2017 SUMMER LOADS & RESOURCES ASSESSMENT

California ISO
May 11, 2017
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I. EXECUTIVE SUMMARY

The 2017 Summer Loads and Resources Assessment provides an assessment of the upcoming summer supply and demand outlook using a stochastic production simulation modeling approach for 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 robust probabilistic approach using production simulation to assess the supply and demand outlook on an hourly basis. This production simulation was developed using Energy Exemplar’s PLEXOS® Integrated Energy Model (PLEXOS). The CAISO first published the production simulation results in the 2016 Summer Assessment.

Overall CAISO System-wide and Zonal Reliability

In its production simulation process, the CAISO runs a statistically significant number of scenarios – 2,000 unique scenarios – each representing a combination of forecasted 8,760 hourly load profiles and renewable generation levels based on historic annual weather patterns. The simulation seeks the least cost co-optimization to dispatch generation to provide energy, ancillary services and load following to meet system capacity and flexibility requirement. The simulation results revealed ample operating reserve margins for this summer under all scenarios.

The operating reserve margin (ORM) amounts are projections of supply margins over projected hourly demands and includes all resources that the model deems available for that hour. The annual minimum ORM is the lowest amount reached over the 8,760 hours in each of the 2,000 scenarios, all of which occurred during the summer period of each of the 2,000 scenario results at the CAISO system level. The projected 1-in-2 annual minimum ORM for the CAISO system is 19.5 percent (Figure 1, the 1-in-2 is the 50/50 point where half the outcomes are above and half below the 1-in-2 value). The lowest ORM result of all scenarios was 12.8 percent, which represents the lowest ORM the models predict the system would face in the most extreme summer supply and demand condition of the 2,000 scenarios. The projected 1-in-2 summer minimum ORMs for the NP26 and SP26 zones are 19.8 percent and 15.5 percent, respectively. The lowest summer ORMs are 3.7 percent and 8.9 percent for NP26 and SP26, respectively. (Figure 2 and Figure 3).
Figure 1

Forecasted 2017 Summer Minimum ISO Operating Reserve Margin Distribution (ORM)

1-in-2 ORM Result: 19.5%
Minimum ORM Result: 12.8%
(One Occurrence)

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

Figure 2

Forecasted 2017 Summer Minimum NP26 Operating Reserve Margin Distribution

1-in-2 ORM Result: 19.8%
Minimum ORM Result: 3.7%
(One Occurrence)

Figure 2 shows forecast distribution of annual minimum operating reserve margins for NP26.
Figure 3 shows forecast distribution of annual minimum operating reserve margins for SP26.

The projected 1-in-2 system annual minimum ORM for 2017 is greater than the 15 percent planning reserve margin required by the California Public Utilities Commission’s month-ahead system resource procurement requirement under its resource adequacy program (real time operating reserve margin requirements are typically less than planning reserve margin requirements). However, the reserve margins represented in this Assessment do not account for the gas curtailment risks associated with the Aliso Canyon gas storage facility operational restrictions. 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.

The CAISO 2017 1-in-2 peak demand forecast is 46,877 MW, which is 0.6 percent above the 2016 weather normalized peak demand of 46,602 MW. The slight overall demand increase is a result of projected modest economic and demographic growth over 2016, tempered by utility projections of new behind the meter solar installations over the past year. The CAISO 2017 1-in-10 peak demand forecast is 48,845 MW.

The CAISO projects that 52,785 MW of net qualifying capacity (NQC) will be available for summer 2017. From June 1, 2016, to June 1, 2017, approximately 3,090 MW of additional generation is expected to reach commercial operation, with 2,566 MW in the southern portion of the ISO system, 514 MW in the northern portion of the ISO system, and 10 MW in the Valley Electric Association service territory (VEA) located in western Nevada. Of the 3,090 MW, approximately 74 percent is solar, 23 percent is natural gas, 3 percent is battery, and a fraction of a percent are hydro and biofuel. During this same period, 3,149 MW of generation is expected to retire, primarily once-through cooled facilities.
**Hydro Conditions**

Hydro conditions for 2017 have vastly improved over recent years with the statewide average snow water content measuring, as of April 28, 2017, at 158 percent of the April 1 average when snowpack typically reaches its maximum level for the year and statewide precipitation is close to the wettest year recorded. This abundance of rain has nearly all reservoirs near capacity and needing to spill water to make room for spring snow runoff. California hydroelectric capability will be above normal for 2017 providing greater than normal hydro energy during the spring and summer seasons.

