Common Response 7.8
Energy and Hydropower

Introduction

This introduction provides important context to this common response. A similar introduction is provided in each common response to ensure that the reader has the appropriate context when reviewing common responses. For ease of reference, a table of contents is included after this introduction to guide readers to specific subject areas.

Protecting the San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta) watershed and its many beneficial uses of water is one of the State Water Resources Control Board's (State Water Board) primary responsibilities and top priorities. In response to declines of several native aquatic species since the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Watershed (Bay-Delta Plan or Plan) was last comprehensively updated, the State Water Board commenced a process to update the Bay-Delta Plan for the Sacramento River and its tributaries, Delta eastside tributaries (including the Calaveras, Cosumnes, and Mokelumne Rivers), and Delta for the reasonable protection of fish and wildlife beneficial uses, referred to as the Sacramento/Delta Update to the Bay-Delta Plan. The Bay-Delta Plan identifies beneficial uses of water to be protected in the Bay-Delta watershed, water quality objectives and program of implementation to achieve the reasonable protection of those beneficial uses, monitoring, evaluation, and special study provisions. The State Water Board's proposed action to update the Bay-Delta Plan is supported by a Staff Report/Substitute Environmental Document (Staff Report), which provides an evaluation of the environmental impacts and economic effects in support of consideration of different alternatives to update the Bay-Delta Plan to achieve reasonable protection of fish and wildlife beneficial uses in the Sacramento/Delta. The Staff Report is functionally equivalent to an Environmental Impact Report under the California Environmental Quality Act (CEQA) but also provides the additional analyses that support the State Water Board's consideration of the action under the Clean Water Act and Porter-Cologne Water Quality Control Act (Porter-Cologne Act).

Development of the final Staff Report and final draft Bay-Delta Plan were informed by several opportunities for public comment over multiple years. This common response may address issues that were raised during any of those public comment periods. In September 2023, the State Water Board released the 2023 draft Staff Report evaluating different alternatives for the Sacramento/Delta Update to the Bay-Delta Plan for public review and comment. Following release of the 2023 draft Staff Report, the State Water Board released draft amendments to the Bay-Delta Plan in October 2024 (2024 draft Plan) for public review and comment that incorporated alternatives identified in the 2023 draft Staff Report with revisions based on public comments. The State Water Board released revised draft Plan updates in July 2025 (July 2025 revised draft Plan), but delayed public comment on that version of the Plan pending further updates, though some parties did submit public comments on the July 2025 draft that are part of the State Water Board's response to comments. In December 2025, the State Water Board released Chapter 13, *Revised Proposed Plan Amendments*, as a limited recirculation of the 2023 draft Staff Report (2025 partially recirculated draft Staff Report) together with the December 2025 revised draft Plan for public review and comment. These documents reflect the updated proposed project, referred to as the revised proposed Plan amendments, which brings together in the Bay-Delta Plan program of implementation a voluntary agreement (VA) pathway that incorporates commitments identified in the Healthy Rivers and Landscapes (HRL) proposal and would apply to specified HRL water rights, and a regulatory pathway based on the proposed Plan amendments that would apply to other water rights and to any HRL water rights no longer covered under the VA pathway. In August 2026, the State Water Board released a final draft Bay-Delta Plan that included refinements to the revised proposed Plan amendments based on public comments received on the December 2025 revised draft Plan. At the same time, the State Water Board released this final Staff Report, including responses to comments previously received on the draft Staff Report. The final Staff Report informs the State Water Board's consideration of adoption of the Sacramento/Delta updates to the Bay-Delta Plan.

