

# ***Loudoun County Virginia: Data Center Capital of the World “A Strategy for a Changing Paradigm”***

*By  
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## **Author’s Preface**

The opinions and recommendations in this paper represent those of the author alone and in no way represent those of any other Board member, the Loudoun County Board of Supervisors or Loudoun County Staff. Furthermore, these opinions and recommendations have no legal authority nor are they in any way legally binding on any Loudoun County employee.

I was elected to the Loudoun County Board of Supervisors in November 2019 and took office in January 2020. For my entire tenure, our bipartisan Board has had to deal with two enduring and overarching issues: data center growth and housing. While the need for attainable housing in Loudoun County, the wealthiest county in America,<sup>1</sup> remains a critical issue, the explosion of data center growth in the past two years, both unprecedented and accelerating, has created urgent policy issues I believe our Board must now address.

This paper is intended to form the factual basis for a new policy regarding data center growth in Loudoun County. Stated simply—based on the data, logic and conclusions offered herein—the existing paradigm of power generation, transmission and consumption this nation has relied on for more than a century is simply not capable of providing sufficient power to Loudoun County data centers (and very likely Prince William County data centers) going forward. The demand from that sector of our market environment is too high, and that demand is accelerating rapidly to historic levels.

I suspect the data center sector and the power utilities will not agree with several of my conclusions expressed in this paper, and I both respect and value their feedback. However, having done the research on this issue, I believe we have all been considering these changes within the context of our historic organizational paradigms. The data centers’ imperative is to meet market demand, and that’s their focus. Dominion Energy and PJM, the Regional Transmission Organization (RTO) for the northeast power grid, are required by law to provide power to all customers, and that’s their focus. And the Board of Supervisors is an elected body responsible for making land-use decisions and encouraging economic growth, and that has been our focus. But the post-COVID world since 2022 has seen a seismic increase in demand for data representing not an evolution, but a revolution of technological change now very likely

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<sup>1</sup> Ibeh, Kemi. “The Wealthiest County in the U.S. Is Not Where You Think.” Fodor’s Travel. January 23, 2024. <https://www.fodors.com/world/north-america/usa/virginia/experiences/news/heres-where-the-wealthiest-u-s-county-actually-is>

to overwhelm our existing power infrastructure. Essentially, we've invented the airplane but just realized we haven't yet invented runways. This level of systemic change demands new paradigms at almost every level if we are to avoid an involuntary and likely painful landing.

This paper offers a summary of how we got here, presents data to capture the magnitude of the change we are all facing, acknowledges what I believe are the new realities of our current and future data center environment, and proposes the key elements of a new policy going forward. I do not consider the ideas presented or the policy elements I'm proposing the only viable answers to the historic challenges we now face. But my overarching responsibility, and I believe the responsibility of the Loudoun County Board of Supervisors, is to protect the quality of life of our citizens, even if the decisions we make are controversial, politically fraught and decidedly unpopular. My purpose here is to start a conversation based not on our ungrounded hopes but on our fact-based needs. That is the only basis upon which we can, collectively and collaboratively, formulate a transformational strategy for Loudoun County. We are the nexus for the world data center community. We have both a profound responsibility and an historic opportunity to redefine and permanently reshape the digital world and the power infrastructure it relies on. And we must act now.

## Introduction

As of this writing, Loudoun County, Virginia—and more precisely, eastern Loudoun County comprising approximately 30 square miles—is home to 181 data centers. Combined with the rest of Northern Virginia, we have three times more than the second highest concentration in America.<sup>2</sup> In 2022, Dominion Energy forecasted Loudoun County would require about 3.4 Gw of power in 2023<sup>3</sup>, up from just 1 Gw in 2018<sup>4</sup>. That's a 240% increase in the need for electricity in Loudoun County in five years. Stated another way, in 2023, we were expected to use 3.4 times as much power as we did in 2018. If we apply just a linear extrapolation of that growth rate in power demand over the next five years—and that is probably an unrealistically conservative growth rate based on the preponderance of growth trends in power demand—that means by 2028 Loudoun County will require about 11.56 Gw of power.

Regarding actual data center construction growth, in 2018 we had about 13 million sq. ft. of permitted data centers in the county. In 2023, we had 32 million sq. ft. of data centers permitted.<sup>5</sup> That's a 146% increase in five years. Admittedly, much of the square footage increase is likely due, in part, to data centers being built on “land banked” land purchased

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<sup>2</sup> [United States Data Centers: Top 10 Locations in the USA - Dgtl Infra](#)

<sup>3</sup> “Dominion Energy 15-Year Data Center Plan.” Slide #2. <https://sdc.pjm.com/-/media/committees-groups/subcommittees/las/2023/20231018/20231018-item-03a---dominion-large-load-request.ashx>

<sup>4</sup> Abdulsalam, Sami. “Dominion Northern Virginia Area Immediate Need.” Slide #2, “Data Center Alley Area Load Growth and Transmission System.” Slide #3, “Dominion 2022 Load Forecast.” Data interpolated from data center load forecast line (orange). June 7, 2022. <https://www.pjm.com/-/media/committees-groups/committees/teac/2022/20220712/item-08---dominion-northern-virginia---immediate-need.ashx>

<sup>5</sup> Yearly data provided by the Loudoun County Commissioner of Revenue.

previously as a hedge against increasing county resistance to more data centers. This square footage growth trend will continue but likely slow in the near future.

Nevertheless, by every metric, the rate of data center growth in Loudoun County over the past 20 years has been among the highest of any community in the world, and that rate has accelerated exponentially since 2022. All indications suggest, at least in the area of power demanded, it will likely accelerate even more going forward unless outside factors such as availability of power or local government legislative action limit that growth.

Our county is at the edge of the frontier in data center development. The lessons we have learned as a community can serve as invaluable roadmaps for communities across the nation ranging from those contemplating their first data center, to those with modest growth, to those with an established and thriving data center community.

At the same time, because of our uniqueness, many of the challenges we now face have no corollary outside of Loudoun County. Yes, our journey can be instructive to other communities still in the early to moderate growth cycles, but many of the issues our data center community, our utility companies and our local elected leaders are facing now have never before been encountered.

### **Three Key Stakeholder Groups**

There are three core stakeholder groups in Loudoun County with an urgent interest in developing a comprehensive strategy for future data center sector growth: the data center community, the core utilities (electricity, gas, water), and local government representing our citizens who benefit from the data produced by our data centers.

**Data Centers.** This group involves not just data center owners and land developers, but the land-use attorneys representing them, construction companies, unions who provide labor, non-union laborers, and a wide range of corollary businesses that benefit from the construction, growth and increased impact of data centers on our society. All the members of this stakeholder group are primarily focused on enabling data centers to meet the rapidly increasing demand for data processing in our society. Their market imperative is to continue to grow. There are two broad types of data centers:

**Hyperscale (Enterprise) Data Centers.** Hyperscale (100 Mw or more) or Enterprise data centers are generally owned and operated by a single owner and are extremely large with very high power demands. According to an August article in *Enterprise Storage Forum*,<sup>6</sup> a hyperscale data center is any data center with more than 10,000 sq. ft. of space and more than 5,000 servers. However, by this standard, just about every data center in Loudoun County, including most of our legacy data centers, would be considered hyperscale. For the purposes of this paper, I will distinguish

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<sup>6</sup> Vyas, Kashyap. "Hyperscale Data Centers vs. Colocation Data Centers." Enterprise Storage Forum. August 24, 2023. <https://www.enterprisestorageforum.com/cloud/hyperscale-vs-colocation/#:~:text=Hyperscale%20data%20centers%20meet%20enterprise%20data%20needs%20by.essential%20resources%2C%20allowing%20for%20cost-effective%20expansion%20and%20management.>

between the two based on function. An Enterprise data center is usually owned by a single entity and is designed to process enormous data loads at scale for just that entity or perhaps a handful of partners. According to a major colocation data center owner I talked to recently, Hyperscale or Enterprise data centers require significantly more power than Colocation data centers as defined below.