**Impacts of the Aliso Canyon Gas Storage Operating Restrictions**

The CAISO manages the dispatch of several generators dependent on gas coming from the Southern California Gas Company (SoCalGas) system that are impacted by the Aliso Canyon operational restrictions. The CAISO has worked with other state agencies including the California Public Utilities Commission (CPUC) and California Energy Commission (CEC), as well as the Los Angeles Department of Water and Power and SoCalGas to assess the impacts of potential gas limitations. We have also worked with our stakeholders to address impacts that potential operational gas limitations have on dispatch and how commitment and dispatch instructions, especially in real-time, could cause challenges to generators under a daily balancing requirement or an operational flow order when gas system balancing is more critical. Through various stakeholder process and participation in proceedings, the CAISO is continuing to evaluate the issues affecting gas and electric service under the restricted operations of Aliso Canyon and develop procedures to mitigate the issues to the greatest extent possible.

The CAISO implemented several operational tools and market mechanisms in summer 2016 to mitigate the electric system reliability risk posed by the restricted operations of Aliso Canyon. The CAISO proposed and FERC temporarily approved some tariff provisions until November 30, 2016 while approving others as permanent changes. Because Aliso Canyon remained under restricted operations over winter 2016–2017, the CAISO proposed and FERC approved extending most of the temporary tariff provisions through November 2017. If the electric system reliability risk posed by the restricted operations of Aliso Canyon continues beyond November 2017, the CAISO will explore with stakeholders whether to seek further extensions of these measures.

The results of the latest studies and recommendations by various state agencies on the operating restrictions of Aliso Canyon going forward and the projected impacts to electric system reliability are being assessed by the CPUC, CEC, CAISO, and Los Angeles Department of Water and Power. The results of that joint agency assessment will be presented in a report that is expected to be released during the latter half of May 2017.

The risk associated with the gas storage facility restrictions at the Aliso Canyon and other gas storage facilities to electric reliability is greater in the local reliability areas in Southern California than to the CAISO system. This Assessment is a system level assessment and does not provide results on local area resource adequacy issues.

**Once Through Cooled Generation**

The CAISO is also working closely with state agencies and once-through-cooled plant owners as plans are being implemented to comply with the clean water regulations to ensure electric grid reliability is maintained. About 7,612 MW of natural gas fired coastal power plants that use ocean water for cooling are slated to retire, be retrofitted or repowered. The
bulk of the generation retirements forecasted are anticipated to occur in the 2018-2020 time frame.

**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 for potential times of system stress.
II. **SUMMER 2016 REVIEW**

**Demand**

The recorded 2016 summer hourly average peak demand reached 46,008 MW on 7/27/2016. Adjusting the load to normalized weather results in a peak load of 46,602 MW for the California Independent System Operator (CAISO) in 2016, which was an increase of 0.3 percent from the 2015 summer weather normalized peak demand of 46,047 MW. This demand increase was a result of projected modest economic and demographic growth over 2015, based on the economic base case forecast from Moody’s Analytics, and utility projections of new behind the meter solar installations over the past year. The 2016 annual peak demand for the Southern California zone (South of Path 26 or SP26) was 27,679 MW and for the Northern California zone (North of Path 26 or NP26) the annual peak demand reached 20,412 MW. The annual peak for SP26 occurred in June while NP26 and CAISO peaks occurred in July. 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 2007 to 2016. The CAISO summer peak dropped from 48,491 MW in 2007 to 45,809 MW in 2009 as demand moderated during the recession. Since 2009, peak demand fluctuations have been primarily due to changing economic conditions, changing demographics, and weather conditions unique to each year. Peak demand is further impacted by increasing energy efficiency, the use of demand side management and increasing behind the meter solar installations.

*Figure 4* shows the CAISO balancing authority system peak and peaks for Northern and Southern California (2007-2016).
Table 1 shows the difference between 2016 actual peak demands plus demand response (DR) and 2016 1-in-2 peak demand forecasts. The ISO actual peak demand plus DR was lower than the 1-in-2 forecast due to actual weather conditions being different than 1-in-2 weather conditions. The weather normalized peak load for CAISO in 2016 was 46,602 MW.

The actual peak demand plus DR 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-1.5 weather event, milder than 1-in-2 weather conditions for NP26.

However, the actual peak demand plus DR in Southern California was 4 percent 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-7 weather event.

Table 1

<table>
<thead>
<tr>
<th>Zone</th>
<th>Actual</th>
<th>Actual+DR</th>
<th>1-in-2 Forecast</th>
<th>Difference between 1-in-2 Forecast and Actual+DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP26</td>
<td>20,412</td>
<td>20,618</td>
<td>21,014</td>
<td>-2%</td>
</tr>
<tr>
<td>SP26</td>
<td>27,679</td>
<td>28,324</td>
<td>27,269</td>
<td>4%</td>
</tr>
<tr>
<td>ISO</td>
<td>46,008</td>
<td>46,629</td>
<td>47,529</td>
<td>-2%</td>
</tr>
</tbody>
</table>

Note: ISO and the NP26 peaks demand were coincident. The SP26 peak demand was non-coincident.

