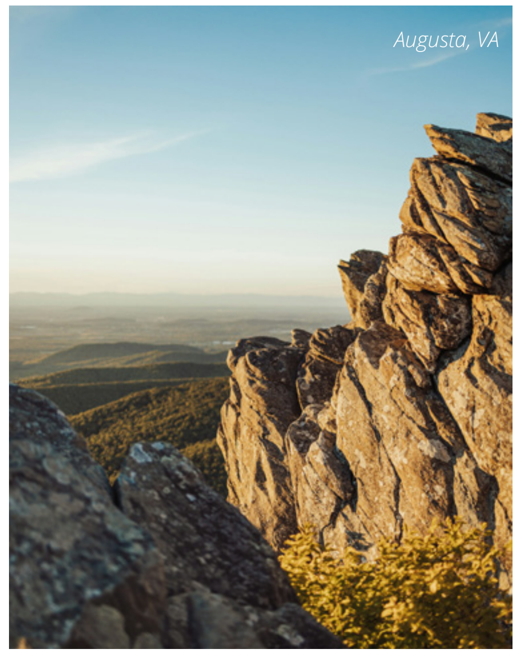
3.2. High Priority. *Bottom-Up.* The energy plans should assess municipality baseline energy costs, emissions, and community vulnerability to climate-induced events (e.g., flooding, heat waves). Energy plans should establish specific goals that reflect the municipality's needs without being tied to statewide targets, although statewide targets can serve as guidance for local goal-setting. Further, energy planning should provide unbiased information about strategies, actions, and policies to address high energy costs, harmful emissions, and community resilience. Finally, energy planning should involve decision making by keycommunity stakeholders and local government officials.

3.3. *Bottom-Up.* Virginia should authorize its public colleges and universities to assist Virginia municipalities in developing and implementing energy plans at no cost to the municipality. This outreach effort will take time, but it can serve to bridge the spectrum of community needs and perspectives. Past educational campaigns have faltered because of the passive approach (e.g., web-based resources), the siloed effort at working only with disadvantaged communities (e.g., former coal dependent communities), and the entities conducting the work (e.g., state agencies).

3.4. *Bottom-Up.* Virginia should require that each of its 21 planning district commissions designate a person to serve as the lead on energy action plans for its member municipalities. This person should serve as the lead on coordinating the energy action plans. In addition, municipalities with populations above 50,000 should be required to implement energy plans, while municipalities with less than 50,000 should make energy planning voluntary.

3.5. ***Bottom-Up.*** Virginia should ensure that outreach in rural areas reflects traditional values and realities. Community-based outreach and education should consider focusing on household energy affordability, community independence and resilience, appreciation of land and property, and community patriotism and pride.

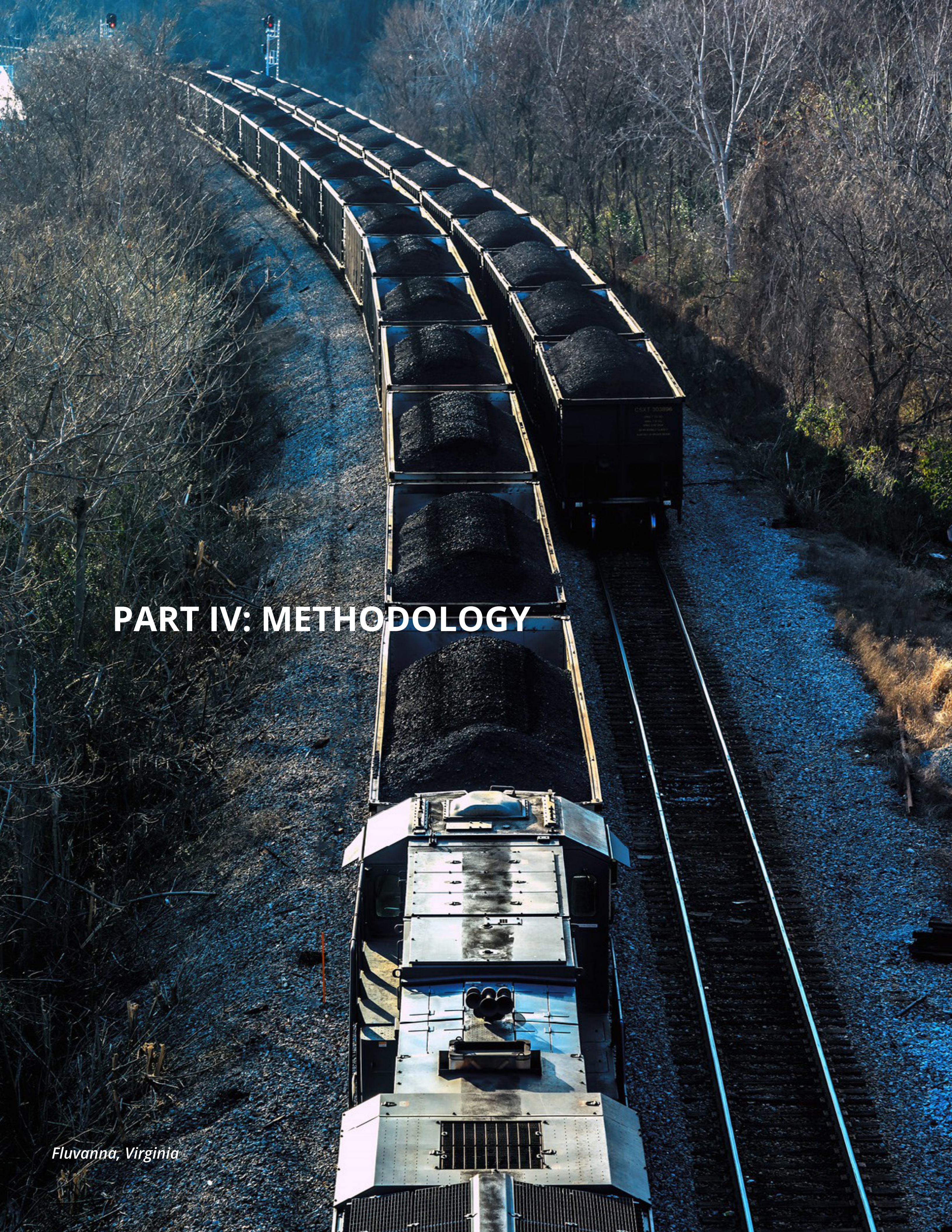
Harrisonburg, VA


Augusta, VA


Alexandria, VA


Charlottesville, VA

PART IV: METHODOLOGY



Fluvanna, Virginia

Overview

The team of analysts worked on this report over two phases. The first phase involved student-developed research, analysis, and writing as part of the Spring 2025 course, Introduction to Energy and Climate Law (GOVT 400/POGO 500). This phase produced the first draft of the report. The second phase involved Student and Non-Resident Fellows in the Center for Energy Science and Policy (Schar School of Policy and Government). This group transitioned the Phase 1 report to its current version.

Process

In both phases, teams of students, fellows, and residents worked on researching, analyzing, and writing the report. In both phases, the team used structured analytic techniques to develop findings and recommendations. The team relied upon the book, Structured Analytic Techniques for Intelligence Analysis (R.J. Heuer Jr and R.H. Pherson, 3rd Ed, CQ Press, 2019) and used a facilitator for these exercises. The following structured analytic techniques were used:

- Exploration: Cluster Brainstorming
- Diagnostic: Key Assumptions Check
- Reframing: Red Hat Analysis
- Foresight: Alternative Futures Analysis

Cluster Brainstorming

This technique generates a comprehensive list of new ideas, or in this case, a list of recommendations. What follows is a brief overview of the genesis of the recommendations.

Build More Generating Sources

By far, the most recommended action was to generate more electricity to meet growing demand. Since Virginia state law mandates renewables, the recommendation was to deploy more solar and wind power. Due to the strong likelihood that federal laws and policies would make deploying solar and wind more economically challenging, the group felt that the state should increase its role in creating incentives to deploy more of this energy source to comply with the Virginia Clean Economy Act.

Ensure Affordable Energy

Equally important was the need to ensure that electricity and fuel costs were affordable. Again, the recommendation was to deploy low-cost solar and wind and encourage more electric vehicles. Without federal incentives for EVs, demand for gasoline and diesel would increase, and consequently, raise fuel prices.

Shift from Large Fixed Sources to Small Distributed Sources of Generation

Of great concern during discussions was the uncertainty in energy demand and the risk of over-building generating sources. To guard against this, the recommendation was to focus on microgrids, roof top solar installations, virtual power plants, and demand response and management programs.

Increase Demand Response Management

This recommendation seems the most obvious, and the group consensus was that much more needed to be done to get more Virginians to participate in these programs. This effort should be folded into the education component.

Maintain Dispatchable Generation

The value of dispatchable fixed sources, like coal, natural gas, and nuclear power was clear and convincing. These will be needed, but the sense of the group discussion was that state law mandated a transition away from fossil fuel sources unless there was an urgent need to keep certain plants operating for reliability purposes.

Create Bi-Partisan Consensus through Education and Energy Planning

A reoccurring theme was the need to ensure that all Virginians were aware of the pros and cons of the various energy sources. There seems to be active disinformation and misinformation campaigns, misunderstandings, confusion, and hostility towards renewable energy and clean transportation. The main thrust of the recommendation was to have each municipality develop their own energy plan that fits their communities' needs. The role of state government would be to assist in this effort by providing support in the form of objective facilitators and provide resources to engage communities appropriately.

Key Assumptions Check

In our analysis, we identified the following key assumptions:

- We assume that data centers want to locate in Virginia for reasons such as lower cost energy, high-speed fiber optic networks, reliable and clean electricity, and tax incentives. This assumption underscores our recommendation for more energy generation quickly to meet demand. While we believe this assumption is correct, we provide the following caveats. Data centers may not want to locate to Virginia because they may face increasing local resistance; or data centers may have an interest in other states with equally attractive infrastructure and taxes; or if Virginia's electricity rates increase it may become more cost effective for data centers to go to other states; or if Virginia's electric grid relies more on fossil fuels then those data centers with clean energy commitments may re-locate to states with clean energy goals.
- We assume that the Virginia state government (executive and legislative branches) supports the state law—Virginia Clean Economy Act. This assumption underpins our recommendations for advancing clean energy generating sources and energy efficiency programs. We believe this is a solid assumption, with one major caveat. If the state government decides to repeal the VCEA, in whole or in part, then our assumption is incorrect and would require re-assessing our recommendations.
    - On the other hand, based on a "red hat" analysis (Devil's Advocate argument), we assume that even if the VCEA were repealed, mounting grid reliability issues or significant price hikes would likely compel state leaders from any party to adopt similar renewable energy and efficiency targets out of practical necessity.
- We assume Virginia's municipalities want to pursue energy action planning because of its value in terms of cost savings and community resilience. This assumption supports our recommendation about the need to develop municipal energy action plans. This assumption requires stating the following caveat. Some rural municipalities may resist energy action plans because they associate it with climate change, or they reject solar and wind energy as liberal policy.
- We assume that a top-down approach at imposing state authority over siting of large solar and wind projects will require a comprehensive

education program prior to its initiation. Further, we assume that without an educational campaign, the politically partisan divide over renewables versus fossil fuels will only worsen. This assumption underlies our recommendation on education and energy action plans. We believe this is a correct assumption, but with caveats. First, many rural Virginians recognize the merits of renewable and clean energy technology and recognize the link between fossil fuel combustion and climate change impacts. Second, a bottom-up education and energy action planning campaign could take several years to implement and see results, therefore the intent behind education and energy planning may not coincide with top-down legislation.

- We assume that the current federal government leadership does not support the mandates of the Virginia Clean Economy Act, advancement of solar and wind projects, and electric vehicles. This assumption supports our recommendations on the need for state-level incentive programs. We believe this is a solid assumption.
- We assume more utility-scale solar projects is the most promising path forward to meeting increasing energy demand. This assumption is central to many of our recommendations. We believe this is a solid assumption, but with caveats. First, federal government policies may increase the price of solar power to the point that it becomes less competitive economically than fossil fuel sources. Second, solar power build out may result in occupying a great deal of land, which could create a backlash against this energy source.
- We assume that public colleges and universities can serve as effective facilitators of education and energy action planning. This assumption supports our recommendation to offer no-cost assistance from public colleges and universities. We may be biased on this one, but we believe this is a solid assumption.
    - A “red hat” analysis finds that some people view college and university faculty and students as “elitists” or co-opted by liberals. Therefore, they might not be the most effective facilitators.

Alternative Futures Analysis

For this technique, we first established the central question or issue we are trying to analyze as follows:

- How can Virginia meet the requirements of its main energy law (VCEA)?

Second, we determined key drivers and uncertainties that will influence the future, as follows:

- Policy stability and regulatory certainty in state leadership (governor, legislature)
- Cost for energy technology (solar, wind, energy storage)

Third, we developed a framework of two of the most critical uncertainties and we used these to create a 2x2 matrix that outlines different combinations of how those uncertainties might play out. The critical uncertainties are as follows:

- Will the newly elected Virginia governor in 2025 support or not support the VCEA? Will the Virginia legislature support or not support the VCEA in its current form?
- Will the cost of solar, wind, and energy storage remain at low cost or become high cost?

		Political Support	
Economic Costs		Favorable	Unfavorable
	Low Cost		
	High Cost		

Fourth, we constructed alternative futures for each cell in the matrix that could explain how that combination of uncertainties could logically lead to a distinct future.

- *Favorable Political Support and Low Technology Cost.* Full support for renewables and VCEA provisions. Higher deployment rate for solar and wind facilities and electric vehicles with state incentives in place (compared to all other scenarios). Fully supportive of outreach and education and local energy plans. Recommendations remain the same.
- *Favorable Political Support and High Technology Cost.* Full support for renewables and VCEA. Lower deployment rate for solar and wind facilities and electric vehicles due to state budget constraints and other priorities and private developers’ economic considerations (compared with favorable political support and low-cost scenario). Alternative recommendations may

include more modest financial support for renewable and clean technology and extending deadlines on fossil-fuel plant retirements and more requirements for large energy demand entities (e.g., data centers) to provide on-site generation and agree to curtailment during peak periods.

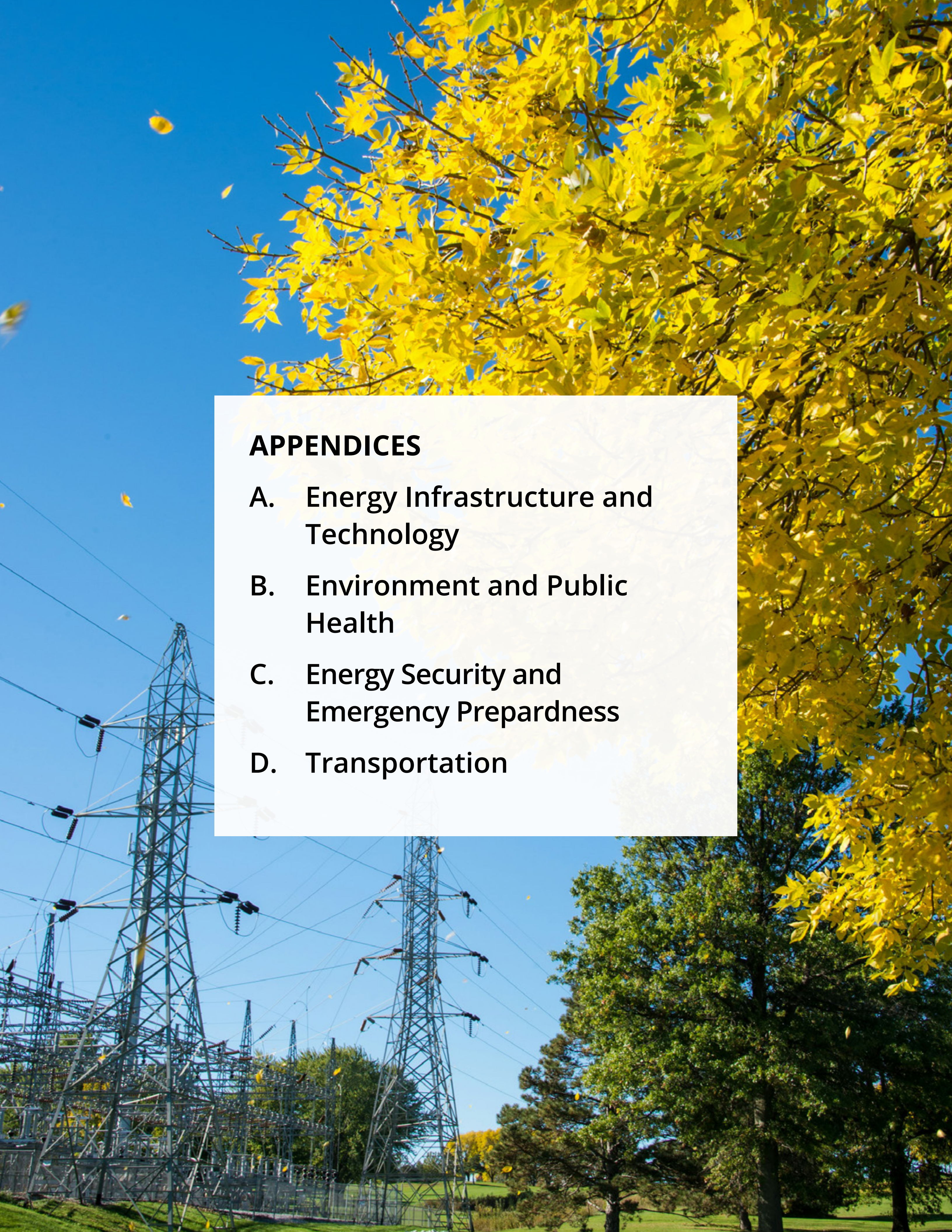
- *Unfavorable Political Support and Low Technology Cost.* Likely changes to VCEA. More emphasis on natural gas and coal generation. Renewable energy still provides better value on fuel margins compared to fossil fuels, which private developers pursue. No public outreach and education and local energy plans. Alternative recommendations may include minimal support for renewable and clean technology to address high cost of energy and to ensure grid reliability, but without state mandates or financial support (e.g., Texas model).
- *Unfavorable Political Support and High Technology Cost.* Likely changes to VCEA. More emphasis on natural gas and coal generation. State and private developers are less likely to pursue solar and wind. No public outreach and education and local energy plans. Alternative recommendations may include support for more restrictions on large demand entities to provide on-site generation and agree to curtailment during peak periods.

The recommendations presented in this report were developed to be most effective and fully implementable under the Favorable Political Support and Low Technology Cost scenario. However, they are designed to be robust and scalable, offering pragmatic pathways to improve energy affordability and reliability even in other, more challenging futures. For instance, the emphasis on local energy action planning and deploying DERs provides value regardless of state-level political shifts or fluctuating technology costs.

Note on References

As stated in the Methodology section, our reference style is as follows: Name of the organization. Article or subject title. Author(s). Date.

For any questions regarding methodology, data, or source notes, please contact the Center for Energy Science and Policy, www.cesp.gmu.edu.



APPENDICES

A. Energy Infrastructure and Technology

B. Environment and Public Health

C. Energy Security and Emergency Preparedness

D. Transportation

Appendix A
ENERGY INFRASTRUCTURE AND TECHNOLOGY

Summary

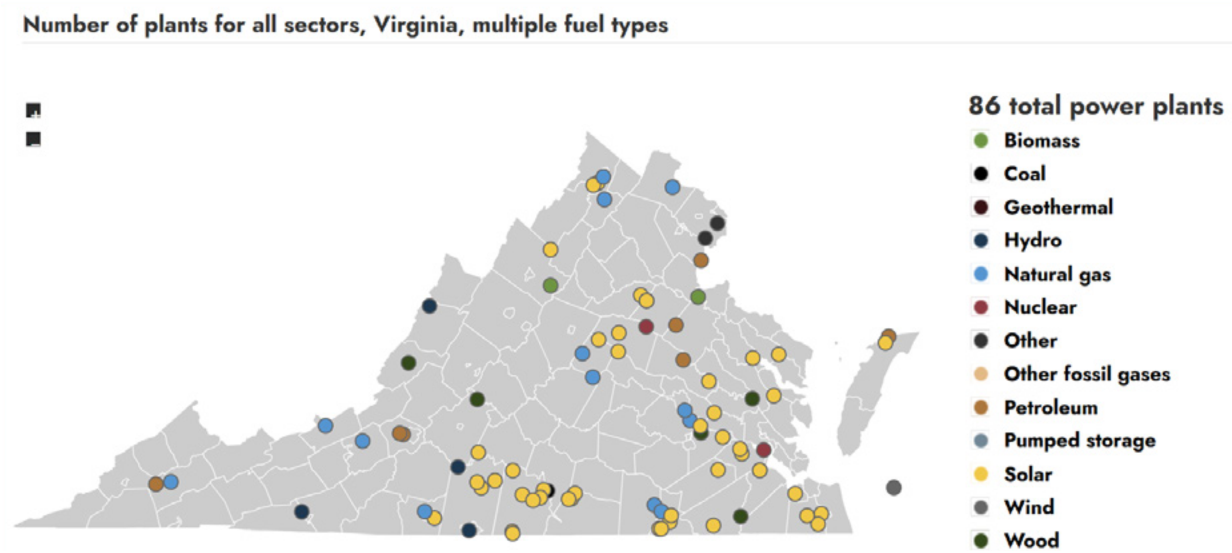
Virginia's infrastructure has supported a variety of energy sources, including fossil fuels, nuclear, and renewables. It has a diverse energy infrastructure and technology system. It stands apart from other states in its large reserves of coalbed methane (used for natural gas production) and pumped hydropower storage capability.