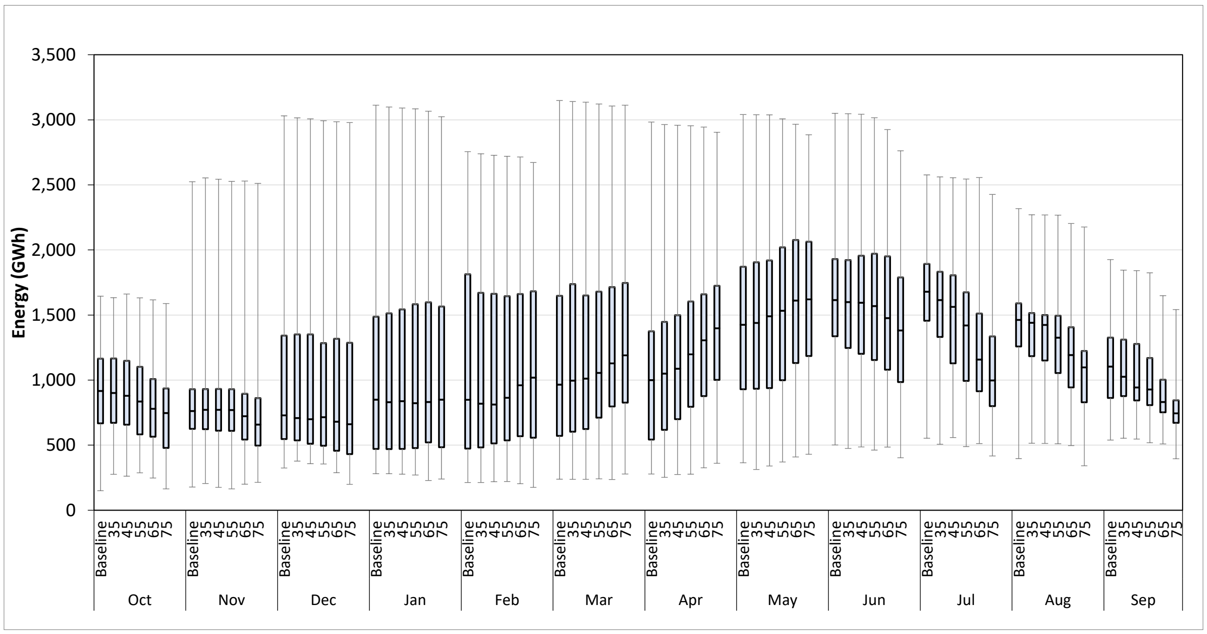
With respect to the CEQA impact conclusions, it is important that they be understood in the context of the overall nature of the proposed project, which is intended to be an environmental restoration action. CEQA only considers changes that could negatively impact the existing environment and does not recognize or offset negative changes with improvements that could result from an environmentally beneficial project. Here, the impacts that could potentially result from implementation of the restoration action occur in a system that has been highly altered, and the project would be expected to improve conditions for native fish and wildlife in the Sacramento/Delta watershed over time. However, the project will also result in changes in hydrology and changes in water supply that could result in some potentially significant adverse environmental impacts at certain times and locations that must be analyzed under CEQA. These potentially significant environmental impacts should be viewed in light of the overall purpose and goals of the Sacramento/Delta update to the Bay-Delta Plan.

This common response addresses comments raised regarding the energy impact analysis in the 2023 draft Staff Report and the 2025 partially recirculated draft Staff Report. Appendix F of the State CEQA Guidelines (Cal. Code Regs., tit. 14, § 15000 et seq.) contains recommendations for assessing energy impacts and mitigation measures that may be considered in making a decision on a project. CEQA requires a discussion of potential energy impacts to ensure that energy implications are considered, with emphasis on avoiding or reducing inefficient, wasteful, and unnecessary consumption of energy. Appendix F was used as guidance for the discussion of the energy implications of the Plan amendments.

As part of the energy analysis, modeling was performed to assess changes in hydropower generation and energy needed to convey Delta exports. Calculations for this energy modeling used Sacramento Water Allocation Model (SacWAM) results for flow and reservoir water surface elevations. After the release of the 2023 draft Staff Report and in preparation for SacWAM of the revised proposed Plan amendments, adjustments and updates were made to SacWAM for the newest round of modeling (see Appendix H1a, *Sacramento Water Allocation Model Methods*). None of these changes produced changes in flow and storage that would be large enough to alter energy impact conclusions beyond what is described in the energy analysis in the 2023 draft Staff Report.

