

# **Power Markets Overview**

## ***Series 1***

### **California Independent System Operator**

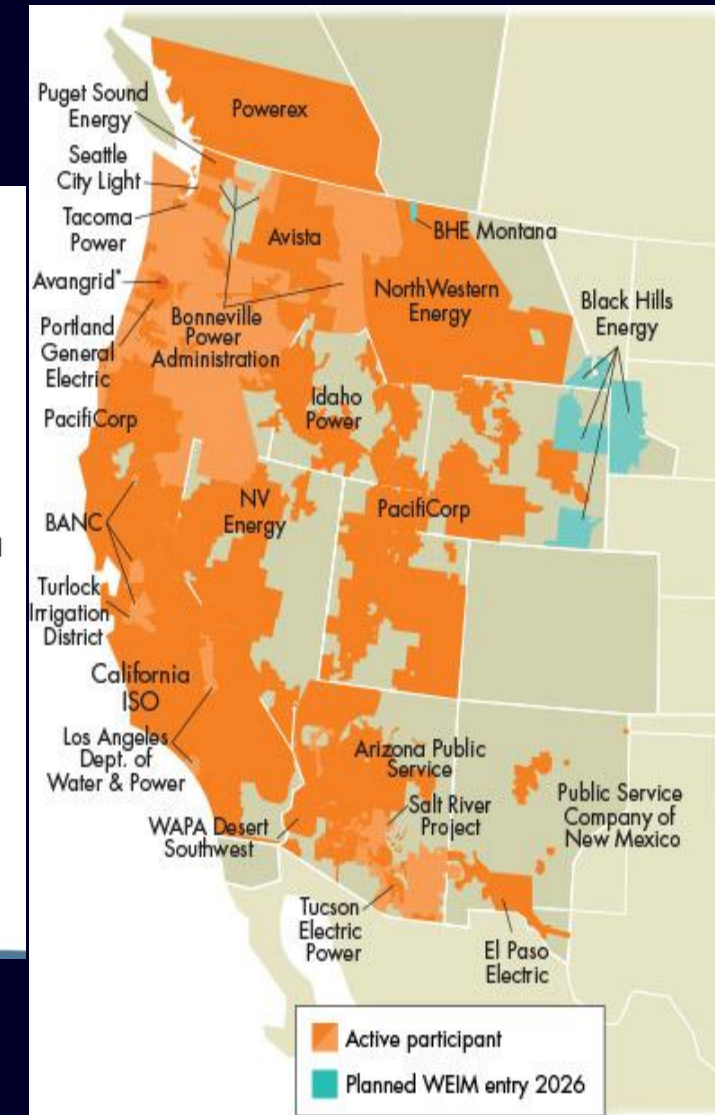
**PS-AM PF Power & Renewables Team**

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**November 12, 2024**

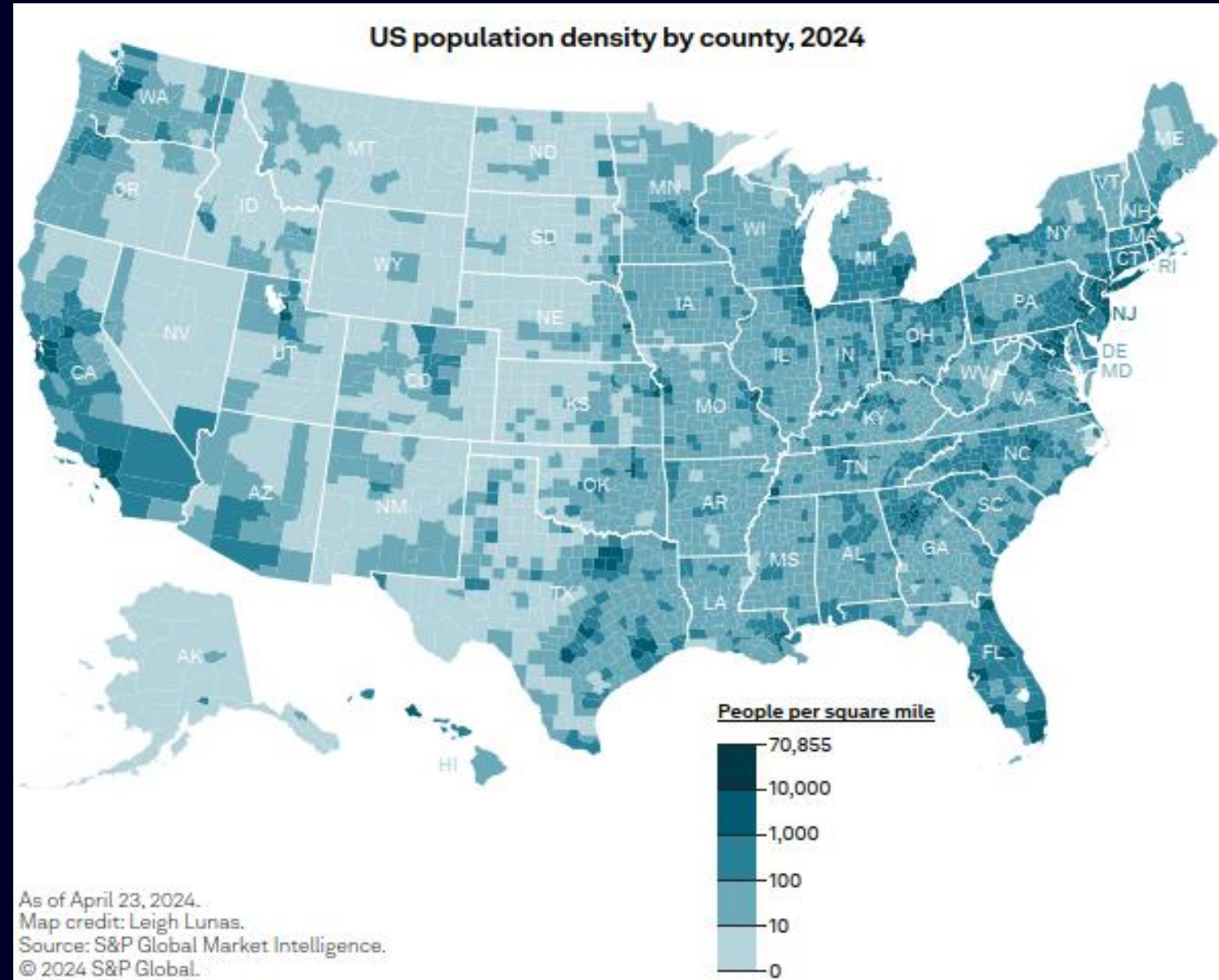
# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

- California Independent System Operator (CAISO) is a federally-regulated non-profit organization
- CAISO manages the high-voltage electric grid in California and portions of Nevada and operates liquid day-ahead and real-time energy and ancillary services market
- CAISO is one of 9 Independent System Operators (ISO) and/or Regional Transmission Operators (RTO) in North America
- CAISO participates in the Western Energy Imbalance Market (WEIM)



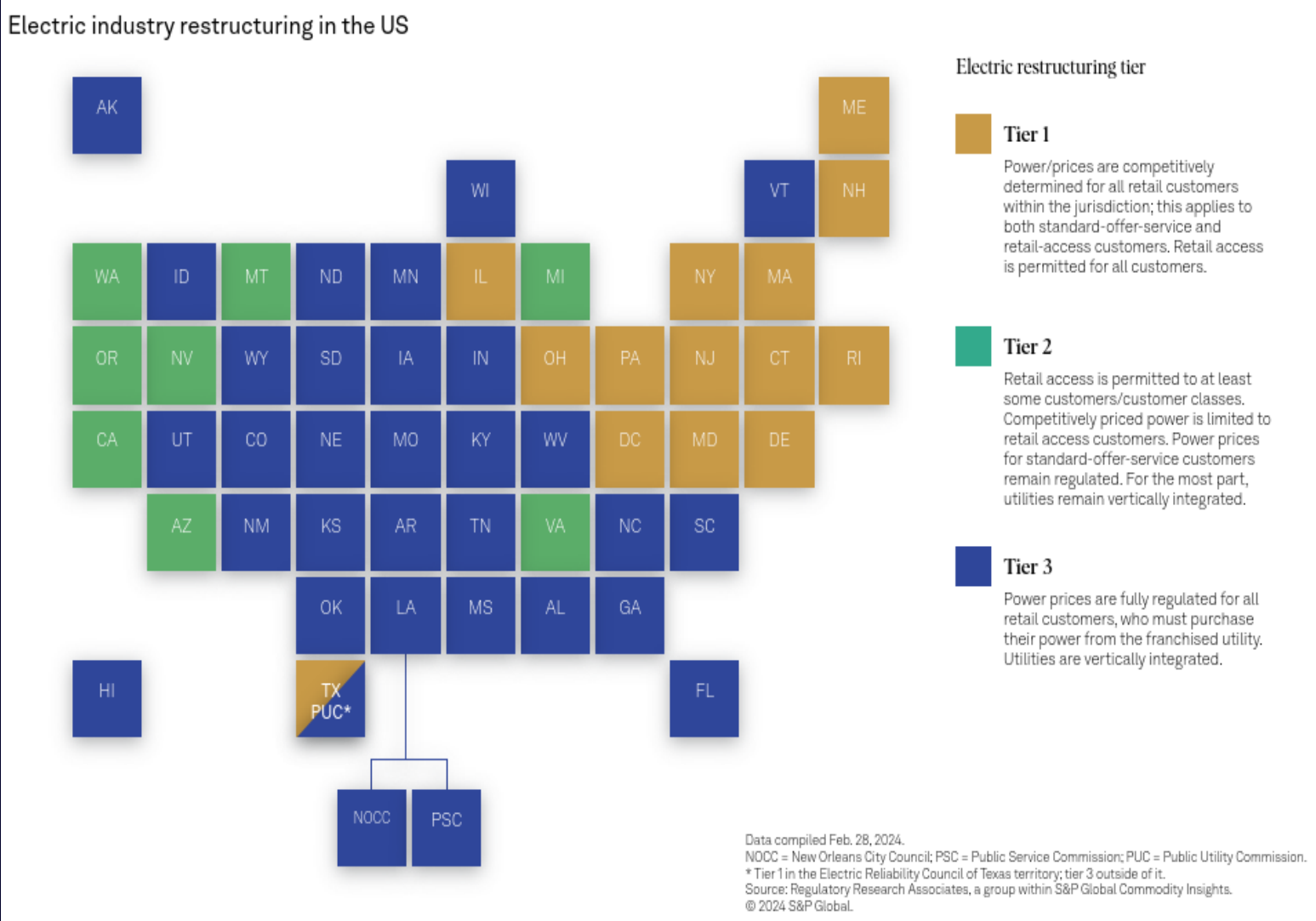
# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

- California has a population of ~39 million
- Population grew by over 25% through the 1980s and 12% through the 1990s
- Population is expected to reach ~55 million by 2050
- Its economy is the world's 5th largest and includes a major high-technology sector
- It produces 13% of US gross domestic product (GDP)

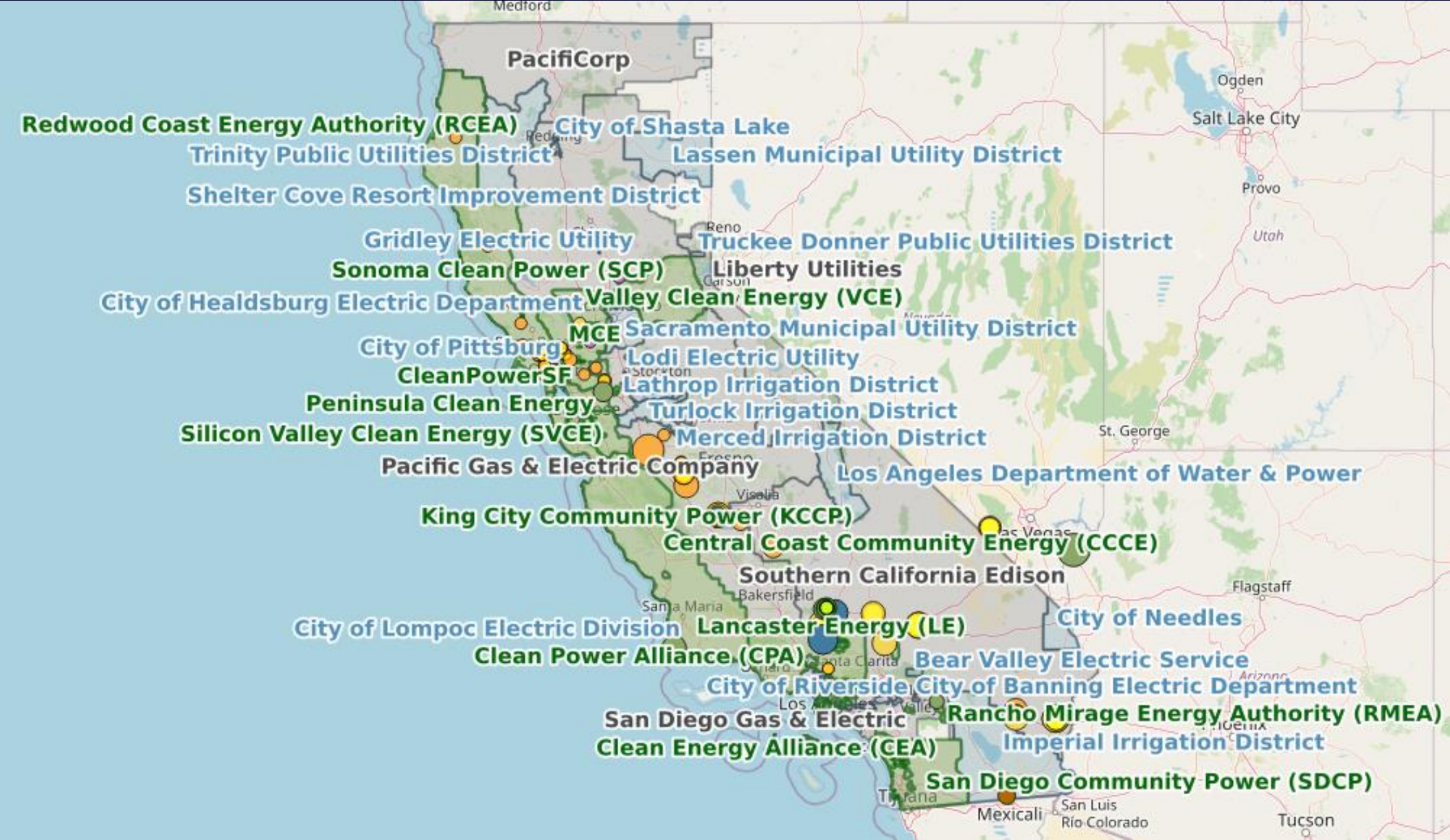


# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

- Electric Utility Industry Restructuring Act in 1996 put into place a ‘deregulation’ scheme which sought to bring competition into generation, attracting needed investment, while leaving transmission and distribution as regulated monopolies
- Before 'deregulation', electric utilities, which have a legal obligation to serve their customers' demands, could build plants regardless of the expense and recover costs from customers. In 1996, utilities owned 81% of the total generating capacity and the average retail price was \$0.095/kWh, the 10th highest in the United States
- Required the major utilities to divest at least half their major generation assets, so that their ownership fell to 46% of the total capacity

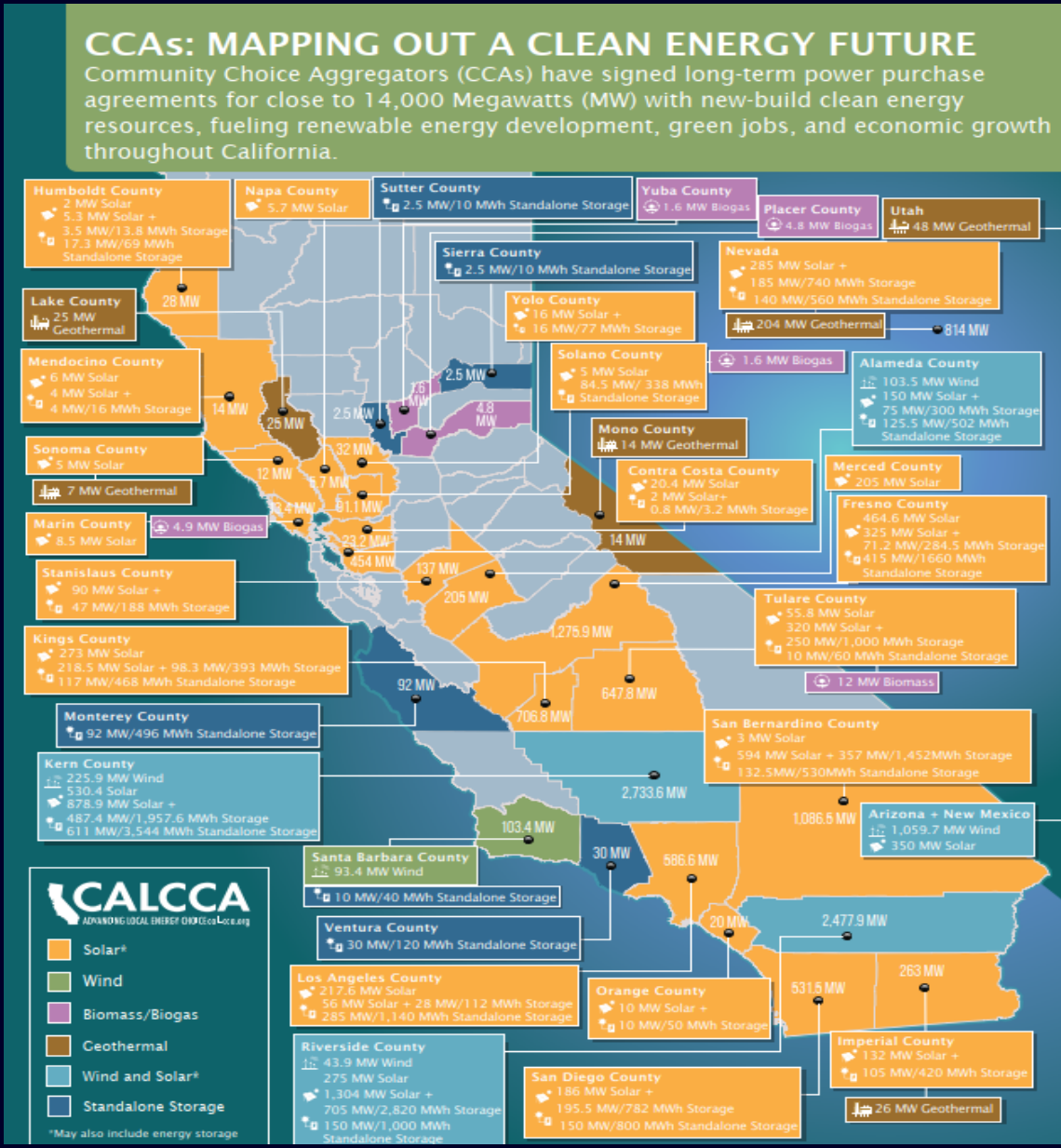


# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)