This section explains the physical support structure for Virginia's energy sources across all sectors, geographic locations and company identification, and list of facilities.

Key Takeaways

- Virginia exports more coal internationally than any other U.S. state. It has 3 remaining coal power plants.
- Virginia has the third largest deposit of coalbed methane in the country, after Colorado and New Mexico, which is used for natural gas production.
- Virginia has over 300 utility scale solar farms and is anticipated to be the site of the largest offshore wind farm in the country. Virginia imported the 10th highest amount of solar photovoltaic (PV) modules among states.

Figure 24: Virginia Power Plants



I. Coal

Mines

Virginia currently has 41 operational coal mines, a decrease from 141 in 2002, located entirely along the Appalachian Plateau in southwest Virginia (See Figure 25). Of the 41 active mining sites, 31 are surface mines and 10 are underground mines, with the underground mines accounting for the bulk of coal produced, according to U.S. government data.[155]

Exports

Virginia has the nation's largest coal port complex – Port of Norfolk – and is the leading exporter of U.S. coal. In 2023, about a third of the nation's total coal exports, 30 to 40 million tons of coal annually, were shipped through the Norfolk Customs District. This area includes Hampton Roads, Norfolk, and Newport News. Almost all coal exported from Virginia's seaports came from other states, according to U.S. government data and academic reporting.[156]

Power Plants

Virginia has three coal-fired power plants. The first is the 610 MW Virginia City Hybrid Energy Center in Wise County, in the southwestern region near the West Virginia and Kentucky borders. The second is the 848 MW Clover power plant in

Figure 25: Virginia Coal Fields

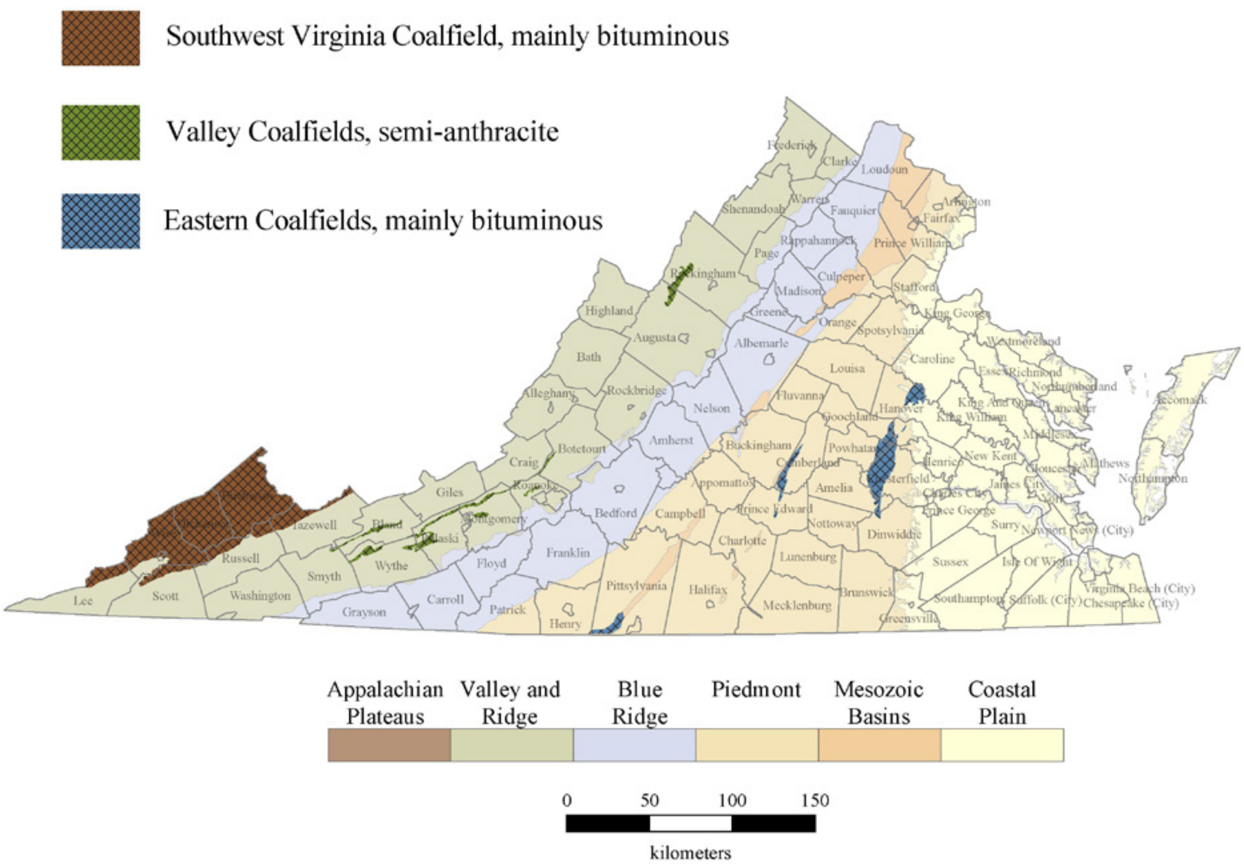
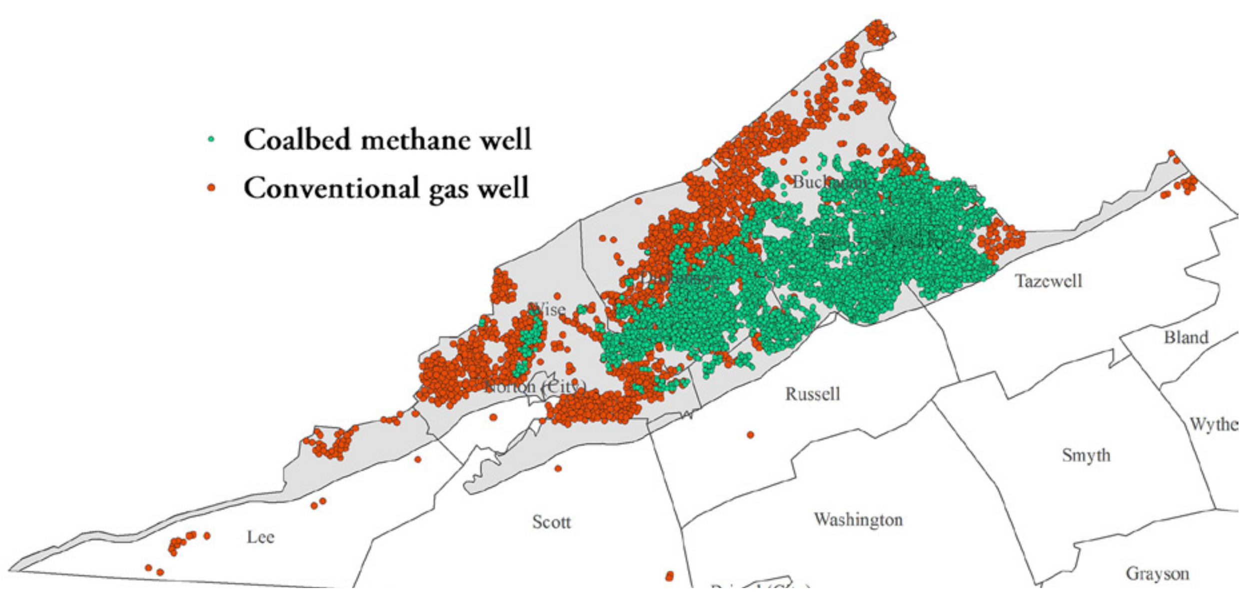


Figure 26: Virginia Coalbed Methane Deposits



Halifax County in south central region (Southside) near the North Carolina border. A third plant, Virginia City Hybrid Energy Center, uses both coal and biomass, according to U.S. government data.[157]

Transport

Railroads transport most of Virginia's coal (~63 percent) from coal mines to coal plants (both interstate and intrastate) and to the Norfolk Customs District for export to other countries. Five railroad companies service Virginia: two large regional railroad companies (CSX and Norfolk Southern) and three local short line railroad companies (Commonwealth Railway, Norfolk and Portsmouth Belt Lines Railway, and Chesapeake Western Railway). Coal is also shipped by truck (~28 percent) to states like Kentucky and North Carolina, and by river (~8.5 percent) to states like Illinois, Michigan, and Mississippi), according to U.S. government and state data.[158]

II. Natural Gas

Virginia's natural gas infrastructure includes an extensive network of interstate and intrastate pipelines, natural gas storage facilities, natural gas producing wells, and natural gas-fired power plants. Virgina has no natural gas processing facilities.

Mines

Most of Virginia's natural gas comes from coalbed methane deposits. In fact, Virginia has the third largest deposit of coalbed methane in the country, after Colorado and New Mexico. Virginia's coalbed methane and conventional wells are in the state's southwestern corner (see Figure 26), according to U.S. government and state data.[159]

Transport

Natural gas traverses Virginia via pipelines (interstate and intrastate). Four interstate natural gas pipelines service Virginia and provide the bulk of its natural gas. Based on pipeline geography, Virginia imports most of its natural gas from Maryland (69 percent) and West Virginia (31 percent). Virginia, in turn, exports natural gas to states such as North Carolina (58 percent), Tennessee, and Washington DC, according to U.S. government data.[160] The four interstate natural gas pipeline companies are as follows:

- Transcontinental Gas Pipe Line (owned by Transco): Extends from the Gulf Coast (Texas and Louisiana) through the southeastern U.S. (10,500-mile length). It delivers 15 percent of the nation's natural gas and has a capacity of

3.5 trillion cubic feet per year.

- Columbia Gas Transmission (owned by TC Energy): Transports natural gas from the Appalachian Basin through Virginia to the northeastern U.S. (11,899-mile length). It has a capacity of 3.4 trillion cubic feet per year.
- East Tennessee Natural Gas Pipeline (owned by Enbridge): Runs from eastern Tennessee into southwestern Virginia and beyond (1,510-mile length). Its capacity is 679 billion cubic feet per year.
- Mountain Valley Pipeline (owned by Mountain Valley Pipeline): Extends from northwestern West Virginia through southern Virginia (303-mile length). Its capacity is 730 billion cubic feet per year.

Seven intrastate pipeline companies distribute natural gas to residents, businesses, and storage facilities in specific geographic areas (see Figure 28), according to U.S. government data,[161] as follows:

- Appalachian Natural Gas Distribution Company
- Atmos Energy
- Columbia Gas of Virginia, Inc.
- Roanoke Gas Company
- Southwestern Virginia Gas Company
- Virginia Natural Gas, Inc.
- Washington Gas Light Company

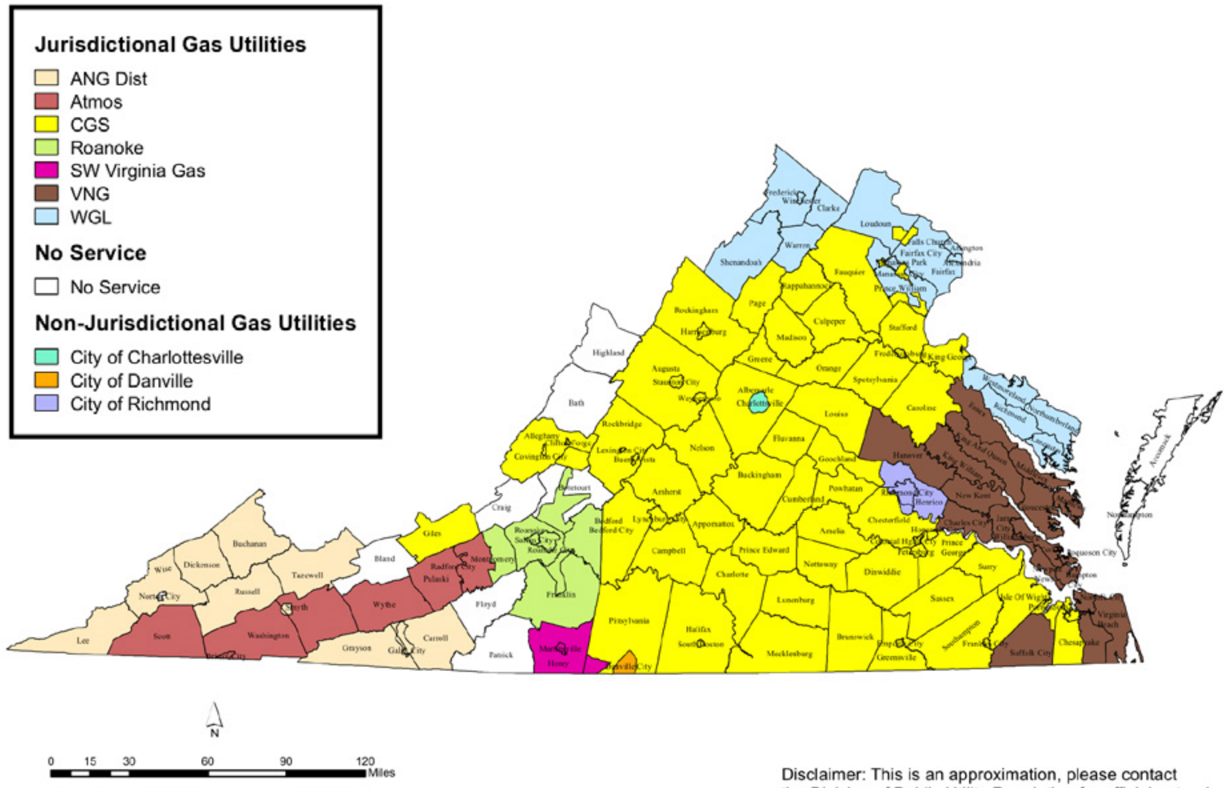
Storage

Natural gas storage in Virginia has more than doubled over the past 20 years (from 3.4 to 7.5 million cubic feet). A portion of this natural gas is placed in the state's two underground natural gas storage facilities, both in Washington County (Southwest Virginia). Their combined total storage capacity is almost 9 billion cubic ft, according to U.S. government data.[162] Virginia has 2 liquefied natural gas facilities with a total storage capacity of 407,000 barrels.

Power Plants

Virginia has approximately 30 natural gas plants (see Figure 28). Of the ten power plants that generate the most electricity, eight are natural gas plants (the other two are nuclear). Combined, Virginia's top eight natural gas plants generate over 44 million megawatt-hours (MWh) annually, according to U.S. government data.[163]

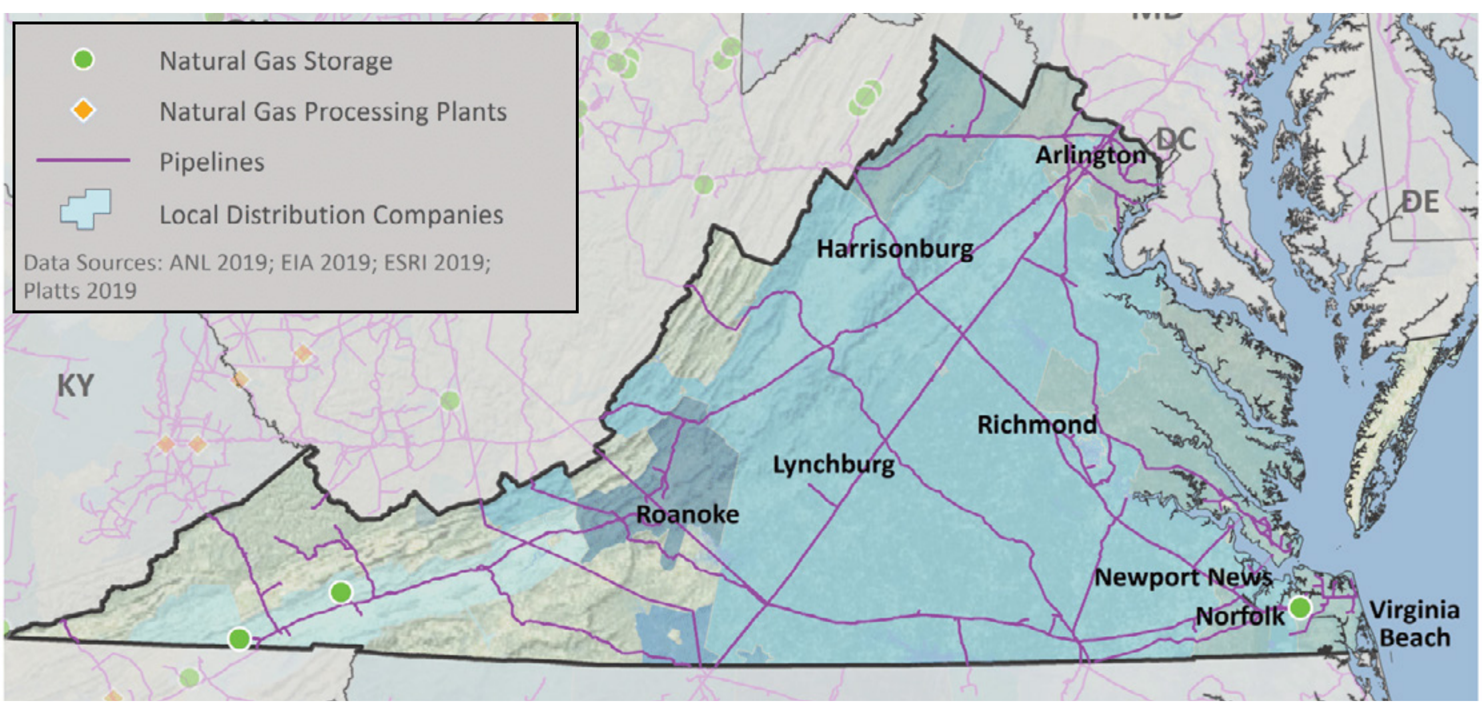
Figure 27: Natural Gas Distribution and Service Territories, 2020



Source: State Corporation Commission, 2020
Created by: Division of Public Utility Regulation, 2020

Disclaimer: This is an approximation, please contact the Division of Public Utility Regulation for official natural gas territory maps.

Figure 28: Natural Gas Pipeline, Storage, and Processing



Virginia has four renewable natural gas (RNG) plants that convert organic waste matter to natural gas, according to state data.[164] The organic waste is derived from municipal solid waste landfills, wastewater treatment plants, organic waste plants, and livestock manure plants. RNG requires processing raw material to remove carbon dioxide, water, and other trace chemicals. The amount of RNG from these plants is small, although exact amounts were not obtainable. The four plants in Virginia are as follows:

- Roanoke City (Roanoke Gas Company): wastewater treatment-based digester
- Prince William County (Washington Gas Light Company): regional landfill
- Sussex County (Align RNG): livestock manure plant
- Suffolk City (Southeastern Public Service Authority): regional landfill

Other operations exist in Virginia to capture coalbed methane emissions and convert this to natural gas. For example, CNX Resources captures methane emissions from Virginia's largest coal mine, the Buchanan Mine, and transports this through pipelines.

III. Nuclear

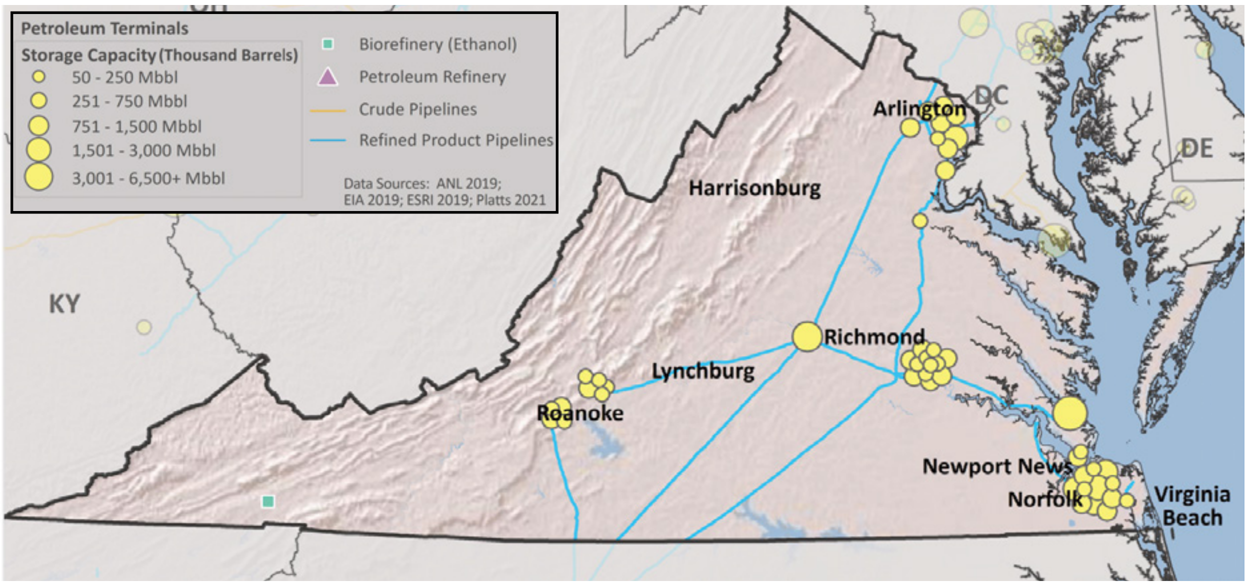
There are two nuclear power plants operating in Virginia, with two reactors each: North Anna Power Station and Surry Power Station. Both are owned and operated by Dominion Energy.