Generation

Actual daily generation levels during June through September 2016 for the CAISO system and the SP26 and NP26 zones are shown in Appendix A: 2016 Summer Supply and Demand Summary Graphs.

Interchange

Figure 5 shows the 2016 CAISO peak and the net interchange over the weekday summer peak load period. There are numerous factors that determine the level of interchange between the CAISO and other balancing authorities at any given point in time. These factors typically include market dynamics, demand within various areas, day-ahead forecasts accuracy, generation availability, transmission congestion, hydro conditions, and more recently, levels of renewable generation. On any given day, the degree to which any one of these interrelated factors influence import levels can vary greatly. Actual daily Import levels during June through September 2016 for the CAISO system and the SP26 and NP26 zones are shown in Appendix B: 2016 Summer Imports Summary Graphs.
Figure 5 shows the amount of imports at CAISO daily system peaks.
III. SUMMER 2017 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 2017 summer peak is estimated to be 52,785 MW using the final NQC list that was used for the California Public Utilities Commission (CPUC) and CAISO’s resource adequacy program for compliance year 2017, which is posted on the CAISO website.\(^1\) 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.\(^2\)

Each year, the CPUC, California Energy Commission (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 accounting for 61.1 percent and the second largest generation type is hydro which accounts for 14.2 percent. Solar accounts for 13.7 percent. Wind, geothermal, and biofuel units make up about 6.1 percent. Nuclear generation is 4.3 percent while oil generation provides 0.4 percent. The overall resource NQC amount is shown in the NQC by fuel type chart in Appendix C: 2017 CAISO Summer On-Peak NQC Fuel Type.

Generation Addition

Table 2 shows the total net qualifying capacity generation of 3,090 MW from new generation interconnected to the CAISO balancing authority that came on line in the period from 6/1/2016 to 6/1/2017. This new NQC included 2,576 MW in SP26 (Southern California Edison (SCE), San Diego Gas & Electric (SDG&E), and Valley Electric Association (VEA)) and 514 MW in NP26 (Pacific Gas & Electric (PG&E)).

| Generation Additions (NQC MW) From 6/1/2016 to 6/1/2017 |
|------------------|---|---|---|---|---|
|                   | PG&E | SCE | SDG&E | VEA | ISO |
| Battery           | 0    | 42  | 38    | 0   | 80  |
| Biofuel           | 2    | 0   | 0     | 0   | 2   |
| Hydro             | 7    | 0   | 0     | 0   | 7   |
| Natural Gas       | 0    | 68  | 631   | 0   | 699 |
| Solar             | 505  | 1,548 | 239 | 10  | 2,302 |
| Total             | 514  | 1,658 | 908 | 10  | 3,090 |

\(^1\) Final Net Qualifying Capacity Report for Compliance Year 2017: [http://www.caiso.com/planning/Pages/ReliabilityRequirements/Default.aspx](http://www.caiso.com/planning/Pages/ReliabilityRequirements/Default.aspx)

\(^2\) Master Control Area Generating Capability List: [http://www.caiso.com/participate/Pages/Generation/Default.aspx](http://www.caiso.com/participate/Pages/Generation/Default.aspx)
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 a broad range of operating conditions. 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.

Conventional generation units such as gas and nuclear are individually modeled while non-dispatchable qualifying facilities (QFs), biofuel and geothermal generation are modeled using their fixed hourly generation profiles which are developed based on the projected capacities and historical generation profiles on an aggregated basis.

**Stochastic Simulation Approach to Assess Supply and Demand**

Significant amounts of new renewable generation have 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 near-term reliability.

As new renewable resources come on the system, 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. The CAISO’s evolving net load profile – the balance of load needing to be served after intermittent resources have served a portion of the total load – has become known as the duck curve. This and the growing amount of behind the meter photovoltaic (PV) solar, which is changing the CAISO’s gross load profile, have created the need for forecasting the day ahead renewable generation profiles along with the day ahead load profile, creating more uncertainty for CAISO operations. The result is greater ramping requirements than what have been required from the generation fleet in the past.

To assess the changing resource needs from the increasing number of variable resources, the CAISO has enhanced its probabilistic approach and developed a stochastic simulation model using Energy Exemplar’s PLEXOS® Integrated Energy Model (PLEXOS) to assess resource adequacy based on the availability of system resource capacity and system flexibility requirements. The simulation covers 38 Western Electric Coordinating Council (WECC) zones with 100 WECC interchange paths. The model uses a mixed-integer linear programing to determine the optimal generation dispatch. The model runs chronologically to dispatch energy, 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 up and down time, heat rate, and ramp rate for each generator in the CAISO.

