

Power Markets Overview

Series 2

Electric Reliability Council of Texas

PS-AM PF Power & Renewables Team

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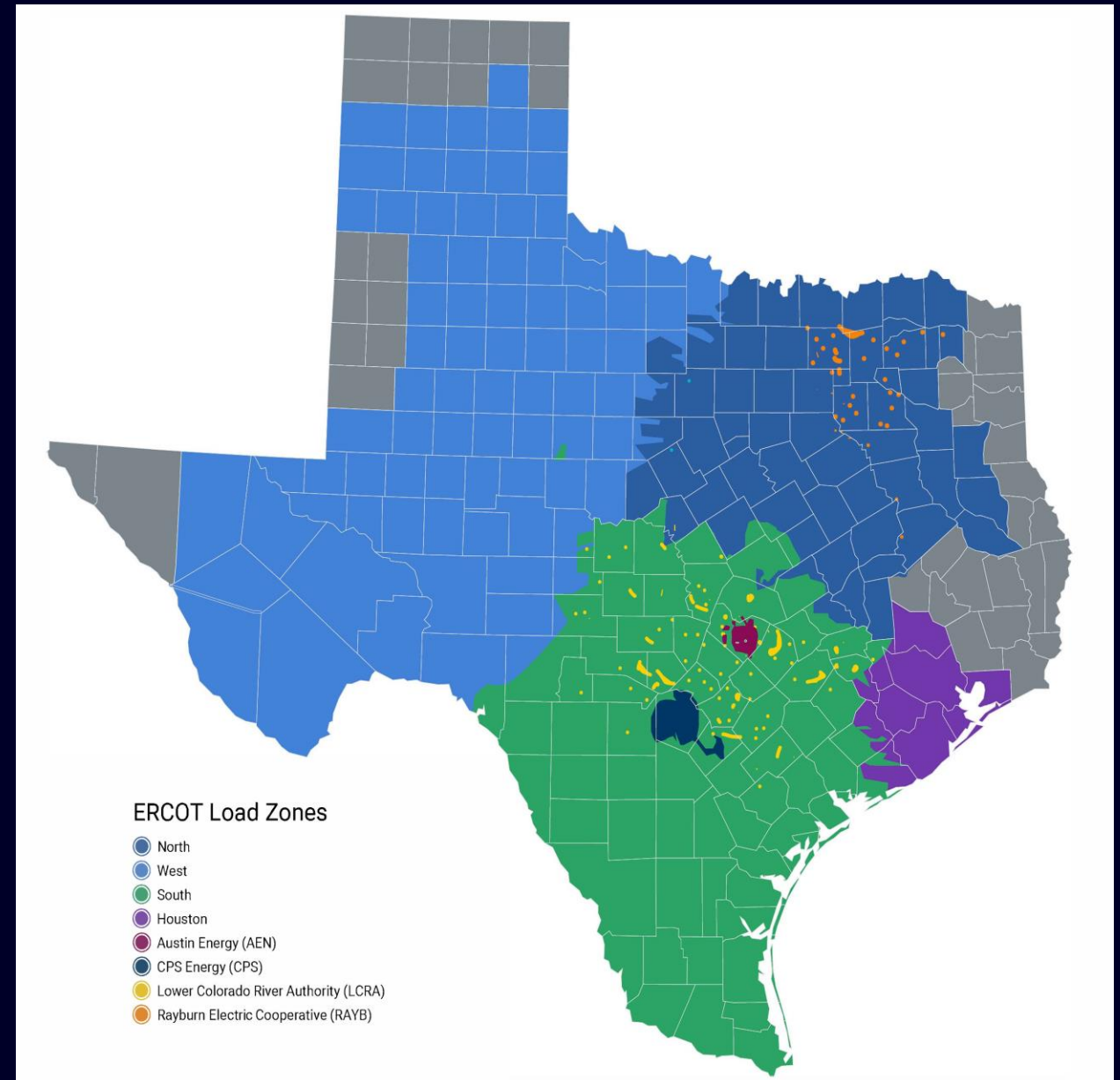
PS-AM PF Power & Renewables - Power Markets Overview (ERCOT)

- Electric Reliability Council of Texas (ERCOT) is the Independent System Operator (ISO) for the ERCOT Interconnection.
- ERCOT is one of 9 Independent System Operators (ISO) and/or Regional Transmission Operators (RTO) in North America
- ERCOT is non-profit organization responsible for the reliable transmission of electricity across the power grid, managing the flow of electricity to over 26 million customers.



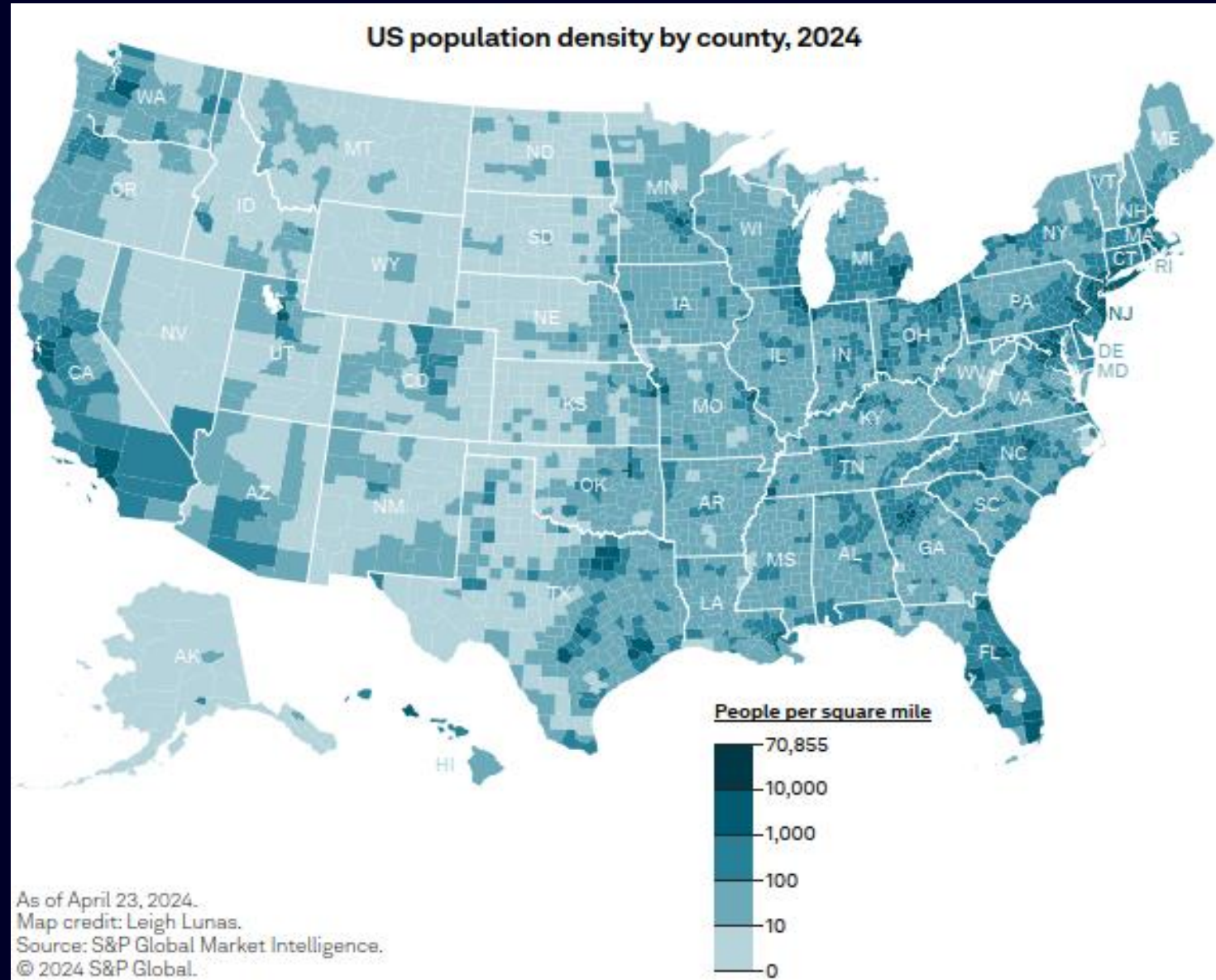
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- ERCOT serves approximately 90% of the electric load in Texas (75% of the Texas land area).
- ERCOT is an “independent” interconnection with the U.S. (i.e. it is not synchronized with the Eastern and Western Interconnections).
- ERCOT is not subject to oversight or regulation of the Federal Energy Regulatory Commission (“FERC”) and has limited interties to surrounding power regions.
- ERCOT is represented by four load zones consisting of North, West, South and Houston.



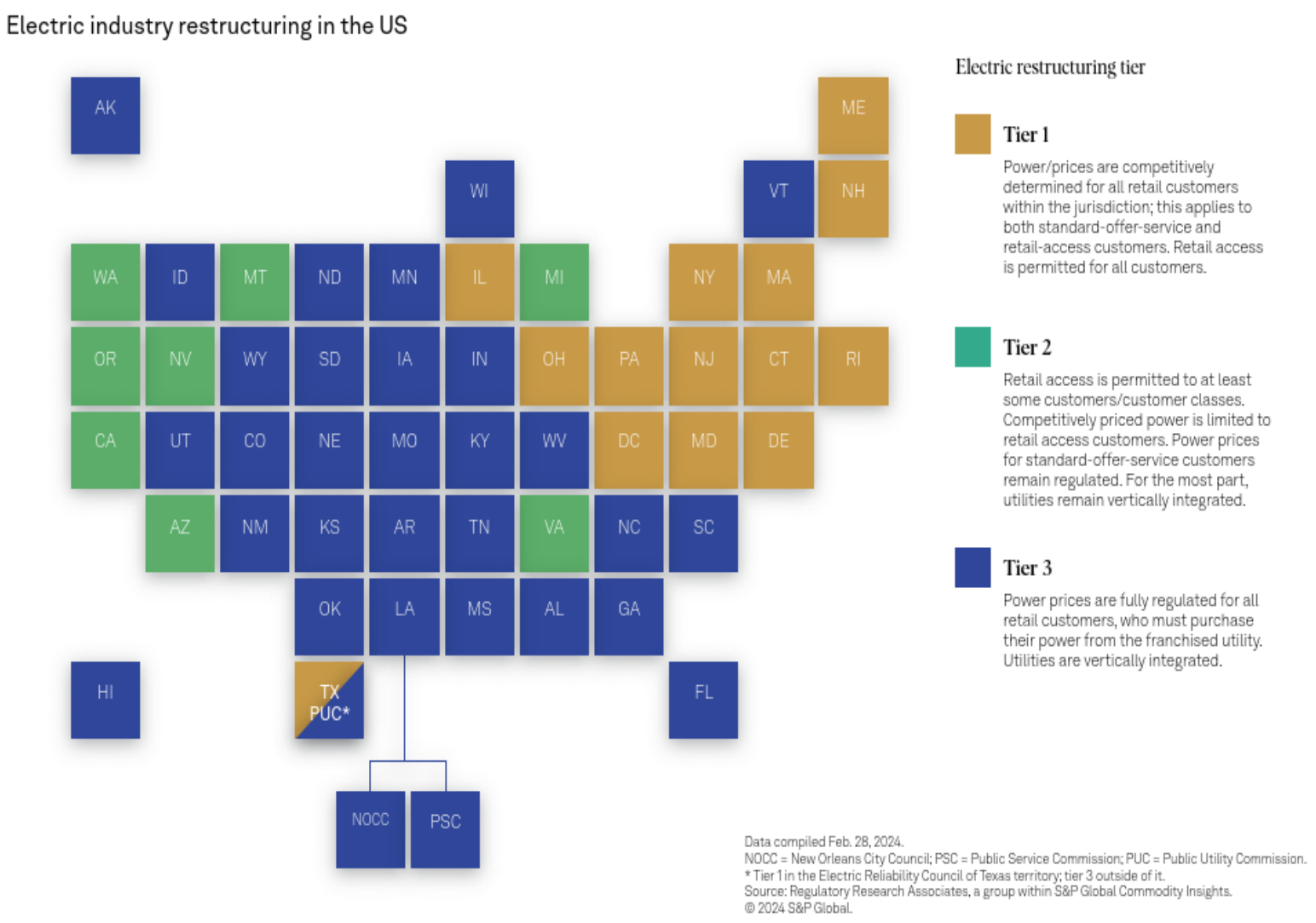
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- Texas has a population of ~31 million
- ~118% population growth since 1980
- Population is expected to reach ~47 million by 2050, 88.3% increase since 2010
- Its economy is the world's 8th largest
- It produces 9% of US gross domestic product (GDP) (20%+ of US exports; top state for 20+ years)



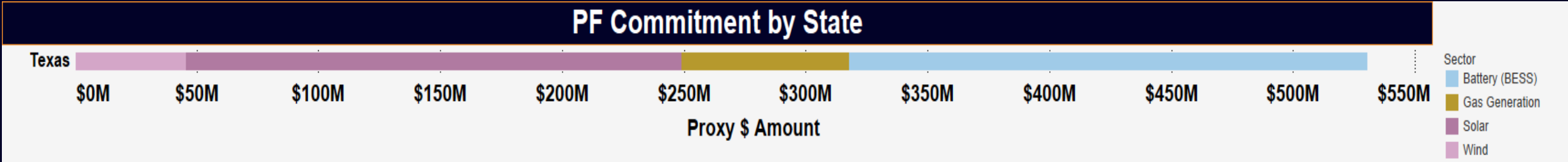
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- Senate Bill (SB) 373 deregulated the Texas wholesale electricity market in 1995.
- SB 7 deregulated the retail electricity market in 1999.
- Full retail choice became effective in 2002. Vertically-integrated utilities were “unbundled” (generation divested) and newly-formed Retail Electric Providers (REPs) were allowed to compete for customers and purchase wholesale power from the open market.
- Incumbent utilities continue to own and manage transmission/distribution systems.
 - ✓ *Exceptions are certain municipally-owned utilities, electric cooperatives and river authorities.*

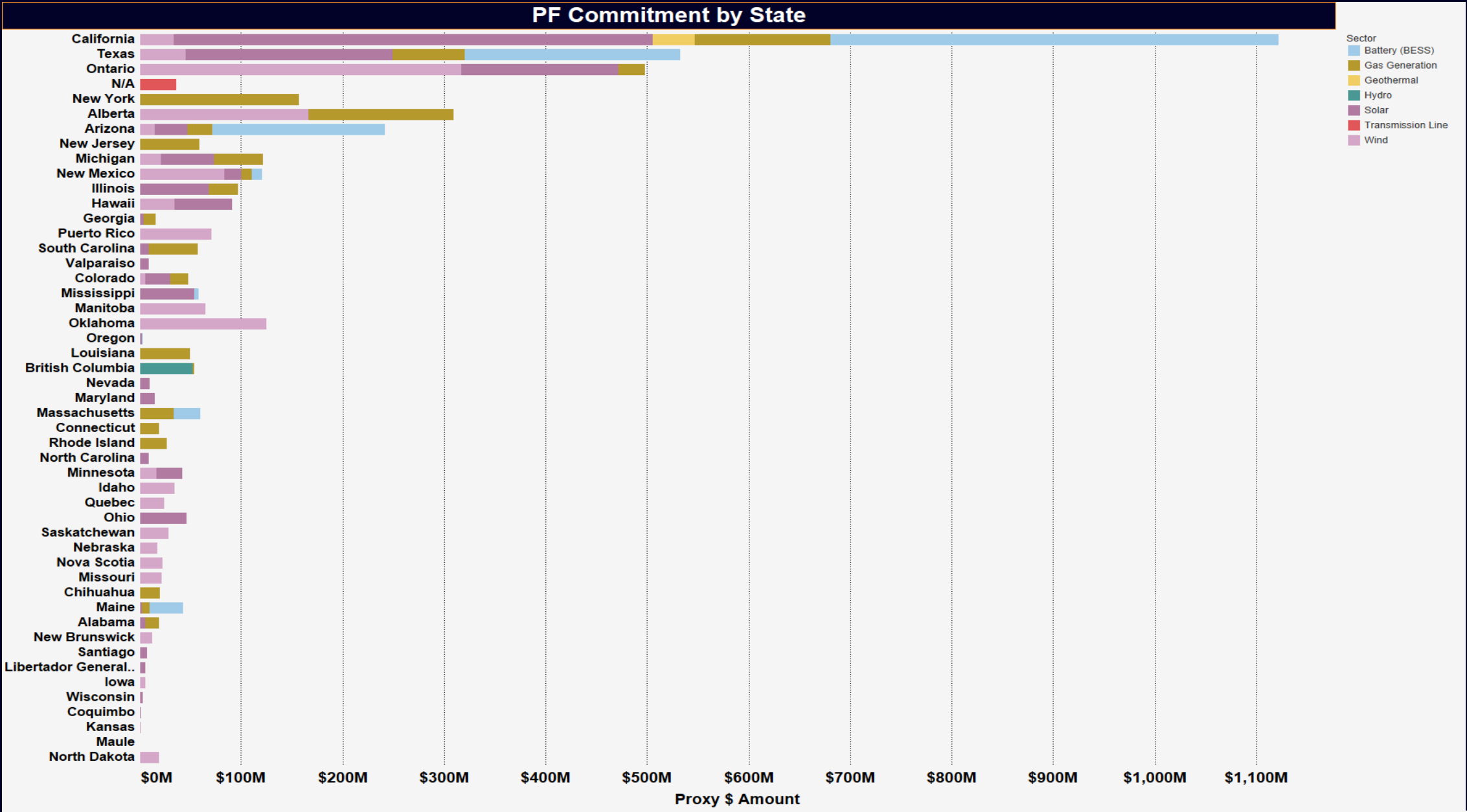


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- 23 Borrowers [15% of total PF Power & Renewables portfolio]
- \$575 million in Commitments [13% of total PF Power & Renewables portfolio]
 - 39% of Borrowers (41% of Commitments) - Solar/Solar+Battery Storage
 - 35% of Borrowers (39% of Commitments) - Standalone Battery Storage
 - 13% of Borrowers (12% of Commitments) - Thermal/Gas-Fired Power
 - 13% of Borrowers (8% of Commitments) - Wind