**Colocation Data Centers.** Colocation data centers are owned by a company that leases data rack space to tenant companies. It's a shared-space data center often hosting hundreds of clients who own and operate their own servers and infrastructure in an ideal data processing environment. The power requirements of a Colocation data center are much less than Hyperscale/Enterprise data centers.

**Core Utilities.** Though services like internet, phone, cable T.V. etc. can be considered utilities, for the purposes of this discussion, we will limit our focus to just the core utilities of electricity, water and gas. The principal core utility and the one facing the most urgent current demand in Loudoun County due to accelerating data center growth is power (electricity). However, our other two utilities could play increasingly important roles in the future. Submerged data racks using water cooling could significantly lower data center power needs, and use of onsite gas-generated electricity is a viable future option. Rapid growth in these sectors would also require more resources. But this paper's principal focus will be on power. There are two major players and one minor player in the Loudoun County power space:

**Dominion Energy.** Dominion Energy is the largest supplier of electricity in the Commonwealth of Virginia and the predominant electricity provider in Loudoun County. It is an Investor-Owned utility and **is required by Virginia law to provide power to every customer it serves.** This is a critical point underlying the entire issue of data center growth in Loudoun County and will be addressed later.

**PJM.** According to the PJM website, "PJM is a Regional Transmission Organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia."<sup>7</sup> PJM monitors and regulates all the power companies in the northeast region, including Dominion Energy, to ensure the stability and resiliency of the entire northeast power grid. Northern Virginia, and specifically Loudoun County, are among PJM's largest customers due to our data centers. Approximately 60% of the PJM grid is carbon dioxide-producing, and about 40% is carbon-net-zero energy with about 82% of the carbon-net-zero portion being nuclear.<sup>8</sup> As we will note later in this paper, that ratio could change significantly in the years ahead.

**Northern Virginia Electric Cooperative (NOVEC).** According to their website, "NOVEC is a distribution electric cooperative. NOVEC purchases wholesale power through the PJM marketplace."<sup>9</sup> As stated, NOVEC's principal function is to

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<sup>7</sup> <https://www.pjm.com/about-pjm>

<sup>8</sup> [https://en.wikipedia.org/wiki/PJM\\_Interconnection](https://en.wikipedia.org/wiki/PJM_Interconnection)

<sup>9</sup> [https://www.novec.com/About\\_NOVEC/index.cfm](https://www.novec.com/About_NOVEC/index.cfm)

distribute electricity purchased by wholesale providers. Generally, they provide power to residential customers and commercial businesses not powered by Dominion. They are not a major player in the data center space.

**Local Elected Officials Representing the Community.** In Loudoun County, the senior elected body charged with land-use planning is the nine-member Board of Supervisors (BOS). The BOS works for the citizens of Loudoun County and must be responsive to their needs and concerns. No individual Supervisor may act alone; all proposed actions by the BOS require at least five votes to be implemented.

Regarding the BOS's role in land-use issues, the extent of BOS involvement in the decision-making process for land development depends on what type of land development is proposed. There are generally two types: "by right" and legislative.

**"By Right."** Every parcel of land in the county has permitted uses, and if a landowner decides to develop one of those permitted uses, s/he is not required to obtain BOS approval to develop that land unless they wish to change a "by right" use or add a new use.

**Legislative.** If the landowner decides to modify the use of the land beyond what's permitted "by right," s/he must submit a legislative application to county staff and obtain final approval from the BOS.

**The Roles of the Comprehensive Plan and the Zoning Ordinance.** Key to understanding the planning environment within which these three stakeholders have been operating throughout the period of rapid data center growth is the relationship between the Loudoun County Comprehensive Plan and the Zoning Ordinance. Stated simply, the Comprehensive Plan is the Board of Supervisors' vision of how land should be developed in the county (plus the transportation infrastructure needed to support that vision). The Zoning Ordinance is the legally binding code landowners must abide by when developing their land, and it is used to implement the vision outlined in the Comprehensive Plan. The Comprehensive Plan is not legally enforceable; the Zoning Ordinance is.

These two documents should always be in alignment and updated every five years. Yet Loudoun County went from 2001 to 2019 without a complete update of its Comprehensive Plan and from 2003 to 2023 without a corresponding update of its Zoning Ordinance. These two decades precisely aligned with the growth, from inception to maturity, of the data center sector in Loudoun County, the largest such sector in the world today. The BOS finally updated the Comprehensive Plan in 2019, but it took four more years to update the Zoning Ordinance in December 2023. These four years of misalignment between the Comprehensive Plan and the Zoning Ordinance occurred just as data centers began exercising their "by right" development options. Additionally, PJM, Dominion, and Aurora Energy, a leading global advisor to energy investors, mark 2022 as the first year data center power demand began increasing rapidly.<sup>10</sup> This plan/ordinance misalignment could not have occurred at a worse time and seriously limited the Board's ability to manage data center growth as envisioned in the Comprehensive Plan. This tension will be addressed in more detail later.

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<sup>10</sup> <https://auroraer.com/company/about/>

## How We Got Here: A Timeline of the Growth of the Loudoun County Data Center Sector

The following is a timeline of key events shaping the proliferation of data centers in Loudoun County:

- 1993 Update of 1972 Zoning Ordinance: No mention of data centers.
- 1990s (latter half): Metropolitan Area Exchange-East established in Loudoun County; AOL HQ comes to Ashburn in 1997 and expands on existing fiber optic network.
- 2000 Loudoun County Zoning Administrator determination: data centers are viewed as similar to office buildings in the 1993 Zoning Ordinance. Office parks are a hot trend.
- 2001: General Plan (land use) updated.
- 2003: Revised 1993 Zoning Ordinance to match the 2001 General Plan: First Mention of Data Centers in the Zoning Ordinance.
- 2008: Loudoun County Economic Development initiates marketing strategy to actively recruit data centers to build on land specifically permitting data centers.
- 2014: Zoning Ordinance Amendment (ZOAM) addressing data center sight, setback, sound.
- 2019: General Plan updated (land use).
- 2022: May-Aug: The Loudoun County Transportation and Land Use Committee (TLUC) holds a series of three meetings to inventory current and potential locations of data centers, obtain staff recommendations about how best to manage data center growth, and to determine the best process to implement a future data center Comprehensive Plan Amendment (CPAM)/Zoning Ordinance Amendment (ZOAM) to codify those managerial changes. Dominion announces new 500/230 Kv Wishing Star-Mars transmission line.
- 2022: Jul: PJM informs Dominion Energy it has underestimated power infrastructure needs. Dominion Energy informs “Data Center Alley” it will have less power available for at least five years. The power “constrained area” is created until new power lines can be built by 2027.<sup>11 12</sup> PJM announces a new 500 Kv line from Doubs-Aspen.<sup>13</sup>
- 2023: Dominion Energy announces a new 500/230Kv transmission line along Route 7 in Loudoun County.<sup>14</sup> This line and the southern Wishing Star-Mars line will form a loop to “Data Center Alley.”
- 2023: Dec: Zoning Ordinance Rewrite (ZOR) to align with the 2019 Comprehensive Plan is approved by the BOS. This zoning ordinance rewrite established new, more restrictive

