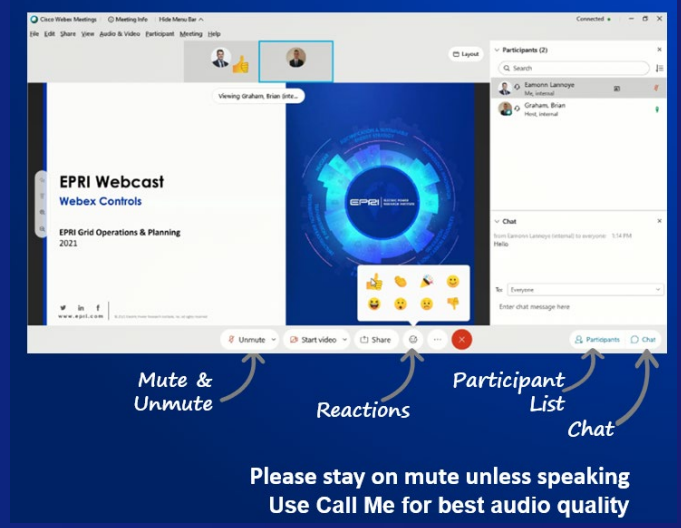
Large Loads and Resource Adequacy

for Transmission Operations & Planning

Transmission Operations and Planning
Innovating Grid Operations, Shaping Strategic Planning

View from The TOP
Transmission Operations & Planning R&D
Public Webinar Series

Resource Adequacy Forum



Please stay on mute unless speaking
Use Call Me for best audio quality

REC This webcast will be recorded

www.epri.com

Welcome and Agenda

Introduction to the EPRI View from the TOP - 2026 Webinar Series and EPRI Resource Adequacy Forum
Andreas Klaube - EPRI

Impacts of Large Load Additions on the **PJM Resource Adequacy Process**
Patricio Rocha Garrido, PhD - PJM

Large Load Growth Trends, Challenges and Opportunities
David Larson, PhD - EPRI

EPRI DCFlex Initiative: Ongoing Work on Large Loads and RA
Irene Danti Lopez, PhD - EPRI

Questions and Open Discussion
(5 Mins All - Moderated by EPRI)

Transmission Operations and Planning

Innovating Grid Operations, Shaping Strategic Planning

View from The TOP

Transmission Operations & Planning R&D Public Webinar Series

New for 2026: A public webinar series

- R&D highlights from EPRI and our global collaborators
- 8-12 webinars delivered throughout 2026
- Topics spanning operations, planning and markets issues
- Coordinated with existing EPRI forums
- Open to all participants

Not a Member? Sign up Here!

Next webinar date: Thursday, May 7
Data Center Load Fluctuations and Impact on Generation

Recordings & materials posted at: top.epri.com/view-from-the-top

Transmission Operations & Planning

- EPRI's Transmission Operations & Planning (TOP) program conducts collaborative research to support reliable, resilient, and economic planning and operation of the bulk electric power system for transmission owners and system operators

- **Focus Areas**
  - Transmission Operations
  - Transmission Planning
  - Bulk System Integration of Renewables and Distributed Energy Resources
  - Electricity Market Design and Operation

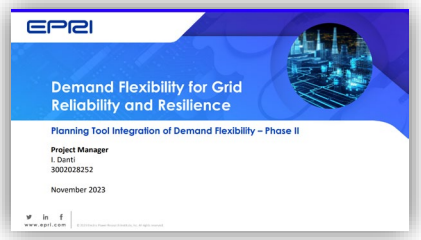
- **Value to Industry**
  - Deliver leading-edge research, software tools, and technical guidance
  - Leverage global collaboration across utilities, ISOs, and subject-matter experts
  - Help the industry manage rapid system change, including renewables, large loads, and climate-driven risks

Learn more about TOP: https://top.epri.com/

EPRI Base Research Timeline – Demand Flexibility, DERs, Electrification and Large Loads in RA

Demand-Side Resources in Resource Adequacy: 2021 – 2023 Research Compilation

- Modelling disaggregated residential and commercial demand response and DER load shapes in RA
- Guidelines for developing DER and demand response models
- Understanding impact on resource adequacy



Demand Flexibility for Grid Reliability and Resilience: Planning Tool Integration of Demand Flexibility – Phase II

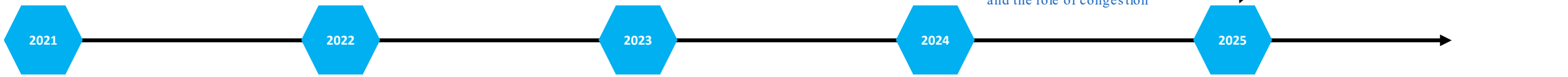
- Framework for modelling light-duty EV impacts across multiple planning functions (capacity expansion, RA, PCM and distribution planning)
- Impact of different EV flexibility profiles across planning functions

Integrating DERs into RA: Understanding Opportunities and Deliverability Limitations Based on RA and DSO Coordination

- Ensuring that RA services provided by distribution-located assets are deliverable when needed
- Understanding the role of dual participation in RA and DSO services and the role of congestion

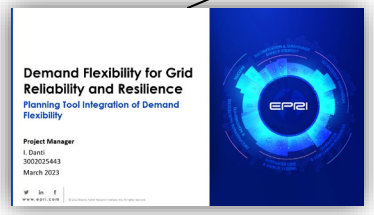
PS173C

Ongoing work on large load electrified load representations and impacts on resource adequacy.



Demand Flexibility for Grid Reliability and Resilience: Planning Tool Integration of Demand Flexibility

- Understanding demand flexibility approaches across multiple planning functions
- Laying out a framework to characterize demand flexibility



Rapid Electrification: Load Materialization Timelines and Implications for Planning

- Examines load growth and drivers in electric transportation, data centres, industrial process heat generation, H_2 electrolysis
- Identifies potential risks from RA perspective

DCFlex

Flexible Data Center Designs	Transformational Utility Programs	Operational Flexibility Framework
Collaborate on creating new designs that enable flexible operations, benefiting all grid-connected consumers	Develop utility programs that support data center flexibility while addressing equity and affordability	Help establish communication and control protocols that speed up interconnection and enable flexible operations

Key Gaps in Modeling Large Loads in RA Studies

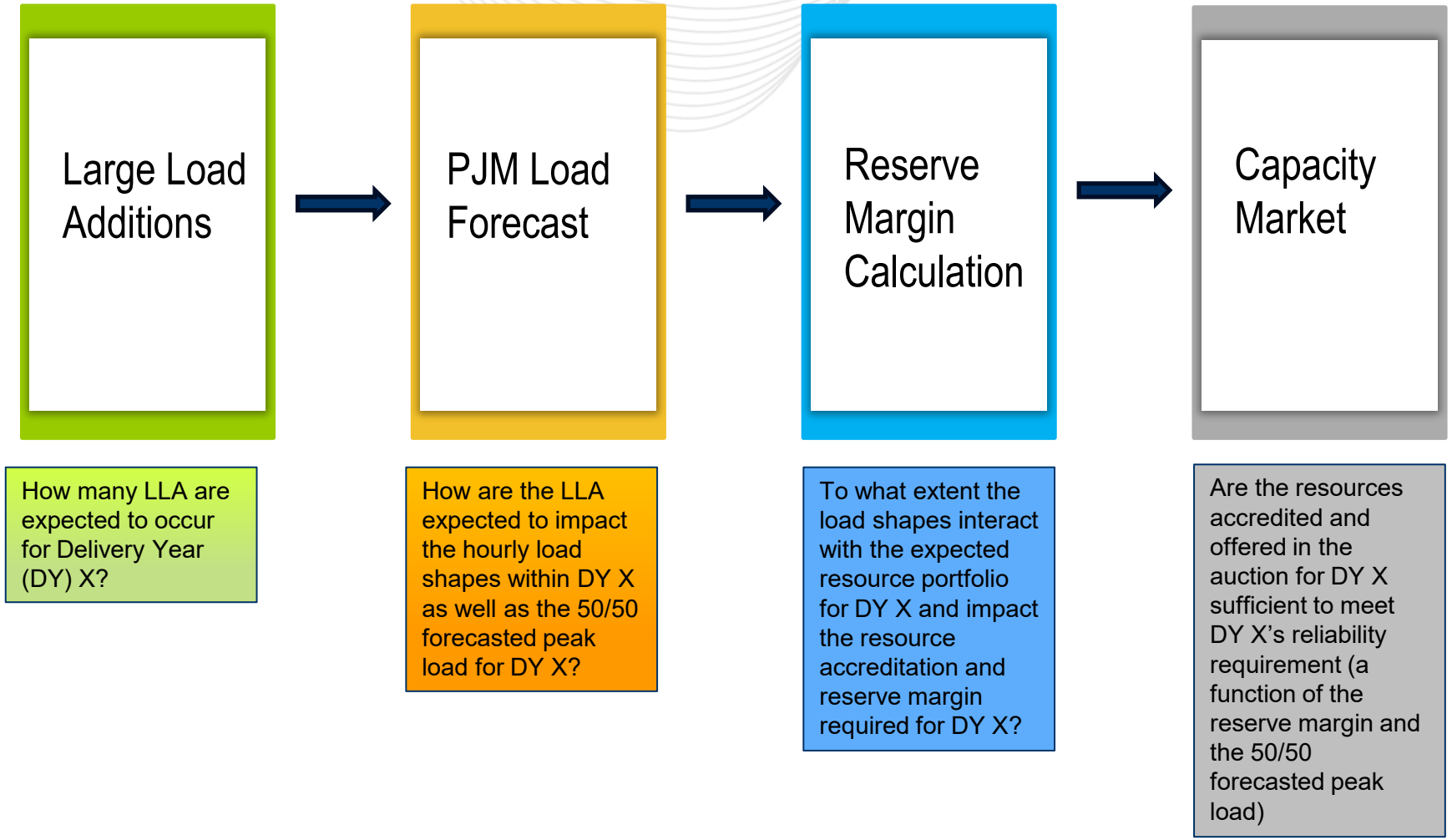
1. Load shape is inconsistently represented across large-load types
2. Screening approaches are not substitutes for a probabilistic RA study
3. Large loads are usually treated as firm demand
4. Flexibility is discussed but rarely modeled endogenously
5. Uncertainty is addressed via scenarios, not operating envelopes
6. Limited guidance on “minimum flexibility required to remain at-criterion”

Impacts of Large Load Additions on the PJM Resource Adequacy Process

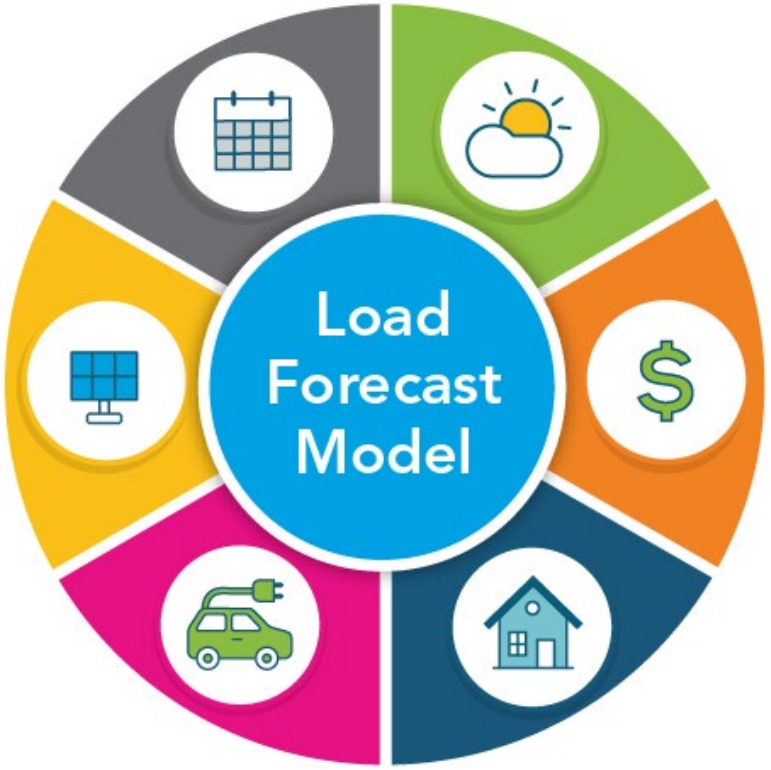
Patricio Rocha-Garrido, PhD

Principal Engineer
Resource Adequacy Planning

From Large Load Additions To Capacity Market



PJM Load Forecasting



Weather Conditions

- Weighted-average temperature, humidity and wind speed
- Cooling and heating degree days
- 30+ weather stations across PJM

