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POWER HUNGRY DATA CENTERS & THE ELECTRIC GRID

WHAT RAPID LOAD GROWTH MEANS FOR HOMEOWNERS, BUSINESSES AND HVAC/R EQUIPMENT

USA INNOVATION

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Executive Summary

Artificial intelligence, cloud computing, streaming, digital commerce, and connected services all depend on data centers. These facilities are essential infrastructure, but the newest generation of AI-oriented data centers can require electricity at a scale that was uncommon a few years ago. The result is a new era of rapid load growth in parts of the United States.

Lawrence Berkeley National Laboratory estimates that U.S. data centers used about 176 terawatt-hours (TWh) of electricity in 2023, equal to roughly 4.4% of total U.S. electricity consumption. Its June 2026 update projects that data centers could account for about 11.8% of U.S. electricity use by 2030, with modeled scenarios ranging from 9.5% to 15.3%. [1][2].

For homeowners and businesses, the concern is not that every nearby data center automatically creates a damaging surge. The grid is designed to serve changing loads, and utilities actively reinforce it. The practical concern is that rapid, concentrated load growth can require new generation, substations, transmission lines, switching operations, protection schemes, and operating practices. During faults, outages, restoration, equipment switching, lightning, or local utility events, customers can still experience short-duration voltage sags, swells, transients, or sustained abnormal voltage. Modern HVAC/R equipment, especially inverter-driven compressors, variable-speed motors, communicating controls, and electronic boards can be sensitive to these conditions.

BOTTOM LINE

Grid growth and data-center expansion make power-quality resilience more important. A layered strategy: sound grounding and bonding, service-level surge protection, equipment-level surge protection, voltage monitoring, anti-short-cycle protection, and phase monitoring for three-phase systems, can reduce the probability that a power disturbance becomes an expensive HVAC/R failure.

The Data-Center Load Shift in Four Numbers

Metric	Documented/ Projected Level	Why it Matters
U.S. data-center electricity use, 2023	176 TWh / 4.4% of U.S. electricity	Already a major national load category.
Projected share, 2023	11.8% central estimate; 9.5%-15.3% scenario range	Planning must account for unusually fast and uncertain growth.
Virginia commercial electricity sales growth, 2019 - 2025	Nearly +30 million MWh	EIA says the increase was largely driven by data centers, along with EVs and building electrification.
PJM 2025 planning expansion under review	~$11.6 billion of backbone transmission enhancements	PJM says future reliability needs are driven predominantly by load growth, including concentrated data-center demand.

Why Data Centers are Changing Grid Planning

Traditional electricity demand grew slowly enough in many regions that utilities could plan years ahead using relatively stable trends. Large data centers change that pattern because a single campus can represent hundreds of megawatts of demand, may operate around the clock, and may be proposed in clusters near fiber routes, land, water, and existing transmission infrastructure.

The Department of Energy notes that data-center demand is growing rapidly, varies significantly by region, can be geographically constrained, and often requires firm power because facilities are designed for continuous operation. [3]

The North American Electric Reliability Corporation (NERC) similarly identifies new data centers as the main source of projected load growth in its latest long-term reliability work. [4]

This has three major consequences for the public:

- More infrastructure must be built. Utilities and regional grid operators may need new transmission lines, substations, transformers, generation, storage, and distribution upgrades.
- Planning becomes more uncertain. Projects can be delayed, canceled, expanded, or energized in stages, making load forecasts harder to match with generation and network construction.
- Power-quality and protection coordination receive more attention. Very large electronic loads can react quickly to voltage disturbances, and grid operators now explicitly study how those loads behave during faults.

What Changes on the Grid and What Does Not

It is useful to separate capacity stress from power quality. Capacity is the ability of the grid to supply enough power. Power quality describes whether the voltage and frequency delivered to equipment stay within acceptable limits and whether disruptive transients occur.

A heavily loaded region does not automatically deliver "dirty power." Utilities regulate voltage and build redundancy. However, a faster-growing, more complex system has more equipment, more switching, more interconnections, and more operating states. Disturbances can originate from lightning, utility faults, failed equipment, capacitor-bank switching, transformer energization, large motors, distributed generation, restoration after outages, and other events. Data-center growth is one factor increasing the scale and complexity of the system in certain regions.

