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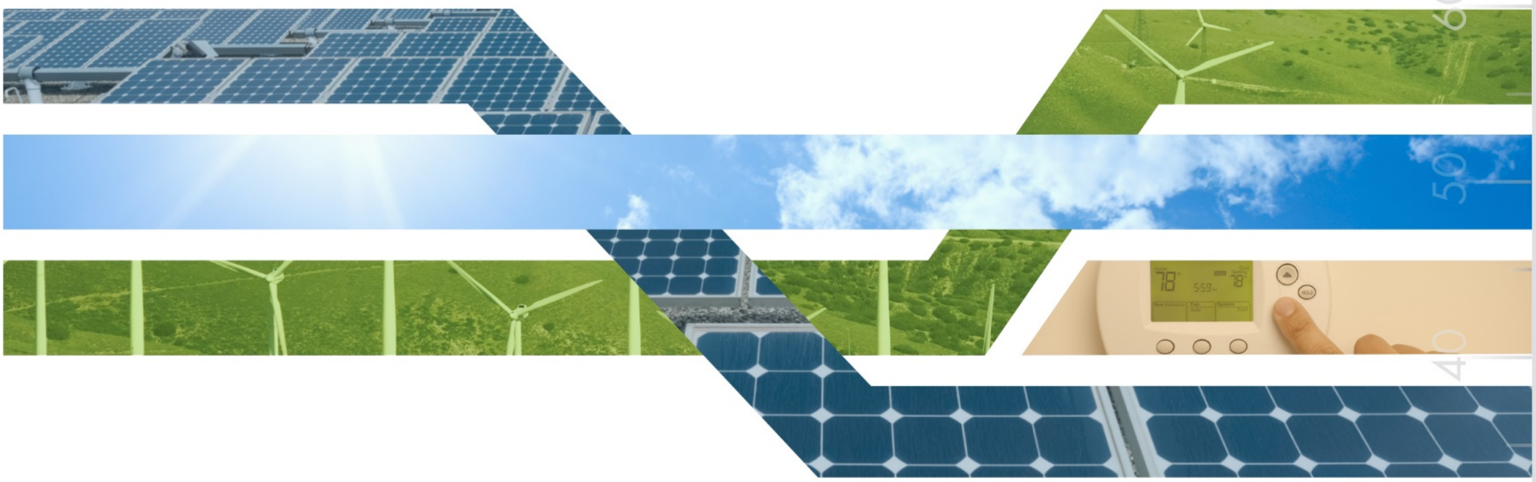
2016 SUMMER LOADS & RESOURCES ASSESSMENT



California ISO

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I. EXECUTIVE SUMMARY

The *2016 Summer Loads and Resources Assessment* provides an assessment of the upcoming summer supply and demand outlook using a stochastic simulation approach in the California Independent System Operator (CAISO) balancing authority area. The CAISO works with state agencies, generation and transmission owners, load serving entities, and other balancing authorities to formulate the summer forecast and identify any issues regarding upcoming operating conditions. The Assessment considers the supply and demand conditions across the entire CAISO balancing authority area (representing about 80 percent of California), and then further considers separately the conditions in the Northern California zone (North of Path 26 or NP26) and the Southern California zone (South of Path 26 or SP26).

To assess the changing resource mix related to the increasing penetration of renewable resources in the CAISO that results in changing operational needs, the CAISO developed a more robust probabilistic approach using production simulation to assess the supply and demand outlook for the 2016 Assessment on an hourly basis.

Overall CAISO System-wide and Zonal Reliability

The projected 1-in-2 annual minimum operating reserve margin (ORM) for the CAISO system is 24.4 percent. The ORM amounts in this Assessment are projections of supply margins over projected hourly demands and includes all resources that are in a state that would enable them to produce energy if called upon to meet peak demand (*Figure 1)*. The projected 1-in-2 annual minimum operating reserve margins for the NP26 and SP26 zones are 21.3 percent and 25.6 percent, respectively *(Figure 2 and Figure 3)*.

These projected 1-in-2 annual minimum ORMs for 2016 are significantly greater than the 15 percent planning reserve margin required by the California Public Utilities Commission's month-ahead resource procurement requirement under its resource adequacy program. These ORMs were outcomes from the stochastic simulation of 2000 samples. Each sample has an 8,760 hour annual profile. However, the reserve margins represented in this assessment do not account for the gas curtailment risks that were identified in the Aliso Canyon Risk Assessment Technical Report[1] for the summer months.

The CAISO 2016 1-in-2 peak demand forecast is 47,529 MW, which is 0.8 percent above the 2015 weather normalized peak demand of 47,167 MW. The modest demand increase is a result of projected modest economic growth over 2015, based on the economic base case forecast from Moody's Analytics, and utility projections of new behind the meter solar installations for 2016. The CAISO 2016 1-in-10 peak demand forecast is 49,771 MW.

The CAISO projects that 54,459 MW of net qualifying capacity (NQC) will be available for summer 2016. From June 1, 2015, to June 1, 2016, a total of 2,306 MW of additional generation is expected to reach commercial operation, with 1,520 MW in SP26 and 786 MW in NP26. As of March 11, 2016, 1,903 MW of this additional generation was in commercial operation with an additional 403 MW expected by June 1, 2016. Of the 2,306 MW,

[1] Aliso Canyon Risk Assessment Technical Report http://www.energy.ca.gov/2016_energypolicy/documents/2016-04-08_joint_agency_workshop/Aliso_Canyon_Risk_Assessment_Technical_Report.pdf

approximately 85 percent is solar, 6 percent is natural gas, 4 percent is wind, 4 percent is hydro, and 1 percent is biofuel. During this same period, 355 MW of generation retired in SP26.

Figure 1

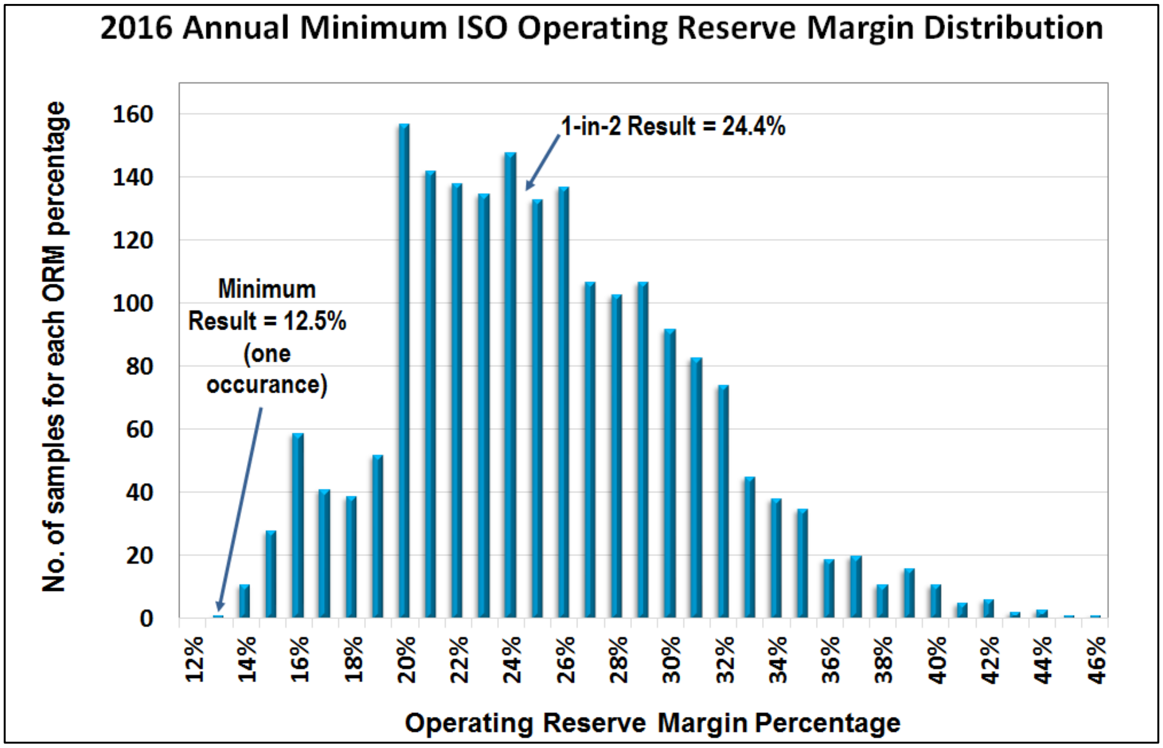


Figure 1 shows forecasts of annual minimum operating reserve margins for the CAISO.

Figure 2

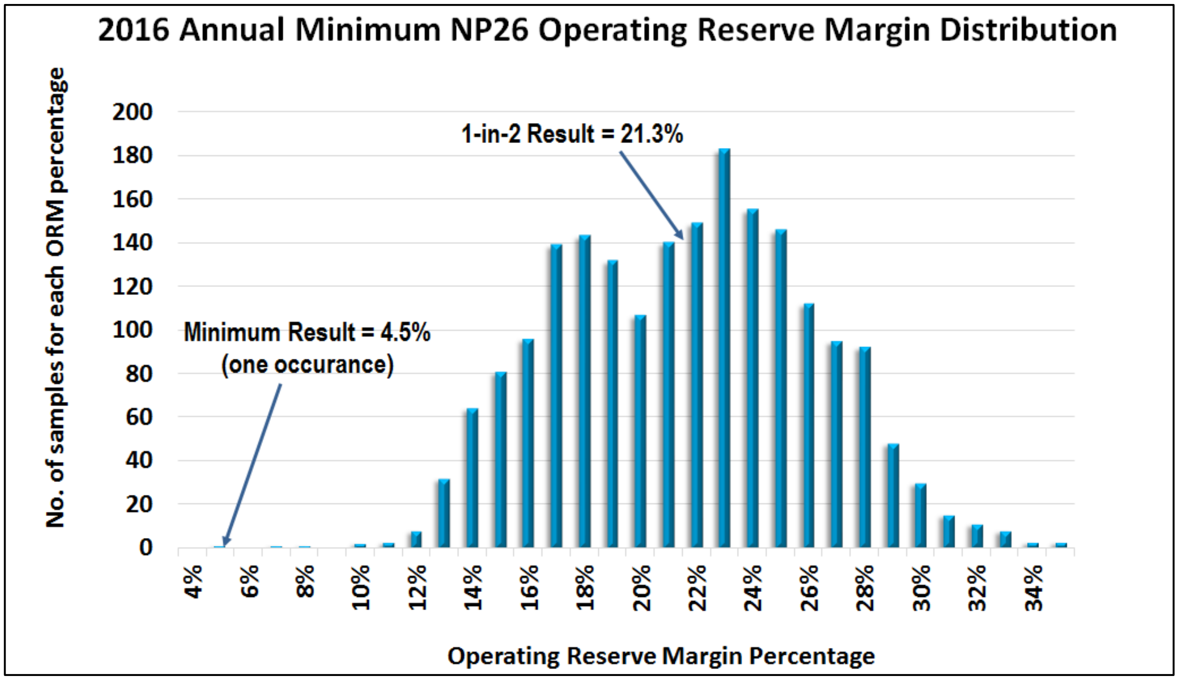


Figure 2 shows forecasts of annual minimum operating reserve margins for NP26.

Figure 3

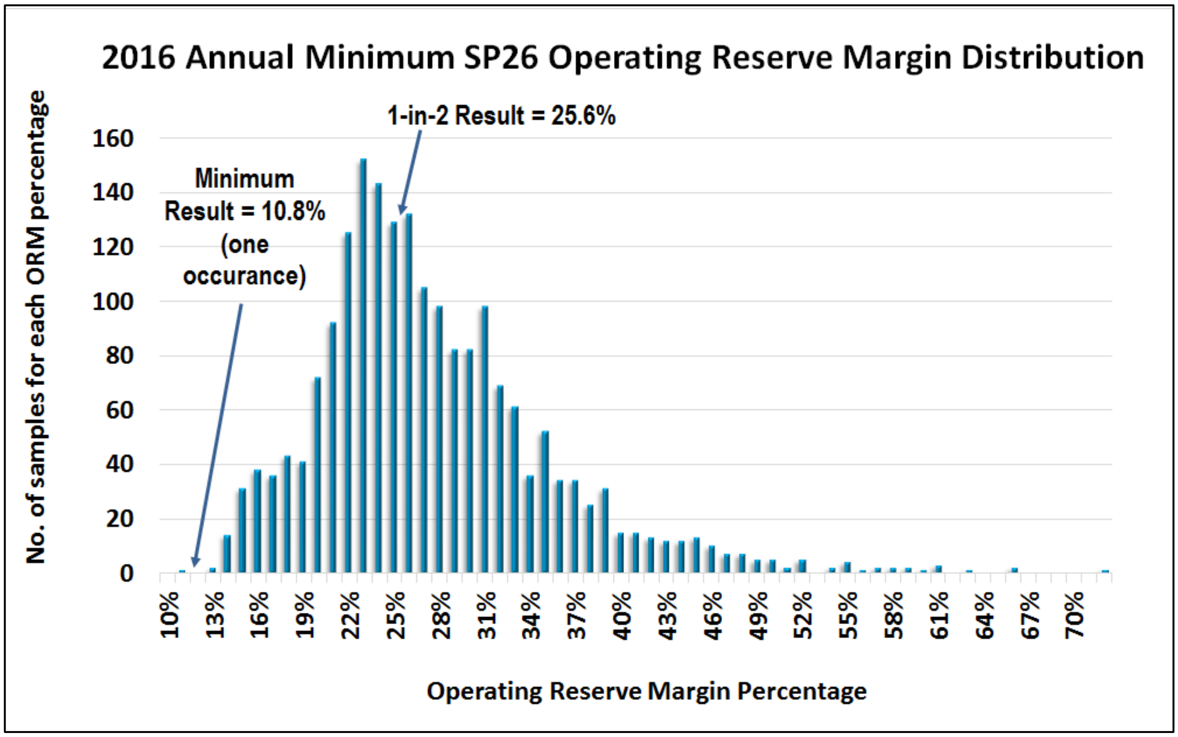


Figure 3 shows forecasts of annual minimum operating reserve margins for SP26.

Impacts of the Aliso Canyon Gas Storage Operating Restrictions

One of the wells at the Aliso Canyon gas storage facility (Aliso Canyon) developed an uncontrolled gas leak in October 2015 that lasted into February 2016 when the well was successfully sealed. The gas leak incident caused the California Public Utility Commission (CPUC) to issue an order directing Southern California Gas Company (SoCalGas) to draw down the field to 15 billion cubic feet. No new injections to the gas storage facility are currently permitted. Limited withdrawal capability exists to maintain energy reliability.

Responding to an emergency order issued by Governor Brown, a team comprised of the California Energy Commission (CEC), CPUC, CAISO, Los Angeles Department of Water and Power (LADWP) and SoCalGas was formed to identify potential risks, as well as possible mitigation measures and address potential electric reliability concerns for the coming summer across the LA Basin and throughout Southern California. Technical experts from the team performed an Aliso Canyon risk assessment and documented their findings in the Aliso Canyon Risk Assessment Technical Report. Seventeen gas-fired power plants totaling 9,500 MW located in the LADWP and the CAISO balancing authority areas were identified as the electric generation most directly affected by Aliso Canyon's reduced capabilities. The Technical Report found that if no gas can be withdrawn from Aliso Canyon during the coming summer months, a significant risk exists of natural gas curtailments during up to 16 days this summer. These curtailments could interrupt service and affect millions of electric customers during as many as 14 summer days. Several factors contribute to this risk including mismatches between scheduled gas on the pipeline system and actual daily gas demand, planned and unplanned outages to non-Aliso storage facilities that reduce supply, and planned and unplanned pipeline outages that reduce delivery capacity. Prolonged periods of high electrical demand also increase the risk of gas curtailments and electrical service interruption. This happens during extreme heat waves when air conditioning use spikes and all natural gas-fired electricity generation is required.

The reserve margins represented in this assessment do not account for the gas curtailment risk identified in the Aliso Canyon Risk Assessment Technical Report. If any gas supply curtailment were to occur to gas fired generation in Southern California at the levels that were identified in the technical assessment the reserve margins in SP26 could be depleted. However, the risk of interrupting load on any particular day would depend on local constrained conditions within Southern California as well as the extent to which the transmission system and available supply is capable of absorbing gas curtailment in real-time.

The CAISO manages the dispatch of several generators in the CAISO balancing area dependent on gas coming from the SoCalGas system that are either directly or indirectly impacted by the Aliso Canyon operational constraints. The CAISO recognizes concerns that its commitment or dispatch instructions, especially in real-time, could cause challenges to generators under a daily balancing requirement or an operational flow order. The CAISO has completed a stakeholder process that proposed market mechanisms and other tools the CAISO can use, including the mitigation measures explored by the task force, to mitigate the risks to gas and electric reliability to avoid electric service interruptions to the extent possible. The measures approved by the CAISO Board of Governors[2] and filed with the Federal Energy Regulatory Commission[3] are designed to ensure the CAISO's dispatches are better coordinated with the constrained gas system and minimize, to the extent possible, the impact of further challenges to gas and electric system reliability this summer. The measures help ensure that the limitations of the constrained gas system are reflected in the CAISO market processes. This is either through bids submitted by affected generators, or through operational tools by which the CAISO further constrains market dispatches and transmission flows to ensure its markets produce solutions that are reflective of the constraints the gas system imposes on electrical generators. The measures are summarized below and provided in greater detail later in this Assessment:

1) Provide to scheduling coordinators, for informational purposes only, advisory commitment schedules produced in the residual unit commitment process conducted in a two-day-ahead basis.

2) Implement a timelier and more accurate gas commodity prices used for commitment costs bid caps, default energy bids, and generated bids in the day-ahead market.

3) Increase the gas commodity price used to calculate commitment costs and default energy bids for resources served by the affected gas systems.

[2] Revised Draft Final Proposal - Aliso Canyon Gas-Electric Coordination. Available at http://www.caiso.com/Documents/RevisedDraftFinalProposal_AlisoCanyonGas_ElectricCoordination.pdf
[3] May 9, 2016 Tariff Amendment - Enhance Gas-Electric Coordination - Limited Operation of Aliso Canyon Natural Gas Storage Facility (ER16-1649)

4) Allow resources to rebid their resource commitment costs in the CAISO real-time market if the resource was not committed in the day-ahead market and the resource has not already started up and in its minimum run time range.[4]

5) Ensure the CAISO's short-term unit commitment process does not commit resources in the real-time that were not committed in the day-ahead and does not automatically resubmit bids into real-time market.

