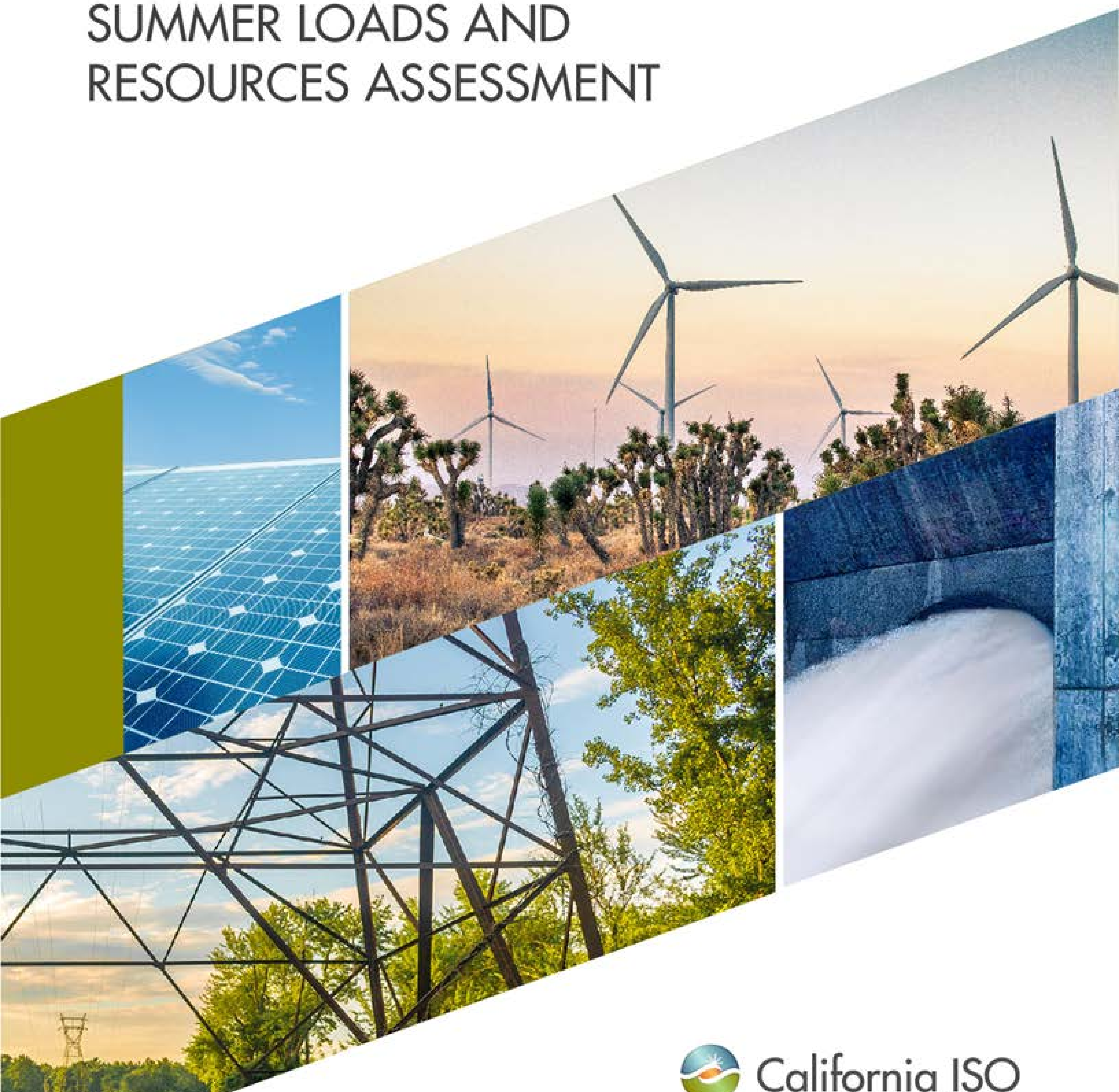
2020 SUMMER LOADS AND RESOURCES ASSESSMENT



California ISO

May 15, 2020

Table of Contents

I. EXECUTIVE SUMMARY

The *2020 Summer Loads and Resources Assessment ("2020 Assessment")* provides an assessment of the upcoming summer supply and demand outlook for the California Independent System Operator (CAISO) balancing authority area. In developing the supply and demand forecasts and identify potential issues concerning upcoming operating conditions for the summer 2020, the CAISO uses internal sources of information, third party modeling tools, and public information from various state agencies, generation and transmission owners, load serving entities, and other balancing authorities (BAs). The 2020 Assessment considers the supply and demand conditions across the entire CAISO balancing authority area, and to a more limited extent, the entire Western Electricity Coordinating Council (WECC).

To better assess summer operating conditions given the changing resource mix of higher penetration of renewable resources and fewer dispatchable conventional gas fired resources, the CAISO developed a stochastic production simulation model using the PLEXOS market simulation software. The model is designed to run 2,000 unique randomly generated scenarios of forecasted hourly load and renewable generation to assess CAISO's resource adequacy for system capacity, ancillary service, and flexible capacity on an hourly basis. The 2020 Assessment presents results from a base case and a sensitivity case to consider the impacts of more conservative levels of net imports.

The base case results show that the CAISO has a low probability of experiencing operating conditions that would lead to shedding firm load in summer 2020. However, if summer conditions are less favorable, resulting in lower levels of imports as assumed in the sensitivity case, the probability of shedding firm load will increase. The risk in 2020 primarily stems from less than average hydro conditions resulting in reduced energy from hydro resources across the summer, but particularly impactful in late summer. Furthermore, the CAISO daily peak period has shifted to later in the day when solar generation is near or at zero levels, resulting in the CAISO's highest demand levels being supplied by the remaining non-solar fleet. With lower than normal hydro conditions, the CAISO may have to rely more heavily on imports from neighboring BAs during the CAISO summer peak hours. However, if a heat wave occurs that impacts a broader area than the CAISO, the availability of surplus energy to import into the CAISO could be diminished.

While the CAISO has a low probability of a system capacity shortfall, there is a material risk of shortfalls in load following up capacity, particularly in the late afternoon when solar generation is near or at zero and net imports diminish from neighboring BAs while system demand is increasing. These shortfalls generally do not result in operational impacts as there is no impact if the intra hour variability and uncertainty needs fail to materialize, but it is an indicator of increasing tightness of dispatch capability. However, if a load following shortfall were to occur when actual intra hour variability and uncertainty needs do materialize, it may be necessary in some cases to rely on regulation or operating reserve to maintain balance between supply and demand and maintain frequency within required limits further challenging the CAISO's ability to meet performance standards.

Peak Demand Forecast

The CAISO 2020 1-in-2 peak demand forecast is 45,907 MW, which is 0.2 percent above the 2019 weather normalized peak demand of 45,826 MW.[1] The relatively unchanged demand projection is a result of projected modest economic growth over 2019, continuing load reductions from behind-the-meter solar installations, and energy efficiency programs. The CAISO 2020 1-in-5 and 1-in-10 peak demand forecast are 47,775 MW and 48,457 MW, respectively.

No attempt was made to predict potential ongoing impacts to loads due to COVID-19 through the summer period. At the time of writing this report, too many unknowns existed to produce a viable and meaningful COVID-19 load impact scenario. As of the writing of the report, the CAISO has experienced load reductions of 5 to 8 percent on weekdays, and 1 to 4 percent on weekends, with the largest reductions occurring over the morning peak hours. Similar to its European counterparts, including Italy and Spain, the ISO observed greater load decreases as the stay-at-home conditions continued. However, 2020 summer weather has yet to materialize across the CAISO balancing authority area to provide an indication of the levels of load reduction during periods of heavy air conditioning driven loads. While the CAISO does recognize there are likely to be lasting effects from COVID-19 throughout the 2020 summer period, there is not enough data to forecast the magnitude and hourly profile of those impacts.

Hydro Conditions

California hydro conditions for summer 2020 are below normal. The statewide snow water content for the California mountain regions peaked at 63 percent of average on April 7, 2020. Also on that date, California major reservoir storage levels were at 101 percent of average.

The Northwest River Forecast Center projected the April to August reservoir storage at The Dalles Dam on the Columbia River to be 95 percent of average. Since the 2019 – 2020 snow water content and reservoir levels are similar to 2017 – 2018 levels, the 2018 hydro generation profile was selected for the 2020 modeling process.

Net Import Constraints

When high temperatures increase electric energy consumption in California, neighboring BAs' electric energy consumption is often high as well. As a result, imports from neighboring BAs will usually decrease when the CAISO's demand ramps up to its peak. In order to reflect this system operation situation in the CAISO's production simulation model, a net import nomogram was developed based on 2017 to 2019 historical EMS data. *Figure 1* shows the net imports during the daily peak hour when demand is at or above 41,000 MW[2] for all summer months during 2017 – 2019. Analyses of the monthly trends of net imports demonstrate a declining nature of net imports as demand increases. *Figure 1* shows the net import nomograms for the base case and sensitivity case during the peak hours of hour-ending 16 – 21 to cap the level of net imports allowed by the model. The upper dashed line represents the base case nomogram while the lower dashed line defines the sensitivity case

[1] The actual 2019 peak of 44,148 MW occurred on 8/15/2019 at HE 18:00. The weather normalized peak is a simulated amount of what the peak demand would have been under normal or 1-in-2 weather conditions.

[2] 41,000 MW is 90 percent of the forecast of the CAISO 2020 1-in-2 peak demand of 45,907 MW.

nomogram. During non-peak hours the net imports are capped at 11,666 MW, the highest net import experienced during all hours of 2019.

Figure 1

2017 – 2019 summer net imports at time of daily peaks above 41,000 MW and

On-peak net import nomograms for the base case and sensitivity case

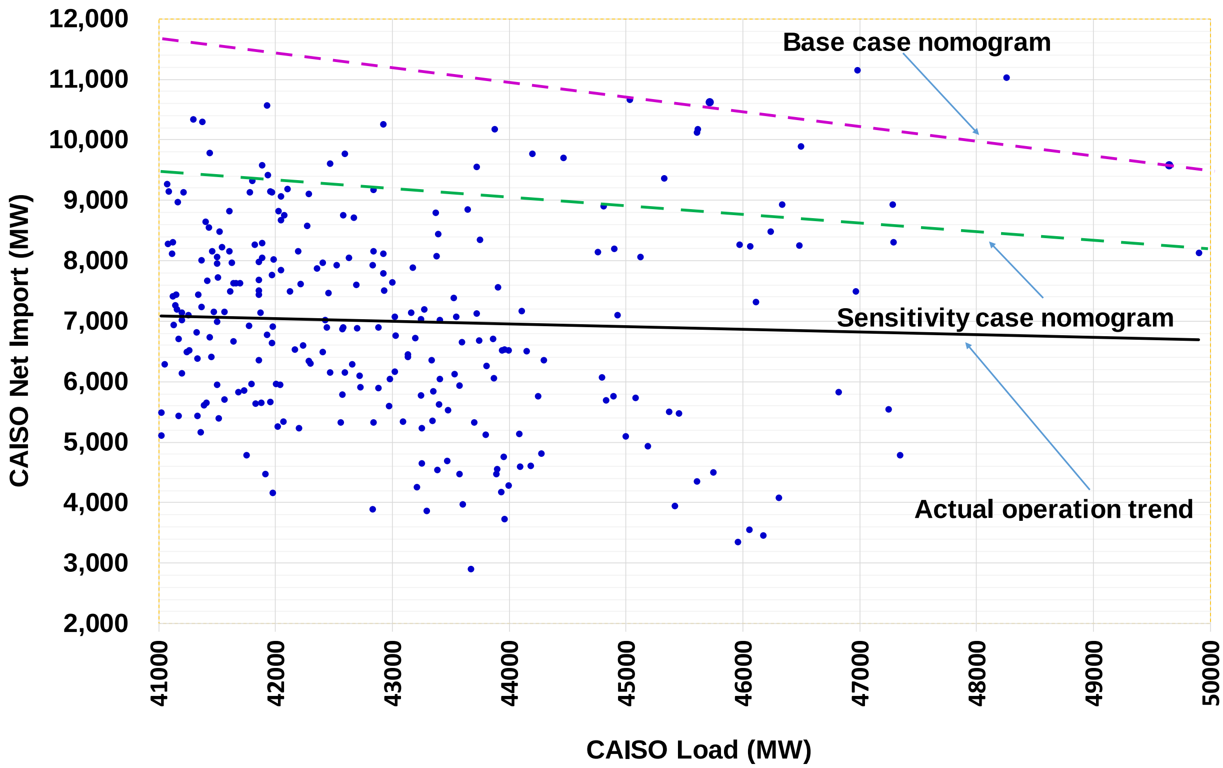


Figure 1 shows CAISO net imports at time of daily peaks above 41,000 MW vs. CAISO load from 2017 to 2019.

Table 1 shows historical CAISO net imports when the CAISO load is equal to or greater than 43,000 MW during 2017 to 2019. The maximum net import recorded a decline trend from 11,147 MW in 2017 to 8,792 MW in 2019. The CAISO system reliability depends on a certain range of net imports from neighboring balancing authorities, particularly during higher system peaks. This trend indicates that the availability of imports at historical levels could be at risk at times when CAISO may be most dependent on such imports.

Table 1

CAISO net imports with CAISO load equal to or greater than 43,000 MW during Summer from 2017 to 2019

Year	2019	2018	2017
Min	4,743	2,898	3,263
First Quartile	6,046	4,166	5,272
Median	6,615	5,136	7,062
Third Quartile	7,434	6,602	8,300
Max	8,792	9,541	11,147

System Capacity

The CAISO projects system capacity levels of 48,012 MW in June, 48,555 MW in July, 46,903 MW in August, and 44,543 MW in September for summer 2020. The decline of available capacity from July to September derives from the diminishing effective load carrying capability of solar generation and hydro generation.

From June 1, 2019, to June 1, 2020, approximately 3,423 MW of installed capacity will reach commercial operation: 1,734 MW is dispatchable and 1,689 MW is non-dispatchable.[3] During the same period, 1,991 MW of generation capacity will retire or mothball: 1,926 MW is dispatchable and 65 MW is non-dispatchable. While the net of additions and retirements is an increase of 1,432 MW, the effective load carrying capability of these resources results in only a net increase of 38 MW during the month of September, which is the difference between the effective load carrying capability of the generation additions of 1,990 MW and retirements of 1,952 MW in September.

When the model simulation depletes all available generating resources before meeting the load and ancillary service requirements, the model will utilize demand response programs. The demand response capability in the CAISO market for 2020 is estimated to be 1,339 MW.

Simulation Results

The 2020 Assessment performed base case and sensitivity case studies to assess the system reliability.

[3] Non-dispatchable resources are technologies that are dependent on a variable fuel source and are modeled in PLEXOS as energy production profiles based on historical generation patterns. Non-dispatchable technologies include biofuels, geothermal, wind, solar, run-of-river hydro, and non-dispatchable natural gas.

Base Case Study

The 2020 Assessment uses loaded capacity and available unloaded capacity to characterize the capacity adequacy of the system. Loaded capacity is the generation capacity that is serving load. The unloaded capacity refers to any portion of online generation capacity that is not serving load and offline generation capacity that can come online in 20 minutes or less to serve load as well as curtailable demands such as demand response, interruptible pumping load, and aggregated participating load that can provide non-spinning reserve or demand reduction. The unloaded capacity includes operating reserves the system procures. The Unloaded Capacity Margin (UCM) is the excess of the available resources, within 20 minutes or less, over the projected load expressed as a percentage on an hourly basis.

The model calculates an UCM for each hour modeled. Taking into account the unloaded capacity margin for all of 2,928 summer hours[4] within each of the 2,000 summer scenarios, the median[5] value of all unloaded capacity margin values is 41.3 percent (*Figure 2)*.

Figure 2

CAISO Unloaded Capacity Margins

Base case (June through September 2020)

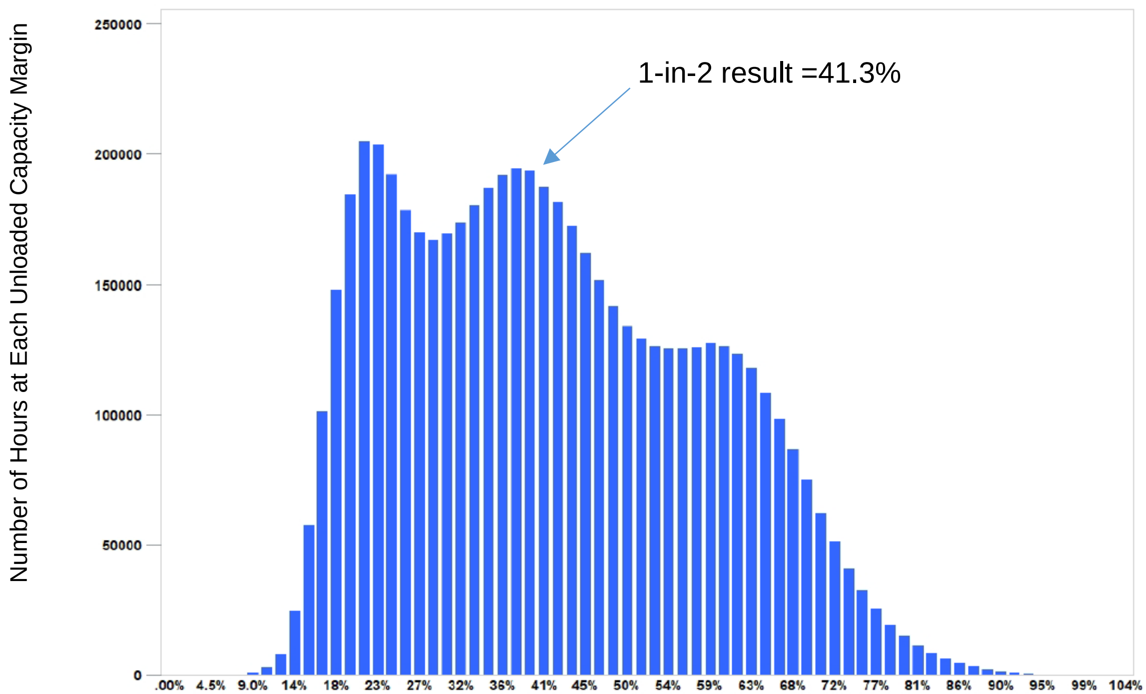


Figure 2 shows the distribution of the UCMs over all 2,928 summer operating hours from all 2,000 scenarios.

[4] The study period of June 1 through September 30 in each scenario represents 2,928 hours (24 hours × 122 days).

[5] The median is the value that is in the middle of the model results data set, where there is a 50 percent probability that the result will be above the median and a 50 percent probability that the result will be below the median.

Levels of UCM above the operating reserve requirement for any given hour (typically around 6 percent) signify that capacity is available beyond the requirement for operating reserves, which to the extent available, can be used during system contingencies.

The lowest UCM from each scenario modeled is termed the Minimum Unloaded Capacity Margin (MUCM). The MUCMs of all 2,000 scenarios simulated are used to determine the probability of various events occurring. *Table 2* shows scenarios with extreme low operating reserves where the MUCM is at emergency levels (stage 2, stage 3)[6] and scenarios with unserved energy. The CAISO system has a 3.7 percent probability of operating at stage 2 based on 74 scenarios having at least one hour that met the definition of a stage 2 condition, a 1.1 percent probability at stage 3 based on 21 scenarios having one hour or more that met the definition of a stage 3 condition, and a 0.2 percent probability with unserved energy based on 3 scenarios showing one hour or more of unserved energy.

Table 2

Base case probability of system capacity shortfall

Base Case	Shortfall Probability	Number of Shortfall Scenarios
Stage 2	**3.7%**	**74**
Stage 3	**1.1%**	**21**
Unserved energy	**0.2%**	**3**

Figure 3 shows the number of scenarios with operating reserves at emergency levels of stage 2, stage 3 and unserved energy. Demand response programs would have been utilized as needed to maintain a 6 percent operating reserve margin and would be fully utilized in cases where the operating reserve margin is below 6 percent. Should CAISO system operating conditions go into the emergency stages, the CAISO will issue a notice of potential load interruptions to utilities and implement the mitigation operating plan to minimize loss of load in the CAISO balancing authority area described in the *Preparation for Summer Operation* section at the end of the *Executive Summary*. Whether actual interruptions would occur depends on the specific circumstances and potential for recovering reserves.

[6] See System Alerts, Warnings and Emergencies Fact Sheet on CAISO webpage – http://www.caiso.com/informed/Pages/Notifications/NoticeLog.aspx

Figure 3

Scenarios with operating reserves at stage 2, stage 3 and unserved energy

Base case

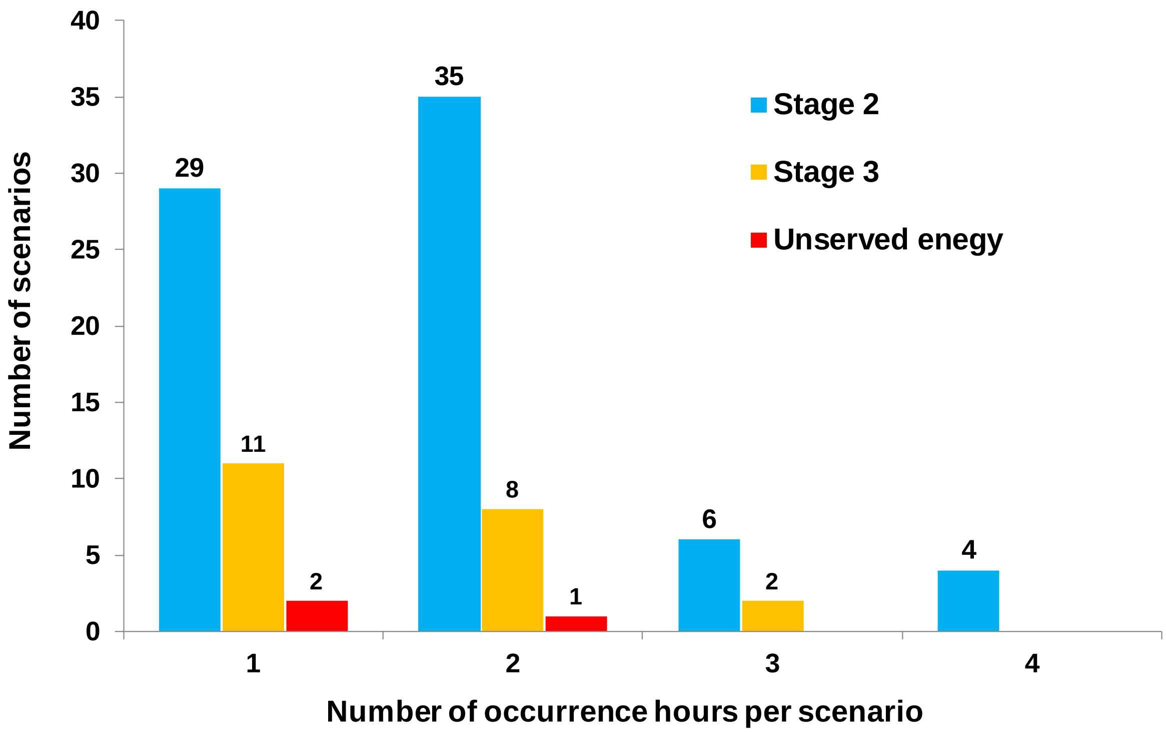


Figure 3 shows scenario occurrences with operating reserves at stage 2, stage 3 and unserved energy.

Figure 4 shows the amount of unserved energy for each hour of unserved energy and the CAISO load levels they occurred at. Of the three scenarios having unserved energy, one scenario has two hours of occurrence, as shown in *Figure 3*. All unserved energy occur in August. The CAISO loads when unserved energy occurs range from 48,900 MW to 50,232 MW, which are above the 1-in-10 peak demand forecast of 48,457 MW.

Figure 4

CAISO loads versus scenarios where unserved energy occurs

Base case

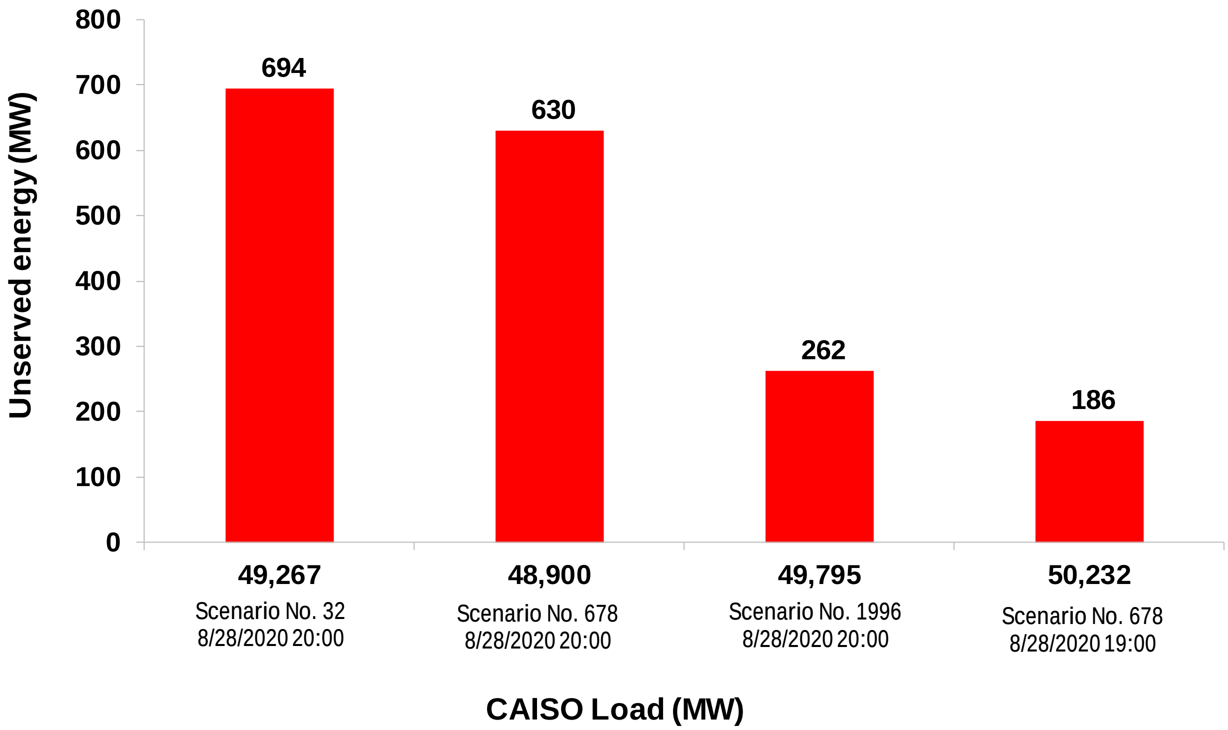


Figure 4 shows CAISO load level versus unserved energy.