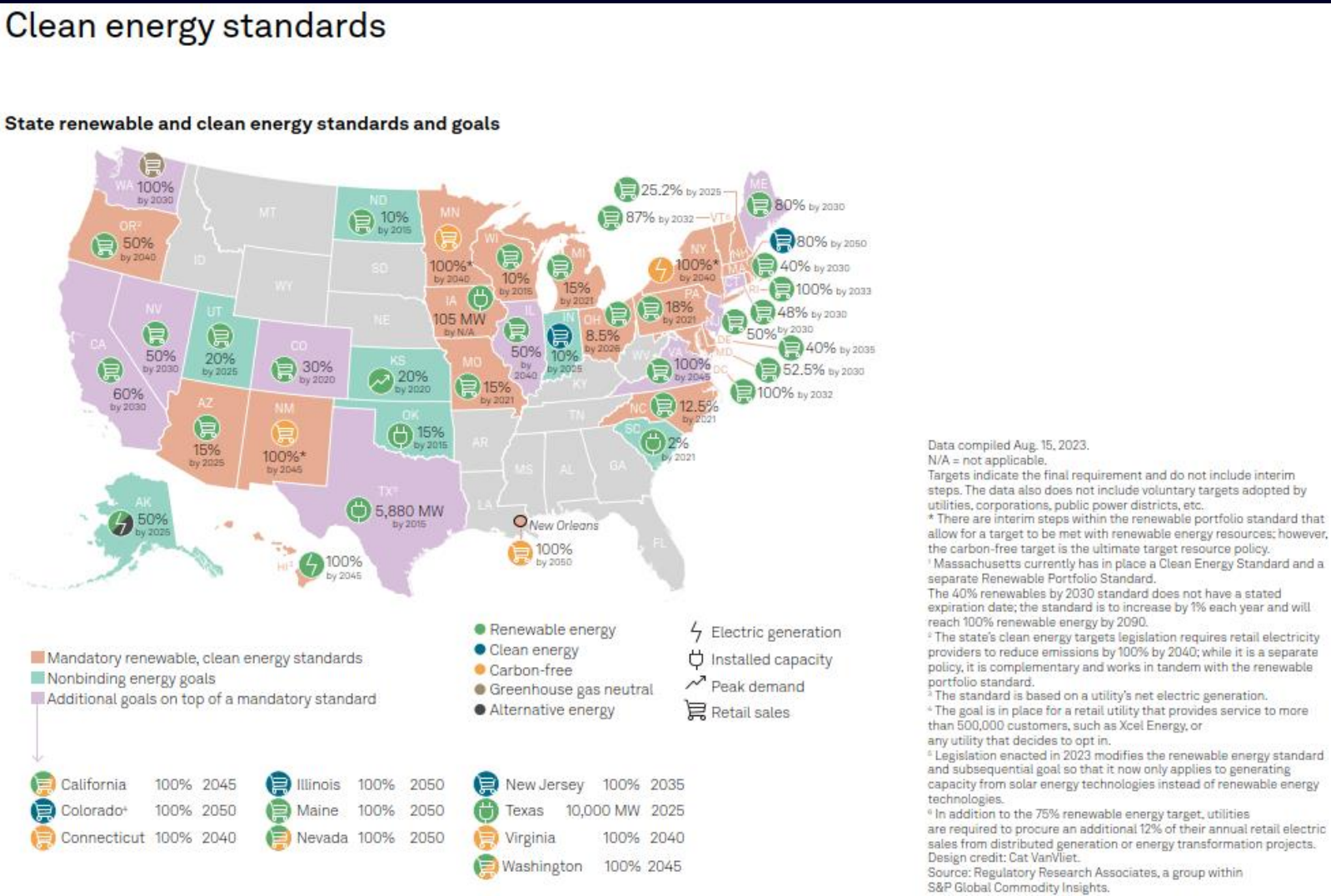


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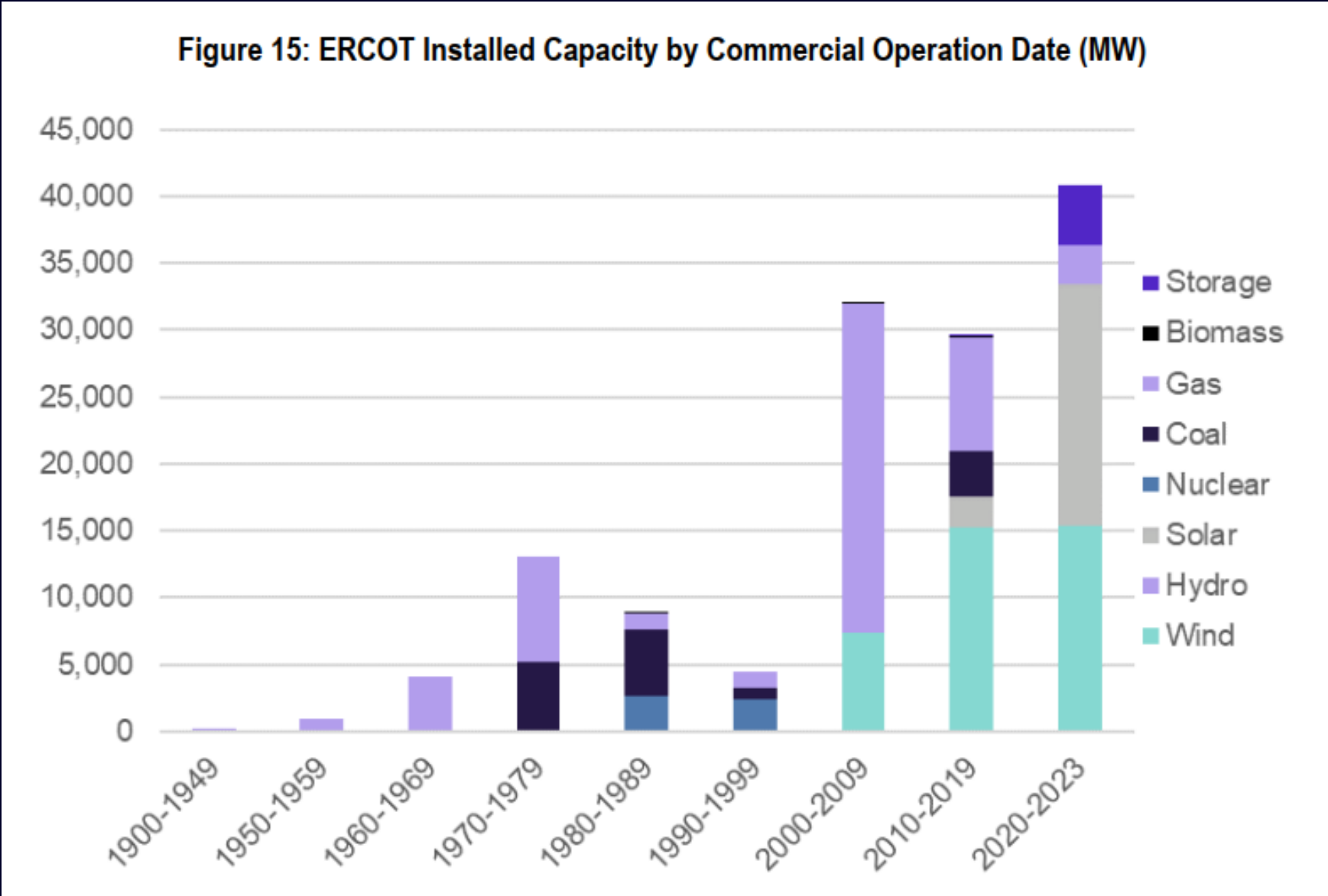
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- Texas' Renewable Portfolio Standard (RPS) program was established in 1999 by SB 7 with the initial requirement of 5.9GW of cumulative installed renewable capacity by 2015.
- The program was accelerated in 2005 with SB 20 which increased the target to 10GW by January 1, 2025.
- Texas surpassed the 2025 target in 2009.
- ERCOT (alone) has over 60GW of installed wind and solar capacity present-day.



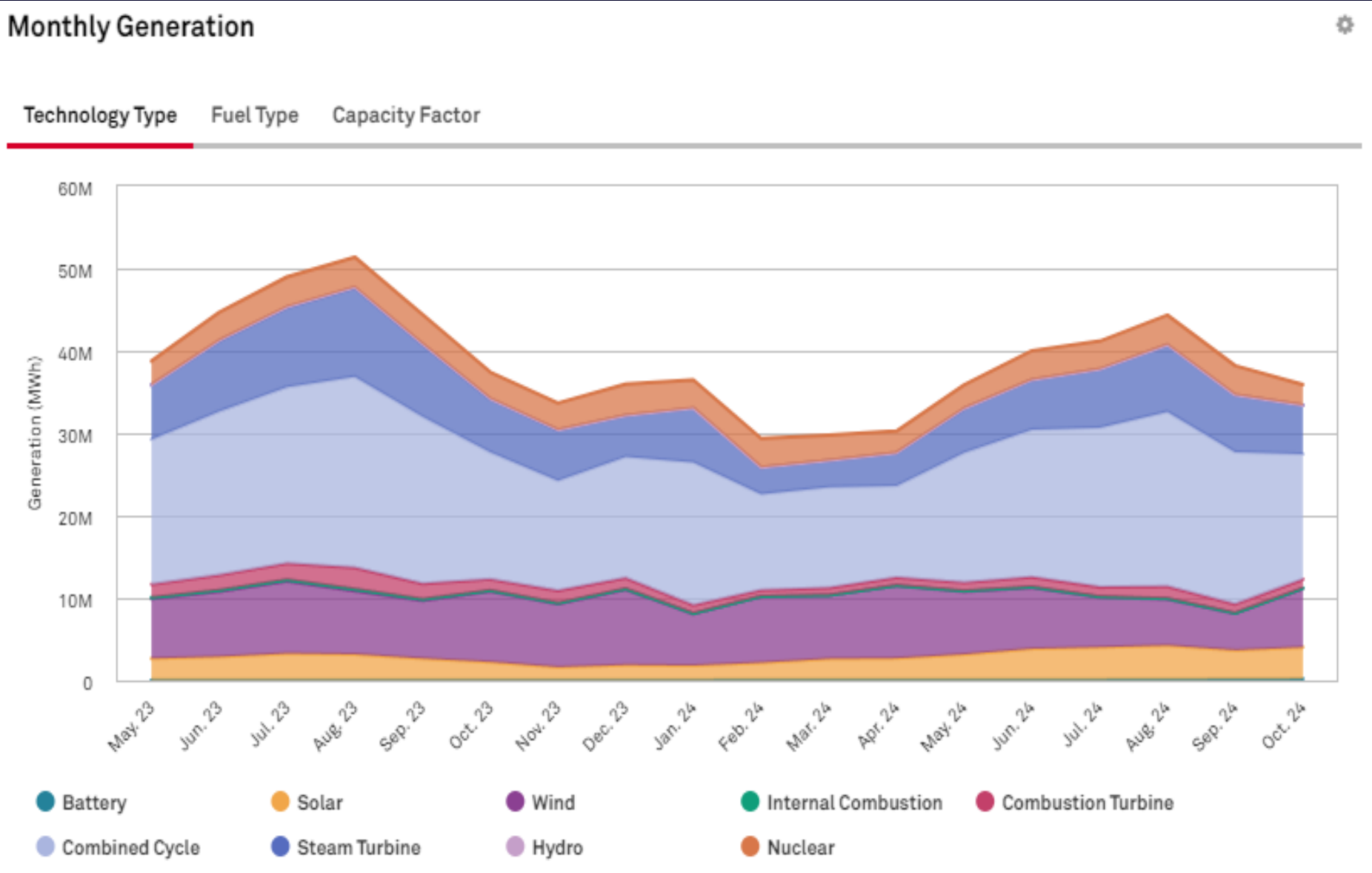
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- ERCOT is among the easiest places to develop renewables in the U.S.
- Ease and low cost of siting
- Ease of permitting
- Ease of interconnection
- Network upgrade costs across ERCOT are “socialized” across the entire customer base instead of being paid for by projects themselves.
- However, there is pitfalls to this as resources can face substantial market/congestion risk as congestion levels must be high enough to justify ERCOT’s construction of network upgrades. For example, there is significant congestion in the Texas panhandle as result of high number of interconnecting wind projects. This congestion and curtailment risk to cash flow security (even for projects which have offtake agreements, as generators typically take on basis risk in these agreements) is the key risk to clean energy deployment within ERCOT.



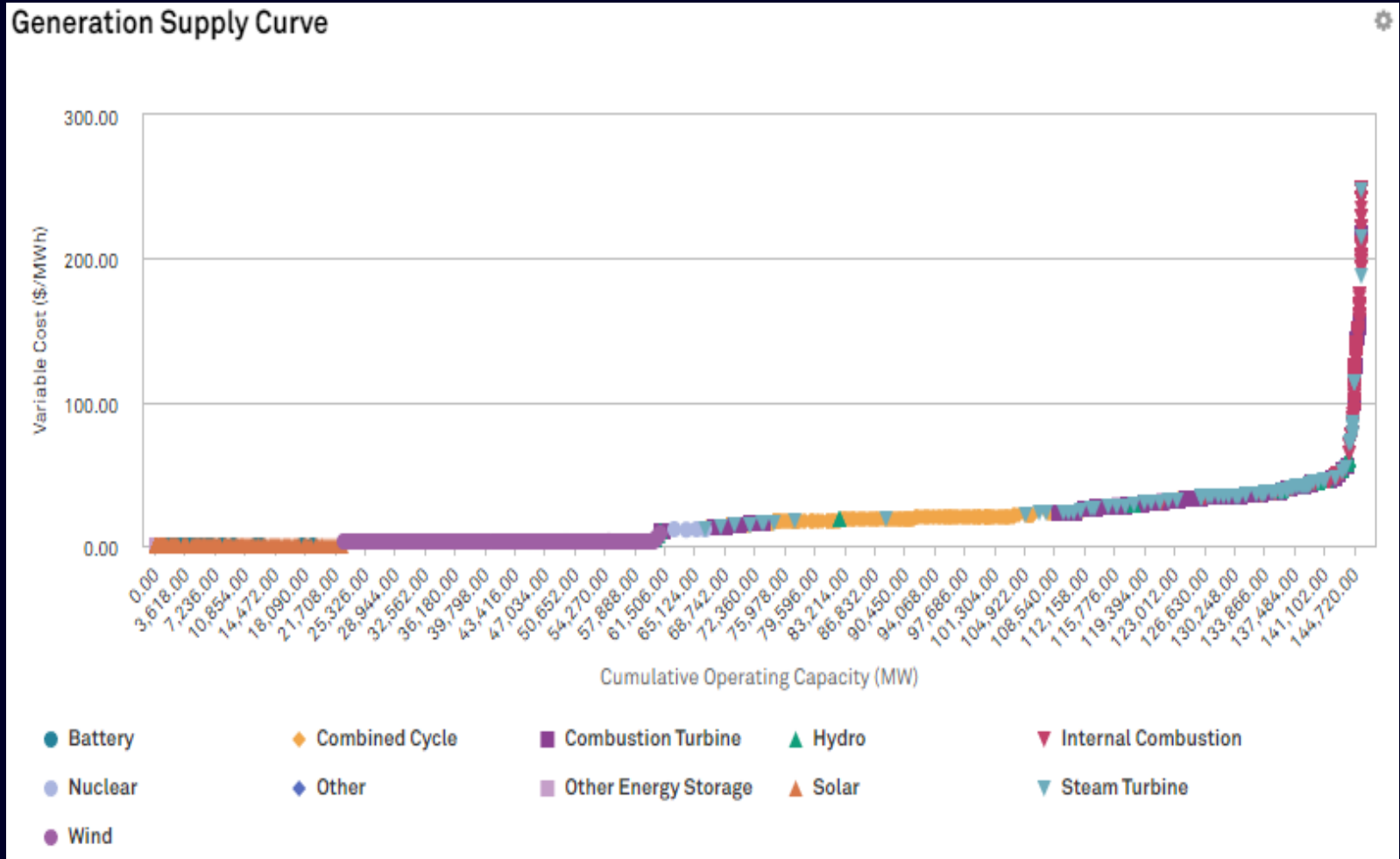
Source: Leidos Engineering, LLC

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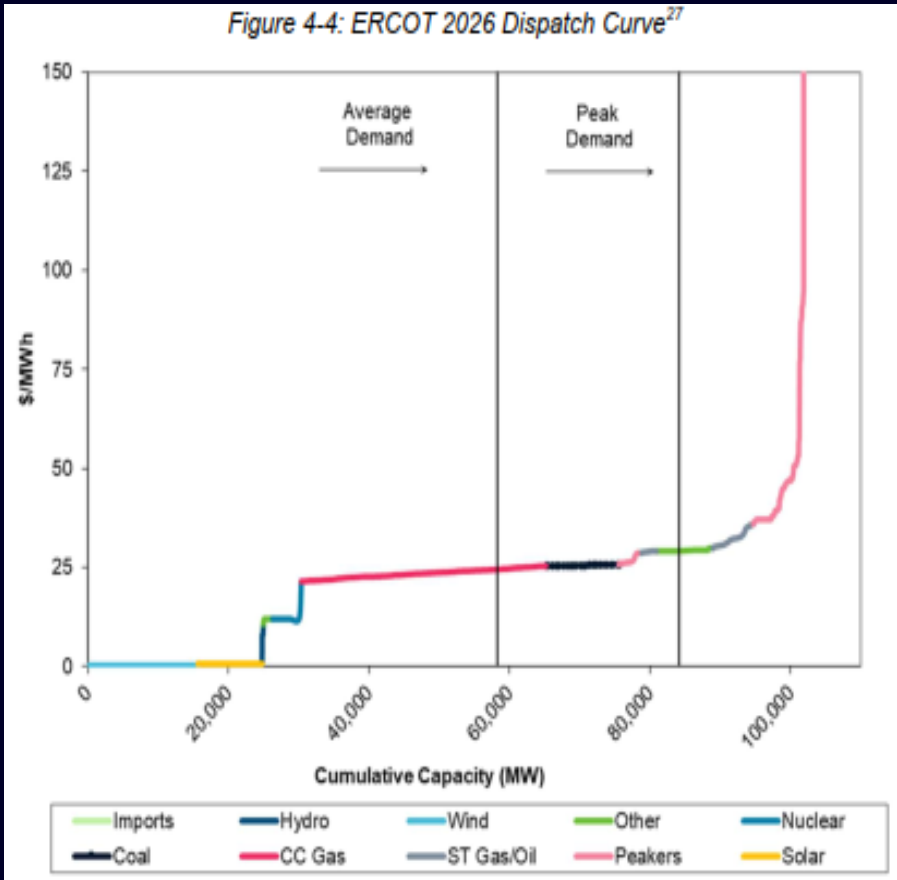


