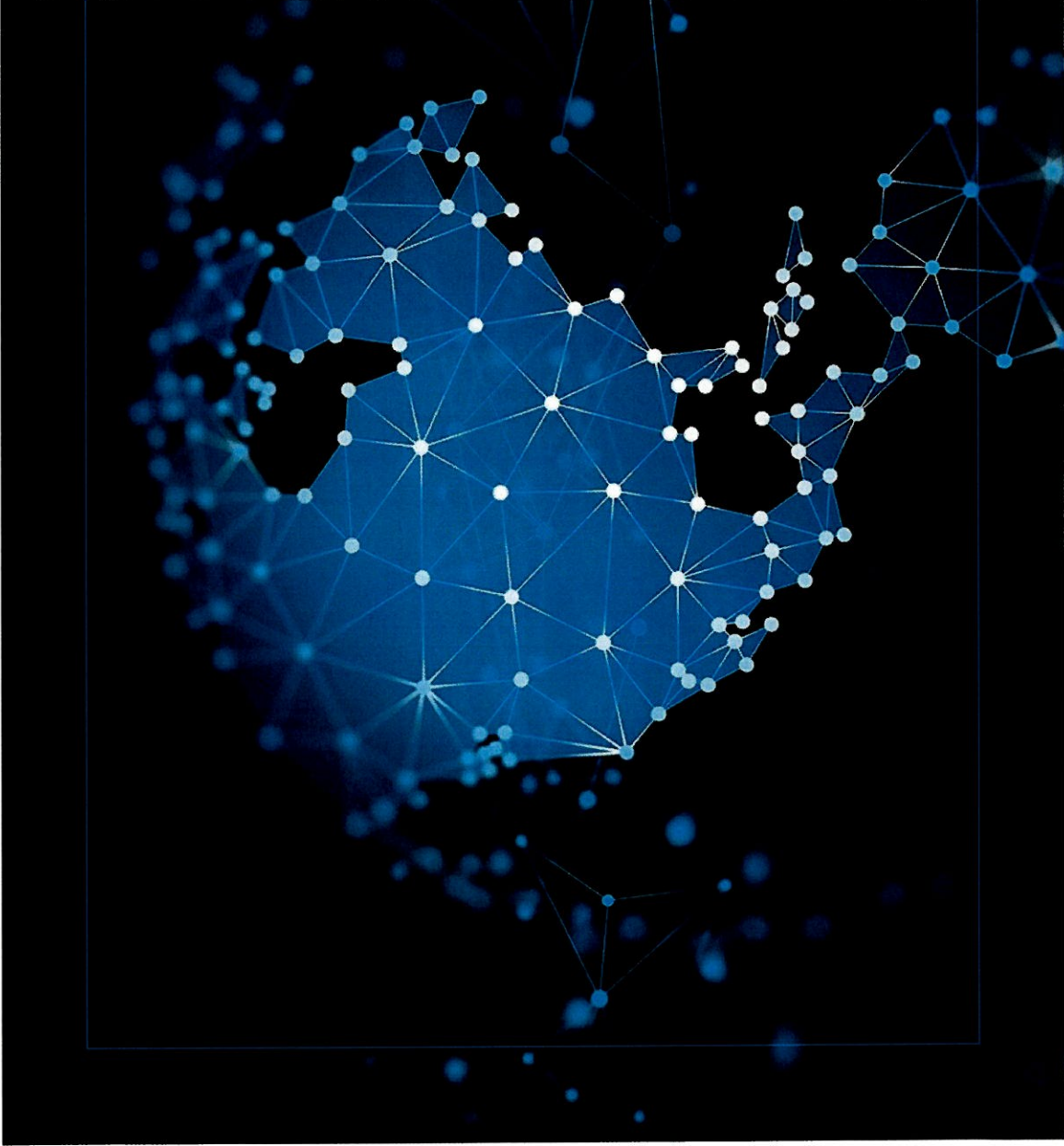




LAS Meeting  
August 26<sup>th</sup>, 2026

CRA Charles River  
Associates



## Meeting agenda

| Topic                                              | Timing                 |
|----------------------------------------------------|------------------------|
| <b>Introductions and July 13 LAS Meeting Recap</b> | <b>9:10 – 9:20 AM</b>  |
| Top-Down: Unconstrained View                       | 9:20 – 9:35 AM         |
| Top-Down: Constraints                              | 9:35 – 10:00 AM        |
| Bottom-Up Forecast                                 | 10:00 – 10:15 AM       |
| Load Profile Assumptions                           | 10:15 – 10:25 AM       |
| Forecast Reconciliation and BTM                    | 10:25 – 10:45 AM       |
| Scenarios                                          | 10:45 – 11:00 AM       |
| <i>Break</i>                                       | <i>11:00– 11:10 AM</i> |
| Q&A                                                | 11:10 – 11:55 AM       |
| Next Steps & Close                                 | 11:55 – 12:00 PM       |



## Today's presenters



**Project Director**  
Margarita Patria, PhD



**Project Manager**  
Oliver Stover, PhD

## PJM Data Center Capacity & Peak Demand Forecast

CRA's independent, hourly load forecast for PJM (2027–2047). Presented to the LAS on July 13, 2026

### PROJECT SCOPE

**Independent PJM-wide data center forecast** with hourly load profiles and explicit uncertainty quantification, integrating bottom-up project intelligence with top-down market analysis to support transmission planning, reliability, and resource adequacy.

|          |                      |
|----------|----------------------|
| Horizon  | 2027–2047            |
| Region   | PJM                  |
| Method   | Bottom-up / Top-down |
| Timeline | May–Oct 2026         |

### METHODOLOGY STEPS

- 1 Top-down Demand and Constraint Modeling.** Start with unconstrained demand but forecast what can actually materialize. National AI and non-AI demand is tested against power, semiconductor, infrastructure, and supply-chain constraints. The model is recursive, allowing constraints and market responses to evolve over time but also slowing demand in response to constraints.
- 2 Bottom-Up: Site-level project pipeline scored on siting favorability and developer readiness.** CRA reconciles PJM/EDC/LSE and commercial project data, distinguishes true duplicates from development optionality, and evaluates project maturity, ramping, and zonal attractiveness.
- 3 Reconciliation:** Top-down determines scale; bottom-up determines location and timing. The two views are reconciled into one internally consistent PJM forecast that honors physical constraints. Excess pipeline may be delayed, relocated, served BTM, ramped more slowly, or not realized; future demand beyond the visible pipeline is represented through generic projects.
- 4 Hourly forecasts** reflect evolving data-center operating behavior. Forecasted capacity is translated into hourly load profiles by zone and workload type, incorporating stochastic variation, use of hybrid BTM resources, and changes in load factors and operating patterns over time.
- 5 Scenarios** capture alternative paths for data-center growth. Scenarios test different assumptions around AI adoption, efficiency, power availability, infrastructure, and supply-chain constraints to show how demand could evolve under different plausible futures.

### NEXT STEPS

- Sept 4** LDE form submissions due
- Sept–Oct** Individual EDC/LSE meetings
- Oct 14** Final results at LAS meeting



## Meeting agenda

| Topic                                       | Timing                 |
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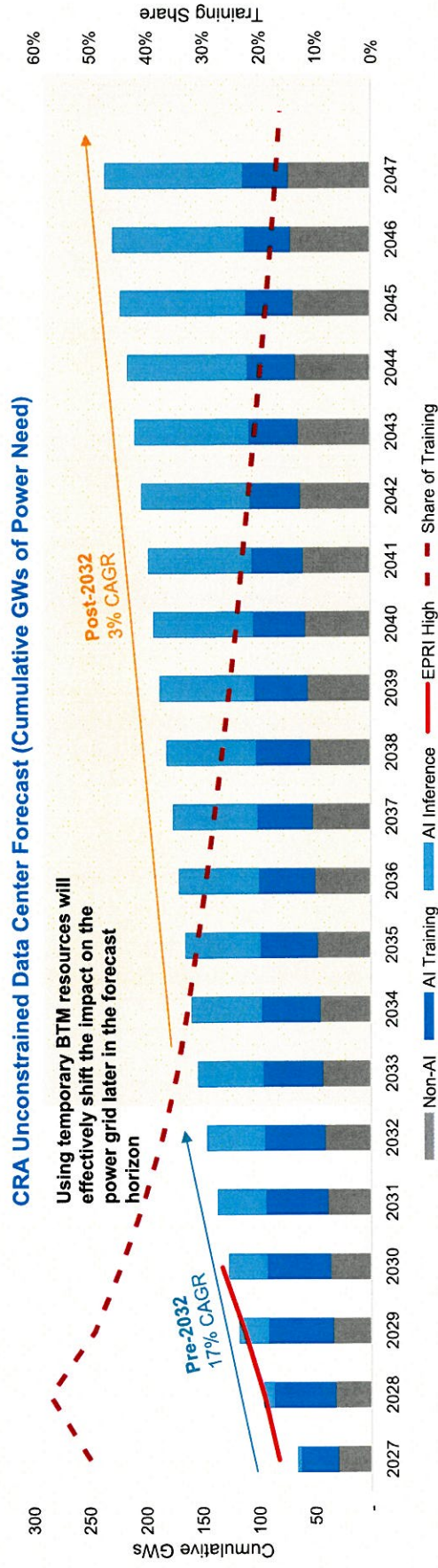




## Top-Down: Unconstrained View – Expected Growth

No forecasts contained within this document should be considered a “Final” forecast

# Top-Down forecast starts with unconstrained national demand, which includes non-AI, AI training, and AI inference components, each with its own growth trajectory



| Pre-2032                                |                              |                                                                                                                                                                                                                 | Post-2032                   |                                                                                                                                                                                                             |  |
|-----------------------------------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Aggregate CAGR for Unconstrained Demand |                              |                                                                                                                                                                                                                 | 3%                          |                                                                                                                                                                                                             |  |
| - Non-AI Demand                         | +6% YoY                      | Assumes linear growth for non-AI related demand.                                                                                                                                                                | +4% YoY                     | Assumes linear growth for non-AI related demand.                                                                                                                                                            |  |
| - AI Training Demand                    | +10% YoY                     | Assumes that public training data is available and expanding compute supply fuel a capability race, driving rapid growth in annual AI training compute demand.                                                  | -2% YoY                     | As large models exhaust publicly available data*, a shift to disciplined (smaller) model development and chip processing efficiency drives down total annual compute demand for AI training (see paper)*.   |  |
| - AI Inference Demand                   | +75% YoY (small base number) | Assumes that AI adoption grows at a similar trajectory as U.S. internet adoption, with a higher growth factor for both work and individual use. Forecasted edge compute is removed from unconstrained forecast. | +6% YoY (large base number) | Assumes that AI adoption continues the pre-2032 trajectory. Reaching 90% adoption for individual use around 2032, and 90% adoption for work-related use by around 2041. Forecasted edge compute is removed. |  |

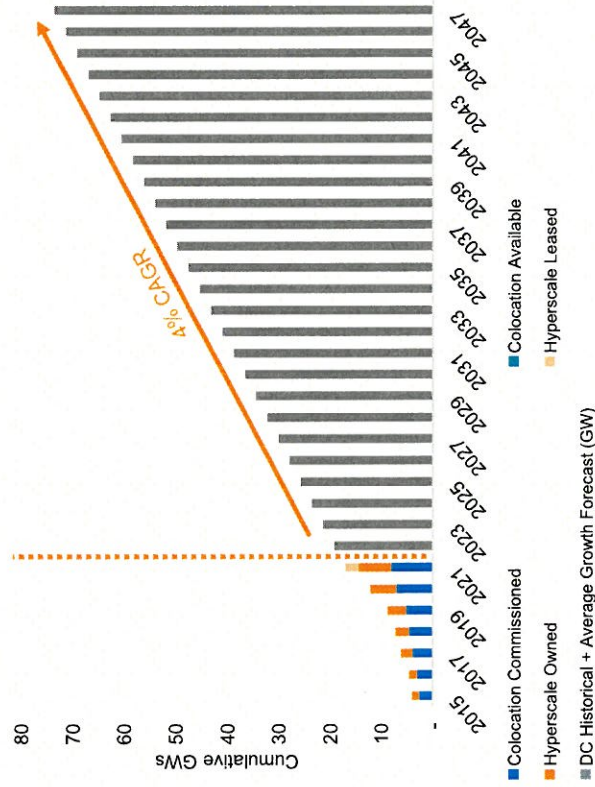
Notes: CAGR = Compound Annual Growth Rate, Sources: Nvidia, Epoch.AI, DatacenterHawk, Pew Research Center, St. Louis Federal Reserve, Ericsson Market Intelligence, Brookings Institute || See Following Slides for Details



## Non-AI grows at a steady rate due to traditional digital economy needs

No forecasts contained within this document should be considered a "Final" forecast

CRA Unconstrained Non-AI Data Center Forecast



### Approach

- Calculate historical GWs growth in Owned, Leased, Available, and Commissioned data centers between 2015 ~ 2021
- Apply average growth GWs to forecast period to capture stable "non-AI" segment of data center growth

| Variable          | Value       | Source                                                                                                                   |
|-------------------|-------------|--------------------------------------------------------------------------------------------------------------------------|
| Historical Window | 2015 ~ 2021 | Investor memos: 2021 cut off based on investment memos of data center providers, mentions "AI" investments first in 2022 |
| YoY Growth        | 4%          | Resulting growth rate from applying linear average growth between 2015 ~ 2022                                            |

### Assumptions

- Assume "AI Growth" occurs in 2022. All-else-equal, assume that non-AI growth stays consistent YoY
- Assumes 'typical' PUE for non-AI data centers to be 1.32 per EPRI ([link](#))
- Elected to use linear model instead of directly applying CAGR growth, as inputting CAGR values may distort long-term growth due to a small starting base

Sources: DatacenterHawk



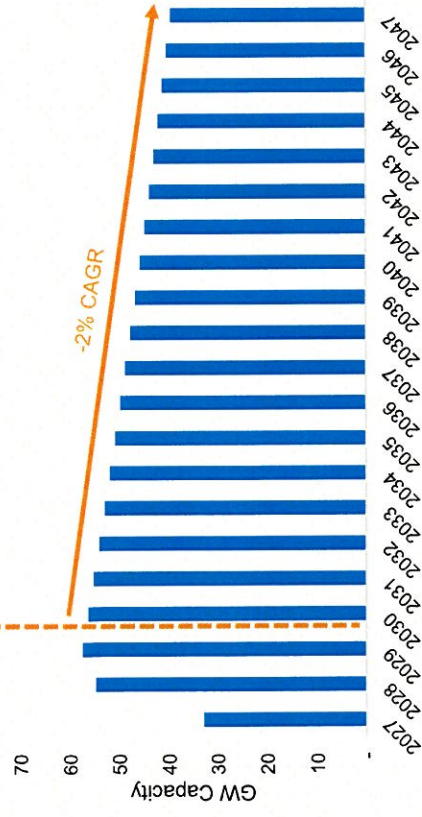


# AI training grows, then declines as models exhaust data and gain efficiency

No forecasts contained within this document should be considered a "Final" forecast

## CRA National Unconstrained AI Training Forecast

As Large Language Models (LLMs) exhaust publicly available data, a shift to **disciplined (smaller) model development and chip processing efficiency** drives down total annual compute demand for AI training.



## Assumptions

- Assumes fixed server overhead of 1.82 (Epoch.ai), meaning that for every watt of GPU draw, the other components of a rack require 84% of the power of the GPU
- Assumes significant models grow at 11% YoY, using median YoY growth since 1990
- Assumes 1.1 PUE across future periods for AI Training ([link](#))
- Assumes 10% GPU idle rate when computing tasks ([link](#))
- Assumes final training is 10% of R&D, consistent with recent estimates ([link](#))

## Approach

- Estimated total training calculations needed using model quantity and average model training intensity
- Converted model training calculations needed to chips required, with assumptions on GPU processing speed and power draw
- Used GPU power draw, supporting server compute needed, and assumed PUE to arrive at capacity needed for new models

| Variable | Initial Value | Growth Rate | Source |
|----------|---------------|-------------|--------|
|----------|---------------|-------------|--------|

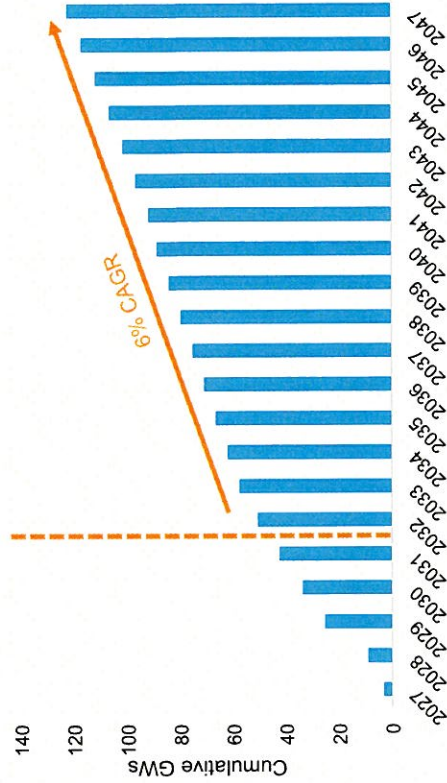
|                                |                             |                                                                                                                            |                                                                                                                                                        |
|--------------------------------|-----------------------------|----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Avg. Model Size                | 1.4E+25 FLOPs               | 4.3x/year in recent years, slowing to 1/2 by 2028, and 1/4th at 7.5% CAGR of growth by 2030 to reflect lack of public data | Epoch.ai: <a href="#">notable models</a> ; <a href="#">expected date of public data</a> exhaustion is 2028, with ~95% confidence of exhaustion by 2030 |
| Number of New Models           | 170 Publicly Notable models | 1.11x/year to reflect historical growth rates                                                                              | Epoch.ai: data on <a href="#">notable models</a>                                                                                                       |
| Chip Processing Speed (FLOP/s) | 9.89E+14                    | 1.34x/year growth rate based on average growth of GPUs processing speed*                                                   | Epoch.ai: data on <a href="#">machine learning hardware</a>                                                                                            |
| Chip Power Draw (W)            | 700 W                       | 1.1x/year growth rate based on average growth of GPUs processing speed                                                     | Epoch.ai: data on <a href="#">machine learning hardware</a>                                                                                            |



## AI inference grows steady as AI is increasingly adopted

No forecasts contained within this document should be considered a "Final" forecast

CRA National Unconstrained AI Inference Forecast (No Edge)



### Assumptions

- Assumes edge inference is **not** a part of the large load forecast
- Assumes fixed server overhead of 1.84 (per Epoch.ai), meaning that for every watt of GPU draw, the other components of a rack require 84% of the power of the GPU
- Assumes parameters size scale at the same rate as training size per Chinchilla Scaling Laws and "Small Models" paper, estimated at 7.5% YoY in future years
- Assumes 1.1 PUE across future periods for AI Inference ([link](#))
- Assumes 10% GPU idle rate during tasks computation ([link](#))
- Assumes that "on peak" usage needs to cover 75% of total usage ([link](#))

### Approach

- Estimated adoption rates in the U.S. based on historical internet adoption curve and recent work & individual adoption studies
- Combined adoption rates with usage intensity to arrive at total compute needed to process requests
- Converted model training calculations needed to chips required, with assumptions on GPU processing speed and power draw
- Used GPU power draw, supporting server compute needed, and assumed PUE to arrive at capacity needed for new models

| Variable                       | 2025 Value                                                              | Growth Rate                                                              | Sources                                                                                              |
|--------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Adoption Rates                 | Around 50% for individual use; 40% for work use                         | Based on adjusted internet adoption growth rates                         | St. Louis Fed Study, <a href="#">FRED Internet Adoption Data</a>                                     |
| Usage Intensity                | <b>19 and 29</b> from Brookings survey data for individual and work use | Proxy based on mobile internet traffic data growth rates                 | Brookings Institute <a href="#">AI Use Survey</a> , <a href="#">Ericsson Internet Traffic Growth</a> |
| Chip Processing Speed (FLOP/s) | 9.89E+14                                                                | 1.34x/year growth rate based on average growth of GPUs processing speed* | Epoch.ai: data on <a href="#">machine learning hardware</a>                                          |
| Chip Power Draw (W)            | 700 W                                                                   | 1.1x/year growth rate based on average growth of GPUs processing speed   | Epoch.ai: data on <a href="#">machine learning hardware</a>                                          |

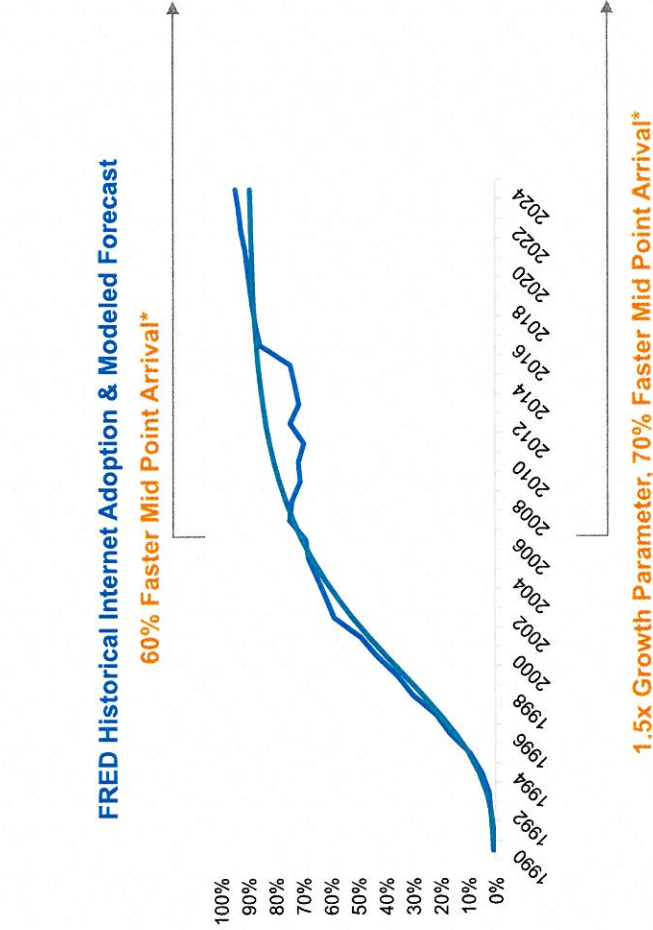
**CRA** Charles River Associates

Sources: Epoch.ai, Brookings Institute, St. Louis Federal Reserve, Ericsson Market Intelligence



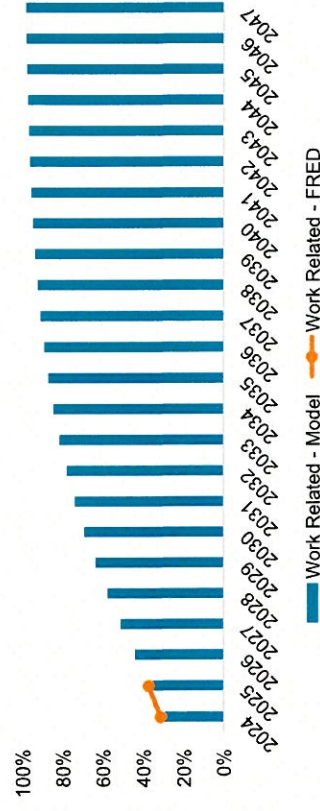
No forecasts contained within this document should be considered a "Final" forecast

## CRA anchored AI adoption curve to historical internet adoption shape, while capturing the accelerated rate of growth of AI adoption

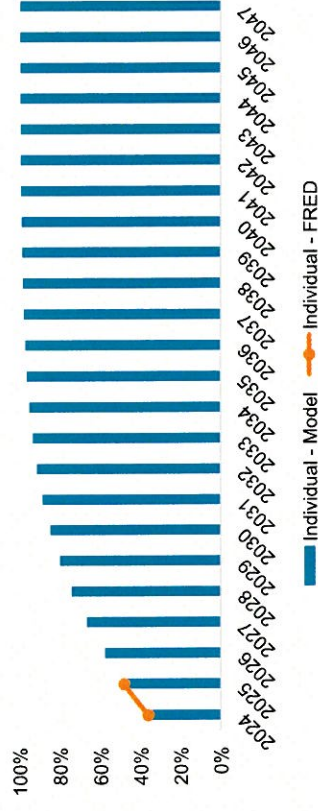


\*: Start Year adjusted to fit curve, assume AI start year = 2022

Work Related Base Case Adoption Rate Forecast



Individual Use Base Case Related Adoption Rate Forecast

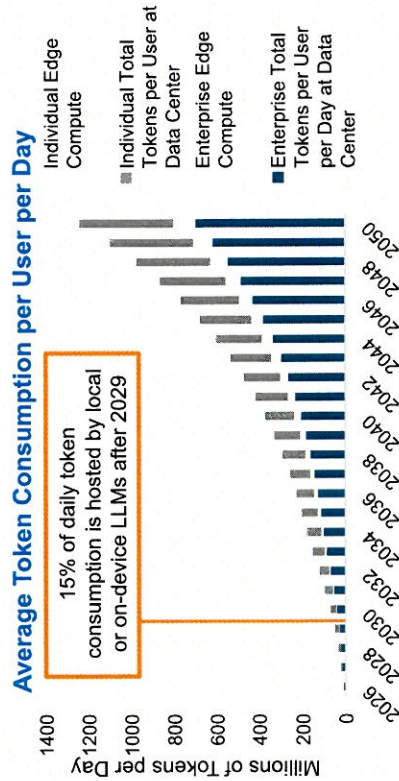




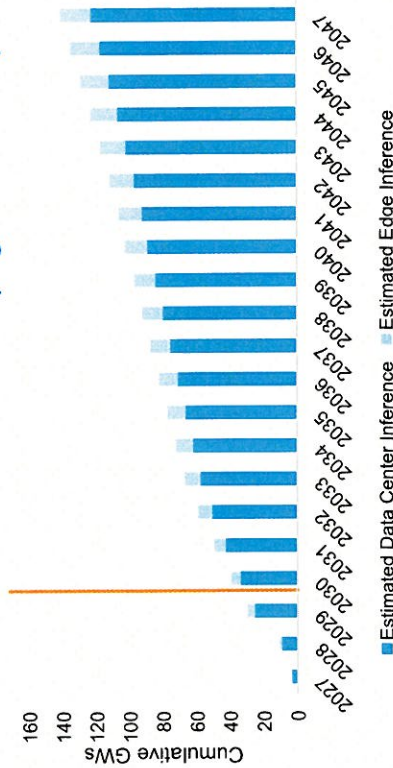
No forecasts contained within this document should be considered a "Final" forecast

# Edge compute growth has been excluded from inference component of the forecast to capture compute migration to local devices

This is because edge compute is projected to shift processing from large data centers into distributed, on-device processing within customer hardware.



## Cumulative Inference Demand (Edge + Data Center)



## Approach

- From the estimated users that have edge-capable devices, remove the share of estimated daily token usage on the edge from total inference demand

| Variable                                         | 2029 Value                       | Growth Rate                                               | Source                                       |
|--------------------------------------------------|----------------------------------|-----------------------------------------------------------|----------------------------------------------|
| Share of households with personal computers      | 90%                              | N/A                                                       | Census.gov data on Computer and Internet Use |
| Share of tokens moving to local and edge compute | 15% of total daily usage by 2029 | Assumed constant rate after 2029, linear growth from 2025 | OpenRouter State of AI 2025                  |

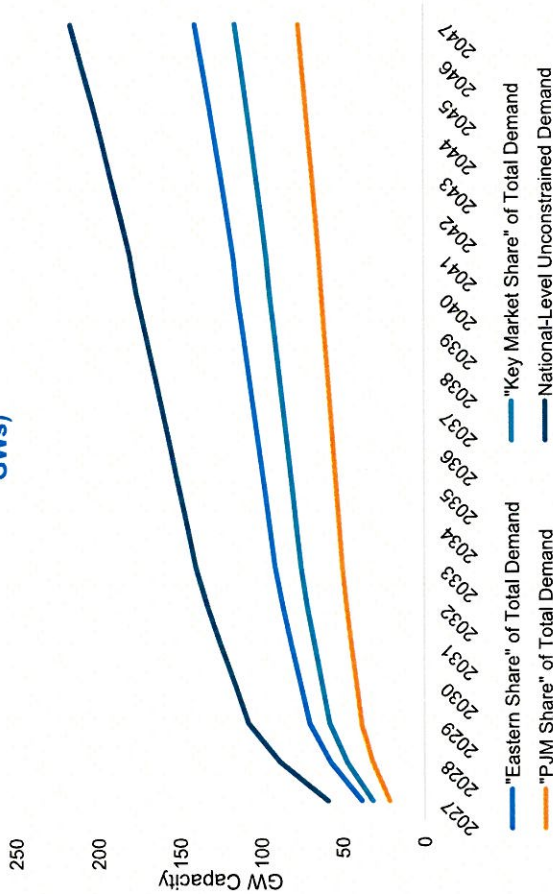
## Assumptions

- Before 2029, local LLM consumption grows linearly to 15% of total average daily consumption
- Assumes that households with edge capable devices will migrate their inference needs onto the edge

No forecasts contained within this document should be considered a "Final" forecast

## Historical shares of national AI demand are *initially* held constant across key geographies

CRA Unconstrained Data Center Forecast, Key Regions (Cumulative GWs)



### Assumptions

- Assumes market share stays constant across forecast horizon
- "Market Share" is defined as the share of Owned, Operated, and Under Construction GWs in a specific ISO/RTO (e.g., PJM, MISO, ERCOT) relative to the total GWs in North America

### Approach

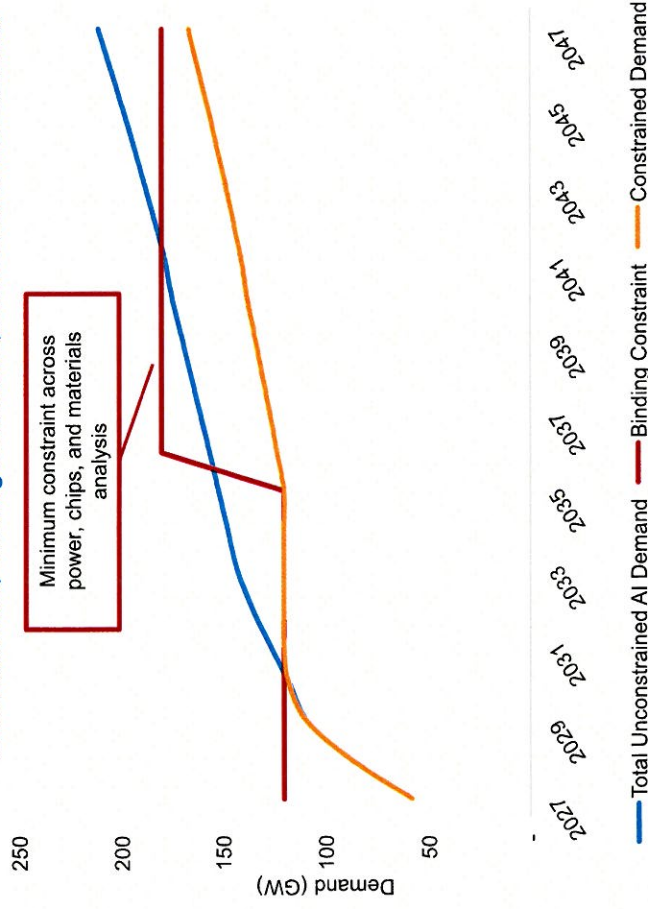
- Apply historical market share percentiles to national-level, unconstrained data center forecast
- Assume US data centers do not go international, and PJM's market share remains constant, unless PJM-specific constraints slow growth. Unmet PJM demand may try to shift to other Key Markets listed below.

| Variable                      | Value                       | Source                                               |
|-------------------------------|-----------------------------|------------------------------------------------------|
| "Key Markets" Market Share    | 54% (of total market share) | CRA Data Center Database (DatacenterHawk, Cleanview) |
| (PJM, MISO, ERCOT, SPP, SERC) |                             |                                                      |
| PJM Market Share              | 35% (of total market share) | CRA Data Center Database (DatacenterHawk, Cleanview) |



## Binding constraints will limit the level of realizable demand. As constraints relax, growth rates preserved from the unconstrained forecast will be applied to the constrained forecast

Unconstrained, Binding Constraint, and Constrained Demand



\*Binding constraints presented here are illustrative for discussion on constraint logic

### Approach

- Apply constraints on unconstrained demand. The constraint acts as a ceiling for how much demand can be realized
- Constraint is minimum across all constraints considered: power, chips, and material availability
- Growth rates ( $g_t$ ) are preserved from the unconstrained demand, but applied to the lower of prior forecast or realized demand:

$$Target_t = \min(Achieved_{t-1}, Target_{t-1}) * (1 + g_t)$$

### Assumptions

- Capacity that could not be built is assumed to be partially lost through efficiency improvements, adoption delays, or price friction, rather than returning as pent-up demand.
- Overshoots do not increase future targets. Functionally, the forecast can be adjusted downward, but not upward.

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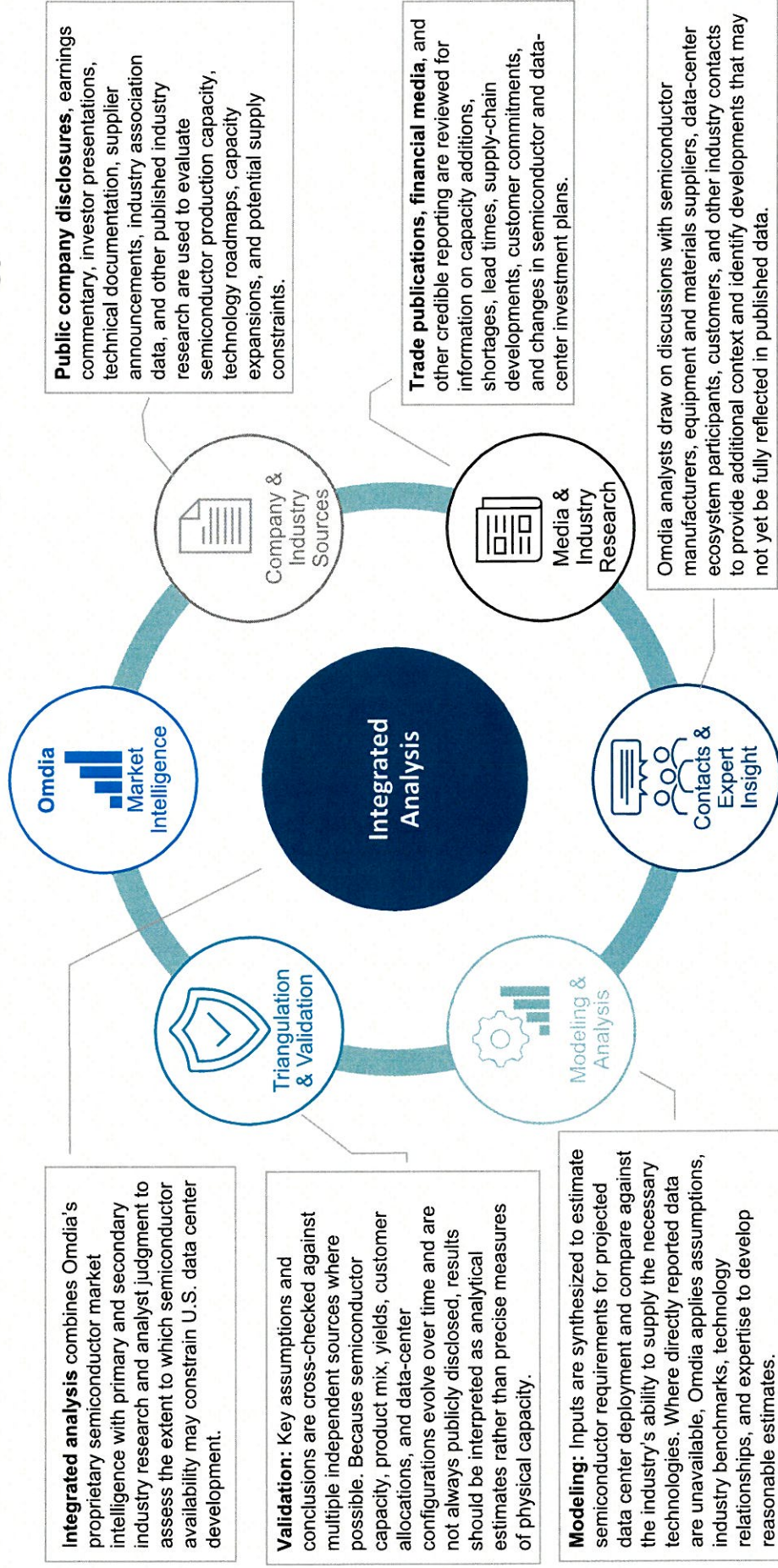


## Few physical constraints are truly PJM-specific; most reflect broader national or global limitations that manifest differently within PJM

| Constraint                                                                | Geographic Scope of Constraint |          |        | Rationale                                                                                               |
|---------------------------------------------------------------------------|--------------------------------|----------|--------|---------------------------------------------------------------------------------------------------------|
|                                                                           | PJM                            | National | Global |                                                                                                         |
| Semiconductor availability                                                | ✓                              | ✓        | ✓      | Global manufacturing capacity and supply chains                                                         |
| Critical metals / materials – copper, steel, aluminum                     | ✓                              | ✓        | ✓      | Globally traded commodities and manufacturing inputs                                                    |
| Power availability / ability to serve new load                            | ✓                              | ✓        |        | Increasingly a U.S.-wide constraint, though severity varies by market                                   |
| Generation / supply build limits – gas turbines, batteries, nuclear, etc. | ✓                              | ✓        |        | U.S. deployment constrained by manufacturing capacity, with globally sourced equipment/materials        |
| Generator interconnection queues                                          | ✓                              | ✓        |        | National challenge, with PJM-specific queue rules, backlog and timelines                                |
| Generation retirements                                                    | ✓                              | ✓        |        | Occurring across the U.S.; PJM's specific retirement trajectory drives regional impacts                 |
| Transmission availability / buildout                                      | ✓                              | ✓        |        | Broad U.S. constraint, with PJM-specific transmission needs and planning processes                      |
| Natural gas infrastructure / fuel availability                            | ✓                              | ✓        |        | National/regional pipeline constraint, with specific limitations within parts of PJM                    |
| Permitting / siting                                                       | ✓                              | ✓        |        | Federal, state and local requirements constrain development across the U.S., with PJM-state differences |
| Capacity market / market design                                           | ✓                              | ✓        |        | Specific to PJM's market structure and rules                                                            |



## Omdia assessed semiconductor constraint using the following methodology



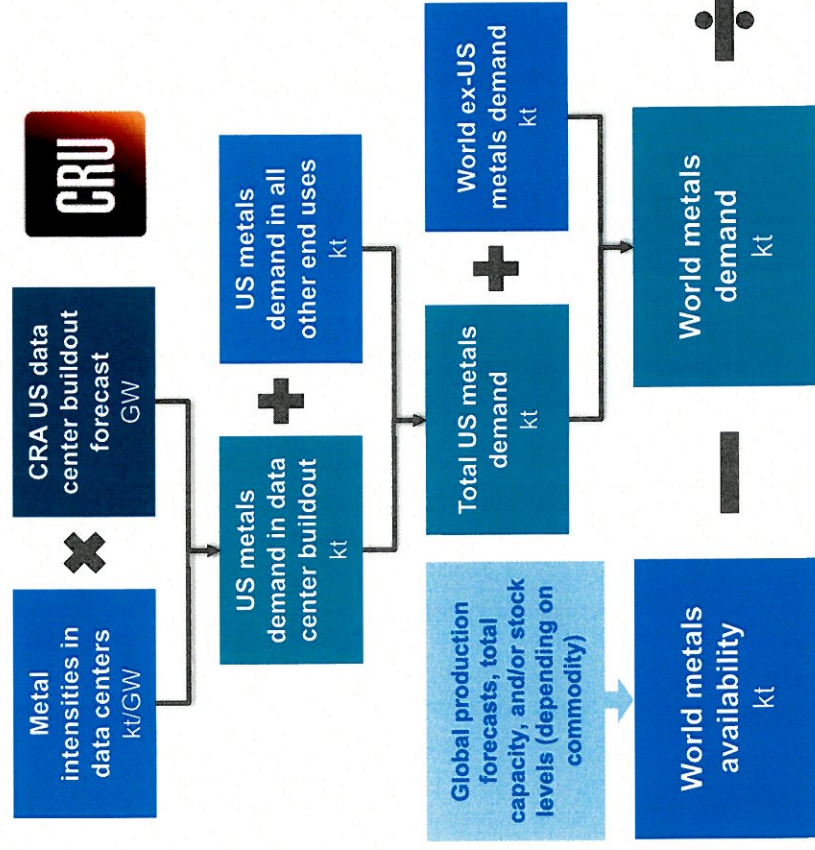


## Semiconductor constraints are adjusted for the immediate- to near-term and beyond as risks change and bottlenecks emerge and resolve

|                                    | Critical constraints                                                             | How binding?                                                                                                                  | Long-term and secondary impacts                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------------------------|----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Immediate-Term</b><br>(2026-27) | Advanced chip packaging capacity remains constrained                             | ➔<br><b>Moderately</b> – ramp trails demand, timeline uncertain                                                               | <ul style="list-style-type: none"> <li>Physical and disaster risk in concentrated manufacturing regions</li> <li>AI hardware consuming memory supply that would support traditional server deployments</li> <li>Emerging difficulties sourcing advanced materials at scale</li> <li>Limited testing capacity for advanced AI chips</li> <li>Assembly and delivery of complete AI systems is constrained by manufacturing capacity</li> </ul> |
|                                    | Critical chip packaging material in short supply, significantly increasing costs | ➔<br><b>Very</b> – gap hits 40% by 2028                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                    | Lead times for key semiconductor inputs remain elevated                          | ➔<br><b>Not Very</b> – new capacity is expected by 3Q27                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                    | High-performance AI memory is fully allocated; limiting new projects             | ➔<br><b>Moderately</b> – stack yield limits near-term scaling                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                    | Manufacturing is concentrated in a small number of countries                     | ➔<br><b>Moderately</b> – concentration and geopolitical risk, but does not constrain output on its own                        |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Near-Term</b><br>(2028-32)      | Limited specialized production environment and workforce                         | ➔<br><b>Partly</b> – output is limited by facility growth and available workforce, construction and upskilling can take years |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                    | Next gen memory is still uncertain and faces scaling risks                       | ➔<br><b>Very</b> – manufacturing capacity limits efficiency growth                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                    | Advanced manufacturing technology is not at full-scale                           | ➔<br><b>Not very</b> – future scaling may be impacted, but long lead time to catch up                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                    | New capabilities are outpacing manufacturing capability and capacity             | ➔<br><b>Moderately</b> – manufacturing limits outputs until scaled up which can take years                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                              |



## CRU assessed metal constraint using the following methodology



CRU's assessment evaluates whether global production, inventories, and available manufacturing capacity for copper, aluminum, and electrical steel can meet anticipated demand growth from data centers and other end uses, focusing on 2027-2030 as the key years for potential shortages.

CRA incorporates CRU's findings into the US data center forecast by translating any projected global supply deficit into a potential reduction in US buildout. The constraint is allocated based on the US share of projected demand for the affected material, and the resulting material shortfall is converted into an equivalent reduction in data center capacity (GW).

Despite potential global constraints, data centers may be better positioned than many traditional end uses to secure scarce materials, especially given the relatively small portion of total development costs. As a result, actual impacts could be lower than modeled.

$$\text{Metal intensities in data centers kt/GW} = \text{Annual constrained US data center buildout on \% of global demand GW}$$

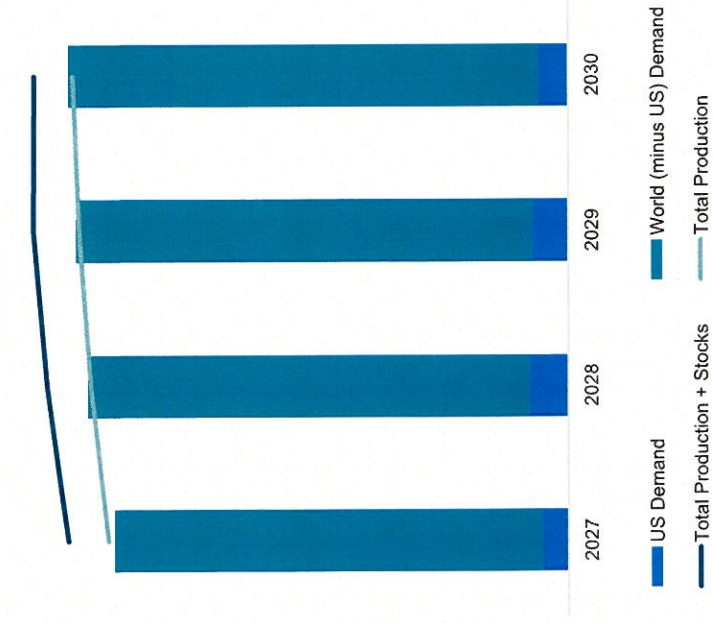
Key:

- CRU data
- CRA data
- CRU modelled data specific to this project

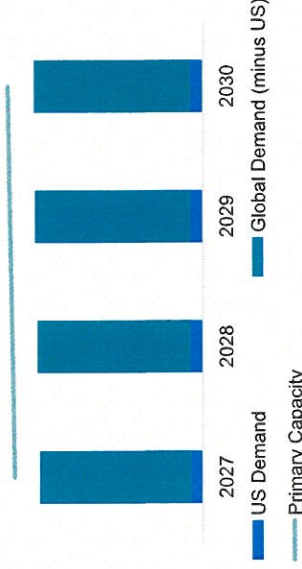


## Critical metals and other materials face most risk in the near term, but broader long-term constraints are not expected

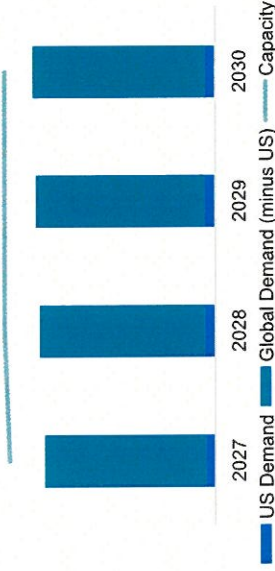
Refined Copper Supply and Demand Balance



Primary Aluminum Supply and Demand Balance



Electrical Steel Supply and Demand Balance



CRU's analysis indicates material availability for data center development should generally be sufficient over the long term, with the primary risk period occurring during the expected peak of global data center buildout from 2027-2030.

Copper faces the greatest potential supply risk, as availability is ultimately constrained by mining production and the pace at which new supply can be developed. For aluminum and electrical steel, these markets typically operate with some unused capacity, allowing producers to increase output in response to higher demand. CRU therefore evaluates both current production and capacity that could be brought online to determine whether shortages are likely to emerge.

Beyond 2030, CRU expects global markets to adjust to growing demand through capacity expansions, investment in new production, and other supply-side responses. While short-term imbalances may occur during the peak buildout period, the outlook suggests that material markets can adapt over time, reducing sustained shortage risk.