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<sup>11</sup> RTO Insider LLC. “PJM Orders Dominion ‘Immediate Need’ Projects to Serve Load Jump in ‘Data Center Alley.’” June 16, 2024. <https://www.rtoinsider.com/30472-pjm-orders-dominion-immediate-need-projects-load-jump-data-center-alley/>

<sup>12</sup> Abdulsalam, Sami. “Data Center Planning and Need Assessment Update.” PJM. January 10, 2023. <https://www.pjm.com/-/media/committees-groups/committees/teac/2023/20230110/item-04---data-center-load-planning.ashx>

<sup>13</sup> PJM. “Transmission Expansion Advisory Committee (TEAC) Recommendations to the PJM Board.” PJM. Dec. 11, 2023. Slide 44, last entry in table. <https://pjm.com/-/media/committees-groups/committees/teac/2023/20231205/20231205-pjm-teac-board-whitepaper-december-2023.ashx>

<sup>14</sup> Kirby, Jess. “Lansdowne residents oppose Route 7 transmission line proposal.” Loudoun Times Mirror. Oct. 5, 2023. [https://www.loudountimes.com/news/lansdowne-residents-oppose-route-7-transmission-line-proposal/article\\_46190288-639f-11ee-9908-7722c63f7ffd.html](https://www.loudountimes.com/news/lansdowne-residents-oppose-route-7-transmission-line-proposal/article_46190288-639f-11ee-9908-7722c63f7ffd.html)

construction and performance standards for data centers and attached Special Exceptions (SPEX) to data centers being built on Research and Development Park or Office Park land.

- 2023: Dec: PJM announces acceptance of a NextEra proposal to build a new 500Kv transmission line through western Loudoun County.<sup>15</sup> Public resistance is significant.
- 2024: Mar: The Loudoun County Board of Supervisors denies the construction of a 4.9 million sq. ft./600 Mw data center next to a residential neighborhood but approves the application when the applicant reduces its size to 1.3 million sq. ft., the “by right” permitted size, and retains the environmental proffers from the larger application.

It’s important to note here the strategy initiated in 2008 by the Loudoun County Economic Development Department had the full support of the Loudoun County Board of Supervisors and proved to be enormously successful.

- There has not been a single day in the past 14 years when a data center was not under some type of initial construction or expansion in Loudoun County.
- Loudoun County now has 181 data centers, more than any other community on Earth.<sup>16</sup>
- Loudoun County’s data center market is greater than the next six U.S. markets combined.<sup>17</sup>
- In 2021, “Data Center Alley” in Loudoun County, VA hosted 70% of the world’s internet traffic (current estimates now place that figure at 65%).<sup>18</sup>

And the reasons why the Loudoun County BOS fully supported this program are easy to discern:

- Enormous tax revenue: In FY2025, Loudoun County estimates about \$895M in data center real and personal property tax revenue. The county’s entire operating budget is projected to be \$940M.<sup>19</sup>
- As a result of data center tax revenue, Loudoun County has the lowest real property tax rate in NOVA; about 25% lower than our neighbors.<sup>20</sup>
- A data center costs the county \$0.04 per \$1 of tax revenue received, whereas normal businesses cost about \$0.25 per \$1 of revenue.<sup>21</sup>
- Data centers put very few cars on the road.

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<sup>15</sup> Kirby, Jess. “PJM advances proposal for transmission line in western Loudoun.” Loudoun Times Mirror. Dec. 13, 2023. [https://www.loudountimes.com/0local-or-not/1local/pjm-advances-proposal-for-transmission-line-in-western-loudoun/article\\_c0202122-99e3-11ee-9896-b71271fc88fc.html](https://www.loudountimes.com/0local-or-not/1local/pjm-advances-proposal-for-transmission-line-in-western-loudoun/article_c0202122-99e3-11ee-9896-b71271fc88fc.html)

<sup>16</sup> Zhang, Mary. “United States Data Centers: Top 10 Locations in the USA.” Dgtl Infra. April 11, 2024. <https://dgtlinfra.com/united-states-data-centers/>

<sup>17</sup> Vogelsong, Sarah. “Virginia Has the Biggest Data Center Market in the World. Can It Also Decarbonize Its Grid?” Inside Climate News. May 24, 2024. <https://insideclimatenews.org/news/24052024/virginia-data-center-market-electricity-demand/>

<sup>18</sup> Woolridge, Ginger. “How Ashburn, VA became the Colocation Mecca known as Data Center Alley.” Lightyear. Nov. 12, 2021. <https://lightyear.ai/blogs/ashburn-colocation-data-center-alley>

<sup>19</sup> Loudoun County FY2025 Appropriations Resolution; Commissioner of Revenue. Available on request.

<sup>20</sup> “City of Alexandria Revenues.” City of Alexandria. 2024. Pg. 7-19 table.

<https://www.alexandriava.gov/sites/default/files/2023-02/Section%2007%20Revenues%20FY24.pdf>

<sup>21</sup> Northern Virginia Technology Council. “The Impact of Data Centers on Virginia’s State and Local Economies 5th Biennial Report.” April, 2024. Pg. 7. <https://info.nvtc.org/acton/attachment/45522/f-1c3915e6-b8b1-4914-818e-9fae14877a3d/1/-/-/-/2024%20NVTc%20Data%20Center%20Report.pdf>

- Data centers put very few kids in schools.

Thus, with the full and enthusiastic support of the Board of Supervisors and the visionary foresight of the Loudoun County Department of Economic Development, Loudoun County capitalized on its unique geography (Washington, D.C. and Dulles Airport), its role as a high-tech digital incubator and home of the internet, and its extensive fiber-optic infrastructure touting the lowest latency rates in the industry to become ground zero for historic digital development. Until 2022, though Dominion and the Department of Economic Development had cautioned for years infrastructure would have to be built to accommodate the rapid increase in demand for power, the future looked relatively unconstrained.

Then, in 2022, PJM informed Dominion Energy that Dominion’s infrastructure predictions were significantly underestimating the growing power needs of Loudoun County’s data center sector. In response, Dominion Energy established what is now known as the “constrained area” in Loudoun County and informed the data center sector they would have significant power constraints until 2027 when new transmission lines could be built. This marked the start of a sobering new reality in Loudoun County: the rapid growth of three competing forces affecting the data center community and the larger Loudoun County community.

### **Three Accelerating, Co-Dependent, Conflicting Trends**

There is no question three co-dependent, conflicting trends are going to dominate the Loudoun County data center landscape for the foreseeable future: 1) Rapidly increasing demand for data 2) Rapidly increasing demand for power to process that data 3) Rapidly increasing local community resistance to changes in quality of life, changes to neighborhoods, and the proliferation of overhead transmission lines.

