# Informing the **Transmission Discussion**

A Look at Renewables Integration and Resilience Issues for Power Transmission in Selected Regions of the United States

January 2020

scottmadden
MANAGEMENT CONSULTANTS

WIRES

# Regional Discussion

CALIFORNIA ISO

# Contents



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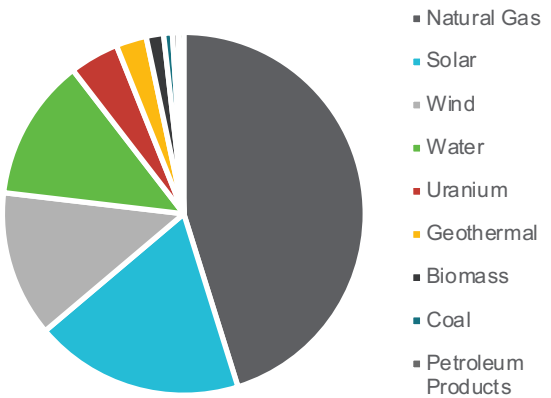
# Overview

### Description of Region

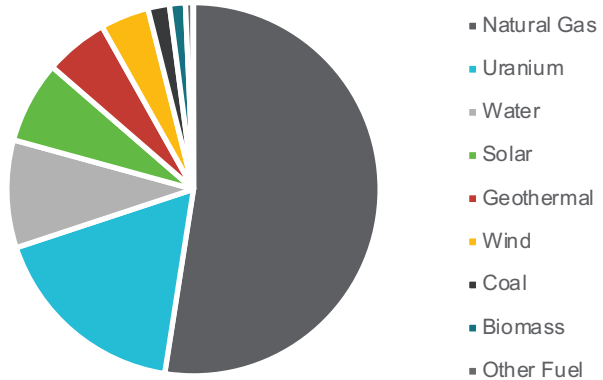
- California ISO (CAISO) is the balancing authority for the majority of the state of California, and it serves as the only ISO in the Western Interconnect.
- CAISO manages the majority of the grid in the state of California that encompasses about 26,000 miles of transmission lines over more than 155,000 square miles, serving 30 million people.
- Reserve margins for the region are expected to be more than 19% in 2020 and 22% in 2022 (compared with a 15% target margin level).

| Key Regional Statistics | |
|---|---|
| **States Covered** | California |
| **Square Miles Covered** | ~155,000 |
| **No. of Utilities** | 6 investor-owned utilities, 18 retail electric service providers, 20 CCAs, 4 cooperatives |
| **No. of Customers/Pop. Served** | 39.8 M population |
| **Installed Capacity** | 66,736 MWs |
| **Transmission Line Miles** | 27,000 miles |
| **Peak Hour Demand (2018)** | 186,040 MWs summer<br>(179,759 MWs winter) |
| **Net Energy for Load** | 286,000 GWhs |
| **Forecast Growth (Annual)** | -0.54%-1.22% peak load growth<br>0.99%-1.59% demand (usage) growth |

**2019 Capacity Mix by Fuel**




**2018 Energy Mix by Fuel**



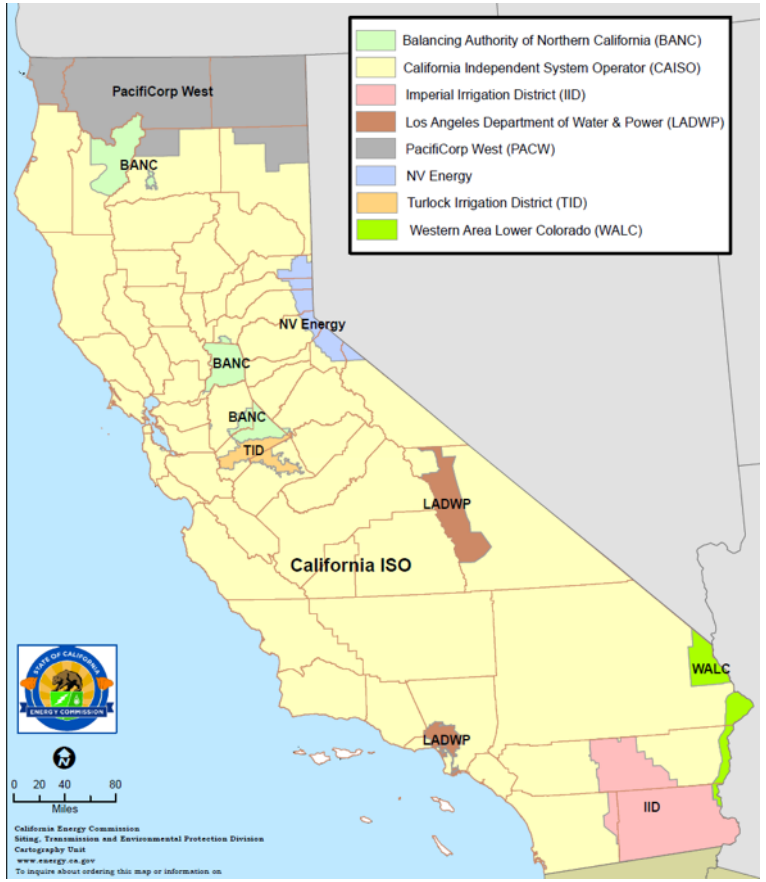

Sources: NERC 2018 LTRA; 2018 CED
Notes: Not necessarily coincident; net internal demand is net of demand response; California is the only state in the Western Interconnection that has a wide-area Planning Reserve Margin requirement, currently 15%.

# Overview (Cont'd)

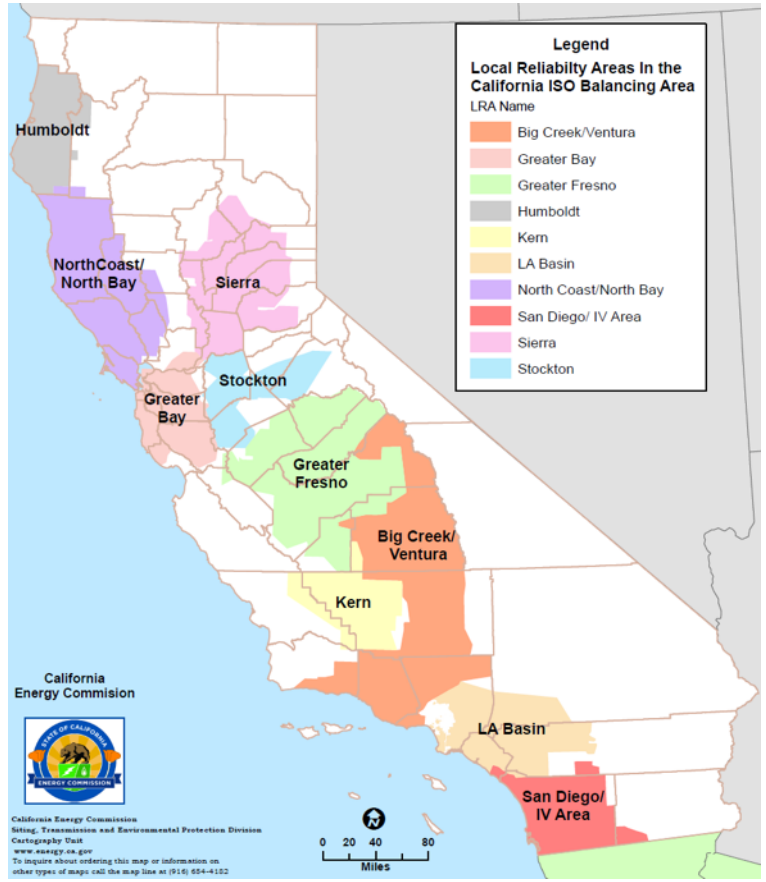
**Balancing Authorities (BAs) and Local Reliability Areas**

- CAISO serves as the balancing authority for the majority of the contiguous area of the state of California, with a few exceptions:
  - Balancing Authority of Northern California (BANC)
  - Imperial Irrigation District (IID)
  - Los Angeles Department of Water & Power (LADWP)
  - PacifiCorp West (PACW)
  - NV Energy (Nevada Power)
  - Turlock Irrigation District (TID)
  - Western Area Lower Colorado (WALC)
- CAISO is comprised of multiple local reliability areas within CAISO's balancing area.

**Balancing Authorities in California**




**Local Reliability Areas in CAISO**




Source: California Energy Commission (CEC)

# Overview (Cont'd)

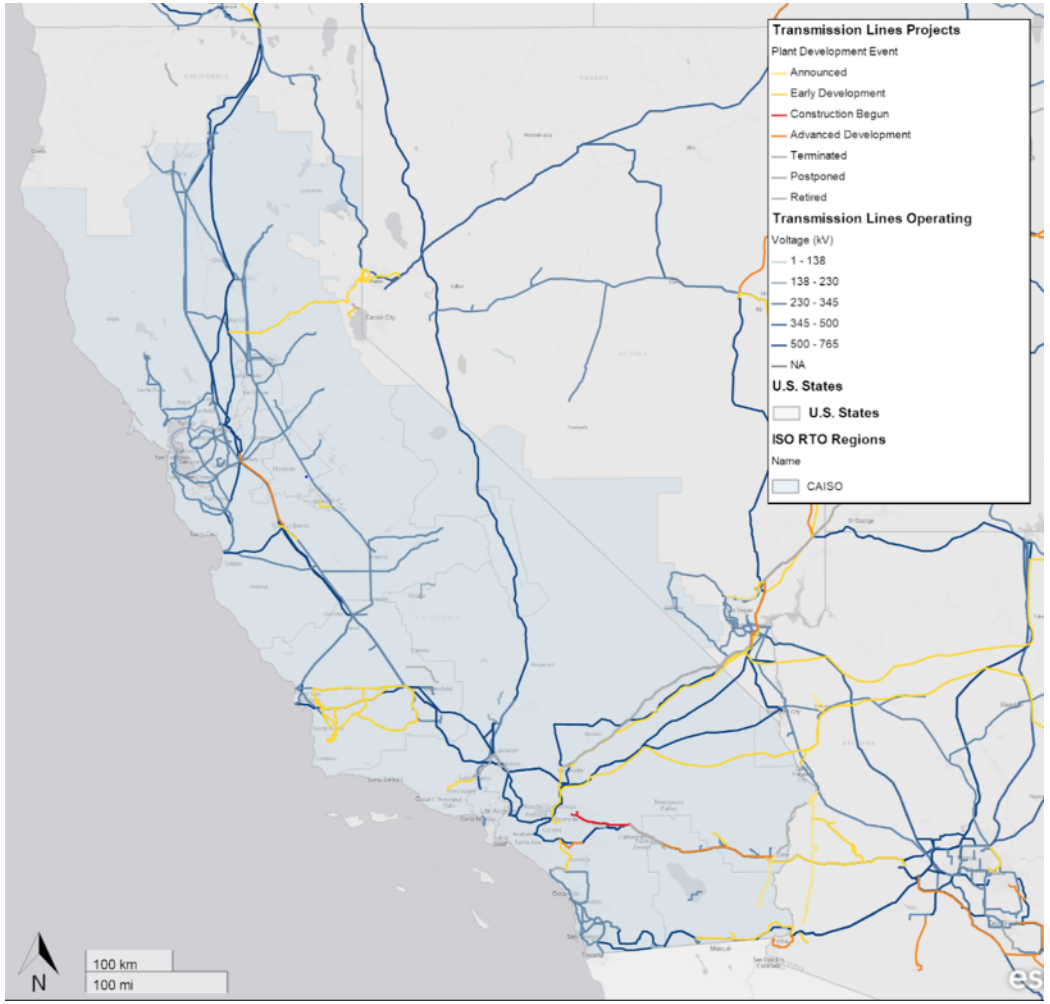
**Reliability Assessment Study Areas**

- Reliability assessments are performed at the bulk system (north and south), as well as local study areas on the CAISO-controlled grid:
  - Northern California (bulk) system – 500 kV facilities and selected 230 kV facilities in the PG&E system
  - Southern California (bulk) system – 500 kV facilities in the SCE and SDG&E areas and the 230 kV facilities that interconnect the two areas
  - Pacific Gas and Electric (PG&E) Local Areas
    - Humboldt area
    - North Coast and North Bay areas
    - North Valley area
    - Central Valley area
    - Greater Bay area
    - Greater Fresno area
    - Kern Area
    - Central Coast and Los Padres areas
  - Southern California Edison (SCE) local areas:
    - Tehachapi and Big Creek Corridor
    - North of Lugo area
    - East of Lugo area
    - Eastern area
    - Metro area
  - San Diego Gas & Electric (SDG&E) main transmission/subtransmission
  - Valley Electric Association (VEA) area*


*Note: GridLiance West LLC (GLW) owns 230kV facilities in VEA's service territory. VEA operates and maintains GLW's 230kV facilities.
Source: CEC IEPR

# Overview (Cont'd)

**Operating and Planned Transmission Lines by Status and Voltage**




- There is significant internal transfer capability within CAISO, which allows for transfers within the system. In addition to the other BAs located in California listed earlier, CAISO is also interconnected with BAs and control areas outside of California, including Arizona Public Service (APS), Comision Federal de Electricidad (CFE), Salt River Project (SRP), Sierra Pacific Power, and Western Area Power Administrator (WAPA).
- According to NERC, approximately 190 miles of new transmission lines are either in the planning stages or under construction as of late 2018 (see table below). The majority of the 22 projects were primarily driven by reliability; two projects were driven by variable generation integration; and two projects were driven by economics and congestion.