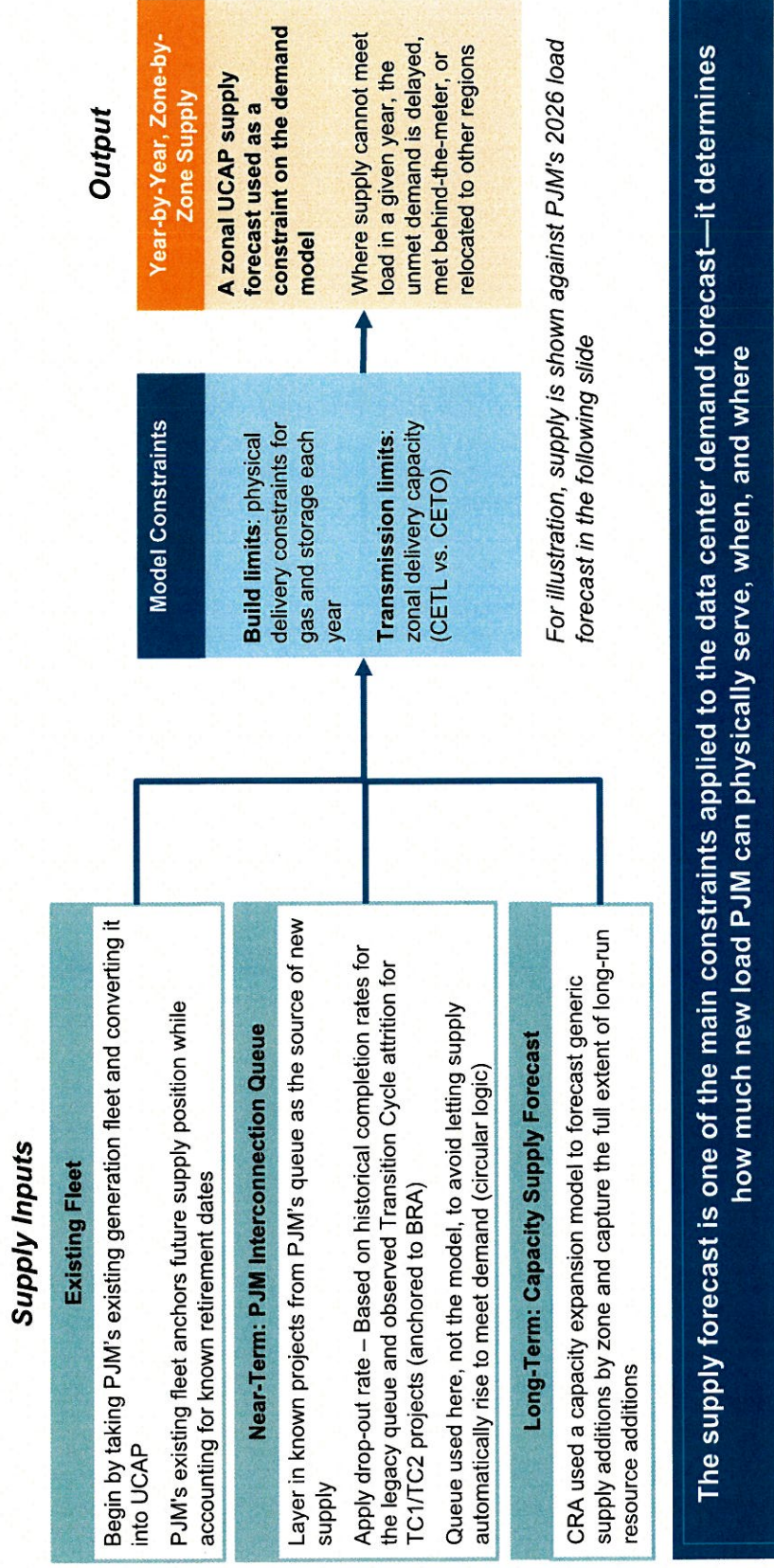
## Constraints on power supply effectively slow data center adoption



- CRA assumes that policy, market, or operational actions will return the market to the traditional “1-in-10” reliability standard in the longer term. Potential mechanisms to ensure long-term reliability outlooks include state policy interventions, or data center commitments to provide flexibility. Current projected shortfalls provide an upper bound for the tolerance for capacity shortfalls.
- As a result, future data center growth will require increasing levels of load flexibility and/or delayed ramp rates as a result of PJM-wide and zonal supply-demand tightening. While data centers may gain greater ability to shift computing workloads over time, **BTM resources will play a critical near- and medium-term role.**
- Potential BTM resources include **RICE units, fuel cells, combustion turbines, combined-cycle units, batteries, and demand response** from other customers.
- Like front-of-meter resources, BTM resources face limits on **deployment at the site, zonal, and national levels.** However, BTM resources may be deployed more rapidly because they can often avoid traditional generator interconnection processes.
- The ability to **dynamically shift computing demand across sites and regions** is expected to increase over time as the workload shifting technology becomes more mature, enhancing overall system flexibility.



**CRA constructed a forecasted view of PJM's electric supply for each year of the study period by PJM zone and technology in unforced capacity ("UCAP") terms**

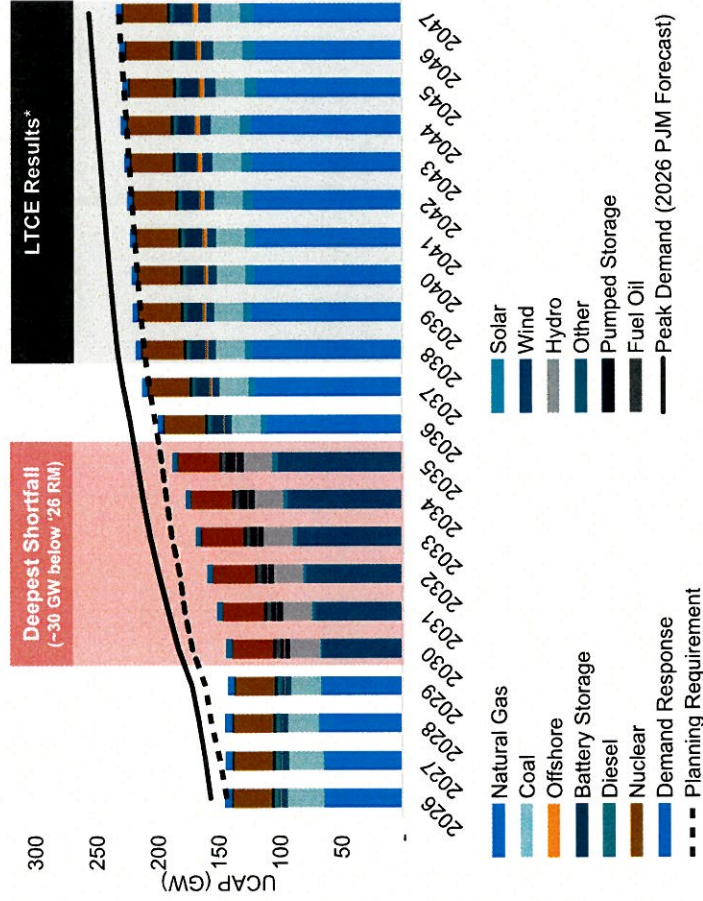




## Base-case supply forecast (UCAP) vs. PJM 2026 load forecast

There is not enough supply to meet data center growth charted in PJM's 2026 load forecast; 2030-2035 represents the deepest shortfall

PJM Base Case Supply Forecast (UCAP)



\*Note – This view reflects only the LTCE buildout post-2038. It does not incorporate the post-2038 additional gas/storage that can be built up to their annual build limits.

### Key Takeaways:

- **Short from the start:** A structural supply gap opens in 2027/28 and persists across the horizon.
  - Deliverable UCAP falls below the reserve requirement even before major load growth arrives
- **Physical, not financial:** The gap holds despite strong willingness to pay because turbines, transformers, EPC labor, and interconnection throughput cannot be accelerated by price signals alone.
- **Deepest gap in the 2030s:** ~30 GW below the reserve requirement (with 2026 load forecast), when the interconnection queue thins and LTCE builds are subject to the gas and storage build limits. This highlights the impact of global supply chain limitations that PJM cannot control.
- **Load goes elsewhere:** Gap pushes new large loads toward BTM self-supply, relocation to headroom regions like MISO and SPP, waiting for interconnection, or becoming subject to IRAS.
- **Moving target:** The PJM 2026 load forecast shown here is a placeholder; our demand forecast is iterative, so as load and queue status update, the size and timing of the gap will shift rather than remain fixed.



## Transmission limits (CETO) scale based on known 2030 values

### Assumptions

- **Pre-2031 constraints:** CRA assumes published CETO/CETL values are applicable to the beginning of the forecast period.
- **Future CETO (post-2030):** Updated each year by zonal peak-load growth, then adjusted for net in-zone UCAP changes by accounting for capacity additions and retirements.
- **Data center headroom:** The additional load a zone can absorb before its Tx system can no longer reliably deliver power. As load grows, the zone's import need (CETO) rises; once it approaches the zone's import capability (CETL), the zone is constrained and cannot host more load until transmission is upgraded.

- $CETO * 1.15 > CETL$  is the PJM published constraint formula

- **Interim relief:** CRA does not add additional power to a constrained zone to relieve the deliverability gap before the line is built.

- **Simplifications:** modeled at zonal LDA level only.

- Sub-zonal LDAs (DPL South, CLEV, PSEG North) captured within parent zone; RECO inherits EMAAC

**Post-2038: Transmission constraint no longer applied**

CETO after 2030 is projected based on the 2030 value

2030 CETO is scaled by the change in peak coincident load relative to 2030 levels

CETO is then adjusted to reflect changes in future-year and 2030 available capacity

$$CETO_{t,z} = \left[ CETO_{2030,z} \times \frac{LOAD_{t,z}}{LOAD_{2030,z}} \right] - (UCAP_{t,z} - UCAP_{2030,z})$$

\* Subscript t denotes year of analysis; z represents zone

### Sources

#### PJM Planning Parameters

For published auction years

#### 2030 RTEP Values

CETO/CETL provided by PJM for upcoming 2030 RTEP

### Additional Information

## Transmission limits (CETL) and transmission expansion (RTEP) account for the ability to build new transmission

If CETL exceeds  $CETO \times 1.15$  in year  $t$ , the zone is considered **unconstrained**

$$CONSTRAINED_{t,z} = \begin{cases} CETL_{t,z} \geq CETO_{t,z} \times 1.15 = \mathbf{0} \\ CETL_{t,z} < CETO_{t,z} \times 1.15 = \mathbf{1} \end{cases}$$

If  $CETO \times 1.15$  exceeds the CETL for that year, the zone becomes **constrained**

### Feedback welcome!

Results are subject to assumptions around how Tx constraints relax over time (which is in PJM's control). Failing to account for the ability to invest in new Tx would artificially limit growth.

Transmission capacity is assumed to be added through the RTEP process after 3 years of construction, available on year 4

$$CETL_{t,z} = CETL_{t-1,z} + ADDER \times CONSTRAINED_{t-3,z}$$

Calibrated to 4,000 MW based on historical transmission additions

### Assumptions

- **RTEP:** If a zone ever becomes constrained, it ignites the RTEP process to bring new transmission online.
- **Future CETL:** Updated each year by zone with the previous year's CETL and any additional transmission.
- **Adder value:** Parameterized as 4,000 MW based on historically observed transmission additions; all additions are assumed at this value.
- **Timeline:** We assume a 4-year timeline from the zonal constraint becoming active to when relief occurs. This assumes that a constraint can be identified a year early with perfect foresight (5 years total) and is standardized across all zones.
- **Compounding additions:** If a zone adds transmission but still is constrained, then the process is assumed to ignite again. The zone can continue adding transmission until after 2038 when the transmission constraint is no longer applied.

### Sources

#### Additional Information

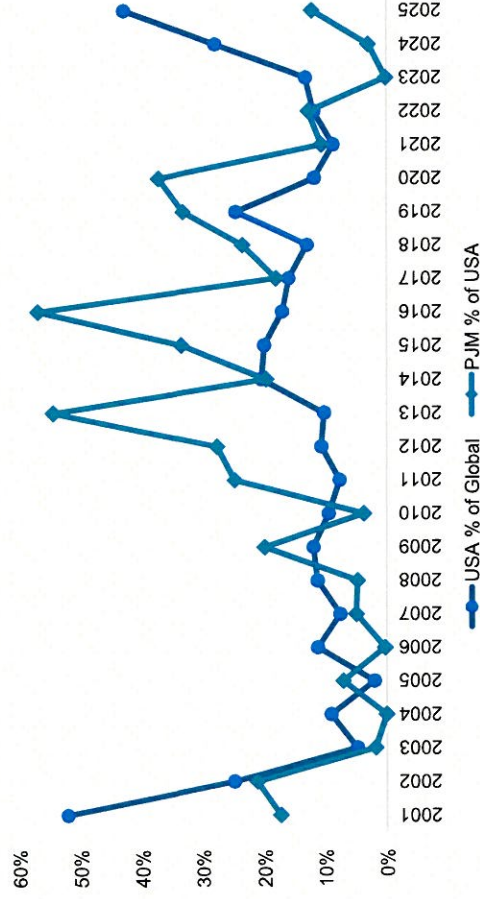
**PJM Planning Parameters** For published auction years

**2030 RTEP Values** CETO/CETL provided by PJM for upcoming 2030 RTEP



## Natural gas build limits (historical) show uptick in demand for turbines in US

Historical Share of Gas Turbine Orders (2001-2025)



### Sources

#### McCoy Power Reports – Gas Turbine Order Data

Global gas turbine order database (1980-2025), including project location, order and operating dates, turbine model, manufacturer, purchaser, and delivery status.

### Additional Information

### Assumptions – Natural Gas Build Limits

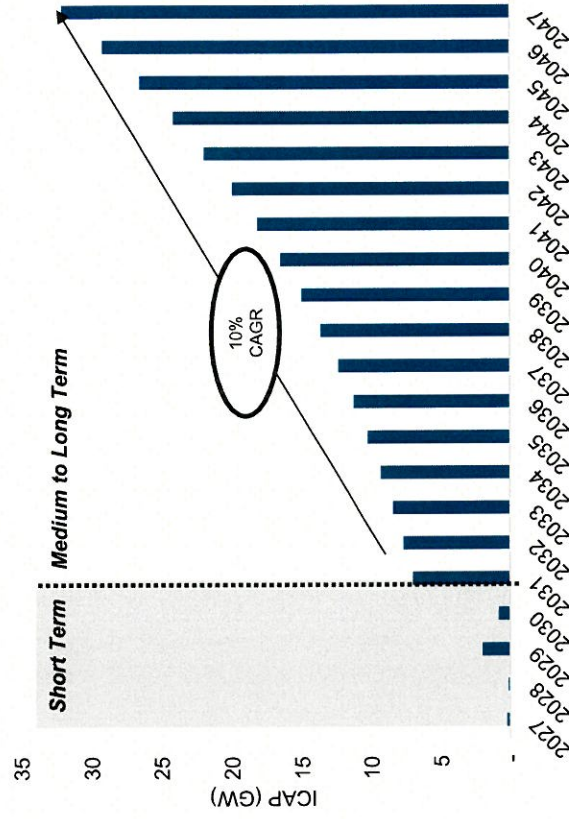
- Based on 2001-2025 historical gas turbine order and delivery data.
- U.S. share of global orders and PJM share of U.S. orders are held at 2025 levels to reflect sustained data center-driven demand growth.
- Lead-time analysis shows recent gas turbine projects require ~36 months from order to operation, with orders translated into future online capacity accordingly (e.g., 2025 orders → 2028 operations).
- Future limits scale with turbine manufacturing expansion, OEM backlog growth, and delivery trends.
- Build limits represent a physical upper bound based on turbine availability, supply chain constraints, lead times, and EPC execution capacity.

### Gas Turbine Deliveries – Historical Trend

- U.S. share of global gas turbine orders increased to ~42% in 2025, reflecting growing domestic power demand.
- PJM represented ~12% of U.S. turbine orders in 2025, with recent growth supported by accelerating data center development.
- Recent ordering trends indicate increasing U.S. and PJM demand for new gas generation, supporting higher future build capability.

## Natural gas build limits (2027-2047) are assumed to grow over time

Natural Gas Build Limits (ICAP)



### Methodology

#### Short Term Build Limits (2027-2030)

- Build capacity based on active PJM queue projects.
  - Gas projects from queue only included if either under construction or as mentioned in an IRP

#### Medium to Long Term Build Limits (2031-2047)

- Annual build limits derived from historical gas turbine order trends and projected manufacturing capacity growth.
  - Global gas turbine manufacturing capacity assumed to increase 10% annually based on OEM expansion plans and announced investments\*.
    - Note: The 10% growth rate reflects the conservative end of publicly reported manufacturing expansion estimates; the Abundance Scenario applies a higher rate within this range*
  - U.S. and PJM shares of future turbine deliveries held at 2025 levels, reflecting continued concentration of data center-driven demand.
  - Projected global turbine deliveries allocated to PJM based on geographic distribution of orders reflecting DC demand growth.

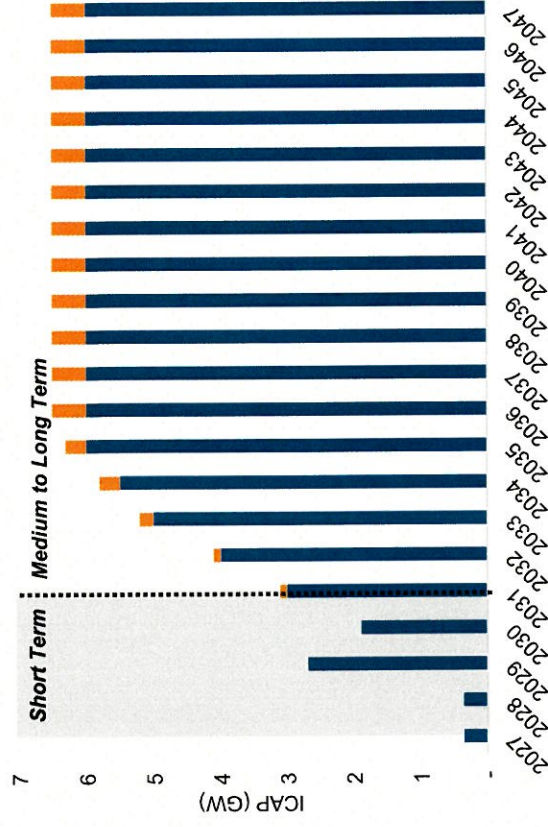
#### Interpretation

- Represents a physical upper bound on gas capacity that could be delivered to PJM.
  - Reflects turbine manufacturing capability, supply chain availability, and expected turbine allocation patterns.
  - **Values do not represent a forecast of expected gas additions.**



## Storage build limits (2026-2047) are assumed to grow and then plateau

Storage Build Limits (ICAP)



### Methodology

#### Lithium Ion

- Near-term storage limits based on the active storage development pipeline and projects advancing toward commercial operation.
- Mid- to long-term additions ramp up to ~6 GW/year and remain flat, reflecting a realistic buildout pace, state policy goals and efficiency gains.

#### Other Technologies

- Storage limits are benchmarked to CAISO's technology adoption curve, which reflects a more mature market
- Non-lithium-ion storage is assumed to maintain the same share of total BESS additions observed in CAISO, applied with a five-year lag to reflect PJM's slower market development.
- The PJM lithium-ion buildout serves as the baseline forecast to determine this constraint.

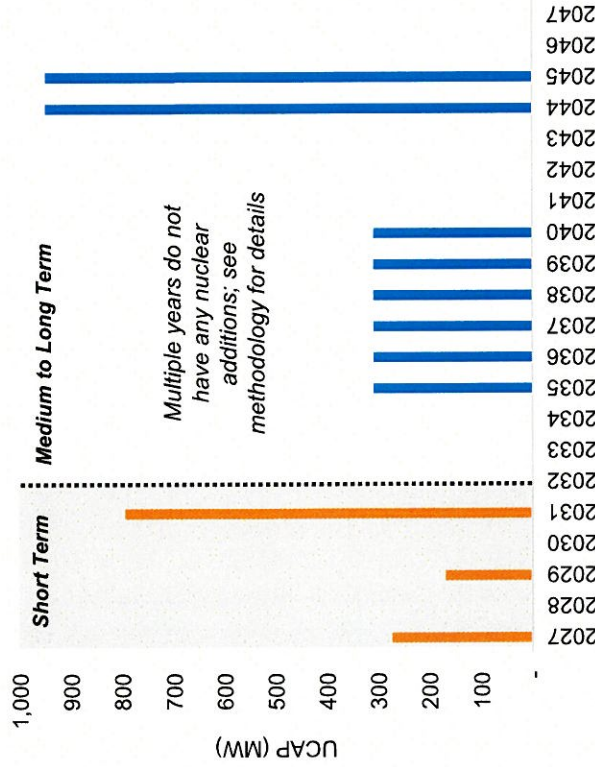
#### Interpretation

- Represents a physical upper bound on battery storage capacity that could be delivered to PJM.
  - Reflects battery cell and transformer manufacturing capacity, supply chain availability, and expected allocation of storage to PJM.
  - **Values do not represent a forecast of expected BESS additions.**

\*Sources: [EIA](#); [US DOE](#); [CPUC AB1373](#); CAISO 20 Year Transmission Outlook; Virginia H.B. 895

## Nuclear additions are driven by announcements and policy-drivers

Base Case Nuclear Additions (UCAP)



### Sources

#### CRA Analysis

- PJM RRI and TC2 Queue
- Dominion Energy 2025 IRP Update
- Constellation FERC waiver filing (Mar 2026)

### Additional Information

CRA analyzed announced and in-queue nuclear builds across a range of public sources for the near term, and drew long-term additions from utility IRPs and the LTCE economic buildout.

- Short term (2027-2030): nuclear additions are limited to uprates already in the PJM interconnection queue and RRI, plus one announced restart
  - Crane Clean Energy Center (835 MW restart) is the single largest near-term addition; the 2031 in-service date reflects the waiver submitted to FERC in March 2026
- Long term (2031-2047): nuclear additions do not come solely from the LTCE
  - Dominion: nuclear is included as an IRP addition - as a vertically integrated utility, Dominion can build and rate-base new nuclear, entering in the late 2030s
  - ComEd: new nuclear enters in the mid-2040s - CEJA-driven gas retirements leave the zone short of both capacity and energy after 2040, and the Aurora economic buildout selects nuclear to fill the gap

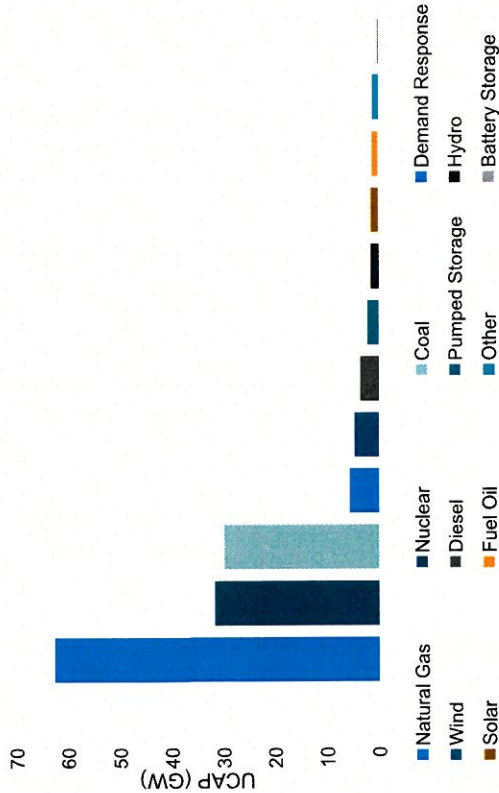
Near-Term Nuclear Uprates and Additions (in Queue)

| Project                   | Zone  | Type    | MW Capacity | Online  |
|---------------------------|-------|---------|-------------|---------|
| Crane Clean Energy Center | PPL   | Restart | 835         | 2031    |
| LaSalle                   | ComEd | Uprate  | 174         | 2027-30 |
| Byron                     | ComEd | Uprate  | 43          | 2027-30 |
| Braidwood                 | ComEd | Uprate  | 58          | 2027-30 |
| Salem                     | PSEG  | Uprate  | 228         | 2027-30 |



## Existing supply in PJM

PJM 2026 Existing Supply (UCAP)



| Sources             | Additional Information                                                                                                  |
|---------------------|-------------------------------------------------------------------------------------------------------------------------|
| Energy Velocity     | Used to find all tech types, except for gas, by zone (Compilation of EIA 860, Hitachi/ABB Research, NERC ES&D research) |
| PJM 2026 IMM Report | Source for gas ICAP by zone                                                                                             |
| ELCC Class Ratings  | For 2025/2026 Base Residual Auction                                                                                     |

### Approach

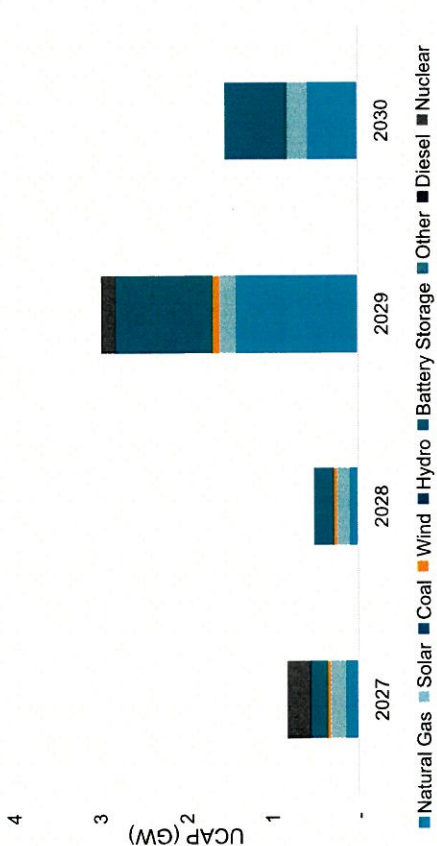
- Total set of existing non-gas resources sourced from Energy Velocity (EV) by PJM zone
- ICAP of dispatchable generation (high ELCC) cross-referenced with PJM 2026 IMM Report
- ICAP converted to UCAP using 2026 ELCC class ratings

| Tech type | ELCC Value (2026) | Notes                         |
|-----------|-------------------|-------------------------------|
| Gas       | 70%               | Weighted average of CT and CC |
| Coal      | 83%               | -                             |
| Nuclear   | 95%               | -                             |
| BESS      | 52%               | 4-hour storage used           |

Existing fleet held at 2026 accreditation values as the baseline before annual ELCC evolution is applied

## Interconnection queue in PJM

PJM Queue after Drop Out Rate Applied (UCAP)



| Sources                   |  | Additional Information                                                                                |  |
|---------------------------|--|-------------------------------------------------------------------------------------------------------|--|
| PJM Interconnection Queue |  | Legacy queue which includes older entrants. TC1 and TC2 resources excluded to avoid double-counting   |  |
| TC1                       |  | Transition Cycle 1 projects, from PJM website                                                         |  |
| TC2                       |  | Transition Cycle 2 projects, from PJM website                                                         |  |
| IRPs                      |  | Gas projects included in IRPs automatically included in buildout. IRPs used include Dominion and APS. |  |

**Queue drives near-term supply; LTCE drives long-term supply.**  
The queue provides an independent supply signal for 2027-2030.

**Approach**

- Assumed near-term additions (2027-2030) taken from PJM interconnection queue to avoid circularity between load forecast and supply forecast\*
- Legacy queue, TC1, and TC2 combined; TC1/TC2 excluded from legacy count to avoid double-counting
- Gas additions limited to named projects from integrated utility resource plans (IRPs) (e.g., Dominion, APS), under construction, or an update from PJM's Reliability Resource Initiative (RRI)

**Assumptions**

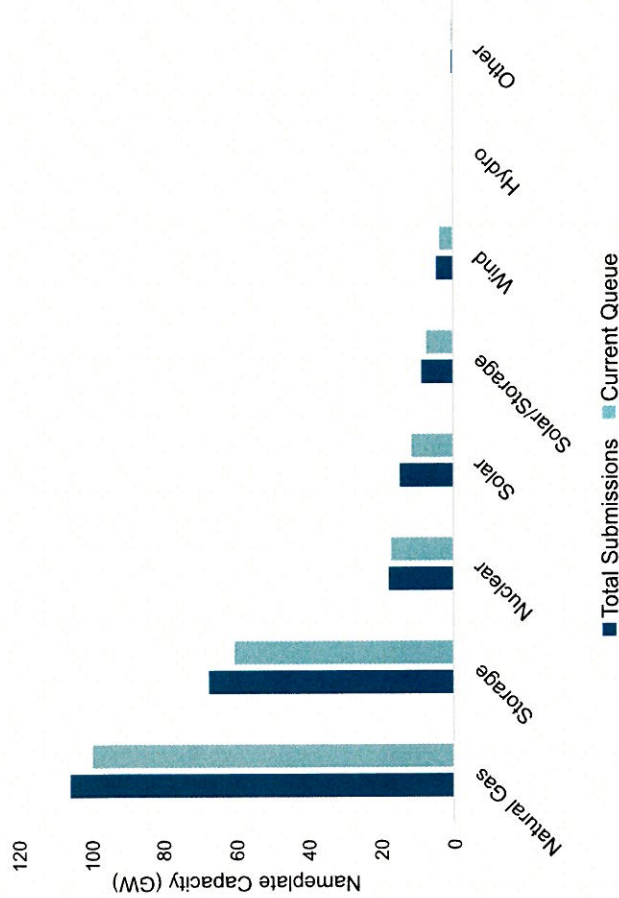
- Only resources currently active in the queue included; "partially in-service" excluded
- TC2 projects without a COD distributed using TC1's tech-specific COD distribution
- Multi-fuel projects split across listed technologies
- Assumed future drop-out rates are applied by technology and are specific to each queue cohort (Legacy, TC1, TC2), reflecting the different attrition observed in each

| Technology                   | Legacy queue <sup>1</sup> | TC1          | TC2           |
|------------------------------|---------------------------|--------------|---------------|
| Solar                        | 69%                       | 10%          | 55%           |
| Wind                         | 40%                       | 10%          | 52%           |
| Battery Storage <sup>2</sup> | 69%                       | 10%          | 55%           |
| Source                       | Historic queue data       | BRA-Anchored | TC1 drop-outs |



## How CRA handles Cycle 1

PJM Cycle 1 Total Submissions vs. Current Queue (Nameplate Capacity)



**CRA incorporates Cycle 1 into the LTCE as generic additions, rather than as dated queue entries, for the base case**

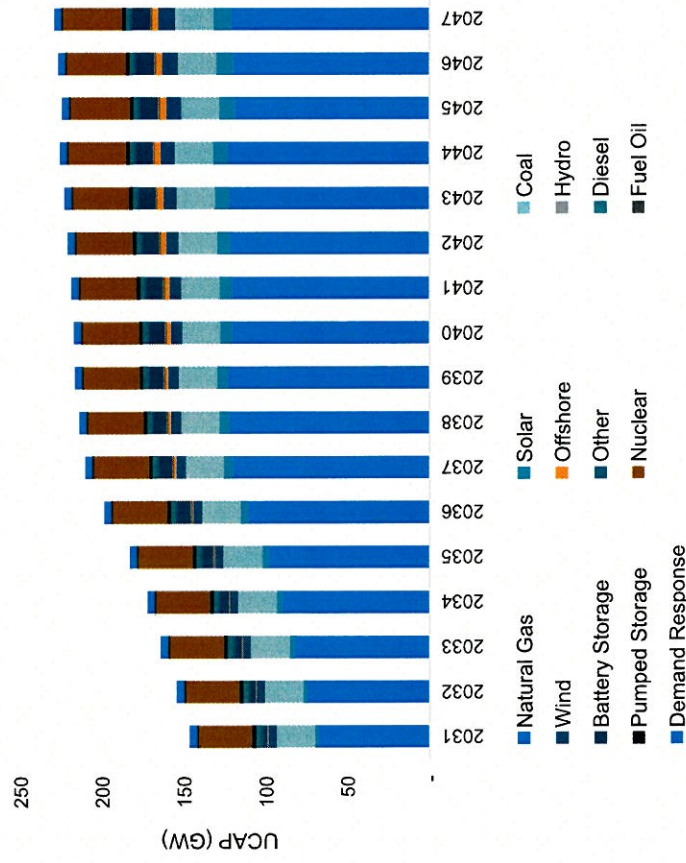
- Additional Cycle 1 projects are captured as generic units, realized post-2030, under the Abundance Scenario to acknowledge interconnection queue improvements

### Why?

- Scale:** 711 projects, representing 201 GW of nameplate capacity, are currently active in Cycle 1
- No reliable timing or attrition signal:** Cycle 1 is the first cycle under the reformed process, so its new structure and shifting dynamics make it difficult to reliably extrapolate CODs or attrition rates from the Transition Cycles
- Timing points to the LTCE window:** New queue processing takes ~2 years, combined with multi-year build times for high-ELCC resources (gas, nuclear), the earliest realistic online date falls within the LTCE period (2031+)

## LTCE results show a steady build of resources over time across all technology types

PJM Supply Mix (UCAP)



### Approach

- Long-term supply (2031-2047) from CRA's Aurora LTCE model, with endogenous build and retirement decisions
- LTCE picks up where the near-term queue leaves off, subject to build limits and transmission limits
- Cycle 1 projects represented through generic LTCE additions rather than dated queue entries, given queue processing time (see Cycle 1 slide)

### Assumptions

#### LTCE results reflect:

- Fuel prices transition from near-term market forwards to CRA long-term fundamental forecasts.
- Policy reflected: OBBBA, CEJA, state RPS, and Clean Grid Act; new-build costs from NREL/EIA; ITC/PTC incorporated.
- Environmental compliance costs applied (CO2 via RGGI and applicable programs, SO2, NOx).
- PJM-published ELCC accreditation applied to all resource types
- Gas and storage builds constrained to annual build limits; any capacity above the limit is pushed to later years until it fits.
- Post-2038, no power or transmission constraint is applied; gas and storage limited only by the build limit.

### Sources

#### Additional Information

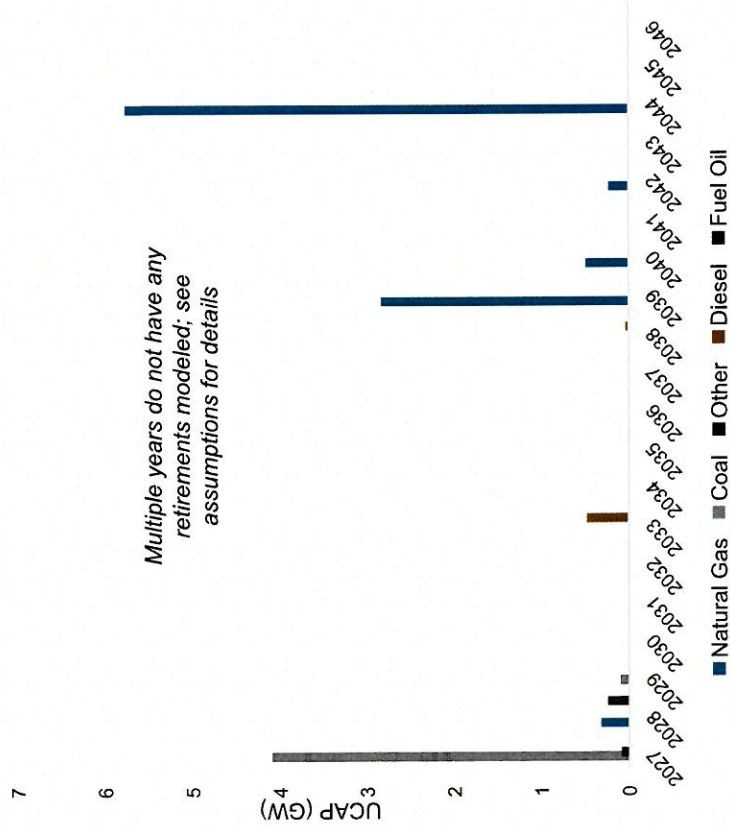
#### CRA Analysis

Long-term supply forecast based on LTCE model results, including endogenous build and retirement decisions.



## Modest retirement of existing plants

### PJM Announced & Economic Retirements (UCAP)



#### Approach

Two retirement channels:

- **Short term:** Announced retirements as fixed inputs
- **Long term:** Economic retirements determined endogenously by the LTCE

#### Assumptions

##### Short-term retirements

- Based entirely on public deactivation requests sourced from Energy Velocity

- Coal retirements concentrated in 2027-2028 (~6.1 GW)

##### Long-term retirements

- Post-2035, retirements are driven by state/federal policy (e.g., CEJA) or revenue-adequacy challenges
- Economic retirements are a model output, not an input, and respond to prices, fuel costs, and accreditation

#### Sources

##### Energy Velocity

Used to find all tech types, by zone (Compilation of EIA 860, Hitachi/ABB Research, NERC ES&D research)

##### Public Policy

Legislated retirement schedules and emissions policy (e.g., Illinois CEJA, RGGI, EPA rules) informing long-term deactivations

## Capacity accreditation is taken from PJM-published values

**ELCC Values from PJM BRA and PJM Preliminary Class Ratings**

| Year         | Gas  | Solar | Coal | Wind | OSW  | Hydro | Battery Storage | Diesel | Pumped Hydro | Nuclear | Fuel Oil | DR   |
|--------------|------|-------|------|------|------|-------|-----------------|--------|--------------|---------|----------|------|
| <b>2026</b>  | 0.70 | 0.09  | 0.83 | 0.41 | 0.68 | 0.40  | 0.52            | 0.91   | 0.4          | 0.95    | 0.61     | 0.85 |
| <b>2027</b>  | 0.70 | 0.09  | 0.83 | 0.41 | 0.68 | 0.40  | 0.52            | 0.91   | 0.4          | 0.95    | 0.61     | 0.85 |
| <b>2028</b>  | 0.75 | 0.07  | 0.85 | 0.34 | 0.6  | 0.35  | 0.59            | 0.93   | 0.37         | 0.96    | 0.61     | 0.91 |
| <b>2029</b>  | 0.71 | 0.07  | 0.83 | 0.35 | 0.57 | 0.37  | 0.42            | 0.91   | 0.37         | 0.95    | 0.62     | 0.77 |
| <b>2030</b>  | 0.71 | 0.07  | 0.83 | 0.34 | 0.53 | 0.38  | 0.37            | 0.91   | 0.38         | 0.95    | 0.63     | 0.74 |
| <b>2031</b>  | 0.72 | 0.07  | 0.82 | 0.31 | 0.47 | 0.39  | 0.30            | 0.91   | 0.39         | 0.95    | 0.64     | 0.7  |
| <b>2032</b>  | 0.74 | 0.07  | 0.81 | 0.26 | 0.38 | 0.39  | 0.25            | 0.91   | 0.39         | 0.95    | 0.66     | 0.68 |
| <b>2033</b>  | 0.75 | 0.07  | 0.81 | 0.22 | 0.32 | 0.38  | 0.25            | 0.91   | 0.38         | 0.96    | 0.68     | 0.68 |
| <b>2034</b>  | 0.75 | 0.07  | 0.80 | 0.20 | 0.28 | 0.38  | 0.24            | 0.91   | 0.38         | 0.95    | 0.69     | 0.67 |
| <b>2035*</b> | 0.76 | 0.07  | 0.80 | 0.19 | 0.26 | 0.38  | 0.23            | 0.91   | 0.38         | 0.95    | 0.70     | 0.66 |

### Sources

#### BRA ELCC Class Rating

Final class ratings from published Base Residual Auction planning parameters

#### PJM Preliminary ELCC Class Ratings (2027/28 – 2035/36)

PJM-published preliminary class ratings for delivery years without final BRA results

\* ELCCs held constant post 2035/36 DY

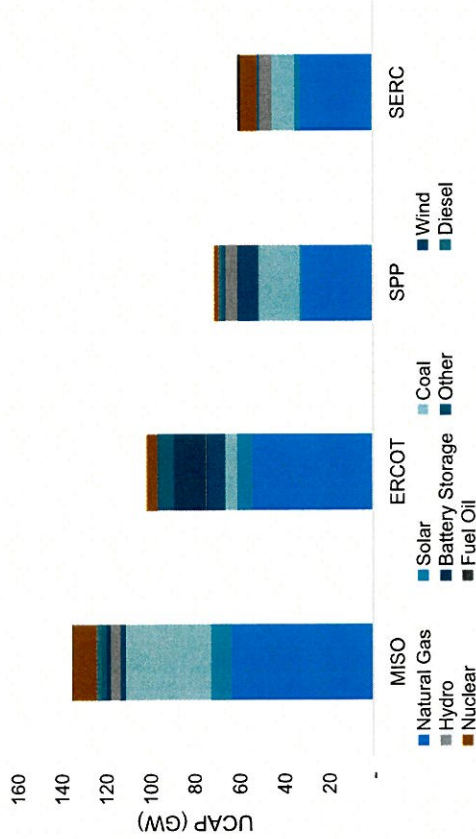
### Assumptions

- All ELCC values are taken directly from PJM published class ratings; CRA did not independently derive or adjust any accreditation values
  - Published BRA class ratings used for DYs with auction results
  - PJM Preliminary Class Ratings (2027/28-2035/36) used for DYs that do not yet have auction results or published planning parameters
- Gas ELCC applied as a capacity-weighted average of PJM's published CC and CT class ratings, reflecting PJM's fleet composition
- 4-hour duration used as the storage class rating across the forecast
- ELCC values held constant post 2035/36 DY**



## Existing supply in other regions

Non-PJM ISOs Resource Mix (UCAP)



| Sources                           | Additional Information                                                                                    |
|-----------------------------------|-----------------------------------------------------------------------------------------------------------|
| Energy Velocity                   | Used to identify all resources, by ISO (Compilation of EIA 860, Hitachi/ABB Research, NERC ES&D research) |
| ISO-Specific Accreditation Values | Most recent accreditation values used to convert ICAP to UCAP                                             |

### Approach

- Same method as PJM: 2026 existing fleet in ICAP by region (MISO, SPP, ERCOT, SERC) from Energy Velocity
- ICAP converted to UCAP using region-specific accreditation values

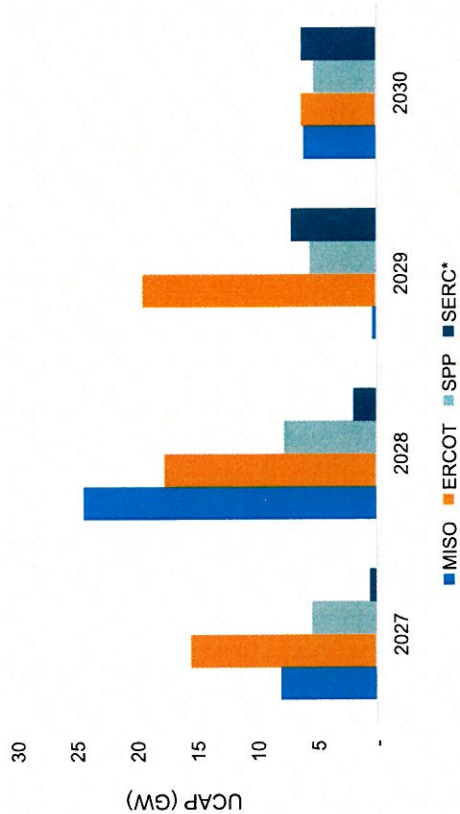
### Assumptions

- Regions selected as the primary candidates for data center migration out of PJM
- Only resources listed as in operation are included
- If accreditation values are not available for a resource in a specific ISO, the value is based on a neighboring ISO's

| Variable | Accreditation Value |
|----------|---------------------|
| Gas      | 89 – 92%            |
| BESS     | 61 – 100%           |
| Coal     | 72 – 90%            |
| Nuclear  | 95 – 98%            |

## Interconnection queue in other regions

Non-PJM Queue Additions (UCAP, GW)



| Sources | Additional Information                 |
|---------|----------------------------------------|
| MISO    | MISO generation queue, MISO ERAs Queue |
| SPP     | SPP generation queue                   |
| ERCOT   | ERCOT generation queue                 |
| SERC*   | Utility IRPs and CRA LTCE Analysis     |

\*Note – From CRA LTCE Analysis

### Approach

- Near-term additions (2027-2030) driven by the interconnection queue rather than LTCE, when possible, to avoid circularity
- ICAP converted to UCAP using region-specific accreditation values

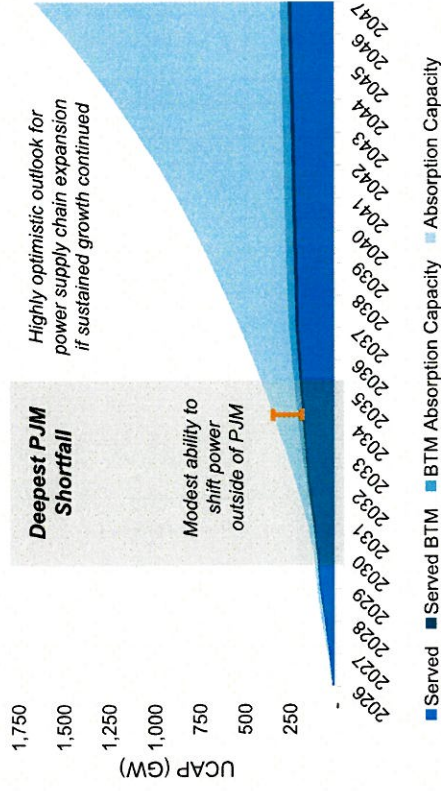
### Assumptions

- Drop-out rates are tech-specific and ISO-specific, based on historic averages. Nuances include:
  - ERCOT: historic withdrawal rates; changing ISO environment results in required Interconnection Agreement to be counted additions in 2027-28 (this constraint loosens in '29-30)
  - MISO: a 10% future drop-out rate is applied to Expedited Resource Addition Study (ERAS) gas resources in lieu of a historically-informed drop-out rate



## CRA projects modest additional headroom in non-PJM regions

### Non-PJM Served DC Load and Available Headroom



#### Approach

- Near-term additions (2027-2030) follow queue methodology
- Long-term LTCE adjusted to meet build limit constraints for natural gas and storage to account for all potential generation resources
- Data center load forecasts held at ISO's internal view\*
- Build limits and data center forecasts implicitly simulate the attractiveness to data centers in these regions and the impact of policy on the ability to develop new generation.

