**Exploring the Opacity of the Cloud**

A Research Paper submitted to the Department of Engineering and Society

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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## INTRODUCTION

Cloud computing is a prevalent, yet enigmatic technology where some have faked knowledge about it. In a study conducted by Wakefield Research (2012) commissioned by cloud provider Citrix, approximately 22 percent of respondents admitted to pretending to be knowledgeable about the cloud in the workplace, 14 percent during job interviews, and notably, about 17 percent during first dates. When questioned about the meaning of "the cloud," 29 percent of participants believed it referred to the "fluffy white thing" floating in the sky, and 51 percent thought that adverse weather conditions could negatively affect cloud computing (Wakefield Research, 2012). The vice president of corporate marketing at Citrix remarked that "[t]his survey clearly shows that the cloud phenomenon is taking root in our mainstream culture, yet there is still a wide gap between perception and realities of cloud computing" (Wakefield Research, 2012). Despite widespread recognition of an intangible digital resource known as the cloud, a significant lack of understanding persists among the general public, particularly those not immersed in the technology sector.

In the twenty-first century, where we mediate reality through rapidly evolving technologies, Vallor (2021, pp. 79-83) asserts that technosocial blindness (society's hazy understanding of the technologies that are shaping our lives) greatly impedes our ability to make meaningful technomoral choices. In other words, the growing gap between technology dependence and technology comprehension hamper our ability to decide how to live well with these technologies. In Flint, Michigan, for example, it wasn't until "the support of doctors, scientists, journalists, and citizen activists" that residents were able to expose "the city's severe mismanagement of its drinking water." (Denchak, 2018). Before public awareness of the water infrastructure, a highly used but ignored technology, residents were inhibited from living well by

months of lead poisoning and the third-largest legionnaires outbreak in U.S. history (Denchak, 2018). By bringing the infrastructure and its shortcomings to light, residents reclaimed the ability to live well—they avoided using the well-proven malfunctioning water supply and ultimately, they contended with authorities to provide them with safe water.

In this paper, I argue that only by increasing the visibility of the cloud can stakeholders make more informed decisions about how to live well. As such, this study will aim to reduce the hiddenness of this seemingly unobtrusive technology. Focusing on data centers in Virginia, I will employ the sociotechnical theories of Social Construction of Technology (SCOT) and Engineering as Social Experimentation (Klein & Kleinman, 2002; Martin & Schinzinger, 2005). Using SCOT, this study will identify relevant groups and their interpretations of the cloud to develop a fuller sense of the infrastructure's history, current state, and trajectory. Using Engineering as a Social Experimentation, this study will establish the authority's responsibilities in addressing technosocial blindness.