Energy Efficiency/End-Use Characteristics

- Cooling equipment saturation and efficiency
- Heating equipment saturation and efficiency
- Other equipment saturation and efficiency

Economic

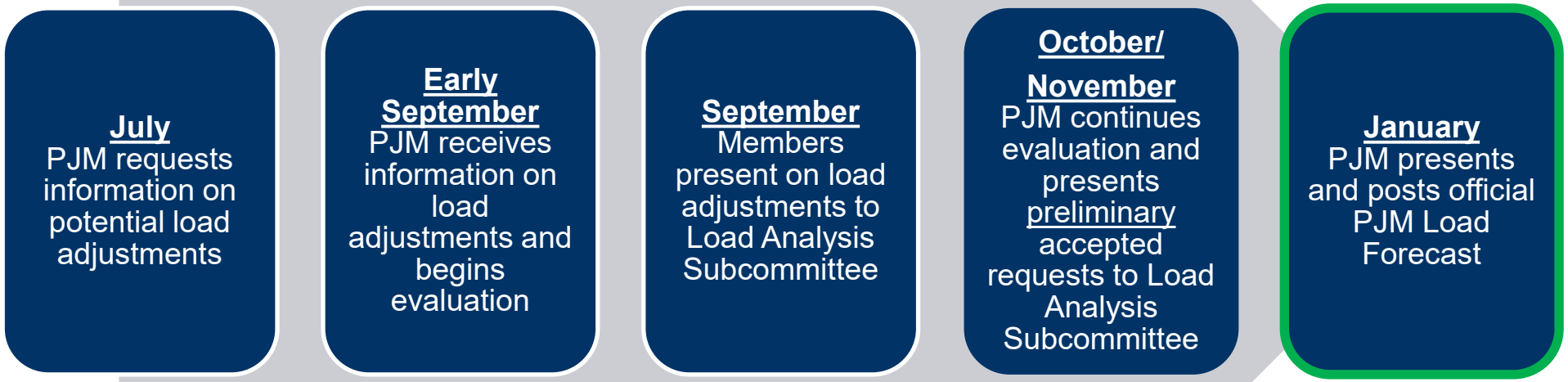
- Real personal income
- Households
- Employment
- Working-age population
- Real industrial output

Calendar/Solar Data & Electric Vehicles

- Day of week
- Month
- Weekends/ Holidays
- Distributed solar generation
- Plug-in electric vehicles

Timeline for Large Load Adjustments

Official request sent July 1



Incorporating Data Center into Load Forecast

Historical Loads

−

Existing Data Center Load History

=

Net Forecast (excluding data center history)

Net Forecast (excluding data center history)

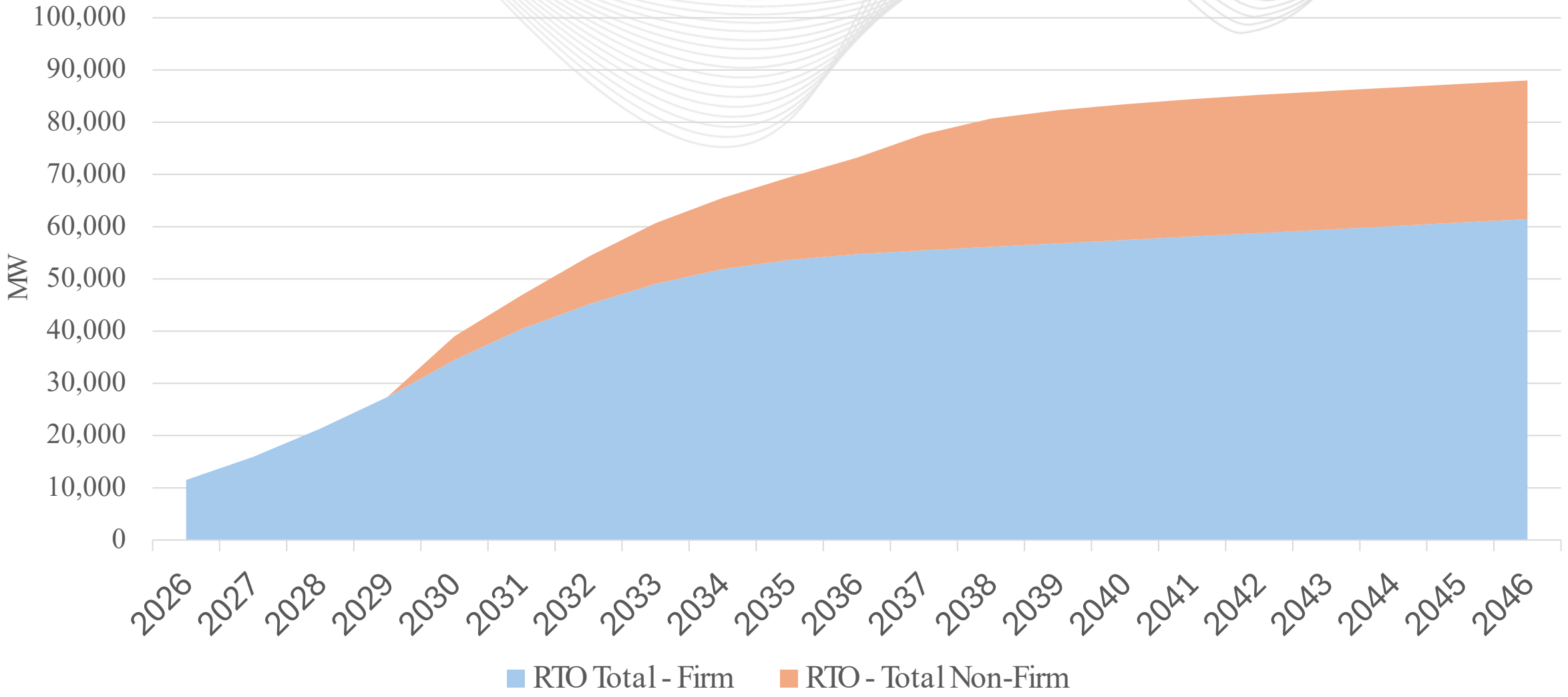
+

Total Data Center Load (history and forecast)

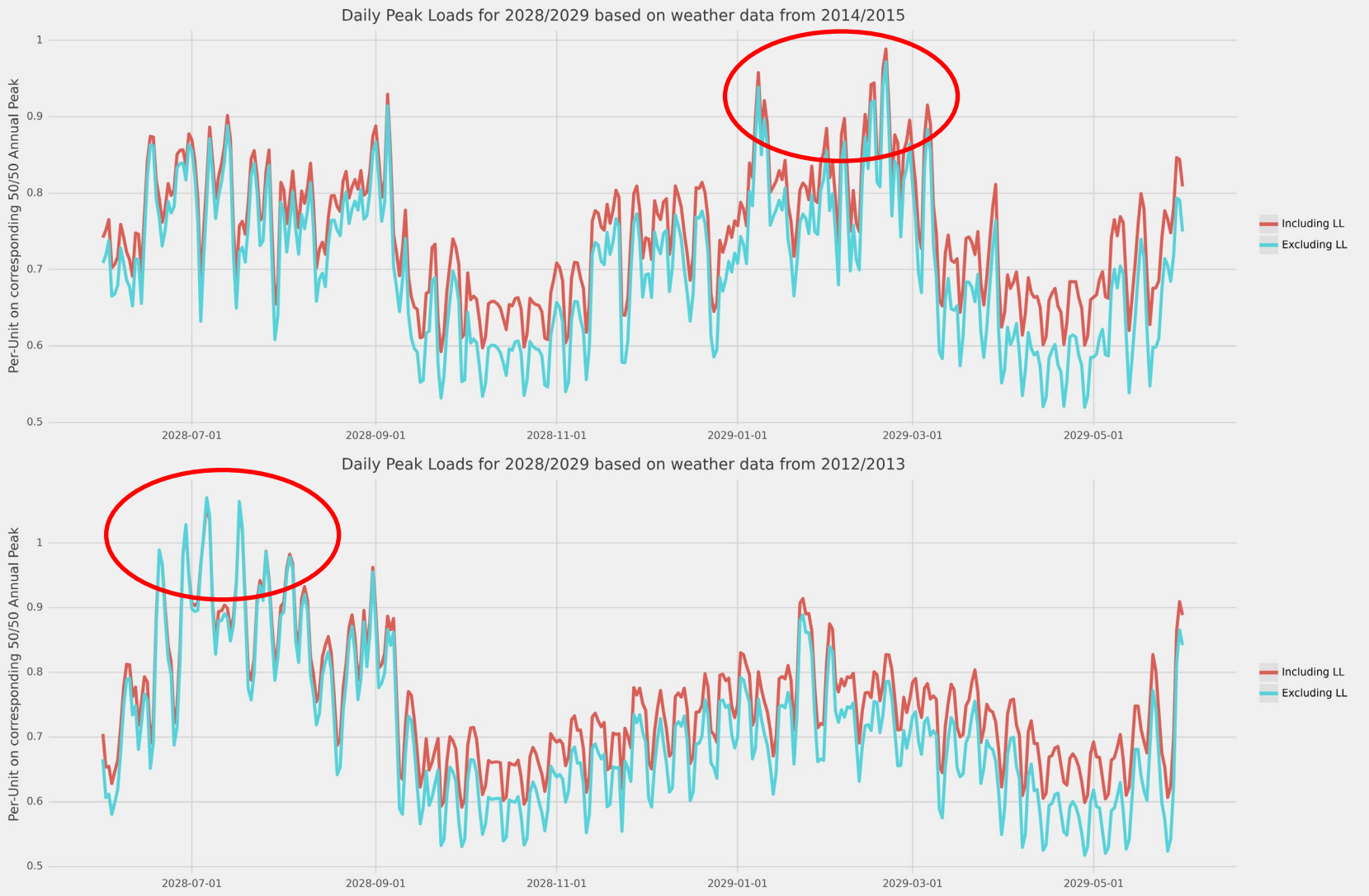
=

Final Forecast Load

2026 Load Forecast: RTO Large Load Adjustments



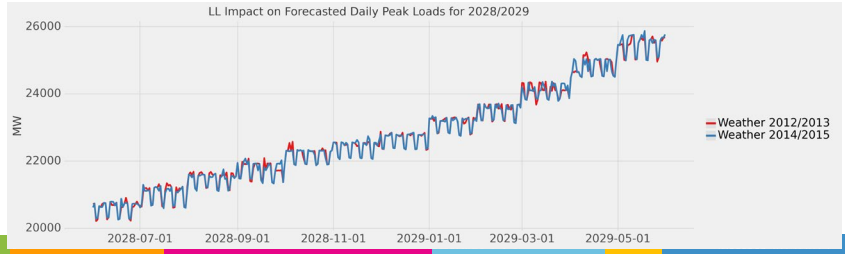
LLA impact on Load Shapes



LLA impact is not limited to median forecasted peak load values. There is also an impact to intra-year load shapes.

The resulting intra-year load shapes impact reserve margin and winter/summer risk share.

