

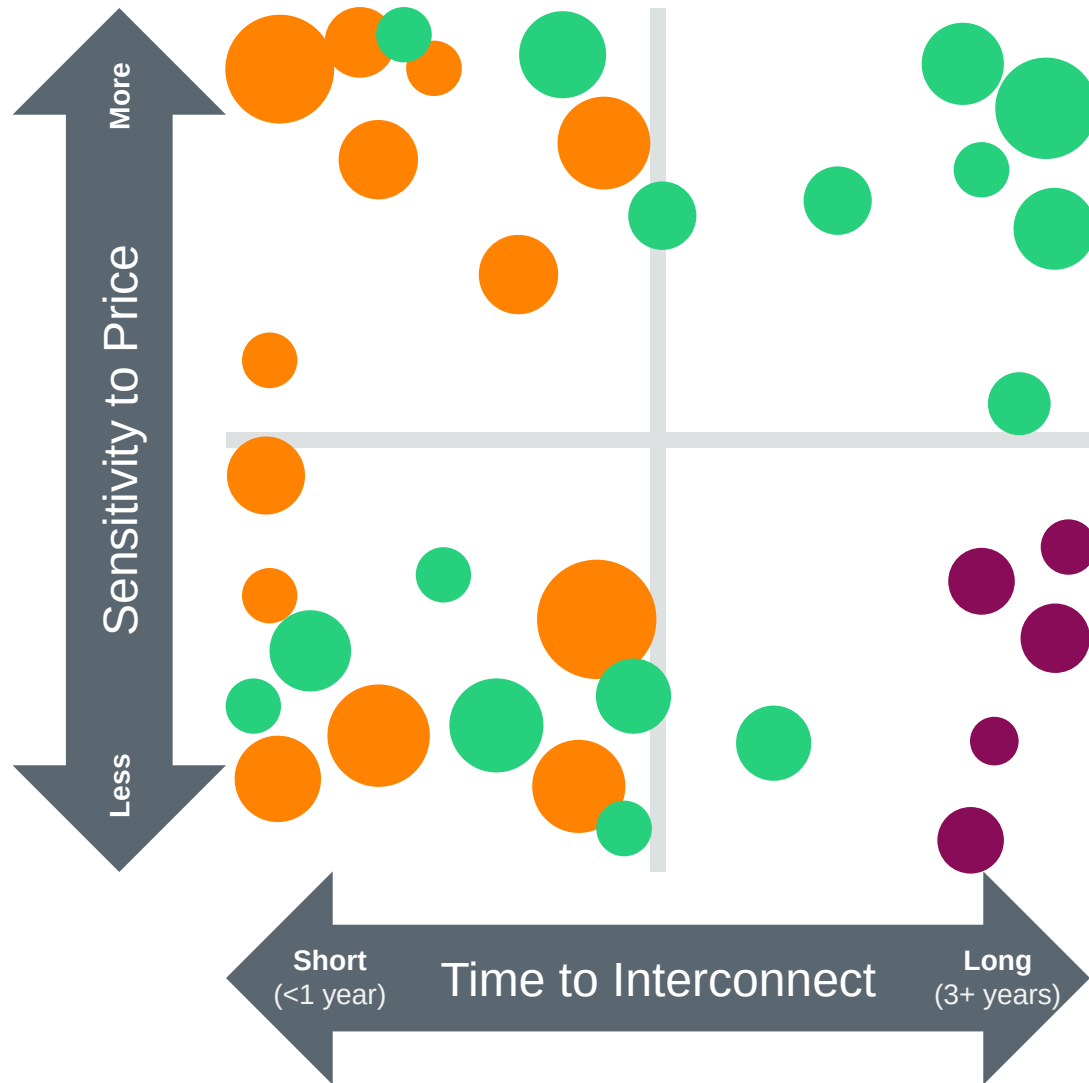


Integrating Large, Flexible Loads – Challenges for Grid Planning and Reliability

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October 25, 2023

Changing Characteristics of Large Loads Coming to ERCOT



Historical Large Loads

- Typically industrial facilities
- Long timelines to interconnect can be studied by traditional planning processes
- Little price-sensitive behavior in real-time