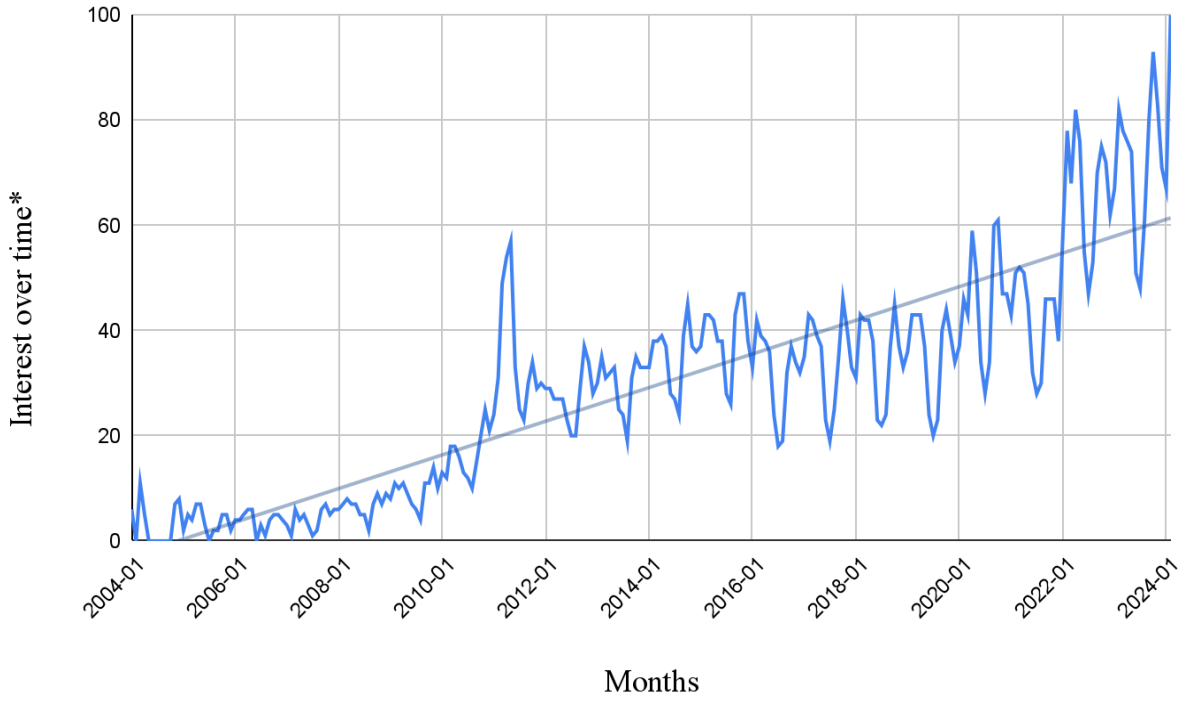
**HIDDENNESS OF THE CLOUD**

Cloud computing was first conceived in 1961 when MIT Professor, computer and cognitive scientist John McCarthy imagined a future where computing resources (e.g., networks, servers, storage, applications, and services) would be operated as public utilities, with one of the first implementations in 1999 (McCarthy, n.d.; Surbiryala & Rong, 2019, p. 1). The cloud has been around for about 63 years as a brilliant concept, and 16 years with market with alternatives (Jones, 2024; Surbiryala & Rong, 2019, p. 2; Amazon, 2021; MSV, 2020). Nonetheless, 54% of Americans claimed to have never used cloud computing before; however, 95% of them did in fact use social media (e.g., Facebook, Instagram, TikTok), online banking (e.g., Capital One, Chase, Bank of America), online shopping (e.g., Amazon Prime, eBay, Etsy), online gaming

(e.g., Poker, Chess, Fortnite), online photo storage (e.g., iCloud photos, Google Photos, Snapchat), online music streaming (e.g., Spotify, Apple Music, YouTube Music), online video streaming (e.g., Netflix, Hulu, Max), or online file sharing (e.g., Google Drive, Dropbox, OneDrive), all relying on some form of cloud computing (Wakefield Research, 2012). [Note: Examples in parentheses are author-provided for illustration purposes.]. About a decade after the Wakefield research, the public remains cloud illiterate. Given the search term "what is the cloud," Google Trends (n.d.) shows a steady increase in interest in this term in Virginia and the United States with top interest peaks between 2022 and 2024. This suggests that people are still, and perhaps even more confused about this technology. Though we depend on it daily, it is as if the cloud is so seamlessly integrated, camouflaged, and unnoticeable.

