Utility Experiences and Trends Regarding Data Centers

2024 Survey



Project Manager
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Abstract

Providing power for data centers (DC) is a growing challenge for the electric power industry, both due to the load growth from DCs in aggregate and the increasing power demand of individual DCs related to cloud and artificial intelligence (AI) applications, for example, training large language models (LLMs). Despite many anecdotal reports on DC development, there is limited broadscale information available regarding utility interconnection requests and how utilities analyze and review these requests. This report summarizes a survey conducted in May–July 2024 to assess present utility DC service requests, processing and analysis of those requests, and integration into load forecasting. The results highlight shared challenges regarding powering DCs and the need for industry-wide collaboration.

Keywords

Data centers
Interconnection requests
Large loads
Load forecasting
Load growth
Program on Technology Innovation

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Executive Summary

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Primary Audience: Transmission planners, distribution planners, and load forecasters

Secondary Audience: Transmission operators, distribution operators

KEY RESEARCH QUESTION

What is present utility understanding and leading practices addressing data center (DC) service requests and integrating those requests into planning and operation processes?

RESEARCH OVERVIEW

This document summarizes results from a utility survey conducted by EPRI regarding DCs. The survey was distributed to utilities across the globe, with responses collected May–July 2024. A total of 25 utilities responded, which included both transmission and distribution utilities from the United States (22 utilities), Canada (two utilities), and Europe (one utility).

KEY FINDINGS

- Current DC interconnection requests are trending to larger sizes, with 60% of the 25 responding utilities having requests for 500 MW or larger and 48% with requests for 1,000 MW or larger. None of the responding utilities have existing DC connections greater than 500 MW.
- All responding utilities have current DC requests that, in aggregate, exceed their operational DC connections. Almost half have requests that exceed 50% of their present system peak demand.

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Executive Summary

KEY FINDINGS (CONTINUED)

- Some utilities have already experienced operational impacts from connected DCs, with the most common impact being increased load ramp rates (26% of responding utilities).
- Most responding utilities (75%) presently use their standard large load service request process for DCs, rather than a DC specific process.
- There is no consensus among the responding utilities on how to incorporate DC service requests in their load forecasts but there are shared challenges given the speculative nature of some service requests.
- The majority of responding utilities project DC loads to be a significant portion of their peak load in five years, including almost half (48%) predicting that 10% or more of their five-year forecasted peak will come from DCs. In comparison, only 23% of responding utilities have existing DCs whose sum capacity is equal to 10% or more of their current peak load.

WHY THIS MATTERS

Data centers are increasing their power demands substantially across the globe, driven in part by emerging artificial intelligence (AI) technologies such as large language models (LLMs). This document provides insights into utility trends and practices regarding DC interconnection requests, including how utilities are handling the growing number and size of DC interconnection requests.

HOW TO APPLY RESULTS

These results provide insights into current industry practices for assessing DC interconnection requests, analyzing and evaluating such requests, and incorporate such requests into load forecasts. The results can be leveraged by stakeholders throughout electric utilities, such as transmission planners, distribution planners, load forecasters, and executive leadership.

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Executive Summary

LEARNING AND ENGAGEMENT OPPORTUNITIES

- This report was prepared as part of EPRI's Load Forecasting Initiative. Emerging topics in load forecasting are discussed at the Load Forecasting Interest Group meetings. More information about the initiative, including how to receive the Load Forecasting Initiative newsletter and get invitations to initiative meetings, can be found at: https://msites.epri.com/lfi

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PROGRAM: Technology Innovation (TI)

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Introduction

Background and Motivation

- Data centers play a central role in supporting the use of cloud computing and digital services across both the public and private sectors.
- Emerging AI technologies such as LLMs are contributing to rapid growth in DCs and their associated electric power demands, both in aggregate and at the local grid level.[1]
- Meeting the increased power demands of DCs poses a variety of challenges for the electric power industry, which are expected to require coordinated efforts across industry, academia and government.[2] This is expected to include collaboration between electric utilities and DC developers, owners/operators, etc., on topics such as the interconnection request process, load forecasting, and load flexibility.
- Collaboration and coordination efforts on this topic will benefit from knowledge sharing. However, to date, there is limited information across electric utilities regarding the DC interconnection request process.
- To help remedy this lack of shared knowledge, **EPRI conducted a survey to learn about how utilities assess, process, and analyze DC service requests, and integrate those requests into load forecasts.**
- The rest of this document summarizes the survey responses and key learnings.

[1] *Powering Intelligence: Analyzing Artificial Intelligence and Data Center Energy Consumption*. EPRI, Palo Alto, CA: 2024. 3002028905.

[2] *Recommendations on Powering Artificial Intelligence and Data Center Infrastructure.* U.S. Department of Energy: Secretary of Energy Advisory Board. July 2024. https://www.energy.gov/sites/default/files/2024-08/Powering AI and Data Center Infrastructure Recommendations July 2024.pdf

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Survey results collected May–July 2024

- **Responses from 25 utilities** (transmission, distribution, and co-ops)
  - 22 U.S. utilities
  - 2 Canadian utilities
  - 1 European utility

- Responses included staff with Transmission Planning, Distribution Planning, and Load Forecasting roles/responsibilities

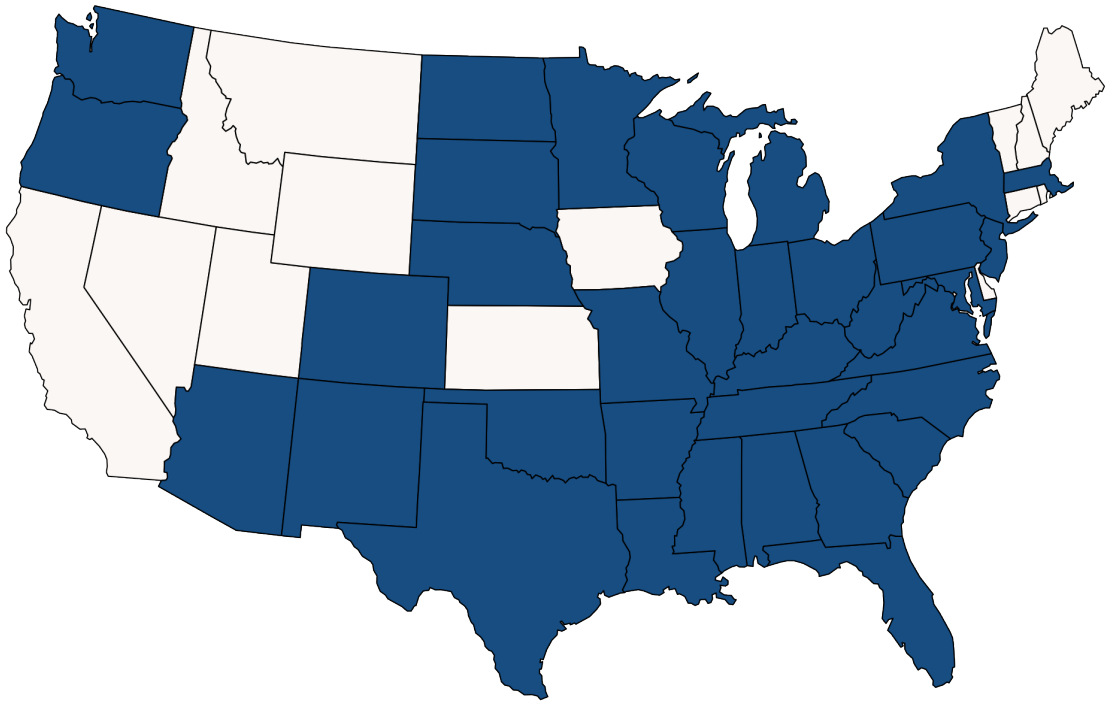


Figure: States where one or more responding utilities operate are shown in **blue**.