Winter peaks when including LLA are more extreme as a share of the corresponding 50/50 annual peaks than when LLA are excluded. The opposite is true for summer peaks

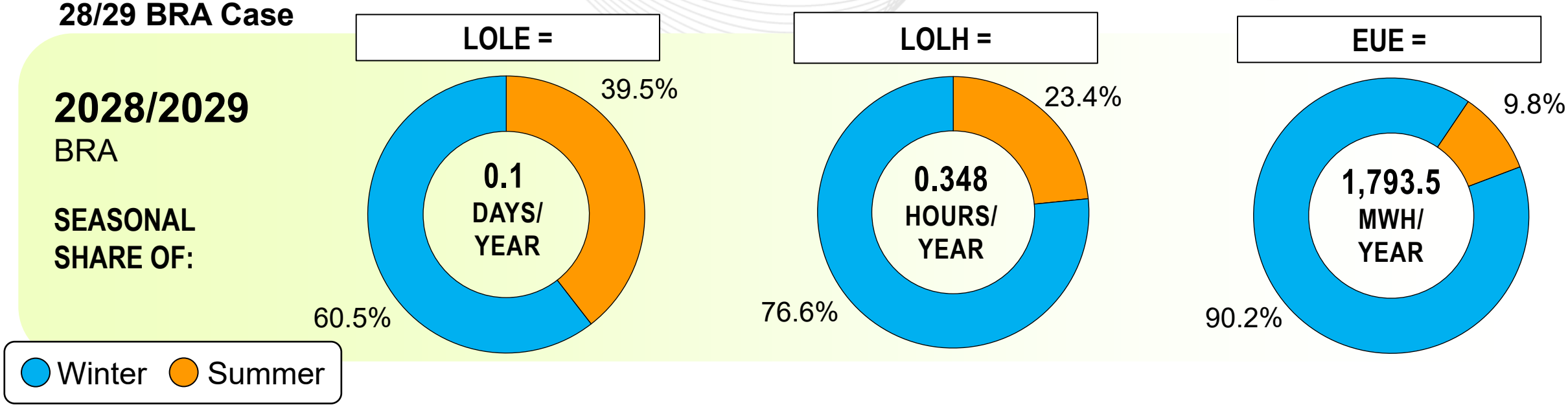


LLA Impact on ELCC Model and Reserve Margin Model

RISK SHARE
28/29 BRA Case

2028/2029
BRA

SEASONAL SHARE OF:



All RA metrics show that majority of loss of load risk is in the winter season.

Part of this is driven by the impact of LLA on extreme winter peaks

LLA Impact on ELCC Model and Reserve Margin Model

ACCREDITATION
28/29 BRA Case

ELCC Class	Final Rating
Onshore Wind	34%
Offshore Wind	60%
Solar Fixed Panel	7%
Solar Tracking Panel	10%
Landfill Gas Intermittent	50%
Hydro Intermittent	35%
4-hr Storage	59%
6-hr Storage	68%
8-hr Storage	71%
10-hr Storage	78%

ELCC Class	Final Rating
DR	91%
Nuclear	96%
Coal	85%
Gas CC	78%
Gas CT	67%
Gas CT Dual Fuel	79%
Diesel	93%
Steam	75%
Waste to Energy Steam	84%
Oil-Fired CT	83%

LLA Impact on ELCC Model and Reserve Margin Model

- Reserve Margin for 28/29 BRA Case is 20%
  - It would have been slightly lower had LLA not existed.

LLA Impact on Capacity Market

PARAMETER	28/29 BRA Value	Estimated 28/29 BRA minus LLA
ICAP (MW)	196,871	196,871
Installed Reserve Margin (IRM)	20.0%	20.0%
Accredited UCAP (MW)	154,234	154,234
Pool-Wide Average UCAP Factor	0.7834	0.7834
Forecast Pool Requirement (FPR)	0.9401	0.9401
Peak Load Forecast (MW)	**165,567**	**144,287**
"Reliability Requirement" (FPR x Peak Load Forecast)	155,650	135,644
UCAP Surplus (Accredited UCAP – "Reliability Requirement")	-1,416	+18,590

Peak Load Difference = 21,280 MW

Potential impact to accreditation, IRM and FPR have been ignored in the Estimated 28/29 BRA minus LLA column. Only the lower Peak Load Forecast Value has been reduced to account for LLA.

Note that the quantities used in the actual capacity market auctions are different from those presented in the table.

Conclusion

- Large Load Additions have not only impacted forecasted peak loads in PJM
  - LLA have also impacted intra-year load shapes, which in turn yield impacts to accreditation and reserve margin levels
  - However, this impact is of second-order, and the largest impact from a Resource Adequacy perspective is that to forecasted peak loads

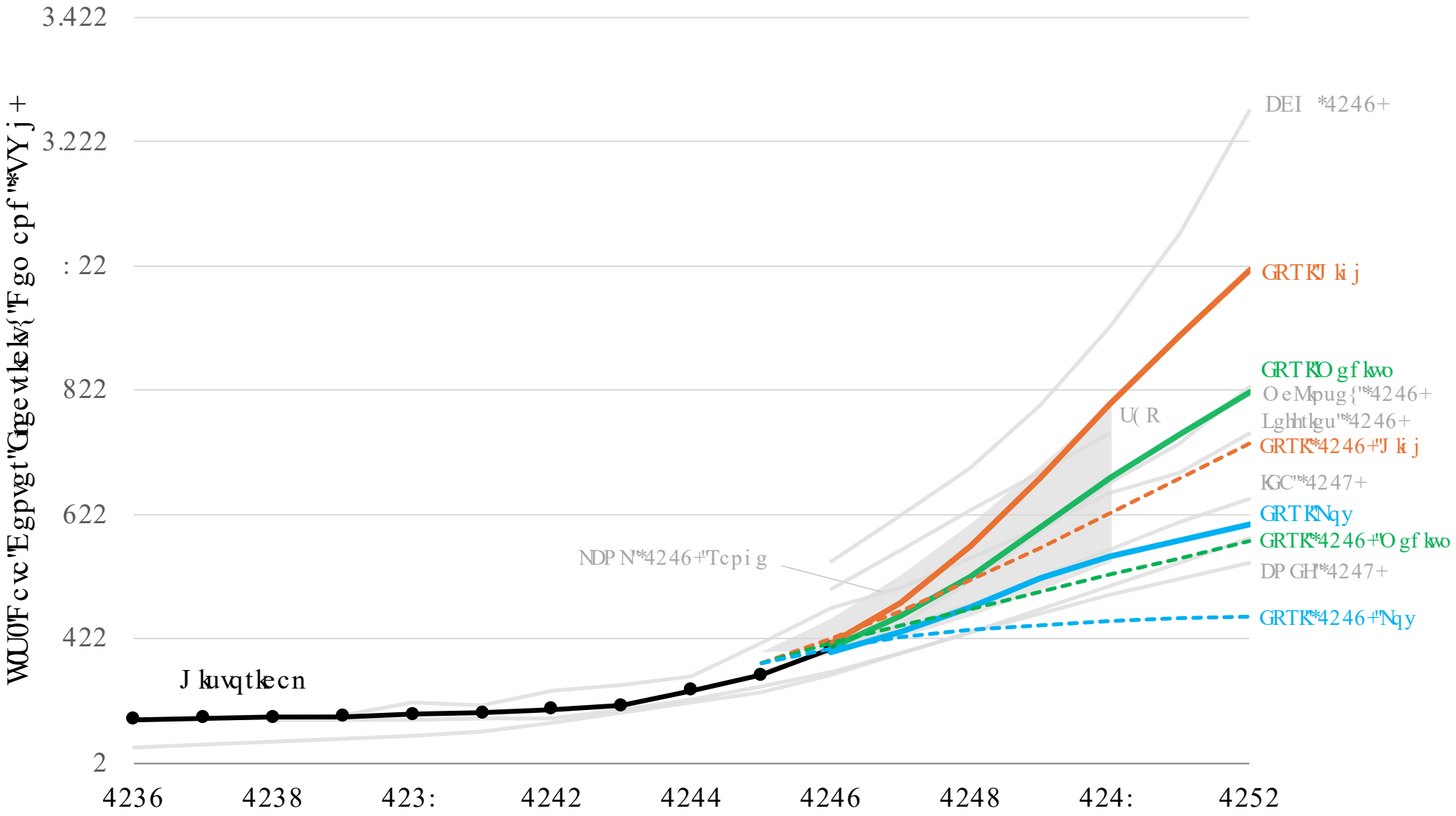
Large Load Growth Trends, Challenges and Opportunities

David Larson, PhD
Sr Team Lead
dlarson@epri.com

Powering Intelligence 2026 (Free EPRI Report)

powering-intelligence.epri.com

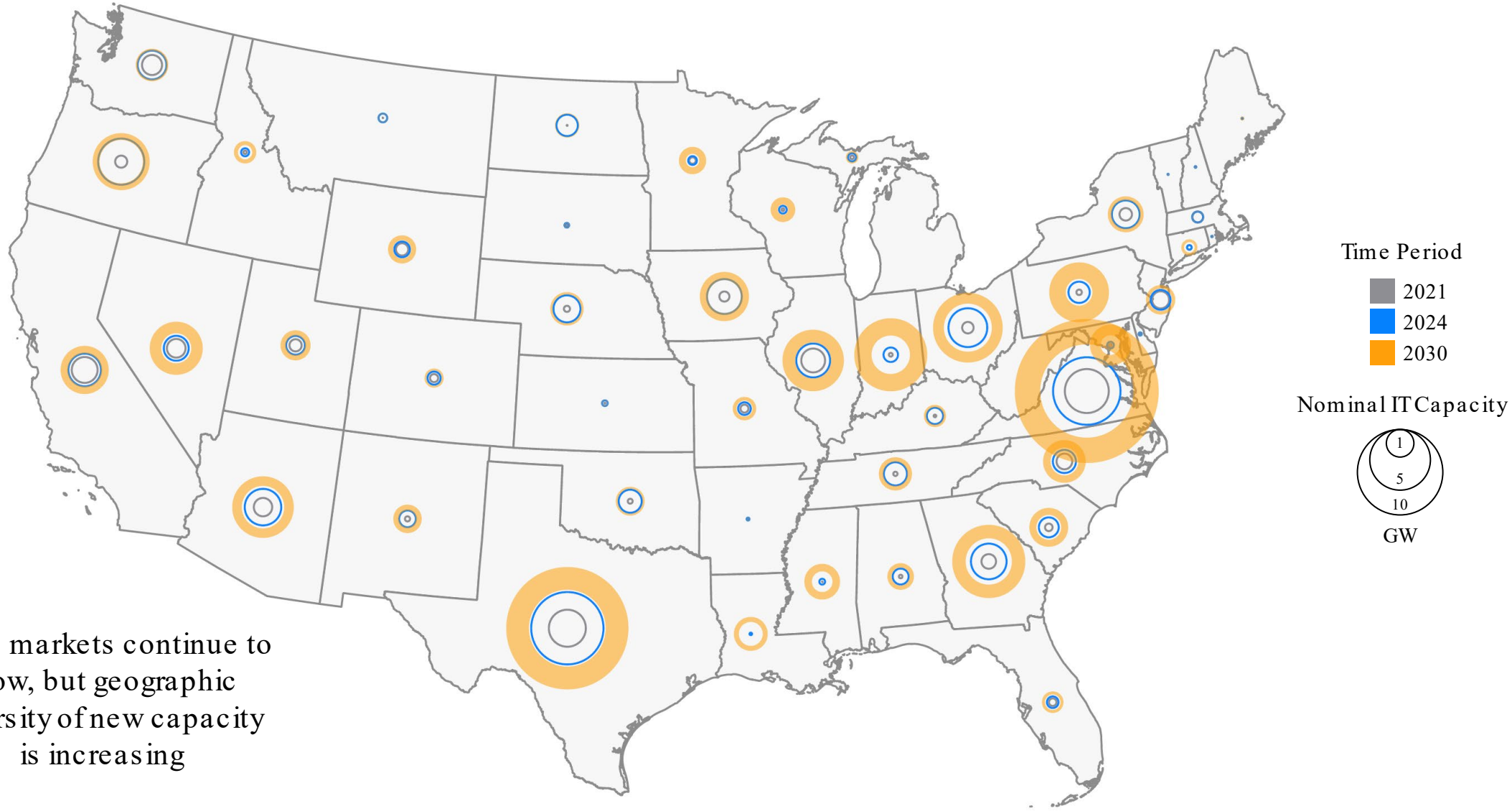
U.S. Data Center Load Growth: Projections Vary