The North Anna Power Station in Louisa County has been operating since 1978. The plant's two Westinghouse pressurized water reactors generated 2,000 MW annually, according to U.S. government data.[165] The plant services the greater Richmond area and Northern Virginia, powering 450,000 homes, according to the utility company.[166]

The Surry Power Station in Surry County has been operating since 1972. Like North Anna, Surry uses the Westinghouse pressurized water reactor design. Surry generates 1,700 MW annually, powering 420,000 homes.[167]

The Nuclear Regulatory Commission has extended the operating licenses for both plants. Surry Unit 1 can operate through May 2052, Surry Unit 2 through January 2053, North Anna Unit 1 through 2058, and North Anna Unit 2 through 2060.[168]

Figure 29: Virginia Petroleum Product Pipelines



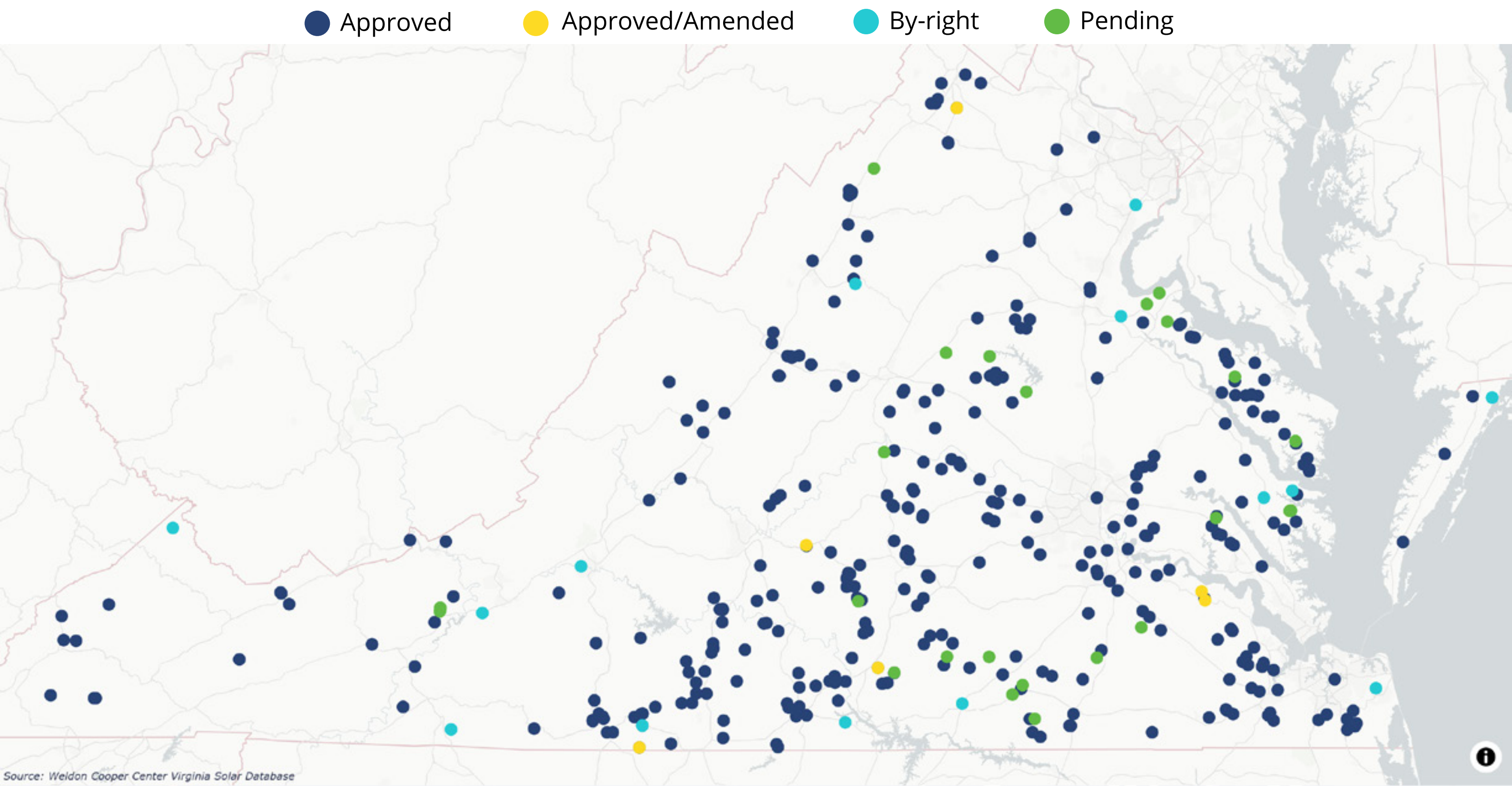
IV. Petroleum

Petroleum products, such as gasoline and diesel, traverses Virginia via pipelines and tanker trucks. Two major interstate pipelines deliver petroleum products. The Colonial Pipeline originates in Texas and has several delivery locations in Virginia before reaching its endpoint in New Jersey. The other major pipeline is the PPL Pipeline, which brings petroleum products north from Louisiana and Mississippi to its terminus in northern Virginia (see Figure 29).

Petroleum products also arrive at marine ports, such as the Port of Norfolk, which are then distributed throughout the region via pipelines. In 2022, the Port of Norfolk received nearly 15,000 b/d of petroleum products. Imports of petroleum products originate in Canada and the Netherlands, as well as from domestic movements from Texas and Louisiana.

Virginia maintains minimal crude oil production (2 wells in the southwest region) and has no petroleum refining facilities. In 2022, Virginia had over 40 petroleum product terminals for storage, 2,800 gas stations, and several other product facilities.

Figure 30: Weldon Cooper Center's Solar Dashboard, Utility-Scale Solar Projects, Approved, By-right, and Pending, 2025



Visualizations reflect all projects in the database as of June 18, 2025. Project Size map includes all projects regardless of local permit status. Source: solardatabase.coopercenter.org.

V. Renewable Infrastructure

Solar

In 2022, Virginia imported 560,000 solar photovoltaic (PV) modules, which is the 10th highest state for imports,[1] according to U.S. government data.[169] Currently, Virginia has 339 approved utility-scale solar farms (see Table 6 for top ten), according to academic center reporting.[170] Virginia's current total operating solar nameplate capacity for approved projects is over 14,000 MW. The largest solar farms are concentrated in Southern and Central Virginia. Most solar farms produce up to 4 MW (42 percent), while solar farms in the 5 to 19 MW range represent 26 percent, and solar farms in the 20 to 149 MW range represent 29 percent, and finally solar farms above 149 MW represent 3 percent.[171]

[1] In order from highest to lowest for top ten: CA (4.4 M), TX (3.7 M), FL (2.4 M), SC (1.6 M), NJ (1.1 M), CO (787K), OH (699K), AZ (691K), PA (641K), and VA (560K).

As of mid-2025, Virginia had 30 utility-scale solar projects pending approval (see Figures 30-32), for a total of over 2,000 MW. The rate of project approvals has slowed since 2023, which saw 52 project approvals. As of mid-2025, permit approvals have decreased to 12 projects. While during the same period, project denials have decreased as well from 2023 to mid-2025 (from 23 to 2 denials). In total, 18 percent of solar projects were denied, according to academic center reporting.[172] Nonetheless, Virginia's top-10 highest capacity utility scale solar facilities produce over 1.5 GW of electricity (see Table 6).[173]

Table 6: Top-10 Largest Capacity Utility Scale Solar Farms in Virginia

Site Name	Location	Capacity (MW)	Year Built
Pleinmont Solar 2	Spotsylvania County	240	2021
Skipjack Solar Center	Charles City County	175	2022
Highland Solar Energy Station 1	Spotsylvania County	165	2020
Cavalier Solar	Isle of Wright	156	2024
Fort Powhatan Solar	Prince George County	150	2022
Colonial Trail West	Surry County	142	2019
Chesapeake Solar Project	Chesapeake City	132	2023
Bartonsville Energy Facility, LLC	Frederick County	130	2024
Bookers Mill Solar	Richmond County	127	2024
Maplewood Solar	Pittsylvania County	120	2022

Wind

Wind energy infrastructure in Virginia is primarily focused on offshore development, with the Coastal Virginia Offshore Wind (CVOW) project representing the state's flagship initiative in this sector. CVOW is the largest offshore wind project in the United States. Located off the coast of Virginia Beach, approximately 26 miles from shore, this project is expected to come online in late 2026, according to state and utility owner reporting.[174] The project will include 176 14.7-megawatt Siemens Gamesa turbines, placed on 113,000 acres of Virginia coastal water (see Figure 33), according to utility reporting.[175] The turbines will rise above the water to a maximum of 800 feet. Despite their height, the distance from shoreline and the earth's curvature will make the turbines difficult to see from the shore.

The supporting infrastructure on land begins with an underwater cable that connects to a landing point on a state military reservation south of Virginia Beach.

Figure 31: Weldon Cooper Center's Local Solar Permit Status Summaries

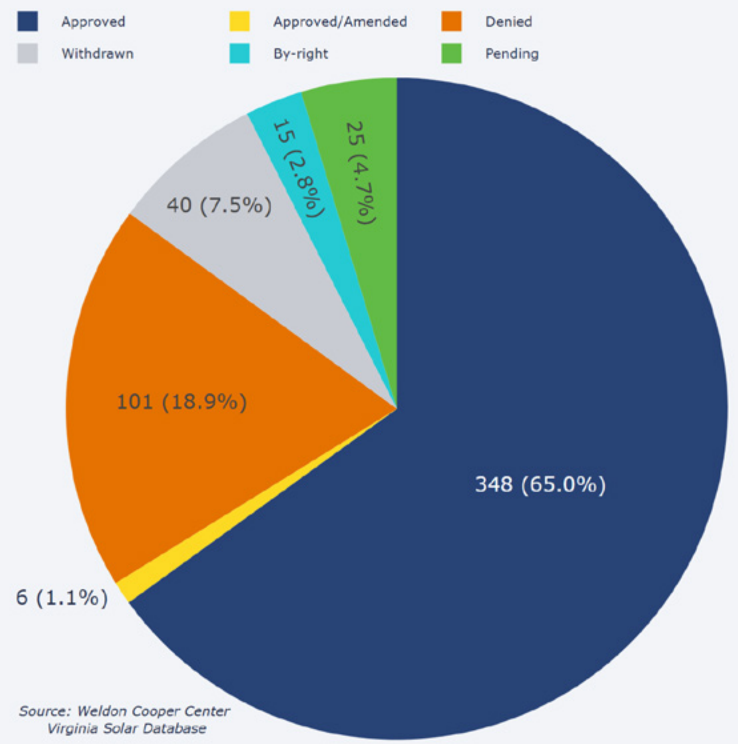


Figure 32: Virginia's Solar Project Outcomes, 2013-2025

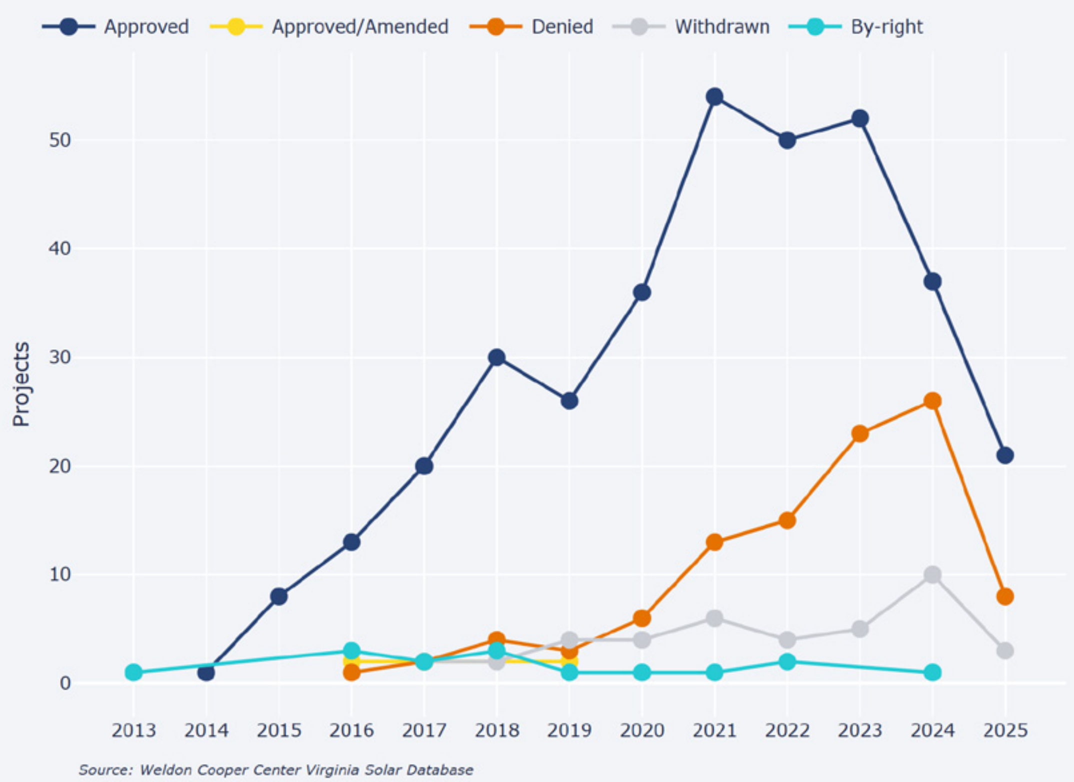


Figure 33: Dominion Energy Offshore Wind Project Infrastructure

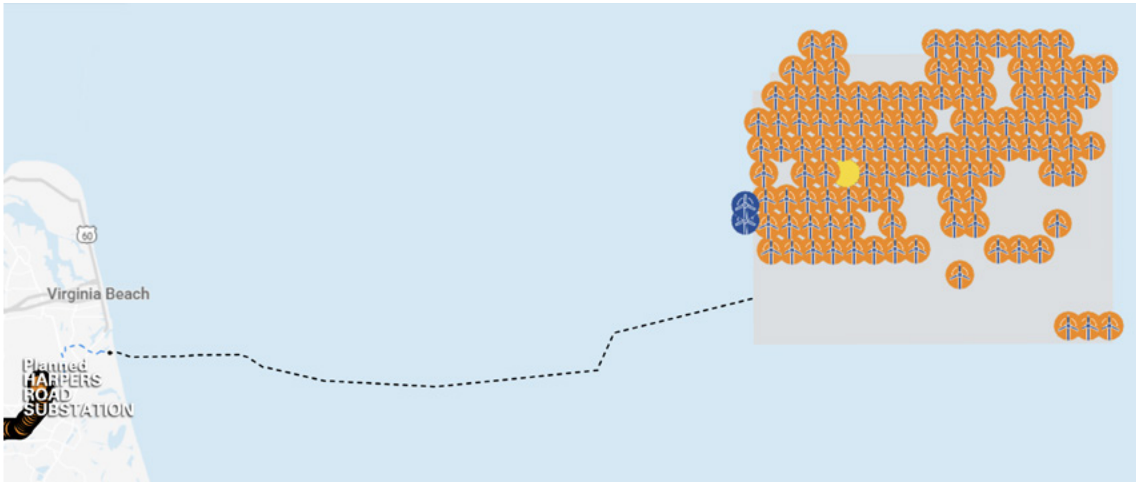
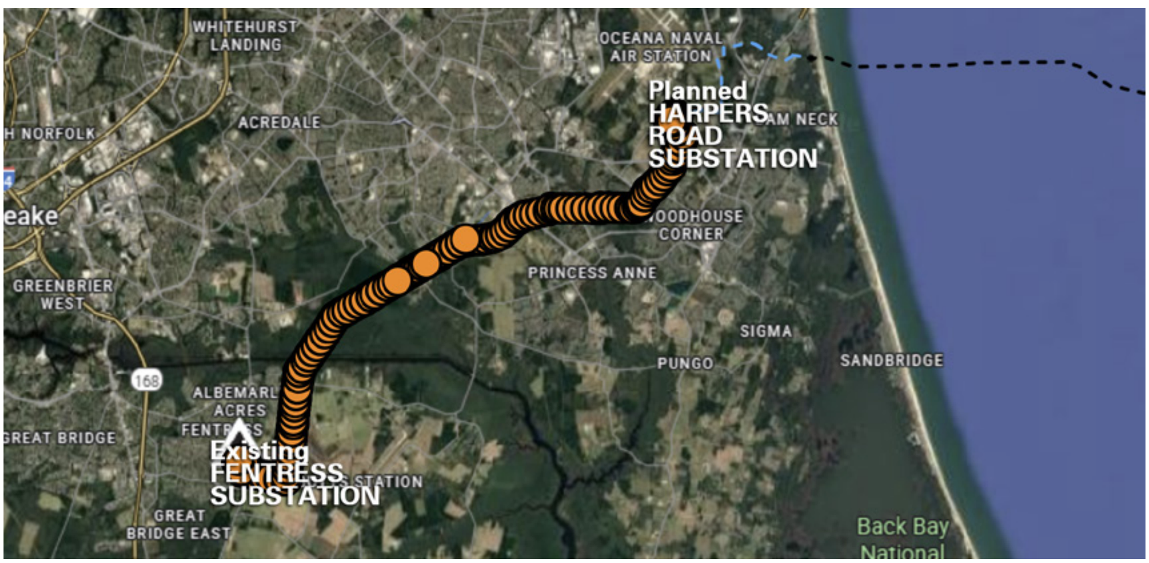


Figure 34: Dominion Energy Land Support Infrastructure



From this point, Dominion has planned a route of new overhead power lines to the Harpers Road substation in Virginia Beach, almost entirely on state (State Military Reservation) and federal land (U.S. Oceana Naval Air Station). From this substation, Dominion will construct new, and use existing, overhead power lines to the existing substation at Fentress in Chesapeake, Virginia (see Figure 34).[176]

Hydropower

Virginia has 25 conventional hydroelectric power plants and two (unconventional) pumped storage plants, according to U.S. government data.[177] Note, pumped storage plants consume more energy than they produce due to the energy required to move the water to a higher elevation. Pumped storage plants serve as a back-up power source during peak usage times.

Virginia's largest conventional hydroelectric plant is the John K. Kerr plant in Mecklenburg County which produces 426 gigawatt-hours (GWh), in the southwestern part of the state. It is owned by the federal government and built by the Rural Electrification Administration and U.S. Army Corps of Engineers. It came online in 1953 after six years of construction. Its surface area is 50,000 acres, according to the plant operator.[178]

The two pumped hydroelectric plants are in Bath County and Bedford/Pittsylvania counties. The Bath County facility is the largest pumped-storage power station in the United States. Owned by Dominion Energy, the facility began operation in 1985 and is licensed to operate through 2026. Currently, there is a pending re-license application with the Federal Energy Regulatory Commission to extend operation. The facility has a structural volume of 18 million cubic yards. The entire surface area is 555 acres, according to utility data.[179] The average annual energy generation (2014 to 2023) is 3.7 million MWh, and the average annual pumping consumption (2000 to 2020) is 4.5 million MWh.

The facility located in Bedford and Pittsylvania Counties is operated by Appalachian Power and known as the Smith Mountain Project. It began operation in 1963 and has a surface area of over 20,000 acres. The total capacity is 247K MWh, and the gross generation is 157K MWh. Its operating license expires in 2039 and can be re-licensed, according to the plant operator.[180]

Biomass

Virginia has seven biomass plants that use waste wood left behind as part of the logging process for roundwood. These are wood pellet manufacturing plants. Dominion Energy operates four facilities in Altavista, Hopewell, Southampton, and the Virginia City Hybrid Energy Center. The Altavista, Hopewell, and Southampton plants were originally coal-fired plants that were converted to use biomass material (the three plants can power 38,000 homes), according to the utility company.[181] The Virginia City Hybrid Energy Center uses a mix of biomass (20 percent) and coal (80 percent). The remaining three biomass plants include the Northern Virginia Electric Cooperative facility in Halifax, and two paper mills: WestRock in Covington, and International Paper in Franklin.

VI. Electric Grid

Virginia's electric grid infrastructure accommodates all energy sources: coal, natural gas, nuclear, hydro, oil, and renewables (see Figure 35). The grid is dominated by two investor-owned companies – Dominion Energy and Appalachian Power (see Figure 36), as well as regional electric cooperatives and municipal-owned electric utilities, according to U.S. government data.[182]

- Dominion Energy serves approximately 2.7 million homes and businesses in Virginia (and a smaller amount in North Carolina). It operates approximately 6,600 miles of transmission lines throughout its service territory, which covers approximately 30,000 square miles.
- Appalachian Power serves about 1 million people across Virginia, West Virginia, and Tennessee.