**Increasing Demand for Data.** As shown below, the years between 2016-2024 have seen staggering data center growth in Loudoun County:<sup>22</sup>

- In 2016, 8.8 million sq. ft. of permitted data center floor space
- In 2017, 10.1 million sq. ft. (14.7% increase)
- In 2018, 13.1 million sq. ft. (29.7% increase)
- In 2019, 18.3 million sq. ft. (39.7% increase)
- In 2020, 21.5 million sq. ft. (17.5% increase)
- In 2021, 26.4 million sq. ft. (22.8% increase)
- In 2022, 28.1 million sq. ft. (6.4% increase)
- In 2023, 31.9 million sq. ft. (13.5% increase)
- In 2024, 41.2 million sq. ft. (29.2% increase; 8 mil. sq. ft. permitted but not yet built)

This steady increase in data center square footage is the result of the growth of our society’s dependence on social media, “smart” device technology, personal computing and communication, and a host of other data-dependent advancements our society has come to depend on. And now, Artificial Intelligence (AI) is expected to increase the demand for data exponentially again. A January 2024 article by a major data center realty company suggests

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<sup>22</sup> Data provided by the Loudoun County Commissioner of the Revenue, May 31, 2024.



consumers and businesses will generate twice as much data in the next five years as was generated in the previous ten.<sup>23</sup> That’s a statement with staggering implications. The article provides a stark prediction of the speed and magnitude of growth in the data center sector and also illustrates convergence of the three conflicting growth trends:

“With the growing demands of AI, data center storage capacity is expected to grow from 10.1 zettabytes (ZB) in 2023 to 21.0 ZB in 2027, for a five-year compound annual growth rate of 18.5%[1]. Not only will this increased storage generate a need for more data centers, but generative AI’s greater energy requirements – ranging from 300 to 500+ megawatts – will also require more energy efficient designs and locations. The need for more power will require data center operators to increase efficiency and work with local governments to find sustainable energy sources to support data center needs.”<sup>24</sup>

### **Increasing Demand for Power**

Global growth in data center power demand in Virginia is increasing at a rate far exceeding Dominion Energy’s capacity to provide it. A January 2024 Data Center Dynamics article projected data center power consumption will double by 2030.<sup>25</sup> This trend is magnified in Loudoun County because of our unique data center load. In a May 2, 2024 article, Bloomberg reports that Northern Virginia data center developers are now asking Dominion Energy for the energy equivalent of several nuclear reactors’ output. In a recent quarterly earnings call, Dominion Energy’s CEO Bob Blue stated that Dominion Energy is now receiving requests from data center campus developers for “several gigawatts” of power.<sup>26</sup> This is a staggering increase in data center power demand in just a few years. Below is a summarized timeline of actual power usage in Loudoun County since 2018, the year we first reached approximately 1 Gw (1,000 Mw; a megawatt is one million watts) of power consumption in “Data Center Alley.”<sup>27</sup>

- 2018: 1 Gw (chart interpolation)
- 2019: 1.5 Gw (chart interpolation)
- 2020: 1.6 Gw (chart interpolation)

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<sup>23</sup> Steele, Kimberly. “Growth of AI creates unprecedented demand for global data centers.” Jones Lang LaSalle IP, Inc. January 31, 2024. <https://www.us.jll.com/en/newsroom/growth-of-ai-creates-unprecedented-demand-for-global-data-centers>

<sup>24</sup> Ibid.

<sup>25</sup> Gooding, Mathew. “Newmark: US Power Consumption to Double by 2030.” Data Center Dynamics. January 15, 2024. <https://www.datacenterdynamics.com/en/news/us-data-center-power-consumption/#:~:text=While%20the%20hyperscalers%20typically%20need,up%20from%2017GW%20in%202022.>

<sup>26</sup> Saul, Josh. “Data Centers Now Need a Reactor’s Worth of Power, Dominion Says.” Bloomberg. May 2, 2024. [https://www.bloomberg.com/news/articles/2024-05-02/data-centers-now-need-a-reactor-s-worth-of-power-dominion-says?utm\\_source=website&utm\\_medium=share&utm\\_campaign=email](https://www.bloomberg.com/news/articles/2024-05-02/data-centers-now-need-a-reactor-s-worth-of-power-dominion-says?utm_source=website&utm_medium=share&utm_campaign=email)

<sup>27</sup> Abdulsalam, Sami. “Dominion Northern Virginia Area Immediate Need.” Slide #2, “Data Center Alley Area Load Growth and Transmission System.” Slide #3, “Dominion 2022 Load Forecast.” Data interpolated from data center load forecast line (orange). PJM. July 12, 2022. <https://www.pjm.com/-/media/committees-groups/committees/teac/2022/20220712/item-08---dominion-northern-virginia---immediate-need.ashx>

- 2021: 2.0 Gw (chart interpolation)
- 2022: 2.8 Gw (actual)<sup>28</sup>
- 2023: 3.4 Gw (forecast)<sup>29</sup>(This is a 240% increase, or 3.4X increase, in five years.)
- 2028: 8.3 Gw (projected summer peak load of 83 power substations built, permitted or planned in Loudoun County)<sup>30</sup>

If we assume a linear growth rate over the next five years similar to the previous five years, Loudoun County will require 11.56 Gw of power by 2028. But Artificial Intelligence (AI) is raising power demand much faster than a simple linear rate. As the use of AI grows, the need for more computing power within existing data centers means the demand for power within those walls is going to increase commensurately. According to an article in Data Center Dynamics, the average data rack power usage in a typical hyperscale data center today is 10-14 Kw. Because of their much higher reliance on Graphics Processing Units (GPUs) within the data rack, AI applications are going to increase that data rack power consumption to 40-60 Kw.<sup>24</sup> That's as much as a sixfold increase in the power requirement for an existing data center. This means that, using a base year of 2023 and 3.4 Gw of power consumption, by 2028, Loudoun County could easily require as much as 20 Gw of power due to AI demands. Put more bluntly, we could stop building data centers today, and that would not stop a significant increase in data center demand for more power in the near to mid-term.

A disturbing, unintended consequence of this growth has also emerged. A recent New York Times article addressed an industry trend to slow or shelve plans to decommission legacy fossil fuel power plants in an effort to meet demand. According to this article, by 2030, power demands by the nation's data centers could triple.<sup>31</sup> A February 2023 report by PJM shows the RTO planning to retire about 40 Gw of old power plants by 2030 while expecting about 11 Gw of new orders by that same date.<sup>32</sup> Obviously much higher demands for power could significantly affect this projection. These trends have very serious implications for our efforts to meet our

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<sup>28</sup> Dominion Energy. "Dominion Energy 2023 15-Year Data Center Plan." Slide #2. <https://sdc.pjm.com/-/media/committees-groups/subcommittees/las/2023/20231018/20231018-item-03a---dominion-large-load-request.ashx>

<sup>29</sup> Ibid.

<sup>30</sup> Mai, Rachael. Matrix compiled from multiple, monthly PJM reports cataloguing 83 Loudoun County substations (existing, permitted or planned) and their projected summer peak loads in 2028. May 1, 2024.

<sup>31</sup> Plumer, Brad and Popovich, Nadja. "A New Surge in Power Use is Threatening U.S. Climate Goals." The New York Times. March 14, 2024. <https://www.nytimes.com/interactive/2024/03/13/climate/electric-power-climate-change.html>

<sup>32</sup> PJM. "Energy Transition in PJM: Resource Retirements, Replacements & Risks." PJM. February 24, 2023. <https://www.pjm.com/-/media/library/reports-notice/special-reports/2023/energy-transition-in-pjm-resource-retirements-replacements-and-risks.ashx>

climate change goals. In 2023, global temperatures increased 1.3 degrees centigrade.<sup>33</sup> Six global tipping points will be reached at a 1.5-degree rise.<sup>34</sup>

It is fair here to note the data center community is pursuing very aggressive sustainability goals, goals that are far more aggressive than many other business enterprises. Unfortunately, by relying on power provided exclusively by the utility companies, their lofty sustainability goals are going to be negatively impacted if the utility companies continue this trend of postponing or even reversing the decommissioning of fossil-fuel power plants.

Recognizing this rapid growth in demand, in the summer of 2022 PJM advised Dominion Energy it would need to significantly increase its transmission infrastructure to handle the projected load in Loudoun County and to specifically address the urgent power constraints in “Data Center Alley.” First, they needed to get power from the existing Loudoun north/south main transmission line to “Data Center Alley” to relieve the constraint. Then, they needed to bring additional power into Loudoun County from the north and south and connect it to the main north/south line to address the rapid growth in aggregate Loudoun County power demand.