**Figure 1**

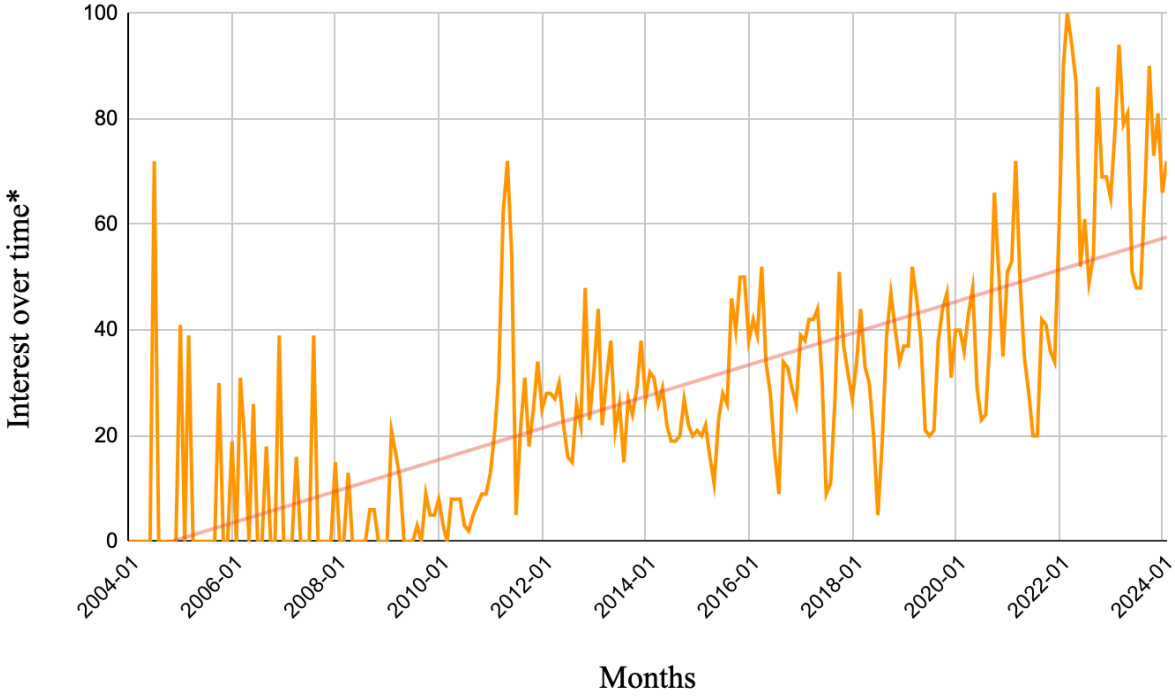
*What is the Cloud — United States, 2004 - 2024*



*Note*. This figure represents search trends on Google for the term “what is the cloud” in the United States for the years 2004 - 2024 (Google Trends, n.d.). Data was taken from Google Trends, and the visual was reformatted to include a trendline. “Numbers represent search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. A score of 0 means there was not enough data for this term.” (Google Trends, n.d.).

**Figure 2**

*What is the Cloud — Virginia, 2004 - 2024*




*Note*. This figure represents search trends on Google for the term “what is the cloud” in Virginia for the years 2004 - 2024 (Google Trends, n.d.). Data was taken from Google Trends, and the visual was reformatted to include a trendline. “Numbers represent search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. A score of 0 means there was not enough data for this term.” (Google Trends, n.d.).

Susan Leigh Star (1999, p. 381) explains that infrastructures that are deeply “sunk into … structure, social arrangements, and [other] technologies” are very hidden. While Vallor diagnoses society with technosocial blindness, Star diagnoses technologies with invisibility, both leading to

the same outcome: we cannot see the effects of these technologies. This is precisely why Vallor argues that "our growing technosocial blindness," which she calls "acute technosocial opacity, makes it incredibly difficult to identify, seek, and secure the ultimate goal of ethics—a life worth choosing, a life lived well" (2021, p. 83). How could we reasonably predict "what we [can] do with these technologies, and what they will do with us … without attending to a host of interrelated political, cultural, economic, environmental, and historical factors that co-direct human innovation and practice?" (Vallor, 2021, p. 82). In other words, how can we aim to live well blindly, without acknowledging the multi-faceted ways these technologies are co-shaping the human experience?

Star (1999, p. 382) expands that deeply embedded technologies remain hidden until they break down, undoing "the invisible quality of working infrastructure." Public utilities like water, electricity, and telecom are good examples of such infrastructures. Though we cannot reckon to live without them, we barely and rarely acknowledge the existence of underground pipes, overground telephone poles, and ambidextrous electric lines; that is until they break down. Working infrastructure can easily be abstracted and ignored, whereas dysfunctional technology draws attention to itself by the very nature that the failures and inconveniences cannot be ignored.