Current Wave of Large Loads

- Mostly cryptomining, data centers, some oil field Load
- Much shorter timeline to interconnect (months rather than years)
- Some Loads are extremely sensitive to price

Projected Future Large Loads

- Hydrogen/electrofuel production, data centers, some cryptomining
- Range of interconnection timelines and price sensitivity

Planning the Grid for Large, Flexible Loads

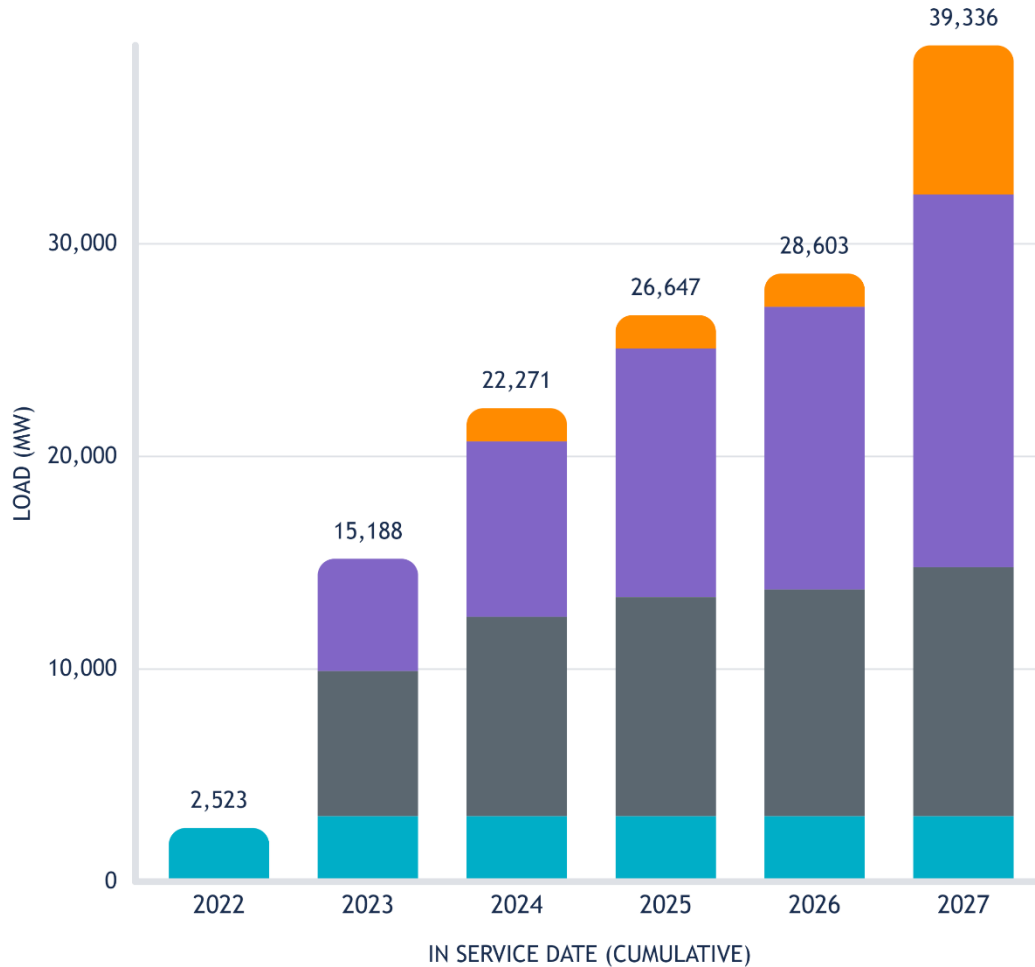
There are two primary challenges that make planning the grid in a world of large, flexible loads (LFLs) difficult:

The **growth** of the load is hard to predict

The **behavior** of the load is hard to predict

Tracking Large Loads with Short Timelines to Interconnect

Actual and Projected LFL Growth 2022-2027

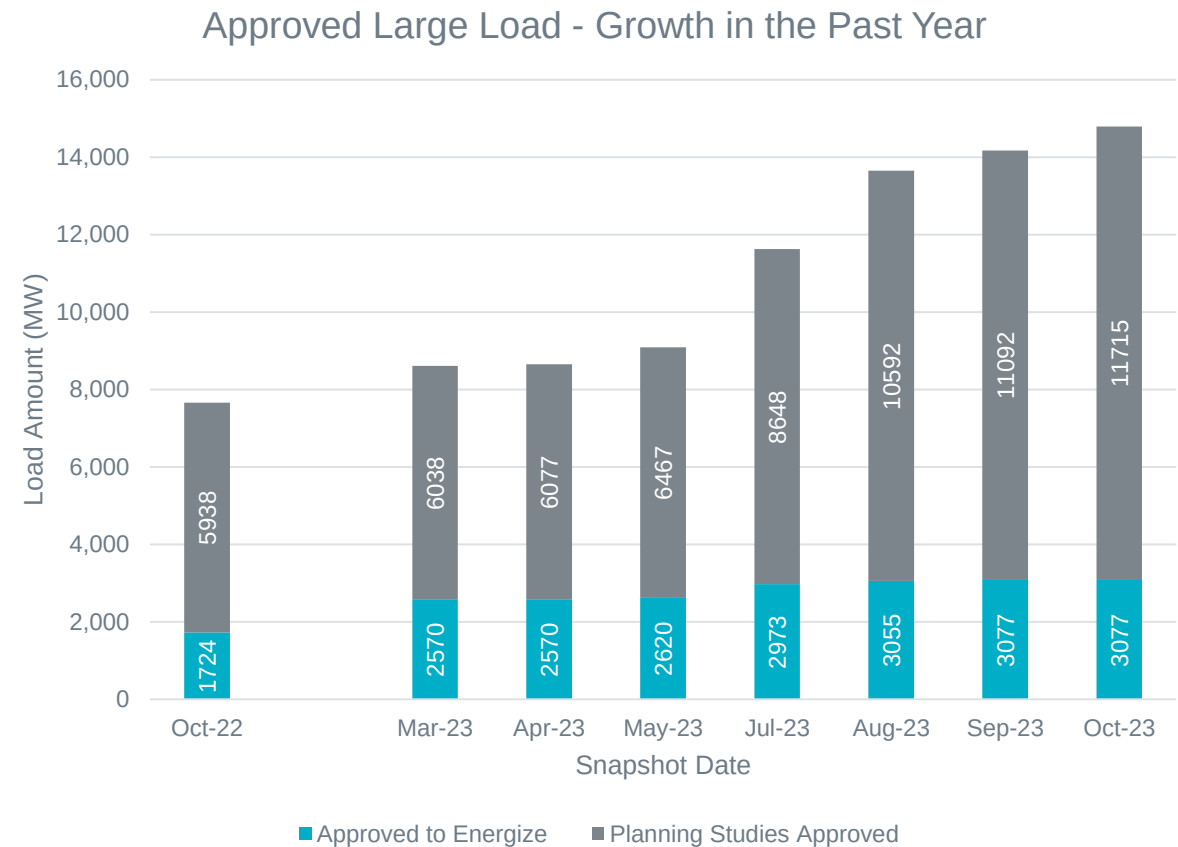


Project Status	2022	2023	2024	2025	2026	2027
No Studies Submitted	-	-	1,566	1,566	1,566	7,012
Under ERCOT Review	-	5,282	8,247	11,697	13,297	17,532
Planning Studies Approved	-	6,829	9,381	10,307	10,663	11,715
Approved to Energize	2,523	3,077	3,077	3,077	3,077	3,077
Total (MW)	2,523	15,188	22,271	26,647	28,603	39,336