For hours in which supply is sufficient, the model determines how much reserve margin exists and calculates the annual minimum ORM based on the load and available resources, imports, and exports for each 8,760 hour annual profile. Otherwise, the model records and reports the unserved hours and unserved energy where demand exceeds supply.
Generation Unavailability
Forced outages are generated for individual units on a random basis by PLEXOS using the unit’s historical forced outage rate with a uniform distribution function. Planned outages are sourced from the 2017 CAISO outage management system.

Table 3 shows the resources that have retired since June 2016 and the resources that are expected to retire by June 1, 2017. The last column of Table 3 shows resources that are once through cooled and subject to the State Water Resources Control Board policy on the use of coastal and estuarine waters for power plant cooling. For further details see the Once Through Cooled Generation section later in this assessment. Of the 3,149 MW of generation that have or will retire by June 1, 2017, 2,708 MW are in NP26 and 441 MW are in SP26.

<table>
<thead>
<tr>
<th>Resource Name</th>
<th>Resource ID</th>
<th>August NQC (MW)</th>
<th>PTO</th>
<th>OTC</th>
<th>Retired</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pittsburg Unit 5</td>
<td>PITTSP_7_UNIT 5</td>
<td>312</td>
<td>PG&amp;E</td>
<td>Y</td>
<td>12/31/2016</td>
</tr>
<tr>
<td>Pittsburg Unit 6</td>
<td>PITTSP_7_UNIT 6</td>
<td>317</td>
<td>PG&amp;E</td>
<td>Y</td>
<td>12/31/2016</td>
</tr>
<tr>
<td>Pittsburg Unit 7</td>
<td>PITTSP_7_UNIT 7</td>
<td>530</td>
<td>PG&amp;E</td>
<td>Y</td>
<td>12/31/2016</td>
</tr>
<tr>
<td>Moss Landing 6</td>
<td>MOSSLD_7_UNIT 6</td>
<td>754</td>
<td>PG&amp;E</td>
<td>Y</td>
<td>1/1/2017</td>
</tr>
<tr>
<td>Moss Landing 7</td>
<td>MOSSLD_7_UNIT 7</td>
<td>755</td>
<td>PG&amp;E</td>
<td>Y</td>
<td>1/1/2017</td>
</tr>
<tr>
<td>Oildale Energy Unit 1</td>
<td>OILDAL_1_UNIT 1</td>
<td>40</td>
<td>PG&amp;E</td>
<td>N</td>
<td>12/31/2016</td>
</tr>
<tr>
<td>Inland Empire Energy Center Unit 2</td>
<td>INLDEM_5_UNIT 2</td>
<td>335</td>
<td>SCE</td>
<td>N</td>
<td>3/2/2017</td>
</tr>
<tr>
<td>Encina Unit 1</td>
<td>ENCINA_7_EA1</td>
<td>106</td>
<td>SDG&amp;E</td>
<td>Y</td>
<td>5/8/2017</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3,149</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 0 to its minimum capacity. Similarly, when a generator is in the process of shutting down it cannot provide ancillary or load following services once its ramping down passed its minimum capacity threshold. Once a generator is committed, it must remain operating 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 at least its specified minimum down time.

Once a generator is operating within its operating range (between its minimum and maximum capacity) it must meet the following criteria. If a generator is ramping up, the regulation up, spinning, and non-spinning provided by the 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 the generator cannot exceed its 60-minute ramping capability and unused capacity. During ramping down, the difference between its minimum capacity and its operating point limits the regulation-down and load following-down provided by a generator. Therefore, the model sets 60 minutes ramping time for energy, 20 minutes for load following, and 10 minutes for ancillary services in each hour’s simulation. Each dispatchable generator can run with a maximum ramp rate between its minimum and maximum capacity.
**Hydro Generation**

Hydro conditions for 2017 are vastly improved over recent years. As of April 28, 2017, the statewide snow water content for the California mountain regions was 194% of average for that date and 158% of the April 1 average, which is when snowpack typically reaches its maximum level for the year (Figure 6). Statewide precipitation is close to the wettest year recorded with Northern California above the previously recorded wettest year, Central California tracking the wettest year, and only the Tulare Basin tracking below the wettest year (Figures 7–9). The abundance of rain has nearly all reservoirs near capacity and many have spilled water to make room for spring snow runoff. California hydroelectric capability will be above normal for 2017 providing greater than normal hydro energy during the spring and summer seasons.

As of April 28, 2017, the Northwest River Forecast Center projected the April to August reservoir storage in Columbia - Dalles Dam to be 126 percent of average. Current 2017 water supply projections for the Pacific Northwest are above 2016 levels. There are no concerns with Pacific Northwest hydroelectric generation.