To further assess resource adequacy for the summer period, the MUCM from each of the 2,000 scenarios are shown in *Figure 5*. While *Figure 2* shows the UCM for all hours of all scenarios, *Figure 5* only shows the MUCM for each scenario, which range from a high of 17 percent down to the lowest result of zero. The zero results are hours where the supply is less than demand, and represents the most extreme hours within the 2,000 scenarios considered.

Figure 5

Base case CAISO Minimum Unloaded Capacity Margin

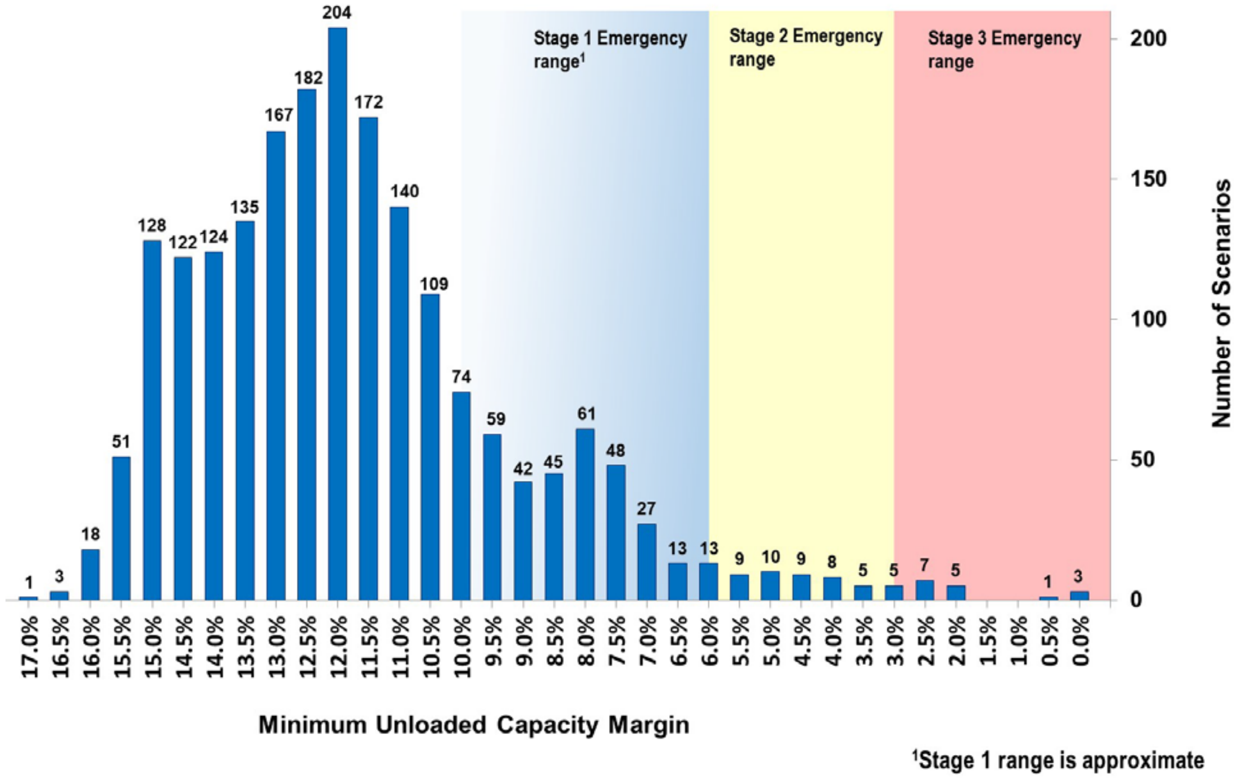


Figure 5 shows forecast distribution of summer MUCM for the CAISO.

Figure 6 shows the distribution of the MUCM over the hours of the day in which they occurred. The solar generation profile anticipated during the 2020 summer peak day is shown to provide a reference related to the profile of the hours of highest risk. The MUCM has the highest level of occurrences at hour ending 20 (i.e., 8:00 pm). The timing of 91 percent of the MUCM values fall in periods of significantly reduced or no solar generation.

Figure 6

Base case Minimum Unloaded Capacity Margin occurrences and solar generation profile

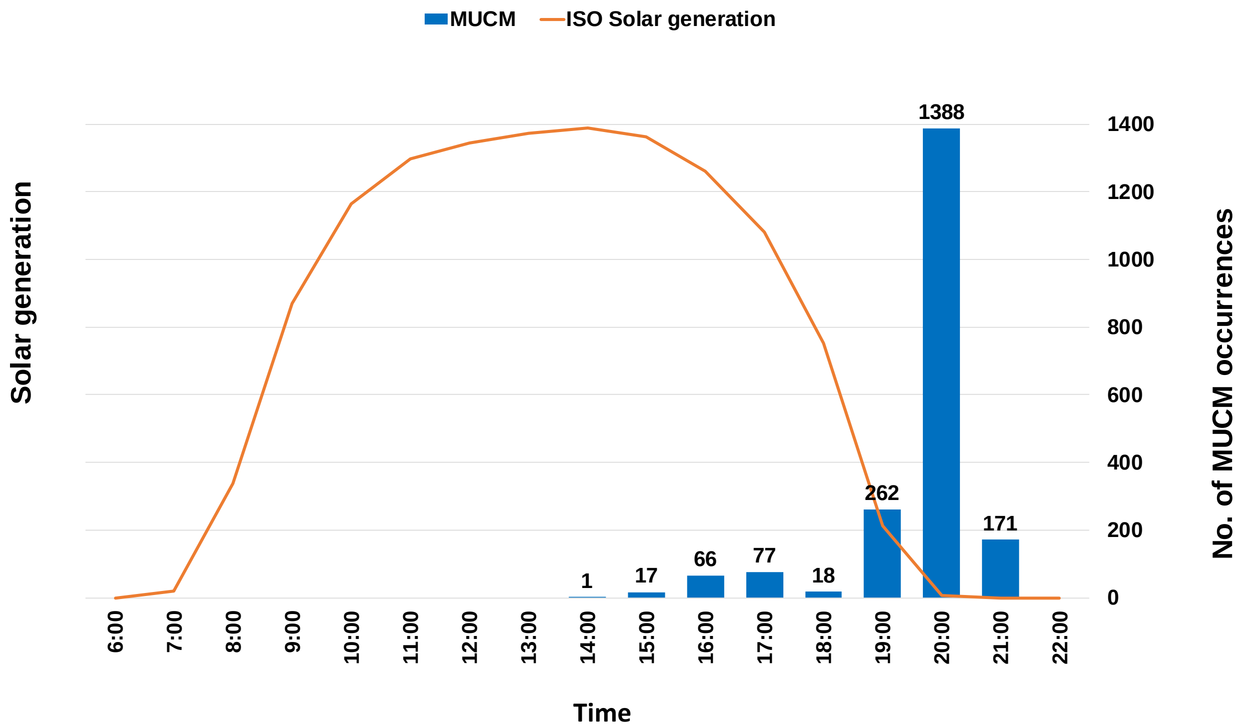


Figure 6 shows the MUCM occurrence hour with the solar generation profile.

Sensitivity Case Study

In order to understand the vulnerability of the CAISO system under conditions of moderately lower net imports than the base case, the CAISO performed a sensitivity case study with the CAISO net imports capped at the more conservative nomogram in *Figure 1.* The nomogram is designed to follow the declining level of the upper range of available imports as the CAISO load increases, consistent with the declining levels of actual net imports as shown in *Table 1*.

The sensitivity case simulation results indicate that the CAISO system will have a 10.6 percent probability operating at a stage 2 emergency (211 scenarios produced at least one hour of potential stage 2), a 4.7 percent probability at stage 3 (94 scenarios produced an hour or more of potential stage 3), and a 1.6 percent probability with unserved energy (31 scenarios showed at least one hour of potential unserved energy), as shown in *Table 3*.

Table 3

Sensitivity case probability of CAISO system capacity shortfall

Sensitivity Case	Shortfall Probability	Number of Shortfall Scenarios
Stage 2	10.6%	211
Stage 3	4.7%	94
Unserved energy	1.6%	31

Table 4 compares the probability of CAISO system capacity shortfall between the base case and the sensitivity case, revealing the criticality of imports to the CAISO during system peak hours at high load conditions. If the CAISO is limited to the more conservative import levels of the sensitivity case, the probability of falling into stage 2 conditions is three times more likely, and falling into stage 3 conditions where firm load is shed is over four times more likely. The sensitivity case also produced eight times the number of scenarios with unserved energy results than the low level observed in the base scenario. The sensitivity study results reveal that 85 percent of the hours of unserved energy occurred from August 28 to September 28, further indicating that the CAISO will be at the greatest operational risk during late summer if low hydro availability occurs together with low net imports due to high peak demands in its neighboring balancing authority areas.

Table 4

Probability of CAISO system capacity shortfall

Base case compared to Sensitivity case

Result	Base Case	Sensitivity Case
Stage 2	3.7%	10.6%
Stage 3	1.1%	4.7%
Unserved energy	0.2%	1.6%

Status of the Aliso Canyon Gas Storage Operating Restrictions

Natural gas needs in Southern California are met by a combination of major gas pipelines, distribution gas infrastructure and gas storage facilities. Four major gas storage facilities are located in the Southern California Gas system, the largest of which is the Aliso Canyon facility located in Los Angeles County. Following a significant natural gas leak in late 2015, the injection and withdrawal capabilities of the Aliso Canyon were severely restricted.

Aliso Canyon directly supplies 17 gas-fired power plants with a combined total 9,800 MW of electric generation in the Los Angeles basin and indirectly impacts 48 plants with a combined total 20,120 MW of electric generation across Southern California. There are limitations in attempting to shift power supply from resources affected by Aliso Canyon to resources that are not affected because of certain factors, such as local generation requirements, transmission constraints and other resource availability issues.

On April 15, 2020, the CPUC staff published the Summer 2020 Southern California Reliability Assessment[7], which concluded that conditions had improved as compared to the same time last year. This is the result of having more gas in storage at Aliso Canyon and SoCalGas' three other storage fields going into the summer, the return to service of Line 235-2 which had been out of service since October 2017, and regulatory actions by the CPUC. Specifically, on July 23, 2019 the CPUC made revisions to the Aliso Canyon Withdrawal Protocol to remove its classification as "an asset of last resort" to provide SoCalGas with more flexibility to use Aliso Canyon to balance the system and ease energy price spikes[8]. The Summer 2020 Southern California Reliability Assessment also presented an analysis of a peak demand summer day under the base and worst-case gas balance scenarios. While findings show that non-Aliso withdrawals would be sufficient to meet demand under both scenarios at the daily level, hourly demand and gas deliveries on a peak day may still trigger a need for withdrawal at Aliso Canyon[9].

Conclusion

Projections for summer 2020 show that the CAISO faces a low, but somewhat increased risk of encountering operating conditions that could result in operating reserve shortfalls than was projected for 2019. The increased risk in 2020 over 2019 is primarily a result of lower than normal hydro conditions resulting in reduced energy from hydro resources across the summer, but particularly impactful in late summer. The CAISO will be at the greatest operational risk of a system capacity shortage later in the summer if hot weather occurs that extends beyond the CAISO footprint and diminishes the availability of surplus energy in neighboring balancing authorities for imports into the CAISO during peak hours when solar production is near or at zero. The 2020 Assessment does not specifically assess the risk associated with transmission outages due to wildfires, which could hinder imports during critical supply conditions. Supply disruptions due to public safety power shutoff procedures are also not addressed in this report.

While the CAISO has a low probability of a system capacity shortfall, there is a material risk of shortfalls in load following up capacity, particularly in the late afternoon when solar generation is near or at zero and net imports diminish from neighboring BAs while system demand is increasing. These shortfalls generally do not result in operational impacts as there is no impact if the intra hour variability and uncertainty needs fail to materialize, but it is an indicator of increasing tightness of dispatch capability. However, if a load following shortfall were to occur when actual intra hour variability and uncertainty needs do materialize, it may be necessary in some cases to rely on regulation or operating reserve to

[7] California Public Utilities Commission, Summer 2020 Southern California Reliability Assessment, April 15, 2020. Available at: https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/News_Room/NewsUpdates/2020/Summer2020-ReliabilityAssessment_Final.pdf In prior years, this had been a joint report between the staffs of the CPUC, CAISO, Los Angeles Department of Water and Power, and California Energy Commission.

[8] Aliso Canyon Withdrawal Protocol: https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/News_Room/NewsUpdates/2019/UpdatedWithdrawalProtocol_2019-07-23%20-%20v2.pdf.

[9] Summer 2020 Southern California Reliability Assessment, pp. 14-15.

maintain balance between supply and demand and maintain frequency within required limits further challenging the CAISO's ability to meet performance standards.

Preparation for Summer Operation

Producing this report and publicizing its results is one of many activities the CAISO undertakes each year to prepare for summer system operations. Other activities include coordinating meetings on summer preparedness with the WECC, California Department of Forestry and Fire Protection (Cal Fire), natural gas providers, Transmission Operators and neighboring balancing areas. The ISO's ongoing coordination activities with these entities help to ensure everyone is prepared for the upcoming summer operational season.

II. SUMMER 2019 REVIEW

Demand

The recorded 2019 summer hourly average peak demand reached 44,148 MW[10] on 8/15/2019 at 18:00. Under a 1-in-2 weather condition, the 2019 weather normalized peak load is 45,826 MW. The 2019 annual peak demand for the Southern California zone (South of Path 26 or SP26) reached 27,116 MW and for the Northern California zone (North of Path 26 or NP26), the annual peak demand was 21,091 MW. The annual peaks for the CAISO and NP26 occurred on 8/15/2019 at hour ending 18:00 and 19:00, respectively, while the annual peak for Southern California zone occurred on 9/4/2019 at hour ending 16:00.

Figure 7 shows actual monthly peak demands from 2009 to 2019 for the CAISO, SP26 and NP26. Since 2009, annual peak demand has fluctuated primarily due to weather conditions unique to each year and changing economic conditions and demographics. CAISO peak demand has been significantly offset by the behind-the-meter solar installations during solar production hours, shifting the system peak hour to later in the evening when behind the meter solar production and grid-connected solar energy production is low or zero. To a lesser extent, increasing energy efficiency and the use of demand side management impacted peak demand as well.

Figure 7

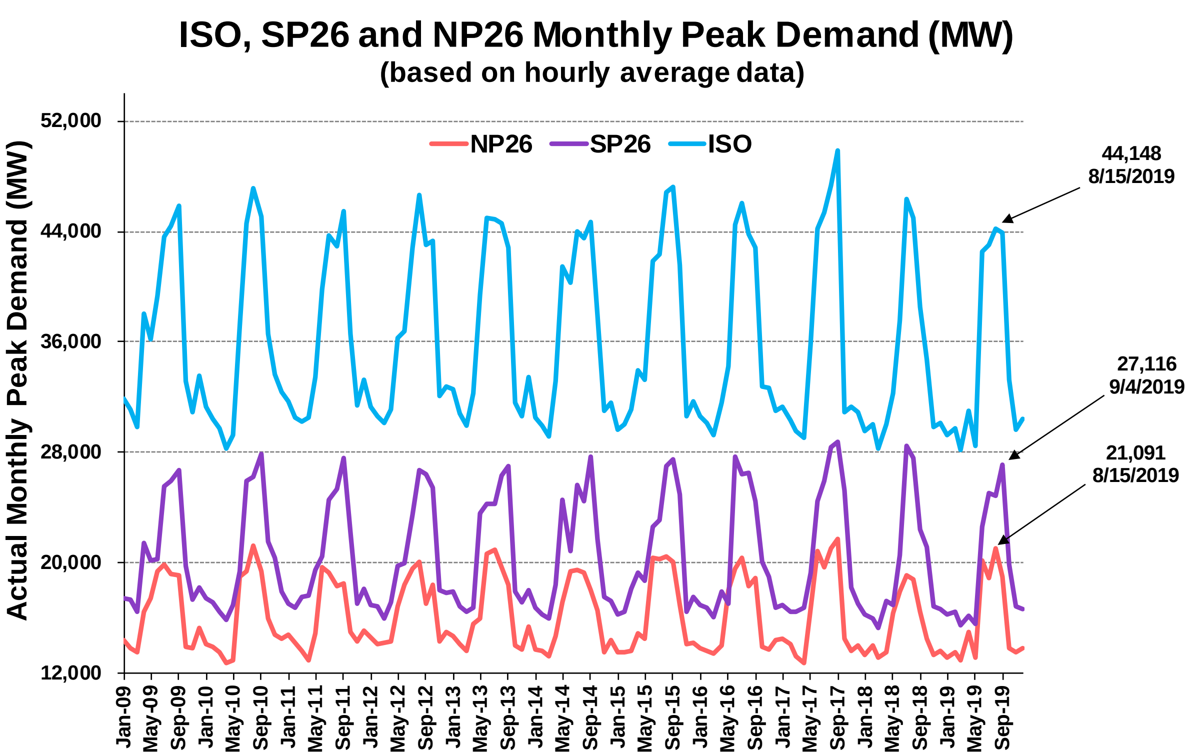


Figure 7 shows the CAISO system peak and peaks for Northern and Southern California (2009-2019).

[10] All demand data represented in this report is hourly average demand.

Table 5 shows the 2019 actual peaks, 2019 triggered demand response, 2019 weather normalized peaks, and the 2019 1-in-2 peak demand forecasts. Weather conditions during the CAISO actual peak were mild, ranked as 1-in-1.2 weather conditions, lower than a 1-in-2 weather event. The weather normalized peak load for CAISO in 2019 was 45,826 MW. The actual peak demand in Northern California was 0.2 percent higher than the 1-in-2 peak demand forecasts for NP26. The weather at the time of the actual NP26 peak demand was a 1-in-2.2 weather event. The actual peak demand in Southern California was 0.8 percent lower than the 1-in-2 forecast peak demand for SP26. The weather at the time of the SP26 peak demand was a 1-in-1.2 weather event.

Table 5

2019 CAISO actual, normalized and forecast peak (MW)

Zone	Actual	DR	Actual + DR	Normalized	1-in-2 Forecast	Actual + DR vs. Forecast	Forecast vs. Normalized	Time
NP26	21,091	43	21,134	20,263	20,369	3.8%	0.5%	8/15/19 19:00
SP26	27,116	496	27,612	27,689	27,889	-1.0%	0.7%	9/4/19 16:00
ISO	44,148	334	44,482	45,826	46,511	-4.4%	1.5%	8/15/19 18:00

Supply

Actual daily supply and demand from June through September 2019 for the CAISO system, the SP26, and NP26 zones are shown in *Appendix A: 2019 Summer Supply and Demand Summary Graphs.*

Interchange

Figure 8 shows the 2019 CAISO peak demand and the net imports over the weekday summer load period. The net imports provided in *Figure 8* are limited to those days when the CAISO daily system peak was 90 percent or more than the 2019 summer peak. There are numerous factors that determine the level of interchange between the CAISO and other balancing authorities at any given time. These factors include market dynamics, the availability of generation internal and external to the CAISO, resource adequacy contracting, transmission congestion, hydro conditions, forecasted renewable generation, demands within various areas, and day-ahead forecasts accuracy. On any given day, the degree to which any one of these interrelated factors influence import levels can vary greatly. Actual daily Import levels from June through September 2020 for the CAISO system and the SP26 and NP26 zones are shown in *Appendix B: 2019 Summer Imports Summary Graphs.*

Figure 8

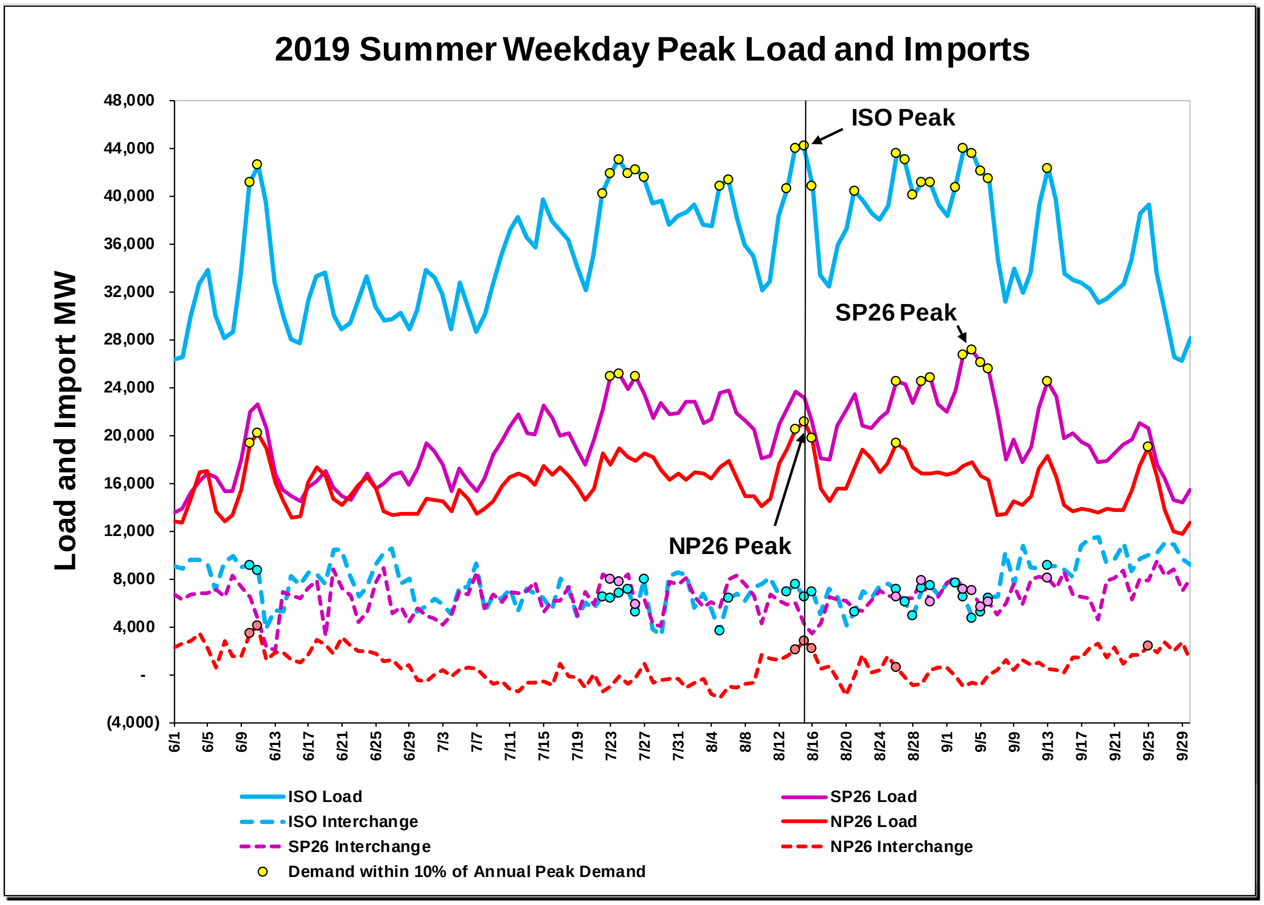


Figure 8 shows the amount of imports at CAISO 2019 daily system peaks.

III. SUMMER 2020 ASSESSMENT

CAISO Loads

Annual Peak and Energy Forecast

The CAISO's annual peak and energy forecast process has five steps. The first step is to develop daily peak and energy models for NP26 (Pacific Gas and Electric), and SP26 (Southern California Edison, San Diego Gas and Electric, and Valley Electric Association),[11] and the CAISO using MetrixND®. The inputs are weather data, economic and demographic data, and historical loads (adding demand response back in and excluding water delivery pumping loads). The second step uses a weather simulation program to generate 175 weather scenarios using 25 years of historical weather data from 1995 through 2019. Seven different weather scenarios are developed for each historical year to simulate calendar effects across the weekdays. The third step uses a peak and energy simulation process to generate 175 annual peak and energy amounts through the MetrixND® models based on the 175 weather scenarios. The fourth step randomly generates 5,000 samples from each area's range of 175 annual peak and energy amounts. Finally, a range of typical pump loads during summer peak conditions are added back into the loads to arrive at 5,000 annual peak loads. The 1-in-2 peak load is calculated at the 50th percentile of the 5,000 annual peak loads, the 1-in-5 peak load is calculated at the 80th percentile and the 1-in-10 peak load is calculated at the 90th percentile.

The weather data comes from 24 weather stations located throughout large population centers within the CAISO balancing authority. Weather data used in the model include maximum, minimum and average temperatures, cooling degree days, heat index, relative humidity, solar radiation indices, as well as various temperature weighting indices.

The historical loads are hourly average demand values sourced from the CAISO energy management system (EMS). Water delivery pump loads were not included in the historical demand as they do not react to weather conditions in a similar fashion and are subject to interruption. Pump loads are added back into the forecast demand based on a range of typical pump loads during summer peak conditions.

The CAISO uses gross domestic product and population developed by Moody's Analytics for the metropolitan statistical areas within the CAISO as the economic and demographic indicators to the models. *Figure 9* shows a baseline economic scenario forecast developed by Moody's Analytics that represent the outlook of how the economy could perform based on Moody's baseline assumptions. The baseline forecast is the median scenario wherein there is a 50 percent probability that the economy will perform better and a 50 percent probability that the economy will perform worse.

It is important to note that the forecast is based on the Moody's gross domestic product forecasts released in December 2019. The gross domestic product data reflects actual historical data through Dec 31, 2018 (January 2019 and later historical data are estimates of actual GDP). Consequently, this forecast is based on the most current data available at the time it was developed. *Figure 10* shows CAISO 1-in-2, 1-in-5, and 1-in-10 peak forecasts based on the base case economic scenarios from Moody's Analytics.