Because of larger hydrological effects, most energy-related comments were focused on the methods of analysis and the potential impacts associated with the unimpaired flow scenarios described in Section 7.8, *Energy*, of the Staff Report and not on the analysis of the voluntary agreements. Specific topics covered in Section 7.8 include project effects on hydropower generation, energy savings associated with reduced exports, effect on peak generation, reliability of the California electric grid, effects on local and regional energy supplies, effects on compliance with existing energy standards, and energy that may be used to replace reductions in Sacramento/Delta water supply. While some commenters had specific criticisms of the material in the Staff Report, many commenters utilized and repeated information from the analyses in their comments, suggesting that the analysis is meeting CEQA's purpose of informing the public and decision-makers.

The analysis shows that changes in hydrology affecting flows and reservoir levels would result in an increase in hydropower generation in spring and a decrease in summer (Figure CR 7.8-1). Decreases in hydropower generation may necessitate increased production from other power facilities. In the near-term, this replacement energy would likely come from natural gas-fired power facilities. Many comments expressed concern related to consequences of changes in hydropower generation, particularly under the regulatory pathway. Although hydropower generation would be affected seasonally, on an annual basis, percent change in hydropower generation would be relatively small at most facilities, both because the total annual unimpaired inflow to the upper watersheds (where most hydropower facilities are located) would not change and because reservoir storage would not be greatly reduced. In general, comments on the analysis of hydropower results focused on possible effects associated with reduction in summer generation and not on annual effects.



Energy for scenarios was estimated with flow and storage simulated by SacWAM.
GWh = gigawatt hour

Figure CR 7.8-1. Monthly Hydropower Generation for Sacramento River Watershed and Delta Eastside Tributaries Regions—Facilities Potentially Subject to Changes in Flow as Simulated by SacWAM (copy of Figure 7.8-10 from Section 7.8, *Energy*)

Changes in water supply include reduced Sacramento/Delta supply to some agricultural and municipal uses and could result in a reduction in the energy used to convey Sacramento/Delta supply. The reduction in Sacramento/Delta supply could cause an increase in energy use to replace supplies if water users implement actions such as increased groundwater pumping, operation of desalination facilities, or other water management actions. The various energy requirements of these actions are compared and evaluated in Section 7.8, *Energy*. This comparative analysis also includes the energy requirements that may result from operation of a desalination facility to replace reduced supplies. (Construction and maintenance of a desalination facility is comprehensively addressed in Section 7.22, *New or Modified Facilities*; however, for the purposes of the comparative energy analysis, operational energy requirements of desalination are relevant to and discussed in Section 7.8.)

This common response addresses recurring comments and common themes with respect to energy. Specifically, this common response addresses the following topics raised by commenters:

- Local effects
- Effects on peaking generation at hydropower facilities
- Effects on reliability of the California electrical grid
- Effects during droughts and electrical emergencies
- The importance of hydropower generation to the future of California's electrical grid, and
- Energy to replace reductions in Sacramento/Delta surface water supplies

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Overview

As explained in the *Environmental Setting*, Section 7.8.2.4, *Hydropower Generation and Related Energy Use*, numerous hydropower generation facilities are in the Sacramento River watershed and Delta eastside tributaries regions. Four large reservoirs in the Sacramento Valley generate a considerable percentage of hydropower in the Sacramento/Delta. These reservoirs are Shasta, Oroville, New Bullards Bar, and Folsom. Facilities at these reservoirs are evaluated in more detail than other hydropower facilities because they would be likely to experience the largest changes in hydropower generation associated with changes in hydrology due to their size and the estimated changes in operations at these reservoirs. Water in these large reservoirs and other rim reservoirs is not stored solely for the purpose of energy generation. Water stored in these reservoirs is intended for supply upon release, with electrical generation being incidental to the release. Electrical generation at the re-regulating facilities downstream of these rim reservoirs (e.g., Keswick, Thermalito, Narrows, and Nimbus Powerhouses) is also dependent on the releases for water supply.