There are 13 electric cooperatives that serve smaller areas of Virginia. The three largest are Northern Virginia Electric Cooperative, Rappahannock Electric Cooperative, and Shenandoah Valley Electric Cooperative. The 13 electric cooperatives serve approximately 696,000 residents and represent about 16 percent of all electricity sales. Combined, they supply approximately 21 million MWh, according to U.S. government data.[183]

The transmission grid in Virginia consists of high-voltage lines operating at various capacities, primarily 500 kilovolt (kV), 230 kV, and 115 kV. The 500 kV lines serve as the main arteries of the transmission system, carrying large amounts of power over long distances with minimal energy losses. The 230 kV and 115 kV lines form the regional network, connecting generation sources to substations and load centers throughout the state. This hierarchical design ensures efficient power delivery while maintaining system reliability.

Microgrids: Virginia has five microgrids with a total capacity of 47 MW (see Table 7). These microgrids use a variety of energy sources, including diesel fuel and natural gas. A microgrid system is a localized energy system that can operate

Figure 35: Virginia Electric Sector

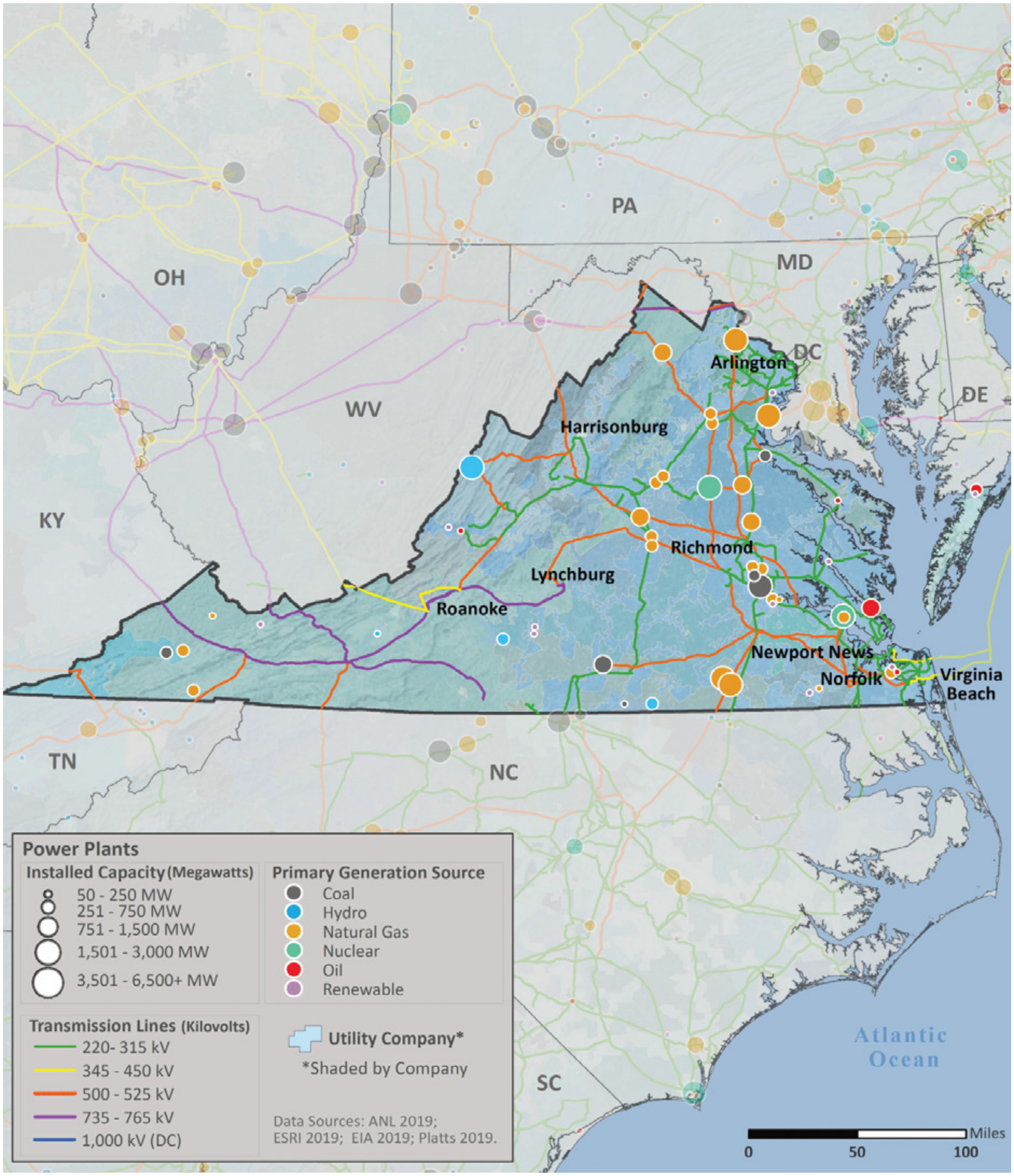
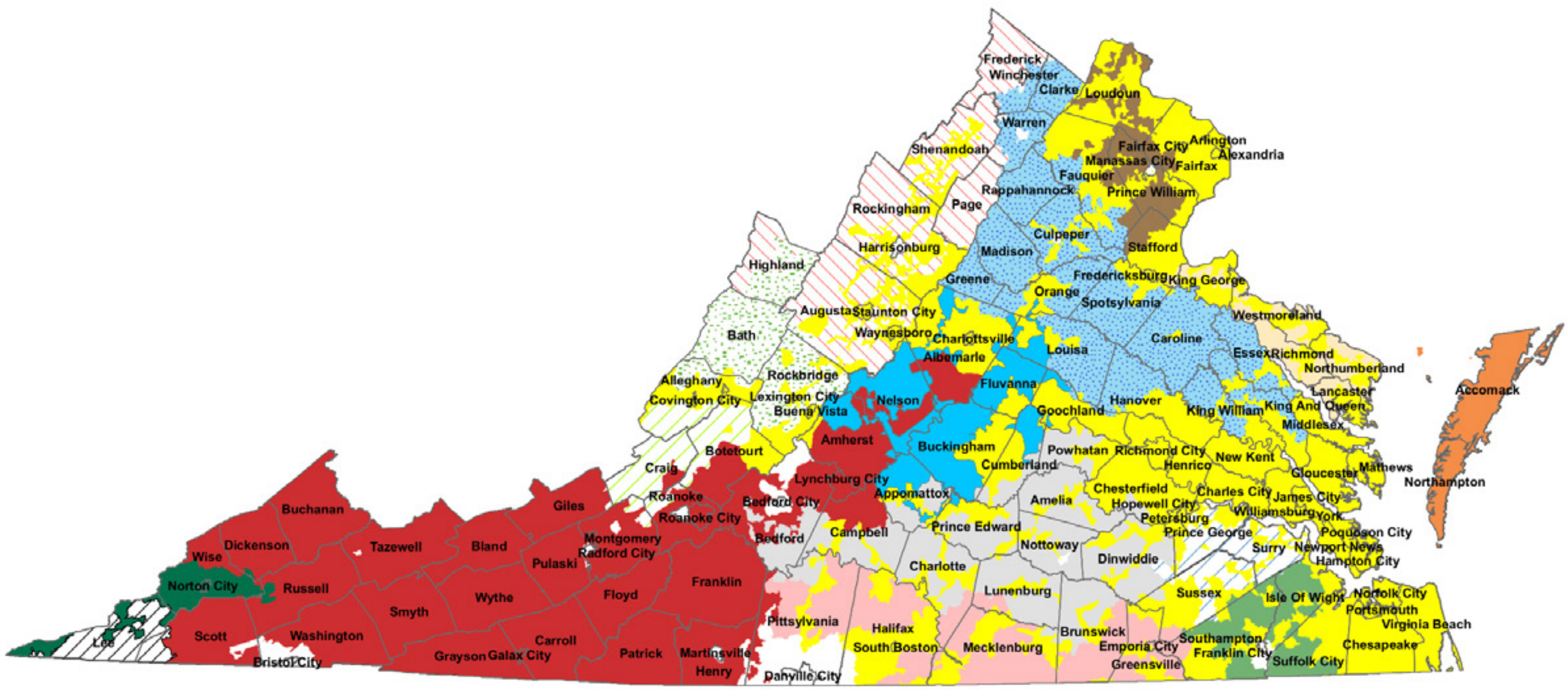
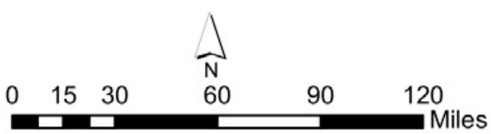


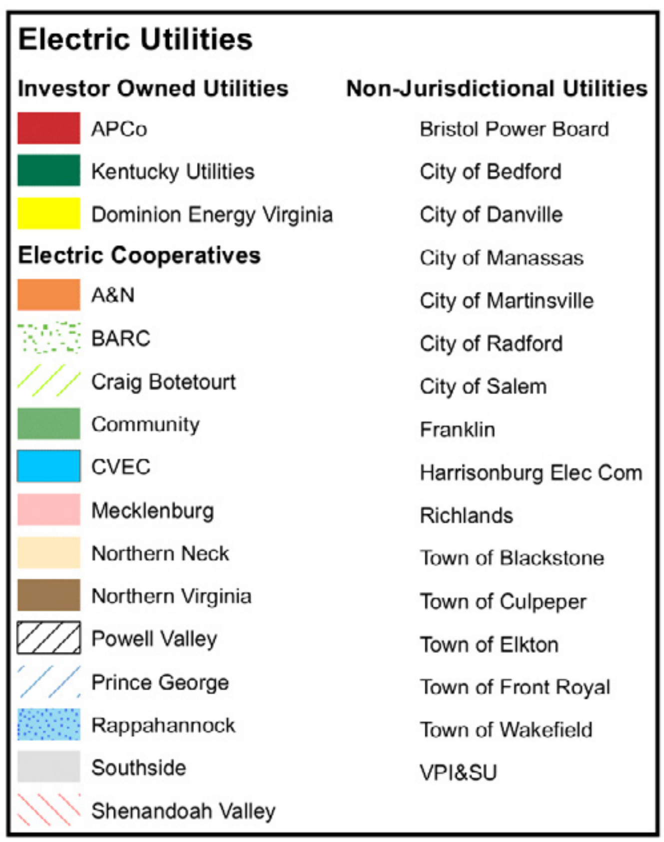
Figure 36: Virginia Electric Service Territories, 2020





Source: State Corporation Commission, 2020
Created by: Division of Public Utility Regulation, 2020

Disclaimer: This is an approximation, please contact the Division of Public Utility Regulation for official electric territory maps.



independently or in conjunction with the traditional power grid. Microgrids lessen the impact of grid interference, supporting resilience, decarbonization, and affordability, according to U.S. government data.[184]

Table 7: Virginia Microgrid Capacity, 2024

Project Name	Entity	City	Year Op.	Primary Application	Grid Connection	Microgrid Type	Generation Capacity (kW)	Storage Capacity (kW)	Technologies
Data Center Microgrid	Bloom Energy	Ashburn	2021	Data Center	Yes	Continuous	600.0	0.0	Fuel Cell
Middletown Data Center Microgrid	Cardinal Energy	Middletown	2022	Data Center	Yes	Continuous	15,500.0	0.0	Fuel Cell
Fort Belvoir	U.S. Military	Belvoir	---	Military	Yes	Continuous	2,505.0	0.0	Diesel, Natural Gas
Naval Support Facility, Dahlgren	U.S. Military	Dahlgren	---	Military	Yes	Continuous	14,000.0	0.0	Diesel
HP Hood, LLC	ZF Energy Development	Winchester	2016	Food and Beverage Processing	Yes	Continuous	14,500.0	0.0	CHP

Smart Meters and Grids

In 2008, Virginia had about 8,000 Advanced Metering Infrastructure (AMI) devices in homes. By 2023, Virginia had added over three million AMI devices (or Smart Grid Meters). The transition to AMI devices represents almost 90 percent of all electric meters in Virginia, according to U.S. government data.[185] The remainder are Automated Meter Reading devices (electronic transfer of data only) and standard meters. AMI devices are intended to provide automated data collection, enable two-way communication between the meter and the central system, and provide real-time consumption data. AMI devices are intended to enable energy management with demand response programs. Dominion Energy maintains a comprehensive deployment map that details the staged implementation of AMI infrastructure across Virginia.

Grid Enhancing Technologies

Grid Enhancing Technologies (GETs) increase transmission capacity, optimize power flow, and enhance system reliability without requiring extensive new transmission line construction. GETs have the potential to add up to 40 percent more capacity to the current grid and save costs related to grid congestion.[186] In mid-2024, Virginia passed a law (HB 862) that requires that electric utilities consider GETs in their Integrated Resource Plan process.[187]

GETs include dynamic line ratings, advanced power flow control devices, and topology optimization. In 2019, Dominion Energy installed high temperature conductors on all 230 kV reconductor and new build projects (adding or replacing 800 miles as of the end of 2023), which has provided a 50 percent increase in capacity. Dominion also utilizes technology to automatically regulate grid voltage, manage power quality, and help operators with system restoration, according to the utility.[188]

Virginia's legislative framework now requires utilities to conduct cost-benefit analyses of GETs before proceeding with new transmission infrastructure projects. This policy approach is designed to ensure that cost-effective grid optimization solutions are fully considered before more expensive traditional infrastructure expansions are undertaken. This requirement is expected to accelerate the adoption of these innovative technologies throughout Virginia's transmission system, according to industry reporting.[189]

Demand Side Management and Energy Efficiency

Virginia's two main utilities use demand response (DR) programs. DR programs work by having its participants conserve or shift electricity use in response to grid signals (e.g., high electricity demand, inadequate energy supply, high electricity prices and high emissions).

In 2013, Virginia energy efficiency programs saved 26,000 MWh, of which residential programs represented more than half of the savings. By 2023, the savings exceeded over 243,000 MWh – an eight-fold increase, according to U.S. government data.[190] By 2023, the savings from the commercial sector represented 55 percent and residential represented 45 percent.[191] Some examples of energy efficiency programs include incentives to install or purchase:

- Energy-efficient lightbulbs
- Programmable thermostats to control heating and cooling systems
- Energy management and control systems in commercial and industrial facilities
- Electric, battery, or plug-in hybrid vehicles

<u>Virginia Public Buildings</u>: Virginia's Department of Energy (VDOE) manages a DR program with the private company, Voltus. According to VDOE, over 400 public facilities can participate in the program (e.g., schools, municipal buildings, and waste/water treatment plants). Over a three-year period, VDOE's DR program has saved more than $20 million in revenue for the state, according to state reporting.[192]

Virginia Industry and Businesses: Dominion Energy offers industry and commercial business the opportunity to participate in a distributed generation (DG) program, whereby participants reduce their electricity use during times when the power grid is experiencing heavier than normal use. Participants switch their power source from the electric grid to a backup generator during peak energy usage. In return, the customer receives a monthly incentive payment based on their reduced power consumption. Dominion partners with a private company, PowerSecure International, to manage the DG program. Virginia's businesses can also participate in a PJM program like the Dominion program, operated by CPower Energy, according to industry reporting.[193]

Residents: Dominion Energy and Appalachian Power provide Demand Side Management (DSM) opportunities for residents, particularly low-income residents. DSM programs offer incentives, such as rebates to install energy efficient appliances in homes. Other examples of DSMs include smart thermostats, LED lightbulbs, and air sealing. According to Dominion, in 2023, its DSM program had 371,000 customers participate in an energy efficiency education program.[194] According to Appalachian Power, in 2021 and 2022, it deployed almost 6,000 smart meters, conducted over 3,000 energy audits, weatherized 500 homes, issued over 300,000 home energy reports, provided $1,500 in Energy Star appliance rebates, and delivered over 9,000 energy efficiency kits.[195]

Virtual Power Plants

Virginia is on the cusp of utilizing virtual power plants (VPPs) with recently enacted legislation. A VPP aggregates distributed energy resources, such as home or vehicle batteries and devices whose consumption is adjustable (such as electric water heaters and appliances) and controls the rate at which each source charges or discharges (accepts or delivers power). Virginia Senate Bill (S.B.) 1100 and House Bill (H.B.) 1062, passed by the General Assembly in 2024, explicitly enable customer owned distributed energy resources (including on site batteries) to participate in demand response or peak reduction programs, distinct from net metering rules.[196] In February 2025, Virginia passed S.B. 1040 and S.B. 1100, directing Dominion Energy to propose a pilot program testing VPP technologies for demand management.[197] H.B. 2346, also passed in early 2025, mandates that Phase II utilities (Dominion Energy) petition the State Corporation Commission to launch a statewide VPP pilot project.[198]

The development of virtual power plant infrastructure in Virginia reflects growing recognition of demand-side resources as valuable grid assets. By aggregating and coordinating distributed energy resources, these systems can provide services like traditional power plants but with greater flexibility and lower environmental impact.

It should be noted that VPPs are not favored by regulated utilities because they are low capital investments. VPPs are the business interest of IT companies that specialize in aggregation. Utilities are not optimizers of aggregation despite having the privilege of real-time customer data. These misaligned incentives will likely create challenges without regulatory attention.

Net Metering

In 2018, there were only 8,000 customers in Virginia using net metering with solar power, which generated 70,000 MWh. By 2023, net metering customers with solar power increased to 60,000, accounting for an eight-fold increase in capacity to 631,000 MWh in five years. The residential sector represents the bulk of net metering customers (58,500), but there is a small commercial segment using net metering (1,500), according to U.S. government data.[199]

Appendix B
ENERGY SECURITY AND EMERGENCY PREPAREDNESS

Summary

Over the past 10 years, Virginia has had reliable electricity delivery. It has had sufficient reserve capacity to meet expected peak demand in the electric sector. Reliability and electricity interruptions are largely a factor in weather-related events (e.g., trees falling on electric transmission lines). Virginia's emergency preparedness complies with federal requirements and processes and resembles other states.

This section explains the governance of energy security and preparedness, reliability assessments during peak usage periods, the causes of interruptions, and the emergency and security plans in place. In the context of this chapter, "energy security" refers to reliability of energy delivery. Issues of price affordability and predictability are addressed in the Prices and Expenditures chapter.

Key Takeaways

- The PJM region (Virginia and 12 other states) has sufficient operating reserves installed to meet target reserve margin for Summer 2025, which is necessary to meet the one-day-in-10-years loss of load expectation criteria.
- Virginians experience an average of 5.5 hours of electricity interruptions annually, which is consistent with the national average.
- Virginians experience between 1 and 1.5 total events annually, which also matches the national average.

I. Electricity Sector

Governance

The North American Electric Reliability Corporation (NERC) is responsible for ensuring the reliability and security of the U.S. electric grid, of which Virginia is part of the eastern interconnection grid. NERC develops and enforces reliability standards under the authority of the Federal Power Act. It also assesses seasonal and long-term reliability issues; monitors the bulk power system through system awareness; and educates, trains, and certifies industry personnel, according to the regulatory authority.[200] The U.S. Federal Energy Regulatory Commission exercises oversight authority over NERC.

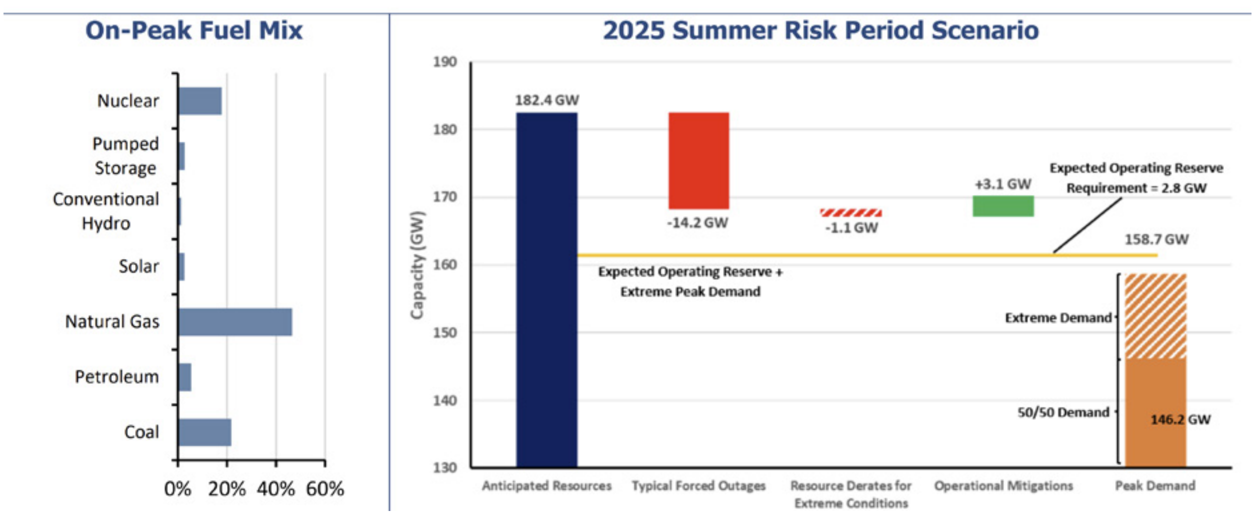
NERC is responsible for over 80 mandatory reliability standards subject to enforcement, such as on cyber and physical swecurity, power balancing and contingency reserves, emergency operations, transmission maintenance, interconnection requirements, and cold weather preparedness.[201]

Reliability (2025 Summer PJM Region)

For the summer of 2025, NERC's estimate for the PJM region (Virginia and 12 other states) is that installed operating reserves[1] are 27 percent, which is above the target reserve margin of 17.7 percent. The target reserve is necessary to meet the one-day-in-10-years loss of load expectation criteria. Therefore, according to NERC, the PJM region expects resources to meet operating reserve requirements for peak summer needs (i.e., status is normal risk). During extreme high temperatures that can cause record demand, NERC's

[1] "Operating reserves" represents the electric generating capacity available to the system operator within a short interval of time to meet demand in case a generator goes down or there is another disruption to the supply.