#### Assumptions

- If regional forecast ends prior to 2047, DC demand is extrapolated from current data and is assumed to track growth trends of ISOs with available data
- Absorption capacity = max (0, UCAP – forecasted peak load\*(1+RM))**
  - Measured as the ability of an ISO or region to serve additional DC load than what is in their forecast; a **positive value indicates room to host relocated PJM load**
- BTM Absorption capacity = max (0, BTM capacity - unserved DC load\*(1+RM))**
  - Measured as the ability of an ISO or region to host additional DC load than what is in their forecast BTM; a **positive value indicates room to host relocated PJM load**
- Output feeds the "where does displaced PJM load go" question

#### Sources Additional Information

|              |                                                     |
|--------------|-----------------------------------------------------|
| <b>MISO</b>  | MISO queue, CRA LTCE Analysis, MISO DC Forecast     |
| <b>SPP</b>   | SPP queue, CRA LTCE Analysis, SPP DC Forecast       |
| <b>ERCOT</b> | ERCOT queue, CRA LTCE Analysis, ERCOT DC Forecast   |
| <b>SERC*</b> | Utility IRPs and CRA LTCE Analysis, CRA DC Forecast |

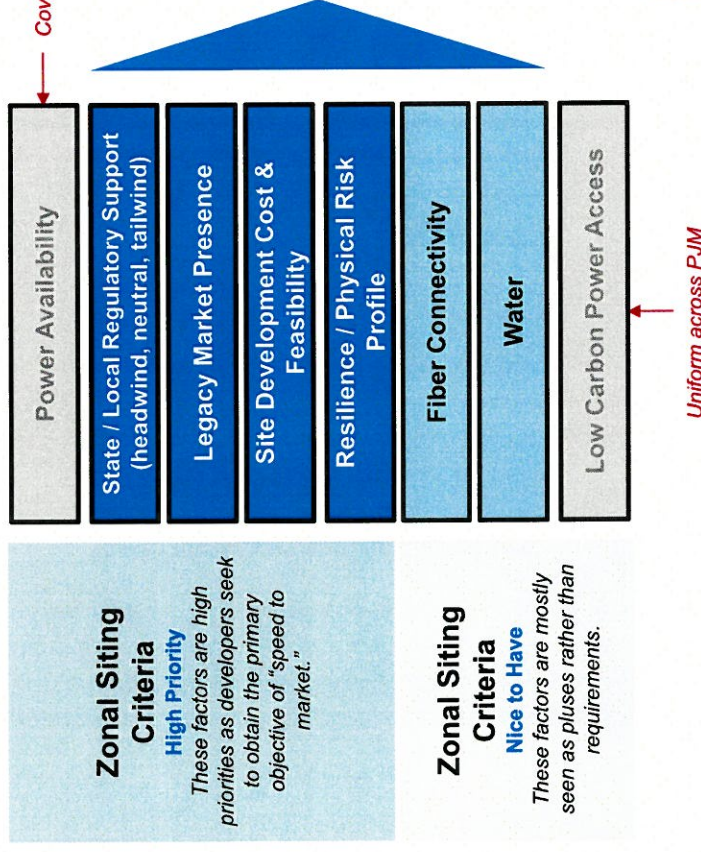
\*Note – No official DC forecast available; CRA compiled internal forecast

## Meeting agenda

| Topic                                       | Timing                  |
|---------------------------------------------|-------------------------|
| Introductions and July 13 LAS Meeting Recap | 9:10 – 9:20 AM          |
| Top-Down: Unconstrained View                | 9:20 – 9:35 AM          |
| Top-Down: Constraints                       | 9:35 – 10:00 AM         |
| <b>Bottom-Up Forecast</b>                   | <b>10:00 – 10:15 AM</b> |
| Load Profile Assumptions                    | 10:15 – 10:25 AM        |
| Forecast Reconciliation and BTM             | 10:25 – 10:45 AM        |
| Scenarios                                   | 10:45 – 11:00 AM        |
| <i>Break</i>                                | <i>11:00 – 11:10 AM</i> |
| Q&A                                         | 11:10 – 11:55 AM        |
| Next Steps & Close                          | 11:55 – 12:00 PM        |



To determine where projects are most likely to be sited, each PJM zone was assessed against key DC developer siting criteria



Evaluation Criteria

For each **PJM Zone** rank Relative Favorability

1 = Low  
2 = Average/Medium  
3 = High

X

Assign Category Importance Multiplier

Higher weighting for “High Priority” vs. “Nice to Have”; Scale of 1-5

= **Zonal Evaluation Criteria**

**Targeted Outcome:**

Assessment of the relative attractiveness of PJM zones to weight pipeline projects and allocate the top-down forecast, with growth concentrated in higher-scoring zones and less weight assigned to projects in lower-scoring zones

**CRA's model treats market formation as a two-part process: first, whether a dormant zone becomes a durable market; second, how annual demand is allocated once a zone is live**

### **What Gets Built In 'Live' Markets vs. What Takes Off**

**Core finding:** CRA observed multimodal behavior in the historical data: existing markets build proportionally to existing market share but are capped based on physical limits. New markets take off proportional to national growth. Attractive markets are more likely to take off but are hard to predict beforehand.





CRA conducted detailed research to assign each criterion a favorability score, then applied an importance multiplier to reflect its relative influence on DC siting decisions

| Category                            | Research Conducted                                                                                                                                                                                                                                                              | 1 = Lower Favorability                                                        | 2 = Medium Favorability                                                        | 3 = High Favorability <b>X</b>                                                   | Category Importance Multiplier<br>1 = Lowest, 5 = Highest |
|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------|-----------------------------------------------------------|
| State / Local Regulatory Support    | Existing/proposed State and local bills that would hinder DC development mapped to PJM zones                                                                                                                                                                                    | Restrictive or uncertain approval environment.                                | Permitting path exists but with some risk.                                     | Supportive policy and clear approval path.                                       | 4                                                         |
| Legacy Market Presence              | Sum of commissioned, available, under construction and planned MW of power as per merged datacenterHawk + Cleanview data set                                                                                                                                                    | Limited existing presence or customer activity.                               | Emerging presence, but pipeline depth or customer momentum remains uncertain.  | Established market with proven delivery track record and active customer demand. | 3                                                         |
| Site Development Cost & Feasibility | <ul style="list-style-type: none"> <li><b>Energy costs:</b> PJM historical zonal hourly LMP (Energy Velocity)</li> <li><b>Land costs:</b> Rural farm real estate \$/acre by State (USDA 2025)</li> <li><b>Tax incentives:</b> State-level DC tax incentives research</li> </ul> | Limited or uncertain incentives, excess vacancies in colocation availability. | Some incentives available, but not clearly differentiating, average vacancies. | Strong incentives that improve site competitiveness, low vacancies.              | 2                                                         |
| Resilience / Physical Risk Profile  | FEMA National Risk Index v1.20 (December 2025) by county mapped to state and zone; includes Inland Flooding, Severe Storms, Wildfire, Winter Storms, Extreme Heat risks                                                                                                         | High physical risk exposure.                                                  | Manageable risk with mitigation.                                               | Low risk and strong resilience profile.                                          | 2                                                         |

CRA Independent Assessment of Project Siting Realization Probabilities

**CRA conducted detailed research to assign each criterion a favorability score, then applied an importance multiplier to reflect its relative influence on DC siting decisions**  
*(Continued)*

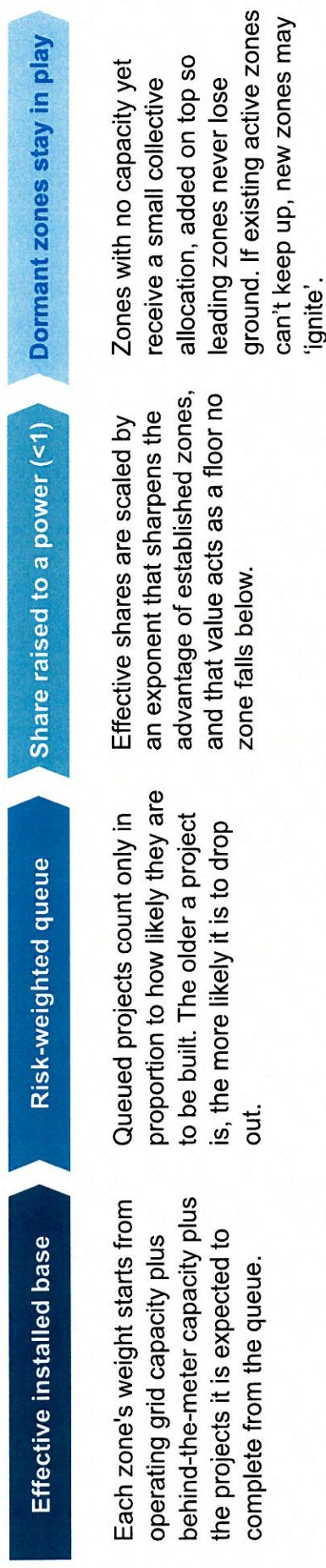
| Category           | Research Conducted                                                             | 1 = Lower Favorability              | 2 = Medium Favorability                          | 3 = High Favorability <b>X</b>                        | Category Importance Multiplier<br>1 = Lowest, 5 = Highest |
|--------------------|--------------------------------------------------------------------------------|-------------------------------------|--------------------------------------------------|-------------------------------------------------------|-----------------------------------------------------------|
| Fiber Connectivity | ITU Fiber Optic Maps (high-level and relative view evaluated between PJM zone) | Limited connectivity or redundancy. | Connectivity available but may require buildout. | Strong fiber access, redundancy, and latency profile. | <b>2</b>                                                  |
| Water              | World Resources Institute's Aqueduct 4.0 Water Risk Atlas database             | Material water or labor constraint. | Available but with some cost or planning risk.   | Adequate water and labor to support growth.           | <b>1</b>                                                  |
| Low Carbon Power   | Treated as uniform across PJM                                                  | N/A                                 | N/A                                              | N/A                                                   | <b>1</b>                                                  |

CRA Independent Assessment of Project Siting Realization Probabilities



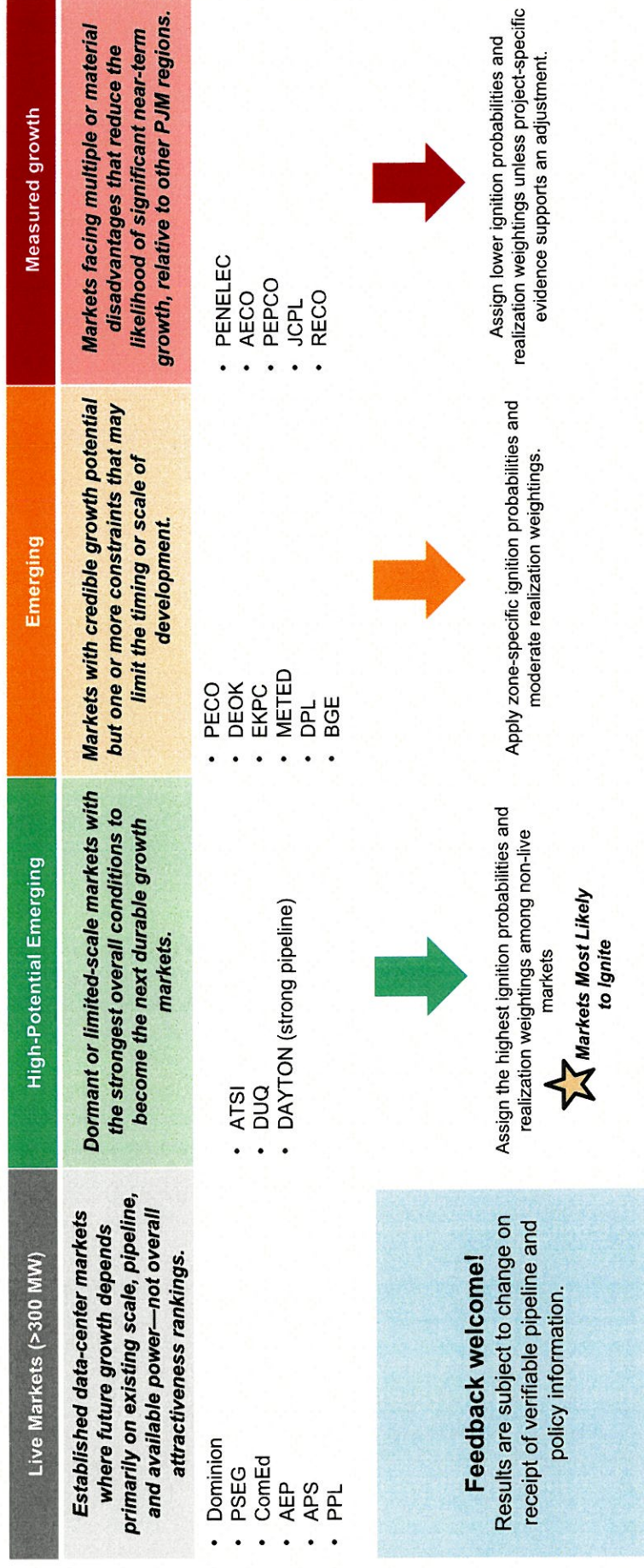
## New projects are ‘selected’ to achieve grid connection in proportion with existing market share

Statistical analysis showed that year-over-year capacity additions are highly correlated with existing market share, but growth gradually spreads into new markets over time. This reflects data center developers’ preference for expanding in established markets while simultaneously pursuing development opportunities in smaller and emerging markets.



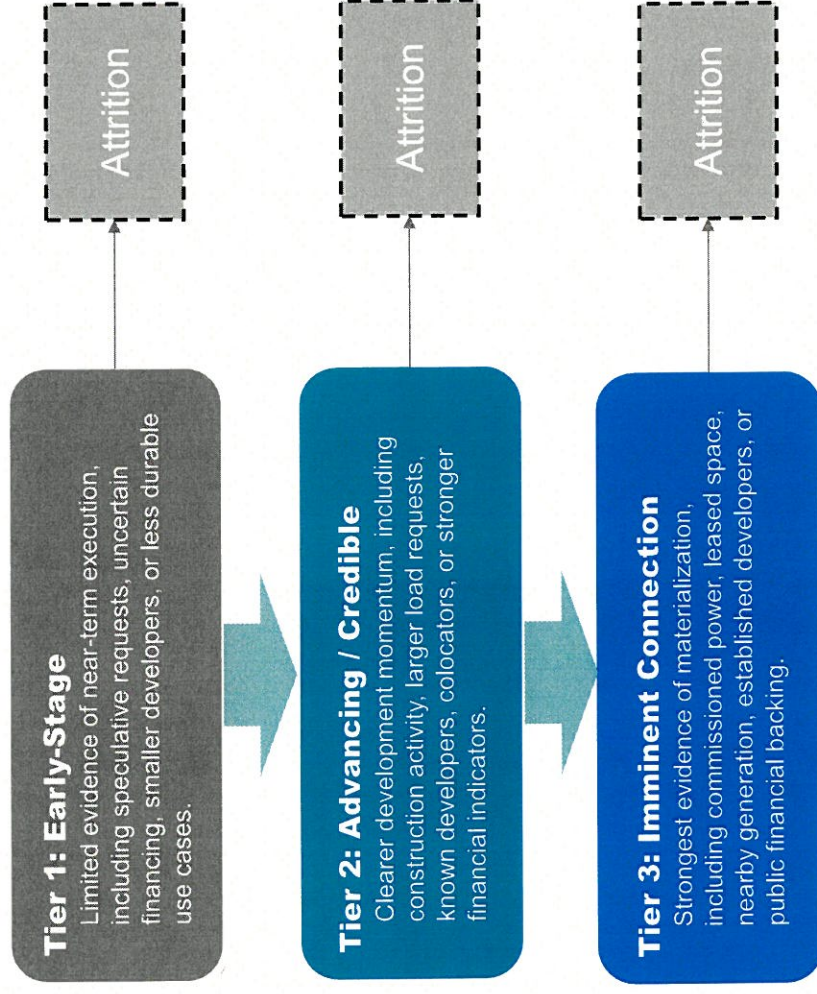
**Net Effect:** Growth concentrates where capacity and credible pipelines already exist, while emerging zones keep a realistic chance of landing the next project and capacity gradually spreads across the market.

## Based on CRA's assessment, emerging zones are classified by their relative potential to ignite and sustain data-center growth





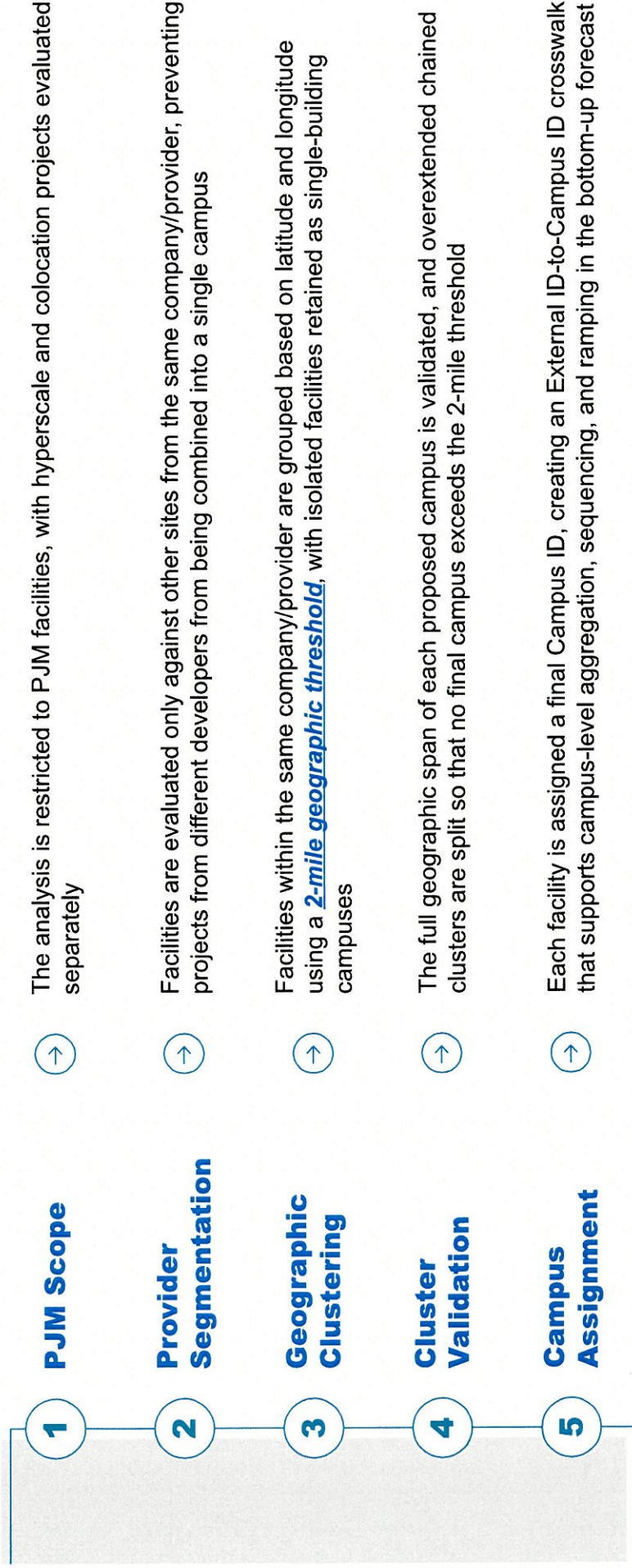
## Readiness tiers are used to evaluate the maturity of the pipeline



How the queue is modelled

- Projects are assigned to readiness tiers based on observable development indicators.
- A **Markov model** estimates the probability that projects advance tiers, remain at current tier, or get cancelled over time.
- These probabilities are learned from observed project progression data rather than assumed uniformly across the queue.
- “Generic” projects are added separately to preserve expected future demand in areas where known queues may not fully capture market activity.
- If a zone shows signs of acceleration, generic demand allows the forecast to reflect emerging opportunity before named projects appear in the queue.

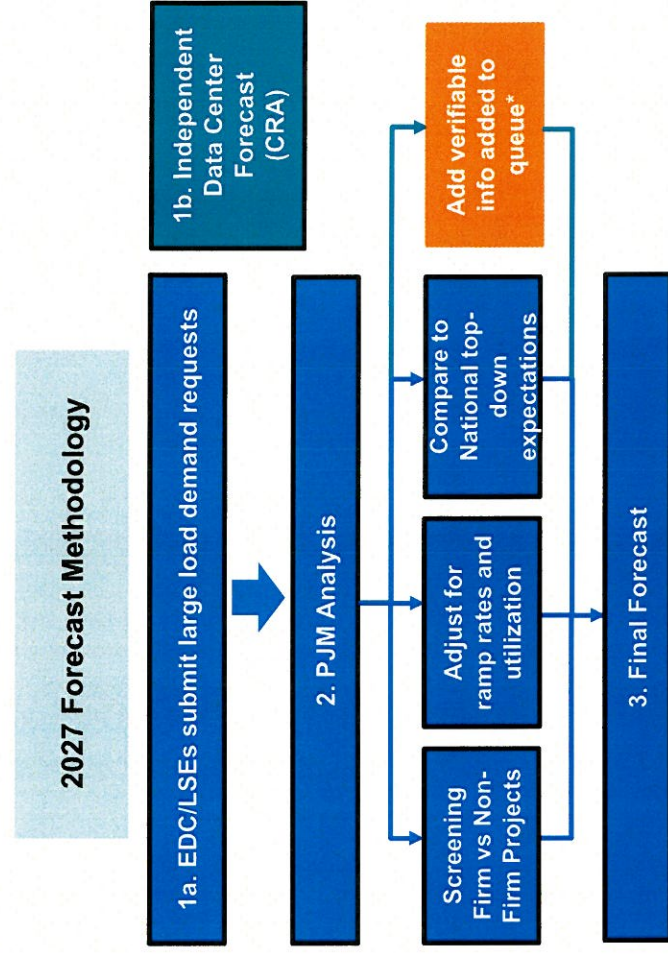
## CRA groups nearby facilities from the same developer into campuses to jointly simulate buildings that operate as a shared investment decision



Source: DatacenterHawk; CRA Analysis



**PJM is altering its approach to annual forecasting by introducing CRA's independent forecast to improve the evaluation of large loads submitted by LSEs/EDCs for the 2027 forecast**



*\*CRA will incorporate project-specific information or adjust applicable build limits where stakeholders provide sufficient, verifiable evidence to support the change.*

## Meeting agenda

| Topic                                       | Timing                  |
|---------------------------------------------|-------------------------|
| Introductions and July 13 LAS Meeting Recap | 9:10 – 9:20 AM          |
| Top-Down: Unconstrained View                | 9:20 – 9:35 AM          |
| Top-Down: Constraints                       | 9:35 – 10:00 AM         |
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| <i>Break</i>                                | 11:00– 11:10 AM         |
| Q&A                                         | 11:10 – 11:55 AM        |
| Next Steps & Close                          | 11:55 – 12:00 PM        |



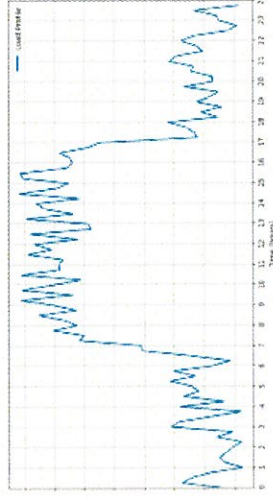
## Characteristic hourly shapes

Public data on the operational load profiles and load factors of data centers is limited, and potential evolution of load profile and load factors is uncertain. LBNL's data center load shape generator will be used as a foundation to create the characteristic load shape.

### Approach

- Characteristic hourly shapes will be anchored to [LBNL's publicly available Data Center and Industrial Electrical Load Shape Generator](#)
- Any changes based on expert conversations will be documented

Example of LBNL's Characteristic Hourly Shape for Business Diurnal Hourly Load



Example of LBNL's Characteristic Hourly Shape for Flat Hourly Load



### Identify Characteristic Shapes

To best capture 'typical' hourly behavior for different data center workloads (normalized to 0~1)

### Incorporate Stochasticity

To best capture a range of potential events, rather than a single characteristic shape

### Apply Forecasted Capacity

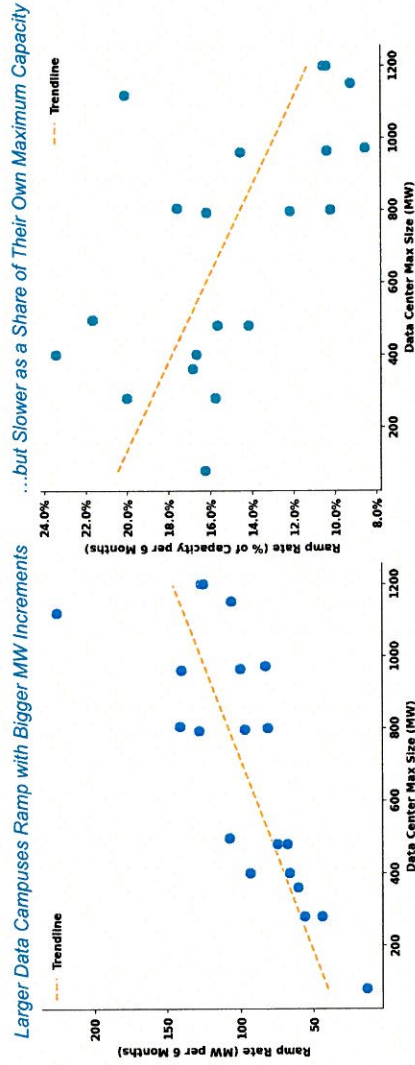
Scale normalized by expected data center growth by zone, distributed by estimated relative compute needs for

Source: [LBNL Data Center and Industrial Electrical Load Shape Generator](#)

Note: CRA acknowledges that the exact evolution of hourly profiles is uncertain and is rapidly evolving. LBNL provides a solid, publicly verifiable foundation to create characteristic hourly load. Any modifications to LBNL's outputs will be documented.

## Ramp rates (absent constraints)

Larger data center campuses generally ramp with higher MWs, but are proportionally slower relative to smaller sites

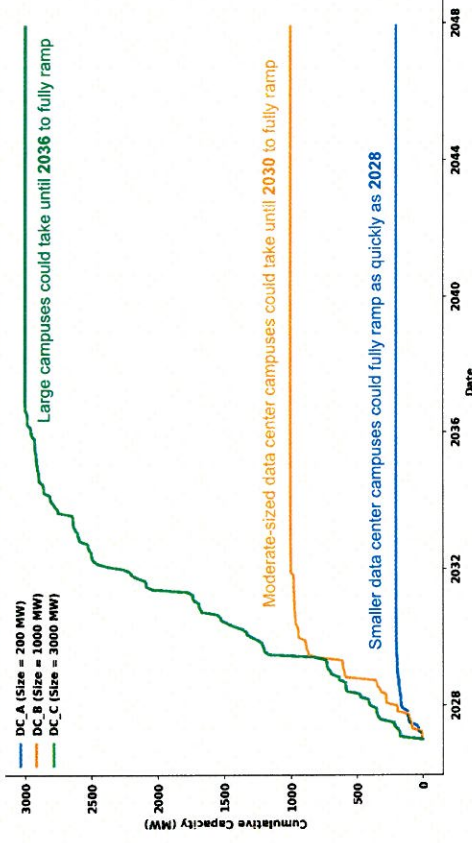


Note: calculated as the change in observed MW capacity between each month and the same data center's capacity 6 months earlier, averaged across the ramp period (which is between the first MWs coming online, and when the data center's MWs are equal to the maximum observed in the data)

### Approach

- **Learn the pattern:** Fit historical ramp rates and timing as a function of data center size.
- **Preserve uncertainty:** Capture how different campuses deviate from the size-based trend.
- **Generate realistic ramps:** Combine the expected size-based curve with observed deviations from similar projects to create plausible MW ramp trajectories

Example of modeled data center ramps:  
larger data centers ramp slower than smaller data centers



Example where all data center campuses start their ramp at the same time.

### Assumptions

- Assumes size is the key dominant factor when considering data center ramp rates – the larger the load, the slower the ramp to full capacity
- This is to ensure that CRA is not selecting ramp rates based on other business-specific characteristics to preserve objectivity



IT load is typically a fraction of total metered demand, as data centers typically require non-IT supporting equipment to operate effectively

## “Total Metered Demand”



Power Usage Effectiveness (PUE) is the ratio between Total Metered Demand and IT Load

$$PUE = \frac{\text{Total Metered Demand}}{\text{IT Load}}$$

### Approach

- Apply PUE to IT load to estimate Total Metered Demand

$$\text{Total Metered Demand} = \underbrace{PUE}_{\text{CRA Estimates}} * \underbrace{\text{IT Load}}_{\text{datacenterHawk}}$$

### Assumptions

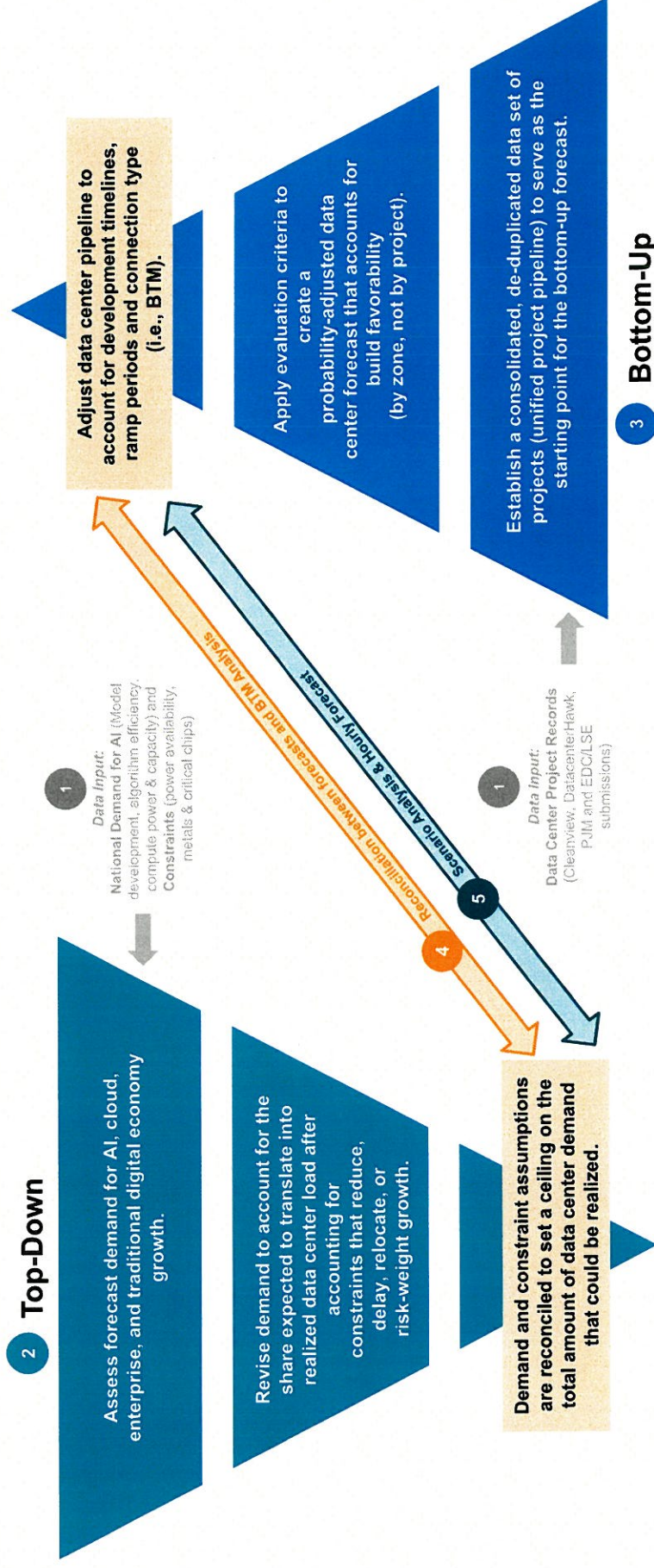
- PUE estimates for data centers at 1.32 per EPRI’s capacity-weighted averages for facility-level data ([link](#))

## Meeting agenda

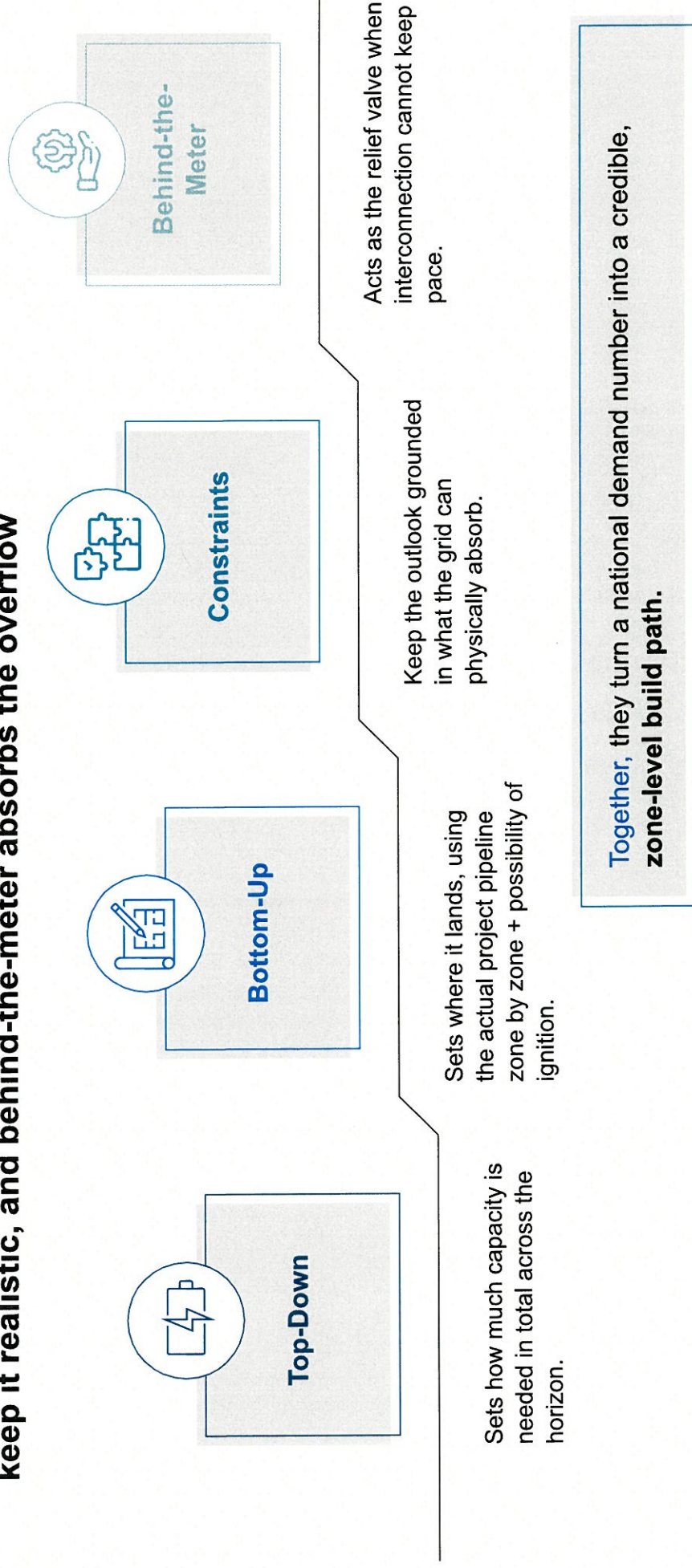
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## Methodology overview to produce 20-year hourly load forecast



**Four layers work together: demand sets the size, the pipeline sets the location, constraints keep it realistic, and behind-the-meter absorbs the overflow**





## Seven sequential steps reconcile unconstrained demand with zonal and PJM limits, then capture the final build



## Behind-the-Meter offers a critical relief for constrained power systems



*The split between the two follows observed proportions in the announced project pipeline*

**RECONNECTION** — both behind-the-meter outcomes are temporary: islanded sites seek grid service once the zone can accommodate them, approximately two years, returning on non-firm service and retaining their generation. That capacity re-enters the zonal capacity position as the load returns to grid-served load, lifting net load in the later years of the forecast.



## Island and hybrid configurations differ in whether grid connection is retained, determining how each is sized and counted

| HYBRID                                                                                                                                                                                                                                                                                                                                                                            | ISLAND                                                                                                                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Grid-connected — self-supplies part of the time                                                                                                                                                                                                                                                                                                                                   | No grid service — self-supplies its full load                                                                                                                                                                                                                                            |
| <p><b>Sizing</b></p>  <p>Power load served = 1.00x<br/>generation installed = 1.11x (ICAP)<br/>= 0.69x (UCAP)</p>                                                                                                                                                                              | <p><b>Sizing</b></p>  <p>Power load served = 1.00x<br/>generation installed = 1.67x (ICAP)<br/>= 1.14x (UCAP)</p>                                                                                      |
| No reserve margin — the grid provides redundancy.                                                                                                                                                                                                                                                                                                                                 | Redundancy for forced outages, with no external backstop.                                                                                                                                                                                                                                |
| <p><b>Why this configuration</b></p> <p>Preferred wherever a connection can be obtained. Grid energy is cheaper in most hours, the option to purchase retains value even at low utilization, and the grid clears faults and supports restart.</p>                                                                                                                                 | <p><b>Why this configuration</b></p> <p>The forced outcome where grid service cannot be obtained on the required timeline — not a preferred design. An islanded site cannot lean on the grid to clear faults or restart, which is materially harder at scale.</p>                        |
| <p><b>In the load forecast</b></p> <p>The load remains and is served under firm service; the generation offsets part of it.</p>                                                                                                                                                                                                                                                   | <p><b>In the load forecast</b></p> <p>Neither the load nor its generation appears on the system until reconnection.</p>                                                                                                                                                                  |
| <p><b>In the capacity position</b></p> <p>Credited at its accreditation factor, with peak and energy assessed net of behind-the-meter dispatch. Credited because sites are built at approximately one-to-one with no reserve margin, so they cannot be assumed reliably interruptible — and because the technology mix points to a capacity rather than an energy motivation.</p> | <p><b>In the capacity position</b></p> <p>Not credited, as the resources are absent from the system. The site returns to the forecast on reconnection, which is assumed approximately two years after the zone can accommodate it, on non-firm service and retaining its generation.</p> |
| <p><b>Populations</b></p> <p>Sites built as hybrid take firm service and operate for arbitrage and coincident-peak management. Islanded sites that reconnect return on non-firm service and are curtailable.</p>                                                                                                                                                                  | <p><b>Populations</b></p> <p>A single population, which converts to hybrid on reconnection.</p>                                                                                                                                                                                          |
| <p><b>COMMON TO BOTH:</b> the split between the two follows observed proportions in the announced project pipeline, and all behind-the-meter capacity is temporary — a bridge held only until grid service becomes available.</p>                                                                                                                                                 |                                                                                                                                                                                                                                                                                          |

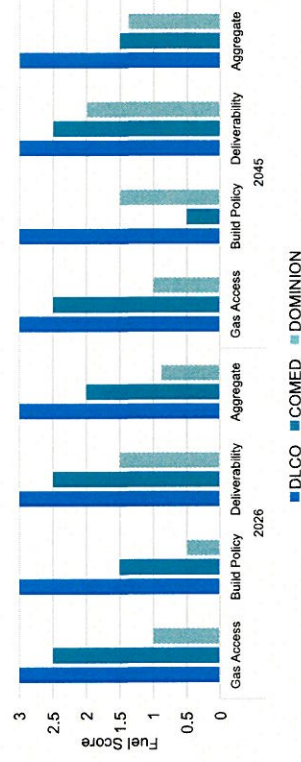
## Fuel scores – how much BTM gas can physically and legally be built?

### What the scores are

- The score represents a zone-year assessment of whether gas-fired behind-the-meter generation can physically and legally be built — not whether anyone wants to build there, which is handled separately.
- Three sub-factors, each scored 0–3, averaged into a composite: gas access, build policy, and deliverability. Build policy has double weight because it is the most important.

- Gas access** – distance to interstate mainline with spare capacity, and mainline utilization. Sourced from pipeline GIS and capacity postings
  - Build policy** – state and local permitting posture toward on-site generation and associated pipeline infrastructure, including moratoria and litigation history
  - Deliverability** – winter basis spread at the serving hub versus Henry Hub, and frequency of operational flow orders or curtailment notices
- A separate binary buildable-policy flag gates the zone entirely; where it is zero, no behind-the-meter generation is permitted regardless of the other scores.

Sample Fuel Scores



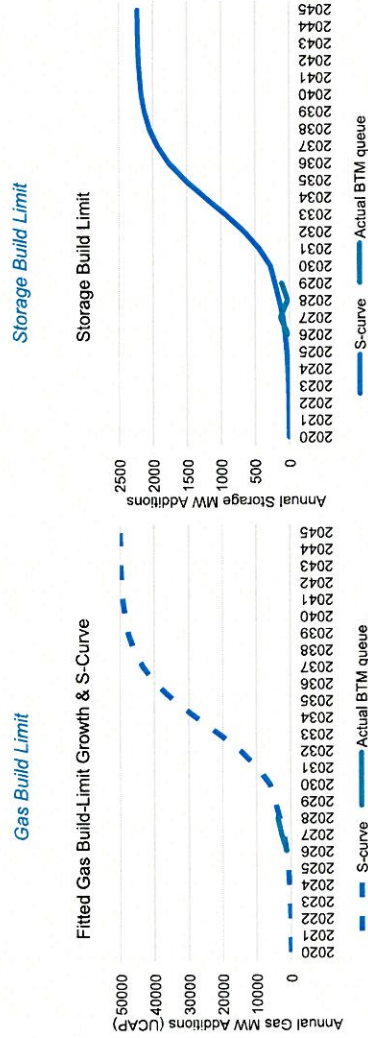
Fuel Scores Rubric

|                  | What it captures                                                                               |  |  |  | 0                                | 1                         | 2                   | 3                                  |
|------------------|------------------------------------------------------------------------------------------------|--|--|--|----------------------------------|---------------------------|---------------------|------------------------------------|
| Gas Access       | Is the gas physically there and can pipe reach the site? (basin proximity + pipeline headroom) |  |  |  | Pipeline island, far from supply | Lateral-dependent, tight  | Mainline accessible | On/near basin, mainline with spare |
| Build Policy     | Can you permit and build the pipe/lateral the gas facility?                                    |  |  |  | Moratorium / de facto ban        | Hostile, litigated        | Mixed/slow          | Supportive                         |
| Deliverability   | Will gas show up when needed? (firm availability + winter constraint risk)                     |  |  |  | Regular curtailment              | Tight, interruptible-only | Workable            | Firm available, low winter risk    |
| Buildable Policy | Can BTM generation be built at all?                                                            |  |  |  | No                               | Yes                       | N/A                 | N/A                                |



## Projecting the Behind-the-Meter build limit

As with grid-connected resources, the ability to build BTM resources is assumed to grow over time



Note: calculated as the change in observed MW capacity between each month and the same data center's capacity 6 months earlier, averaged across the ramp period (which is between the first MWs coming online, and when the data center's MWs are equal to the maximum observed in the data)

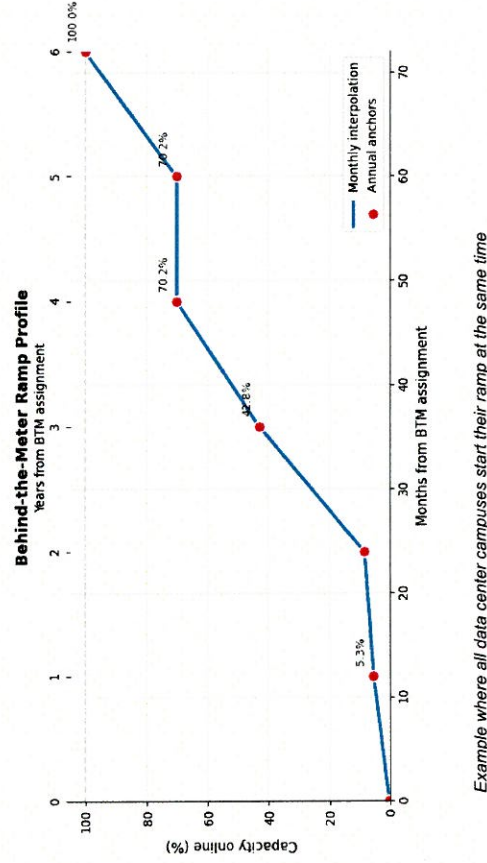
### Approach

- Applied PJM-wide, not zonally
- Announced BTM projects with a commercial online date, aggregated by year and used as an annual flow
- Absent a formal queue, the pipeline is the equivalent revealed-preference signal
- Joined to US turbine orders under 100 MW, 2020–25 — same manufacturing base, so the longer history informs the shape
- The junction carries the last observed growth rate, so the splice adds no step; the fitted logistic levels off rather than compounding

Source: LSE Submissions

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Assumed BTM ramp rate:  
BTM projects ramp slower than grid-connected projects



Example where all data center campuses start their ramp at the same time

### Assumptions

- Assumes ramp rates follow year-over-year build trends as observed in public announcements
- Build rates are slower than grid-connected projects due to the need to self-build power

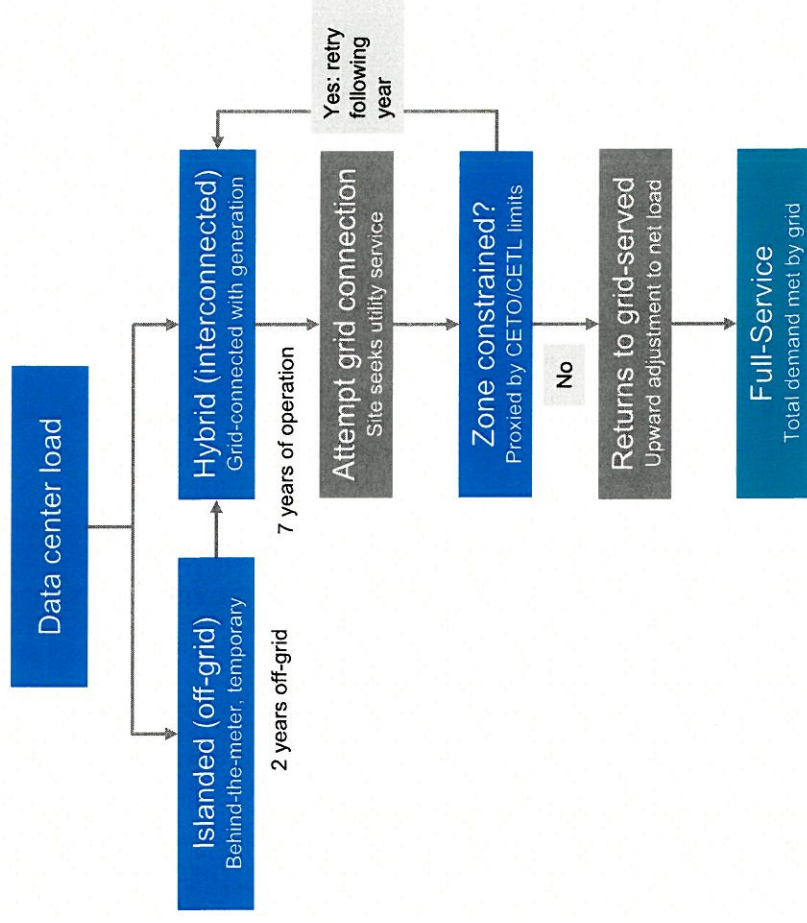
Source: CRA analysis, Cleanview



## Data centers with BTM generation will ultimately seek grid reconnection

### Key Assumptions

1. Islanded behind-the-meter build allows data centers to come online *early*, but it is *expensive* relative to grid service.
2. Data centers without utility connection are assumed to seek grid service as soon as it becomes available, consistent with a connection being preferred wherever it can be obtained.
3. Islanded sites cannot be added to hybrid demand in any year that zone is *constrained*, as proxied by CETO/CETL limits in each year.
4. Islanded sites are assumed to try to become hybrid *seven years* after demand is forecasted, subject to above constraint. This is the average time until a major overhaul would be required on the existing generating resources.
  - BYOG connection timelines are assumed to be shorter than full-service data centers (which average 4-7 years depending on zonal constraints)
5. Sites return on non-firm service, retaining their generation, and are therefore *curtailable* following reconnection.
  - Consistent with observed trends in existing data centers connecting to grid service with existing backup generation
6. Reconnected capacity re-enters the balance and the associated load returns to grid-served load, producing an *upward adjustment* to net load in the later years of the forecast net of on-site generation.