6) Include a new constraint in the CAISO markets that the CAISO operators can use to better ensure dispatches are consistent with observed gas system limitations and avoid further stressing the gas system, which could in turn adversely impact electric grid reliability.

7) Expand the CAISO's authority to reserve internal transfer capability by adjusting transmission constraints on the system it operates and release this internal transfer capability as needed.

8) Provide the CAISO with authority to suspend convergence bidding if the CAISO determines it is adversely affecting market efficiency.

9) Add tariff provisions that allow scheduling coordinators to seek after-the-fact cost recovery from the Commission in a section 205 filing, to the extent they are otherwise unable to recover their costs through the CAISO's cost-recovery mechanisms.

In addition to these measures, the ISO is increasing its operational coordination with SoCalGas as well as LADWP to increase awareness of changing operational conditions and be ready to act appropriately to mitigate risks to gas and electric reliability. Last, the ISO is also collaborating with Peak reliability coordinator and WECC to ensure the transfer capability is maximized to the extent possible during periods of electric supply challenges brought on by gas curtailments.

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 Western Electricity Coordinating Council (WECC), California Department of Forestry and Fire Protection (Cal Fire), natural gas providers and neighboring balancing areas. The CAISO's ongoing relationships with these entities help to ensure everyone is prepared during times of system stress.

The CAISO is also working closely with state agencies and once-through-cooling plant owners as they develop plans to comply with the regulations that ensures electric grid reliability is maintained throughout the transition in which 9,847 MW of natural gas fired coastal power plants that use ocean water for cooling are required to be retired, retrofitted

[4] The CAISO developed this proposal prior to the issues created by the Aliso storage facility arose. However, this flexibility is helpful in ensuring that if the generator faces higher costs in the real-time than it did in the day-ahead, it can reflect those higher costs in its bids and allow the CAISO real-time market to consider those costs accordingly.

or repowered. The bulk of the generation retirements forecasted to occur as a result of this requirement are anticipated in the 2017-2020 time frame.

The CAISO manages the dispatch of several generators dependent on gas coming from the SoCalGas system that are impacted by the Aliso Canyon operational constraints. The CAISO recognizes concerns that its commitment or dispatch instructions, especially in real-time, could cause challenges to generators under a daily balancing requirement or an operational flow order. Through its stakeholder process the CAISO is continuing to evaluate the issues affecting gas and electric service under the constrained conditions due to limited operability of Aliso Canyon and develop procedures to mitigate the issues to the greatest extent possible.

II. SUMMER 2015 REVIEW

Demand

The recorded 2015 summer peak demand reached 47,257 MW on September 10, 2015. Adjusting the load to normalized weather results in a peak load of 47,167 MW for the CAISO in 2015, which is an increase of 2 percent from the 2014 summer weather normalized peak demand of 46,229 MW. The load growth is the result of continued economic recovery from the recession, which was somewhat muted by the continuing trend of behind the meter solar photovoltaic installations. The SP26 annual peak demand was 27,475 MW and NP26 annual peak demand reached 20,462 MW. The annual peak for NP26 occurred in August while SP26 and CAISO peaks occurred in September. The annual peaks did not occur coincidently because of weather diversity between northern and southern California.

Figure 4 shows CAISO, SP26 and NP26 actual monthly peak demand from 2006 to 2015. The CAISO summer peak dropped each year from 50,085 MW in 2006, which was high because of extreme weather conditions and a stronger economy, to 45,809 MW in 2009 as demand moderated during the recession. Demand has fluctuated since 2009 based on changing economic, demographic and weather conditions.

Figure 4

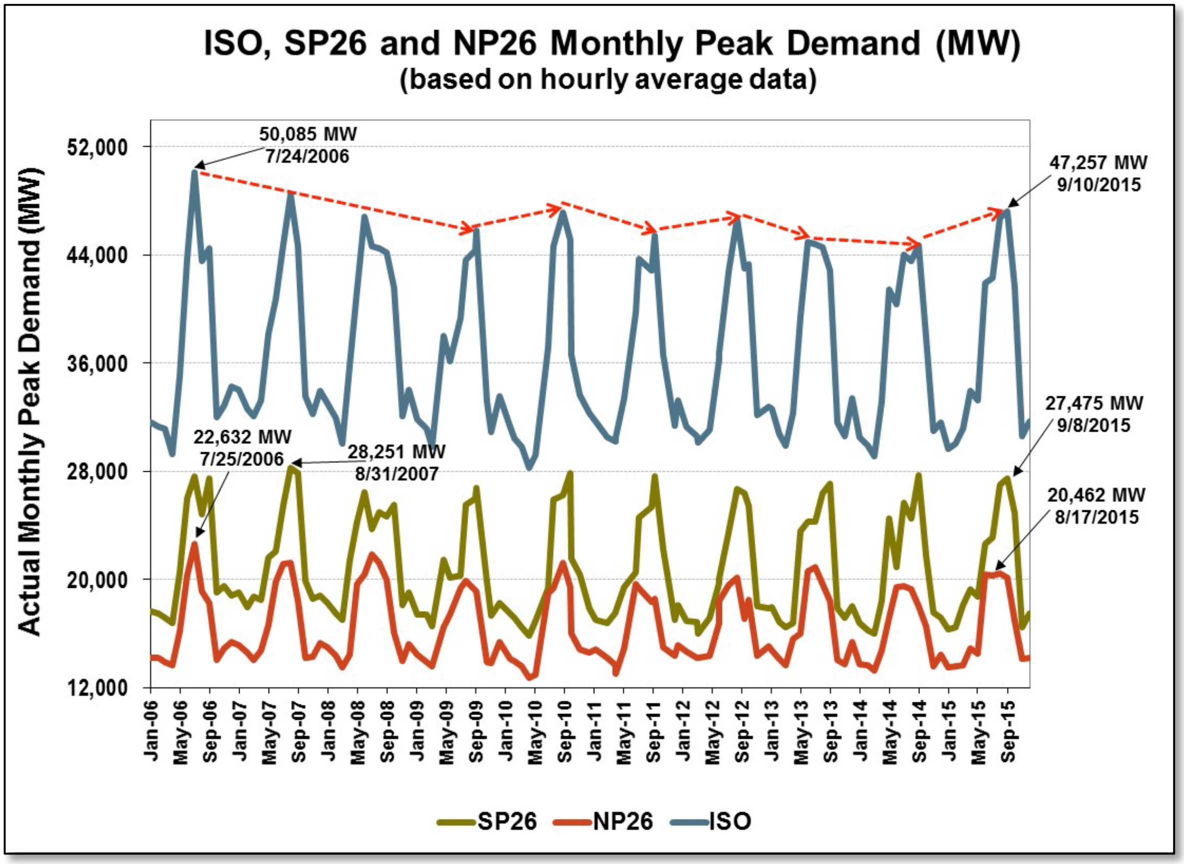


Figure 4 shows the CAISO balancing authority system peak as well as peaks for Northern and Southern California (2006-2015).

Table 1 shows the difference between 2015 actual peak demands and 2015 1-in-2 peak demand forecasts. The actual peak demand in 2015 equated to a 1-in-3 temperature event. The weather normalized peak load for CAISO in 2015 was 47,167 MW.

The actual peak demand in Northern California was 2 percent lower than 1-in-2 forecast peak demand for NP26. The weather at the time of the actual NP26 peak demand was a 1-in-1.7 temperature event. A combination of a mild weather pattern and use of demand response were the main contributors to the actual peak demands being lower than 1-in-2 forecast peak demands for NP26.

However, the actual peak demand in Southern California was 1 percent MW higher than the 1-in-2 forecast peak demand for SP26. The weather at the time of the SP26 peak demand was a 1-in-3 temperature event.

Table 1

2015 ISO Actual Peak vs Forecast			
Zone	2015 Actual	2015 1-in-2 Forecast	Difference from 1-in-2 Forecast
ISO	47,257	47,188	0%
SP26	27,475	27,183	1%
NP26	20,462	20,832	-2%

Generation

Actual daily generation levels during June through September 2015 for the CAISO system, the SP26 and NP26 zones are shown in *Appendix A: 2015 Summer Supply and Demand Summary Graphs.*

Interchange

Figure 5 shows the 2015 CAISO peak and the net interchange over the weekday summer peak load period. There are numerous factors that determine to the level of interchange between the CAISO and other balancing authorities at any given point in time.

Figure 5

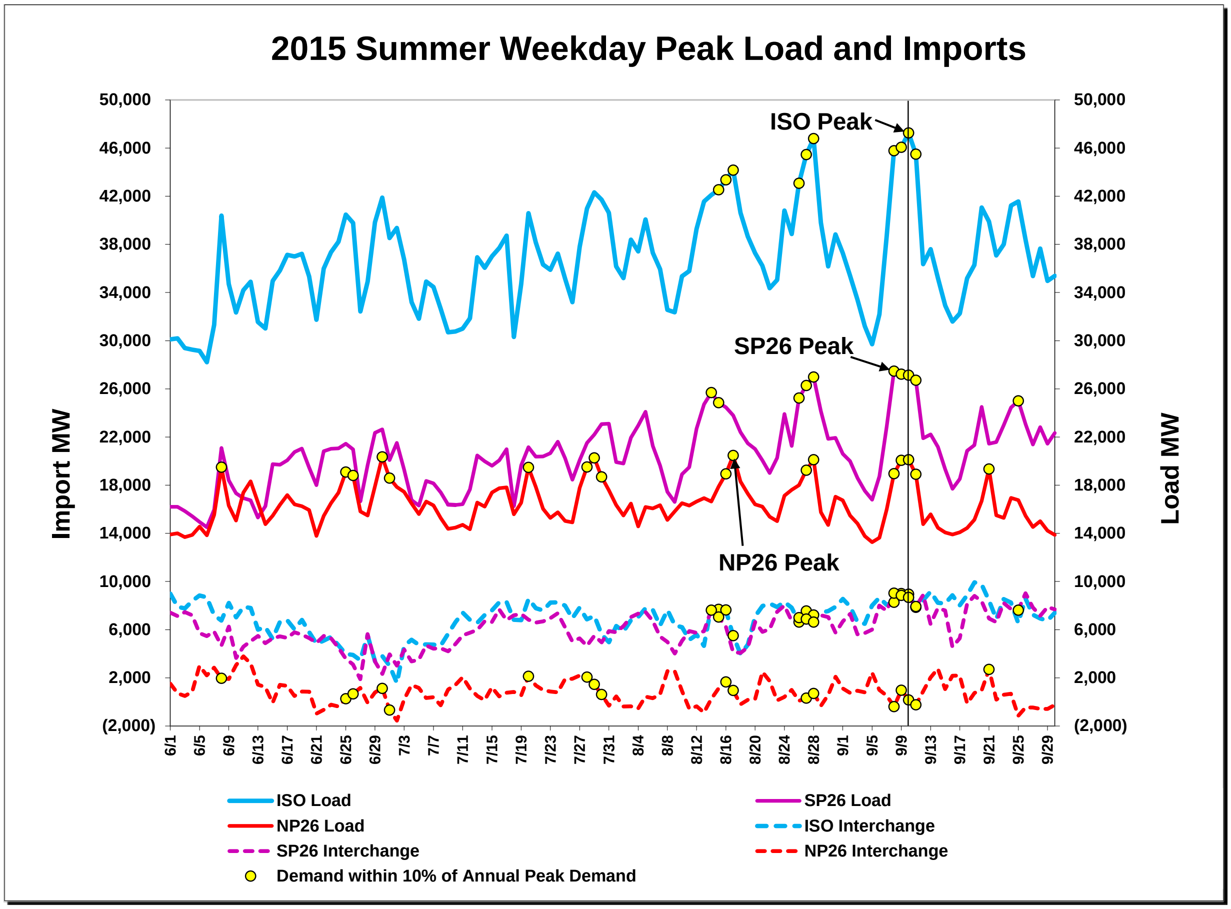


Figure 5 shows the amount of imports at CAISO daily system peaks.

III. SUMMER 2016 ASSESSMENT

Net Qualifying Capacity

The CAISO bases its operating reserves on the total net qualifying capacity (NQC) of its resource fleet. Total CAISO generation NQC for the 2016 summer peak is estimated to be 54,459 MW, a net 1,951 MW increase from June 1, 2015. Each year, the CPUC, CEC and CAISO work together to publish an NQC list, which describes the amount of capacity that can be counted from each resource to meet Resource Adequacy (RA) requirements in the CPUC's and CAISO's RA programs. The NQC for dispatchable resources depends on its availability and deliverability — the ability of the grid to deliver the generation to load centers. The CAISO determines the net qualifying capacity by testing and verification as outlined in the CAISO tariff and the applicable business practice manual.

The largest single generation resource type is natural gas generation accounting for 64.6 percent and the second largest generation type is non-hydro renewables including geothermal, biogas, biomass, wind and solar units that make up about 16.8 percent. Hydro accounts for 13.9 percent. Nuclear generation accounts for 4.1 percent while other fossil fuel generation provide 0.5 percent. The overall combined hydro resource NQC amount, regardless of a hydro unit's ability to qualify as a Renewables Portfolio Standard (RPS) resource, is shown in the NQC by fuel type chart shown in *Appendix C: 2016 CAISO Summer On-Peak NQC Fuel Type.*

Generation Addition

Table 2 shows the total net qualifying capacity generation of 1,902 MW from new generation interconnected to the CAISO balancing authority that came on line in the period from 6/1/2015 to 3/11/2016. This new NQC included 1,264 MW in SP26 and 638 MW in NP26. After 3/11/2016, 404 MW of additional NQC is expected to come on line by June 1, 2016, with 256 MW in SP26 and 148 MW in NP26 as shown in *Table 3.* During this same period, 355 MW of generation retired in SP26.

Table 4 shows the total generation capacity changes within the CAISO since 6/1/2015 and expected by 6/1/2016. A total of 2,306 MW of generation additions are expected to enter commercial operation for this summer, 1,520 MW in SP26 and 786 MW in NP26. This table was developed using the final NQC list that was used for the CPUC and CAISO's resource adequacy program for compliance year 2016, which the CAISO posted to its website. Generators who chose not to participate in the NQC process were added using the CAISO Master Control Area Generating Capability List, which is also posted on the CAISO website.[5]

[5] *Master Control Area Generating Capability List* website : http://www.caiso.com/participate/Pages/Generation/Default.aspx

Table 2

ISO Generation Additions from 6/1/2015 to 3/11/2016 (MW of NQC)			
Fuel Type	NP26	SP26	ISO
Battery	5	0	5
Biogas	1	0	1
Biomass	12	0	12
Hydro	0	0	0
Natural Gas	0	0	0
Solar	618	1226	1844
Wind	2	38	40
Total	638	1,264	1,902

Table 3

ISO Projected Generation Additions from 3/12/2015 to 6/1/2016 (MW of NQC)			
Fuel Type	NP26	SP26	ISO
Battery	0	0	0
Biogas	5	12	17
Biomass	0	0	0
Hydro	90	6	96
Natural Gas	5	135	140
Solar	44	62	106
Wind	4	41	45
Total	148	256	404

Table 4

Generation Additions from 6/1/2015 to 6/1/2016 (MW of NQC)			
Fuel Type	NP26	SP26	ISO
Battery	5	0	5
Biogas	6	12	18
Biomass	12	0	12
Hydro	90	6	96
Natural Gas	5	135	140
Solar	662	1288	1950
Wind	6	79	85
Total	786	1,520	2,306

This assessment uses all capacity available within the CAISO balancing authority regardless of contractual arrangements to evaluate resource adequacy in order to understand how the system will respond under contingencies. While some resources may not receive contracts under the resource adequacy program, and 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 report.

Conventional generation units such as gas and nuclear are individually modeled while biofuel and geothermal generation have their fixed hourly generation profiles that were developed based on the projected capacities and historical generation data on an aggregation basis.

New Stochastic Simulation Approach to Assess Supply and Demand Outlook

Significant amounts of new renewable generation has reached commercial operation and this trend is expected to continue as new renewable generation comes on line to meet the state's 33 percent RPS milestone by 2020 and the 50 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 a unique challenge for the analytical tools previously used by the CAISO to assess the near-term reliability picture.

As new renewable resources come on the system, equal amounts of flexible capacity from the existing fleet will not be retiring because the flexibility of the existing fleet (or potentially new flexible resources) is needed to integrate the new renewable resources. This has resulted in increasing capacity reserve margins. CAISO reliability requirements are evolving from a capacity requirement to meet peak load conditions to a peak and flexible capacity requirement where flexible capacity is needed to meet periods of high ramping requirements, both in the upward and downward directions. Daily demand profiles and daily renewable generator production profiles frequently combine to produce ramping requirements significantly greater than what has been required from the generator fleet in the past. Combining demand and renewable production profiles can produce periods of oversupply where renewable generation needs to be curtailed, particularly during the lower load spring and fall months when renewable generation is abundant.

To assess the changing resource needs from the increasing number of variable resources, the CAISO explored a more robust probabilistic approach and developed a PLEXOS stochastic simulation model to assess resource adequacy in capacity demand and flexibility requirement. The model uses a mixed-integer linear programing to determine the optimal dispatch for each hour of a net load profile based on the netting of load and renewable production. The simulation covers 39 WECC zones with 102 WECC interchange paths. The model runs chronologically to dispatch energy, ancillary services and load following to seek the least cost co-optimized solution to meet the capacity demand and flexibility requirement simultaneously. Operational constraints include forced and planned outage rates, unit commitment minimum up and down times, and ramp rate capabilities of each generator in the CAISO.

For hours where supply is sufficient, the model will determine how much reserve margin exists and calculates the annual minimum ORM based on available resource, import, export, and load for each 8,760 hour annual profile. Otherwise, the model will capture and report expected unserved hours and expected unserved energy by averaging number of hours and number of MWh per year where demand exceeds supply.

Generation Unavailability

For individual modeled units, each unit's forced outage was generated randomly based on its forced outage rate with a uniform distribution function while planned outages are sourced from 2016 CAISO Outage Management System report.

Unit Commitment

In each hour simulation, the model set 60 minutes ramping time for energy, 20 minutes for load following, and 10 minutes for ancillary services. Each dispatchable generator can run with a maximum ramp rate between minimum and maximum capacity.