Source: S&P Global Market Intelligence

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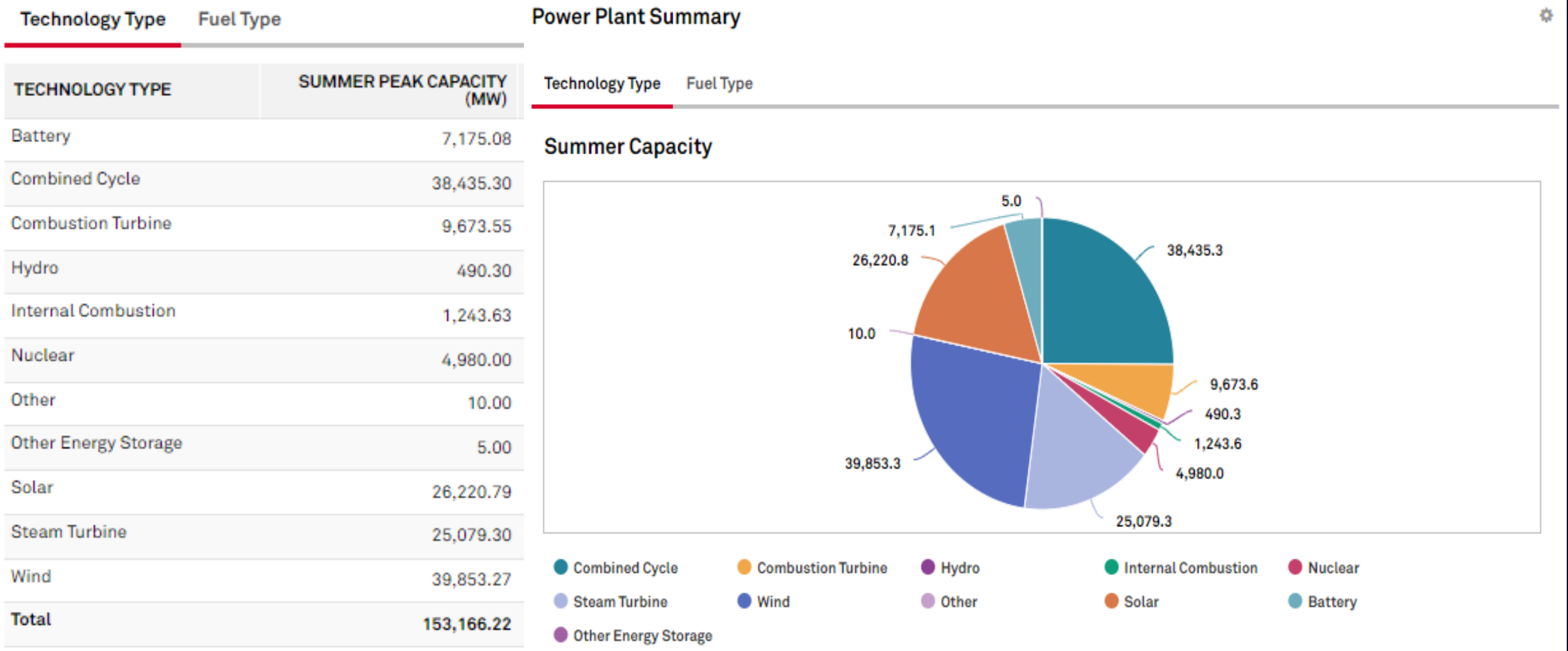


Source: S&P Global Market Intelligence



Source: PA Consulting Group Inc.

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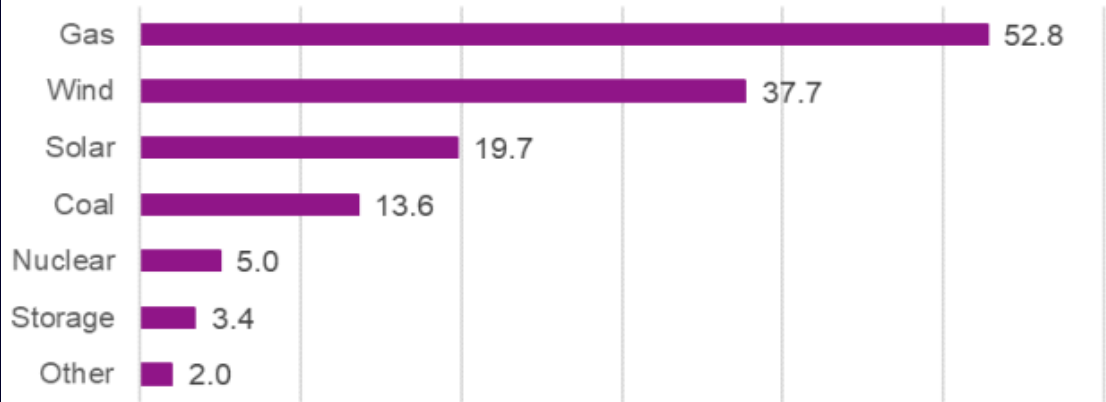


Source: S&P Global Market Intelligence

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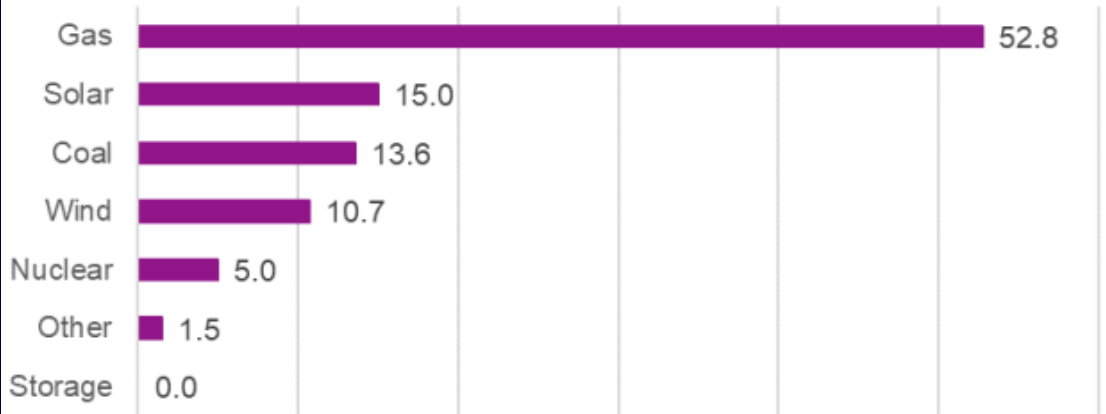
- For the purpose of calculating capacity contribution and reserve margin (13.75%, non-binding/non-enforceable), ERCOT discounts resources as follows:
 - ✓ Wind to 22% of its nameplate rating; West (panhandle) wind to 29% of its nameplate rating; South (coastal) wind to 60% its nameplate rating.
 - ✓ Solar to 76% of its nameplate rating.
 - ✓ BESS has no capacity contribution.

Figure 5: ERCOT Nameplate Capacity (GW)



Note: Natural gas estimate includes Private-Use Networks.

Figure 6: ERCOT Firm Capacity (GW)



Source: Leidos Engineering, LLC

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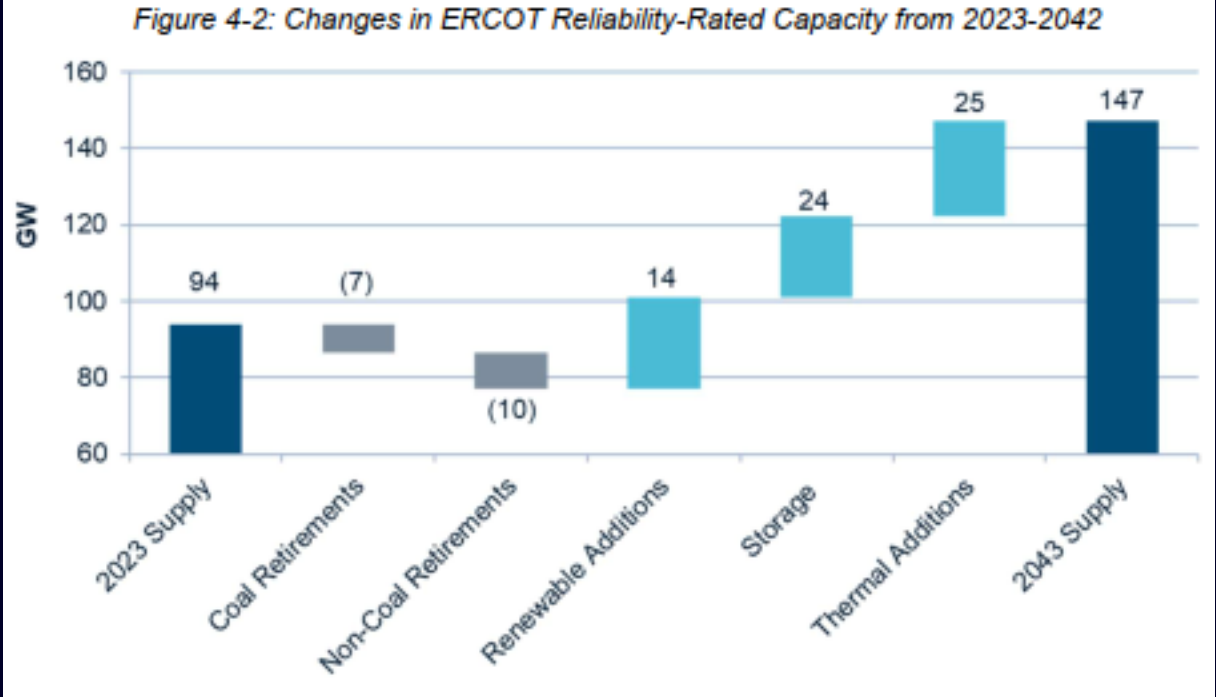
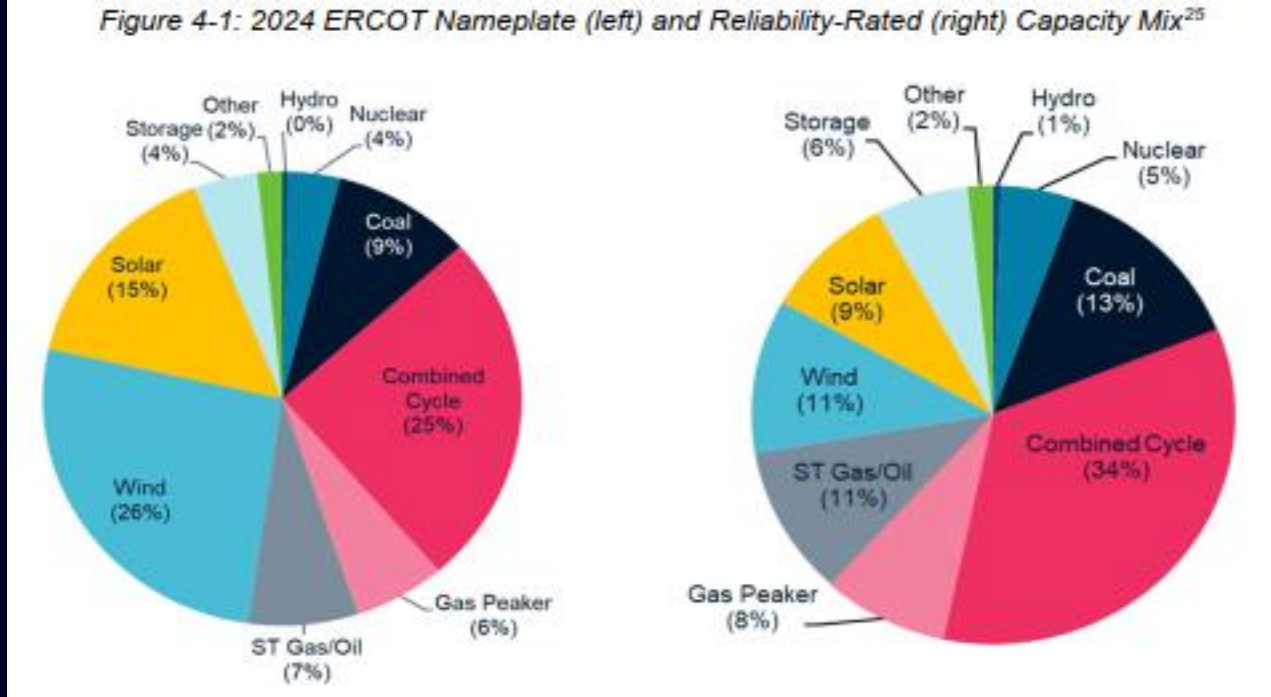
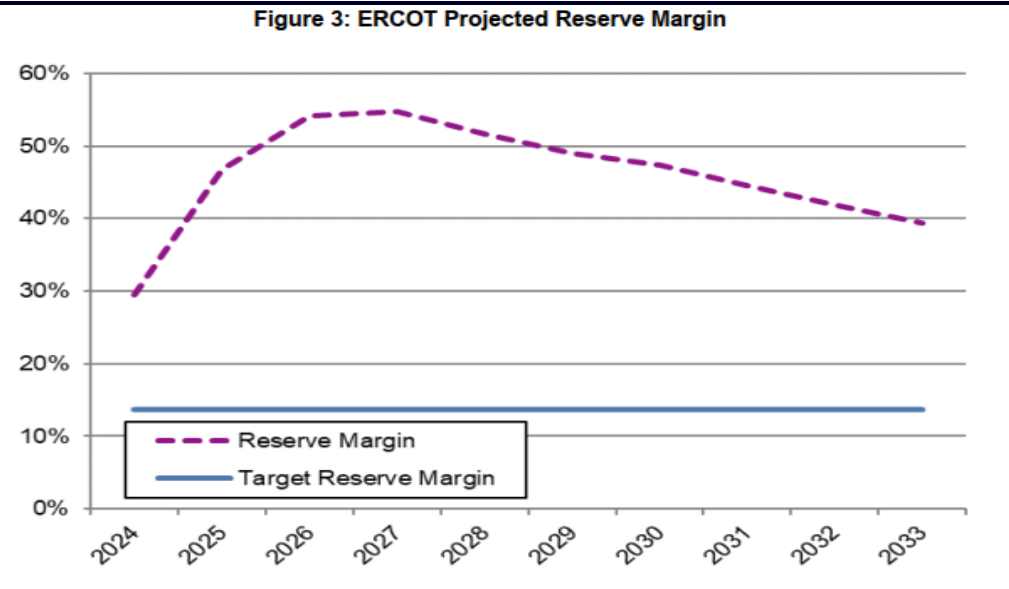
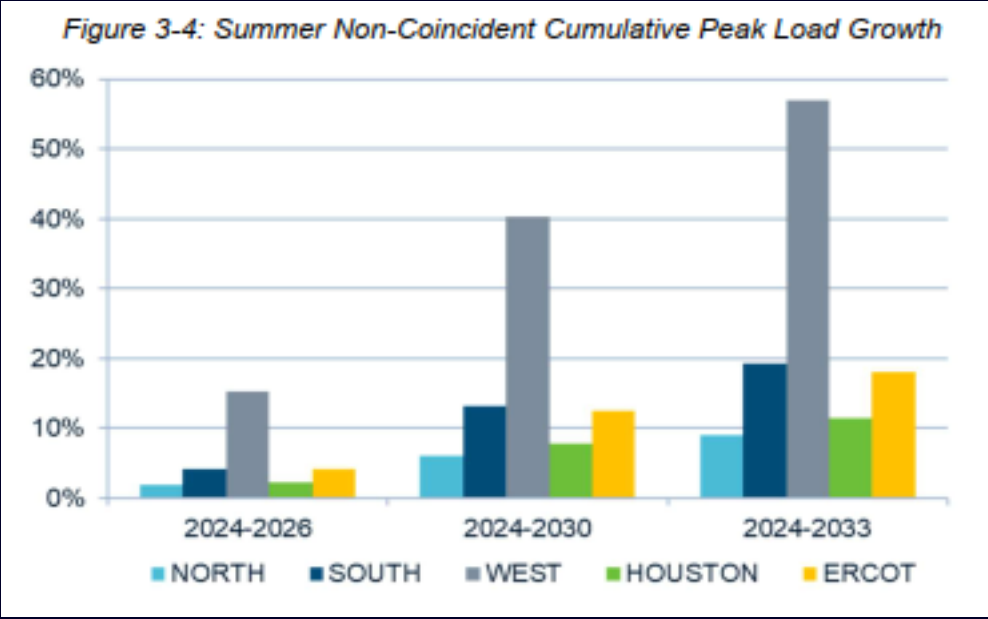
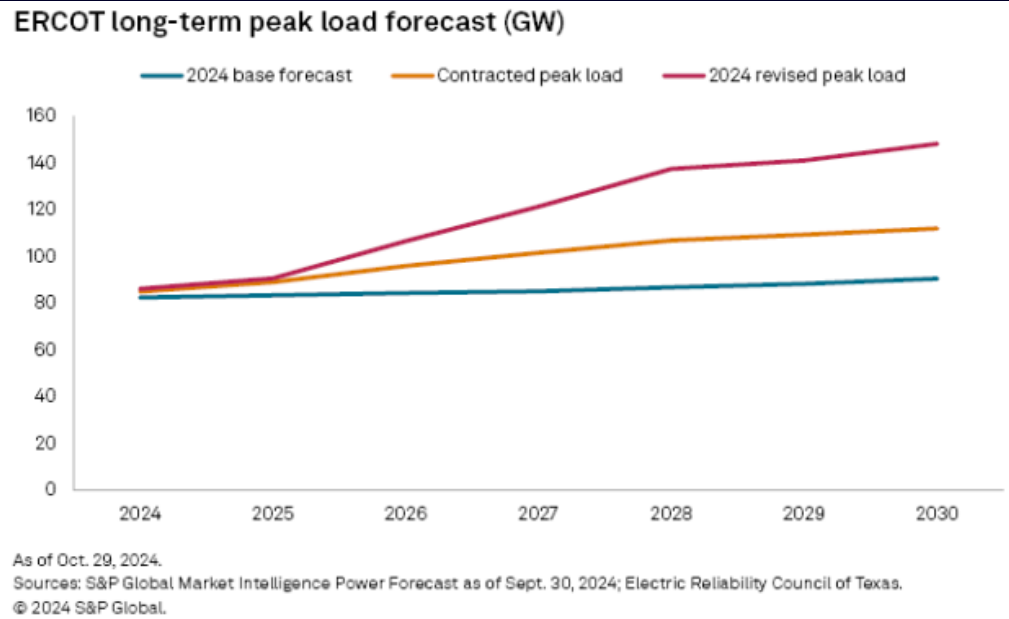