Numerous reservoirs in the upper watersheds are primarily operated for hydropower production, although some have a water supply component for agriculture and urban use. The hydropower projects store as much water in spring as possible while sending any excess runoff through the powerhouses. This allows substantial releases from storage in summer months during times of peak energy demand. Many of the upstream powerhouses are run-of-the-river facilities that depend on river flow and an elevation drop with little or no storage. Most of the facilities are regulated by the Federal Energy Regulatory Commission (FERC) and under Clean Water Act section 401. Several facilities depend on interbasin diversions that move water from one watershed to another. For example, diversions from the South Yuba River watershed to the Bear River via the Drum Canal provide flow to Drum 1 and 2 hydropower facilities.

Local, regional, and systemwide impacts are evaluated as part of the hydropower calculations and power flow analysis described in Section 7.8, *Energy*, and Appendix A5, *Hydropower, Energy Grid, and Export Energy Analyses*. Regional and local energy effects are considered in Section 7.8 for Impact EN-c, *The effects of the project on local and regional energy supplies and requirements for additional capacity*, which focusses on those regions most likely to experience reductions in hydropower generation. To consider whether reductions in hydropower generation could negatively affect electricity delivery anywhere in the state, a grid reliability analysis was performed. Regional differences are also evaluated for impact EN-e, *Energy requirements and energy use efficiencies by amount and fuel type for each stage of the project*, which considers regional differences in energy required to provide water supply.

The Plan amendments are intended to be complementary to FERC and water quality certification requirements to provide sufficient flow for instream beneficial uses. Provisions for adaptive implementation of the numeric inflow requirements are provided to optimize flows to benefit native fish and wildlife while also minimizing water supply impacts, and for the numeric inflow requirements to be implemented in a coordinated fashion with the cold water habitat and inflow-based Delta outflow requirements. Adaptive implementation may be allowed on a seasonal, annual, or long-term basis as part of local cooperative solutions or may be required by the Executive Director or State Water Board. Water right holders may propose local cooperative solutions for individual tributaries, two or more tributaries, or for regions. Adaptive implementation may also be used to integrate, as appropriate, Bay-Delta Plan requirements with water quality certification requirements, water right orders, or other existing environmental requirements.

As discussed in Chapter 5, *Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta*, the Plan amendments would require reservoir operators in the Sacramento/Delta to develop and implement long-term strategies and annual operations plans for approval by the State Water Board to implement the cold water habitat objective in a way that considers a tributary's unique structural, operational, and hydrological characteristics. The proposed Plan amendments allow for and encourage water users on tributaries to work together to meet the proposed flow and cold water habitat requirements in a manner that minimizes impacts on hydropower production to the extent possible. The program of implementation would allow two or more tributaries to work together to meet numeric requirements. This approach could be a method for tributaries with significant interbasin diversions for hydropower production to reduce impacts on hydropower, although there could still be issues with timing and other issues that would need to be addressed.

Evaluation of Local Effects

As described in more detail in subsections below, multiple commenters expressed concern about hydropower effects in their facilities or regions. For example, Yuba Water Agency commented that their hydropower generation at Colgate Powerhouse would be disproportionately affected, which is related to local effects associated with Plan amendment compliance points. Several commenters claimed that the hydropower analysis did not evaluate hydropower effects in their upper-watershed region or did not evaluate effects on particular utilities or agencies. Some commenters performed their own estimates of how they would be affected. And some commenters expressed concern that reductions in hydropower generation could cause grid reliability issues in their region.