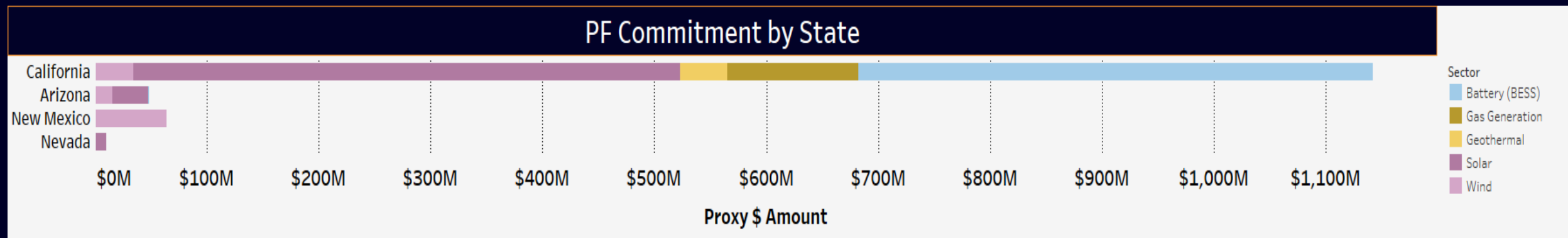
# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

- Community Choice Aggregators (CCAs) are local government entities that buy electricity for residents and businesses, and work with investor-owned utilities (IOUs) to deliver power and maintain the grid. CCAs allow communities to choose their electricity sources and reinvest their money locally
- 2002: The California Legislature passed AB 117, which enabled Community Choice Aggregation
- 2010: Marin Clean Energy (MCE) became the first CCA in California, serving customers in Marin County.
- 2011: The Legislature passed SB 790, which provided guidance on forming CCAs and established a Code of Conduct for how electrical corporations should treat CCAs
- 2015: Lancaster Energy became the first stand-alone CCA in California, providing electricity to nearly 95% of Lancaster's residents
- 2016: The California Community Choice Association (CalCCA) was formed to represent the interests of CCA providers at the California Legislature
- 2018: 10 CCAs launched in one year, marking a big year for CCA growth
- 2024: 25 operational CCAs; serving more than 14 million customers in California

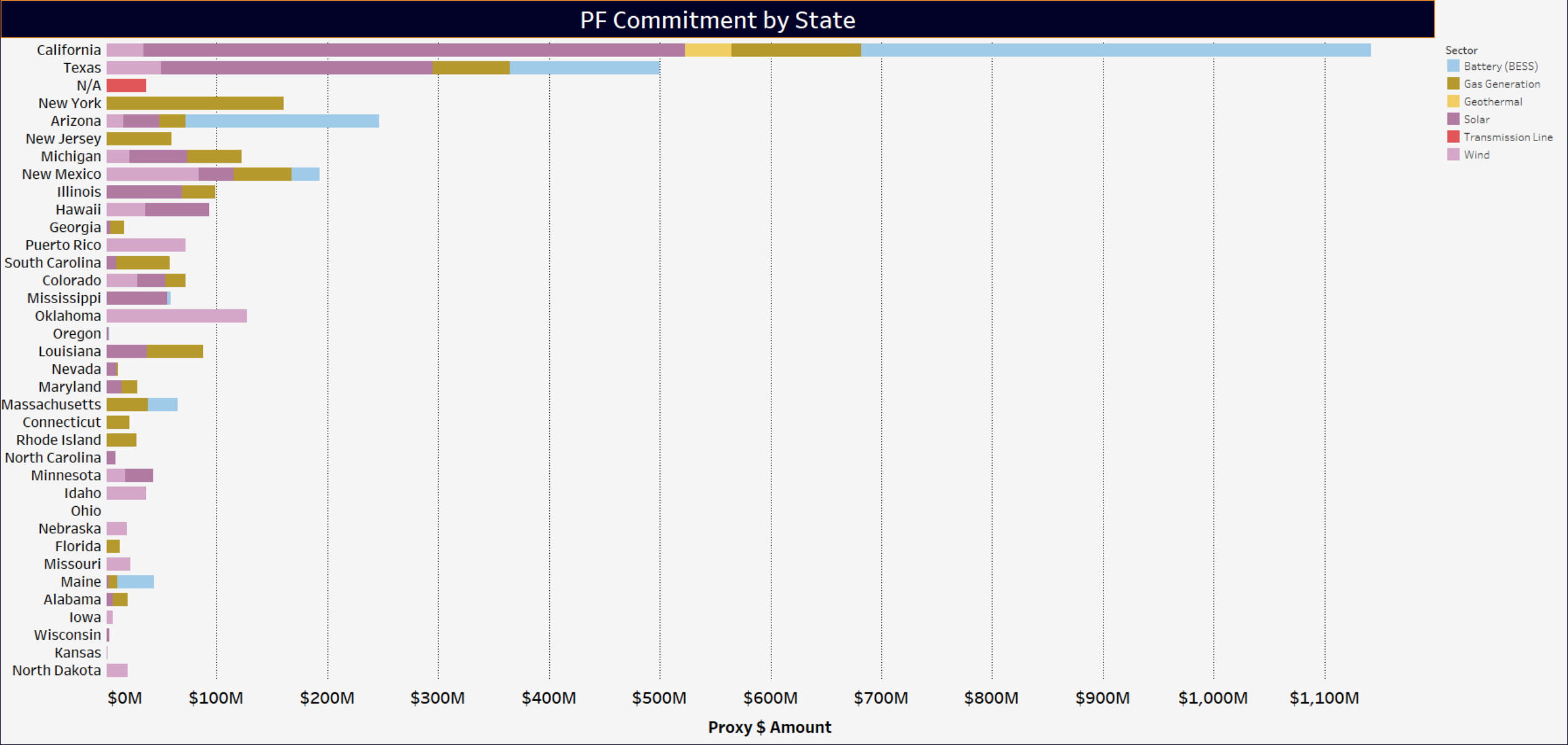


# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

- **48 Borrowers [30% of total PF Power & Renewables portfolio]**
- **\$1.5 billion in Commitments [31% of total PF Power & Renewables portfolio]**
  - 58% of Borrowers (50% of Commitments) - Solar / Solar+Co-located Battery Storage
  - 19% of Borrowers (23% of Commitments) - Standalone Battery Storage
  - 10% of Borrowers (10% of Commitments) - Thermal/Gas-Fired Power
  - 8% of Borrowers (13% of Commitments) - Wind
  - 4% of Borrowers (4% of Commitments) - Other Power (Geothermal)



# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

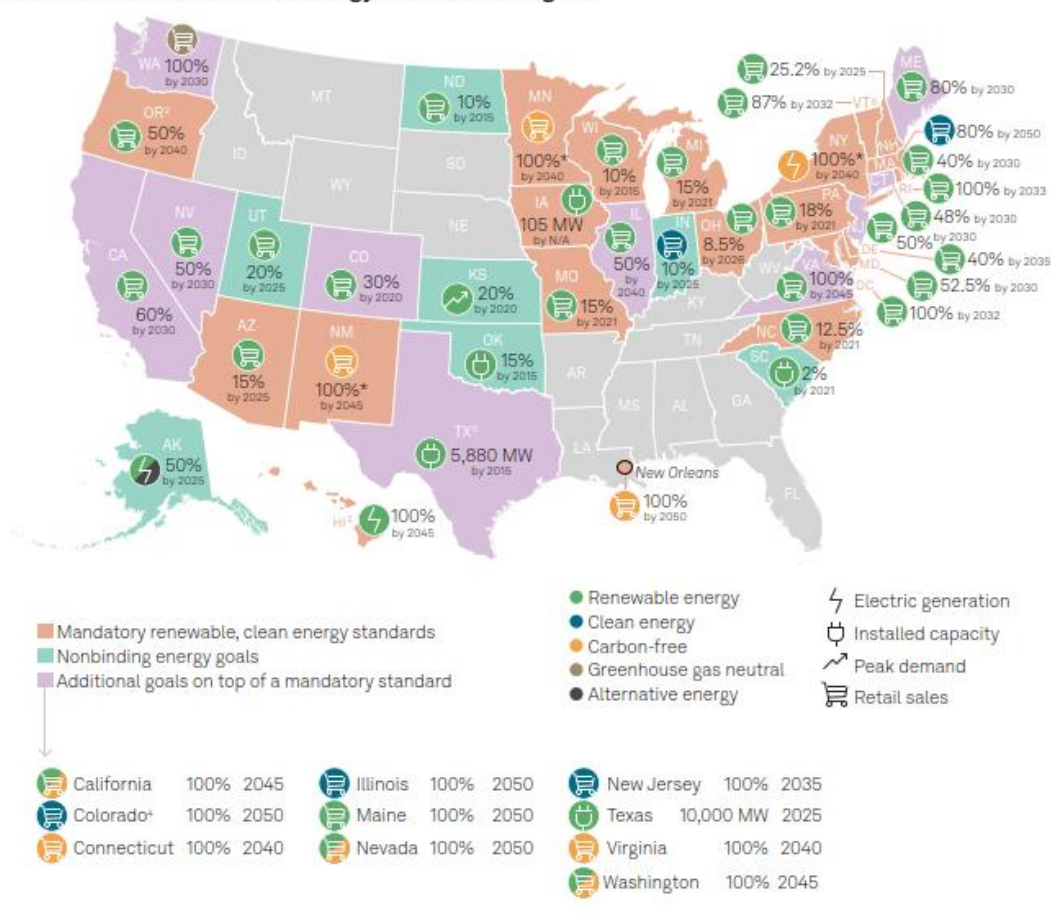


# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

- California's Renewable Portfolio Standard (RPS) program was established in 2002 by Senate Bill (SB) 1078 (Sher, 2002) with the initial requirement that 20% of electricity retail sales must be served by renewable resources by 2017.
- The program was accelerated in 2015 with SB 350 (de León, 2015) which mandated a 50% RPS by 2030. SB 350 includes interim annual RPS targets with three-year compliance periods and requires 65% of RPS procurement to be derived from long-term contracts of 10 or more years.
- In 2018, SB 100 (de León, 2018) was signed into law, which again increases the RPS to 60% by 2030 and requires all the state's electricity to come from carbon-free resources by 2045.

## Clean energy standards

State renewable and clean energy standards and goals



Data compiled Aug. 15, 2023.  
N/A = not applicable.  
Targets indicate the final requirement and do not include interim steps. The data also does not include voluntary targets adopted by utilities, corporations, public power districts, etc.  
\* There are interim steps within the renewable portfolio standard that allow for a target to be met with renewable energy resources; however, the carbon-free target is the ultimate target resource policy.  
† Massachusetts currently has in place a Clean Energy Standard and a separate Renewable Portfolio Standard.  
The 40% renewables by 2030 standard does not have a stated expiration date; the standard is to increase by 1% each year and will reach 100% renewable energy by 2090.  
‡ The state's clean energy targets legislation requires retail electricity providers to reduce emissions by 100% by 2040; while it is a separate policy, it is complementary and works in tandem with the renewable portfolio standard.  
§ The standard is based on a utility's net electric generation.  
|| The goal is in place for a retail utility that provides service to more than 500,000 customers, such as Xcel Energy, or any utility that decides to opt in.  
¶ Legislation enacted in 2023 modifies the renewable energy standard and subsequent goal so that it now only applies to generating capacity from solar energy technologies instead of renewable energy technologies.  
‡ In addition to the 75% renewable energy target, utilities are required to procure an additional 12% of their annual retail electric sales from distributed generation or energy transformation projects.  
Design credit: Cat VanVliet.  
Source: Regulatory Research Associates, a group within S&P Global Commodity Insights.

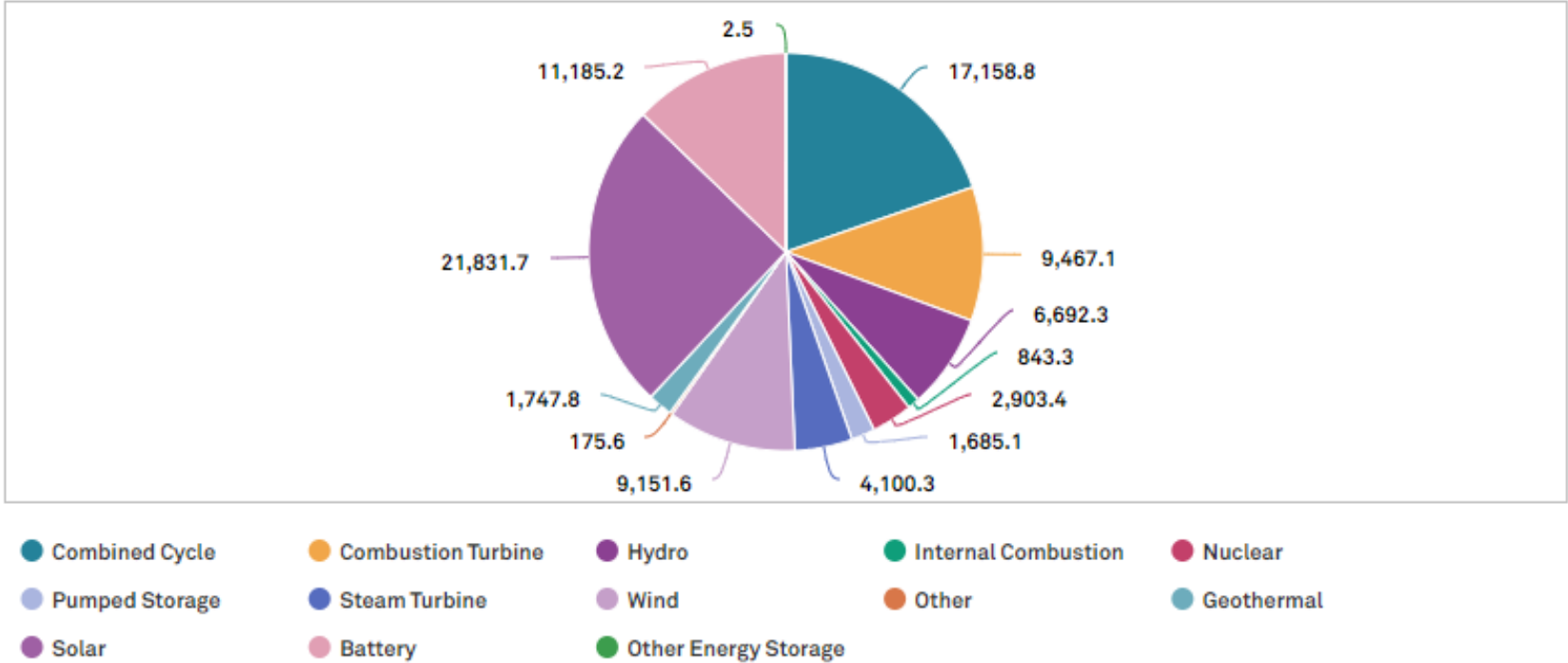
# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

| Technology Type      | Fuel Type                 |
|----------------------|---------------------------|
| TECHNOLOGY TYPE      | SUMMER PEAK CAPACITY (MW) |
| Battery              | 11,185.24                 |
| Combined Cycle       | 17,158.78                 |
| Combustion Turbine   | 9,467.09                  |
| Geothermal           | 1,747.75                  |
| Hydro                | 6,692.30                  |
| Internal Combustion  | 843.33                    |
| Nuclear              | 2,903.38                  |
| Other                | 175.60                    |
| Other Energy Storage | 2.50                      |
| Pumped Storage       | 1,685.10                  |
| Solar                | 21,831.67                 |
| Steam Turbine        | 4,100.25                  |
| Wind                 | 9,151.63                  |
| Total                | 86,944.62                 |