## Economic dispatch modeling yields hour-to-hour economic dispatch of BTM resources

### 1. Grouping tranches

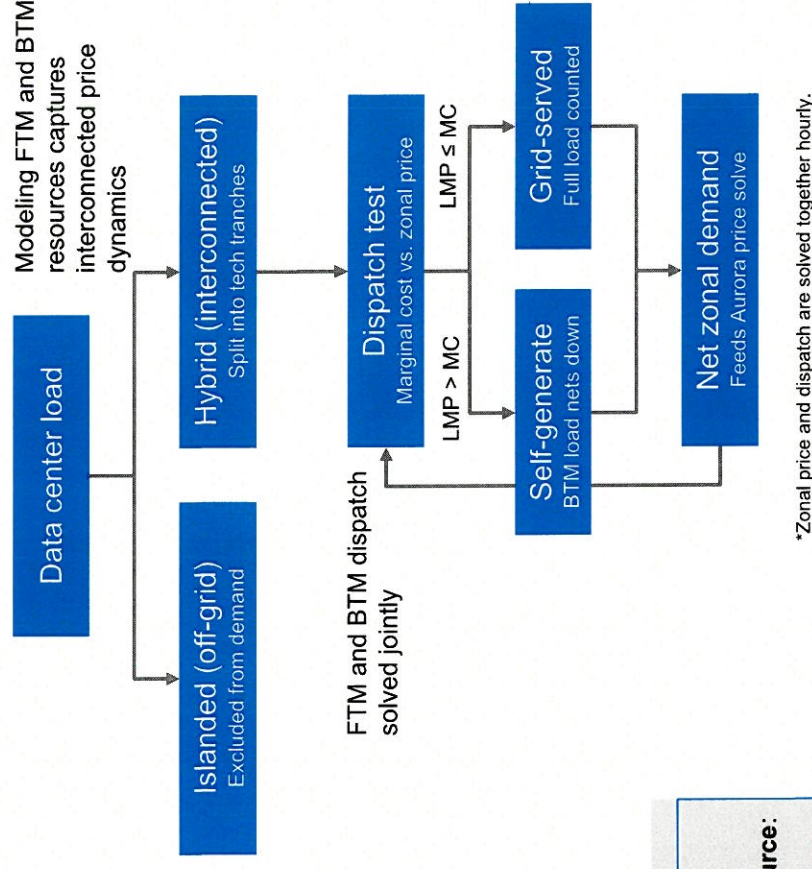
Hybrid BTM resources are grouped into technology-specific tranches by zone. Each tranche is entered into a production cost model that **reduces the gross BTM datacenter load in its zone** — it does not compete as a supply offer in the broader market and carries no capacity accreditation.

### 2. Dispatch logic

In each hour, model compares each marginal cost to the zonal clearing price. If marginal cost < zonal price, the resource tranche dispatches, reducing datacenter grid draw by that amount. If marginal cost  $\geq$  price, the tranche stays off and the load is served from the grid.

### 3. Islanded resources

Islanded data centers have no electrical interconnection and are therefore excluded from the zonal demand forecast, reflecting that they would have no impact on net system demand. They only enter the model once they interconnect, at which point they are treated as hybrid resources (see prev. slide).



#### Key Takeaway:

Because tranche dispatch is price-driven rather than a fixed schedule, the **resulting zonal price series approximates when the operator would turn on its FTM resource**: self-generate when it is cheaper than buying, draw from the grid when it is not.

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| Q&A                                         | 11:10 – 11:55 AM        |
| Next Steps & Close                          | 11:55 – 12:00 PM        |



## Impact of Scenarios

Using scenarios can illustrate how demand growth and constraints interact under different states of the world, how quickly constraints relax, and therefore how much national demand can realistically translate into regional load

| State of the World                                                   | Constraint Environment                                                                                                                                       | Impact on Top-Down Forecast                                                                                                                                                                                                                                                                                   |
|----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Base Case / Managed Growth</b>                                    | AI adoption continues, but power, supply chain, and siting constraints slow realization. Going forward, new infrastructure accelerates beyond current rates. | <br><i>Demand grows steadily, but constraints cap near-term load realization and push some growth into later years.</i>                                                                                                      |
| <b>Abundance Case</b>                                                | Infrastructure, compute, and power constraints are relaxed faster than base case expectation; efficiency gains also improve.                                 | <br><i>Faster load growth enabled by fewer binding constraints limiting demand realization.</i>                                                                                                                              |
| <b>Power-Constrained Growth &amp; Evolving Inter-region dynamics</b> | AI demand remains strong, but power availability and interconnection remain severely constrained (current rates remain), particularly in legacy markets.     | <br><i>National demand exists, but regional load realization is significantly limited by deliverability, cost, and timing of power. Data centers are likely to increasingly shift toward emerging and tertiary markets.</i> |
| <b>Slower Adoption</b>                                               | AI adoption is more measured due to cost, use-case uncertainty, efficiency improvements, or customer adoption friction.                                      | <br><i>Lower overall demand trajectory, with less pressure on infrastructure constraints and slower regional siting.</i>                                                                                                   |

## Scenarios test a range of internally consistent outcomes

| Scenario            | S-D Outlook                     | AI Adoption                        | AI Efficiency                                           | BTM Generation                                             |
|---------------------|---------------------------------|------------------------------------|---------------------------------------------------------|------------------------------------------------------------|
| <b>Abundance</b>    | More generation added than base | Same as base                       | Same as base                                            | Same availability as base, but less usage                  |
| <b>Constrained</b>  | Less generation added than base | Same as base                       | Incentivized to innovate:<br>Increased efficiency gains | Build limits tighten, but larger shortfalls yield more BTM |
| <b>Low Adoption</b> | Same as base                    | Lower adoption rate than base case | Same as base                                            | Build limits unchanged, less shortfall so less BTM         |

*Most significant implication*



## Supply build-out is determined by multiple levers

While near term queue-based outlook remains the same, changes are applied to LTCE forecast (2031 – 2047)

| Scenario                                                     | Gas build limit      | Storage build limit                                 | Cycle 1 treatment                                         | Post-2038 constraint and transmission logic |
|--------------------------------------------------------------|----------------------|-----------------------------------------------------|-----------------------------------------------------------|---------------------------------------------|
| <b>Abundance</b><br><i>More generation added than base</i>   | Increase to 18% CAGR | Quicker ramp and higher constraint                  | Decreased attrition represented by build limit relaxation | Off                                         |
| <b>Base Case</b><br><i>Base case</i>                         | Remain at 10% CAGR   | Ramp to 6 GW and remain flat                        | Included as generic units in LTCE                         | Off                                         |
| <b>Constrained</b><br><i>Less generation added than base</i> | Decrease to 5% CAGR  | Minimal increase in constraint, increase to ~3.5 GW | Lower levels of additional resources via build limits     | Off                                         |

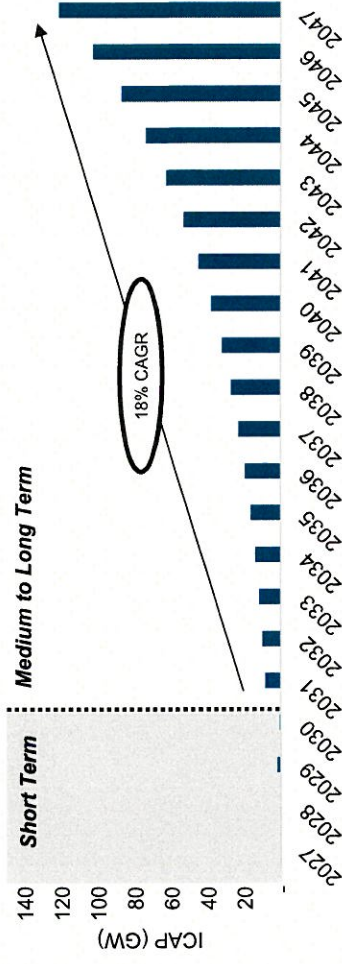
## Turbine and battery supply chains adapt more quickly to increased demand

### Supply Forecast Details for Abundance Case

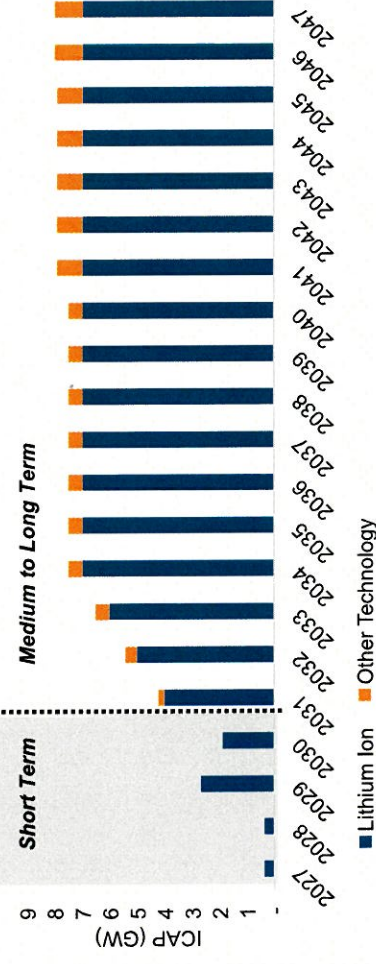
- A relaxed turbine constraint is the key lever to achieving this scenario and enabling an accelerated gas build-out; an increased storage constraint allows for additional batteries to come online
- Medium-term gas additions are built sooner due to relaxed constraints, reducing UCAP shortfall by up to ~6 GW annually
- However, near-term shortfalls (2027–2030) remain unchanged as the queue remains a fixed addition

| Base Case                        |        | Abundance Case |
|----------------------------------|--------|----------------|
| <i>In UCAP</i>                   |        |                |
| Highest Shortfall                | 28 GW  | 28 GW          |
| Cumulative Shortfall (2031–2047) | 125 GW | <125 GW        |
| Gas Additions (2031–2047)        | 53 GW  | >53 GW         |

CRA “Abundance Case” Gas Turbine Constraint (ICAP)



CRA “Abundance Case” Battery Constraint (ICAP)



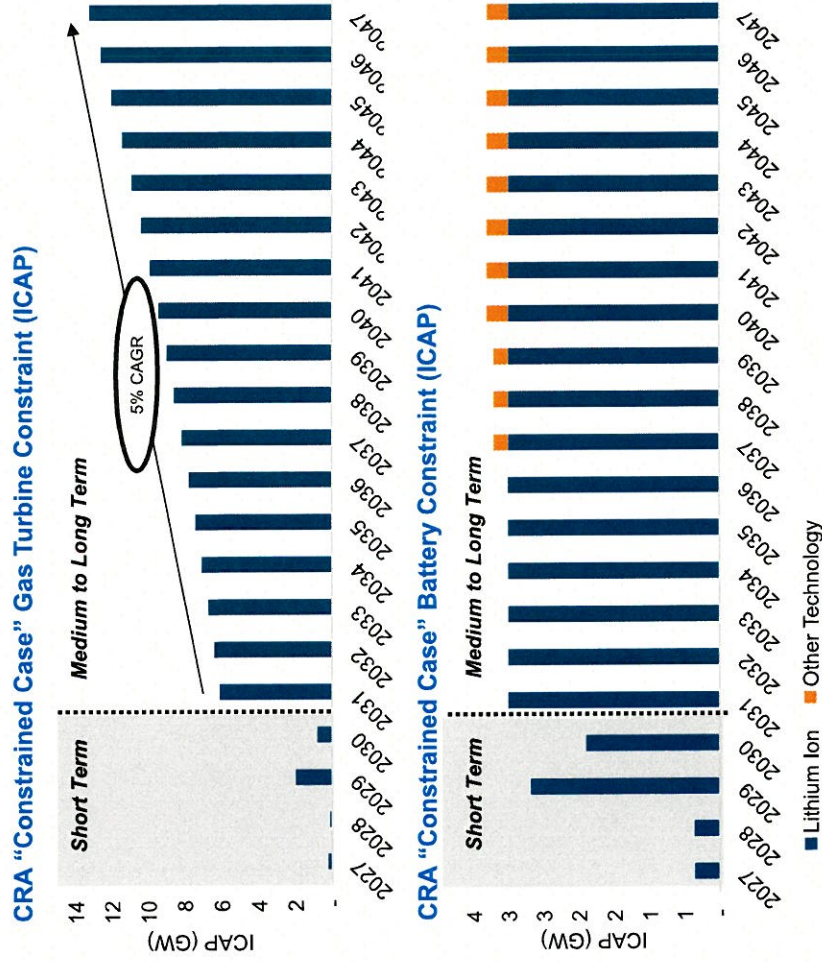


## Turbine and battery supply chains lag even as demand grows

### Supply Forecast Details for Constrained Case

- A tightened turbine constraint along with a lower battery constraint prevents new generation from coming online at the same rate as other cases
- Medium-term gas additions are built later due to harsher constraints, increasing UCAP shortfall by up to ~16 GW annually
- However, near-term shortfalls (2027–2030) remain unchanged as the queue remains a fixed addition

|                                  | Base Case<br>In UCAP | Constrained<br>Case |
|----------------------------------|----------------------|---------------------|
| Highest Shortfall                | 28 GW                | 28 GW               |
| Cumulative Shortfall (2031–2047) | 125 GW               | >125 GW             |
| Gas Additions (2031–2047)        | 53 GW                | <53 GW              |



## Scenarios test a range of internally consistent outcomes

| Scenario            | S-D Outlook                     | AI adoption                        | AI efficiency                                        | BTM generation                                             |
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| <b>Constrained</b>  | Less generation added than base | Same as base                       | Incentivized to innovate: Increased efficiency gains | Build limits tighten, but larger shortfalls yield more BTM |
| <b>Low Adoption</b> | Same as base                    | Lower adoption rate than base case | Same as base                                         | Build limits unchanged, less shortfall so less BTM         |

*Most significant implication*



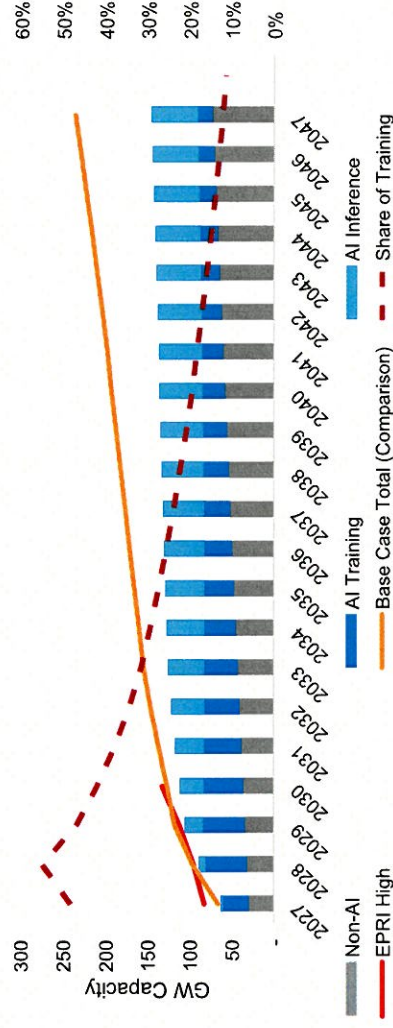
## Forced innovation case represents a scenario where AI demand remains strong, but power constraints are persistent

### What Needs to be True in the “Forced Innovation” Case

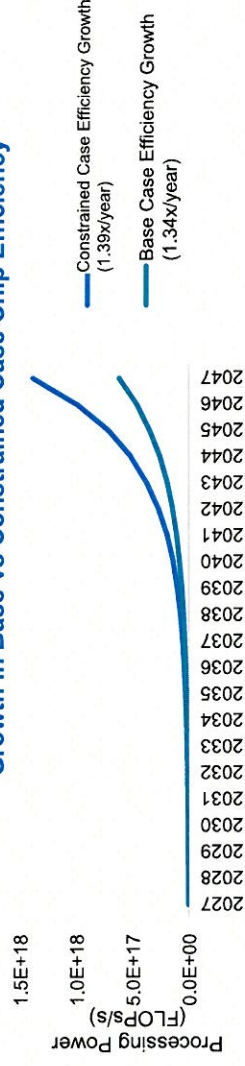
- AI adoption remains strong as companies realize productivity gains from AI
- Power constraints increasingly limit data center expansion and deployment of power-intensive hardware
- Market pressure shifts to upstream suppliers, incentivizing chip manufacturers to focus on computationally efficient designs, increasing chip processing efficiency
- Efficient chip design enables AI adoption while counteracting MW demand growth

|          | Base Case Growth                | Constrained Case Growth |
|----------|---------------------------------|-------------------------|
| Adoption | 95% Individual Adoption by 2040 | No Change               |
| Chips    | 1.34x/year                      | 1.39x/year (+5%)        |

CRA “Forced Innovation Case” Data Center Forecast (Cumulative GWs)



### Growth in Base vs Constrained Case Chip Efficiency



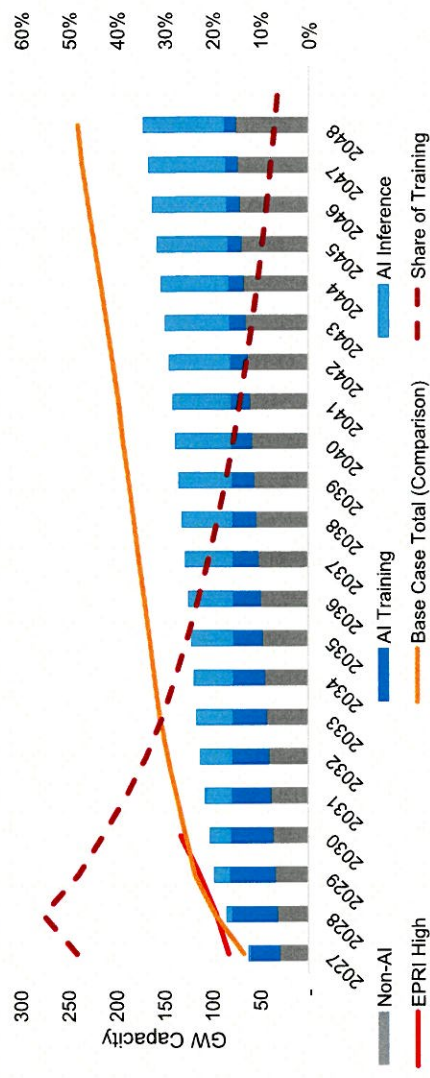
## Lower adoption case represents a scenario where AI struggles to gain traction, causing a decline in demand

### 'What Needs to be True' in the Lower Adoption Case

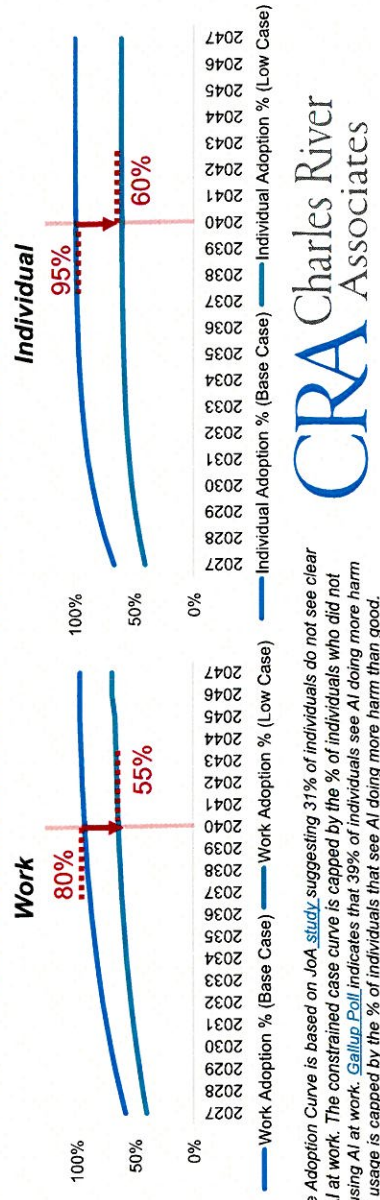
- Enterprise AI adoption slows as productivity gains fall short of expectations.
- Weaker demand reduces AI development investment and model development activity.
- Fewer breakthrough models further dampen adoption, creating a self-reinforcing slowdown in AI growth.

|          | Base Case Growth                                                                                    | Lower Adoption Case Growth                                                                                                |
|----------|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| Adoption | 95% Individual Adoption by 2040<br>80% Enterprise Adoption by 2040<br>11% CAGR in AI Models Trained | 60% (-35%) Individual Adoption by 2040<br>55% (-25%) Enterprise Adoption by 2040<br>5.5% CAGR in AI Models Trained (-50%) |
| Chips    | 1.34x/year                                                                                          | No Change                                                                                                                 |

CRA "Lower Adoption Case" Data Center Forecast (Cumulative GWs)



CRA "Lower Adoption Case" Adoption Forecast (% U.S. Population)



Lower Adoption Case Adoption Curve is based on JoA study suggesting 31% of individuals do not see clear benefits from using AI at work. The constrained case curve is capped by the % of individuals who did not report benefits from using AI at work. Gallup Poll indicates that 39% of individuals see AI doing more harm than good. Individual usage is capped by the % of individuals that see AI doing more harm than good.



## Meeting agenda

| Topic                                       | Timing                  |
|---------------------------------------------|-------------------------|
| Introductions and July 13 LAS Meeting Recap | 9:10 – 9:20 AM          |
| Top-Down: Unconstrained View                | 9:20 – 9:35 AM          |
| Top-Down: Constraints                       | 9:35 – 10:00 AM         |
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| Scenarios                                   | 10:45 – 11:00 AM        |
| <b>Break</b>                                | <b>11:00 – 11:10 AM</b> |
| Q&A                                         | 11:10 – 11:55 AM        |
| Next Steps & Close                          | 11:55 – 12:00 PM        |

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| <b>Next Steps &amp; Close</b>               | <b>11:55 – 12:00 PM</b> |

## Next Steps

- EDC/LSE form submissions due – September 4
- Individual meetings with EDCs/LSEs in September/October
- Final results presentation October 14 LAS meeting

We thank you for your support and participation, both today and throughout this process!

For any additional questions or comments please reach out to [Load\\_Analysis\\_Team@pjm.com](mailto:Load_Analysis_Team@pjm.com).

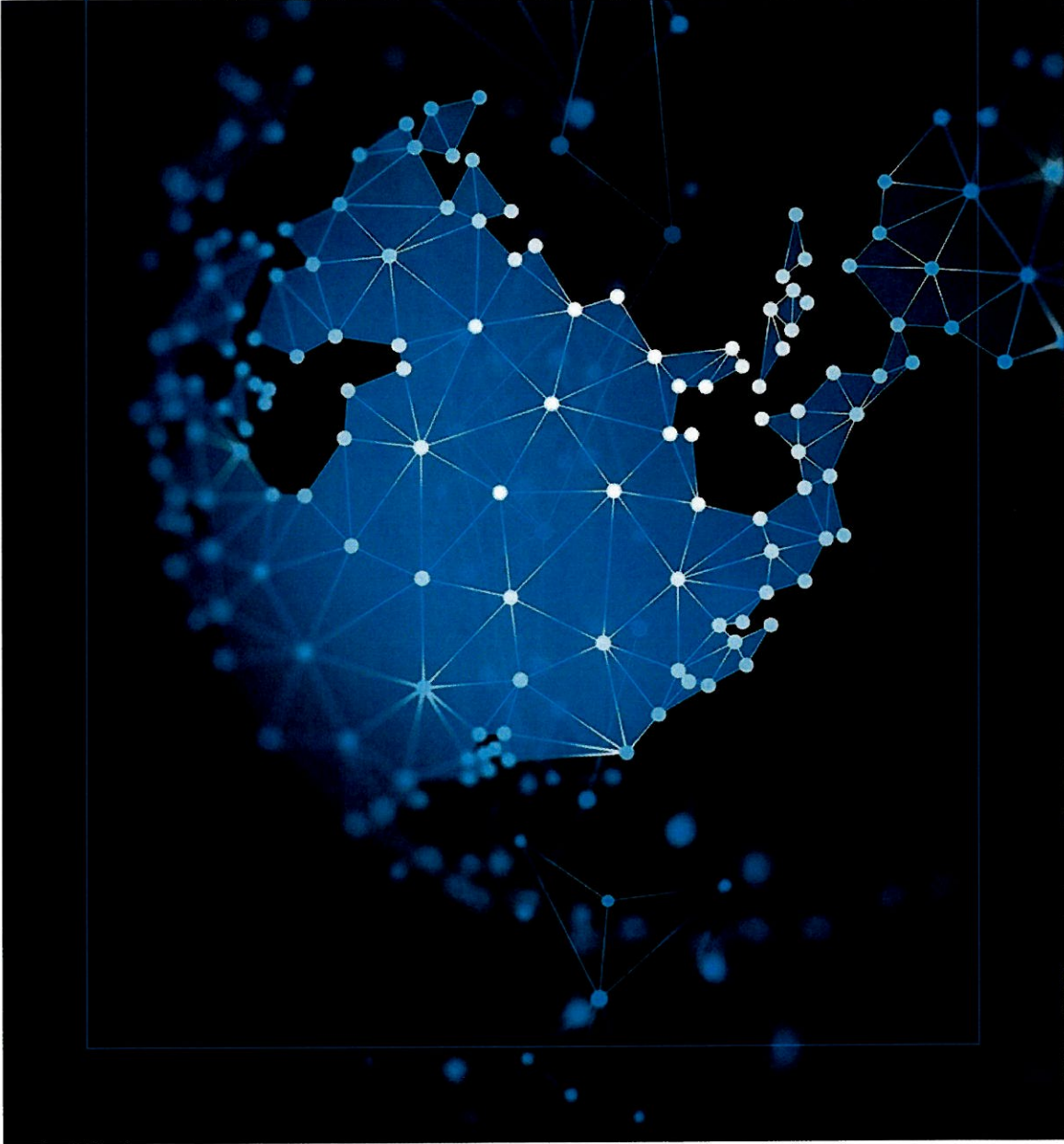


# CRA Charles River Associates



**LAS Meeting**  
**August 26<sup>th</sup>, 2026**

**CRA** Charles River  
Associates





## Meeting agenda

| Topic                                              | Timing                 |
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## Today's presenters



**Project Director**  
Margarita Patria, PhD



**Project Manager**  
Oliver Stover, PhD



# PJM Data Center Capacity & Peak Demand Forecast

## CRA's independent, hourly load forecast for PJM (2027–2047). Presented to the LAS on July 13, 2026

### PROJECT SCOPE

**Independent PJM-wide data center forecast** with hourly load profiles and explicit uncertainty quantification, integrating bottom-up project intelligence with top-down market analysis to support transmission planning, reliability, and resource adequacy.

|          |                      |
|----------|----------------------|
| Horizon  | 2027–2047            |
| Region   | PJM                  |
| Method   | Bottom-up / Top-down |
| Timeline | May–Oct 2026         |

### NEXT STEPS

- Sept 4LDE form submissions due
- Sept–OctIndividual EDC/LSE meetings
- Oct 14Final results at LAS meeting

### METHODOLOGY STEPS

- Top-down Demand and Constraint Modeling.** Start with unconstrained demand but forecast what can actually materialize. National AI and non-AI demand is tested against power, semiconductor, infrastructure, and supply-chain constraints. The model is recursive, allowing constraints and market responses to evolve over time but also slowing demand in response to constraints.
- Bottom-Up: Site-level project pipeline scored on siting favorability and developer readiness.** CRA reconciles PJM/EDC/LSE and commercial project data, distinguishes true duplicates from development optionality, and evaluates project maturity, ramping, and zonal attractiveness.
- Reconciliation:** Top-down determines scale; bottom-up determines location and timing. The two views are reconciled into one internally consistent PJM forecast that honors physical constraints. Excess pipeline may be delayed, relocated, served BTM, ramped more slowly, or not realized; future demand beyond the visible pipeline is represented through generic projects.
- Hourly forecasts** reflect evolving data-center operating behavior. Forecasted capacity is translated into hourly load profiles by zone and workload type, incorporating stochastic variation, use of hybrid BTM resources, and changes in load factors and operating patterns over time.
- Scenarios** capture alternative paths for data-center growth. Scenarios test different assumptions around AI adoption, efficiency, power availability, infrastructure, and supply-chain constraints to show how demand could evolve under different plausible futures.

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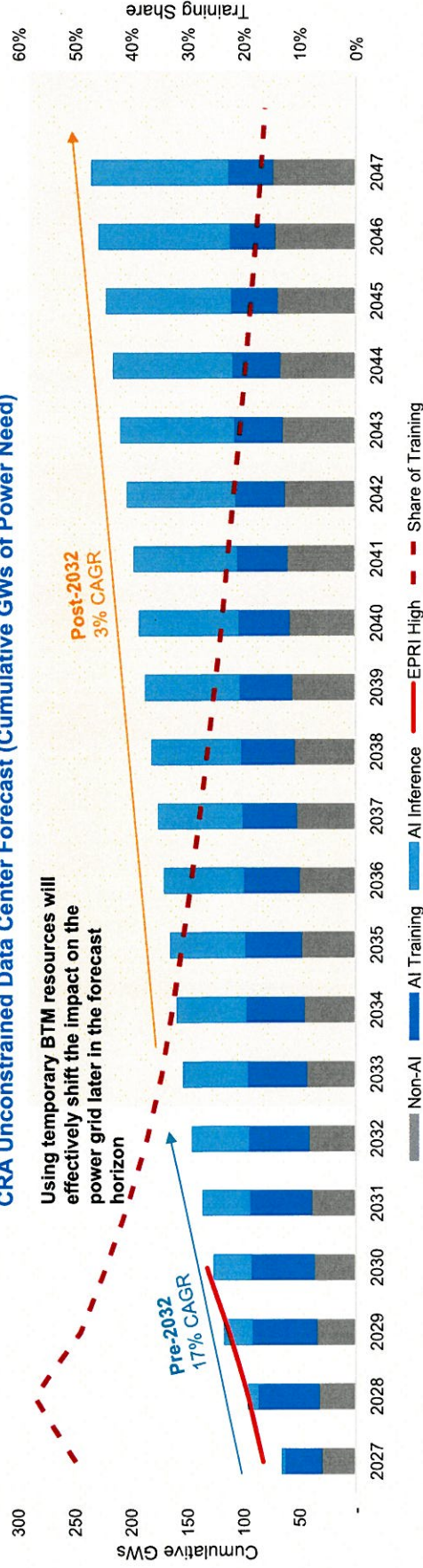


## Top-Down: Unconstrained View – Expected Growth

No forecasts contained within this document should be considered a "Final" forecast

# Top-Down forecast starts with unconstrained national demand, which includes non-AI, AI training, and AI inference components, each with its own growth trajectory

CRA Unconstrained Data Center Forecast (Cumulative GWs of Power Need)



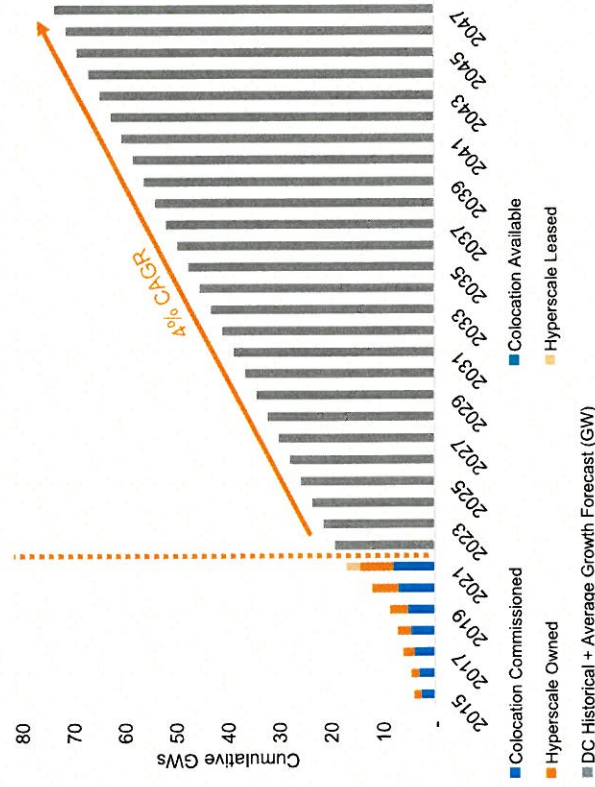
| Aggregate CAGR for Unconstrained Demand |                              |                                                                                                                                                                                                                 | Pre-2032                    | Post-2032                                                                                                                                                                                                   |
|-----------------------------------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| - Non-AI Demand                         | +6% YoY                      | Assumes linear growth for non-AI related demand.                                                                                                                                                                | 17%                         | 3%                                                                                                                                                                                                          |
| - AI Training Demand                    | +10% YoY                     | Assumes that public training data is available and expanding compute supply fuel a capability race, driving rapid growth in annual AI training compute demand.                                                  |                             |                                                                                                                                                                                                             |
| - AI Inference Demand                   | +75% YoY (small base number) | Assumes that AI adoption grows at a similar trajectory as U.S. internet adoption, with a higher growth factor for both work and individual use. Forecasted edge compute is removed from unconstrained forecast. |                             |                                                                                                                                                                                                             |
|                                         |                              |                                                                                                                                                                                                                 | +4% YoY                     | Assumes linear growth for non-AI related demand.                                                                                                                                                            |
|                                         |                              |                                                                                                                                                                                                                 | -2% YoY                     | As large models exhaust publicly available data*, a shift to disciplined (smaller) model development and chip processing efficiency drives down total annual compute demand for AI training (see paper)*.   |
|                                         |                              |                                                                                                                                                                                                                 | +6% YoY (large base number) | Assumes that AI adoption continues the pre-2032 trajectory. Reaching 90% adoption for individual use around 2032, and 90% adoption for work-related use by around 2041. Forecasted edge compute is removed. |



## Non-AI grows at a steady rate due to traditional digital economy needs

No forecasts contained within this document should be considered a "Final" forecast

CRA Unconstrained Non-AI Data Center Forecast



### Assumptions

- Assume "AI Growth" occurs in 2022. All-else-equal, assume that non-AI growth stays consistent YoY
- Assumes "typical" PUE for non-AI data centers to be 1.32 per EPRI ([link](#))
- Elected to use linear model instead of directly applying CAGR growth, as inputting CAGR values may distort long-term growth due to a small starting base

Sources: DatacenterHawk

### Approach

- Calculate historical GWs growth in Owned, Leased, Available, and Commissioned data centers between 2015 ~ 2021
- Apply average growth GWs to forecast period to capture stable "non-AI" segment of data center growth

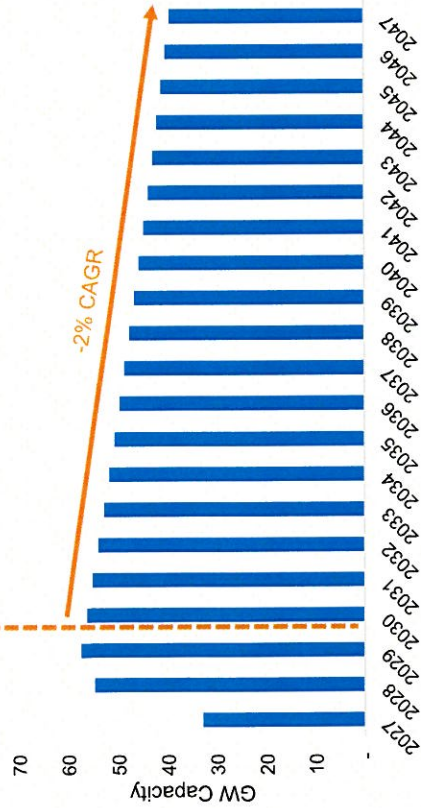
| Variable          | Value       | Source                                                                                                                   |
|-------------------|-------------|--------------------------------------------------------------------------------------------------------------------------|
| Historical Window | 2015 ~ 2021 | Investor memos: 2021 cut off based on investment memos of data center providers, mentions "AI" investments first in 2022 |
| YoY Growth        | 4%          | Resulting growth rate from applying linear average growth between 2015 ~ 2022                                            |



## AI training grows, then declines as models exhaust data and gain efficiency

### CRA National Unconstrained AI Training Forecast

As Large Language Models (LLMs) exhaust publicly available data, a shift to **disciplined (smaller) model development and chip processing efficiency** drives down total annual compute demand for AI training.



### Assumptions

- Assumes fixed server overhead of 1.82 (Epoch.ai), meaning that for every watt of GPU draw, the other components of a rack require 84% of the power of the GPU
- Assumes significant models grow at 1% YoY, using median YoY growth since 1990
- Assumes 1.1 PUE across future periods for AI Training ([link](#))
- Assumes 10% GPU idle rate when computing tasks ([link](#))
- Assumes final training is 10% of R&D, consistent with recent estimates ([link](#))

No forecasts contained within this document should be considered a "Final" forecast

### Approach

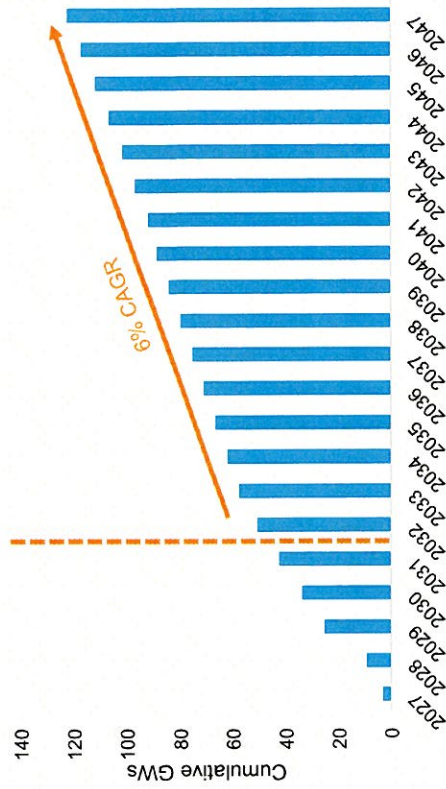
- Estimated total training calculations needed using model quantity and average model training intensity
- Converted model training calculations needed to chips required, with assumptions on GPU processing speed and power draw
- Used GPU power draw, supporting server compute needed, and assumed PUE to arrive at capacity needed for new models

| Variable                       | Initial Value               | Growth Rate                                                                                                                            | Source                                                                                                                                                 |
|--------------------------------|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Avg. Model Size                | 1.4E+25 FLOPs               | 4.3x/year in recent years, slowing to 1/2 by 2028, and 1/4 <sup>th</sup> at 7.5% CAGR of growth by 2030 to reflect lack of public data | Epoch.ai: <a href="#">notable models</a> ; <a href="#">expected date of public data</a> exhaustion is 2028, with ~95% confidence of exhaustion by 2030 |
| Number of New Models           | 170 Publicly Notable models | 1.11x/year to reflect historical growth rates                                                                                          | Epoch.ai: data on <a href="#">notable models</a>                                                                                                       |
| Chip Processing Speed (FLOP/s) | 9.89E+14                    | 1.34x/year growth rate based on average growth of GPUs processing speed*                                                               | Epoch.ai: data on <a href="#">machine learning hardware</a>                                                                                            |
| Chip Power Draw (W)            | 700 W                       | 1.1x/year growth rate based on average growth of GPUs processing speed                                                                 | Epoch.ai: data on <a href="#">machine learning hardware</a>                                                                                            |



## AI inference grows steady as AI is increasingly adopted

CRA National Unconstrained AI Inference Forecast (No Edge)



### Assumptions

- Assumes edge inference is **not** a part of the large load forecast
- Assumes fixed server overhead of 1.84 (per Epoch.ai), meaning that for every watt of GPU draw, the other components of a rack require 84% of the power of the GPU
- Assumes parameters size scale at the same rate as training size per Chinchilla Scaling Laws and "Small Models" [paper](#), estimated at 7.5% YoY in future years
- Assumes 1.1 PUE across future periods for AI Inference [\(link\)](#)
- Assumes 10% GPU idle rate during tasks computation [\(link\)](#)
- Assumes that "on peak" usage needs to cover 75% of total usage [\(link\)](#)

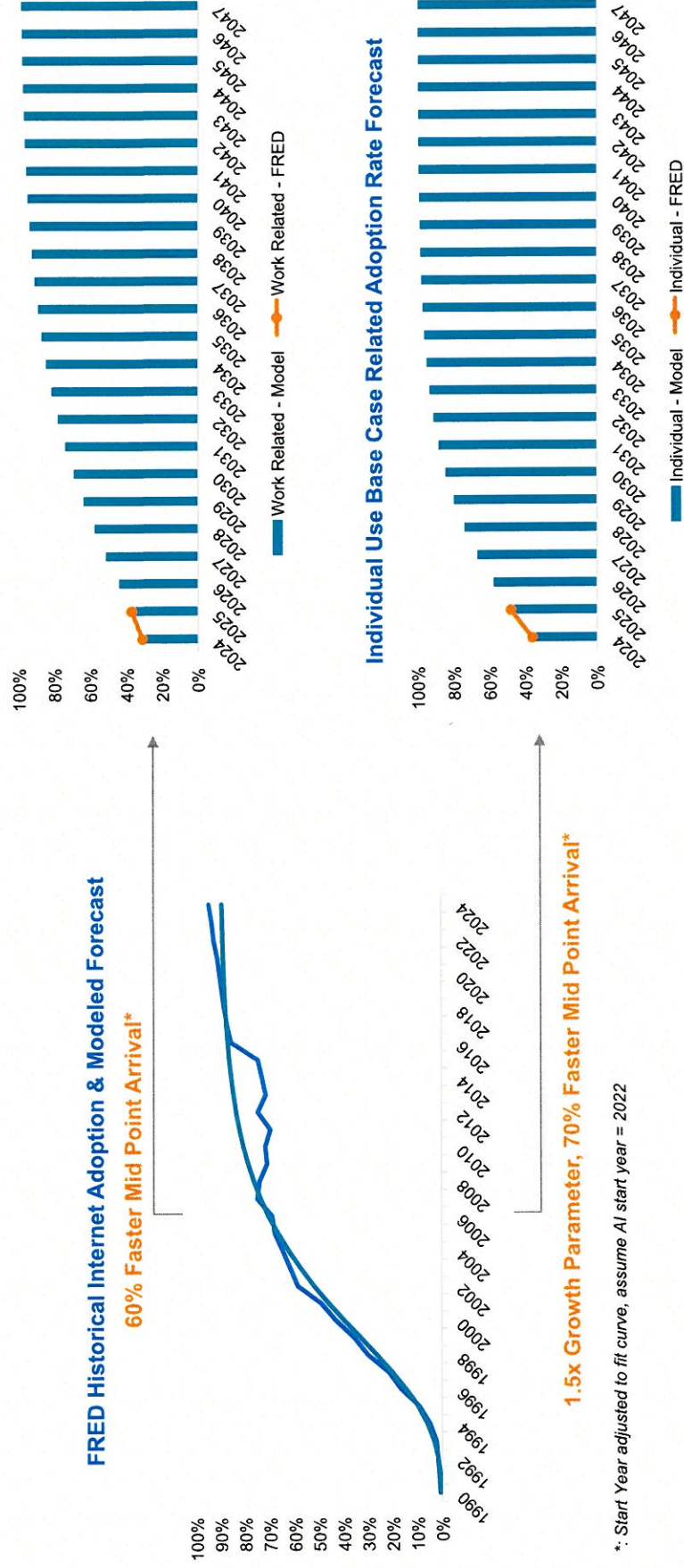
### Approach

- Estimated adoption rates in the U.S. based on historical internet adoption curve and recent work & individual adoption studies
- Combined adoption rates with usage intensity to arrive at total compute needed to process requests
- Converted model training calculations needed to chips required, with assumptions on GPU processing speed and power draw
- Used GPU power draw, supporting server compute needed, and assumed PUE to arrive at capacity needed for new models

| Variable                       | 2025 Value                                                              | Growth Rate                                                              | Sources                                                                                              |
|--------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Adoption Rates                 | Around 50% for individual use; 40% for work use                         | Based on adjusted internet adoption growth rates                         | St. Louis Fed Study, <a href="#">FRED Internet Adoption Data</a>                                     |
| Usage Intensity                | <b>19 and 29</b> from Brookings survey data for individual and work use | Proxy based on mobile internet traffic data growth rates                 | Brookings Institute <a href="#">AI Use Survey</a> , <a href="#">Ericsson Internet Traffic Growth</a> |
| Chip Processing Speed (FLOP/s) | 9.89E+14                                                                | 1.34x/year growth rate based on average growth of GPUs processing speed* | Epoch.ai: data on <a href="#">machine learning hardware</a>                                          |
| Chip Power Draw (W)            | 700 W                                                                   | 1.1x/year growth rate based on average growth of GPUs processing speed   | Epoch.ai: data on <a href="#">machine learning hardware</a>                                          |



## CRA anchored AI adoption curve to historical internet adoption shape, while capturing the accelerated rate of growth of AI adoption

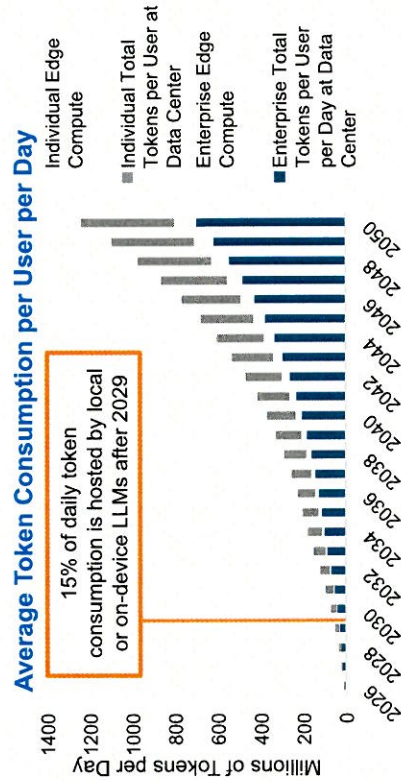


\*: Start Year adjusted to fit curve, assume AI start year = 2022

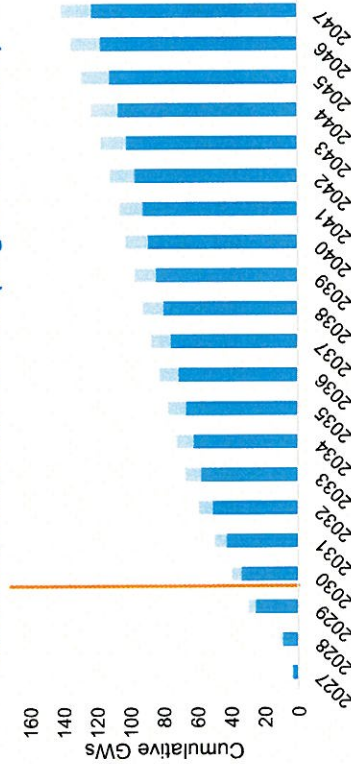
1.5x Growth Parameter, 70% Faster Mid Point Arrival\*

## Edge compute growth has been excluded from inference component of the forecast to capture compute migration to local devices

This is because edge compute is projected to shift processing from large data centers into distributed, on-device processing within customer hardware.