Staff Report Analysis of Individual Facilities

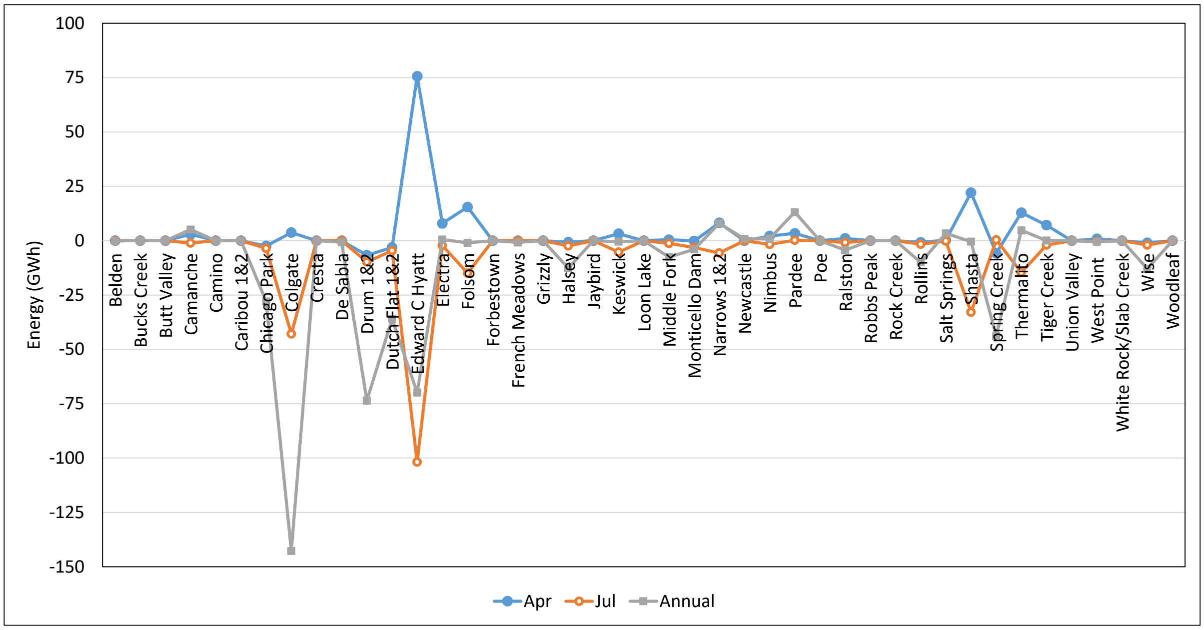
Several commenters claimed that the staff report did not evaluate effects on their local facilities. While it is not necessary for the staff report to examine detailed individual effects on all potentially affected parties (please see Common Response 7.1, *General CEQA and Approach to the Analysis*, regarding scope of analysis), the analysis of hydropower effects in the Staff Report considers local effects in several ways. One way is by estimating hydropower generation at individual facilities. Changes in generation were estimated at the 47 largest facilities expected to be affected by changes in hydrology. The 47 facilities analyzed individually are identified in Appendix A5, *Hydropower, Energy Grid, and Export Energy Analyses*, in the section titled *Hydropower Facilities Modeled*.

As described in Appendix A5, *Hydropower, Energy Grid, and Export Energy Analyses*, these facilities represent almost all the hydropower capacity potentially affected by changes in hydrology. They represent 79.4 percent of the total hydropower capacity in the Sacramento/Delta. Approximately 16.8 percent of the remaining hydropower capacity is at facilities not expected to be affected by the type of hydrologic changes likely to occur with the Plan amendments. Facilities potentially affected by changes in hydrology but not evaluated in detail represent only 3.8 percent of hydropower capacity in the Sacramento/Delta. As a result, detailed hydropower analysis covered 95.4 percent of generation capacity in the Sacramento/Delta (79.4/[79.4+3.8]) that potentially could be affected by changes in hydrology.