Sources of Load Growth Uncertainty

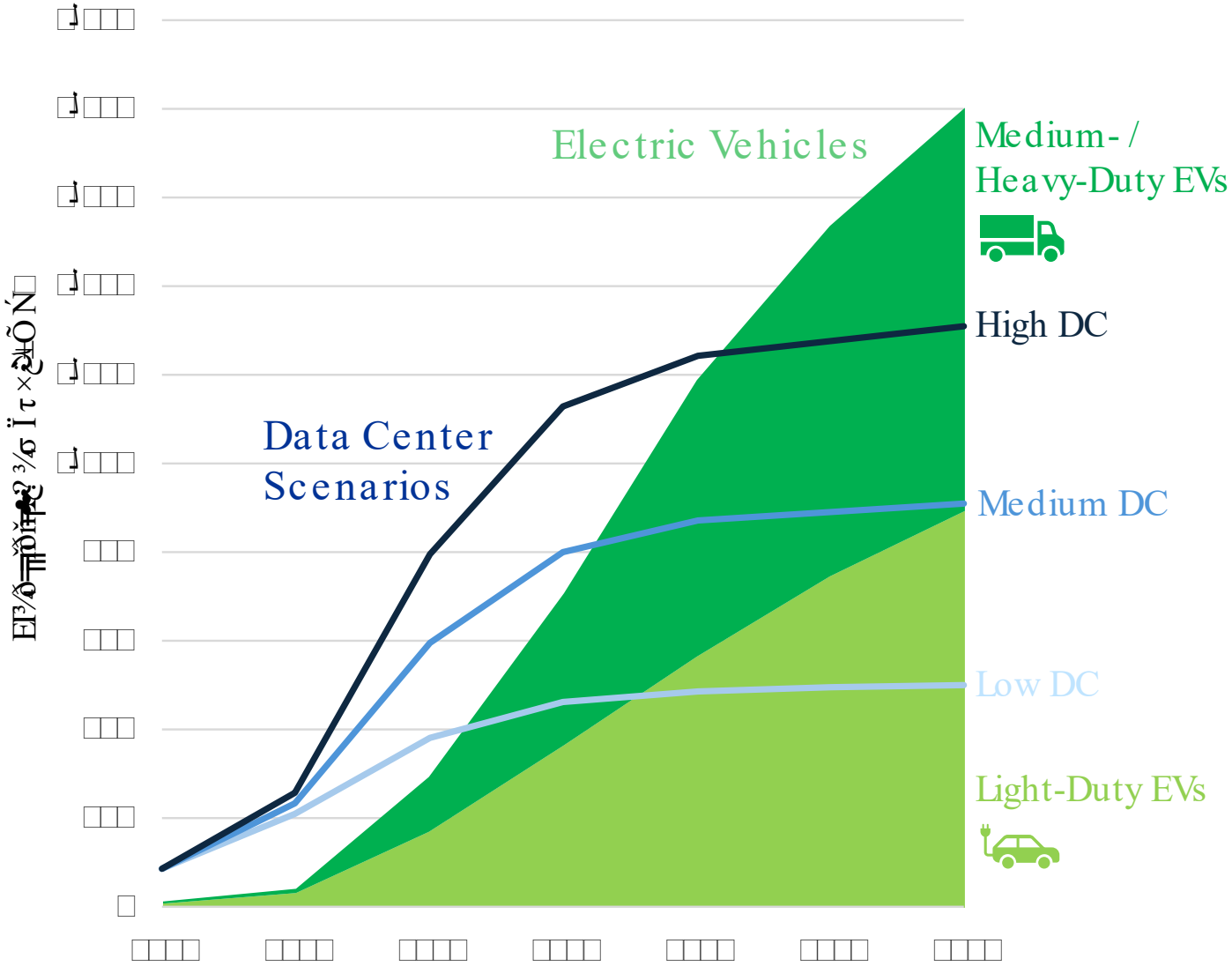
- Some data center projects will **not materialize**
- Data centers take time to **ramp up their load** after connection to the grid
- **Actual demand** is different than contracted capacity
- History **may not be predictive** of future data center designs, operating behaviors, etc.

U.S. Data Center Capacity by State (EPRI)



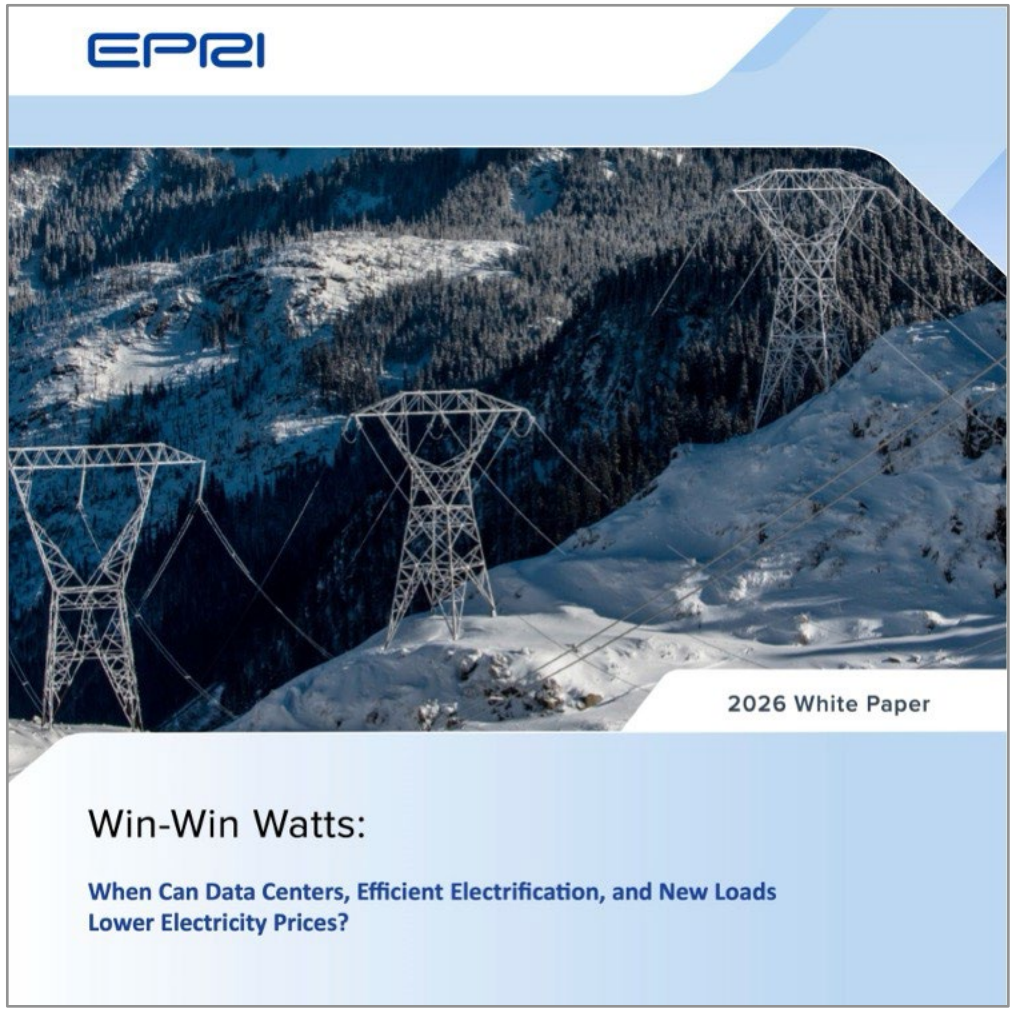
Large markets continue to grow, but geographic diversity of new capacity is increasing

Data Center Load vs Projected EV Charging Load



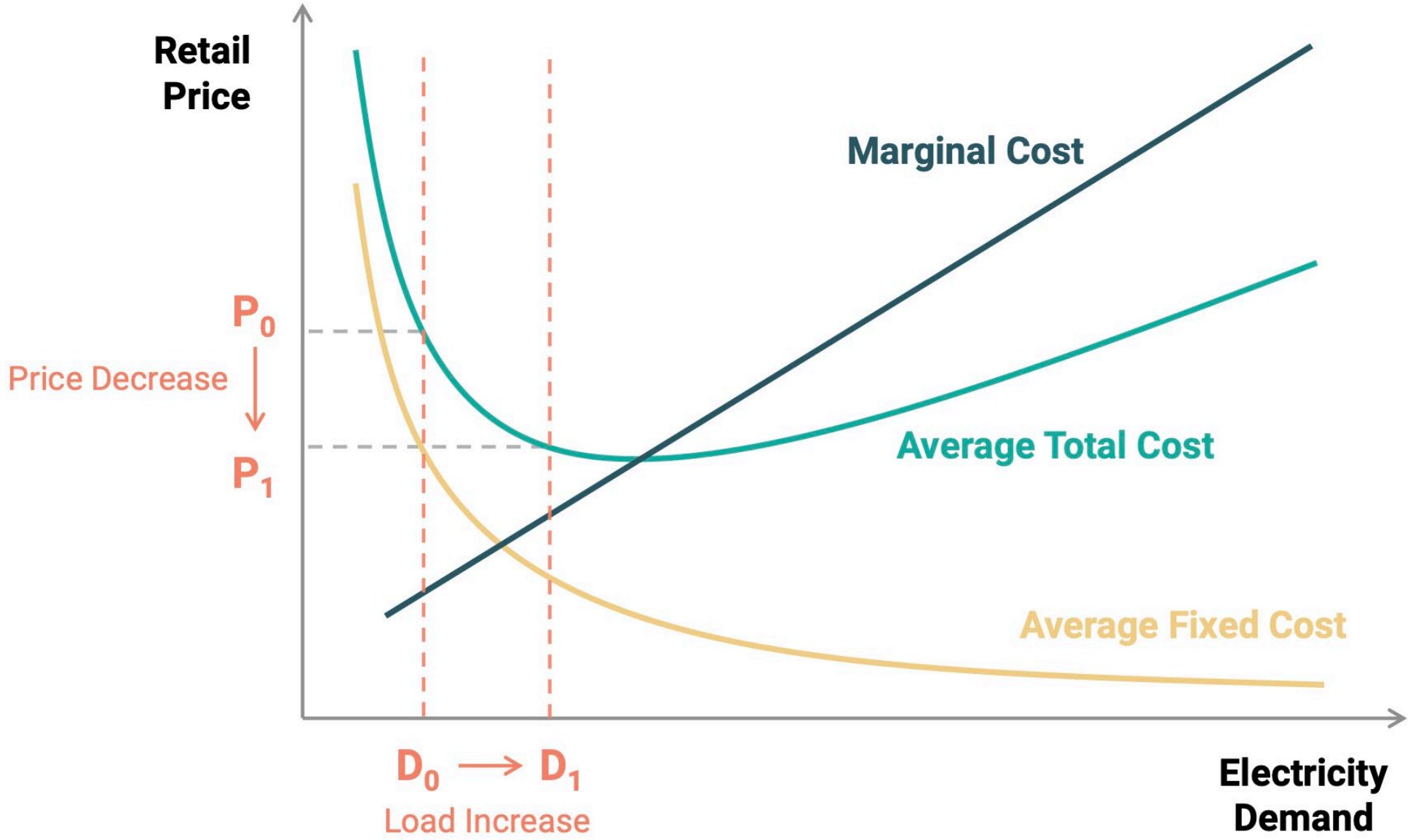
- DC is larger now and growing faster than EV load in U.S.
- But ceiling is potentially higher for EV load in the long run
- Significant uncertainty around projections for EV adoption and efficiency – new EPRI research is exploring a broader range of scenarios
  - EVs2Scale2030
  - Valuing EV Efficiency Improvements (EPRI, 2024)

