



Coal Ash

charting the future for a byproduct from Virginia's past

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Prepared for

Secretary of Transportation,
W. Sheppard Miller III



FRANK BATTEN SCHOOL
of LEADERSHIP and PUBLIC POLICY

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This [project] is a humble offering to Him. An attempt to say "THANK YOU GOD" through our work, even as we do in our hearts and with our tongues. May He help and strengthen all men in every good endeavor.

Disclaimer

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, or by any other agency.

University of Virginia Honor Code

On my honor as a University of Virginia student, I have neither given nor received unauthorized aid on this assignment



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<https://www.nationalgeographic.com/environment/article/coal-other-dark-side-toxic-ash>.

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Terminology

B: Billion

CCR: Coal Combustion Residuals

CUP: Conditional Use Permit

DEQ: Virginia Department of Environmental Quality

DOE: Department of Energy

Dominion: Dominion Energy

M: Million

Office: Virginia's Office of the Governor

REE: Rare Earth Element

S.B. 1355: Virginia Senate Bill 1355 (2019)

TVA: Tennessee Valley Authority

VGA: Virginia General Assembly

Executive Summary

A great challenge facing Virginia decisionmakers in the coming years is deciding how we will store coal ash, generated as a byproduct of electricity generation. The improper storage of this material has led to the contamination of groundwater and waterways, endangering Virginians and the environment they inhabit. This paper will give further background on this topic, establishing how we got here and why the issue has not yet been resolved and evaluate the consequences of improper coal ash management.

In order to address this problem of unsafely stored coal ash, three policy options, based on the most prevalent solutions suggested in the present literature, will be explored:

1. Increase Coal Ash Recycling
2. Increase Rare Earth Element Extraction Funding
3. Construct On-Site Landfills Designated for Reuse

These alternatives will be judged on the criteria of cost, effectiveness, political feasibility, and environmental impact. The most weight will be put on cost, since minimizing financial burden for Virginians is of utmost priority.

The final recommendation put forth is to **construct on-site landfills designated for reuse**. This alternative is the most cost-effective, politically feasible, and surprisingly, environmentally conscious. This paper also includes a strategy for implementation, largely rooted in increasing communication between stakeholders and holding Dominion Energy accountable for proper execution.

Introduction

For nearly a century, Dominion Energy (Dominion) has been burning coal to generate electricity for Virginians, but electricity has not been the only output. A tremendous amount of coal ash, or coal combustion residuals (CCR), have also been produced. To be precise, Virginia has over 51.5 million cubic yards (CY) of CCR (Earthjustice, 2023); enough to fill nearly 16 thousand Olympic-size swimming pools. The challenge Virginia now faces is what to do with a large portion of it as we phase out coal and move to alternative energy sources.

The following report is the result of rigorous research into the burgeoning field of CCR management. The latest innovations and understandings of the dangers of CCR have been drawn upon to generate an informed and comprehensive report on this important issue facing Virginia. Numerous stakeholders across Virginia have been consulted to gain a wide breadth of insights into the coal ash problem. Representatives of municipalities, state agencies, utility companies, and environmental advocacy organizations have all contributed valuable perspectives in pursuit of coming to well-informed decisions surrounding coal ash in Virginia.

The aim of this report is to synthesize all of this research in a digestible and informative way, providing clarity on a surprisingly complex problem. There are numerous stakeholders involved across local, state, and federal levels, all with varying degrees of influence over the destiny of CCR. The decisions made by each of these stakeholders will result in outcomes that have tangible impacts on Virginians. It is my hope that the following will help in discerning the path forward together, navigating the intricate landscape of this century-old conundrum.

This report is meant to foster a greater understanding of the CCR problem, inform on the policy options available throughout the entire CCR disposal process, evaluate those options on criteria in line with the interests of Virginians, and put forth a recommendation for best practices and how they might begin to be implemented.

Problem Statement

In the next few years, the Commonwealth of Virginia is faced with making difficult decisions regarding how they will manage the storage or reuse of over 27 million CY of coal ash generated from four coal-fired power plants over the past century (Dominion Energy, 2022b). The problem is not limited solely to the volume of CCR, but extends to the contents of CCR. Coal ash contains harmful elements like mercury and arsenic, posing a serious threat to the environment if handled improperly. Concerns have manifested from the possibility of inadequately stored CCR seeping into the groundwater, contaminating nearby private water wells and waterways (ubiquitous next to coal-fired power plants) (US EPA, 2014). **Failing to manage coal ash properly in the coming years would have grave financial and environmental consequences for all Virginians**, underscoring the need for tact and careful consideration in this process.

Client Overview

My client is the Virginia Secretary of Transportation, W. Sheppard Miller III, a member of the Governor's Cabinet. The Office of the Governor is dedicated to improving the quality of life for every Virginian and making sure laws are "faithfully executed" (Va. Const. art. V, § 7). Ensuring Dominion's compliance with state regulations regarding the disposal of coal ash is a responsibility that ultimately rests with the Office of the Governor. They are tasked with working alongside Dominion to dispose of coal ash in a way that is best for Virginians; keeping in mind the financial burden on ratepayers, the wellness of impacted communities, and environmental safety.

Governor Glenn Youngkin's Office has taken a business-minded approach to resolving issues in the Commonwealth. As such, there is a premium placed on innovative solutions that make economic sense. It is with this lens that policy options regarding the management of coal ash are evaluated, taking into account all of the latest research in order to make informed decisions at this critical juncture. This report seeks to put forth a practical recommendation for the management of CCR, keeping in mind the various stakeholders, limitations, and opportunities surrounding this vital moment in Virginia's history and for Virginia's future.

Background

Coal production in Virginia has been in decline for decades now, being replaced increasingly by clean energy. With the cost of mining increasing in Appalachia due to the need for underground mines as opposed to surface mines, the depletion of coal reserves across the Commonwealth, and a competitive advantage in the coal market held by the West have all contributed to this steep decline (Virginia Coal, n.d.). This coupled with environmental concerns have contributed to Dominion's goal of achieving net zero emissions by 2050 (Dominion Energy, 2020). The shift to natural gas, solar, and wind energy have led to closure plans for Dominion's coal-fired power plants in Virginia. After all these years of burning coal, the time has come to clean up.