- **Approved to Energize** – Projects that have received Approval to Energize from ERCOT Operations. NOTE: not all MWs in this category have been observed to be operational (see next slide)
- **Planning Studies Approved** – Projects that have received ERCOT approval of required interconnection studies. Any MWs that were not approved are reclassified as No Studies Submitted.
- **Under ERCOT Review** – Projects that have studies under review by ERCOT
- **No Studies Submitted** – Projects that are tracked by ERCOT but that have not yet provided sufficient information for ERCOT to begin review. Additionally, MWs that were not approved by ERCOT after review of planning studies are included in this category until a path to interconnect these MWs is identified or the customer cancels the interconnection request.

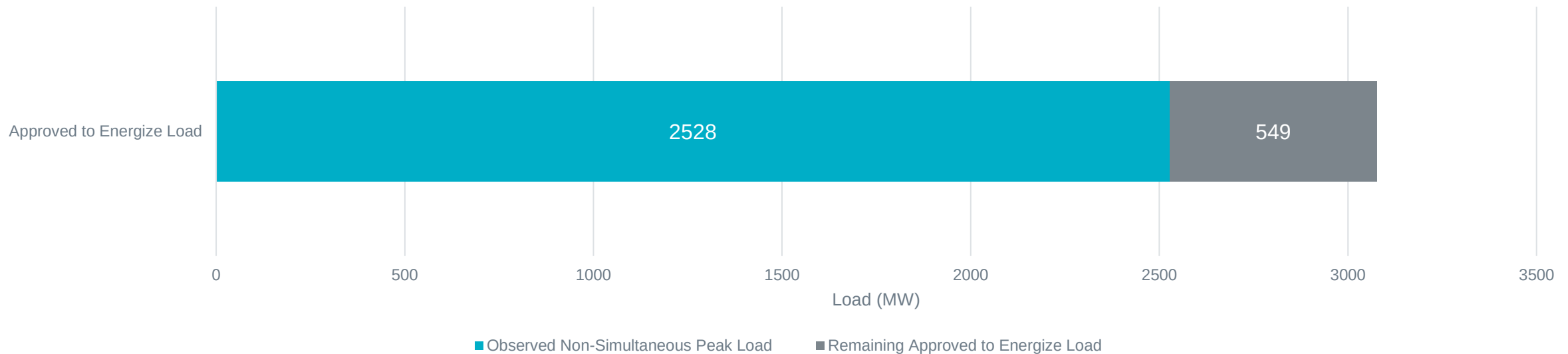
Challenges – Actual Growth is Difficult to Project

- ERCOT is seeing significant growth in the amount of project MW that has completed planning review and then stalled.
- Only 507 MW has requested approval to energize in the past 6 months.
- Will the remaining 11.7 GW request approval to energize? If so, when will that happen?



Loads Approved to Energize – Observations

- Of the 3,077 MW that have received Approval to Energize, ERCOT has observed a **non-simultaneous** peak consumption of 2,528 MW
 - This is calculated as the sum of the maximum value for each individual load regardless of when that maximum occurred
 - This value represents how much approved load ERCOT believes is now operational