**Proposed Transmission Projects (Line Length in Circuit Miles) in CAISO (as of Dec. 2018)**

| Operating Voltage Class (kV) | Conceptual | Planned | Under Construction |
|---|---|---|---|
| 100–120 | 30 | 25 | - |
| 121–150 | - | - | - |
| 200–299 | 65 | 17.3 | 48 |
| 400–599 | - | 4.6 | - |
| Grand Total | 95 | 46.9 | 48 |

Source: NERC 2018 Electricity Supply & Demand

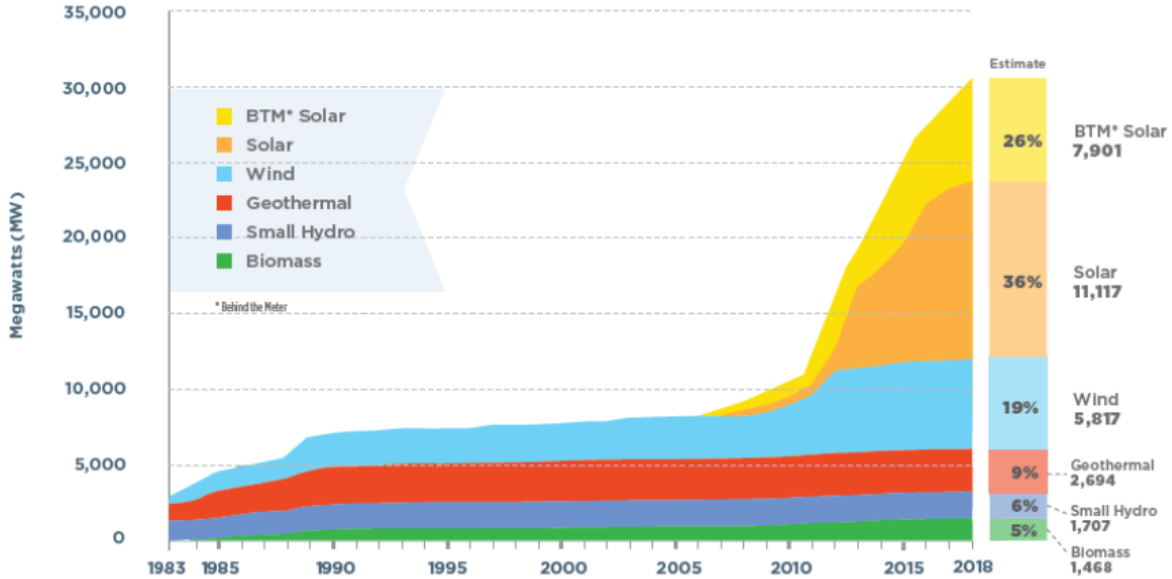
Sources: NERC 2018 LTRA; NERC ES&D; CAISO

# Overview (Cont'd)

**Unique Market Characteristics**

- CAISO is a region that has already experienced a significant build-out of variable renewable energy capacity, including utility-scale capacity, as well as behind-the-meter solar capacity.
- Renewable generation projects outside of California have contracted with California's load serving entities (LSEs) to provide clean power to meet in-state demand, and out-of-state renewable capacity represents approximately 25% of the total renewable capacity reported by California today (as qualified to meet renewable portfolio standard's requirements).
- The retail power market in California is also in the midst of a major transition, as a significant portion of the load served today by the three large investor-owned utilities (IOUs) in California are in the process of migrating to alternative providers called Community Choice Aggregators (CCAs). The implications of this transition are significant:
  - In its evaluation of integrated resource plan (IRP) filings of IOUs and CCAs, the latter filing for the first time in 2018, the California Public Utility Company (CPUC) found that the majority of new resource build-out is being driven by CCA load growth. While the IOUs proposed to invest in approximately 1,000 MWs of new resources by 2030, CCA proposed more than 10,000 MWs.
  - Of that total planned resource investment, more than 60% is solar photovoltaic (PV). Another 10% is expected to come from battery storage, with the remainder comprised of biogas, biomass, geothermal, and wind.
  - CPUC expressed concerns about how plans and priorities of the different parties will be balanced to maintain stability in the future (see quote at right).

**Annual Cumulative Installed Renewable Capacity (Incl. Behind-the-Meter Solar)**




Source:

"Overall, the CCAs have shown, in their individual IRPs collectively, a preference for solar and wind resources, as well as four-hour batteries, supplemented by imported hydroelectric power. However, to balance the system between now and 2030, the resource balance will need to include a mix of existing and new resources, a mix of baseload and intermittent resources, and a mix of renewable, storage, and conventional fossil-fueled resources. In analyzing the IRPs of all of the LSEs, there is inconsistent, and in some cases, nonexistent, recognition of these realities." (CPUC, Decision 19-04-040, May 1, 2019)

Sources: CEC IEPR; CPUC, Proceeding R. 16-02-007, Decision 19-04-040

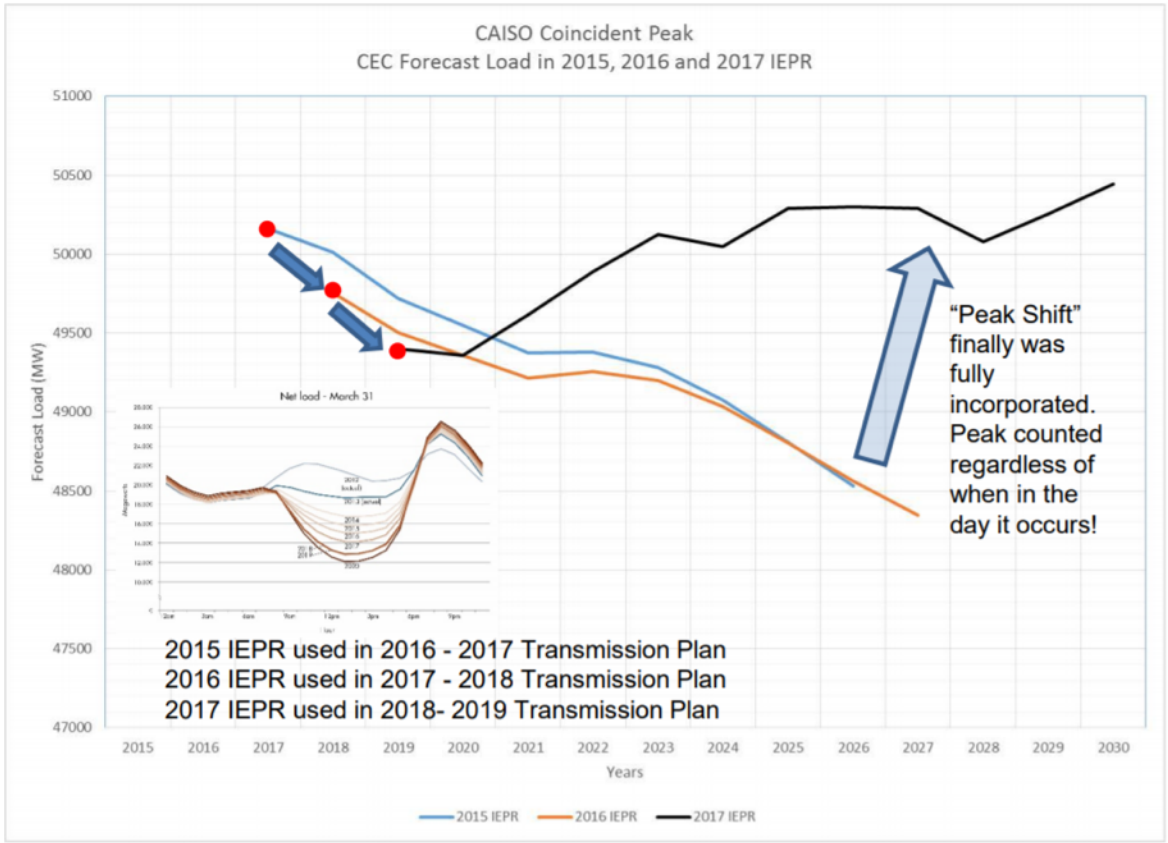
# Transmission Topography and Investment

### Congestion Impacts on System Prices

- Locational price differences due to congestion in both the day-ahead and 15-minute markets increased in 2018, particularly on constraints associated with major transmission limits separating northern and southern California (Path 26) in the third quarter. Key congestion trends during the year include the following:
  - For the year, congestion increased day-ahead prices in the SCE area by $1.87/MWh and in the SDG&E area by about $4.19/MWh. Congestion decreased day-ahead prices in the PG&E area by $2.73/MWh.
  - In the 15-minute market, patterns of congestion were similar to the day-ahead market. The primary constraints were associated with Path 26, the Serrano 500/230 kV transformer, and the Round Mountain-Table Mountain nomogram. These constraints increased prices in southern California, in the Western Energy Imbalance Market areas with significant transmission capacity into southern California, and decreased prices elsewhere.
  - In the fourth quarter of 2018, significant congestion on the Tracy-Los Banos outage nomogram increased prices in northern California and EIM areas north of the constraint and decreased prices south of the constraint. Over the course of the fourth quarter, this south-to-north congestion offset much of the impact of continued congestion on Path 26 and other constraints, so the overall net average impact of congestion on prices was relatively low for the fourth quarter.
  - The frequency and impact of congestion in the day-ahead market on most major interties was lower in 2018 compared to 2017. This was primarily driven by lower congestion on interties connecting the independent system operator (ISO) to the Pacific Northwest (Malin and NOB).

### Shifting Peak Demand from Mid-day to Late Afternoon

- Hourly load shapes were incorporated in the planning process beginning in 2017 (for 2018–2028 timeframe), and they clearly indicated the shifting shape of the hourly demand curve in the region.