Table 3-8: Cumulative Capacity Retirements: 2024 – 2026, 2024 – 2030, & 2024-2033 (Nameplate MW)

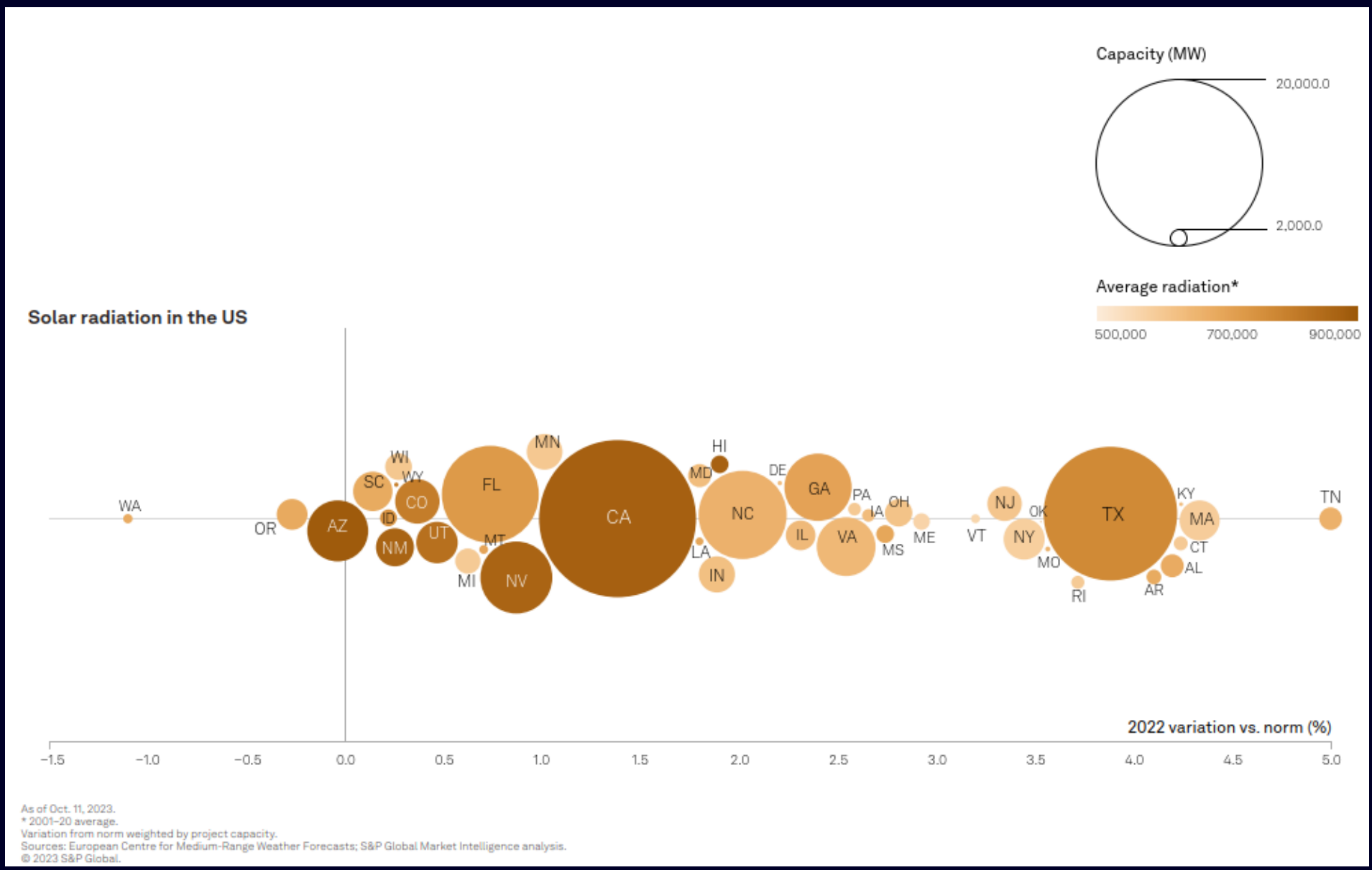
Transmission Zone	2024 - 2026		2024 - 2030		2024 - 2033	
	Coal	Natural Gas	Coal	Natural Gas	Coal	Natural Gas
North	2,455	1,500	4,144	1,907	4,144	2,475
South	0	859	1,990	1,739	1,990	1,809
West	0	152	0	152	0	386
Houston	0	0	0	611	1,317	1,163
Total	2,455	2,511	6,134	4,409	7,451	5,833

Source: PA Consulting Group Inc.

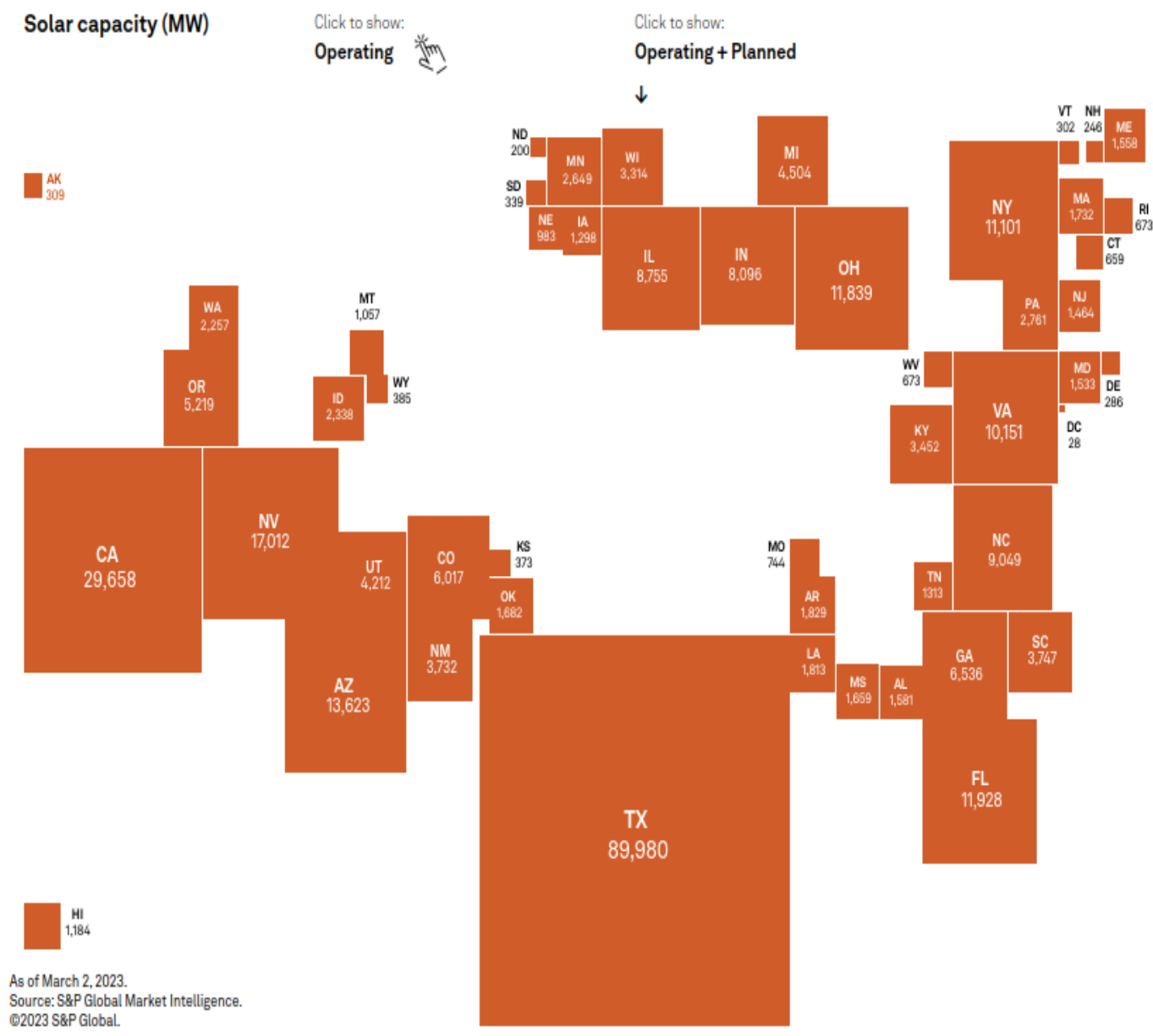
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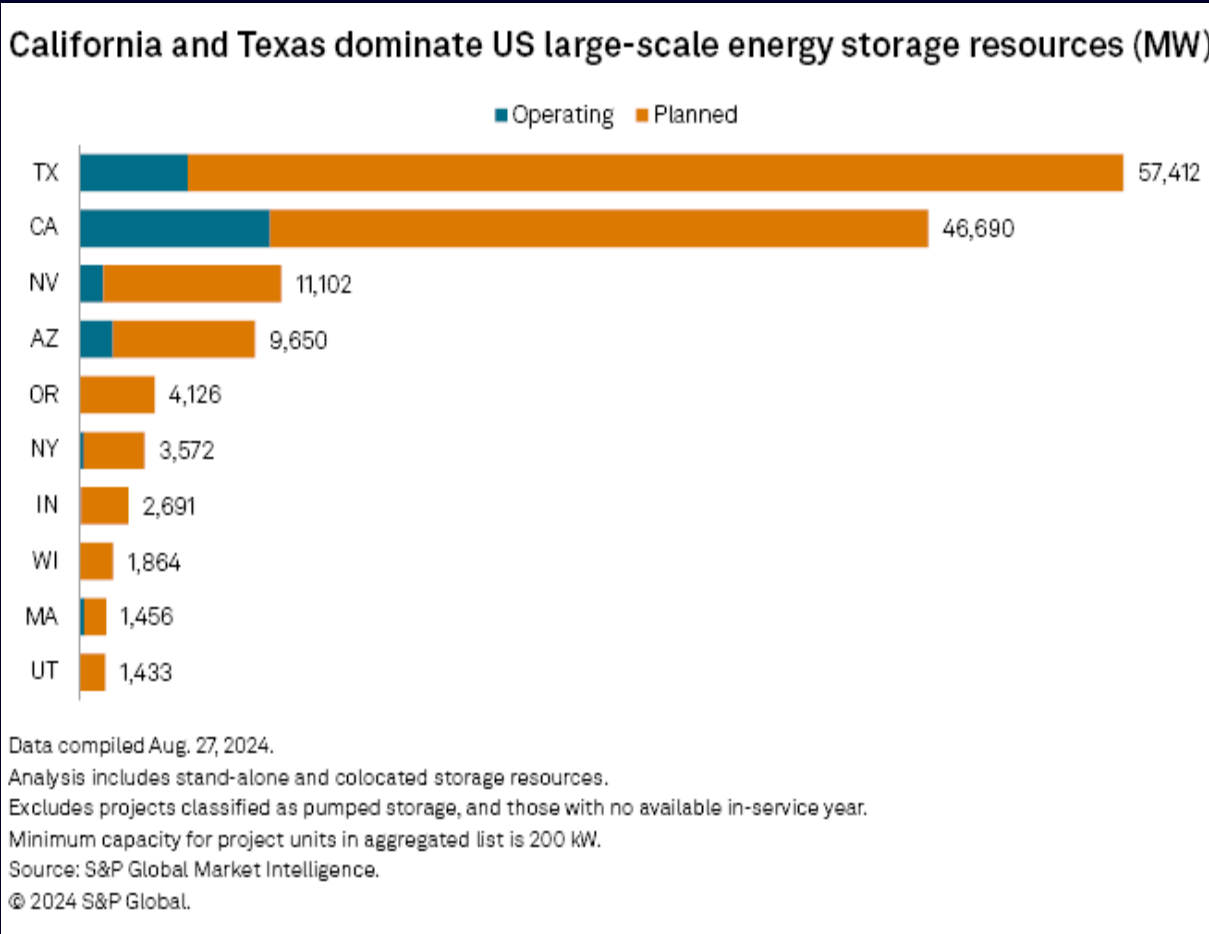
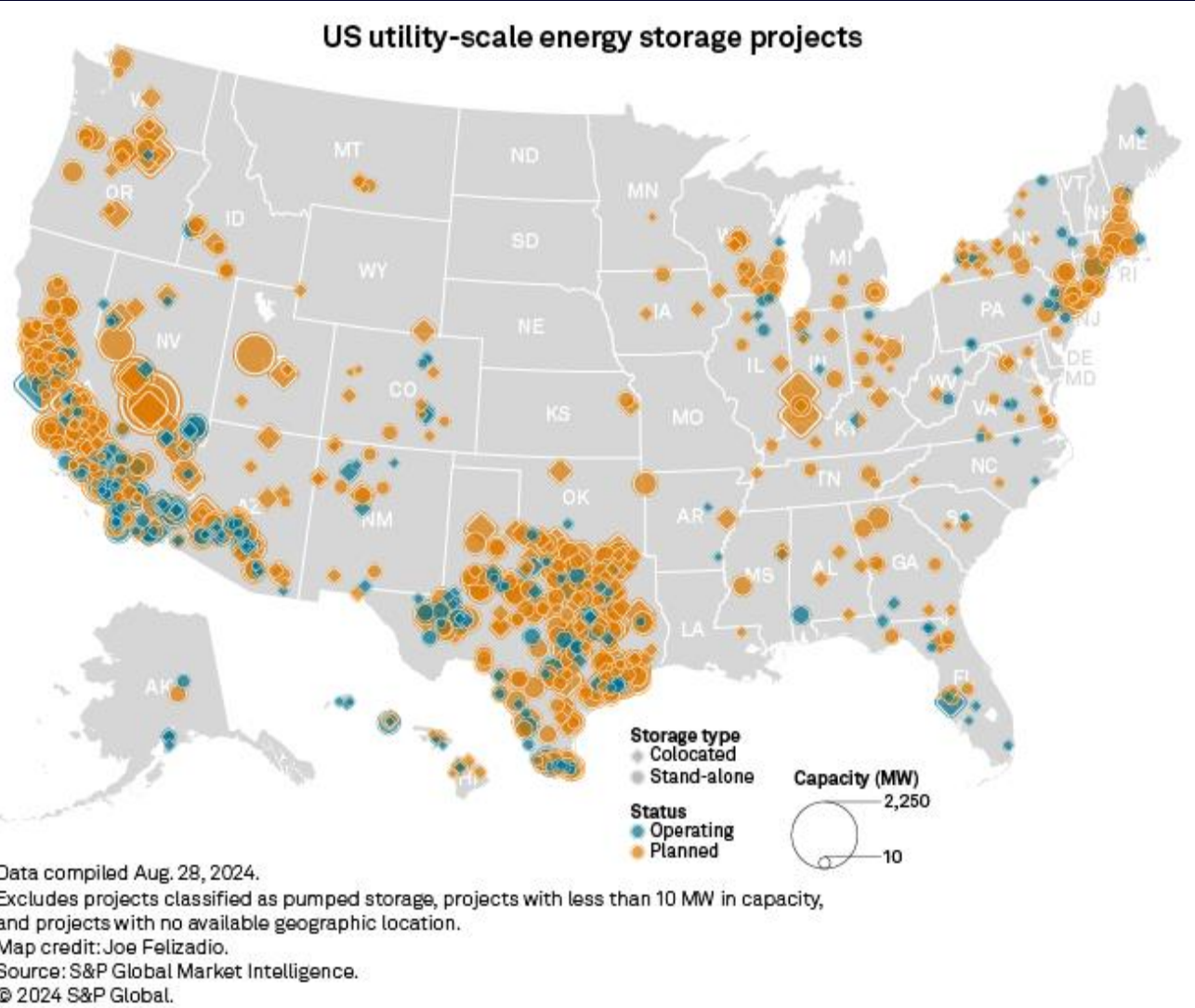
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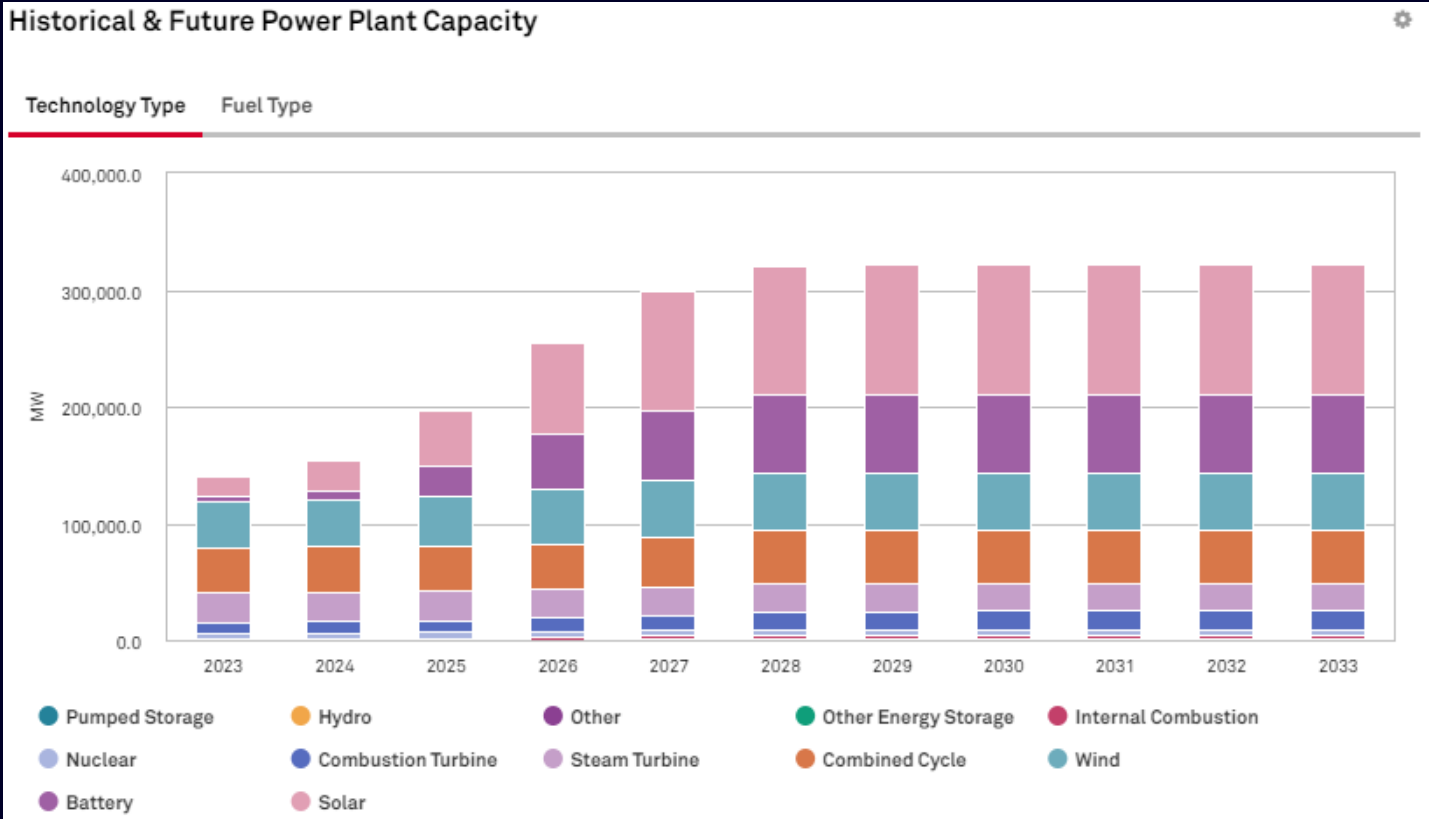
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Source: S&P Global Market Intelligence

