Tech & AI Systems | Jan 17, 2026 | 9 min read | By Bryan White

Summer Heat and Data Center Growth Compounding East Coast Grid Risks

Climate Change * AI * Computing

Introduction: The Fragile Equilibrium of the PJM Interconnection

The synchronous alternating-current grid of the Eastern United States -- specifically the 13-state plus District of Columbia footprint managed by the PJM Interconnection for 65 million residents -- stands at a historic inflection point.[1] For nearly a century, grid reliability has rested on second-by-second equilibrium between generation and consumption across spinning turbines. After a decade of flat electricity demand enabled by LED lighting and HVAC efficiency gains, the explosive proliferation of hyperscale Artificial Intelligence (AI) data centers has collided with accelerating fossil fuel plant retirements and summer climate extremes intensified by climate change.[1][2][3]

According to PJM's 2025 Long-Term Load Forecast, summer peak demand is projected to surge by 3.6% annually -- climbing ~70 gigawatts (GW) from a historical 2006 record of 165.6 GW (165,563 MW) to 183 GW by 2030 and 220 GW by 2039.[1][2][4] Approximately 30 GW of near-term additions between 2025 and 2030 stem directly from large data center loads.[1][3] Simultaneously, PJM warns of a "crossover" supply trap in which up to 40 GW of dispatchable thermal generation retires by 2030 faster than backlogged renewable resources can interconnect, turning controlled rolling blackouts from a remote tail risk into a central operational hazard for the summers of 2026 and beyond.[1][5][6]

Load Pockets and Capacity Scarcity Across the Eastern Grid

This demand shock is acutely concentrated in Northern Virginia's "Data Center Alley" (Loudoun, Prince William, and Fairfax counties), which routes roughly 70% of global internet traffic.[7] Because local electricity demand far exceeds local generation capacity, the Dominion Energy and Baltimore-Washington corridors form a heavily congested load pocket dependent on high-voltage transmission imports from Midwest wind and Pennsylvania nuclear facilities. PJM has already identified immediate N-1 reliability violations near Dulles Airport requiring multi-billion-dollar transmission upgrades that will take years to construct.[7]

The economic severity of this reserve erosion materialized in PJM's 2025/2026 Capacity Auction, where clearing prices across the RTO jumped nearly 800% from ~$30-$50/MW-day to $269.92/MW-day, while constrained zones hit punitive administrative caps of $444.26/MW-day in Dominion (Virginia) and $466.35/MW-day in BGE (Baltimore) -- translating into 20-30% retail rate hikes.[8] Total procured capacity (145,777 MW) fell ~6,625 MW short of PJM's installed reserve margin target.[8][9]

| Zone / Metric | | 2010s / Prior Baseline | | 2025/2026 Forecast & Auction | | Operational Implication |

| PJM Summer Peak Load | | ~150 GW (165.6 GW 2006 record) | | 183 GW (2030) / 220 GW (2039) | | +30 GW data center surge by 2030.[1][4] |

| RTO Capacity Clearing Price | | ~$30-$50 / MW-day | | $269.92 / MW-day (~800% surge) | | 6,625 MW reserve margin shortfall.[8] |

| Dominion Zone (Virginia) | | ~$70 / MW-day | | $444.26 / MW-day (~530% surge) | | Severe Data Center Alley transmission congestion.[7][8] |

| BGE Zone (Baltimore) | | ~$70 / MW-day | | $466.35 / MW-day (~560% surge) | | Deactivation of Brandon Shores/Wagner coal units.[8] |

The Physics of Grid Failure: Thermal Sag, Voltage Collapse, and Inertia Loss

The vulnerability of the East Coast grid is governed by hard physical laws of thermodynamics and electromagnetism across three distinct failure modes:

* Joule Heating and Conductor Sag: Electrical current (I) flowing through aluminum-steel transmission conductors generates resistive heat proportional to I2R (Joule's Law). Unrelenting 24/7 data center baseloads prevent nighttime conductor cooling, while 95-100 deg F summer ambient temperatures sharply reduce atmospheric convection cooling, derating safe line ampacity precisely when residential air-conditioning peaks.[10] Under an N-1 contingency loss of one major circuit in Northern Virginia, remaining lines thermally expand and sag toward trees or structures, forcing operators to shed load immediately to prevent ground-fault short circuits.[7][10]