TOTAL VIRGINIA COAL PRODUCTION

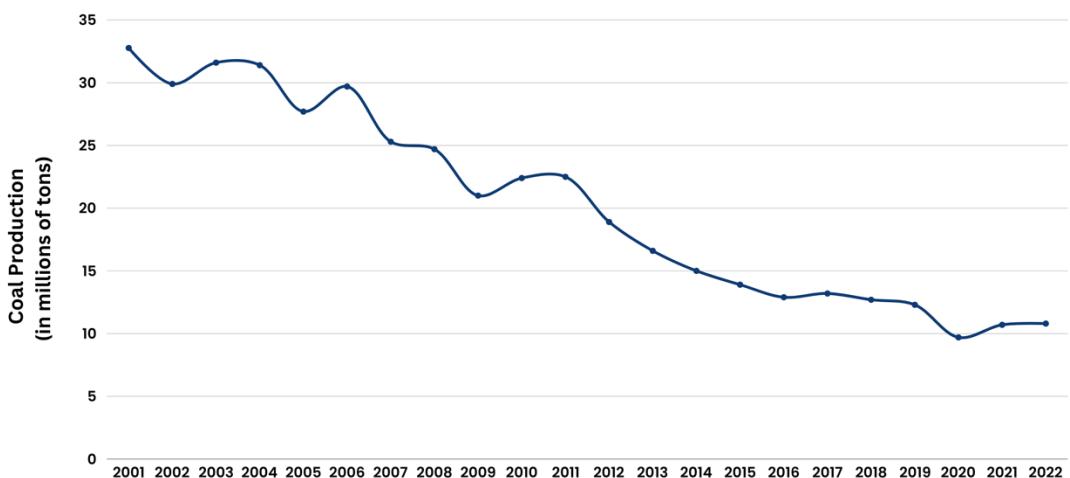


Figure 1: Adapted from API Dashboard, US EIA

For the majority of the time that coal has been produced, the disposal of coal ash went largely unregulated, with the toxic nature of the material widely unknown. Utility firms would dump coal ash into abandoned mine shafts or load them into unlined landfills. When these landfills were lined, it was with clay liners, which do not prevent leachates from getting into the groundwater and surrounding waterways (Lombardi, 2009).

In 1999, environmental advocacy groups caught the attention of the EPA with claims of CCR damaging public health through the contamination of local drinking wells. The EPA launched an investigation in 2000, beginning to verify claims of CCR causing damage of

public health and identifying other claims as potential threats to public health. This investigation continued with new claims being filed over the years, notably a case where a dam holding back a coal ash pond (a common CCR storage mechanism where CCR are mixed with water in a pit to prevent airborne spread of the material) failed, releasing coal-ash contaminated water into the Delaware River.

The scope of this spill was not as large as those to come, garnering less attention from the EPA and the public. In 2007, the EPA published a report of their findings from this investigation, noting 67 proven or potential cases of groundwater pollution as a result of CCR out of 85 total cases evaluated (US EPA, 2007). The scope of the coal ash problem was still largely hidden from public view, not gaining political traction until a year after the report was published as a result of a catastrophic environmental disaster.

In 2008, a dike burst at the Tennessee Valley Authority (TVA) Kingston Fossil Plant, releasing over five million CY of coal ash into nearby waterways, spanning about 300 acres (US EPA, 2016). Over 70 tons of harmful chemicals infected the Emory River causing catastrophic environmental damage and cleanup costs totaled over \$1 billion. 40 workers involved in the cleanup effort have died in the decade following the spill and 400 more have fallen ill as a result of the long-term exposure to coal ash, with lymphoma and bone cancer among the diagnoses (Fox, 2019).



Figure 2: [safronie]. (December 21, 2018). "I took this picture shortly after the Kingston TVA Coal Ash Spill in Kingston, Tenn. 10 years ago.[Online forum post].Reddit.https://www.reddit.com/r/Tennessee/comments/a89l5u/i_took_this_picture_shortly_after_the_kingston/

The TVA Kingston spill was not an isolated incident. More recently, in 2014, 39,000 tons of coal ash and 27 million gallons of coal ash pond water spilled into the Dan River in North Carolina and spread across the state border. The spill jeopardized the drinking water supply of Virginians and caused lasting ecological damage (U.S. Department of the Interior, n.d.).

The EPA responded to these spills with stricter requirements for the disposal and management of CCR with the 2015 Coal Ash Rule and have proposed revisions as recently as May of 2023 to further tighten regulations on management of CCR. The stipulations of the rule are such that utilities are required to maintain the structural integrity of CCR surface impoundments in accordance with mandated periodic assessments of CCR units by engineers. Weekly inspections of CCR units are also required, along with hazard evaluations, meant to assess the risk of potential failures of surface impoundments, resulting in a coal ash spill (US EPA, 2014b).

The 2015 Coal Ash Rule also mandates the protection of groundwater with a provision requiring utilities to monitor wells nearby CCR units and take corrective action if hazardous elements are detected. The locations where CCR landfills can be placed is restricted, preventing the storage of CCR in areas subject to earthquakes or in other unstable areas, like wetlands. Composite liners are also required for new landfills, replacing the old unlined or clay-lined landfills that failed to prevent toxic elements of CCR from leaching into groundwater (US EPA, 2014b).

Virginia legislation went above the requirements of the EPA's rule with S.B. 1355, passing in the 2019 session with bipartisan support. While the 2015 Coal Ash Rule allows existing unlined landfills to continue to operate, this bill requires Dominion to remove all of the CCR for recycling or deposition in a lined landfill in line with federal standards. Recycling of 25% of CCR is required under this bill, along with a provision mandating Dominion to provide connections to the municipal water supply for every residence within a half mile of CCR units. Dominion is also required to review proposals from firms seeking to beneficially reuse Dominion's CCR. Dominion must submit biennial reports on beneficial reuse plans received and reviewed, and on closure plans and progress. Lastly, Dominion can recover the costs associated with CCR cleanup through ratepayers up to \$225 million a year (S.B. 1355, 2019).