During ramping up, the regulation up, spinning, and non-spinning provided by a generator cannot exceed its 10-minute ramping up capability and unused capacity; the regulation up, spinning, and non-spinning and load following up provided by a generator cannot exceed its 20-minute ramping capability and unused capacity; and energy, regulation up, spinning, and non-spinning, and load following up provided by a generator cannot exceed its 60-minute ramping capability and unused capacity. During ramping down, the difference between its minimum capacity and operating point limits the regulation-down and load following-down provided by a generator.

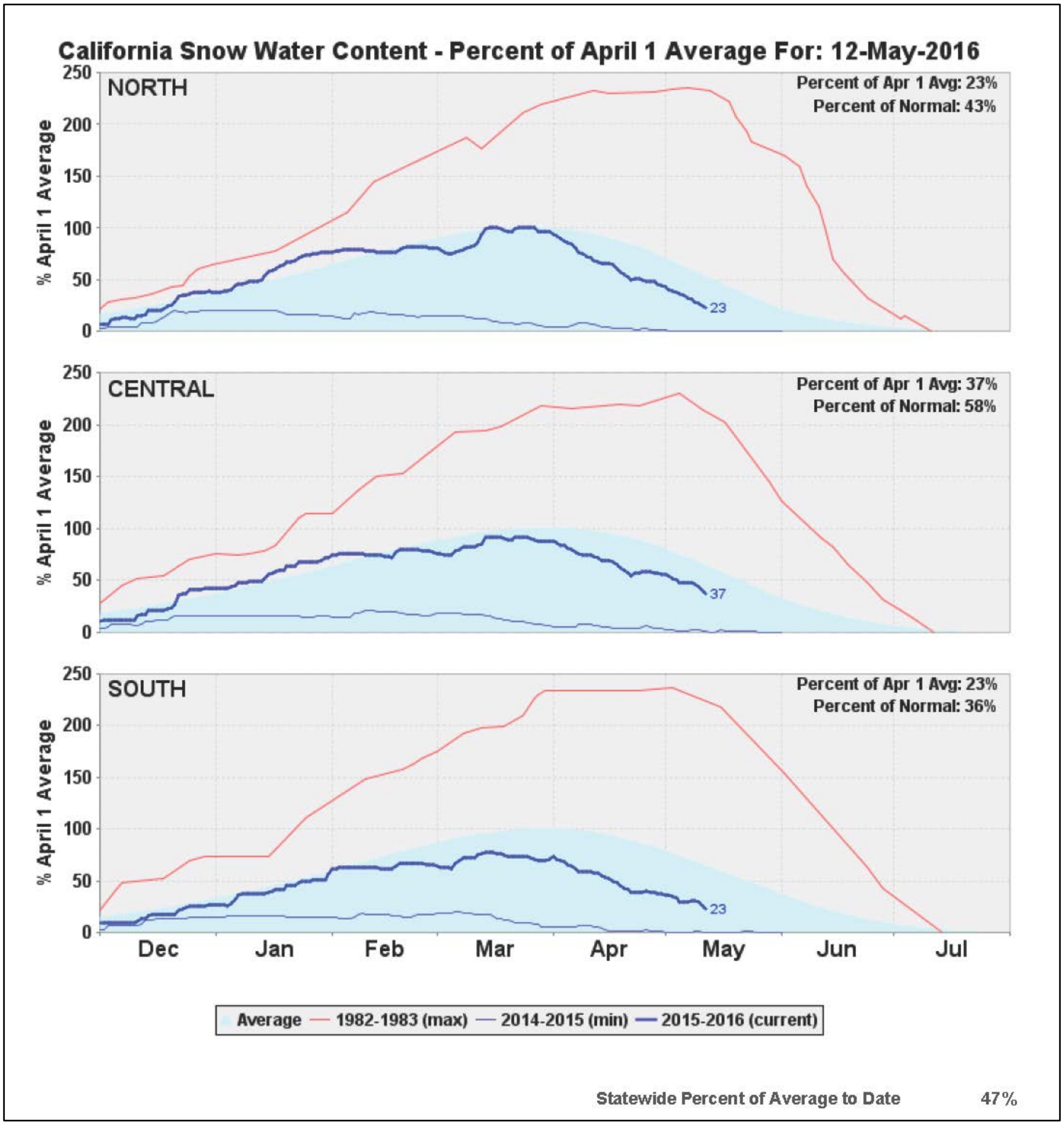
A generator needs start-up time to ramp from 0 MW to its minimum capacity. Before reaching minimum capacity, the generator cannot provide ancillary service or load following. Similarly, when a generator is in the process of shutting down there is a time frame between minimum capacity and complete shutdown where the generator cannot provide ancillary service or load following service. If a generator is committed, it must stay on for a minimum timeframe before it can be shut down. Once it is shut down, the resource will not be available for commitment until its minimum down time is over.

Hydro Generation

Hydroelectric capability is projected to be near normal for the 2016 spring and summer seasons. Hydro generation is modeled on an aggregated basis with two types: run-of-river and dispatchable. Run-of-river hydro generation has a fixed generation profile derived from historical data for the north and south. The dispatchable hydro generation is optimized subject to the daily energy limits and daily maximum values which are derived from historical data. Dispatchable hydro can provide ancillary services and load following. Pump storage generators are modeled individually and are optimized subject to storage capacity, inflow and target limits, and cycling efficiency.

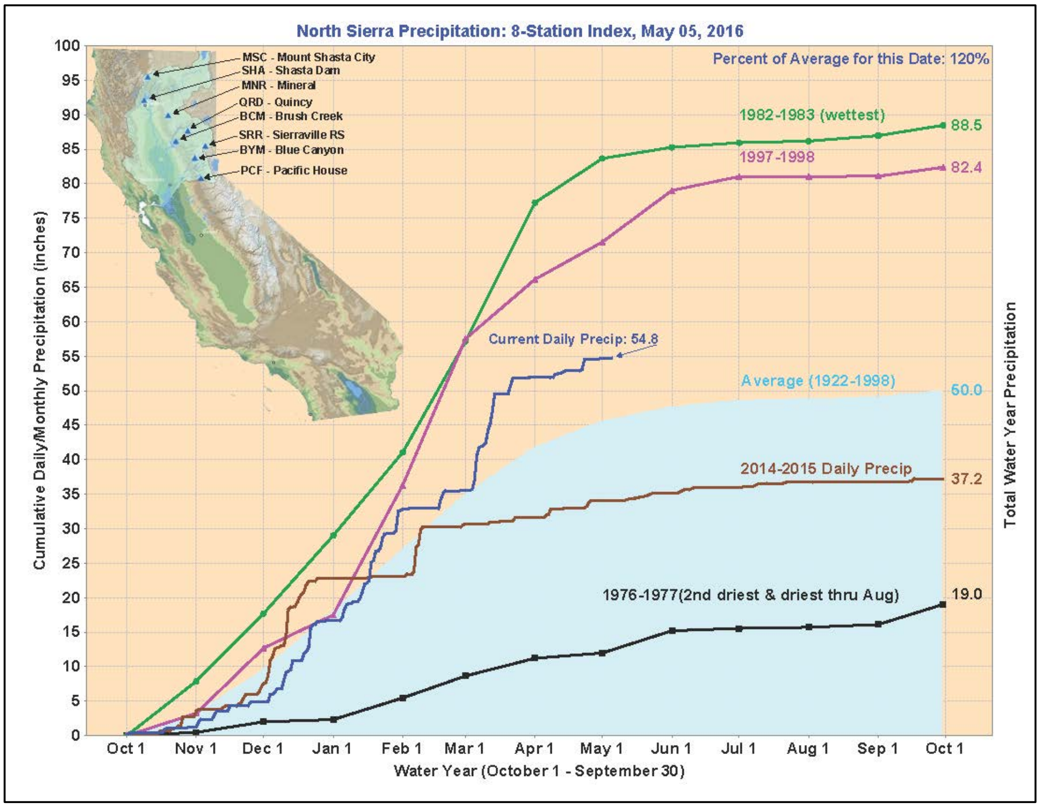
The close to normal hydro generation assumption was based on data as of March 30, 2016 that indicated the statewide snow water content was 87 percent of average for that date. Current snow water content is shown in *Figure* 6 and shows that snow melt runoff is progressing more quickly than the historical average. This situation is not significant enough to warrant revision of the hydro assumption used in for this Assessment. *Figure 7, 8* and *9* provide the latest water year's history of precipitation for North Sierra, San Joaquin and Tulare Basin, which has tracked approximately average or better. In addition, Northwest River Forecast Center projected the April to August reservoir storage in Columbia - Dalles Dam to be 101 percent of average. Water supply for Pacific Northwest in 2016 is higher than that in 2015. There are no concerns with Pacific Northwest hydroelectric generation.

Figure 6



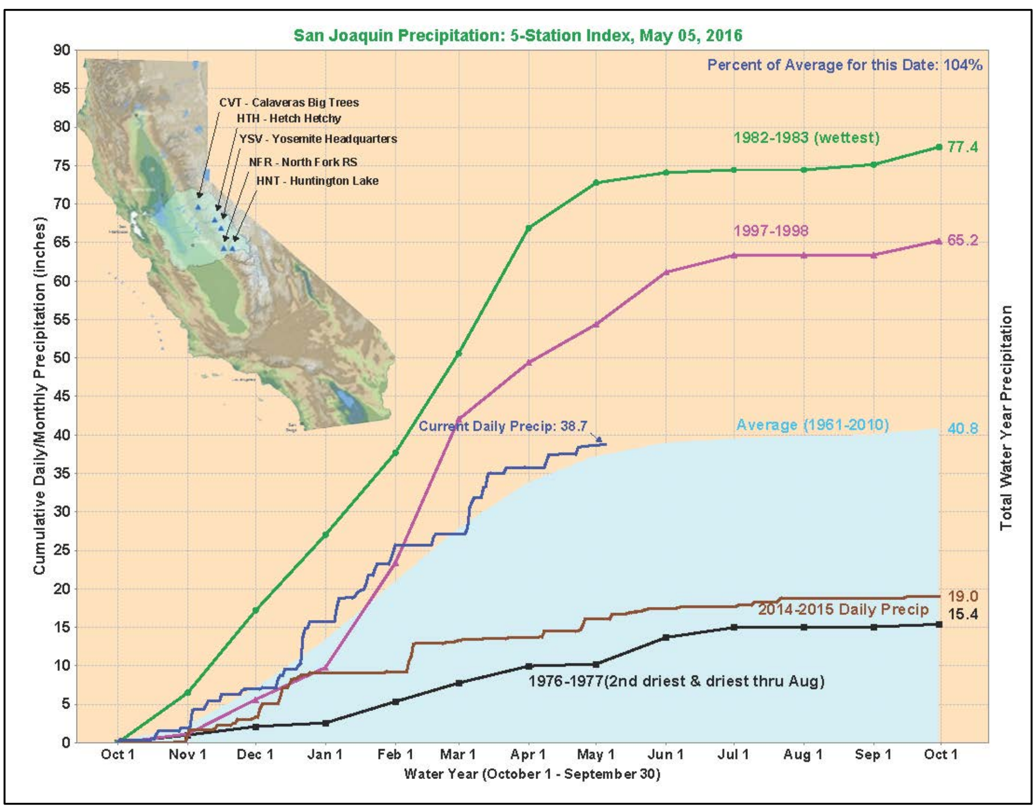
Source: California Department of Water Resources

Figure 7



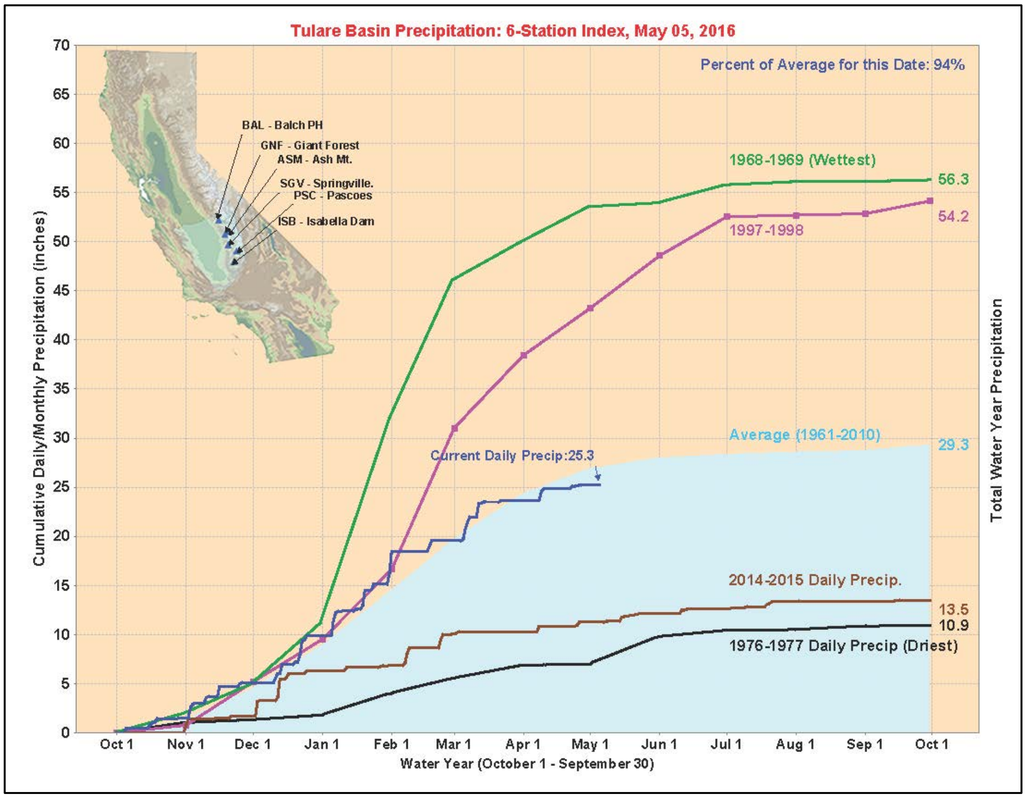
Source: California Department of Water Resources

Figure 8



Source: California Department of Water Resources

Figure 9



Source: California Department of Water Resources

Demand Response

Demand response programs reduce end-user loads in response to high prices, financial incentives, environmental conditions or reliability issues. They 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 categorized as event based and non-event based. Non-event based demand response is reflected in the demand forecast. Event based demand response or dispatchable demand response is modeled as a supply resource that has triggering conditions in the stochastic simulation model. Event-based demand response resources can be either on or off. They include base interruptible programs, aggregator managed portfolios, capacity bidding programs, demand bidding programs, smart AC, summer discount plans, and demand response contracts.

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 responses are needed.

CAISO Loads

Annual Peak Forecast

The annual peak forecast process has three steps. The first is to develop daily peak forecast models for PG&E Bay, PG&E Valley, SCE, and SDG&E in MetrixND®, the forecasting tool used by the CAISO. The inputs are historical loads, weather data, economic and demographic data, and calendar information. In the second step, a simulation program generates 147 weather scenarios though 21 years of historical weather data from 1995 through 2015. Each historical year has seven different weather scenarios so that each year has a scenario that starts on each of seven days of a week. Finally, 147 annual peaks are produced by combining the MetrixND models with the 147 weather scenarios.

The historical loads are hourly average demand values sourced from the CASIO energy management system (EMS) from January 1, 2003 through September 30, 2015. Water delivery pump loads were not counted 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.

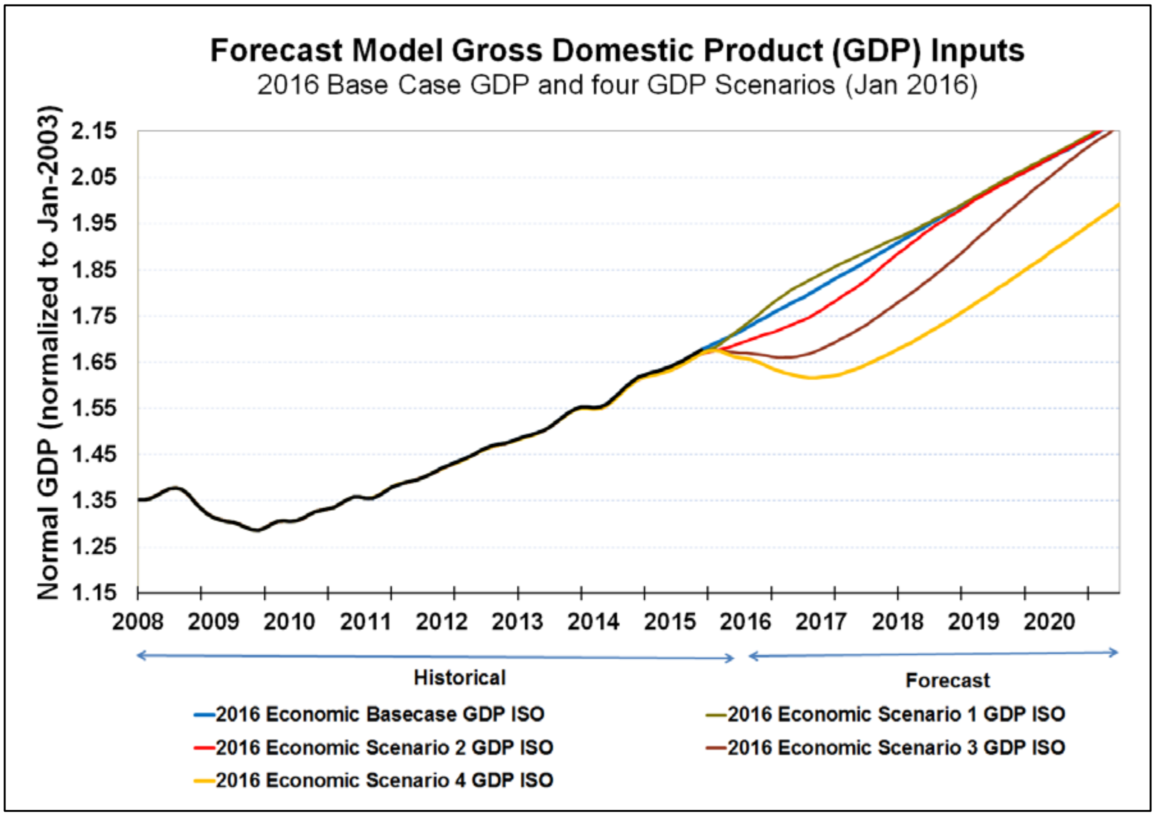
The weather data comes from 24 weather stations located throughout large population centers within the CAISO balancing authority. Weather data used in the model include maximum, minimum and average temperatures, cooling degree days, heat index, relative humidity, solar radiation indexes, as well as a 631 three day temperature weighting index.