The 2017 snow water content shown in Figure 6 is currently near the levels for 2011. Because 2011’s hydro energy generation was the highest in the past 10 years, and the CAISO has the hydro generation data for that year, the 2011 hydro profile was used for modeling the 2017 hydro generation. Hydro generation is modeled on an aggregated basis with two types, 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. 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.
Figure 6

California Snow Water Content - Percent of April 1 Average For: 28-Apr-2017

NORTH

Percent of Apr 1 Avg: 145%
Percent of Normal: 196%

Central

Percent of Apr 1 Avg: 169%
Percent of Normal: 200%

South

Percent of Apr 1 Avg: 150%
Percent of Normal: 182%

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 programs include real-time pricing and load shifting. Event based or dispatchable demand response programs are modeled as a supply side resources that have 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 and Energy Forecast

The CAISO’s annual peak and energy forecast process has three steps. The first is to develop daily peak and energy forecast models for PG&E, 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 154 weather scenarios using 22 years of historical weather data from 1995 through 2016. 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, 154 annual peaks are produced by combining the MetrixND® models with the 154 weather scenarios through a peak simulation process.

The historical loads are hourly average demand values sourced from the CAISO energy management system (EMS) from January 1, 2003 through September 30, 2016. 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 and demographic indicators to the models. Figure 10 shows five economic scenario forecasts developed by Moody’s Analytics that represent different outlooks of how the economy could 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 Growth Scenario, which 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 Growth Scenario in which there is a 75 percent probability that economic conditions will be better, broadly speaking, and a 25 percent probability that conditions will be worse.
- **Scenario 3** is a Moderate Recession Scenario in which there is a 90 percent probability that the economy will perform better, broadly speaking, and a 10 percent probability that it will perform worse.
- **Scenario 4** is a Protracted Slump Scenario in which there is a 96 percent probability that the economy will perform better, broadly speaking, and a 4 percent probability that it will perform worse.
Figure 10 shows that under the most likely scenario (base case) the economy will experience a modest recovery this year.

In Figure 10, scenario 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, 2017. It is important to note that these forecasts are based on the Moody’s gross domestic product forecasts released in December 2016. The gross domestic product data reflects actual historical data through Dec 31, 2015 (January 2016 and later historical data are estimates of actual GDP). Consequently, this forecast is based on the most current 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 2017 base case forecasted peak demand is a modest 0.6 percent increase over the CAISO 2016 weather normalized peak demand. The slight increase in peak demand is a result of projected modest economic growth over 2016, based on the economic base case forecast from Moody’s Analytics, and offset to some extent by utility projections of new behind the meter solar installations over the past year.
Figure 11

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

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 requirements 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 program 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 load.

Interchange

The model simulated 38 WECC zones and 100 WECC interchange paths between zones, shown in Figure 12. 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 reflected the maximum simultaneous transfer capabilities. In addition, a total CAISO maximum import limit was set based on historical import patterns. Exports 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.
Stochastic Scenarios

In its production simulation process, the CAISO runs a statistically significant number of scenarios – 2,000 unique scenarios – each representing a combination of forecasted 8,760 hourly load profiles and renewable generation levels based on historic annual weather patterns. The CAISO uses a two-step process to generate the 2,000 random scenarios. The first step is to build three pools of load, wind, and solar profiles. In this step, 12 years of historical hourly load profiles were matched with the 154 annual peak and annual energy forecasts to produce 154 hourly load scenarios in a load pool; 9 years of historical hourly wind capacity factors were multiplied with the projected wind capacity in 2017 to generate 9 hourly wind scenarios in a wind pool; and 4 years of historical hourly solar capacity factors were multiplied with the projected solar capacity in 2017 to generate 4 hourly solar scenarios in a solar pool. The second step is to randomly generate 2,000 scenarios from the load, wind, and solar pools. One random draw from each of the load, wind, and solar pools creates a scenario, which contains one load, wind, and solar profile. A total of 2,000 draws generates 2,000 scenarios of load, wind, and solar from 5,544 possible scenarios (154 load profiles x 4 solar profiles x 9 wind profiles), illustrated in Figure 13.

Two thousand randomly drawn scenarios of load, wind, and solar for PG&E, SCE, and SDG&E were developed based on the CAISO load forecast process while the load profiles
for the rest of the 35 WECC zones were prepared based on a 1-in-2 peak and energy forecast from WECC. VEA is included in the SCE zone.

Figure 13: 2,000 scenarios of load, wind and solar are randomly selected from 5,444 scenarios.

Probabilistic Analysis

The PLEXOS stochastic model was applied to perform the 2017 summer loads and resources assessment study. The model used a mixed-integer linear programing to dispatch available resources to meet load demand and flexible capacity requirements. The simulation runs 2,000 scenarios on an hourly interval chronologically. Each scenario had an 8,760 hour annual profile. The optimization time horizon was set as 24 hours. The end status of one optimization is used as the initial status of the next optimization.

