



By: Andrew Ballantyne, PE, Master Electrician and Kendra Wolfel, PE

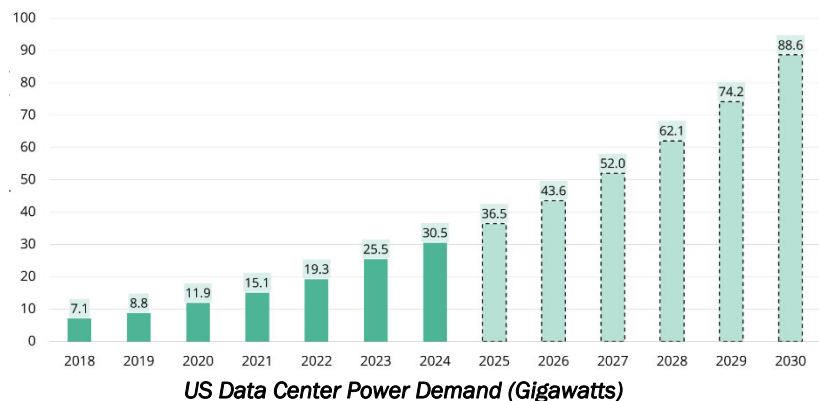
Wunderlich – Malec Engineering, Inc

The Power Strain: Can the Grid Manage the Data Center Boom?

Challenge

As data centers rapidly expand across the U.S., they are placing unprecedented demand on the nation's power infrastructure. These mission-critical facilities serve as the foundation of today's digital economy, supporting everything from AI computing and cloud storage to real-time data processing. They require vast amounts of continuous and reliable electricity. This surge in energy consumption is putting significant strain on the aging U.S. electrical grid, particularly in regions that are already facing capacity challenges.

Approximately 45% or 5,400 of the World's Data Centers are in the US with continued exponential growth thru 2030. The power consumption of data centers is forecasted to triple by 2030 (see graph). To put this in perspective: A single hyperscale data center's power consumption will draw approximately **100 megawatts (MW) continuously – about as much as a small city** and when dozens of these facilities cluster in one region, the stress on the electrical grid is unprecedented.



This power demand and our aging electrical grid presents significant challenges. Here are potential solutions:

1. The Grid Wasn't Designed for This

The U.S. 20th Century electrical grid, much of which was constructed 50 to 70 years ago with components that are nearing or exceeding their intended life cycle was not designed to support the demands of hyperscale data centers consuming hundreds of megawatts (MW) of electricity. Expanding transmission and substation capacity often requires 5 to 10 years of planning, driven by permitting, environmental reviews, and construction delays. However, data center companies seek rapid deployment to meet surging demand. This need for data center operations and grid readiness represents one of the most urgent challenges in the energy sector today.

The Fix: Fast-Track Substation Deployment

- Pre-engineered, modular substations and control houses can be manufactured and tested off-site, shipped, and installed in as little as 12 to 18 months, significantly reducing traditional project timelines.
- At Wunderlich-Malec, we have significantly streamlined electrical substation deployment and accelerated interconnection by delivering plug-and-play modular control houses.
- Leading hyperscale data center constructors have adopted prefabricated electrical control house construction to reduce schedules, reduce costs and improve quality and safety.

2. Powering Data Centers: Where Will the Electricity Come From?

The scale and reliability that data centers demand mean that many data centers will need dedicated generation sources, and a diversified strategy of energy sourcing is essential. Each sourcing option comes with its own set of challenges.

The Likely Options:

- **Natural Gas:** While reliable and scalable, natural gas contributes significantly to greenhouse gas emissions, making it a less favorable option in a climate-conscious world.
- **Small Modular Nuclear Reactors (SMRs):** These emerging, carbon-free reactors hold significant promise but face regulatory and cost hurdles that limit widespread deployment prior to the next decade.
- **Renewable Energy:** Solar and wind provide clean, sustainable power but lack consistency, especially in areas prone to variable weather conditions.
- **Diesel/Petroleum Backup:** A common failsafe for emergencies but untenable for long-term solutions due to environmental and scalability concerns.

The Fix: Hybrid Energy Solutions with Smarter Interconnections &

- Data centers will require a balanced mix of grid power, localized generation, and energy storage. Proper grid studies, protection & control design, and relay coordination will be essential to ensure reliability and efficiency.
- Wunderlich-Malec specializes in integrating these power sources seamlessly, providing expertise in protection & control engineering, relay settings, and grid interconnection studies to support resilient and scalable data center operations.

3. The Reliability Problem: When the Grid Can't Keep Up

Large, concentrated Data Center loads pose significant stability risks to the grid. Voltage fluctuations, harmonics, and system-wide instability become serious concerns when integrating substantial loads into the aging grid network.

The Fix: Advanced Grid Protection & System Coordination

- Early collaboration between data center developers and utilities is critical to designing protection systems that prevent cascading failures and maintain grid stability.
- At Wunderlich-Malec, we specialize in:
 - Relay coordination & protection settings to prevent blackouts and ensure continuous service.
 - Substation automation for real-time grid stability control and monitoring.
 - Turnkey protection & control solutions to integrate data centers without compromising the surrounding grid.
 - Grid impact studies to ensure smooth interconnection approvals and identify potential challenges before they arise.