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Data Center (DC) categorization used in the survey*:

- **Hyperscale (aka cloud):** Large-scale DCs owned and operated by a cloud service provider, for example, Amazon Web Services (AWS), Google Cloud and Microsoft Azure, who sell digital services to individuals and companies based on its computing infrastructure
- **Enterprise:** Private DCs owned and operated by a company to meet its own computing needs
- **Colocation (aka colo or multi-tenant):** DCs owned and operated by a company that leases space to other organizations to house their servers
- **Connectivity:** Telecommunications service providers (for example, Verizon and AT&T)

*We did not to include crypto mining facilities in our survey.

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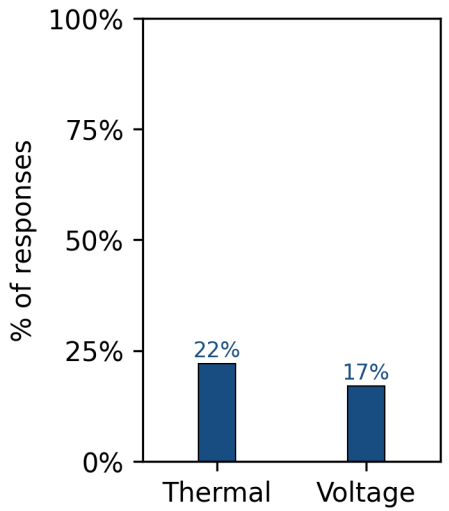
Examples of how to interpret plots in this report:

(a) % of responses plot

Question: have existing DCs caused any thermal or voltage violations? [select all that apply]

Results: 23 utilities responded:

- 22% selected thermal
- 17% selected voltage



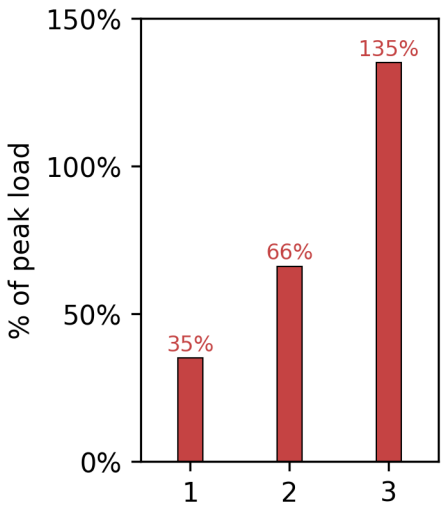
How to interpret:

- Of the 23 utilities who responded to this question, 22% (five utilities) have experienced thermal violations and 17% (four utilities) have experienced voltage violations.
- Some utilities have experienced both thermal and voltage violations, but the plot does not show that result.

(b) % of peak load plots

Question: as a percentage of present peak load, what is the aggregate amount of DC requests under review?

Results: Utility 1 answered 35%, Utility 2 answered 66%, and Utility 3 answered 135%



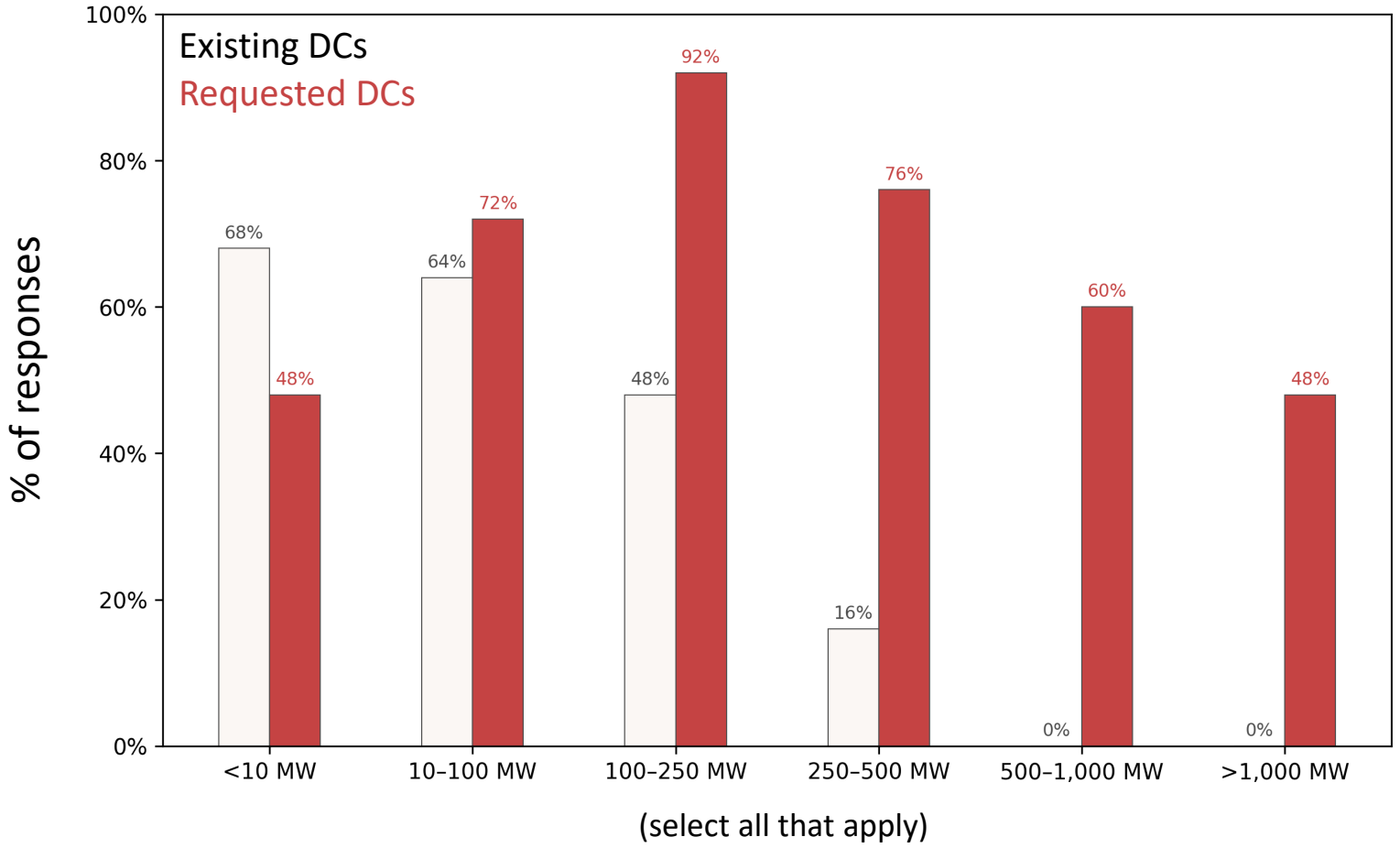
How to interpret:

- If Utility 3 adds up the GW size of all DC requests under review, the total GW value is equal to 135% of Utility 3's 2024 peak load. For example, Utility 3 might have 5.4 GW of requests vs a 4 GW peak load (5.4 GW / 4 GW = 135%).
- The plot does not show each utility's peak load to avoid identifying the utilities.