[11] The electric utility loads referenced within NP26 and SP26 are at the Transmission Access Charge area level.

Figure 9

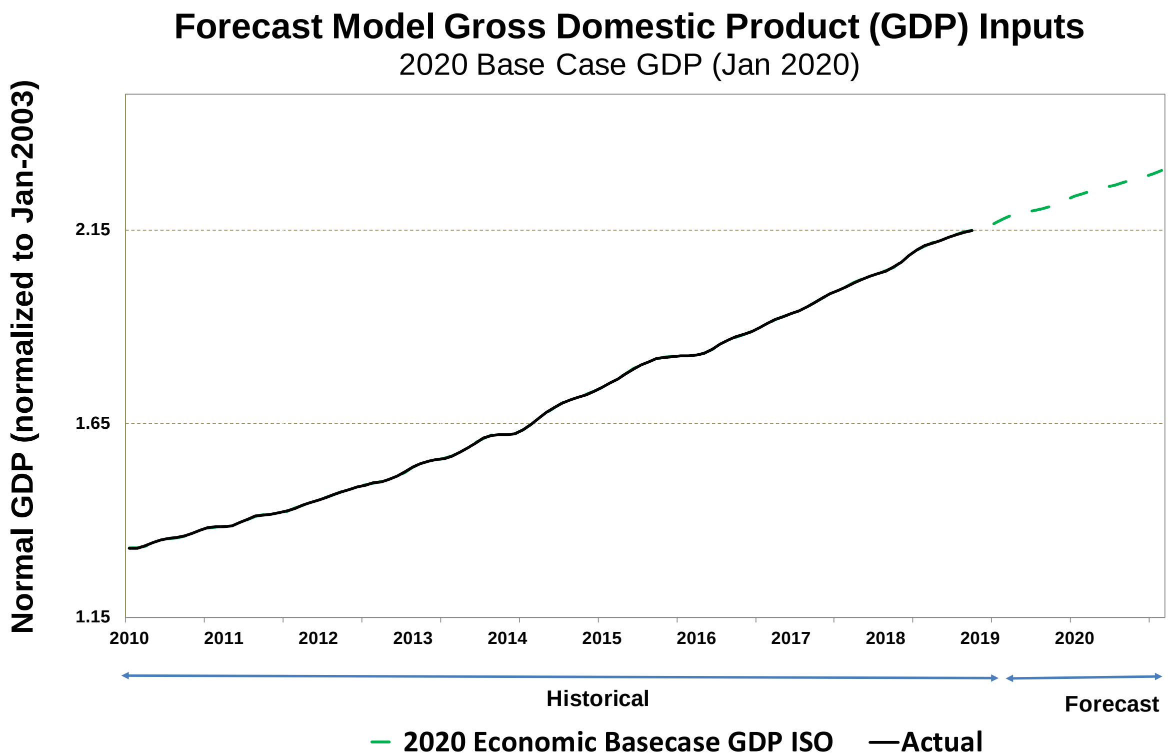


Figure 9 shows 2020 base case Gross Domestic Product for the metropolitan statistical areas within the CAISO.

Figure 10

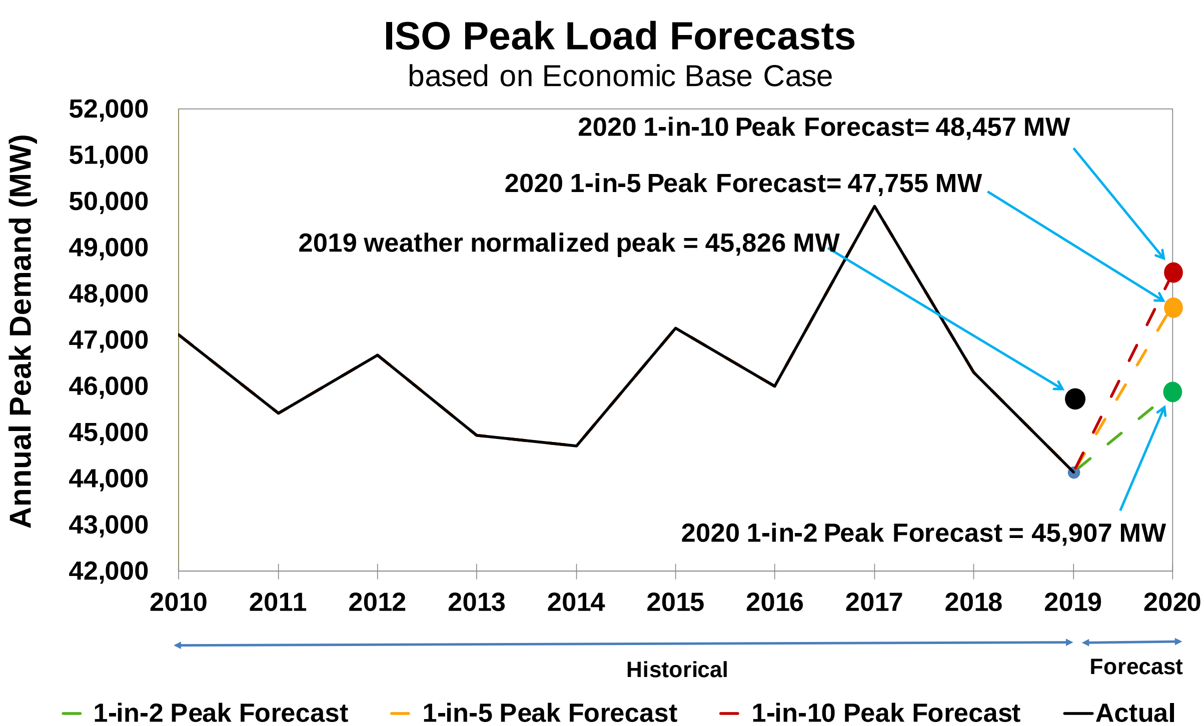


Figure 10 shows CAISO 2020 1-in-2, 1-in-5 and 1-in-10 peak forecasts.

The 2020 1-in-2 peak forecast of 45,907 MW[12] is only a 0.2 percent increase from the CAISO 2019 weather normalized peak demand of 45,826 MW. The relatively unchanged demand projection is a result of projected modest economic growth over 2019, based on the economic base case forecast from Moody's Analytics, continuing load reductions from ongoing behind-the-meter solar installations and energy efficiency program impacts on peak demand. The 1-in-2, 1-in-5 and 1-in-10 peak load forecasts for 2020 are shown in *Table 6.*

Table 6

2020 Peak Demand Forecast (MW)

2020	ISO	SP26	NP26
1-in-2	45,907	27,820	20,245
1-in-5	47,755	28,865	21,101
1-in-10	48,457	29,571	21,811

Net load is defined as hourly load minus grid-connected wind and solar production. In other words, net load is the remaining load that the CAISO dispatches resources to serve after the gross load has been reduced by the amount of energy production from renewable resources. Renewable resources have an energy profile based on the availability of the resource they utilize to produce energy such as solar and wind. The net load is served by the resources that the CAISO is able to dispatch. *Table 7* shows the forecasted net peak load for 2020. No attempt was made to predict potential ongoing impacts to loads due to COVID-19 through the summer period.

Table 7

2020 Net Peak Load Forecast (MW)

2020	CAISO Net Peak Load Forecast
1-in-2	40,370
1-in-5	43,239
1-in-10	44,572
Max	47,838

12 The CAISO developed 1-in-2 peak demand forecast of 45,907 MW is within 0.57 percent of the California Energy Commission's 1-in-2 Managed Forecast - Mid Demand / Mid AAEE Case of 45,647 from its 2019 Integrated Energy Policy Report.

Hydro Generation

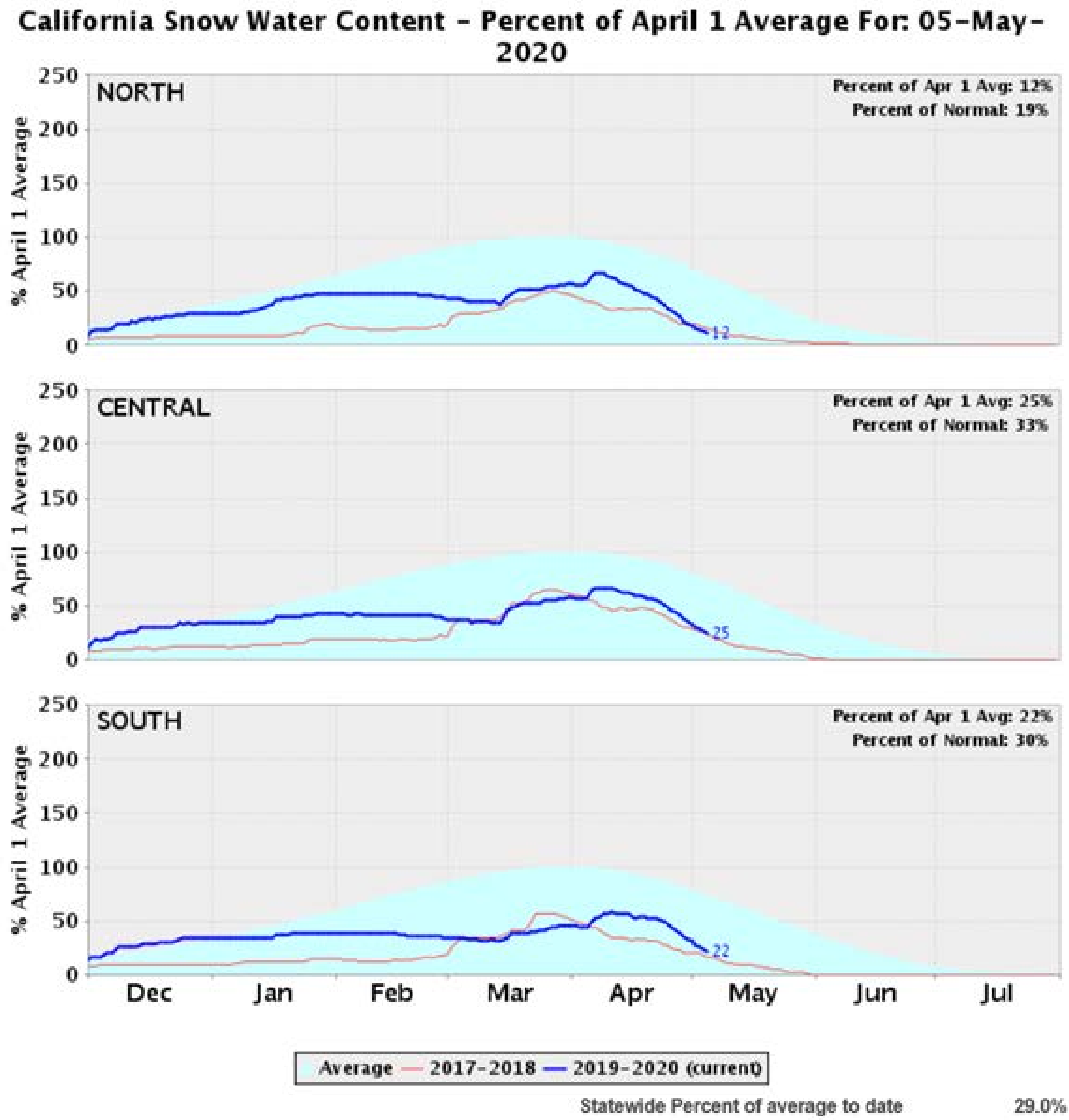
California hydro conditions for 2020 are below normal. The statewide snow water content for the California mountain regions peaked at 63 percent of average on April 7, 2020. Also on that date, California major reservoir storage levels were at 101 percent of average. California 2020 hydroelectric capability is lower than 2019 when the statewide snow water content on April 11 was 161 percent of the average.

As of April 20, 2020, the Northwest River Forecast Center projected the April to August reservoir storage at The Dalles Dam on the Columbia River to be 95 percent of average, roughly equivalent to the 94 percent of average experienced in 2019.

Hydro generation is modeled on an aggregated basis as two types: non-dispatchable run-of-river and dispatchable hydro generation. Run-of-river hydro generation has a fixed generation profile derived from historical data for the north and the south while the dispatchable hydro generation is optimized subject to the daily energy limits and daily maximum and minimum values, which are derived from historical data from years with similar snowpack and reservoir conditions. Dispatchable hydro generation can provide system capacity, ancillary service and flexible capacity. Pump storage generators are modeled individually and are optimized subject to storage capacity, inflow and target limits, and cycling efficiency.

Figure 11 is a chart of the daily snow water content for 2019 – 2020, which is similar to 2017 – 2018's levels, shown as well. As a result, the 2018 hydro generation profile was used for the 2020 modeling process. *Figure 12* shows the storage levels of the major reservoirs across the state. *Figures 13, 14 and 15* provide the latest water year's history of precipitation for the North Sierra, San Joaquin and Tulare Basins. Statewide precipitation was approximately 63 percent of average on April 20.

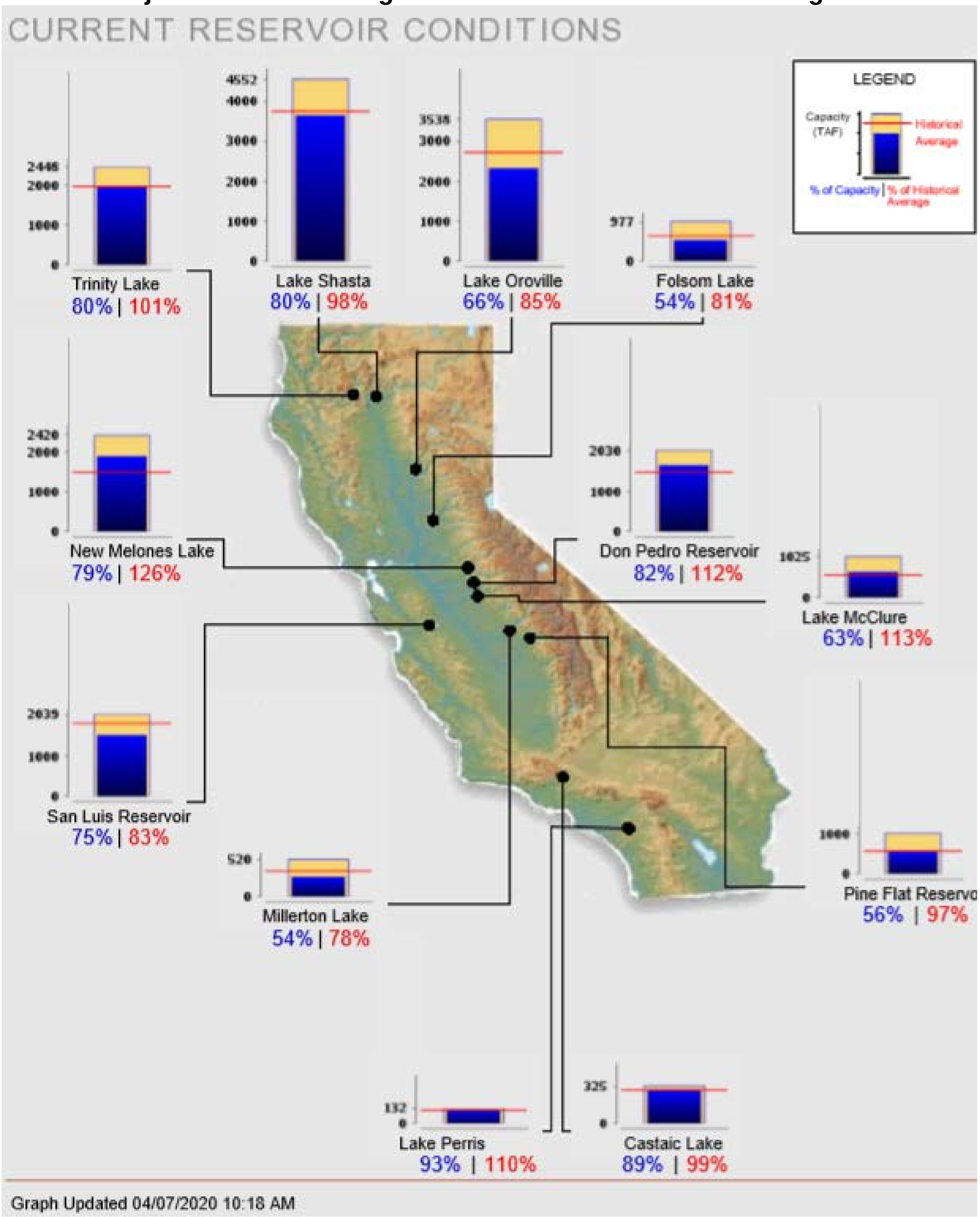
Figure 11



Source: California Department of Water Resources

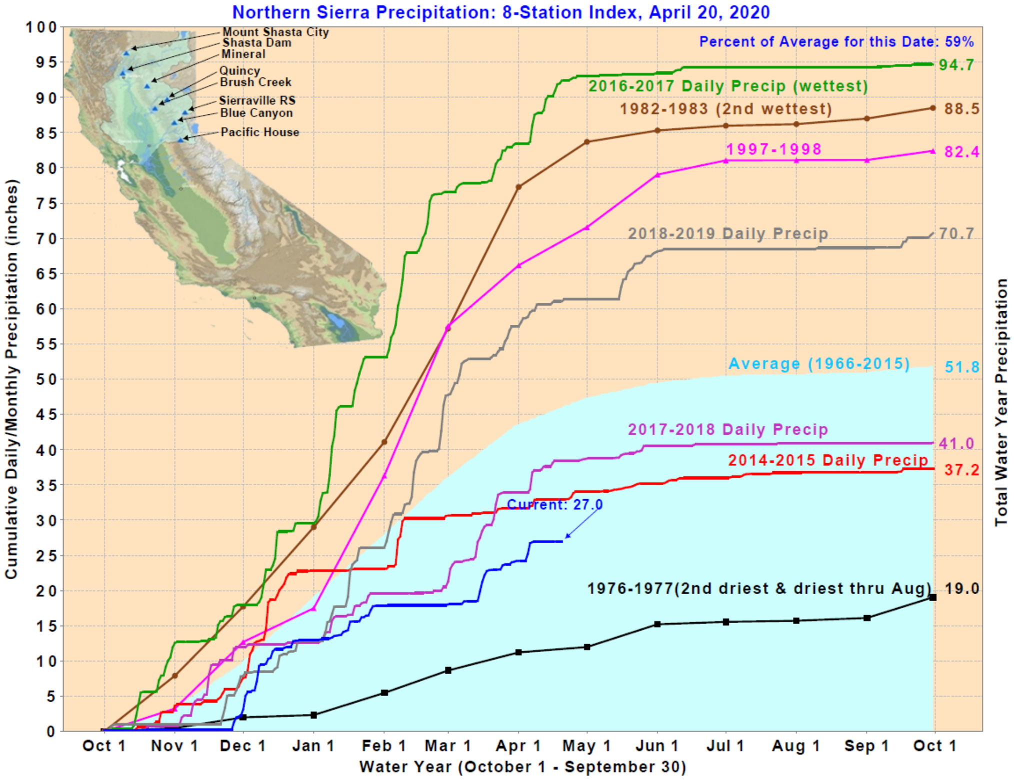
Figure 12

Major Reservoir Storage Levels Peaked at 101% of Average.



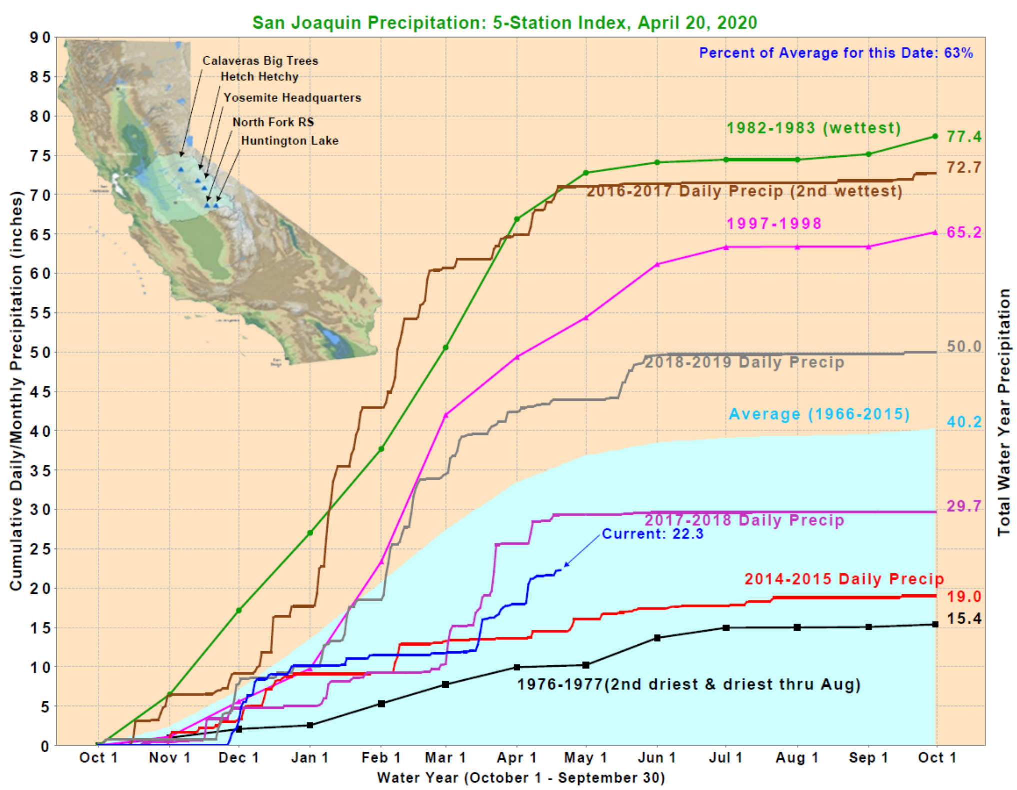
Source: California Department of Water Resources

Figure 13



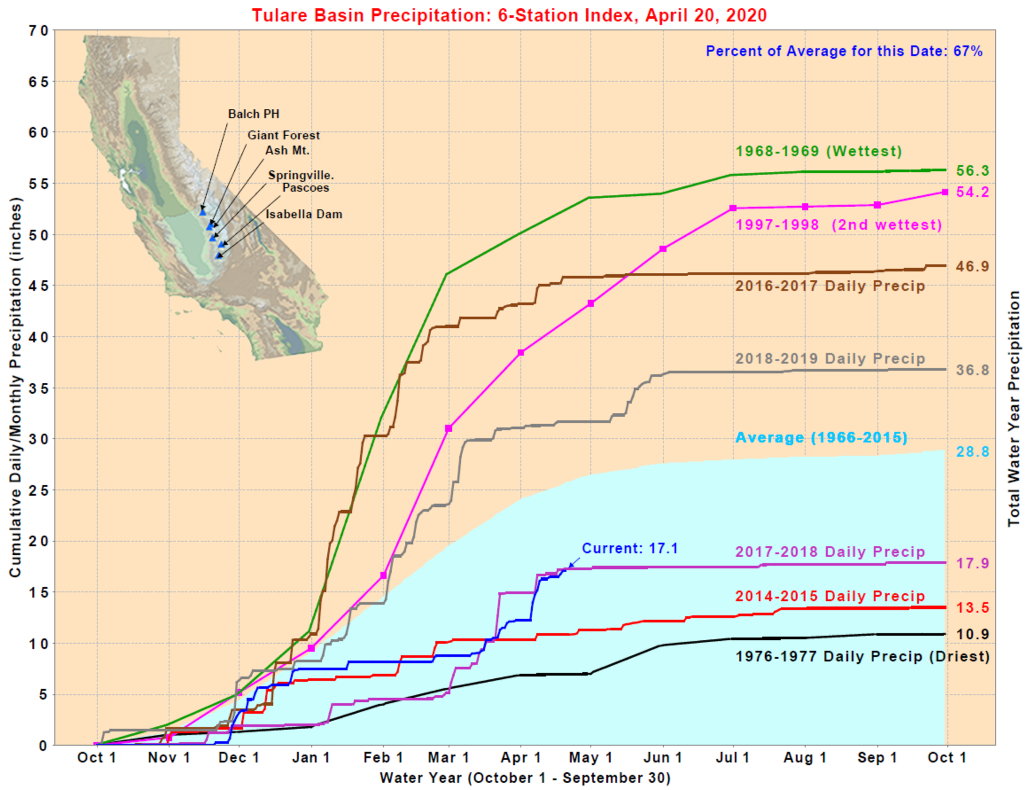
Source: California Department of Water Resources

Figure 14



Source: California Department of Water Resources

Figure 15



Source: California Department of Water Resources

System Capacity

The CAISO projects summer 2020 system capacity levels of 48,012 MW in June, 48,555 MW in July, 46,903 MW in August, and 44,543 MW in September using the final net qualifying capacity (NQC) list that was used for the California Public Utilities Commission's (CPUC) and CAISO's resource adequacy program for compliance year 2020, and is posted on the CAISO website.[13]. The decline of available capacity from July to September stems from the diminishing effective load carrying capability of solar and wind generation in the calculation of NQC for wind and solar resources, and the wane of hydro generation from June through September. The CAISO Master Control Area Generating Capability List, posted on the CAISO website[14] provides access to the information in the CAISO Master File database.

Each year, monthly qualifying capacity (QC) values are developed for generators eligible to participate in the CPUC's Resource Adequacy (RA) program. The CAISO uses the QC values to develop the NQC for each eligible generator and publishes the NQC list. The NQC values for each resource describes the amount of generation that has been deemed deliverable and can be utilized to meet RA requirements. The NQC value for dispatchable

[13] Final Net Qualifying Capacity Report for Compliance Year 2020:
http://www.caiso.com/planning/Pages/ReliabilityRequirements/Default.aspx
[14] Master Control Area Generating Capability List:
http://www.caiso.com/planning/Pages/GeneratorInterconnection/Default.aspx (under Atlas Reference)

resources depend on its demonstrated capacity and deliverability — the ability of the grid to deliver the generation to load centers. The CAISO determines the NQC by testing and verifying as outlined in the CAISO tariff and the applicable business practice manual. The NQC values for solar have been declining because the CAISO system peak has shifted to later in the day when solar production is diminished to levels at or near zero.