## CLOUD INFRASTRUCTURE IN VIRGINIA

Currently, Virginia has 280 data center facilities consuming a total of 4,093 megawatts, where approximately 92 percent are concentrated in Northern Virginia (Baxtel, n.d.). In the assessment, Dominion Northern Virginia Area Immediate Need (Abdulsalam, 2022), PJM, the regional transmission company, reported that the "data center additions for the 2022 Load Forecast … were noticeably higher than were provided in the prior year". As a result of this

rapidly growing highly concentrated load in the Northern Virginia and Dulles Airport region, it is predicted that there will be unreliable electricity starting in 2024 and into 2027 (Abdulsalam, 2022). Even with the proposed baseline and supplemental upgrades, this rise in electricity usage from data centers is brewing the perfect storm for outage conditions in 2025 (Abdulsalam, 2022). Only by commencing more comprehensive transmission upgrades can the "remaining reliability violations anticipated in 2025" be adequately addressed and mitigated (Abdulsalam, 2022).

Although this assessment serves as a good resource to heed the warning signs of infrastructure mishap, allowing us to respond proactively and prevent the consequences of infrastructure breakdown, the existence of such resources, however, doesn't guarantee good dissemination of information or, its intended result, technosocial awareness to those affected. Sparked by a desire to evaluate the effectiveness of this publicly available document, this research paper will investigate how, if at all, local stakeholders—residents, policymakers, and businesses— are responding to Dominion's immediate need. To develop the research methodology, this study will draw frameworks and approaches from two sociotechnical theories, Social Construction of Technology and Engineering as Social Experimentation.

**RESEARCH APPROACH**

In their book *Introduction to Engineering Ethics*, Martin and Schinzinger (2005, pp 89-90) assert that engineering is a social experimentation, beginning and concluding with partial ignorance. Similar to any experimentation, engineers are grappling with incomplete knowledge: authorities weren't aware (at first) of the impending public health crisis when they supplied residents waters using forgotten pipes (Denchak, 2018), autonomous driving technologies like Tesla's Autopilot didn't foresee the outcome of 736 crashes and 17 fatalities (Merrill & Siddiqui, 2023), and companies using A.I. art generation didn't predict the sheer pushback from the digital

artist community “desperately attempt[ing] to avoid contributing to — or being exploited by — the growing AI infestation” in the digital art market (Weatherbed, 2024). These examples encapsulate the inherent uncertainty accompanying any engineering endeavor.

Therefore, like any experimentation, this framework suggests that engineering necessitates constant monitoring and responding to feedback (Mark & Schinzinger, 2005, p. 115). As for autonomous driving, Tesla recalled more than 360,000 vehicles over software concerns (Merrill & Siddiqui 2023). In response to artists’ outrage regarding AI usage in art, some companies showed support by deleting their AI-aided images and issuing apologies (Weatherbed, 2024). In both cases, the social experimenters monitored, or at least, responded to feedback, allowing them to promptly rectify identified problems and avert further disasters. As for Flint, however, residents were “chronically ignored, overlooked, and discounted … for 18 months,” leading to a devastating public health crisis (Denchak, 2018).

Social Construction of Technology (widely known as SCOT) is a framework studying “the design, development, and transformation of technology to improve our understanding of the social shaping of technology” (Klein & Kleinman, 2002, pp. 28-30). One of the central predicates of SCOT is “[r]elevant social groups,” a group where “all members of a certain social group share the same set of meanings, attached to a specific artifact” (Klein & Kleinman, 2002, p. 30). When an artifact is being designed, relevant groups negotiate over its design; once a consensus is reached—each group agrees that the artifact is working according to each group's unique interpretations—the designing phase reaches closure (Klein & Kleinman, 2002, p. 30). To understand the trajectory of this technology, and to unveil the hidden forces paving the path for the future, we must understand how the notable relevant groups in Virginia are interpreting and negotiating the cloud.

To map out relevant groups and their predispositions, the SCOT approach would begin with a list of several groups, or types of groups, asking each of the groups to identify other relevant groups (Klein & Kleinman, 2002, p. 30). This step can be repeated as many times as needed, growing a more exhaustive list of stakeholders. This research will employ a similar strategy. Beginning with types of groups to explore, we will examine residents, businesses, and policymakers, but instead of the SCOT way of interviewing listed groups to identify other groups, this study will map out relevant groups by scavenging through the publicly accessible websites of the already established groups.