The difficulty in implementing closure plans lies within all the stakeholders involved that need to coordinate in order to take action. Localities in which Dominion currently operate CCR units have pushed back against plans to landfill CRR on the site of power plants, concerned about the potential environmental impacts. This is particularly salient due to the precarious locations of these plants; all located next to waterways because of the need for a nearby water source for cooling. While localities are concerned with what presents the least environmental risk, Dominion is seeking to minimize costs for Virginia ratepayers. Some localities have pushed for CCR to be moved out of their city limits entirely, and others have pushed for CCR to be recycled as much as possible, with what's left being moved to an off-site landfill by rail or barge. The lowest financial cost is achieved by constructing new landfills on the site of power plants, next to current CCR units, in order to minimize transportation costs (Palermo, 2023). This gap in proposed management of CCR

combined with mixed levels of agency is the largest reason this problem has not yet been resolved.

This mixed agency problem is particularly present in the case of the Chesapeake Energy Center. Chesapeake pushed back against Dominion's broad-sweeping control over how to manage CCR in their city, requiring them to obtain a conditional use permit (CUP) to move CCR from one place to another. Dominion fought back against this requirement, but through an extensive litigation process, Chesapeake City obtained the right to require Dominion to file for a CUP. This gave Chesapeake significantly more control over the process of CCR disposal, controlling the means of transportation, time period for removal, and how CCR are to be used within city limits. This power has even extended to Chesapeake requiring for all CCR to either be recycled or moved to a site outside the City of Chesapeake (J. McNamara, personal communication, November 3, 2023).

Litigation processes like the one that took place in Chesapeake are also happening in varying degrees regarding other locations regulated by Virginia S.B. 1355: at Bremo Power Station, Chesterfield Power Station, and Possum Point Power Station. Application for land use permits for the construction of on-site landfills, evaluation of offers from materials firms seeking to recycle CCR, and continued input from local communities and advocacy groups are the primary factors halting a permanent resolution to the CCR problem.

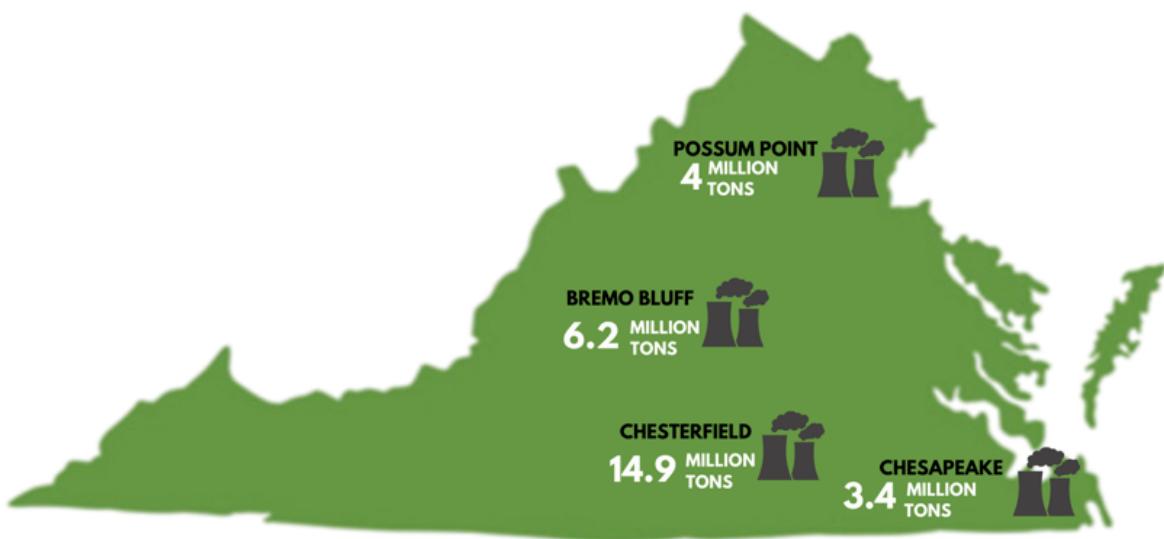


Figure 3: Coal Ash Sites Targeted by 2019 Virginia Legislation (Adapted from SELC, 2019)

Consequences

A failure to manage CCR properly could have disastrous environmental and financial impacts. The past proposed route of capping CCR units in place, not removing them from their unlined holdings, has been shown to not be a viable path forward. For one, unlined CCR sites have been shown to leach harmful elements into the groundwater, potentially impacting nearby wells. While this effect seems ambiguous, it has generated immense costs for adjacent utility firms.

For years, Duke Energy was engaged in intense litigation with environmental advocacy groups following their proposed plan of cap in place. Clean Water Act violations were identified at all sites, with the fallout from this being amplified by the collapse of their Dan River site which released toxic coal ash into the nearby waterway. The result of all this litigation was a North Carolina mandate to excavate all CRR sites, not capping in place. Duke Energy incurred fines totaling over \$100 million and five years of criminal probation. These costs do not include the enormous litigation costs, labor hours, or damage to their public reputation (Holleman, 2020).

Beyond costs to utilities associated with coal ash spills, there will be necessary costs to Virginia ratepayers in order to excavate CCR from unlined sites and into lined landfills or process the CCR for recycling. As part of the legislation requiring Dominion to excavate and recycle CCR, the Virginia General Assembly (VGA) also made a provision for Dominion to recover up to \$225 million annually in costs to accomplish the cleanup effort. This cost recovery, if fully used, will result in a monthly increase of \$5 for the average ratepayer (Palermo, 2023).

Policy Alternatives

The Base Case

If nothing is done to change the current course of action, the commonwealth of Virginia is faced with a daunting next several years. In addition to years of litigation over landfilling, transportation, recycling, and timeframe costs and ratios (i.e., landfilling on site or offsite, type of landfill, amount of CCR placed in landfills vs. being recycled, how much CCR to transport by truck, rail, or barge, and the costs of doing so, etc.), Virginia utility ratepayers will be on the hook for up to \$3.3 billion over 15 years (S.B. 1355, 2019). With every moment this problem is not resolved, toxic elements from coal ash will continue to seep into nearby groundwater and waterways, jeopardizing the health and safety of Virginians.