Figure 37: PJM Summer Risk, 2025



report highlights the need for energy demand-response resources and programs to help reduce load during these times. The peak load fuel mix for the region includes natural gas (~45 percent), coal (~20 percent), and nuclear (~20 percent) (see Figure 37).[202] Pumped hydropower and solar, combined with battery storage, are also options for peak load generation.

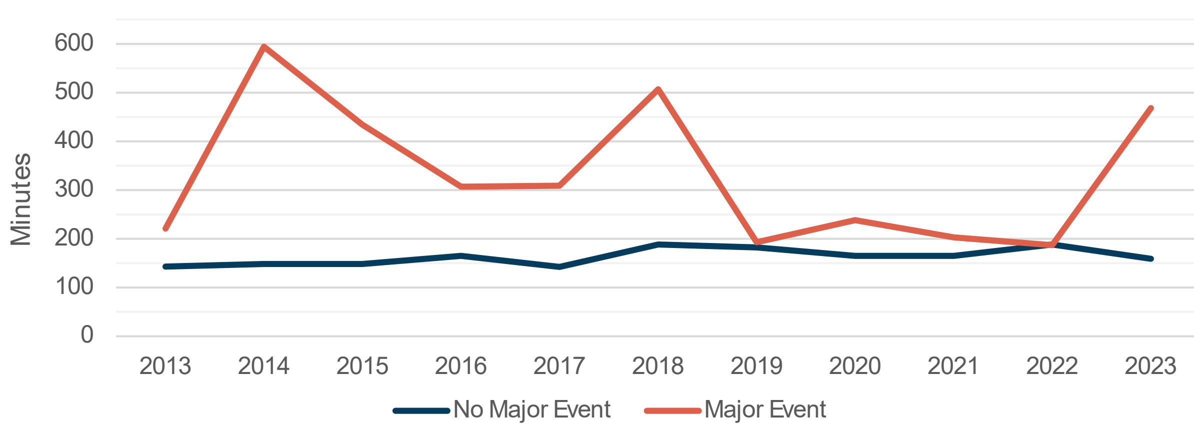
2013 NERC Long-Term Assessment

NERC's 2013 10-year "Long-Term Reliability Assessment" projected that the anticipated reserve margin for the PJM region was well above the target reserve margin for the next decade, although narrowing towards 2023. Of note, the 2013 report finds that "from a Regional Transmission Expansion Plan perspective, generation deactivations [retirements] coupled with steady load growth and sluggish generation additions can lead to the emergence of reliability criteria violations in many areas of PJM."[203]

Electricity Interruptions

Since 2013, Virginians have experienced an average of 5.5 hours of electricity interruptions annually, which is consistent with the national average. This includes occurrences with a major event, such as snowstorms and cold fronts, tornados, extreme heat, heavy rainfall, and floods. The leading causes of electric outages are weather or falling trees (34 percent) and faulty equipment and human error (28 percent). During outages not related to a major event, Virginia experiences an average of 3.5 hours of electricity interruption annually, according to U.S. government data.[204] This measurement is known as the "System Average Interruption Duration Index" (SAIDI), which is the average cumulative outage duration (in minutes and/or hours) for each customer served. With an increasing frequency of major events, the duration of interruptions is anticipated to increase (see Figure 38).

Figure 38: Virginia System Average Interruption Index Duration, 2013-2023



The "System Average Interruption Frequency Index" (SAIFI) is another reliability index used by electric power utilities. Where a SAIDI measures minutes or hours interrupted, the SAIFI measures the frequency of events (i.e., the total number of electricity outage events). Virginia experiences between one and 1.5 total events annually, which also matches the national average.[205]

The U.S. government compares SAIDI and SAIFI values of each state against the U.S. average to determine the impact that major events have on electricity reliability. For example, the 2022 data on frequency of interruptions (SAIFI) and hours without power (SAIDI) identifies Florida, West Virginia, Vermont, and Maine as having issues with electricity reliability. Some notable major events in 2022 included Hurricane Ian (2.6 million customers in Florida without power for over two weeks), Hurricane Nicole (300,000 customers in Florida without power), and Winter Storm Elliott (1.5 million customers in several states without power). Customers in these states experienced up to 19 hours without electricity.[206] Virginia is in the average range.

II. Natural Gas Sector

Governance

The U.S. Department of Transportation (Pipeline and Hazardous Materials Safety Administration) inspects state pipelines under its safety regulatory program. It uses a series of performance metrics, including damage prevention, leak management, and other incidents that may cause natural gas pipelines to halt service.[207]

Reliability

Most issues with reliability of natural gas distribution involve excavation damage. These issues are partly due to third-party actions or aging infrastructure, and not system design failure. Note, Virginia's distribution system still uses cast iron or bare steel, especially in older cities. Since 2010, the number of excavation damage occurrences have dropped almost in half (from 1.7 to 1 per thousand planned excavations).[208] On a 10-year average, Virginia had four natural gas incidents annually, at an average cost of $4.4M annually. This is well below the national average.[209]

III. Petroleum Sector

Governance

The U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration tracks incidents involving petroleum transport by rail, truck, and pipeline.[210]

Reliability

Over the reporting period of 1986 to 2019, Virginia's petroleum supply was most impacted by derailments, collision, or rollovers when transported by truck (8th leading cause nationwide at $70,000 per year); incorrect operations when transported by rail (4th leading cause nationwide at $2.02M per year); and material failures when transported by product pipelines (4th leading cause nationwide at $9.47M per year), according to U.S. government data.[211]

IV. Emergency Preparedness

Emergency Governance

The Virginia Department of Emergency Management (VDEM) coordinates operations in times of natural, man-made, acts of terrorism, or cyber-related events. It accomplishes this through emergency management protocols to "prevent, prepare for, respond to, recover from, and mitigate threats to the Commonwealth."[212] It works with local, state, tribal, and federal agencies and voluntary organizations to provide these crucial services. One of these organizations is the Virginia Fusion Center (wVFC), located in North Chesterfield, Virginia. The VFC provides a centralized location for federal, state, and local law enforcement and criminal intelligence to share and disseminate information about threats to state security.

Virginia Emergency Operations Plan

The Virginia Emergency Operations Plan includes procedures and protocols for emergencies and disasters that involve state, tribal, and local governments. The purpose of this plan is to preserve life, public health, property, essential services, and economic recovery.[213] Upon an emergency declaration by the governor, this plan authorizes the waiver or exemption from registration, licensing, or permitting requirements.

The Virginia Department of Emergency Management publishes annexes to the Virginia Emergency Operations Plan, including plans on energy security, radiological emergencies, hazardous materials exposure, and cyber-attacks.

Virginia Energy Security Plan

The Virginia Energy Security Plan has a short-term focus on emergency response and restoration efforts and a long-term focus on planning and proactive measures to identify and mitigate risks and vulnerabilities in critical energy infrastructure. These efforts may include investing in infrastructure upgrades, diversifying energy sources, enhancing cybersecurity measures, promoting renewable energy development, and implementing strategies to reduce dependence on single points of failure.[214]

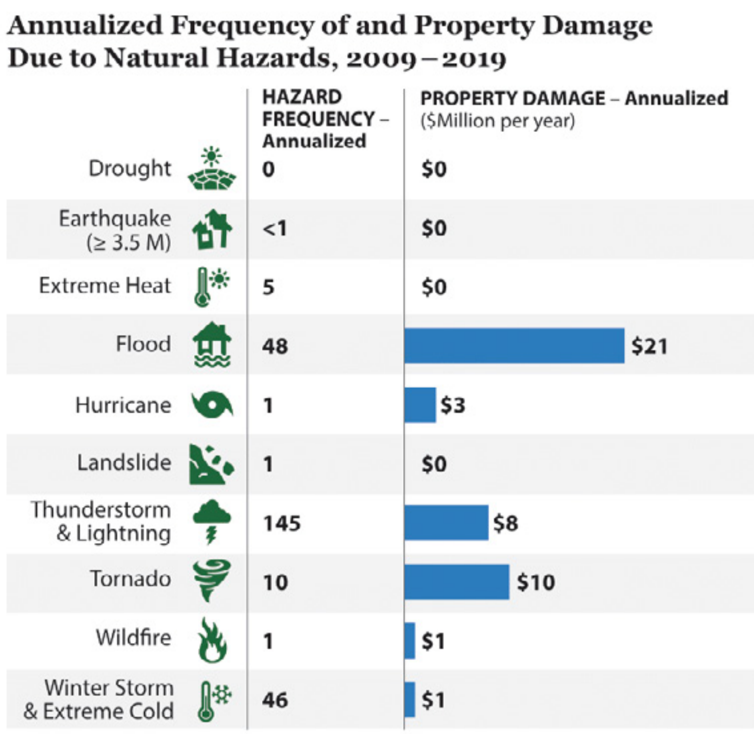
The energy security plan identifies two major vulnerability categories: natural disasters and physical/cyber threats. Natural disasters include floods, sea level rise, hurricanes, tornados, thunderstorms, extreme cold and heat, earthquakes, landslides, wind, wildfires, and drought. There are many examples of these events impacting Virginia in recent history, including Hurricanes Ida (2021), Denis (2005), Gaston (2004), and Floyd (1999). From 2013 to 2019, Virginia had 108 major disaster declarations and 134 emergency declarations. These events have impacted several areas, primarily by flooding. In fact, flooding costs Virginia $21M annually, which is the leading cause nationwide at $12 billion per year (see Figure 39), according to U.S. government data.[215]

Cyber threats involve sophisticated IT and operational intrusions that take control of operating systems and/or steal data. One example of a cyberattack affecting Virginia was the 2021 Colonial Pipeline ransomware attack, which shut down petroleum movement in the region.

Physical attacks on infrastructure can range from gunshots fired at energy infrastructure to theft of critical materials. For example, in December 2022, two electric substations in North Carolina were the target of intentional gunfire that caused 45,000 residents to lose power for nearly four days while extensive repairs were required, according to press reporting.[216]

In case of an energy emergency event, Virginia authorities would work on planning, policy, collaboration, communication, facilitation, and education. For example, in a petroleum emergency the Virginia Department of Energy receives requests from fuel oil suppliers, transporters, or trade associations to implement vehicle weight and driver hours of service waivers.[217]

Figure 39: Virginia Natural Hazards - Cost and Frequency



Data Sources: NOAA and USGS

Appendix C
ENVIRONMENT AND PUBLIC HEALTH

Summary

Virginia has made progress in improving its environment and public health over the past several decades. In recent years, however, Virginia's air quality has worsened and may be trending toward unhealthy levels. This is especially true for ground level ozone and fine particulate matter. Virginia also emits a high amount of total carbon dioxide emissions, although its emissions have decreased over the years largely a result of transitioning to cleaner sources of energy. The sector of most concern is the transportation sector, which emits the most carbon emissions of any sector, followed closely by the commercial sector.

This section examines how major pollutants affect Virginians' public health, energy-related impacts on air and water pollution, and the profile of carbon dioxide emissions across several metrics.

Key Takeaways

- Virginia is becoming a cleaner and healthier place to live, but there is still concern over increasing emissions from the transportation and commercial sectors and localized impacts from air pollutants.
- Over the past 25 years, Virginia reduced total nitrous oxides emissions by 61 percent, sulfur dioxide emissions by 89 percent, and fine particulate matter emissions by 35 percent. These emission reductions came mostly from the electricity sector, which has transitioned away from coal-powered plants to cleaner emitting sources.
- The following Northern Virginia counties are in "non-attainment" status for ground level ozone: Loudoun, Prince William, Arlington, and Fairfax (these counties exceeded federal emission limits).

Key Takeaways (continued)

- A new form of Black Lung disease is on the rise in the Appalachian region (silicosis) from inhalation of coal rock dust. This affects more minors than historical levels (1 in 5) and at a faster rate (i.e. miners are diagnosed at younger ages).
- In 2022, Virginia emitted 96 million metric tons of carbon dioxide, which placed it in the 15th highest ranking state. But it emits less CO_2 per dollar of economic activity than most states.

I. Air Quality

Virginia's annual air quality meets federal standards, but certain regional fluctuations come close to or exceed federal air quality limits. Virginia's air quality is impacted by fossil-fueled power plants and gasoline and diesel vehicles. Additionally, forest fires, dust storms, and other transboundary movements impact air quality. The pollutants of most concern for public health in Virginia are carbon dioxide, particulate matter, sulfur dioxide, nitrogen oxides, ground-level ozone, and inhalation of coal dust. Harmful air pollutants have economic costs, such as lost workdays, increased health care costs, and premature deaths from respiratory complications and cancers, according to U.S. government sources.[218]

Between 1990 and 2017, Virginia reduced total nitrous oxides (61 percent), sulfur dioxide (89 percent), and fine particulate matter (35 percent) – pollutants primarily emitted by fossil-fueled power plants, vehicles, and industrial sources, according to U.S. government data.[219] The bulk of reductions come from the electricity sector. These decreases occurred despite increased electricity production (20 percent), population growth (1 million), and a doubling of GDP. These improvements are largely due to the shift from coal to natural gas and renewables.

In each emissions category, Virginia's national ranking improved. For sulfur dioxide, Virginia dropped from 17th to 25th in emissions and nitrogen oxides emissions dropped from 23rd to 32nd, according to U.S. government data.[220]

II. Air Pollutants

Particulate Matter

Fine Particulate Matter ($PM_{2.5}$) can come from manmade or natural sources. Manmade sources include the burning of fossil fuels in power plants and vehicles. Natural sources can include ash and gases from wildfires and volcanoes. $PM_{2.5}$ can cause premature death in people with heart or lung disease, nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing, according to U.S. government data and health association reporting.[221]

Table 8: Virginia Areas with Highest $PM_{2.5}$

Annual Mean Test	Percentile Test
City of Richmond	Rockingham County
Fairfax County (Springfield)	Frederick County
Arlington County	Fairfax County (Springfield)
Frederick County	Albemarle County
Fairfax County (Franconia)	Fairfax County (Franconia)
Henrico County	

From 2021 to 2023, Virginia municipalities did not exceed the $PM_{2.5}$ federal ambient air quality limit. $PM_{2.5}$ is tested in two ways. The first is by an annual mean averaged over three years. The second is by percentile (98th percentile averaged over three years). The areas with the highest $PM_{2.5}$ readings for the annual test were (in order of high to low): Richmond, Springfield/Fairfax, Arlington, Frederick, Franconia, and Henrico. The areas with the highest $PM_{2.5}$ readings for the percentile test are (in order of high to low): Rockingham, Frederick, Springfield/Fairfax, Albemarle, and Franconia, according to state data (see Table 8).[222]

On an annual basis, one Virginia county did exceed the three-year federal limit.[1]In 2023, Rockingham County, in Virginia's northwest valley region, exceeded $PM_{2.5}$ air quality limits (see Figure 40). Albemarle and Frederick Counties in the northern valley region came close to exceeding the $PM_{2.5}$ standard. In the northern region, the following areas also came close to exceeding $PM_{2.5}$ limits, according to state data: Franconia, Fairfax, and Springfield (see Figure 41).[223]

Virginia's average exposure to $PM_{2.5}$ is 6.9 micrograms per cubic meter, which ranks 14th highest nationally in the United States, according to a health association.[224] On an annual basis, $PM_{2.5}$ concentrations in Virginia have contributed to approximately

[1] This is not a violation of the Clean Air Act since the exceedance was not exceed the federal test procedure.

Figure 40: PM$_{2.5}$ Exceedance in the Shenandoah Valley Region

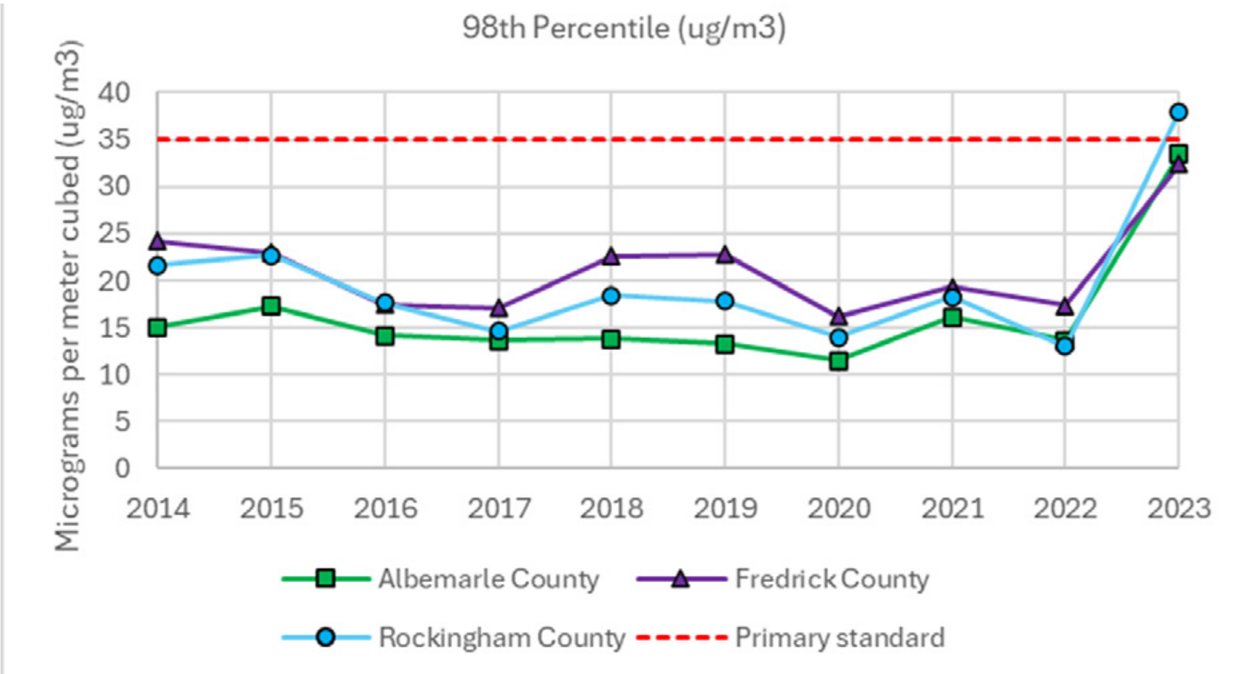
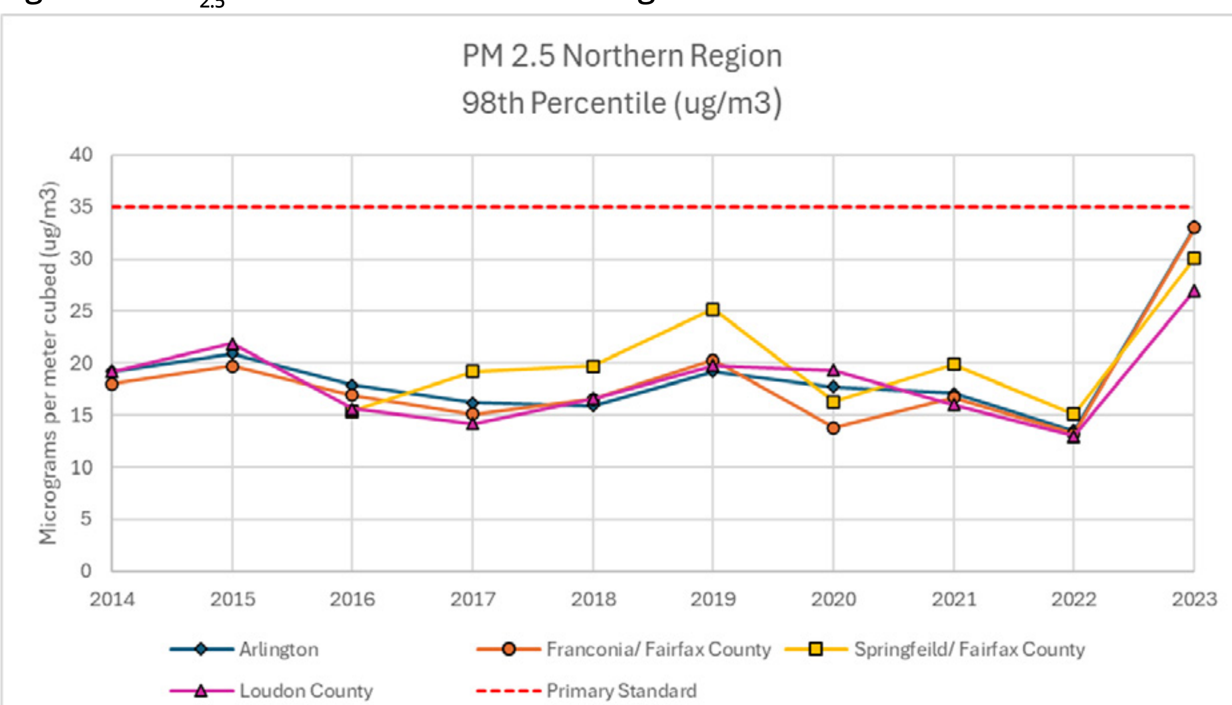


Figure 41: PM$_{2.5}$ Exceedance in Northern Virginia



3,000 premature deaths, 3,600 hospitalizations, and 1,600 emergency department visits annually, according to an assessment by IEc.[225] This health burden translates to about $23 billion in social welfare costs each year, stemming from increased healthcare expenses, reduced labor productivity, and diminished quality of life.[226]

Particulate Matter$_{10}$ (PM_{10})

In 2023, one county (Fairfax County) exceeded the PM_{10} standard, which is tested over a 24-hour period. While PM_{10} has particles larger than $PM_{2.5}$, it is still in a size range that can pose similar health problems as $PM_{2.5}$.[227]

Sulfur Dioxide

Sulfur dioxide (SO_2) can harm the human respiratory system and make breathing difficult. People with asthma, particularly children, are sensitive to these effects. The sources of SO_2 include power plants, internal combustion engines, manufacturing, and industrial processes. SO_2 can also travel long distances, according to U.S. government data and health association reporting.[228]

In 2021, one county (Giles County) exceeded the SO_2 federal ambient air quality limit. The Lhoist North America manufacturing facility, in Giles County along the West Virginia border, consists of an underground limestone mine and preparation plant. It is included here because the plant failed to have continuous monitoring systems, which is required in many industrial facilities and power plants. In 2022, Giles County came close to exceeding the SO_2 limit. Over a three year period (2021 to 2023), Giles County had the highest SO_2 concentrations in the state, more than all Virginia monitoring sites combined, according to state data.[229]

Ozone

Ground-level ozone is not emitted directly into the air but is created by chemical reactions between nitrous oxides (NO_x) and volatile organic compounds (VOCs). It can cause shortness of breath, wheezing and coughing, asthma attacks, increased risk of respiratory infections, and increased susceptibility to pulmonary inflammation. Long-term exposure is associated with metabolic disorders, nervous system issues, reproductive issues (including reduced male and female fertility and poor birth outcomes), and increased respiratory and cardiovascular-related mortality, which are the main drivers of total mortality, according to U.S. government data and health association reporting.[230]

The following counties have had days that exceeded the federal ground-level ozone standard from 2021-2023 (in order of highest days exceeded to lowest days exceeded): Arlington, Fairfax, Prince William, Loudon, Stafford, Frederick, Fauquier, Rockingham, Hanover, and Suffolk.