**RELEVANT GROUPS AND THEIR INTERPRETATIONS**

Using the paradigms established by SCOT and Engineering as Social Experimentation, we can refine the question as such: how are relevant groups monitoring, interpreting, and responding to Dominion's immediate needs?

In this paper, we have already identified two relevant groups and representatives of electricity businesses, Dominion and PJM. They interpret data centers as more business and market, however, the unexpected growth in forecasted data center energy consumption, either from more data centers being built or data centers using more energy (likely both) poses a problem for the integrity of their product. As a result, Dominion and PJM could risk losing trust amongst Virginian residents, companies, and existing data centers, as well as proposed data centers. As we can already see in their article about their immediate need, it is clear that they are already putting serious efforts into upgrading the electric system to provide reliable electricity for current customers and customers to come. For this group, to live well means to meet the needs of their customers.

We continue to map out involved groups starting with a more comprehensive entity: the Virginia Economic Development Partnership (VEDP). The VEDP (n.d.) created in 1995, advances economic opportunity for the Commonwealth of Virginia, collaborating with the local, regional, and state partners with offices in Virginia, Germany, Japan, Taiwan, and South Korea. "With dedicated and knowledgeable professionals committed to Virginia's economic success, VEDP helps businesses find the resources they need to make relocation and expansion successful endeavors." (VEDP, n.d.). Working on both local and international scales, the VEDP is strongly established as the economic authority of Virginia and the governmental relevant group.

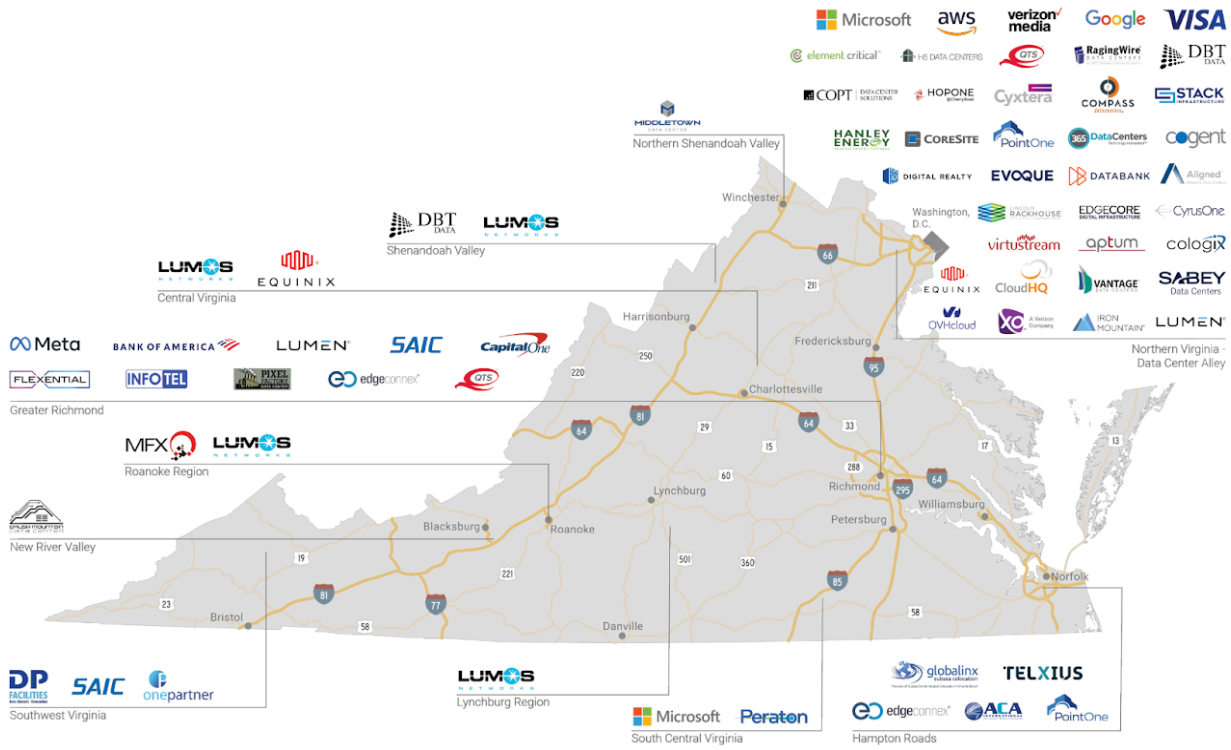
What makes the VEDP (n.d.) a relevant group is their particular affinity towards data centers, listed as one of their key industries of focus. They report that "Virginia hosts one of the largest data centers market in the world and is home to 35% (almost 150) of all known hyperscale data centers worldwide." (VEDP, n.d.). With words like "benefit from densely packed fiber backbones," "advantageous cost environment centered on a competitive tax rate," "affordable and abundant electricity (with rapidly expanding renewable power options)," and "competitive construction costs", the VEDP attempts to draw international attention to resources available in Virginia. But at first glance, those words seem to contradict and misinterpret Dominion's immediate need, especially the part that mentions "affordable and abundant electricity (with rapidly expanding renewable power options)".