Common Electrical Disturbances That Matter to HVAC/R

Disturbance	Plain-Language Meaning	Typical Duration	HVAC/R Reason
Transient Surge	A very fast spike above normal voltage	Microseconds to milliseconds	Can puncture semiconductor junctions, damage boards, controls, sensors, or insulation.
Voltage Swell/ Over voltage	Voltage rises above normal for longer than a transient	Cycles to seconds, or sustained	Stresses capacitors, motors, power supplies, and electronic controls.
Voltage Sag / Brownout	Voltage drops below normal	Cycles to seconds, or sustained	Motors draw higher current for a given load; contactors may chatter; electronics may reset; compressors may fail to start cleanly.
Interruption / Outage	Voltage falls to near zero	Momentary to sustained	Risk often occurs during shutdown and especially restoration if equipment restarts too quickly or voltage is unstable.
Phase loss / Imbalance	One phase is missing or three-phase voltages differ materially	Variable	Can overheat three-phase motors and compressors and cause severe current imbalance.

IMPORTANT DISTINCTION: SURGE PROTECTION IS NOT VOLTAGE REGULATION

A surge protective device (SPD) is designed to divert short-duration transient energy. It does not correct a sustained brownout, sustained over voltage, phase loss, or voltage imbalance. Those conditions require monitoring and protective disconnection, and three-phase systems require phase-aware protection.

Why Modern HVAC/R Equipment is More Vulnerable

Older HVAC systems were primarily electromechanical. Modern systems still contain motors and compressors, but they also include microprocessor boards, variable-frequency drives, electronically commutated motors, inverter modules, pressure and temperature sensors, communicating thermostats, and networked controls. These electronics improve efficiency and comfort, but they also create more pathways for electrical damage.

The most expensive failures are not always dramatic. A severe transient can cause immediate board failure, while repeated smaller events can weaken components over time. Low voltage can cause a motor or compressor to draw elevated current, create heat, and experience difficult starts. Rapid power restoration can cause short cycling if pressure has not equalized, adding mechanical and electrical stress.

For businesses, three-phase systems introduce additional risks. Phase loss, phase reversal, and voltage imbalance can damage motors even when average line voltage appears reasonable. That is why a commercial power-protection strategy should not stop at surge suppression.

Real-World Case Studies

Case Study 1: Northern Virginia - A Regional Grid Transformed by Data-Center Demand
Virginia is the clearest U.S. example of concentrated data-center load growth. In May 2026, the U.S. Energy Information Administration reported that commercial electricity sales in Virginia increased by nearly 30 million MWh from 2019 through 2025, with the increase largely driven by data centers, as well as electric-vehicle adoption and building electrification. In PJM's Dominion zone, the summer peak reached 23,905 MW in 2025, 23% higher than 2019, while the 2025-26 winter peak was 45% higher than the 2019-20 winter season. [5]

PJM has responded with major transmission planning. In late 2025 it described approximately $11.6 billion in proposed backbone transmission enhancements, stating that future reliability issues were being driven predominantly by increasing load, including heavy concentration in Northern Virginia and additional data-center growth elsewhere in PJM. [6]

Public lesson: even when customer voltage remains within utility standards most of the time, extraordinary load growth changes the physical grid serving a region. Homeowners and businesses should expect ongoing construction, switching, new substations, and changing network configurations - and should treat equipment-level power protection as prudent risk management rather than waiting for a damaging event.

Case Study 2: July 10, 2024 - Approximately 1,500 MW of Voltage-Sensitive Load Drops
NERC documented a major Eastern Interconnection disturbance in which a transmission fault was associated with the simultaneous reduction of approximately 1,500 MW of voltage-sensitive load, primarily data centers. The data-center substations did not necessarily trip; instead, multiple facilities reduced grid consumption and shifted some load to backup systems in response to the transient voltage disturbance. [7]

NERC has since emphasized voltage and frequency ride-through for large loads because sudden demand changes can themselves create system-stability challenges. [7][8]

Public lesson: this event demonstrates that voltage disturbances on the bulk grid are real and that highly electronic facilities can react within seconds or faster. It does not prove that data centers caused the initiating fault. It does show why utilities, data centers, businesses, and homeowners all benefit from equipment designed to tolerate or safely disconnect from abnormal voltage.