Win-Win Watts (Free EPRI Report)



winwin.epri.com

New Loads *Can* Lower Electricity Prices

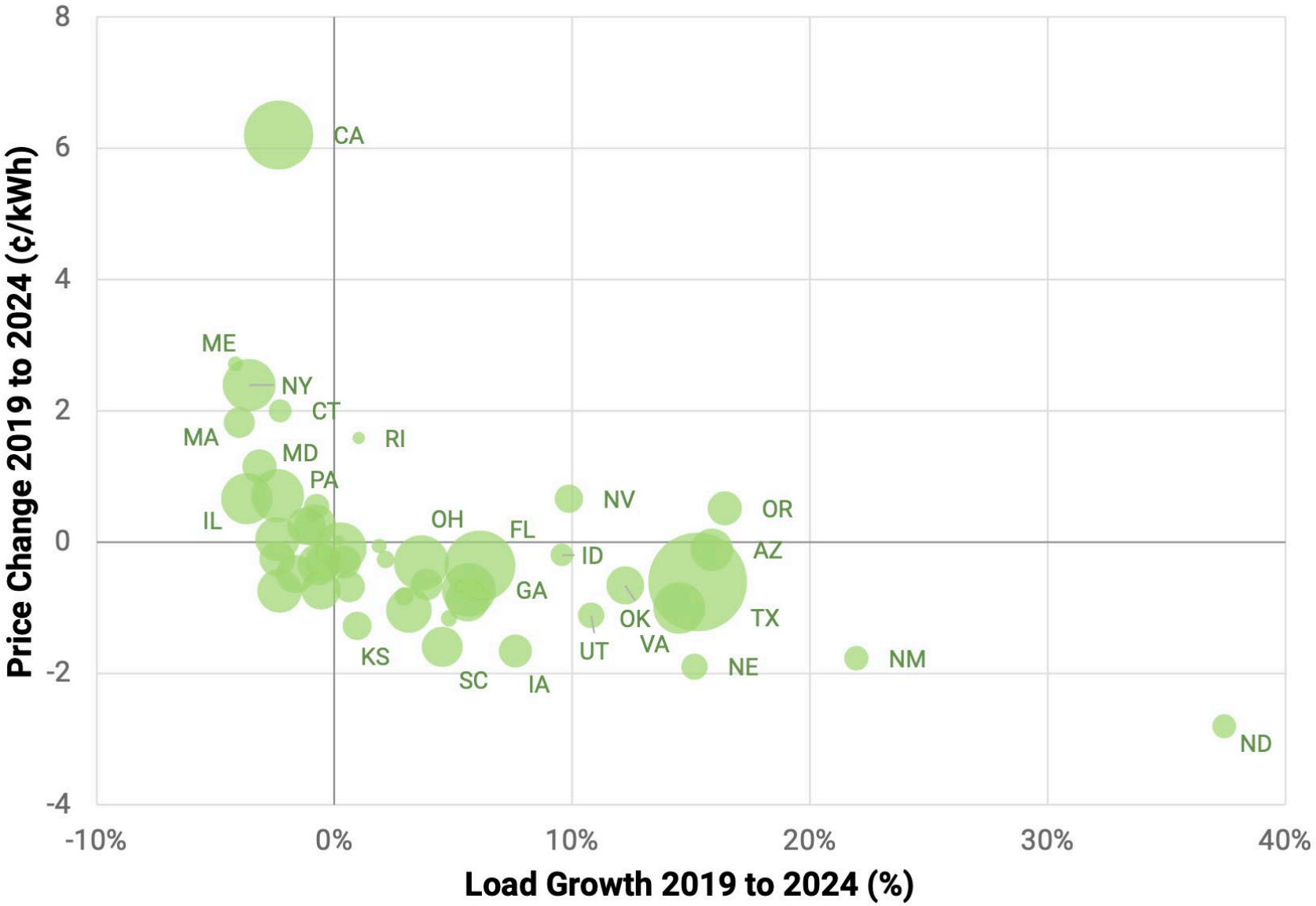


Under the right conditions, growing load can:

- Lower average electricity prices by **spreading system costs** over more kilowatt-hours (kWh)
- Improve **utilization of existing assets** and enable more efficient grid planning
- **Accelerate deployment** of clean electricity resources and emerging technologies
- Support **better system operations** and lower emissions

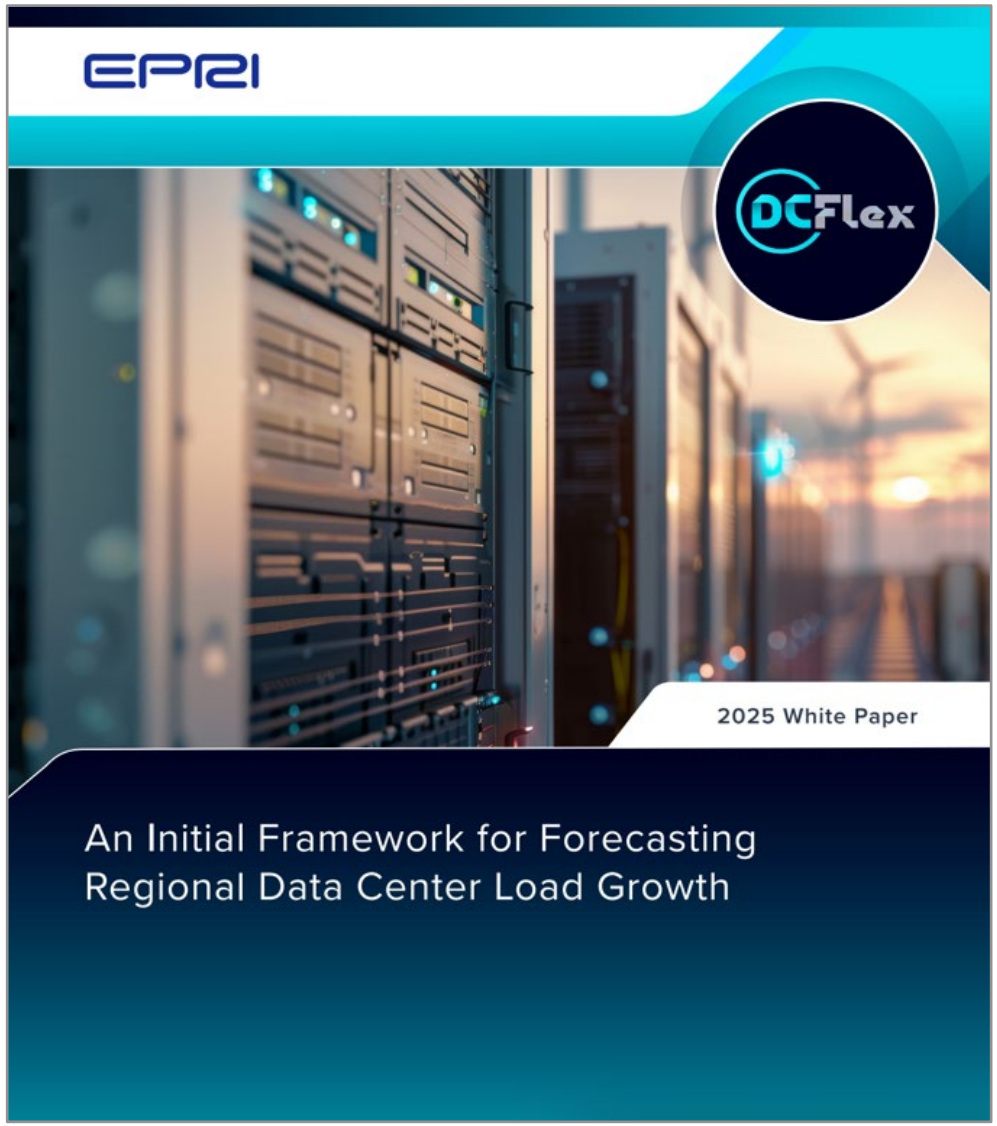
But the details matter

Some Empirical Evidence of These Price Effects:



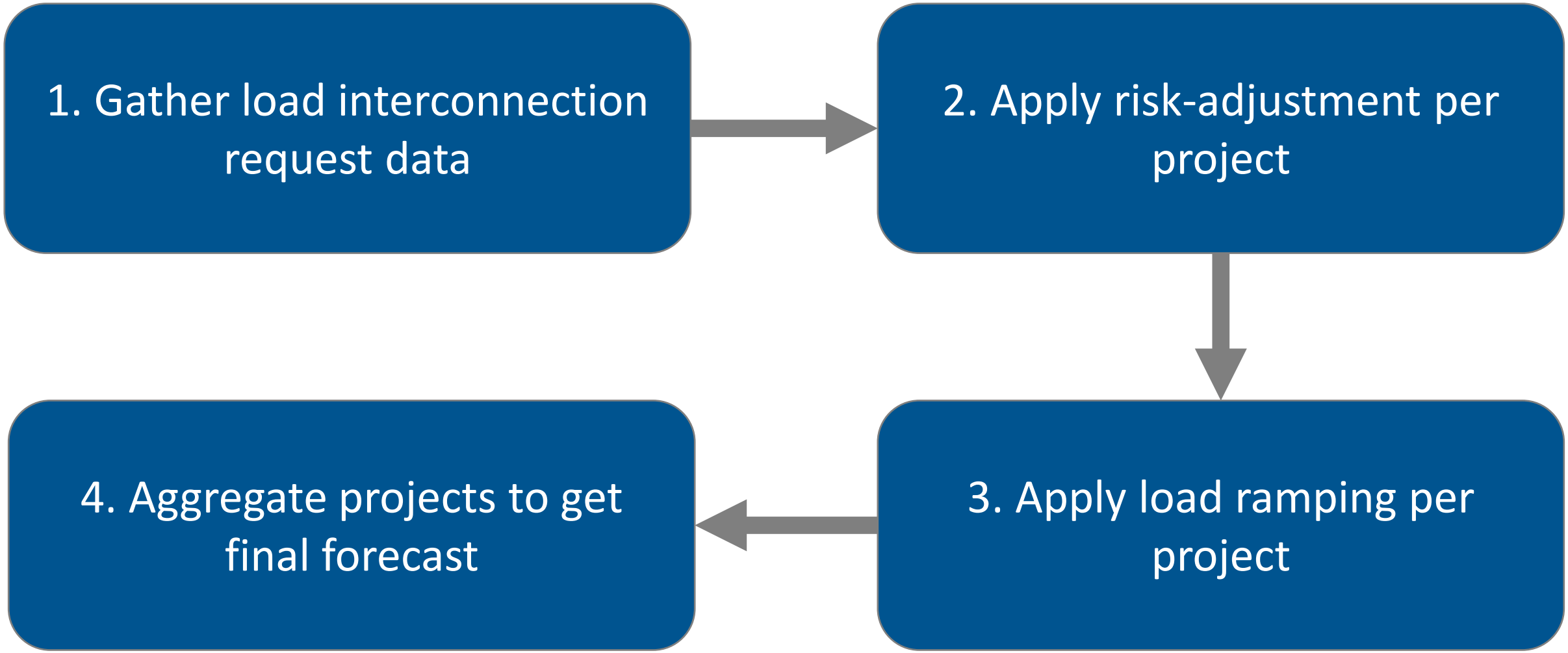
DCFlex Load Forecasting Framework

- Provides a **framework** to forecast data center loads on a regional basis and within service territories
- Leverages readily-available data from load **interconnection requests**
  - does **not** require a long history of data centers
- Currently only available to DCFlex members