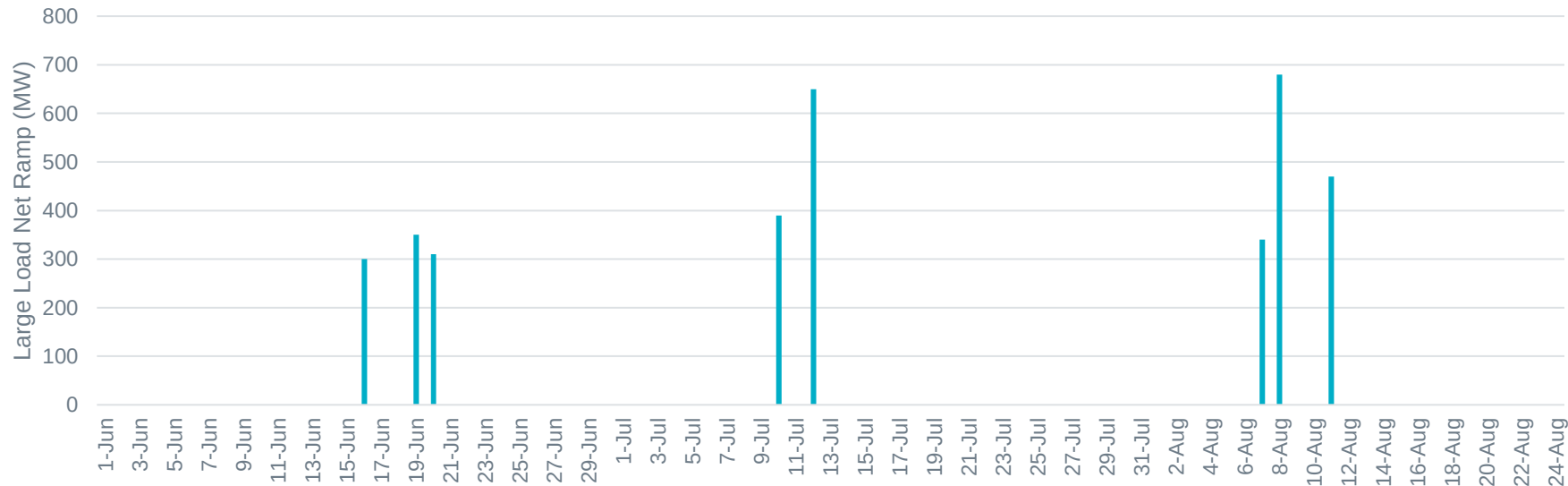


Interconnection Process – Path Forward

- On August 1, ERCOT submitted PGRR111 to establish a formal interconnection process for Large Loads connecting in less than 2 years
- As proposed, PGRR111 addresses some of these challenges by
 - Instituting fees and deadlines in the interconnection process
 - Requiring all Large Loads to submit to ERCOT a plan detailing their energization schedule and to keep that plan updated
- The PGRR is under discussion by stakeholders

Summer 2023 – Unexpected Large Load Behavior

- Since June 1, ERCOT has experienced 8 operating days where at least 300 MW of Large Load ramped up within 15 minutes when system prices were above \$250/MWh and system reserve levels were declining.