## Power Plant Summary

Technology Type   Fuel Type

## Summer Capacity



Source: S&P Global Market Intelligence

# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

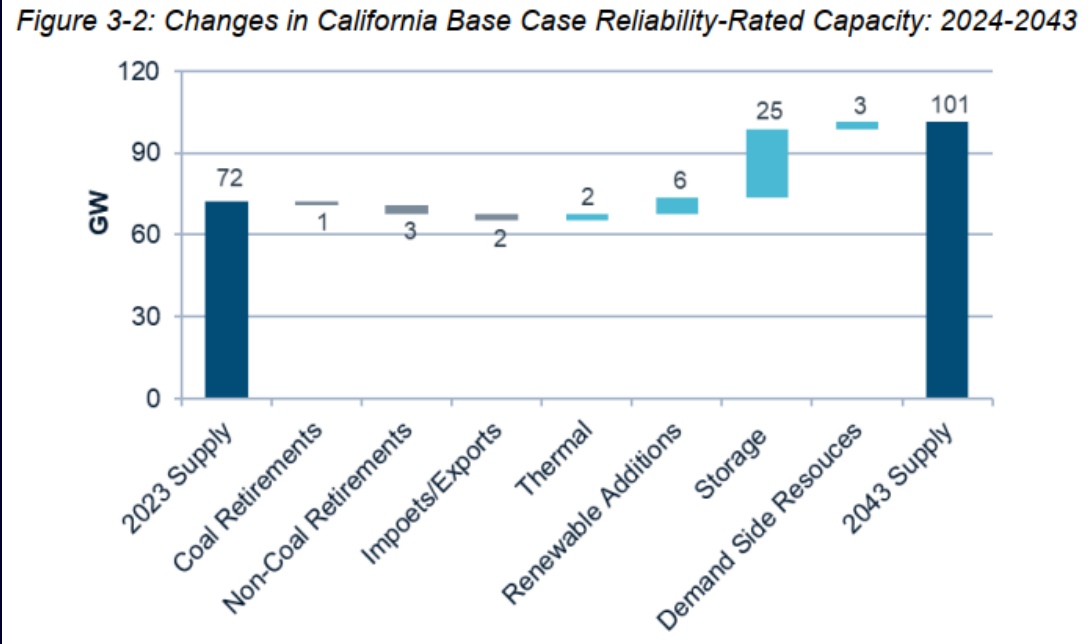
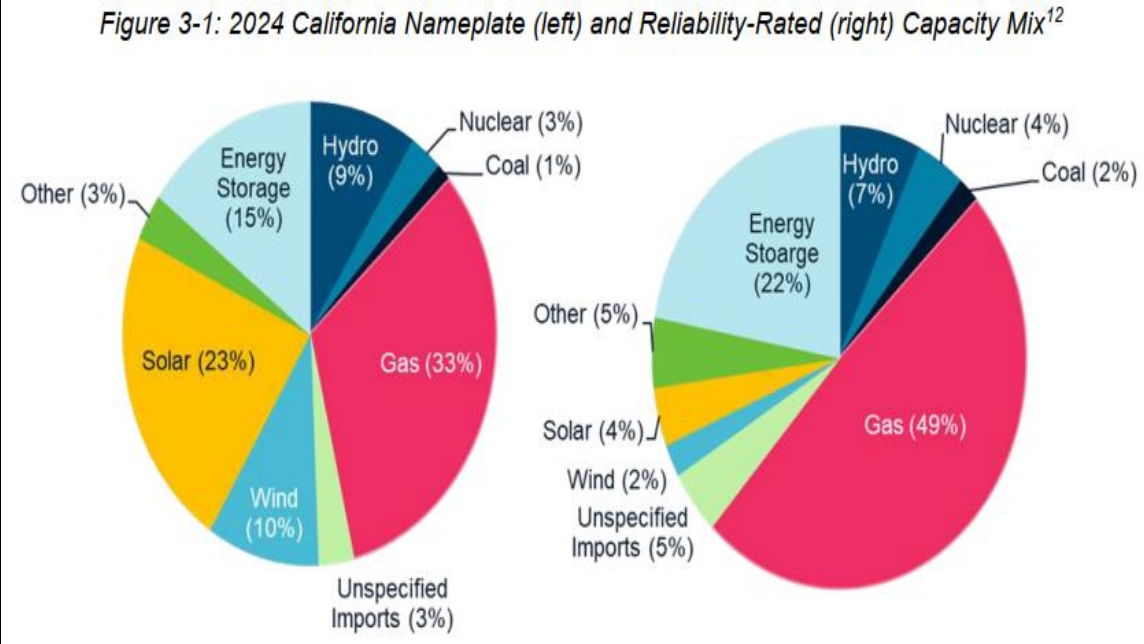
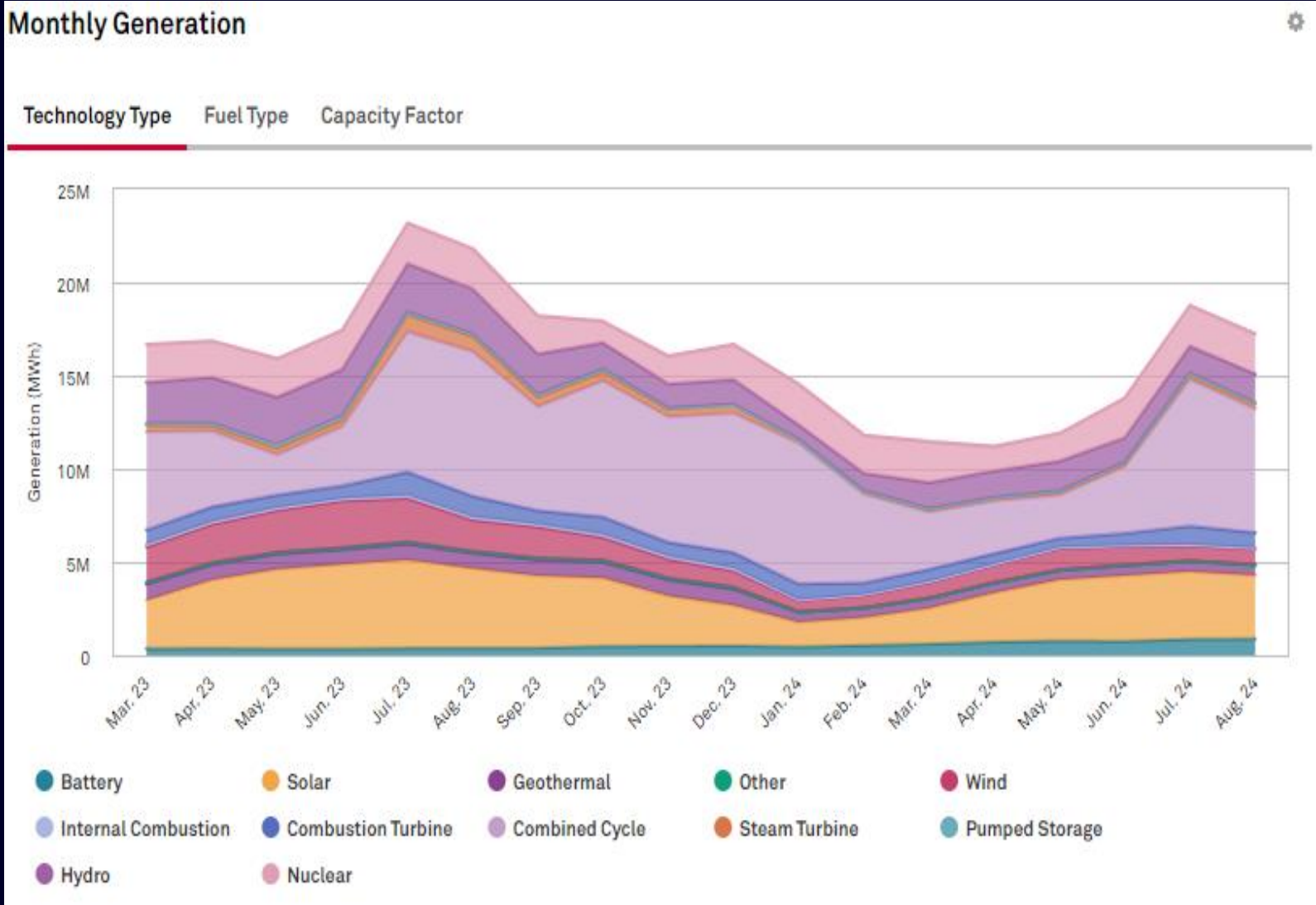


Table 4-8: Remaining OTC Thermal Capacity Retirements

| Facility              | Type       | Capacity (MW) | Previous Expected Retirement Year | Current Expected Retirement Year |
|-----------------------|------------|---------------|-----------------------------------|----------------------------------|
| Redondo Beach 5, 6, 8 | ST Gas/Oil | 841           | 2021                              | 2024                             |
| Alamitos 3-5          | ST Gas/Oil | 1,152         | 2021                              | 2027                             |
| Huntington Beach 2    | ST Gas/Oil | 226           | 2021                              | 2027                             |
| Ormond Beach 1-2      | ST Gas/Oil | 1,491         | 2021                              | 2027                             |
| Scattergood 1-2       | ST Gas/Oil | 268           | 2025                              | 2030                             |
| Haynes 1-2            | ST Gas/Oil | 444           | 2030                              | 2030                             |
| Harbor 5              | CC         | 231           | 2030                              | 2030                             |
| Diablo Canyon 1       | Nuclear    | 1,122         | 2025                              | TBD                              |
| Diablo Canyon 2       | Nuclear    | 1,118         | 2025                              | TBD                              |

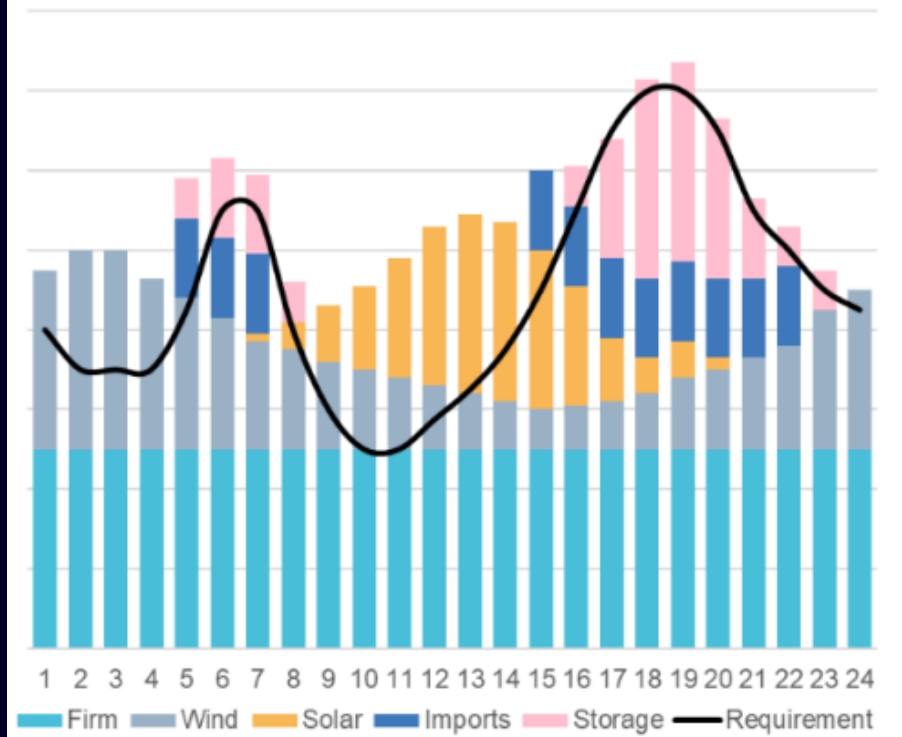
Source: PA Consulting Group Inc.

# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)



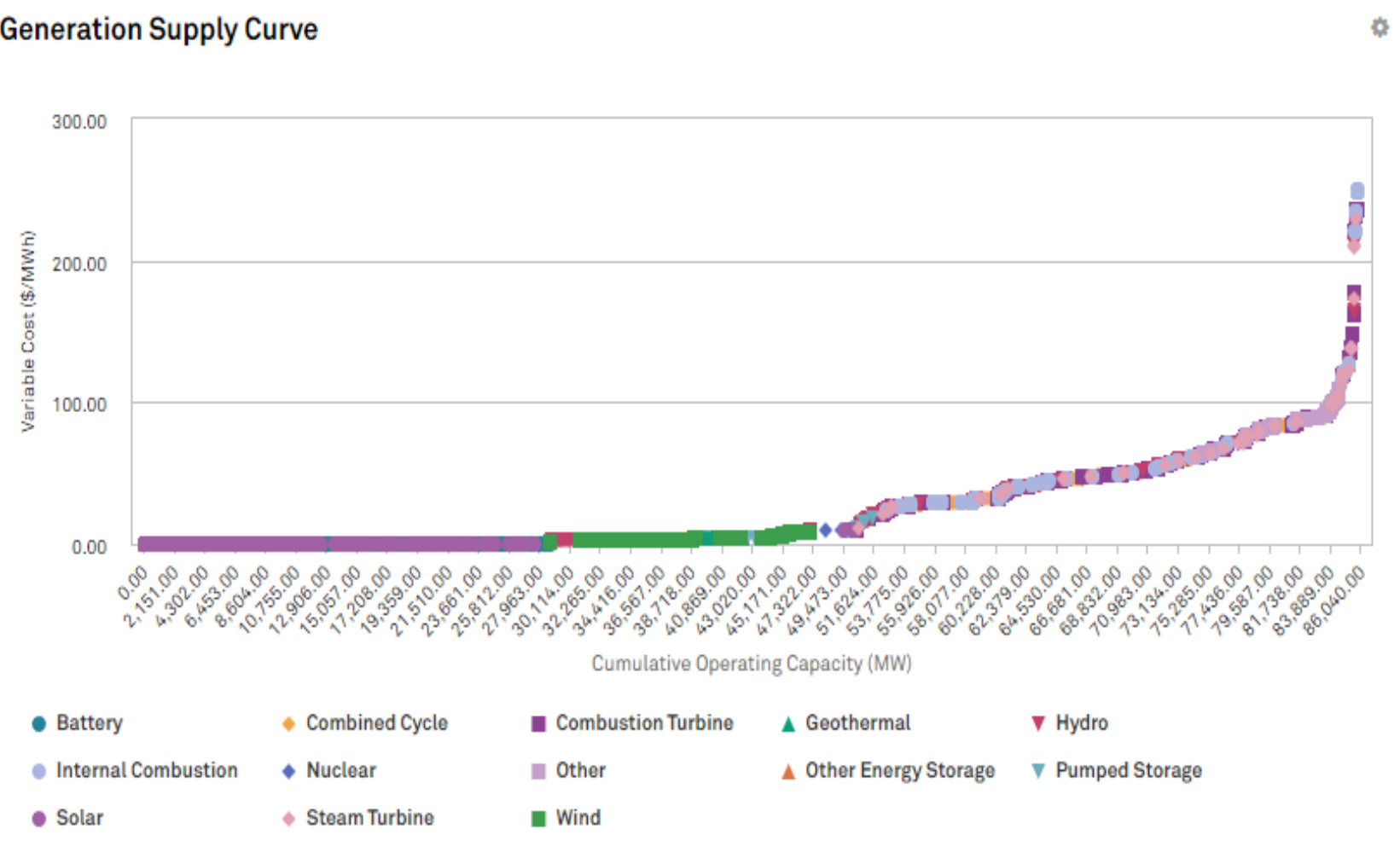
Source: S&P Global Market Intelligence

Figure 4-5: Illustrative Slice-of-Day Showing (NQC MWh)

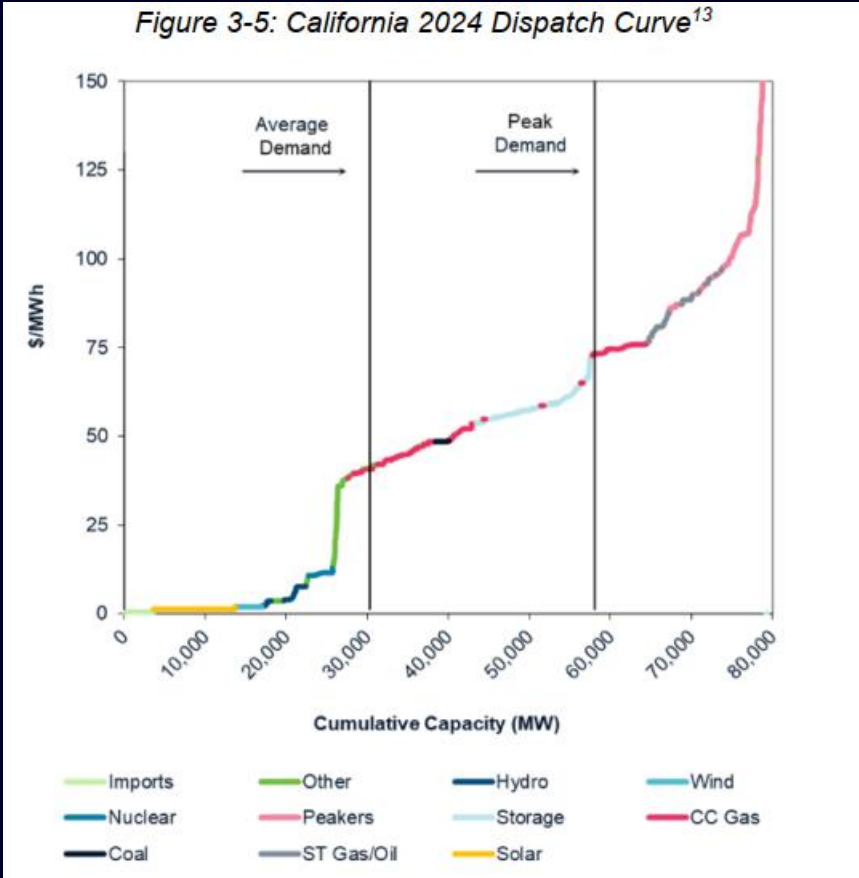


Source: PA Consulting Group Inc.