To tackle the first and more urgent challenge, Dominion announced it would build a closed loop connecting the north/south main transmission lines to “Data Center Alley” in eastern Loudoun. Dominion is now planning a new 500/230 Kv line from the Wishing Star to Mars substations in the southern part of the county and a 500/230 Kv line between the Aspen and Golden substations in the northern part of the county. The loop will be completed with the addition of a third 500/230 Kv line connecting the Golden substation in the northern portion of the loop to the Mars substation in the southern part of the loop. Again, these three lines don’t add new power from outside the county, and they won’t be built until 2027 at the earliest. They do not, by themselves, address the enormous future increase in demand projections expected for all of Loudoun County as a result of our high concentration of data centers.

To address this future demand and bring more power into the county, in December 2023 PJM accepted a proposal from NextEra, a Florida-based power company, to run a new 500 Kv line from an existing east/west line in West Virginia south through the heartland of western Loudoun County agriculture to connect to the north/south main transmission line. Dominion is also planning to run a new 500 Kv line from the south to connect to the main Loudoun County line. These two new lines will increase the aggregate size of the Loudoun power grid.

The table below provides an inventory of the main transmission lines of the current Loudoun grid and then adds the two new lines to the mix. To understand the table, one must understand how much power each type of line can deliver. As a rough planning factor, depending on

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<sup>33</sup> Harvey, Chelsea; Weiss, Zia and E&E News. “The State of the Planet in 10 Numbers.” Scientific American. November 20, 2023. <https://www.scientificamerican.com/article/the-state-of-the-planet-in-10-numbers/>

<sup>34</sup> Singh, Inayat. “At current rates, 5 key climate tipping points are already possible, new study warns.” CBC. Sept. 11, 2022. “Climate Tipping Elements” graphic. <https://www.cbc.ca/news/science/tipping-point-climate-change-paris-agreement-1.6577630>

distance, a 500 Kv line can deliver between 1.0-1.5 Gw of power and a 230 Kv line can deliver about 500 Mw of power.<sup>35</sup>

#### Current Lines Bringing Power Into Loudoun County:

- From the north: (1) 500 Kv line = 1.5 Gw; (2) 230 Kv lines = 1 Gw
- From the south: (2) 500 Kv lines = 3.0 Gw; (2) 230 Kv lines = 1.0 Gw
- Total currently coming into Loudoun = **6.5 Gw**, but not to “Data Center Alley”
- Aspen/Golden (north), Wishing Star/Mars (south), Golden/Mars line = closed loop to “Data Center Alley” but adds no new power

#### Planned new lines by 2027 (earliest)

- From the north, new Mid Atlantic Resiliency Link (MARL): (1) 500 Kv line = 1.5 Gw; new 500 Kv line in the Doubs-Aspen corridor: (1) Kv line = 1.5 Gw
- From the south, new Morrisville-Wishing Star line: (1) 500 Kv line = 1.5 Gw
- Total planned by 2027: **11 Gw** (existing 6.5 Gw + 4.5 Gw new lines)

Yet as we saw earlier, with the advent of AI, Loudoun could easily see its power demand rise to as much as 20 Gw by 2028, far more than will be available through the above buildout schedule. While Dominion and PJM will likely assert this demand can be met by more infrastructure construction, I believe the data indicates these new transmission lines will not keep pace with the rapid increase in future demand in Loudoun County.

Nor have we addressed the 30 million sq. ft. of data centers recently approved in Prince William County immediately adjacent to Loudoun County’s southern border. If we assume a 1 million sq. ft. data center will request from Dominion about 1 Gw of power, the Prince William County campus will require about 30.0 Gw of power. And the lines delivering this added power will almost certainly come through Loudoun County.

### **Increasing Community Resistance**

Prior to 2022, the proliferation of data centers in Loudoun County was largely confined to land parcels intended for data center construction, and they were largely accepted by our citizens. The BOS received occasional complaints about the loss of green space, the visual impact of massive data center buildings, the noise these facilities made both with cooling fans and backup diesel generators, and the environmental impact associated with extremely large power consumption, but this pushback was largely generalized. Our citizens also understood and accepted that Loudoun County data centers kept our real property tax rates about 25% lower than our Northern Virginia neighboring jurisdictions.

But in 2022, the Board of Supervisors began sensing real community resistance to more data centers in Loudoun County. At about that time, data center companies had started running out

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<sup>35</sup> Power Engineers. “500 kV AC/DC Extra-High Voltage Transmission Project.” Power Engineers. 2024. <https://www.powereng.com/library/500-kv-acdc-extra-high-voltage-transmission-project>

of industrial land to build on and had begun to exercise their “by right” options to build on parcels they had bought years earlier zoned for office parks, research and development parks and industrial parks, many of which are located near residential neighborhoods. This began to create real tensions between communities, Supervisors and the data center sector. For example, in 2019, there were no data centers in Ashburn District (the community of Ashburn actually encompasses two districts: Ashburn and Broad Run). As of this date, four hyperscale data centers are being constructed in the Ashburn district, all “by right” and all across the street from residential communities.

Community resistance increased dramatically when in 2023, Dominion Energy announced it would need to construct four new overhead transmission lines to relieve the power constraints in the county and specifically in “Data Center Alley.” The previously mentioned Aspen/Golden line would run along Rte. 7, a heretofore unthinkable routing Loudoun County Boards for the previous 25 years had sworn would never happen. Earlier in 2023, Dominion Energy had announced the Wishing Star/Mars line in southern Loudoun, but that line would run through a flood plain away from houses and drew little community response. Then a new line would connect the new Golden substation in the north to the new Mars substation in the south to close the loop to “Data Center Alley.” Finally, a fourth line, a so-called “green field” transmission line—the previously mentioned MARL line—would run through western Loudoun County between the Potomac and Leesburg cutting across active farmlands, wetlands, tree conservation areas and through the historic village of Waterford. The public outcry was both immediate and predictable.

Thus, between 2022-2024, community resistance to more data centers, more overhead transmission lines, more substations and more consumption of fossil fuel energy reached unprecedented levels and began to have a major impact on BOS decision-making. As discussed earlier, in March of 2024, for the first time, the BOS voted 5-4 to deny a major data center application to build a 2.9 million sq. ft. data center. The applicant resubmitted the application scaled down to 1.3 million sq. ft., the “by right” permitted size, and, to their credit, retained a substantial environmental package in the application. That scaled down application passed by a vote of 6-3. But that application marked the first time a major, new data center application was denied by the BOS.

The “by right” growth of data center construction since 2022 in Loudoun County has proven to be particularly problematic for the BOS. As a result, in late 2023, the BOS took steps to require BOS review of some of these types of parcels and will likely require oversight of all data center construction in the near future. But since 2022, “by right” construction has proliferated as land specifically intended for data centers became scarce.

To be clear, no one is to blame for this confluence of these three conflicting trends. The speed with which the entire data center environment has evolved is staggering, and each of the stakeholders has, heretofore and understandably, responded to that change largely within their respective silos and process paradigms.

**BOS Focus.** From the BOS point of view, prior Loudoun County Boards and the Department of Economic Development saw an opportunity to get in on the ground floor of revolutionary technology likely to bring enormous economic growth to our community. It would enable us for

almost 20 years to lower taxes even though our population growth was the highest in Virginia for that entire period.

**Data Center Focus.** Similarly, the data center community was and is simply responding to revolutionary changes in the market and historic demand for data.

**Utility Focus.** And that demand for data has translated into an insatiable demand for power. The energy utilities are required by law to provide sufficient power to their customers even if demand for that power is increasing at an unprecedented rate. Asked at public meetings, including Board of Supervisors meetings, if they will be able to meet growing demand, they always assure their audiences they will—because the law requires them to.