Case Study 3: Georgia - building nearly 10 GW while trying to shield existing ratepayers
Georgia illustrates the economic side of the same issue. In December 2025, the Georgia Public Service Commission approved an agreement certifying 9,985 MW of new generation, with approximately 80% expected to serve data centers. The Commission also adopted large-load rules and financial protections intended to prevent existing residential and small-business customers from subsidizing infrastructure built for data centers. [9][10]

Public lesson: data-center growth is large enough to influence generation planning, customer-class design, and utility regulation. Similar policy debates are occurring in other fast-growth states, including Virginia, where regulators have created a separate rate structure and cost-allocation safeguards for large data-center customers. [11]

What Homeowners Can Do

1. Start with the electrical system. Have a qualified electrician verify grounding, bonding, neutral integrity, panel condition, and obvious loose or overheated connections. Surge protection cannot compensate for unsafe wiring or a failing neutral.
2. Use service-level surge protection. A Type 1 or Type 2 SPD at the service or main distribution point provides a first layer of defense for the home. The National Electrical Code has required surge protection for services supplying dwelling units since the 2020 edition, although local adoption and enforcement dates vary. [12]
3. Add HVAC-specific surge protection near the condensing unit or disconnect. This shortens the electrical path between the SPD and the equipment being protected and adds a second protective layer.
4. Protect against abnormal voltage, not just spikes. A line-voltage monitor can disconnect the HVAC system during sustained overvoltage or undervoltage and reconnect only after acceptable voltage returns.
5. Use anti-short-cycle delay. After an outage or disturbance, a delay prevents an air conditioner or heat pump from immediately restarting against high refrigerant pressure.
6. Inspect protection devices periodically. Many SPDs include a status indicator. If protection status is lost, the device should be replaced according to manufacturer instructions.
7. Document recurring events. If lights repeatedly dim, electronics reset, HVAC contactors chatter, or equipment faults coincide with utility disturbances, record dates and times and contact the utility and an HVAC/electrical professional.

What Homeowners Can Do

Commercial facilities have the same basic risks as homes, but the financial exposure is larger: equipment downtime, spoiled inventory, comfort complaints, tenant disruption, lost productivity, emergency service, and damage to multiple rooftop units or refrigeration circuits at once.

- Install coordinated SPDs at service entrance, distribution panels, and sensitive HVAC/R equipment where appropriate.
- For three-phase equipment, monitor phase loss, phase reversal, voltage imbalance, overvoltage, and under voltage.
- Use programmable restart delays so multiple compressors do not all re-energize simultaneously after an outage.
- Maintain fault history where possible. Recorded voltage faults help technicians distinguish refrigerant/mechanical problems from incoming-power problems.
- Include power-quality checks in preventive maintenance, especially after utility work, repeated outages, lightning events, or expansion of nearby large electrical loads.
- For mission-critical refrigeration or process cooling, consider a formal power-quality study with logging equipment. A week or month of voltage data can reveal sags, swells, imbalance, and event timing that a single service call cannot capture.

A Layered Protection Framework

Layer	Purpose	Examples	What it Does Not Replace
Building / Service	Reduce transient energy entering the electrical system	Type 1 or Type 2 SPD at service/main panel	Equipment-level protection, voltage monitoring, good grounding
Branch / Equipment	Clamp transients close to HVAC/R load	Type 2 SPD at disconnect/panel	Protection from sustained over/under voltage
Voltage Monitoring	Disconnect during unacceptable sustained voltage	Single-phase line voltage monitor	Transient surge suppression unless integrated
Phase Protection	Prevent operation under damaging three-phase conditions	Phase loss/reversal/ unbalance monitor	Surge suppression unless integrated
Restart Control	Avoid rapid compressor restart after disturbance	Anti-short-cycle delay	Surge or voltage monitoring

Recommended ICM Controls Devices

The correct device depends on service voltage, phase, equipment full-load current, local code, and the protection objective. Installation should be performed by a qualified HVAC technician or licensed electrician in accordance with product instructions and applicable codes.

ICM518 - whole-home / split-phase surge protection
Best fit: residences and 120/240 V split-phase services. UL Listed Type 1 or Type 2 SPD, 240 VAC split phase, NEMA Type 4X enclosure, 100 kA maximum surge current. Use as the building-level surge layer where the electrical configuration is compatible. [13]

ICM517A - equipment-level single-phase surge protection
Best fit: air conditioners, heat pumps, refrigeration, motors, and other 120/240 V single-phase equipment. Type 2 SPD, NEMA Type 4X enclosure, 100 kA maximum surge current, with status indication. Commonly installed at an electrical panel or HVAC disconnect. [14]

ICM517A-Lite - compact equipment-level surge protection
Best fit: applications where compact Type 2 surge protection is desired. Rated for 120/240 V single-phase service with 60 kA maximum surge capacity and a NEMA Type 4X enclosure. [15]