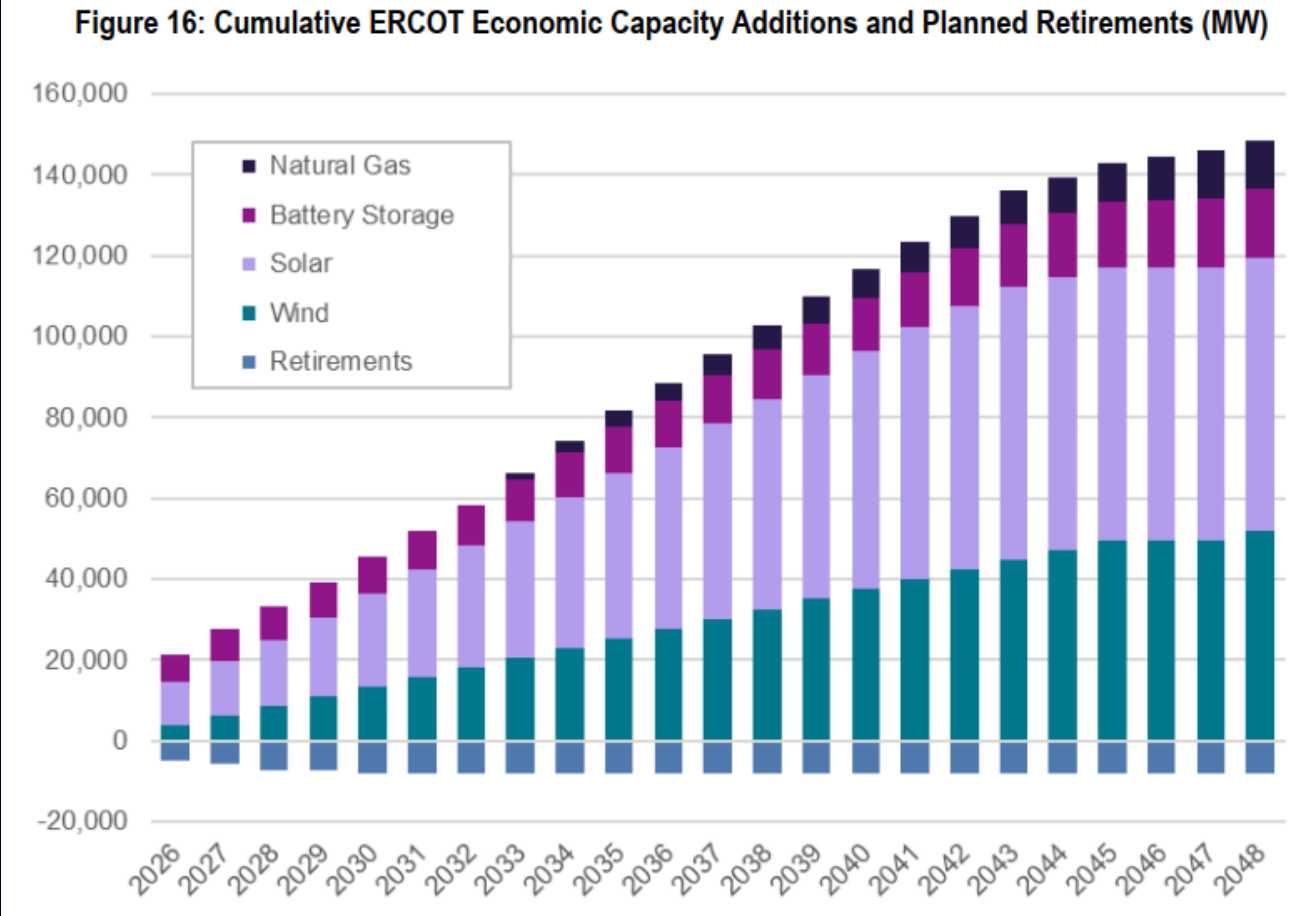
- PA Consulting forecasts 73 GW of solar and wind, 34 GW of battery storage and 25 GW of new, gas-fired generation capacity additions, plus 17 GW of thermal retirements over the next 25 years.

Table 3-7: Cumulative Capacity Additions by Zone and Fuel Type: 2024 - 2033 (Nameplate MW)

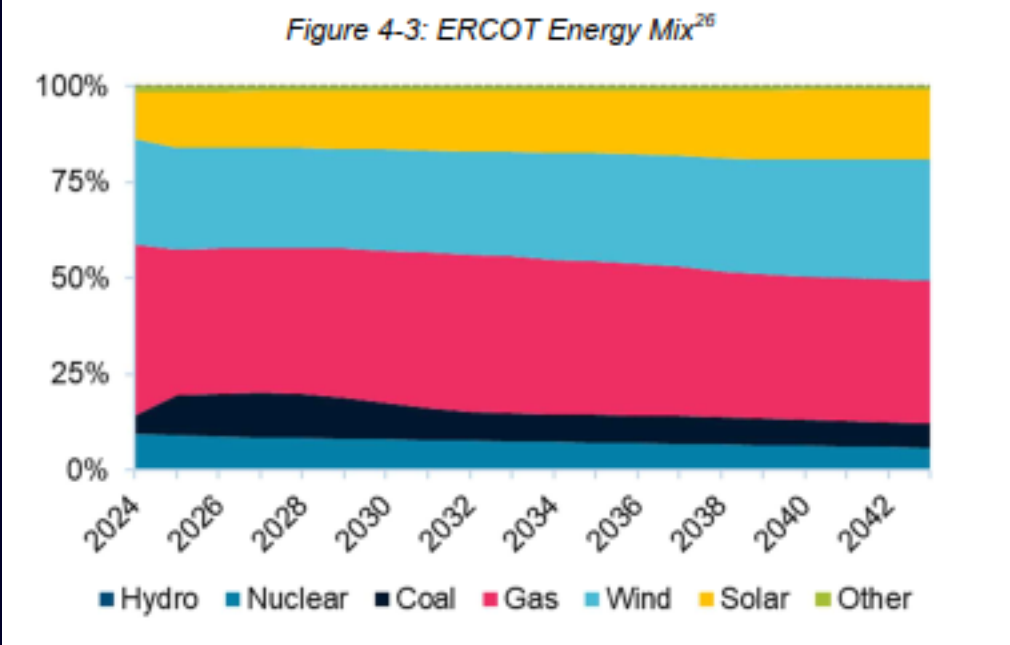
Transmission Zone	Gas CT	Solar	Onshore Wind	Energy Storage
North	1,025	8,158	2,854	3,545
South	820	7,757	2,666	2,754
West	1,435	6,652	6,110	5,940
Houston	1,025	2,193	0	2,222
Total	4,305	24,760	11,630	14,461

Source: PA Consulting Group Inc.

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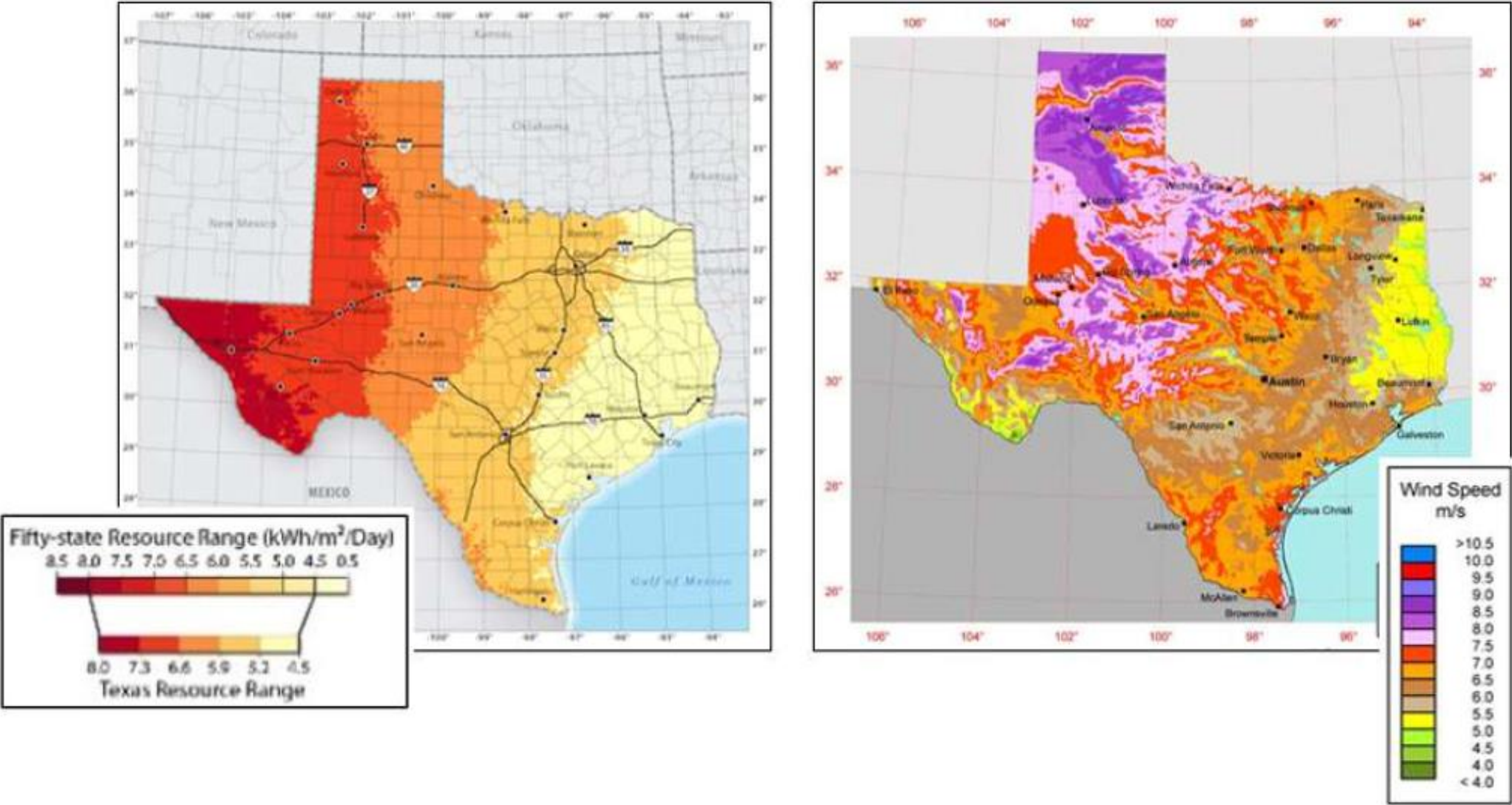


Source: Leidos Engineering, LLC



Source: PA Consulting Group Inc.