### **Facing the New Realities**

However we got here, we're here now. Going forward, it is incumbent upon all stakeholders—the data center community, Dominion Energy/PJM and the Board of Supervisors—to develop a strategy based on the new realities we face, a strategy that protects the quality of life of every Loudoun County citizen and reflects the tough choices we are clearly going to have to make. Based on the facts thus far presented, I believe the following are some obvious new realities we, as a Board, must address:

1. **In the author's opinion, the Loudoun County electrical grid is now significantly oversubscribed, and planned new powerline construction will likely lag rapidly increasing power demand for years to come.**

Adding new data centers that rely on overhead transmission lines to an already oversubscribed grid simply makes no sense.

2. **Halting new data center construction will not solve the problem.**

Even if all new data center construction is halted immediately, the oversubscription of the power grid in Loudoun County will continue as our dependence on AI—requiring up to a sixfold increase in processing power within existing data centers—proliferates throughout the world.

3. **“Data Center Alley” rapidly rising power demand will slow the retirement of fossil fuel power plants throughout the PJM/Dominion service area.**

This is the only way PJM/Dominion can meet the increasing demand. The majority of power being delivered to Loudoun County data centers is derived from fossil fuels, and this percentage will likely increase to meet demand. This could be slowed somewhat if PJM/Dominion accelerate their conversion to carbon-net-zero fuels in response to aggressive data center programs demanding the utilities do just that, but the net result of these competing trends is difficult to predict.

4. **Community resistance is going to rapidly increase.**

Thus far proposed are the Wishing Star/Mars line in the south, the new MARL line in the west, a new line from Doubs-Aspen, the new Aspen/Golden line proposed along Rte. 7 in the north, and the new line from Golden-Mars through “Data Center Alley.” But they won't be

enough. A second line down Rte. 7 is probably next up. After that, Dominion will have likely used the last available routing to “Data Center Alley” that won’t require using eminent domain. The next available routes along the W+OD Trail or the Dulles Greenway will require the use of eminent domain to obtain the necessary right of way. Community resistance will build accordingly. If incumbent elected officials are then voted out of office, they will be replaced by other elected officials with a mandate to vehemently oppose the data center and utility sectors.

5. **Burying 500 Kv transmission lines delivering AC power is possible but challenging and expensive; burying 500 Kv High Voltage DC (HVDC) lines is much easier and more efficient, however HVDC lines are most appropriate for very long distances.**

Undergrounding a 500 Kv AC line has only been done once in the U.S. In 2013, an underground 500 Kv line was constructed traversing 3.7 miles through Chino Hills, CA. The project took three years and cost \$224 million (not including the seven years of court battles).<sup>36</sup> Underground lines transmitting AC power must be insulated, usually with oil, and buried in a concrete tunnel, require much higher power transmission to deliver the same energy due to energy losses underground, are much harder and take longer to repair, and are not practical over long distances.<sup>37</sup> Undergrounding HVDC is now a viable alternative, loses very little power when buried, is used in many locations around the world and accepts renewable energy additions to the grid more easily.<sup>42</sup> However, HVDC generally only makes sense for transmission over very long distances and may have limited applicability in Loudoun County.

6. **Solar and wind are not viable alternatives for Loudoun County data centers.**

- a. **Solar.** The average solar panel is about 23% efficient in converting the sun’s energy into electricity.<sup>38</sup> It requires about 10 acres of land to generate 1 Mw of power.<sup>39</sup> Loudoun County has 181 data centers using about 3.4 Gw of power in 2023. That would require 34,000 acres of solar panels. If power demand in Loudoun County for the next five years grows at the same rate as the previous five years (this does not account for AI growth), the county will be using 11.56 Gw of power in 2029. That would require 115,600 acres of solar panels. The entire landmass of Loudoun County is about 333,000 acres.

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<sup>36</sup> Nisperos, Neil. “Edison about to flip the switch on controversial power line project through Chino Hills.” Daily Bulletin. October 30, 2016. <https://www.dailybulletin.com/2016/10/30/edison-about-to-flip-the-switch-on-controversial-power-line-project-through-chino-hills/>

<sup>37</sup> XcelEnergy. “Overhead vs. undergrounding. Information about burying high-voltage transmission lines.” XcelEnergy Information Sheet. 2021. <https://www.transmission.xcelenergy.com/staticfiles/microsites/Transmission/Files/PDF/Projects/CO/Avery/Transmission-CO-Avery-Substation-Overhead-Vs-Underground-Info-Sheet.pdf>

<sup>38</sup> Solar.com. “Solar Panel Efficiency - Pick the Most Efficient Solar Panels.” 2024. <https://www.solar.com/learn/solar-panel-efficiency/>

<sup>39</sup> Arthur, Luke. “Understanding Solar Farms.” Simple Solar. May 3, 2024. [https://getsimplesolar.com/how-many-acres-solar-panels-produce-1-megawatt/#:~:text=To%20make%20one%20megawatt%20\(MW,they%27re%20supposed%20to%20make.](https://getsimplesolar.com/how-many-acres-solar-panels-produce-1-megawatt/#:~:text=To%20make%20one%20megawatt%20(MW,they%27re%20supposed%20to%20make.)

- b. **Wind.** As an illustrative, Vineyard Wind, a 62-turbine wind farm being built off the coast of Martha's Vineyard, will generate 806 Mw of electricity when complete.<sup>40</sup> At completion, this offshore wind farm will generate enough power to power 400,000 homes in the local area. It would meet the power needs of about 10 of Loudoun County's 181 data centers.

**7. The 135-yr. old paradigm of power generated by large, remote power plants and transmitted across hundreds of miles of transmission lines will no longer work for Loudoun County's globally unique needs.**

Given the above power demand projections and the time it takes to build new power infrastructure, it seems highly unlikely our traditional approach of delivering power to a consumer market as large and growing as Loudoun County can safely and effectively serve our needs.

### **Strategies for the Future**

Clearly there is no "silver bullet" to meet these complex challenges, especially in Loudoun County. Any approach will require the thoughtful integration of a range of options to meet the growing demand for more power from the data center sector in ways that do not drastically and negatively impact the quality of life of our residents. Obviously whatever strategies are developed will be policy decisions for the Board of Supervisors to make by a majority vote.

Offered below are some suggested options by the author and as such are entirely subjective and debatable. They will likely generate considerable discussion, hopefully based upon the factual foundation thus far provided. It seems clear however that, over the next ten years, the Board of Supervisors will likely be faced with a repeating binary choice: 1) Accept the traditional paradigm of AC power generated at massive, remote power plants, transmitted over hundreds of miles of overhead transmission lines, then delivered to customers, including Loudoun's data centers with their historic demand for power. The likely result will be a significant threat to Loudoun County's power grid resiliency and a lattice of overhead transmission lines throughout Loudoun County. Or, 2) Reject that 135-yr. old power infrastructure paradigm and begin creating a radically new power delivery model and market environment whereby large power consumers generate the amount of carbon-net-zero power they need onsite and deliver surplus power onto the regional power grid. This is precisely the model the Department of Defense (DoD) has adopted. In a recent update to Title 10, DoD has directed all Services to make select military bases and critical installations energy independent and resilient through the use of onsite, sustainable energy generation, including long-term energy storage and nuclear and hydrogen power generation. This program is now being implemented worldwide.<sup>41</sup>

Here, then, are some possible strategies for consideration:

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<sup>40</sup> Vineyard Wind. "Avangrid, CIP Announce First Power from Nation-Leading Vineyard Wind 1 Project." Vineyard Wind. January 3, 2024. <https://www.vineyardwind.com/press-releases/2024/1/3/cip-avangrid-announce-first-power-from-nation-leading-vineyard-wind-1-project>