Source:

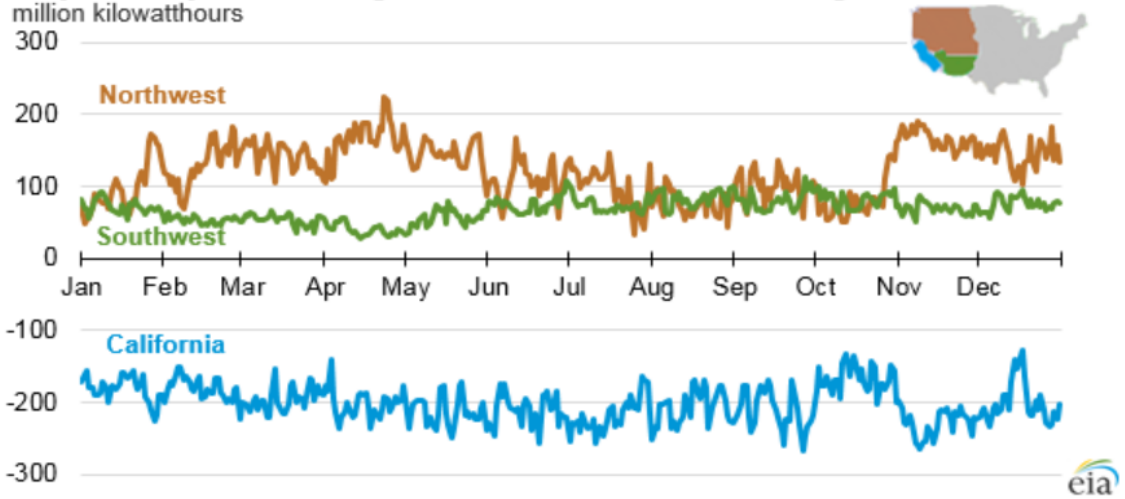
Sources: 2018 Market Performance Report; CEC IEPR

# Transmission Topography and Investment (Cont'd)

### Imports and Exports Play a Large Role in the Region

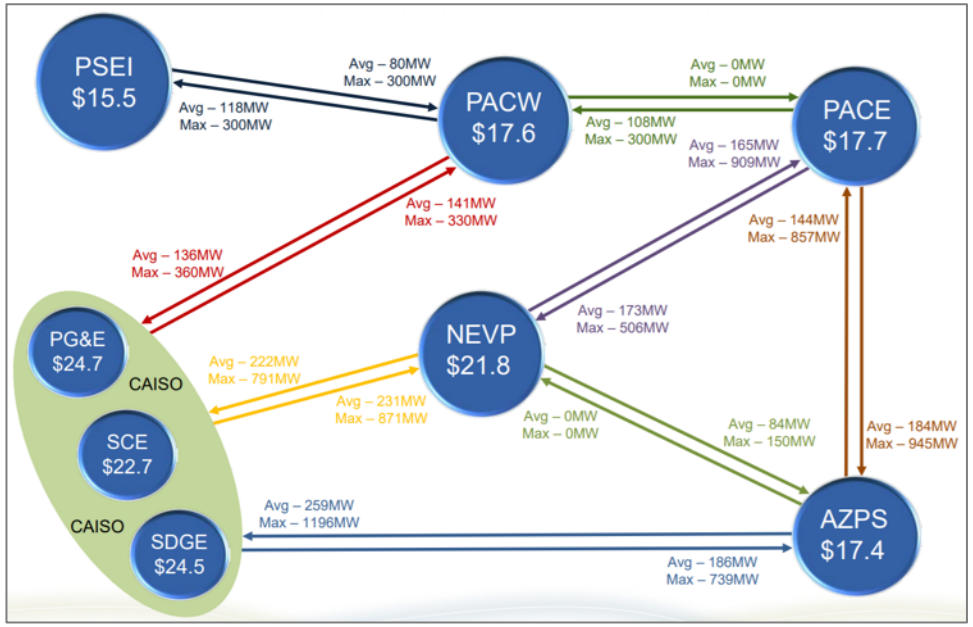
- In 2016, CAISO imported a net daily average of 201 million kWh throughout the year from other western regions, or about 26% of its average daily demand. Those imports were supplied by the other two regions that make up the Western Interconnect.
  - The Northwest region supplied a daily average of 122 million kWh (61%).
  - The Southwest region supplied the bulk of the remainder 68 million kWh per day on average (34%).
- Year-to-date 2019, net interchange is down slightly from 2016 levels (bottom right), but it still represents a substantial portion of how the region serves its load.

**Daily electricity net interchange for the Western Interconnection regions, 2016**

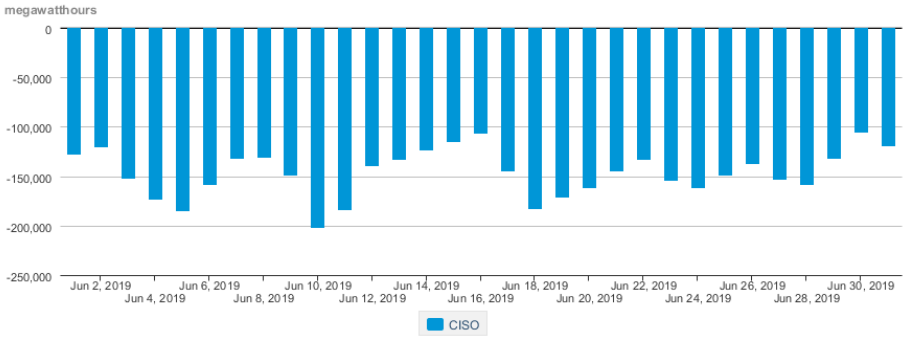



**Source:** U.S. Energy Information Administration, U.S. Electric System Operating Data
**Note:** Net interchange values are aggregates of reported metered flow values on transmission tie lines between balancing authorities.

**Energy Transfers Among Regions in the WECC (Q1, 2017)**




**Balancing authority in-flow (-) and out-flow (+) 06/01/2019 – 07/01/2019, EDT**




eia Source: U.S. Energy Information Administration

Sources: 2018 Market Performance Report; CEC IEPR

# Transmission Topography and Investment (Cont'd)

### FERC-Jurisdictional Investment Base

- FERC policy has been to permit a utility to establish transmission rates using a formula-based approach that updates rates annually, and approximately 100 utilities nationwide currently employ formula rates for transmission. Among companies in CAISO, SCE and SDG&E currently employ formula-based rates. SDG&E has been operating under a formula-based framework since 2007, and SCE transitioned from a stated rate to a formula-based framework in 2012. PG&E has historically operated under a traditional rate case framework, but the company proposed shifting to a formula-based approach in October 2018. The two independent transcos, DATC Path 15 and Trans Bay Cable, operate under traditional rate case frameworks, with new rate cases typically filed at FERC every three years.
- California utilities calculate both wholesale and retail base revenue requirements; the wholesale base revenue requirement values are presented at the right. These revenue requirements are generally recovered through CAISO's transmission access charge (TAC). CAISO's current TAC structure is a two-part rate charged to each MWh of internal load and exports. Revenue requirements associated with facilities rated 200 kV and above are recovered through a system-wide "postage stamp" rate, known as the high voltage or "regional" rate, whereas revenue requirements for facilities rated below 200 kV are recovered via utility-specific rates charged to load within the utility's service territory, known as the low-voltage or "local" rate. The regional TAC recovers the revenue requirement for all participating transmission owners, which CAISO then distributes to each individual transmission owner based on its FERC-approved revenue requirement.
- The tables at the right provide a summary of the operating subsidiaries of each holding company in CAISO, including trends in rate base over the past nine years and authorized ROE incentives as applicable.

**Current California ISO Transmission Rate Base Summary**

| Filing Entity | 2018 Trans. Rate Base ($000) | 2019 Trans. Rate Base ($000) | 2018-19 Rate Base Change (%) | Base ROE (%) | Portion of Rate Base Subject to Incentive ROE ($000) | Portion of Rate Base Subject to Incentive ROE (%) | Incentive ROE (%) |
|---|---|---|---|---|---|---|---|
| Southern California Edison | 5,451,343 | 5,624,393 | 3.17 | 10.90* | 150,232 | 2.67 | 11.55* |
| | | | | | 687,752 | 12.23 | 11.90* |
| | | | | | 2,728,701 | 48.51 | 12.05* |
| Pacific Gas and Electric | 6,935,253 | 6.927,768 | -0.11 | 12.50* | None | NA | NA |
| San Diego Gas & Electric | 3,244,395 | 3,685,149 | 12.97 | 11.20* | None | NA | NA |
| DATC Path 15 | 104,850 | 104,850 | 0 | 13.5 | None | NA | NA |
| Trans Bay Cable | 476,383 | 476,383 | 0 | NA | None | NA | NA |

Notes: As of Jan. 10, 2019. NA = not available or not applicable. *Inclusive of 50 basis point adder for membership in CAISO
Source: Regulatory Research Associates, a group within S&P Global Market Intelligence

**Transmission Rate Base Values for California ISO Utilities ($000)**

| Filing Entity | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | CAGR 2011-19 (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Southern California Edison | 2,064,394 | 2,569,533 | 3,256,238 | 4,076,161 | 4,679,376 | 5,171,547 | 5,483,030 | 5,451,343 | 5,624,393 | 13.35 |
| Pacific Gas and Electric | 2,717,253 | 3,045,904 | 3,967,792 | 3,765,968 | 4,086,597 | 5,120,000 | 6,712,509 | 6,935,253 | 6,927,769 | 12.41 |
| San Diego Gas & Electric | 1,001,092 | 1,085,868 | 1,185,324 | 1,222,194 | 2,820,111 | 2,895,781 | 3,207,000 | 3,244,395 | 3,665,149 | 17.61 |

Notes: As of Jan. 10, 2019. CAGR = compound annual growth rate
Source: Regulatory Research Associates, a group within S&P Global Market Intelligence



Source: Regulatory Research Associates, a group within S&P Global Market Intelligence

# Transmission Topography and Investment (Cont'd)

**Transmission Projects**

- Several transmission projects in CAISO are being developed to facilitate the importation of renewable energy generated in states other than California.
  - TransWest Express: The 730-mile project from Wyoming to Nevada, with an expected in-service date of 2023 and a budget of $3 billion, is intended to provide transmission capacity to connect Wyoming wind resources with loads in California.
  - Ten West Link Transmission Line: The 114-mile project would interconnect future renewable energy resources in both Arizona and California to the bulk transmission grid in what was designated in 2007 as a National Interest Electric Transmission Corridor, largely following the established corridor used by the existing Devers-Palo Verde 500-kV No. 1 line that connects APS transmission facilities in Arizona to Southern California Edison (SCE) in California.

| Project Name | Project Owner(s) | Project Length (miles) | Project Voltage (kV) | From State | To State | From ISO | To ISO | Yr. in Svc. | Current Development Status | Project Type | Est. Const. Costs ($000) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Apex-Crystal Transmission Line | Southern California Public Power Authority | 11.00 | 525 | Nevada | Nevada | CAISO | CAISO | 2022 | Early Development | New | 65,000 |
| Bighorn-Eldorado | NV Energy, Inc. | 24.00 | 500 | Nevada | Nevada | CAISO | CAISO | 2026 | Early Development | New | 55,000 |
| Blythe to Goldmine Tap Line Upgrade | Western Area Power Administration | 42.00 | 230 | California | California | CAISO | CAISO | NA | Announced | Rebuild | 53,800 |
| Bouse to Kofa Upgrade | Western Area Power Administration | 76.00 | 230 | Arizona | Arizona | CAISO | NA | 2024 | Announced | Upgrade | 31,100 |
| Centennial II (Harry Allen – Northwest 500 kV Line) | NV Energy, Inc. | 30.00 | 500 | Nevada | Nevada | CAISO | CAISO | 2027 | Announced | New | NA |
| Desert Southwest Transmission (Keim Station to Devers Stn.) | Imperial Irrigation District | 118.00 | 500 | California | California | CAISO | CAISO | NA | Adv. Development | New | 350,000 |
| Devers – El Casco (West of Devers Upgrade ) | Southern California Edison Company | 30.00 | 220 | California | California | CAISO | CAISO | 2021 | Constr. Begun | Rebuild | NA |
| Devers – San Bernardino (West of Devers Upgrade ) | Southern California Edison Company | 43.00 | 220 | California | California | CAISO | CAISO | 2021 | Constr. Begun | Rebuild | NA |
| Devers – Vista No. 1 and No. 2 (West of Devers Upgrade) | Southern California Edison Company | 45.00 | 220 | California | California | CAISO | CAISO | 2021 | Constr. Begun | Rebuild | NA |
| Eagle Mountain Transmission Line | Eagle Crest Energy Company | 16.00 | 500 | California | California | CAISO | CAISO | 2020 | Early Development | New | NA |
| El Casco – San Bernardino (West of Devers Upgrade ) | Southern California Edison Company | 14.00 | 220 | California | California | CAISO | CAISO | 2021 | Constr. Begun | Rebuild | NA |
| Etiwanda-San Bernardino (West of Devers Upgrade ) | Southern California Edison Company | 3.50 | 220 | California | California | CAISO | CAISO | 2021 | Constr. Begun | Rebuild | NA |
| Great Basin Energy | Genova Energy Link, Llc, Lk Energy LLC, Rooney Engineering, Inc. | 125.00 | 450 | Nevada | California | NA | CAISO | 2020 | Early Development | New | 850,000 |
| Griffith to North Havasu Transmission Line | Tucson Electric Power Company | 40.00 | 230 | Arizona | Arizona | CAISO | CAISO | NA | Early Development | New | 106,000 |
| Harcuvar Transmission (Bouse to D-CR) | Central Arizona Water Conservation District | 65.00 | 230 | Arizona | Arizona | CAISO | NA | 2020 | Early Development | New | NA |