The largest generation resource fuel type is natural gas, accounting for 60.2 percent of CAISO summer maximum on-peak available capacity, and the second largest generation type is hydro, which accounts for 16.3 percent. Solar, based on effectively load carrying capability, accounts for 9.0 percent. Wind, geothermal, and biofuel units make up 6.7 percent. Nuclear generation is 4.7 percent, demand response is 1.9 percent and oil generation provides 0.3 percent. The overall resource percentages by fuel type is shown in a chart in *Appendix C: 2020 CAISO Summer Maximum On-Peak Available Capacity by Fuel Type.*

System Capacity Additions

Table 8 shows the total new installed generation capacity of 3,423 MW that have interconnected to the CAISO balancing authority or are expected to from 6/1/2019 to 6/1/2020.

Table 8

Generation Additions (MW)

From 6/1/2019 to 6/1/2020

Fuel Type	PG&E	SCE	VEA	SDG&E	ISO
Battery		5		251	256
Biofuel	6	3			9
Gas		1,478			1,478
Hydro	17				17
Solar	390	477	100	400	1,367
Wind	9	287			296
Total	422	2,250	100	651	3,423

System Capacity Retirements and Unavailability

Forced outages are generated for individual units on a random basis by PLEXOS using each unit's historical forced outage rate with a uniform distribution function based on 2015 through 2017 individual historical summer forced outages. Planned outages are sourced from the CAISO outage management system.

Table 9 shows the resources that have retired or mothballed since June 1, 2019. To date, there are no other known additional retirements that will take place by June 1, 2020. Of the

1,991 MW of generation that have retired since June 1, 2019, 1,926 MW are dispatchable and 65 MW are non-dispatchable. While the net of additions and retirements is an increase of 1,432 MW, the effective load carrying capability of these resources results in only a net increase of 38 MW during the month of September, which is the difference between the effective load carrying capability of the generation additions of 1,990 MW and retirements of 1,952 MW in September.

Table 9

Recently Retired or Mothballed Generation (6/1/2019 to 6/1/2020)

RESOURCE ID	Current Status	MW	Actual offline Date	Fuel Type	PTO	Dispatchable
SAUGUS_2_TOLAND	Retired	2	8/31/2019	BioGas	SCE	N
CHINO_6_SMPPAP	Retired	23	9/6/2019	GAS	SCE	Y
REDOND_7_UNIT 7	Retired	493	10/1/2019	GAS	SCE	Y
KRAMER_1_KJ5SR5	Retired	13	11/1/2019	SOLR	SCE	N
KRAMER_1_SEGSR3	Retired	13	11/1/2019	SOLR	SCE	N
KRAMER_1_SEGSR4	Retired	13	11/1/2019	SOLR	SCE	N
GOLETA_6_GAVOTA	Retired	10	11/2/2019	GAS	SCE	N
VALLEY_5_RTS044	Retired	4	11/30/2019	SOLR	SCE	N
OTAY_6_LNDFL5	Retired	2	12/13/2019	BioGas	SDGE	N
OTAY_6_LNDFL6	Retired	2	12/13/2019	BioGas	SDGE	N
OTAY_6_UNITB1	Retired	2	12/13/2019	BioGas	SDGE	N
DINUBA_6_UNIT	Mothballed	4	12/31/2019	Biomass	PG&E	N
INLDEM_5_UNIT 1	Retired	340	1/15/2020	GAS	SCE	Y
ALAMIT_7_UNIT 1	Retired	175	1/31/2020	GAS	SCE	Y
ALAMIT_7_UNIT 2	Retired	175	1/31/2020	GAS	SCE	Y
ALAMIT_7_UNIT 6	Retired	495	1/31/2020	GAS	SCE	Y
HNTGBH_7_UNIT 1	Retired	226	1/31/2020	GAS	SCE	Y
Non-Dispatchable		65				
Dispatchable		1,926				
ISO		1,991				

Unit Commitment

The PLEXOS production simulation applies unit commitment constraints for generator startups and shutdowns, using the following criteria. While the generator is starting up, it cannot provide ancillary or load following services while ramping from initial synchronization to its minimum allowed operating capacity. Similarly, when a generator is in the process of shutting down it cannot provide ancillary or load following services once it has ramped down passed its minimum capacity threshold. Once a generator is committed, it must remain in operation for its minimum run time before it can be shut down. After a generator has been shut down, it is not available for commitment again until it has been off for its specified minimum down time.

Once a generator is operating within its operating range (between its minimum and maximum capacity) it must meet the criteria set out below.

If a generator is ramping up:

- Regulation up, spinning, and non-spinning provided by a generator cannot exceed its 10-minute ramping up capability and unused capacity;
- Energy, regulation up, spinning, and non-spinning provided by a generator cannot exceed its 60-minute ramping capability and its available unused capacity.

During ramping down:

- The difference between a generator's minimum capacity and its current operating point determine the amount of regulation-down and load following-down that can be provided by a generator.

Therefore, the model sets 60 minutes ramping time for energy and 10 minutes for ancillary services in each hour's simulation.[15] Each dispatchable generator can run at its maximum ramp rate between its minimum and maximum capacity.

Curtailable Demand and Demand Response

Curtailable Demand includes demand response, pumping load, and aggregated participating load that can provide non-spinning reserve or demand reduction. Curtailable demand reduces end-user loads in response to high prices, financial incentives, environmental conditions or reliability issues. It can play an important role to offset the need for more generation and provide grid operators with additional flexibility in operating the system during periods of limited supply.

Demand response programs can be modeled as supply side resources that have triggering conditions in the stochastic simulation model. They include base interruptible programs, aggregator managed portfolios, capacity bidding programs, demand bidding programs, smart AC, summer discount plans, and demand response contracts.

Whenever the model depletes all available resources before meeting the load and ancillary service requirements the model will utilize demand response programs. The maximum available Reliability Demand Response Resource and Proxy Demand Resource in the CAISO market for 2020 is 1,339 MW.

[15] The maximum ancillary service (regulation or spinning) a generator can provide (the maximum ramp up rate × 10 minutes) is calculated by PLEXOS on an hourly basis.

The Flex Alert program is a voluntary energy conservation program that alerts and advises consumers about how and when to conserve energy. The Flex Alert program continues to be a vital tool for the CAISO during periods of high peak demand or other stressed grid conditions to maintain system reliability. The alerts also serve as a signal that both non-event and event-based demand response are needed.

Interchange

The model simulates 35 WECC zones and 91 WECC interchange paths between zones, as shown in *Figure 16*. The zonal interchange path limits were set based on the WECC Path Rating Catalog. Transmission limits within the zones were not modeled and the model cannot provide results related to local capacity requirements. The transfer capabilities between any two adjacent zones reflect the maximum simultaneous transfer capabilities. In addition, a total CAISO maximum net import limit was set based on historical net import patterns. Path 15 and Southern California Import Transmission (SCIT) nomogram constraint were enforced in the model.

Figure 16

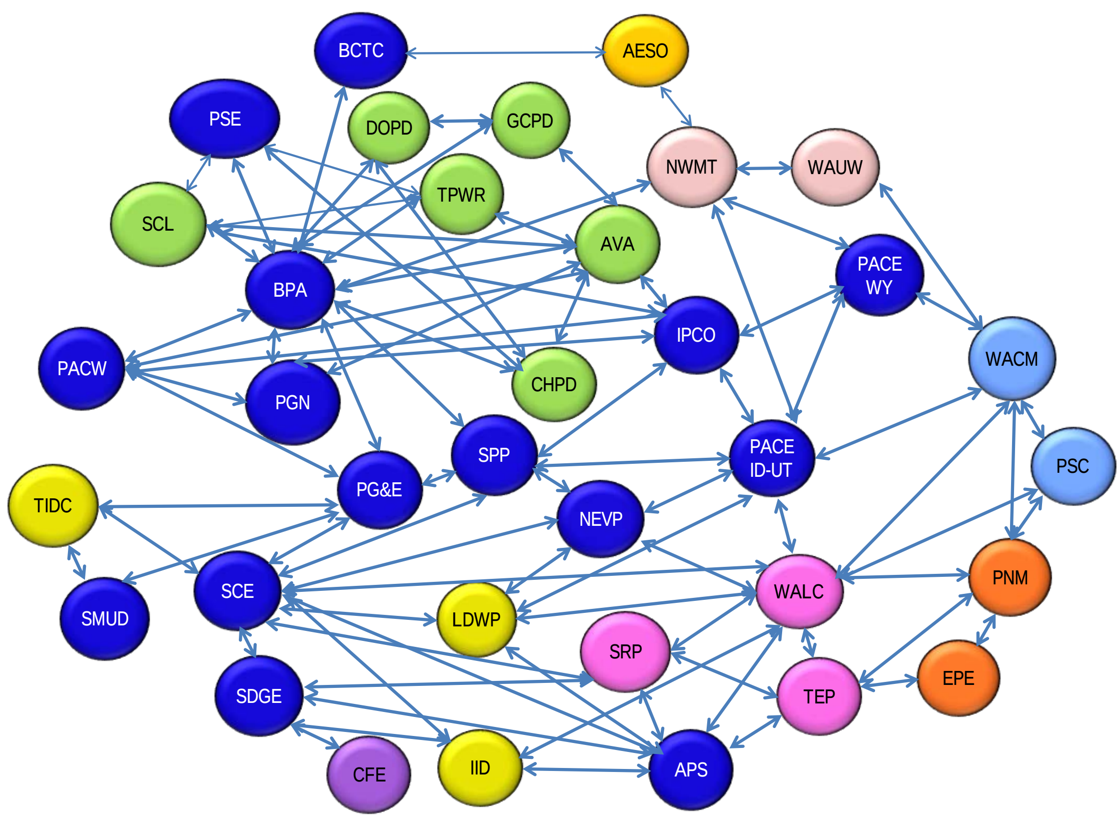


Figure 16: Simulation covers 35 WECC zones and 91 paths.

Net Import Constraints

When seasonal high temperature increase electric energy consumption in California, neighboring BAs' electric energy consumption are often high as well. Under these conditions, imports from neighboring BAs will frequently be reduced when the CAISO's demand ramps up to its peak. In order to reflect this system operation situation in the CAISO's production simulation model, a net import nomogram was developed based on historical EMS net import data from 2017 to 2019. *Figure 17* shows the net imports during the daily peak hour when demand is at or above 41,000 MW[16] for all summer months during 2017 – 2019. Analyses of the monthly trends of net imports demonstrate a declining nature of net imports as demand increases. *Figure 17* shows the net import nomograms for the base case and sensitivity case during the peak hours of hour-ending 16 – 21 to cap the level of net imports allowed by the model. The upper dashed line represents the base case nomogram while the lower dashed line defines the sensitivity case nomogram. During non-peak hours the net imports are capped at 11,666 MW, the highest net import experienced during all hours of 2019. The charts in Appendix B provide additional information on net imports at time of daily peak demand.

- Off peak net imports (HE 1 - 15, 22 - 24): capped at 11,666 MW (the maximum net imports during 2019)
- On peak nomograms (HE 16 - 21):
  - Base case nomogram: Net imports capped at 11,666 MW when CAISO peak is 41,000 MW, declining to 9,500 MW when CAISO peak is 50,000 MW
  - Sensitivity case nomogram: Imports capped at 9,426 MW when CAISO peak is 41,000 MW and 8,115 MW when CAISO peak is 50,000 MW

[16] 41,000 MW is 90 percent of the forecast of the CAISO 2020 1-in-2 peak demand of 45,907 MW.

Figure 17

2017 – 2019 summer net imports at time of daily peaks above 41,000 MW and

On-peak net import nomograms for the base case and sensitivity case

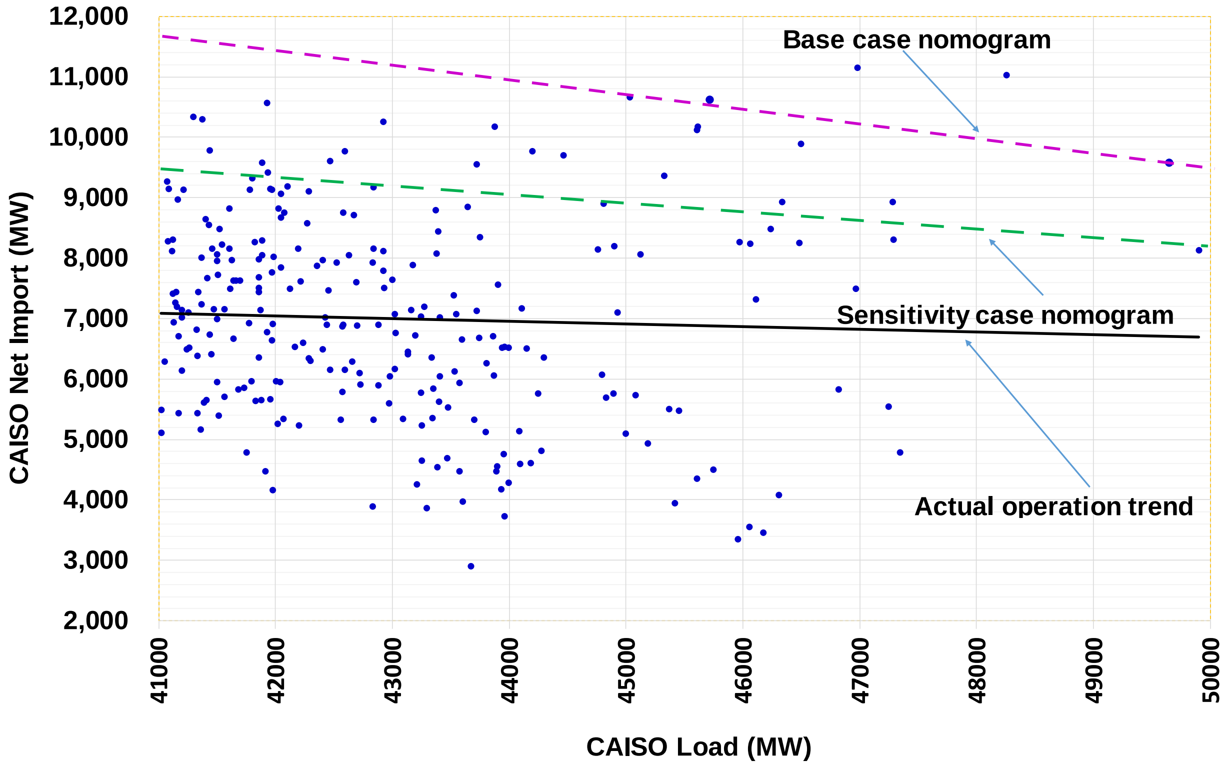


Figure 17 shows CAISO net imports at time of daily peaks above 41,000 MW vs. CAISO load from 2017 to 2019.

Stochastic Simulation Approach

To evaluate resource adequacy and to understand how the system will respond under a broad range of operating conditions the modeling methodology uses all active market participant capacities available within the CAISO balancing authority regardless of contractual arrangements. While some resources may not receive contracts under the resource adequacy program, and may possibly contract with entities outside the CAISO for scheduled short-term exports, these resources are still considered available to the CAISO for the purposes of this assessment. Resources not procured for the resource adequacy program do not have must offer obligation to the CAISO Day Ahead and Real Time Market. The CAISO may be able to utilize these non-RA resources, if physically available, via the backstop Capacity Procurement Mechanism.

Conventional generation units such as gas and nuclear are modeled as individual dispatchable units while non-dispatchable resources, such as qualifying facilities (QFs), biofuel, geothermal, solar and wind, are modeled using fixed hourly generation profiles based on aggregated historical hourly generation profiles, which are adjusted based on the projected capacity additions and retirements.

In recent years, significant amounts of new renewable generation, especially solar, have reached commercial operation to meet the 60 percent requirement by 2030. To successfully meet the state's RPS goals, increasing amounts of flexible and fast responding resources must be available to integrate the growing amounts of variable resources. These increasing amounts of variable resources integrated with the CAISO grid pose unique challenges for CAISO operations and for the analytical tools used by the CAISO to assess near-term reliability.

As new renewable resources come on the system, the CAISO reliability focus has evolved from meeting the gross peak demand to meeting both net peak demand and flexible capacity requirements. The gross peak usually occurs at the hour ending 16:00 to 18:00 while net peak occurs in the hour ending 19:00 to 21:00 timeframe where solar generation is close to zero. The CAISO's evolving net load profile – gross load minus grid-interconnected solar and wind generation – has become known as the duck curve. The growing amount of photovoltaic solar generation that is interconnected to the CAISO grid continues to change the CAISO's net load profile and creates more challenges and uncertainty for CAISO operations.

Photovoltaic solar generation located behind the customer meter is an additional impact, affecting the gross load and further decreasing the net load the CAISO serves. The result is a constantly increasing ramping requirement, significantly more than what has been required from the generation fleet in the past, both in the upward and downward directions. Furthermore, solar generation does not provide significant power at the hours ending 19:00 to 21:00, which leads to reliance on gas and other non-solar generation after sunset. The continuing decline in dispatchable generation in the CAISO as dispatchable units retire is beginning to challenge the CAISO's system ability to meet its net peak demand after sunset and flexible capacity requirements.

To assess the changing resource needs from the increasing number of variable resources and declining fleet of dispatchable resources, the CAISO started to use the PLEXOS stochastic model in the development of the 2016 Summer Assessment. To mimic the real-time market short-term unit commitment function during the window extending 4.5 hours prior to real-time and the real-time unit dispatch function 1 hour 45 minutes prior to real-time for the intra-hour requirement to cover intra-hour uncertainty and variability, the CAISO calculates the intra-hour regulation and load following requirements and convert these intra-hour requirements to hourly requirements using a probabilistic Monte Carlo simulation program developed by Pacific Northwest National Laboratory and inputs them as system requirements in the PLEXOS stochastic model.

The model simulates 35 WECC zones with 91 WECC interchange paths. It uses a mixed-integer linear programing to determine the optimal generation dispatch. The model runs chronologically to dispatch capacity, ancillary services and load following to seek the least cost co-optimized solution to meet the system demand and flexibility requirement simultaneously. Operational constraints include forced and planned outage rates, unit commitment parameters, minimum unit up and down times, unit heat rates, and ramp rates for each generator in the CAISO.

The model runs 2,000 scenarios on an hourly interval chronologically. Each scenario has a 2,928-hour profile from June 1 to September 30[17]. The optimization time horizon was set

[17] The study period of June 1 through September 30 in each scenario represents 2,928 hours (24 hours × 122 days).

as 24 hours. The end status of one optimization is used as the initial status of the next optimization. For hours in which supply is sufficient, the model calculates the Unloaded Capacity Margin (UCM) and determines the Minimum Unloaded Capacity Margin (MUCM) for each 2,928-hour profile scenario based on load and available resources including curtailable demand, imports, and exports. Each of the 2,000 scenarios produce one MUCM value over the 2,928 hours from June 1 through September 30. If supply is not sufficient, the model reports the unserved hours and unserved energy where demand exceeds supply.

$$\text{UCM}(t) = \frac{Available\ Resources(t) + Import(t) - Export(t)}{Load(t)^{18}} - 1$$

$$\text{MUCM} = \text{Min}\left(UCM\ (1), \ldots, UCM\ (t), \ldots, UCM(2{,}928)\right)$$

The 2,000 unique scenarios are randomly generated – each representing a combination of forecasted 2,928 hourly load profiles and renewable generation levels based on historic annual weather patterns – using a two-step process. The first step is to build three pools of load, wind and solar profiles. In this step, twenty five years of historical daily weather profiles were used to forecast 175 daily and annual peak profiles and annual energy loads, which are adjusted to actual historical hourly load profiles to create 175 hourly load profiles. These 175 hourly load profiles were combined with 11 hourly wind and 6 hourly solar profiles to generate 11,550 scenarios[19], among which 2,000 scenarios were randomly selected for the stochastic modeling process, illustrated in *Figure 18*.

Figure 18

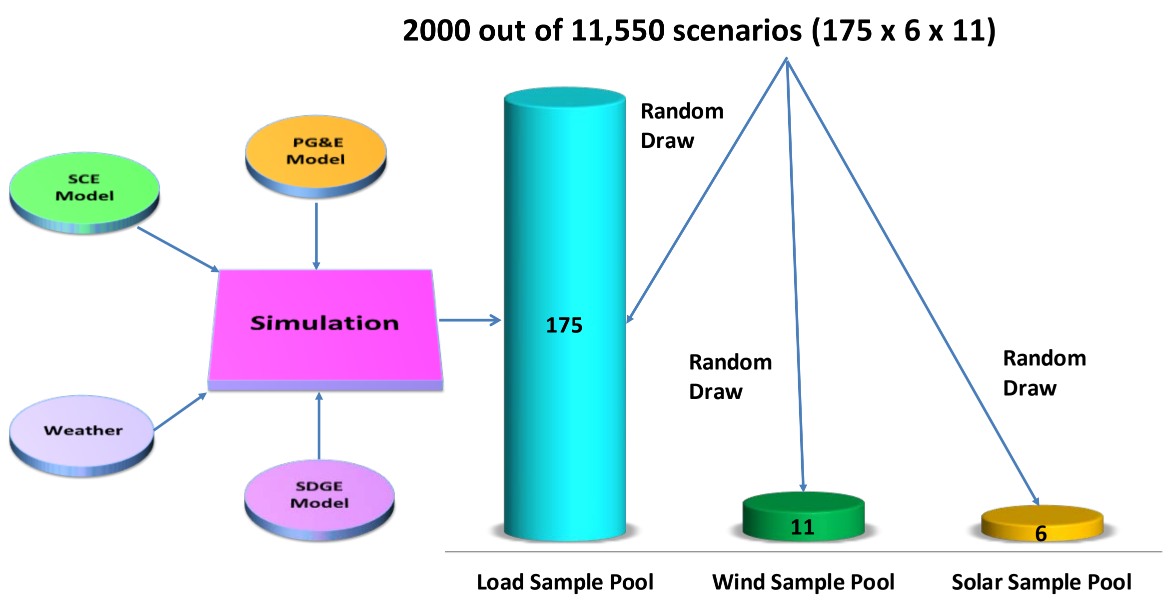


Figure 17: 2,000 scenarios of load, wind and solar are randomly selected from 11,550 scenarios.

[18] Gross or total ISO load as opposed to net load or consumption which includes load served by behind the meter resources.
[19] 175 load profiles ✕ 6 solar profiles ✕ 11 wind profiles equals 11,550 scenarios.

Simulation Results

The 2020 Assessment performed base case and sensitivity case studies to assess the resource adequacy based on historical net import levels and under a more conservative net import assumption. The simulation results include the system capacity adequacy, ancillary service and flexible capacity adequacy

Base Case Study

System Capacity Adequacy

The model produces an UCM for each hour modeled. Taking into account the unloaded capacity margin for all of 2,928 hours within each of the 2,000 summer scenarios, the UCM ranges from a high of 95 percent, down to a low of zero, with a very small number of scenarios at both extremes. The median value of all unloaded capacity margin values is 41.3 percent *(Figure 19)*.

Figure 19

CAISO Unloaded Capacity Margins

Base case (June through September 2020)

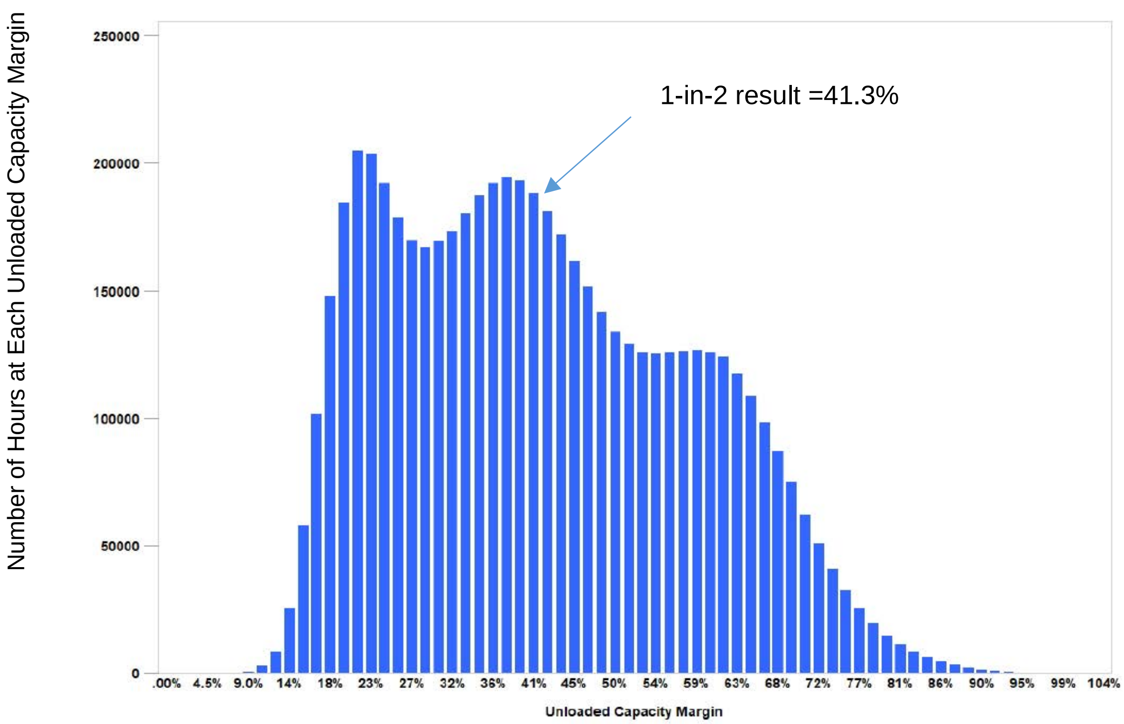


Figure 19 shows the distribution of the UCMs over all 2,928 summer operating hours from all 2,000 scenarios.

The CAISO has developed a series of emergency stages[20] to communicate periods of low operating reserve conditions. A stage 1 emergency is usually issued when the CAISO anticipates or forecasts the system will not be able to maintain the required contingency reserve level, and there are insufficient additional resources (in or out of market) to maintain or recover the contingency reserves required. The CAISO will usually issue a stage 1 emergency when the operating reserve is seesawing above, then below the contingency reserve requirement and load continues to increase or energy supplies continues to decline. A stage 2 is an indication that all the steps available under a stage 1 do not resolve or recover the reserve deficiency and the system is using non-spin reserves to meet load and spin requirements, thereby making non-spin and contingency reserves deficient. A stage 3 is an indication the system cannot maintain the spinning reserve requirement, generally 3 percent of load, and firm load interruption is imminent or in progress.