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

Annual Minimum ORM = \( \text{Min} (ORM(1), \ldots, ORM(t), \ldots, ORM(8760)) \)

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

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

Expected Unserved Hours = \( \frac{\sum_{k=1}^{M} Unserved \ Hours_k}{2,000} \)
Expected Unserved MWh = \frac{\sum_{k=1}^{M} \text{Unserved MWh}_k}{2,000}

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

The operating reserve margin (ORM) amounts in this Assessment are projections of supply margins over projected hourly demands and includes all resources that the model deems available for that hour. The annual minimum ORM is the lowest amount reached over the 8,760 hours in each of the 2,000 scenarios, all of which occurred during the summer period of each of the 2,000 scenario results at the CAISO system level. The projected 1-in-2 annual minimum ORM for the CAISO system is 19.5 percent (Figure 14, the 1-in-2 is the 50/50 point where half the outcomes are above and half below the 1-in-2 value). The lowest ORM result of all scenarios was 12.8 percent, which represents the lowest ORM the models predict the system would face in the most extreme supply and demand condition of the 2,000 scenarios. The projected 1-in-2 summer minimum ORMs for the NP26 and SP26 zones are 19.8 percent and 15.5 percent, respectively. The lowest summer ORMs are 3.7 percent and 8.9 percent for NP26 and SP26, respectively. (Figure 15 and Figure 16). The minimum ORMs for CAISO, SP26 and NP26 are projected to be above the 3 percent firm load shedding threshold in the most extreme scenario for each area. However, the CAISO prepares contingency plans to deal with extreme events that could lead to firm load shedding.

Local resource adequacy is beyond the study scope of this Assessment because the models do not cover local transmission constraints within each zone. Furthermore, the reserve margins represented in this assessment do not account for the gas supply risk associated with the Aliso Canyon gas storage facility operational restrictions and do not take into account any significant transmission outages that potentially could occur during the summer.

**Figure 14**

*Forecasted 2017 Summer Minimum ISO Operating Reserve Margin Distribution (ORM)*

*Figure 14 shows forecasts of annual minimum operating reserve margins for the CAISO.*
Figure 15 shows forecasts of annual minimum operating reserve margins for the NP26.

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

The CAISO, Los Angeles Department of Water and Power, California Energy Commission and California Public Utilities Commission (Joint Agencies) published a risk assessment and technical report in April 2016. The report indicated that the limited operability of the Aliso Canyon storage facility posed a significant risk to electric reliability during the summer months of 2016. To address these reliability concerns, these agencies took many steps to manage system conditions.

The CAISO implemented several operational tools and market mechanisms in summer 2016 to mitigate the electric system reliability risk posed by the restricted operations of Aliso Canyon. The CAISO proposed and FERC temporarily approved some tariff provisions until November 30, 2016 while approving others as permanent changes. Because Aliso Canyon remained under restricted operations over winter 2016–2017, the CAISO proposed and FERC approved extending most of the temporary tariff provisions through November 2017. If the electric system reliability risk posed by the restricted operations of Aliso Canyon

continues beyond November 2017, the CAISO will explore with stakeholders whether to seek further extension of these measures.

Other actions included SoCalGas adjusting natural gas balancing rules to provide stronger incentives for natural gas customers, such as electric generators, to align their natural gas schedules and burns. Furthermore, electric operators and gas system operators developed enhanced coordination procedures. These actions, in addition to relatively well-forecasted load and weather conditions during the 2016 summer, contributed to system reliability during that time.

On January 17, 2017, the Department of Conservation’s Division of Oil, Gas, and Geothermal Resources (DOGGR) announced that it had completed its comprehensive safety review of the Aliso Canyon Storage Facility. The safety review determined Aliso Canyon could operate in a reduced fashion. On February 15, 2017 SoCalGas released a Storage Safety Enhancement Plan\(^6\) that was updated on February 17.\(^7\)

The results of the latest studies and recommendations by various state agencies on the operating restrictions of Aliso Canyon going forward and the projected impacts to electric system reliability are being assessed by the Joint Agencies. The results of the Joint Agencies assessment for this summer and beyond will be presented in a report that is expected to be released during the latter half of May 2017.

The risk associated with the gas storage facility restrictions at the Aliso Canyon and other gas storage facilities to electric reliability is greater in the local reliability areas in Southern California than to the CAISO system.

**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 the 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 4 shows the power plants that are subject to the Policy. Of the OTC units’ 18,322 MW of generating capability affected by the policy, 8,470 MW are in compliance. The remaining 7,612 MW of generation will be required to repower, be retrofitted or retire in by the end of 2020. Compliance for Diablo Canyon is subject to a pending study by a Water Board Review Committee for Nuclear Fueled Power Plants.