The following Northern Virginia counties are in “non-attainment” status for ground level ozone: Loudoun, Prince William, Arlington, and Fairfax. Ozone “non-attainment” status means the area exceeds the level of 0.070 parts per million over an eight-hour period over (three-year average measurement) (see Table 9).

Nitrogen Oxides

From 2021 to 2023, Virginia municipalities did not exceed the NO_x federal ambient air quality limits over both means of testing (annual and percentile), according to state reporting.[231] Note, NO_x emissions contribute to ground-level ozone.

Coal Dust

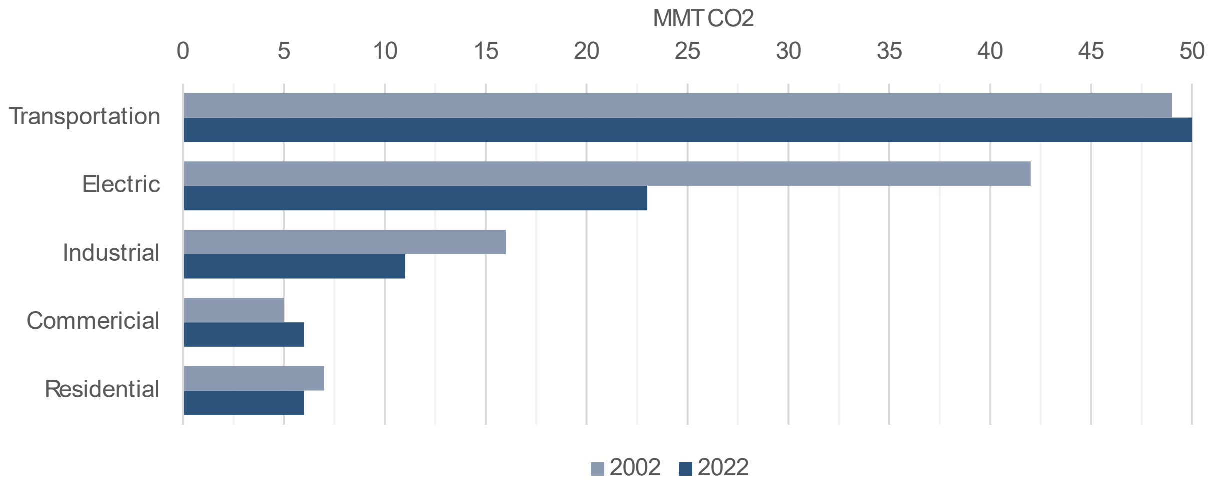
Inhalation of coal dust can lead to pneumoconiosis (also known as Black Lung Disease). In the Appalachian region, the average rate of death from pneumoconiosis is almost 11 cumulative deaths per county (compared to 3.5 outside of this region). This is significantly more deaths, both overall and accounting for population size, according to U.S. government data.[232] Pneumoconiosis causes inflammation (swelling and irritation) and fibrosis (thickening or scarring) in lung tissue brought about by inhaling dust particles in and around coal mines, according to medical literature.[233]

Table 9: Virginia Localities with Highest Ozone, 2023

Locality	Status
Arlington County	Non-attaintment
Fairfax County	Non-attaintment
Prince William County	Non-attaintment
Loudoun County	Non-attaintment
City of Alexandria	Non-attaintment
City of Fairfax	Non-attaintment
City of Falls Church	Non-attaintment
City of Manassas Park	Non-attaintment
City of Manassas	Non-attaintment

While some consider Black Lung Disease largely eradicated, a new form of this disease, silicosis, has emerged. Silicosis is caused by inhaling crystalline silica, a kind of coal rock dust that encases the remaining coal in the Appalachian region. This new disease is affecting younger miners in only a matter of years, as opposed to decades of exposure. The infection rate has gone from 1 in 10 to 1 in 5, according to press reporting.[234]

Figure 42: Carbon Dioxide Emissions by Sector



Carbon Dioxide

In 2002, Virginia emitted 119 million metric tons (mmt) of carbon dioxide (CO_2), which placed the state 15th highest nationally. By 2022, Virginia had decreased CO_2 emissions by almost 20 percent to 96 mmt, but remained 15th nationally, according to U.S. government data.[235] Compared to the states in the PJM Mid-Atlantic, Virginia emits more CO_2 than New Jersey, West Virginia, Maryland, and Delaware, but less than Pennsylvania.

Carbon Intensity of Economy

In 2002, the U.S. had an average state-wide carbon intensity[2] of 400 metric tons of CO_2 per dollar and Virginia's carbon intensity was below the national average (at 365 metric tons per dollar). This placed the state 34th nationally. By 2022, the national average had decreased by almost half to 226 metric tons of CO_2 per dollar and Virginia was again below the national average (at 203 metric tons per dollar) and fell to 36th nationally. This means Virginia emits less CO_2 per dollar of economic activity than 35 other states. Among the PJM Mid-Atlantic states, Virginia emits less than the other states, except for New Jersey and Maryland, according to U.S. government data.[236]

Carbon Dioxide Emissions (Per End Use Sector)

Virginia's transportation sector has consistently emitted more CO_2 emissions over the past 20 years than any other sector. Except for the commercial sector, all other

[2] "Carbon intensity" measures the amount of carbon dioxide equivalent (CO_2e) emitted per unit of activity, output, or product.

sectors have decreased CO_2 emissions, according to U.S. government data (see Figure 42), with the most significant decrease from the electric sector.[237]

Compared to other states in the PJM Mid-Atlantic, Virginia's transportation sector CO_2 emissions exceed those in New Jersey, Maryland, West Virginia, and Delaware, but are less than those in Pennsylvania. In the electric and industrial sectors, Virginia emits more CO_2 than all states except for Pennsylvania and West Virginia. In the commercial sector, Virginia emits more CO_2 than Delaware, Maryland, and West Virginia, but less than New Jersey and Pennsylvania.

Carbon Dioxide Emissions Per Capita

In 2002, Virginia's per capita CO_2 emissions (16 metric tons) were less than the U.S. average (20 metric tons). By 2022, Virginians had reduced per capita CO_2 emissions by 32 percent (to 11 metric tons), which was also less than the U.S. average (15 metric tons), according to U.S. government data.[238] Within the PJM Mid-Atlantic states, Virginia has the third lowest per capita emissions behind Maryland and New Jersey.

Coal Ash

Virginia faces significant challenges with coal ash disposal, a byproduct of coal-fired power plants. It contains heavy metals and other contaminants like arsenic, mercury, and cadmium. Exposure to coal ash has been linked to cancer, heart and thyroid disease, reproductive failure, and neurological harm. Virginia utilities operate 17 federally regulated coal ash ponds and landfills containing more than 51 million cubic yards of toxic waste at eight coal plants. In 2024, the U.S. Environmental Protection Agency issued a rule that requires power plants to clean up their toxic coal ash. In addition, Virginia hosts at least 19 inactive coal ash landfills and legacy ponds that escaped federal regulation. The exact number remains unknown because utilities were not required to report on these sites.[239]

According to Dominion Energy, it is acting to permanently close its coal ash ponds. These ponds are at Possum Point Power Station in Dumfries, Chesterfield Power Station near Richmond, Bremo Power Station in Fluvanna County, and the Chesapeake Energy Center in Chesapeake. Dominion also stores ash in landfills at Yorktown Power Station, Chesterfield Power Station, Clover Power Station, and the Virginia City Hybrid Energy Center. Dominion will remove and treat all the water in the ponds, and then the ash will be removed and recycled or disposed of in a lined landfill that meets federal standards.[240]

III. Water Contamination

The energy sector can affect water quality in several ways. Fossil fuel power plants discharge pollutants directly into water, natural gas operations (pipeline construction and storage) leak pollutants into waterways, coal mining leaks sediments into waterways (known as acid mine drainage), biomass facilities leak nutrients into waterways, hydropower plants alter water flow and trap sediments, and solar and wind impact land use that affect waterways.

In 2024, more than three-quarters of Virginia's rivers, lakes and estuaries were "impaired,"[3] as defined by Virginia's Water Quality Standards and the Clean Water Act.[241] Overall, Virginia's water quality conditions do not support recreation in rivers, fish consumption in lakes, and aquatic life and fish consumption in estuaries.

There can be many causes of impairment, such as temperature increases, elevated pH levels, agricultural run-off, atmospheric deposition, industrial discharges, and natural conditions and sources. The energy sector can contribute to these impairments (e.g., temperature increases, industrial discharges, and atmospheric deposition). Some examples:

- Power plants that burn coal to create electricity are the largest source of emissions, accounting for about 44 percent of all manmade mercury emissions, according to U.S. government data.[242]
- Dams and impoundments along Virginia's James River Basin (central part of the state) have been identified as suspected sources of erosion and sedimentation, according to state data.[243]
- Coal and surface mines in the Tennessee-Big Sandy River Basin (southwest part of the state) have been identified as suspected sources of discharges of pollutants into waterways, according to state data.[244]

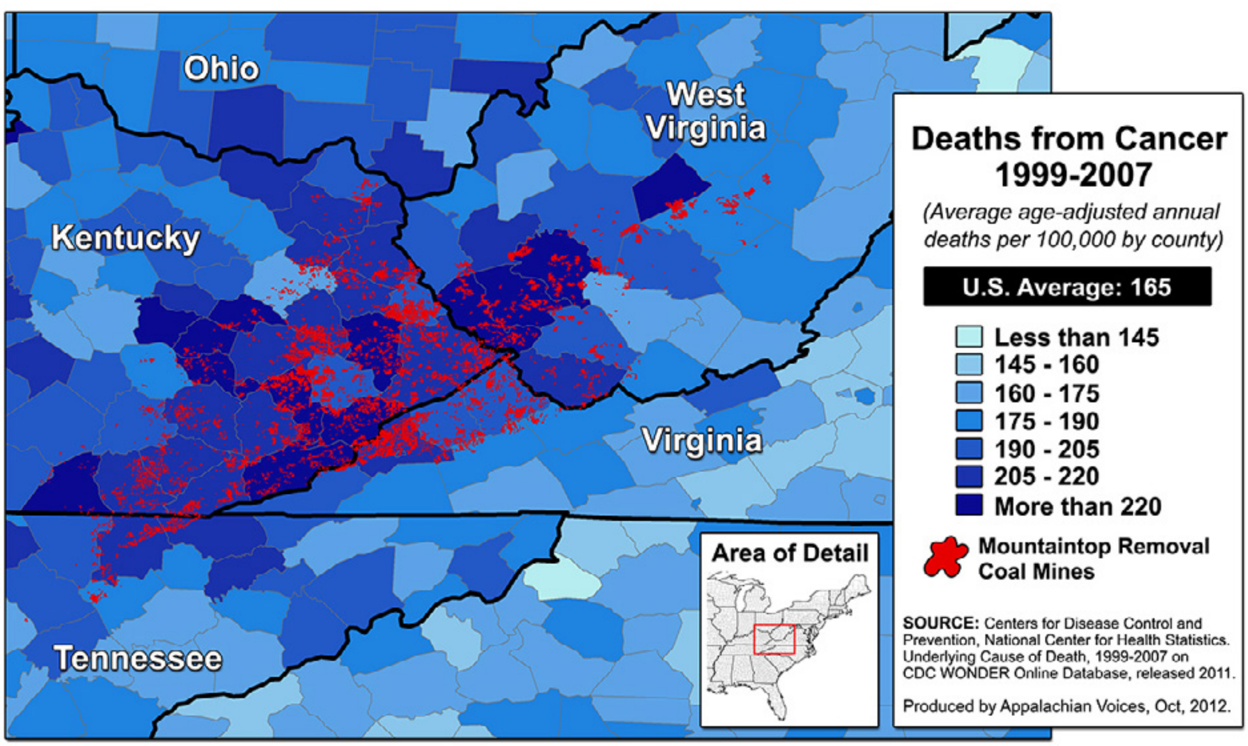
IV. Mountain Top Removal Mining

Mountain Top Removal Mining (MTRM) has been found to increase cancer and cardiovascular and respiratory diseases for those living nearby. Virginia has 31 surface mines that use MTRM to access coal. This process involves removing land above coal seams, which releases air pollutants such as PM, NO_x, and SO_2. There is also well documented damage to streams as overburden (excavated land and sediments) accumulates in waterways. Some findings from studies:

[3] "Impairment" refers to a waterbody that exceeds the state water quality standard for its designated use (e.g., swimming).

- An epidemiological study found that living near MTRM contributes to lung cancer incidence. The study found that inhalation of PM promoted tumor growth in humans, according to academic research.[245]
- A study comparing self-reported cancer rates from two West Virginia communities (a MTRM community and a non-MTRM community) found that the MTRM community reported increased cancer cases, according to academic research (see Figure 44).[246]
- From 2000 to 2004, lung cancer mortality was higher in areas of heavy Appalachian coal mining. The study found that higher mortality may have been caused by exposure to coal-mining environmental pollutants, although other contributing factors (e.g., smoking) may have also contributed, according to academic research.[247]
- Chronic cardiovascular disease mortality rates were significantly higher in MTRM areas compared to non-MTRM, although other factors could have contributed (e.g., obesity, poverty, lower education rates), according to academic research.[248]

Figure 43: Cancer Rates and Proximity to Mountain Top Removal Coal Mines

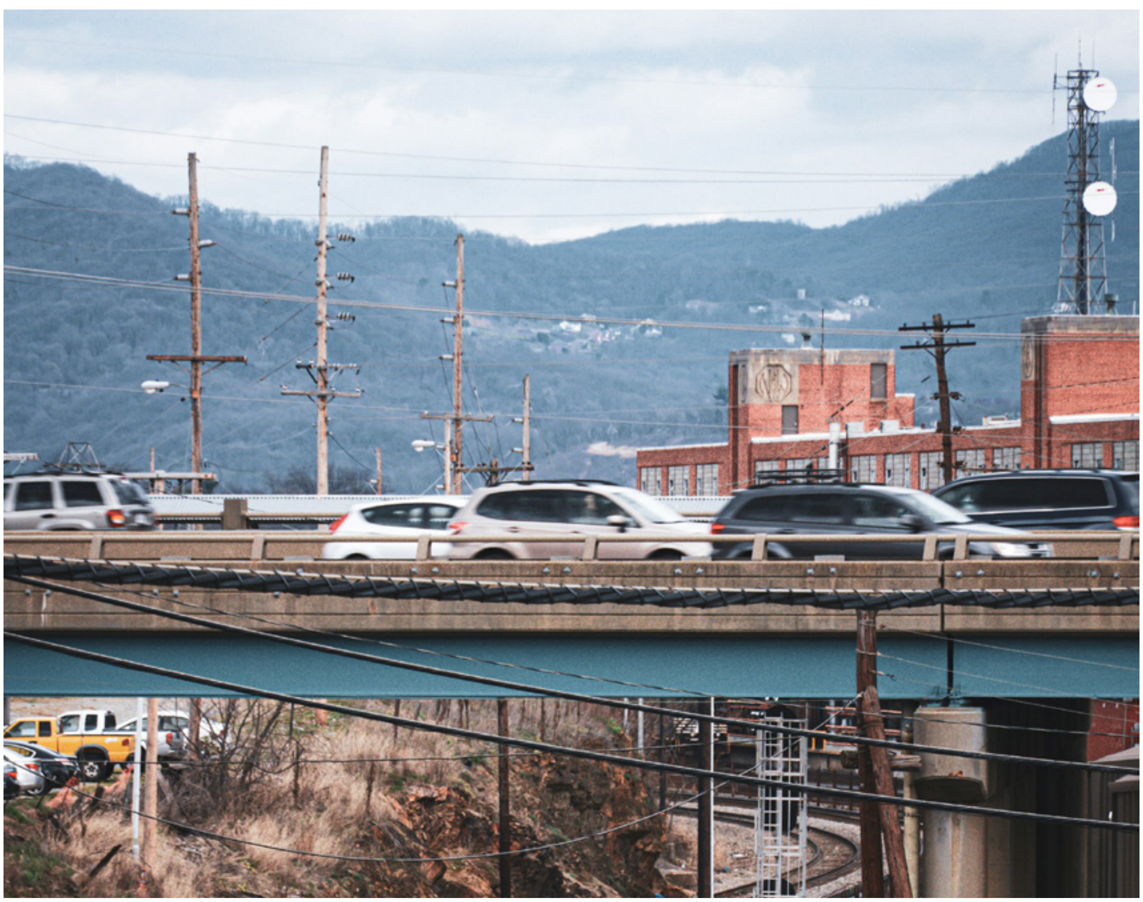


V. Transportation

Areas with higher vehicle volume may have more premature deaths from air pollution. In 2023, Virginians logged approximately 88,000 million vehicle miles travelled (VMT), which is the 11th highest state for VMT, according to U.S. government data.[249]

Federal clean air regulations require counties and cities in the northern Virginia area to use reformulated motor gasoline blended with ethanol to reduce harmful emissions. Several counties in the Richmond and the Norfolk-Virginia Beach-Newport News metropolitan areas in central and eastern Virginia also require reformulated motor gasoline to reduce ozone levels and smog.[250]

In 2016, air pollution from the transportation sector led to 485 premature deaths in Virginia. Of these, 334 deaths were attributed to in-state emissions, while vehicle emissions from Virginia contributed to approximately 535 premature deaths in other states. The primary pollutants responsible were ozone and $PM_{2.5}$ emitted by cars, trucks, and buses, according to academic research.[251]



Appendix D
TRANSPORTATION AND FUELS

Summary

Gasoline-fueled vehicles, or internal combustion engines, dominate Virginia's light-duty vehicle population. Over the past five years, electric vehicles (battery electric and plug-in hybrid vehicles) and EV charging infrastructure represent a growing segment of Virginia's transportation landscape.

Energy issues related to transportation are addressed in several other chapters (e.g., consumption, infrastructure). This chapter focuses on vehicles only. Other forms of transportation (rail, truck, ship, pipeline) are addressed in other chapters.