Table 10 and Figure 20 show base case results where the CAISO system has 3.7 percent probability of operating at stage 2, based on 74 scenarios that produced at least one hour of potential stage 2 emergency conditions, 1.1 percent probability at stage 3, based on 21 scenarios that produced an hour or more of potential stage 3 emergency conditions, and 0.2 percent probability of unserved energy with 3 scenarios showing unserved energy. Demand response programs would have been utilized if needed to maintain a 6 percent operating reserve margin and would be fully utilized in cases where the operating reserve margin is below 6 percent. Under this severe operating condition, the CAISO will issue a notice of potential load interruptions to utilities – whether actual interruptions would occur depends on the specific circumstances and potential for recovering reserves.

Table 10

Base case probability of system capacity shortfall

Base Case	Shortfall Probability	Number of Shortfall Scenarios
Stage 2	3.7%	74
Stage 3	1.1%	21
Unserved energy	0.2%	3

[20] See System Alerts, Warnings and Emergencies Fact Sheet on CAISO webpage: http://www.caiso.com/informed/Pages/Notifications/NoticeLog.aspx

Figure 20

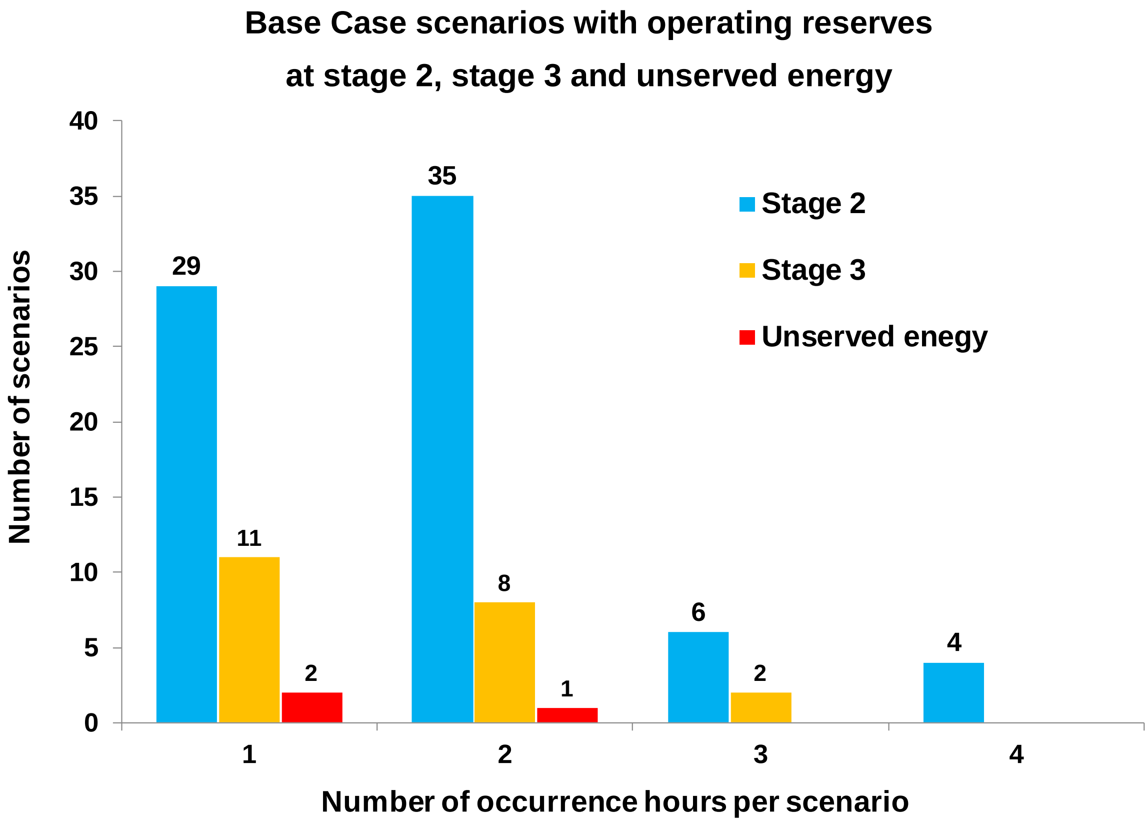


Figure 20 shows scenario occurrences with operating reserves at stage 2, stage 3 and unserved energy.

To further assess resource adequacy for the summer period, the Minimum Unloaded Capacity Margin value, equal to the lowest unload capacity margin in all 2,928 hours in each scenario, is determined for each of the 2,000 scenarios. The MUCM values from the base case range from a high of 17 percent down to the lowest result of zero (*Figure 21*). The zero result represents the most extreme hourly supply and demand condition within the 2,000 scenarios considered where in addition to the UCM at zero, there is an amount of energy that is not served (see *Figure 23*). The median value is 11.5 percent. Three out of 2,000 scenarios show unserved energy.

Figure 21

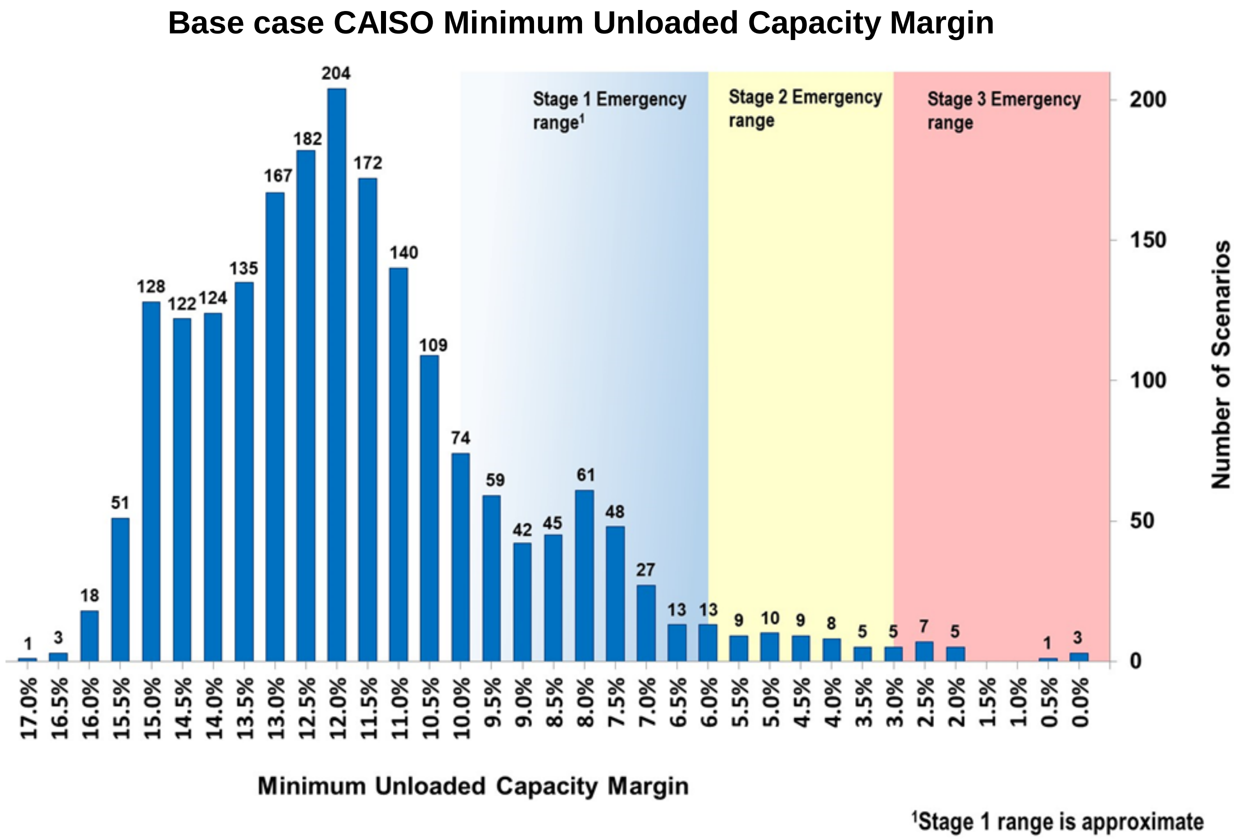


Figure 21 shows forecast distribution of summer MUCM for the CAISO.

Figure 22 shows the base case distribution of the hour that each MUCM occurred in comparison to the hours of solar generation during the 2020 summer peak day. The MUCM has the highest level of occurrences at hour ending 20:00, when solar generation has reached zero. *Figure 22* demonstrates that the timing of 91 percent of the MUCM values fall in periods of low or zero solar generation.

Figure 22

Base case Minimum Unloaded Capacity Margin occurrences and solar generation profile

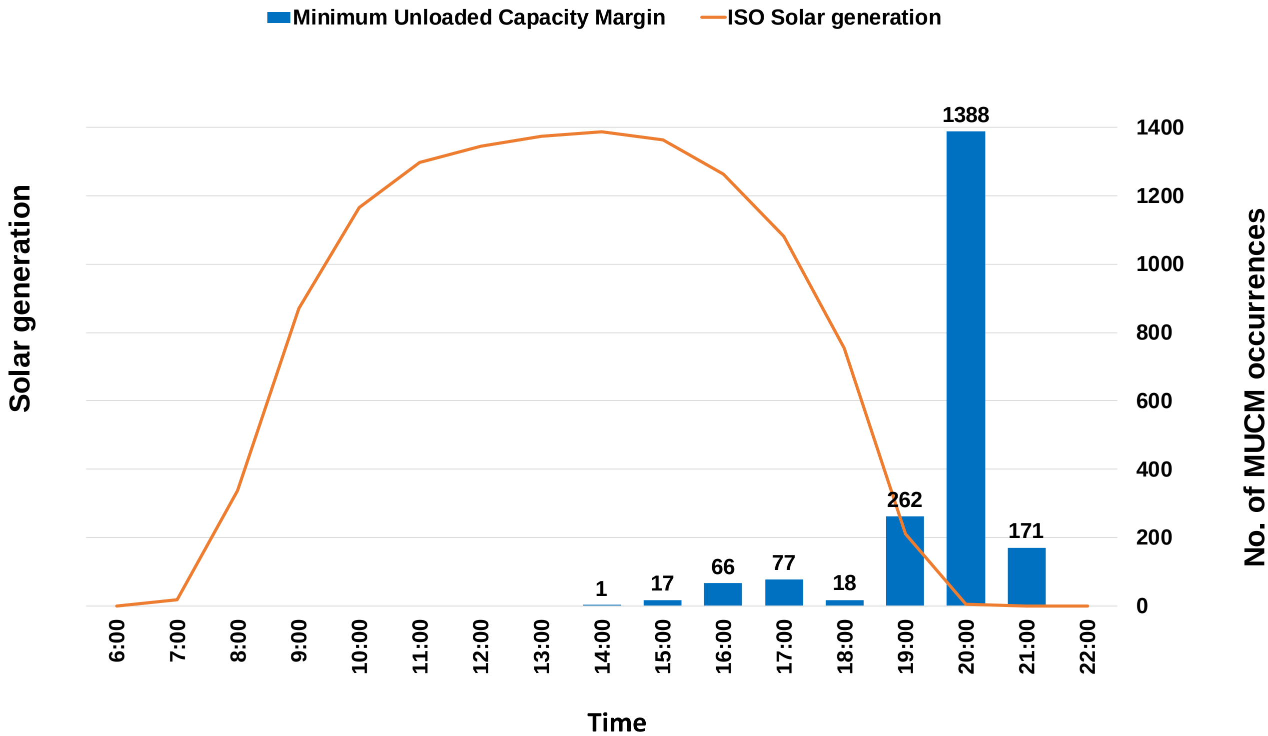


Figure 22 shows the MUCM occurrence hour with the solar generation profile.

Figure 23 shows the base case occurrences of unserved energy and the corresponding CAISO load levels. Three scenarios have unserved energies: one scenario has two hours of occurrences, each of the other two scenarios has one hour of occurrence. All hours of unserved energy occur in August. The CAISO loads when unserved energy occurs range from 48,900 MW to 50,232 MW, which are above the 1-in-10 peak demand forecast of 48,457 MW.

Figure 23

CAISO loads versus scenarios where unserved energy occurs

Base case

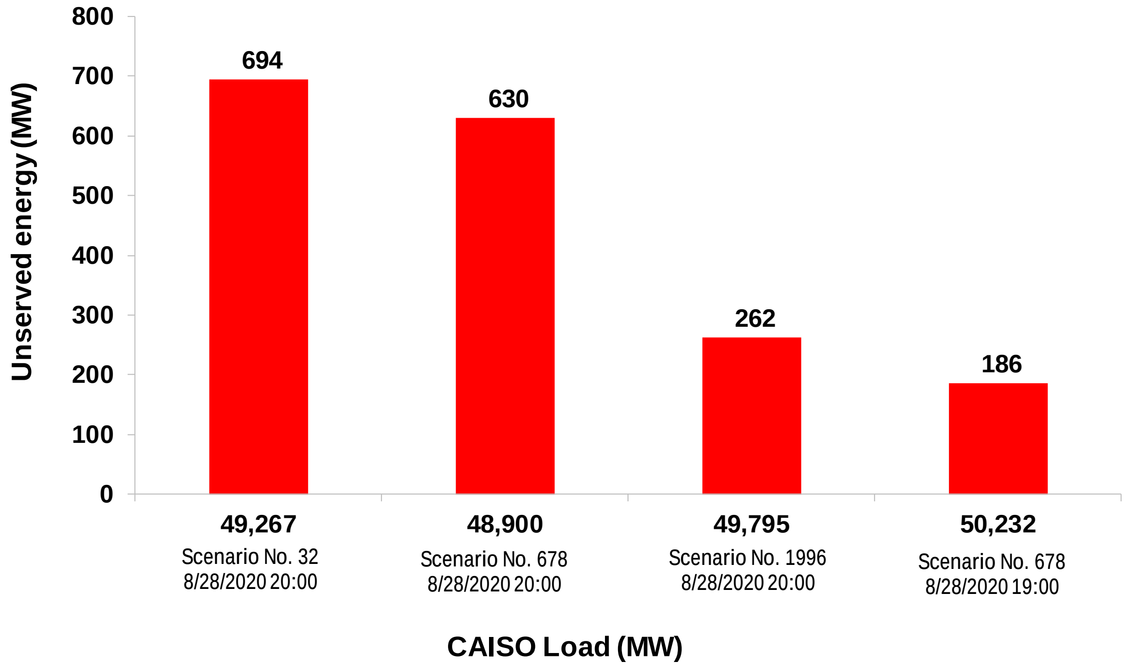


Figure 23 shows CAISO unserved energy vs CAISO loads.

Ancillary Service and Flexible Capacity Adequacy

In addition, to assess system capacity adequacy, the PLEXOS model assesses the ancillary service and flexible capacity adequacy in the CAISO market. *Table 11* and *Figure 24* show the base case results where the CAISO system has a 10.8 percent probability of a load following up shortage, based on 215 scenarios that produced an hour or more of the shortage, a 2.5 percent probability of a spinning shortage, based on 50 scenarios that produced an hour or more of the shortage, and a 0.3 percent probability of a regulation up shortage based on 6 scenarios that produced one hour or more of a potential shortage.

The model's load following shortfall result is an indicator of tightness of dispatch capability. In actual real time operations a load following shortfall occurs and impacts ability to meet demand only when actual intra hour variability and uncertainty needs materialize. A load following shortfall does not have an operational impact when potential intra-hour uncertain and variability do not materialize. Therefore, load following shortfalls observed in hourly production simulations may only have a minimal operational impact. However, if a load following shortfall were to occur when actual intra hour variability and uncertainty needs do materialize, prices may rise and in some cases it may be necessary to rely on regulation or operating reserve to maintain balance between supply and demand. Otherwise, the CAISO system may face operational challenges maintaining frequency within required limits. The scarcity of ancillary service and flexible capacity could cause NERC Control Performance Standard 1 (CPS1) violations, frequency deviation, increased area control error, and high scarcity prices.

Table 11

Probability of ancillary service and flexible capacity shortfall

Base case

Base Case	Shortfall Probability	Number of Shortfall Scenarios
Load following up	10.8%	215
Spinning	2.5%	50
Regulation up	0.3%	6

Figure 24

Scenarios with regulation up, spinning and load following up shortage

Base case

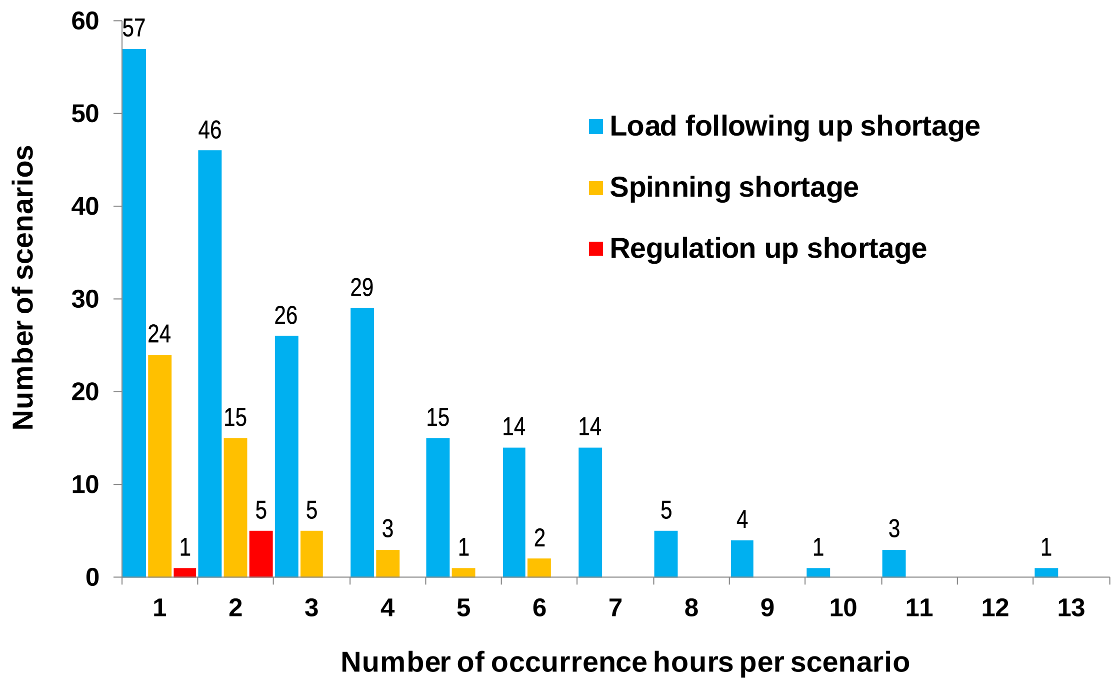


Figure 24 shows scenario occurrences with regulation up, spinning and load following up shortage.

Sensitivity Case Study

System Capacity Adequacy

In order to understand the vulnerability of the CAISO system to potential limitations of net imports, a sensitivity case was modeled using the more conservative net import nomogram in *Figure 17*. *Table 12* and *Figure 25* show the sensitivity case results where the CAISO system has an 10.6 percent probability of operating at stage 2, based on 211 scenarios that produced at least one hour of stage 2 emergency conditions, a 4.7 percent probability at stage 3, based on 94 scenarios that produced an hour or more of stage 3 emergency conditions, and a 1.6 percent probability with unserved energy, based on 31 scenarios showing at least one hour of unserved energy.

Table 12

Sensitivity case probability of system capacity shortfall

Sensitivity Case	Shortfall Probability	Number of Shortfall Scenarios
Stage 2	10.6%	211
Stage 3	4.7%	94
Unserved energy	1.6%	31

Figure 25

Scenarios with operating reserves at stage 2, stage 3 and unserved energy Sensitivity case

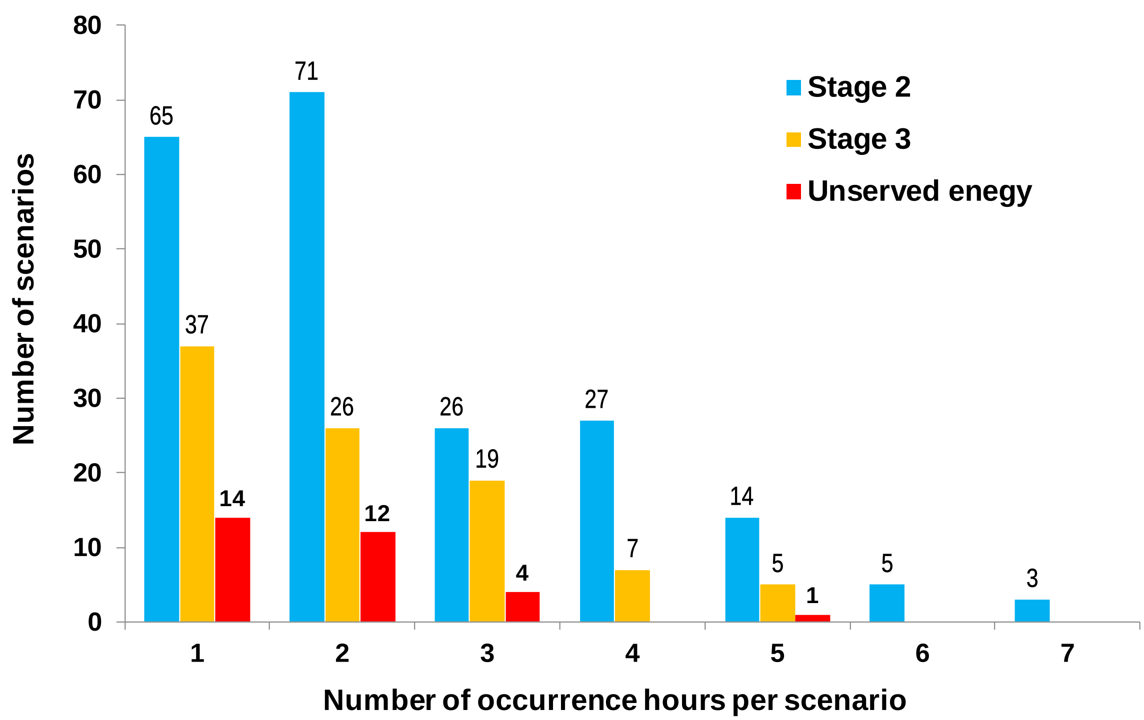


Figure 25 shows scenario occurrences with operating reserves at stage 2, stage 3 and unserved energy.

Figure 26 shows the sensitivity case distribution of MUCM values ranging from a high of 16.5 percent down to the lowest result of zero. The median value is 10.8 percent.

Figure 26

Sensitivity case CAISO Minimum Unloaded Capacity Margins

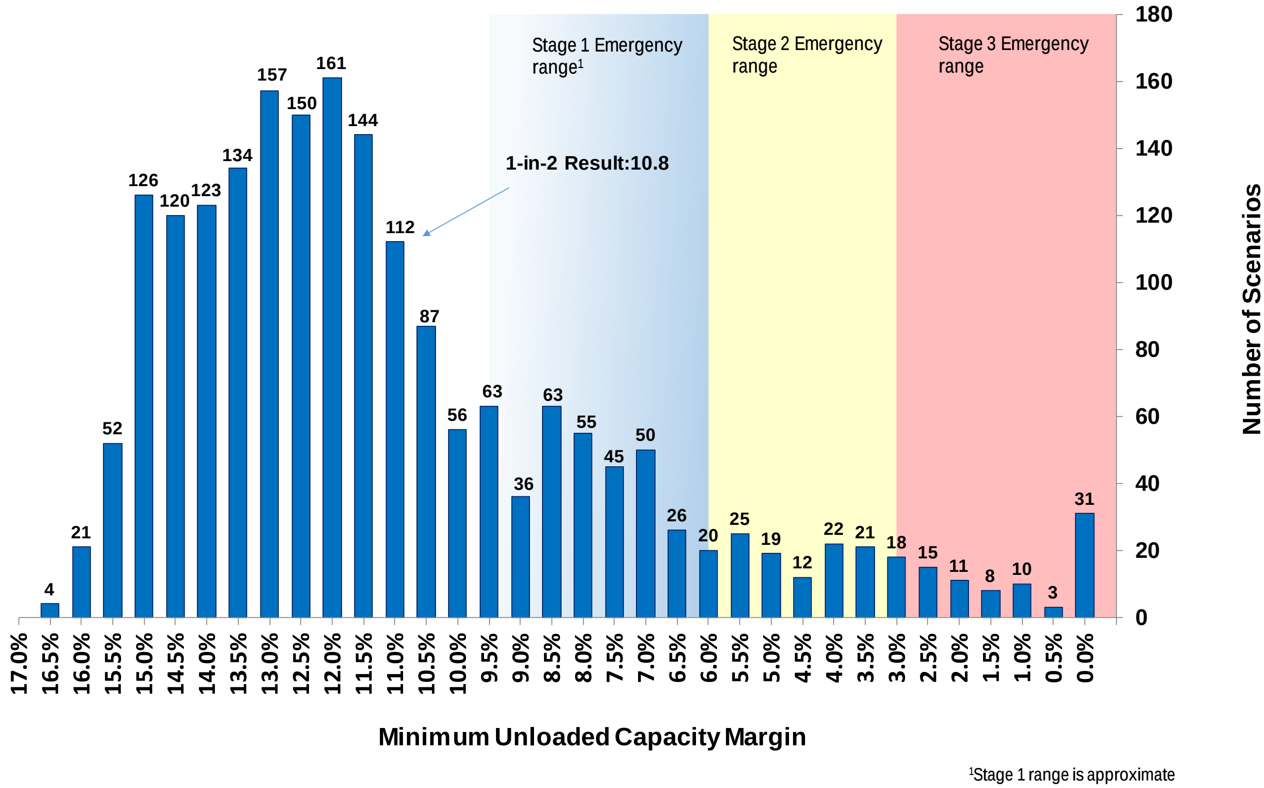


Figure 26 shows forecast distribution of summer MUCM for the CAISO.

Figure 27 shows the sensitivity case distribution of the hour that each MUCM occurred in comparison to the hours of solar generation during the 2020 summer peak day. The difference between results of the base and the sensitivity cases are relatively minor.