* Reactive Power Depletion and Voltage Collapse: Server power supplies and cooling induction motors consume vast reactive power (MVAR) to sustain magnetic fields. Because reactive power suffers heavy losses over long transmission distances, importing active power into Northern Virginia depletes local MVAR reserves.[11] As voltage sags, constant-power server loads draw higher current to compensate, accelerating line voltage drop in a positive feedback loop that can trigger cascading wide-area voltage collapse within seconds.[11]

* Erosion of Synchronous Inertia: North America's 60 Hz frequency stability relies on the rotational kinetic energy stored in heavy spinning rotors of coal, nuclear, and gas turbines.[12] Retiring thermal generators in favor of digital Inverter-Based Resources (IBRs) such as solar photovoltaics -- while adding gigawatts of zero-inertia data center load -- accelerates Rate of Change of Frequency (RoCoF) during faults.[12][13] If frequency drops below ~59.5 Hz before synchronous condensers or governors respond, automatic Under-Frequency Load Shedding (UFLS) relays trip neighborhood feeders offline.[12][14]

| Physical Constraint | | Failure Mechanism | | Data Center & Climate Driver | | Grid Consequence |

| Thermal Limit | | I2R Joule heating -> conductor expansion/sag -> ground fault. | | 24/7 high current + summer heat derating convective cooling. | | Manual load shedding to prevent line faults.[7][10] |

| Voltage Stability | | MVAR deficit -> voltage drop -> motors draw more current -> collapse. | | Cooling induction motors & long-distance power imports. | | Sudden

wide-area cascading blackout.[11] |

| System Inertia | | Loss of spinning mass -> rapid 60 Hz frequency drop during trips. | | 40 GW coal/gas retirements + non-inertial AI load spikes. | | Automatic Under-Frequency Load Shedding.[12] |

Hyperscale AI Thermodynamics, Queue Bottlenecks, and Regulatory Conflict

Unlike traditional 5-10 kW cloud racks, AI clusters running NVIDIA H100 or Blackwell accelerators draw up to 100 kW per rack, requiring direct-to-chip liquid cooling and running flat-out for months during model training alongside latency-critical inference concentrated along Northern Virginia's MAE-East fiber backbone.[15][16][17] While PJM's transition to a "first-ready, first-served" cluster interconnection queue and multi-million-dollar network upgrade costs delay replacement renewable projects until 2029-2030,[6] regulatory battles over existing baseload power have erupted. In late 2024, the Federal Energy Regulatory Commission (FERC) rejected an amended Interconnection Service Agreement that would have allowed Amazon Web Services to co-locate 960 MW "behind the meter" at Talen Energy's Susquehanna nuclear plant in Pennsylvania, citing ratepayer cost-shifting and grid reliability risks.[18][19] In January 2026, federal officials and PJM state governors proposed an emergency capacity auction requiring hyperscalers to underwrite 15-year contracts for new generation, while in July 2026 PJM's 2028/2029 Base Residual Auction again cleared at the FERC-approved $325.00/MW-day RTO price cap (falling 6,831 MW short of its 156,013 MW UCAP reliability requirement alongside a 165,954 MW peak load forecast), underscoring unresolved tensions over FERC behind-the-meter co-location rules and speculative large-load queues.[20][21][19]

