ESIG
Large Loads
Task Force

ESIG
ENERGY SYSTEMS
INTEGRATION GROUP

Forecasting for Large Loads

Current Practices and Recommendations

EXECUTIVE SUMMARY

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After two decades of relatively flat demand, the U.S. electricity system is projected to grow significantly over the next few years. Utility load forecasts project an increase in peak demand on the order of 166 GW by 2030, a 20% increase from estimated peak load in 2025. Data centers are expected to account for roughly 55% of projected demand growth, with other new large loads accounting for most of the remaining growth.

While there is consensus that several U.S. regions will experience significant load growth, its pace and scale remain uncertain. Reflecting that uncertainty, the same aggregate U.S. utility load forecasts from only three years ago, in 2022, projected peak demand growth of just 24 GW. Utility forecasters must manage this uncertainty to develop accurate forecasts that are used to inform resource and transmission planning.

Inaccuracies in load forecasts have important consequences. Load forecasts that underestimate actual demand can lead to both resource adequacy risks and a risk of under-serving customers due to insufficient infrastructure. Conversely, load forecasts that overstate demand could result in higher electricity prices to utility customers for energy facilities built in excess of actual need. If load forecasts are inaccurate, they make it hard for utilities to efficiently plan and construct the necessary generation, transmission, and other facilities needed to serve new large loads together with other loads.

See the full report—
Forecasting for Large Loads : Current Practices and Recommendations

FIGURE ES-1

Five Large Load Characteristics and Forecast Metrics

Project Realization	Energization Date	Load Realization	Load Ramping	Load Factor or Load Shape
The rate at which projects included in the load forecast are placed in service • Often presented as a percentage of project requests expected to come to fruition	The beginning of commercial operation by projects, including anticipated delays	The forecast peak load that the project is expected to require once it's fully scaled up • Often presented as a percentage of requested peak load	The monthly or annual forecast of demand during the startup period of commercial operation • Often presented as a percentage of requested peak load	• Load factor: Actual energy use as a proportion of facility capacity • Load shape: More detailed information on power needs, for example, an hourly schedule of energy use

Large load forecasts can characterize and evaluate new loads using five core metrics: project realization, energization date, load realization, load ramping, and load factor/load shape. Together, these describe whether, when, and how completely large load projects materialize and how they use electricity over time. Applying these metrics consistently improves comparability and transparency across forecasts.

Source: Energy Systems Integration Group.

Load forecasting is more difficult today than at any time in the past several decades. To date, the vast majority of load forecasts have used traditional econometric load forecasting techniques based on historical data. Most of that growth came from residential, commercial, and industrial customers whose individual loads were not often large enough to require special adjustments to the forecast. But emerging large loads—including data centers, manufacturing, and electric vehicle fleet charging—differ from traditional sources of demand growth. For most of the U.S. now, the large load forecast is *the* load forecast that matters.

Findings of the Large Loads Task Force

The lack of historical data on many of these new types of facilities and the rapidly evolving technology driving this load growth present novel challenges for load forecasters and grid planners. The Load Forecasting Project Team for ESIG's Large Loads Task Force offers the following nine findings.

Finding 1: Large load forecast methods lack transparency and consistency.

After reviewing over two dozen large load forecasts spanning diverse regions of the U.S., the project team found significant inconsistencies in how load forecasts describe and assess large loads. Ideally, each large load forecast would characterize and evaluate new loads using all five metrics shown in Figure ES-1. These metrics can be applied both to individual project loads and to other energy and demand included in the large load forecast.

Finding 2: Customer-supplied data and historical data are currently insufficient for accurate forecasting.

For most load forecasts, large loads—particularly data centers—have become a planning challenge only in the past few years. Project maturity can affect whether projects are factored into load forecasts through the project realization metric as well as the degree of confidence applied to other load forecast metrics supplied by customers. Many utilities find customer-

supplied data to be unreliable in certain respects, and because the load growth has occurred recently and suddenly, they have little historical data to rely on. Due to customer privacy and competitive business concerns, data sharing between utilities is rare. The resulting lack of data is a significant obstacle to accurate forecasting.