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Data Center Trends

Data Center interconnection requests trending to larger MW sizes*



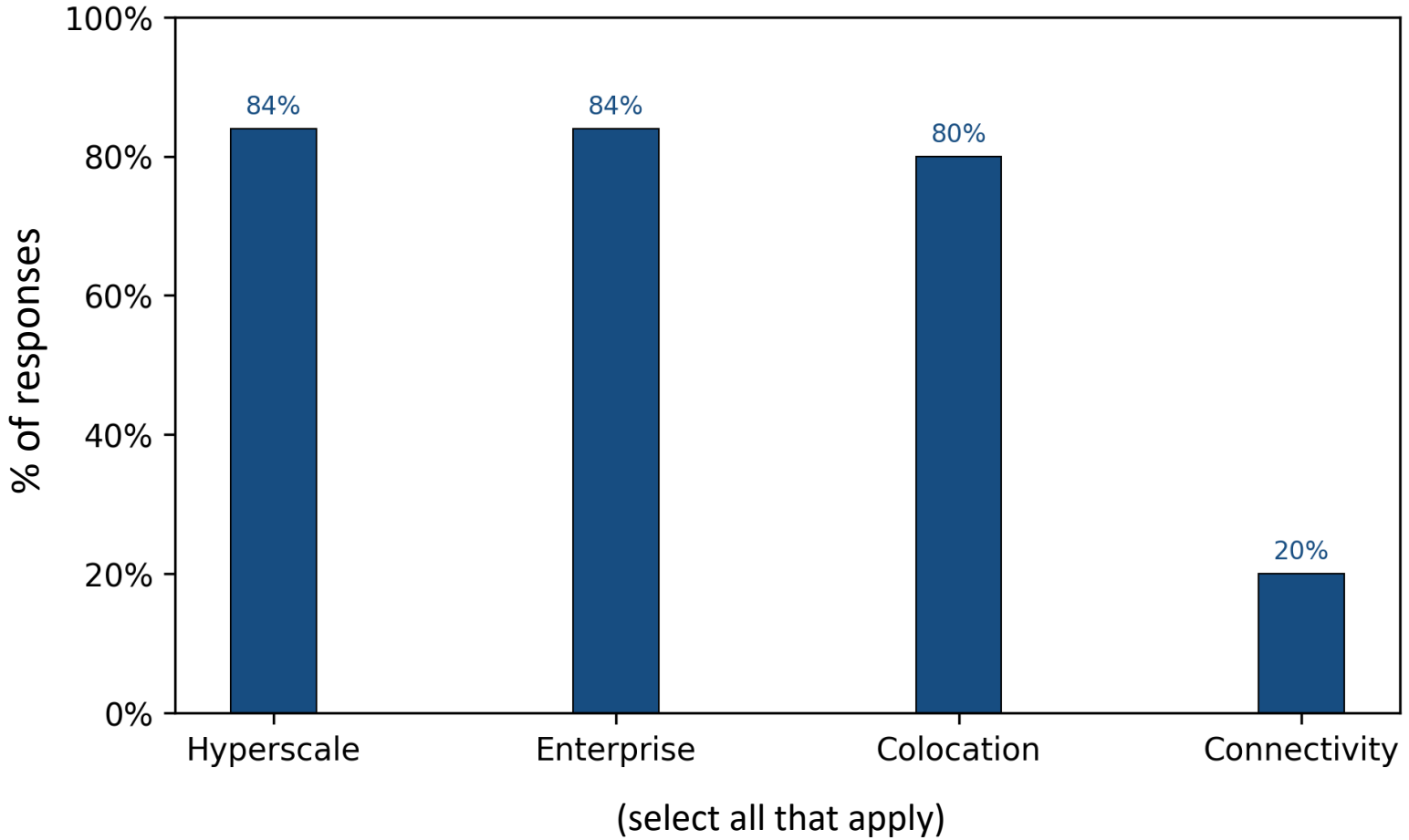
Not shown in this plot, but of the 25 responding utilities:

- 92% serve DCs today but all are <500 MW and most are <100 MW
- 100% have DC interconnection requests under review

*The corresponding survey question asked which sizes of DCs are requesting interconnection, not how many requests of each size.

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Majority of responding utilities have interconnection requests from multiple DC types*