Figure 27

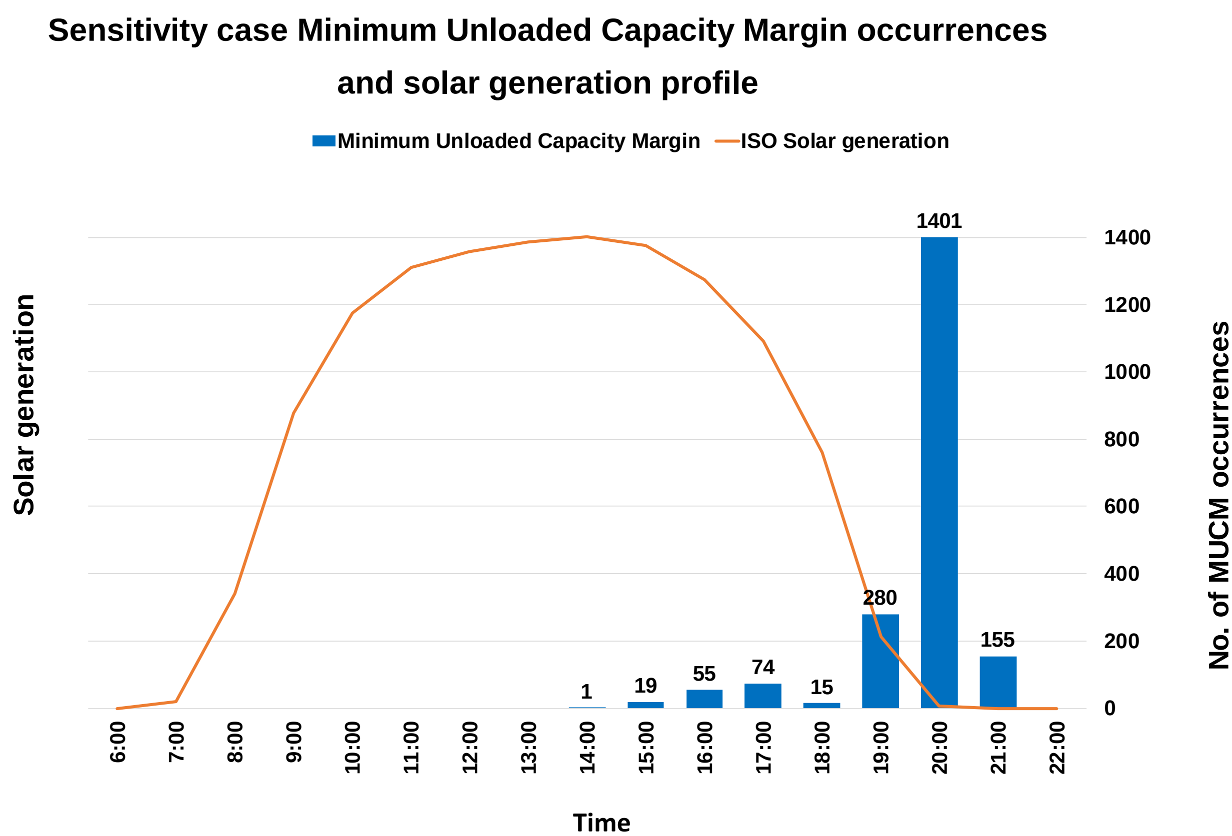


Figure 27 shows the MUCM occurrence hour with the solar generation profile.

Ancillary Service and Flexible Capacity Adequacy

Table 13 and Figure 28 shows the sensitivity case results where the CAISO system has a 25 percent probability of operating in a load following up shortage, based on 493 scenarios that produced at least one hour of shortage, a 9.1 percent probability of a spinning shortage, based on 181 scenarios that produced an hour or more of shortage, and a 2.5 percent probability of a regulation up shortage, based on 50 scenarios that produced an hour or more of shortage.

Table 13

Probability of ancillary service and flexible capacity shortfall

Sensitivity case

Sensitive Case	Shortfall Probability	Number of Shortfall Scenarios
Load following up	25%	493
Spinning	9.1%	181
Regulation up	2.5%	50

Figure 28

Ancillary service and load following up shortages

Sensitivity case

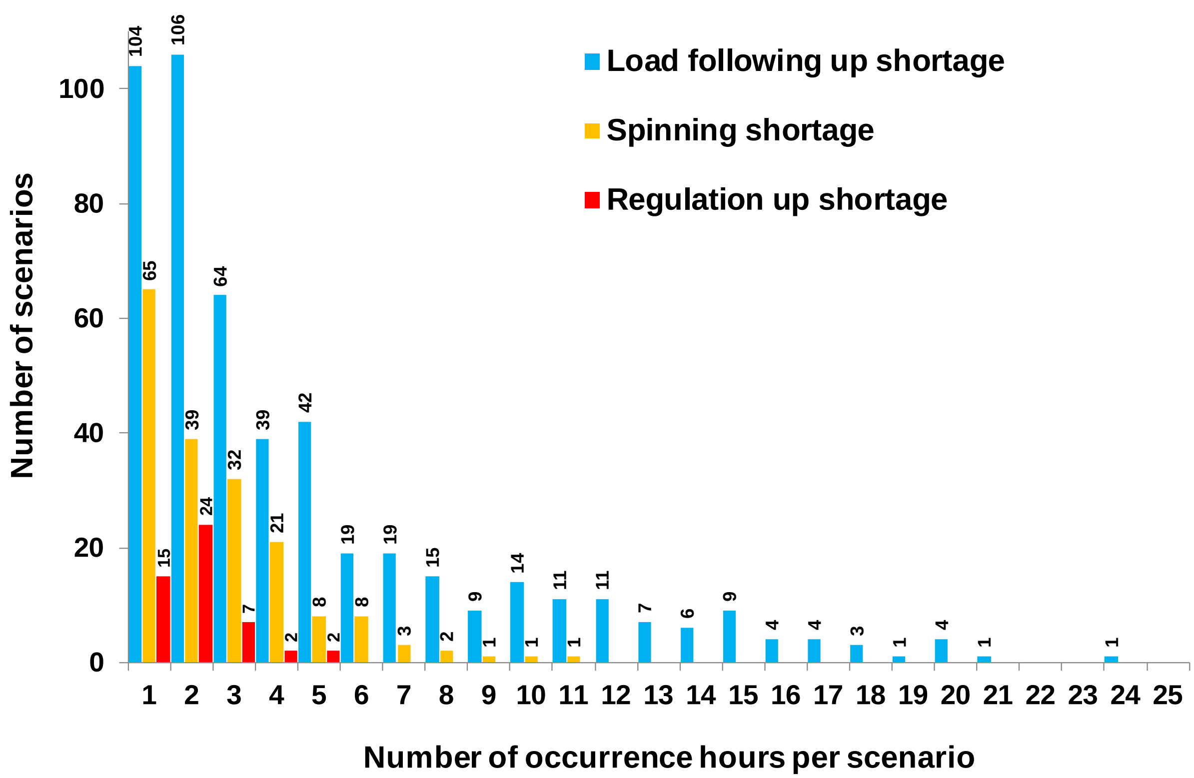


Figure 28 shows scenario occurrences with ancillary service and load following up shortages.

Table 14 compares the probability of CAISO system capacity shortfall between the base case and the sensitivity case, revealing the criticality of imports to the CAISO during system peak hours during high load conditions. If the CAISO is limited to the more conservative import levels of the sensitivity case, the probability of falling into stage 2 conditions is three times more likely, and falling into stage 3 conditions where firm load is shed is over four times more likely. The sensitivity case also produced eight times the number of scenarios with unserved energy results than the low level observed in the base scenario. The sensitivity study results reveal that 85 percent of the hours of unserved energy occurred from August 28 to September 28, further indicating that the CAISO will be at the greatest operational risk during late summer if low hydro availability occurs together with low net imports due to high peak demands in its neighboring balancing authority areas.

Table 14

Probability of CAISO system capacity shortfall

Base case compared to Sensitivity case

Result	Base Case	Sensitivity Case
Stage 2	**3.7%**	**10.6%**
Stage 3	**1.1%**	**4.7%**
Unserved energy	**0.2%**	**1.6%**

Impacts of the Aliso Canyon Gas Storage Operating Restrictions

Natural gas needs in Southern California are met by a combination of major gas pipelines, distribution gas infrastructure and gas storage facilities. Four major gas storage facilities are located in the Southern California Gas system, the largest of which is the Aliso Canyon facility located in Los Angeles County. Aliso Canyon and other gas storage facilities are used year-round to support the delivery of gas to core and non-core users. Among the non-core users are electric generators, which help meet electric demands throughout the region.

Following a significant natural gas leak in late 2015, the injection and withdrawal capabilities of the Aliso Canyon were severely restricted. These restrictions impacted the ability of pipeline operators to manage real-time natural gas supply and demand deviations, which in turn could have had impacts on the real-time flexibility of natural gas-fired electric generators in Southern California. This primarily impacted resources operated in the Southern California Gas Company (SoCalGas) and San Diego Gas and Electric (SDG&E) service areas, collectively referred to as the SoCalGas system.

Aliso Canyon directly supplies 17 gas-fired power plants with a combined total 9,800 MW of electric generation in the Los Angeles basin and indirectly impacts 48 plants with a combined total 20,120 MW of electric generation across Southern California. There are limitations in attempting to shift power supply from resources affected by Aliso Canyon to resources that are not affected because of certain factors, such as local generation requirements, transmission constraints and other resource availability issues.

To address the continued operating restrictions at Aliso Canyon, the CAISO and the California Public Utilities Commission (CPUC) have taken separate but complementary actions to manage the current situation while the state considers the long-term need and viability of the storage facility.

Starting in summer 2016, the CAISO received approval from the Federal Energy Regulatory Commission (FERC) to implement on a temporary basis three operational tools and market mechanisms to mitigate the electric system reliability risk posed by restricted operations at Aliso Canyon. The first was a maximum gas constraint tool to manage generator gas consumption in southern California within bounds established by SoCal Gas. The second was the ability for CAISO to manually override the competitive path assessment to determine if transmission constraints are uncompetitive. This action allows supply limitations to be reflected in the market power mitigation process. Lastly, the CAISO could suspend virtual bidding if the maximum gas constraint was causing market inefficiencies. On December 31, 2019, the CAISO received approval from the FERC to make permanent the three main operational tools and market mechanisms.[21] In addition, the CAISO worked closely with SoCalGas to develop enhanced coordination procedures which SoCalGas adjusted natural gas balancing rules to provide stronger incentives for natural gas customers, such as electric generators, to align their natural gas schedules and burns.

On April 15, 2020, CPUC staff published Summer 2020 Southern California Reliability Assessment,[22] which concluded that conditions had improved as compared to the same time last year. This is driven by more gas in storage at Aliso Canyon and SoCalGas' three other storage fields, the return to service of Line 235-2 which had been out of service since October 2017, and regulatory actions at the CPUC. Specifically, on July 23, 2019 the CPUC made revisions to the Aliso Canyon Withdrawal Protocol to remove its classification as "an asset of last resort" to provide SoCalGas with more flexibility to use Aliso Canyon to balance the system and ease energy price spikes.[23] The Summer 2020 Southern California Reliability Assessment also presented an analysis of a peak demand summer day under the base and worst-case gas balance scenarios. While findings show that non-Aliso withdrawals would be sufficient to meet demand under both scenarios at the daily level, hourly demand and gas deliveries on a peak day may still trigger a need for withdrawal at Aliso Canyon.[24]

Lastly, given the timing of Summer 2020 Southern California Reliability Assessment release, there was insufficient time and data to conduct an analysis on the impact of the stay-at-home orders to combat the COVID-19 pandemic. Early indications show unpredictable

[21] Federal Energy Regulatory Commission, Order Accepting Tariff Revisions, ER20-273-000, December 31, 2019.

[22] California Public Utilities Commission, Summer 2020 Southern California Reliability Assessment, April 15, 2020. Available at: https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/News_Room/NewsUpdates/2020/Summer2020-ReliabilityAssessment_Final.pdf In prior years, this had been a joint report between the staffs of the CPUC, CAISO, Los Angeles Department of Water and Power, and California Energy Commission.

[23] Aliso Canyon Withdrawal Protocol: https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/News_Room/NewsUpdates/2019/UpdatedWithdrawalProtocol_2019-07-23%20-%20v2.pdf

[24] Summer 2020 Southern California Reliability Assessment, pp. 14-15.

hourly gas usage and potential demand forecasting errors may result in an increased need to withdraw gas from storage.

Once Through Cooled Generation

On May 4, 2010, the State Water Resources Control Board (SWRCB) adopted a policy on the use of coastal and estuarine waters for power plant cooling (Policy). The Policy applies to 19 power plants, some of which have already retired, that together had the ability to withdraw over 15 billion gallons per day from the state's coastal and estuarine waters using a single-pass system, also known as once-through cooling (OTC). *Table 15* shows the power plants that are subject to the Policy. Of the OTC units' 17,277 MW of generating capability affected by the policy, 11,304 MW are in compliance. The remaining 3,733 MW of gas-fired generation will be required to repower, be retrofitted or retire by the end of 2023 with Diablo Canyon retiring later.

The Statewide Advisory Committee on Cooling Water Intake Structures (SACCWIS) recommended the State Water Board consider extending the OTC Policy compliance date for Alamitos Units 3, 4, and 5, Ormond Beach Units 1 and 2, and Huntington Beach Unit 2 for three years through December 31, 2023, and Redondo Beach Units 5, 6, and 8 for one year through December 31, 2021 to address local and system-wide grid reliability concerns. These system-wide grid reliability concerns come from the shifting daily peaks to later in the day when solar resources are not available to meet peak demand; the changes in the calculation of net qualifying capacity for wind and solar resources to be less than previously determined; an increase in reliance on the net imports over historical levels; and earlier-than-expected retirements of non-OTC resources. The necessity of additional power becomes imperative for summer peak during the hot days. The SACCWIS continues to assess the reliability impacts to the CAISO grid in the implementation of the OTC Policy.

On November 7, 2019, Decision (D.)19-11-016 was approved by commissioners of the CPUC, completing the IRP process for R.16-02-007. D.19-11-016 directs 3,300 MW of new procurement from load serving entities under the CPUC's jurisdiction to ensure system-wide electric reliability. The decision also recommends that the State Water Board consider revising the OTC Policy to extend the compliance dates for Alamitos Units 3, 4, and 5, Huntington Beach Unit 2, Redondo Beach Units 5, 6, and 8, and Ormond Beach Units 1 and 2.[25]

[25] Statewide Advisory Committee on Cooling Water Intake Structures – Final Recommended Compliance Date Extensions for Alamitos, Huntington Beach, Ormond Beach, and Redondo Beach Generating Stations January 23, 2020, pp. 5-6. https://www.waterboards.ca.gov/water_issues/programs/ocean/cwa316/saccwis/docs/final_report.pdf

Table 15

Generating Units Compliance with California Statewide Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling					
Plant (Unit)	**Owner**	**State Water Resources Control Board Compliance Date**	**Planned retirement Date by Generating Owners**	**Capacity (MW)**	**PTO Area**
Compliance Plan Yet to be Implemented (Natural Gas Fired)					
Huntington Beach Units 2	AES	12/31/2023		226	SCE
Redondo Beach Units 5,6,8	AES	12/31/2021		850	SCE
Alamitos Units 3,4,5	AES	12/31/2023		1,166	SCE
Ormond Beach Units 1 and 2	NRG	12/31/2023		1,491	SCE
			Total MW	**3,733**	
In Compliance**					
Huntington Beach Units 1	AES	1/31/2020		226	SCE
Alamitos Units 1,2,6	AES	1/31/2020		845	SCE
Redondo Beach Units 7	AES	10/1/2019		493	SCE
Encina Power Station Units 2-5	NRG	12/12/2018		840	SDG&E
Mandalay Units 1 and 2	NRG	2/15/2018		430	SCE
Encina Power Station Units 1	NRG	5/8/2017		106	SDG&E
Moss Landing Units 6 and 7	Dynegy	1/1/2017		1,500	PG&E
Pittsburg Units 5, 6 and 7	NRG	12/31/2016		1,159	PG&E
Huntington Beach Units 3-4[1]	AES	12/7/2012		452	SCE
Humboldt	PG&E	Sept. 2010		105	PG&E
Potrero Unit 3	GenOn	2/28/2011		206	PG&E
South Bay	Dynegy	1/1/2011		702	SDG&E
Contra Costa Units 6 and 7	NRG	5/1/2013		674	PG&E
San Onofre Unit 2 & 3	SCE	6/7/2013		2,246	SCE
El Segundo Units 3	NRG	7/1/2014		335	SCE
El Segundo Units 4	NRG	12/31/2015		335	SCE
Morro Bay Units 3 and 4	Dynegy	2/5/2014		650	PG&E
			Total MW	**11,304**	
Notes**: these generating units were retired.					
Nuclear Plant to be in compliance					
Diablo Canyon	PG&E	12/31/2025		2,240	PG&E
			Total MW	**2,240**	
			Total of all OTC Units	**17,277**	

Conclusion

Projections for summer 2020 show that the CAISO faces a low, but somewhat increased risk of encountering operating conditions that could result in operating reserve shortfalls than was projected for 2019. The increased risk in 2020 over 2019 is primarily a result of lower than normal hydro conditions resulting in reduced energy from hydro resources across the summer, but particularly impactful in late summer. The CAISO will be at the greatest operational risk of a system capacity shortage later in the summer if hot weather occurs that extends beyond the CAISO footprint and diminishes the availability of surplus energy in neighboring balancing authorities for imports into the CAISO during peak hours when solar production is near or at zero. Availability of sufficient imports during high peak load conditions is critical to ensuring system reliability. The greatest risk would be if such an event occurred during late summer as hydro availability wanes and the solar production afternoon ramp-down begins earlier in the day.

The continuing decline in dispatchable generation as gas units retire creates further challenges for meeting the CAISO flexible capacity requirement and the peak demand, which is now occurring later in the day when solar output is at or near zero. While the CAISO has a low probability of a system capacity shortfall, there is a material risk of shortfalls in load following up capacity, particularly in the late afternoon when solar generation is near or at zero and net imports diminish from neighboring BAs while system demand is increasing. These shortfalls generally do not result in operational impacts as there is no impact if the intra hour variability and uncertainty needs fail to materialize, but it is an indicator of increasing tightness of dispatch capability. However, if a load following shortfall were to occur when actual intra hour variability and uncertainty needs do materialize, it may be necessary in some cases to rely on regulation or operating reserve to maintain balance between supply and demand and maintain frequency within required limits further challenging the CAISO's ability to meet performance standards.

A conservative net import sensitivity study results show that reduced levels of net imports during high demand conditions significantly affects system reliability. If import levels during 2020 summer peak conditions are significantly lower than the levels assumed in the base case nomogram, the impact will be that the actual system reliability will tend towards the more challenging sensitivity study results. This could occur under above normal high temperatures in the CAISO that extend across the Southwest or into the Northwest. Such conditions would produce high loads in the CAISO and in its neighboring balancing authority areas, resulting in decreased imports into the CAISO. The CAISO operations has procedures in place that can be used to facilitate the less extreme scenarios through out of market activities. However, in potential extreme weather cases the CAISO could be faced with the necessity of having to shed frim load.

The risks to electric reliability associated with the gas storage facility restrictions at the Aliso Canyon and other gas storage facilities has reduced from 2019. The risk of gas supply issues is greater in the local reliability areas in Southern California than to the CAISO system and are not included in the modeling results. Although non-Aliso withdrawals would be sufficient to meet demand under base and worst-case gas balance scenarios at the daily level, hourly demand and gas deliveries on a peak day may still trigger a need for withdrawal at Aliso Canyon.

This Assessment is a system level assessment and does not provide results on local area resource adequacy issues. In addition, this Assessment does not include potential risks associated with transmission facility forced outages, including transmission outages due to wildfires, which could hinder imports during critical supply conditions. Supply disruptions due to public safety power shutoff procedures are also not addressed in this report.

No attempt was made to predict potential ongoing impacts to loads due to COVID-19 through the summer period. At the time of writing this report, too many unknowns existed to produce a viable and meaningful COVID-19 load impact scenario. As of the writing of the report, the CAISO has experienced load reductions of 5 to 8 percent on weekdays, and 1 to 4 percent on weekends, with the largest reductions occurring over the morning peak hours. Similar to its European counterparts, including Italy and Spain, the ISO observed greater load decreases as the stay-at-home conditions continued. However, 2020 summer weather has yet to materialize across the CAISO balancing authority area to provide an indication of the levels of load reduction during periods of heavy air conditioning driven loads. While the CAISO does recognize there are likely to be lasting effects from COVID-19 throughout the 2020 summer period, there is not enough data to forecast the magnitude and hourly profile of those impacts.

The CAISO annually trains its grid operators to be prepared for system events, and to brush up on current operating procedures and utility best practices. Furthermore, the CAISO meets with WECC, Cal Fire, gas companies, and neighboring balancing authorities to discuss and coordinate on key areas. The CAISO fosters ongoing relationships with these organizations to ensure reliable operation of the market and grid during normal and critical periods.

Should CAISO system operating conditions go into the emergency stages, such as operating reserve shortfalls where non-spinning reserve requirement cannot be maintained or spinning reserve is depleted and operating reserve falls below minimum the requirement, the CAISO will implement the following mitigation operating plan to minimize loss of load in the CAISO balancing authority area:

- Utilization of Flex Alert program, signaling that the CAISO expects high peak load conditions. This program has been proven to reduce peak load in the CAISO balancing authority Area.
- Utilization of CAISO Restricted Maintenance program. This program is intended to reduce potential forced outages during the high peak load conditions.
- Manual post-day ahead unit commitment and exceptional dispatch of resources under RA contract to ensure ability to serve load and meet flexible ramping capability requirements.
- Manual exceptional dispatch of intertie resource that have Resource Adequacy obligation to serve CAISO load.
- Utilization of Alert/Warning/Emergency program.
- Utilization of Demand Response program including the Reliability Demand Response Resources (RDRR) under the “Warning” stage.
- Manual exceptional dispatch and utilization of back stop Capacity Procurement Mechanism for physically available resources that have un-contracted RA capacity.

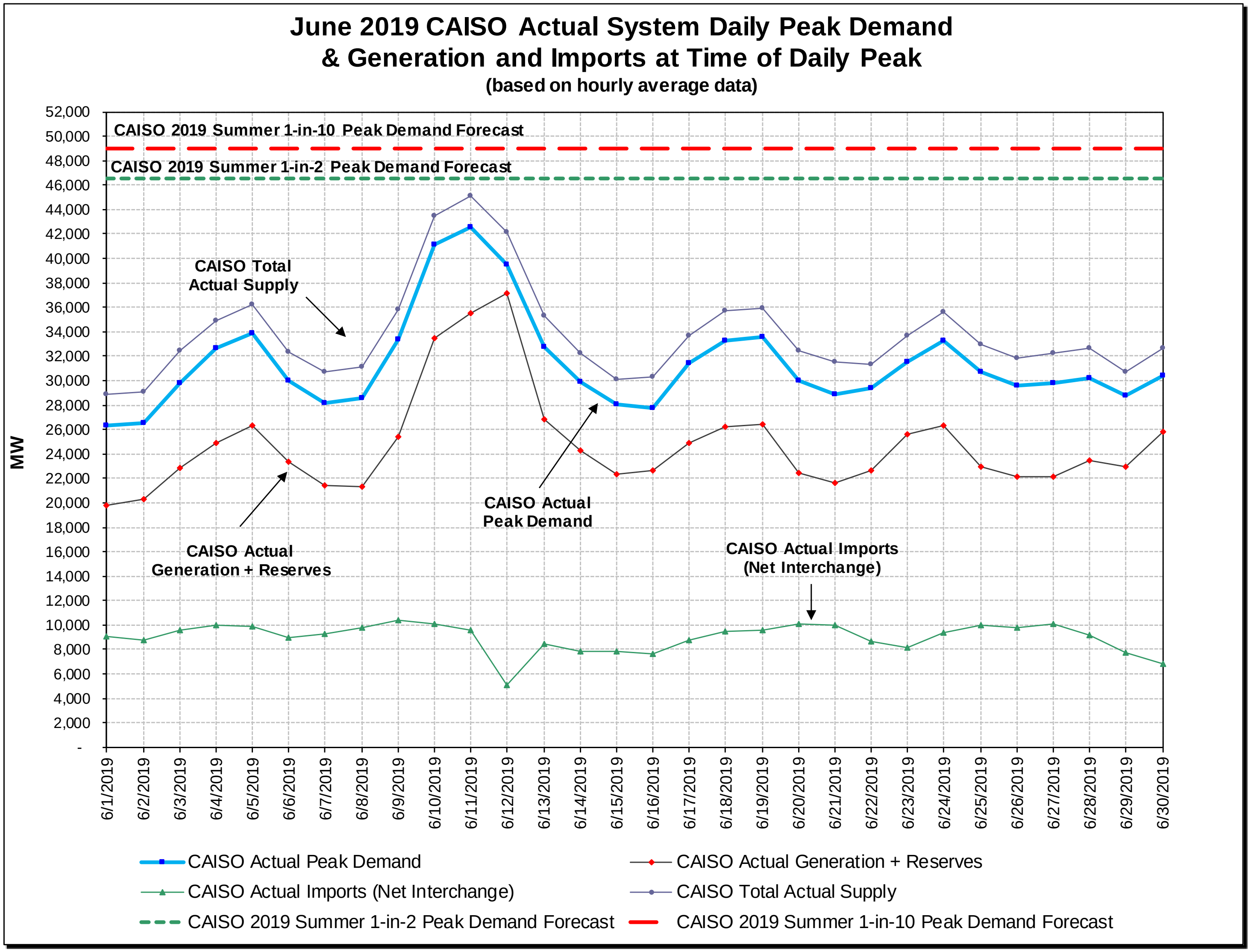
IV. APPENDICES

A. 2019 Summer Supply and Demand Summary Graphs

B. 2019 Summer Imports Summary Graphs

C. 2019 CAISO Summer Maximum On-Peak Available Capacity by Fuel Type

Appendix A: 2019 Summer Supply and Demand Summary Graphs



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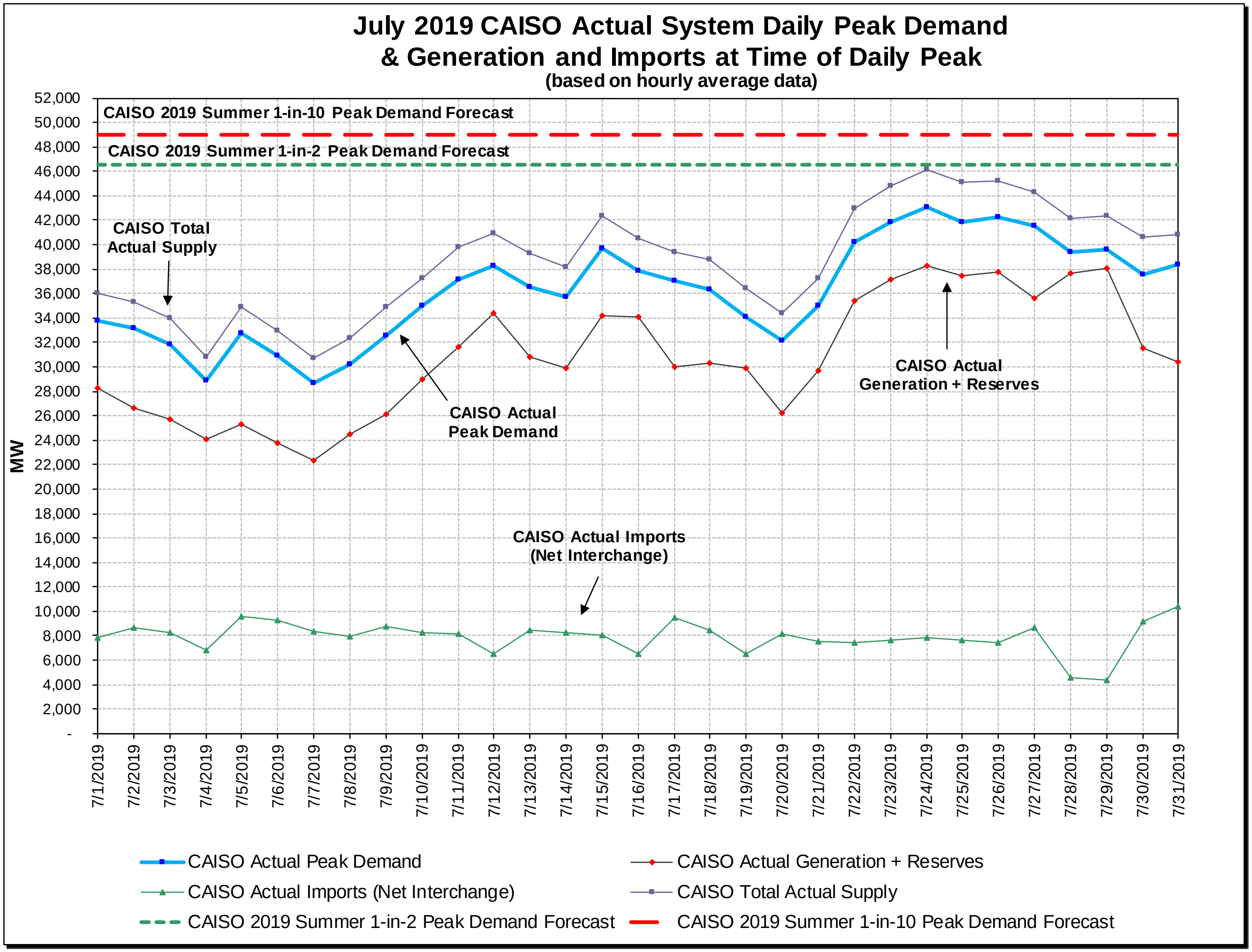