**Cumulative Inference Demand (Edge + Data Center)**



Source: US Census Bureau: Computer and Internet Use in the United States: 2021, OpenRouter State of AI 2025 Study, Zima Local LLM Deployment Trend Forecast

### Approach

- From the estimated users that have edge-capable devices, remove the share of estimated daily token usage on the edge from total inference demand

| Variable                                         | 2029 Value                       | Growth Rate                                               | Source                                                                                                      |
|--------------------------------------------------|----------------------------------|-----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| Share of households with personal computers      | 90%                              | N/A                                                       | <a href="https://www.census.gov/computer-and-internet-use">Census.gov</a> data on Computer and Internet Use |
| Share of tokens moving to local and edge compute | 15% of total daily usage by 2029 | Assumed constant rate after 2029, linear growth from 2025 | <a href="#">OpenRouter State of AI 2025</a>                                                                 |

### Assumptions

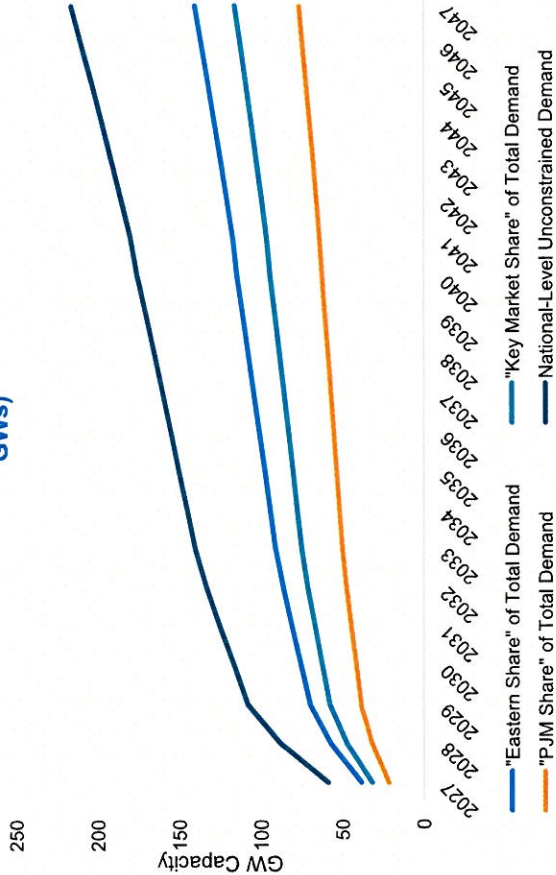
- Before 2029, local LLM consumption grows linearly to 15% of total average daily consumption
- Assumes that households with edge capable devices will migrate their inference needs onto the edge



No forecasts contained within this document should be considered a "Final" forecast

## Historical shares of national AI demand are initially held constant across key geographies

CRA Unconstrained Data Center Forecast, Key Regions (Cumulative GWs)



### Assumptions

- Assumes market share stays constant across forecast horizon
- "Market Share" is defined as the share of Owned, Operated, and Under Construction GWs in a specific ISO/RTO (e.g., PJM, MISO, ERCOT) relative to the total GWs in North America

### Approach

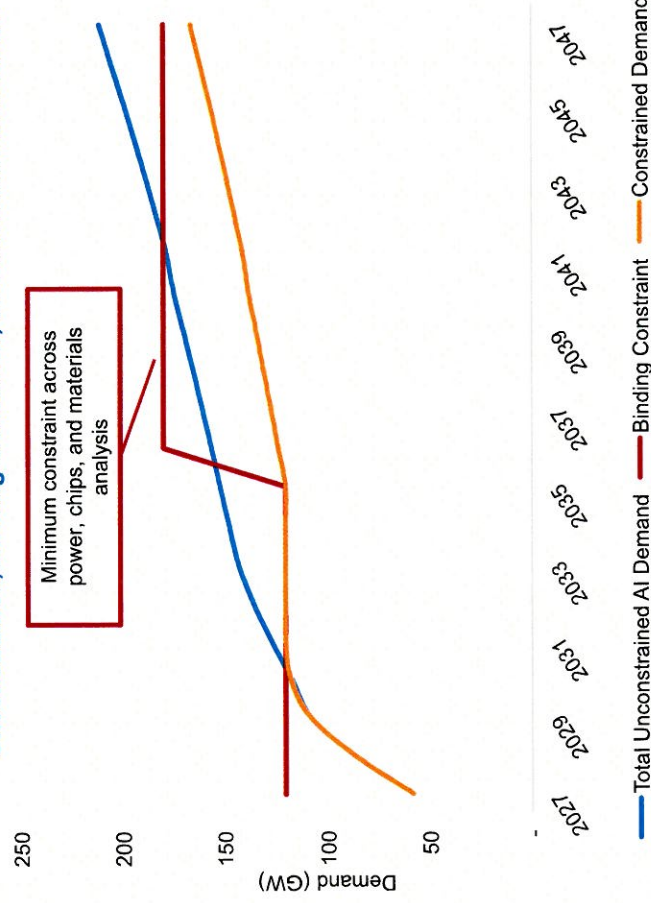
- Apply historical market share percentiles to national-level, unconstrained data center forecast
- Assume US data centers do not go international, and PJM's market share remains constant, unless PJM-specific constraints slow growth. Unmet PJM demand may try to shift to other Key Markets listed below.

| Variable                      | Value                       | Source                                               |
|-------------------------------|-----------------------------|------------------------------------------------------|
| "Key Markets" Market Share    | 54% (of total market share) | CRA Data Center Database (DatacenterHawk, Cleanview) |
| (PJM, MISO, ERCOT, SPP, SERC) |                             |                                                      |
| PJM Market Share              | 35% (of total market share) | CRA Data Center Database (DatacenterHawk, Cleanview) |



## Binding constraints will limit the level of realizable demand. As constraints relax, growth rates preserved from the unconstrained forecast will be applied to the constrained forecast

Unconstrained, Binding Constraint, and Constrained Demand



\*Binding constraints presented here are illustrative for discussion on constraint logic

### Approach

- Apply constraints on unconstrained demand. The constraint acts as a ceiling for how much demand can be realized
- Constraint is minimum across all constraints considered: power, chips, and material availability
- Growth rates ( $g_t$ ) are preserved from the unconstrained demand, but applied to the lower of prior forecast or realized demand:

$$Target_t = \min(Achieved_{t-1}, Target_{t-1}) * (1 + g_t)$$

### Assumptions

- Capacity that could not be built is assumed to be partially lost through efficiency improvements, adoption delays, or price friction, rather than returning as pent-up demand.
- Overshoots do not increase future targets. Functionally, the forecast can be adjusted downward, but not upward.



## Meeting agenda

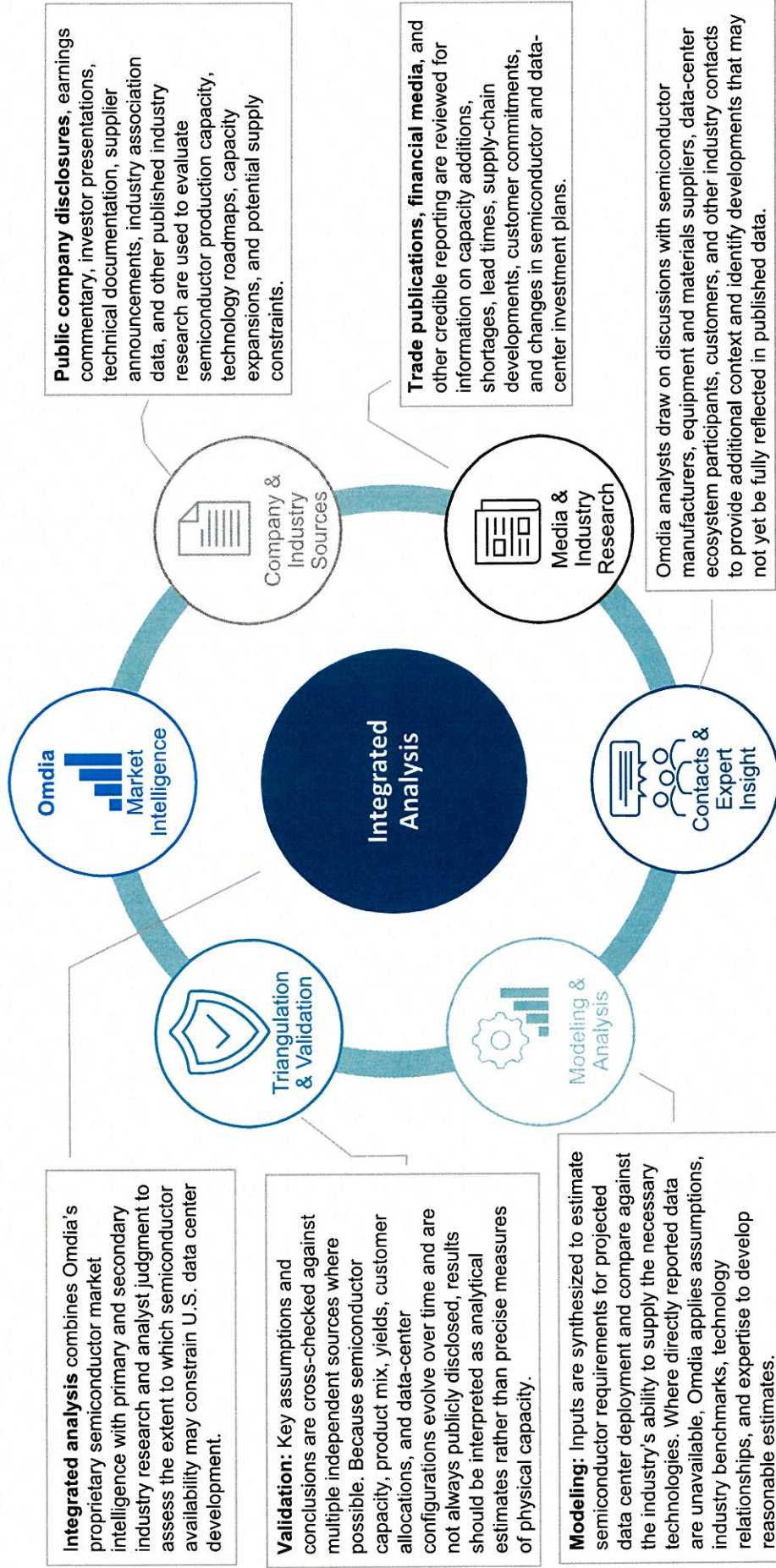
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| Next Steps & Close                          | 11:55 – 12:00 PM       |

## Few physical constraints are truly PJM-specific; most reflect broader national or global limitations that manifest differently within PJM

| Constraint                                                                | Geographic Scope of Constraint |          |        | Rationale                                                                                               |
|---------------------------------------------------------------------------|--------------------------------|----------|--------|---------------------------------------------------------------------------------------------------------|
|                                                                           | PJM                            | National | Global |                                                                                                         |
| Semiconductor availability                                                | ✓                              | ✓        | ✓      | Global manufacturing capacity and supply chains                                                         |
| Critical metals / materials – copper, steel, aluminum                     | ✓                              | ✓        | ✓      | Globally traded commodities and manufacturing inputs                                                    |
| Power availability / ability to serve new load                            | ✓                              | ✓        |        | Increasingly a U.S.-wide constraint, though severity varies by market                                   |
| Generation / supply build limits – gas turbines, batteries, nuclear, etc. | ✓                              | ✓        |        | U.S. deployment constrained by manufacturing capacity, with globally sourced equipment/materials        |
| Generator interconnection queues                                          | ✓                              | ✓        |        | National challenge, with PJM-specific queue rules, backlog and timelines                                |
| Generation retirements                                                    | ✓                              | ✓        |        | Occurring across the U.S.; PJM's specific retirement trajectory drives regional impacts                 |
| Transmission availability / buildout                                      | ✓                              | ✓        |        | Broad U.S. constraint, with PJM-specific transmission needs and planning processes                      |
| Natural gas infrastructure / fuel availability                            | ✓                              | ✓        |        | National/regional pipeline constraint, with specific limitations within parts of PJM                    |
| Permitting / siting                                                       | ✓                              | ✓        |        | Federal, state and local requirements constrain development across the U.S., with PJM-state differences |
| Capacity market / market design                                           | ✓                              | ✓        |        | Specific to PJM's market structure and rules                                                            |



## Omdia assessed semiconductor constraint using the following methodology

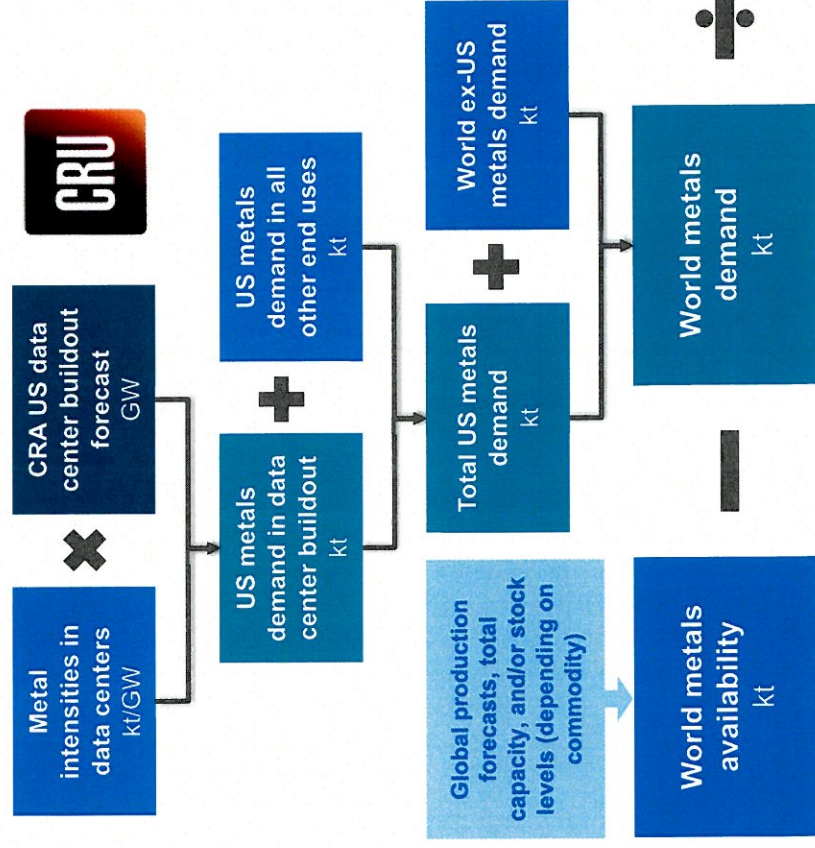


## Semiconductor constraints are adjusted for the immediate- to near-term and beyond as risks change and bottlenecks emerge and resolve

|                                    | Critical constraints                                                             | How binding?                                                                                                                  | Long-term and secondary impacts                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------------------------|----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Immediate-Term</b><br>(2026-27) | Advanced chip packaging capacity remains constrained                             | ➔<br><b>Moderately</b> – ramp trails demand, timeline uncertain                                                               | <ul style="list-style-type: none"> <li>Physical and disaster risk in concentrated manufacturing regions</li> <li>AI hardware consuming memory supply that would support traditional server deployments</li> <li>Emerging difficulties sourcing advanced materials at scale</li> <li>Limited testing capacity for advanced AI chips</li> <li>Assembly and delivery of complete AI systems is constrained by manufacturing capacity</li> </ul> |
|                                    | Critical chip packaging material in short supply, significantly increasing costs | ➔<br><b>Very</b> – gap hits 40% by 2028                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                    | Lead times for key semiconductor inputs remain elevated                          | ➔<br><b>Not Very</b> – new capacity is expected by 3Q27                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                    | High-performance AI memory is fully allocated; limiting new projects             | ➔<br><b>Moderately</b> – stack yield limits near-term scaling                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                    | Manufacturing is concentrated in a small number of countries                     | ➔<br><b>Moderately</b> – concentration and geopolitical risk, but does not constrain output on its own                        |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Near-Term</b><br>(2028-32)      | Limited specialized production environment and workforce                         | ➔<br><b>Partly</b> – output is limited by facility growth and available workforce, construction and upskilling can take years |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                    | Next gen memory is still uncertain and faces scaling risks                       | ➔<br><b>Very</b> – manufacturing capacity limits efficiency growth                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                    | Advanced manufacturing technology is not at full-scale                           | ➔<br><b>Not very</b> – future scaling may be impacted, but long lead time to catch up                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                                    | New capabilities are outpacing manufacturing capability and capacity             | ➔<br><b>Moderately</b> – manufacturing limits outputs until scaled up which can take years                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                              |



## CRU assessed metal constraint using the following methodology



CRU's assessment evaluates whether global production, inventories, and available manufacturing capacity for copper, aluminum, and electrical steel can meet anticipated demand growth from data centers and other end uses, focusing on 2027-2030 as the key years for potential shortages.

CRA incorporates CRU's findings into the US data center forecast by translating any projected global supply deficit into a potential reduction in US buildout. The constraint is allocated based on the US share of projected demand for the affected material, and the resulting material shortfall is converted into an equivalent reduction in data center capacity (GW).

Despite potential global constraints, data centers may be better positioned than many traditional end uses to secure scarce materials, especially given the relatively small portion of total development costs. As a result, actual impacts could be lower than modeled.

$$\text{Metal intensities in data centers kt/GW} = \text{Annual constrained US data center buildout based on \% of global demand GW}$$

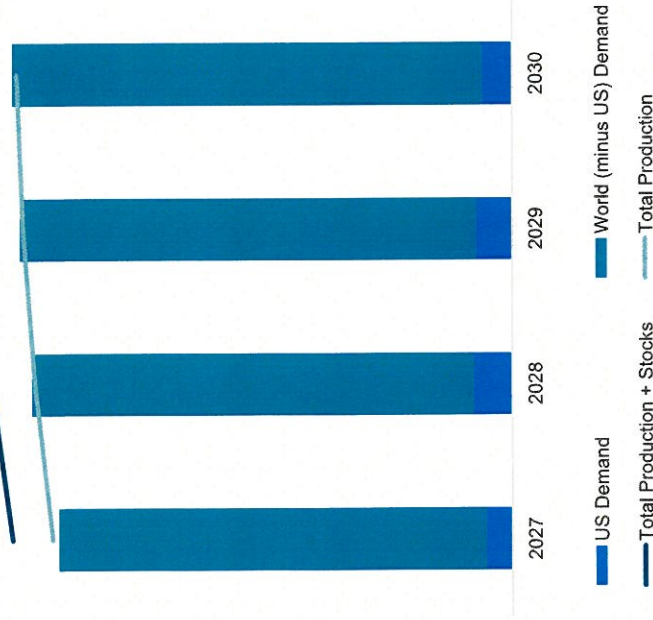
Key:

- CRU data
- CRA data
- CRU modelled data specific to this project

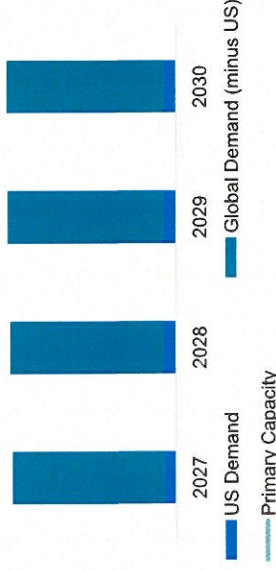


## Critical metals and other materials face most risk in the near term, but broader long-term constraints are not expected

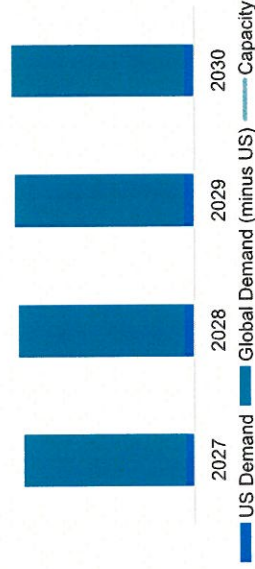
Refined Copper Supply and Demand Balance



Primary Aluminum Supply and Demand Balance



Electrical Steel Supply and Demand Balance



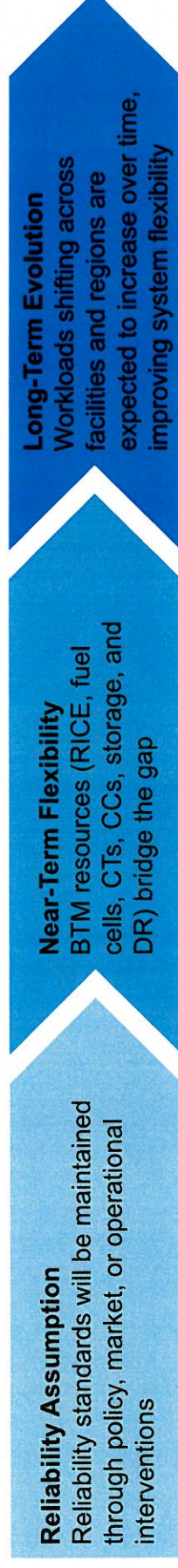
CRU's analysis indicates material availability for data center development should generally be sufficient over the long term, with the primary risk period occurring during the expected peak of global data center buildout from 2027-2030.

Copper faces the greatest potential supply risk, as availability is ultimately constrained by mining production and the pace at which new supply can be developed. For aluminum and electrical steel, these markets typically operate with some unused capacity, allowing producers to increase output in response to higher demand. CRU therefore evaluates both current production and capacity that could be brought online to determine whether shortages are likely to emerge.

Beyond 2030, CRU expects global markets to adjust to growing demand through capacity expansions, investment in new production, and other supply-side responses. While short-term imbalances may occur during the peak buildout period, the outlook suggests that material markets can adapt over time, reducing sustained shortage risk.



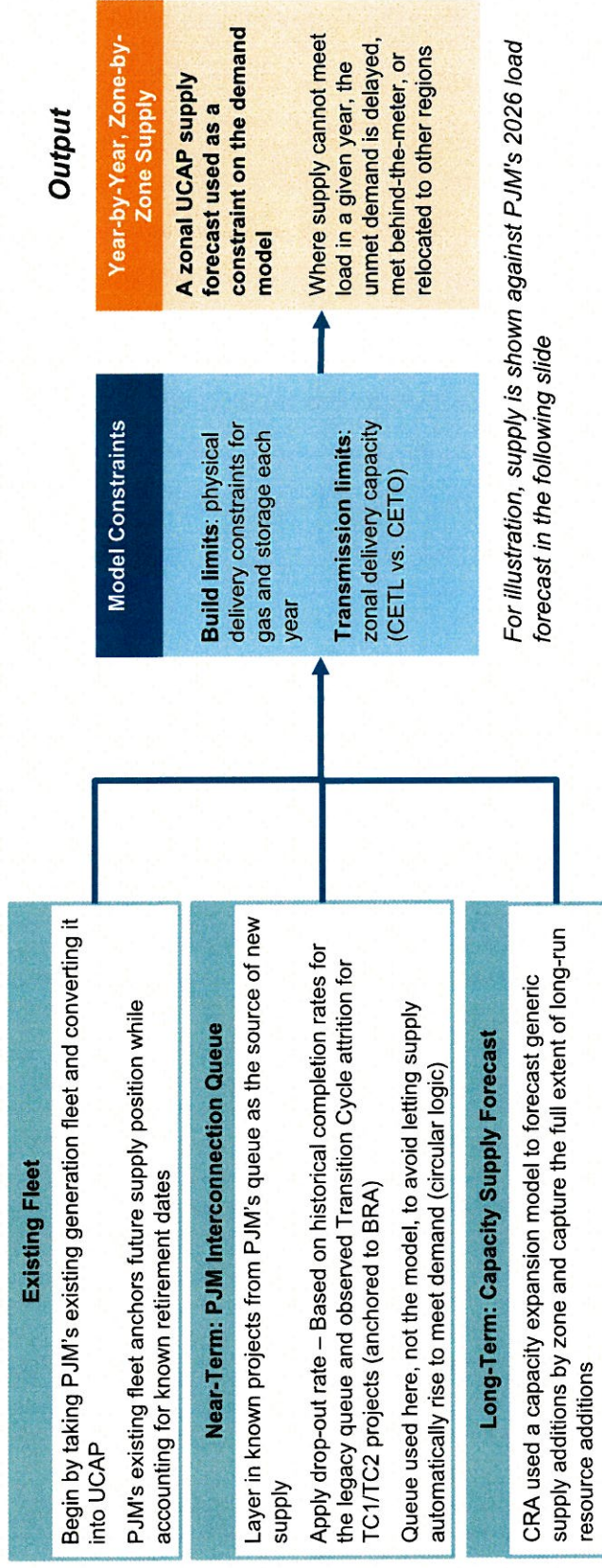
## Constraints on power supply effectively slow data center adoption



- CRA assumes that policy, market, or operational actions will return the market to the traditional “1-in-10” reliability standard in the longer term. Potential mechanisms to ensure long-term reliability outlooks include state policy interventions, or data center commitments to provide flexibility. Current projected shortfalls provide an upper bound for the tolerance for capacity shortfalls.
- As a result, future data center growth will require increasing levels of load flexibility and/or delayed ramp rates as a result of PJM-wide and zonal supply-demand tightening. While data centers may gain greater ability to shift computing workloads over time, **BTM resources will play a critical near- and medium-term role.**
- Potential BTM resources include **RICE units, fuel cells, combustion turbines, combined-cycle units, batteries, and demand response** from other customers.
- Like front-of-meter resources, BTM resources face limits on **deployment at the site, zonal, and national levels.** However, BTM resources may be deployed more rapidly because they can often avoid traditional generator interconnection processes.
- The ability to **dynamically shift computing demand across sites and regions** is expected to increase over time as the workload shifting technology becomes more mature, enhancing overall system flexibility.

**CRA constructed a forecasted view of PJM's electric supply for each year of the study period by PJM zone and technology in unforced capacity ("UCAP") terms**

### Supply Inputs



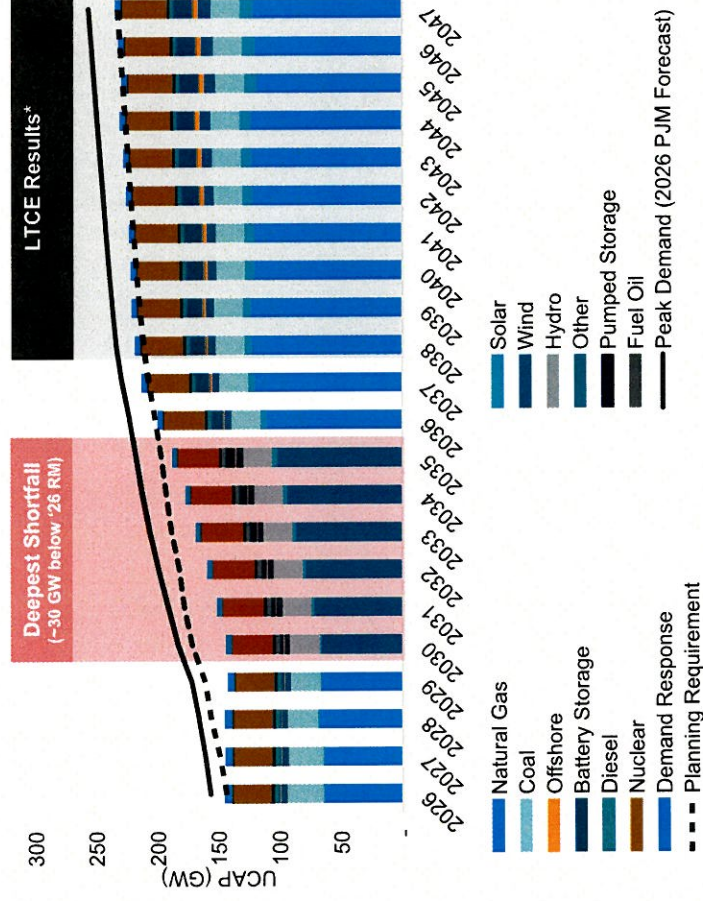
**The supply forecast is one of the main constraints applied to the data center demand forecast—it determines how much new load PJM can physically serve, when, and where**



## Base-case supply forecast (UCAP) vs. PJM 2026 load forecast

There is not enough supply to meet data center growth charted in PJM's **2026 load forecast**; 2030-2035 represents the deepest shortfall

PJM Base Case Supply Forecast (UCAP)



\*Note – This view reflects only the LTCE buildout post-2038. It does not incorporate the post-2038 additional gas/storage that can be built up to their annual build limits.

### Key Takeaways:

- **Short from the start:** A structural supply gap opens in 2027/28 and persists across the horizon.
  - Deliverable UCAP falls below the reserve requirement even before major load growth arrives
- **Physical, not financial:** The gap holds despite strong willingness to pay because turbines, transformers, EPC labor, and interconnection throughput cannot be accelerated by price signals alone.
- **Deepest gap in the 2030s:** ~30 GW below the reserve requirement (with 2026 load forecast), when the interconnection queue thins and LTCE builds are subject to the gas and storage build limits. This highlights the impact of global supply chain limitations that PJM cannot control.
- **Load goes elsewhere:** Gap pushes new large loads toward BTM self-supply, relocation to headroom regions like MISO and SPP, waiting for interconnection, or becoming subject to IRAS.
- **Moving target:** The PJM 2026 load forecast shown here is a placeholder; our demand forecast is iterative, so as load and queue status update, the size and timing of the gap will shift rather than remain fixed.

## Transmission limits (CETO) scale based on known 2030 values

### Assumptions

- **Pre-2031 constraints:** CRA assumes published CETO/CETL values are applicable to the beginning of the forecast period.
- **Future CETO (post-2030):** Updated each year by zonal peak-load growth, then adjusted for net in-zone UCAP changes by accounting for capacity additions and retirements.
- **Data center headroom:** The additional load a zone can absorb before its Tx system can no longer reliably deliver power. As load grows, the zone's import need (CETO) rises; once it approaches the zone's import capability (CETL), the zone is constrained and cannot host more load until transmission is upgraded.

- CETO \* 1.15 > CETL is the PJM published constraint formula

- **Interim relief:** CRA does not add additional power to a constrained zone to relieve the deliverability gap before the line is built.

- **Simplifications:** modeled at zonal LDA level only.

- Sub-zonal LDAs (DPL South, CLEV, PSEG North) captured within parent zone; RECO inherits EMAAC

**Post-2038: Transmission constraint no longer applied**

CETO after 2030 is projected based on the 2030 value

2030 CETO is scaled by the change in peak coincident load relative to 2030 levels

CETO is then adjusted to reflect changes in future-year and 2030 available capacity

$$CETO_{t,z} = \left[ CETO_{2030,z} \times \frac{LOAD_{t,z}}{LOAD_{2030,z}} \right] - (UCAP_{t,z} - UCAP_{2030,z})$$

\* Subscript t denotes year of analysis; z represents zone

### Sources

**PJM Planning Parameters**

For published auction years

**2030 RTEP Values**

CETO/CETL provided by PJM for upcoming 2030 RTEP

### Additional Information



## Transmission limits (CETL) and transmission expansion (RTEP) account for the ability to build new transmission

If CETL exceeds  $CETO \times 1.15$  in year  $t$ , the zone is considered **unconstrained**

$$CONSTRAINED_{t,z} = \begin{cases} CETL_{t,z} \geq CETO_{t,z} \times 1.15 = 0 \\ CETL_{t,z} < CETO_{t,z} \times 1.15 = 1 \end{cases}$$

### Feedback welcome!

Results are subject to assumptions around how Tx constraints relax over time (which is in PJM's control). Failing to account for the ability to invest in new Tx would artificially limit growth.

If  $CETO \times 1.15$  exceeds the CETL for that year, the zone becomes **constrained**

Transmission capacity is assumed to be added through the RTEP process after 3 years of construction, available on year 4

$$CETL_{t,z} = CETL_{t-1,z} + ADDER \times CONSTRAINED_{t-3,z}$$

Calibrated to 4,000 MW based on historical transmission additions

### Assumptions

- **RTEP:** If a zone ever becomes constrained, it ignites the RTEP process to bring new transmission online.
- **Future CETL:** Updated each year by zone with the previous year's CETL and any additional transmission.
- **Adder value:** Parameterized as 4,000 MW based on historically observed transmission additions; all additions are assumed at this value.
- **Timeline:** We assume a 4-year timeline from the zonal constraint becoming active to when relief occurs. This assumes that a constraint can be identified a year early with perfect foresight (5 years total) and is standardized across all zones.
- **Compounding additions:** If a zone adds transmission but still is constrained, then the process is assumed to ignite again. The zone can continue adding transmission until after 2038 when the transmission constraint is no longer applied.

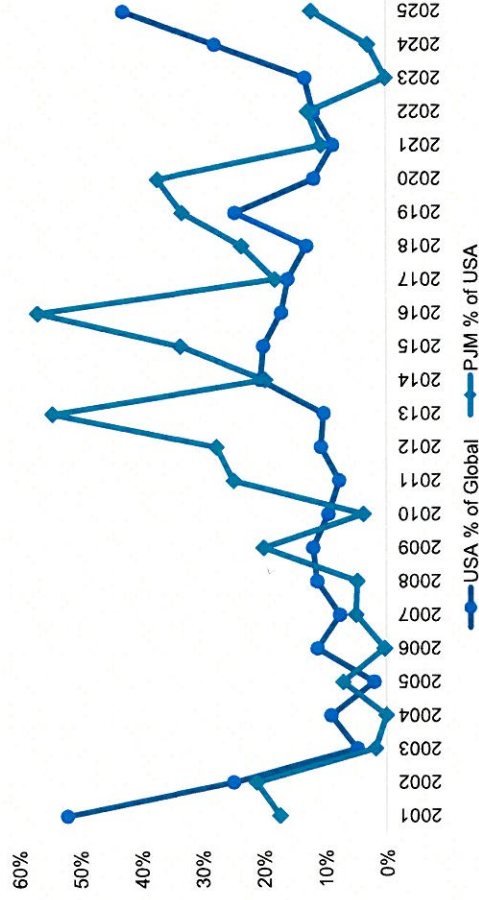
### Sources

#### Additional Information

| PJM Planning Parameters | For published auction years                      |
|-------------------------|--------------------------------------------------|
| 2030 RTEP Values        | CETO/CETL provided by PJM for upcoming 2030 RTEP |

## Natural gas build limits (historical) show uptick in demand for turbines in US

Historical Share of Gas Turbine Orders (2001-2025)



### Sources

#### McCoy Power Reports – Gas Turbine Order Data

Global gas turbine order database (1980-2025), including project location, order and operating dates, turbine model, manufacturer, purchaser, and delivery status.

### Additional Information

### Assumptions – Natural Gas Build Limits

- Based on 2001-2025 historical gas turbine order and delivery data.
- U.S. share of global orders and PJM share of U.S. orders are held at 2025 levels to reflect sustained data center-driven demand growth.
- Lead-time analysis shows recent gas turbine projects require ~36 months from order to operation, with orders translated into future online capacity accordingly (e.g., 2025 orders → 2028 operations).
- Future limits scale with turbine manufacturing expansion, OEM backlog growth, and delivery trends.
- Build limits represent a physical upper bound based on turbine availability, supply chain constraints, lead times, and EPC execution capacity.

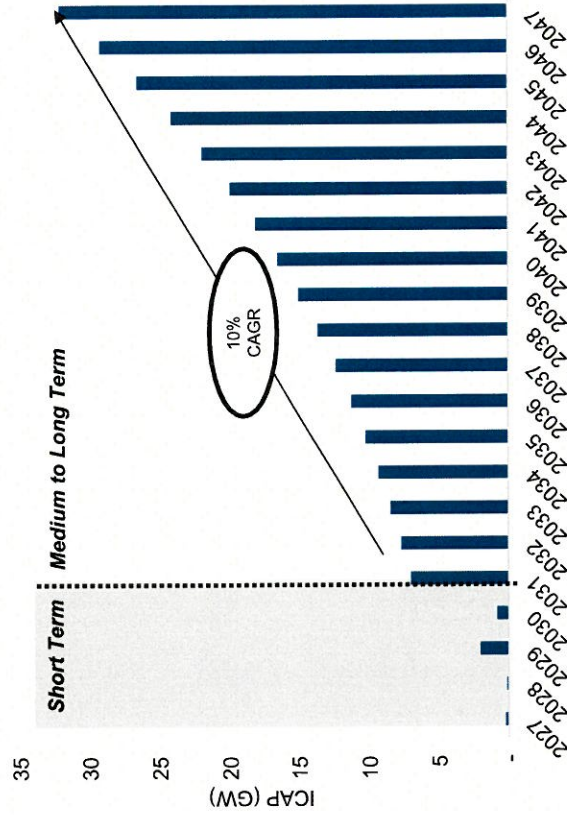
### Gas Turbine Deliveries – Historical Trend

- U.S. share of global gas turbine orders increased to ~42% in 2025, reflecting growing domestic power demand.
- PJM represented ~12% of U.S. turbine orders in 2025, with recent growth supported by accelerating data center development.
- Recent ordering trends indicate increasing U.S. and PJM demand for new gas generation, supporting higher future build capability.



## Natural gas build limits (2027-2047) are assumed to grow over time

Natural Gas Build Limits (ICAP)



### Methodology

#### Short Term Build Limits (2027-2030)

- Build capacity based on active PJM queue projects.
  - Gas projects from queue only included if either under construction or as mentioned in an IRP

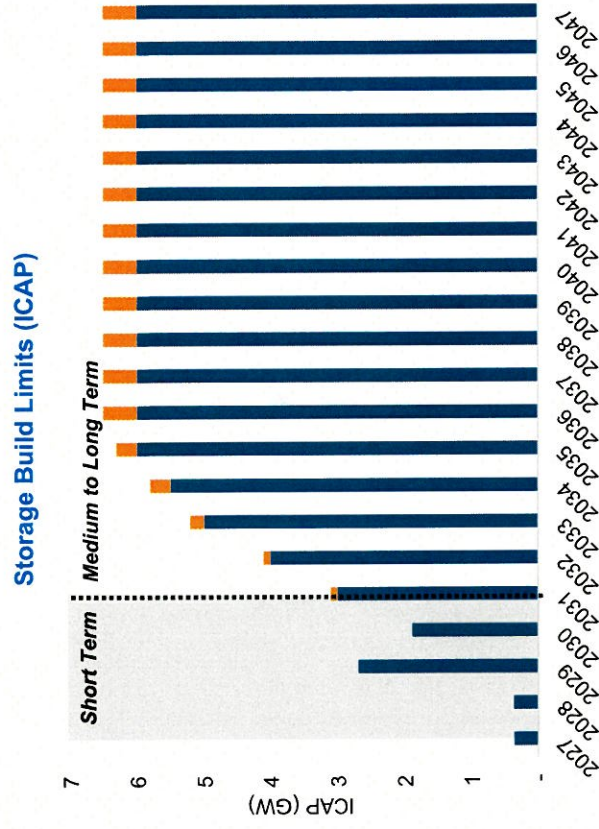
#### Medium to Long Term Build Limits (2031-2047)

- Annual build limits derived from historical gas turbine order trends and projected manufacturing capacity growth.
    - Global gas turbine manufacturing capacity assumed to increase 10% annually based on OEM expansion plans and announced investments\*.
- Note: The 10% growth rate reflects the conservative end of publicly reported manufacturing expansion estimates; the Abundance Scenario applies a higher rate within this range*
- U.S. and PJM shares of future turbine deliveries held at 2025 levels, reflecting continued concentration of data center-driven demand.
  - Projected global turbine deliveries allocated to PJM based on geographic distribution of orders reflecting DC demand growth.

#### Interpretation

- Represents a physical upper bound on gas capacity that could be delivered to PJM.
  - Reflects turbine manufacturing capability, supply chain availability, and expected turbine allocation patterns.
  - **Values do not represent a forecast of expected gas additions.**

## Storage build limits (2026-2047) are assumed to grow and then plateau



### Methodology

#### Lithium Ion

- Near-term storage limits based on the active storage development pipeline and projects advancing toward commercial operation.
- Mid- to long-term additions ramp up to ~6 GW/year and remain flat, reflecting a realistic buildout pace, state policy goals and efficiency gains.

#### Other Technologies

- Storage limits are benchmarked to CAISO's technology adoption curve, which reflects a more mature market
- Non-lithium-ion storage is assumed to maintain the same share of total BESS additions observed in CAISO, applied with a five-year lag to reflect PJM's slower market development.
- The PJM lithium-ion buildout serves as the baseline forecast to determine this constraint.

#### Interpretation

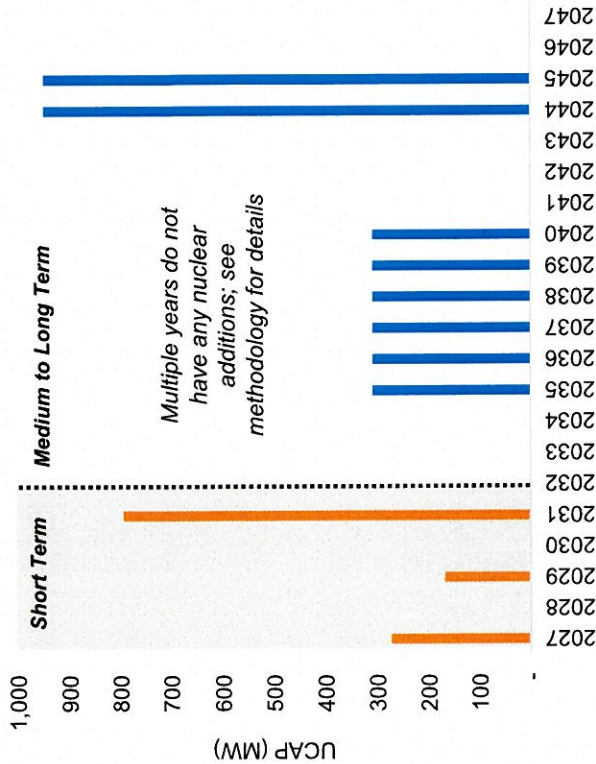
- Represents a physical upper bound on battery storage capacity that could be delivered to PJM.
  - Reflects battery cell and transformer manufacturing capacity, supply chain availability, and expected allocation of storage to PJM.
  - Values do not represent a forecast of expected BESS additions.

\*Sources: EIA; US DOE; CPUC AB1373; CAISO 20 Year Transmission Outlook; Virginia H.B. 895



## Nuclear additions are driven by announcements and policy-drivers

Base Case Nuclear Additions (UCAP)



### Sources

### CRA Analysis

- PJM RRI and TC2 Queue
- Dominion Energy 2025 IRP Update
- Constellation FERC waiver filing (Mar 2026)

### Additional Information

CRA analyzed announced and in-queue nuclear builds across a range of public sources for the near term, and drew long-term additions from utility IRPs and the LTCE economic buildout.

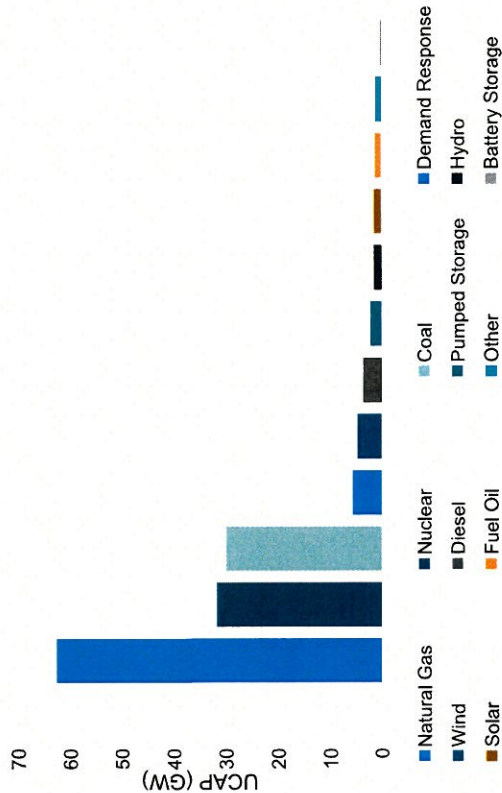
- Short term (2027-2030): nuclear additions are limited to uprates already in the PJM interconnection queue and RRI, plus one announced restart
  - Crane Clean Energy Center (835 MW restart) is the single largest near-term addition; the 2031 in-service date reflects the waiver submitted to FERC in March 2026
- Long term (2031-2047): nuclear additions do not come solely from the LTCE
  - Dominion: nuclear is included as an IRP addition - as a vertically integrated utility, Dominion can build and rate-base new nuclear, entering in the late 2030s
  - ComEd: new nuclear enters in the mid-2040s - CEJA-driven gas retirements leave the zone short of both capacity and energy after 2040, and the Aurora economic buildout selects nuclear to fill the gap

Near-Term Nuclear Uprates and Additions (in Queue)

| Project                   | Zone  | Type    | MW Capacity | Online  |
|---------------------------|-------|---------|-------------|---------|
| Crane Clean Energy Center | PPL   | Restart | 835         | 2031    |
| LaSalle                   | ComEd | Uprate  | 174         | 2027-30 |
| Byron                     | ComEd | Uprate  | 43          | 2027-30 |
| Braidwood                 | ComEd | Uprate  | 58          | 2027-30 |
| Salem                     | PSEG  | Uprate  | 228         | 2027-30 |

## Existing supply in PJM

PJM 2026 Existing Supply (UCAP)



| Sources             | Additional Information                                                                                                  |
|---------------------|-------------------------------------------------------------------------------------------------------------------------|
| Energy Velocity     | Used to find all tech types, except for gas, by zone (Compilation of EIA 860, Hitachi/ABB Research, NERC ES&D research) |
| PJM 2026 IMM Report | Source for gas ICAP by zone                                                                                             |
| ELCC Class Ratings  | For 2025/2026 Base Residual Auction                                                                                     |

### Approach

- Total set of existing non-gas resources sourced from Energy Velocity (EV) by PJM zone
- ICAP of dispatchable generation (high ELCC) cross-referenced with PJM 2026 IMM Report
- ICAP converted to UCAP using 2026 ELCC class ratings

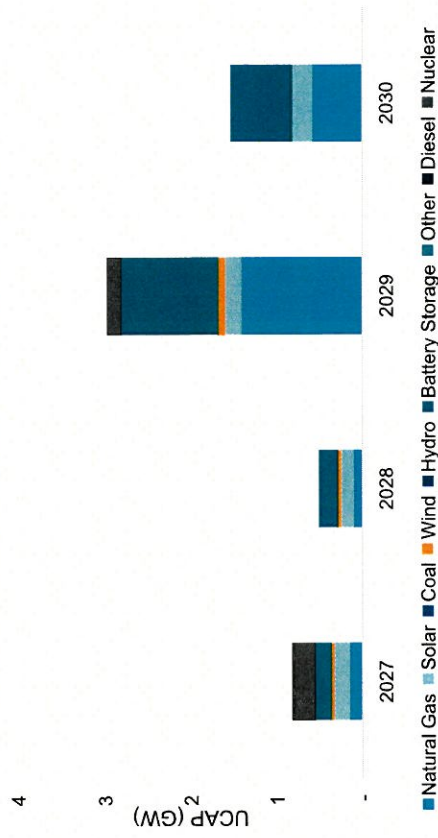
| Tech type | ELCC Value (2026) | Notes                         |
|-----------|-------------------|-------------------------------|
| Gas       | 70%               | Weighted average of CT and CC |
| Coal      | 83%               | -                             |
| Nuclear   | 95%               | -                             |
| BESS      | 52%               | 4-hour storage used           |

Existing fleet held at 2026 accreditation values as the baseline before annual ELCC evolution is applied



## Interconnection queue in PJM

PJM Queue after Drop Out Rate Applied (UCAP)



### Sources Additional Information

| PJM Interconnection Queue | Legacy queue which includes older entrants. TC1 and TC2 resources excluded to avoid double-counting   |
|---------------------------|-------------------------------------------------------------------------------------------------------|
| TC1                       | Transition Cycle 1 projects, from PJM website                                                         |
| TC2                       | Transition Cycle 2 projects, from PJM website                                                         |
| IRPs                      | Gas projects included in IRPs automatically included in buildout. IRPs used include Dominion and APS. |

**Queue drives near-term supply; LTCE drives long-term supply.**  
The queue provides an independent supply signal for 2027-2030.