Increase Coal Ash Recycling

Dominion is required to recycle 25% of CCR from their four major coal-fired power plants that host CCR units. Recycling of CCR for use in concrete has shown to be a popular means for beneficial reuse across the nation. CCR normally consists of 20% bottom ash and 80% fly ash, both of which have shown to be substitutes for materials used in creating concrete. Fly ash is an adequate substitute for cement, even showing increased long-term strength and workability over the control, while bottom ash has shown to be a partial or even total replacement for sand used in concrete (Rafieizonooz et al., 2016).

Utility firms partner with private materials firms that specialize in processing CCR for beneficial reuse (mostly as Portland Cement) and distributing them to the market. Utilities receive bids from these firms, specifying how much of the CCR they can use, how they will process the CCR, and how long the life of the project will be. The cost of carrying out this operation is then offset by the revenue generated from the sales of processed coal ash.

Partnerships with these private materials firms have recently begun in many southeastern states by other utility companies. Georgia Power has been the industry leader in coal ash reuse. They currently recycle 85% of all their coal ash, reducing the amount of landfill space required and offsetting the closure costs for consumers. In October of 2023, Georgia Power announced a new beneficial reuse project in partnership with Eco Material Technologies, a firm that specializes in eco-friendly cement alternatives. Over the 15-year life of the project, 8 million tons of coal ash is expected to be processed and used in concrete. Georgia Power has launched similar projects over the past few years resulting in an expected coal ash reuse totaling 19 million tons over the next two decades (Georgia Power, 2023). Eco Material Technologies announced in January of 2024 that a similar project will be launched in partnership with Alabama Power in the near future (Eco Material Technologies, 2024).

Duke Energy has also ventured into the coal ash beneficial use space in partnership with the SEFA group. They have begun processing coal ash for recycling at three different plants, resulting in 1.2 million tons of coal ash being processed annually. Duke Energy claims that this endeavor is not motivated solely by environmental consciousness, but largely by the economic interests of consumers. The guiding principle is that the cost of constructing and operating the processing plants is less than if they were to transport the ash to a lined landfill (Boraks, 2020).

Dominion has also stepped into this domain, dealing with Charah Solutions in 2021 to recycle and sell 8.1 million tons of coal ash over the next 12 years (Charah Solutions, 2021). Virginia legislation already requires Dominion to accept and consider bids for beneficial reuse on an ongoing basis, but does not mandate Dominion to recycle any more than 25% of CCR (S.B. 1355, 2019). This alternative would seek to increase the amount of CCR that Dominion recycles by lobbying the VGA to introduce legislation mandating a higher percentage of CCR to be recycled.

Increase Rare Earth Element Extraction Funding

This alternative is the most speculative, seeking to extract rare earth elements (REEs), highly valuable elements used in most modern technology, from CCR. Bolstering the domestic supply of REEs is a high national priority given that China has a near monopoly on this valuable resource. U.S. policymakers are concerned that an overreliance on foreign nations for the supply of REEs is dangerous, especially since demand for technologies that require these REEs is projected to rapidly grow in the coming years (Paullin, 2023). These critical minerals are especially needed in the move towards clean energy, with electric vehicles and wind turbines requiring them in order to be built (DOE, 2021).

Large amounts of funding from the Department of Energy (DOE) have gone into produce REEs domestically. In 2021, the DOE awarded \$19 million for projects across the nation seeking to extract these REEs from fossil fuel sources. Among the recipients of this funding is the Virginia Center for Coal and Energy Research at Virginia Tech. They received \$1.5 million to research the extraction of REEs from coal ash among other resources in the Central Appalachian Region (DOE, 2021).

The potential is certainly there for REE extraction, but the trouble lies in scaling the process up in an economically sustainable way. To get one ton of REEs, 2,000 tons of CCR need to be handled (Paullin, 2023). Research shows that this is a reasonable level of REEs within coal ash. There are often more than \$45 of REEs per ton of CCR, making the extraction of REEs from coal ash a profitable endeavor. There are low-cost technologies

available to extract REEs from CCR, but scaling it up beyond a lab setting has yet to be accomplished (Free et al., 2020).

Continued funding will be needed for this research to continue. The aim of this policy alternative is to secure funding for this research, as well as lobby the federal government to allow for long-term storage of CCR. This element would be necessary, as it would not be viable to excavate CCR from landfills once they have been permanently closed.

Construct On-Site Landfills Designated for Site Reuse

The policy being pursued by Dominion most is creating landfills on the sites of their power plants, minimizing costs, local neighborhood traffic, impacts of fugitive dust, and meeting or exceeding Department of Environmental Quality (DEQ) requirements (Dominion Energy, 2022a). This policy alternative adds to this course of action by introducing a rezoning element, preparing on-site landfills to be reused for purposes that benefit the communities they inhabit as opposed to detracting from them.

Following the closure of coal ash landfills, the municipalities they inhabit could implement land reuse, transforming the closed landfills to public parks, driving ranges, solar panel arrays, or a variety of other community-benefiting projects. This is a long-term plan, as the post-closure care period under the 2015 Coal Ash Rule is 30 years, thus the physical development of a project could not begin until then (US EPA, 2014b). However, rezoning the sites of the landfills to be designated for projects such as a solar field or public park could be an important short-term step in making this a future reality.

Landfill parks have been in use since the early 20th century with the creation of Rainier Playfield from Rainier Dump in Seattle, which the city followed up twenty years later with the conversion of Miller Street Dump, manifesting in a section of the Washington Park Arboretum (Harnik et al., 2006). Virginia already hosts perhaps the greatest success story of a landfill being converted into a community staple. Mount Trashmore Park, located in Virginia Beach, VA is the quintessential example of a landfill reuse project done well. The nature of a landfill is such that it cannot normally be used by private developers given that digging is not feasible. However, landfills are perfectly suited for being used as parks, becoming natural buffers against urban sprawl (Johnson et al., 2009).

One benefit that a landfill holds over other types of land in regards to park development is that a landfill has significantly less economic and accounting costs (i.e., opportunity cost and acquisition cost) than any other type of land. However, the maintenance costs of a landfill park are often much higher than a typical park because of the complexities associated with developing a park on top of hazardous waste (Johnson et al., 2009). In Voorhees, New Jersey, there is a 46-acre site by the name of Voorhees Environmental Park.

To fund the maintenance of this large park, the Voorhees Township set apart a section of the park for a solar panel array, an ongoing revenue stream sufficient to sustain the park (Hoefer et al., 2016).