29

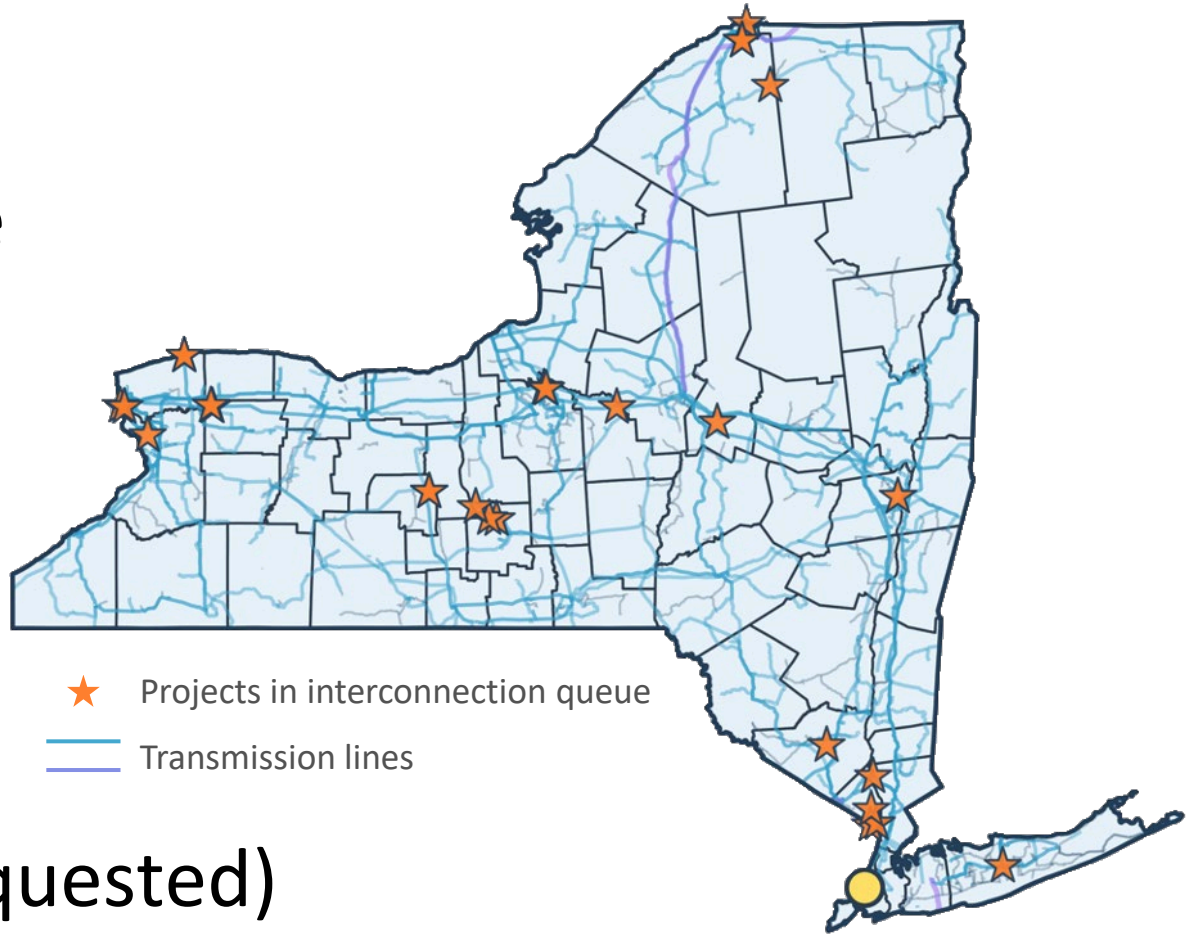
DCFlex Forecast Framework



30

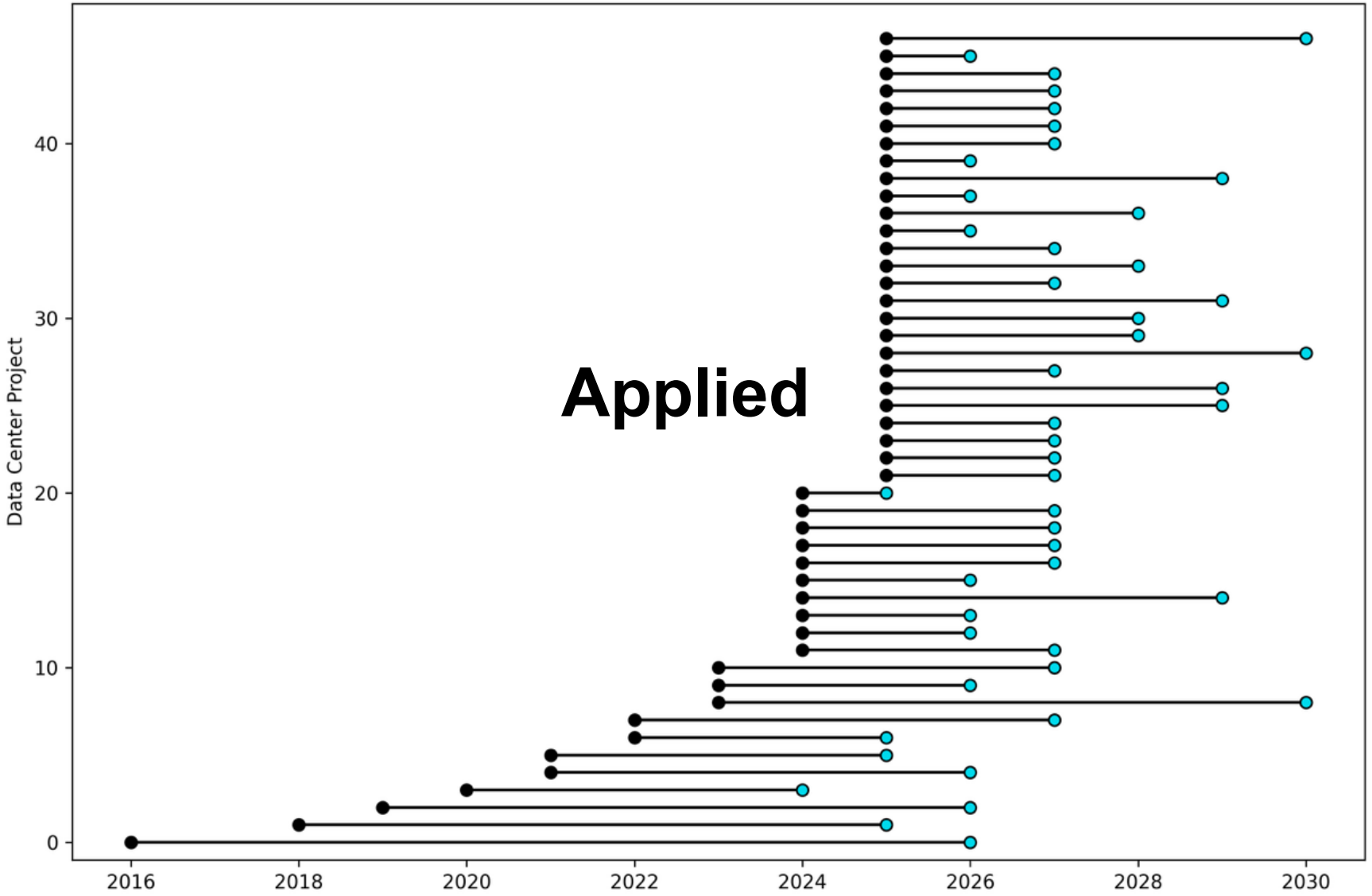
Example: New York State

- **47 projects** (as of Jan. 2026) in the interconnection queue*
  - 30 projects in Sep. 2025
- Largest project: 1,935 MW
- Typical project: 50–300 MW
- **~12 GW** of aggregate capacity (requested)
  - Equal to ~37% of NYISO's summer peak load (~32 GW)



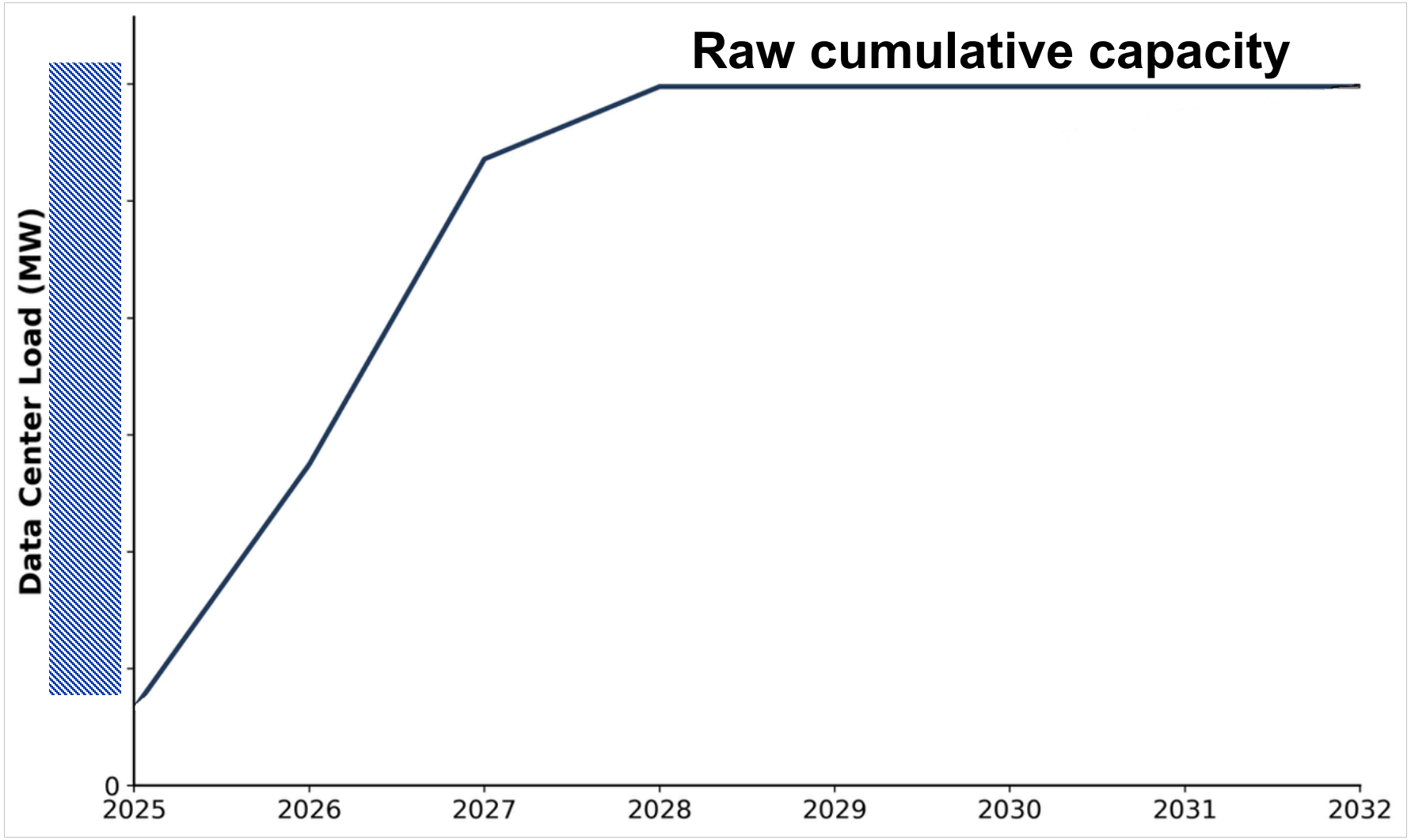
*Data source: https://www.nyiso.com/interconnections