Sources: S&P Global Market Intelligence; NERC

# Transmission Topography and Investment (Cont'd)

## Transmission Projects (Cont'd)

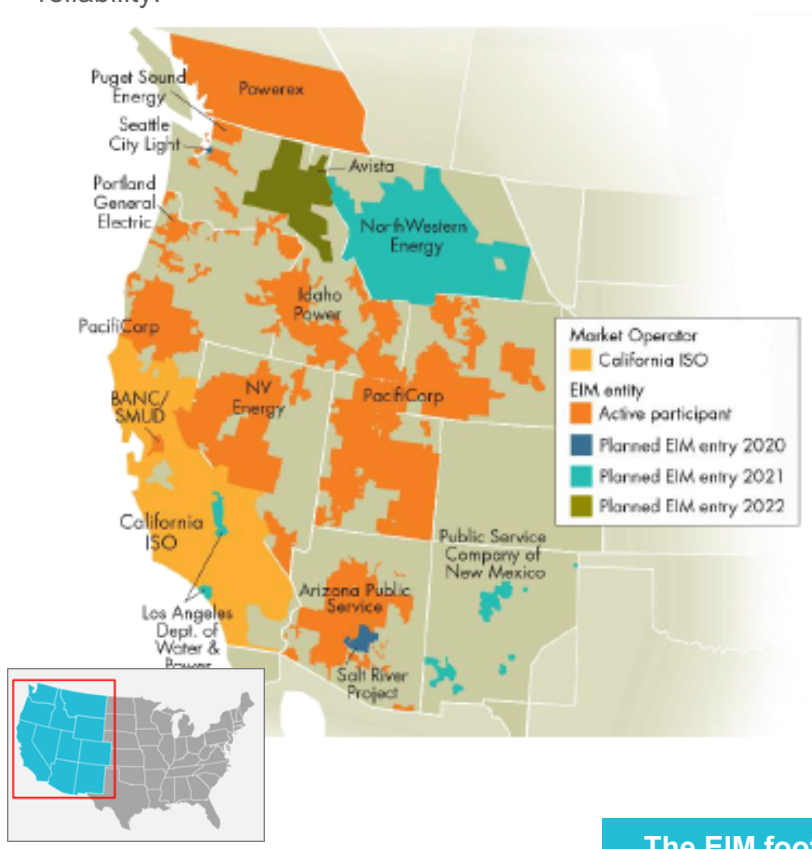
| Project Name | Project Owner(s) | Project Length (miles) | Project Voltage (kV) | From State | To State | From ISO | To ISO | Yr. in Svc. | Current Development Status | Project Type | Est. Const. Costs ($000) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Harcuvar Transmission (Bouse - Harquahala) | Central Arizona Water Conservation District | 30.00 | 230 | Arizona | Arizona | NA | CAISO | 2020 | Early Development | New | NA |
| Harry Allen-Eldorado Transmission Line (ON Line Expansion) | LS Power Development, LLC | 60.00 | 500 | Nevada | Nevada | CAISO | CAISO | 2020 | Adv. Development | New | 145,500 |
| Line 625 (Kings Beach - Tahoe City) Upgrade | Emera Incorporated, Liberty Power | 15.00 | 120 | California | California | CAISO | CAISO | 2019 | Early Development | Upgrade | NA |
| Los Banos - San Luis 230kV Transmission Line | Western Area Power Administration | 3.00 | 230 | California | California | CAISO | CAISO | 2023 | Early Development | New | NA |
| Merced South 115 kV Transmission Line | Merced Irrigation District | 14.00 | 115 | California | California | CAISO | CAISO | NA | Early Development | New | NA |
| Midway-Santa Maria Upgrade (Midway- Andrew 230 kV) | Pacific Gas and Electric Company | 100.00 | 230 | California | California | CAISO | CAISO | 2025 | Early Development | Upgrade | NA |
| Moorpark-Pardee 230-kV No. 4 Circuit Line | Southern California Edison Company | 26.00 | 230 | California | California | CAISO | CAISO | 2020 | Early Development | New | NA |
| North Gila-Imperial Valley #2_Green Path | Southwest Transmission Partners, Llc | 97.00 | 500 | California | Arizona | CAISO | CAISO | 2022 | Early Development | New | NA |
| Parker to Bouse Rebuild Transmission Line | Western Area Power Administration | 15.00 | 230 | California | Arizona | CAISO | CAISO | NA | Announced | Rebuild | NA |
| Parker to Headgate Rock Rebuild | Western Area Power Administration | 16.00 | 161 | California | Arizona | CAISO | CAISO | NA | Announced | Rebuild | NA |
| Pathfinder Transmission (Zephyr) | American Transmission Company LLC, Duke Energy Corporation | 850.00 | 500 | Wyoming | Nevada | NA | CAISO | 2023 | Early Development | New | 2,600,000 |
| Renewable Transmission Initiative (Bordertown To California) | NV Energy, Inc. | 12.00 | 120 | California | California | CAISO | CAISO | NA | Early Development | New | 11,800 |
| Riverside Transmission Reliability | Riverside City of, Southern California Edison Company | 10.00 | 230 | California | California | CAISO | CAISO | 2023 | Early Development | New | NA |
| San Bernardino – Vista Line Rebuild (Segment 2 - West of Devers) | Southern California Edison Company | 3.50 | 220 | California | California | CAISO | CAISO | 2021 | Constr. Begun | Rebuild | NA |
| San Luis - Dos Amigos 230 kV Transmission Line | Western Area Power Administration | 20.00 | 230 | California | California | CAISO | CAISO | 2023 | Early Development | New | NA |
| Talega Escondido/Valley Serrano Interconnect (Northern) | Nevada Hydro Company | 16.00 | 500 | California | California | CAISO | CAISO | NA | Early Development | New | NA |
| Talega Escondido/Valley Serrano Interconnect (Southern) | Nevada Hydro Company | 16.00 | 500 | California | California | CAISO | CAISO | NA | Early Development | New | NA |
| Ten West Link Transmission Line (Delaney – Colorado River) | Abengoa, S. A., Starwood Energy Group Global, LLC | 114.00 | 500 | Arizona | California | NA | CAISO | 2020 | Early Development | New | 300,000 |
| Tracy - Los Banos 230 kV Transmission Line | Western Area Power Administration | 62.00 | 500 | California | California | CAISO | CAISO | 2023 | Advanced Development | New | NA |
| TransWest Express | TransWest Express, LLC | 730.00 | 600 | Wyoming | Nevada | NA | CAISO | 2023 | Advanced Development | New | 3,000,000 |
| Valley-Ivyglen Subtransmission | Southern California Edison Company | 27.00 | 115 | California | California | CAISO | CAISO | 2021 | Advanced Development | New | NA |

Sources: S&P Global Market Intelligence; NERC

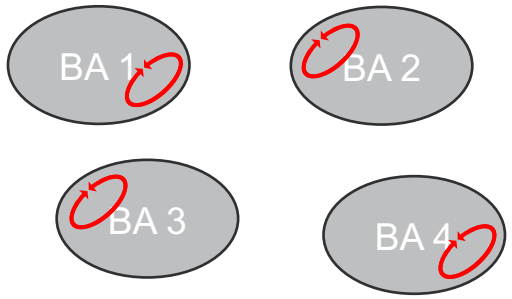
# Transmission Topography and Investment (Cont'd)

**Western Energy Imbalance Market (EIM)**

- The Western EIM is the system launched in 2014 that balances electricity supply and demand imbalances every five minutes with the lowest cost energy available in the western United States across EIM entities with a more diversified portfolio of generation resources.
- Through participation in this market, each balancing authority will preserve autonomy, improve renewable energy integration, reduce costs for customers, and enhance reliability.

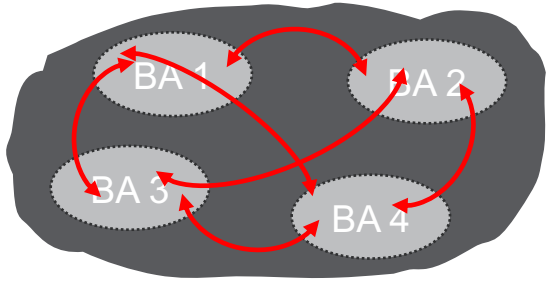



**Before EIM:**
**Each BA balances supply and demand independently.**




- Smaller pools of balancing resources result in a less efficient way to manage risk
- More expensive
- More challenging to integrate wind and solar

**After EIM:**
**EIM offers balancing across participating BAs* throughout the region.**




- More diverse resource portfolio results in more efficiency (just like stocks and bonds)
- Best reliability for least cost
- Increased flexibility and responsiveness for wind and solar integration

*Note: Recent tariff revisions have added the ability of transmission owners located between participants to provide additional capacity for transfers, potentially further increasing efficiencies.

**The EIM footprint now includes portions of Arizona, California, Canada, Idaho, Nevada, Oregon, Utah, Washington, and Wyoming.**

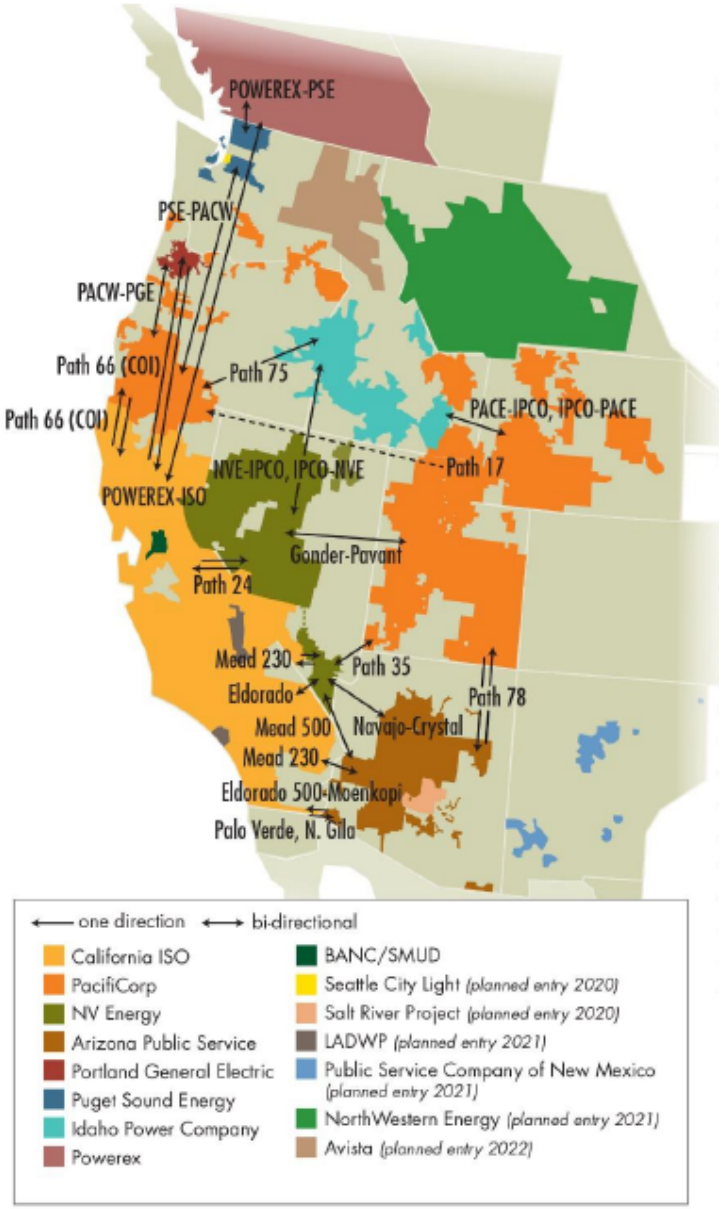
Source: CAISO

# Transmission Topography and Investment (Cont'd)

**Western EIM (Cont'd)**

- Benefits of the EIM: Total aggregate benefits are estimated to be $650.26 million from EIM inception in 2014 through Q1 2019.
  - Recent highlights:
    - More efficient dispatch, both interregionally and intraregionally, in the 15-minute market and real-time dispatch (RTD). Q1 2019 estimated savings are $85.38 million. This figure represents cost savings and the use of surplus renewable energy to displace conventional generating resources.
    - Reduced renewable energy curtailment. Q1 estimated reduction is 52,254 MWs, displacing approximately 22,365 metric tons of $CO_2$.
    - Reduced flexibility ramping reserves needed in all BA areas. Q1 reduction is 2,320 MWs in the upward direction and 2,320 MWs in the downward direction.

