ESIG
Large Loads
Task Force

ESIG
ENERGY SYSTEMS
INTEGRATION GROUP

Transmission Planning with Large Loads

Current Practices and Recommendations

EXECUTIVE SUMMARY

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Electricity systems across the United States are experiencing a surge of proposed large loads that is materially different in both scale and speed from historical load growth. These new loads include data centers, artificial intelligence (AI) facilities, advanced manufacturing, and other large electricity users. The pace, scale, geographical concentration, and uncertainty associated with large load development are placing unprecedented pressure on transmission planning processes, which were largely designed around slower, more incremental patterns of load growth.

Unlike historical loads, new large loads often seek interconnection within a few years, far faster than transmission planning, permitting, and construction timelines can typically support. Some large load facilities can reach gigawatt scale, cluster in the same areas, and materially affect local and regional system needs. In addition, many proposed projects may not ultimately materialize, and the operating characteristics of completed projects can

The report examines how large loads are exposing structural weaknesses in current transmission planning and offers practical steps to shift planning from reactive responses to more integrated, durable, cost-effective outcomes.

See the full report—
Transmission Planning with Large Loads: Current Practices and Recommendations

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introduce additional uncertainty for planners. In many regions, near-term interconnection and reliability needs are increasingly driving large, expensive, and long-lasting transmission investments that may solve immediate problems but do not create durable headroom for other new loads and generators or address long-term transmission needs.

The dramatic growth in large load interconnection requests calls for a new approach to transmission planning. This report from the ESIG Large Loads Task Force's transmission planning project team examines how large loads are exposing structural weaknesses in current transmission planning and offers practical steps to shift planning from reactive responses to more integrated, durable, cost-effective outcomes.

Why Current Planning Processes Are Not Well Suited to Large Load Growth

Much of the current transmission planning effort in the United States is focused on meeting regional reliability and load-growth needs over a 10-year horizon following applicable North American Electric Reliability Corporation (NERC) and regional planning criteria.

Because these processes are designed to address immediate study needs and usually do not weigh broader system costs and benefits, they tend to select the lowest-cost project that solves the immediate and specific transmission need, even when a different solution would provide greater overall system value. More than 90% of transmission investment is still driven by these near-term, reliability-at-the-lowest-cost planning processes rather than through proactive, long-range, multi-value planning processes.

Under traditional load growth conditions, this combination of near-term reliability planning, separate interconnection studies, and project-by-project transmission development worked reasonably well for discrete, localized needs. Large loads strain current planning processes because they can trigger broader regional needs and require trade-offs across longer planning horizons, larger geographies, and a wider range of solution types.

Three Structural Challenges

Silos

Transmission planning in the United States is fragmented by function, time horizon, study method, and institutional and geographical boundaries. Load interconnection, generator interconnection, reliability planning, economic studies, asset management, and long-range planning often are separate planning processes with different timelines, tools, assumptions, and decision paths. The fragmentation of transmission planning extends across jurisdictions and geographies. Utilities, regional transmission organizations (RTOs) and independent system operators (ISOs), and state agencies operate with different responsibilities and approval paths.

The impact of a proposed large load can extend across a regional system and affect several of these planning functions. The same system need can therefore be examined several times in different ways by different teams on different schedules without producing one clear, comprehensive transmission plan for the area. The lack of planning consistency and communication across the planning silos makes it easier to move forward with the transmission projects developed to address the initial need—typically narrower-scope, local projects—rather than broader regional solutions that can provide greater overall value. Broader solutions avoid a string of piecemeal incremental upgrades that would come at a higher total cost.

Timing Mismatch

Large load development timelines, especially for data centers, are often measured in months to a few years. By contrast, transmission planning and development operates on 5- to 10-year planning, regulatory, siting, and construction timelines. This timing discrepancy leaves transmission planning largely reactionary and constantly in catch-up mode, which can bias planners toward projects that can move most quickly through the clearest study frame and approval path. That pressure can make near-term, narrowly scoped interconnection or local reliability fixes more likely, even when the underlying needs are broader and longer term.