Finding 3. Load forecasts are using weighting methods and thresholds to evaluate prospective load.

While the new large load interconnection "pipeline" likely totals several hundred gigawatts of load, not every project discussed with utilities will be built. Utilities and regional grid planners are using several methods to estimate large load growth because many customer requests will not lead to completed projects (project realization), some completed projects will be smaller than initially requested (load realization), and completion schedules will slip (energization date and load ramping). To address these realities, load forecasts may simply exclude all requests that are not yet fully contracted for service. If a load forecast includes customer requests that are not yet fully contracted for service, the forecast may discount the load and may also adjust the schedule, accounting for delays relative to the customer's request. These weighting methods and thresholds reduce the large load forecast from several hundred gigawatts in the U.S. pipeline to a forecast that makes up the majority of a five-year load growth forecast of "just" 166 GW.

Finding 4. Some large load forecast practices insufficiently differentiate between types of large loads.

In addition to data centers, large load requests include several types of industrial and manufacturing facilities, oil and gas production loads, mining projects, and large fleet and public charging stations for electric vehicles. Yet some forecasts use the same weighting methods and thresholds for all types of large loads with little differentiation, despite substantive differences between load types. This practice is also common within broad large load categories, with different types of data centers forecast using the same weighting methods and thresholds. In many forecasts, the practices used for differentiating and forecasting large load types are not described transparently.

Finding 5. Data centers have distinctive characteristics that increase uncertainty compared to other large loads.

These characteristics include the following:

- Very large technology firms are developing data centers at multiple sites—sometimes served by a single utility but also spanning multiple regions. Shifting business plans and cancelling projects has greater potential to significantly reshape utility needs than project cancellations by other large load customers.
- Customer service requests from data centers often include incomplete engineering plans, yet seek rapid completion schedules.
- Data center development depends on an unusually complex set of supply chains and contractors. Collectively, these limited resources will constrain aggregate data center growth.
- Novel technologies, such as new artificial intelligence (AI) training, may yield load shapes that differ from those anticipated by the data center owner. While some utilities successfully apply historical data in planning for new large loads, gigawatt-scale AI projects are unprecedented.

Finding 6: Data center developers do not generally share alternative site locations and plans with utilities.

For the most part, individual utility large load forecasts generally do not consider whether prospective customers

may be considering alternative sites within or outside their service territory because they lack awareness of those alternative sites. Some utilities and grid planners are introducing requirements for data center developers to report this information.

Finding 7: Most large load forecasts do not have much geographical detail for all proposed projects, only for contracted projects.

For prospective load, utility and regional system plans do not usually include specific locations for long-term load growth. That makes it difficult to plan how to build out the transmission system to serve future large loads individually and collectively.

Finding 8: Utility rate tariff reforms are helping to reduce load forecast uncertainty.

For example, one utility has significantly reduced its large load forecast after regulatory approval of a tariff that requires an applicable large load to meet certain development milestones.

Finding 9: Few large load forecasts include any meaningful consideration of load flexibility.

However, EPRI, the Lawrence Berkeley National Laboratory, and others are exploring large load flexibility as a means to more rapidly integrate new loads and reduce utility capital costs while meeting reliability and other grid needs.

Recommendations of the Large Loads Task Force

The Large Loads Task Force makes the following 10 recommendations on load forecasting.

Recommendation 1: Use all five large load metrics to create a large load forecast.

A well-structured large load forecast will clearly describe, collect applicant data for, and use the five large load metrics (project realization, energization date, load realization, load ramping, and load factor or load shape) (Finding 1, Figure ES-1, p. 2) to characterize and weight information about large loads used to construct the large load forecast. Weighting factors for each load forecast metric could be informed by a maturity assessment, ideally as described in Recommendation 9. This can include thresholds for considering or excluding project information in load forecast development: projects that do not meet certain maturity thresholds may not be considered in the load forecast.

Recommendation 2: Develop a consistent framework to differentiate among types of large loads.