<sup>41</sup> TITLE 10 / Subtitle A / PART IV / CHAPTER 173 / SUBCHAPTER I / § 2911. May 31, 2024. [https://uscode.house.gov/view.xhtml?req=\(title:10%20section:2911\(b\)%20edition:prelim\)](https://uscode.house.gov/view.xhtml?req=(title:10%20section:2911(b)%20edition:prelim))



## 1. PJM/Dominion Energy: Increase Transmission Capacity in the Near Term.

### a. Reconductoring.

Reconductoring using advanced conductors for existing and new overhead transmission lines can double the capacity of those lines fairly quickly. Many lines in Europe have already been reconducted, but U.S. power companies are reluctant to follow suit because the technology is new and there are currently regulatory challenges. Given increasing demand, especially in Loudoun County, PJM and Dominion may have no choice. Reconductoring, whereby steel-core lines are replaced with carbon composite cores surrounded by integrated tetrahedral aluminum conductors would boost transmission capacity significantly (possibly double) and slow the proliferation of new transmission lines in Loudoun County. This increased capacity would eventually be overtaken once again by rising demand, but, if combined with other measures, could be a valuable tool in building a new energy transmission paradigm.<sup>42</sup>

### b. Create a High Voltage Direct Current (HVDC) Parallel Loudoun Power Grid

Data centers are beginning to look seriously at converting their entire internal operation to DC power, and it is likely several in Loudoun County already have.<sup>43</sup> This has several advantages, including 1) DC power is less complex than AC power, 2) it requires less equipment space, 3) it offers better, more reliable power quality, 4) it offers modular, scalable operations, 5) and it can be easily integrated with other power sources.

At the same time, the National Renewable Energy Laboratory (NREL), a Department of Energy laboratory, is exploring the expanded use of HVDC transmission lines in more multiple connection environments.<sup>44</sup> Recent technological advances now make the use of HVDC transmission lines a real alternative to the present AC-power dependent U.S. power grid. HVDC transmission lines are currently used in many countries. An HVDC transmission line is far more efficient in transmitting high-voltage power across long distances, experiences much less power loss through transmission, can be buried underground much more easily and with little loss of power, and is much better suited to allowing a grid to accept power from renewable and onsite sources.<sup>45</sup>

What if PJM, Dominion Energy, the Commonwealth of Virginia and Loudoun County collaboratively proposed to DoE and NREL the creation of national pilot project to create a separate HVDC power grid in Loudoun County specifically to deliver HVDC power directly to Loudoun County data centers, the highest concentration of data

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<sup>42</sup> Plumer, Brad. "The U.S. Urgently Needs a Bigger Grid. Here's a Fast Solution." The New York Times. April 9, 2024. <https://www.nytimes.com/2024/04/09/climate/electric-grid-more-power.html>

<sup>43</sup> Howard. "Direct Current (DC) Power: Is It the New Normal for Data Centers?" FS. June 1, 2022. <https://community.fs.com/article/direct-current-dc-power-is-it-the-new-normal-for-data-centers.html>

<sup>44</sup> NREL. "On the Road to Increased Transmission: High-Voltage Direct Current." NREL.gov. June 12, 2024. <https://www.nrel.gov/news/program/2024/on-the-road-to-increased-transmission-high-voltage-direct-current.html>

<sup>45</sup> Berthou, Andreas. "The Benefits of High-Voltage Direct Current (HVDC) Power." EE Power. October 19, 2020. <https://eepower.com/technical-articles/the-difference-that-dc-makes/#>

centers in the world? DoE could provide funding (likely several billion dollars) to build the six new lines already being planned for Loudoun County as advanced conductor, HVDC lines. Meanwhile, data centers could begin planning to fully convert to internal DC power by 2027, the projected completion data for the new lines. At completion of the pilot project, Loudoun County would have two separate power grids, an AC grid for residences and normal-sized commercial customers, and a DC grid exclusively for data centers.

This is obviously theoretical, but if PJM and Dominion have to build these lines anyway, why not make the project a national pilot project and incorporate state-of-the-art technology throughout the pilot project? This would include using all advanced conductors to double line capacity and using largely buried HVDC transmission lines to distribute DC electricity directly to data centers.

The advantages of this admittedly bold concept would be significant:

- 1) The existing AC power grid in Loudoun County would immediately stabilize as data centers were moved off that grid;
- 2) A large infusion of DoE funding would relieve PJM and Dominion Energy of the burden of financing the currently planned infrastructure upgrades, a burden existing residential and commercial customers will undoubtedly have to bear;
- 3) Two separate grids would facilitate two separate billing systems for Dominion Energy, thereby relieving residential/small commercial customers from having to help pay the added infrastructure costs associated with the growing power consumption by the data centers;
- 4) A significant portion of the new HVDC power grid could be buried near sensitive areas;
- 5) The new HVDC grid would be much more adaptable to the incorporation of onsite data center microgrids with multiple DC power sources such as natural gas, battery backup, hydrogen fuel cells and small, modular reactors;

## 2. **Loudoun County: Promote or Require Data Centers to Use Onsite, Carbon-Net-Zero Power Production Through Microgrids.**

Again, in the author's opinion, it seems quite likely the existing power grid in Loudoun County will remain insufficient to adequately power our high concentration of data centers for the foreseeable future.

Given this likely reality, the only near-term way forward appears to be increased transmission capacity combined with onsite power production through the use of microgrids. As stated earlier, Loudoun County's highly dense data center environment is unique in the data center world today. This means we are literally on the frontier of a new digital age. We are now faced with a simple binary choice: lead, through innovation and imagination, or wait and react too little, too late to a rapidly expanding traditional power grid

infrastructure inappropriate for Loudoun County's needs and unable to solve our unique demand challenges.

### **What is a Microgrid?**

A microgrid consists of a load (entity requiring power) and multiple energy sources (delivering that power) all connected to each other and the power grid but capable of operating independently in "island" mode.<sup>46</sup> One example of microgrids in Loudoun County are data centers operating on diesel generator backup. However, our future goal should be to require or incentivize our data center community to develop a new type of microgrid such that interconnected onsite power sources are as close to carbon-net-zero as possible and designed to act not solely as backup power but as a continuing source of independent power for the data center.

In researching this paper, I encountered a common theme among many I talked to when I raised the issue of onsite power production. Many believe autonomous, onsite power production is still purely theoretical and that practical demonstrations of this technology are years away. I was one of those people. What I have learned, however, is that there are several working installations delivering onsite power with the potential to provide the Loudoun County data center sector a viable way forward.

Below are several examples of onsite power delivery methods that exist today:

**Battery Energy Storage Systems (BESS).**<sup>47</sup> A battery energy storage system captures energy from various sources and stores it for later use. These are most often used to capture renewable energy produced, for example from solar or wind installations, but they can be used to store energy from any source. They are typically used as backup power to augment a continuous power supply.

**Natural/Renewable/Mobile Gas.**<sup>48, 49</sup> Gas power generation is not carbon-net-zero and, if delivered through utility gas pipelines, is a fossil fuel derived energy source. Renewable natural gas (RNG) is waste gas produced by organic waste, captured, and delivered to the microgrid. Mobile, liquified gas can be renewable natural gas or any form of natural gas liquified and delivered to the microgrid by truck. While gas is not entirely carbon-net-zero, it is orders of magnitude cleaner burning than diesel fuel. For this reason, gas microgrids could play a major role in replacing Loudoun County's approximately 4,000 diesel backup generators as a near term interim step towards carbon-net-zero microgrids. Moreover, a gas microgrid design could relatively easily accommodate a conversion to an onsite nuclear power source within the microgrid when such power sources become available.