### Approach

- Assumed near-term additions (2027-2030) taken from PJM interconnection queue to avoid circularity between load forecast and supply forecast\*
- Legacy queue, TC1, and TC2 combined; TC1/TC2 excluded from legacy count to avoid double-counting
- Gas additions limited to named projects from integrated utility resource plans (IRPs) (e.g., Dominion, APS), under construction, or an uprate from PJM's Reliability Resource Initiative (RRI)

### Assumptions

- Only resources currently active in the queue included; "partially in-service" excluded
- TC2 projects without a COD distributed using TC1's tech-specific COD distribution
- Multi-fuel projects split across listed technologies
- Assumed future drop-out rates are applied by technology and are specific to each queue cohort (Legacy, TC1, TC2), reflecting the different attrition observed in each

| Technology                   | Legacy queue <sup>1</sup> | TC1          | TC2           |
|------------------------------|---------------------------|--------------|---------------|
| Solar                        | 69%                       | 10%          | 55%           |
| Wind                         | 40%                       | 10%          | 52%           |
| Battery Storage <sup>2</sup> | 69%                       | 10%          | 55%           |
| Source                       | Historic queue data       | BRA-Anchored | TC1 drop-outs |

\* CRA recognizes some projects withdrew from the Transition Cycles and reapplied to Cycle 1. These projects are captured as generic units in the LTCE

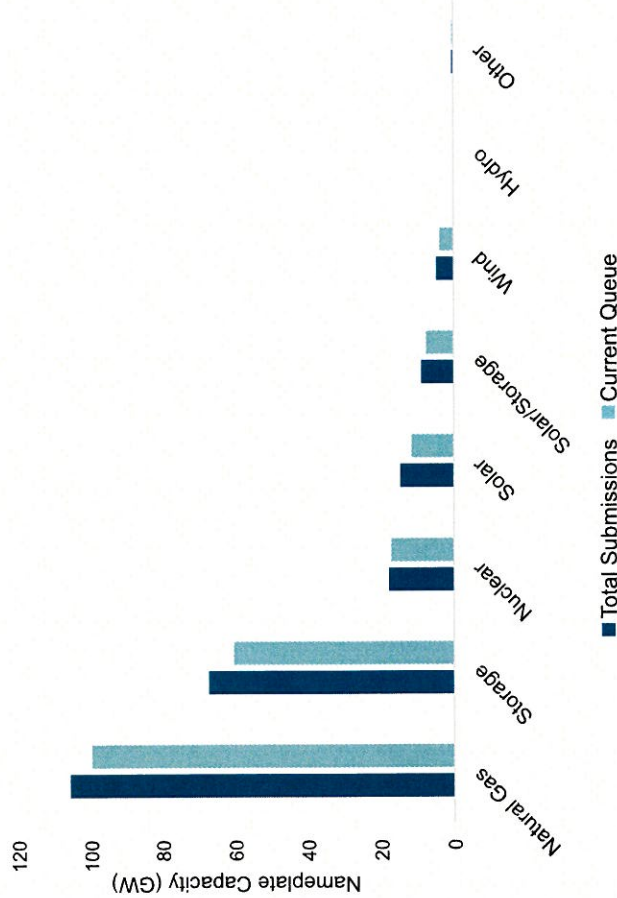
buildout, unless specifically named in an IRP.

<sup>1</sup> Average from 2027 – 2030.

<sup>2</sup> Battery Storage drop-out rate is set equal to that of solar due to limited historic data.

## How CRA handles Cycle 1

PJM Cycle 1 Total Submissions vs. Current Queue (Nameplate Capacity)



**CRA incorporates Cycle 1 into the LTCE as generic additions, rather than as dated queue entries, for the base case**

- Additional Cycle 1 projects are captured as generic units, realized post-2030, under the Abundance Scenario to acknowledge interconnection queue improvements

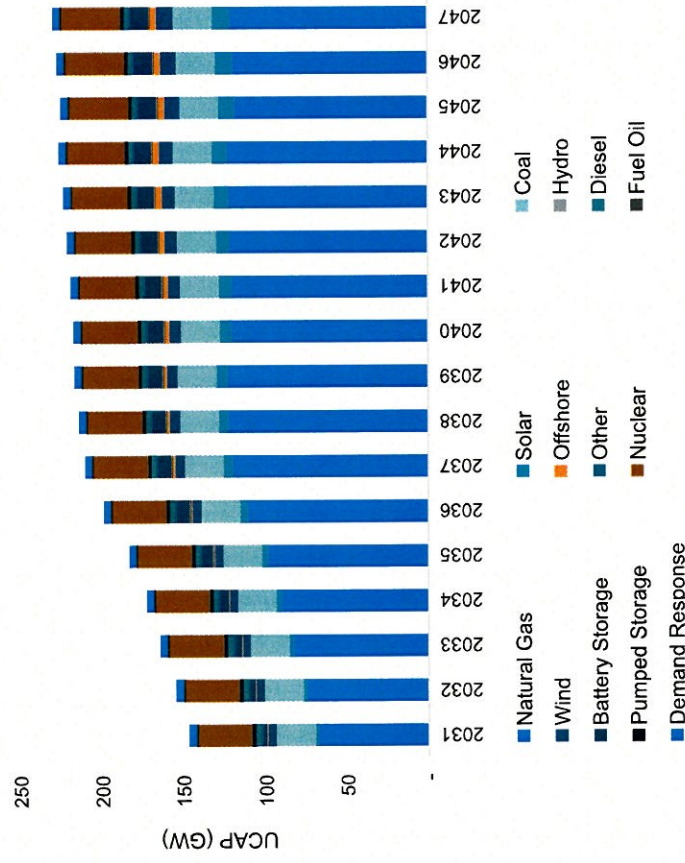
### Why?

- Scale:** 711 projects, representing 201 GW of nameplate capacity, are currently active in Cycle 1
- No reliable timing or attrition signal:** Cycle 1 is the first cycle under the reformed process, so its new structure and shifting dynamics make it difficult to reliably extrapolate CODs or attrition rates from the Transition Cycles
- Timing points to the LTCE window:** New queue processing takes ~2 years, combined with multi-year build times for high-ELCC resources (gas, nuclear), the earliest realistic online date falls within the LTCE period (2031+)



## LTCE results show a steady build of resources over time across all technology types

PJM Supply Mix (UCAP)



### Approach

- Long-term supply (2031-2047) from CRA's Aurora LTCE model, with endogenous build and retirement decisions
- LTCE picks up where the near-term queue leaves off, subject to build limits and transmission limits
- Cycle 1 projects represented through generic LTCE additions rather than dated queue entries, given queue processing time (*see Cycle 1 slide*)

### Assumptions

#### LTCE results reflect:

- Fuel prices transition from near-term market forwards to CRA long-term fundamental forecasts.
- Policy reflected: OBBBA, CEJA, state RPS, and Clean Grid Act; new-build costs from NREL/EIA; ITC/PTC incorporated.
- Environmental compliance costs applied (CO2 via RGGI and applicable programs, SO2, NOx).
- PJM-published ELCC accreditation applied to all resource types
- Gas and storage builds constrained to annual build limits; any capacity above the limit is pushed to later years until it fits.
- Post-2038, no power or transmission constraint is applied; gas and storage limited only by the build limit.

### Sources

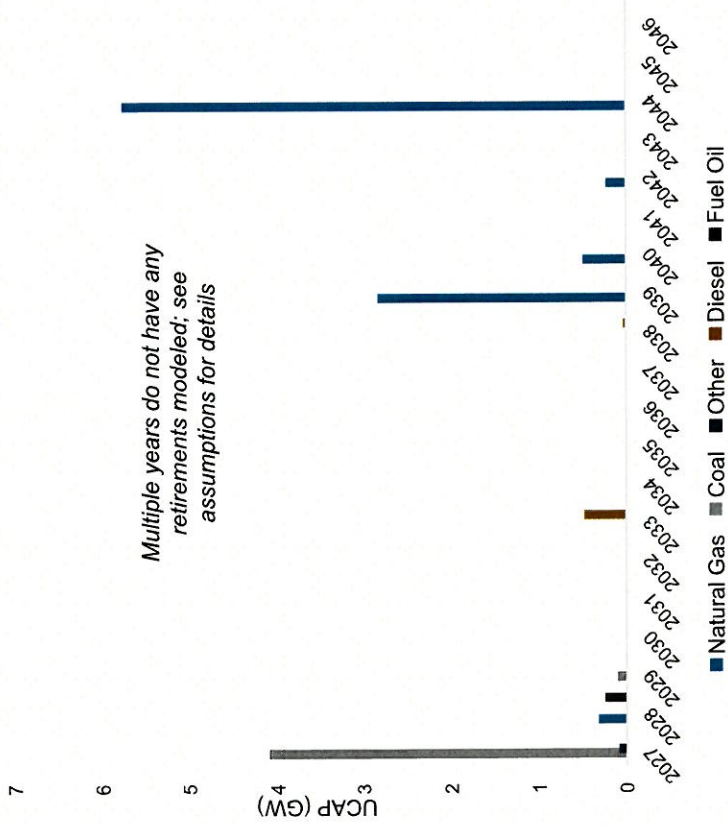
#### Additional Information

#### CRA Analysis

Long-term supply forecast based on LTCE model results, including endogenous build and retirement decisions.

## Modest retirement of existing plants

PJM Announced & Economic Retirements (UCAP)



### Approach

Two retirement channels:

- **Short term:** Announced retirements as fixed inputs
- **Long term:** Economic retirements determined endogenously by the LTCE

### Assumptions

#### Short-term retirements

- Based entirely on public deactivation requests sourced from Energy Velocity

- Coal retirements concentrated in 2027-2028 (~6.1 GW)

#### Long-term retirements

- Post-2035, retirements are driven by state/federal policy (e.g., CEJA) or revenue-adequacy challenges
- Economic retirements are a model output, not an input, and respond to prices, fuel costs, and accreditation

### Sources

#### Additional Information

Used to find all tech types, by zone (Compilation of EIA 860, Hitachi/ABB Research, NERC ES&D research)

#### Energy Velocity

Legislated retirement schedules and emissions policy (e.g., Illinois CEJA, RGGI, EPA rules) informing long-term deactivations

#### Public Policy



## Capacity accreditation is taken from PJM-published values

ELCC Values from PJM BRA and PJM Preliminary Class Ratings

| Year  | Gas  | Solar | Coal | Wind | OSW  | Hydro | Battery Storage | Diesel | Pumped Hydro | Nuclear | Fuel Oil | DR   |
|-------|------|-------|------|------|------|-------|-----------------|--------|--------------|---------|----------|------|
| 2026  | 0.70 | 0.09  | 0.83 | 0.41 | 0.68 | 0.40  | 0.52            | 0.91   | 0.4          | 0.95    | 0.61     | 0.85 |
| 2027  | 0.70 | 0.09  | 0.83 | 0.41 | 0.68 | 0.40  | 0.52            | 0.91   | 0.4          | 0.95    | 0.61     | 0.85 |
| 2028  | 0.75 | 0.07  | 0.85 | 0.34 | 0.6  | 0.35  | 0.59            | 0.93   | 0.37         | 0.96    | 0.61     | 0.91 |
| 2029  | 0.71 | 0.07  | 0.83 | 0.35 | 0.57 | 0.37  | 0.42            | 0.91   | 0.37         | 0.95    | 0.62     | 0.77 |
| 2030  | 0.71 | 0.07  | 0.83 | 0.34 | 0.53 | 0.38  | 0.37            | 0.91   | 0.38         | 0.95    | 0.63     | 0.74 |
| 2031  | 0.72 | 0.07  | 0.82 | 0.31 | 0.47 | 0.39  | 0.30            | 0.91   | 0.39         | 0.95    | 0.64     | 0.7  |
| 2032  | 0.74 | 0.07  | 0.81 | 0.26 | 0.38 | 0.39  | 0.25            | 0.91   | 0.39         | 0.95    | 0.66     | 0.68 |
| 2033  | 0.75 | 0.07  | 0.81 | 0.22 | 0.32 | 0.38  | 0.25            | 0.91   | 0.38         | 0.96    | 0.68     | 0.68 |
| 2034  | 0.75 | 0.07  | 0.80 | 0.20 | 0.28 | 0.38  | 0.24            | 0.91   | 0.38         | 0.95    | 0.69     | 0.67 |
| 2035* | 0.76 | 0.07  | 0.80 | 0.19 | 0.26 | 0.38  | 0.23            | 0.91   | 0.38         | 0.95    | 0.70     | 0.66 |

### Sources

#### BRA ELCC Class Rating

Final class ratings from published Base Residual Auction planning parameters

#### PJM Preliminary ELCC Class Ratings (2027/28 – 2035/36)

PJM-published preliminary class ratings for delivery years without final BRA results

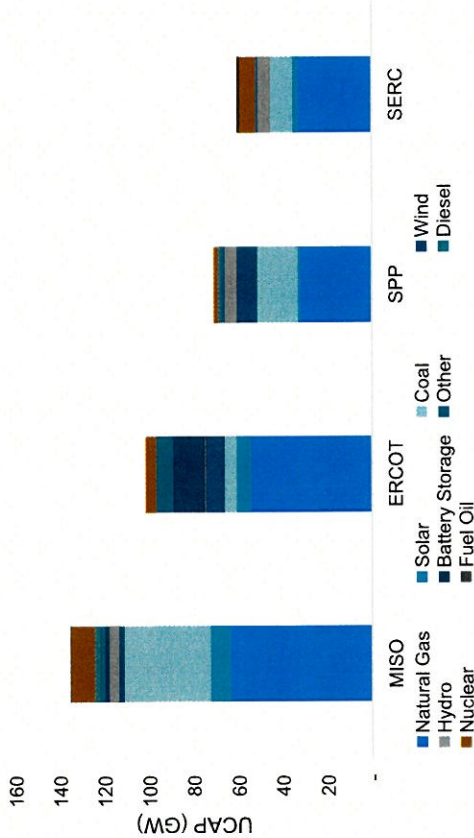
\* ELCCs held constant post 2035/36 DY

### Assumptions

- All ELCC values are taken directly from PJM published class ratings; CRA did not independently derive or adjust any accreditation values
  - Published BRA class ratings used for DYs with auction results
  - PJM Preliminary Class Ratings (2027/28-2035/36) used for DYs that do not yet have auction results or published planning parameters
- Gas ELCC applied as a capacity-weighted average of PJM's published CC and CT class ratings, reflecting PJM's fleet composition
- 4-hour duration used as the storage class rating across the forecast
- ELCC values held constant post 2035/36 DY

## Existing supply in other regions

Non-PJM ISOs Resource Mix (UCAP)



| Sources                           | Additional Information                                                                                    |
|-----------------------------------|-----------------------------------------------------------------------------------------------------------|
| Energy Velocity                   | Used to identify all resources, by ISO (Compilation of EIA 860, Hitachi/ABB Research, NERC ES&D research) |
| ISO-Specific Accreditation Values | Most recent accreditation values used to convert ICAP to UCAP                                             |

### Approach

- Same method as PJM: 2026 existing fleet in ICAP by region (MISO, SPP, ERCOT, SERC) from Energy Velocity
- ICAP converted to UCAP using region-specific accreditation values

### Assumptions

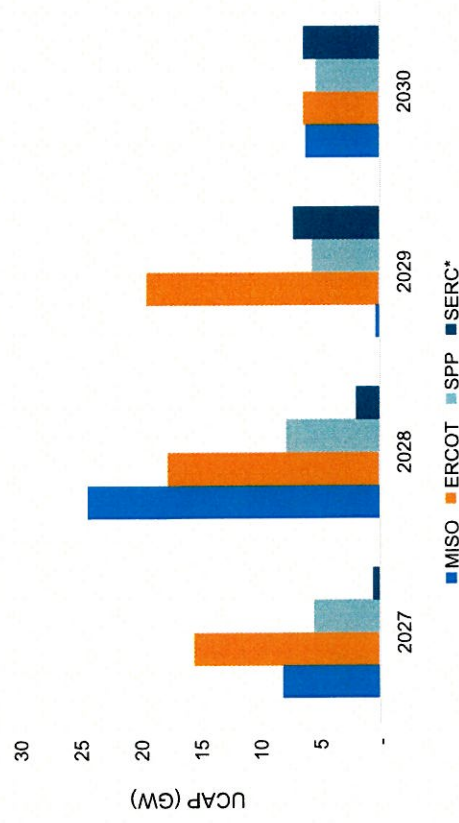
- Regions selected as the primary candidates for data center migration out of PJM
- Only resources listed as in operation are included
- If accreditation values are not available for a resource in a specific ISO, the value is based on a neighboring ISO's

| Variable | Accreditation Value |
|----------|---------------------|
| Gas      | 89 – 92%            |
| BESS     | 61 – 100%           |
| Coal     | 72 – 90%            |
| Nuclear  | 95 – 98%            |



## Interconnection queue in other regions

Non-PJM Queue Additions (UCAP, GW)



| Sources | Additional Information                 |
|---------|----------------------------------------|
| MISO    | MISO generation queue, MISO ERAs Queue |
| SPP     | SPP generation queue                   |
| ERCOT   | ERCOT generation queue                 |
| SERC*   | Utility IRPs and CRA LTCE Analysis     |

### Approach

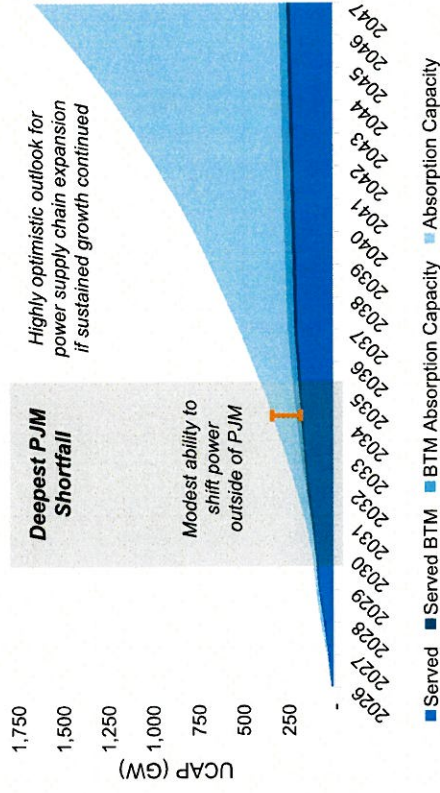
- Near-term additions (2027-2030) driven by the interconnection queue rather than LTCE, when possible, to avoid circularity
- ICAP converted to UCAP using region-specific accreditation values

### Assumptions

- Drop-out rates are tech-specific and ISO-specific, based on historic averages. Nuances include:
  - ERCOT: historic withdrawal rates; changing ISO environment results in required Interconnection Agreement to be counted additions in 2027-28 (this constraint loosens in '29-30)
  - MISO: a 10% future drop-out rate is applied to Expedited Resource Addition Study (ERAS) gas resources in lieu of a historically-informed drop-out rate

## CRA projects modest additional headroom in non-PJM regions

### Non-PJM Served DC Load and Available Headroom



#### Sources Additional Information

|              |                                                     |
|--------------|-----------------------------------------------------|
| <b>MISO</b>  | MISO queue, CRA LTCE Analysis, MISO DC Forecast     |
| <b>SPP</b>   | SPP queue, CRA LTCE Analysis, SPP DC Forecast       |
| <b>ERCOT</b> | ERCOT queue, CRA LTCE Analysis, ERCOT DC Forecast   |
| <b>SERC*</b> | Utility IRPs and CRA LTCE Analysis, CRA DC Forecast |

\*Note – No official DC forecast available; CRA compiled internal forecast

#### Approach

- Near-term additions (2027-2030) follow queue methodology
- Long-term LTCE adjusted to meet build limit constraints for natural gas and storage to account for all potential generation resources
- Data center load forecasts held at ISO's internal view\*
- Build limits and data center forecasts implicitly simulate the attractiveness to data centers in these regions and the impact of policy on the ability to develop new generation.

#### Assumptions

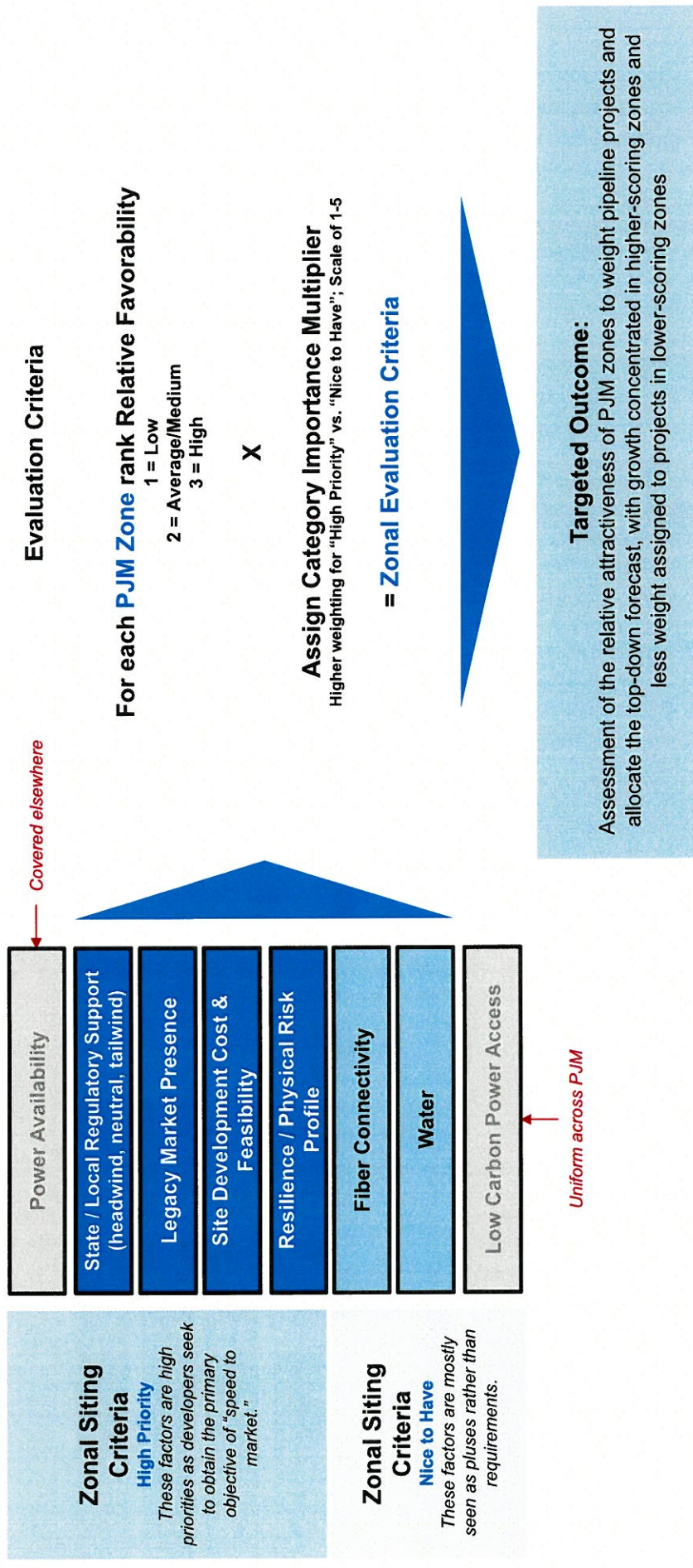
- If regional forecast ends prior to 2047, DC demand is extrapolated from current data and is assumed to track growth trends of ISOs with available data
- Absorption capacity = max (0, UCAP – forecasted peak load\*(1+RM))**
  - Measured as the ability of an ISO or region to serve additional DC load than what is in their forecast; a **positive value indicates room to host relocated PJM load**
- BTM Absorption capacity = max (0, BTM capacity - unserved DC load\*(1+RM))**
  - Measured as the ability of an ISO or region to host additional DC load than what is in their forecast BTM; a **positive value indicates room to host relocated PJM load**
- Output feeds the "where does displaced PJM load go" question



## Meeting agenda

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| Top-Down: Constraints                       | 9:35 – 10:00 AM         |
| <b>Bottom-Up Forecast</b>                   | <b>10:00 – 10:15 AM</b> |
| Load Profile Assumptions                    | 10:15 – 10:25 AM        |
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| Scenarios                                   | 10:45 – 11:00 AM        |
| <i>Break</i>                                | 11:00 – 11:10 AM        |
| Q&A                                         | 11:10 – 11:55 AM        |
| Next Steps & Close                          | 11:55 – 12:00 PM        |

To determine where projects are most likely to be sited, each PJM zone was assessed against key DC developer siting criteria





**CRA's model treats market formation as a two-part process: first, whether a dormant zone becomes a durable market; second, how annual demand is allocated once a zone is live**

### What Gets Built In 'Live' Markets vs. What Takes Off

**Core finding:** CRA observed multimodal behavior in the historical data: existing markets build proportionally to existing market share but are capped based on physical limits. New markets take off proportional to national growth. Attractive markets are more likely to take off but are hard to predict beforehand.



CRA conducted detailed research to assign each criterion a favorability score, then applied an importance multiplier to reflect its relative influence on DC siting decisions

| Category                            | Research Conducted                                                                                                                                                                                                                                                                    | 1 = Lower Favorability                                                        | 2 = Medium Favorability                                                        | 3 = High Favorability                                                            | Category Importance Multiplier<br>1 = Lowest, 5 = Highest |
|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------|-----------------------------------------------------------|
| State / Local Regulatory Support    | Existing/proposed State and local bills that would hinder DC development mapped to PJM zones                                                                                                                                                                                          | Restrictive or uncertain approval environment.                                | Permitting path exists but with some risk.                                     | Supportive policy and clear approval path.                                       | 4                                                         |
| Legacy Market Presence              | Sum of commissioned, available, under construction and planned MW of power as per merged datacenterHawk + Cleanview data set                                                                                                                                                          | Limited existing presence or customer activity.                               | Emerging presence, but pipeline depth or customer momentum remains uncertain.  | Established market with proven delivery track record and active customer demand. | 3                                                         |
| Site Development Cost & Feasibility | <ul style="list-style-type: none"> <li>• <b>Energy costs:</b> PJM historical zonal hourly LMP (Energy Velocity)</li> <li>• <b>Land costs:</b> Rural farm real estate \$/acre by State (USDA 2025)</li> <li>• <b>Tax incentives:</b> State-level DC tax incentives research</li> </ul> | Limited or uncertain incentives, excess vacancies in colocation availability. | Some incentives available, but not clearly differentiating, average vacancies. | Strong incentives that improve site competitiveness, low vacancies.              | 2                                                         |
| Resilience / Physical Risk Profile  | FEMA National Risk Index v1.20 (December 2025) by county mapped to state and zone; includes Inland Flooding, Severe Storms, Wildfire, Winter Storms, Extreme Heat risks                                                                                                               | High physical risk exposure.                                                  | Manageable risk with mitigation.                                               | Low risk and strong resilience profile.                                          | 2                                                         |

CRA Independent Assessment of Project Siting Realization Probabilities



CRA conducted detailed research to assign each criterion a favorability score, then applied an importance multiplier to reflect its relative influence on DC siting decisions  
(Continued)

| Category           | Research Conducted                                                             | 1 = Lower Favorability              | 2 = Medium Favorability                          | 3 = High Favorability                                 | Category Importance Multiplier<br>1 = Lowest, 5 = Highest |
|--------------------|--------------------------------------------------------------------------------|-------------------------------------|--------------------------------------------------|-------------------------------------------------------|-----------------------------------------------------------|
| Fiber Connectivity | ITU Fiber Optic Maps (high-level and relative view evaluated between PJM zone) | Limited connectivity or redundancy. | Connectivity available but may require buildout. | Strong fiber access, redundancy, and latency profile. | 2                                                         |
| Water              | World Resources Institute's Aqueduct 4.0 Water Risk Atlas database             | Material water or labor constraint. | Available but with some cost or planning risk.   | Adequate water and labor to support growth.           | 1                                                         |
| Low Carbon Power   | Treated as uniform across PJM                                                  | N/A                                 | N/A                                              | N/A                                                   | 1                                                         |

CRA Independent Assessment of Project Siting Realization Probabilities

## New projects are ‘selected’ to achieve grid connection in proportion with existing market share

Statistical analysis showed that year-over-year capacity additions are highly correlated with existing market share, but growth gradually spreads into new markets over time. This reflects data center developers’ preference for expanding in established markets while simultaneously pursuing development opportunities in smaller and emerging markets.

### Effective installed base

Each zone's weight starts from operating grid capacity plus behind-the-meter capacity plus the projects it is expected to complete from the queue.

### Risk-weighted queue

Queued projects count only in proportion to how likely they are to be built. The older a project is, the more likely it is to drop out.

### Share raised to a power (<1)

Effective shares are scaled by an exponent that sharpens the advantage of established zones, and that value acts as a floor no zone falls below.

### Dormant zones stay in play

Zones with no capacity yet receive a small collective allocation, added on top so leading zones never lose ground. If existing active zones can't keep up, new zones may ‘ignite’.

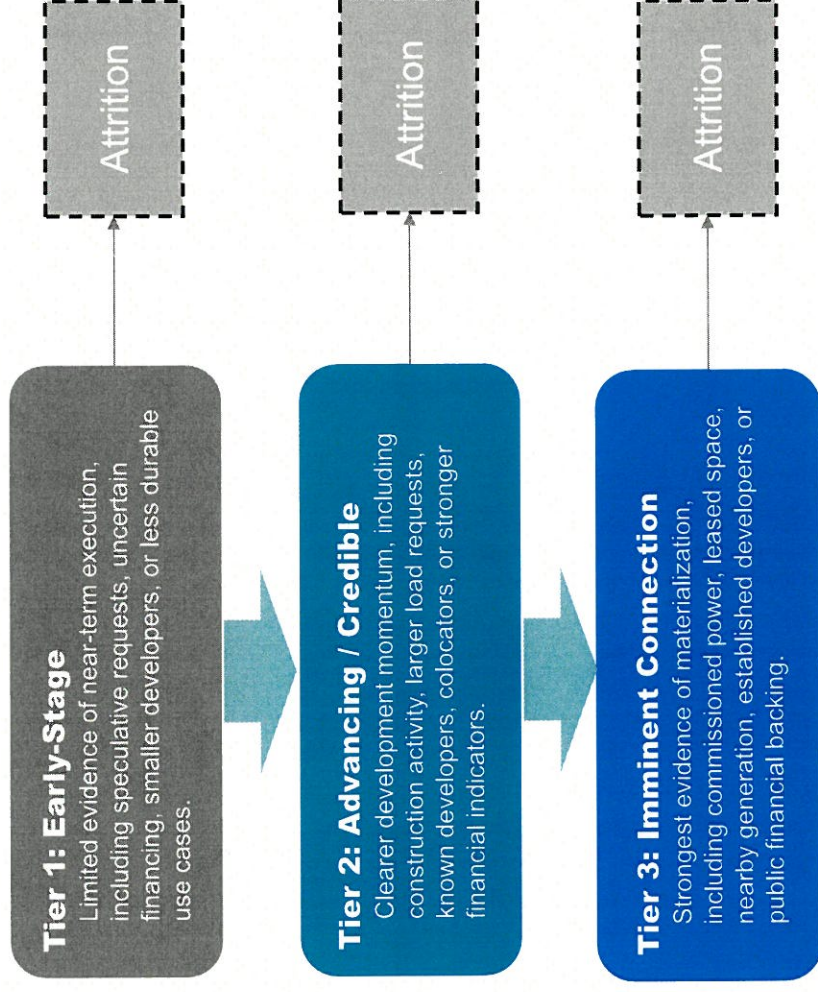
**Net Effect:** Growth concentrates where capacity and credible pipelines already exist, while emerging zones keep a realistic chance of landing the next project and capacity gradually spreads across the market.



## Based on CRA's assessment, emerging zones are classified by their relative potential to ignite and sustain data-center growth



## Readiness tiers are used to evaluate the maturity of the pipeline

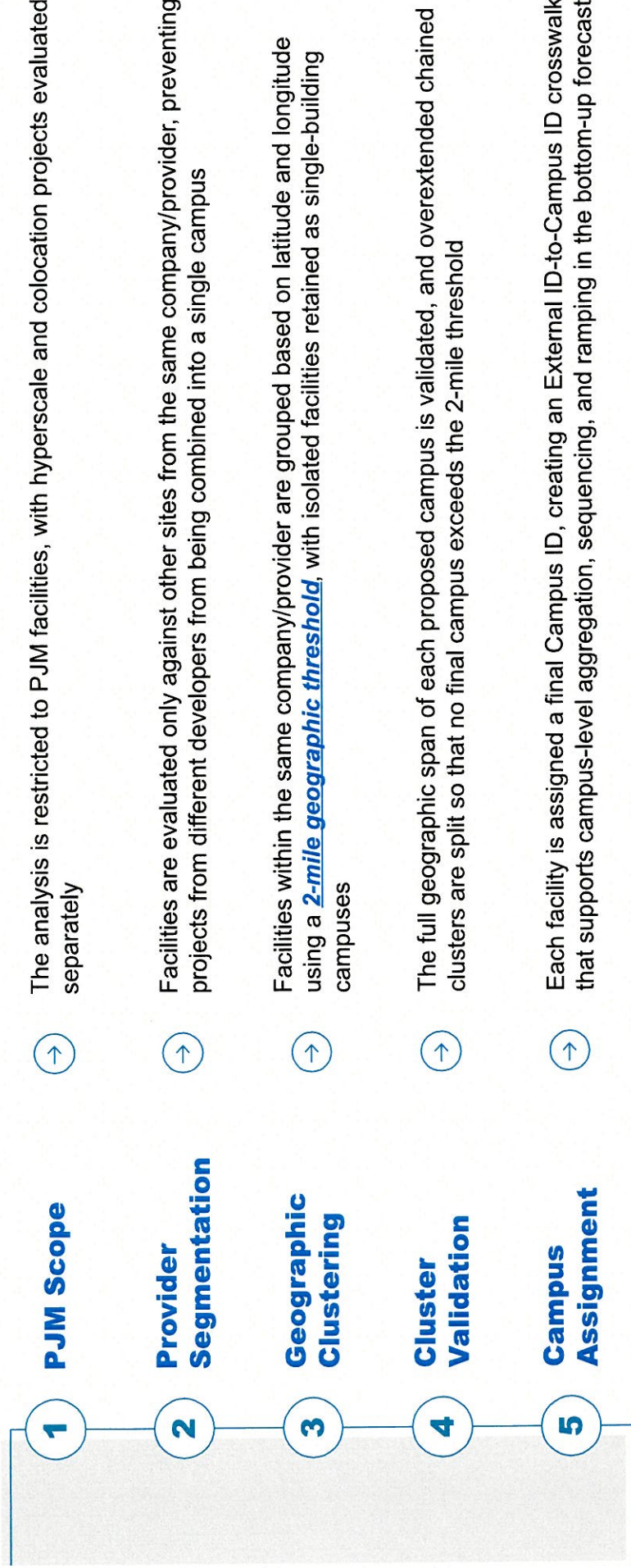


How the queue is modelled

- Projects are assigned to readiness tiers based on observable development indicators.
- A **Markov model** estimates the probability that projects advance tiers, remain at current tier, or get cancelled over time.
- These probabilities are learned from observed project progression data rather than assumed uniformly across the queue.
- “Generic” projects are added separately to preserve expected future demand in areas where known queues may not fully capture market activity.
- If a zone shows signs of acceleration, generic demand allows the forecast to reflect emerging opportunity before named projects appear in the queue.

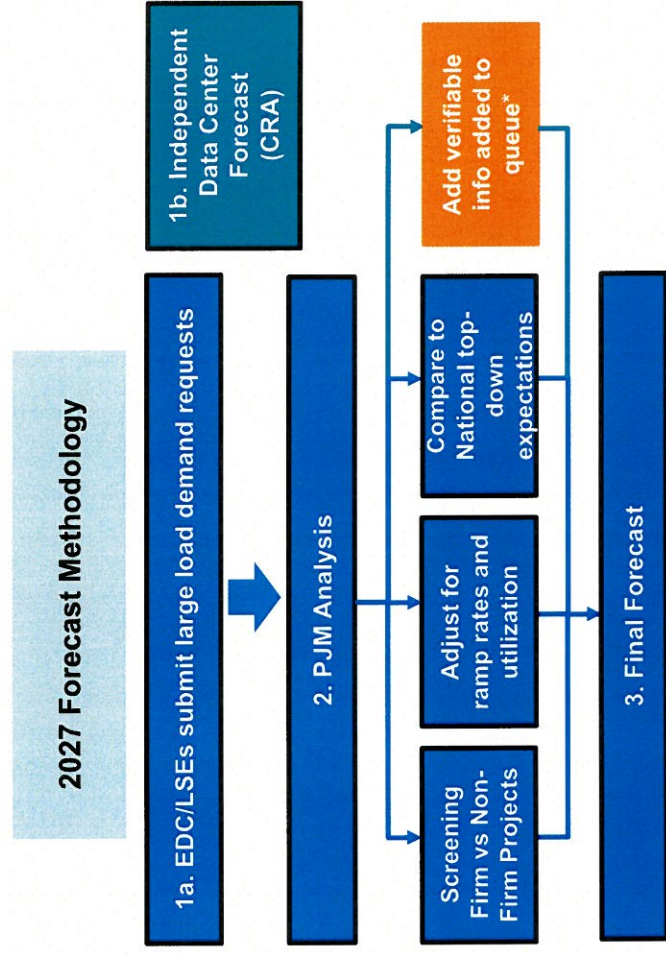


## CRA groups nearby facilities from the same developer into campuses to jointly simulate buildings that operate as a shared investment decision



Source: DatacenterHawk; CRA Analysis

**PJM is altering its approach to annual forecasting by introducing CRA's independent forecast to improve the evaluation of large loads submitted by LSEs/EDCs for the 2027 forecast**



*\*CRA will incorporate project-specific information or adjust applicable build limits where stakeholders provide sufficient, verifiable evidence to support the change.*



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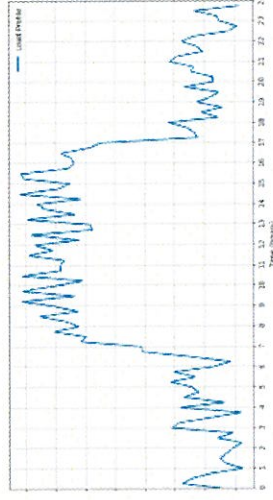
## Characteristic hourly shapes

Public data on the operational load profiles and load factors of data centers is limited, and potential evolution of load profile and load factors is uncertain. LBNL's data center load shape generator will be used as a foundation to create the characteristic load shape.

### Approach

- Characteristic hourly shapes will be anchored to [LBNL's publicly available Data Center and Industrial Electrical Load Shape Generator](#)
- Any changes based on expert conversations will be documented

Example of LBNL's Characteristic Hourly Shape for Business Diurnal Hourly Load



Example of LBNL's Characteristic Hourly Shape for Flat Hourly Load



### Identify Characteristic Shapes

To best capture 'typical' hourly behavior for different data center workloads (normalized to 0~1)

### Incorporate Stochasticity

To best capture a range of potential events, rather than a single characteristic shape

### Apply Forecasted Capacity

Scale normalized by expected data center growth by zone, distributed by estimated relative compute needs for

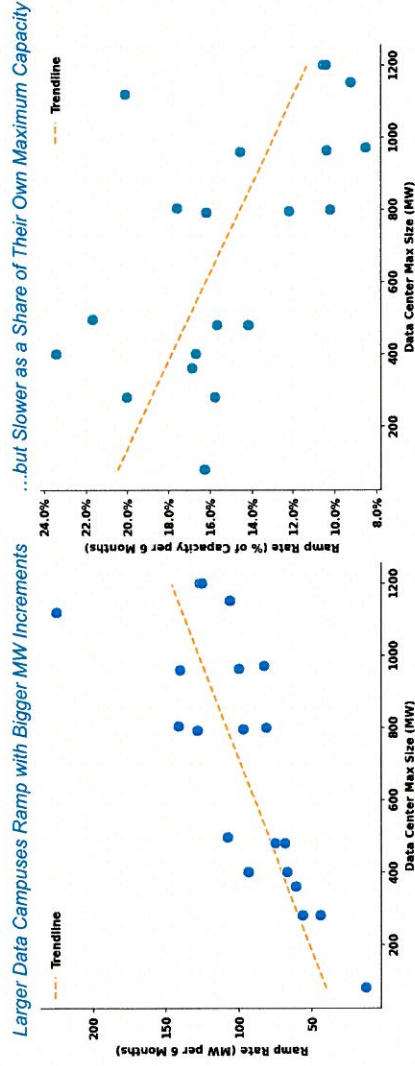
Source: [LBNL Data Center and Industrial Electrical Load Shape Generator](#)

Note: CRA acknowledges that the exact evolution of hourly profiles is uncertain and is rapidly evolving. LBNL provides a solid, publicly verifiable foundation to create characteristic hourly load. Any modifications to LBNL's outputs will be documented.



## Ramp rates (absent constraints)

Larger data center campuses generally ramp with higher MWs, but are proportionally slower relative to smaller sites

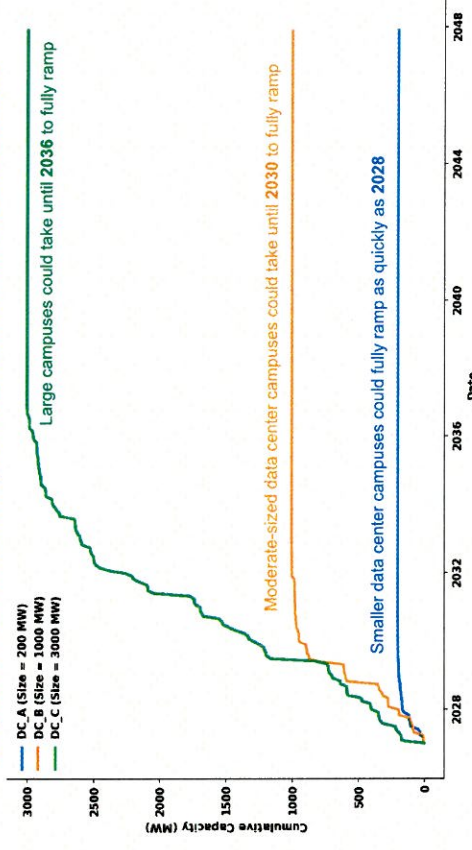


Note: calculated as the change in observed MW capacity between each month and the same data center's capacity 6 months earlier, averaged across the ramp period (which is between the first MWs coming online, and when the data center's MWs are equal to the maximum observed in the data)

### Approach

- **Learn the pattern:** Fit historical ramp rates and timing as a function of data center size.
- **Preserve uncertainty:** Capture how different campuses deviate from the size-based trend.
- **Generate realistic ramps:** Combine the expected size-based curve with observed deviations from similar projects to create plausible MW ramp trajectories

Example of modeled data center ramps:  
larger data centers ramp slower than smaller data centers



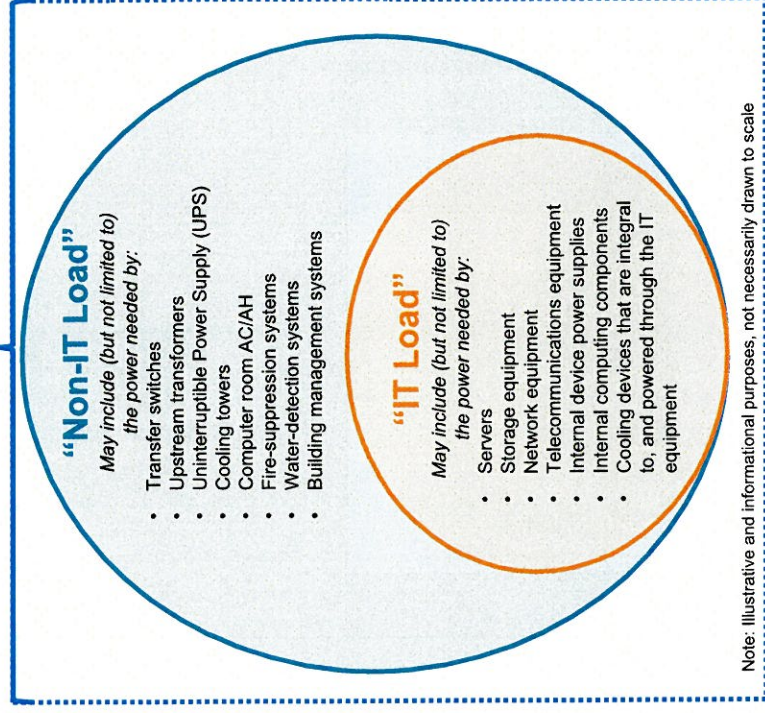
Example where all data center campuses start their ramp at the same time.