While this solution comes with challenges, it is a forward-thinking way to repurpose land that is a detriment to a community into a value-added project. This is not technically a reuse of the coal ash itself, but is an important alternative to discuss given the inevitable presence of landfills as a result of CCR.

Criteria

Each policy alternative will be evaluated using the following criteria. The Governor's Office has specified cost as a top concern, aiming to limit the financial burden placed on Virginians. Other criteria are used to ensure the coal ash problem is resolved in a timely and effective manner.

Cost

The top priority for the client is finding a solution that makes financial sense (S. Estes, personal communication, November 13, 2023). Anything done in addition to the base case will preferably not add burdens on ratepayers without potential returns. This criterion will consider the high-end cost estimates for each policy alternative. Costs borne by Dominion will be costs shouldered by Virginian ratepayers (S.B. 1355, 2019). As such, the cost to Dominion will be synonymous with the cost to ratepayers.

The cost total for each alternative will be generated by only taking the plans at Bremo Bluff and Possum Point in consideration, given that the maximum amount of recycling is already taking place at the Chesterfield and Chesapeake sites in order to meet the requirements set forth by the VGA (S.B. 1355, 2019). Because these two sites are inflexible, the cost estimates will cancel out across alternatives. The high end of these cost estimates will be used because that is the cost that could ultimately be shouldered by ratepayers.

For increasing recycling of CCR, the cost will be identified using bids from CCR beneficial reuse firms given to Dominion in 2018. The cost for rare earth element extraction will factor in both the cost for long-term CCR storage and any costs Virginians would take on in funding or implementing REE extraction. The cost estimate for on-site landfills will be generated using the cost estimate given for Possum Point and scaled up for Bremo Bluff. This estimate will then be increased by 20% to estimate the maximum cost (identifying the Possum Point on-site landfill as a class 2 price estimate).

Effectiveness

In addition to not placing an undue financial burden on Virginians, the coal ash problem must be resolved effectively. Effectiveness will be measured by the percent of coal ash that is taken care of as a result of the policy alternative. Note that effectiveness in terms of securing the health of Virginians and the environment is addressed in a separate criterion. Also note that the effectiveness criterion will not assess anything other than containing CCR in a manner consistent with federal and state regulations. While some alternatives

may present effectiveness towards other aims, those aims are not within the scope of this report.

Political Feasibility

The complexity of this problem largely has to do with the conflicting desires of various stakeholders. The preferred plans of Dominion, policymakers, advocacy groups, and Virginians are all to some degree misaligned. The criterion of political feasibility will evaluate how likely the policy alternative is to be implemented. This criterion does not weigh each stakeholder equally, but considers the political power each group holds and identifies which alternatives are most likely to have enough support behind them to be adopted. Each alternative will be assigned a value of low, medium, or high political feasibility based on evidence of support from each stakeholder group.

Environmental Impact

Environmental impacts are directly linked with costs to ratepayers down the line, as demonstrated by the TVA Kingston coal ash spill (US EPA, 2016). In addition to financial costs associated with a spill, there are costs to the health of Virginians and to the environment. Both of these come with associated financial costs (e.g., medical care and cleanup efforts) and physical costs. Taking environmental impact into account is critical in ensuring the recommendation is fully effective in addressing the motivation behind Virginia's coal ash problem. As such, each policy alternative will be ranked from (1) to (3) on environmental impact with (1) posing the lowest risk to (3) posing the highest. This will be done by evaluating the available research regarding the risks each alternative poses through pollution of groundwater, waterways, and the air at every stage of the process.

Findings

Increase Coal Ash Recycling

Cost: The total cost estimate for recycling the maximum amount of CCR and putting the remaining CCR in on-site landfills is \$1.554B over the life of the recycling programs (Appendix).

The reported high-end cost estimate for recycling at the two plants that have not yet accepted offers for beneficial use, Bremo Bluff and Possum Point, are \$1.203 billion and \$942 million respectively (AECOM, 2019). However, these cost estimates require firms to transport CCR not beneficially used by truck or by train to an off-site landfill. There is no official cost estimate given for the case in which a firm would recycle the maximum amount of CCR (50%) and then landfill the rest in an on-site landfill. This is the more accurate case and the case for the Chesterfield beneficial use project begun in 2021 (Charah Solutions, 2021).

To isolate the cost of recycling CCR from off-site landfill transportation costs, separate cost estimates from Dominion for Possum point are used (Dominion Energy, 2022a). In these estimates, transporting all CCR at Possum Point to an off-site landfill by rail costs \$1.19B and it costs \$943M to recycle half of the ash and transport the rest off-site by rail. By taking half of the cost for complete off-site transportation and removing that from the recycling costs, we can find the isolated cost of recycling CCR. This is valid because the cost of transportation is identified using railcars per week, making the cost proportional to how many trips need to be made and how many railcars are used.

This isolated recycling cost estimate is then added together with the entire cost of landfilling on site, given that the bulk of the cost is likely from the construction of the landfill, not moving the CCR into the landfill. To get the cost estimate for Bremo Bluff, the same process was conducted, but costs for transporting CCR to an off-site landfill were scaled up to match the greater quantity of CCR at Bremo Bluff.

Effectiveness: Recycling 50% of the CCR at each site, the maximum amount recyclable (Palermo, 2023), and putting the rest in an on-site landfill, accounts for all of the coal ash in ways that comply with state and federal regulations. Recycling CCR for use in cement is identified as encapsulated beneficial use which is allowed under EPA regulations (US EPA, 2014b).

Political Feasibility: Recycling coal ash is seen as the most environmentally conscious method of dealing with it, gaining support of environmental advocacy groups like the Southern Environmental Law Center and the Potomac Riverkeeper Network. Legislators and

impacted communities are also in favor of this option because it removes the coal ash from their communities. This appears to be a much cleaner way of dealing with coal ash, putting locals at ease (Palermo, 2023). The trouble is that Dominion has not accepted the bids made from firms for these two sites, signaling their desire to move forward with on-site landfills without recycling at these locations. Mandating acceptance of these offers could prove difficult and could have implications in the process of coming to an agreement with a materials firm.