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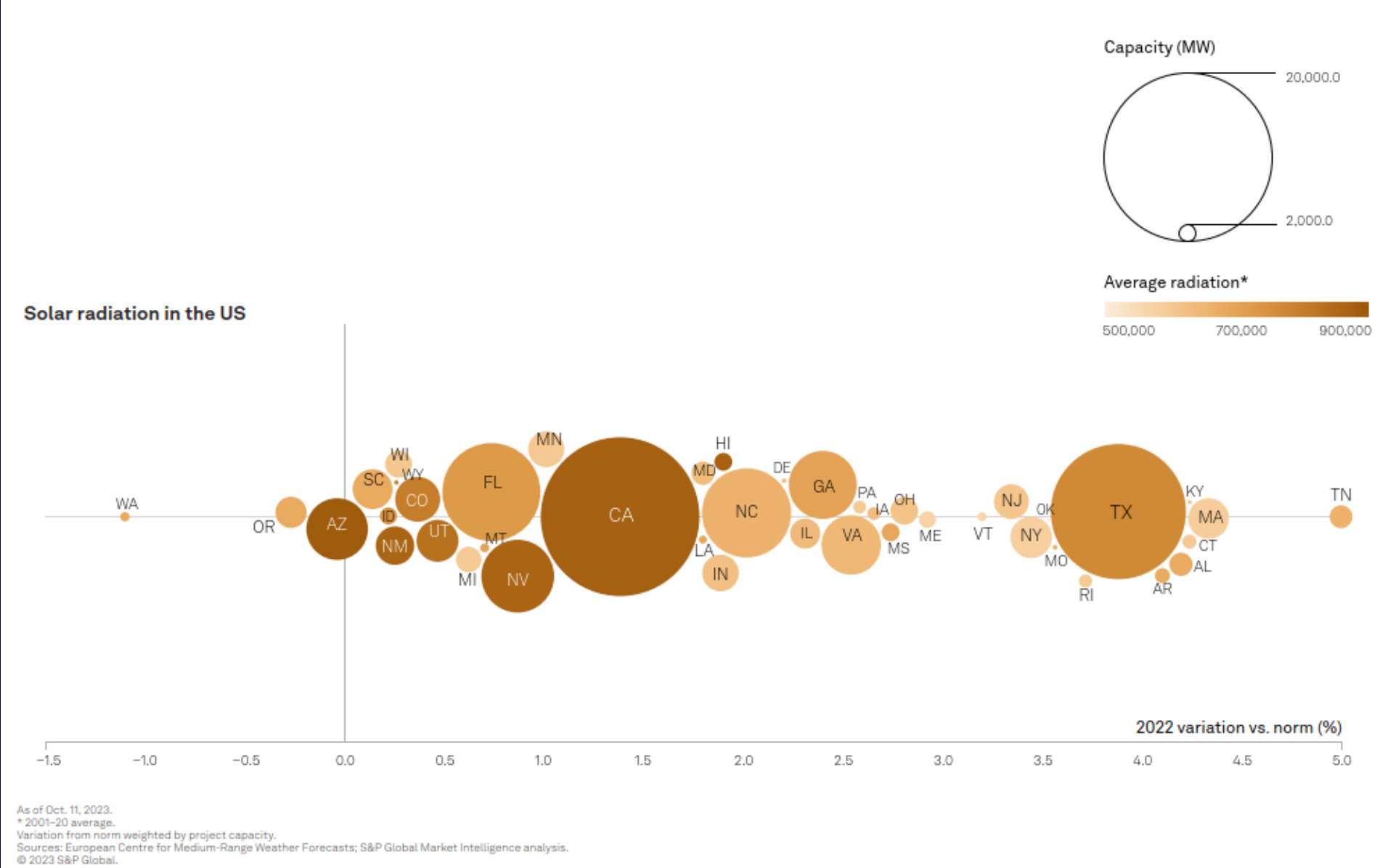


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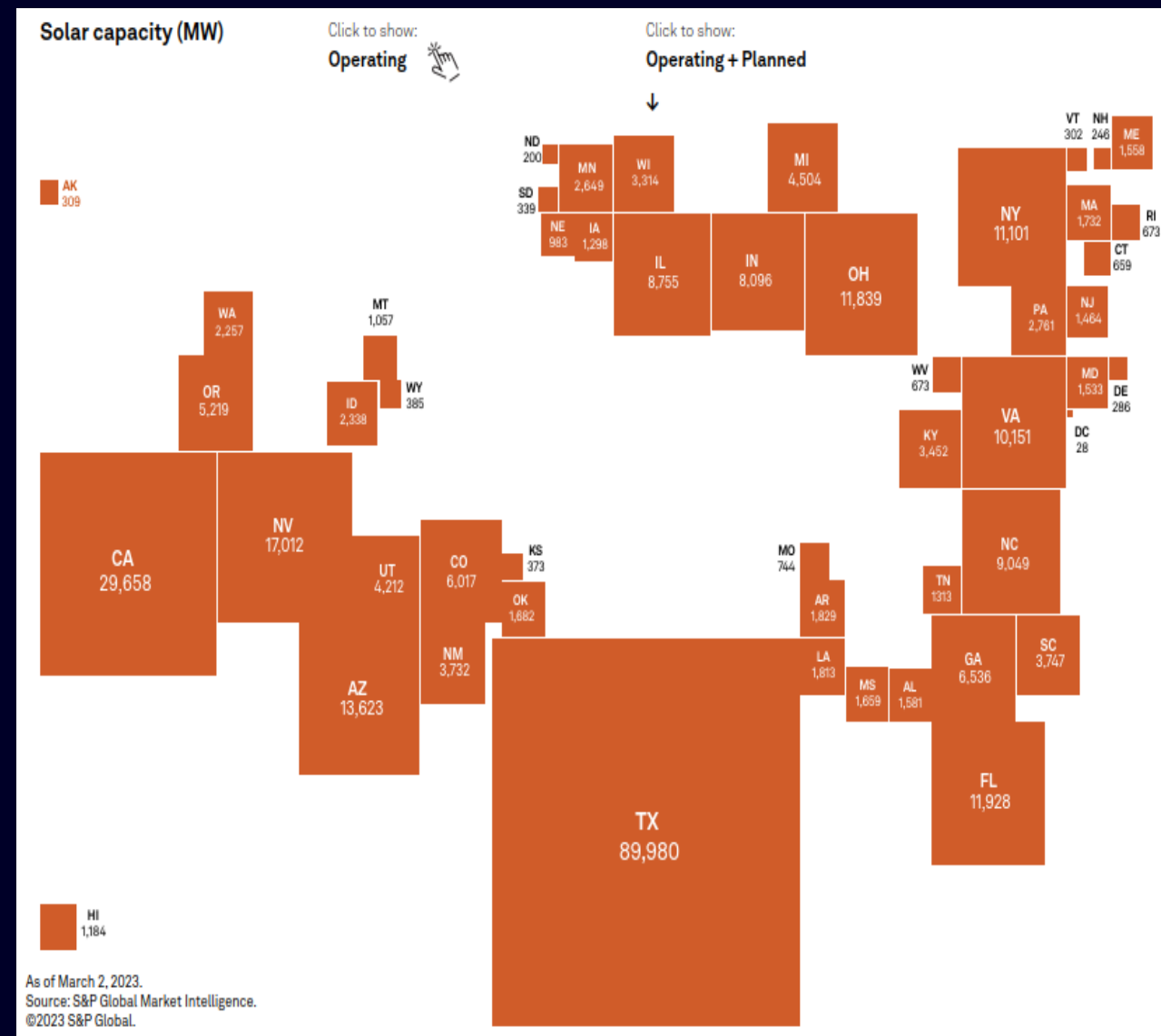
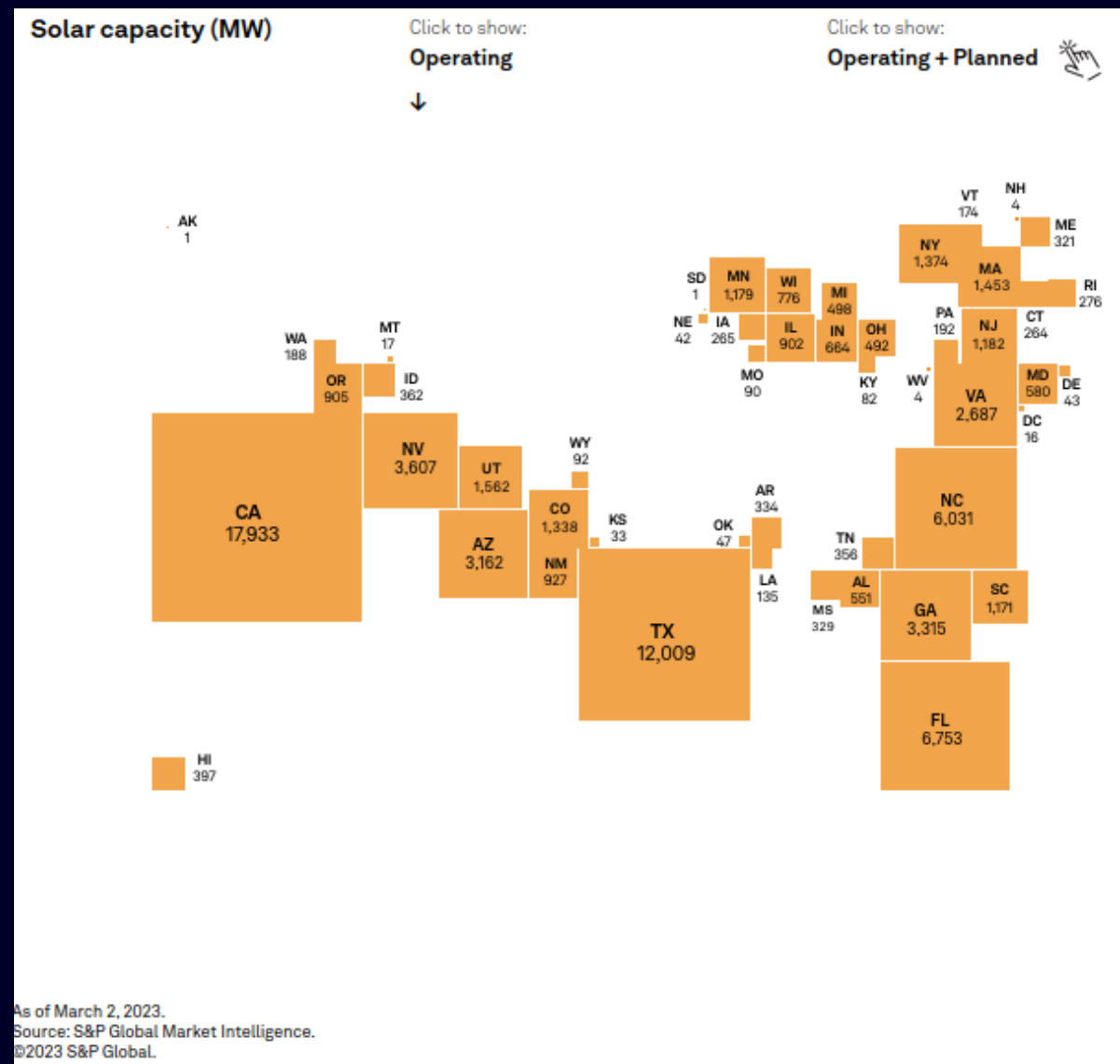


Source: PA Consulting Group Inc.

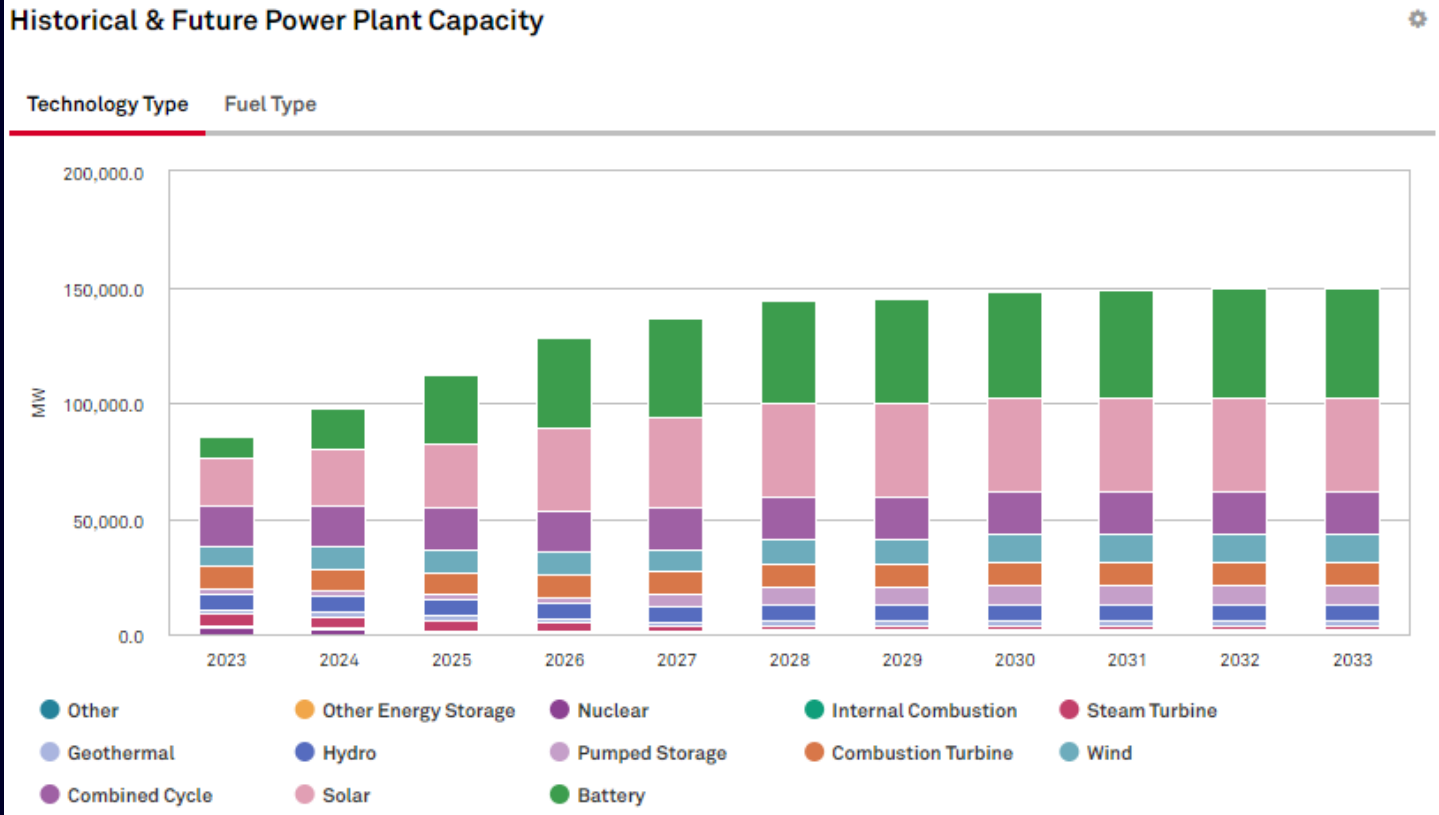
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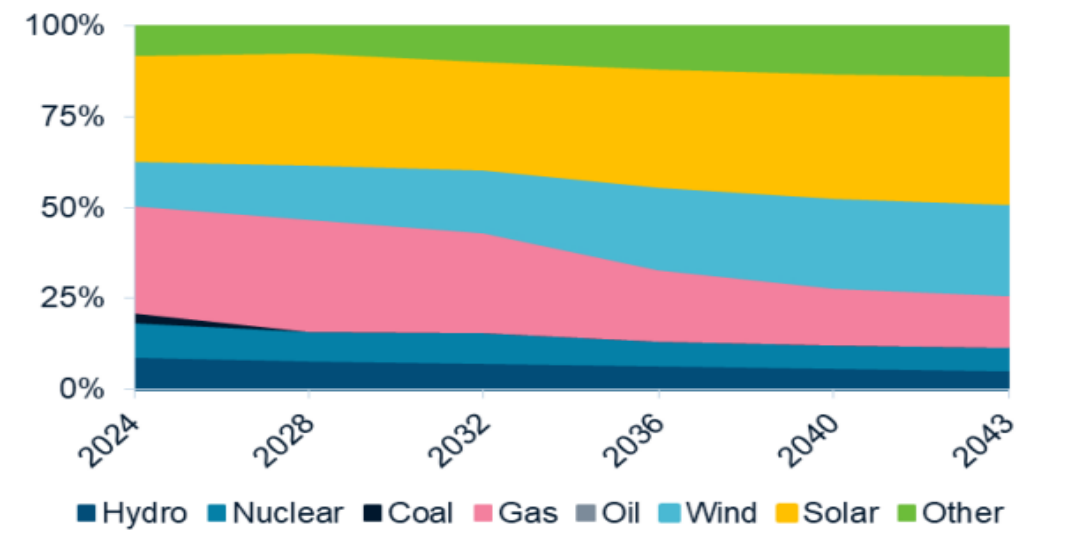