**Hydrogen Fuel Cells.**<sup>50</sup> Hydrogen is present in abundance throughout nature, but it is rarely available in a free form. Instead, it is usually part of the chemical makeup of other energy

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<sup>46</sup> NREL. "Microgrids." <https://www.nrel.gov/grid/microgrids.html>

<sup>47</sup> ABB. "What Are Battery Energy Storage Systems?" <https://electrification.us.abb.com/battery-energy-storage-systems-bess-basics>

<sup>48</sup> <https://enchantedrock.com/the-advantages-over-diesel/>

<sup>49</sup> <https://www.sapphiregasolutions.com/renewable-natural-gas/>

<sup>50</sup> <https://www.energy.gov/eere/fuelcells/hydrogen-and-fuel-cell-technology-basics>

sources such as oil, gas, biomass or even water. Through various processes, these compounds can become the source of clean-burning hydrogen. If fossil fuels are used as the source, the hydrogen is electro-chemically converted to heat and water cleanly, but the energy source is not sustainable. If water is used as the hydrogen source, it can be electro-chemically converted using energy from solar or wind sources, and the heat produced is both sustainable and carbon-net-zero. One company I spoke with has produced 188 working hydrogen fuel cells and has set a goal to produce 100 Mw by the end of 2024. These cells produce about 2.5 Mw per cell and can be arrayed as needed to produce sufficient onsite energy.<sup>51</sup>

**Micro/Small Modular Reactors.** A micro nuclear reactor is a small nuclear reactor capable of producing up to 20 Mw of electricity independently. A Small Modular Reactor (SMR) is similar but is capable of producing 20-300 Mw of electricity.<sup>52</sup> These reactors can be cooled by light water, the existing technology, or by gas, liquid metal or molten salt.<sup>53</sup> One such reactor, called a sodium-cooled fast reactor, is eight years into the 10-yr. Nuclear Regulatory Commission licensing process, can run on waste uranium, is self-stabilizing and self-controlling (shuts itself down if cooling is removed), and has just been provisionally selected by DoD to provide an independent, carbon-net-zero power microgrid to Eielson AFB, AK.<sup>54</sup> Several of these reactors are expected to be operational in 2024/2025.<sup>49</sup>

### **Strategy Implementation: Creating a New Paradigm for Loudoun County**

To create a policy strategy for the future, the Board of Supervisors should first identify the characteristics of an ideal data center best suited for Loudoun County. Then, through a combined Comprehensive Plan Amendment/Zoning Ordinance Amendment, the BOS should establish the legal and policy tools to create a supportive regulatory and incentivized business environment encouraging a transformational sector change. If successful, we could become a world pioneer ushering in a new age of data center design supported by a transformed national power grid. At the same time, we would could create a thriving new green business market here in Loudoun County.

The following is a proposed list of desired attributes for a new generation of Loudoun County data centers:

- 1. Microgrid onsite power production**
- 2. Carbon net-zero power (backup or prime)**
- 3. Leadership in Energy and Environmental Design (LEED) Gold Certified or above buildings**
- 4. Power Usage Efficiency (or an industry-standard alternative metric) of 1.15 or less**

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<sup>51</sup> Inci, Mustafa. "Future vision of hydrogen fuel cells: A statistical review and research on applications, socio-economic impacts and forecasting prospects." ScienceDirect. October, 2022. <https://www.sciencedirect.com/science/article/abs/pii/S2213138822007871#:~:text=HFC%20technologies%20have%20started%20to%20be%20used%20as,buildings%2C%20industry%20heat%3B%20and%20more%20futuristic%20trend%20implementations.>

<sup>52</sup> Idaho National Laboratory. <https://inl.gov/trending-topics/microreactors/>

<sup>53</sup> DoE, Dept. of Nuclear Energy. <https://www.energy.gov/ne/advanced-small-modular-reactors-smrs>

<sup>54</sup> Oklo. <https://oklo.com/newsroom/news-details/2023/Oklo-Tentatively-Selected-to-Provide-Clean-and-Resilient-Power-to-Eielson-Air-Force-Base/default.aspx>

5. **Hot/Cold aisle containment**
6. **In-rack/In-row cooling**
7. **Liquid-submerged data racks**
8. **Waste heat reuse systems**

Using this list of desired attributes, we would then create a new policy through, 1) the application of ideal data center conditional use performance standards for new data centers, and 2) the creation of a Green Business Development Zone with significant tax benefits for existing data centers that incorporate in whole or in part the attributes of an ideal data center.

### **Summary**

Implementation of the above strategy would accomplish several urgently needed objectives. It would:

- **Implement Conditional Use Performance Standards for New Data Centers.** No new data centers would be permitted to connect to an already significantly oversubscribed power grid in Loudoun County without first developing self-sustaining microgrids onsite. The mandatory performance standards for new data centers would ensure any new data center built after a certain date would operate on continuous and backup power provided through onsite-generated, reduced carbon power sources.
- **Create a Green Business Development Zone.** By aspiring to join the Green Business Development Zone, existing data centers now paying \$4.15/\$100 of property value could receive up to a 50% tax rebate if they retrofitted their existing facilities with some of the desired attributes shown above. Given that in 2025 the data center community in Loudoun County is expected to pay approximately \$666 million in Business Personal Property Tax, this program would offer a significant tax incentive to reduce data center load on the PJM power grid and reduce the sector's reliance on fossil fuels.
- **Establish Loudoun County as a Green Data Center Environment.** Loudoun County would become a role model for communities around the world seeking to host green data centers in their community or to transform the data center markets they already have.
- **Enable Decommissioning of Fossil Fuel Power Plants.** This strategy could substantially reduce the pressure on Dominion Energy and PJM to slow the process of decommissioning fossil fuel plants and enable them to meet their climate change goals. Note: data centers are only one part of the puzzle, albeit the largest piece in Loudoun County. The rapid proliferation of electric vehicles will also contribute to the pressure on the grid, but in Loudoun County the power demand of data centers very likely far exceeds the demand from electric vehicles.
- **Increase Loudoun County's Power Grid Resiliency.** Incentivizing data centers to develop autonomous, onsite power will increase grid resiliency and reduce the threat to residential and other commercial users posed by rapidly increasing demands on our power grid. It would also help keep rates low for non-data center customers. During off-peak hours, each autonomous data center power source would be able to provide

carbon-net-zero energy to the North America power grid, thereby helping the nation achieve its climate change goals.

- **Create a New Loudoun County Market for a Burgeoning Green Microgrid Industry.** Just as the sector's rapid growth over the past twenty years led to an economic boom in Loudoun County, transforming Loudoun County's data center industry to the use of green microgrids could have similarly beneficial business revenue effects. Such a change could attract green industry companies to the county and have a significant, positive multiplier effect on Loudoun County's entire business environment by diversifying our tax revenue with a host of complementary businesses supporting the transformation.

## Challenges

Without question, there are major challenges implementing this strategy. Here are a few:

- Will Dominion Energy allow point source power generation in its market?
- If a data center chooses to install a nuclear micro- or small modular reactor, how difficult will it be to establish Nuclear Regulatory Commission protocols in Loudoun County?
- Will the Loudoun County community ever accept nuclear power even if confronted with the reality of the binary choice between limitless expansion of overhead power lines or onsite nuclear power?
- It will take 12-18 months to implement a formal CPAM/ZOAM change. Will BOS votes prior to this codified change reflect a willingness to implement the new strategy?

The list of challenges is no doubt long and complex. But the stakes of the game have never been higher for our county. Our task is not to fight the changing environment. Our task as Loudoun County's elected governing body is to learn how our environment is changing and adapt to the changes in a way that preserves our quality of life and protects the people we work for. I believe we're up to the task.