Date of Application vs Requested Service Start



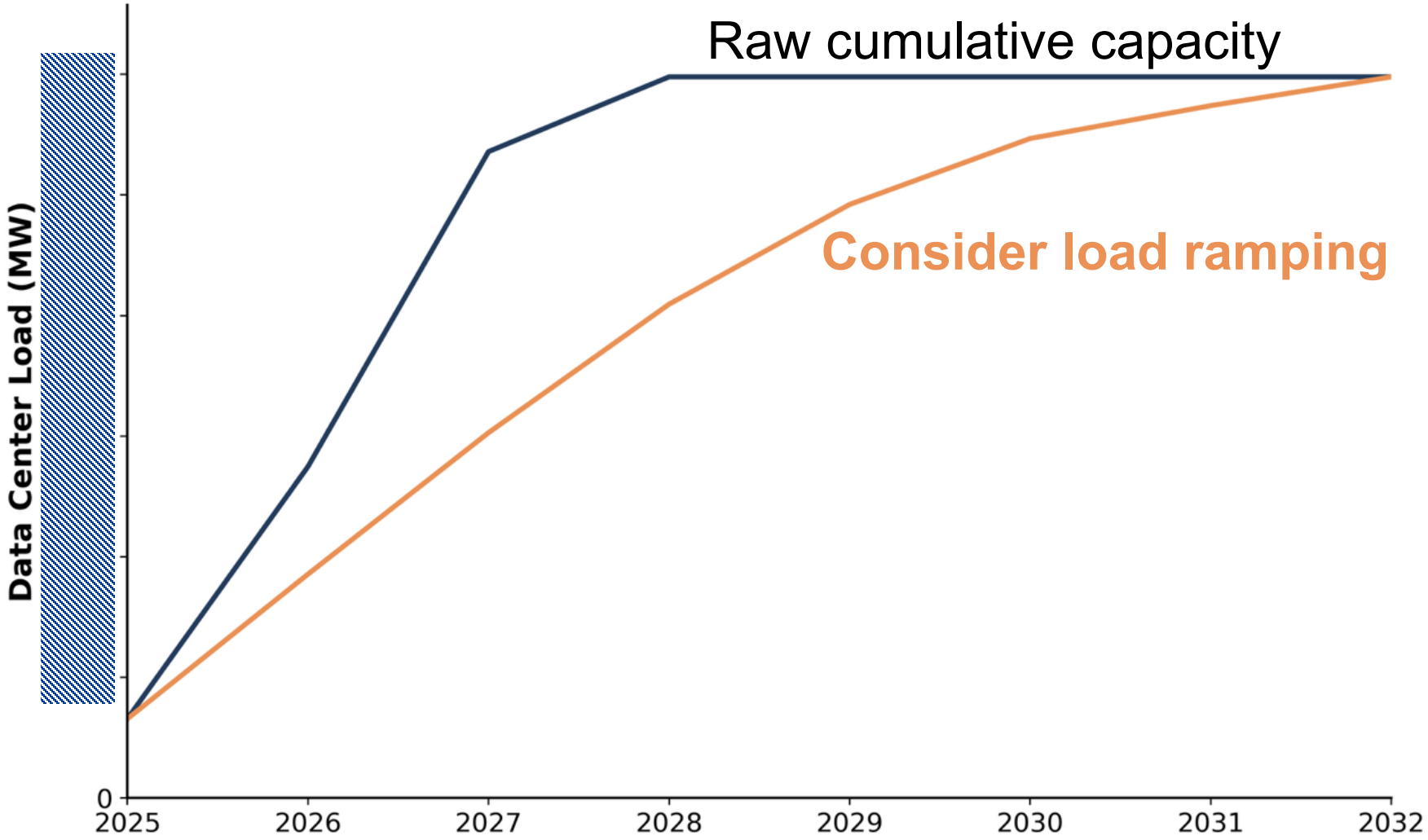
32

Example Load Forecasts



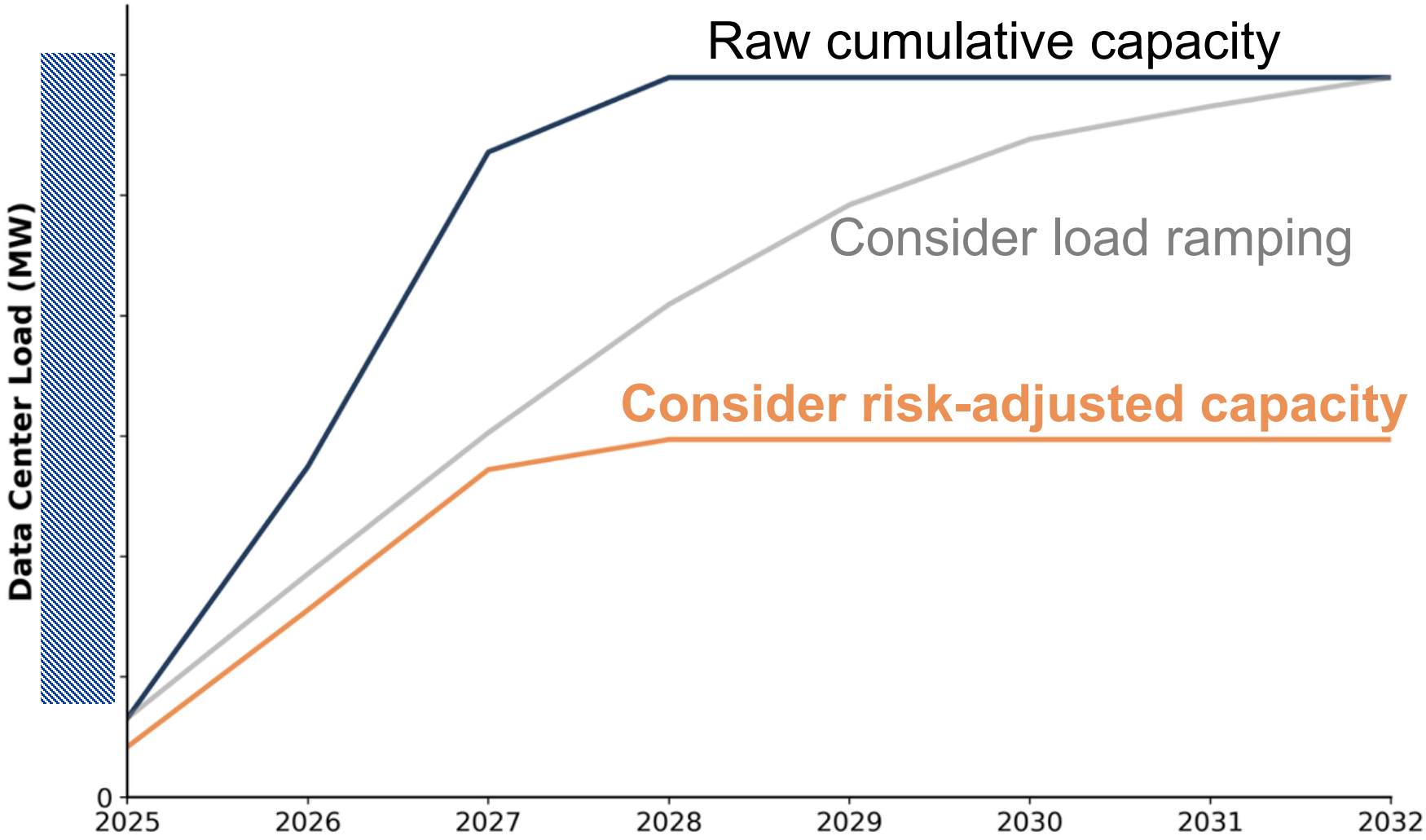
33

Impact of Load Ramping



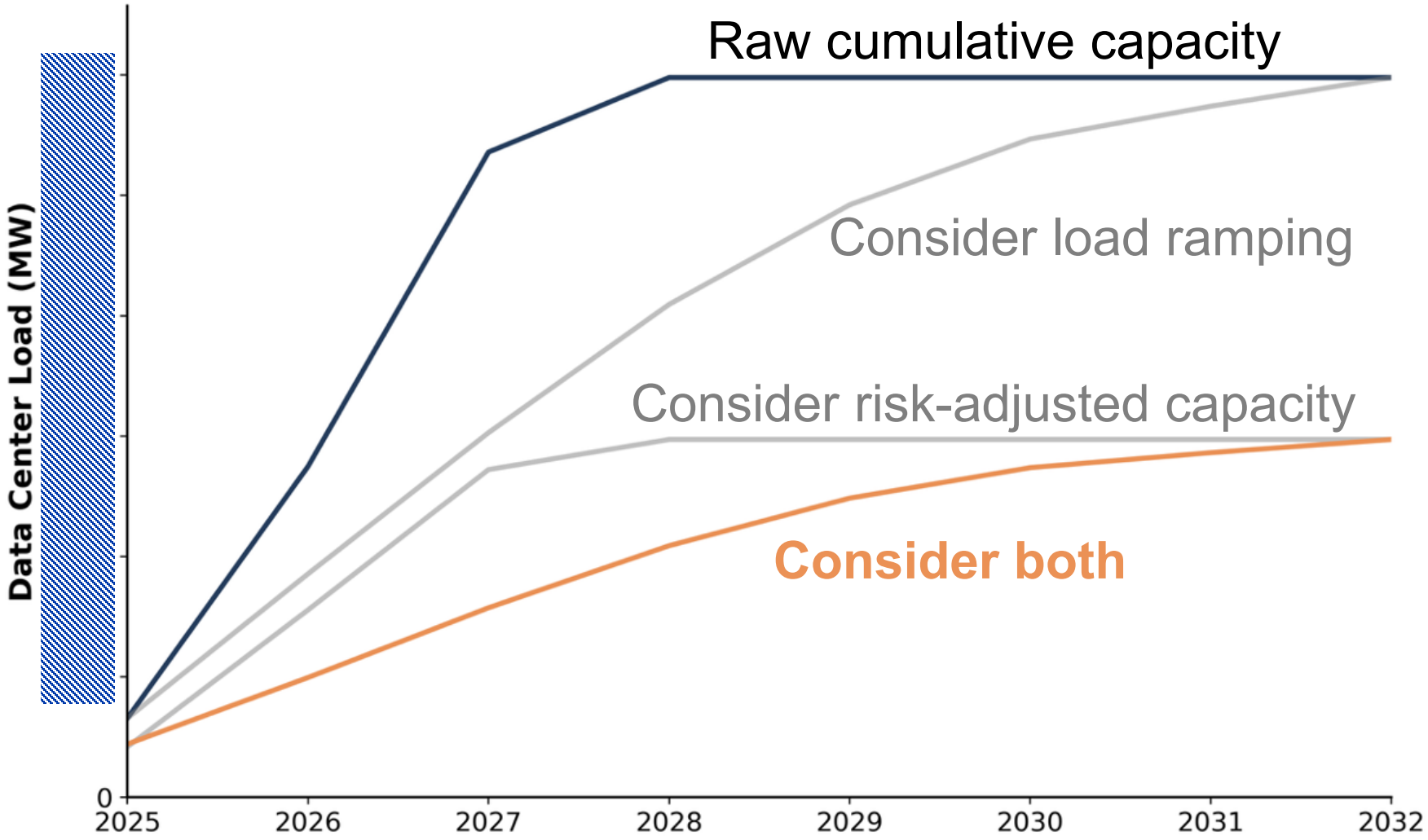
34

Impact of Risk-Adjusted Capacity



35

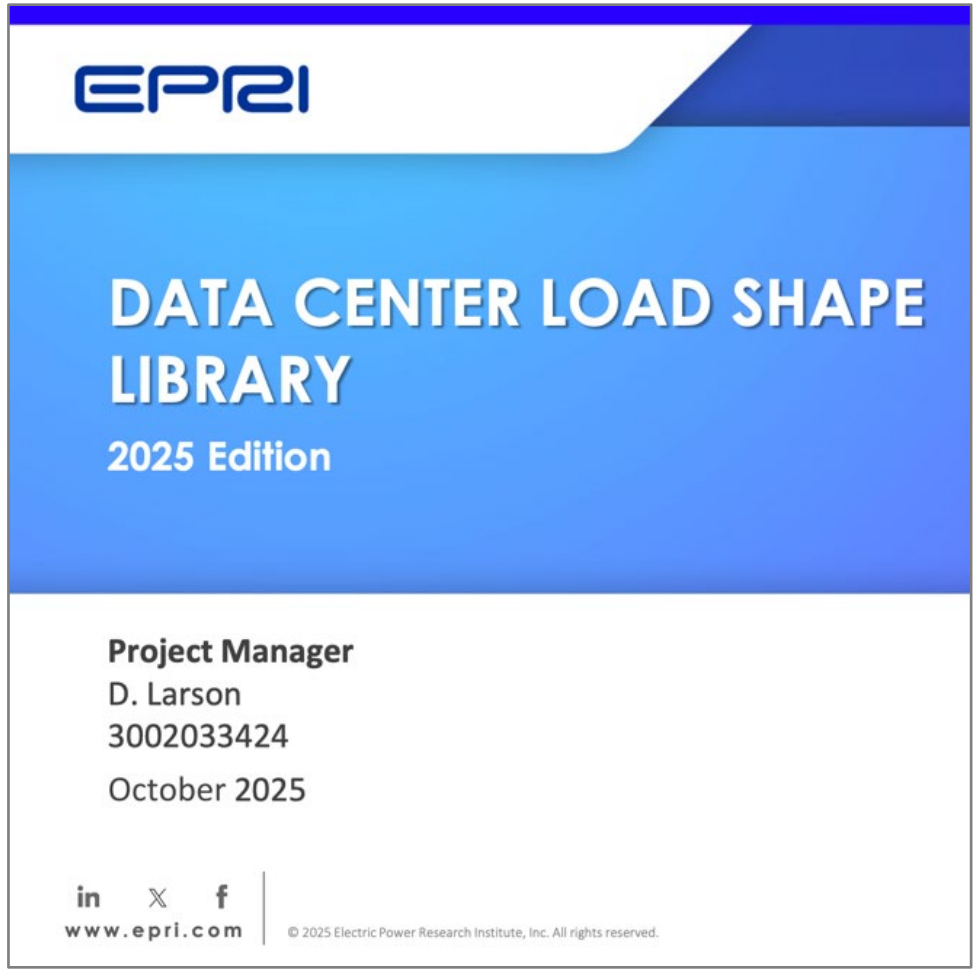
Impact of Ramping + Risk-Adjusted Capacity



36

DCFlex Data Center Load Shape Library

- First set of data center **load shapes**
  - Working to expand with more data
- Based on **empirical data from real-world data centers**
  - All are fully ramped up
  - Each have 1+ years of hourly data
  - Mixture of sizes (MW), workloads, etc.
- Currently **only available to DCFlex members**



37

EPRI DCFlex Initiative:

Ongoing Work on Large Loads and Resource Adequacy

Irene Danti Lopez, PhD
Sr Team Lead
idantilopez@epri.com

Optimize Data Center Operational Flexibility to Help Strengthen the Grid

10+
demo sites

- ARIZONA, U.S.
- NORTH CAROLINA, U.S.
- PARIS, FRANCE
- VIRGINIA, U.S.
- ILLINOIS, U.S.
- TEXAS, U.S.
- LONDON, U.K.