Source: S&P Global Market Intelligence

- PA Consulting expects 33 GW of new battery storage, 30 GW of new solar, 5 GW of new onshore wind and 6 GW of new offshore wind additions in CAISO over the next 20 years
- Equates to just 6 GW of reliability-rated renewable additions

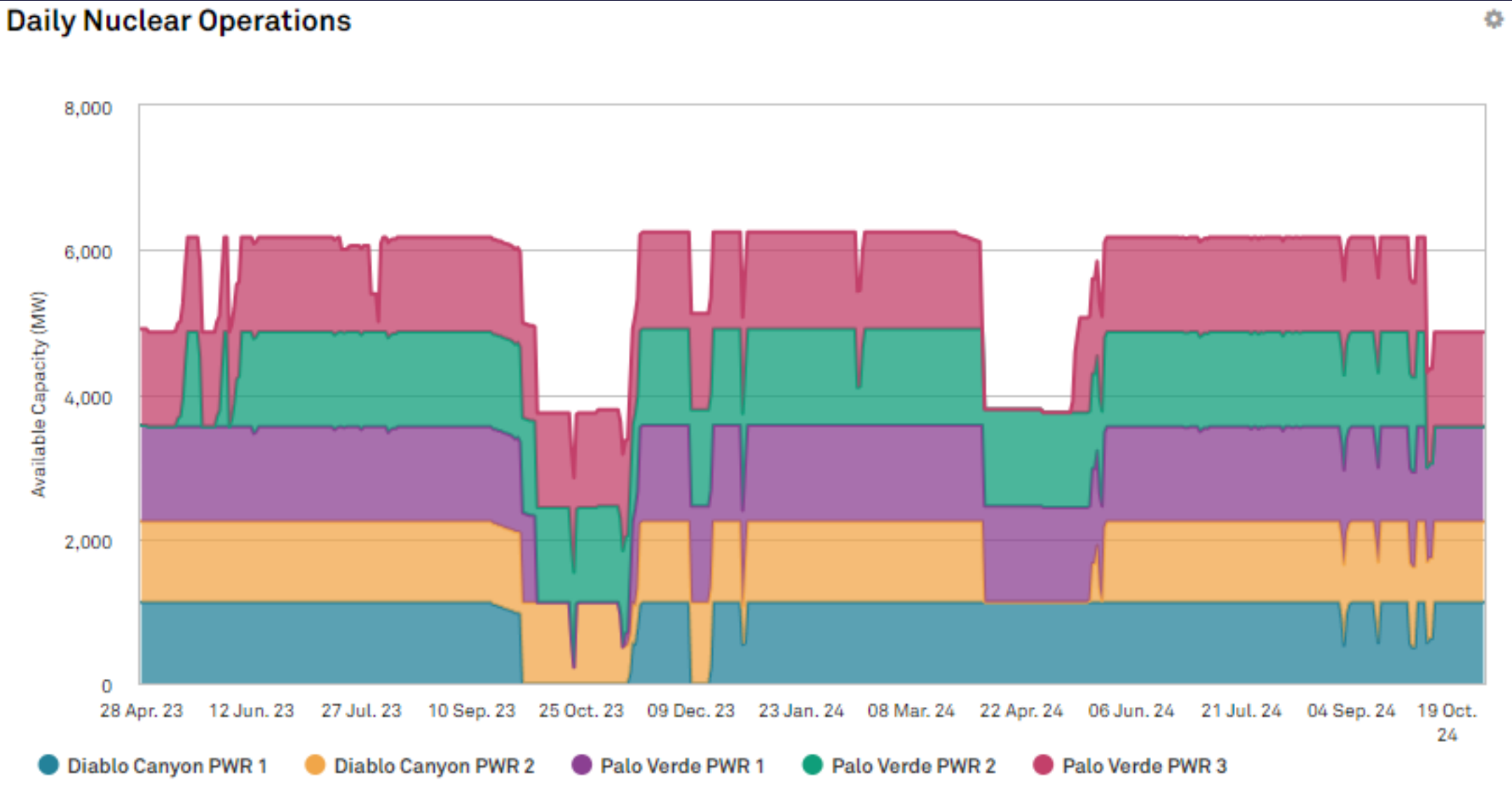
- 85 GW of capacity additions are required to reach California decarbonization goals by 2035 based on CAISO's 2023-2024 transmission planning process

Figure 3-3: California Energy Mix



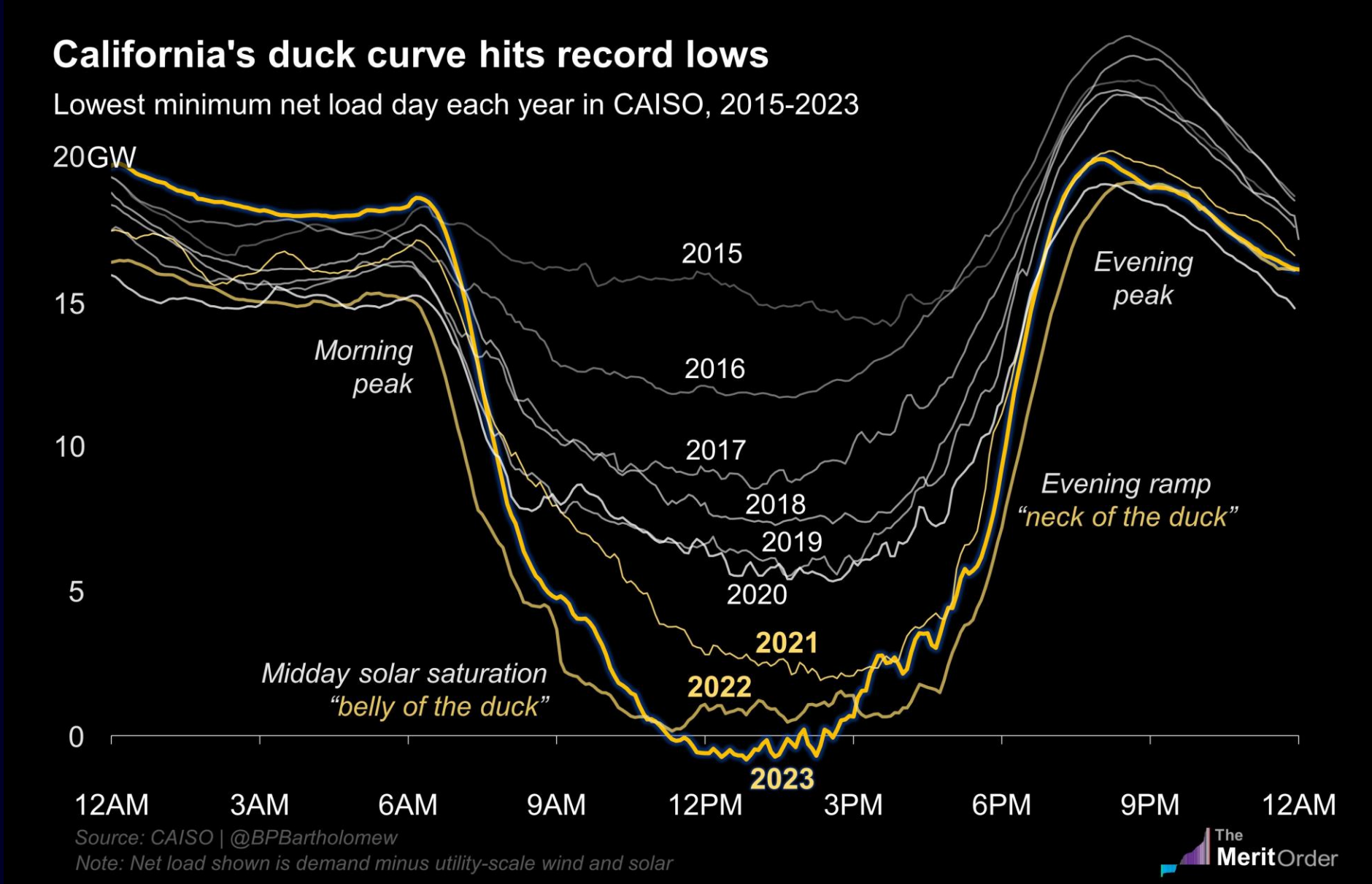
Source: PA Consulting Group Inc.

# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)



Source: S&P Global Market Intelligence

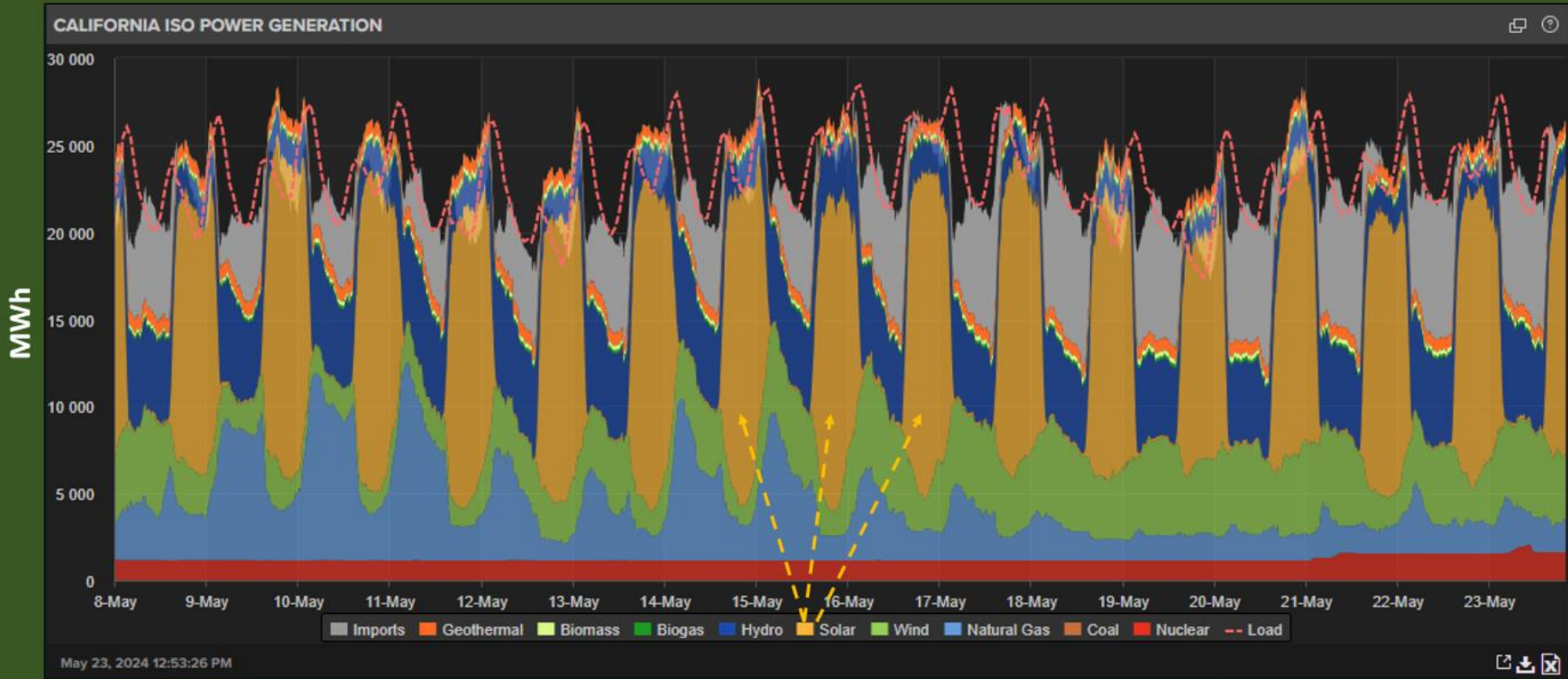
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# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

## California's power mix from May 8 through May 23, 2024

California's power system must accommodate large surges and declines in solar output each day

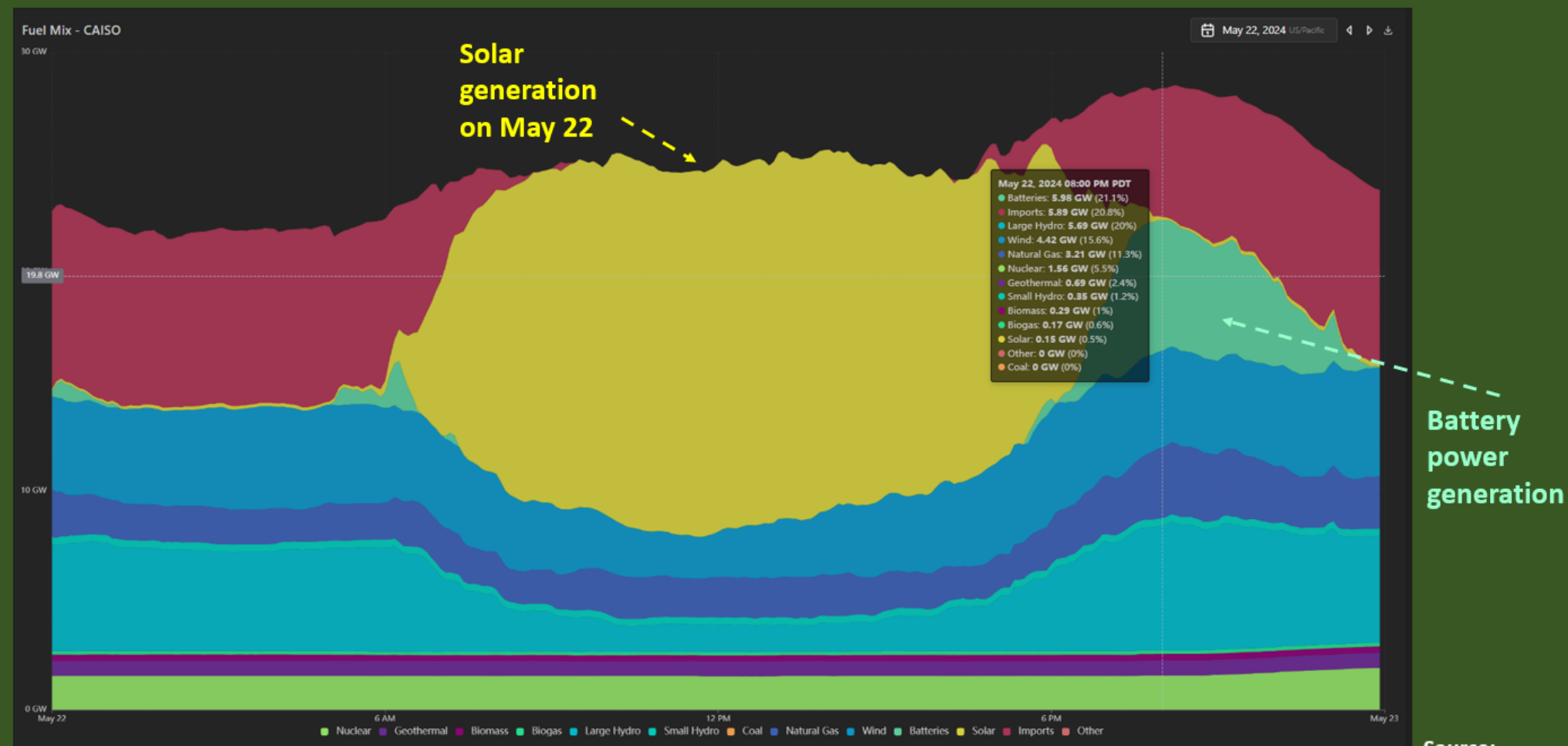


Source: LSEG

# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

## California's battery network kicks in when the sun goes down

Batteries provide around 20% of California's power needs at 8pm, when solar output stops but overall demand rises



Source:  
GridStatus

# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

**California's surge in solar output distorts system load and pushes prices lower**  
California's power prices routinely turn negative during periods of excess solar production