| First Quarter 2019 EIM Benefits by Region (in $ Millions) | | | | |
|---|---|---|---|---|
| **Region** | **January** | **February** | **March** | **Total** |
| APS | $1.10 | $4.76 | $2.34 | $8.20 |
| CAISO | $1.25 | $5.63 | $6.20 | $13.08 |
| IPCO | $1.64 | $4.21 | $2.60 | $8.45 |
| NV Energy | $1.09 | $2.20 | $2.42 | $5.71 |
| PacifiCorp | $5.56 | $11.01 | $7.19 | $23.76 |
| PGE | $1.36 | $5.36 | $5.02 | $11.74 |
| PWRX | $1.23 | $2.91 | $3.09 | $7.23 |
| PSE | $0.85 | $4.18 | $2.18 | $7.21 |
| **Total** | **$14.08** | **$40.26** | **$31.04** | **$85.38** |




Source: EIM Benefits Report

# Resilience Issues

### Overview

- California is the third largest state by area, and it is the most populous state in the United States, with more than 39 million residents. As a frame of reference, the annual GDP for California in 2018 was $11.9 trillion, by far the largest state economy in the United States.
- Historically, California has been vulnerable to wildfires and heat waves that impact both demand and energy infrastructure, and the state has been impacted by many large, well-publicized wildfires in recent years. Extreme heat also affects thermal generation, as ambient air and water temperatures can cause de-rates.
- While CAISO determined that the system had a very low probability of a system capacity shortage that would potentially necessitate demand curtailments in the summer of 2019, it did find a higher potential for shortages of upward ramping capability during certain times of the day, which would create operational risks. These upward ramping shortages are most prevalent in the late afternoon when solar generation output decreases while system demand is still high. Without sufficient upward ramping capability within CAISO to offset the loss of solar output during these times, neighboring BA areas would have to provide the necessary support to balance supply and demand to maintain system frequency under normal conditions.
- CAISO will be at the greatest operational risk during late summer, as the availability of hydro energy wanes and potential high peak demands in neighboring BA areas decrease the availability of imports into CAISO. The continuing decline in dispatchable generation as gas units retire creates further challenges for meeting CAISO's flexible capacity requirement and the peak demand, which is now occurring later in the day when solar output is at or near zero.
- Three 55 MWs oil-fired units in CAISO will be needed through 2018 to ensure reliability. CAISO's board of governors extended a reliability must-run (RMR) contract in September 2017 for the three units located near Oakland, CA.
- A study by WECC, which includes CAISO as one of four U.S. reliability assessment areas, examined the impacts to reliability associated with the interdependence of the natural gas and electric systems. The key findings include the Western Interconnections facing increasing volumetric and flexibility constraints, and disruptions in the natural gas system could potentially translate quickly to loss of load in the Desert Southwest and Southern California regions.

**Reported Electric Disturbance Events Affecting California (2017- Apr. 2019)**

| Cause | 2017 | 2018 | 2019 YTD |
|---|---|---|---|
| Fuel Supply Deficiency | 5 | 0 | 1 |
| Severe Weather | 13 | 7 | 4 |
| Vandalism | 2 | 12 | 5 |
| Suspected Physical Attack | 0 | 0 | 0 |
| Actual Physical Attack | 0 | 0 | 0 |
| Suspicious Activity | 1 | 3 | 1 |
| Transmission Interruption | 2 | 1 | 0 |
| System Operations | 2 | 3 | 1 |
| Generation Inadequacy | 2 | 0 | 0 |

Note: For multiple causes, classified under one only.
Source: DOE OE-417; ScottMadden analysis

### Transmission Projects in the San Onofre Area

| | Transmission Projects | Sponsor | Target In-Service Dates |
|---|---|---|---|
| 1 | Talega Synchronous Condensers (2x225 MVAR) | SDG&E | In-service 8/7/2015 |
| 2 | Extension of Huntington Beach Synchronous Condensers (280 MVAR) | SCE | Retired 12/31/2017 |
| 3 | Imperial Valley Phase Shifting Transformers (2x400 MVAR) | SDG&E | In-service 5/1/2017 |
| 4 | Sycamore Canyon–Peñasquitos 230kV Line | SDG&E | In service 8/29/2018 |
| 5 | Miguel Synchronous Condensers (450/-242 MVAR) | SDG&E | In-service 4/28/2017 |
| 6 | San Luis Rey Synchronous Condensers (2x225 MVAR) | SDG&E | In-service 12/29/2017 |
| 7 | San Onofre Synchronous Condensers (1x225 MVAR) | SDG&E | In service 10/16/2018 |
| 8 | Santiago Synchronous Condensers (1x225 MVAR) | SCE | In-service 12/31/2017 |
| 9 | Mesa Loop-In Project and South of Mesa 230kV Line Upgrades | SCE | Delayed until 3/1/2022 |

Source: California Energy Commission

Sources: CAISO; NERC 2018 LTRA; WECC; DOE

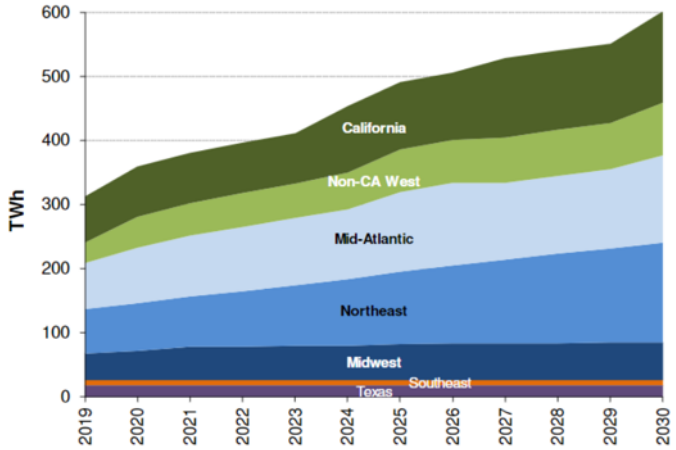
# Resilience Issues (Cont'd)

| Selected Major Bulk Power Events Affecting California | |
|---|---|
| **Event** | **Description** |
| System Challenges in Southern California | ▪ Southern California has been the focus of major electric reliability concerns beginning with the outage of the two San Onofre Nuclear Generating Station (SONGS) units in January 2012, followed by the decision to retire SONGS in 2013, and the major gas leak discovered in October 2015, at the Aliso Canyon natural gas storage facility.<br>▪ Those events, coupled with the expected compliance-related closure of several southern California coastal power plants that use ocean water for cooling, as well as the ongoing natural gas pipeline outages on Southern California Gas's system, are tightening the region's energy supply. |
| Wildfires:<br>▪ Blue Cut (Aug. 16, 2016)<br>▪ Canyon 2 (Oct. 9, 2017)<br>▪ Camp (2018)<br>▪ Kincade, Tick, et al (2019) | ▪ Over the 2000–2016 period, wildfires in parts of California cost utilities more than $700 million in transmission and distribution related damages. Total wildfire damages to all sectors of the economy were naturally much larger. Over the past two years, California has experienced the deadliest and most destructive wildfires in its history. A relatively small number of catastrophic wildfires were responsible for a disproportionate share of the transmission and distribution related damages. These wildfires are difficult to defend against and very hard to predict—as evidenced by the massive wildfires that occurred in 2017 and 2018 and continue to occur in 2019. California utilities have been preemptively cutting power to large numbers of customers in fire prone areas in 2019 attempting to prevent fires from starting in the first place, and the state continues to battle multiple ongoing fires as of this writing despite those efforts.<br>▪ The Blue Cut fire began in the Cajon Pass, just east of Interstate 15. The fire quickly moved toward an important transmission corridor that is comprised of three 500 kV lines owned by SCE and two 287 kV lines owned by the Los Angeles Department of Water and Power (LADWP). By the end of the day, the SCE transmission system experienced thirteen 500 kV line faults, and the LADWP system experienced two 287 kV faults as a result of the fire.<br>▪ The Canyon 2 fire caused two transmission system faults near the Serrano substation east of Los Angeles. The first fault was on a 220 kV transmission line, and the second fault was on a 500 kV transmission line. Both resulted in the reduction of solar PV generation across a wide region of SCE's footprint. |
| Seismic Activity | ▪ The resilience of California's natural gas transmission and distribution system was tested when the most powerful earthquake in 20 years struck a remote area of the state on July 5, 2019. Initial assessments indicate that the system held up, despite reports tying several fires to gas pipeline ruptures during the quake and a smaller one the previous day.<br>▪ A 6.4 magnitude tremor struck the area along the border between Kern and San Bernardino counties July 4, followed by a 7.1 magnitude quake July 5. In the aftermath, state and local officials linked a handful of fires to ruptured gas lines resulting from the quakes, Reuters reported. |
| Gas-Power Interdependence | ▪ In addition to the challenges outlined above that are unique to southern California, the issue of gas-power market interdependence represents a resilience risk for the entire CAISO market. Some degree of gas-fired generation will be required to balance variable renewable generation in CAISO, and those generation resources will be competing for constrained fuel supplies with end-use load from gas LDCs in the winter and other generators in the region in the summer. |

Sources: S&P Global Market Intelligence; 4th CA Climate Assessment

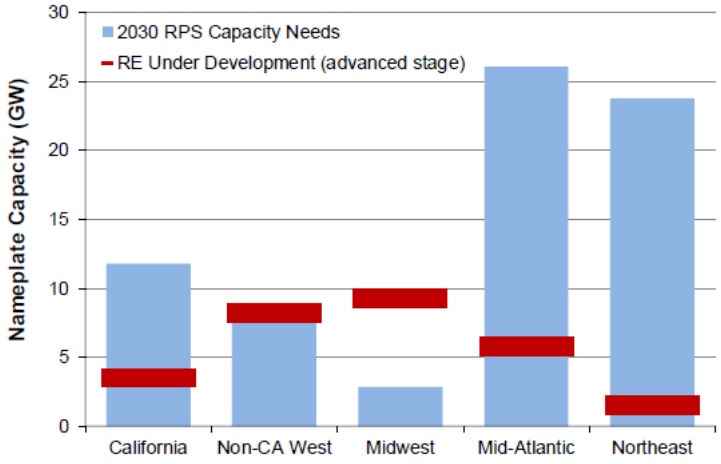
# Renewables Integration

**Projected U.S. RPS Demand (Total Compliance Requirements) per DOE LBNL (2019–2030) (as of July 2019) (in TWh)**




Source: LBNL

**Required RPS Capacity Additions (GW) (LBNL Estimates)**




Source: LBNL

**Demand-Side Considerations: Renewable Portfolio Standards**

- RPS-driven demand has led to significant additions of renewable energy capacity to date, and projected demand for renewable resources in the CAISO region is expected to be substantial as depicted in the California section of the graph top left.
- Further, as depicted bottom left and on the next page, the demand for renewable energy is expected to far exceed the capacity currently under development. As discussed separately in the section of this report on WECC outside of California, many projects in other regions of the western U.S. are being developed on the basis of delivering renewable energy into CAISO.
- Several utilities in California have also introduced clean energy commitments (see below).