Spencer Adkins, director of CCR projects for Dominion, suspects that legislation mandating the recycling of coal ash has artificially altered the market because coal ash recycling firms know Dominion is under legal obligation to recycle a portion of its coal ash (personal communication, February 12, 2024). By mandating a processing facility, firms may present Dominion with less optimal offers than they would get in a perfectly free market.

Furthermore, Dominion has been given a strict time limit in which to complete the disposal of CCR which has been pushed back due to litigation resulting from the concerns of municipalities with Dominion's proposed plans. Pushing back this time limit through the legislature may be possible, but if it were not to occur in a timely manner, this alternative may prove to be less feasible.

Environmental Impact: While it is true that the recycling of CCR is positive in the traditional understanding of environmental impact, there are certain factors that make this alternative less environmentally friendly than it appears. The level of transportation needed to transport coal ash to the proper markets causes environmental detriment. The fuel needed to transport the CCR by truck is immense and there are real implications for traffic, further increasing the environmental impact.

By transporting coal ash by trucks so frequently, there is increased risk for coal ash debris to escape and even a risk of accidents happening that could have more severe environmental effects. Aside from this, beneficial use of CCR has been shown to not pose any hazardous threat once it is encapsulated into concrete, not causing any further environmental detriment (US EPA, 2014b). Any coal ash that is recycled is no longer a threat to groundwater or waterways which is an added benefit.

Increase Rare Earth Element Extraction Funding

Cost: Strictly in terms of cost to Virginia ratepayers, this alternative can range from costing nothing to costing some amount under \$1.06B (Appendix).

There is a possibility this alternative would cost nothing to ratepayers if provisions were made for CCR to stay in place as they are in order to maintain easy access for harvesting if

technology to process CCR for rare earth elements becomes available in the coming years. The only costs associated with this alternative would be the funding of the research, provided by the state or federal government, and the facilities to process CCR would be constructed using government funds or by a private developer.

Potential costs to Virginians would only come about if federal regulations were to shift and CCR were allowed to be stored in specialized long-term storage facilities in line with some policymakers' recommendations (Seidler & Malloy, 2020). Federal and state regulations would have to change such that Dominion would be allowed to not begin closure of CCR units, and instead have them open for easy access in the future. The costs of these specialized long-term storage facilities would still involve the excavation needed for on-site landfills, but they would not have to go through the closure process. Putting the coal ash from Bremo Bluff and Possum Point in long-term storage facilities would likely result in a cost somewhere under \$1.06B (Appendix).

It is true that the revenue generated by this endeavor could help to subsidize the cost of creating permanent landfills and of recycling, but the mechanisms by which this could be accomplished are unclear. It would be presumptuous to assume any portion of the revenue would go towards the cleanup of coal ash. Additionally, the process is still so far away from being actualized, which limit the ability to forecast financial outcomes.

Effectiveness: While this alternative may prove to be profitable and even revitalizing for the Southwest region of Virginia, it is not effective within the scope of this problem. Processing the coal ash for REEs still leaves behind nearly all the coal ash at the end of the process.

Political Feasibility: Creating a stipulation allowing for coal ash to remain where it lies is an absolute non-starter. Every party involved has moved far past the status quo and political gears have been turning at a state and federal level to prevent stagnation. Even the chance of allowing for long-term storage facilities is slim given that this provision would have to be made at the federal level, beyond the influence of state actors. The possible loopholes associated with allowing for long-term storage as opposed to closure also contribute to the unlikelihood of this change occurring.

These are challenges that would be present if the technology to extract REEs from coal ash was on the way in the next decade, but are even more insurmountable given that we have no definitive timeline on the ability to scale up REE extraction. The idea of pausing the coal ash management process in the midst of all the moving pieces at work is unfathomable.

If coal ash were the only resource that presented an opportunity for REE extraction, the chances of making it available for longer may show promise, solely because of the

immense economic upside. However, this is not the case. Research has been done on numerous other deposits that show promise as well. What sets these other sources apart is that they will be more accessible for longer, meaning the opportunity cost of closing CCR units is significantly reduced (Vogelsong, 2021).

Environmental Impact: The environmental impact of excavating and transporting coal ash for the purposes of REE extraction would certainly be negative. The processes involved may also cause environmental detriment. Acids presently used in smaller quantities in lab settings may present a real danger to the environment if scaled up for industrial use, generating additional streams of waste. The profitability and excitement tied into this endeavor may lead to environmental risks being overlooked. Other concerns have surfaced regarding the workers that would be handling the coal ash on a day-to-day basis and the negative health impacts this may bring about (Vogelsong, 2021).

[**Construct On-Site Landfills Designated for Site Reuse**](#)

Cost: The estimated cost of moving forward with on-site landfills at the Bremo Bluff and Possum point locations would total \$1.06B (Appendix) for ratepayers over the course of eight years (Dominion Energy, 2022a). Any potential costs of landfill site reuse would not begin until after landfill closure and a monitoring period of 30 years and would likely be a city project, not having a significant cost on Virginians (US EPA, 2014b). Similar landfill site reuse projects have used solar panel arrays to generate a revenue stream sufficient to significantly offset costs (Hoefer et al., 2016). These factors in combination make financial burden on Virginians negligible.

Effectiveness: On-Site landfills would account for all of the coal ash from Dominion's CCR units that have not already agreed on being recycled. These state-of-the-art landfills are to be made with synthetic liners that exceed the regulatory requirements in place, meaning they satisfy the effectiveness criterion (Dominion Energy, 2022a).

Political Feasibility: Plans to construct an on-site landfill at Bremo Bluff has received little visible pushback from the community, likely because of the more isolated location of the Bremo Bluff site. Possum Point, on the other hand, has brought up concerns surrounding the presence of a landfill so close to the Potomac River and residential areas. The Prince William County Supervisor and the Potomac Riverkeeper Network have both spoken out against Dominion's proposal to construct an on-site landfill. Virginia Senator Scott Surovell has been heavily involved in this process to date, particularly since Possum Point is included in his district, but declined to comment on the proposed plan, instead noting the complexity of the decision (Palermo, 2023).