Load  
impact of  
surplus  
solar  
output

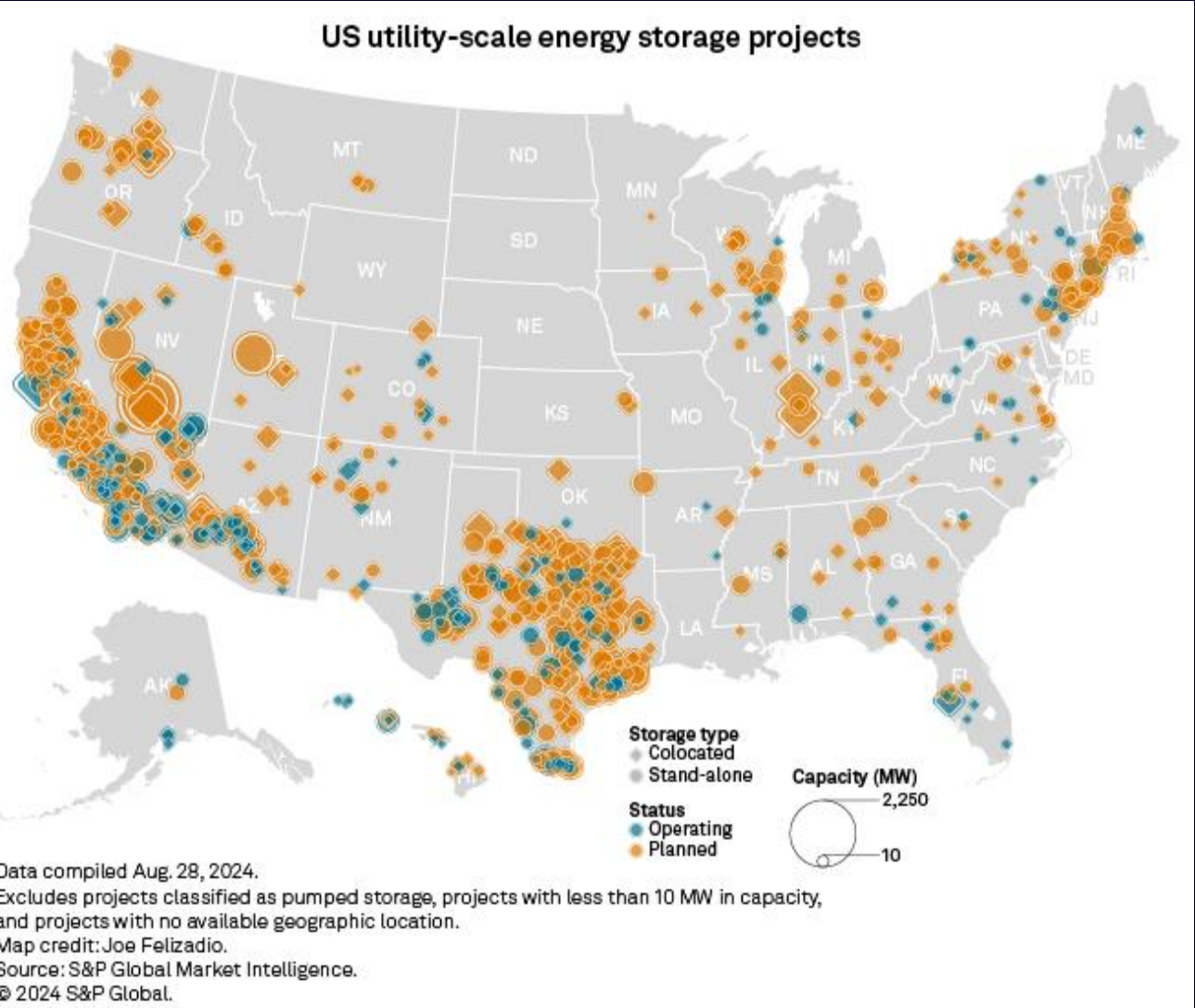
Price  
response  
to surplus  
solar  
output

Solar  
generation  
on May 22

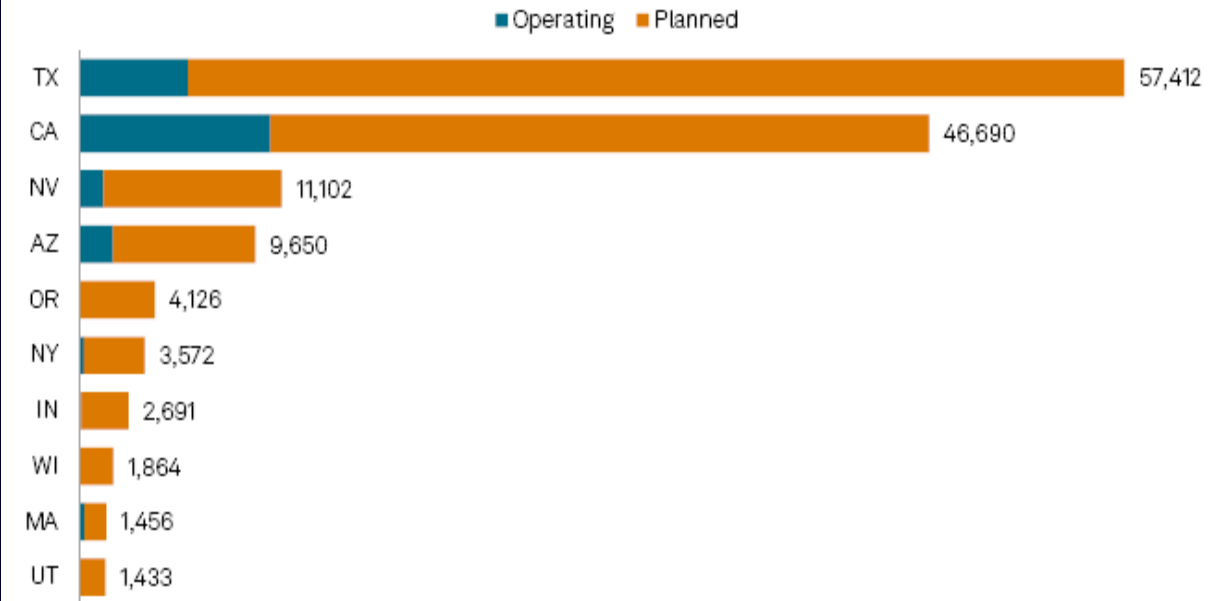


Source:  
GridStatus

# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)



California and Texas dominate US large-scale energy storage resources (MW)



Data compiled Aug. 27, 2024.  
Analysis includes stand-alone and colocated storage resources.  
Excludes projects classified as pumped storage, and those with no available in-service year.  
Minimum capacity for project units in aggregated list is 200 kW.  
Source: S&P Global Market Intelligence.  
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# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

- CAISO operates a day-ahead energy market, a real-time energy market, and a broader energy imbalance market via the WEIM
- CAISO uses the day-ahead market to determine market-clearing energy prices and unit commitments, and to ensure adequate energy is scheduled to meet projected hourly demand on the following day
- CAISO's real-time market facilitates procurement of power to meet demand not covered by day ahead schedules. All settlement in the real-time market occurs at 15-minute intervals, improving price transparency and price formation
- CAISO operates the WEIM, an energy-only balancing market that runs every five minutes to deploy sufficient power generation to meet load at the lowest cost, across its footprint and much of Western Electricity Coordination Council (WECC)
- To meet its reliability standards, CAISO procures (at the 10-minute level) regulation up, regulation down, spinning reserve, and non-spinning reserve ancillary services in day-ahead and hour-ahead markets. These ancillary services are co-optimized with the clearing of energy bids and may also be self-provided by generators

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Figure 3-4: Changes in California ELCC from 2024-2043

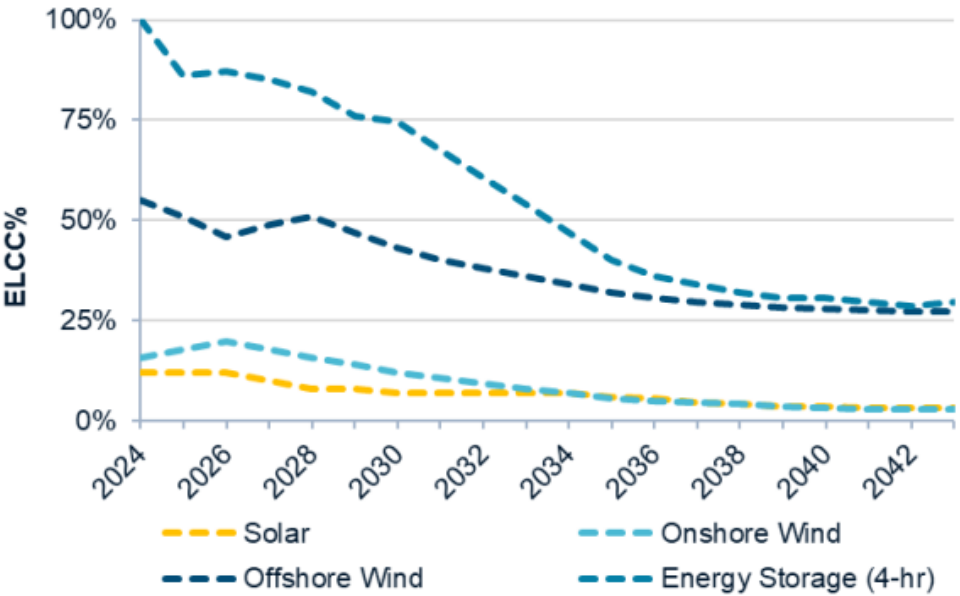


Figure 3-8: California SP-15 Market Power Price Projections

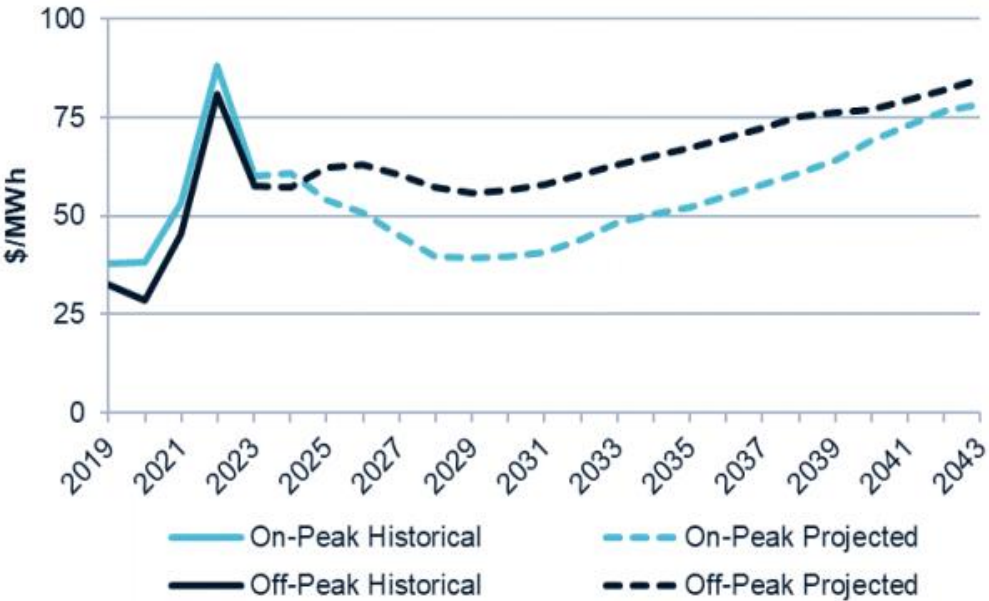
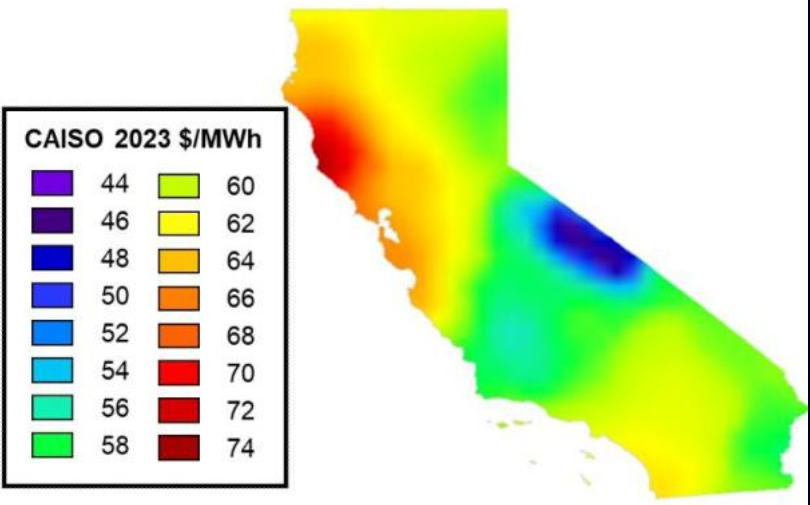


Figure 5-1: California 2023 Average Day-Ahead LMP<sup>88</sup>

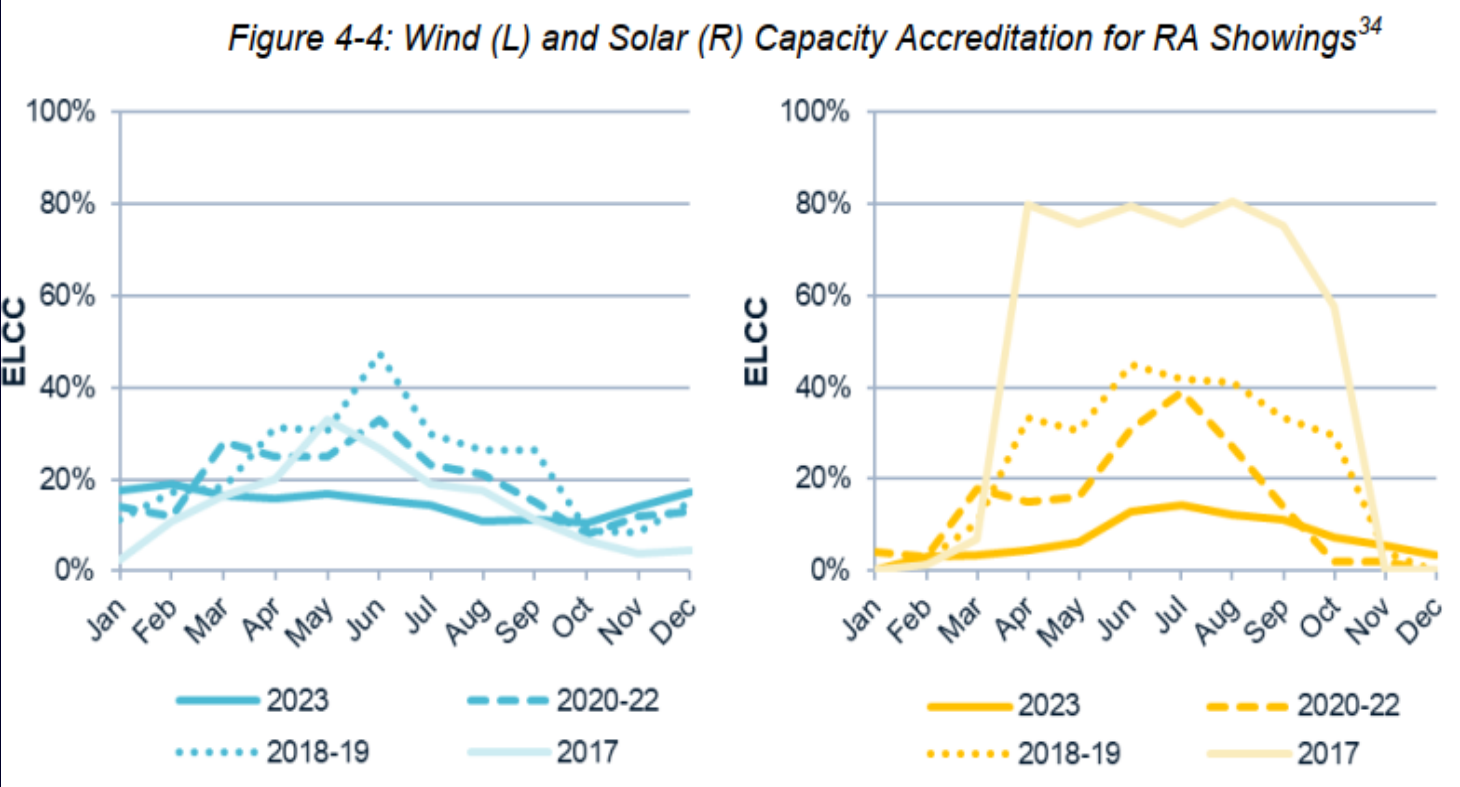
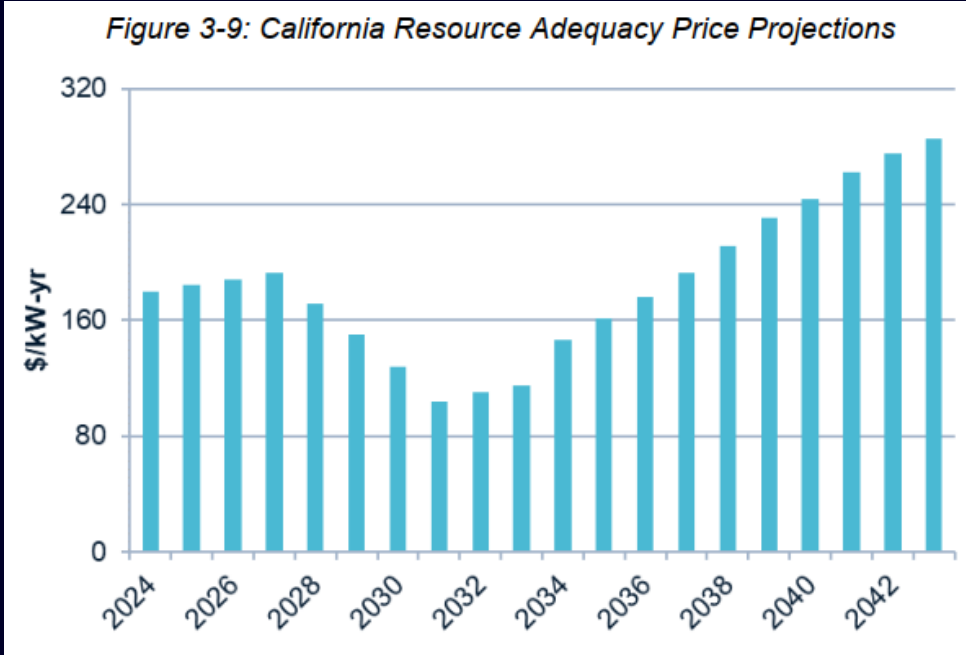