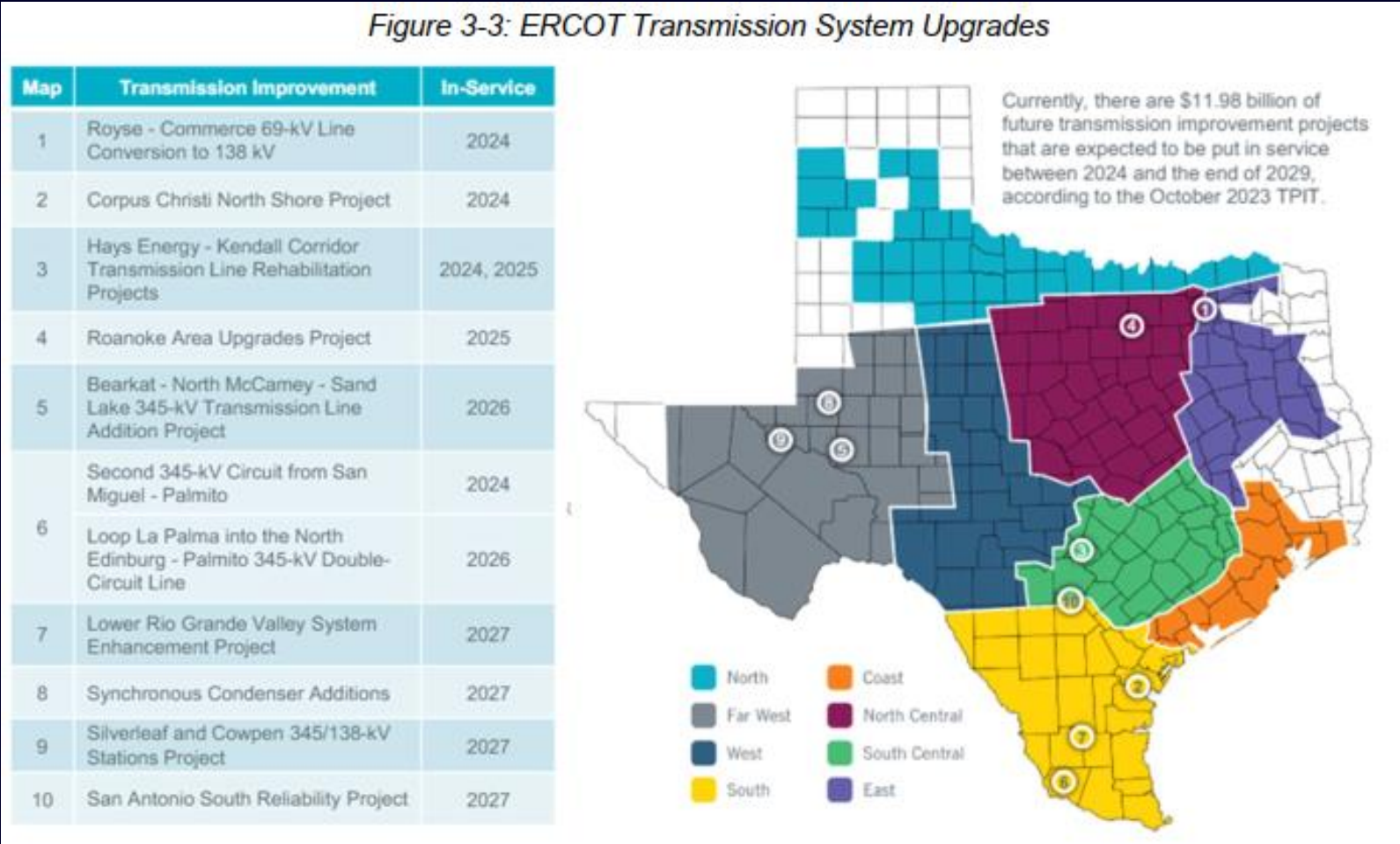
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Source: PA Consulting Group Inc.

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- ~\$12 billion of future, transmission improvement projects are expected to be energized by 2029.
- 10 projects; mostly in West and South load zones.
- Targeted to meet critical transmission needs and constraints between areas of high renewable penetration and major load centers.
- Two large-scale transmission projects (2033 targeted energization) are expected between West and North and South load zones and Houston and North and South load zones.



Source: PA Consulting Group Inc.

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- ERCOT is an energy-only market without an administered capacity market or formal enforcement of a target reserve margin.
- ERCOT's nodal Day-Ahead Market (DAM) and Real-Time Market (RTM) function as the constructs for balancing supply and demand as well as resource adequacy.
- As an energy-only market, the primary means for ERCOT to incentivize new capacity to enter the market is through allowing higher system wide price caps. The energy offer cap in ERCOT is currently set at \$5,000/MWh. The energy pricing resulting from this offer cap is referred to as "scarcity pricing" via the Operating Reserve Demand Curve (ORDC).
- In addition to an energy market, ERCOT operates several ancillary service markets to reliably operate the system.
- Ancillary services include: 1) Regulation (Reg Up and Reg Down), 2) Responsive Reserve Service (RRS), 3) Non-Spinning Reserve Service (NSRS) and 4) ERCOT Contingency Reserve Service (ECRS).
- Ancillary services are required to maintain system reliability and provide functions including load and generation balancing, maintaining reserve resources, supporting system voltage and frequency, supplementing the grid following loss of power, managing congestion and constraints, and reducing load in emergencies.

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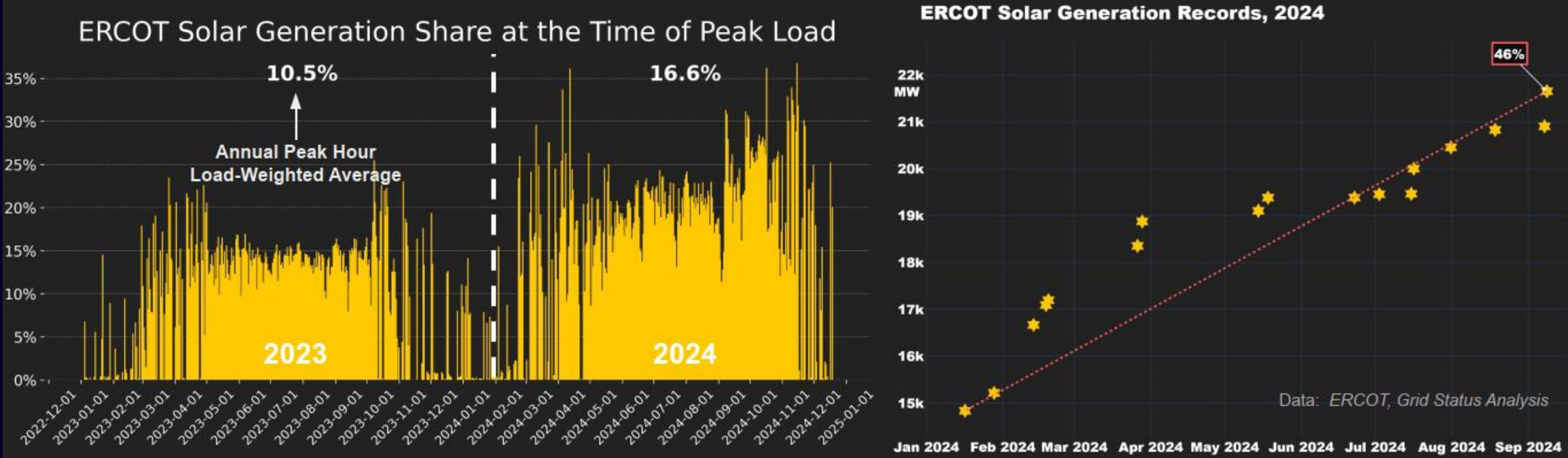
- DAM for energy is a voluntary, financial-forward market that is co-optimized to clear with ancillary services with settlements for each hour the following day.
 - RTM facilitates managing real-time differences between actual load and scheduled power. ERCOT performs a Security Constrained Economic Dispatch (SCED) process to determine.
 - ERCOT is a nodal design (over 8,000 nodes) and determines a Locational Marginal Price (LMP) for energy and congestion. ERCOT runs the SCED every 5 minutes using bids by individual resources. Even though prices are determined every 5 minutes, settlement is performed in 15-minute intervals.
 - Unlike DAM for energy, ancillary services market is physically-settled.
- ✓ Reg Up and Reg Down are measures to continuously balance supply and demand and maintain system frequency (60 Hz) by either rapidly increasing or decreasing output to balance energy being delivered on the grid and the actual system load. Must be online and ready to immediately deploy.
 - ✓ RRS must be online, ready to deploy within 10 minutes and be sustainable for 1-hour (includes load willing to be interrupted).
 - ✓ ECRS must be online, ready to deploy within 10 minutes and be sustainable for 2 hours.
 - ✓ NSRS can be either online or offline, capable of ramping to a specific output within 30 minutes and be sustainable for 1-hour (includes load consumption).

Ancillary Service	Deployment
Regulation Up Service	Instantaneous
Regulation Down Service	Instantaneous
Responsive Reserve Service (to include FFR in future)	Within 10 minutes (autonomously deployed by PFR and FFR settings)
ERCOT Contingency Reserve Service	Within 10 minutes (triggered and deployed by real-time market)
Non-Spinning Reserve Service	Within 30 minutes

Source: PA Consulting Group Inc

In 2024, ERCOT took the top spot in grid-scale solar generation

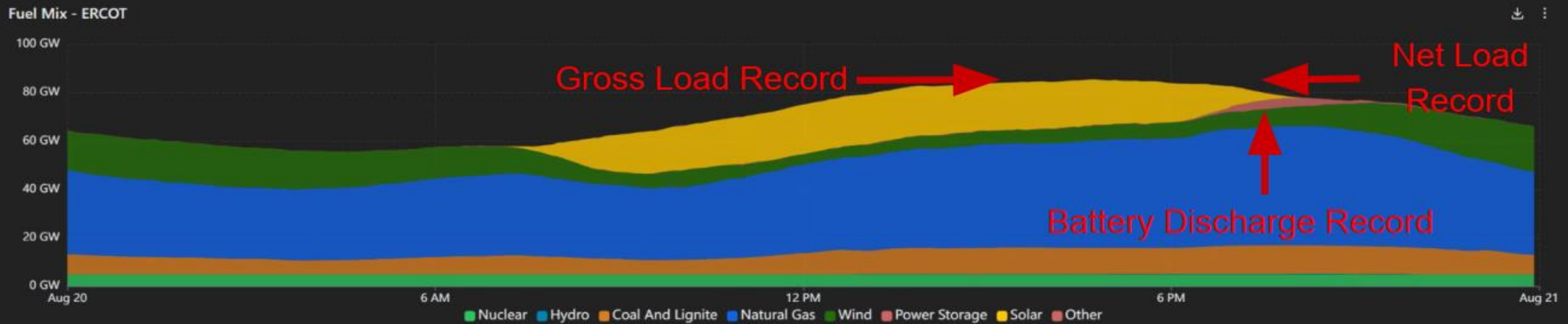
Grid-connected solar out continued to rise in 2024, surpassing CAISO and breaking 20 GW. With an east-west geographic diversity and relatively little behind-the-meter solar, ERCOT also saw PV often meeting a substantial portion of peak demand.



Breaking Down a Record-Setting Day in ERCOT

GridStatus

August 20th, 2024 saw records for demand, solar generation, net load, and battery discharge alongside prices near the cap; another example of how operations in the market are evolving



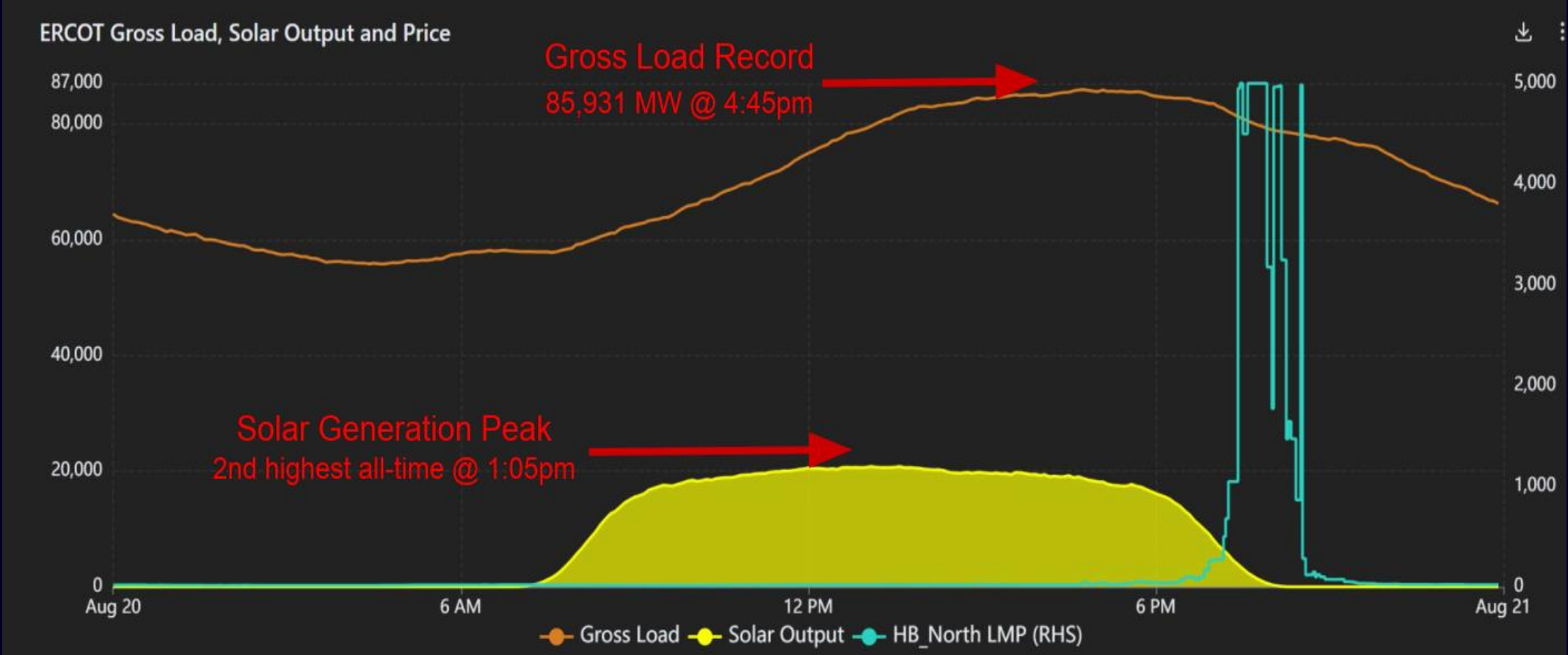
Source: ERCOT and Grid Status



ERCOT set a new all-time record for demand



Solar generation was high all day, keeping prices under control even through the record-setting peak load



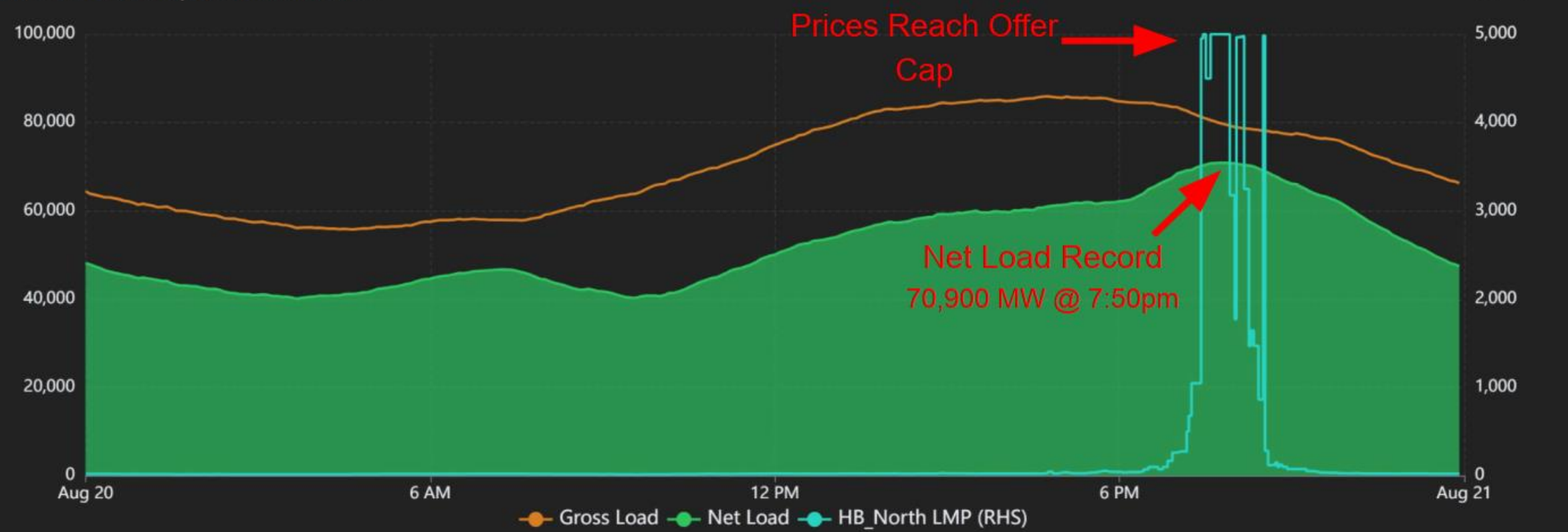
Source: ERCOT and Grid Status

As solar ramped down, ERCOT set a new maximum net load record

Net load is demand that must be met by resources with a higher marginal cost. Load remained high as the sun set. High prices correlate to high net load rather than gross load