I. Registered Vehicles

Virginia has about 60,000 miles of public roads and over seven million registered light-duty vehicles. In 2023, Virginians drove an average of 14,000 miles annually, totaling over 88 million miles. This is the 11th highest nationally. Gasoline-fueled vehicles dominate the vehicle population, according to U.S. government sources (see Table 10).[252]

Table 10: Virginia Electric Vehicle Registration Growth, 2016-2023

Year	Total EVs	EV % of Total LDV[1]	National Rank
2016	7,000	0.1	17th
2017	11,000	0.2	17th
2018	18,500	0.3	14th
2019	24,700	0.3	14th
2020	31,200	0.4	14th
2021	45,100	0.6	14th
2022	67,600	1.0	12th
2023	104,900	1.5	13th

1 *Light-duty vehicle*

Electric Vehicles

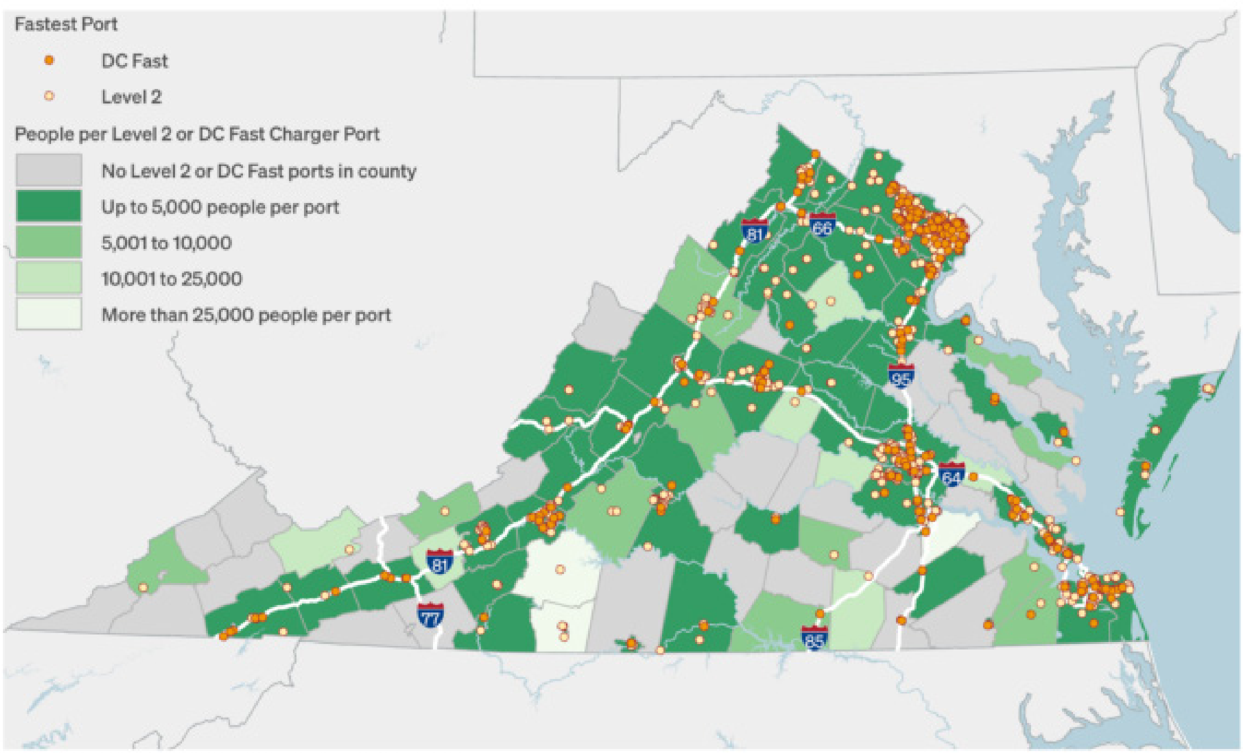
In 2016, Virginia had approximately 7,000 electric vehicles (battery and plug-in). By 2023, the share of electric vehicles (EV) had grown by more than 1,000 percent to over 100,000 EVs. This represents 1.5 percent of total light duty vehicles and places the state 13th highest for EVs,[1] according to U.S. government data (see Table 11).[253]

[1] In order of highest to lowest (top 10): CA (1.5M), FL (294K), TX (269K), NY (207K), WA (182K), NJ (165K), IL (125K), CO (119K), MA (109K), AZ (108K), GA (108K).

Table 11: Virginia Vehicle Registration and Fuel/Charging Availability, 2023

Vehicle Type	Total Registrations	Fuel/Charging Avalability
All vehicles	7.1 M	
Gasoline	6.6 M	2,800 gas stations
Diesel	153,000	
Hybrid Electric	229,000	
Electric Vehicles (EV)	85,000	1,650 public locations (5,700 ports)
Plug-In Hybrids	27,000	
Biodiesel	44,000	33 Locations
Compressed Natural Gas (CNG)	300	
Ethanol/Flex Fuel (E-85)	484,000	103 Locations

Figure 44: EV Charging Stations in Virginia, 2024



Map created by: Miller Cochran (mcochran@selcnc.org)
Last updated: August 20, 2024
Sources: US Census Bureau, Commonwealth of Virginia, Alternative Fuels Data Center
Note: Many stations have multiple ports. Data is from August 2024

0 30 60 90 120 Miles

II. EV Infrastructure

The number of public EV-charging stations has also increased over the past seven years, from 200 in 2014 to over 1,600 in 2023.[254] The distribution of EV infrastructure shows a concentration in urban and suburban areas, particularly in Northern Virginia, Richmond, and Hampton Roads, as well as along the major roadways (See Figure 44).

III. Alternative Fuels

Biodiesel

Biodiesel production in Virginia is limited. It has one biodiesel production facility with a nominal capacity of approximately five million gallons per year, though actual production typically ranges between 1.5 to 2 million gallons annually, according to U.S. government data.[255] Virginia's consumption of biodiesel is approximately 868,000 barrels in 2023. Virginia is a net importer of this alternative fuel.[256]

Virginia has established several programs to support biodiesel infrastructure development. The Virginia Department of Energy offers incentives for biodiesel producers, including tax credits for each gallon purchased. These incentives can provide up to $5,000 in financial support for qualifying biodiesel operations and aim to stimulate the expansion of biodiesel production and distribution infrastructure.[257]

Ethanol and Flex-Fuel

Virginia's ethanol infrastructure has experienced significant changes in recent years. It previously had an ethanol production facility in Hopewell, in the Richmond-Petersburg region. However, this facility has since been decommissioned due to low profit margins, and Virginia currently has no active ethanol production plants and significantly fewer ethanol stations compared to EV charging locations. Despite lacking in-state production capacity, ethanol remains an important component of Virginia's transportation fuel infrastructure through blended gasoline products. The latest data finds that Virginia consumes almost 10 million barrels of ethanol in 2023, according to U.S. government sources.[258]

Natural Gas and Propane

Virginia's infrastructure for natural gas and propane as transportation fuels is limited but serves specific market segments. Natural gas vehicles are used mostly for high-mileage, centrally fueled fleets because they can provide fuel range support for operations that stay within a region supported by reliable compressed natural gas fueling infrastructure. These vehicles can be solely dedicated to natural gas or bi-fueled (natural gas and gasoline). Virginia's natural gas vehicle fuel consumption is about 680 million cubic feet annually.

Propane vehicles, also known as liquefied petroleum gas (LPG) vehicles, can also come in as dedicated or bi-fueled. Examples of propane vehicles include light- and medium-duty vehicles, such as trucks and taxis, and heavy-duty vehicles, such as school buses. In Virginia, propane vehicles consume about 53,000 barrels annually.[259] This adoption rate has led to correspondingly limited infrastructure development.

IV. Vehicle-to-Grid Technology

Vehicle-to-Grid (V2G) technology in Virginia remains in the early stages of deployment, with initial pilot projects demonstrating the potential for bidirectional power flow between electric vehicles and the electrical grid. This infrastructure enables electric vehicles to serve as mobile energy storage units, providing power back to the grid during peak demand periods or emergencies, while recharging during off-peak hours.

A notable V2G implementation in Virginia involves Fairfax County Public Schools, which has partnered with Dominion Energy in an electric school bus initiative. Under this arrangement, Dominion Energy maintains ownership of the bus batteries and charging infrastructure, providing the utility with potential V2G capabilities. While Dominion has not yet fully employed these buses for V2G applications, the school district's energy management professionals are actively monitoring this use case, which would allow the electric bus fleet to function as distributed energy resources when not transporting students, according to the public school system.[260]

Appendix E

VIRGINIA ELECTRIC PLANTS BY GENERATION CAPACITY

Plant Name	Energy Source	Generation Capacity (MWh)
North Anna	Nuclear	15,828,266
Surry	Nuclear	13,834,669
Greensville County Power Station	Natural Gas	10,286,001
Warren County	Natural Gas	8,468,725
Brunswick County Power Station	Natural Gas	6,337,633
Doswell Energy Center	Natural Gas	5,297,757
Potomac Energy Center, LLC	Natural Gas	4,430,148
Tenaska Virginia Generating Station	Natural Gas	3,933,012
Bear Garden	Natural Gas	3,023,135
Chesterfield	Natural Gas	2,429,174

Note on References

As stated in the Methodology section, our reference style is as follows: Name of the organization. Article or subject title. Author(s). Date.

For any questions regarding methodology, data, or source notes, please contact the Center for Energy Science and Policy, www.cesp.gmu.edu.

Index: Figures

Index: Figures *(continued)*

Index: Figures *(continued)*

Index: Figures *(continued)*

Index: Tables

Index: Tables *(continued)*

Index: Images

Page 79: Thorne, Tim. (March 6, 2024). *Rotunda at the University of Virginia.* [Photograph]. Unsplashed.

Hummell, Joshua. (October 31, 2023). A *brick sidewalk in Alexandria* [Photograph]. Unsplash.

Chiado, Anthony. (December 10, 2019). *Gray building in Harrisonburg.* [Photograph]. Unsplash.

Villaire, Nathaniel. (July 8, 2021). *Humpback Rock* [Photograph]. Unsplash.

Page 80: Dickinson, Bill. (February 25, 2016). *River of Coal* [Photograph]. CC BY-NC-ND 2.0. Flickr.

Page 87: American Public Power Association. (June 24, 2020). *Yellow-petaled tree on green grass field near cable posts* [Photograph]. Unsplash.

Page 96: Stuart, Michael. (December 10, 2019). *North Anna Nuclear Power Plant* [Photograph]. CC BY-SA 4.0. Wikipedia.

Page 101: Davis, Bud. (September 5, 1997). USACE *John H. Kerr Dam and Lake* [Photograph]. U.S. Army Corps of Engineers Digital Visual Library. Public Domain.

Page 107: Paltera, Stefano. (October 6, 2009). *U.S. Department of Energy* 2009 *Solar Decathlon.* [Photograph]. CC BY-ND 2.0. Flickr.

Page 124: Zhang, Tian. (August 19, 2020). *Roanoke railway.* [Photograph]. Unsplash.

Endnotes

1 Commonwealth of Virginia. (March 25, 1999). *Chapter 23. Virginia Electric Utility Restructuring Act*. Va. Code § 56-576.

2 Virginia Senate Joint Subcommittee. (1999). "Report of the Joint Subcommittee Studying Restructuring of the ELectric Utility Industry to the Governor and the General Assembly of Virginia." *Senate Document* No. 34., Division of Legislative Services.

3 Simeone, Christina and Hanger, John. (October 28, 2016). "A Case Study of Electric Competition Results in Pennsylvania: Real Benefits and Important Choices Ahead." *University of Pennsylvania Kleinman Center for Energy Policy.*

4 Virginia Legislative Transition Task Force. (2002). "2002 Status Report: The Development of a Competitive Retail Market for Electric Generation within the Commonwealth of Virginia." *Virginia State Corporation Commission.*

5 State Corporation Commission. (2004). "Report regarding the advancement of competition in Virginia." *Section* 56-596 B.

6 Virginia Electric Utility Regulation Act, (2025). Va. Code § 56-576 et seq.

7 GreenHurlocker, PLC. (April 17, 2018). Guide to Electric Utility Regulation in Virginia. 2nd Ed.

8 Virginia Electric Utility Regulation Act, (2025). Va. Code § 56-576 et seq.GreenHurlocker, PLC. (April 17, 2018). *Guide to Electric Utility Regulation in Virginia*. 2nd Ed.

9 Virginia Clean Economy Act 2020 (2025). Va. Acts Ch. 1193.

10 VCEA. Mandatory RPS Program. § 56-585.5 C and § 56-585.5 D.

11 VCEA. Solar and Wind Public Interest Declarations. § 56-585.1 A 6. Also, Off-Shore Wind. § 56-585.1:11 B.

12 Dominion Energy. (2025). Renewable Energy Portfolio Standard Program. Mandatory Renewable Energy Portfolio Standard Program.

13 Virginia State Corporation Commission. (2024). Petition of Virginia Electric and Power Company for approval of its 2024 RPS Development Plan pursuant to § 56-585.5 D 4 of the Code of Virginia. [Case No. PUR-2024-00094]. August 14, 2024.

14 VCEA. Dominion -Renewable Energy Targets. § 56-585.5 D 2.

15 Virginia State Corporation Commission. (2024). Petition of Virginia Electric and Power Company for approval of its 2024 RPS Development Plan pursuant to § 56-585.5 D 4 of the Code of Virginia. [Case No. PUR-2024-00094]. August 14, 2024.

16 Dominion Energy. Press Release. "Dominion Energy Virginia proposes new rates to continue delivering reliable service and increasingly clean energy." April 1, 2025.

17 VCEA. APCo -Renewable Energy Targets. § 56-585.5 D 1.

18 Virginia State Corporation Commission. (2024). Petition of Appalachian Power Company for approval of its 2024 RPS Plan under § 56-585.5 of the Code of Virginia and related requests (Case No. PUR-2024-00020). April 25, 2024.

19 Virginia Clean Economy Act, 2020. (2025). Va. Acts Ch. 1193.

20 Charlie Paulinn. (2023). "Virginia groups struck a deal on biomass plants. Amendments from Youngkin are more controversial." Virginia Mercury. April 11, 2023.

21 VCEA. Retirement of Carbon Emitting Electric Generating Facilities. § 56-585.5.

22 Virginia Department of Energy. (2025). Carbon-Emitting Facility Retirement Tracking – Based on 2020 Form EIA-860 Data.

23 VCEA. Energy Storage Resources. § 56-585.5 E.

24 North Carolina Clean Energy Technology Center. (2024). Energy storage targets by

state (DSIRE data, September 2024) [PowerPoint slide]. Database of State Incentives for Renewables & Efficiency (DSIRE).

25 Virginia State Corporation Commission. (2024, August 14). Petition of Virginia Electric and Power Company for approval of its 2024 RPS Development Plan pursuant to § 56-585.5 D 4 of the Code of Virginia. [Case No. PUR-2024-00094].

26 VCEA. Energy Efficiency Programs. § 56-596.2.

27 VCEA. Energy Efficiency Programs. § 56-585.1.A.5.c.

28 Virginia State Corporation Commission. "Annual Report on Energy Efficiency Programs and the Annual Report on the Feasibility of Achieving Energy Efficiency Goals." Oct. 1, 2024.

29 Direct Testimony of David F. Walker. "Schedule 3 at 1, Application of Virginia Electric and Power Company for approval of its 2023 DSM Update, Case No. PUR-2023-00217. Dec. 11, 2023.

30 Virginia State Corporation Commission. "Annual Report on Energy Efficiency Programs and the Annual Report on the Feasibility of Achieving Energy Efficiency Goals." Oct. 1, 2024.

31 Dominion Energy. (2025). Coastal Virginia Offshore Wind.

32 Virginia Department of Energy. (2025). Renewable Energy: Wind Power.

33 Id.

34 Id.

35 North Carolina Clean Energy Technology Center. (2024). Offshore wind targets by state (DSIRE data, September 2024).

36 VCEA. Net-Metering. § 56-594.

37 Cardinal News. (April 15, 2025). Mecklenburg County blocks future large-scale solar development. By Matt Busse.

38 VCEA, Special Exemption for Solar Photovoltaic Projects (HB 655/SB 870). § 15.2-2288.8.

39 Paulinn, Charles. "Localities, rural lawmakers win in halting solar siting reform in Virginia." Inside Climate News. March 26, 2025.

40 VCEA. Clean Economy and Community Flood Preparedness Act. (HB 981/SB 1027), §§ 10.1-603.24 &10.1-603.25, 10.1-1329 – 10.1331.

41 Virginia Energy Efficiency Council. "Regional Greenhouse Gas Initiative."

42 Vaughan, N. (2025). The Regional Greenhouse Gas Initiative in Virginia. Virginia Conservation Network.

43 Federal Register. Unleashing American Energy. January 29, 2025.

44 Harvard Law School, Environmental and Energy Law Program. The Social Cost of Greenhouse Gases. March 12, 2025.

45 Clean Air Act. Section 177.

46 NC Clean Energy Technology Center. (2024, September). California Regulation Adoption. (DSIRE data, September 2024) [PowerPoint slide]. Database of State Incentives for Renewables & Efficiency (DSIRE).

47 Office of Governor Glenn Youngkin. (2024, June 5). Governor Glenn Youngkin and Attorney General Jason Miyares: Virginia Will Exit California Electric Vehicle Mandate at End of Year.

48 U.S. Energy Information Administration (EIA), State Energy Data System (SEDS) 1960-2022, Total energy consumption, real GDP, and energy intensity. June 28, 2024.

49 Id. See Table C14. Total energy consumption estimates per capita by end-use sector, ranked

by state, 2022.

50 U.S. Energy Information Administration (EIA), State Energy Data System (SEDS) 1960-2022, Total energy consumption, real GDP, and energy intensity. June 28, 2024.

51 Id. See Primary energy consumption by source.

52 Id. See Total energy consumption by end-use sector.

53 Id.

54 Id. See Total energy consumption per capita.

55 Id. See Total energy consumption per capita by end-use sector.

56 Id. See Table C78.

57 Id. See Table PT2 Primary energy production estimates in trillion btu.

58 EIA, In Brief Analysis, "Virginia was the top net electricity recipient of any state in 2023," December 20, 2024; Virginia State Electricity Profile, Table 10, Supply and Disposition of Electricity. 2023.

59 EIA, State Profile and Energy Estimates, Virginia Profile Overview, Quick Facts; Coal Explained, Coal Imports and Exports.

60 EIA, Coal Data Browser, aggregate coal mine production, historic coal production data, 2002-2022; State Energy Data System. June 28, 2024.

61 EIA. Virginia State Energy Data System. Primary Energy Production in BTU. 2002 and 2022.

62 EIA, Natural Gas Summary, Estimated Production, 2002 – 2022; Virginia State Profile and Estimates, 2023; Natural Gas Gross Withdrawals and Production, 2002 – 2022; State Energy Data System. June 28, 2024.

63 EIA, State Profile and Energy Estimates, Rankings: Crude Oil Production, February 2025 (thousand barrels per day); Crude Oil Production, 2002 – 2022.

64 EIA, State Energy Data System. Wood and Waste Production Worksheet. June 28, 2024.

65 EIA, State Profile and Energy Estimates, Primary energy production in Btu – renewable energy and total energy. June 28, 2024; Summary and state rankings; State Energy Data System. Other Renewable Production Worksheet. June 28, 2024.

66 U.S. Energy Information Administration (EIA), State Profile and Energy Estimates, Virginia Profile Data, Prices (Petroleum, Natural Gas, Coal, and Electricity, 2002 to 2022; see also Prices, Sales Volumes & Stocks by State (in Petroleum, Natural Gas, Coal, and Electricity).

67 Id. Natural Gas Prices—Virginia. Data for 2025.

68 Id. See other states (DE, MD, NJ, PA, WV).

69 U.S. Energy Information Administration (EIA), State Profile and Energy Estimates, Virginia Profile Data, Prices (Natural Gas).

70 EIA, Electric Power, Annual, Average retail price of electricity to ultimate customers (Residential, Commercial, Industrial, and Total). October 10, 2024.

71 Id.

72 Id.

73 EIA, Electric Power, Annual, Retail sales of electricity to ultimate customers, by state and by sector. October 10, 2024.

74 Id. See other states (DE, MD, NJ, PA, WV).

75 EIA, State Profile and Energy Estimates, Table ET2. Total end-use energy price and expenditure estimates, 1970-2022, Virginia.

76 Id.

77 EIA, Table 1.6 State-Level Energy Consumption, Expenditure, and Price Estimates. 2010.

78 EIA, Virginia State Profile and Energy Estimates, Table E15. Total energy price and expenditure estimates (total, per capita, and per GDP), ranked by state. 2022.

79 EIA, State Profile and Energy Estimates, Total Expenditures per Capita (DE, MD, PA, NJ, WV).

80 U.S. Department of Energy. (2023). United States Energy & Employment Report (USEER). Washington, DC: U.S. DOE.

81 Id., U.S. Energy Information Administration, Virginia State Profile and Energy Estimates, Energy Indicators, Civilian Labor Force (4.6 million).

82 U.S. Department of Energy. (2023). United States Energy & Employment Report (USEER). Washington, DC: U.S. DOE.

83 Id.

84 Id. 2023 County-Level USEER Data.

85 American Council for an Energy-Efficient Economy. 2025 State Energy Efficiency Scorecard. Martch 18, 2025.

86 Id.

87 Id.

88 Id

89 Joint Economic Committee Minority. “Recent Clean Energy Programs Lower Costs for Families and Are Vital to U.S. Manufacturing, Jobs, and Energy Security.” May 2025.

90 Id.

91 Virginia Energy Efficiency Council. “RGGI Facts & FAQs.”

92 VPM News. “Dominion Energy will reinstate RGGI surcharge for ratepayers.” Patrick Larsen. July 26, 2023.

93 U.S. Energy Information Administration. (2023). Virginia State Energy Profile and Renewable Energy Statistics.

94 Id.

95 Virginia Electric and Power Company’s 2024 Integrated Resource Plan filing pursuant to Va. Code § 56-597 et seq. Case No. PUR-2024-00184.

96 Virginia State Corporation Commission. “Technical Conference on Electric Utilities and Load Growth.” Case Number PUR-2024-00144. December 16, 2024. Comments of Stan Blackwell, Director of Dominion Energy’s Data Center.