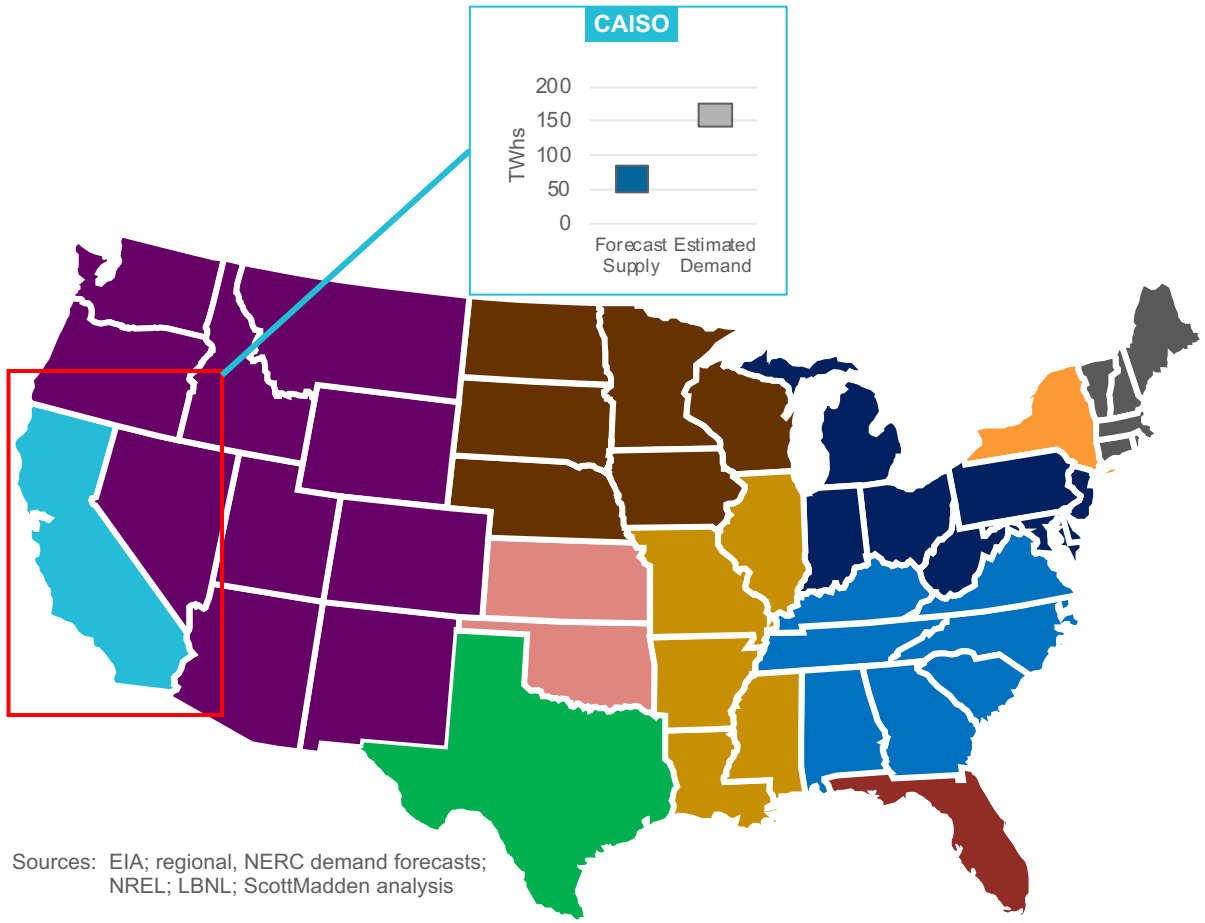
| Utility Name (States of Operation) | Goal Type | Target Dates | Description (Date Implemented) |
|---|---|---|---|
| Los Angeles Department of Water and Power (CA) | Emission Reduction | 2050 | 100% net-zero emissions by 2050 |
| Pacific Gas & Electric (CA) | Emission Reduction | 2022<br>2030 | ▪ Reduce 1 million tons of GHG emissions from company operations by the end of 2022<br>▪ 40% reduction in GHG emissions from 1990 levels by 2030 |
| Sacramento Municipal Utility District (CA) | Emission Reduction | 2040 | 100% net-zero emissions by 2050 |
| Southern California Edison (CA) | Emission Reduction | 2030<br>2050 | ▪ 40% reduction in GHG emissions from 1990 levels by 2030<br>▪ 80% reduction in GHG emissions from 1990 levels by 2050 |

Source: SEPA

Sources: LBNL 2019 RPS Analysis; SEPA

# Renewables Integration (Cont'd)

**CAISO Potential Policy-Driven Renewable Energy Demand and Forecast Supply (2030) (as of June 2019)**




Sources: EIA; regional, NERC demand forecasts; NREL; LBNL; ScottMadden analysis

**Demand-Side Considerations:**
**Renewable Portfolio Standards (RPS) Supply-Demand Balance**

- As seen in the map at left, the estimated demand for renewable resources in the CAISO region is expected to significantly outpace the forecast supply of renewables in the region, suggesting that future demand, at least in part, will need to be met by resources from outside the CAISO region.
- Legislative initiatives have helped drive much of the growth of renewables in California's electricity sector. California's RPS, enacted in 2002, has evolved to require increasing amounts of renewable resources in the state's electricity system. In 2015, Senate Bill 350 increased the RPS requirement from 33% to 50% by 2030. Senate Bill 100 sets a planning target of 100% renewable and zero-carbon electricity resources by 2045 and increases the 2030 RPS target from 50% to 60%.
- Transmission planning: In its last three transmission planning cycles (2015–2016, 2016–2017, and 2017–2018), CAISO did not identify new projects necessary to meet California's 33% RPS, as many previously identified projects have been approved or are in the permitting process. Future CAISO transmission planning process (TPP) cycles will focus on moving beyond the 33% framework when new generation portfolios are developed under the resource planning processes.
- Regulatory approval process: The first step in the regulatory process to develop a new transmission project is an approval based on a finding of need by CAISO in its annual TPP or by another BA in a similar planning process. For projects sponsored by IOUs, CPUC next considers CAISO's approved projects and reviews them for California Environmental Quality Act (CEQA) compliance. CPUC issues certificates of public convenience and necessity for transmission lines at 200 kV and above or permits to construct for projects between 50 kV and 200 kV. CPUC issues a notice of exempt construction for the replacement of existing transmission lines, which are exempt from CPUC CEQA review under CPUC General Order 131-D, Section III, Subsections A or B.1. For a project sponsored by a POU, the POU board of directors can act as CEQA lead agency.

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Sources: LBNL 2019 RPS Analysis; EIA; regional, NERC demand forecasts; NREL Standard Scenarios; LBNL; CEC IEPR; CEC Progress Report; ScottMadden analysis

# Renewables Integration (Cont'd)

**Subset of Transmission Projects Tracked by CEC due to Potential to Expand Integration and Delivery of Renewables (June 2018)**

| Transmission Project | California ISO Status[1] | CPUC Status | Construction Status | Actual and Expected In-Service Date |
|---|---|---|---|---|
| 1 – Sunrise Powerlink 500 kV line | Approved | CPCN Approved | Operational | 2012 |
| 14 – Imperial Valley-Liebert (formerly Collector) 230 kV line[2] | Approved Policy | N/A | N/A | N/A |
| 15 – Sycamore Canyon-Peñasquitos 230 kV Line | Approved Policy with Reliability Benefits | CPCN Approved[3] | Planning/Design | 2018 |
| 2 – Tehachapi 500 kV line | Approved | CPCN Approved | Operational[4] | 2016 |
| 3 – Colorado River-Valley 500 kV line | Approved | CPCN and PTC Approved | Operational | 2013 |
| 4 – West of Devers 230 kV Reconductoring[5] | LGIA | CPCN Approved | Under Construction[6] | 2022 |
| 5 – Eldorado-Ivanpah 230 kV line | LGIA | CPCN Approved | Operational | 2013 |
| 6 – South of Contra Costa 230 kV Reconductoring | LGIA | CPCN Approved | Operational | 2012 |
| 7 – Pisgah-Lugo 500 kV line[7] | N/A | N/A | N/A | N/A |
| 8 – Borden-Gregg 230 kV Reconductoring | LGIA | NOC/CPCN TBD | On Hold | Unknown |
| 9 – Carrizo-Midway 230 kV Reconductoring | LGIA | NOC Approved | Operational | 2013 |

Source: CEC

**Demand-Side Considerations:**
**Transmission Projects to Support Renewable Portfolio Standards**

- Transmission projects tracked for the potential to support the state's renewable energy goals are a small subset of the reliability, economic, and policy projects approved and assessed by CAISO in the TPP. The 2017–2018 transmission plan identifies 13 new transmission projects needed for reliability and 4 new transmission projects needed for economic purposes. All but one of the newly approved transmission projects are expected to cost less than $50 million (each). The plan identifies no new transmission projects needed to meet the current transmission planning cycle target for achieving the 33% RPS by 2020.
- The plan identifies 28 previously approved transmission projects costing $50 million or more (each), including 9 lines in progress and 4 lines on hold. The plan identifies 122 previously approved transmission projects costing less than $50 million (each), including 10 lines in progress, 1 line on hold, and 10 lines canceled.
- With the completion of its 2017–2018 TPP cycle, CAISO has concluded its three-year, in-depth review of previously approved projects. For the third consecutive cycle, CAISO has canceled a significant number of previously approved transmission projects at significant cost savings.
  - In the 2015–2016 TPP, 13 projects were canceled, savings not stated.
  - In the 2016–2017 TPP, 13 projects were canceled, savings not stated.
  - In the 2017–2018 TPP, 20 projects were canceled, saving at least $2.6 billion.
- The 2017–2018 review has been the most comprehensive to date, resulting in cancellations of projects no longer needed and modifications of projects to better match changing expectations about need. The project cancellations and modifications involve mostly smaller projects that were not moving forward. The reassessment was initiated in response to changing peak load forecasts. CAISO concluded that decreased demand was compounded by greater than expected growth of behind-the-meter solar PV generation, which shifted the traditional peak demand hour later in the day in some parts of the state.

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Source: CEC Tracking Progress Report

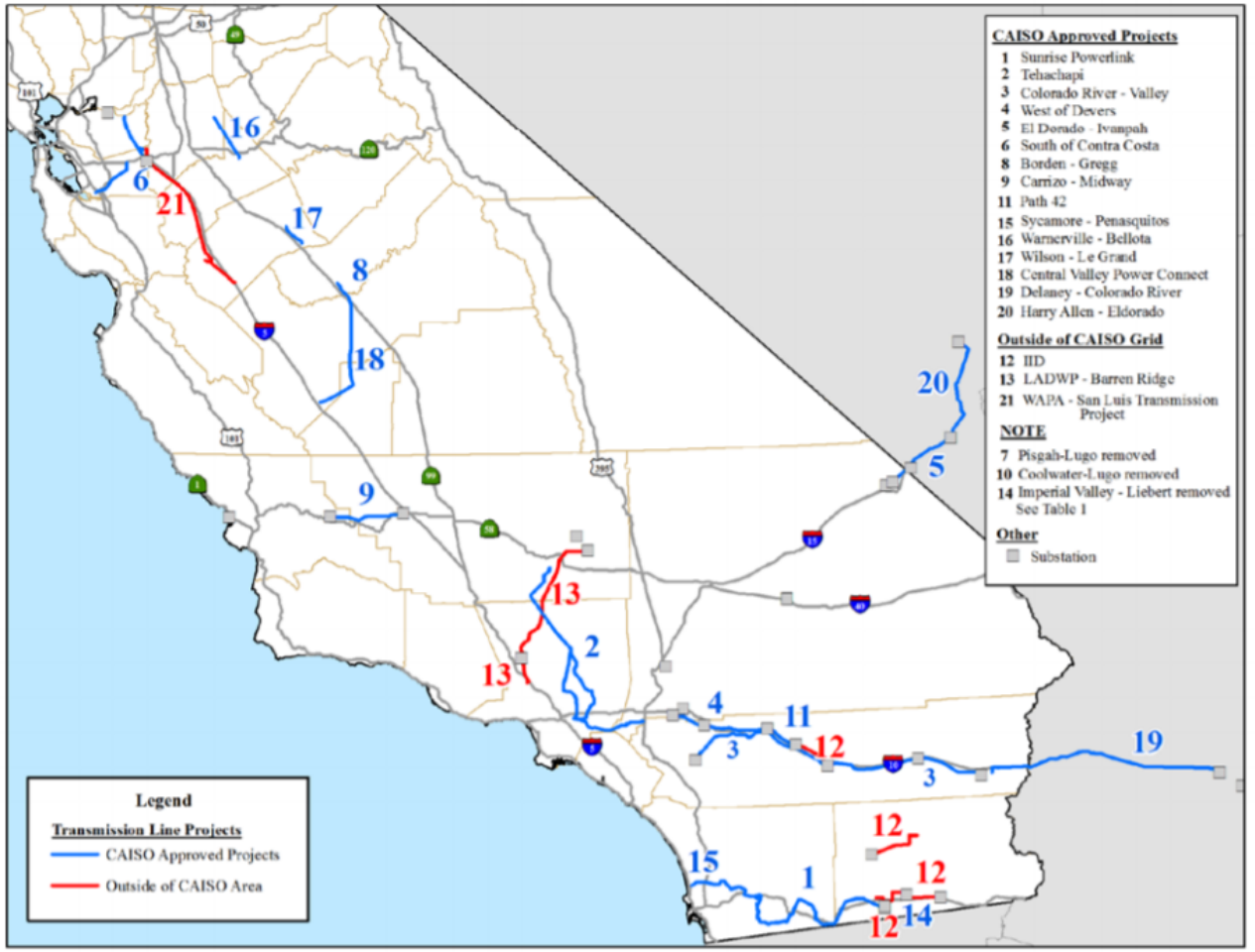
# Renewables Integration (Cont'd)