### Assumptions

- Assumes size is the key dominant factor when considering data center ramp rates – the larger the load, the slower the ramp to full capacity
- This is to ensure that CRA is not selecting ramp rates based on other business-specific characteristics to preserve objectivity

IT load is typically a fraction of total metered demand, as data centers typically require non-IT supporting equipment to operate effectively

## “Total Metered Demand”



Power Usage Effectiveness (PUE) is the ratio between Total Metered Demand and IT Load

$$PUE = \frac{\text{Total Metered Demand}}{\text{IT Load}}$$

### Approach

- Apply PUE to IT load to estimate Total Metered Demand

$$\text{Total Metered Demand} = \underbrace{PUE}_{\text{EPRI}} \times \underbrace{\text{IT Load}}_{\text{datacenterHawk}}$$

### Assumptions

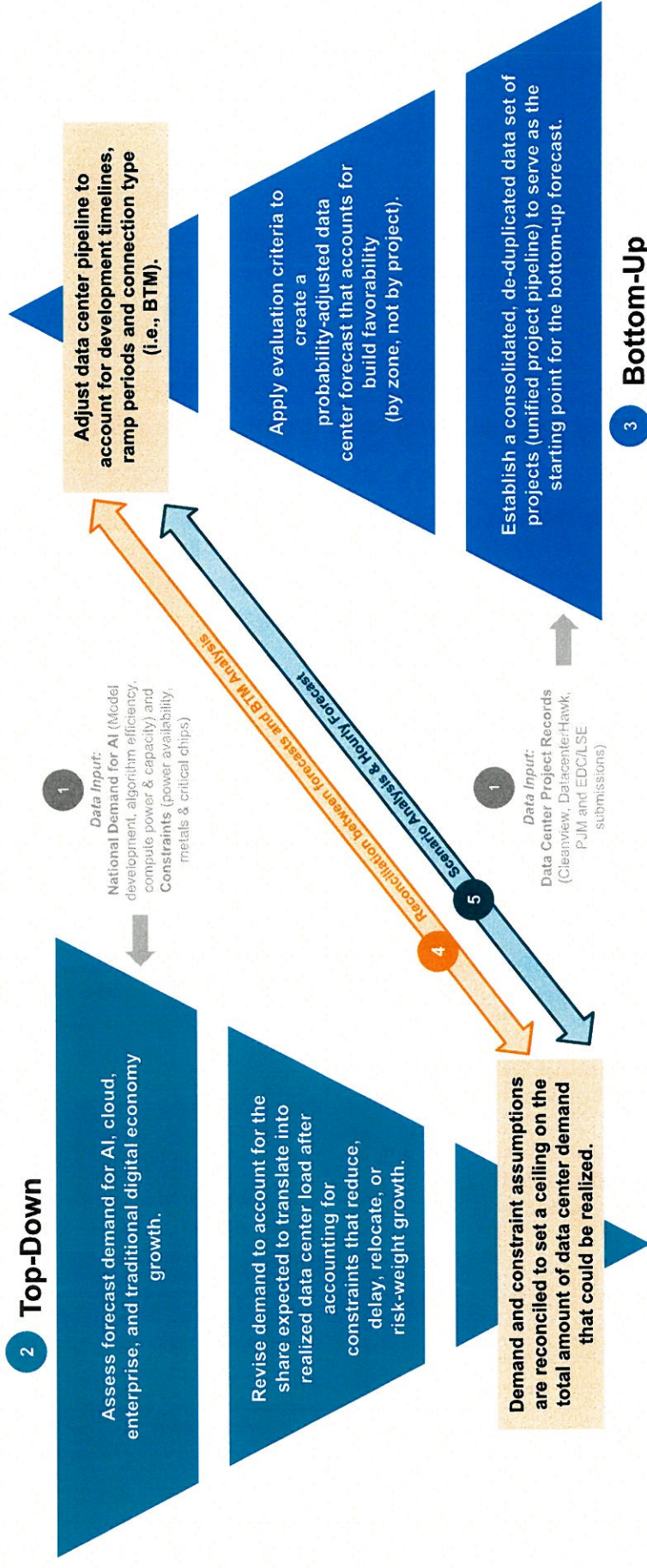
- PUE estimates for data centers at 1.32 per EPRI's capacity-weighted averages for facility-level data ([link](#))



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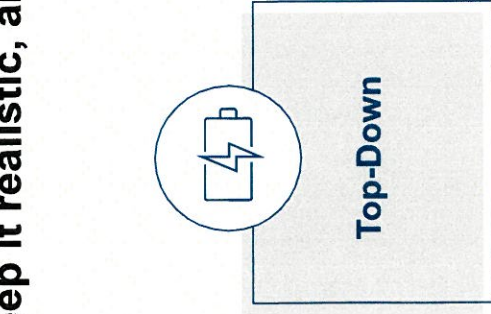
## Methodology overview to produce 20-year hourly load forecast



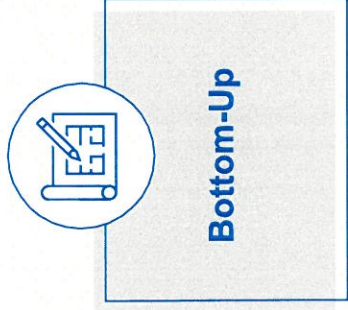




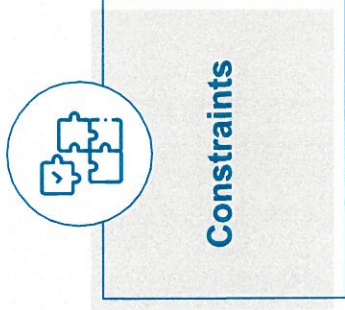
**Four layers work together: demand sets the size, the pipeline sets the location, constraints keep it realistic, and behind-the-meter absorbs the overflow**



Sets how much capacity is needed in total across the horizon.



Sets where it lands, using the actual project pipeline zone by zone + possibility of ignition.



Keep the outlook grounded in what the grid can physically absorb.



Acts as the relief valve when interconnection cannot keep pace.

**Together, they turn a national demand number into a credible, zone-level build path.**

## Seven sequential steps reconcile unconstrained demand with zonal and PJM limits, then capture the final build





## Behind-the-Meter offers a critical relief for constrained power systems



The split between the two follows observed proportions in the announced project pipeline

**RECONNECTION** — both behind-the-meter outcomes are temporary: islanded sites seek grid service once the zone can accommodate them, approximately two years, returning on non-firm service and retaining their generation. That capacity re-enters the zonal capacity position as the load returns to grid-served load, lifting net load in the later years of the forecast.



## Island and hybrid configurations differ in whether grid connection is retained, determining how each is sized and counted

| <b>HYBRID</b><br>Grid-connected — self-supplies part of the time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>ISLAND</b><br>No grid service — self-supplies its full load                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Sizing</b></p> <div> <div></div> <div>Power load served = 1.00x<br/>generation installed = 1.11x (ICAP)<br/>= 0.69x (UCAP)</div> </div> <p>No reserve margin — the grid provides redundancy.</p> <p><b>Why this configuration</b></p> <p>Preferred wherever a connection can be obtained. Grid energy is cheaper in most hours, the option to purchase retains value even at low utilization, and the grid clears faults and supports restart.</p> <p><b>In the load forecast</b></p> <p>The load remains and is served under firm service; the generation offsets part of it.</p> <p><b>In the capacity position</b></p> <p>Credited at its accreditation factor, with peak and energy assessed net of behind-the-meter dispatch. Credited because sites are built at approximately one-to-one with no reserve margin, so they cannot be assumed reliably interruptible — and because the technology mix points to a capacity rather than an energy motivation.</p> <p><b>Populations</b></p> <p>Sites built as hybrid take firm service and operate for arbitrage and coincident-peak management. Islanded sites that reconnect return on non-firm service and are curtailable.</p> | <p><b>Sizing</b></p> <div> <div></div> <div>Power load served = 1.00x<br/>generation installed = 1.67x (ICAP)<br/>= 1.14x (UCAP)</div> </div> <p>Redundancy for forced outages, with no external backstop.</p> <p><b>Why this configuration</b></p> <p>The forced outcome where grid service cannot be obtained on the required timeline — not a preferred design. An islanded site cannot lean on the grid to clear faults or restart, which is materially harder at scale.</p> <p><b>In the load forecast</b></p> <p>Neither the load nor its generation appears on the system until reconnection.</p> <p><b>In the capacity position</b></p> <p>Not credited, as the resources are absent from the system. The site returns to the forecast on reconnection, which is assumed approximately two years after the zone can accommodate it, on non-firm service and retaining its generation.</p> <p><b>Populations</b></p> <p>A single population, which converts to hybrid on reconnection.</p> |
| <p><b>COMMON TO BOTH:</b> the split between the two follows observed proportions in the announced project pipeline, and all behind-the-meter capacity is temporary — a bridge held only until grid service becomes available.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |



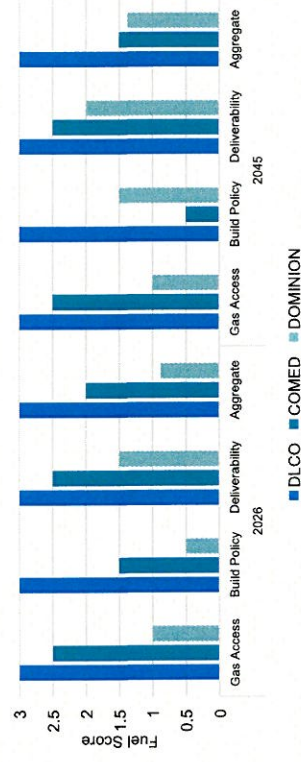
## Fuel scores – how much BTM gas can physically and legally be built?

### What the scores are

- The score represents a zone-year assessment of whether gas-fired behind-the-meter generation can physically and legally be built — not whether anyone wants to build there, which is handled separately.
- Three sub-factors, each scored 0–3, averaged into a composite: gas access, build policy, and deliverability. Build policy has double weight because it is the most important.

- Gas access** – distance to interstate mainline with spare capacity, and mainline utilization. Sourced from pipeline GIS and capacity postings
  - Build policy** – state and local permitting posture toward on-site generation and associated pipeline infrastructure, including moratoria and litigation history
  - Deliverability** – winter basis spread at the serving hub versus Henry Hub, and frequency of operational flow orders or curtailment notices
- A separate binary buildable-policy flag gates the zone entirely; where it is zero, no behind-the-meter generation is permitted regardless of the other scores.

Sample Fuel Scores

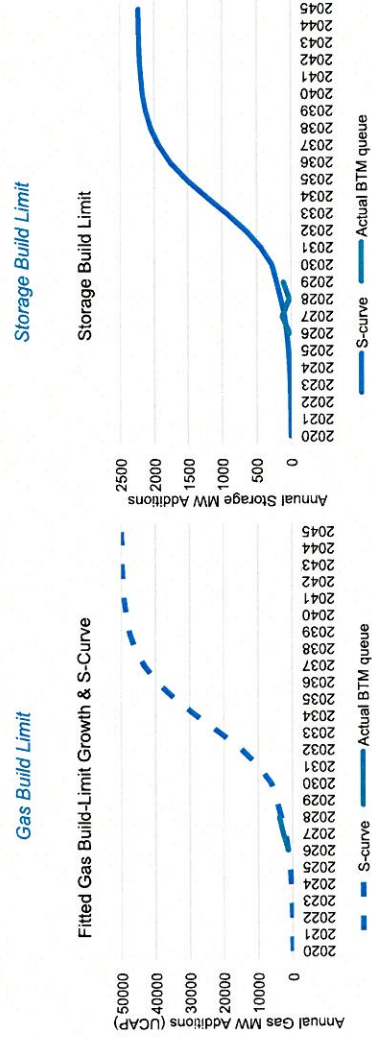


Fuel Scores Rubric

|                  | What it captures                                                                               | 0                                | 1                         | 2                   | 3                                  |
|------------------|------------------------------------------------------------------------------------------------|----------------------------------|---------------------------|---------------------|------------------------------------|
| Gas Access       | Is the gas physically there and can pipe reach the site? (basin proximity + pipeline headroom) | Pipeline island, far from supply | Lateral-dependent, tight  | Mainline accessible | On/hear basin, mainline with spare |
| Build Policy     | Can you permit and build the pipe/lateral the gas facility?                                    | Moratorium / de facto ban        | Hostile, litigated        | Mixed/slow          | Supportive                         |
| Deliverability   | Will gas show up when needed? (firm availability + winter constraint risk)                     | Regular curtailment              | Tight, interruptible-only | Workable            | Firm available, low winter risk    |
| Buildable Policy | Can BTM generation be built at all?                                                            | No                               | Yes                       | N/A                 | N/A                                |

## Projecting the Behind-the-Meter build limit

As with grid-connected resources, the ability to build BTM resources is assumed to grow over time



Note: calculated as the change in observed MW capacity between each month and the same data center's capacity 6 months earlier, averaged across the ramp period (which is between the first MWs coming online, and when the data center's MWs are equal to the maximum observed in the data)

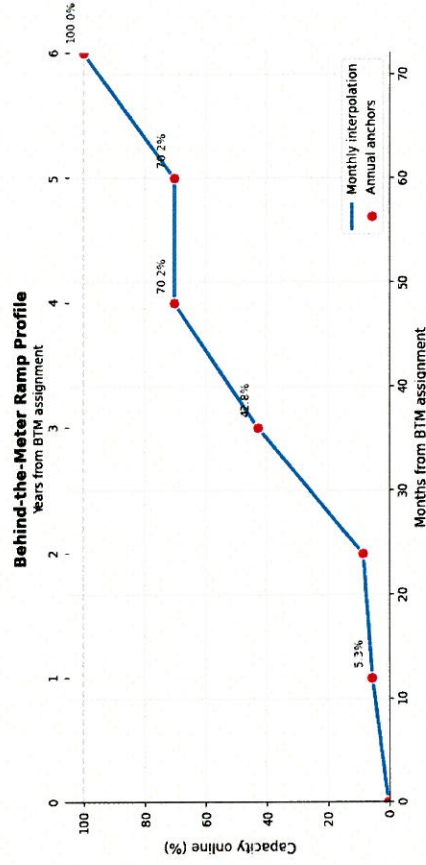
### Approach

Applied PJM-wide, not zonally  
 Announced BTM projects with a commercial online date, aggregated by year and used as an annual flow  
 Absent a formal queue, the pipeline is the equivalent revealed-preference signal  
 Joined to US turbine orders under 100 MW, 2020–25 — same manufacturing base, so the longer history informs the shape  
 The junction carries the last observed growth rate, so the splice adds no step; the fitted logistic levels off rather than compounding

Source: LSE Submissions

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Assumed BTM ramp rate:  
 BTM projects ramp slower than grid-connected projects



Example where all data center campuses start their ramp at the same time

### Assumptions

- Assumes ramp rates follow year-over-year build trends as observed in public announcements
- Build rates are slower than grid-connected projects due to the need to self-build power

Source: CRA analysis, Cleanview

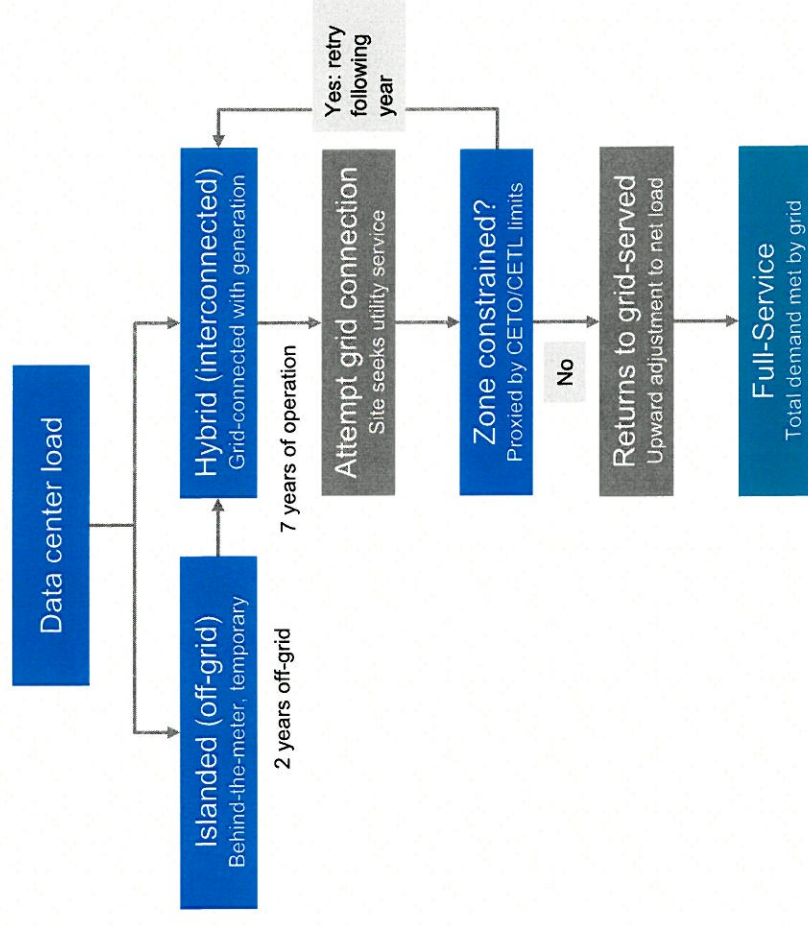




## Data centers with BTM generation will ultimately seek grid reconnection

### Key Assumptions

1. Islanded behind-the-meter build allows data centers to come online early, but it is *expensive* relative to grid service.
2. Data centers without utility connection are assumed to seek grid service as soon as it becomes available, consistent with a connection being preferred wherever it can be obtained.
3. Islanded sites cannot be added to hybrid demand in any year that zone is *constrained*, as proxied by CETO/CETL limits in each year.
4. Islanded sites are assumed to try to become hybrid *seven years* after demand is forecasted, subject to above constraint. This is the average time until a major overhaul would be required on the existing generating resources.
  - BYOG connection timelines are assumed to be shorter than full-service data centers (which average 4-7 years depending on zonal constraints)
5. Sites return on non-firm service, retaining their generation, and are therefore *curtailable* following reconnection.
  - Consistent with observed trends in existing data centers connecting to grid service with existing backup generation
6. Reconnected capacity re-enters the balance and the associated load returns to grid-served load, producing an *upward adjustment* to net load in the later years of the forecast net of on-site generation.





## Economic dispatch modeling yields hour-to-hour economic dispatch of BTM resources

### 1. Grouping tranches

Hybrid BTM resources are grouped into technology-specific tranches by zone.

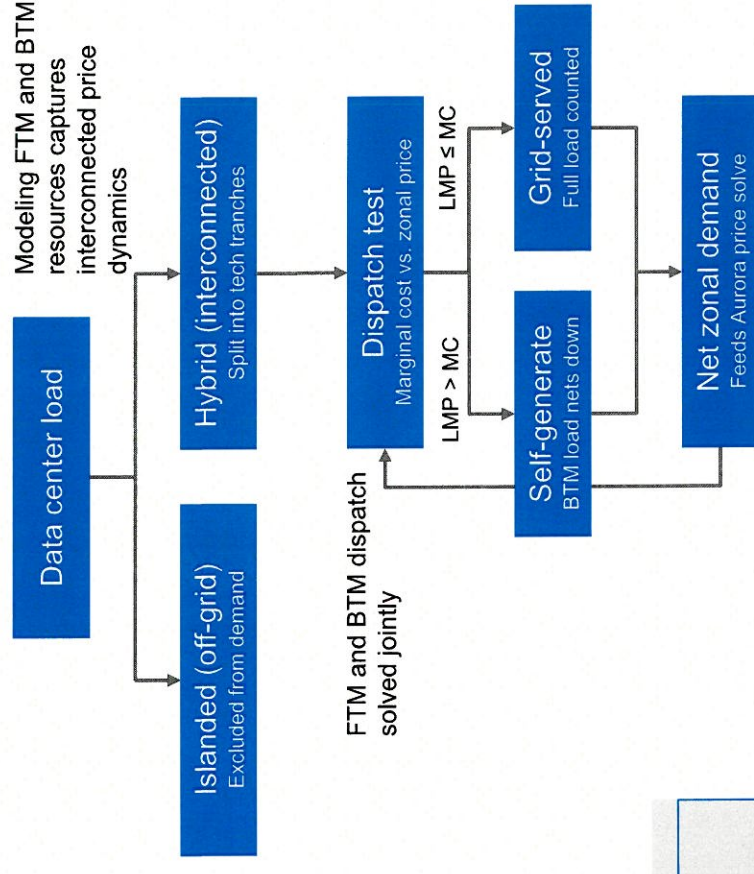
Each tranche is entered into a production cost model that **reduces the gross BTM datacenter load in its zone** — it does not compete as a supply offer in the broader market and carries no capacity accreditation.

### 2. Dispatch logic

In each hour, model compares each marginal cost to the zonal clearing price. If marginal cost < zonal price, the resource tranche dispatches, reducing datacenter grid draw by that amount. If marginal cost  $\geq$  price, the tranche stays off and the load is served from the grid.

### 3. Islanded resources

Islanded data centers have no electrical interconnection and are therefore excluded from the zonal demand forecast, reflecting that they would have no impact on net system demand. They only enter the model once they interconnect, at which point they are treated as hybrid resources (see prev. slide).



\*Zonal price and dispatch are solved together hourly.

#### Key Takeaway:

Because tranche dispatch is price-driven rather than a fixed schedule, the **resulting zonal price series approximates when the operator would turn on its FTM resource: self-generate** when it is cheaper than buying, draw from the grid when it is not.



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| Load Profile Assumptions                    | 10:15 – 10:25 AM        |
| Forecast Reconciliation and BTM             | 10:25 – 10:45 AM        |
| <b>Scenarios</b>                            | <b>10:45 – 11:00 AM</b> |
| <i>Break</i>                                | 11:00 – 11:10 AM        |
| Q&A                                         | 11:10 – 11:55 AM        |
| Next Steps & Close                          | 11:55 – 12:00 PM        |

## Impact of Scenarios

Using scenarios can illustrate how demand growth and constraints interact under different states of the world, how quickly constraints relax, and therefore how much national demand can realistically translate into regional load

| State of the World                                                   | Constraint Environment                                                                                                                                       | Impact on Top-Down Forecast                                                                                                                                                                                                                                                                                   |
|----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Base Case / Managed Growth</b>                                    | AI adoption continues, but power, supply chain, and siting constraints slow realization. Going forward, new infrastructure accelerates beyond current rates. | <br><i>Demand grows steadily, but constraints cap near-term load realization and push some growth into later years.</i>                                                                                                      |
| <b>Abundance Case</b>                                                | Infrastructure, compute, and power constraints are relaxed faster than base case expectation; efficiency gains also improve.                                 | <br><i>Faster load growth enabled by fewer binding constraints limiting demand realization.</i>                                                                                                                              |
| <b>Power-Constrained Growth &amp; Evolving Inter-region dynamics</b> | AI demand remains strong, but power availability and interconnection remain severely constrained (current rates remain), particularly in legacy markets.     | <br><i>National demand exists, but regional load realization is significantly limited by deliverability, cost, and timing of power. Data centers are likely to increasingly shift toward emerging and tertiary markets.</i> |
| <b>Slower Adoption</b>                                               | AI adoption is more measured due to cost, use-case uncertainty, efficiency improvements, or customer adoption friction.                                      | <br><i>Lower overall demand trajectory, with less pressure on infrastructure constraints and slower regional siting.</i>                                                                                                   |



## Scenarios test a range of internally consistent outcomes

| Scenario     | S-D Outlook                     | AI Adoption                        | AI Efficiency                                        | BTM Generation                                             |
|--------------|---------------------------------|------------------------------------|------------------------------------------------------|------------------------------------------------------------|
| Abundance    | More generation added than base | Same as base                       | Same as base                                         | Same availability as base, but less usage                  |
| Constrained  | Less generation added than base | Same as base                       | Incentivized to innovate: Increased efficiency gains | Build limits tighten, but larger shortfalls yield more BTM |
| Low Adoption | Same as base                    | Lower adoption rate than base case | Same as base                                         | Build limits unchanged, less shortfall so less BTM         |

*Most significant implication*

## Supply build-out is determined by multiple levers

While near term queue-based outlook remains the same, changes are applied to LTCE forecast (2031 – 2047)

| Scenario                                                     | Gas build limit      | Storage build limit                                 | Cycle 1 treatment                                         | Post-2038 constraint and transmission logic |
|--------------------------------------------------------------|----------------------|-----------------------------------------------------|-----------------------------------------------------------|---------------------------------------------|
| <b>Abundance</b><br><i>More generation added than base</i>   | Increase to 18% CAGR | Quicker ramp and higher constraint                  | Decreased attrition represented by build limit relaxation | Off                                         |
| <b>Base Case</b><br><i>Base case</i>                         | Remain at 10% CAGR   | Ramp to 6 GW and remain flat                        | Included as generic units in LTCE                         | Off                                         |
| <b>Constrained</b><br><i>Less generation added than base</i> | Decrease to 5% CAGR  | Minimal increase in constraint, increase to ~3.5 GW | Lower levels of additional resources via build limits     | Off                                         |



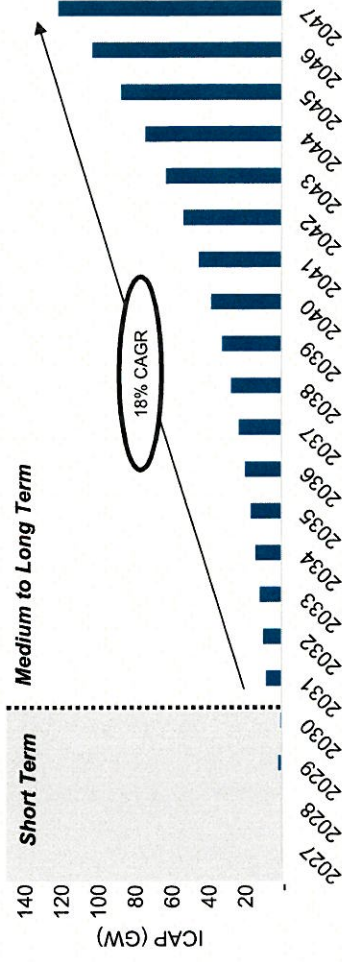
## Turbine and battery supply chains adapt more quickly to increased demand

### Supply Forecast Details for Abundance Case

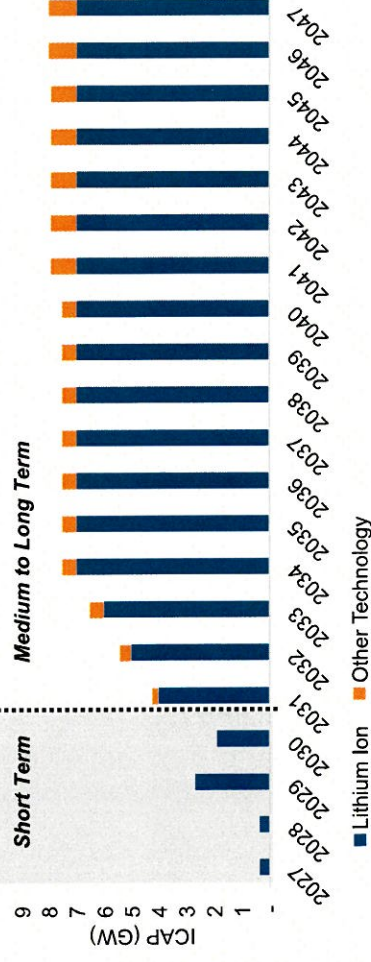
- A relaxed turbine constraint is the key lever to achieving this scenario and enabling an accelerated gas build-out; an increased storage constraint allows for additional batteries to come online
- Medium-term gas additions are built sooner due to relaxed constraints, reducing UCAP shortfall by up to ~6 GW annually
- However, near-term shortfalls (2027–2030) remain unchanged as the queue remains a fixed addition

|                                  | Base Case | Abundance Case |
|----------------------------------|-----------|----------------|
| <i>In UCAP</i>                   |           |                |
| Highest Shortfall                | 28 GW     | 28 GW          |
| Cumulative Shortfall (2031–2047) | 125 GW    | <125 GW        |
| Gas Additions (2031–2047)        | 53 GW     | >53 GW         |

CRA “Abundance Case” Gas Turbine Constraint (ICAP)



CRA “Abundance Case” Battery Constraint (ICAP)

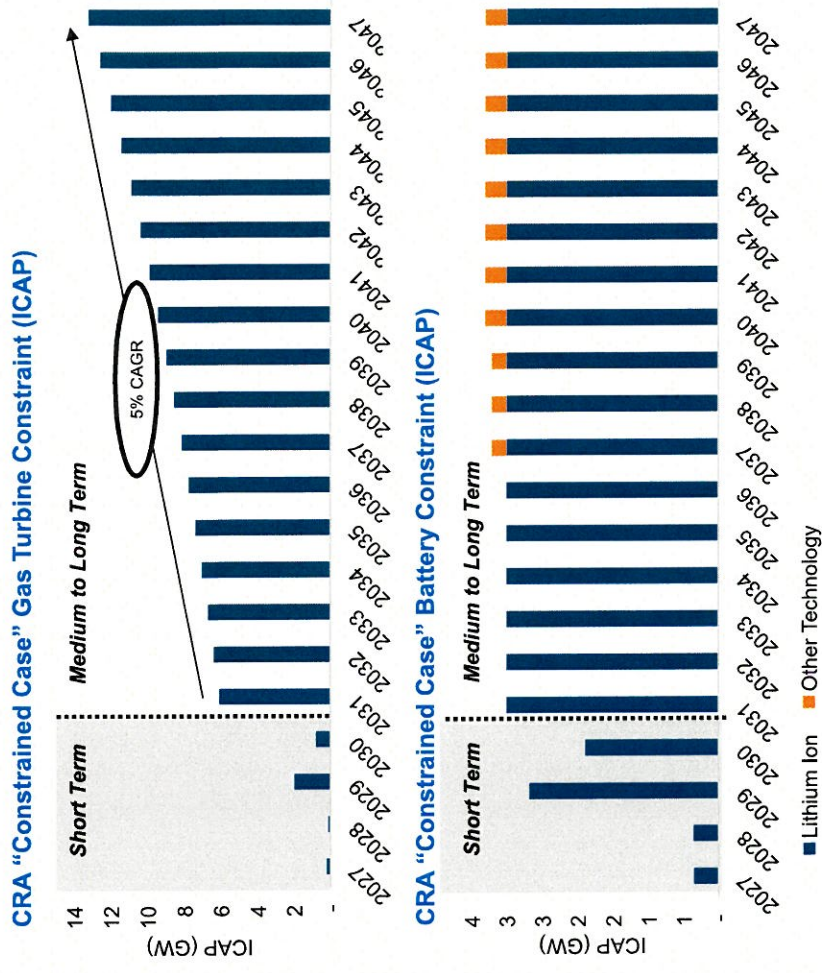


## Turbine and battery supply chains lag even as demand grows

### Supply Forecast Details for Constrained Case

- A tightened turbine constraint along with a lower battery constraint prevents new generation from coming online at the same rate as other cases
- Medium-term gas additions are built later due to harsher constraints, increasing UCAP shortfall by up to ~16 GW annually
- However, near-term shortfalls (2027–2030) remain unchanged as the queue remains a fixed addition

|                                  | Base Case | Constrained Case |
|----------------------------------|-----------|------------------|
| <i>In UCAP</i>                   |           |                  |
| Highest Shortfall                | 28 GW     | 28 GW            |
| Cumulative Shortfall (2031–2047) | 125 GW    | >125 GW          |
| Gas Additions (2031–2047)        | 53 GW     | <53 GW           |



Sources: [Utility Dive GE Article](#); [GE Vernova](#); [S&P Global Article](#); [CAISO 20 Year Transmission Outlook](#)



## Scenarios test a range of internally consistent outcomes

| Scenario            | S-D Outlook                     | AI adoption                        | AI efficiency                                        | BTM generation                                             |
|---------------------|---------------------------------|------------------------------------|------------------------------------------------------|------------------------------------------------------------|
| <b>Abundance</b>    | More generation added than base | Same as base                       | Same as base                                         | Same availability as base, but less usage                  |
| <b>Constrained</b>  | Less generation added than base | Same as base                       | Incentivized to innovate: Increased efficiency gains | Build limits tighten, but larger shortfalls yield more BTM |
| <b>Low Adoption</b> | Same as base                    | Lower adoption rate than base case | Same as base                                         | Build limits unchanged, less shortfall so less BTM         |

*Most significant implication*

## Forced innovation case represents a scenario where AI demand remains strong, but power constraints are persistent

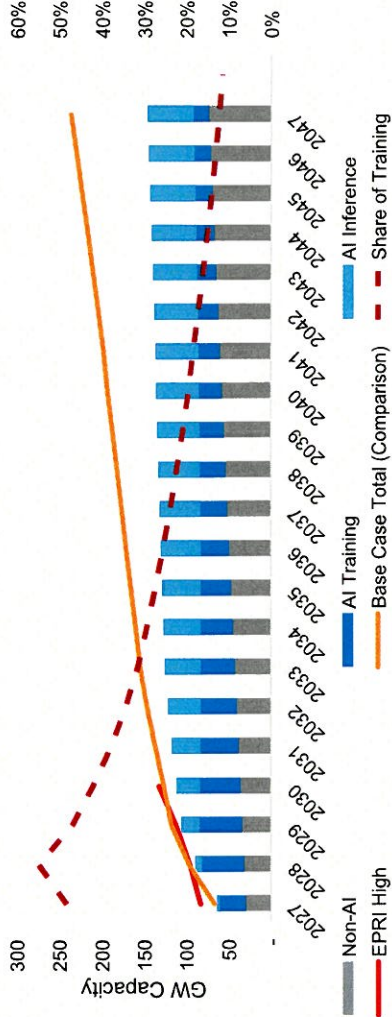
### What Needs to be True in the “Forced Innovation” Case

- AI adoption remains strong as companies realize productivity gains from AI
- Power constraints increasingly limit data center expansion and deployment of power-intensive hardware
- Market pressure shifts to upstream suppliers, incentivizing chip manufacturers to focus on computationally efficient designs, increasing chip processing efficiency
- Efficient chip design enables AI adoption while counteracting MW demand growth

|          | Base Case Growth                | Constrained Case Growth |
|----------|---------------------------------|-------------------------|
| Adoption | 95% Individual Adoption by 2040 | No Change               |
| Chips    | 1.34x/year                      | 1.39x/year (+5%)        |

Sources: Epoch.ai

CRA “Forced Innovation Case” Data Center Forecast (Cumulative GWs)



Growth in Base vs Constrained Case Chip Efficiency





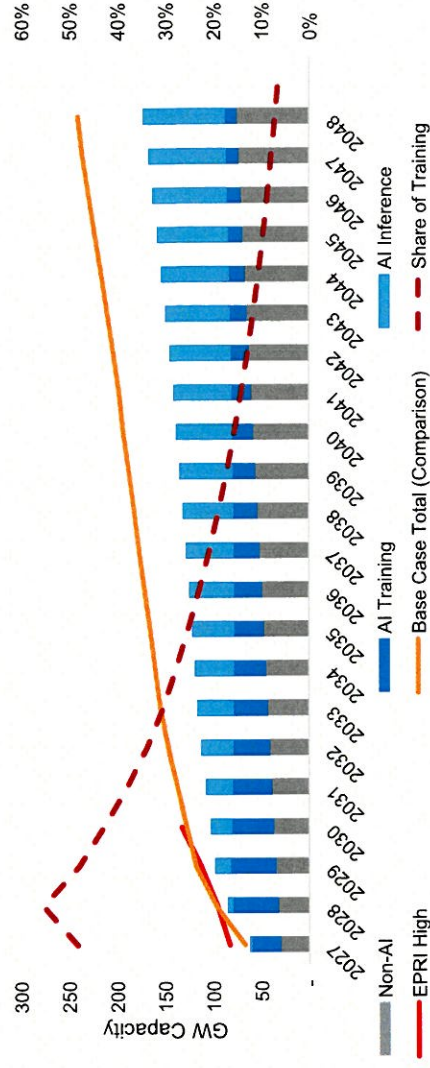
## Lower adoption case represents a scenario where AI struggles to gain traction, causing a decline in demand

### 'What Needs to be True' in the Lower Adoption Case

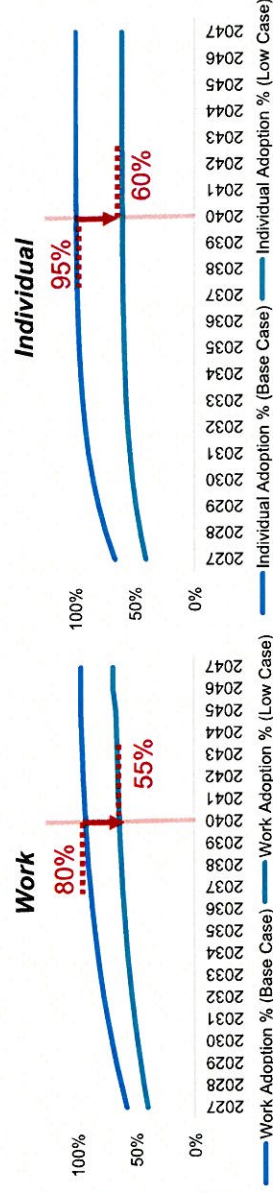
- Enterprise AI adoption slows as productivity gains fall short of expectations.
- Weaker demand reduces AI development investment and model development activity.
- Fewer breakthrough models further dampen adoption, creating a self-reinforcing slowdown in AI growth.

|          | Base Case Growth                                                                                    | Lower Adoption Case Growth                                                                                                |
|----------|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| Adoption | 95% Individual Adoption by 2040<br>80% Enterprise Adoption by 2040<br>11% CAGR in AI Models Trained | 60% (-35%) Individual Adoption by 2040<br>55% (-25%) Enterprise Adoption by 2040<br>5.5% CAGR in AI Models Trained (-50%) |
| Chips    | 1.34x/year                                                                                          | No Change                                                                                                                 |

CRA "Lower Adoption Case" Data Center Forecast (Cumulative GWs)



CRA "Lower Adoption Case" Adoption Forecast (% U.S. Population)



Lower Adoption Case Adoption Curve is based on JoA study suggesting 31% of individuals do not see clear benefits from using AI at work. The constrained case curve is capped by the % of individuals who did not report benefits from using AI at work. Gallup Poll indicates that 39% of individuals see AI doing more harm than good. Individual usage is capped by the % of individuals that see AI doing more harm than good.

## Meeting agenda

| Topic                                       | Timing                  |
|---------------------------------------------|-------------------------|
| Introductions and July 13 LAS Meeting Recap | 9:10 – 9:20 AM          |
| Top-Down: Unconstrained View                | 9:20 – 9:35 AM          |
| Top-Down: Constraints                       | 9:35 – 10:00 AM         |
| Bottom-Up Forecast                          | 10:00 – 10:15 AM        |
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| Next Steps & Close                          | 11:55 – 12:00 PM        |



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| Q&A                                         | 11:10 – 11:55 AM        |
| <b>Next Steps &amp; Close</b>               | <b>11:55 – 12:00 PM</b> |



## Next Steps

- EDC/LSE form submissions due – September 4
- Individual meetings with EDCs/LSEs in September/October
- Final results presentation October 14 LAS meeting

We thank you for your support and participation, both today and throughout this process!

For any additional questions or comments please reach out to [Load\\_Analysis\\_Team@pjm.com](mailto:Load_Analysis_Team@pjm.com).

CRA Charles River  
Associates



## LOAD ANALYSIS SUBCOMMITTEE (LAS)

### MISSION

The PJM Load Analysis Subcommittee (LAS) reports to the PJM Planning Committee (PC) and is responsible for soliciting stakeholder input and providing review of PJM reports, technical analysis and coordination of information related to the electric peak demand and energy forecasts, weather and peak load studies, and normalization as required to support the Reliability Assurance Agreement (RAA) of PJM Interconnection.

### PARENT COMMITTEE

PJM Planning Committee (PC)

### RESPONSIBILITIES

1. Review historical and forecast peak demand and energy data of the respective PJM members for various reports required by PJM.

- PJM Load Forecast Report
- PJM Summer and Winter Normalized Peaks
- Other reports requested by the PC

2. Provide a forum for discussion on:

- Forecast methodology
- Underlying economic/demographic and weather factors
- Current and anticipated influences on peak and energy forecasts
- Input and feedback on forecast assumptions such as distributed solar, large loads, and other emerging trends

### ADMINISTRATIVE

- All PJM stakeholders may appoint representatives to the subcommittee and attend meetings.
- PJM will designate a subcommittee facilitator and secretary.
- The facilitator and secretary will be responsible for preparing and issuing all reports, scheduling periodic meetings and conference calls as necessary, and recording and preparing the minutes of each meeting.
- The subcommittee is expected to meet as required to address its workload or the discretion of the facilitator, with opportunities for both in-person and via teleconference.
- This is a non-voting subcommittee. Decision making will be aided by the use of non-binding polling in accordance with Manual 34. Any recommendations from the LAS will be forwarded to the PC for consideration and voting.

- Each member should have the authority to commit resources in order to support the requirements of the Load Analysis Subcommittee (LAS).

## Revision History

August 2024



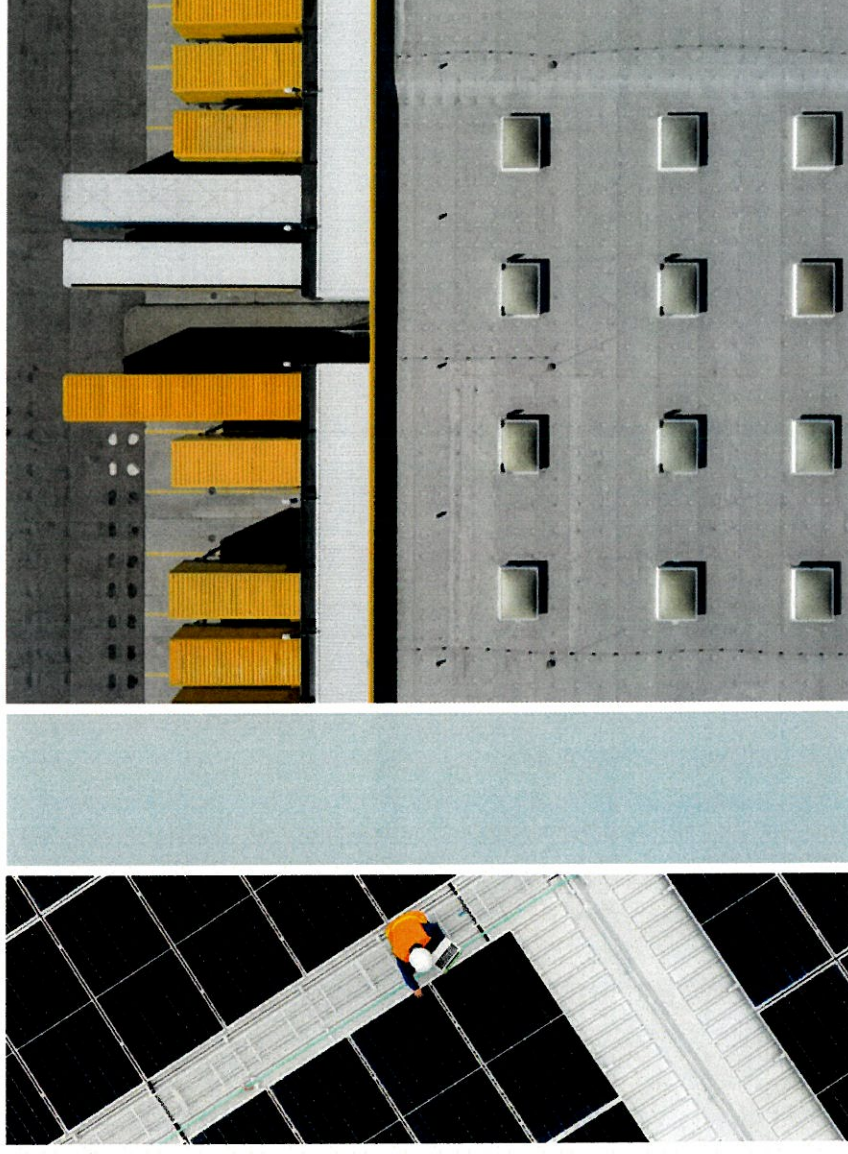
CERA Consulting

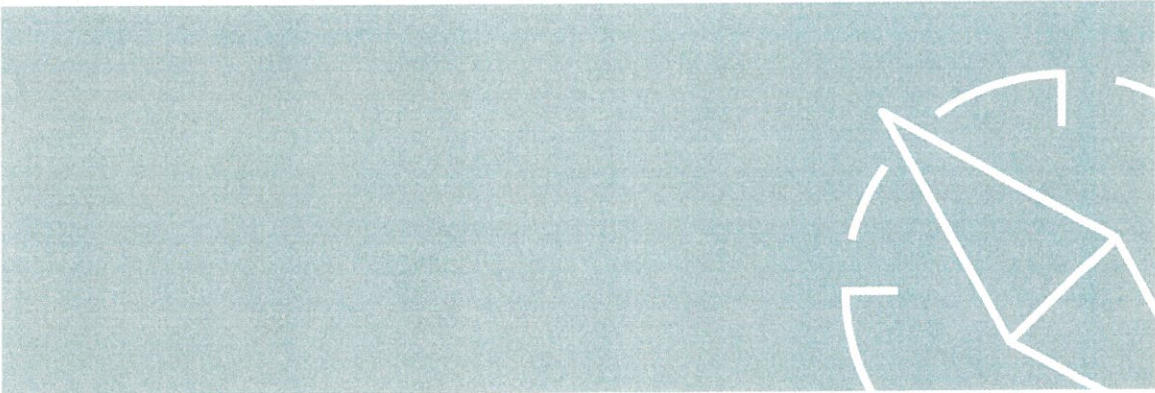
# PJM Solar and Battery Forecast 2026

Prepared for PJM

July 13, 2026  
Phase I – Key Assumptions

CERA Consulting is the consulting arm of S&P Global Energy





# Contents

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| 2. Policy Assumptions |
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| 3. Capital Cost Assumptions |
|-----------------------------|

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# Solar PV and battery forecasting methodology



## Analytical Framework

The S&P Global outlook for solar power takes into account multiple drivers and inhibitors that reflect the maturity of the market and its growth potential for solar and batteries.

Key components of our framework for assessing market attractiveness for solar:

- State renewable policy (including renewable portfolio standard [RPS], net energy metering [NEM], community solar, and renewable corporate policies)
- Regulatory incentives
- Solar resources
- Site approval
- Grid access and offtake



## Short-term data points

In the short term (one to four years), our forecast is based primarily on existing policies, the late-stage project pipeline, and status of procurement and equipment orders.

Key data inputs collected and assessed by S&P Global energy analysts include:

- Project announcements
- Utility requests for proposal (RFPs), auctions, and tenders
- Existing mandates and incentives
- Project development track record
- Reported costs and pricing
- Supply chain announcements and equipment orders



## Longer-term assumptions

In the longer term (5–20 years), our forecast draws upon rigorous bottom-up research and on economic fundamentals, energy prices, and macroeconomic factors.