97 Utility Drive. “A fraction of proposed data centers will get built. Utilities are wising up.” Brian Martucci. May 15, 2025. Referencing comments by Astrid Atkinson, a former Google senior director of software engineering and now co-founder and CEO of grid optimization software provider Camus Energy.

98 Id. Referencing comments by Schneider Electric, a French multinational corporation that specializes in digital automation and energy management.

99 Lawrence Berkeley National Laboratory. “Long term load forecasting accuracy in electric utility integrated resource planning.” Energy Policy. Volume 119, August 2018, Pages 410-422.

100 Electric Power Research Institute. “Utility Experiences and Trends Regarding Data Centers: 2024 Survey.” Sep 16, 2024.

101 Id.

102 Open Circuit Podcast. “The data center boom: ‘All the cheap power is gone.’” February 21, 2025. Comment by Stephen Lacey.

103 Virginia State Corporation Commission. “Technical Conference on Electric Utilities and Load Growth.” Case Number PUR-2024-00144. December 16, 2024. Comments of Aaron Tinjum, Vice President, Energy. Data Center Coalition.

104 Virginia State Corporation Commission. “Technical Conference on Electric Utilities and Load Growth.” Case Number PUR-2024-00144. December 16, 2024. Comments of Brian George, Google Global Energy Market Development.

105 Virginia State Corporation Commission. “Technical Conference on Electric Utilities and Load Growth.” Case Number PUR-2024-00144. December 16, 2024. Comments of Gaurav Karandikar, Director of Reliability Assessment and Technical Services at Southeastern Electric Reliability Corporation (SERC) (one of the six regional entities work under the delegation agreement with the North American Electric Reliability Corporation (NERC).

106 Utility Drive. “A fraction of proposed data centers will get built. Utilities are wising up.” Brian Martucci. May 15, 2025. Referencing comments by Karl Rábago, principal at Rábago Energy and a former commissioner at the Texas Public Utility Commission.

107 LegiScan. Texas Senate Bill 6. “Relating to the planning for, interconnection and operation of, and costs related to providing service for certain electrical loads and to the generation of electric power by a water supply or sewer service corporation.”

108 Tyler Norris. Comments at the NASEO-NARUC webinar and Data Center Coalition Energy Forum, Washington, DC, August 12, 2025.

109 U.S. Congress. H.R.1 - One Big Beautiful Bill Act. 119th Congress (2025-2026).

110 The Diplomat. “How China Became the World’s Clean Tech Giant.” Rakshith Shetty. April 27, 2024.

111 U.S. Department of the Treasury. “Beginning of Construction Requirements for Purposes of the Termination of Clean Electricity Production Credits and Clean Electricity Investment Credits for Applicable Wind and Solar Facilities.” Section 3. Notice 2025-42. August 15, 2025.

112 Energy Innovation. “Assessing Impacts Of The House “One Big Beautiful Bill Act” On U.S. Energy Costs, Jobs, Health, Emissions.” Robbie Orvis, Megan Mahajan, Rachel Goldstein, Dan O’Brien, and Olivia Ashmoore. June 11, 2025.

113 NERA Economic Consulting. “Electricity Price Impacts of Technology-Neutral Tax Incentives With Incremental Electricity Demand from Data Centers (Prepared for Clean Energy Buyers Association). Sugandha Tuladhar, PhD, Julie M. Carey, Scott Bloomberg, Bharat Ramkrishnan, Julie Chen. February 10, 2025.

114 Princeton University ZERO lab. “Impacts of the One Big Beautiful Bill On The US Energy Transition – Summary Report.” Jesse Jenkins, Jamil Farbes, Ben Haley. July 3, 2025.

115 Id.

116 Latitude Media, Catalyst Podcast. “The gas turbine crunch: Demand for fossil gas turbines is up but supply is tight, causing multi-year delays.” Shayle Kann. June 5, 2025. Comments by Anthony Brough, founder and CEO of Dora Partners, a consulting firm focused on the turbine market.

117 S&P Global. “US gas-fired turbine wait times as much as seven years; costs up sharply.” Jared Anderson. May 20, 2025.

118 Rocky Mountain Institute. “Gas Turbine Supply Constraints Threaten Grid Reliability; More Affordable Near-Term Solutions Can Help.” By Jesse Cohen, Tyler Fitch, Lauren Shwisberg. June 18, 2025.

119 Open Circuit. “The data center boom: ‘All the cheap power is gone’. February 21, 2025. Comments by Jigar Shaw.

120 PJM Inside Lines. “PJM Generation Interconnection Reforms Continue To Produce Results 63 GW of Transition Projects Will Be Processed in Next 18 Months.” June 4, 2025.

121 Id.

122 Lawrence Berkely National Laboratory. “Queued Up: 2024 Edition Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2023.” Joseph Rand, Nick Manderlink, Will Gorman, Ryan Wiser, Joachim Seel, Julie Mulvaney Kemp, Seongeun Jeong, Fritz Kahrl. April 2024.

123 PJM Inside Lines. “PJM Generation Interconnection Reforms Continue To Produce Results 63 GW of Transition Projects Will Be Processed in Next 18 Months.” June 4, 2025.

124 Power Gird. “PJM, Google and Tapestry Link on AI-Powered Solutions for Electric Grid.” April 14, 2025.

125 Utility Drive. “Governors seek more influence over PJM amid ‘crisis of confidence’.” Ethan Howland. July 18, 2025.

126 PJM Inside Lines. “PJM Chooses 51 Generation Resource Projects To Address Near-Term Electricity Demand Growth.” May 2, 2025.

127 Virginia Business. “Dominion to build yet another solar facility for Facebook Greensville project is eighth collaboration in Va. and N.C..” Sydney Lake. February 13, 2020; NH Business Review. “New Rockingham County building, solar array halfway there.” Angelina Berube Eagle Tribune. July 24, 2024; Colonial Construction Materials. “120 MW Solar Facility in Pittsylvania, Virginia.”

128 Mid-Atlantic Renewable Energy Coalition. “Virginia Must Repair Its Broken Renewable Energy Siting Process.”

129 Virginia Commission on Electric Utility Regulation. “Staff summary and analysis of the One Big Beautiful Bill Act.”

130 U.S. Department of Energy. “Siting of Large-Scale Renewable Energy Projects.”

131 Energy Innovation. “Assessing Impacts Of The House “One Big Beautiful Bill Act” On U.S. Energy Costs, Jobs, Health, Emissions.” Robbie Orvis, Megan Mahajan, Rachel Goldstein, Dan O’Brien, and Olivia Ashmoore. June 11, 2025. Virginia specific data results.

132 Princeton University ZERO laboratory. “Impacts of the One Big Beautiful Bill On The US Energy Transition – Summary Report.” Jesse Jenkins, Jamil Farbes, Ben Haley. July 3, 2025.

133 Rhodium Group. “What Passage of the “One Big Beautiful Bill” Means for US Energy and the Economy.” Ben King, Hannah Kolus, Michael Gaffney, Nathan Pastorek and Anna van Brummen. July 11, 2025.

134 Lazard. “2025 Levelized Cost of Energy.” June 2025.

135 HeatMap. Webinar on “Can the Big Beautiful Bill Take the Heat?” July 11, 2025. Comments by Matthew Zeitlin.

136 Open Circuit. “The data center boom: ‘All the cheap power is gone’. February 21, 2025. Comments by Jigar Shaw.

137 U.S. Congress. H.R.1 - One Big Beautiful Bill Act. 119th Congress (2025-2026).

138 PJM News Release. “PJM Auction Procures 134,311 MW of Generation Resources; Supply Responds to Price Signal.” July 22, 2025.

139 Committee for a Responsible Federal Budget, “Final OBBBA Score Confirms Long Road to Fiscal Recovery,” July 21, 2025; Peter G Peterson Foundation, “Even with Economic Growth Factored In, OBBBA Would Increase Deficits,” June 23, 2025.

140 Energy Innovation. “Assessing Impacts Of The House “One Big Beautiful Bill Act” On U.S. Energy Costs, Jobs, Health, Emissions.” Robbie Orvis, Megan Mahajan, Rachel Goldstein, Dan O’Brien, and Olivia Ashmoore. June 11, 2025. Virginia specific data is available in the individual state fact sheets.

141 Loudon Now. “With Data Centers, Property Tax Revenue Spikes in Leesburg” William Timme. May 28, 2025.

142 Commonwealth of Pennsylvania. “Governor Shapiro Unveils “Lightning Plan” to Strengthen Commonwealth’s Energy Leadership, Create Jobs, and Lower Costs for Consumers.” January 30, 2025. Note, with passage of OBBA, the tax savings in this plan will be reduced.

143 Maryland general Assembly. Renewable Energy Certainty Act (SB0931/HB1036).

144 LegiScan. Virginia House Bill 2126; Senate Bill 1190

145 State of New Jersey. Board of Public Utilities. “N.J. Takes Charge: Launches Landmark Energy Storage Program To Lower Long-Term Costs and Strengthen Power Grid.” June 18, 2025.

146 LegiScan. New Jersey Assembly Bill 5267. 2024-2025 Regular Session.

147 U.S. Department of Energy. “Siting of Large-Scale Renewable Energy Projects.”

148 U.S. Energy Information Administration. “Winter storms have disrupted U.S. natural gas production.” March 13, 2024. See also, Columbia Energy Exchange Podcast. “AI Power Demand and US Energy Policy.” Comments by Michelle Solomon, Senior Policy Analyst, Energy Innovation. February 25, 2025.

149 Utility Drive. “Virtual power plants helped save the grid during heat dome.” Brian Martucci. July 16, 2025.

150 U.S. Congress. H.R.1 - One Big Beautiful Bill Act. 119th Congress (2025-2026).

151 Wood Mackenzie. “Staying power: How new energy realities risk extending coal’s sunset.” David Brown, Anthony Knutson. July, 2025.

152 Utility Drive. “Trump aims to boost coal, in part by ordering power plants to stay open.” Ethan Howland. April 9, 2025.

153 Rhodium Group. “What Passage of the “One Big Beautiful Bill” Means for US Energy and the Economy.” Ben King, Hannah Kolus, Michael Gaffney, Nathan Pastorek and Anna van Brummen. July 11, 2025.

154 Virginia Commission on Electric Utility Regulation. “Staff summary and analysis of the One Big Beautiful Bill Act.”

155 Energy Information Administration (EIA). Virginia State Profile and Energy Estimates. Table 1. Coal Production and Number of Mines by State and Mine Type, 2023 and 2022. See also, Synapse Energy Economics, LLC. Interactive Map of U.S. Power Plants. Map, 2025.

156 Id. Virginia Profile. State Profile and Energy Estimates.

157 EIA. 2023 Form EIA-860 Data - Schedule 3, ‘Generator Data’ (Operable Coal Units Only).

158 EIA. See also Virginia Department of Rail and Public Transport, FY 2024 Annual Report, 2024.

159 EIA. Coalbed Methane data, 2019. See also, Virginia Department of Energy, Natural Gas Production Locations. 2025.

160 EIA. International & Interstate Movements of Natural Gas by State. 2023; ArcGIs. Map Viewer, Interstate Natural Gas Pipelines.

161 EIA. International & Interstate Movements of Natural Gas by State. 2023.

162 EIA. Underground Natural Gas Storage by All Operators.

163 EIA. State Electricity Profiles. Virginia. Table 2B-Ten Largest Plants by Generation (2023).

164 Virginia State Corporation Commission, Biogas Supply Infrastructure Projects. 2025.

165 EIA. Electricity Data Browser. Nuclear.

166 Dominion Energy. Nuclear Facilities.

167 Id.

168 Id.

169 EIA. U.S. PV Module Shipments. Table 9. 2024.

170 University of Virginia. Weldon Cooper Center for Public Service at the University of Virginia. 2025. “Virginia Solar Database.”

171 Id.

172 Cleanview. Virginia Solar Farms. 2025; Real-time Project List & Interactive Map.

173 University of Virginia. Weldon Cooper Center for Public Service at the University of Virginia. 2025. “Virginia Solar Database.”

174 Virginia Department of Energy. Renewable Power. Wind Power

175 Dominion Energy. Coastal Virginia Offshore Wind. Project Facts.

176 Id.

177 EIA. Virginia Profile. State Profile and Energy Estimates

178 John H. Kerr Dam & Reservoir. Hydropower.

179 Dominion Energy. Hydroelectric Facilities. Various Facilities.

180 Smith Mountain Project. Facts.

181 Dominion. Biomass Fuel Facilities.

182 EIA. Virginia State Energy Profile.

183 EIA. Virginia State Energy Profile. Table 9-Sales to ultimate customers. 2023.

184 U.S. Department of Energy, Microgrid Map. 2025. Combined Heat & Power and Microgrid Installation Databases

185 EIA. Table 12 Advanced Metering. 2023.

186 Dominion Energy. Energy Grid Transformation. Fact Sheet. See also, Gribbins, S. (2024, April 6). Grid-Enhancing Technologies Bill Passed in Virginia. Advanced Energy United.

187 Virginia Legislative Information System, HB 862 Electric utilities; integrated resource plans, grid-enhancing technologies and advanced conductors. Introduced by Phil M. Hernandez; approved by Governor Youngkin on April 5, 2024.

188 Dominion Energy. Energy Grid Transformation. Fact Sheet.

189 Gribbins, S. (2024, April 6). Grid-Enhancing Technologies Bill Passed in Virginia. Advanced Energy United.

190 EIA. State Energy Profile Tables. Table 13-Energy Efficiency. 2013-2023.

191 Id.

192 Virginia Department of Energy. Demand Response. 2025.

193 Cpower. Demand Response Program. 2025.

194 Dominion Energy. Save Energy at Home. 2025

195 Appalachian Power. Presentation. Annual Report on Energy Conservation Efforts. 2023.

196 LegiScan. Virginia House Bill 1062. 2024.

197 LegiScan. Virginia Senate Bill 1040.

198 LegiScan. Virginia House Bill 2346.

199 EIA. Table 11. Net Metering. 2023.

200 North American Electric Reliability Corporation. About NERC.

201 NERC. US Reliability Standards.

202 NERC. 2025 Summer Reliability Assessment. May 2025

203 NERC. 2013 Long-Term Reliability Assessment. December 2013.

204 U.S. Energy Information Administration. SEP Tables—Table 17 Reliability. 2013-2023.

205 Id.

206 U.S. Department of Energy. In Brief Analysis. "U.S. electricity customers averaged five and one-half hours of power interruptions in 2022." January 25, 2024.

207 U.S. Department of Transportation. Pipeline and Hazardous Materials Safety Administration. About/Mission.

208 U.S. Department of Transportation. Pipeline and Hazardous Materials Safety Administration. VIRGINIA State Program Metrics. June 2025.

209 U.S. Department of Transportation. Pipeline and Hazardous Materials Safety Administration. All reported incident 20-year trend.

210 U.S. Department of Transportation. Pipeline and Hazardous Materials Safety Administration. Incident Statistics.

211 U.S. Department of Energy. State of Virginia Energy Sector Risk Profile. March 2021.

212 Virginia Department of Emergency Management. Agency Overview.

213 Commonwealth of Virginia Emergency Operations Plan. October 2021.

214 Commonwealth of Virginia. Energy Security Plan. Support Annex Energy Security Plan. Virginia Department of Emergency Management. Virginia Energy. August 2024.

215 NOAA. National Centers for Environmental Information. Billion-Dollar Weather and Climate Disasters. See also, USGS Costs of Weather-related Disasters.

216 New York Times. "North Carolina Power Outages Caused by Gunfire at Substations, Officials Say." Dec. 5, 2022

217 Id.

218 U.S. Environmental Protect Agency, Criteria Air Pollutants from Fossil Fuel Combustion (Ozone, Particulate Matter, Sulfur Dioxide, Nitrogen Dioxide); American Lung Association, Sulfur Dioxide.

219 Virginia Emission Trends 1990-2017 (Source: U.S. Environmental Protection Agency and Energy Information Administration).

220 EIA, Virginia State Electricity Profile (2003, 2023)

221 Id.

222 Virginia Department of Environmental Quality (VDEQ), Virginia Ambient Air Monitoring, 2023 Annual Report, November 2024.

223 Id.

224 United Health Foundation. Explore Air Pollution in Virginia

225 Industrial Economics, Incorporated. (October 28, 2020). "An Assessment of the Health Burden of Ambient $PM_{2.5}$ Concentrations in Virginia." Prepared for The Energy Foundation and Virginia Clinicians for Climate Action. Page 3

226 *Id.*

227 *Id.* Page 4.

228 U.S. Environmental Protect Agency, Criteria Air Pollutants from Fossil Fuel Combustion (Ozone, Particulate Matter, Sulfur Dioxide, Nitrogen Dioxide); American Lung Association, Sulfur Dioxide.

229 DEQ Office of Air Quality Monitoring. (November 2024). "Virginia Ambrient Air Monitoring -

2023 Annual Report." Virginia Department of Environmental Quality. Page 34.

230 U.S. Environmental Protect Agency, Criteria Air Pollutants from Fossil Fuel Combustion (Ozone, Particulate Matter, Sulfur Dioxide, Nitrogen Dioxide); American Lung Association, Sulfur Dioxide.

231 Id.

232 Summit Consulting. (2023). Black Lung Incidence Study Final Report. Chief Evaluation Office, U.S. Department of Labor.

233 Cleveland Clinic, Black Lung Disease (Coal Workers' Pneumoconiosis).

234 New York Times. "How Black Lung Came Roaring Back to Coal Country." Kate Morgan. June 19, 2025.

235 U.S. Energy Information Administration (EIA), Environment, Energy-Related CO2 Emission Data Tables, Table 1, State energy-related carbon dioxide emissions by year

236 Id. Table 7

237 Id. Sectoral Specific (VA, DE, MD, NJ, PA, and WV).

238 Id. Table 4, CO2 Emissions Per Capita.

239 Earth Justice. "Toxic Coal Ash in Virginia: Addressing Coal Plants' Hazardous Legacy." May 4, 2023.

240 Dominion Energy. "Coal Ash FAQs."

241 Virginia Department of Environmental Quality, Virginia's 2024 305(b)/303(d) Water Quality Assessment Integrated Report (Draft), April 2024

242 U.S. Environmental Protection Agency. 2014 National Emissions Inventory, version 2, Technical Support Document. July 2018.

243 Virginia Department of Environmental Quality, Virginia's 2024 305(b)/303(d) Water Quality Assessment Integrated Report (Draft), April 2024

244 Id.

245 Sudjit Luanpitpong, Michael Chen, Travis Knuckles, Sijin Wen, Juhua Luo, Emily Ellis, Michael Hendryx, and Yon Rojanasakul, Environmental Science & Technology 2014 48 (21), 12912-12919, DOI: 10.1021/es504263u

246 Hendryx M, Wolfe L, Luo J, Webb B. Self-reported cancer rates in two rural areas of West Virginia with and without mountaintop coal mining. J Community Health. 2012 Apr;37(2):320-7. doi: 10.1007/s10900-011-9448-5. PMID: 21786205.

247 Hendryx M, O'Donnell K, Horn K. Lung cancer mortality is elevated in coal-mining areas of Appalachia. Lung Cancer. 2008 Oct;62(1):1-7. doi: 10.1016/j.lungcan.2008.02.004. Epub 2008 Mar 18. PMID: 18353487.

248 Esch L, Hendryx M. Chronic cardiovascular disease mortality in mountaintop mining areas of central Appalachian states. J Rural Health. 2011 Winter;27(4):350-7. doi: 10.1111/j.1748-0361.2011.00361.x. Epub 2, 011 Feb 11. PMID: 21967378.

249 U.S. Energy Information Administration, State Profile and Energy Estimates, Profile Data, Economy.

250 Id. Profile Data. Petroleum.

251 Arter, C. A., Buonocore, J., Chang, C., & Arunachalam, S. (2021). Mortality-based damages per ton due to the on-road mobile sector in the Northeastern and Mid- Atlantic U.S. by region, vehicle class and precursor. Environmental Research Letters, 16(6), 065008.

252 Virginia Department of Transportation. Highways; see also U.S. Department of Transportation. Bureau of Transportation Statistics. State Transportation Infrastructure.

Virginia; U.S. Energy information Administration. State Energy Data System. Electric Light Duty Vehicles Overview; EIA. Virginia State Profile. Energy Indicators. Federal data sources cite to higher numbers (76K).

253 U.S. Energy Information Administration. Virginia State Profile and Energy Estimates. Energy Indicators. June 27, 2025.

254 EIA. State Energy Data System. Electric Vehicle Charging Infrastructure. This number does not include single-family residential EV charging locations.

255 U.S. Energy Information Administration. U.S. Biodiesel Plant Production Capacity. 2024.

256 EIA. U.S. States Profile. State Profiles and Energy Estimates. Table F31: Fuel ethanol consumption estimates. 2023.

257 Alternative Fuels Data Center. (2024, March). Biodiesel Laws and Incentives in Virginia. National Renewable Energy Laboratory.

258 EIA, Petroleum & Other Liquids, U.S. Fuel Ethanol Plant Production Capacity, U.S. fuel ethanol plant count by state, 2024. See also, EIA, State Energy Data System, Table F29, Fuel ethanol consumption estimates, 2022.

259 EIA. Virginia Natural Gas Consumption by End Use. See also, Virginia State Profile and Energy Estimates. Table CT7. Transportation sector energy consumption estimates. 1960-2023.

260 Fairfax County Public Schools. Electric School Buses.