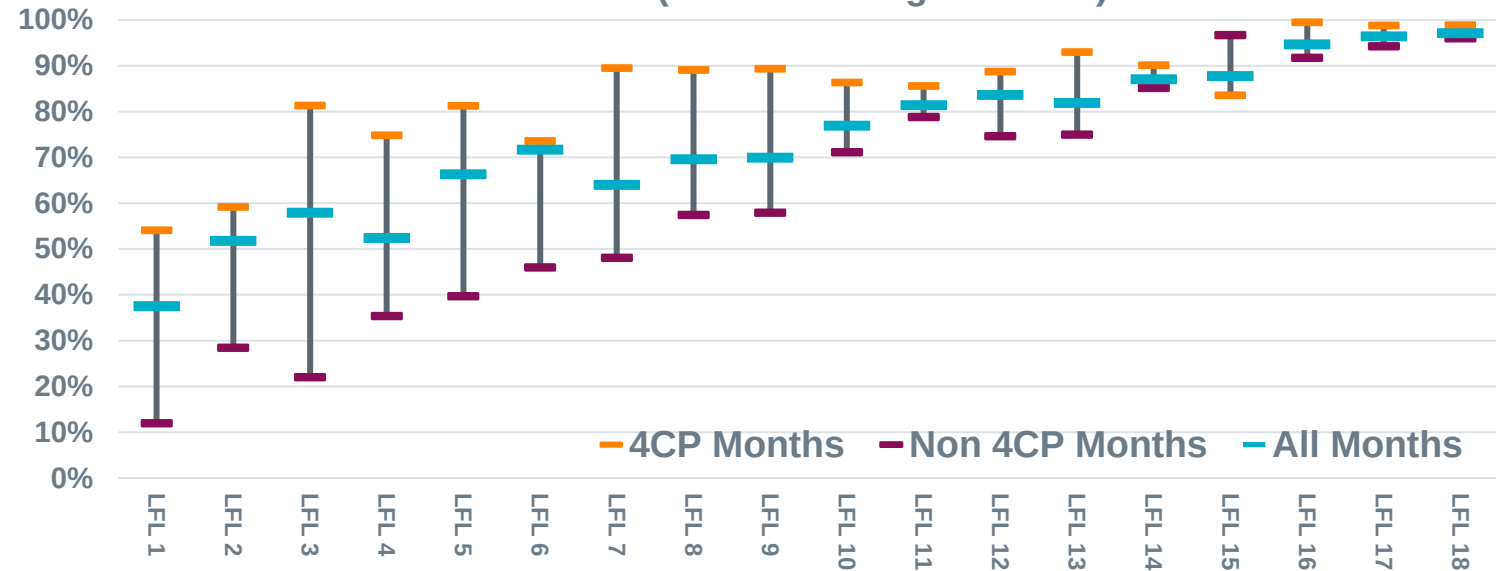
- ERCOT also experienced 27 operating days in 2023 where at least 350 MW of Large Load remained online despite prices in excess of \$500/MWh.

Analysis of Price Responsive Behavior – ERCOT Observations

- Price responsive capabilities vary greatly between loads. The data suggests that many LFLs are primarily responding to 4CP intervals rather than high-price intervals.

	Non 4CP	All	4CP
LFL 1	12%	37%	54%
LFL 2	28%	52%	59%
LFL 3	22%	58%	81%
LFL 4	35%	52%	75%
LFL 5	40%	66%	81%
LFL 6	46%	72%	74%
LFL 7	48%	64%	89%
LFL 8	57%	70%	89%
LFL 9	58%	70%	89%
LFL 10	71%	77%	86%
LFL 11	79%	81%	86%
LFL 12	75%	84%	89%
LFL 13	75%	82%	93%
LFL 14	85%	87%	90%
LFL 15	97%	88%	84%
LFL 16	92%	95%	99%
LFL 17	94%	96%	99%
LFL 18	96%	97%	99%
AVG	62%	74%	84%
AVG (Weighted)	48%	66%	79%

Percentage of 5-min Intervals where LFLs Curtailed for High Prices (OCT-22 through AUG-23)



- The degree to which loads are 4CP vs Price sensitive is demonstrated by their spread. A larger spread indicates a load is primarily responding to 4CP, or their economic curtailment strategy has greatly improved in recent months.
- As indicated by the load weighted averages, larger loads are worse at responding to high prices on average.

Inconsistent Large Load Behavior – Challenge #1

Challenge #1

Inconsistent operational behavior makes both long- and short-term planning difficult.

- If ERCOT plans for an expected Large Load self-curtailment during scarcity and the Load does not respond, it could drive the system into emergency conditions.
- If ERCOT plans for no self-curtailment, it risks overcommitting generation, which will increase consumer costs unnecessarily if the Large Loads do respond.

Large Load Ramping – Challenge #2

- When large loads do vary their consumption, the rate at which they do so is important for short-term planning.
- Background
 - ERCOT dispatches generation every five minutes via the Security Constrained Economic Dispatch (SCED) engine.
 - Regulation Service (RegUp and RegDown) is a pool of MWs reserved to keep grid frequency at 60 Hz by responding to moment-to-moment imbalances between generation and load between each 5-minute dispatch.

