



Interconnection Processes for Large Loads

Current Practices and Recommendations

EXECUTIVE SUMMARY



The interconnection of large loads into the U.S. electric power system has accelerated sharply in recent years, driven primarily by the rapid proliferation of data centers and other high-demand facilities. Interconnection requests for these loads have grown exponentially in both number and magnitude, reshaping load growth forecasts across virtually every region of the country and placing new and unanticipated pressures across the electricity system. The interconnection process, encompassing the technical studies, legal agreements, and procedural requirements necessary to connect new electrical facilities to the grid while preserving system reliability, will need to expand to serve large loads' needs and fully capture their impacts on the grid.

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The pressures inherent in the exponential growth of large load interconnection requests manifest in several interrelated challenges. These include reliability risks, concerns about cost allocation, and disputes between

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large load customers and grid owners and operators over rights, obligations, and timelines. At the bulk power system level, large load facilities introduce novel reliability risks stemming from their very large power demand, power electronic interfaces, and varying power demand dictated by computational processes' intensity, including artificial intelligence training and inference (application) workloads. Financially, the speculative nature of some large load interconnection requests raises legitimate concerns about cost allocation: infrastructure investments triggered by interconnection requests may ultimately be underutilized if large load projects do not advance to commercial operation. These dynamics also have implications for utility customer rates, wholesale market rates, and long-term system planning.

Underpinning all of these challenges is the question of which regulatory authorities have jurisdiction over each aspect of large load interconnection. While generator interconnection is regulated by the Federal Energy Regulatory Commission (FERC) and state public utility commissions, regulatory authority over large load interconnection standards and procedures is less clear. Currently, FERC oversees generator interconnection "for the purpose of making sales of electric energy for resale in interstate commerce" (that is, when the generator plans to sell

electricity at wholesale into interstate markets not directly to an end-use customer).¹ For regulated utilities, state public utility commissions oversee generator interconnection that does not involve sales for resale. The North American Electric Reliability Corporation (NERC), through a stakeholder-driven standards process, sets reliability standards for generation. The development of these standards can be mandated by FERC (e.g., FERC Order 901) or proposed by industry stakeholders (including NERC) based on reliability needs. Furthermore, the new Category 2 inverter-based resources, defined as those "that either have or contribute to an aggregate nameplate capacity of greater than or equal to 20 MVA,"² face 11 applicable NERC reliability standards as of March 2026. However, there is no similar process today for reliability standards for large loads.

Historically, the lack of clarity around regulatory authority over large load interconnection standards and procedures did not lead to significant issues because load growth was incremental and more evenly geographically distributed; however, reliability challenges command much more attention in an era when individual loads may approach or exceed the scale of conventional generating units and connect at all voltage levels of the grid on the distribution system, sub-transmission level, and transmission system. At the time of this writing, load facilities are not required

1 Federal Energy Regulatory Commission, "Improvements to Generator Interconnection Procedures and Agreements (Order 2023)" (2023, p. 804), <https://www.ferc.gov/media/order-no-2023>.

2 North American Electric Reliability Corporation, "Glossary of Terms Used in NERC Reliability Standards" (2026), <https://www.ferc.gov/media/order-no-2023>.

to register with NERC; since they are not NERC-registered entities, they do not have any applicable NERC reliability standards, even as a 1 GW data center can impact the bulk power system far more than, for example, a 20 MW wind plant. NERC is working to rapidly develop registration criteria and reliability standards for large loads in 2026 through its large load action plan.³

At the regional level, existing large load interconnection processes are not sufficient to maintain bulk power system reliability with the increase in interconnection requests and the growing set of risks to the system. Historically, utilities managed all load interconnections directly, regardless of size. As demand from large loads grows and the reliability risks become greater, additional coordination is needed in the large load interconnection process to ensure that all assumptions, data, models, and reliability solutions are shared and managed consistently. This includes coordination between independent system operators (ISOs) and regional transmission organizations (RTOs) and utilities.

The Energy Systems Integration Group's (ESIG's) Large Loads Task Force examined the large load interconnection process in detail, mapped current practices across select utilities and ISO/RTO regions where large load interconnection practices are evolving more rapidly, and identified the gaps, bottlenecks, and systemic risks. This report outlines the challenges and deficiencies and offers recommendations to make the process more harmonized, efficient, and transparent. The recommendations address the unique operational and technical characteristics of new large loads while allowing for local and regional differences.

Key Issues in the Large Load Interconnection Process

The large load interconnection process is the starting point for determining which projects will be able to interconnect to the grid, and when. Understanding this process is essential to any substantive discussion of large load deployment. The interconnection process for large loads needs to address an unusually broad range of issues, including these elements and fundamental questions.

Significant Variation in Large Load Interconnection Processes and Use of Processes Not Designed for Today's Complex Facilities

Load interconnection processes vary significantly across transmission utilities and regions, with many jurisdictions relying on ad hoc procedures that were not designed for facilities of the scale or complexity of today's large loads. In addition, flexible interconnection options, including non-firm, surplus, and provisional service offerings, are not uniformly available or well understood across the industry.