Uncertainty

Large loads introduce a radically different level of planning uncertainty, one that current planning processes cannot address. Large load development is lumpy, location-specific, fast-moving, and highly contingent on commercial, technological, and policy decisions outside the control (and sometimes knowledge) of system planners. The result is substantial uncertainty about ultimate transmission needs, facility development rates, locations, configurations, and the extent of co-located generation/storage or self-supply. This makes it very difficult to establish a base case demand forecast and difficult to determine how much, when, and where transmission will be needed.

Updating Planning Practices to Meet the Needs of Both Large Loads and the Grid

These planning deficiencies are structural and call for a range of responses that can be implemented on different timelines. Some actions can be taken now to improve visibility into where the grid can serve load, make better use of existing capacity, and reduce the risk that near-

term decisions lock in poor long-term outcomes. Other changes require more substantial adjustments to planning methods, study assumptions, and transmission development practices.

Urgent Actions

Determine and Make Visible Where the Grid Can Serve New Large Loads–Now and in the Future

Large load planning benefits from a clear view of where the grid can serve new loads now, where that capability can be expanded quickly, and how those near-term actions fit into likely longer-term transmission development. Headroom studies and system-capacity maps can make that information visible by distinguishing between transmission capacity available now and capacity that could be created quickly with targeted actions. This information can steer large load requests toward locations that are more likely to be workable and reduce the likelihood that the same system limitations are rediscovered through multiple serial project interconnection requests.

Use Tools to Expand Fast-Service Options

Advanced transmission technologies can complement new transmission lines by creating near-term capacity and expanding interconnection headroom while larger transmission solutions are still being planned, permitted, and built. Operational tools, including remedial action schemes, can also increase effective headroom or usable transfer capability under defined conditions on either a temporary (bridge) or a permanent basis. These measures belong in the candidate solution set alongside more conventional transmission options.

Short-lead-time measures are most useful when they help address near-term needs while preserving room for efficient long-term solutions.

Make Co-location and Load Flexibility Real, Visible, and Usable

Large load flexibility, co-location with generation and storage, and self-supply can reduce transmission upgrade requirements, accelerate transmission service, and create a more manageable operating envelope, but only if those characteristics are clearly defined, visible, controllable,

and enforceable in grid operations and the interconnection and transmission planning studies that rely on them.

Large load flexibility and options for co-located resources can be included in planning assumptions only when they are operationally credible and reflected in operating procedures, interconnection agreements, and applicable tariff and market rules. These arrangements can materially increase interconnection headroom and reduce the need for transmission expansion. As such, planners need to prioritize codification of the grid-operating rules defining large load flexibility and co-located resources.

Use a Coordinated Set of Assumptions and Information Across Studies

Current planning for large loads breaks down in part because different planning functions often use different study assumptions, have disconnected workflows, and address different versions of the same underlying problem. A coordinated planning response requires one set of facts: shared assumptions, shared data, and shared cases. Planners across different functions can work to develop a common large load dataset, common scenario definitions across studies, and linked analytical workflows across interconnection studies, reliability planning, economic studies, and longer-horizon planning.

Using a common assumptions log, a needs-and-constraints list, and a large-load data repository can help align studies across planning functions, enabling

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comparisons of multiple transmission solutions and supporting the selection of a more consistent regional portfolio solution.

Near-Term Fixes

In addition to the immediate actions listed above, planners need methods that can test multiple plausible futures, identify scalable options, and compare how different transmission strategies perform when realized conditions differ from expectations.

Use Scenario-Based and Least-Regrets Planning

Scenario planning can explicitly address the uncertainty posed by large load development by testing how transmission plans perform across a range of plausible futures. A least-regrets approach allows for the selection of solutions that perform well across several plausible futures while limiting negative consequences when reality diverges from expectations. Flexible, scalable transmission solutions can be designed to preserve options rather than narrow them.

In fast-growing areas, planners need to assess whether proposed solutions are effective across a range of plausible futures and whether the consequences of underbuilding may outweigh the cost of spending more at the outset. These trade-offs can be quantified using a scenario-based least-regrets planning framework, which can compare serial local fixes, staged regional reinforcements, larger regional or more flexible solutions, and combinations of transmission and operating measures.