There has yet to be any legal action from any party and the power of the county to decide on this proposal is unclear. The county's director of public works did not show signs of

rejecting the plan, instead waiting for more details to come in order to know which permits will be required. The State Corporation Commission also has to approve Dominion's plan, but their primary concern is minimizing costs for ratepayers, making them likely to push this plan through. The overall sentiment from relevant stakeholders appears to be closer to a begrudging compromise as opposed to an outright rejection (Palermo, 2023).

When it comes to the political feasibility of landfill site reuse, particularly for a solar farm, the opportunity cost of developing a solar farm on this future landfill site is significantly lower than on any other property. Landfills are not suitable for much else and regularly become tantamount to brownfields, making the development of a solar farm that generates tax revenue highly feasible. Pushback for solar farms normally stems from complaints about the land being used for other purposes, even just for the sights (Holden, 2023). Especially for the Bremo Power Station landfill, such complaints will likely not be raised due to how secluded the location is. Therefore, it is reasonable to assume that a solar farm at this location will be met with widespread community support. Furthermore, the recent development of the Norge solar facility sets a precedent for Dominion doing the same type of project in Virginia (Sabin, 2024).

In the short-term, gaining approval to begin rezoning these CCR landfill sites show promise of being highly political feasible. Designating these spaces that are seen as detriments to their communities and reshaping them into something that adds value is an initiative that has had immense success in the past with Mt. Trashmore (Johnson et al., 2009). While these landfill site reuses may not look the same as past projects, the principle of adding value for Virginians where there was none before is sure to strengthen the feasibility of this alternative.

Environmental Impact: While this alternative has been held in contempt by environmental advocacy groups, research has shown it to be an environmentally safe option. Surface impoundments such as coal ash ponds do in fact pose health risks as a result of leachates, but landfills, even those with out-of-date clay liners, met EPA standards. These old landfills were proven safe for even those in the 90th percentile of exposure. This is not the highest level of safety desired, but this is where the updated composite liners become relevant. Composite liners, like the ones proposed for use in Dominion's on-site landfills, further reduced environmental risks far below the thresholds that indicate danger to humans or the environment (US EPA, 2014).

The proposed landfill design includes a leachate collection layer and a leak detection layer, among other features. Inspections take place to ensure the correct operation of the landfill and the 30-year monitoring period after closure bolsters the safety of this alternative. Groundwater monitoring is accompanied by a mandate for corrective action should there be any complications. Coal ash spill catastrophes in the past have been the result of severe

oversight, lacking proper monitoring protocols and ignoring stability issues that had known fixes. These disasters were also the result of coal ash ponds, not landfills (Seidler & Malloy, 2020). Per EPA regulations, every new landfill constructed must meet stringent structural requirements, significantly reducing the risk of any accidents occurring (US EPA, 2014b).

On-site landfills also have significantly less transportation-related environmental impacts that come with recycling and off-site landfills, adding another environmental benefit. Regardless of safety measures taken, there is always some amount of risk, however minuscule it may be, associated with constructing landfills so close to important waterways.

Outcomes Matrix

	Cost	Effectiveness	Political Feasibility	Environmental Impact
INCREASE COAL ASH RECYCLING	\$1.554B	100%	Medium	2
INCREASE REE EXTRACTION FUNDING	\$0 - <\$1.06B	0%	Low	3
CONSTRUCT ON-SITE LANDFILLS	\$1.06B	100%	Medium to High	1

Recommendation

Based on my findings, I recommend supporting the construction of on-site coal ash landfills at Brevo Bluff and Possum Point given the information currently available. I also recommend advocating for legislation that would rezone coal ash landfill sites for permitted uses that will benefit local communities like parks or solar farms. While this alternative may not have the flash of recycling coal ash for use in concrete and other construction materials, it is a financially sound option that places the least financial burden on Virginians while still keeping them and the environment safe. Contrary to public perception, this is the most environmentally safe option, especially considering a minimum of half of coal ash will need to be landfilled even in the case of recycling the most coal ash possible. This is also the most cost-effective option, demanding the least from Virginia ratepayers while accomplishing a resolution to the coal ash storage problem.

Low-end cost estimates for the recycling of coal ash are certainly appealing at first sight, but there are still many unknowns in the coal ash market. As other Southeastern utilities continue to step into the beneficial use market, supply continues to grow, meaning demand will also have to grow in order to keep the burden on Virginians minimal. Part of the problem lies in the fact that Southeastern utilities are selling coal ash in the same regional markets, which further calls into question the future stability of market demand, particularly since each utility is supplying a high level of coal ash within the next two decades specifically (because of the time restrictions from the EPA's 2015 Coal Ash Rule) (AECOM, 2019a).

There is evidence that points to a growing market for coal ash products, but there is still a significant amount of progress that needs to take place before the potential of the industry can be realized. The reality is that sustainable markets have not yet been created for CCR. With time, this progress could be made by eco-material firms and utility companies, but time is not a luxury this market has domestically. Were circumstances to change and provisions were made at the federal level to allow for long-term storage, the market for CCR products could be realized and rare earth element extraction could be a possibility (Seidler & Malloy, 2020).

REE extraction is another compelling opportunity, but has the same downsides as CCR recycling. The research is too nascent to leave the door open for the time required for gains to be realized. The unknown environmental impacts should also cause hesitation (Seidler & Malloy, 2020). Aside from these limitations, the larger problem associated with REE extraction is that it does not provide a permanent solution regarding where to store the coal ash.

Implementation

A major hurdle in implementation of this recommendation is the negative public perception of CCR landfills from local communities, governments, and environmental advocacy groups. Choosing to put coal ash into on-site landfills feels like a compromise instead of a legitimate solution to most groups. There is also a lack of vision to see what these landfills could one day turn into, leading to most to see these landfills as permanent negative externalities. In addressing how to implement this recommendation, stakeholders will be identified, their perspectives will be evaluated, and potential next steps for the Office of the Governor will be laid out.

Stakeholders

Dominion Energy: The most influential stakeholder is Dominion Energy. They are the first movers proposing plans, the ones responsible for the execution of coal ash policy, and possess the most knowledge of the complex coal ash landscape. If Dominion is not in support of a plan, it will likely not get implemented properly, failing to reach its full potential. This is one of the benefits of choosing an alternative that is agreeable to Dominion; knowing it has the highest likelihood of being executed to its potential.