ICM493 / ICM493-60A - single-phase voltage monitoring plus surge protection
Best fit: high-value single-phase condensers and mini-splits that need more than surge suppression. The ICM493 family monitors overvoltage and undervoltage, provides anti-short-cycle delay, and includes surge arresters; the 40 A and 60 A versions support different equipment sizes. [16][17]

Sentry 3N1 - integrated disconnect, voltage monitor, and surge protection
Best fit: 208/240 V single-phase HVAC/R where an integrated solution is preferred. Combines a disconnect breaker, field-programmable line-voltage monitoring, and an ICM517A-Lite surge-protection module. [18]

ICM530 - three-phase surge protection
Best fit: commercial three-phase 240 V delta or 120/208 V wye systems. UL Listed Type 1 or Type 2 SPD, 150 kA maximum surge current, NEMA Type 4X enclosure. Pair with appropriate voltage/phase monitoring when the load also needs phase protection. [19]

3VMS-60-208 / 3VMS-60-480 - integrated three-phase voltage and surge protection
Best fit: commercial three-phase HVAC/R equipment requiring both surge suppression and active voltage/phase protection. The 208 V version combines an ICM450A PLUS+ voltage monitor with an ICM530 SPD; the 480 V version uses the corresponding 480 V surge-protection platform. These devices address over/undervoltage and three-phase conditions in addition to transient surges. [20][21]

FOR MOST HOMEOWNERS

A practical protection stack is: (1) whole-home surge protection at the service, plus (2) HVAC-specific surge protection or an integrated voltage-monitor/surge device at the outdoor unit. Homes with expensive inverter-driven systems, mini-splits, or frequent utility disturbances benefit especially from active voltage monitoring.

FOR MOST BUSINESSES

Use coordinated service/panel/equipment SPDs, then add voltage and phase protection at three-phase HVAC/R loads. For critical refrigeration, process cooling, or high-downtime-cost sites, fault history and power-quality logging should be part of the maintenance program.

Conclusion: Protect the Equipment You Already Own

Data centers are not the only reason the electric grid is changing, but they are now one of the most important drivers of U.S. electricity demand growth. The transition is happening fast enough that federal regulators, grid operators, utilities, and state commissions are rewriting planning practices and large-load rules in real time.

For the public, the practical response is not alarm. It is resilience. HVAC/R equipment is expensive, increasingly electronic, and essential during the same heat and cold events that place the most stress on the grid. A layered protection strategy can reduce exposure to transient surges, abnormal voltage, rapid cycling, phase loss, and phase imbalance - and can help prevent a short electrical disturbance from becoming a compressor, motor, or control-board replacement.

No protection device can eliminate every electrical failure. Correct sizing, proper installation, sound grounding and bonding, maintenance, and prompt investigation of repeated power-quality symptoms remain essential. But for many homes and businesses, adding surge and voltage protection is a comparatively small investment relative to the cost and disruption of replacing modern HVAC/R equipment.