ERCOT Gross Load, Net Load and Price



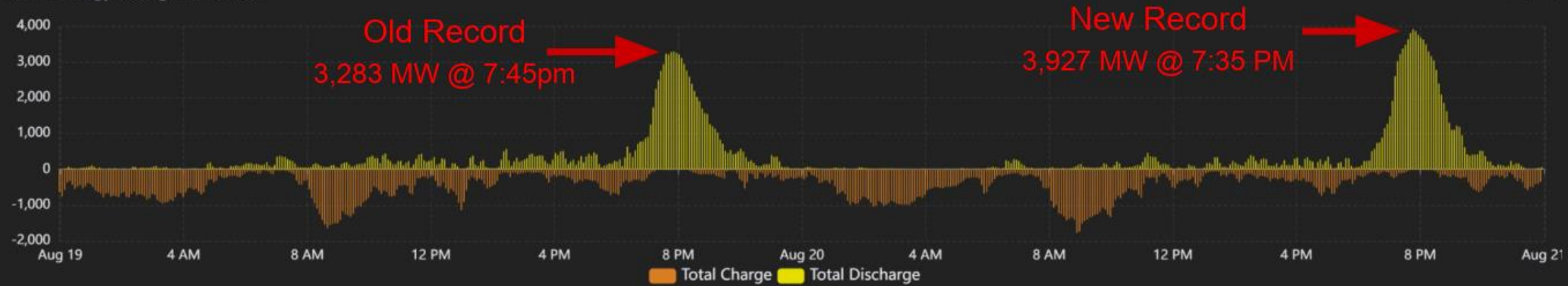
Source: ERCOT and Grid Status

Batteries sent more power to the grid in ERCOT than ever before

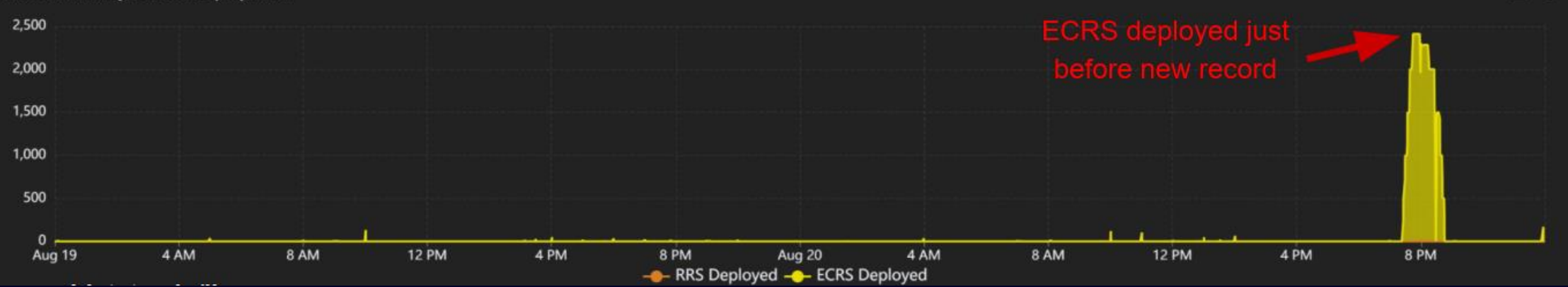
Shattering the previous record, battery discharge peaked 20% higher than the previous record set only the day before as ERCOT released ECRS fully



ERCOT Energy Storage Resources



ERCOT Ancillary Service Deployment



Source: ERCOT and Grid Status



This led to some of the highest sustained real-time energy prices of the year



The Hub average fifteen-minute settlement point price (SPP) nearly reached the \$5,000 bid cap. ERCOT’s ORDC contributed to sustained high prices

ERCOT LMP Prices and Adders



Source: ERCOT and Grid Status

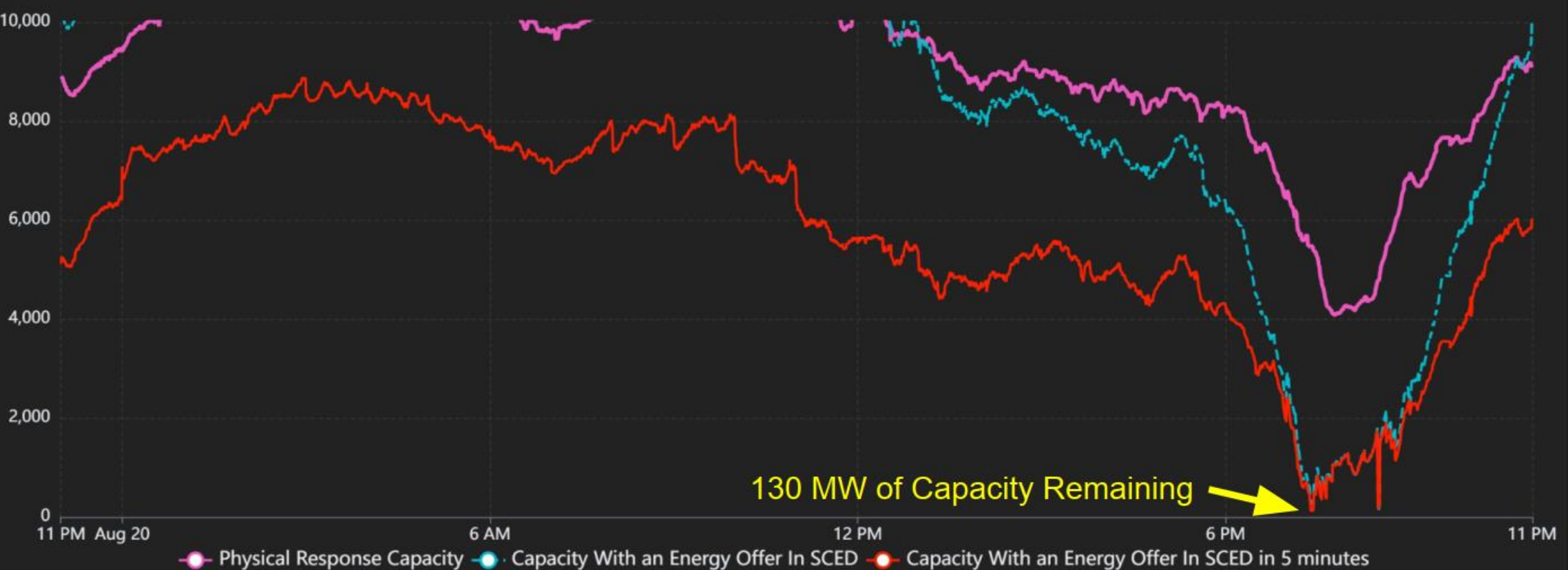


ERCOT deployed nearly all available capacity without experiencing reliability issues



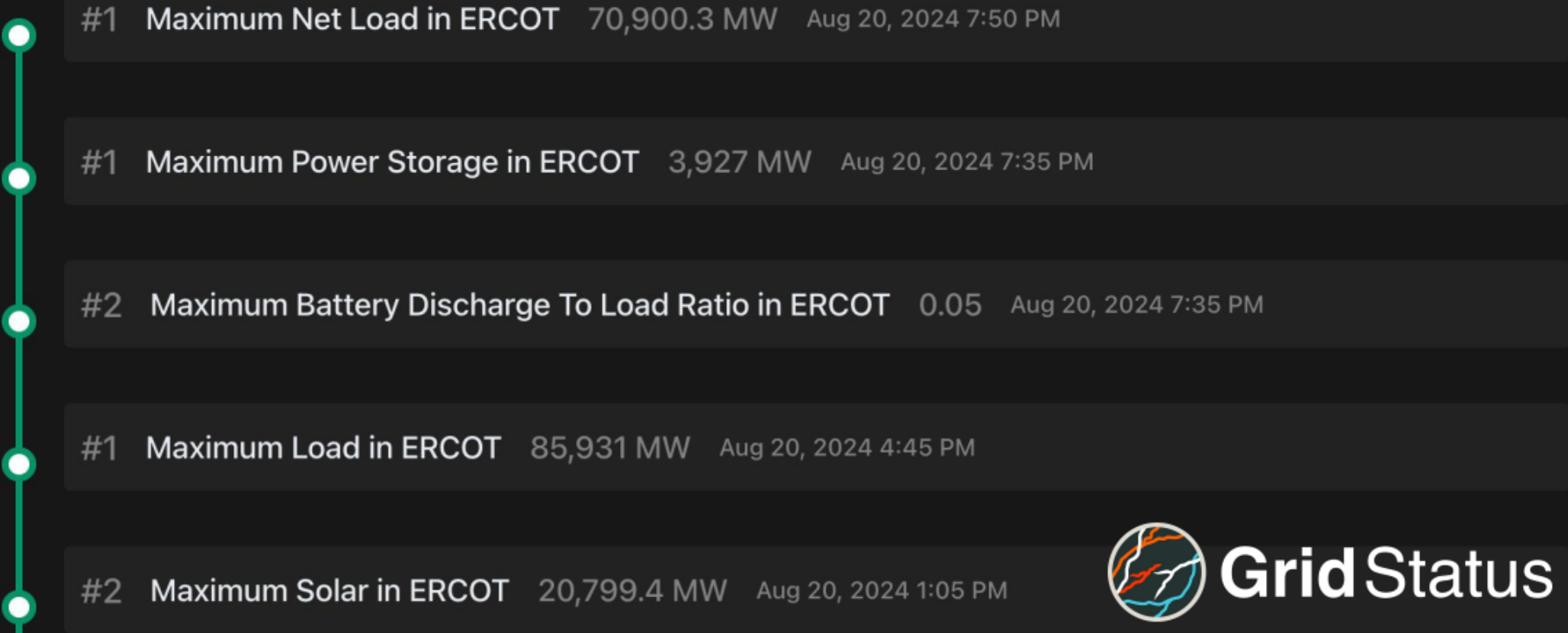
Physical Response Capacity (PRC) and capacity available to SCED within 5 minutes declined significantly despite 2,000 MW of extra capacity released from ECRS

ERCOT Real Time Remaining Capacity (MW)



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Latest ERCOT Records



Source: ERCOT and Grid Status

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Figure 5-22: Historical and Projected Capital Costs by Clean Energy Technology – ERCOT⁶⁹

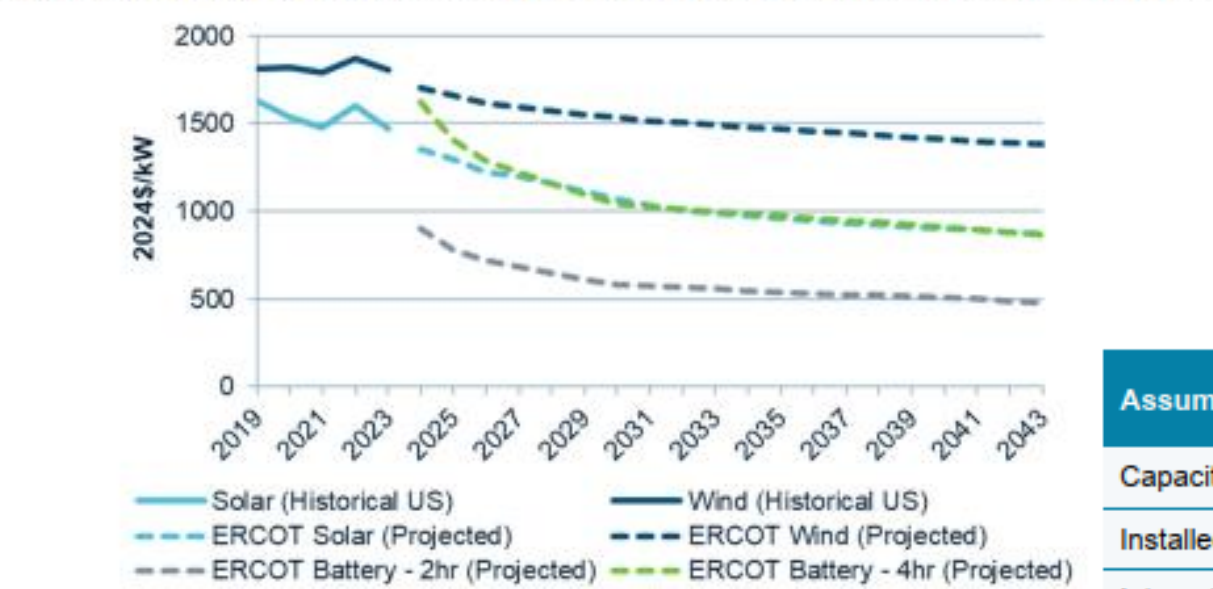


Table 5-4: ERCOT Cost of New Entry Assumptions (2024\$)

Assumption	CC	CT	Solar	Wind	Battery (2-hour)	Battery (4-hour)
Capacity (MW)	920	205	100	100	100	100
Installed capacity cost ⁶⁸ (\$/kW)	1,113	779	1,352	1,706	902	1622
Interest rate on debt (Nominal)	8.2%	8.2%	8.2%	8.2%	8.2%	8.2%
Return on equity (Nominal)	14.0%	14.0%	14.5%	14.5%	14.5%	14.5%
Debt/equity ratio	55/45	50/50	60/40	60/40	60/40	60/40
Financing life (Years)	20	15	25	20	15	15
Property tax	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Corporate tax rate	21.0%	21.0%	21.0%	21.0%	21.0%	21.0%
Full load heat rate (Btu/kWh)	6,550	9,707	N/A	N/A	N/A	N/A
Fixed O&M (\$/kW-year)	20.04	9.49	20.83	39.22	8.24	8.24
Variable O&M (\$/MWh)	3.43	8.97	N/A	N/A	N/A	N/A

Source: PA Consulting Group Inc

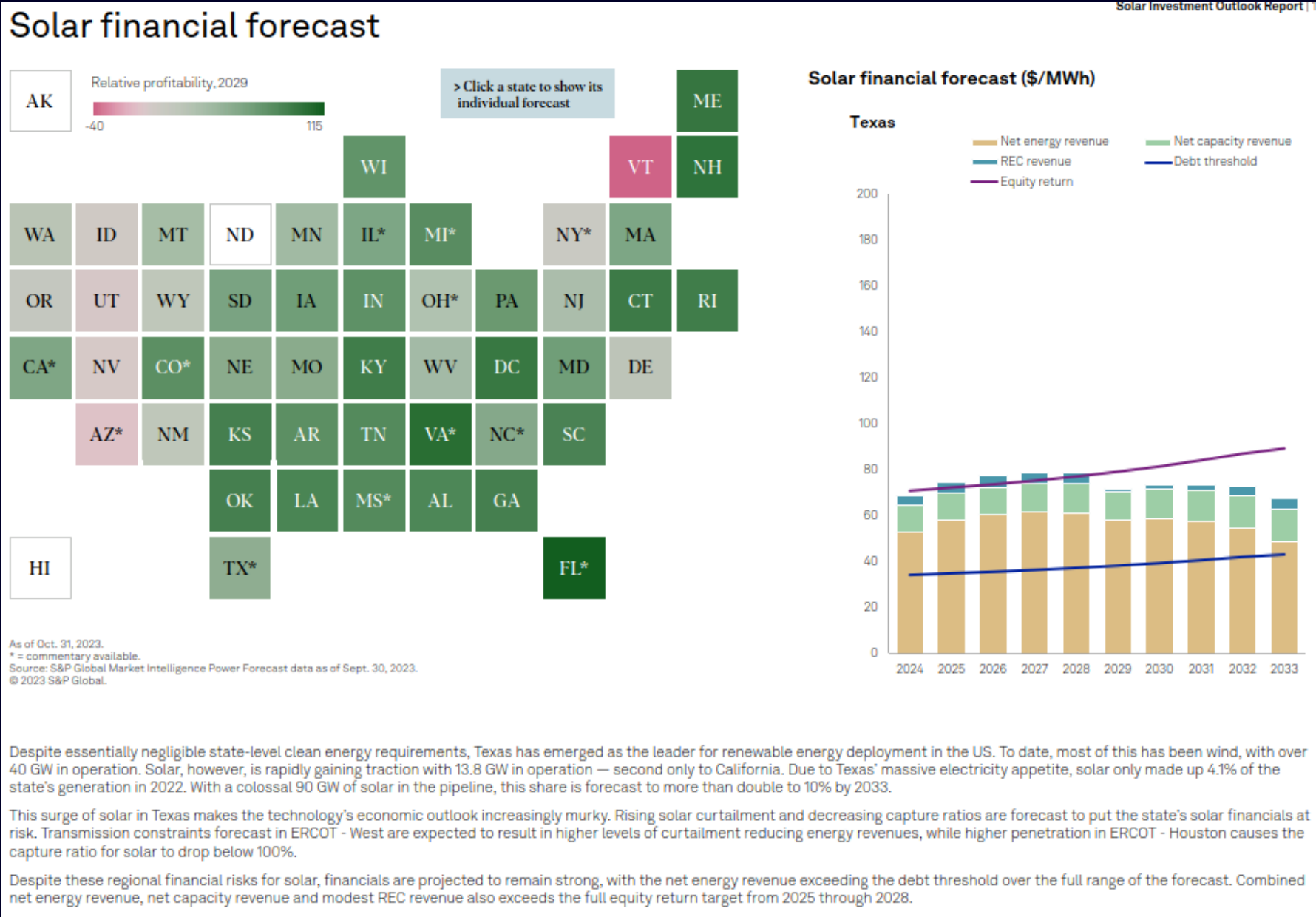
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- Revenue Streams
 - ✓ Classic LSE Toll / PPA
 - ✓ Hedge (HRCO)
 - ✓ Hybrids
 - ✓ Merchant / Arbitrage
- Debt Sizing
 - ✓ 1.2-1.35x DSCRs (contracted)
 - ✓ 1.75-2.00x DSCRs (uncontracted)
 - ✓ Uncontracted haircuts
 - ✓ Merchant Tails
 - ✓ Loan Sweep-Out Points
 - ✓ Basis Risk / Curtailment Risk
 - ✓ Sponsor equity at risk
 - ✓ Commitment Exposure to Market Risk
 - ✓ 50% of Commitment is likely a Bridge Loan to a Tax Equity Investment / Tax Credit Transfer (with a different repayment source)