## Subset of Transmission Projects Tracked by CEC due to Potential to Expand Integration and Delivery of Renewables (June 2018) (Cont'd)

| Transmission Project | California ISO Status[1] | CPUC Status | Construction Status | Actual and Expected In-Service Date |
|---|---|---|---|---|
| 10 – Cool Water-Lugo 230 kV line[8] | LGIA | N/A | N/A | N/A |
| 11 – Path 42 230 kV Reconductoring | Approved Policy | N/A | Operational | 2016 |
| 12 – IID: Path 42 230 kV Reconductoring and additional upgrades (Outside CAISO Grid) | N/A | IID/SCE/BLM Joint Final Mitigated Negative Declaration Adopted | Construction suspended[9] | N/A |
| 13 – LADWP: Barren Ridge 230 kV line (Outside CAISO Grid) | N/A | LADWP/U.S. Forest Service/BLM Joint Final EIS/EIR Adopted | Operational | 2016 |
| 16 – Warnerville-Bellota 230 kV Reconductoring | Approved Policy | NOC Approved | Engineering/ Design | 2024 |
| 17 – Wilson-Le Grand 115 kV Reconductoring | Approved Policy | NOC Approved | Engineering/ Design | 2020 |
| 18 – Central Valley Power Connect (formerly Gates-Gregg 230 kV line) | Approved Reliability With Policy Benefits | CPCN to be Filed | On Hold[10] | 2022 |
| 19 – Ten West Link 500 kV Transmission Line Project (Delaney-Colorado River 500 kV line) | Approved Economic With Reliability and Policy Benefits | CPCN Filed | Competitive Solicitation Process[11] | 2020 |
| 20 – Harry Allen- Eldorado 500 kV line | Approved Economic With Reliability and Policy Benefits | N/A (line is located entirely in Nevada) | Competitive Solicitation Process[12] | 2020 |
| 21 – San Luis Transmission Project | N/A | Western/San Luis & Delta-Mendota Water Authority Joint Final EIS/EIR adopted[13] | Engineering/ Design | 2022 |

Source: CEC

## Map of CAISO and Outside CAISO Grid-Approved Transmission Projects




Source: CEC

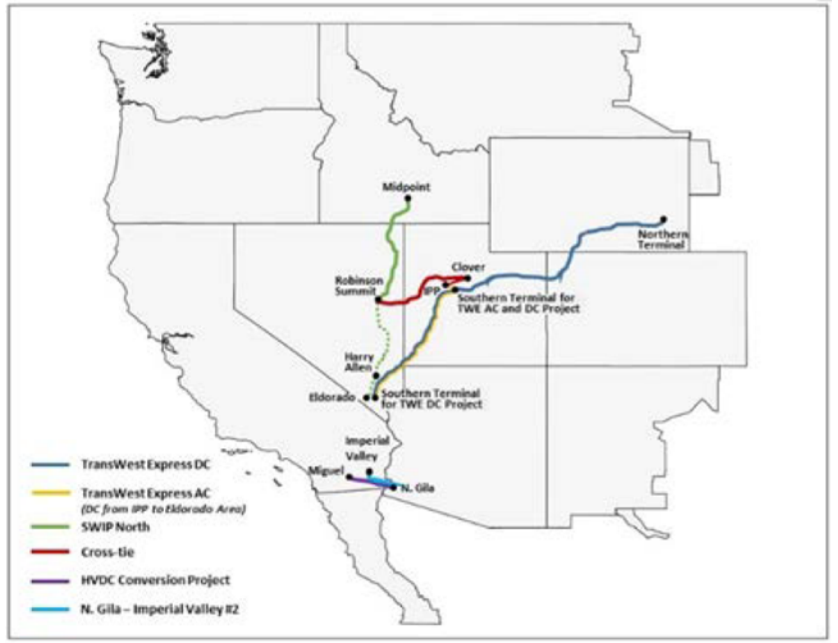
Source: CEC Tracking Progress Report

# Renewables Integration (Cont'd)

### Supply-Side Considerations: Interregional Planning

- CAISO conducts its coordination with neighboring planning regions through the biennial interregional transmission coordination framework established in compliance with FERC Order No. 1000. The ISO's 2018–2019 transmission planning cycle marks the beginning of the second biennial cycle since these coordination processes were put in place, replacing other mechanisms that pre-dated FERC Order No. 1000. This cycle reflects the complete transition from old process to new, taking into account the status of the policy drivers and the progress achieved in implementing the new interregional processes.
- In order to support state policy directives related to increasing renewable energy, CAISO partnered with CEC and CPUC to conduct the renewable energy transmission initiative (RETI) 2.0 to help identify potential transmission opportunities that could access and integrate renewable energy opportunities from regions outside of California. Through its involvement in interregional coordination activities, the ISO considered the interregional transmission projects (ITPs) proposed in the 2016–2017 interregional coordination cycle as a reasonable measure to assess the potential out-of-state transmission opportunities for California and, as such, proposed they be considered within the RETI 2.0 assessment framework. As a result, these ITPs were assessed and considered in the ISO's 2016–2017 and 2017–2018 planning cycles as "special studies" of the 50% RPS that had been established at that time.
- During the course of the 2018–2019 transmission planning cycle, CAISO considered all six ITPs that were submitted during the ITP submission period. Project sponsor's identified need, and the ISO's identified need as determined by the ISO's assessment varied, but there were two common themes among multiple projects:
  - Provide needed transmission capacity between the Wyoming wind resource area and California, facilitate California access to renewables.
  - Decrease San Diego and greater IV/San Diego local capacity requirement (LCR).

**Interregional Transmission Projects (ITPs) Submitted to CAISO (2018–2019)**




| Proposed ITP | Sponsor Identified Need | Cost Allocation | ISO Identified Need in this Planning Cycle |
|---|---|---|---|
| Cross-Tie | Strengthen interconnection between PacifiCorp and Nevada; facilitate California's RPS and GHG needs | ISO, NTTG, WestConnect | None: Based on 2018-2019 plan assumptions |
| HVDC Conversion | Improve/remove existing reliability limitation; decrease San Diego and greater IV/San Diego LCR requirement | Not Requested | Reliability: None<br>Economic: None - BCR less than 1.0 |
| NG-IV#2 | Decrease San Diego and greater IV/San Diego LCR requirement | ISO, WestConnect | Reliability: None<br>Economic: None - BCR less than 1.0 |
| SWIP - North | Economic, policy, reliability, reduce congestion on COI, facilitate access to renewables in PacifiCorp | ISO, NTTG, WestConnect | Reliability: None<br>Economic: None - BCR less than 1.0 |
| TransWest Express AC/DC | Provide needed transmission capacity between the Wyoming wind resource area and California, facilitate California access to renewables | ISO, WestConnect | None: Based on 2018-2019 plan assumptions |
| TransWest Express DC | Provide needed transmission capacity between the Wyoming wind resource area and California, facilitate California access to renewables | ISO, WestConnect | None: Based on 2018-2019 plan assumptions |

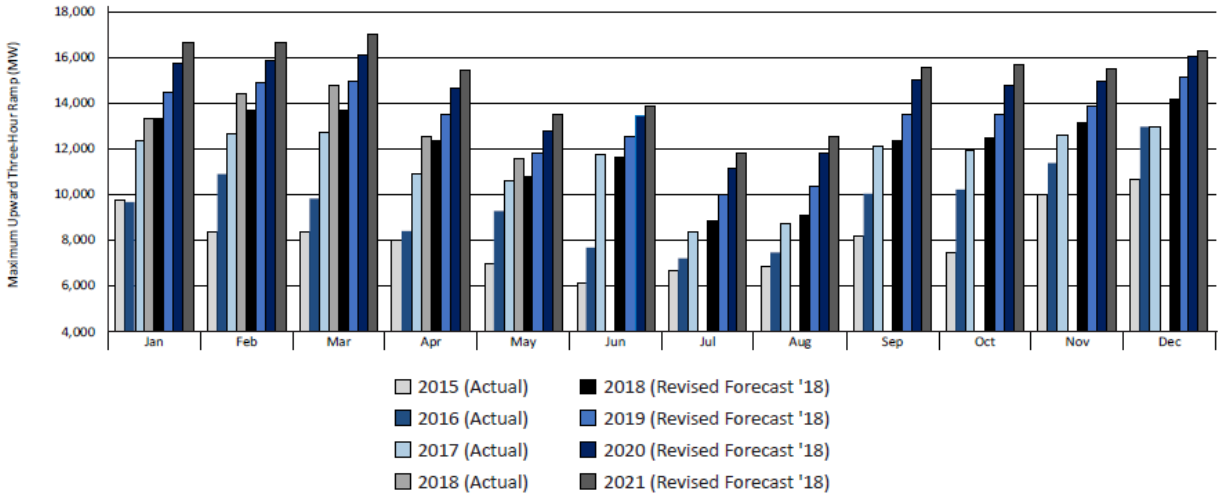
Source: CAISO Transmission Plan

# Renewables Integration (Cont'd)

### Integration Challenges: The Growing Need for Resource Flexibility

- With continued growth in renewables in recent years, there has been growing recognition that system operators need additional flexible capabilities to balance supply and demand. This additional flexibility is required to accommodate morning and late-afternoon ramps in energy net load (load minus solar and wind generation) resulting from solar resource output.
- According to CAISO, ramps and minimum loads are four years ahead of its initial estimates, primarily due to growth in renewable energy projects. Furthermore, because of expected changes in the dispatchable natural gas-fired fleet, CAISO is concerned that it needs greater operational control over resources with flexible capacity.
- With continued rapid growth of distributed solar, CAISO's three-hour ramping needs have reached 14,777 MWs (new record set in March 2018), exceeding earlier projections and reinforcing the need to access more flexible resources. The maximum one-hour net-load upward ramp was 7,545 MWs. This record coincided with utility-scale PV serving nearly 50% of CAISO's demand during the same time period. By 2022, this need increases to 17,000.
- Currently, there are more than 11 GWs of utility-scale and 6.5 GWs of behind-the-meter PV resources in CAISO's footprint, which has the most concentrated area of PV in North America.
- Behind-the-meter PV has continued to grow in CAISO, and the projected behind-the-meter PV is expected to be 12 GWs by 2022.

**Maximum Three-Hour Ramps in CAISO (Actual and Projected) Through 2021**




### Recent and Ongoing Initiatives to Increase Flexibility

- **Flexible Ramping Product:** In 2016, CAISO introduced a formal flexible ramping product into its market system.
- **Day-Ahead Market Enhancement (DAME):** Currently, CAISO is attempting to improve its forecasting methods and apply them to a newly configured day-ahead market (DAH) via the DAME stakeholder process. By moving the DAH market from an hourly forecast to a fifteen-minute forecast, CAISO intends to improve market efficiency and better align resources to meet ramping needs.
- **EIM Expansion:** Expanding the geographic footprint of the market can help in two ways. First, greater diversity of renewable resources can reduce the coincidence of production patterns. Second, loads in larger regions outside CAISO can help absorb excess production, and generating resources in those regions may be able to assist California with upward ramping requirements.