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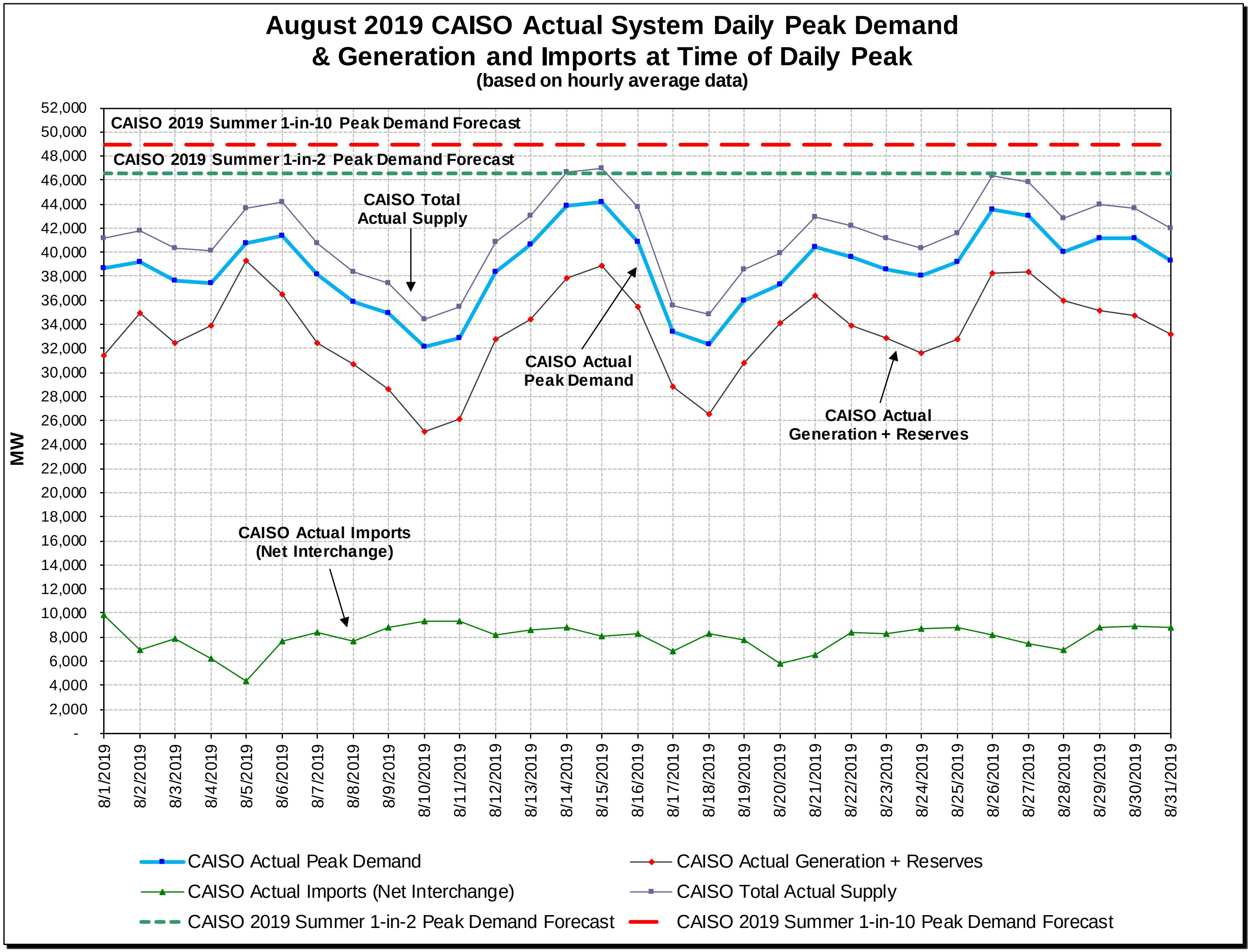

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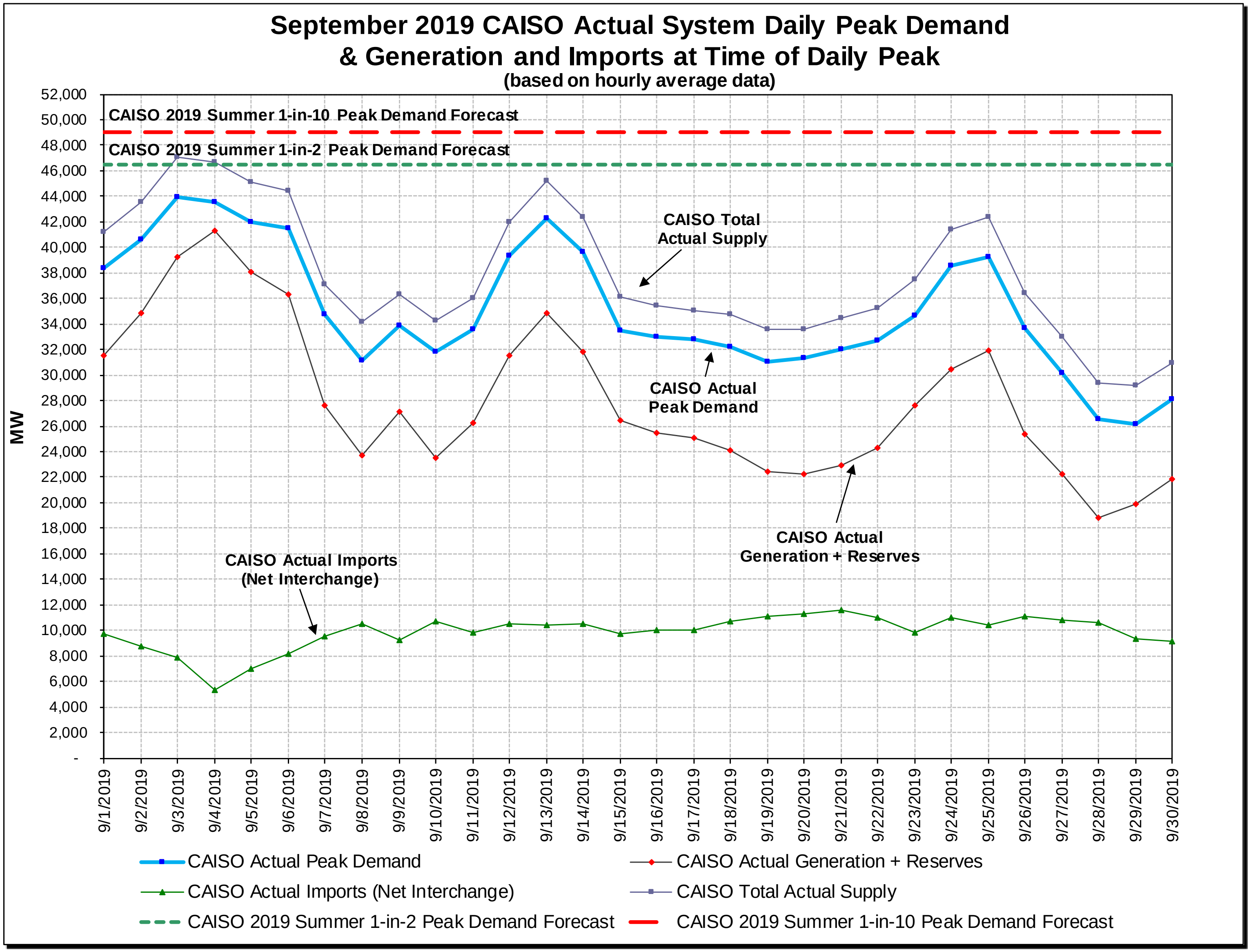

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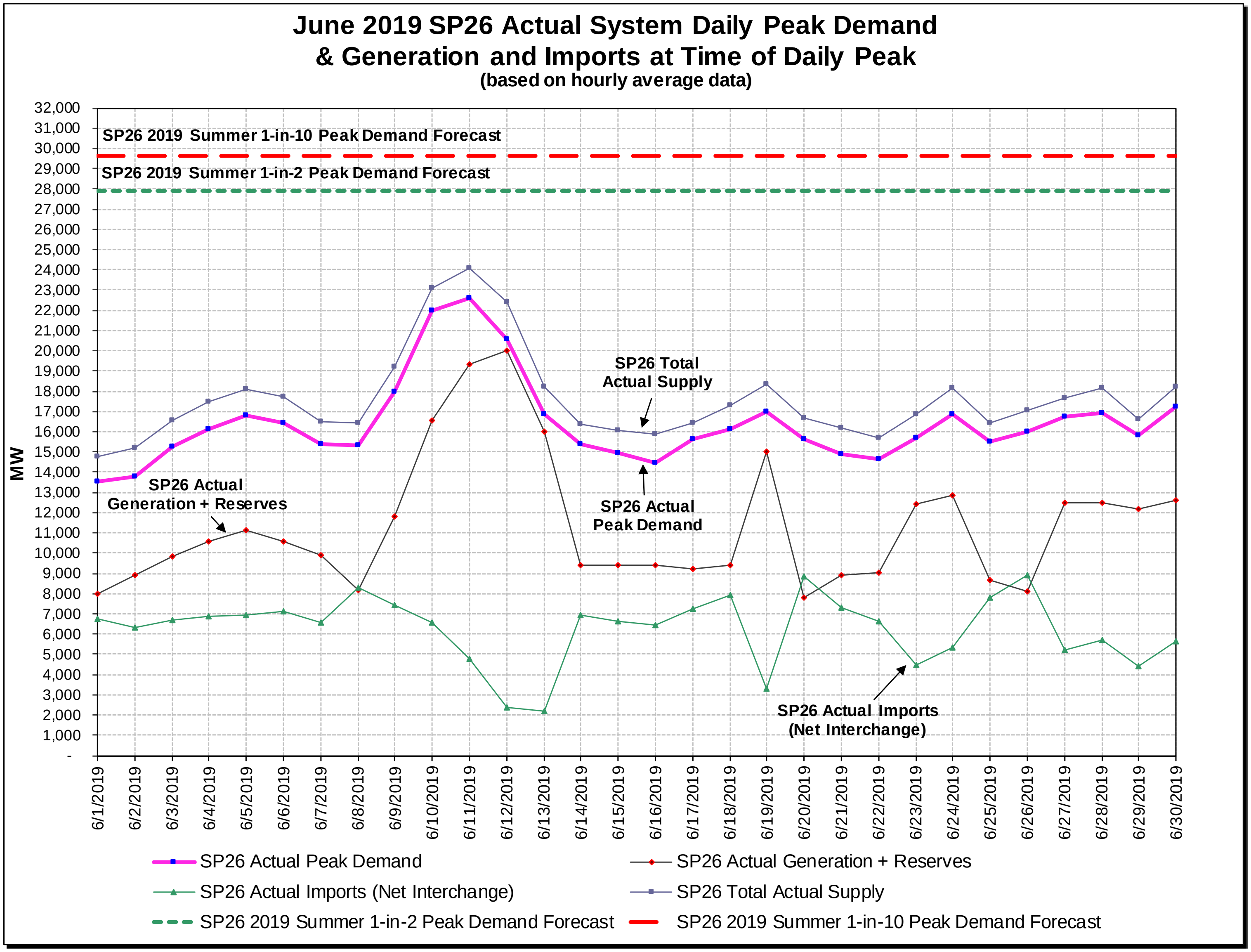

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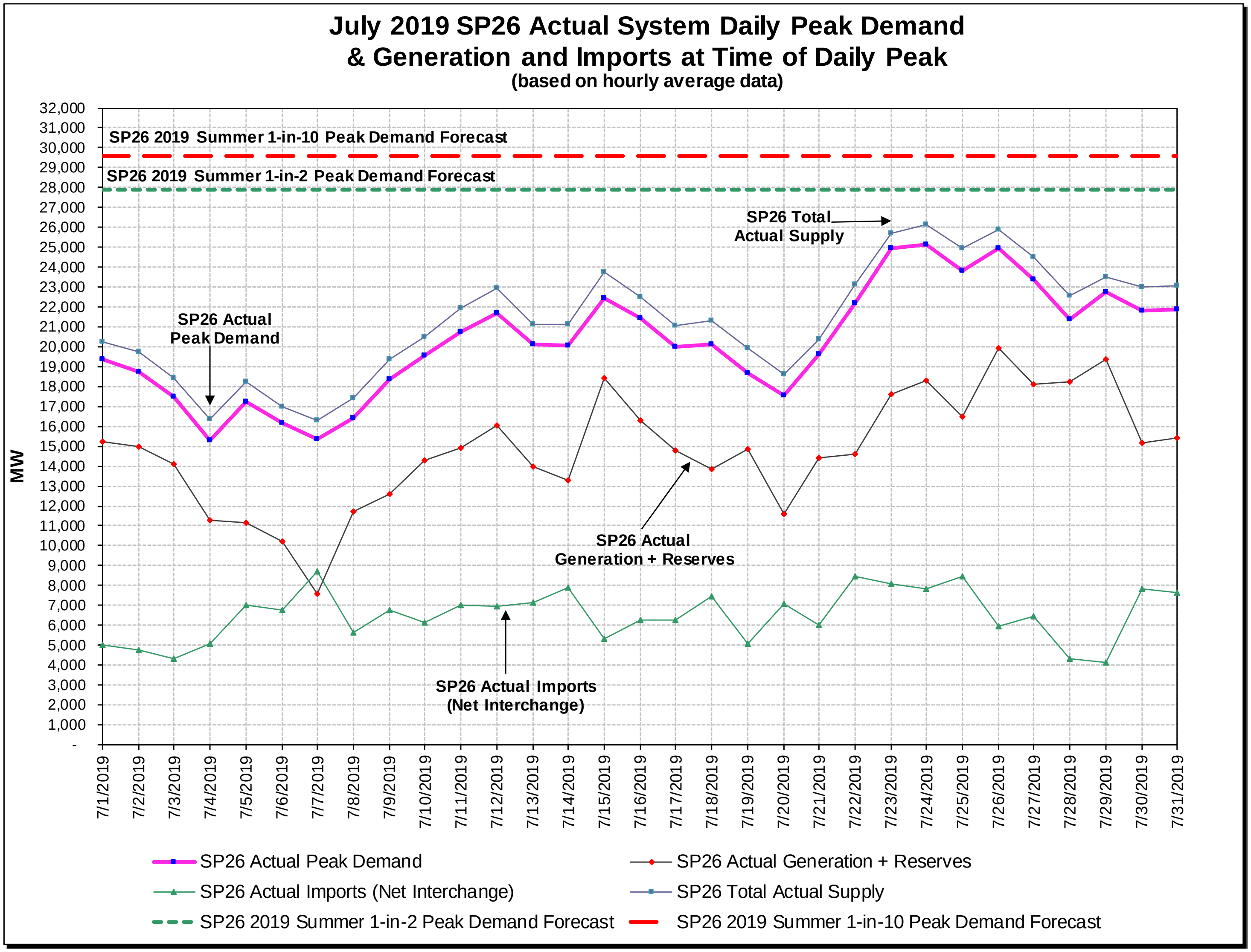

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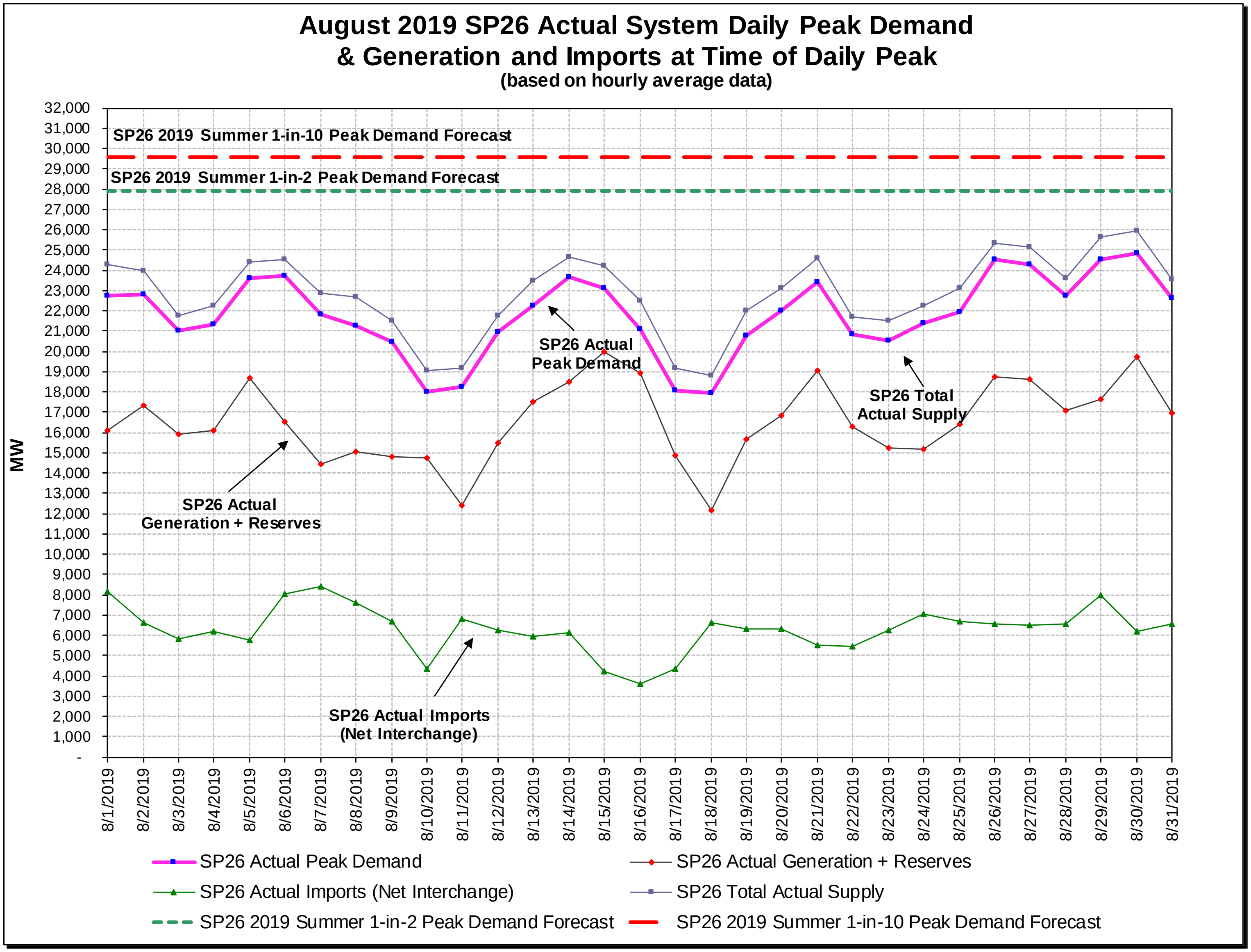

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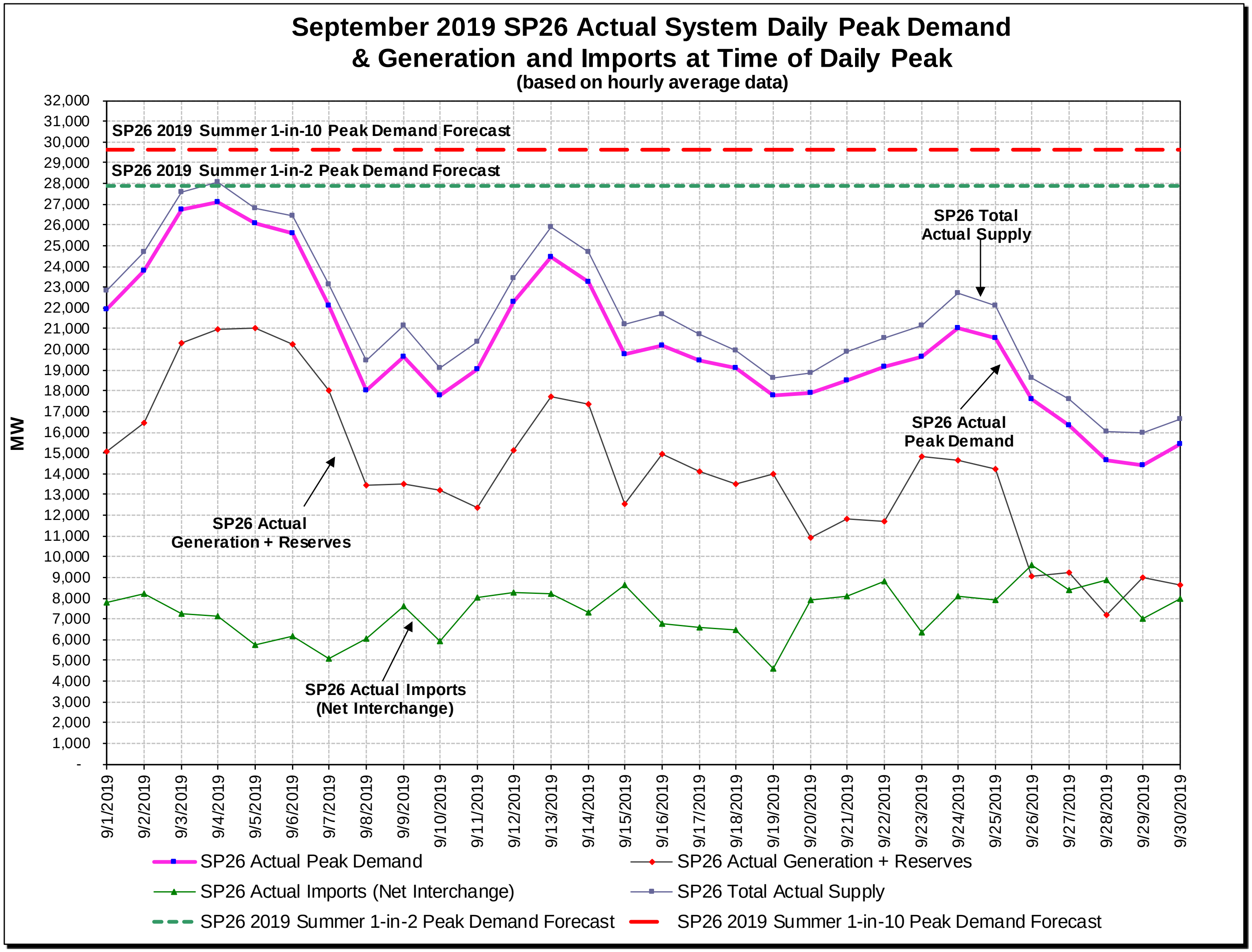