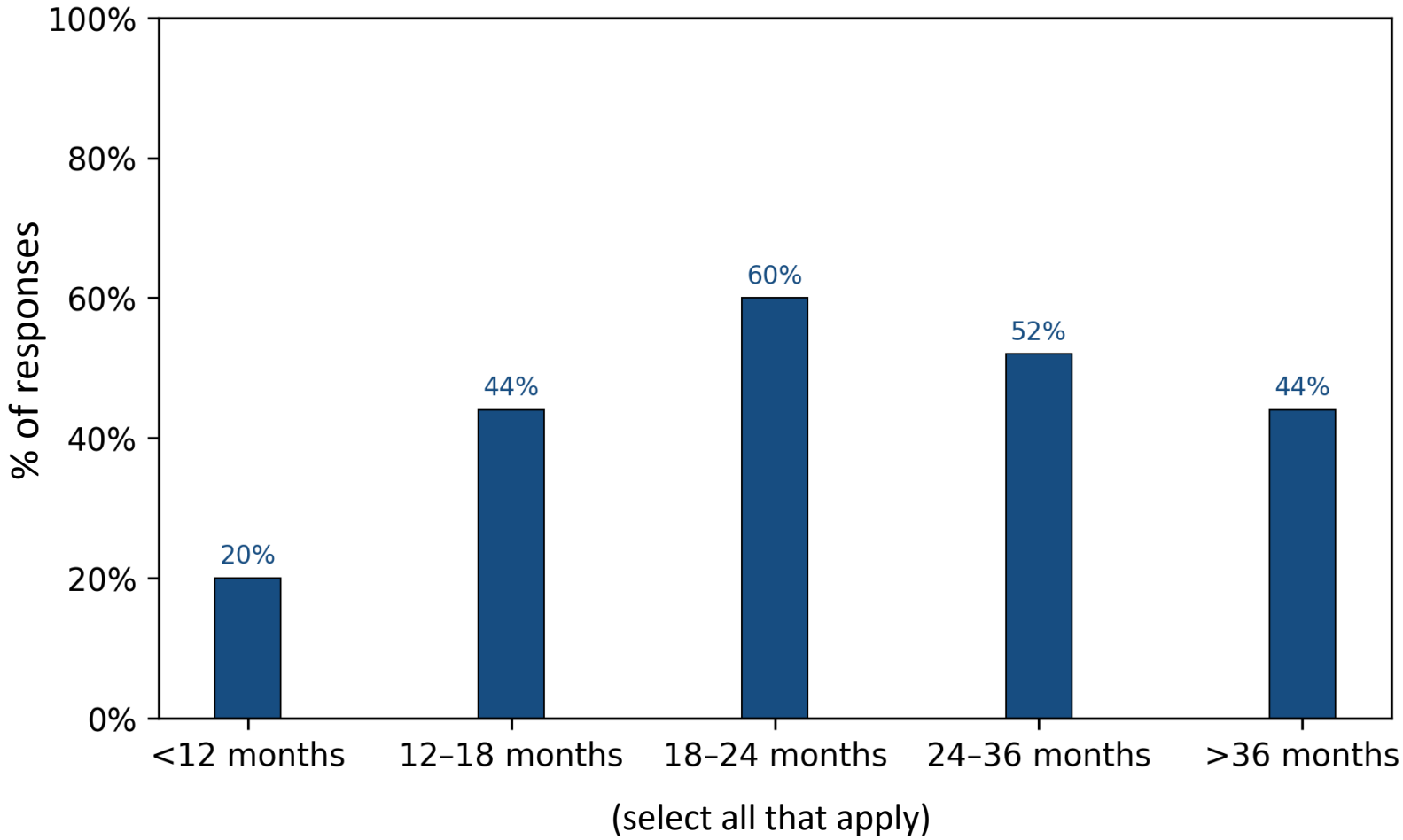


12% of utilities did not select any of the given options, citing a lack of DC classification for DC interconnection requests.

*The corresponding survey question only specified which types of DCs are requesting interconnection, not how many requests of each DC type.

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Requested lead times are usually 36 months or less, with almost half reporting lead times of 18 months or less*

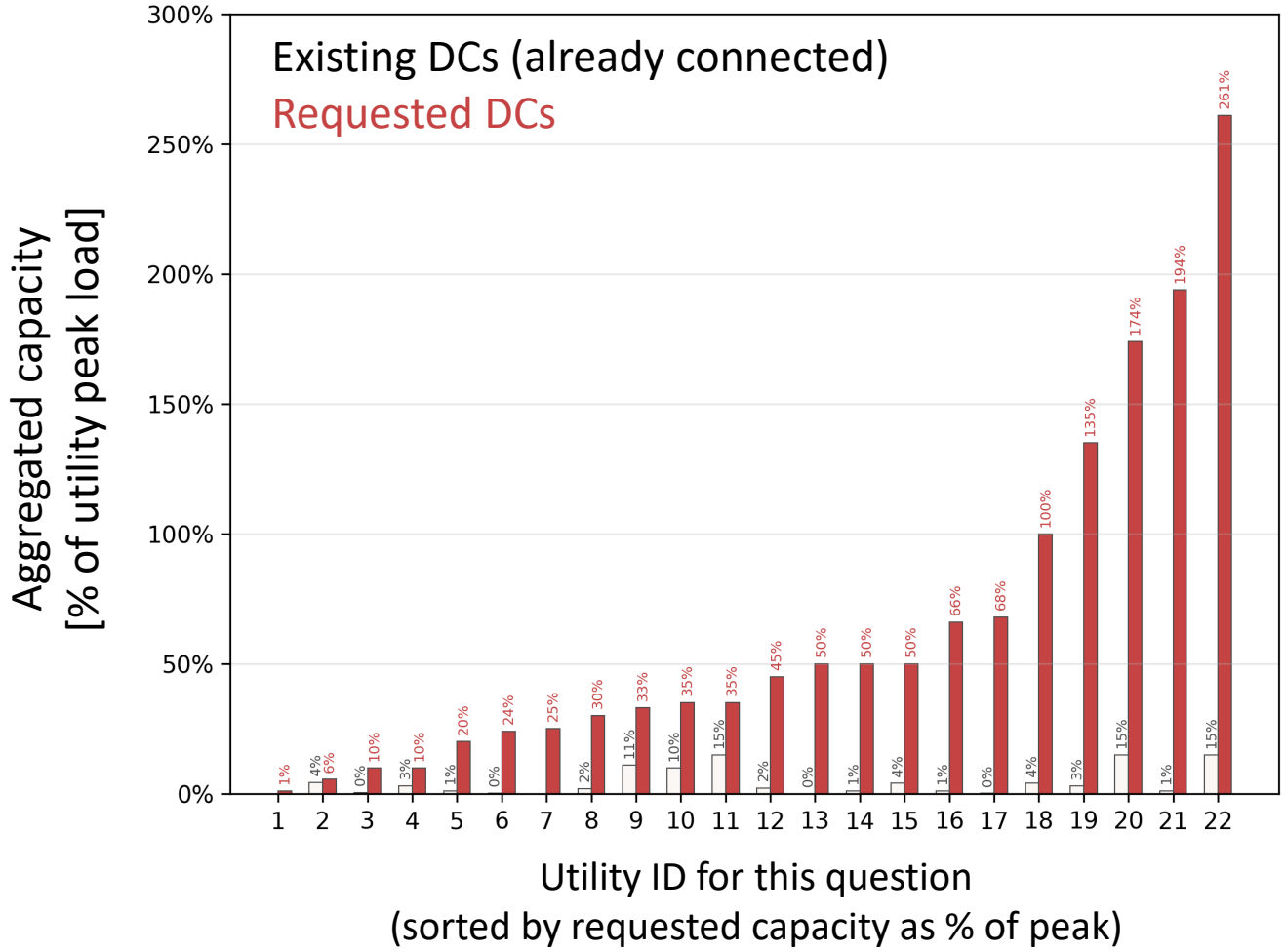


Larger requests can have longer lead times due to required transmission upgrades or supply chain challenges.

*The corresponding survey question only asked which lead times are typical.