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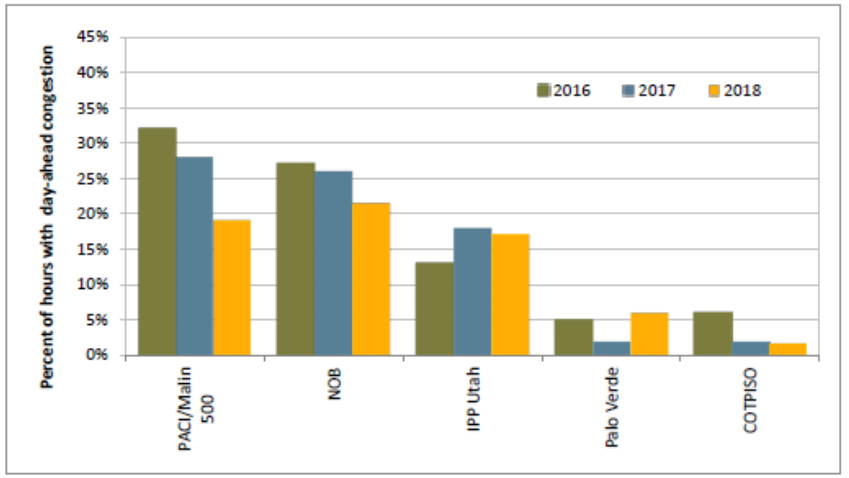
Sources: NERC 2018 LTRA; CEC IEPR

# Renewables Integration (Cont'd)

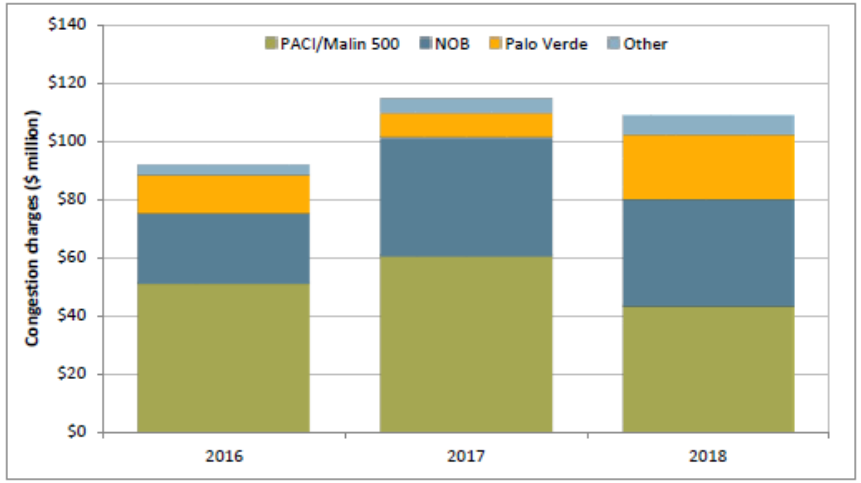
**Integration Challenges: Hydro Generation from the Pacific Northwest**

- CEC and CPUC issued a letter to CAISO requesting evaluation of options to increase transfer of low-carbon electricity between the Pacific Northwest and California.
- Expanded transmission capability, and increasing the transfer of low-carbon supplies to and from the Northwest in particular, was seen to be one of the multiple puzzle pieces that the agencies must examine to build a cumulative phase-out strategy of Aliso Canyon usage and address potential impacts on the gas-fired generation fleet.
- Three scenarios were outlined in the request and addressed in CAISO's 2018–2019 transmission plan:
  - Increase the capacity of AC and DC interties
  - Increase dynamic transfer capacity
  - Implementing sub-hourly scheduling on Pacific DC Interties (also called Path 65)
  - Assigning resource adequacy value to firm zero-carbon imports
- To ensure availability of Pacific Northwest resources to supply load in California in the long term, some market or policy initiatives and regulations may be required. However, details of such market structures, policies, or regulations were beyond the scope of CAISO's study.
- CAISO has initiated a resource adequacy enhancements stakeholder initiative that will include an assessment of the rules for import resource adequacy and a review of the maximum import capability. In addition, CPUC has ongoing resource adequacy and integrated resource plan proceedings that may address these issues.

**Percent of Hours with Congestion on Major Interties**




**Import Congestion Charges on Major Interties**



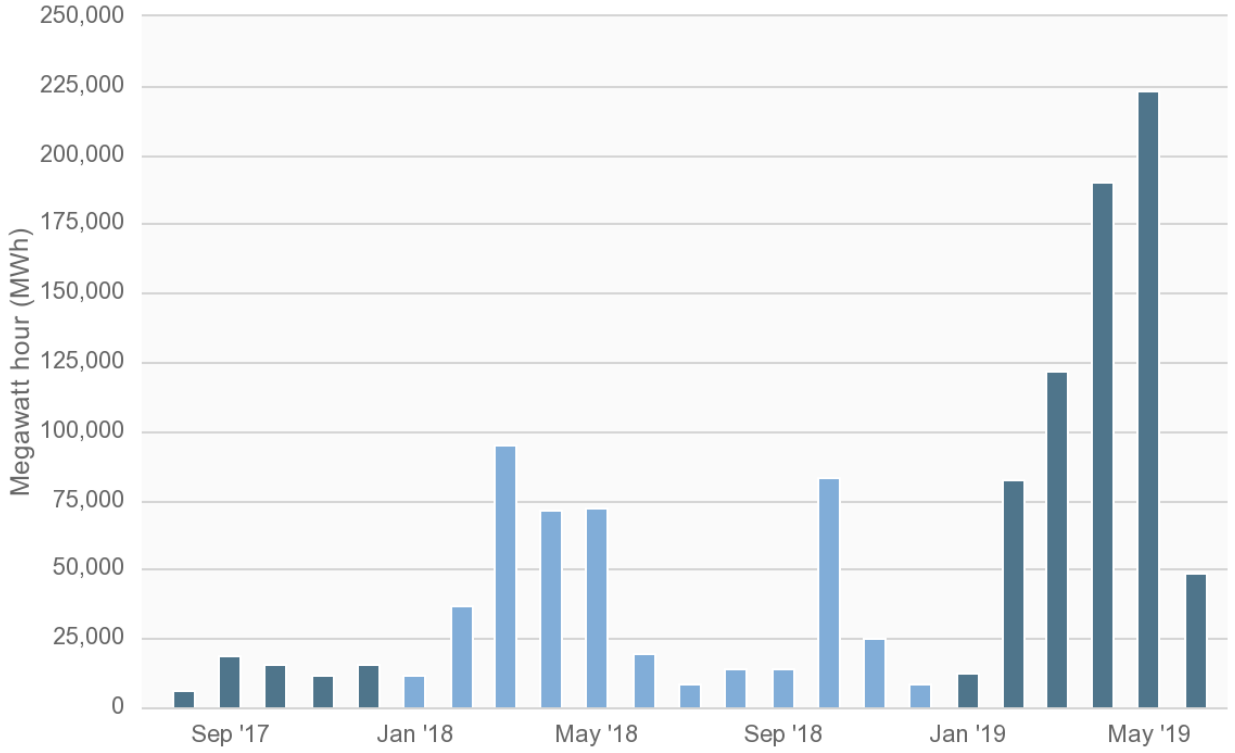

Source: CAISO (http://www.caiso.com/Documents/CPUCandCECLettertoISO-Feb152018.pdf)

# Renewables Integration (Cont'd)

**Integration Challenges: The Renewable Curtailment Opportunity**

- As discussed in the section on the Western EIM, one value that market serves is putting to use over generation from renewable resources in times when it exceeds the corresponding demand for power in each region. And, the Western EIM has provided significant value in avoided curtailments to date.
- However, the rate at which renewables are being added in CAISO, particularly in just the past 12 months, is far outpacing the ability of the Western EIM to absorb and avoid curtailments, as evidenced by the trend at the right, creating several potential challenges:
  - Market Risk – If renewables continue to be overbuilt at increasing rates, they will drive real-time prices lower, distorting price signals in the market.
  - Project Risk – If the attractiveness of new renewable project economics is diminished, projects may not get built.
- Transmission projects, along with demand and energy storage, will represent some of the few emission-free solutions to these risks for the region as renewable penetration increases.

**Wind and Solar Curtailment Totals by Month**




Source: CAISO

# Renewables Integration (Cont'd)

**Integration Challenges: Headwinds for Transmission Development**

- Preference for non-wires alternatives
  - In its energy action plan (EAP), originally jointly adopted in 2003 and updated and reiterated in 2005 and 2008 (EAP II), the CPUC and the CEC defined a "loading order" for energy resources to prioritize future energy investments. Preferred resources, in order of priority, include the following:
    - Energy efficiency
    - Demand-side resources
    - Renewable generation and energy storage
    - Clean conventional electricity supply
  - The EAP represents a coordinated implementation plan for various state energy and environmental policies, principally to address climate change and reduce greenhouse gas emissions.
  - The principles established in the EAP serve as inputs for the long-term procurement proceedings, in which CPUC establishes upfront standards for CAISO's procurement activities and cost recovery by reviewing and approving procurement plans.
  - The most recent proceeding was divided into four different tracks:
    - Track 1 considered issues related to the overall long-term need for new local reliability resources to meet long-term LCRs through 2022. Such long-term LCRs are expected to result from the retirement of thousands of megawatts from current once-through cooling generators to comply with State Water Quality Control Board regulations. Other changes in supply and demand over time will also impact long-term LCRs. As part of each procurement authorization, CPUC has included limits on conventional gas-fired resources and minimum thresholds for meeting requirements with energy storage and other preferred resources.
    - Track 2 considered procurement of system reliability resources for the three major electric IOUs and adopted final planning assumptions and scenarios. These assumptions were used for forecasting system reliability needs for California's electricity grid, and CPUC requested that CAISO use those same assumptions in modeling operational flexibility needs.
    - Track 3 considered a number of rule and policy issues related to IOUs' procurement practices.
    - Track 4 considered additional resource needs related to the long-term outage (and subsequent permanent closure in June 2013) of SONGS.

Source: CEC Energy Action Plans

# Implications for Transmission

| | Resilience | Integration of Renewables | Other Factors | Transmission Opportunities |
|---|---|---|---|---|
| **California ISO** | ▪ Key risks related to severe weather (wildfires and heat waves) and seismic events; recent wildfires have resulted in historic levels of damage<br>▪ Severe weather and vandalism have been the largest causes of electrical disturbances reported in recent years<br>▪ There are volumetric and flexibility constraints on the natural gas system, and a disruption in the gas system could potentially translate quickly to a loss of load in southern California<br>▪ CAISO is heavily dependent on out-of-state imports from the northwest and the southwest to meet system needs | ▪ Currently, there are more than 11 GWs of utility scale and 6.5 GWs of distributed solar in the footprint, and distributed solar is expected to grow to 12 GWs by 2022<br>▪ Wind, geothermal, biomass, biogas, and small hydro comprise the remaining renewable capacity in CAISO, representing an additional 3.7 GWs in aggregate<br>▪ Renewable generation resources located outside the state represent 25% of total renewable capacity reported as qualified to meet RPS requirements today<br>▪ Renewable Energy Transmission Initiative (RETI) has led to the consideration of six different interregional transmission projects to move remote out-of-state renewables into CA<br>▪ Offshore wind development is contingent upon technology improvements, but developers have recently pointed to potential interest among CCAs | ▪ Single-state footprint with very aggressive policies related to renewable energy: 100% by 2045 and 2030 target increased recently from 50% to 60%<br>▪ State environmental requirements make siting and permitting challenging and costly<br>▪ Resource planning via IRPs will be increasingly driven by CCAs going forward, and CCAs have an implicit bias toward local generation resources vs. distant resources delivered long distances via high-voltage transmission lines<br>▪ CEC and CPUC have defined a preferred “loading order” that prioritizes non-wire alternatives over transmission solutions<br>▪ Congestion continues to be a major concern driving needs for mitigation with new transmission projects in some areas of the footprint | ▪ Potential to increase transfer capacity between wind and solar resource areas outside CAISO and demand centers in CA to meet policy needs<br>▪ Increasing transfer capacity with Pacific Northwest (for hydro imports) identified as an important tool for mitigating risks related to phasing out Aliso Canyon gas storage<br>▪ CAISO’s Energy Imbalance Market (EIM) continues to expand its reach into new territory. Even with the EIM, renewable curtailments have continued increasing sharply, suggesting opportunities to put that to use via additional transmission capacity<br>▪ Additional transmission capacity can provide additional flexibility and diversity to address the growing need for ramping capability, resource adequacy<br>▪ Possible integration of offshore wind |

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# Appendix: Transmission Project Selection Criteria

**Planning Process**

- ISO Transmission Plan – An annual process that provides an evaluation of the ISO control grid, examines conventional grid reliability requirements and projects, summarizes key collaborative activities, and provides details on key study areas and associated findings.

**Project Identification**

- Transmission Economic Assessment Methodology (TEAM) groups benefits into the following categories:
  - Production benefits: Benefits resulting from changes in the net ratepayer payment based on production cost simulation as a consequence of the proposed transmission upgrade.
  - Capacity benefits: Benefits resulting from increased importing capability into CAISO's BA or into an LCR area. Decreased transmission losses and increased generator deliverability contribute to capacity benefits as well.
  - Public-policy benefit: Transmission projects can help to reduce the cost of reaching renewable energy targets by facilitating the integration of lower cost renewable resources located in a remote area or by avoiding overbuild.
  - Renewable integration benefit: Interregional transmission upgrades help mitigate integration challenges, such as oversupply and curtailment, by allowing sharing energy and ancillary services among multiple BAs.
  - Avoided cost of other projects: If a reliability or policy project can be avoided because of the economic project under study, then the avoided cost contributes to the benefit of the economic project.

**Criteria for Competitive Projects**

- All regional projects (all more than 200 kV, some less than 200 kV)
- Upgrades/additions to existing lines or on existing rights of way/substations are exempt

**Evaluation Criteria**

- Capabilities of the project sponsor and its team to finance/license/construct/O&M
- Ability to acquire right of way
- Proposed schedule and demonstrated ability to meet schedule
- Technical and engineering qualifications and experience

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