Source: PA Consulting Group Inc

# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

- California does not have a “capacity” market, instead relies on bilateral contracts and utility-owned generation to meet reliability targets through its Resource Adequacy (RA) program
- California Public Utilities Commission (CPUC) conducts a centralized, long-term integrated resource planning (IRP) process to identify future RA procurement needs. RA ensures there is enough capacity and reserves to maintain a balanced supply and demand across the electric system
- CPUC requires suppliers and Load Servicing Entities (LSEs) - IOUs, CCAs, and energy service providers - to have enough contracted capacity to meet system, local, and flexible RA requirements on a year and month-ahead basis (there are penalties for failing to do so)
  - ✓ **System RA** requirements stipulate that LSEs contract enough capacity to meet the 1-in-2 peak demand forecast, plus an additional planning reserve margin. A 1-in-2 peak demand means there’s a 50% chance that the forecast will be less or more than actual peak load. The CPUC’s planning reserve margin is currently set to 17%
  - ✓ **Local RA** requires that LSEs procure the capacity needed to meet demand in the event a local transmission grid emergency occurs
  - ✓ **Flexible RA** requires LSEs to procure enough flexible capacity to meet the highest expected three-hour net load ramp each month. If demand for electricity turns out to be significantly higher than forecasted, especially during extreme region-wide heat waves, there can be periods when there will not be enough resources to meet demand
- Imports from other CAISO balancing areas and other state are a key part of CAISO’s energy mix and they are even more critical when there are insufficient resources within the CAISO footprint to meet demand
- During projected tight energy supplies, CAISO will issue a series of emergency notifications to obtain additional capacity or reduce energy use to relieve stress on the power grid

# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)



Source: PA Consulting Group Inc

# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

Figure 4-21: Historical and Projected Capital Costs by Clean Energy Technology – California<sup>86</sup>

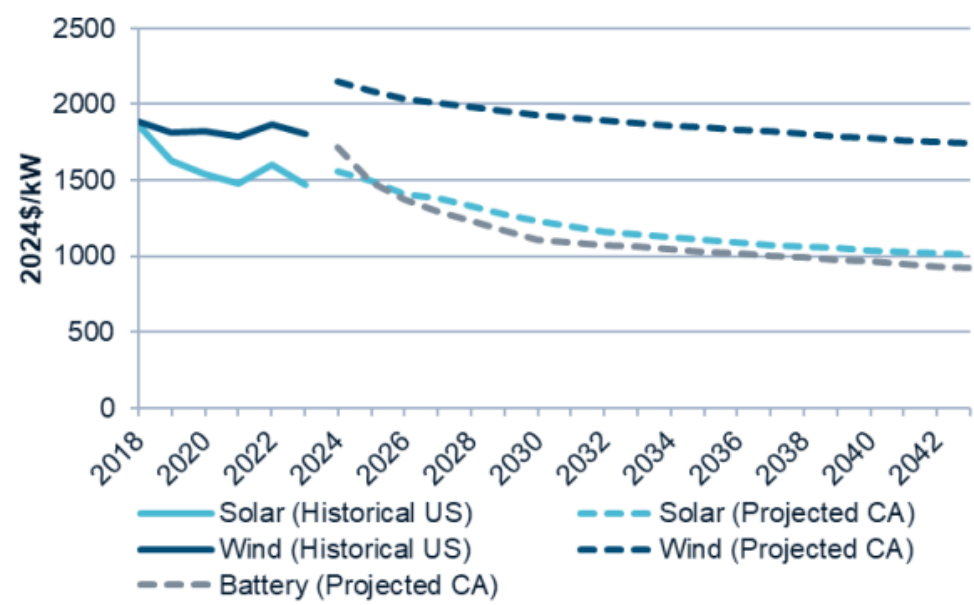


Table 4-10: California Cost of New Entry Assumptions (2024\$)

| Assumption                                    | Solar | Wind  | Battery (4-hour) |
|-----------------------------------------------|-------|-------|------------------|
| Capacity (MW)                                 | 100   | 100   | 100              |
| Installed capacity cost <sup>85</sup> (\$/kW) | 1,557 | 2,148 | 1,719            |
| Interest Rate on Debt (Nominal)               | 5.5%  | 5.5%  | 5.5%             |
| Return on Equity (Nominal)                    | 10.0% | 10.0% | 10.0%            |
| Debt/Equity Ratio                             | 65/35 | 65/35 | 65/35            |
| Debt Term (years)                             | 25    | 20    | 15               |
| Property Tax                                  | 1.1%  | 1.1%  | 1.1%             |
| Corporate Tax                                 | 21.0% | 21.0% | 21.0%            |
| Full Load Heat Rate (Btu/kWh)                 | N/A   | N/A   | N/A              |
| Fixed O&M (\$/kW)                             | 23.98 | 49.39 | 8.73             |
| Variable O&M (\$/MWh)                         | N/A   | N/A   | N/A              |

Source: PA Consulting Group Inc

# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

- The growing tension among electricity sector objectives and policy priorities, combined with the effects of climate change, create a multitude of challenges that system operators, like CAISO, must manage, including (but not necessarily limited to):
  - ✓ **Obstacles to new infrastructure** driven by siting, permitting, and interconnection challenges, lack of transmission capacity, lack of clarity on future policy, and lack of cash flow security
  - ✓ **Resource performance uncertainty** driven by a reduction in fuel diversity, outages of aging dispatchable generation, dispatch inflexibility, and rising penetration of intermittent and duration-limited resources relative to dispatchable resources;
  - ✓ **Demand growth and uncertainty** driven by increasing frequency of extreme weather, electrification, and distributed energy resource (DER) penetration
  - ✓ **Commodity price uncertainty** driven by extreme weather, transmission and storage infrastructure constraints, and policy evolution; and
  - ✓ **Grid instability** driven by a changing balance of spinning turbines that provide inertia and other stability services relative to inverter-based renewable and BESS resources.

# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

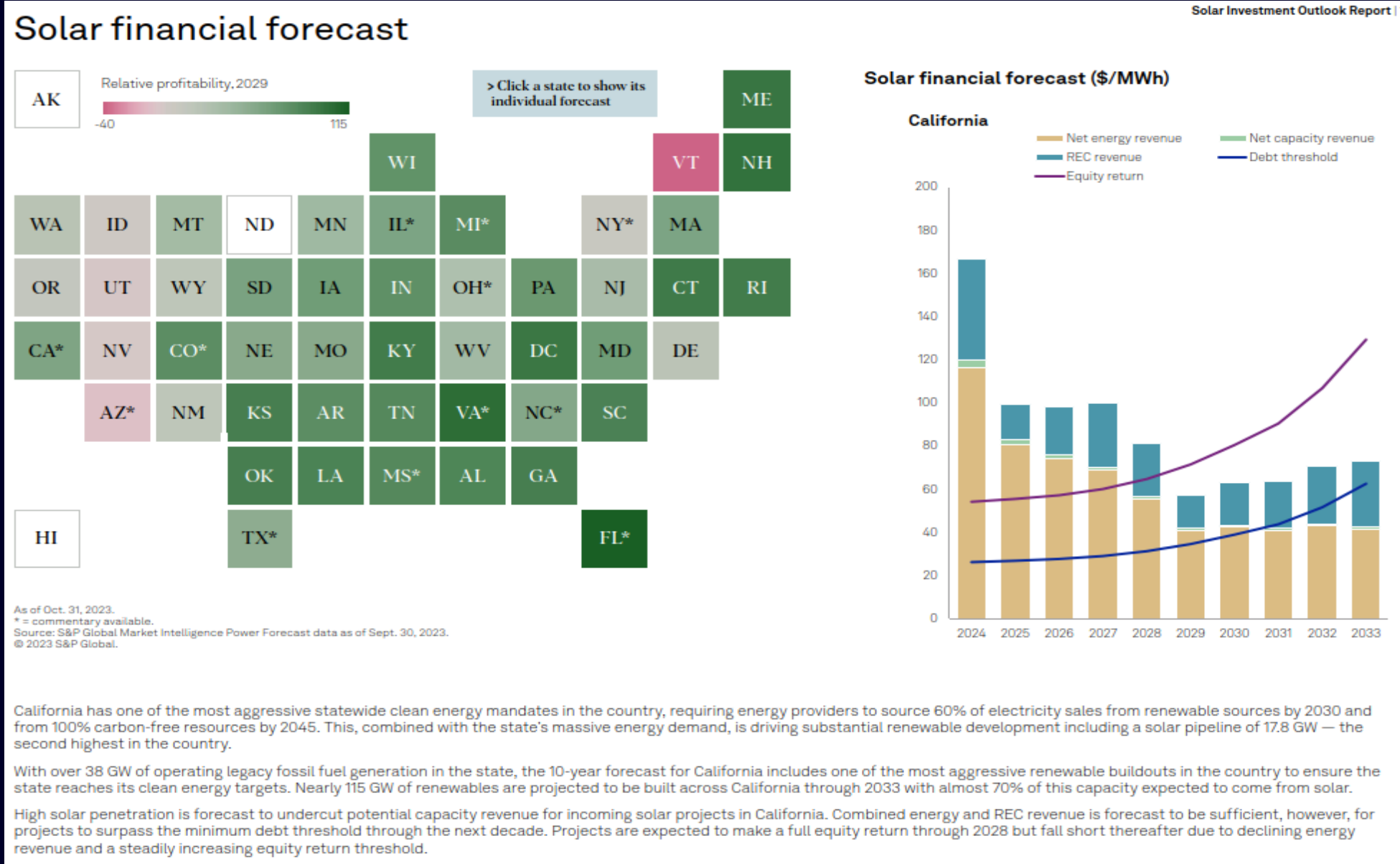
- Revenue Streams
  - ✓ Classic LSE Toll / PPA
  - ✓ Hedge (HRCO)
  - ✓ RA Contract
  - ✓ TB4 Contract
  - ✓ Hybrids
  - ✓ Merchant / Arbitrage
- Debt Sizing
  - ✓ 1.2-1.35x DSCRs (contracted)
  - ✓ 1.75-2.00x DSCRs (uncontracted)
    - ✓ Uncontracted haircuts
  - ✓ Merchant Tails
    - ✓ Loan Sweep-Out 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)

# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

- **Exhibits**

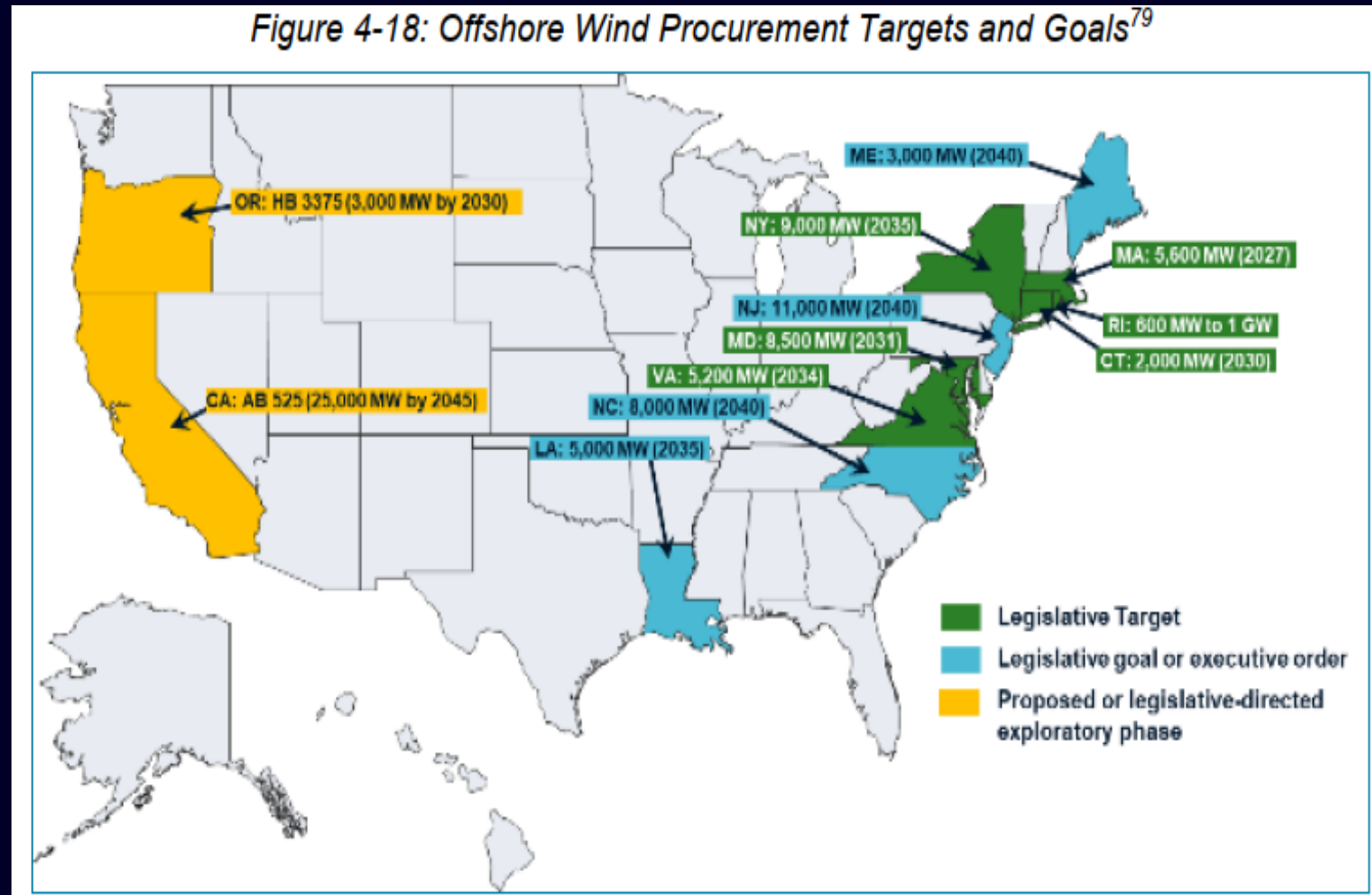
- ✓ Solar Financial Forecast
- ✓ Offshore Wind
- ✓ Interconnection Queue
- ✓ Corporate PPAs
- ✓ Data Centers

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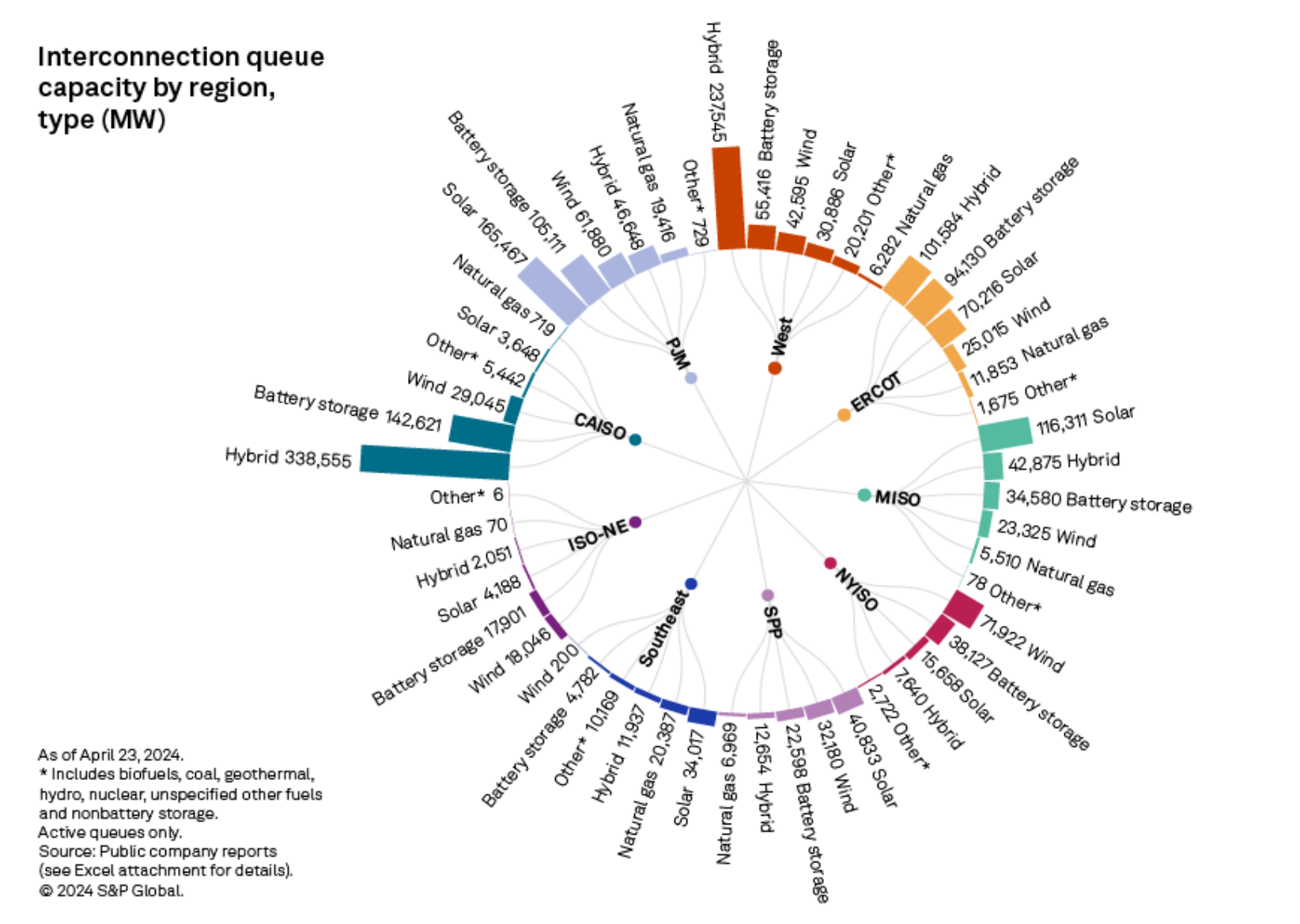
# PS-AM PF Power & Renewables - Power Markets Overview (CAISO)