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Data center requests exceed current connections for all 22 respondents and ≥50% of system peak demand for 10 respondents

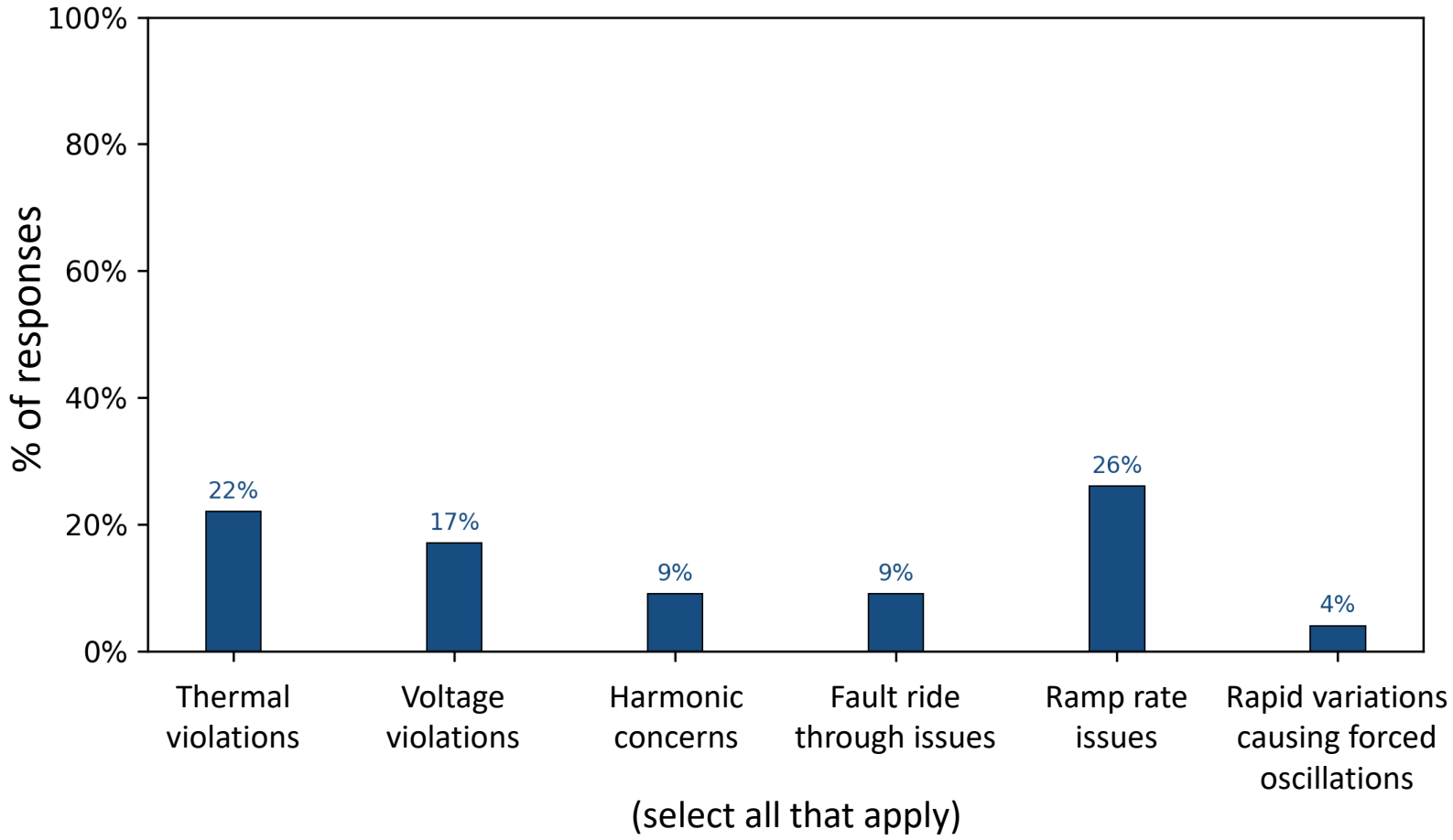


Out of 22 utility responses:

- 23% reported total aggregate DC requests ≥100% of their present peak load
- Most utilities with requests ≥100% of system peak range from ~10–25 GW currently

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Some utilities have experienced operational impacts from existing DCs*



Not shown in this plot, but of the 23 responding utilities (who all have existing DCs):

- Four of the five utilities who have experienced thermal violations have also experienced voltage violations
- The two utilities who have experienced harmonic concerns also experienced thermal violations, voltage violations, and ramp rate issues.

*The corresponding survey question only asked whether such impacts had been experienced, not the magnitude or frequency of the impacts.

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Other data center interconnection request trends:

- **DC customers having special needs for power supply** (compared to other large point load/industrial customers), including:
  - Higher reliability (83% of responses)
  - 24/7 Carbon Free Energy (CFE) (57% of responses)

- **DC customers requesting to increase import capacity** at existing/operational DC sites:
  - 28% of responding utilities have already had formal requests submitted
  - Another 44% of responding utilities have not had requests but anticipate requests in based on customer discussions

- Utility programs to **incentivize DCs to provide grid services** if available (for example, during high-risk grid hours)
  - 20% of responding utilities already have such programs
  - Another 40% of responding utilities are considering such programs

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Planning with Data Centers

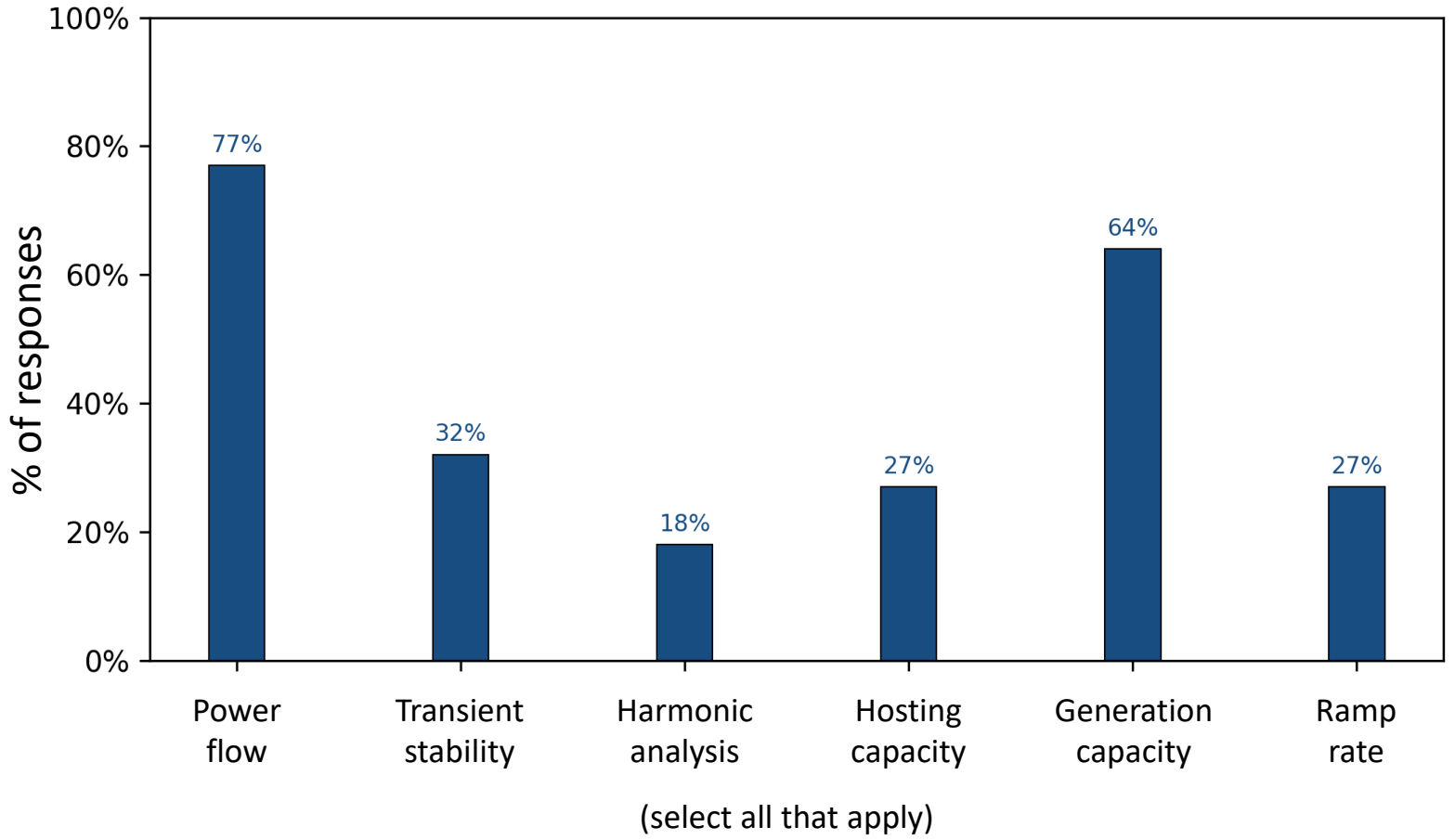
General trends in planning processes with DCs