The CAISO uses gross domestic product and population developed by Moody's Analytics for the metropolitan statistical areas within the CAISO as the economic indicator to the models. *Figure* 10 shows five economic scenario forecasts developed by Moody's Analytics that represents different outlooks of how the economy will play out based on different assumptions such as consumer confidence and household spending, labor markets and credit conditions.

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. Four other scenarios are defined below.

- Scenario 1 is a Stronger Near-Term Rebound Scenario in which the economy rebounds. It is designed so that there is a 10 percent probability that the economy will perform better than this scenario, broadly speaking, and a 90 percent probability that it will perform worse.
- Scenario 2 is a Slower Near-Term Recovery Scenario in which a second, relatively mild, downturn develops. It is designed so that there is a 75 percent probability that economic conditions will be better than this scenario, broadly speaking, and a 25 percent probability that conditions will be worse.
- Scenario 3 is a Moderate Recession Scenario in which a more severe second downturn develops. It is designed so that there is a 90 percent probability that the economy will perform better than this scenario, broadly speaking, and a 10 percent probability that it will perform worse.
- Scenario 4 is a Protracted Slump Scenario, it is designed so that there is a 96 percent probability that the economy will perform better than this scenario, broadly speaking, and a 4 percent probability that it will perform worse.

***Figure* 10**



Source: Macroeconomic Outlook Alternative Scenarios – Dec. 2015

Figure 10 shows that under the most likely scenario (base case) the economy will experience a modest recovery this year.

In *Figure 10, s*cenario 1 is more optimistic than the base case forecast while scenarios 2 through 4 are progressively more pessimistic. The range of divergence between the various scenarios began January 1, 2016. It is important to note that these forecasts are based on the Moody's gross domestic product forecasts released in December 2015. The gross domestic product data reflects actual historical data through Dec 31, 2014 (January 2015 and later historical data are estimates of actual GDP). Consequently, this forecast is based on data available at that time.

Figure 11 shows CAISO 1-in-2 peak demand forecasts based on the five economic scenarios from Moody's Analytics. The 2016 forecasted 0.8 percent increase over the CAISO 2015 normal weather peak demand represents a moderate level of economic recovery over 2015 assuming 1-in-2 weather for the 2016 summer peak demand.

Figure 11

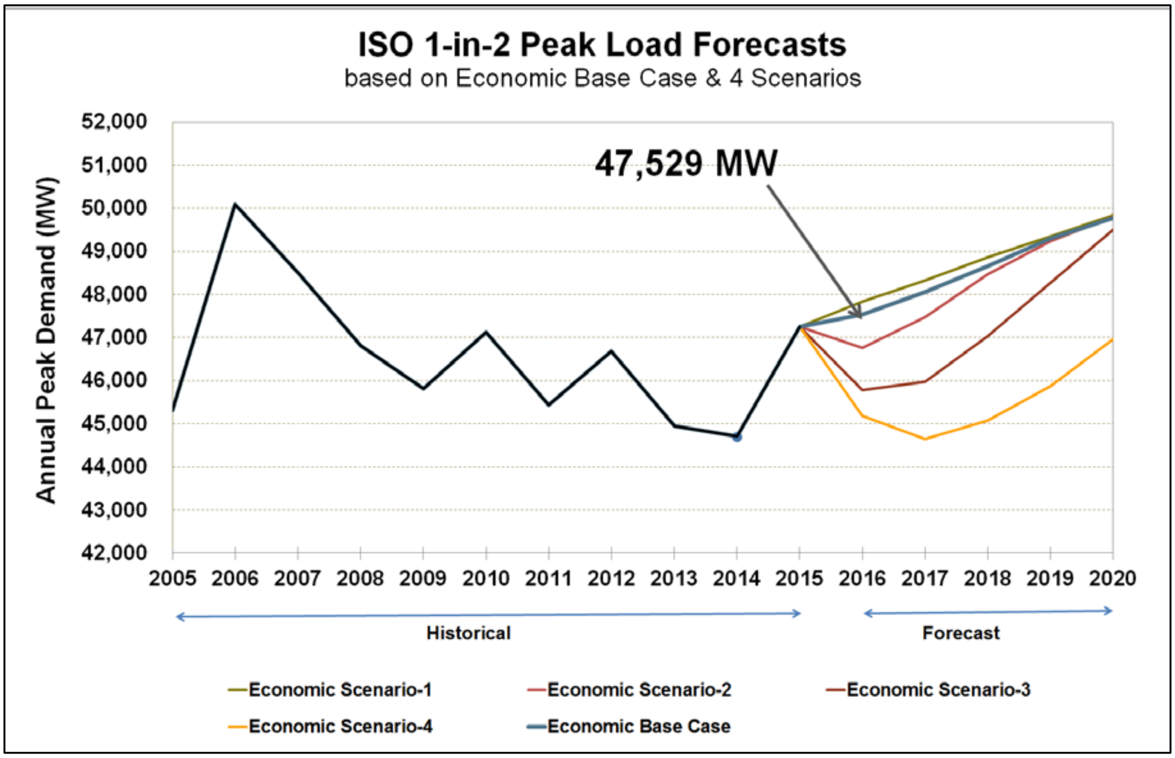


Figure 11 shows that the CAISO annual peak demand will increase in close parallel with base case economic growth (see *Figure 10*).

Hourly Net Load

First, 12 year of historical hourly load profiles were matched with the forecasted 147 annual peak levels to produce 147 gross load samples. Next, four years of hourly solar capacity factors and 10 years of hourly wind capacity factors were combined with projected 2016 wind and solar capacity. The wind and solar capacity factors were multiplied with projected wind and solar installed capacities to arrive at the forecasted wind and solar generation profiles. Finally, hourly net load was calculated by subtracting solar and wind generation from gross load.

Net Load = Gross Load - Solar - Wind

A total of 2000 random samples (100 gross load samples x 4 solar samples x 5 wind samples) were randomly selected. One hundred random draws were taken from a gross load pool of 147 samples, five random draws from wind generation pool of 10 samples, and four draws from solar generation pool as illustrated in *Figure 12*.

Figure 12

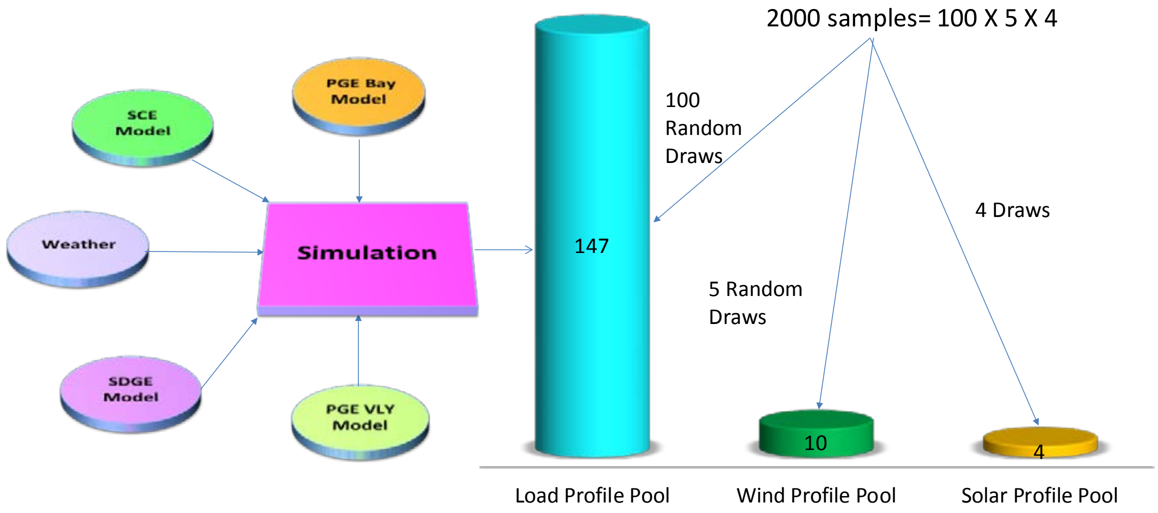


Figure 12 2000 samples of net loads are randomly selected from 5,880 samples

Two thousand (2,000) randomly selected samples of hourly net loads for PG&E Bay, PG&E Valley, SCE, and SDG&E were developed based on the CAISO load forecast process while the rest of the 35 WECC zonal Load profiles were prepared based on a 1-in-2 peak and energy forecast from WECC.

Flexibility

The CAISO used a probabilistic Monte Carlo simulation program to calculate regulation and load following requirements. This program was developed by Pacific Northwest National Laboratory (PNNL) and the CAISO. Flexibility requirement includes ancillary service and load following. Regulation requirement is the largest 1-minute deviation in each 5-minute schedule period of net load within an hour. Load following requirement is the largest deviation between 5-minute schedule and hourly schedule of net loads within the hour. The purpose of this model was to calculate the intra-hour regulation and load following requirements and convert these intra-hour requirements to hourly requirements. Inputs were 1-minute and hourly projected load, wind and solar generation profiles of the simulation year as well as hourly forecast standard deviations of load, wind and solar generation, and real time load forecast standard deviation. Outputs were hourly profiles for regulation and load following requirements. Spinning and non-spinning reserve were each 3 percent of gross load, respectively.

Interchange

The model simulated 39 WECC zones and 102 WECC interchanges between zones *in Figure 13*. The zonal interchange path limits were set based on 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 reflected the maximum simultaneous transfer capabilities. In addition, a total CAISO maximum import limit was set based on historical import patterns. Export from California was subject to the transmission limits of the export paths. Path 15 and Southern California Import Transmission (SCIT) nomogram constraint were enforced in the model.

Figure 13

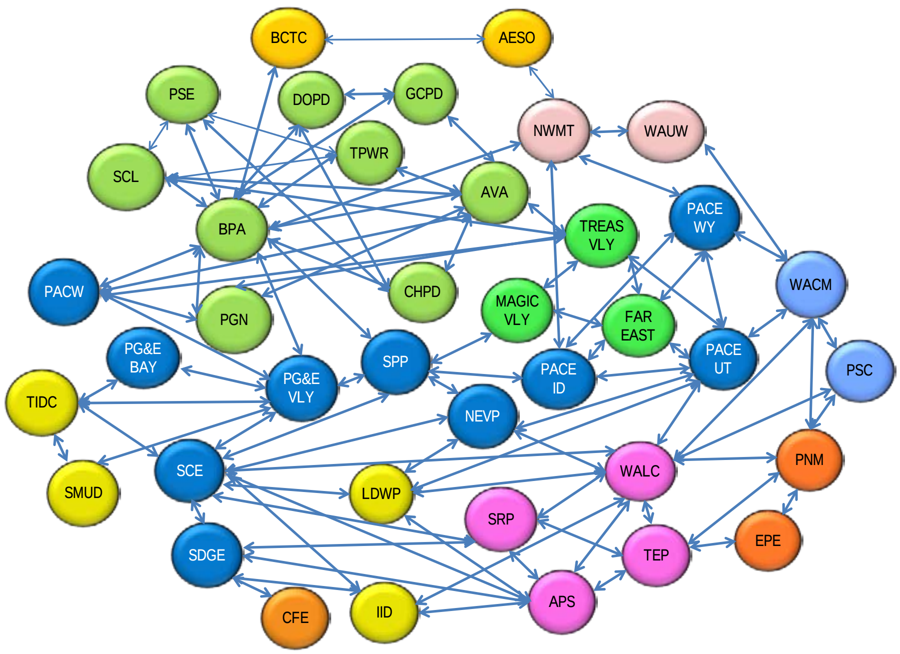


Figure 13 Simulation covers WECC 39 Zones and 102 Paths

Probabilistic Analysis

The PLEXOS stochastic model was applied to perform the 2016 summer loads and resources assessment study. The model used a mixed-integer linear programing to dispatch available resource to meet net load demand and flexible capacity requirement. The simulation ran 2,000 samples on an hourly interval chronologically. Each sample had an 8,760 hour annual profile. The optimization time horizon was set as 24 hours. The end status of one optimization was used as initial status of the next optimization

For sufficient capacity and flexibility, the model reports annual minimum ORM for each 8,760 hour annual profile sample based on available resource including demand response, imports, exports, and load.

Annual Minimum ORM = Min $(ORM\ (1), \ldots, ORM\ (t), \ldots, ORM(8760))$

ORM (t) = $\frac{Available\ Resources(t) + Import(t) - Export(t)}{Load(t)}$ -1

When demand exceeds supply in flexible or system capacity, expected unserved hours and expected unserved energy will be calculated and reported using average of number of hours and number of MWh per year where demand or requirement exceed supply.

$$\text{Expected Unserved Hours} = \frac{\sum_{k=1}^{M} Unserved\ Hours_k}{2000}$$

$$\text{Expected Unserved MWh} = \frac{\sum_{k=1}^{M} \text{Unserved MWh}_k}{2000}$$

Where M is the total number of unserved occurrence in 2,000 runs.

For 2016, the simulation results found no upward shortage in capacity for demand, or for flexible capacity requirements. As a result, the model calculated annual minimum ORM for CAISO, SP26 and NP26. Figures 14, 15, and 16 shows that annual minimum ORMs for CAISO, SP26 and NP26 are projected to be well above the 3 percent firm load shedding threshold in the most extreme scenario for each area. While operating reserves are not necessarily procured on a zonal basis, the information portrayed in Figures 15 and 16 are useful for preparing for contingency events. Even with these projected operating reserve margins the CAISO prepares contingency plans to deal with extreme events that could lead to firm load shedding.

These Figures represent analyses of conditions for the CAISO system as a whole, and for the SP26 and NP26 zones. These results do not account for local transmission constraints within the CAISO system or within each zone. Based on this study methodology, no firm load shedding would be needed under scenarios studied, even the most extreme scenarios. However, the reserve margins represented in this assessment do not account for the gas curtailment risk identified in the Aliso Canyon Risk Assessment Technical Report.

Figure 14

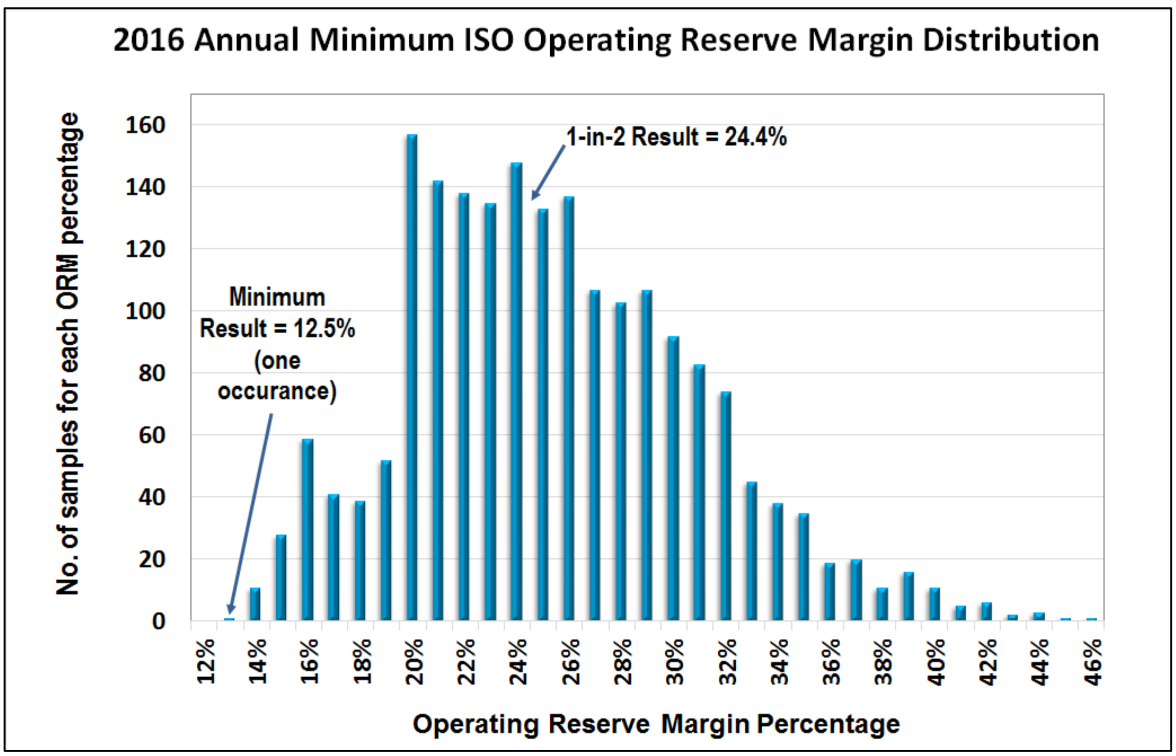


Figure 14 shows forecasts of annual minimum operating reserve margins for the CAISO.