Key data inputs and assumptions include

- Policy and regulatory trends
- Power demand growth and capacity retirements
- Annual solar power pricing forecasts
- Power and gas prices
- Transmission and grid infrastructure



# Key assumptions

## Solar forecast scenario overview

| Assumptions                                                                                                                                                          | Scenario 1: "Higher for longer"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Scenario 2: "Base case"                                                                                                                                                                                                                                                                                                                                                 | Scenario 3: "Solar Rebound"                                                                                                                                                                                                                                                                                                                 |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Federal policy support                                                                                                                                               | OBBA Update to ITC (Homeowner-collected ITC expired Dec 2025, other tax credits for solar expire Dec 2027)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | OBBA Update to ITC (Homeowner-collected ITC expired Dec 2025, other tax credits for solar expire Dec 2027)                                                                                                                                                                                                                                                              | OBBA Update to ITC (Homeowner-collected ITC expired Dec 2025, other tax credits for solar expire Dec 2027)                                                                                                                                                                                                                                  |
| NEM policies and retail rate structures                                                                                                                              | Utilities/PUCs (and regulators approve) reform NEM policy earlier owing to costly DG programs. Current retail rate structures are adjusted; existing NEM caps are maintained (and many reduced). Utilities and PUCs also phase out "community solar" and carve-outs for DERs.                                                                                                                                                                                                                                                                                                                                                      | From 2026 to 2028, utilities adopt (and regulators approve) changes to NEM and retail rate structures, which result in a more cost-based approach to customer-sited solar compensation (see slide X); current detailed state NEM policy (see slides x-x).                                                                                                               | Reflecting a greater emphasis distributed solar as a resource for decarbonization, current retail rate structures and NEM are maintained for three years beyond the reform timeline in the base case; they are then reformed in a similar manner.                                                                                           |
| Solar costs (\$/kW)                                                                                                                                                  | Solar costs continue to increase for the next five years owing to continued supply chain disruptions and trade tensions before resuming their prior rate of decline. Disruptions are linked to continued trade disruptions and uncertainty associated with ever changing trade policies, shipping backlogs, and higher raw material prices due to elevated global demand. Panel availability is restricted through the early 2030s. Continued project delays owing to grid interconnection, zoning and local ordinances cause development costs to increase. Post 2031, costs are expected to increase at a rate of 0.5% per year. | Residential solar costs continue to rise due to increased tariffs and supply constraints as well as the generally inflationary environment. Moving forward, residential solar costs decline by 4% in nominal terms from 2026 to 2033 before slowly increasing to 3% above 2026 by 2047. In real \$ terms, prices are expected to be 35% lower in 2047 compared to 2026. | Solar costs decline by 10% in nominal terms from 2026 to 2034, driven by a combination of technology advancements and a more conducive environment for trade post 2028. Post 2034, the decline in costs levels out owing to technology maturity, land scarcity and greater onshoring, ending 5% below 2026 cost on a nominal basis by 2047. |
| State policy support                                                                                                                                                 | Current RPS policies and state-level incentives are maintained.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Current RPS policies and state-level incentives are maintained.                                                                                                                                                                                                                                                                                                         | Current RPS policies and state-level incentives are maintained.                                                                                                                                                                                                                                                                             |
| Power demand                                                                                                                                                         | Base-case demand                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Base-case demand                                                                                                                                                                                                                                                                                                                                                        | Base-case demand                                                                                                                                                                                                                                                                                                                            |
| Note: DG = distributed generation, ITC = investment tax credit, PUCs = public utility commissions, DERs = distributed energy resources.<br>Source: S&P Global Energy |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                             |
|                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                         | © 2026 S&P Global                                                                                                                                                                                                                                                                                                                           |



## The OBBBA, executive orders, and updated Treasury guidance severely diminish credit opportunities for residential solar projects moving forward

- The One Big Beautiful Bill Act (OBBBA) (signed into law on July 4, 2025), brought significant changes to the tax credits for wind and solar generation, including behind the meter generation
- The OBBBA shortened or abruptly ended all tax credits outlined by the Inflation Reduction Act of 2022 (IRA) for solar
  - Starting in 2026, homeowner-owned residential solar PV systems no longer qualify for the ITC
  - Tax credits for third-party owned systems (leased) are available for projects until 2028
- Historically, qualification for renewable generation tax credits have been subject to safe-harbor provisions that allow for projects to qualify for the full value of the tax credit in the year that “construction begins” so long as the project is online within four years of the start of construction
  - The state of construction was previously defined as either physical work of a significant nature or when a taxpayer pays or incurs over 5% of the total cost. Updated guidance from the Treasury Department requires that physical on site construction started before July 4<sup>th</sup>, 2026 in order to qualify for the ITC
  - Qualified projects still must be online within four years to maintain qualification
- Also under the OBBBA, Foreign Entity of Concern (FEOC) restrictions were expanded to prevent FEOC’s and domestic organizations with certain relationships to FEOC’s from qualifying for any production, investment, or manufacturing tax credits currently available, depending on the amount of material for a project that originated from a FEOC.

## Amended timelines for solar construction

- Most utility scale solar projects must be installed by 2028 to qualify for the production and investment tax credits (PTC and ITC) provided for in the IRA
- FEOC restrictions likely to constrain some solar installations after 2026
- 30% ITC offered to homeowners who install solar + storage projects in their home is no longer available for projects installed after December 31, 2025, which eliminates all federal tax credits available for homeowner-owned systems
- Third-party owned systems still collect ITC through 2027
- Projects must be *installed* by these deadlines but it is not stated that they must be interconnected

### Example construction start dates and impact on tax credits for non-homeowner owned solar systems

| Start of construction (solar PV and wind) | ITC and PTC credit value % | FEOC restriction | In-service deadline |
|-------------------------------------------|----------------------------|------------------|---------------------|
| Before December 2025                      | 100%                       | No               | *4 years            |
| January to July 2026                      | 100%                       | Yes (40%)        | *4 years            |
| August to December 2026                   | 100%                       | Yes (40%)        | Dec. 2027           |
| January to December 2027                  | 100%                       | Yes (45%)        | Dec. 2027           |

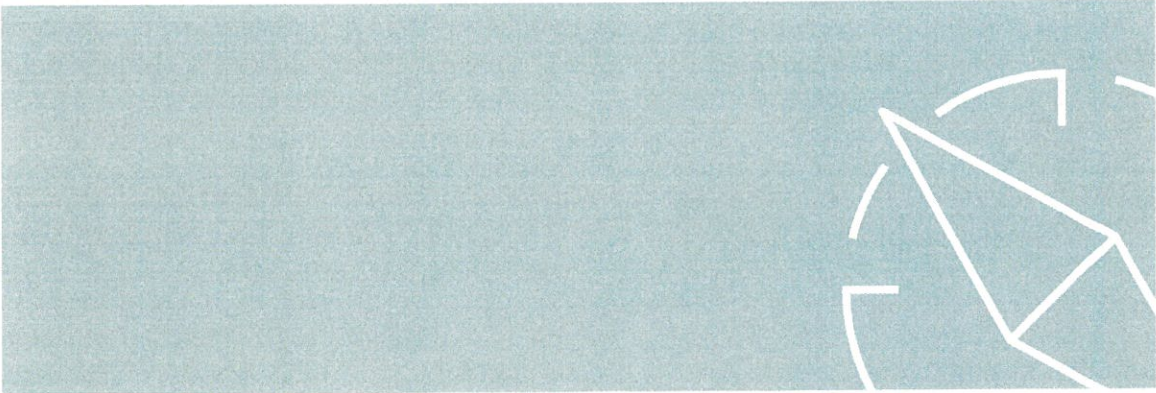
### Example construction start dates and impact on homeowner-collected solar investment tax credits

| Start of construction (solar PV and wind) | ITC and PTC credit value % | FEOC restriction | In-service deadline |
|-------------------------------------------|----------------------------|------------------|---------------------|
| Before December 2025                      | 100%                       | No               | Dec. 2025           |



## Options for NEM and retail rate reform

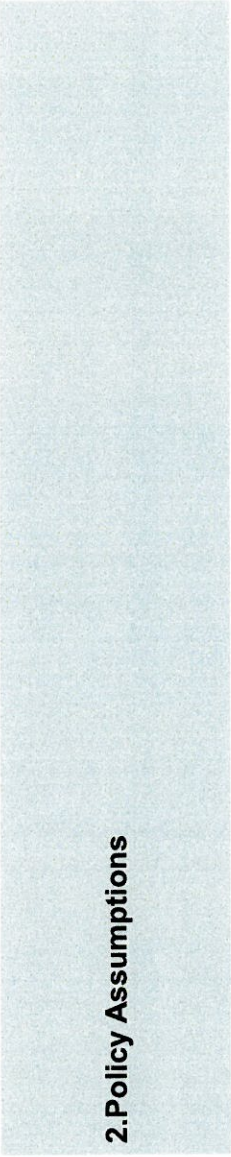
- SPGE will not predict specific changes to state or utility NEM policies or rate structures; however, we assume states will choose from a variety of options that reduce the compensation for customer-sited solar but still provide sufficient compensation for a moderate pace of additions.
- Holistic rate reform options for all residential customers: lower volumetric (dollars per kilowatt-hour) price in favor of higher
  - Minimum (fixed) bill charge
  - Peak-demand (dollars per kilowatt) charge
- Narrowly tailored NEM reform options:
  - Reduce bill credits for all solar generation exported to the grid in real time (may require new meters)
  - Add “standby” or similar charges for NEM customers only
- NEM replacement options:
  - Value-based tariff (adjusted periodically to account for changes in wholesale power markets, transmission and distribution costs, etc.)
  - Transition toward time-of-use (TOU) pricing for all NEM customers
  - Competitive process (for example, rolling tenders or RFPs)



# Contents



1. Scenario Assumptions



2. Policy Assumptions

3. Capital Cost Assumptions





## RPS and NEM policy assumptions by state

| Detailed RPS policy assumptions |                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| State                           | RPS target (percentage of retail sales)*                        | Solar carve-out (percentage of retail sales)*/Distributed carve-outs                                                                                                                                                                                                                                                                                                                                        |
| DE                              | 25% by 2025, 28% by 2030, 40% by 2035                           | 3.5% by 2025, 5% by 2030, 10% by 2035                                                                                                                                                                                                                                                                                                                                                                       |
| DC                              | 100% by 2032                                                    | 2.85% by 2023, 9% by 2032, 15% by 2041                                                                                                                                                                                                                                                                                                                                                                      |
| MD                              | 52.5% by 2030                                                   | 14.5% by 2030                                                                                                                                                                                                                                                                                                                                                                                               |
| NJ                              | 50% by 2030* (100% CES by 2035)                                 | 5.1% by 2021, declining to 2.2% by 2030, gradually reduced to 1.1% by 2033                                                                                                                                                                                                                                                                                                                                  |
| OH                              | 8.5% by 2026                                                    | - (solar carve-out eliminated in 2020)                                                                                                                                                                                                                                                                                                                                                                      |
| PA                              | 18% by 2021                                                     | 0.5% by 2021                                                                                                                                                                                                                                                                                                                                                                                                |
| WV                              | -                                                               | -                                                                                                                                                                                                                                                                                                                                                                                                           |
| IN                              | 10% by 2025 (voluntary)                                         | -                                                                                                                                                                                                                                                                                                                                                                                                           |
| IL                              | 25% by 2025, 40% by 2030, 50% by 2040** (100% CES by 2050)      | - Solar PV 55% of retail sales (27.5% for DG and Community Solar, 25.9% from utility-scale, 1.6% from brownfield projects)**                                                                                                                                                                                                                                                                                |
| KY                              | -                                                               | -                                                                                                                                                                                                                                                                                                                                                                                                           |
| MI                              | 50% by 2030, 60% by 2035*** (80% CES by 2035; 100% CES by 2040) | 0.2% by 2020****                                                                                                                                                                                                                                                                                                                                                                                            |
| NC                              | 12.5% by 2021**** (100% CES by 2050)                            | No fixed solar carve-out; Dominion: 1.1 GW solar procurement by 2035) + 1% in-state DG requirement.                                                                                                                                                                                                                                                                                                         |
| VA                              | 100% by 2045 (Phase II)<br>100% by 2050 (Phase I)*****          | Dominion procurement details: nameplate capacity between 50kW-3 MW. Of the 1,100 MW, 35% of capacity procured shall be from the from solar facilities owned by persons other than a utility. Dominion is required to meet 1% of RPS requirements from DG sources less than 1 MW, no more than 3 MW in one single location. No less than 25% of such 1% shall be composed of low-income qualifying projects. |

TN

Note: RPS includes solar carve-outs. RPS targets are based on Tier 1 requirements where applicable. \*New Jersey RPS target only includes Class I renewable technologies and the solar carve-out. \*\*Illinois requires 55% of RPS procurement from solar, and 250% solar procurements from distributed/community. RPS mandates at least 75% of the standard come from wind and solar. Climate and Equitable Jobs Act invests \$580 million a year to increase Illinois's clean energy from 9% to 50% by 2040. \*\*\*MI also now has a Clean energy standard, which adds nuclear and natural gas generation with CCS to the RPS and requires 80% by 2035 and 100% by 2040. \*\*\*\*RPS compliance in North Carolina can be achieved through energy efficiency and renewable energy credits (RECs) from any state. \*\*\*\*\*In VA, Phase I utilities are required to achieve 14% by 2025, 30% by 2030, 65% by 2040, and 100% by 2050 while Phase II utilities are required to achieve 26% by 2025, 41% by 2030, and 100% by 2045. The primary drivers for solar development include existing Public Utility Regulatory Policies Act (PURPA) policy, planned requests for proposal (RFPs), solar resources, solar costs, and the previous state tax credit.

Source: S&P Global Energy

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## RPS and NEM policy assumptions by state (continued)

| State net energy metering assumptions |                                                     |                                                                                                                                                              | NEM cap                                                                                                                                                                                                                                                                                                       | NEM system size limits                                                                                                                                                                                                                                                                                                                                                                                |
|---------------------------------------|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| State                                 | Utility/territory                                   |                                                                                                                                                              |                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                       |
| DE                                    | All utilities                                       |                                                                                                                                                              | 8% of the capacity needed to meet the electric utility's average Delaware transmission peak demand (utilities may increase limit). Utilities are authorized to disallow additional net-metered energy systems if the aggregate capacity of all net-metered systems exceeds 8% for a particular calendar year. | For all systems designed to produce no more than 110% of expected aggregate electrical consumptions, subject to limits by rate class: 25 kW (residential), 2 MW (Delmarva nonresidential), 500 kW (DEC, DEMEC nonresidential), 150 kW (farms on residential rates, waivers possible for larger systems depending on usage)<br>For 2024 and thereafter, no more than 200% of historical 12-month usage |
| DC                                    | Potomac Electric Power Co (Pepco)                   |                                                                                                                                                              | No cap                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                       |
| MD                                    | All utilities                                       |                                                                                                                                                              | 3,000 MW                                                                                                                                                                                                                                                                                                      | 2 MW or 200% of customer load                                                                                                                                                                                                                                                                                                                                                                         |
| NJ                                    | Investor-owned utilities (IOUs), electric suppliers | No cap (soft cap 5.8% of retail sales)*                                                                                                                      |                                                                                                                                                                                                                                                                                                               | 100% of customer load                                                                                                                                                                                                                                                                                                                                                                                 |
| OH                                    | IOUs                                                | No cap                                                                                                                                                       |                                                                                                                                                                                                                                                                                                               | Not to exceed 120% of customer annual average load                                                                                                                                                                                                                                                                                                                                                    |
| PA                                    | IOUs                                                | No cap                                                                                                                                                       |                                                                                                                                                                                                                                                                                                               | 50 kW (residential), 3 MW (nonresidential), 5 MW (microgrids)                                                                                                                                                                                                                                                                                                                                         |
| WV                                    | All utilities                                       | 3% of peak demand during previous year                                                                                                                       |                                                                                                                                                                                                                                                                                                               | 5 kW (residential), 2 MW (industrial for large IOUs), 1 MW (commercial for large IOUs), 50 kW (C&I for small IOUs)                                                                                                                                                                                                                                                                                    |
| IN                                    | IOUs                                                | No cap (previous 1.5% aggregated cap eliminated with the transition to net billing) **                                                                       |                                                                                                                                                                                                                                                                                                               | 1 MW, not to exceed customer's 12-month usage                                                                                                                                                                                                                                                                                                                                                         |
| IL                                    | IOUs, retail suppliers                              | Removed the NEM cap, but included a cap date of December 31, 2024 or whenever new compensation values are approved, whichever is sooner                      |                                                                                                                                                                                                                                                                                                               | 5 MW, systems must be sized to meet on-site electrical needs                                                                                                                                                                                                                                                                                                                                          |
| KY                                    | IOUs, electric cooperatives except TVA              | 1% of utility's peak load in prior year                                                                                                                      |                                                                                                                                                                                                                                                                                                               | 45 kW                                                                                                                                                                                                                                                                                                                                                                                                 |
| MI                                    | All utilities                                       | 10% of utility average in-state peak load, 50% of which is allocated to systems >20kW but less than 550kW                                                    |                                                                                                                                                                                                                                                                                                               | 550 kW, or ≤ 110% of customer load                                                                                                                                                                                                                                                                                                                                                                    |
| NC                                    | IOUs, electric suppliers                            | No aggregate cap limit (customer-owned systems)<br>Leased Photovoltaic Systems: 1% of the utility's previous five-year average coincident retail peak demand |                                                                                                                                                                                                                                                                                                               | 5 MW or ≤100% of contract demand (customer-owned); lower limits for leased systems (residential: lesser of 20 kW or 100% estimated demand / non-residential: lesser of 1 MW or 100% of contract demand)                                                                                                                                                                                               |
| VA                                    | IOUs, electric cooperatives                         | 1% of in-state peak load                                                                                                                                     |                                                                                                                                                                                                                                                                                                               | 25 kW (residential), 3 MW (nonresidential), Agricultural: 500 kW (aggregated capacity), up to 100% of expected demand                                                                                                                                                                                                                                                                                 |
| TN                                    | N/A                                                 | N/A                                                                                                                                                          |                                                                                                                                                                                                                                                                                                               | N/A                                                                                                                                                                                                                                                                                                                                                                                                   |

Note: \*While no mandatory cap exists, it is at the discretion of the NJBPU to cap at 5.8% of retail sales. \*\*As of July 2022, the Indiana Utility Regulatory Commission has approved four utilities in Indiana to transition from net metering to a new lower rate known as "excess distribution generation" and proposed to instantaneous netting rather than monthly net metering.



# RPS and NEM policy assumptions by state (continued)

## State net energy metering assumptions

| State | NEM remuneration for on-site use or export generation*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | NEG remuneration**                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Community solar                                                                                                                                                                                  |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DE    | Retail (For commission-regulated utilities, retail does not include the societal benefits charges). Excess generation credits set to the volumetric supply and distribution service charges for all customers and shall not reduce any fixed monthly distribution charges                                                                                                                                                                                                                                                                                                                         | Monthly carryover at the utility's retail rate. At the end of the annualized billing period, excess kWh credits shall revert to the electric distribution company and are not reimbursed, credited or otherwise remunerated. Excess kWh credits do not include charges for the societal benefits program                                                                                                                                                            | Virtual net metering. Subscribers to the output of a community system receive retail credit if they are located on the same distribution feeder as the facility. If not, receive wholesale rate. |
| DC    | Retail                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Carries over at retail rate (generation, transmission and distribution components) indefinitely for systems 100 kW or less, at generation rate for systems up to 1 MW***                                                                                                                                                                                                                                                                                            | Virtual net metering (less than 5 MW)                                                                                                                                                            |
| MD    | Retail                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Credited to customer's next bill at retail rate; reconciled annually in April at the commodity energy supply rate or can be accrued indefinitely                                                                                                                                                                                                                                                                                                                    | Virtual net metering (less than 5 MW), individual subscriptions capped at 200kW and credits cannot exceed 200% of subscribers baseline annual usage                                              |
| NJ    | Base \$85 SREC-II price (\$0.085/kWh), non-residential rooftop < 1MW receives \$110, 1-5MW receives \$100 SREC-II, non-residential ground mount <1MW receives \$90, 1-5MW receives \$85 ****                                                                                                                                                                                                                                                                                                                                                                                                      | Monthly carryover. At the end of the annualized period customer is compensated at the avoided-cost of wholesale power.                                                                                                                                                                                                                                                                                                                                              | Up to 5 MW receives \$90 SREC-II (\$0.09/kWh)                                                                                                                                                    |
| OH    | Less than retail                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Credited to next bill at unbundled generation rate (includes energy component but excludes capacity-related compensation)                                                                                                                                                                                                                                                                                                                                           | None                                                                                                                                                                                             |
| PA    | Retail                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Credited at retail rate for a year, then any leftover excess is credited at generation and transmission portion of the retail rate, but not the distribution                                                                                                                                                                                                                                                                                                        | Virtual meter aggregation*****                                                                                                                                                                   |
| WV    | Retail (credits cannot reduce monthly bills below the fixed monthly charge)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Retail, perpetual rollover, no annual true up                                                                                                                                                                                                                                                                                                                                                                                                                       | Virtual net metering                                                                                                                                                                             |
| IN    | Full retail through 2047 for net metering facilities installed by 2017 and through 2032 for those installed by 2022; 125% of average energy market price for facilities installed after 2022. Per SB 309, retail rate net metering has been phased out by July 2022.                                                                                                                                                                                                                                                                                                                              | Full retail through 2047 for net metering facilities installed by 2017 and through 2032 for those installed by 2022. Net billing thereafter determined by instantaneous comparison of generation and consumption. Excess kWh credited at 125% of avoided cost (1.25 x the locational marginal price (LMP) for the applicable utility). NEG credits rollover indefinitely. If a customer elects to cease net metering, any unused credit will revert to the utility. | None                                                                                                                                                                                             |
| IL    | Retail (TOU for customers paying TOU rates)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Non-competitive customers: Credited to customer's next bill as a credit based on electricity supply components of retail rate; granted to utility at end of a 12-month billing cycle<br>Competitive customers: Credited to customer's next bill as a kWh credit at electricity provider's avoided cost of electricity supply over the monthly period.                                                                                                               | Virtual net metering                                                                                                                                                                             |
| KY    | Less than retail                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Utility will purchase all electricity produced at the rate set by the PSC, instead of the retail rate                                                                                                                                                                                                                                                                                                                                                               | Utility-run program                                                                                                                                                                              |
| MI    | Retail                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Retail for systems <20kW, for systems >20kW, credited at power supply component of rate.                                                                                                                                                                                                                                                                                                                                                                            | None                                                                                                                                                                                             |
| NC    | Retail, for existing. Starting on October 1, 2023 current NEM rider replaced with Residential Solar Choice (Rider RSC) and Net Metering Bridge (Rider NMB), Rider RSC requires TOU Pricing, minimum monthly bills, non-bypassable charges, and grid access fees for systems above 15kW-ac. Rider NMB will be available for a limited number of new customers annually for three years and will not require TOU rates. Customers on Rider NMB can stay on that rate for 15 years, before switching to Rider RSC. Existing net metering customers will be switched to Rider NMB on January 1, 2027. | Perpetual rollover<br>Systems installed prior to October 1, 2023: Credited to customer's next bill at retail rate; granted to utility at beginning of summer billing season<br>Systems installed on or after October 1, 2023: Monthly net excess generation credited at the avoided cost rate<br>Production and consumption are netted on a monthly basis. For customers on a time-of-use tariff, netting will occur separately within each time period.            | Utility-run program                                                                                                                                                                              |
| VA    | Retail                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Retail                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Utility-run program                                                                                                                                                                              |
| TN    | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | None                                                                                                                                                                                             |

Note: \*NEM remuneration is a tariff structure under which the utility pays customers for excess generation, up to a given amount. The most common arrangement is "full retail rate NEM", in which excess generation is paid the same volumetric price that the customer pays for electricity; so, exports are effectively netted against grid consumption over a given period (typically one year). \*\*NEG over that period is sometimes paid at a lower rate, often based on the utility's avoided cost. \*\*\*Production and consumption are netted on a monthly basis. \*\*\*\*SREC-II replaced the transition program (TREC). \*\*\*\*\*Virtual meter aggregation is limited to the account holder's meters and only those within two miles of the POI.

## RPS and NEM policy assumptions by state (continued)

| State C&I procurement assumptions |                                         |                                  |  | Renewable energy offerings from utilities or electric suppliers/green tariff | Production for self-consumption—net metering                                             |
|-----------------------------------|-----------------------------------------|----------------------------------|--|------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| State                             | Unbundled energy attribute certificates | Virtual power purchasing allowed |  |                                                                              |                                                                                          |
| DE                                | Allowed                                 | Allowed                          |  | Retail choice                                                                | Up to 2 MW                                                                               |
| DC                                | Allowed                                 | Allowed                          |  | Retail choice                                                                | Up to 1 MW                                                                               |
| MD                                | Allowed                                 | Allowed                          |  | Retail choice                                                                | Up to 2 MW                                                                               |
| NJ                                | Allowed                                 | Allowed                          |  | Retail choice                                                                | Cannot exceed on-site load                                                               |
| OH                                | Allowed                                 | Allowed                          |  | Retail choice                                                                | No size limit                                                                            |
| PA                                | Allowed                                 | Allowed                          |  | Retail choice                                                                | Up to 3 MW, 5 MW for microgrids                                                          |
| WV                                | -                                       | Allowed                          |  | -                                                                            | Up to 2 MW                                                                               |
| IN                                | -                                       | -                                |  | Utility green tariffs / riders are available but utility-specific            | Lesser of 1 MW or the customer's average annual electricity consumption (customer-owned) |
| IL                                | Allowed                                 | Allowed                          |  | Retail choice                                                                | Up to 5 MW                                                                               |
| KY                                | Voluntary                               | -                                |  | Green tariff enabled                                                         | Up to 45 kW                                                                              |
| MI                                | Allowed                                 | -                                |  | -                                                                            | 1 MW                                                                                     |
| NC                                | Allowed                                 | Allowed*                         |  | Green tariff in development                                                  | Customer-owned: Up to 5 MW or 100% contracted demand (1 MW if leased system)             |
| VA                                | Allowed                                 | Allowed**                        |  | Green tariff enabled                                                         | Up to 1 MW                                                                               |
| TN                                | -                                       | -                                |  | -                                                                            | -                                                                                        |

Note: Green tariffs only include programs where utilities build new renewables on behalf of corporate customers. \*In specific utilities \*\*for agricultural sites and school districts up to 10 MW

Source: S&P Global

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# Federal and regional energy storage policy assumptions

| Federal and regional energy storage policy assumptions |                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------------------------------------|------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Category                                               | Policy                                         | Base case                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Federal                                                | Investment Tax Credit (ITC)                    | Under the One Big Beautiful Bill Act (OBBA) section 48E ITC, projects that begin construction until the end of 2033 qualify for 100% of the 30% ITC, after which it phases down to 75% credit (22.5%) available in 2034, 50% credit (15%) in 2035, and 0% thereafter. Projects over 1 MW automatically receive a base tax credit of 6% and can qualify for the full 30% tax credit if prevailing wage and apprenticeship requirements are met. Battery projects that start construction in January 2026 or thereafter are subject to the Foreign Entity of Concern (FEOC) restrictions and the material assistance cost ratio. |
| Regional                                               | PJM capacity market (as applicable to battery) | Assume Minimum Offer Price Rule (MOPR) is revised<br>All other existing market rules, including updated ELCC values, remain in place over forecast period                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| State/city                                             | Energy storage targets                         | Remain in current form                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| State                                                  | Tax credits                                    | Remain or expire as currently scheduled                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| State                                                  | Incentives (e.g., rebates)                     | Assume VA and NJ utilities roll out an incentive program for BTM batteries in effort to comply with state target. Other states remain unchanged                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Source: S&P Global                                     |                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
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## Battery policies by state

| Detailed state energy storage policy assumptions |                                                                |                                                                                                                                                                                                                                                                                                         |
|--------------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| State                                            | Energy Storage Target (MW)                                     | Tax Credits and rebate programs                                                                                                                                                                                                                                                                         |
| DE                                               |                                                                |                                                                                                                                                                                                                                                                                                         |
| DC                                               |                                                                |                                                                                                                                                                                                                                                                                                         |
| MD                                               | 750 MW by 2027, 1.5 GW by 2030, 3 GW by 2023                   |                                                                                                                                                                                                                                                                                                         |
| NJ                                               | 2 GW by 2030                                                   | 30% tax credit*                                                                                                                                                                                                                                                                                         |
| OH                                               |                                                                |                                                                                                                                                                                                                                                                                                         |
| PA                                               |                                                                |                                                                                                                                                                                                                                                                                                         |
| WV                                               |                                                                |                                                                                                                                                                                                                                                                                                         |
| IN                                               |                                                                |                                                                                                                                                                                                                                                                                                         |
| IL                                               |                                                                | Rebate programs (typically for systems below 5 MW):<br>ComEd: Commercial and community solar: \$250/kWh for battery associated with eligible DG facility;<br>Residential and small commercial: \$300/kWh for battery associated with eligible DG facility; Ameren Illinois: \$250-300/kW-DC for battery |
| KY                                               |                                                                |                                                                                                                                                                                                                                                                                                         |
| MI                                               | 2.5 GW by 2029                                                 |                                                                                                                                                                                                                                                                                                         |
| NC                                               |                                                                |                                                                                                                                                                                                                                                                                                         |
| VA                                               | 2.7 GW by 2035 (Dominion), 400 MW by 2035 (APCo)               | Rebate program: Battery Storage: \$400/kWh, max. incentive \$5,400 and max. system size: 13.5 kWh<br>Energy storage systems greater than 5 MW and less than 150 MW are exempt from sales tax.                                                                                                           |
| TN                                               | 2.4 GW by 2028 and 5.3 GW by 2038 (Tennessee Valley Authority) |                                                                                                                                                                                                                                                                                                         |

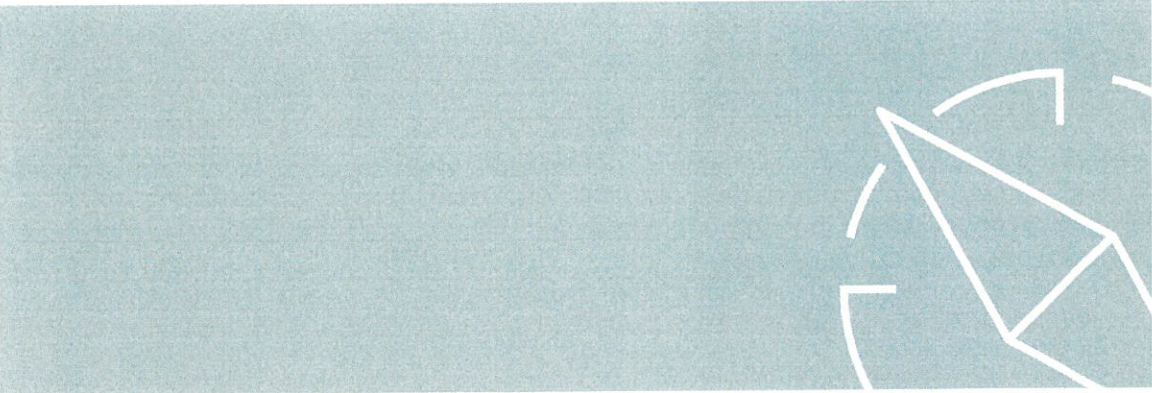
Note: \*Maryland Energy Administration (MEA) 2018 Energy Storage Tax Credit Program offered 30% tax credit of the total installation costs (up to \$5,000 for a residential project and \$75,000 for commercial). \*\* In May 2018, lawmakers passed legislation (S 2314/A 3723) to implement energy storage targets of 600 MW by 2021 and 2 GW by 2030 and requires the BPU to establish a process and mechanism for achieving these targets. \*\*\*The regulations instruct APCo and Dominion to construct or acquire 400 MW and 2,700 MW, respectively, of FTM energy storage resources by 2035. \*\*\*\*Indianapolis Power & Light's (IPL) 2019 IRP proposes replacing coal power with renewables and storage, amounting to approximately 240 MW based on an assumed installed capacity of 3 GW.

Note: \*Maryland Energy Administration (MEA) 2018 Energy Storage Tax Credit Program offered 30% tax credit of the total installation costs (up to \$5,000 for a residential project and \$75,000 for commercial). \*\* In May 2018, lawmakers passed legislation (§ 2314A 3723) to implement energy storage targets of 600 MW by 2021 and 2 GW by 2030 and requires the BPU to establish a process and mechanism for achieving these targets. \*\*\*The regulations instruct APCo and Dominion to construct or acquire 400 MW and 2,700 MW, respectively, of FTM energy storage resources by 2035. \*\*\*\*Indianapolis Power & Light's (IPL) 2019 IRP proposes replacing coal power with renewables and storage, amounting to approximately 240 MW based on an assumed installed capacity of 3 GW.

Source: S&P Global

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1. Scenario Assumptions

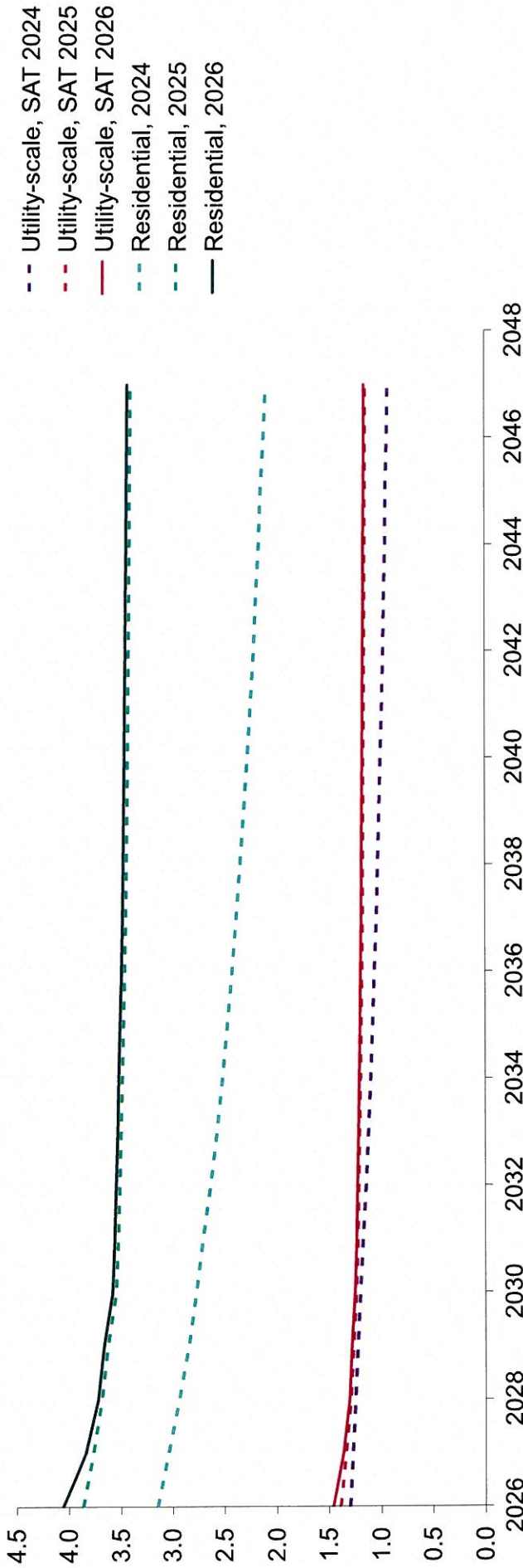
2. Policy Assumptions

**3. Capital Cost Assumptions**

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PJM solar capital costs are higher than the previous forecast, especially in the next 1-3 years

**PJM solar capital costs**  
Real 2025\$/Wac

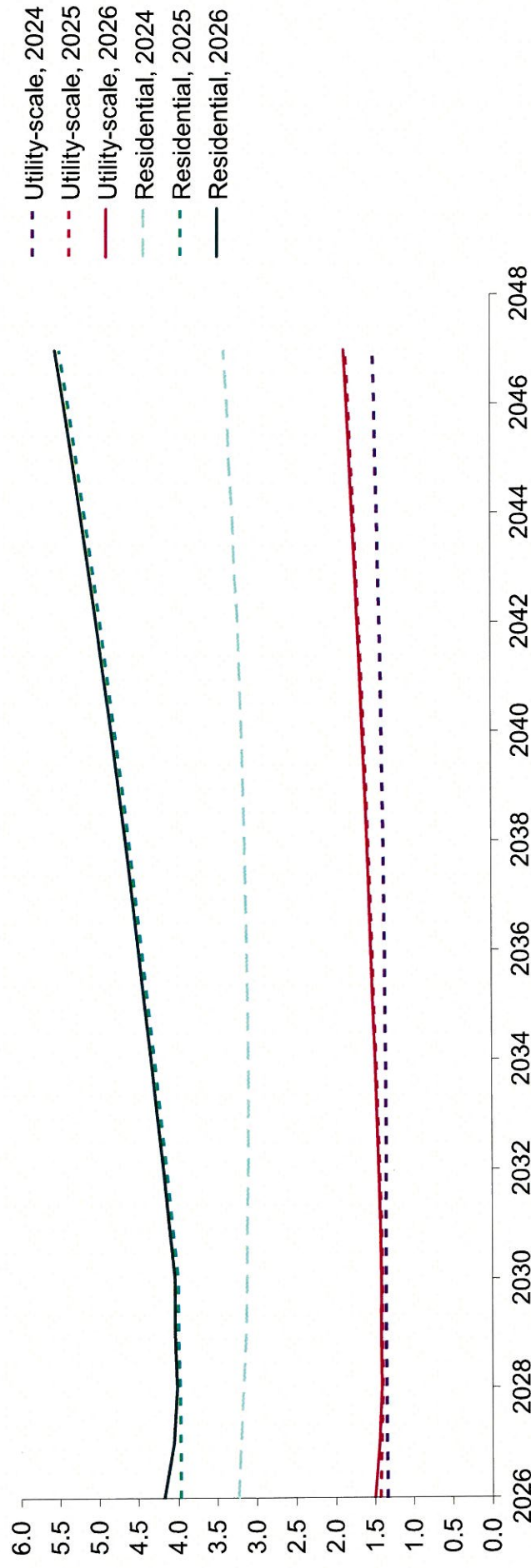




## PJM solar capital costs (nominal)

### PJM solar capital costs

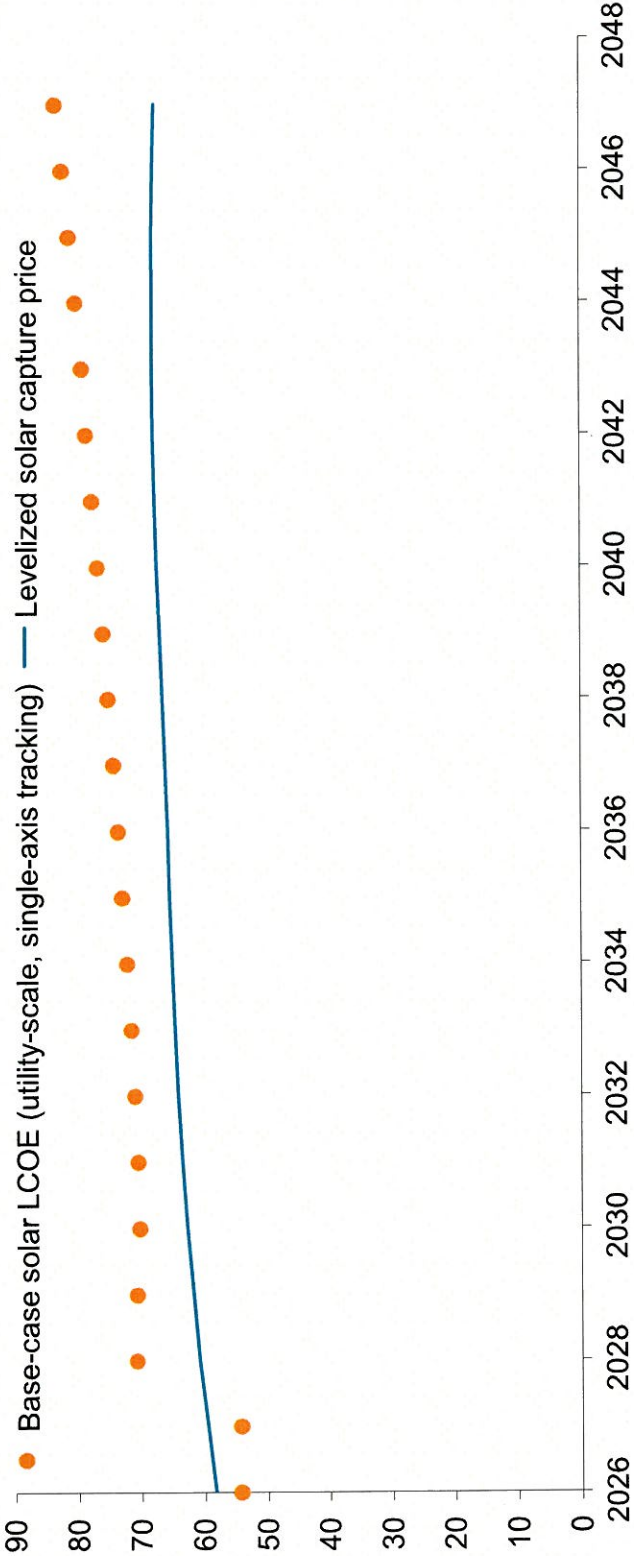
Nominal \$/Wac



# Utility scale solar economics illustrates the impact of the end of the tax credits on levelized costs starting in 2028

## PJM utility solar economics

Nominal \$/MWh



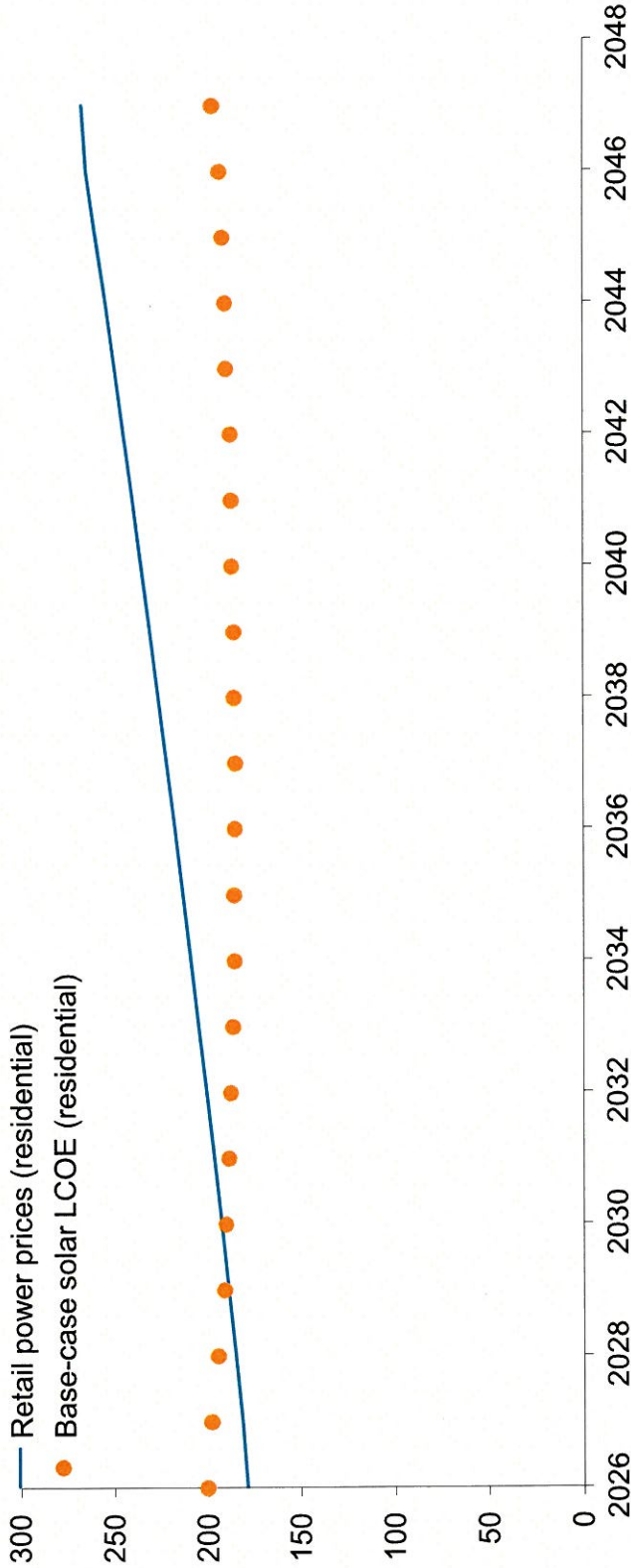
Captured energy prices to solar PV: simple average of PJM East, Dominion Hub, PJM AEP Dayton, PJM ConEd average annual wholesale power prices, In-house View H1 2026  
Source: S&P Global Energy  
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Residential solar economics demonstrate the attractiveness of homeowner systems, even after accounting for the impact of the ITC ending

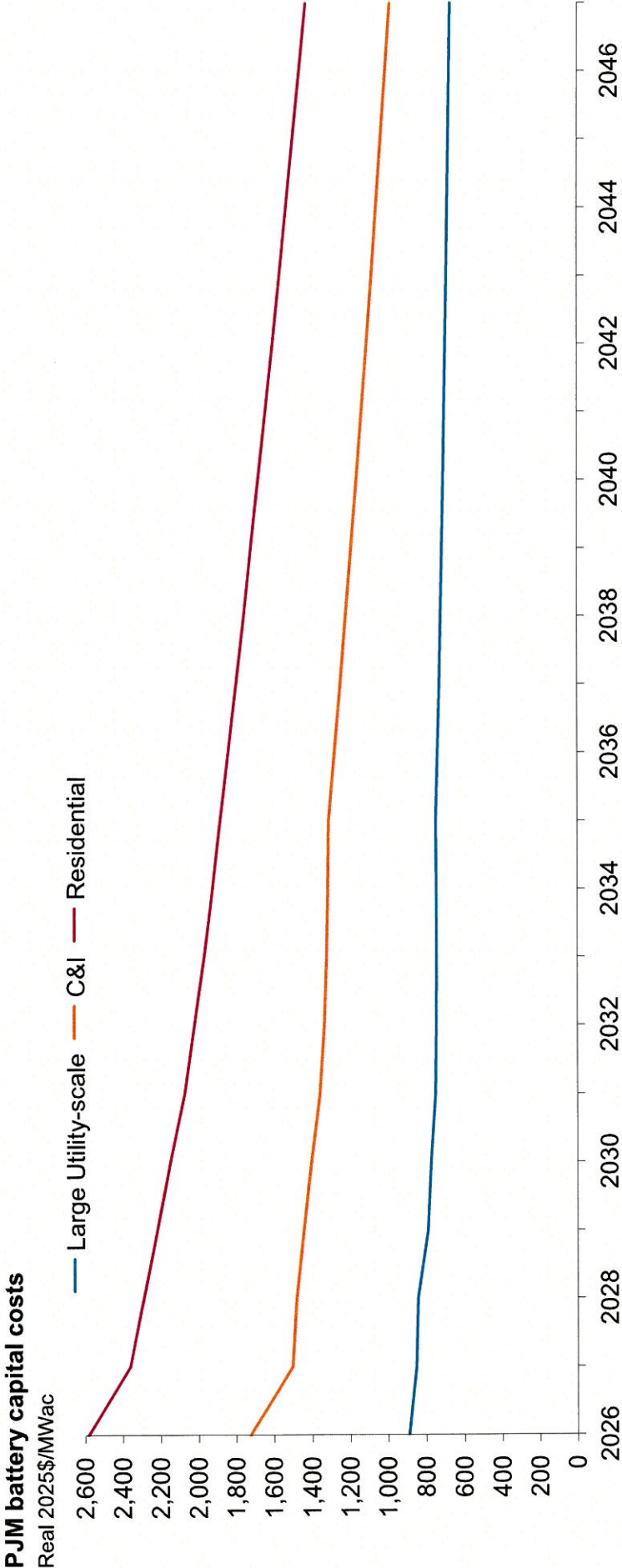
**PJM residential solar economics**

Nominal \$/MWh



Retail power prices (residential) from EIA Annual Energy Outlook 2023 Table 3, Mid-Atlantic Region  
Source: EIA and S&P Global Energy  
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Residential battery systems experience the greatest capex decline, driven by increasing scale and manufacturing efficiencies





# Representative levelized cost of capacity with the phase out of tax credits between 2034 and 2036