So what does this tell us about VEDP monitoring, interpreting, and responding to Dominion's immediate need? First, it seems like the VEDP is somewhat aware of Dominion's proposed plans, the immediate ones, and those to come. This may be the reason that they allude that Virginia has "rapidly expanding … power options." It is thus evident that the VEDP is reasonably monitoring Virgniania's electrical trajectory. How they choose to interpret it,

however, is in a way that paints in good light the opportunities present in Virginia. But this makes sense as one of the primary goals of VEDP is trying to get businesses to relocate to Virginia. To this group, to live well is to advance the economy of Virginia. In this framework, companies should know about any opportunity that can benefit Virginia's economy even though it may take much time or resources to feasibly relocate businesses here. From this, we discover that, though the VEDP may be aware of Dominion's current struggles, the VEDP chooses to promote Virginia to continue augmenting Virginia's economy. Perhaps some of the unexpected increase in data centers reported by Dominion could be attributed to VEDP's persistent promotion of Virginian resources.

The VEDP identifies several notable data center owners in Virginia: Microsoft, AWS, Google, VISA, Meta (formerly known as Facebook), and Capital One. With its recent HQ2 move into Arlington, Virginia, AWS contributes about 25 percent of electricity and land usage, with great concentration in the Northern Virginia regions (Schoettler, 2023; Baxtel, n.d.). As such, AWS is the top data center presence in Virginia, with the close second, Digital Realty Trust, owning about 12.5 percent of the market share (Baxtel, n.d.). As a result, AWS stands as the largest consolidated voice, making it a more prominent entity and having a more boisterous impact in shaping the trajectory of this market. AWS can therefore be used as a SCOT-relevant group, representing the cloud operator business sector.

**Figure 3**
*Data Centers and Owners in Virginia*




*Note*. This figure represents the list of companies and their data center colocations (VEDP, n.d.)

So how does AWS monitor and interpret Dominion's immediate need? AWS has already made significant contributions to building data centers in Virginia, investing $51.9 billion from 2011-2021 (Wehner, 2023). They do not intend to stop there. They plan to invest $35 billion to develop new data centers in Virginia by 2040, and pledge to finance 18 solar farms in Virginia (Wehner, 2023). AWS is here to stay. With multi-billion dollar investments from a very successful company, one would expect that such companies would do their homework regarding the expected availability of electrical and land resources. Now Virginia isn't short on land, and through financing solar farms, AWS seems to be aiding Dominion's immediate need. This leads us to conclude that AWS would be aware and is reasonably vigilant towards Dominion's electrical capacity. It seems like they are interpreting data centers as a valuable market that is

worth investing in, enabling them to reach their goals whilst profiting Virginia as a whole. To this group, living well means long-term symbiotic investment in a region.

Moving on to organized non-profit types that aim to represent the interests of residents, the Piedmont Environmental Council (PEC) stands out as a valuable relevant group, simply because of their exhaustive documentation, analysis, and involvement in Virginia's data centers. The PEC (n.d.), founded in 1972, was built on the mission to protect and restore the lands and waters of the Virginia Piedmont region, to build stronger, more sustainable communities. As such, they find themselves implicated in needing to examine and evaluate how the rapid bloom of data centers could negatively impact Virginia's Piedmont.