Figure 15

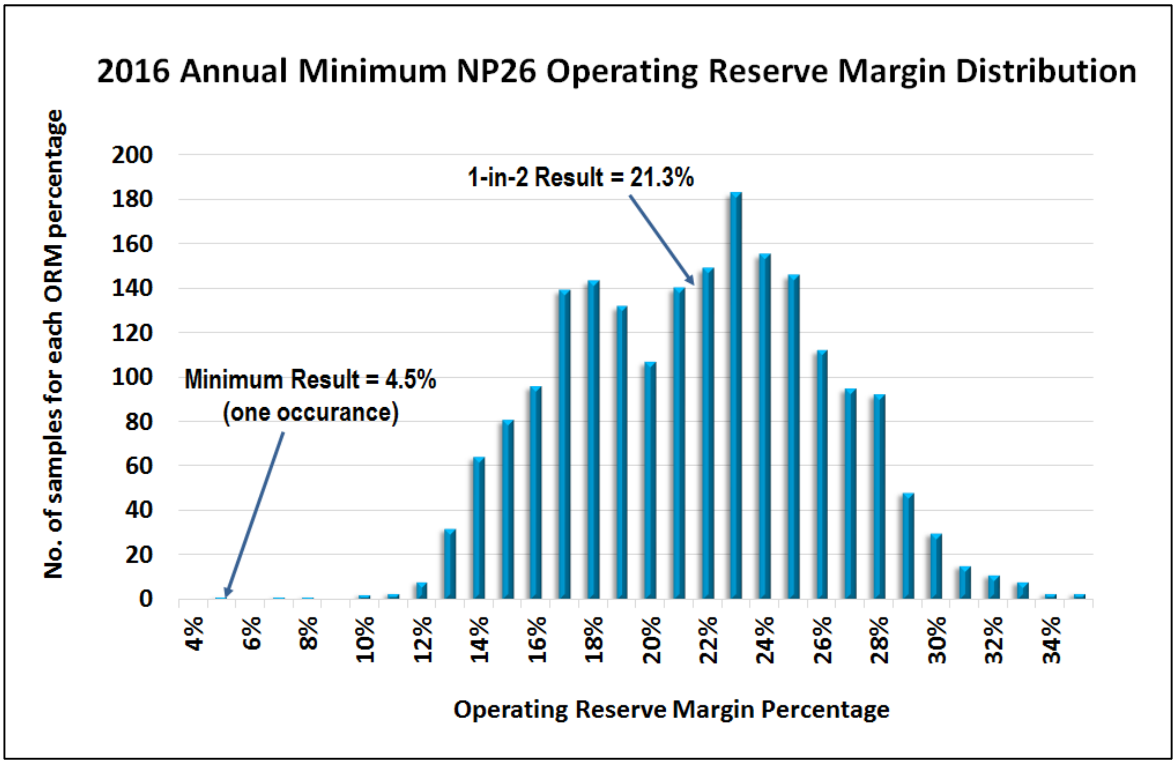


Figure 15 shows forecasts of annual minimum operating reserve margins for the NP26.

Figure 16

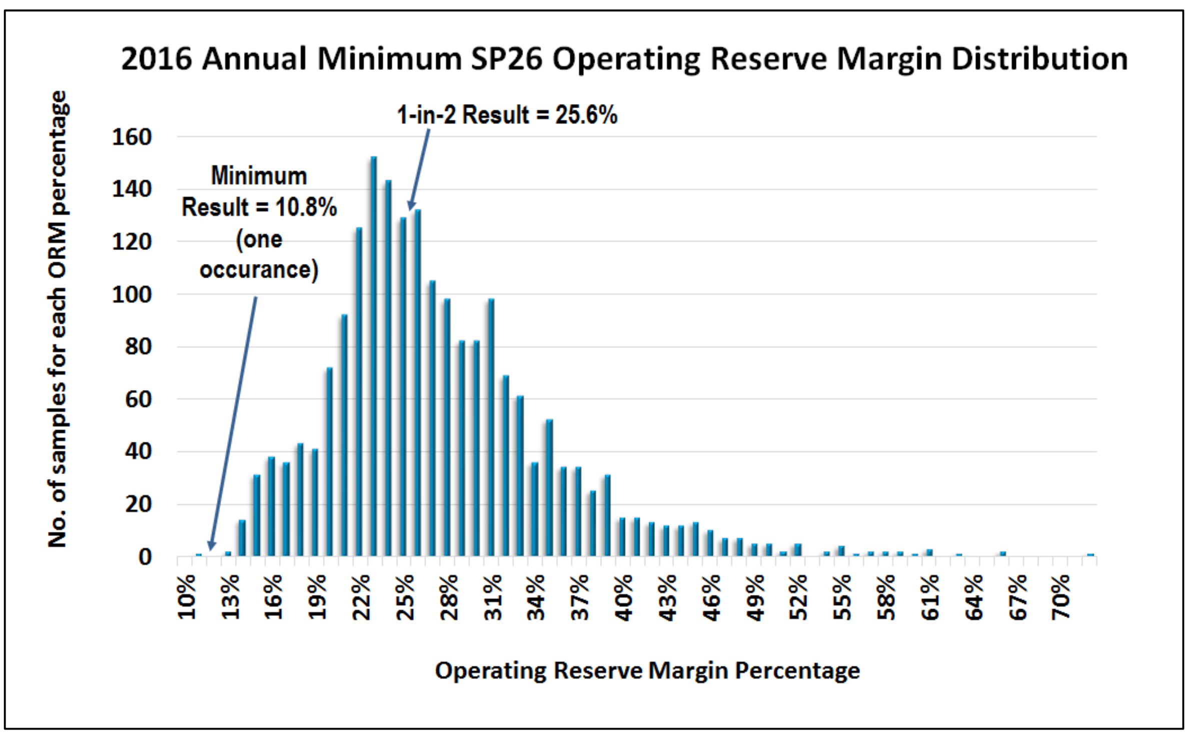


Figure 16 shows forecasts of annual minimum operating reserve margins for the SP26.

Impacts of the Aliso Canyon Gas Storage Operating Restrictions

One of the wells at the Aliso Canyon gas storage facility developed an uncontrolled gas leak in October 2015 that lasted into February 2016 when the well was successfully sealed. The gas leak incident caused the California Public Utility Commission (CPUC) to issue an order directing Southern California Gas Company (SoCalGas) to draw down the field to 15 billion cubic feet. No new injections to the gas storage facility are currently permitted. Limited withdrawal capability exists to maintain energy reliability.

A team comprised of the California Energy Commission (CEC), CPUC, CAISO, Los Angeles Department of Water and Power (LADWP) and SoCalGas was formed to identify potential risks, as well as possible mitigation measures and address potential electric reliability concerns for the coming summer across the LA Basin and throughout Southern California. Technical experts from the team performed an Aliso Canyon risk assessment and documented their findings in the Aliso Canyon Risk Assessment Technical Report.[6] Seventeen gas-fired power plants totaling 9,500 MW located in the LADWP and the CAISO balancing authority areas were identified as the electric generation most directly affected by Aliso Canyon's reduced capabilities. The Aliso Canyon Risk Assessment Technical Report found that if no gas can be withdrawn from Aliso Canyon during the coming summer months, a significant risk exists of natural gas curtailments during up to 16 days this summer when there are mis-matches between scheduled gas supplies and actual gas demand. The gas curtailments could be large enough to electric generations in Southern California to result in the need to potentially interrupt service and affecting millions of electric customers during as many as 14 summer days. Several factors contribute to this risk including mismatches between scheduled gas on the pipeline system and actual daily gas demand, planned and unplanned outages to non-Aliso storage that reduce supply, and planned and unplanned pipeline outages that reduce delivery capacity. Prolonged periods of high electrical demand also increase the risk of gas curtailments and electrical service interruption. This happens during heat waves when air conditioning use spikes and all natural gas-fired electricity generation is required.

The reserve margins represented in this assessment do not account for the gas curtailment risk identified in the Aliso Canyon Risk Assessment Technical Report. If any gas supply curtailment were to occur to gas fired generation in Southern California at the levels that were identified in the technical assessment the reserve margins in SP26 could be depleted. However, the risk of interrupting load on any particular day would depend on local constrained conditions within Southern California as well as the extent to which the transmission system and available supply is capable of absorbing gas curtailment in real-time.

The CAISO manages the dispatch of several generators dependent on gas coming from the SoCalGas system that are either directly or indirectly impacted by the Aliso Canyon operational constraints. The CAISO recognizes concerns that its commitment or dispatch instructions, especially in real-time, could cause challenges to generators under a daily balancing requirement or an operational flow order. The CAISO has completed a stakeholder process that proposed market mechanisms and other tools the CAISO can use, including the mitigation measures explored by the task force, to mitigate the risks to

[6] Aliso Canyon Risk Assessment Technical Report
http://www.energy.ca.gov/2016_energypolicy/documents/2016-04-08_joint_agency_workshop/Aliso_Canyon_Risk_Assessment_Technical_Report.pdf

gas and electric reliability to avoid electric service interruptions to the extent possible. The measures approved by the CAISO Board of Governors and filed with the Federal Energy Regulatory Commission are designed to ensure the CAISO's dispatches are better coordinated with the constrained gas system and minimize, to the extent possible, the impact of further challenges to gas and electric system reliability this summer. The measures help ensure that the limitations of the constrained gas system are reflected in the CAISO market processes. This is either through bids submitted by affected generators, or through operational tools by which the CAISO further constrains market dispatches and transmission flows to ensure its markets produce solutions that are reflective of the constraints the gas system imposes on electrical generators[7]. The measures including the following:

1. To increase access to potentially useful market information prior to the CAISO day-ahead market, the CAISO proposes to provide to scheduling coordinators, for informational purposes only, advisory commitment schedules produced in the residual unit commitment process conducted in a two-day-ahead basis based on available bids and forecasts of system conditions. These advisory schedules are not financially or physically binding but should be useful in assisting scheduling coordinators with gas procurement decisions and gas nominations processes.
2. Implement a timelier and more accurate gas commodity prices used for commitment costs bid caps, default energy bids, and generated bids in the day-ahead market. This method will reflect prevailing gas prices, in contrast to the CAISO's current day-ahead gas price index, which uses prices published the day before the market run. This will enable the day-ahead market to better capture gas price variability that may occur because of summer constraints, resulting in day-ahead schedules that are better aligned with actual gas system conditions.
3. Increase the gas commodity price used to calculate commitment costs and default energy bids for resources served by the affected gas systems by an amount necessary to ensure that the cost minimizing market-clearing process considers the impact of gas system limitations in dispatching these resources, such as the need to limit the dispatch of these resources for local rather than system-wide needs. This will help mitigate against the real-time market dispatching resources that are affected by the absence of available gas from Aliso Canyon and ensure the CAISO dispatches do not further aggravate existing gas system constraints.
4. Allow resources to rebid their resource commitment costs in the CAISO real-time market if the resource was not committed in the day-ahead market and the resource has not already started up and in its minimum run time range.[8] This too can alleviate pressures on the gas and electric system by ensuring these resources' costs in the CAISO real-time market appropriately reflect real-time gas constraints when conditions on the gas system change.
5. Ensure the CAISO's short-term unit commitment process does not commit resources in the real-time that were not committed in the day-ahead and does not

[7] Revised Draft Final Proposal - Aliso Canyon Gas-Electric Coordination. Available at http://www.caiso.com/Documents/RevisedDraftFinalProposal_AlisoCanyonGas_ElectricCoordination.pdf

[8] The CAISO developed this proposal prior to the issues created by the Aliso storage facility arose. However, this flexibility is helpful in ensuring that if the generator faces higher costs in the real-time than it did in the day-ahead, it can reflect those higher costs in its bids and allow the CAISO real-time market to consider those costs accordingly.

automatically resubmit bids into real-time market. In addition to preventing the commitment of resources that have not bid into the real-time market and that have no obligation to do so, this tariff change will avoid exposing resources to additional unplanned real-time gas procurement variability resulting from real-time commitments.

6. Include a new constraint in the CAISO markets that the CAISO operators can use to better ensure dispatches are consistent with observed gas system limitations and avoid further stressing the gas system, which could in turn adversely impact electric grid reliability. Through this additional operational tool, the CAISO market clearing process will be able to limit the maximum amount of generation dispatched in a given area of the CAISO balancing authority area if burning more gas might risk jeopardizing gas and electric system reliability. Similarly, the CAISO will be able to use the constraint to ensure a minimum amount of generation is dispatched in a given area if it is necessary to do so to avoid further stressing the gas system and assure reliability on the electric grid. This constraint will also allow CAISO operators minimize variations between the day-ahead and real-time gas usage if such variations have the potential to undermine gas and electric system reliability.
7. Expand the CAISO's authority to reserve internal transfer capability by adjusting transmission constraints on the system it operates and release this internal transfer capability as needed. The CAISO will be able to use this operational tool in the market clearing process to help ensure that it dispatches or commits resources from other areas of the grid as necessary to ensure that resources in the southern California region are deployed in a manner that recognizes gas system limitations. In conjunction with the need for authority to reserve internal transfer capability, the CAISO is also requesting authority to adjust the network model used in the release of monthly congestion revenue rights to ensure the CAISO does not release rights that will not be sufficiently funded by congestion revenues collected in the day-ahead market.
8. Provide the CAISO with authority to suspend convergence bidding if the CAISO determines it is adversely affecting market efficiency. This authority is necessary so that virtual bidding does not undermine the measures taken by the CAISO to ensure that schedules and dispatches reflect actual physical conditions. This authority is also necessary to ensure, during the summer months when the system will be constrained and the CAISO is implementing the measures proposed in this filing, that virtual bidding does not result in adverse market outcomes that unfairly transfer revenue from one group of market participants to another.
9. Add tariff provisions that allow scheduling coordinators to seek after-the-fact cost recovery from the Commission in a section 205 filing, to the extent they are otherwise unable to recover their costs through the CAISO's cost-recovery mechanisms.

In addition to these measures, the ISO is increasing its operational coordination with SoCalGas as well as LADWP to increase awareness of changing operational conditions and be ready to act appropriately to mitigate risks to gas and electric reliability. Last, the ISO is also collaborating with Peak reliability coordinator and WECC to ensure the transfer capability is maximized to the extent possible during periods of electric supply challenges brought on by gas curtailments.

Once Through Cooling

Table 5 shows the power plants that are subject to the Statewide Water Quality Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling. Of the once through cooling (OTC) units' 17,792 MW of generating capability affected by the regulations, 5,706 MW are in compliance. The remaining 9,847 MW of generation will be required to repower or retire in by the end of 2020, with many expected by the end of 2017. Compliance for Diablo Canyon is subject to a pending study by a Water Board Review Committee for Nuclear Fueled Power Plants.

Currently there are no indications that compliance dates are not achievable. However, an April 2016 draft report of the Statewide Advisory Committee on Cooling Water Intake Structures (SACCWIS) recognized that existing facilities using OTC technology may require an extension of their retirement/repowering plans under the OTC policy compliance schedule if one or more uncertainties combine to threaten local or system reliability or if replacement infrastructure is not developed on a schedule that matches with the existing OTC compliance dates. SACCWIS plans to include the status of new infrastructure development in the CAISO system and local capacity areas to the State Water Board in future discussions concerning the implementation of the OTC policy.

With no planed retirements of any OTC units in the 2016 summer timeframe, no impacts from implementation of the OTC policy are expected during the 2016 summer period.

Table 5

Generating Units Compliance with California Statewide Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling

Plant (Unit)	Owner	Final Compliance Date	Capacity (MW)	PTO Area
Compliance Plan Yet to be Implemented (Natural Gas Fired)				
Encina Power Station Units 1-5	NRG	12/31/2017	946	SDG&E
Pittsburg Units 5 and 6	NRG	12/31/2017	629	PG&E
Moss Landing Units 1 and 2	Dynegy	12/31/2017	1,020	PG&E
Moss Landing Units 6 and 7	Dynegy	12/31/2017	1,500	PG&E
Huntington Beach Units 1-2	AES	12/31/2020	452	SCE
Redondo Beach Units 5-8	AES	12/31/2020	1,343	SCE
Alamitos Units 1-6	AES	12/31/2020	2,011	SCE
Mandalay Units 1 and 2	NRG	12/31/2020	430	SCE
Ormond Beach Units 1 and 2	NRG	12/31/2020	1,516	SCE
		Total MW	**9,847**	
In Compliance				
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	**5,705**	
Compliance pending study by Water Board Review Committee for Nuclear Plants				
Diablo Canyon	PG&E	12/31/2024	2,240	PG&E
		Total MW	**2,240**	
		Total of all OTC Units	**17,792**	

Conclusion

The 2016 PLEXOS stochastic simulation results show no upward shortage in capacity for demand, or for flexible capacity requirements for 2016 at a CAISO system and zonal NP26, and SP26 levels. Continued moderate peak demand growth, combined with the availability of over 2,300 MW of new power generation having come on line since the June 2015 and improving hydro generation conditions result in an overall adequate summer supply outlook for summer 2016 to meet a broad range of operating conditions. However, the Aliso Canyon operating restrictions creates a significant risk of natural gas curtailments that could result in an inability to operate a portion of the gas-fired electricity generation fleet in Southern California. Analysis of this risk has shown that these curtailments could result in interruption of electric service to customers in Southern California, potentially affecting millions during as many as 14 summer days.

The CAISO annually trains its grid operators to be prepared for system events, and understand 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.