When extreme summer heat pushes PJM down its NERC emergency ladder -- from Hot Weather Alerts and EEA Level 1-2 Demand Response to Voltage Reduction and EEA Level 3 Manual Load Dumps (60-90 minute rotating residential blackouts)[22][23] -- data centers disconnect from the grid and fire thousands of backup diesel generators. This "double jeopardy" leaves surrounding communities in sweltering homes without air conditioning while bathing neighborhoods in constant mechanical cooling hum, generator testing noise -- already a flashpoint in Prince William County's Great Oak and Digital Gateway land-use battles -- and tons of nitrogen oxides (NOx) and particulate emissions.[24][25]

| Step | | PJM Emergency Procedure | | Trigger Condition | | Operational Action & Public Impact |

| 1-2 | | Hot Weather Alert & EEA 1 | | Temp >90 deg F; reserves below target | | Maintenance deferred; all generation and imports committed.[22] |

| 3 | | EEA Level 2 | | Reserves critically depleted | | Demand Response curtailed; industrial loads paid to shut down.[22] |

| 4 | | Voltage Reduction | | Reactive voltage support failing | | Distribution voltage lowered 2-5% ("brownout").[23] |

| 5 | | EEA 3: Manual Load Dump | | Thermal/frequency collapse imminent | | Rotating 60-90 min blackouts; data centers switch to diesel.[23] |

Conclusion: Mobilizing for Grid Reliability in the AI Era

Preventing recurring summer blackouts across the PJM Interconnection requires an urgent engineering and regulatory mobilization: fast-tracking high-voltage transmission permitting, deploying Dynamic Line Ratings and synchronous condensers, aligning thermal plant retirements with verified queue additions, and mandating that hyperscale AI training clusters operate as flexible, curtailable loads during peak grid emergencies.[1][14][21]

Updates... (Nov 22, 2026): Added verified publication dates to AEMC Appendix A (Jun 2008, Ref [10]), Siemens Energy (Dec 3, 2025, Ref [14]), EdgeCore (Jun 23, 2025, Ref [16]), CoreSite (Aug 15, 2025, Ref [17]), and the OTC/PJM Emergency Operations Manual overview (Jul 2, 2009, Ref [23]), and replaced the undated EnerSys marketing blog (Ref [15]) with Lawrence Berkeley National Laboratory's 2024 United States Data Center Energy Usage Report (Shehabi et al., 2025; released Dec 2024, doi:10.71468/P1WC7Q). Continues to reflect the 165.6 GW (165,563 MW) 2006 PJM peak baseline and July 2026 2028/2029 Base Residual Auction ($325.00/MW-day cap, 6,831 MW shortfall).

References

* [1] PJM Interconnection (2026). 2026 PJM Load Forecast Report. https://www.pjm.com/-/media/DotCom/library/reports-notices/load-forecast/2026-load-report.pdf

* [2] Utility Dive (2026). PJM trims near-term load forecast on stricter data center vetting, economic outlook. https://www.utilitydive.com/news/pjm-interconnection-load-forecast-data-centers/809717/

* [3] U.S. Department of Energy / Lawrence Berkeley National Laboratory (2024). DOE Releases New Report Evaluating Increase in Electricity Demand from Data Centers. https://www.energy.gov/articles/doe-releases-new-report-evaluating-increase-electricity-demand-data-centers

* [4] PJM Interconnection (2026). Load Forecast Development Process. https://www.pjm.com/planning/resource-adequacy-planning/load-forecast-dev-process

* [5] Yes Energy (2025). What to Know about PJM Plant Retirements. https://www.yesenergy.com/blog/what-to-know-about-pjm-plant-retirements

* [6] The Ohio Manufacturers' Association (2025). PJM's Queue Freeze and Backlog Crisis Drive Up Energy Costs, Stall New Power Projects. https://www.ohiomfg.com/our-communities/pjms-queue-freeze-and-backlog-crisis-drive-up-energy-costs-stall-new-power-projects/

* [7] Loudoun County Government (2025). Loudoun County Data Center Brief. https://www.loudoun.gov/DocumentCenter/View/217605/Loudoun-County-Data-Center-Brief---Turner

* [8] Utility Dive (2025). PJM capacity prices hit record high as grid operator falls short of reliability target. https://www.utilitydive.com/news/pjm-interconnection-capacity-auction-data-center/808264/

* [9] Vicinity Energy (2025). PJM capacity auction results: Why energy bills are rising for Mid-Atlantic customers. https://www.vicinityenergy.us/blog/pjm-capacity-auction-results-why-energy-bills-are-rising-for-mid-atlantic-customers/