Large load facilities' increasingly common pairing with on-site generation puts additional strain on the generator interconnection process, requiring reconsideration of how to study and treat interconnecting generators when they are operationally coupled with large loads. Interconnection processes for co-located large load and generation resources are limited and inconsistently defined, creating uncertainty for developers as well as grid operators.

There is currently no clarity around which entities will regulate and harmonize the various large load interconnection processes (states, FERC, NERC, utilities, ISOs/RTOs) to promote the adoption of core process elements:

- Defined process milestones and timelines
- Defined site-control requirements (e.g., land ownership, leases, permits, easements)
- Milestone-based study fees and financial securities
- Penalties for late-stage withdrawal of interconnection applications
- Cluster study processes and open window application processes
- Option for the interconnection customer to build the interconnection substations and transmission lines to the utility's equipment and construction standards

³ North American Electric Reliability Corporation, "Large Loads Action Plan" (2026), <https://www.nerc.com/initiatives/large-loads-action-plan>.

A Lack of Coordination Between Utilities and ISOs/RTOs

Large load facilities are connecting across all levels of the electricity system through multiple, often separate, interconnection processes. Distribution- and sub-transmission-connected large loads are typically handled directly by utilities; transmission-connected large loads may follow utility-led transmission interconnection processes; and co-located large load and generation configurations may be studied through generation interconnection frameworks administered by ISOs and RTOs. This fragmented structure and lack of coordination creates duplication of effort and makes it difficult to ensure consistent visibility into cumulative system impacts, maintain reliability of the bulk power system, and apply consistent study assumptions, data exchange, timelines, and upgrade determinations across utilities, transmission owners, and ISOs/RTOs. A key question is:

- How can utilities and ISOs/RTOs ensure close coordination and information-sharing between all involved stakeholders?

Lack of Consensus Around Open Questions for Interconnection Studies

The studies performed during the interconnection process are essential to understanding the grid impacts of new

large load facilities. In addition to their size, large loads connecting to the grid today are significant in that they have sophisticated equipment and systems and have new operational characteristics. This requires that detailed steady-state, positive-sequence phasor-domain (PSPD), short-circuit, and even electro-magnetic transient (EMT) studies be performed during the interconnection process to adequately evaluate the impacts these facilities have on the bulk power system. However, there are many open questions surrounding the studies' use, including:

- Which grid reliability studies will be conducted for large loads (e.g., steady state, PSPD, short circuit, EMT)?
- Which entities will run these studies (utilities, ISOs/RTOs, others)?
- What new contingencies and operational conditions need to be studied?
- How will co-located large load facilities with paired generation be studied (e.g., gross or net with what conditions)?

Incomplete or Absent Performance Requirements

Performance requirements for large load facilities are incomplete or absent throughout the industry at the NERC, state, ISO/RTO, and utility levels, leaving gaps in



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the reliability oversight framework for ensuring bulk power system reliability.

- What performance requirements will be placed on the large load facilities at the very beginning of the interconnection process and throughout commercial operation (e.g., voltage and frequency ride-through, power factor requirements, ramp limits)?
- Which entities will define, mandate, harmonize, and enforce these performance requirements (utilities, states, ISOs/RTOs, NERC, FERC)?
- How and when during the interconnection process will conformity with these performance requirements be assessed? How will conformity be verified or tested during commissioning and monitored during the lifetime of the project?

Interconnection Costs and Network Upgrades

Cost allocation frameworks for large load interconnection substations/lines and transmission network upgrade costs lack the structure and clarity needed to protect all customers.

- How will allocation for direct interconnection costs and associated network upgrade costs be addressed for large load facilities?

Slow Speed of Large Load Interconnection

Speed to power is one of the primary drivers for most large loads today. As the industry evolves to handle these new facilities, the large load interconnection process must also evolve to become more efficient and consider new capabilities and grid interconnection arrangements that large loads bring with them.

- How can interconnection processes incentivize “bring your own generation” (BYOG)?
- How will transmission capacity limits and flexibility of large loads (non-firm transmission service) be factored into the large load interconnection process at different levels of the electricity system (distribution, sub-transmission, transmission)?
- How will new grid-service offerings (such as non-firm service, flexible service, surplus service) for large load

interconnection at the transmission and distribution levels affect grid planning and operational studies?

Recommendations

Based on the Large Loads Task Force’s review of current practices and challenges and drawing from the experience and expertise of task force participants including system operators, utilities, data center operators, regulators, and researchers, this report offers a set of recommendations to create a more harmonized, transparent, and efficient interconnection framework for large loads. The recommendations aim to preserve latitude for regional and local variation while establishing the consistency and rigor that large load integration demands.