- Most **do not** presently have a formal DC interconnection queue process to manage service requests
  - Presently, 75% of responding utilities use their standard large load service request process for DCs

- Most (68% of responses) are using **general load models** (no specific DC representation) to analyze requests
  - A few (4% of responses) have a specific DC model, but note that their models are not well validated or need improvement

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Multiple types of operational analyses are considered in evaluating a new DC transmission interconnection request



Not shown in this plot, but of the 22 responding utilities*:

- Only one utility considers all six analyses
- Fifteen utilities consider two or more analyses (with the most common being power flow + generation capacity)
- Three utilities only consider power flow analysis
- One utility only considers generation capacity analysis
- One utility only considers ramp rate analysis

*Three distribution-only utilities did not respond to this question

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Load Forecasting with Data Centers

General trends in load forecasting with DCs

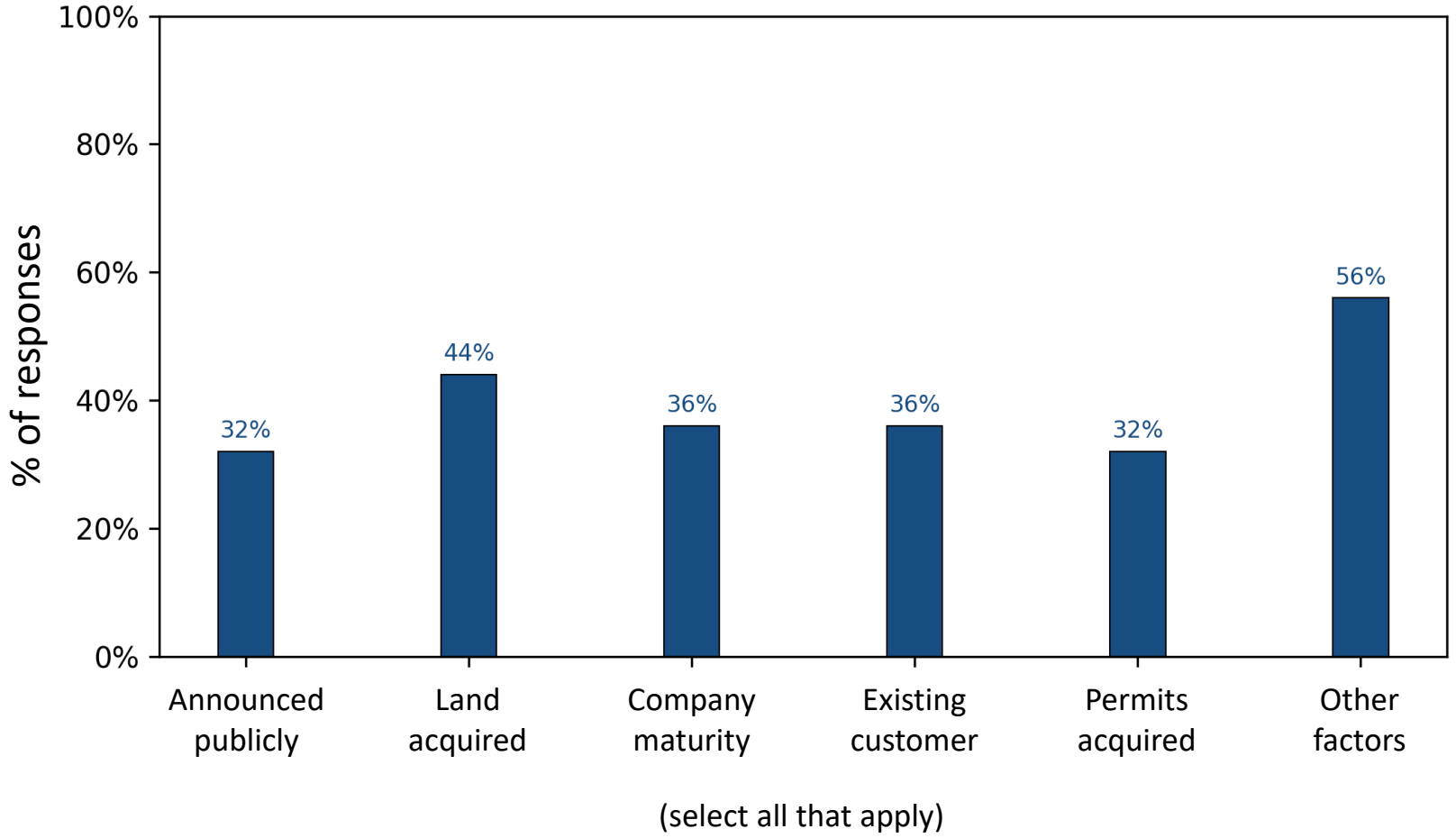
- **No consensus** among 24 responding utilities* on how DC service requests are included in load forecasts
  - Ten utilities include the full requested capacity (as specified by the DC customer) but 8 of the 10 ramp the capacity over time
  - Another eight utilities include a derated capacity value based on specific weighting criteria (see next page)
  - Six utilities do not presently include DC requests in their load forecasts

- All face challenges around incorporating DCs into load forecasts given the **speculative nature** of some DC service requests

*One utility (out of the 25 total) did not respond to this specific question

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Multiple factors considered when screening data center interconnection requests*



The most common “Other factors” response was about whether there is a signed agreement between the DC and the utility.

*The corresponding survey question which factors are considered, not the importance of each factor.