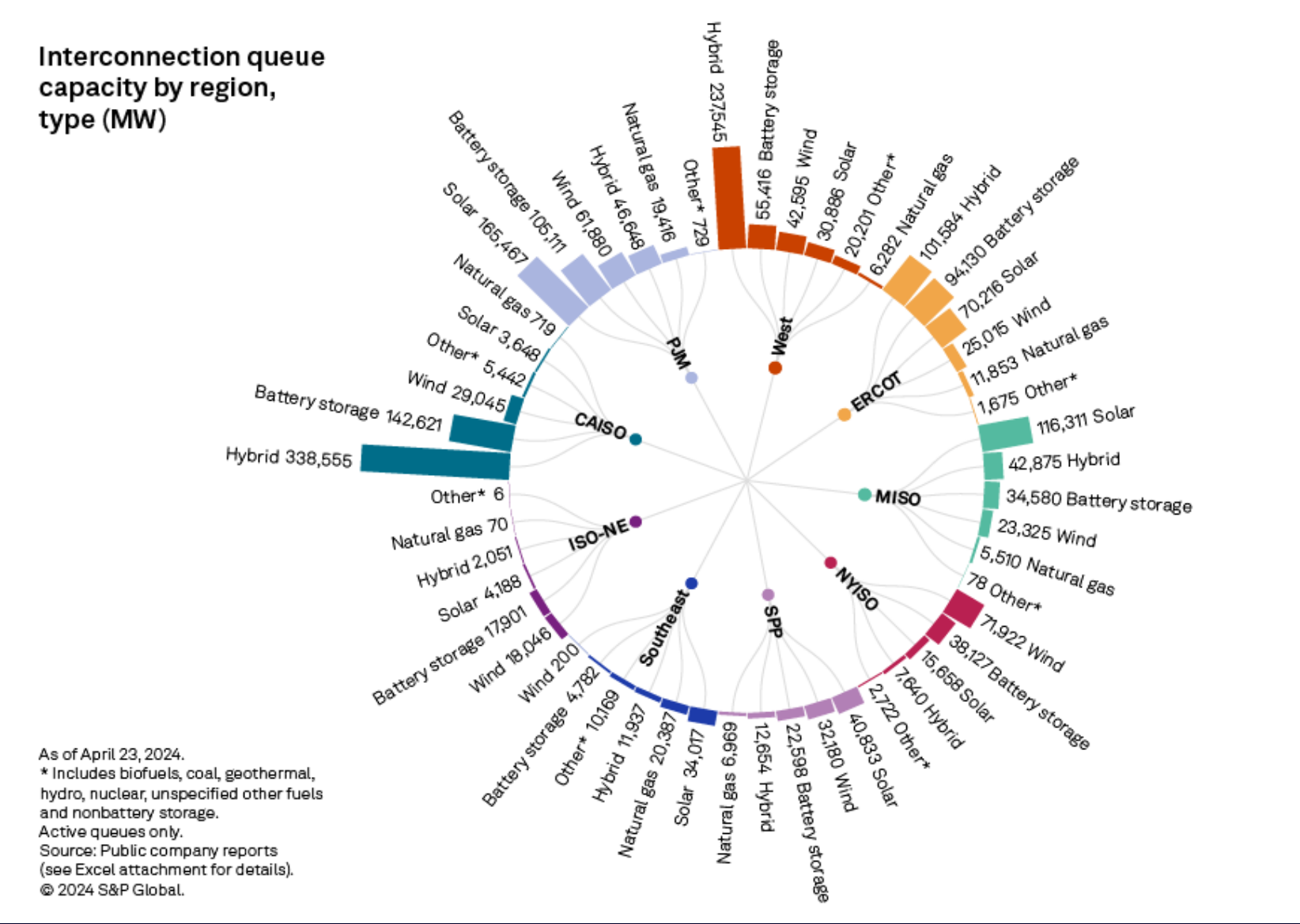
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- Exhibits

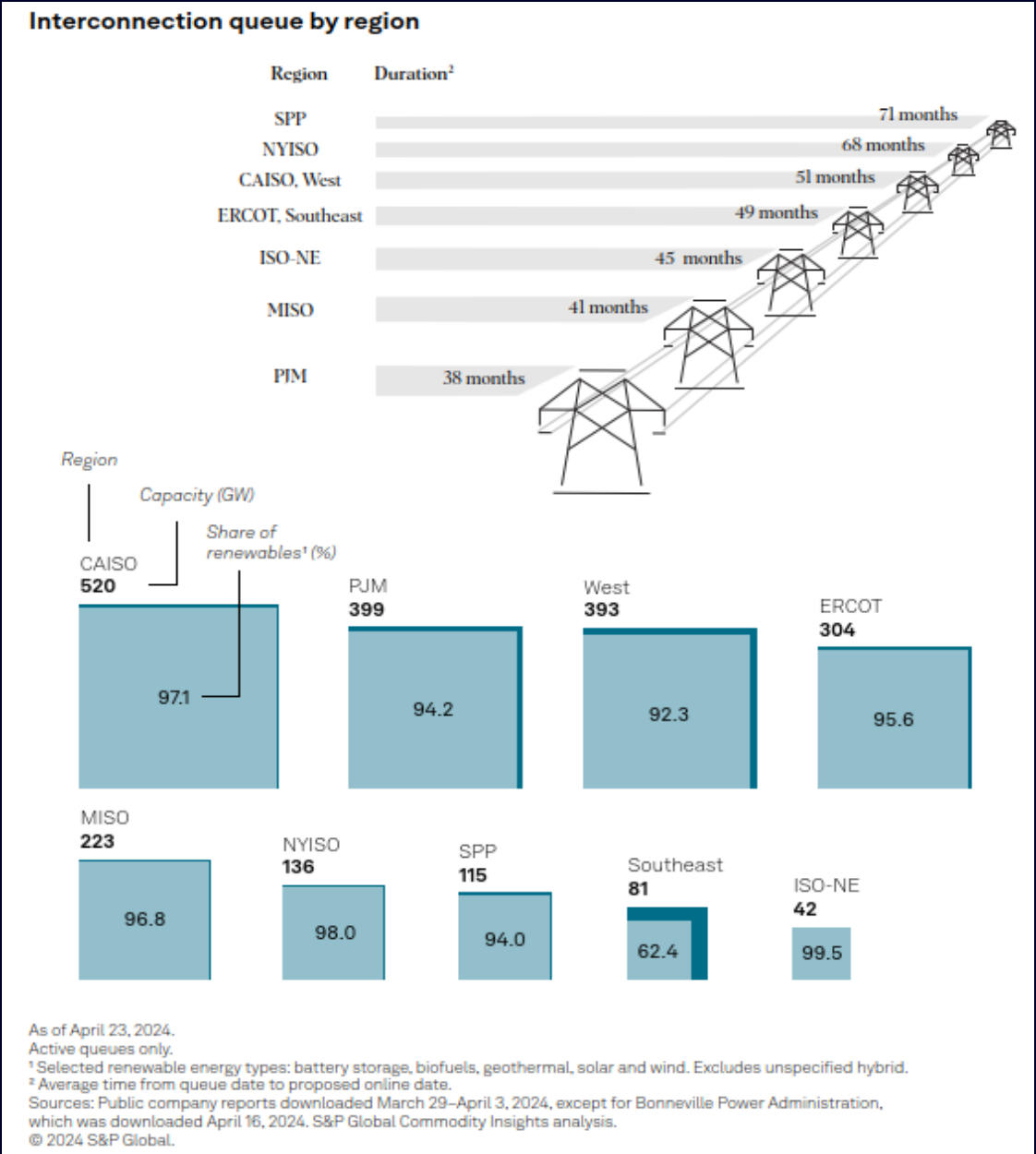
- ✓ Solar Financial Forecast
- ✓ Interconnection Queue
- ✓ Transmission
- ✓ Corporate PPAs
- ✓ Data Centers



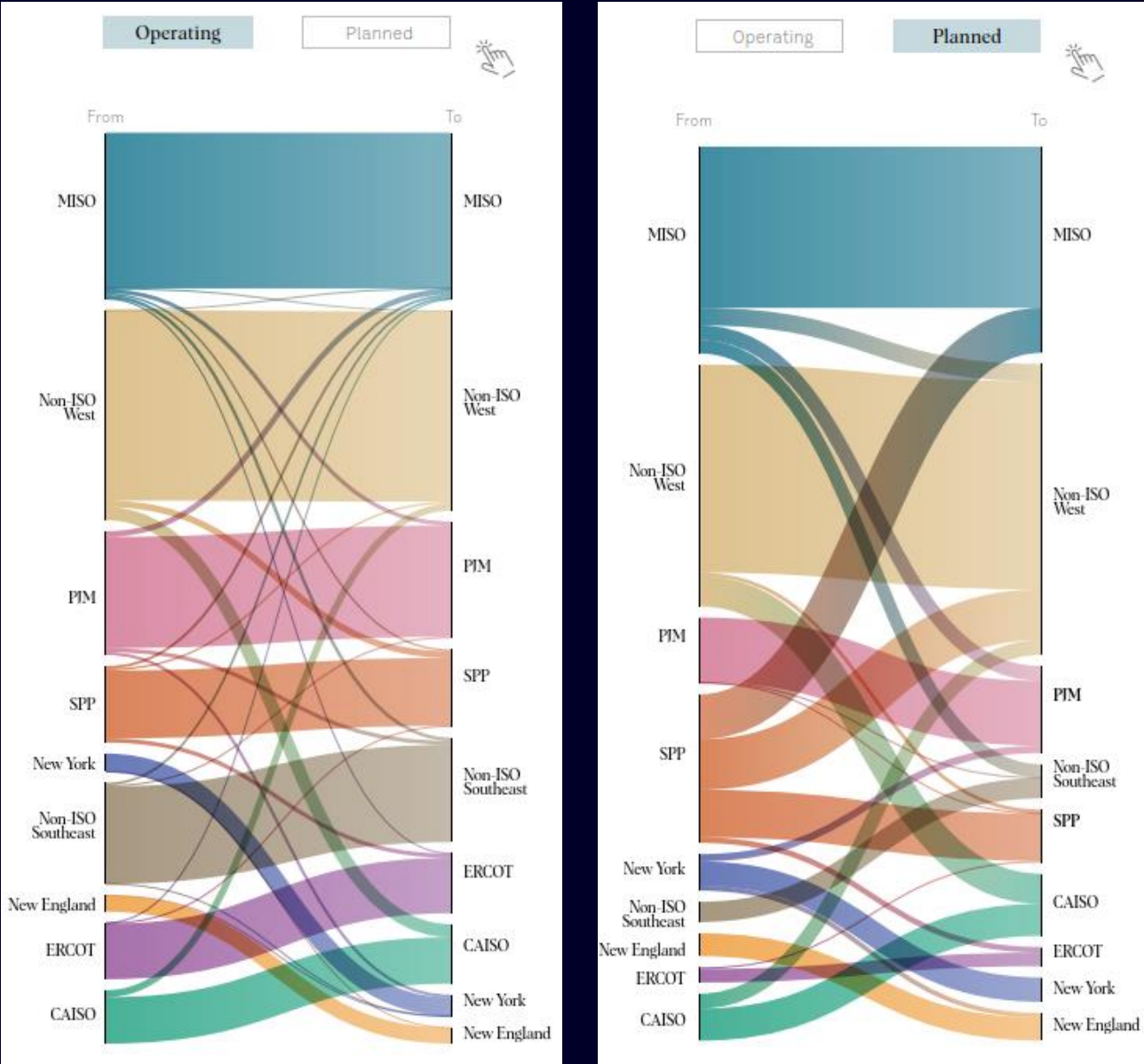
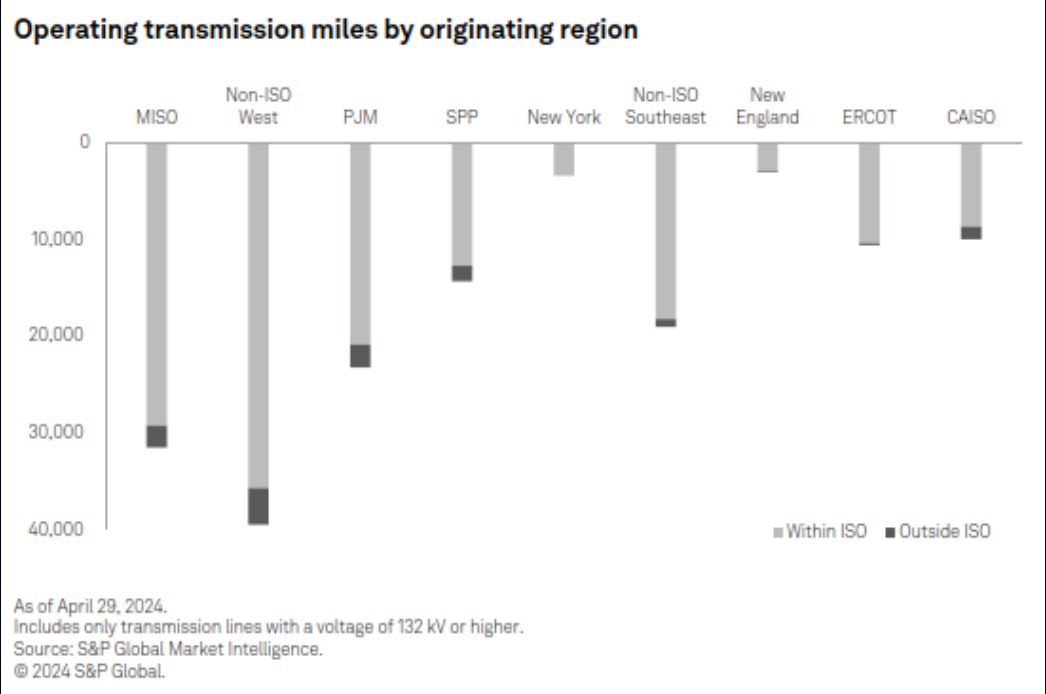
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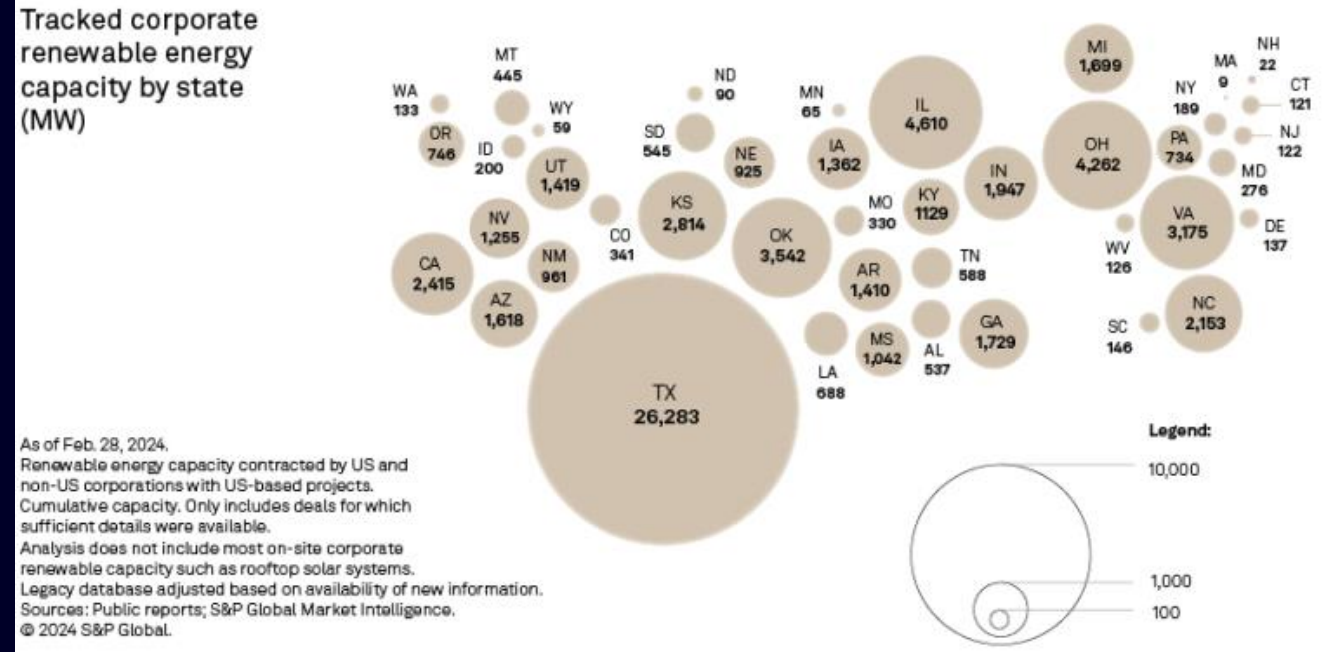
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Renewable energy capacity contracted by US corporations only.
Cumulative capacity. Only includes deals for which sufficient details were available.
Analysis does not include most on-site corporate renewable capacity such as rooftop solar systems.
Legacy database adjusted based on availability of new information.
Map credit: Jonathan Paul Lalgee.
Sources: Public reports; S&P Global Market Intelligence.
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As of Feb. 28, 2024.
Renewable energy capacity contracted by US and non-US corporations with US-based projects.
Cumulative capacity. Only includes deals for which sufficient details were available.
Analysis does not include most on-site corporate renewable capacity such as rooftop solar systems.
Legacy database adjusted based on availability of new information.
Sources: Public reports; S&P Global Market Intelligence.
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