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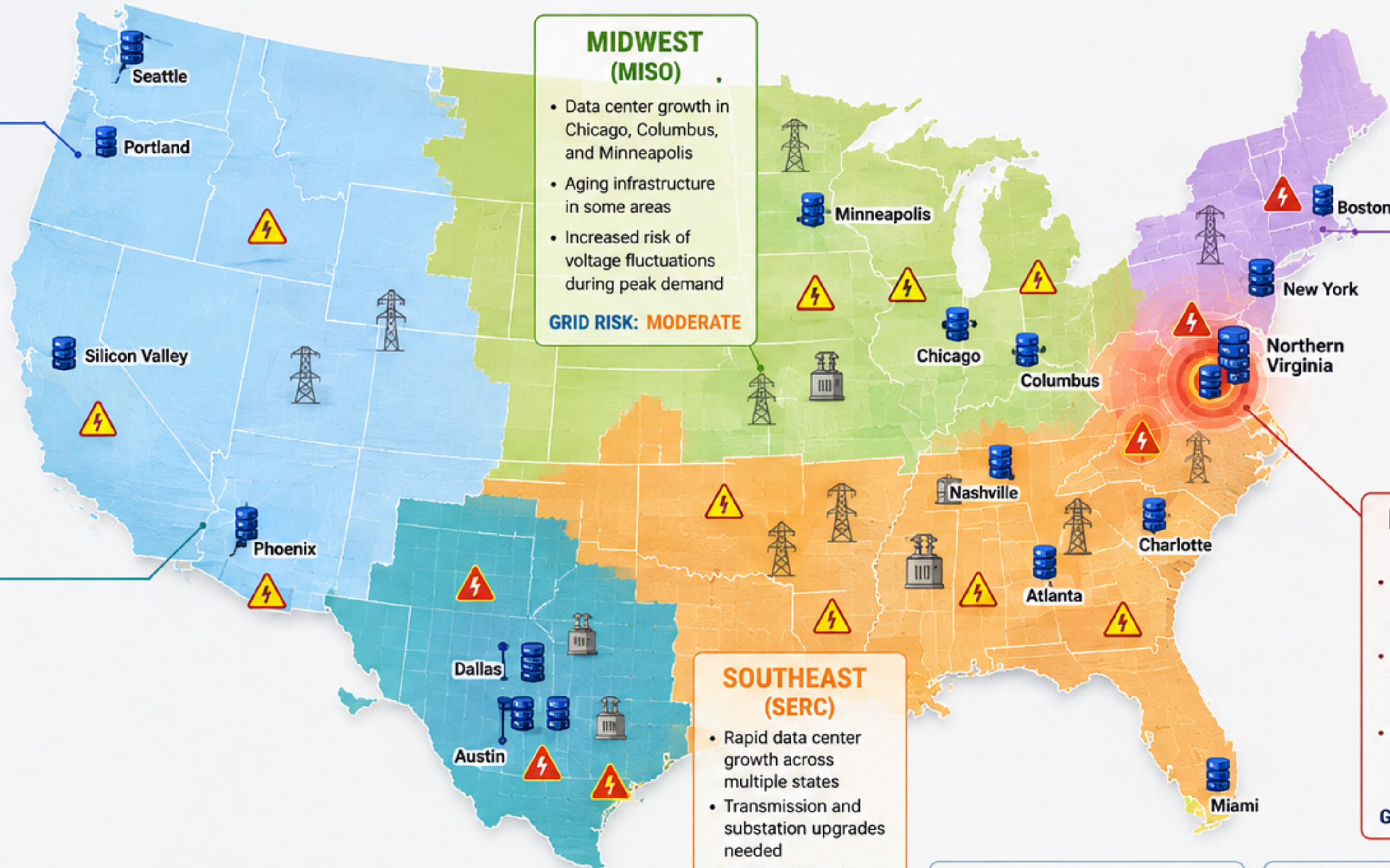
DATA CENTERS & GRID INSTABILITY: REGIONAL IMPACTS

How Rapid Data Center Growth Is Affecting the Electric Grid Across the U.S.



WEST (WECC)

- Growing data center hubs in Phoenix, Las Vegas, Seattle, and Silicon Valley
- Strain on transmission for long-distance power transfers
- Water and cooling constraints in some areas

GRID RISK: MODERATE

TEXAS (ERCOT)

- Fastest load growth in the U.S. driven by data centers and industry.
- Tight supply margins during extreme heat
- Higher risk of outages and conservation events

GRID RISK: HIGH

MIDWEST (MISO)

- Data center growth in Chicago, Columbus, and Minneapolis
- Aging infrastructure in some areas
- Increased risk of voltage fluctuations during peak demand

GRID RISK: MODERATE

SOUTHEAST (SERC)

- Rapid data center growth across multiple states
- Transmission and substation upgrades needed
- Vulnerable to storms and extreme weather

GRID RISK: HIGH

NORTHEAST (NPCC / ISO-NE)

- High data center concentration in Northern Virginia, New York, and Boston
- Limited land and transmission capacity
- Tight reserve margins in extreme weather

GRID RISK: HIGH

MID-ATLANTIC (PJM)

- Epicenter of data center growth (Northern Virginia)
- 23% increase in summer peak demand since 2019
- $11.8B in new transmission projects planned

GRID RISK: VERY HIGH

MAP LEGEND

- Major Data Center Hubs
- High Grid Stress / Instability Risk
- New Substations & Upgrades
- Transmission Expansion Needed
- Highest Impact Concentration

KEY IMPACT DRIVERS

- Rapid, concentrated load growth
- Infrastructure buildout lag
- Large electronic loads sensitive to voltage disturbances
- Extreme weather increases system stress

WHAT THIS MEANS FOR CUSTOMERS

- More frequent voltage sags, swells, and momentary outages
- Higher risk of equipment damage without proper protection
- Surge protection, voltage monitoring, and power quality devices are essential for homes and businesses

Data centers are critical to our digital economy, but their rapid growth is reshaping the grid. Understanding regional impacts helps homeowners and businesses protect what matters most.

Sources: EIA, NERC, PJM, SERC, MISO, ERCOT, ISO-NE, WECC
Data as of May 2025