Large Load Interconnection Process Overall

- The entities that are responsible for large load interconnection processes can follow the recommendations in this report to create more uniform, transparent interconnection processes across the U.S. that will help improve efficiency and speed of large interconnections. It is recommended that the processes be based on clearly defined milestones with readiness requirements that provide credible indication of project viability, roles and responsibilities, timelines, and cost allocation frameworks.
- The potential for development of a FERC Large Load Interconnection Procedure (LLIP) can be explored that establishes a baseline framework for large load interconnection under FERC jurisdiction, analogous to existing generation interconnection procedures, with transparent processes, defined milestones, timelines, and cost responsibility frameworks. States and non-FERC jurisdictional entities could consider adapting the LLIP for large load interconnections over which they have authority.
- The large load interconnection application packages, site control (land ownership, signed lease agreements, or options to purchase or lease land of sufficient size for the facility), and financial readiness requirements can be applied to filter speculative interconnection requests and reduce queue congestion driven by large load projects that lack the commitment to proceed. Harmonizing these requirements insofar as possible



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across the nation will further help to improve the clarity and efficiency of the large load interconnection process.

- Consistent financial security requirements can be implemented across all interconnection providers, including milestone payments and withdrawal penalties, to mitigate the risk of stranded infrastructure investment and ensure appropriate utility cost recovery from large loads.
- Material modification rules can be finalized to maintain the integrity of interconnection queues and study processes as project configurations evolve, balancing the need to accommodate technological change with the need to preserve study integrity and planning assumptions.
- Expanded use of hosting capacity maps early in the siting and interconnection process can guide large load developers toward locations with available grid capacity, reducing initial study complexity and queue processing time.

Large Load Interconnection Process Coordination

- Coordination among utilities and ISOs/RTOs needs to be enhanced throughout the interconnection process, including formal information-sharing protocols and

joint study procedures for facilities that interact with multiple grid layers.

- Queue transparency can be improved at both utilities and ISOs/RTOs, including harmonized treatment of duplicate requests and consistent application of interconnection requirements across service territories.
- Large load interconnections can be integrated into regional transmission planning processes, ensuring that the infrastructure needs of large load growth are reflected in long-term planning and cost allocation frameworks.

Large Load Interconnection Process Studies

- When the volume of large load connection requests exceeds a preset level, utilities and ISOs/RTOs can transition to cluster study approaches for large loads, consistent with reforms already underway for generator interconnection. This approach improves study efficiency and reduces the compounding delays created by serial study queues.
- For every large load interconnection, steady-state, PSPD, and short-circuit studies need to be performed that meet applicable NERC, ISO/RTO, and utility study requirements.

- A screening process can be established to determine when certain large load facilities require EMT studies and those studies performed for the large load facilities identified.
- Harmonized reliability study methods can be developed for studying co-located load and generation, including conditions under which they are studied as a single entity.

Large Load Interconnection Technical Requirements

- Clear performance and capability requirements for large loads can be developed that apply for the lifetime of these facilities. These include detailed technical modeling requirements for PSPD and EMT models that would be submitted as a part of the interconnection application and updated throughout the interconnection process as facility design and construction advances.
- Technical requirements and practices for assessing loads' conformity with the requirements can be unified across the U.S. grid to enable efficiency and consistency for all large load interconnections.
- NERC large load-specific reliability standards can be developed that address load modeling, performance and capability requirements, physical and cybersecurity, operational coordination, data sharing, emergency operating conditions, and other reliability topic areas. NERC has already started work to develop an interim set of requirements for large loads, to be followed by a more comprehensive applicable standards revisions effort.
- NERC can create an additional registration category that would specify which large loads would be subject

to mandatory enforceable requirements within its regulatory area. This separation of large loads in the compliance space can allow for the more efficient creation of technology-specific requirements that will help enhance bulk power system reliability without overburdening traditional large loads (e.g., industrial loads such as steel and glass production) or creating insufficient requirements that fit all large load types. NERC has already begun the work of creating and defining this large load registered entity.

New Solutions to Speed Up Large Load Interconnection

- Harmonized voluntary flexibility products can be developed, including provisional, surplus, and non-firm service options, to give large load customers more flexibility options and accelerate interconnection where firm service is not immediately available.
- Clear, consistent rules can be established for bring-your-own-generation arrangements and generation resources co-located with large loads. The rules will need to clearly define how a co-located resource is treated, modeled, and studied at each of the large load interconnection process milestones.

Staffing Resources

- Utilities and ISOs/RTOs need sufficient staffing resources to process the growing volume and complexity of large load interconnection requests.

Taken together, these recommendations provide a practical and technically grounded pathway toward a large load interconnection framework that supports the reliable, efficient, and timely integration of large load facilities into the U.S. electric power system.

Interconnection Processes for Large Loads: Current Practices and Recommendations, by the Energy Systems Integration Group's Large Loads Task Force, is available at <https://www.esig.energy/reports-briefs/large-load-interconnection-process>.

To learn more about ESIG's work on large loads, please see <https://www.esig.energy/working-groups/large-loads/> or send an email to info@esig.energy.

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