A large load classification system can help to consistently identify large load types across forecasts. Building a database of large load forecast metrics, as discussed in Recommendation 8 below, could inform a load classification system. A forecast that effectively differentiates among large loads will:

- Create classifications to include facilities with similar business purpose and load forecast metrics (project realization, energization date, load realization rate, load ramping rate, and load factor or load shape) and common characteristics such as size and site weather conditions
- Obtain and manage customer data by load type
- Develop a forecasting framework with modeling and validation practices that use similar data and methods for load types with similar maturity in terms of historical experience and predictability of outcomes
- For load types with different levels of maturity, differentiate modeling and validation practices to

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reflect the levels of uncertainty associated with each load and customer type, for all five large load metrics

Recommendation 3: Account for uncertainty.

Optimal planning of transmission and generation investments means accounting for uncertainty in both front-end and back-end risk. Front-end risks refer to uncertainty in the quantity and timing of infrastructure needed to serve new loads. To address these risks, forecasts are often structured around thresholds for project inclusion and weighting of project realization, load realization, and other load metrics to predict outcomes consistent with historical experience, using professional judgment. Back-end risks center on whether the infrastructure and investments built to serve new loads will remain used and useful over the infrastructure's lifetime. Many large load forecasts do not currently address back-end risks and overlook future attrition or systemic risk of customers reducing or cancelling service. This omission could lead to inefficient or excessive utility or regional infrastructure investments.

Recommendation 4: Increase certainty through large load financial requirements.

The main method used by utilities and regional planners to reduce near-term uncertainty is to modify tariff and contract requirements for large loads by requiring various forms of financial commitments and security from the applicant. Because so many large loads have huge financial resources, with single companies clustering several facilities on one utility system or building gigawatt-scale projects, such reforms by themselves are unlikely to remove all major uncertainties. Disclosure requirements and customer-sited generation are emerging practices to reduce uncertainty and financial risks for utilities, transmission planners and operators, and ratepayers.

Recommendation 5: Reduce uncertainty in regional large load forecast practices.

Consistent with Recommendations 2 and 8, regional transmission authorities and the Federal Energy Regulatory Commission are beginning to standardize requirements for customer-supplied information and formalize procedures for evaluating that information. This will help improve the accuracy of large load forecasts. While there are challenges to adopting a uniform interconnection request framework and forecast methodology, greater consistency in terminology, classifications, and ways that regional forecast methods relate to utility forecast methods could improve understanding and quality of large load forecasts.

Recommendation 6: Improve geographical detail.

Large load forecasts may need to incorporate information on large load project geographical locations by geographical zones or subregions and determine how to geographically allocate future large loads for planning purposes. This is particularly important for regional transmission planning authorities.

Recommendation 7: Seek continuous improvement through forecast validation.

As large load forecasting evolves and more information becomes available about the actual performance of large loads connected to the grid, it will be helpful to use this information to validate and improve future large load forecasting models and methods.

Recommendation 8: Collect large load forecast data in a shared database.

Nearly every large utility needs access to historical data for each type of large load, but most don't have such data. A national database would help solve this problem. Establishing such a database will require developing a framework for obtaining, managing, and protecting anonymized customer data; categorizing those data by large load type (Recommendation 2); and creating specifications for each large load metric. The database could begin with a simple set of metrics (including differentiating between large load types) and progress toward more complex metrics.

Recommendation 9: Apply consistent load-weighting and modeling practices.

In line with the North American Electric Reliability Corporation's preliminary draft reliability guideline, the electricity industry could adopt a project maturity assessment framework to define the phases of a large load project's development path and use them for consistent load-weighting and modeling for large load forecast development.

Recommendation 10: Adopt forecast standards for load flexibility.

As large load flexibility options evolve, large load forecasts could add load flexibility metrics used to characterize the loads in the forecast process (Recommendation 1) and treat flexibility consistently across all planning activities. While quantifying load flexibility services from data centers is challenging today, work is progressing to identify load flexibility strategies, including operational services as well as load management or reduction services, that could be included in load forecasts.

Forecasting 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/large-loads-task-force/forecasting/.

To learn more about the topics discussed in this report and in the Large Loads Task Force overall, please send an email info@esig.energy.

The Energy Systems Integration Group is a nonprofit organization that marshals the expertise of the electricity industry's technical community to support grid transformation and energy systems integration and operation. https://www.esig.energy.