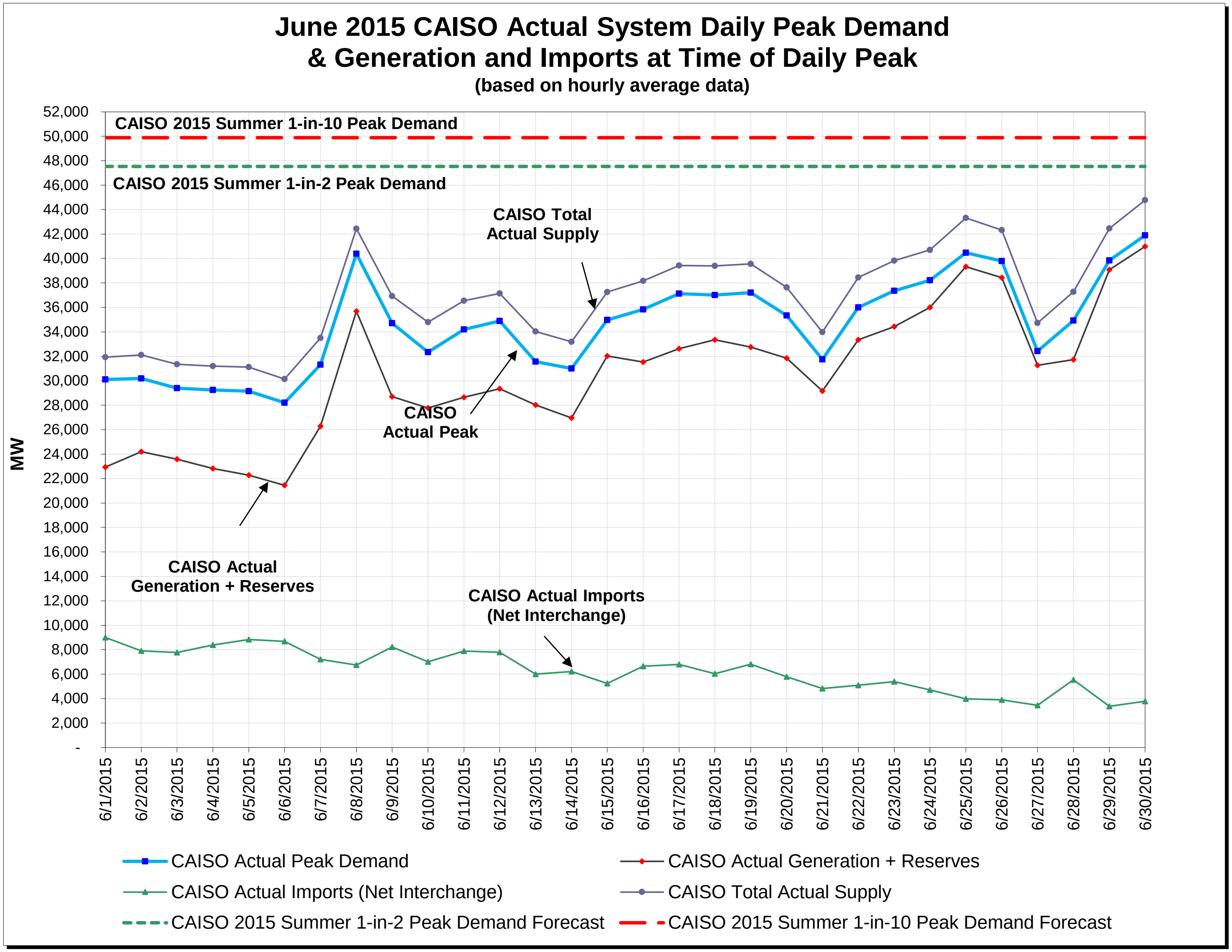
IV. APPENDICES

A: 2015 Summer Supply and Demand Summary Graphs

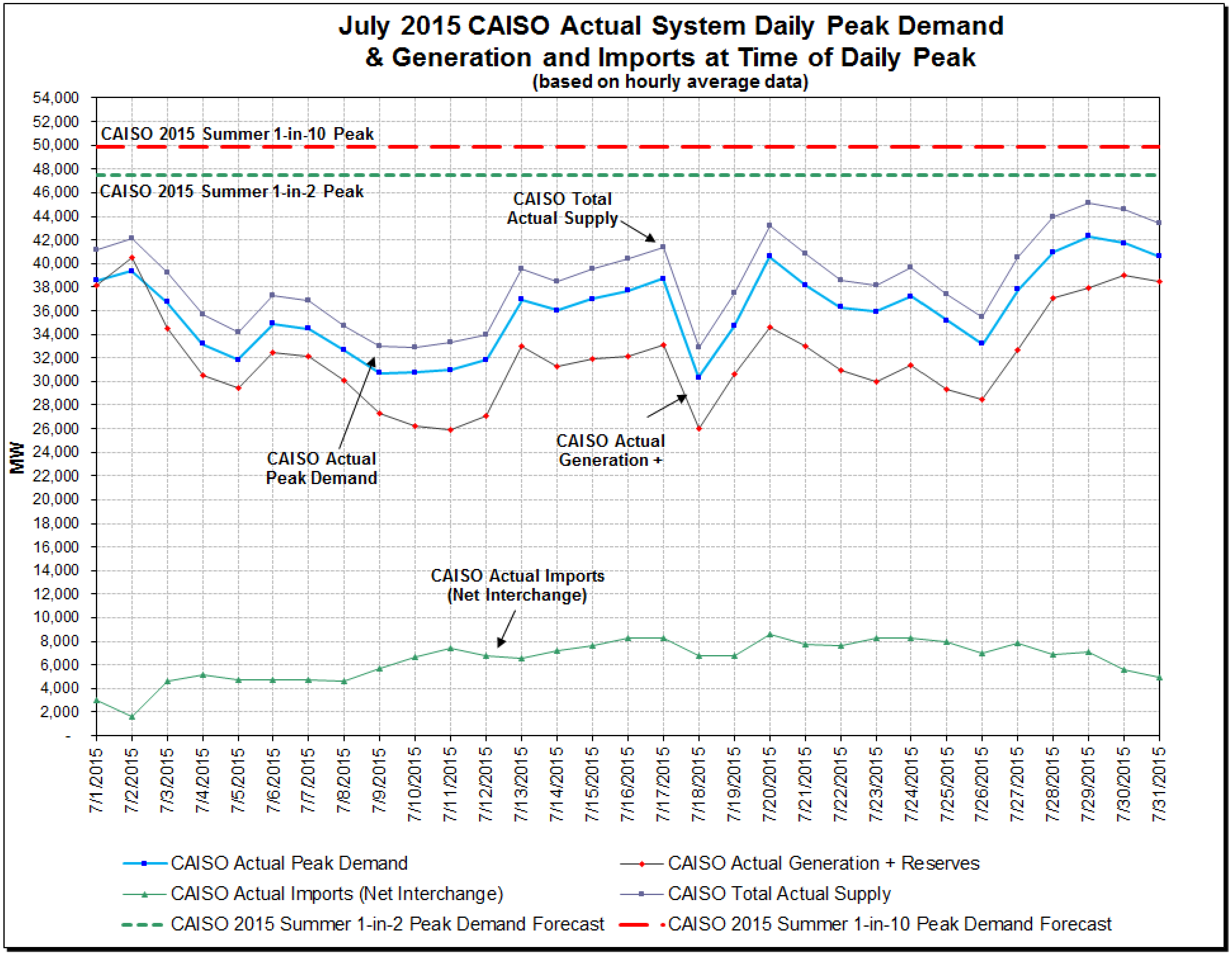
B: 2015 Summer Imports Summary Graphs

C: 2016 CAISO Summer On-Peak NQC Fuel Type

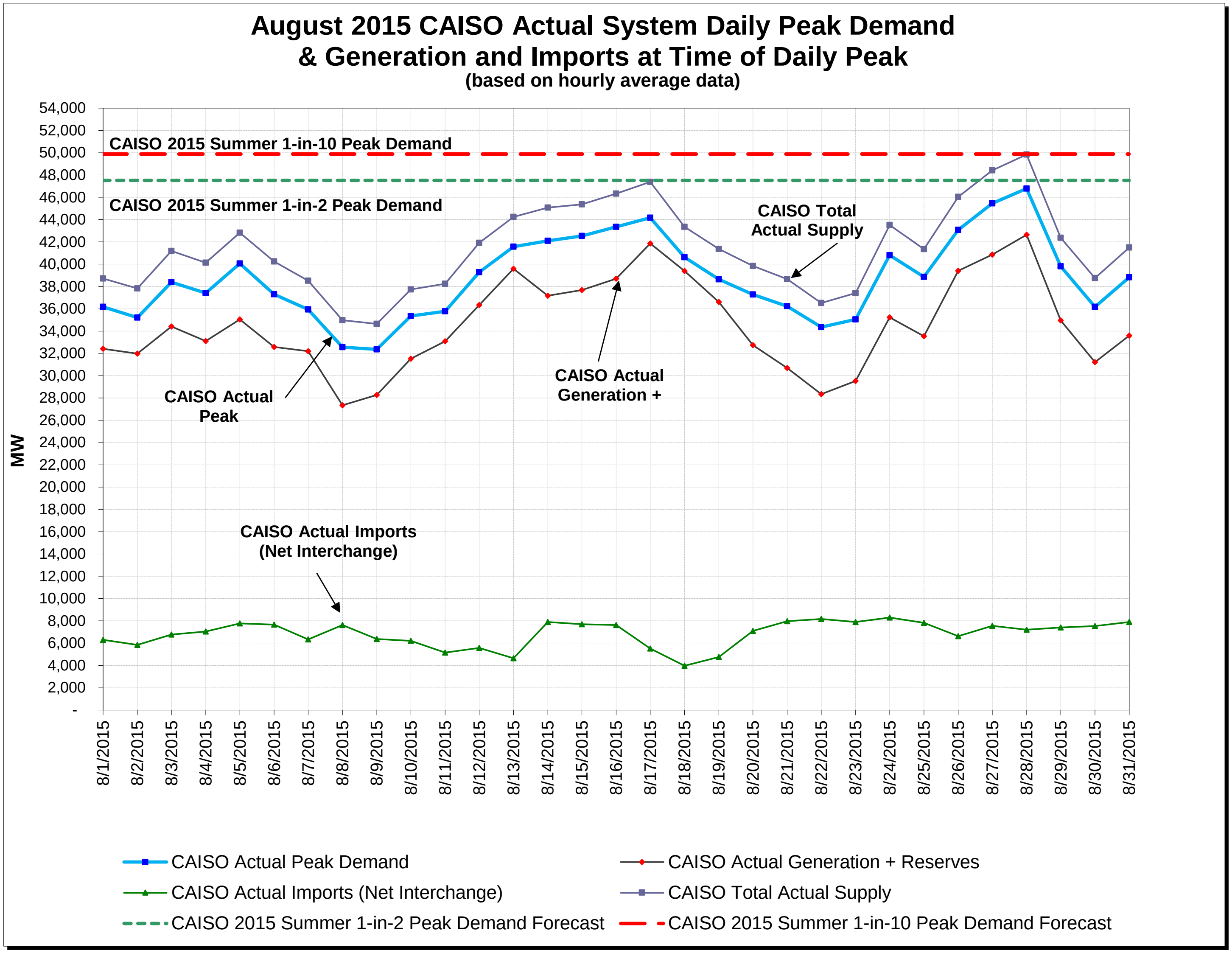
Appendix A: 2015 Summer Supply and Demand Summary Graphs



Appendix A – Continued



Appendix A – Continued



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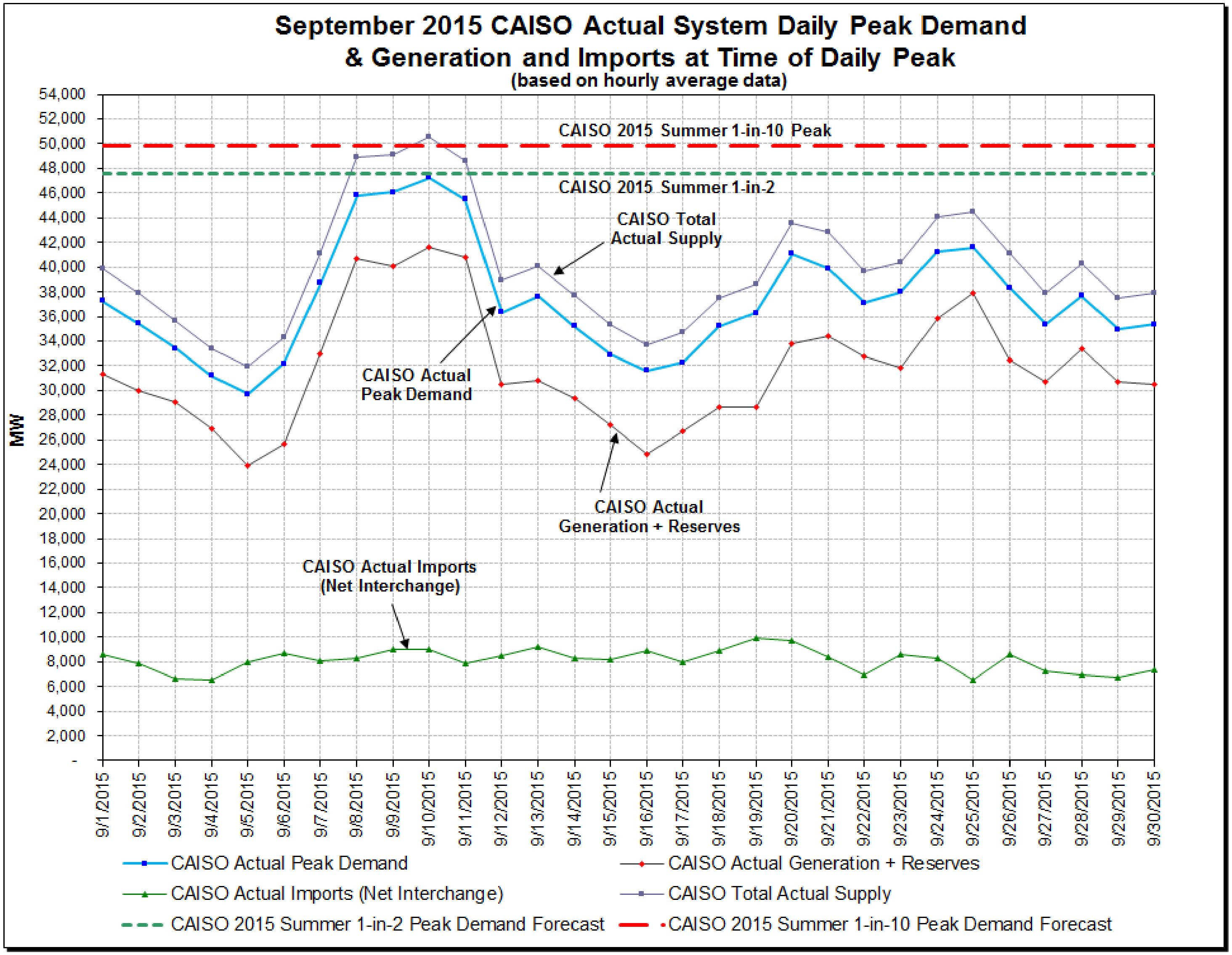

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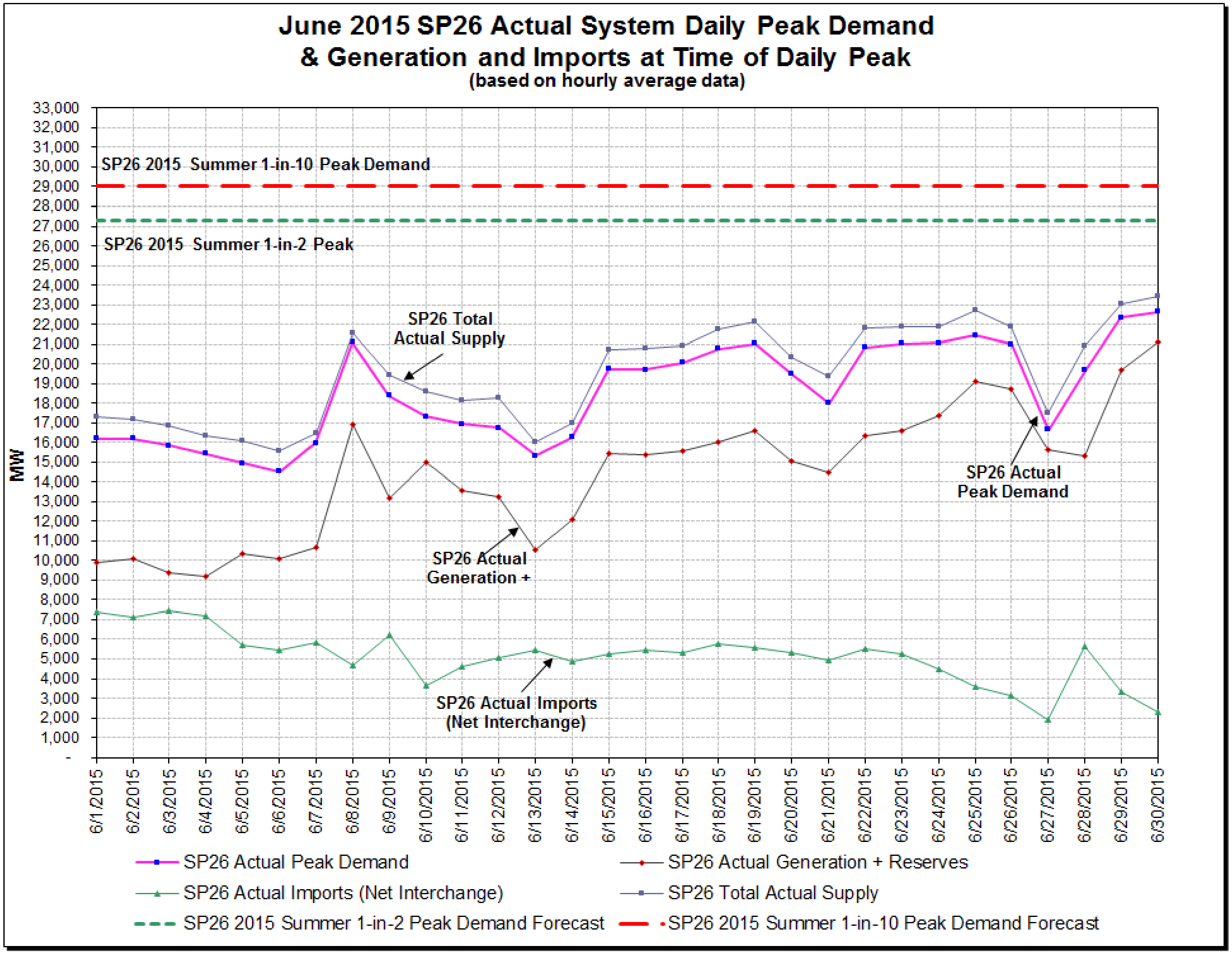