4. The Permitting & Policy Bottleneck

Even with proven existing technology, regulatory processes can delay projects. Data center operators and utilities must navigate complex permitting, interconnection studies, and energy policy hurdles before construction can begin. These delays can extend critical infrastructure projects by months or even years.

The Fix: Proactive Engineering & Planning

- Engaging experts who understand the regulatory landscape early in the process can significantly reduce project timelines and minimize potential delays during approval stages.
- Modular control solutions offer a distinct advantage, allowing manufacturing and system integration to proceed offsite while permitting, environmental approvals, and site preparation continue in parallel. This approach eliminates costly delays and ensures that once permits are secured, ready-to-install control houses and substations can be deployed immediately.
- Wunderlich-Malec offers:
 - Grid impact studies to ensure smooth interconnection approvals and identify potential regulatory challenges.
 - Turnkey project engineering & procurement to streamline approvals and ensure timely project execution.
 - Manufacturing & modular solutions designed to comply with federal and state energy mandates, accelerating project completion and reducing the time spent on regulatory hurdles.

How Wunderlich-Malec is Solving These Challenges

With data center expansion and electrical demand accelerating, grid upgrades must keep pace. Wunderlich-Malec engineers are experts in innovative application of proven technologies. They will collaborate and bridge the gap between high-demand energy users and an evolving electrical grid to provide viable solutions that meet client needs.

Here's how we're making a difference:

- **Modular Control Houses** – Plug-and-play solutions that significantly reduce substation build times and interconnection delays while reducing costs and improving quality.
- **Protection & Control System Expertise** – Ensuring safe and reliable grid integration by developing robust relay settings, automation strategies, and system protection schemes tailored for high-demand loads.
- **Grid Impact & Stability Studies** – Conducting short-circuits, load flow, harmonics, and transient stability studies to assess the effects of new data center loads on the grid, ensuring compliance with utility interconnection requirements.
- **SCADA & Automation for Real-Time Grid Control** – Designing and implementing SCADA, RTU, and automation solutions that provide data centers and utilities with real-time monitoring and control over critical infrastructure.
- **Testing & Commissioning Support** – Our specialized teams offer on-site testing, system commissioning, and relay protection verification to ensure new data center loads operate reliably without compromising grid stability.
- **Fast-Track Manufacturing** – Accelerating the production and delivery of control houses and substation through pre-engineered, modular solutions, allowing for faster project timelines and on-time deployment.

Looking Ahead: Innovation will Bridge the Gap Between Data Centers and the Grid

The data center demand for power will place increasing strain on the grid and at Wunderlich-Malec we meet the challenges of today's grid and tomorrow's needs by offering innovative solutions. We provide grid impact studies, advanced substation and protection system designs and fast-track substation deployment and modular electrical control houses to help ensure reliable and efficient grid integration and electrical power distribution. Our expert engineering enables data centers to meet their growing power needs while maintaining grid stability and minimizing project delays.

The future of data centers depends on an agile, forward-thinking approach, and Wunderlich-Malec is proud to be a key player in this transformation. Partner with Wunderlich-Malec to harness smarter and more sustainable practices for data center success. Get in touch today to explore solutions that deliver reliability, efficiency, and a competitive edge.

Bibliography

1. U.S. Department of Energy. "Clean Energy Resources to Meet Data Center Electricity Demand." *Energy.gov*, U.S. Department of Energy. Retrieved from: <https://www.energy.gov/gdo/clean-energy-resources-meet-data-center-electricity-demand>.
 - a. Covers power demand trends for hyperscale data centers and grid capacity concerns.
2. Data Center Knowledge. "Data Center Power: Fueling the Digital Revolution." *Data Center Knowledge*. Retrieved from: <https://www.datacenterknowledge.com/energy-power-supply/data-center-power-fueling-the-digital-revolution>.
 - a. Provides insights into hyperscale data center power consumption and energy sources.
3. Data Center Knowledge. "Amazon, Meta Join Pledge to Triple Nuclear Capacity by 2050." *Data Center Knowledge*. Retrieved from: <https://www.datacenterknowledge.com/energy-power-supply/amazon-meta-join-pledge-to-triple-nuclear-capacity-by-2050>.
 - a. Explores how companies like Amazon and Meta are investing in Small Modular Reactors (SMRs) for future energy reliability.
4. International Energy Agency (IEA). "What the Data Centre and AI Boom Could Mean for the Energy Sector." *IEA*. Retrieved from: <https://www.iea.org/commentaries/what-the-data-centre-and-ai-boom-could-mean-for-the-energy-sector>.
 - a. Discusses the increasing electricity needs of data centers globally and energy mix considerations.
5. Reuters. "CERAWeek Analysis: Small Nuclear Power Struggles at the Cusp of U.S. Electricity Demand Boom." *Reuters*, 11 Mar. 2025. Retrieved from: <https://www.reuters.com/business/energy/ceraweek-analysis-small-nuclear-power-struggles-cusp-us-electricity-demand-boom-2025-03-11>.
 - a. Examines the feasibility and deployment challenges of SMRs for meeting large-scale electricity demand.
6. Avison Young "Q4 U.S. data center market overview" Retrieved from: <https://www.avisonyoung.us/us-data-center-market-overview>.
 - a. Provides data center power demand.
7. Fortinet. "What Is a Data Center." *Fortinet*. Retrieved from: <https://www.fortinet.com/resources/cyberglossary/data-center>.
 - a. Provides general information on data centers and infrastructure requirements.