* [10] Australian Energy Market Commission (Jun 2008). Congestion Management Review - Final Report, Appendix A: An Introduction to Congestion in the NEM.

https://www.aemc.gov.au/sites/default/files/content/42a1dfd9-bf32-4bf1-bcc4-81dd8095dfc7/Final-Report-Appendix-A-An-introduc

* [11] KTH Royal Institute of Technology (2013). Electricity Market Analysis (EG2060): Transmission Limits and Voltage Collapse. https://www.kth.se/social/upload/51529a1bf2765449565a94e8/L5-L6-2013.pdf

* [12] National Renewable Energy Laboratory (NREL) (2020). Inertia and the Power Grid: A Guide Without the Spin. https://docs.nlr.gov/docs/fy20osti/73856.pdf

* [13] pv magazine USA (Mar 1, 2019). Inertia, frequency regulation and the grid. https://pv-magazine-usa.com/2019/03/01/inertia-frequency-regulation-and-the-grid/

* [14] Siemens Energy (Dec 3, 2025). Synchronous condensers: Key to grid stability in North America. https://www.siemens-energy.com/us/en/home/stories/grid-stability-north-america.html

* [15] Shehabi, A., Smith, S. J., Hubbard, A., Newkirk, A., Lei, N., Siddik, M. A. B., Holecek, B., Koomey, J. G., Masanet, E. R., & Sartor, D. A. (2025; released Dec 2024). 2024 United States Data Center Energy Usage Report (LBNL-2001637). Lawrence Berkeley National Laboratory. https://doi.org/10.71468/P1WC7Q

* [16] EdgeCore Digital Infrastructure (Jun 23, 2025). AI Inference vs. Training: Infrastructure Differences Hyperscalers Must Plan For. https://edgecore.com/ai-inference-vs-training/

* [17] CoreSite (Aug 15, 2025). The Backbone of AI: Performance, Proximity and Bandwidth. https://www.coresite.com/blog/the-backbone-of-ai-performance-proximity-and-bandwidth

* [18] RTO Insider (2024). FERC Rejects Expansion of Co-located Data Center at Susquehanna Nuclear Plant. https://www.rtoinsider.com/91053-ferc-rejects-expansion-co-located-data-center/

* [19] Utility Dive (2024). FERC rejects interconnection pact for Talen-Amazon data center deal at nuclear plant. https://www.utilitydive.com/news/ferc-interconnection-isa-talen-amazon-data-center-susquehanna-exelon/731841/

* [20] Utility Dive (2026). Trump administration pushes PJM to hold 'emergency' auction to supply data centers. https://www.utilitydive.com/news/trump-governors-pjm-emergency-auction-data-centers/809853/

* [21] PJM Interconnection (2026). 2028/2029 Base Residual Auction Report. https://www.pjm.com/-/media/DotCom/markets-ops/rpm/rpm-auction-info/2028-2029/2028-2029-bra-report.pdf

* [22] PJM Interconnection (2024). PJM Manual 13: Emergency Operations (via Kentucky PSC filing). https://psc.ky.gov/pscecf/2023-00009/jessica.fitch-snedegar%40ekpc.coop/01252024042809/PJM_Manual_13.pdf

* [23] Ozone Transport Commission / PJM (Jul 2, 2009). Emergency Operations Manual Overview. https://www.otcair.org/upload/Interest/StationaryArea%20Sources/PJM_Emergency_Operations_Manual.pdf

* [24] Prince William County Government (2024). Data-Center Boom Leads to Noise Disruptions in Loudoun County, Virginia. https://www.pwcva.gov/assets/2024-09/Data-Center%20Boom%20Leads%20to%20Noise%20Disruptions%20in%20Loudoun%20C

* [25] Protect PWC (2022). Prince William Times: Gainesville-area residents take
their fight against the PW digital gateway to court.
https://protectpwc.org/2022/12/06/prince-william-times-gainesville-area-residents-take-their-fight-against-the-pw-digital-gateway-to