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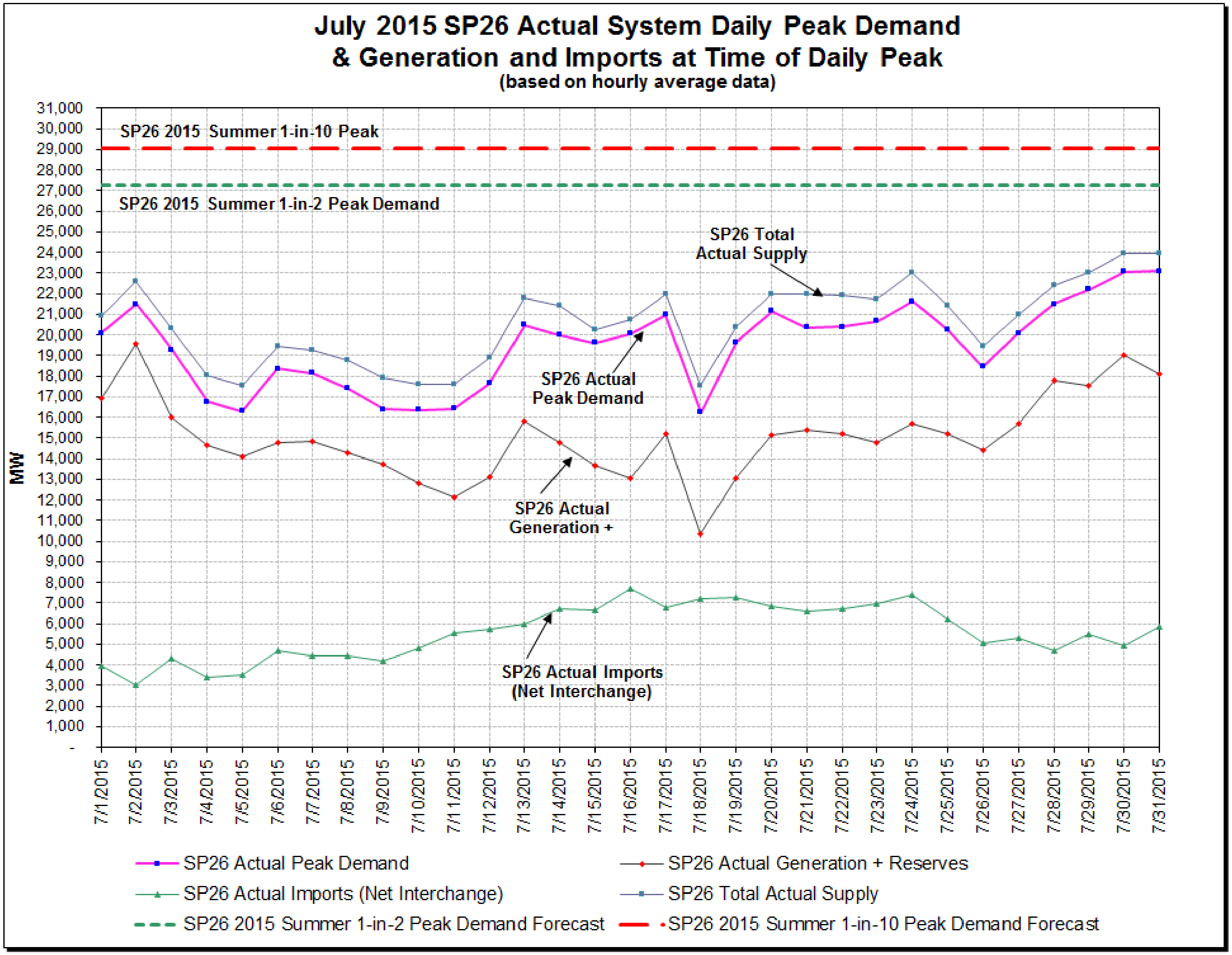

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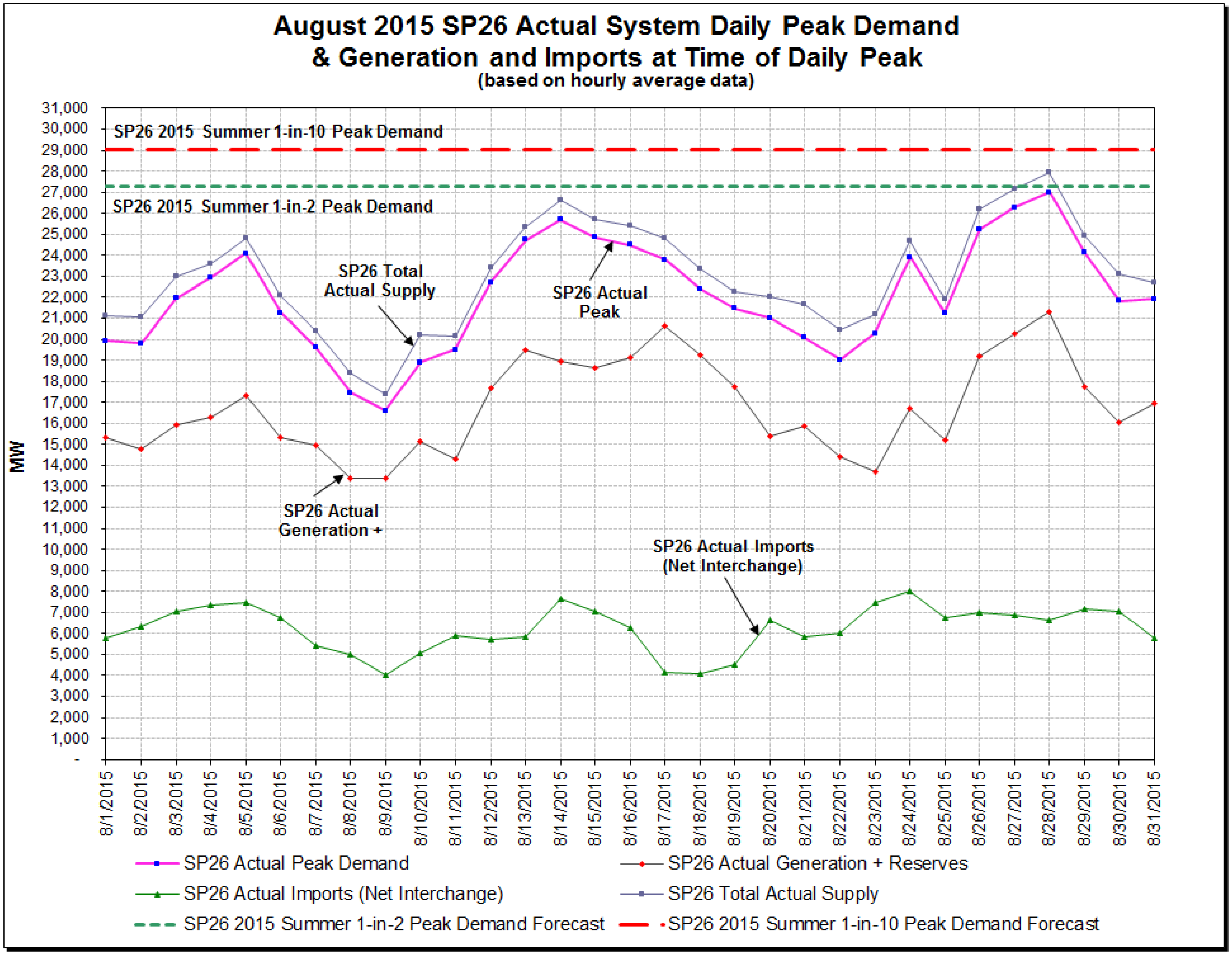

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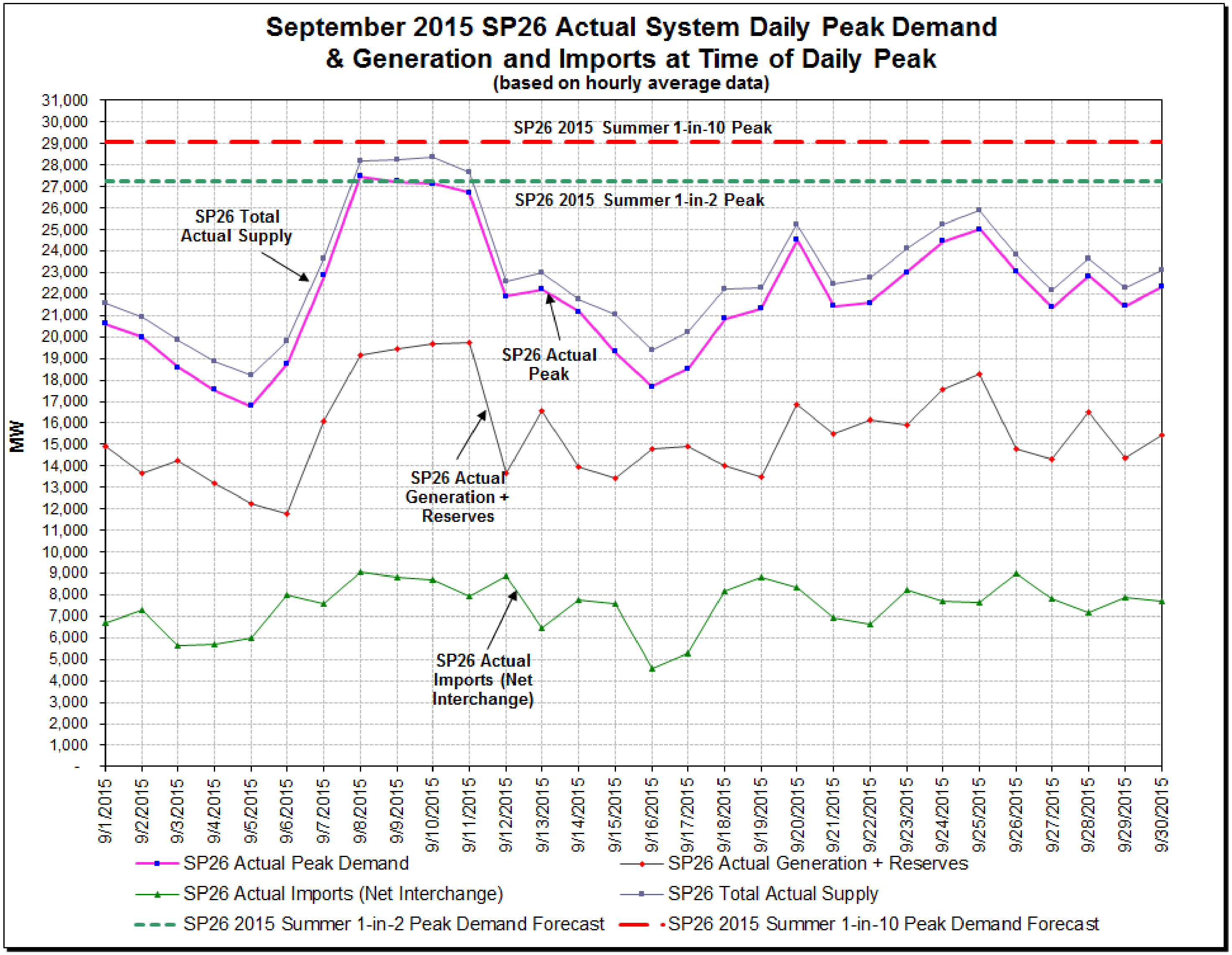

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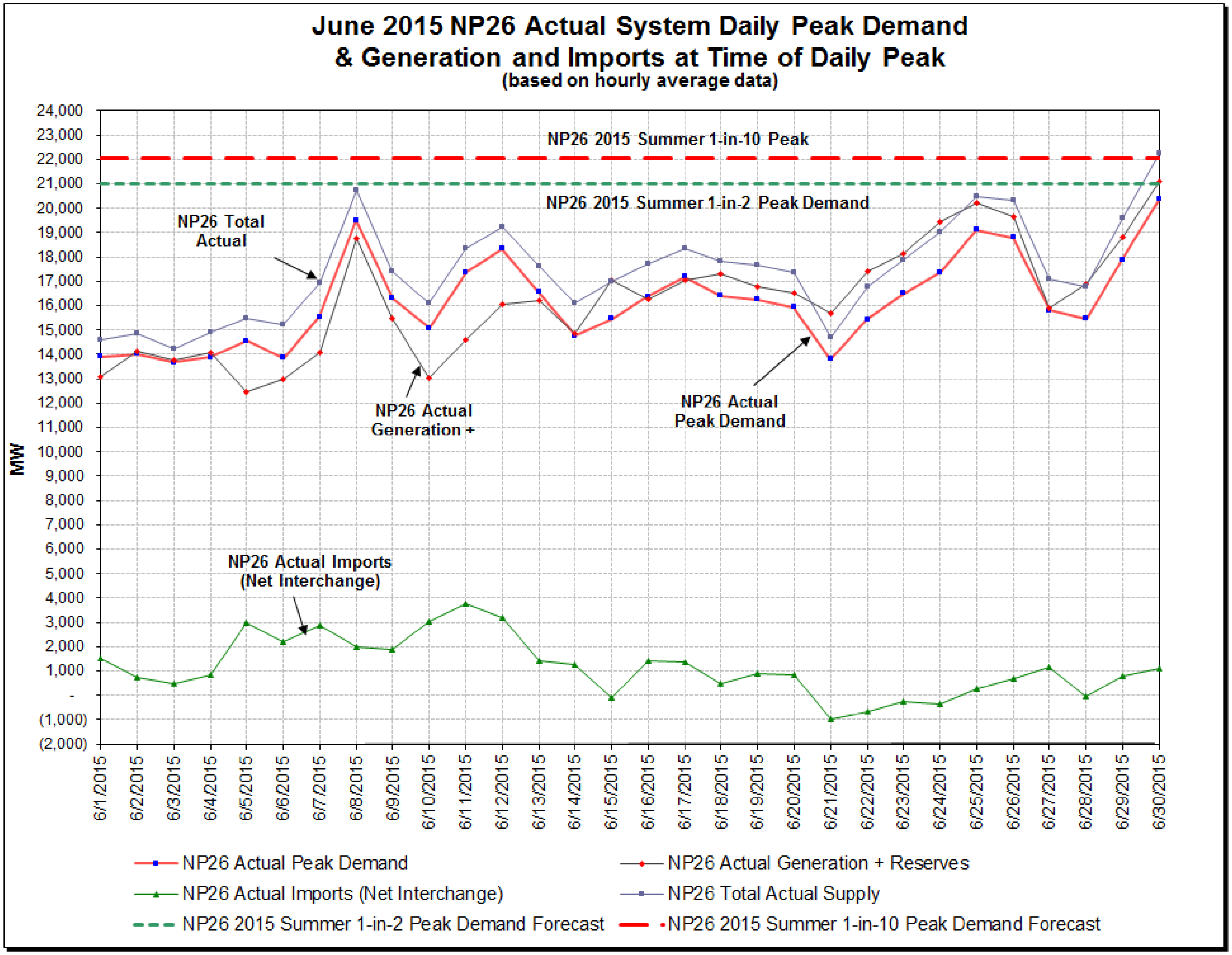

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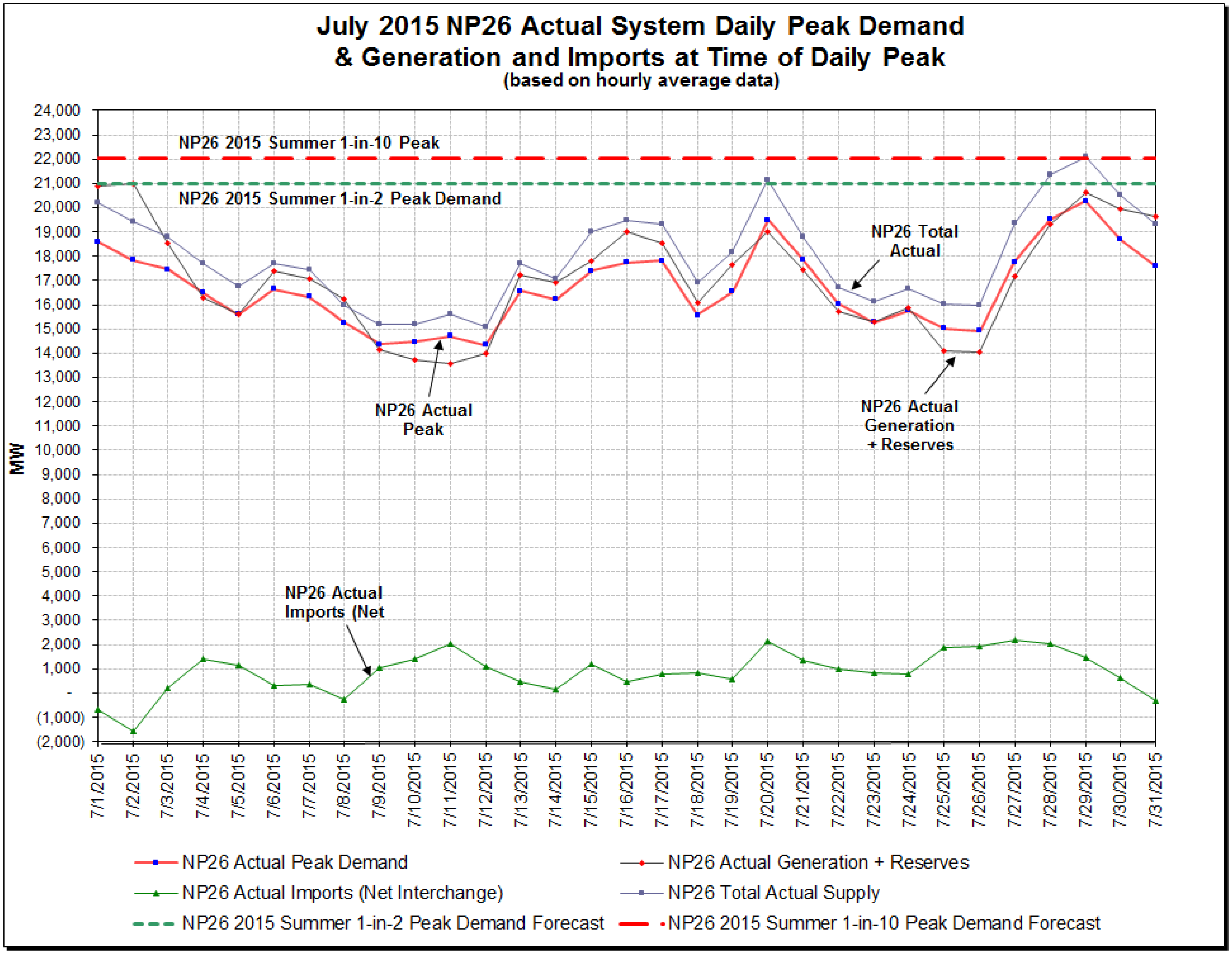