The PEC (n.d.) interprets the explosive growth of the data center industry as posing the following challenges: 1) data centers current need for backup diesel generators because of the unreliable electric power may severely hamper Virginia from achieving clean energy goals, and 2) the transmission line expansions through public and private conserved lands irreversibly erodes the splendor of Virginia's biodiverse ecology. Of the previous relevant groups, PEC seems to have a more environmentally conservative view, choosing first to mitigate ecological side effects before committing to potential economic proliferation. But similar to the previous groups, the PEC desires to benefit Virginia and its residents with a focus on sustainability. For this group, living well means the practices that enable the land, water, and environmental aspects to live well, affording us to enjoy and benefit from them. Julia Bolthouse, a PEC staff put it this way, "The distinction between the natural world and the man-made world seems an arbitrary one. All things are made from natural resources and all life is sustained by natural systems … but none of [it] can thrive if our natural support system is pushed to its breaking point." (Parker, 2023).

In sum, these different relevant groups (Dominion, PJM, VEDP, AWS, PEC) represent the diverse interests for the wellbeing of Virginia—electrically, economically, and ecologically. There seems to be a consensus for the need for electrical upgrades to sustain the forecasted levels of data center increase in Virginia. Through the different technomoral interpretations, these groups offer various resolutions for the predicted electrical deficit. Electrically, either power must be generated and transmitted effectively to data centers, or there must be a halt or decreased pace of data center relocation into Virginia. By prioritizing electrical stability, current users would not need to bear the cost of unreliable power grids in favor of economic growth from new customers. Economically, Virginia must be endorsed as a viable potential for data center solutions, even if the electrical grid may not be ready for it yet, in optimism that it would. By gaining national and international spotlight, Virginia would lend itself to more job opportunities and economic opportunities, perhaps enabling Virginia to afford to upgrade its electrical system even more swiftly. Ecologically, Virginia's goals of suitability and her luscious landscape are threatened by the rapid unchecked expansion of data center infrastructure. To the very least, we must maintain current levels of sustainability and natural, historical land preservation.

## CONCLUSION

The cloud has become a ubiquitous term used to reference almost all internet-based activity, abstracting the physical hardware needed to support it. Though this cloud utility model offers many computing and cost reduction benefits, it ultimately camouflages the infrastructure resulting in widespread technosocial blindness amongst residents and other stakeholders. Dominion's immediate need represents how technosocial blindness can enable infrastructures to come to the brink of breakdown unnoticed. It also serves as a case study that exposes the

different technomoral interpretations of groups at the forefront of shaping cloud infrastructure in Virginia. Looking at the diverse technomoral frameworks helps uncover the various priorities—electrical integrity, economic prosperity, and ecological preservation—and following technomoral resolutions in current discussions. In doing so, it sheds light on how experts directly involved in decision-making are defining what it is to live well, and how they mean to apply it into action. Ultimately, and hopefully, readers of this paper would have come to deeper technosocial awareness of the cloud and become versed in some technomoral frameworks and approaches in such a formative time for Virginia's data centers.

Thus, increasing technosocial awareness enables residents to engage with policies, legislation, and new information without total ignorance. But how can we ensure that users are well-read on technologies impacting them? How can engineers guarantee that users won't be duped into using technology that would ultimately lead to a worse quality of life? How can users carefully consider adopting technologies when there are so many technologies, many are being born many more each day, and there hasn't been enough time to fully understand the ways different ethical priorities compete? I think, at to very least, that engineers must make information more publicly disseminated, perhaps in the form of reports with detailed analyses. In turn, users need to be more vigilant and proactive in reading the documentation of technologies, as well as, investigating current events happening around communities, locales, technologies, and group identities that they are a part of. Hopefully, this results in a more tehcnosocailly clear vision amongst everyone, allowing meaningful conversations and negotiations amongst different ethical priorities.

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