- California offshore wind planning is for 2-5GW by 2030 and 25 by 2045
- PA Consulting indicates a more realistic outcome is 6 GW over the next 20 years
- Diablo Canyon permit extension will create interconnection and transmission risk for offshore wind developments in California

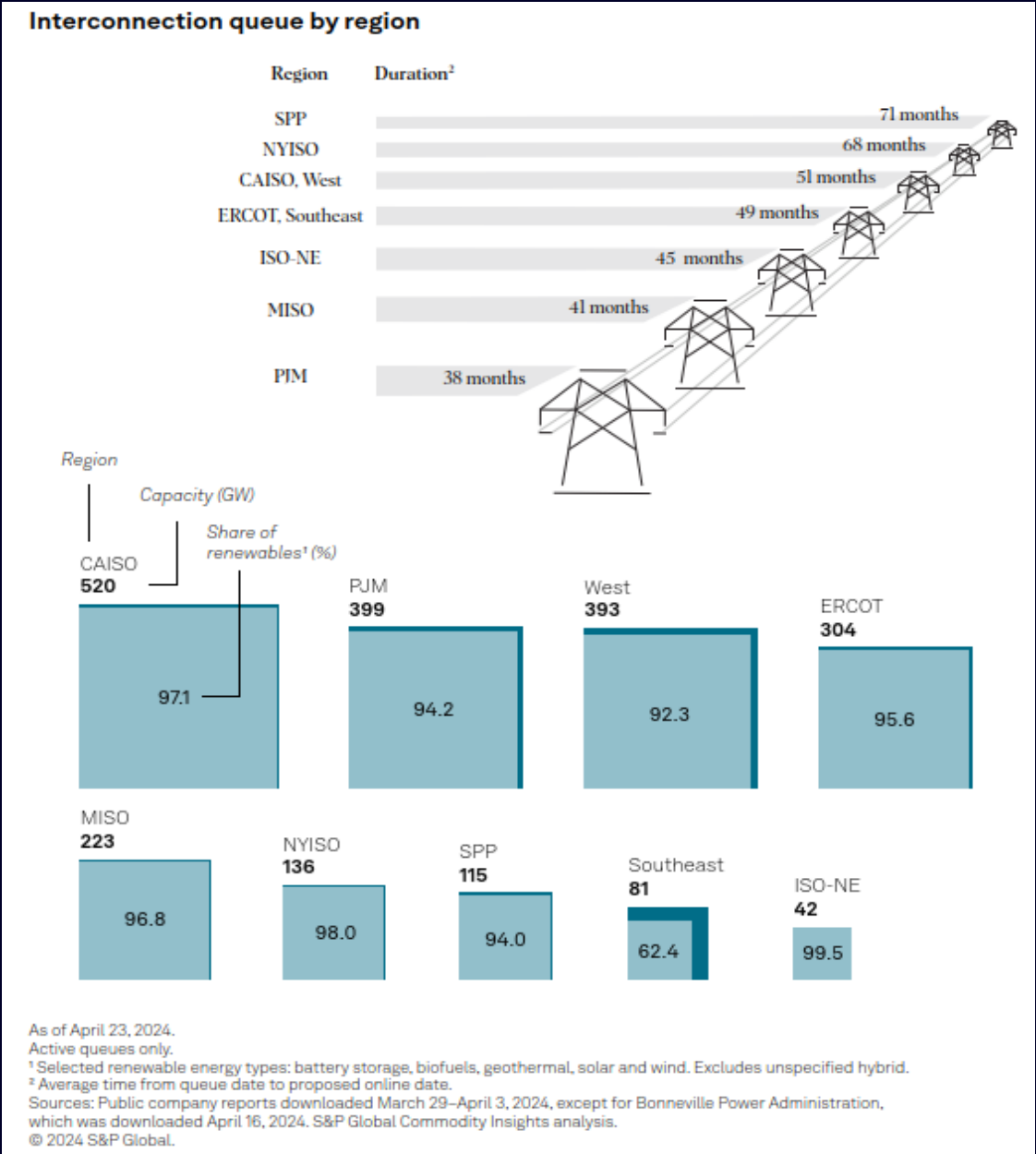


Source: PA Consulting Group Inc

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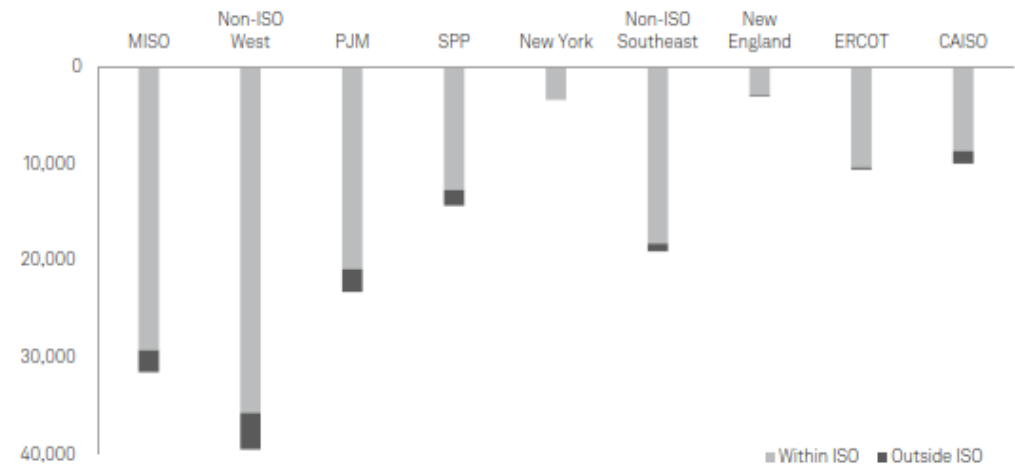


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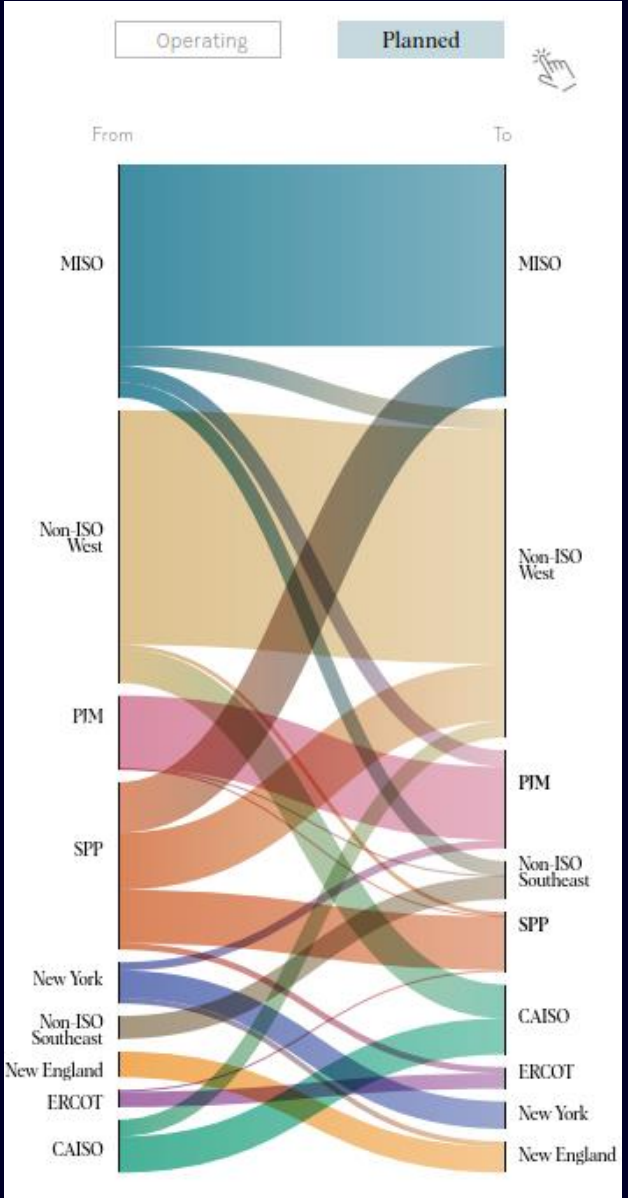
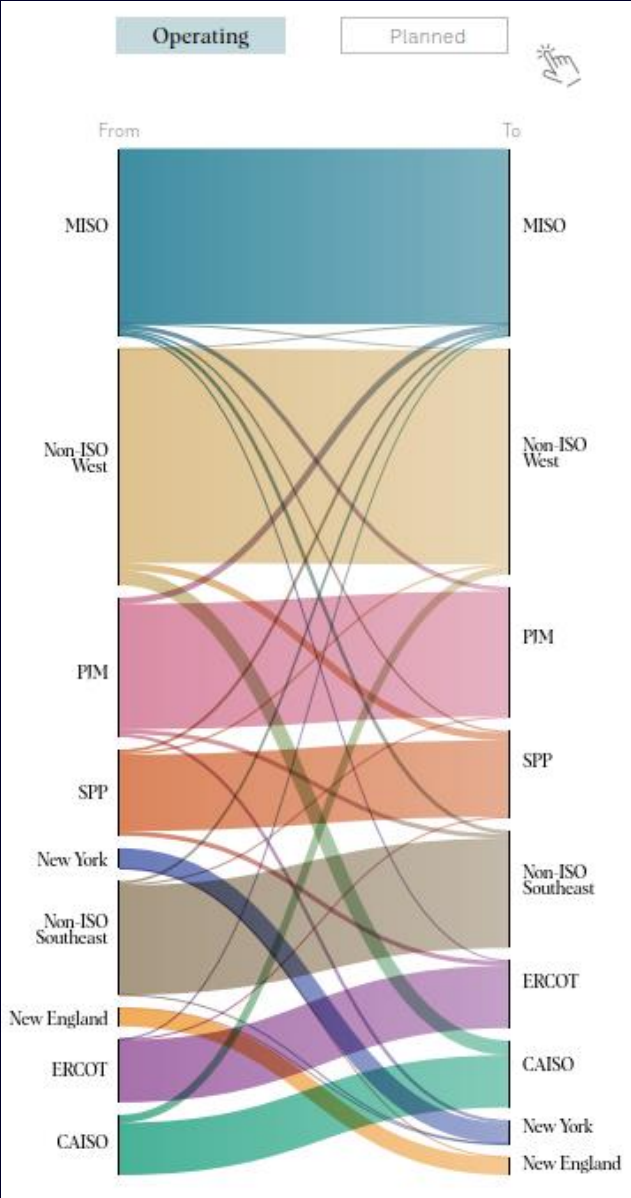


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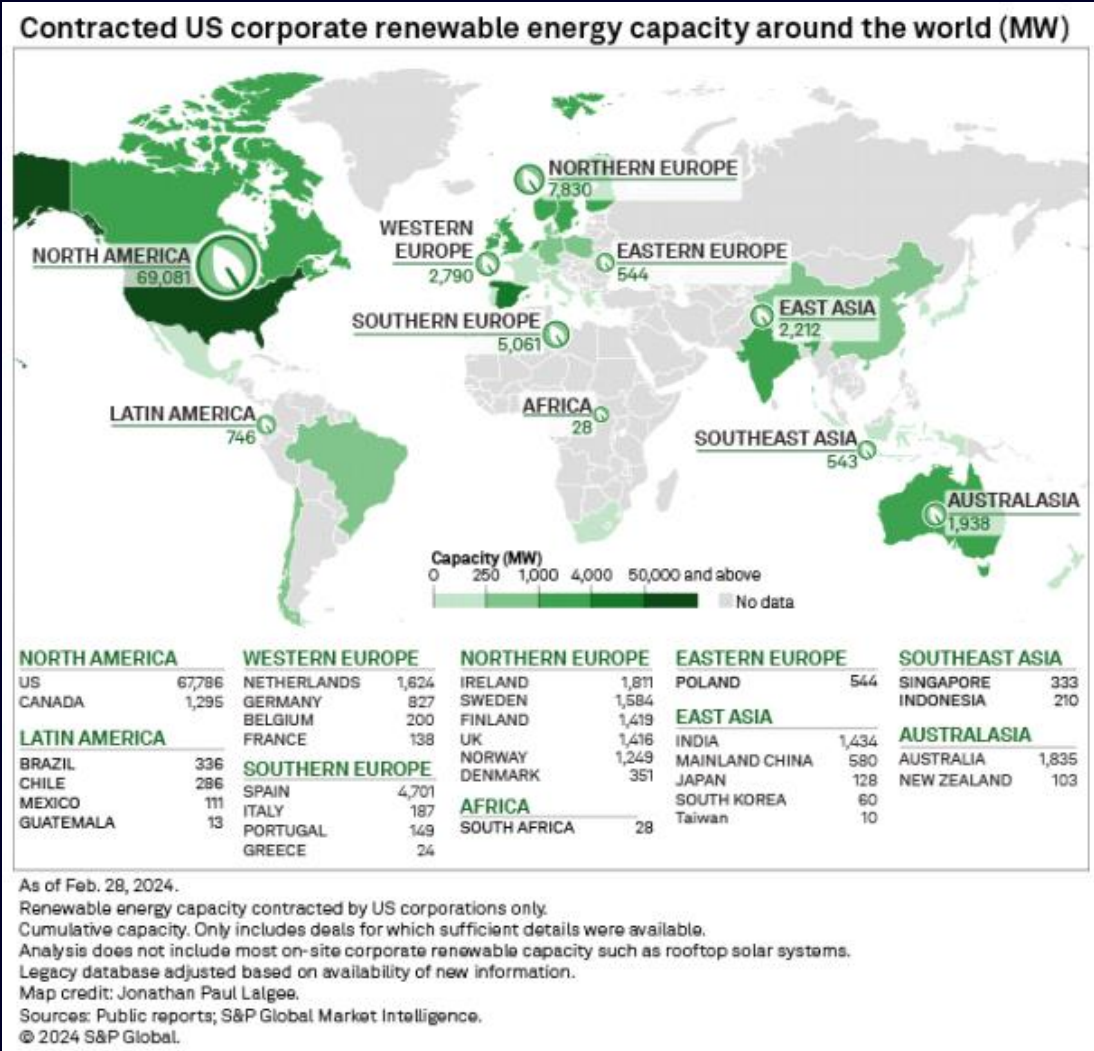
Operating transmission miles by originating region



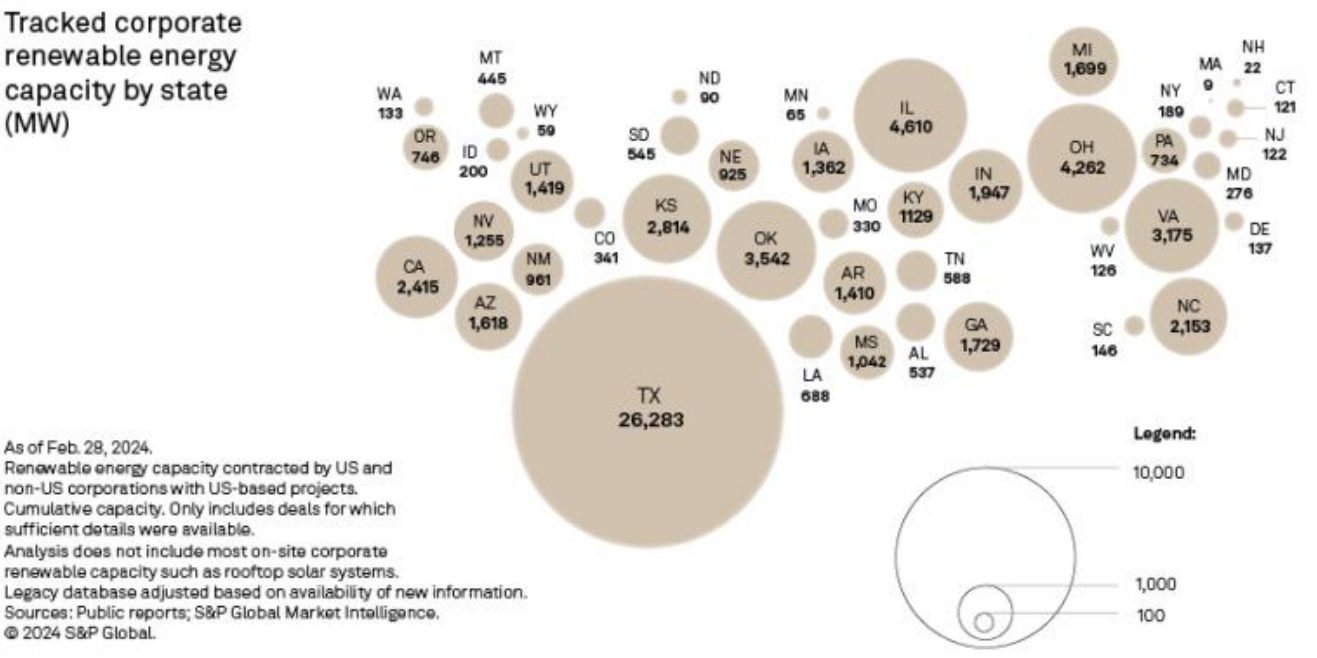
As of April 29, 2024.  
Includes only transmission lines with a voltage of 132 kV or higher.  
Source: S&P Global Market Intelligence.  
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### Tracked corporate renewable energy capacity by state (MW)



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