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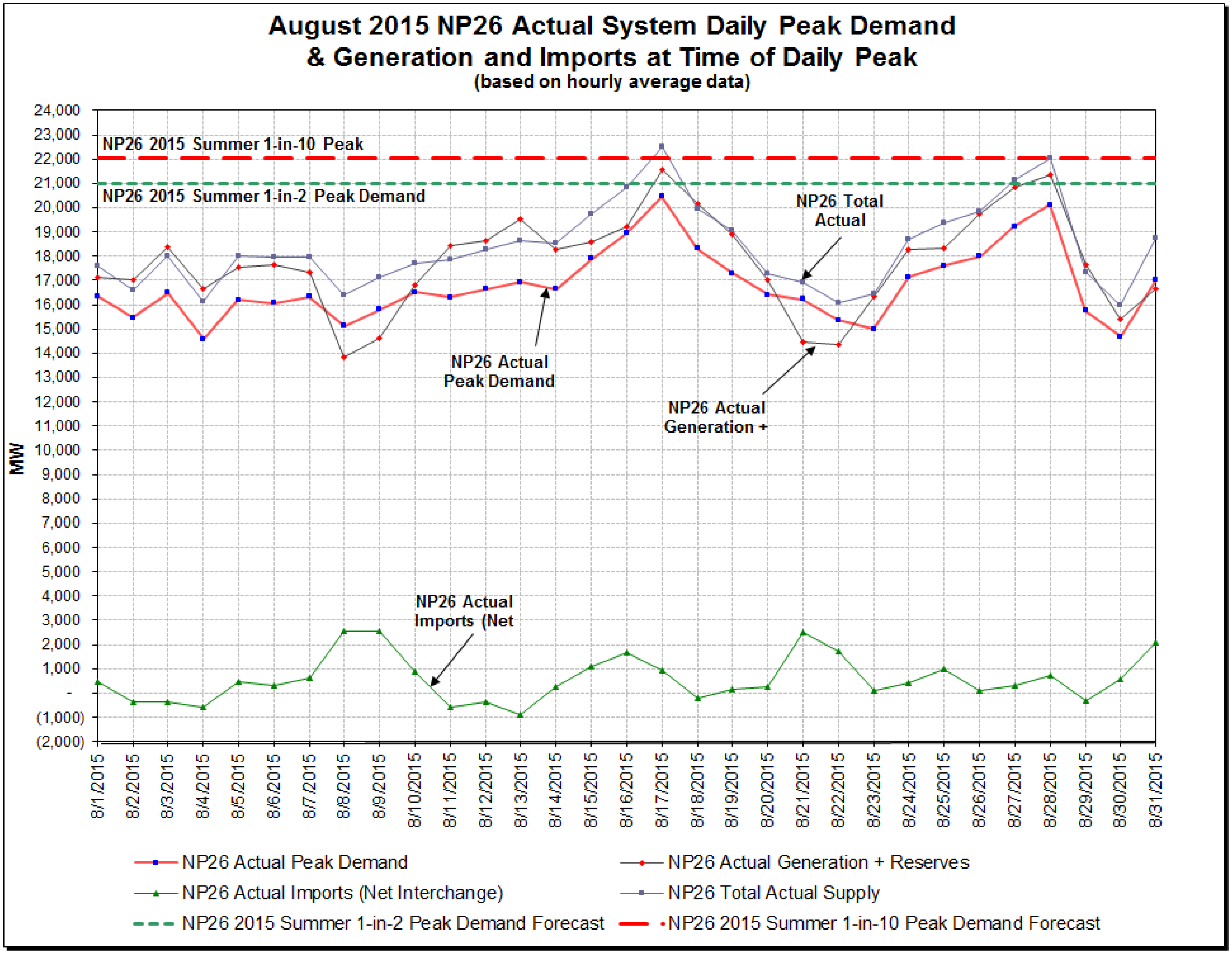

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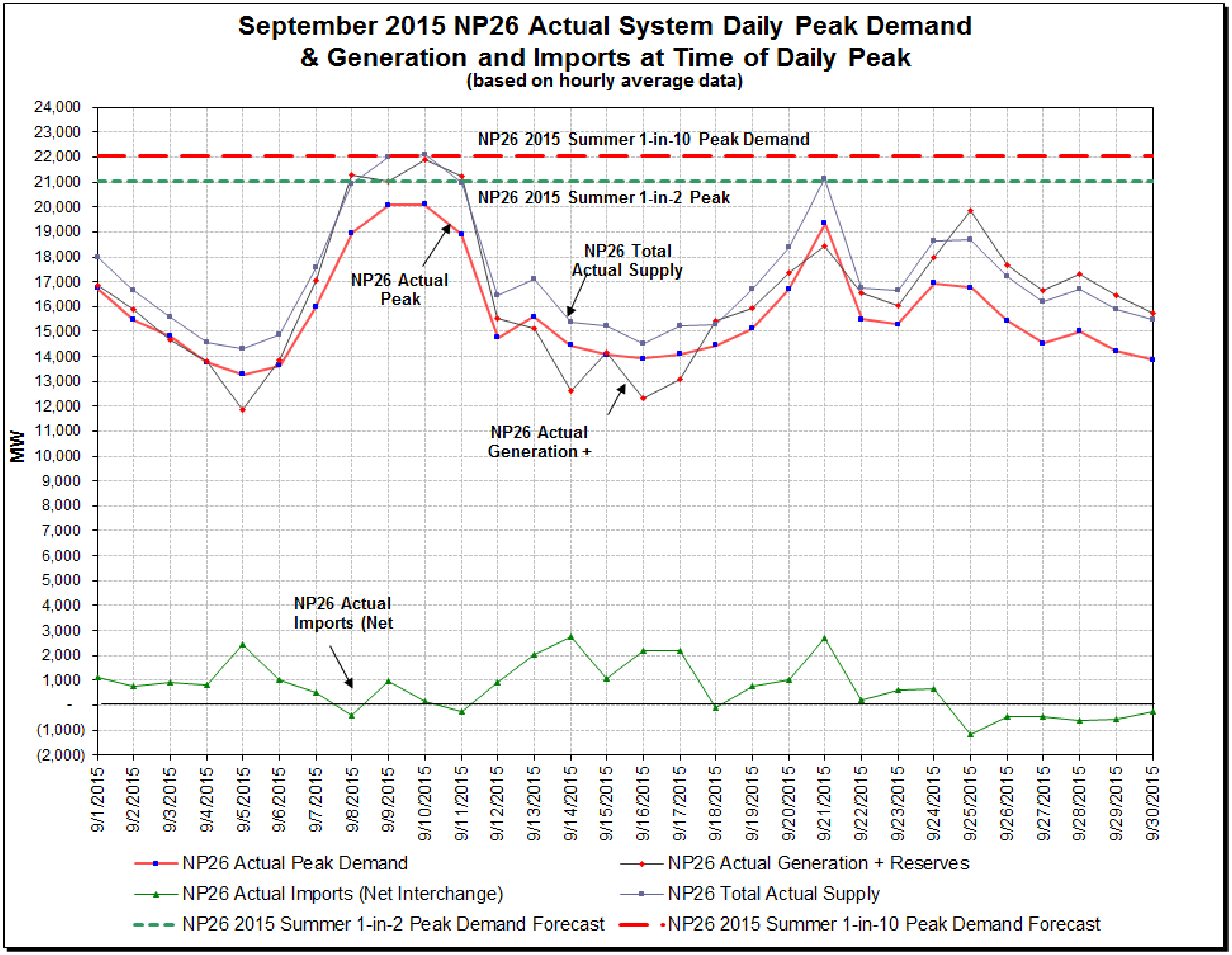
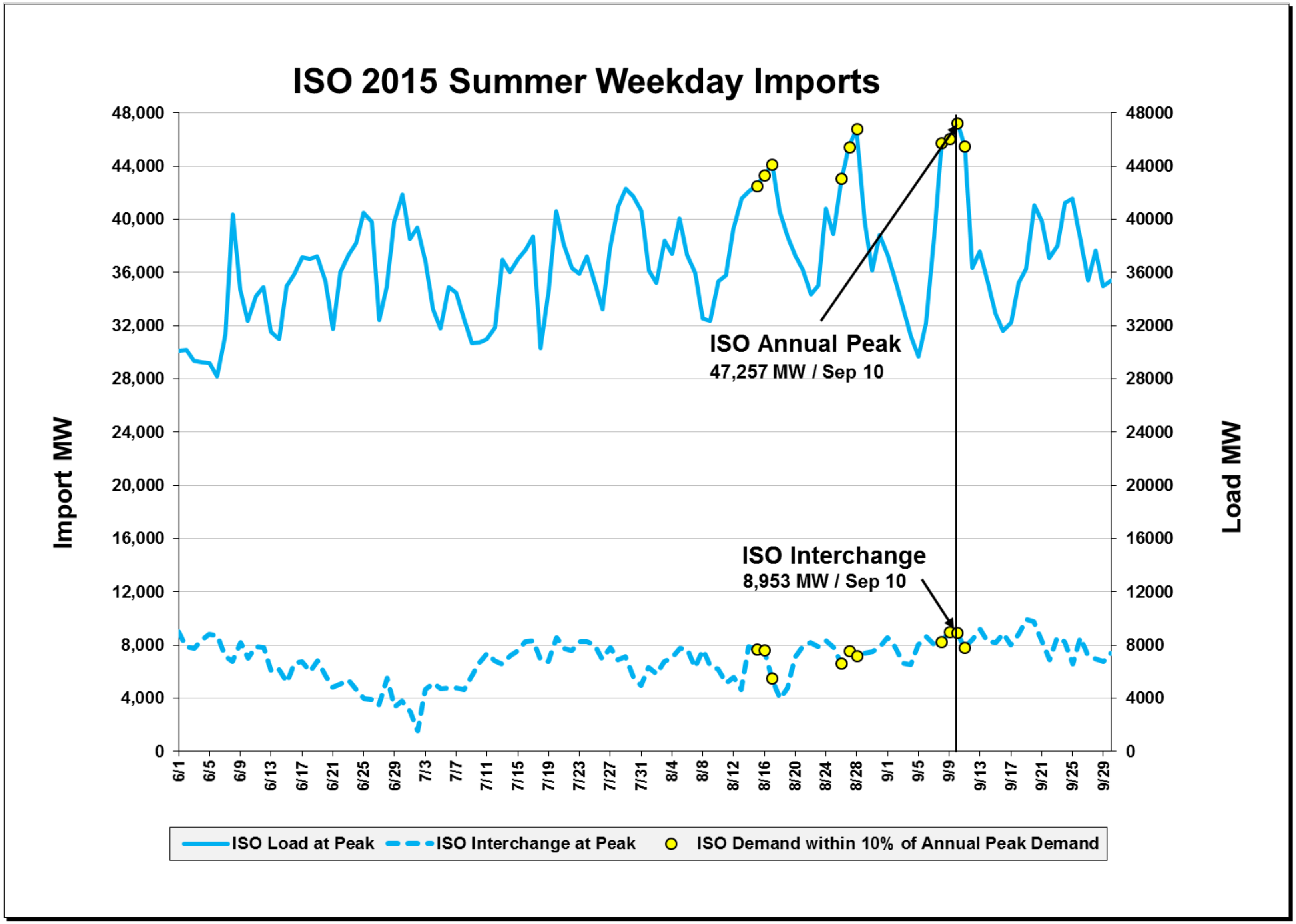


Appendix B: 2015 Summer Imports Summary Graphs



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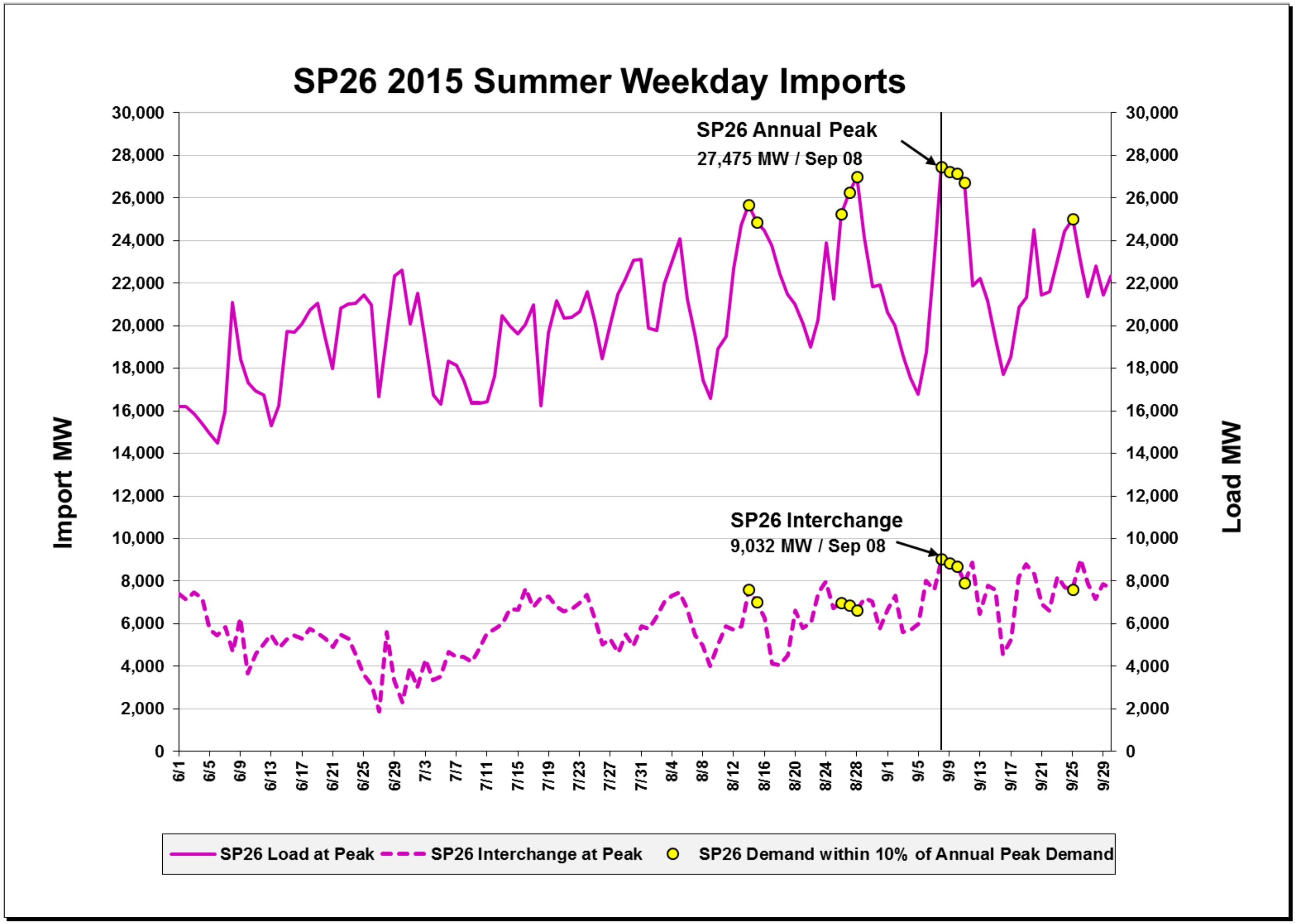

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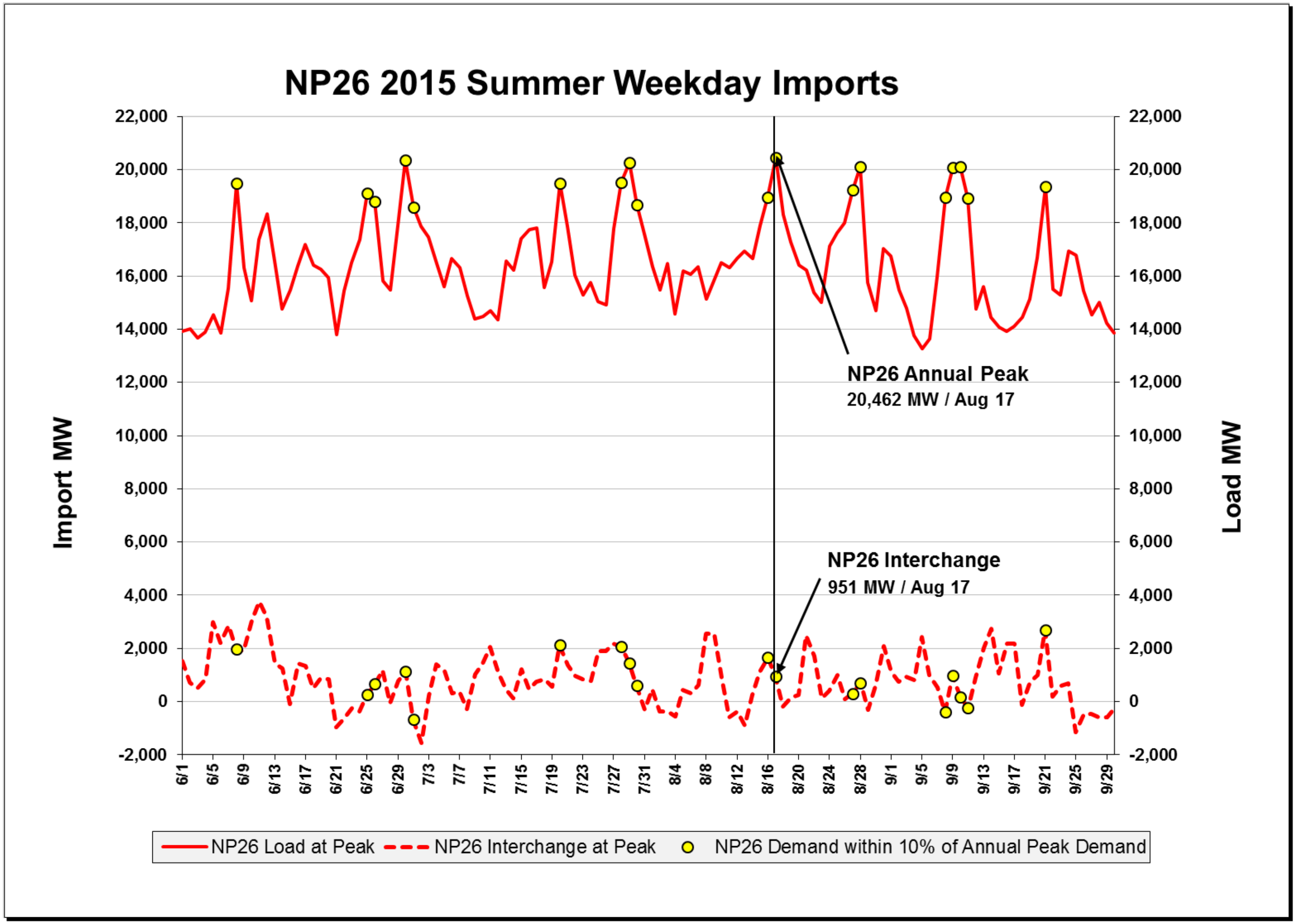

Appendix C: 2016 CAISO Summer On-Peak NQC Fuel Type