Statewide Advisory Committee on Cooling Water Intake Structures (SACCWIS) continues to assess the reliability impacts to the ISO grid in the implementation of the OTC Policy. New generation resources which were interconnected to the ISO grid have replaced 46% of the OTC capacity subject to the OTC policy and additional replacements are under way. Although some OTC units will retire ahead of their compliance dates, the majority of the OTC units are working on their replacement plans to comply with the policy. A few OTC units may still require an extension under the OTC Policy’s compliance schedule if one or

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more uncertainties pose a threat to local or system reliability or if replacement infrastructure is not on a schedule that matches with the existing OTC compliance dates.

SACWIS has sent a recommendation to the SWRCB to extend the compliance date for Encina Units 2-5 to December 31, 2018 due to delays in the Carlsbad Energy Center Project. The SWRCB is expected to adopt the recommendation at their meeting on August 15.

**Table 4**

<table>
<thead>
<tr>
<th>Plant (Unit)</th>
<th>Owner</th>
<th>Final Compliance Date</th>
<th>Capacity (MW)</th>
<th>PTO Area</th>
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<tr>
<td><strong>Compliance Plan Yet to be Implemented (Natural Gas Fired)</strong></td>
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<tr>
<td>Encina Power Station Units 2-5</td>
<td>NRG</td>
<td>12/31/2017</td>
<td>840</td>
<td>SDG&amp;E</td>
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<tr>
<td>Moss Landing Units 1 and 2</td>
<td>Dynegy</td>
<td>12/31/2020</td>
<td>1,020</td>
<td>PG&amp;E</td>
</tr>
<tr>
<td>Huntington Beach Units 1-2</td>
<td>AES</td>
<td>12/31/2020</td>
<td>452</td>
<td>SCE</td>
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<td>Redondo Beach Units 5-8</td>
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<td>SCE</td>
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<td>12/31/2020</td>
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<td>Ormond Beach Units 1 and 2</td>
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<td><strong>Total MW</strong></td>
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<td></td>
<td><strong>7,612</strong></td>
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<tr>
<td><strong>In Compliance</strong></td>
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</tr>
<tr>
<td>Encina Power Station Units 1</td>
<td>NRG</td>
<td>5/8/2017</td>
<td>106</td>
<td>SDG&amp;E</td>
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<td>Dynegy</td>
<td>1/1/2017</td>
<td>1,500</td>
<td>PG&amp;E</td>
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<td>Pittsburg Units 5, 6 and 7</td>
<td>NRG</td>
<td>12/31/2016</td>
<td>1,159</td>
<td>PG&amp;E</td>
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<td>SCE</td>
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<tr>
<td>Humboldt</td>
<td>PG&amp;E</td>
<td>Sept. 2010</td>
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<td>PG&amp;E</td>
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<td>GenOn</td>
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<td>206</td>
<td>PG&amp;E</td>
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<td>702</td>
<td>SDG&amp;E</td>
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<td>PG&amp;E</td>
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<td>El Segundo Units 3</td>
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<td>El Segundo Units 4</td>
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<td>Morro Bay Units 3 and 4</td>
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<td><strong>Total MW</strong></td>
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<td><strong>Compliance pending study by Water Board Review Committee for Nuclear Plants</strong></td>
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</tr>
<tr>
<td>Diablo Canyon</td>
<td>PG&amp;E</td>
<td>12/31/2024</td>
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<td>PG&amp;E</td>
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<tr>
<td><strong>Total MW</strong></td>
<td></td>
<td></td>
<td><strong>2,240</strong></td>
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<tr>
<td><strong>Total of all OTC Units</strong></td>
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<td></td>
<td><strong>18,322</strong></td>
<td></td>
</tr>
</tbody>
</table>

1 HB Units 3-4 conversion into synchronous condensers, which requires operating the plant cooling system and will use ocean water at a rate of approximately 25% of the units operating in its prior mode.
Conclusion

The 2017 PLEXOS stochastic simulation results show no system capacity shortages. The existing resource fleet, continued moderate peak demand growth and above normal hydro generation conditions result in an overall adequate summer supply outlook for summer 2017 to meet a broad range of operating conditions.

The reserve margins represented in this Assessment do not account for the gas curtailment risks that have been identified concerning the Aliso Canyon operational restrictions. The risk associated with the gas storage facility restrictions at the Aliso Canyon and other gas storage facilities pose a greater risk to local area resource adequacy than to CAISO system resource adequacy. 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.