Large Load Ramping – Challenge #2

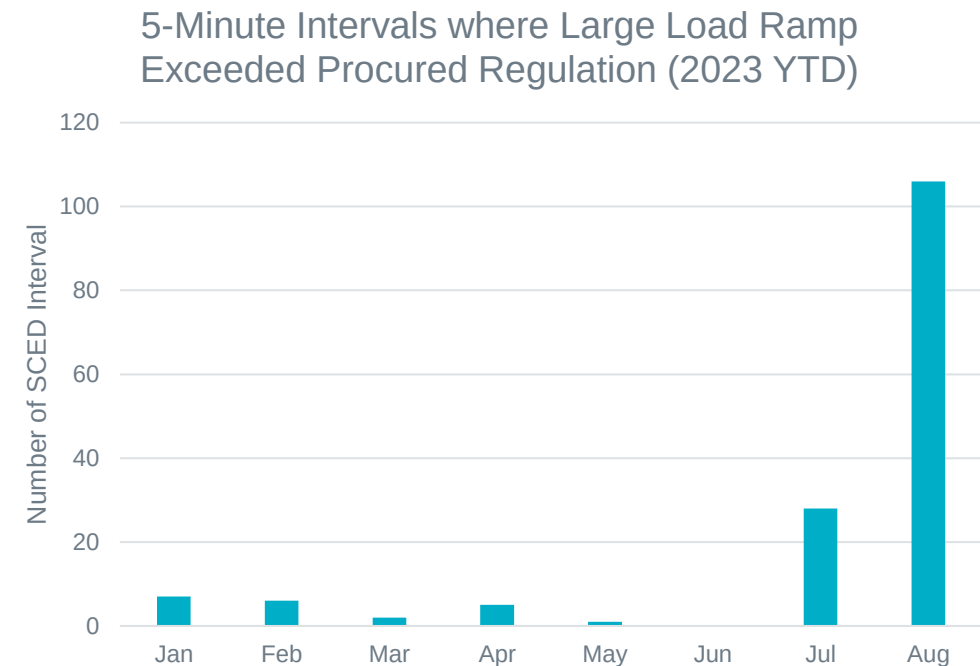
Challenge #2

A growing number of Large Loads can change their MW consumption rapidly enough to exhaust available Regulation service.

- Overwhelming majority of Large Loads today do not participate in ERCOT's Security Constrained Economic Dispatch (SCED)
 - Price responsive Loads may vary consumption at any time without notice or coordination with ERCOT
 - Changes in consumption that occur outside of SCED are also not accounted for when SCED instructs generators how much power to produce

Large Load Ramping and Frequency Control

- In 2023, there have been 155 five-minute SCED intervals where the change in Large Load consumption has exceeded the amount of procured Regulation. It exceeded 50% of procured Regulation in another 556 intervals.
- The loss of some or all available Regulation temporarily limits ERCOT's ability to match generation with demand and control frequency.



Large Load Ramping – Path Forward

- If all Large Loads with approved planning studies were to connect and exhibit ramping behavior outside of SCED similar to current loads, it would be a risk to the system without ERCOT procuring additional Regulation.
- Procuring more Regulation has downsides
 - Regulation MWs are reserved for that service – procuring more takes MWs out of the pool of dispatchable generation, leaving fewer MWs available during tight conditions
 - Regulation is a paid Ancillary Service – procuring more increases costs for ratepayers
- Ultimately, the amount of Regulation needed may simply be infeasible.

Large Load Ramping – Path Forward

- The optimal solution for grid reliability is for more Loads to participate in economic dispatch (SCED) as a Controllable Load Resource (CLR).
 - Load still free to set strike price(s) via bid-to-buy curve
 - Load ramping is coordinated with other grid reliability needs
 - Load becomes eligible to provide Ancillary Services
- Large Loads that do not register as CLRs may have limitations placed on their ramping behavior.¹

Conclusion

- ERCOT, like many grids around the world, is seeing an unprecedented amount of large load interconnecting. These loads differ from past large loads in important ways.
- These differences create uncertainties that impact both long- and short-term planning.
- ERCOT has proposed Revision Requests to address these challenges.

Questions?