Dominion will be in full support of this recommendation, but the key will be applying enough pressure to encourage intentionality in their implementation of it. If this policy alternative is seen as the easy way out, Dominion could be tempted to ease their efforts, matching public expectation. Even while backing Dominion's preferred course of action, an expectation of quality and intentionality in execution needs to be communicated.

Environmental Advocacy Groups: These groups have done immense work in bringing this issue to light over the past few decades. Moving towards a solution that is perceived as the bare minimum will surely be met with resistance. This resistance, in many ways, is not an obstacle, but a necessary feature of implementation. Environmental advocacy groups will play an important role in holding Dominion accountable in carrying out this recommendation with the level of care that they have promised.

There is the risk that too much resistance is put forth, impeding progress to the point of detriment. This is why it will be important to encourage a broader perspective, taking into account the importance of easing the financial burden for Virginians as well as taking care of the environment. Reframing on-site landfills as progress towards environmental safety as opposed to a regressive compromise through open dialogue and partnership in accountability is imperative to the successful implementation of this recommendation.

Local Governments: The support of local governments is perhaps the second most important part of this recommendation behind Dominion's proper implementation. Local governments play a large part in influencing community attitudes towards policy. They have the power to frame policies for their constituents, stirring up support or breeding opposition. Local governments are paramount in easing the implementation process, making their cooperation vital to the success of this recommendation.

Across and within local governments there will likely be mixed attitudes surrounding this recommendation. There will likely be skepticism about Dominion's true motives and reluctant to accept a policy that puts a landfill in their local limits. It will be important to encourage cooperation in this process in order to produce positive outcomes for not just those within their localities, but all over Virginia. The pride of localities must be protected by assuring the highest level of care and a commitment to strict accountability throughout the implementation process.

Next Steps

1. Communicate expectations with Dominion Energy

If this recommendation is adopted, the first step will be communicating gratitude for the work Dominion is doing to ensure positive outcomes for Virginians and extending the Office's partnership in this process. Equally, if not more important is the communication of expectations for and confidence in Dominion's commitment to moving forward with integrity.

2. Communicate commitment to Virginians with impacted state legislators

It will be necessary to talk with the legislators who represent the districts dealing with coal ash management, communicating the importance of this issue. An emphasis should be placed on the complexity of the problem, balancing the need for safety, environmental protection, and equity. Communicate the Office's commitment to and support of pursuing the good for all Virginians; which in this instance looks like holding Dominion accountable to pursue the good of Virginians through proper implementation. Practically, this may look like promising increased enforcement from the DEQ.

3. Communicate the need for dialogue with impacted communities

Fostering discussion between Dominion, relevant state legislators, and the appropriate local governments and environmental advocacy organizations is an important final step in the effective implementation of this recommendation. Moving forward with everybody on the same page will significantly ease difficulty of implementation and

ensure this recommendation reaches its full potential. Compromise will need to be made, but by maintaining open lines of communication between stakeholders there will be increased understanding, limiting unnecessary hindrances. Input at all levels will also limit blind spots, maximizing the success of this recommendation and securing the good for all of Virginia.

Conclusion

On-site coal ash landfills with a special designation for site reuse does not take advantage of the most recent innovations involving coal ash, but it does minimize the financial burden on and environmental risk to Virginians. Beginning the process of landfill site reuse by rezoning them for use as parks or solar farms (or some other project beneficial to the community) is a commitment to these coal ash landfills not remaining underutilized by their communities forever.

This recommendation is the most politically feasible and resolves the coal ash problem in Virginia, giving it the best chance of being implemented with the most cooperation among stakeholders and highest integrity from Dominion Energy. The key for successful implementation of this recommendation is encouraging communication between every stakeholder, all working towards doing right by one another and all of Virginia.

Appendix

Cost to recycle maximum CCR and landfill rest in on-site landfill

\$1.19B (cost to transport all CCRs by rail) / 2 = \$555M (cost to transport half of CCRs)
\$943M (high-end recycling cost estimate) - \$555M = \$388M (isolated recycling cost estimate)
\$388M + \$347M (on-site landfill cost) = \$735M

6.2M (CY of CCR at Brevo Bluff) / 4M (CY of CCR at Possum Point) = 1.55 (scale factor)
\$1.19B x 1.55 = \$1.84B (cost to transport all CCRs by rail at Brevo Bluff)
\$1.84B / 2 = \$922M (cost to transport half of CCRs)
\$1.203B (high-end recycling cost estimate) - \$922M = \$281M (isolated recycling cost estimate)
\$281M + \$538M (on-site landfill cost, scaled up from Possum Point) = \$819M

\$819M + \$735M = \$1.554B (total cost to recycle maximum CCR and landfill rest in on-site landfill at Brevo Bluff and Possum Point)

Cost of on-site landfills for Brevo Bluff and Possum Point

\$538M + 347M = \$885M
Class 2 estimate, +20% = \$1.06B

Possum Point – CCR Disposal Options (SB-1355)

	On site landfill	Recycle Ash (50%) by rail; remainder to landfill by truck	Recycle Ash (50%) by rail; remainder to landfill by rail	Rail – all ash to offsite landfill
Cost	\$347M	\$703M	\$943M	\$1.19B
% recycled	0% (all to on site landfill)	50% (remainder to offsite landfill)	50% (remainder to offsite landfill)	0% (all taken to offsite landfill)
Transportation/ Duration	All ash to remain on site, 8 years	100+ trucks/day and 200+ railcars/week, 12 years	200+ railcars/week, 12 years	200+ railcars /week, 10 years
Technology	New landfill with double-liner system	Cement replacement, remainder to offsite landfill	Cement replacement, remainder to offsite landfill	Subtitle D permitted offsite landfill
Local Permitting	Site Plan, LD/E&S, Bldg. Permit PFR Determination	Site Plan, LD/E&S, Bldg. Permit Transportation Plan	Site Plan, LD/E&S, Bldg. Permit Transportation Plan	Site Plan, LD/E&S, Bldg. Permit Transportation Plan
Environmental Permitting	Solid Waste Closure Solid Waste New Landfill Minor Air Permit Wetlands Permit	Solid Waste Closure Major air permit (for onsite ash processing facility)	Solid Waste Closure Major Air Permit (for onsite ash processing facility)	Solid Waste Closure Minor Air Permit



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