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.
IV. APPENDICES

A: 2016 Summer Supply and Demand Summary Graphs
B: 2016 Summer Imports Summary Graphs
C: 2017 CAISO Summer On-Peak NQC Fuel Type
Appendix A: 2016 Summer Supply and Demand Summary Graphs
July 2016 CAISO Actual System Daily Peak Demand & Generation and Imports at Time of Daily Peak
(based on hourly average data)

CAISO 2016 Summer 1-in-10 Peak
CAISO 2016 Summer 1-in-2 Peak
CAISO Actual Peak Demand
CAISO Total Actual Supply
CAISO Actual Generation + Reserves
CAISO Actual Imports (Net Interchange)

MW
Appendix A – Continued

August 2016 CAISO Actual System Daily Peak Demand & Generation and Imports at Time of Daily Peak
(based on hourly average data)
Appendix A – Continued

September 2016 CAISO Actual System Daily Peak Demand & Generation and Imports at Time of Daily Peak
(based on hourly average data)

- MW

- CAISO Actual Peak Demand
- CAISO Actual Generation + Reserves
- CAISO Actual Imports (Net Interchange)
- CAISO Total Actual Supply
- CAISO 2016 Summer 1-in-2 Peak Demand Forecast
- CAISO 2016 Summer 1-in-10 Peak Demand Forecast
Figure: August 2016 SP26 Actual System Daily Peak Demand & Generation and Imports at Time of Daily Peak (based on hourly average data)

- SP26 2016 Summer 1-in-10 Peak Demand
- SP26 2016 Summer 1-in-2 Peak Demand
- SP26 Actual Peak Demand
- SP26 Actual Generation + Reserves
- SP26 Actual Imports (Net Interchange)
- SP26 Total Actual Supply
- SP26 2016 Summer 1-in-2 Peak Demand Forecast
- SP26 2016 Summer 1-in-10 Peak Demand Forecast
Appendix A – Continued

September 2016 SP26 Actual System Daily Peak Demand & Generation and Imports at Time of Daily Peak
(based on hourly average data)

- SP26 2016 Summer 1-in-10 Peak Demand
- SP26 2016 Summer 1-in-2 Peak Demand
- SP26 Total Actual Supply
- SP26 Actual Peak Demand
- SP26 Actual Generation + Reserves
- SP26 Actual Imports (Net Interchange)
- SP26 2016 Summer 1-in-2 Peak Demand Forecast
- SP26 2016 Summer 1-in-10 Peak Demand Forecast
Appendix A – Continued

June 2016 NP26 Actual System Daily Peak Demand & Generation and Imports at Time of Daily Peak
(based on hourly average data)

NP26 2016 Summer 1-in-10 Peak
NP26 2016 Summer 1-in-2 Peak Demand
NP26 2016 Summer 1-in-10 Peak Demand Forecast

NP26 Actual Peak Demand
NP26 Actual Generation + Reserves
NP26 Total Actual Supply
NP26 Actual Imports (Net Interchange)
NP26 Total Actual Supply
NP26 2016 Summer 1-in-2 Peak Demand Forecast
NP26 2016 Summer 1-in-10 Peak Demand Forecast
Appendix A – Continued

July 2016 NP26 Actual System Daily Peak Demand & Generation and Imports at Time of Daily Peak
(based on hourly average data)

NP26 2016 Summer 1-in-10 Peak
NP26 2016 Summer 1-in-2 Peak Demand
NP26 Total Actual Supply
NP26 Actual Peak Demand
NP26 Actual Generation + Reserves
NP26 Actual Imports (Net)

MW

(10,000)
(2,000)
(1,000)

7/1/2016
7/2/2016
7/3/2016
7/4/2016
7/5/2016
7/6/2016
7/7/2016
7/8/2016
7/9/2016
7/10/2016
7/11/2016
7/12/2016
7/13/2016
7/14/2016
7/15/2016
7/16/2016
7/17/2016
7/18/2016
7/19/2016
7/20/2016
7/21/2016
7/22/2016
7/23/2016
7/24/2016
7/25/2016
7/26/2016
7/27/2016
7/28/2016
7/29/2016
7/30/2016
7/31/2016
Appendix B: 2016 Summer Imports Summary Graphs

ISO 2016 Summer Weekday Import Analysis

ISO Annual Peak
46,008 MW / Jul 27

ISO Interchange
2,335 MW / Jul 27

- ISO Load at Peak
- ISO Interchange at Peak
- ISO Demand within 10% of Annual Peak Demand
NP26 2016 Summer Weekday Import Analysis

NP26 Annual Peak
20,412 MW / Jul 27

NP26 Interchange
-605 MW / Jul 27

Import MW
Load MW

NP26 Load at Peak — NP26 Interchange at Peak — NP26 Demand within 10% of Annual Peak Demand
Appendix C: 2017 CAISO Summer On-Peak NQC Fuel Type

2017 ISO Summer On-Peak NQC by Fuel Type

- Natural Gas: 61.1%
- Hydro: 14.2%
- Solar: 13.7%
- Geothermal: 2.0%
- Biofuel: 1.6%
- Battery: 0.1%
- Wind: 2.5%
- Nuclear: 4.3%
- Oil: 0.4%