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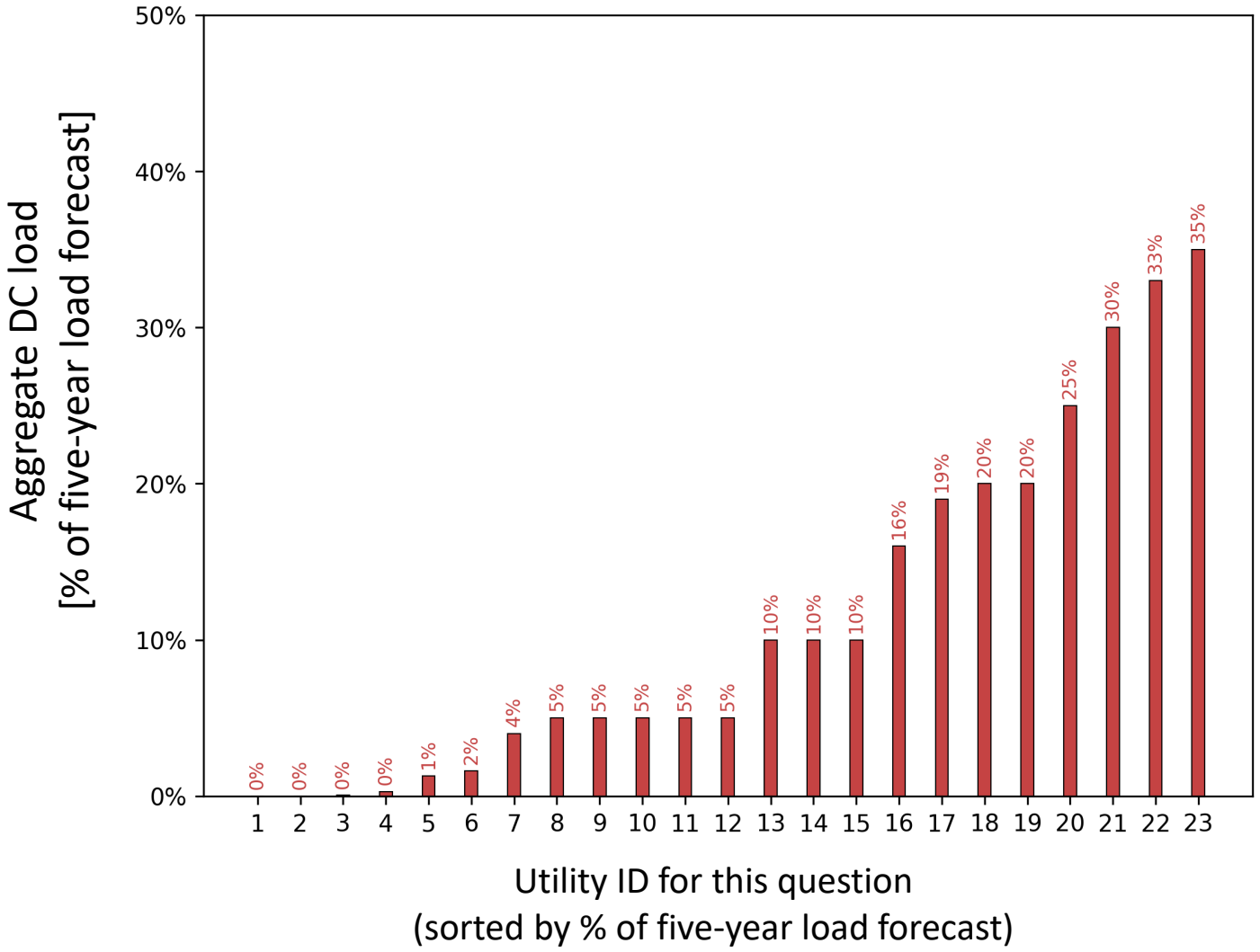
Examples of how five utilities derate requested data center capacity values for use in load forecasting:

- **Utility A:**
  - Derating depends on multiple factors, but DC type has largest impact. Also, generally derate colocation DCs more than enterprise.
  - Derates DCs more than other large loads due to less accurate information from DCs.
- **Utility B:**
  - Considers DCs in the forecast process similar to other large loads. But tends to have less information about DCs, which leads to more uncertainty.
  - For corporate load forecast, consider each DC individually but focus is on forecasting DCs in aggregate.
- **Utility C:**
  - Derates all DC requests by 20% based on prior experience. Will also vary the derating when forecasting multiple scenarios, for example, a 10% and 0% derating.
  - DCs are currently the only sector for which their load forecasts are based on connection requests. However, considering applying a similar derating process for electrolysis projects in the future.
- **Utility D:**
  - Derating based on multiple factors, including historical experience with other similar customers.
  - Currently treats DCs differently from other large loads for load forecasting. Within DCs, derating varies based on type of DC, MW size, etc.
  - Current experience has led to derating crypto mining customers more than hyperscalers given hyperscale DCs tend to more closely adhere to their contract loads.
  - Only considers DC customers in five-year load forecast who have signed an agreement with the utility.
- **Utility E:**
  - Derating depends on multiple factors, but biggest factors are (1) whether the data has submitted a formal connection request and (2) whether there is available infrastructure to support the DC's requested capacity.
  - Derating of DCs for load forecasting is more granular than other large loads given the diversity and uncertainty of DCs as a category.

None of the responding utilities provided an explicit calculation/equation for derating DC for load forecasting.

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Majority of responding utilities are projecting DC loads to be a significant portion of their peak load in five years



Out of 23 utility responses*:

- 48% predict that ≥10% of their peak load in five years will come from DCs
- 26% predict that ≥20% of their peak load in five years will come from DCs
- None of the utilities with aggregate DC requests ≥50% of their present peak load are forecasting DCs as >35% of their five-year forecasted load

*Two utilities (out of the 25 total) did not respond to this question

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Conclusions

Summary

- Meeting the increasing power demands of DCs is a multifaceted challenge that will benefit from coordinated efforts across the electric power and DC industries.
- One aspect of that challenge is limited sharing of knowledge about interconnection requests across electric utilities.
- This document summarized key insights from a utility survey conducted by EPRI from May–July 2024 to **assess how utilities assess DC service requests, process and analyze those requests, and integrate those requests into load forecasts**.

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Key takeaways

- Data center interconnection requests are trending to larger sizes, with 60% of responding utilities having requests for 500 MW or large and 48% with requests for 1,000 MW or larger.
- All responding utilities have DC requests that, in aggregate, exceed their current DC connections. Almost half have requests that exceed 50% of their present system peak demand.
- Some utilities have already experienced operational impacts from connected DCs, with ramp rates issues being the most common (26% of responding utilities).
- Most utilities (75%) presently use their standard large load service request process for DCs, rather than a DC specific process.
- There is no consensus among the responding utilities for how to include DC service requests in load forecasts but there are shared challenges given the speculative nature of some service requests.
- The majority of responding utilities are projecting DC loads to be a significant portion of their peak load in five years, including almost half (48%) predicting that 10% or more of their five-year forecasted peak will come from DCs.