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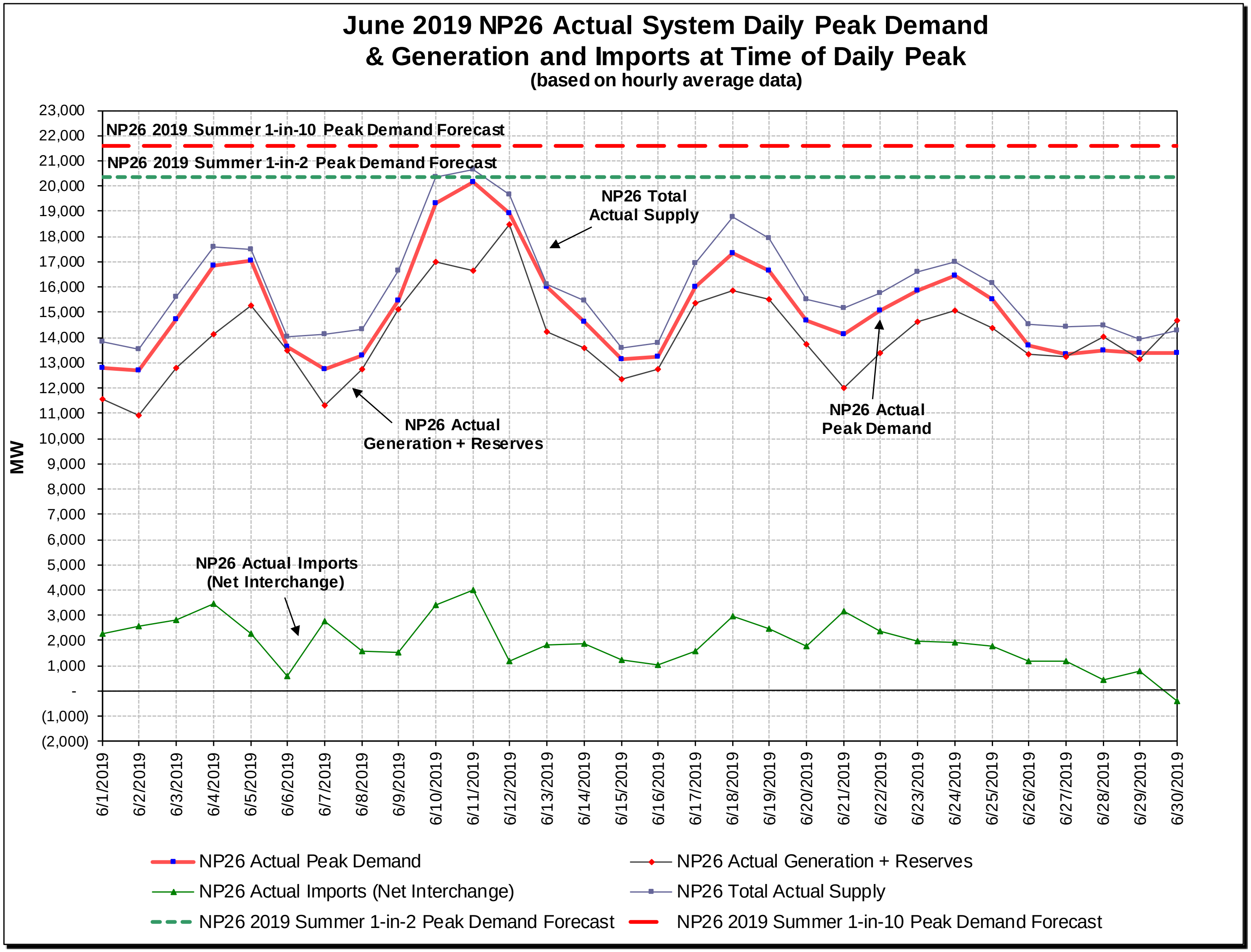

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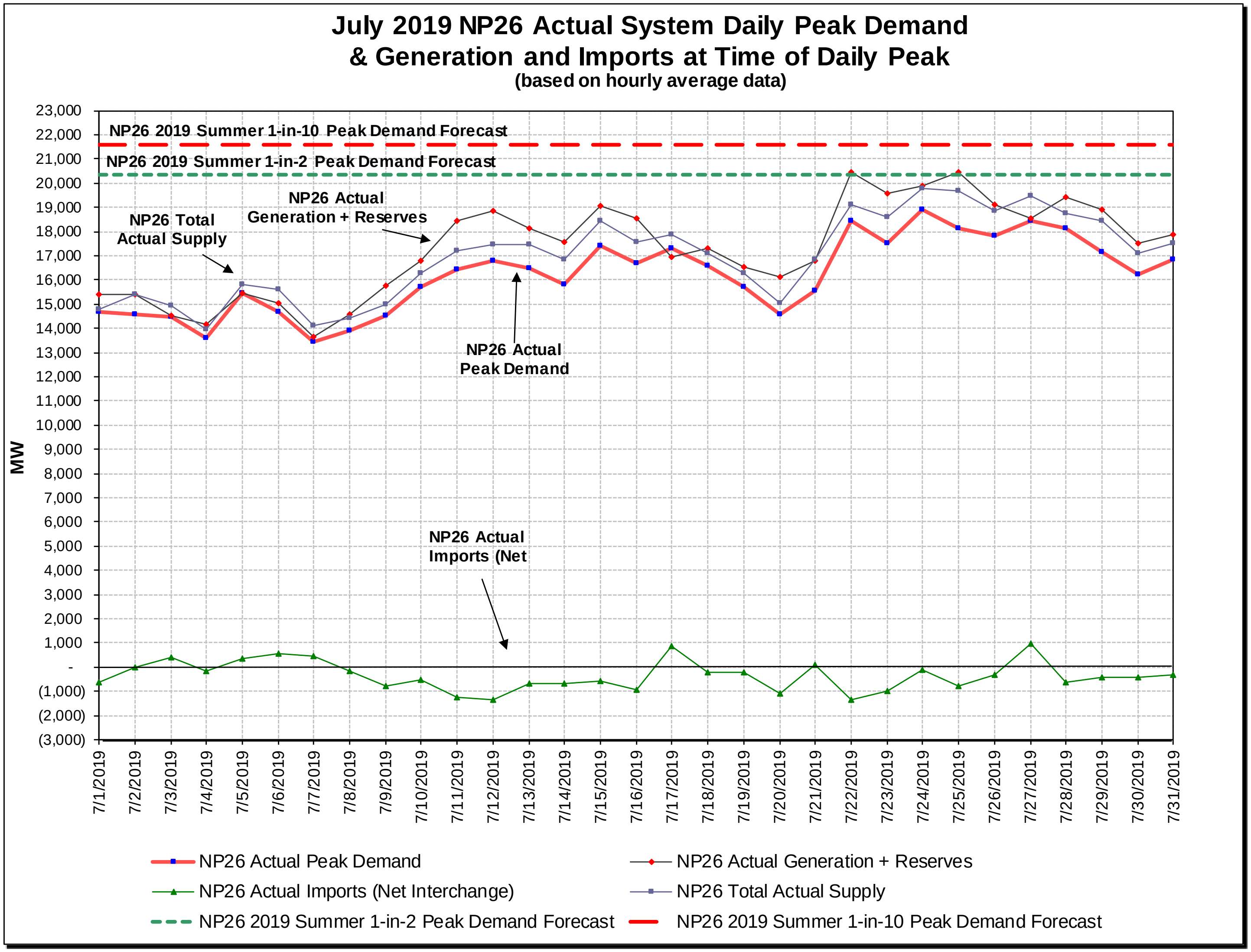

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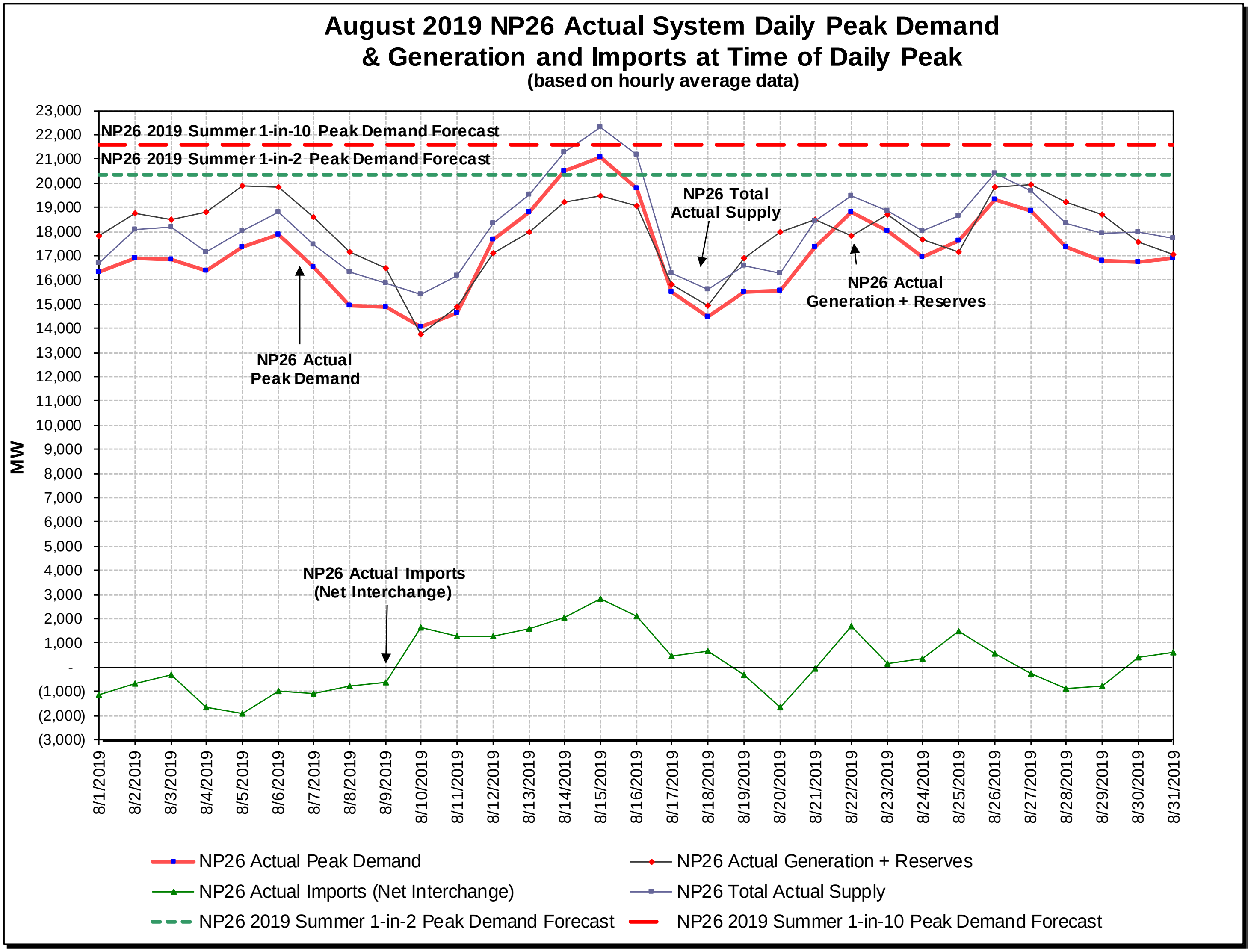

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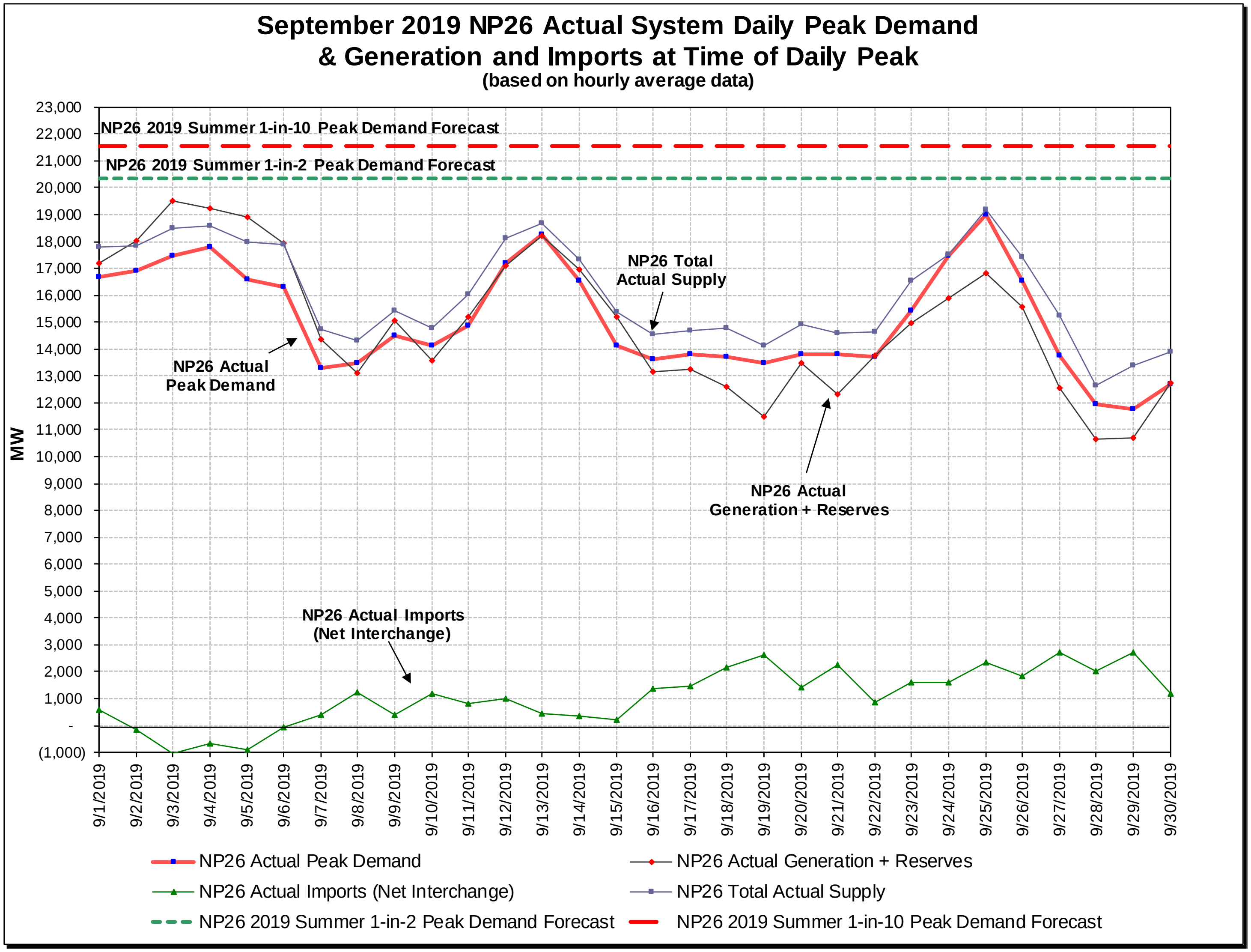
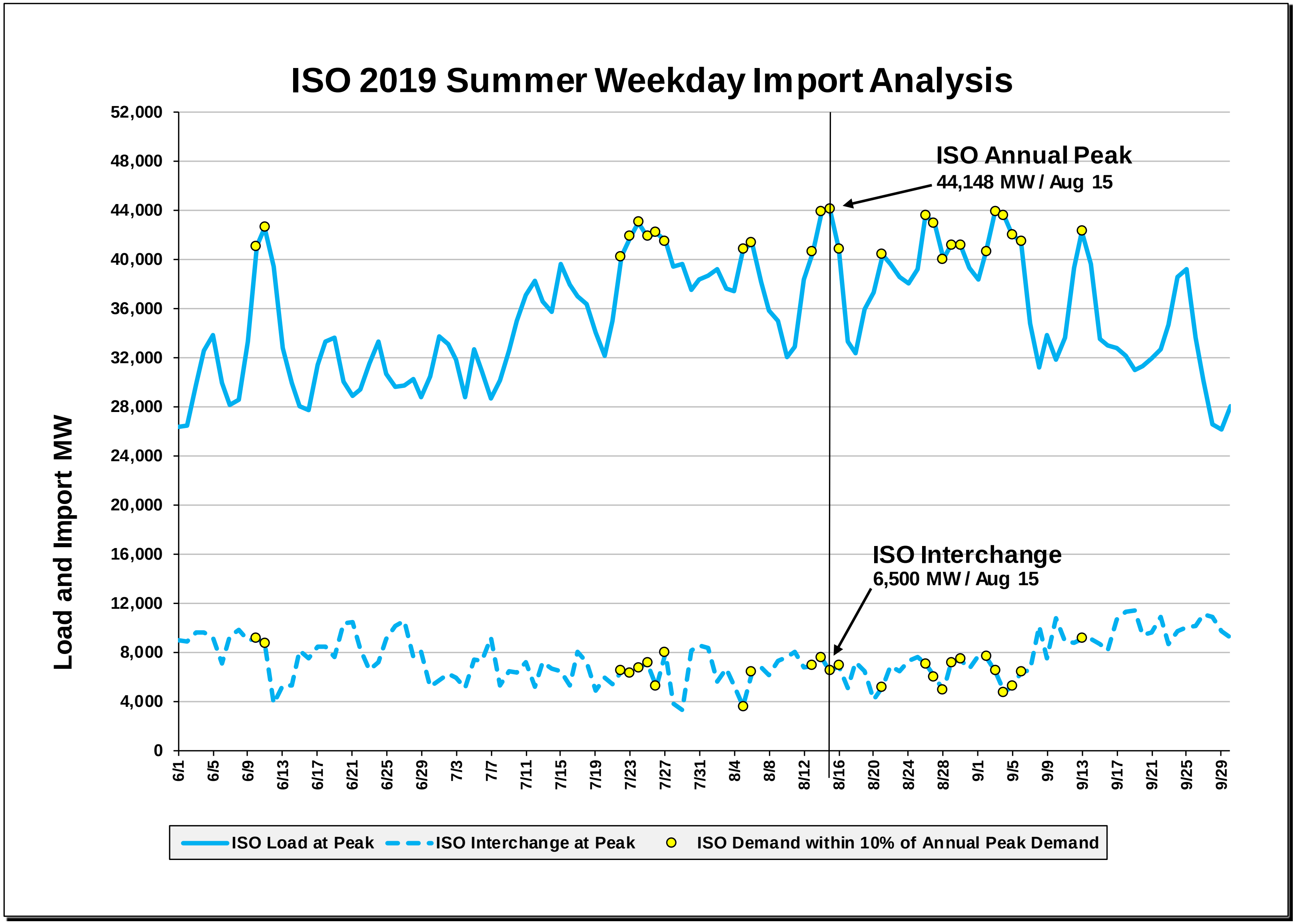


Appendix B: 2019 Summer Imports Summary Graphs



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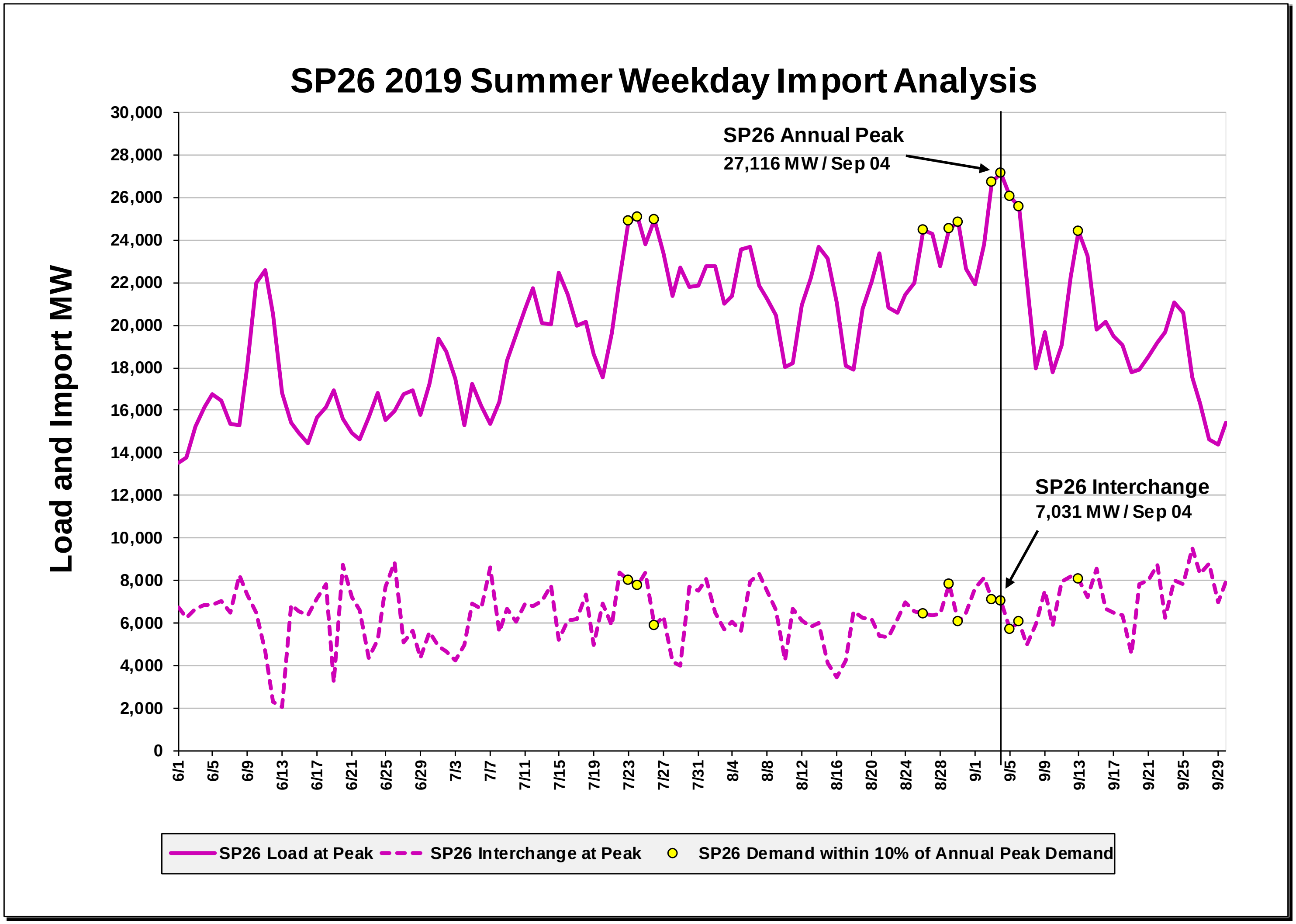

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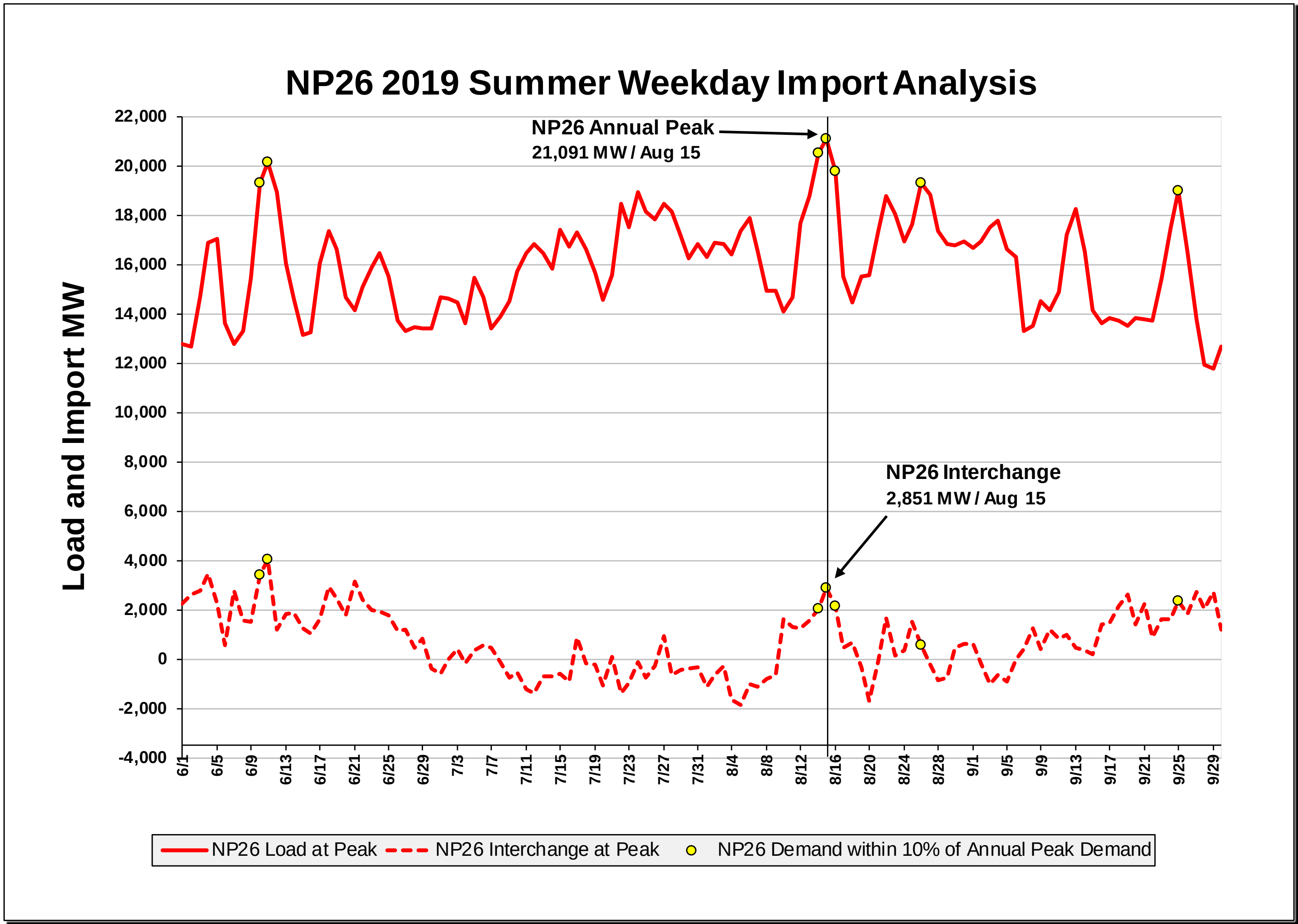

Appendix C: 2020 CAISO Summer Maximum On-Peak Available Capacity by Fuel Type