Design Near-Term Projects for More Robust Long-Term Outcomes

Upgrades to address near-term needs must be tested not only for whether they solve the first identified constraint but also for how well they preserve cost-effective expansion paths if load growth continues, clusters more tightly, or materializes faster than expected. The cost of responding to uncertain large load build-outs can be reduced through more flexible solutions, such as staged construction, higher-voltage-ready structures, transmission paths and substations designed for future expansion, and technologies that can be repurposed or augmented over time. A "future-fit" check can help keep a near-term transmission project from inefficiently limiting future options by testing whether it preserves attractive expansion opportunities if load in the area continues to grow.

Longer-Term Structural Solutions

New large loads are often large enough, fast enough, and uncertain enough that the planning process needs to be able to identify longer-term comprehensive transmission needs before repeated project-level decisions lock in inefficient outcomes.

Shift from Project-by-Project Upgrades to Proactive Long-Term Planning

Transmission planning should evaluate near- and longer-term, region-wide transmission needs more comprehensively across multiple planning processes. The Midcontinent Independent System Operator's (MISO's) Long Range Transmission Planning process is an example of a study that evaluates multiple transmission needs over a 20-year horizon on a multi-benefit basis. A similar approach can be applied to planning for large loads, using robust scenario development and analysis of least-regrets transmission solutions. Scenario-based, multi-benefit, long-term planning is also required by Federal Energy Regulatory Commission (FERC) Order 1920.

Reducing the separation between siloed planning functions is a related but distinct improvement. The Southwest Power Pool's (SPP's) proposed Consolidated Planning Process is one example of a more explicit effort to bring the different planning tracks together. Full

consolidation is not the only way to improve the process, though. Stronger coordination, shared assumptions, better hand-offs, and broader evaluation across existing planning processes can also move regions in the right direction. Together, these changes can move planning away from repeated short-term fixes and toward transmission solutions that better meet overall system needs.

Use Location Signals and Development Zones to Guide Growth

Consideration of the interplay between planning decisions and future large load interconnection requests can reduce unrealistic queue growth, improve siting decisions, and distinguish between places where load can be served now, where near-term tools can create access, and where larger transmission development will still be required.

States, utilities, RTOs/ISOs, transmission owners, regulators, and other stakeholders can work together to identify likely large load development zones and support development of the transmission capacity needed to proactively meet future interconnection requests in these locations. Texas's Competitive Renewable Energy Zones (CREZ) process provides an example of such a locational-development approach. The CREZ process identified generation development areas in advance and proactively built transmission to reach them, rather than waiting to serve projects one interconnection request at a time. The highly localized clustering of large load interconnection requests suggests that a similar approach could support more timely, cost-effective transmission solutions for large loads.

Use Comprehensive and Coordinated Planning to Inform Transmission Decisions

More efficient, coordinated, and consolidated processes can preserve planners' ability to evaluate scalable, multi-driver solutions instead of relying on incremental fixes that narrow the options for more efficient future grid solutions. Multi-driver, multi-benefit, and portfolio-level evaluations are especially useful when the same part of the system is simultaneously affected by reliability, interconnection, congestion, resilience, and broader regional needs.

Regional and interregional transmission solutions can create significant transmission capacity for load and generator interconnections, address future transmission needs, reduce congestion and losses, improve resilience, and reduce regional resource adequacy requirements. The Joint Targeted Interconnection Queue study by SPP and MISO illustrates this point. It identified upgrades to support 9 GW of existing generator interconnection requests and enable another 20 GW near the seam at about half the cost of the regions' more incremental queue-driven processes. MISO's long-range multi-value portfolios provide another example of broader, multi-benefit evaluation, with estimated benefit-cost ratios of 1.8 to 3.8 and support for roughly 136 GW of generation.

A More Proactive, Coordinated, Long-Term Approach

Large loads do not simply create more demand. Their size, speed, concentration, uncertainty, and configurations require fundamental changes to grid planning. Meeting these new challenges necessitates transmission planning processes that can address near-term needs without losing sight of the longer-term system they are shaping.

Transmission Planning with 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/transmission-planning-large-loads.

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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