DCFlex Workstreams

01 Flexible Data Center Design

02 Transformational Utility Programs

03 Grid Planning for Operational Flexibility

04 Data Center Informed Energy Supply

05 Distribution Data Centers

The DCFlex participant panel actively collaborates with regulators, academia, and industry stakeholders – both to share leading practices and insights, and to incorporate diverse perspectives that strengthen the initiative's direction and impact.

Learn More:
dcflex.epri.com

FLEX MOSAIC

Deliver a tiered flexibility framework bridging data center capability to grid needs

Quantifying and Unlocking System Headroom

Developing practical, planner-centric methods to quantify how much additional demand a power system can reliably integrate and how much additional headroom can be unlocked through large load flexibility

Core concepts

Headroom: MW of new load a system can reliably integrate before violating reliability and operability standards

Large Load Flexibility can leverage a range of on-site or contracted resources (load modulation or shifting, back-up or bridge power, and other) to provide demand response and unlock further headroom.

Objectives of this work

- Help planners answer: "How much load can my system integrate *now*?"
- Identify infrastructure-free opportunities to expand load-serving capability.
- Guide investment prioritization, DC siting, flexibility program design, and policy/market rule development.

EPRI's DCFlex is developing a structured, planner-ready method that moves from theoretical to *realistic, decision-grade* headroom estimates, reflecting physical grid limits, operational considerations, and the role of flexible data centers.

Flexibility Needs Assessment

Mar 2026

HOW-TO WHITEPAPER

"A Comprehensive Framework to Assess Technical Headroom for Integrating DCs: An Industry Playbook for Unlocking True System Potential"

Jul 2026

CASE STUDIES

5 North American and European case studies implementing the framework and illustrating the capability of Flexibility Framework classes to unlock headroom

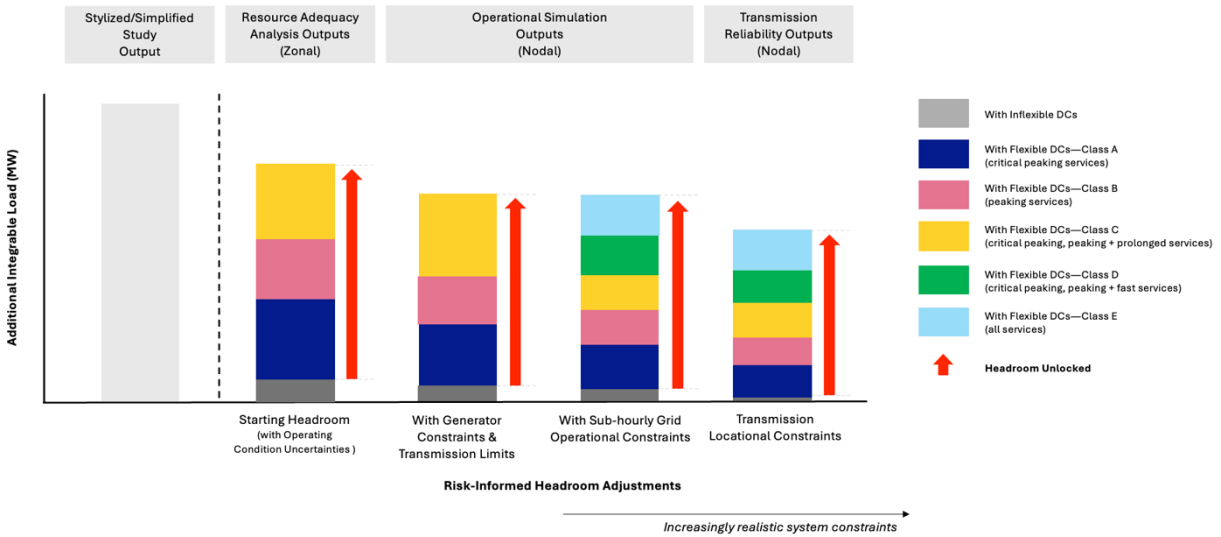
Sep 2026

ACHIEVABLE HEADROOM

Generalizing headroom potential across a diverse range of power systems, highlighting key results and lessons learned from the case studies.

DEVELOPING A FRAMEWORK & INDUSTRY GUIDANCE FOR EVALUATING LARGE LOAD INTEGRATION POTENTIAL IN POWER SYSTEMS

THE COMPONENTS OF HEADROOM

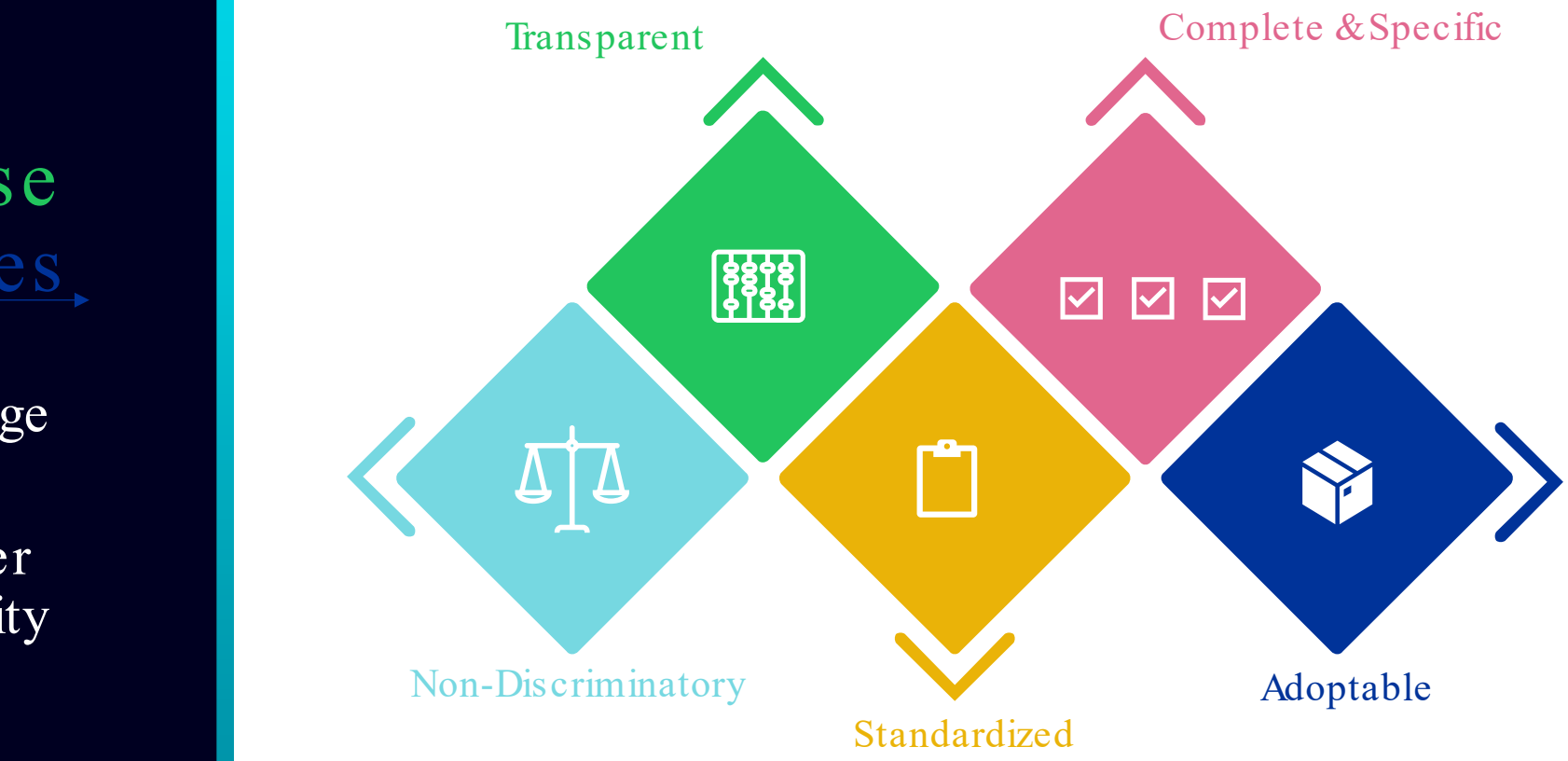


"Uncovering true system headroom by considering realistic grid operations and the full range of DC flexibility archetypes."

Framework Purpose & Guiding Principles

Create a common language for load flexibility

Accelerate speed to power while maintaining reliability

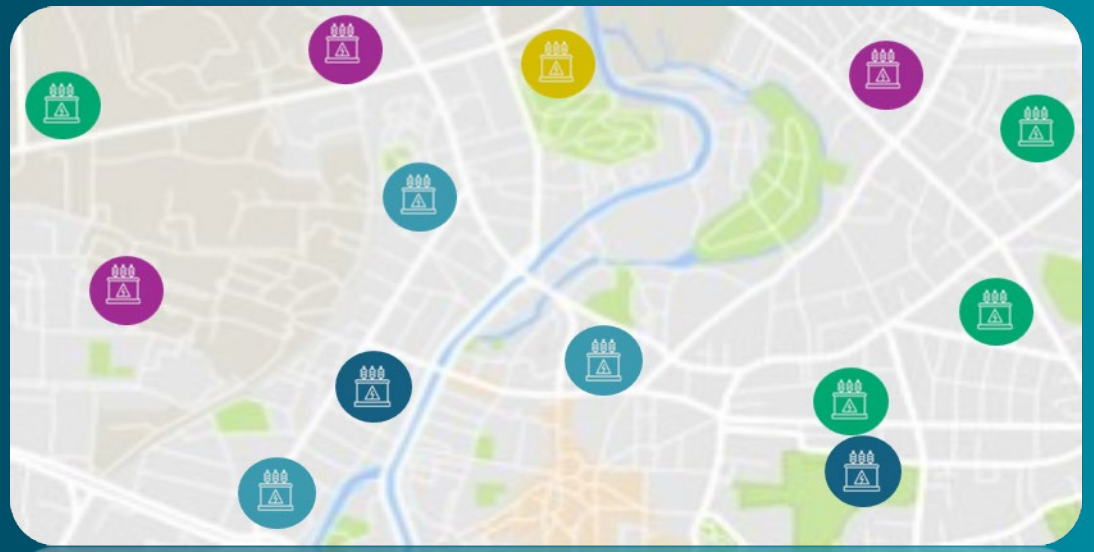


Standardizing Large Load Flexibility Characteristics to Unlock Interconnection

- Class-certified large load profile
- Transparent & predictable flexibility capabilities

Increasing flexibility

A	Critical Peak
B	+ Peak
C	+ Prolonged
D	/+ Fast
E	Fully Dispatchable



- Transparent performance expectations
- Clear signals on flexibility needed

Working Group

California ISO · COMPASS datacenters · Dominion Energy · DUKE ENERGY · ercot · Georgia Transmission · ieso Connecting Today. Powering Tomorrow. · ING · NVIDIA · Schneider Electric

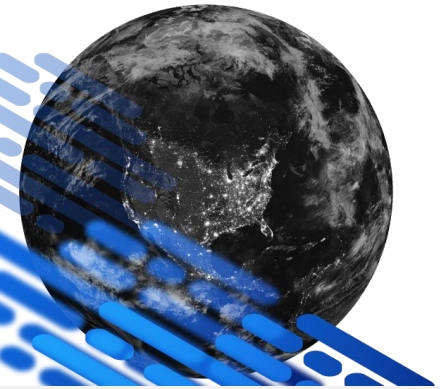

Questions?

Thank You for your participation and engagement.

Look out for the Next 'Views from the TOP' invite for Thursday, May 7, 2026

Not a Member? Sign up Here!

Also, subscribe to the EPRI Resource Adequacy Mailing List



Contact us:
resourceadequacy@epri.com

Scan or Click Here

TOGETHER…SHAPING THE FUTURE OF ENERGY®

www.epri.com