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Next steps and future work

- There are shared challenges—and opportunities—around improving the DC interconnection request process.
- More broadly, there is a need for coordination and collaboration between electricity companies and DC developers/operators to tackle current bottlenecks.
- Future work may focus on one or more of the following topics:
  - Developing a standardized interconnection request process for DCs.
  - Improving planning tools and models to account for DCs.
  - Developing a standardized framework for load forecasting with DCs.
  - Enabling DCs to be flexible loads and incorporating that flexibility into hosting capacity analyses and load forecasts.

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Appendix: Survey Design

Survey Design

- This section documents the survey design, including the questions and options for answering each question.
- The survey itself was created using SurveyMonkey and distributed to ~120 utilities via the EPRI Load Forecasting Initiative's mailing list.
- 25 utilities completed the survey during the May–July 2024 open survey window. However, some utilities chose not to respond to certain questions.
- The results in this document are based on responses to the following survey questions.

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Survey Questions

- **Q1:** Your name: [free response]
- **Q2:** Your email: [free response]
- **Q3:** Your organization: [free response]
- **Q4:** Your job title/role: [free response]

- **Q5:** What size of individual data centers are already interconnected in your service territory? [select all that apply]
  - ❑ <10 MW
  - ❑ 10–100 MW
  - ❑ 100–250 MW
  - ❑ 250–500 MW
  - ❑ 500–1,000 MW
  - ❑ >1,000 MW
  - ❑ No data centers presently served

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Survey Questions

- **Q6:** What size of (new) individual data centers are presently requesting interconnection in your service territory? [select all that apply]
  - ❑ <10 MW
  - ❑ 10–100 MW
  - ❑ 100–250 MW
  - ❑ 250–500 MW
  - ❑ 500–1,000 MW
  - ❑ >1,000 MW
  - ❑ No data centers presently served

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Survey Questions

- **Q7:** What type of data centers are requesting interconnection in your service territory? [select all that apply]
  - ❑ Hyperscale (aka cloud): large-scale data centers owned and operated by a cloud service provider, e.g., Amazon Web Services (AWS), Google Cloud and Microsoft Azure, who sell digital services to individuals and companies based on its computing infrastructure
  - ❑ Enterprise: private data centers owned and operated by a company to meet its own computing needs
  - ❑ Colocation (aka colo or multi-tenant): data centers owned and operated by a company, where the company then leases space to other organizations to house their servers
  - ❑ Connectivity: telecommunications services providers (e.g., Verizon and AT&T)
  - ❑ Other (please specify): [free response]

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Survey Questions

- **Q8:** What are the typical lead times on service requests for data centers? [select all that apply]
  - ❑ <12 months
  - ❑ 12-18 months
  - ❑ 18-24 months
  - ❑ 24-36 months
  - ❑ >36 months
  - ❑ Varies based on service request capacity (please specify): [free response]

- **Q9:** What is the total aggregate capacity of data center service requests currently under review? Please give as a percentage of your current peak demand. For example, 1 GW total of data centers with a 20 GW peak would mean 5% (1 GW data centers / 20 GW peak = 0.05 = 5%). [free response]

- **Q10:** What is the total aggregate capacity of data centers already interconnected? Please give as a percentage of your current peak demand (same as previous question). [free response]

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Survey Questions

- **Q11:** Have you experienced any of the following operational impacts from existing data centers in your service territory? [select all that apply]
  - ❑ Thermal violations
  - ❑ Voltage violations
  - ❑ Harmonic concerns
  - ❑ Fault ride-through issues
  - ❑ Ramp rate issues
  - ❑ Rapid variations causing forced oscillations
  - ❑ Other (please specify): [free response]

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Survey Questions

- **Q12:** Have data center customers had special needs for power supply which are different from other large point loads/industrial customers? [select all that apply]
  - ❑ 24/7 Carbon Free Energy (CFE)
  - ❑ Higher reliability
  - ❑ Other (please specify): [free response]

- **Q13:** Do you have programs that would incentivize data centers to provide services if available? For example, during high-risk grid hours.
  - ❑ No and we are not considering such programs
  - ❑ No, but we are considering such programs
  - ❑ Yes, here is information about our programs: [free response]

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Survey Questions

- **Q14:** Have you had requests to increase import capacity at existing/operational data center sites recently?
  - ❑ Yes, formal requests for increased import capacity at existing sites
  - ❑ No formal requests, but we anticipate this will happen in the future based on industry discussions
  - ❑ No, we do not anticipate this at present

- **Q15:** Do you have a formal data center interconnection queue process to manage the volume/magnitude of service requests? [select all that apply]
  - ❑ Yes, we have a separate Data Center Interconnection Queue
  - ❑ No, but we have a structured data center specific review process
  - ❑ No, we are using our standard large load service request process
  - ❑ Other (please specify): [free response]

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Survey Questions

- **Q16:** What operational impacts or analyses, if any, are considered ine valuating a new data center transmission interconnection request? [select all that apply]
  - ❑ Power flow analysis
  - ❑ Transient stability analysis
  - ❑ Harmonic analysis
  - ❑ System-wide hosting capacity to provide heat maps of available capacity
  - ❑ Generation capacity analysis
  - ❑ Ramp rate analysis for AGC/regulation needs
  - ❑ Other (please specify): [free response]

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Survey Questions

- **Q17:** How are you representing data centers in your planning studies? [select all that apply]
  - ❑ Validated data center model for positive sequence or EMT studies
  - ❑ Specific data center model but not well validated/needs improvement
  - ❑ Using general load models in positive sequence studies, not specific data center representation
  - ❑ Not sure/Other (please specify if Other): [free response]

- **Q18:** How are you included data center service requests in your load forecasts? [select all that apply]
  - ❑ Including full requested capacity as specified by data center starting at requested service date
  - ❑ Including full requested capacity as specified by data center but ramping over time
  - ❑ Including derated capacity value based on specific weighting criteria (if selected, please answer next question)
  - ❑ Not presently including data center requests in load forecasts
  - ❑ Other (please specify): [free response]

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Survey Questions

- **Q19:** If you use a derated capacity value, would you be willing to share your weighting criteria and derating calculation?
  - ❑ Yes, you can contact me to discuss
  - ❑ Maybe; contact me to discuss
  - ❑ No
  - ❑ Yes, here is information on our weighting criteria and derating calculation: [free response]

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Survey Questions

- **Q20:** What factors are you considering when translating a data center service capacity request to your load forecast? [select all that apply]
  - ❑ Public announcements
  - ❑ Land acquired
  - ❑ Company maturity
  - ❑ Existing customer
  - ❑ Permits obtained
  - ❑ Other (please specify all factors): [free response]

- **Q21:** For your 5-year forecast, what percentage [%] of the forecasted peak demand is expected to be data center load? For example, if your forecasted peak demand is 20 GW and you forecast 1 GW of data center load, then you enter 5% (1 GW data center / 20 GW total = 0.05 = 5%). [free response]

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