As described in Section 7.8, *Energy*, changes in hydrology simulated by SacWAM would result in a range of hydropower effects at the hydropower facilities in the Sacramento River watershed and Delta eastside tributaries regions. The largest changes in flow and hydropower would be expected to occur at the rim reservoirs and downstream because modification of the rim reservoir operations is the primary way the flow objectives would be met. Many facilities in the upper watersheds above the rim reservoirs would not be expected to experience large hydrologic changes because consumptive use and reservoir storage in these areas are relatively small. However, in some cases, implementation of the flow objectives could result in a reduction of water diversions between watersheds, particularly for the higher end of the flow range. A reduction in interbasin diversions could reduce generation at upper watershed facilities that depend on the diversions. Conversely, a few facilities may benefit from the retention of flows within a watershed.

To show which facilities would be most affected, Section 7.8, *Energy*, provides a summary of average changes at all the facilities evaluated for the 55 scenario (Figure CR 7.8-2). Effects would be less or more pronounced in the 45 and 65 scenarios, respectively. The figure shows results for April (the month with the largest increases in hydropower generation) and July (the month with the largest decreases in hydropower generation), as well as the annual total. As expected, based on facility size and location, large changes occur at Shasta, Oroville (Hyatt Powerhouse), New Bullards Bar (Colgate Powerhouse), and Folsom. Other facilities that show moderate changes in hydropower generation include the following.

- Keswick Power Plant (supplied primarily by releases from Shasta Reservoir)—Affected primarily by changes in release schedule from Shasta Reservoir but also some reduced inflow from Spring Creek Power Plant.
- Spring Creek Power Plant (supplied by Clear Creek and Trinity River water in Whiskeytown Reservoir)—Inflow from the Trinity River watershed does not change between scenarios, but releases from Whiskeytown Reservoir to the Spring Creek Power Plant are reduced in order to retain more water in Clear Creek.
- Pardee and Camanche Power Plants (supplied by Mokelumne River)—Reduction in diversions from Pardee Reservoir to the East Bay Municipal Utility District pipeline results in more water being released from Pardee and Camanche Reservoirs through their two power plants.
- Thermalito Power Plant (supplied by Feather River)—Affected primarily by changes in release schedule from Lake Oroville.
- Narrows 1 & 2 Power Plant (supplied by Yuba River)—Increase in generation caused by reduction in diversions from the Yuba River to other basins. Also affected by change in releases from New Bullards Bar Reservoir.



GWh = gigawatt hour

Figure CR 7.8-2. Estimated Average Change in Hydropower Generation for the 55 Scenario at Individual Hydropower Facilities (copy of Figure 7.8-14 from Section 7.8, *Energy*)

As described in Section 7.8, *Energy*, some facilities in the upper watershed showed small to large changes in hydropower generation.

- Drum 1 & 2 Powerhouses (located along the conveyance between the Yuba and American Rivers to Bear River)—Reduction in generation caused by reduction in diversions from the Yuba River to the Bear River.
- Halsey and Wise Powerhouses (located along the conveyance between the Bear River to Auburn Ravine and the American River)—Reduction in generation caused by reduction in diversions from Bear River to Auburn Ravine and the American River.
- Chicago Park, Dutch Flat 1 & 2, and Rollins Powerhouses (supplied by the Bear River)—Reductions in hydropower generation caused by reduction in interbasin diversions to the Bear River.
- Middle Fork and Ralston Powerhouses (supplied by water in the Middle Fork American River basin, including the Rubicon River)—Small increases in hydropower in the spring and reductions in the summer caused by increases in releases from Hell Hole and French Meadows Reservoirs to meet instream flow requirements in the spring, followed by reduction in releases in the summer. Occasional exceedances of power plant capacity in the spring result in small reductions in net annual generation.
- Tiger Creek and Electra Power Plants (supplied by North Fork Mokelumne River)—Small increases in hydropower in the spring and reductions in the summer caused by small increases in releases from upstream reservoirs to meet instream flow requirements in the spring, followed by reduction in releases in the summer.

Actual effects on hydropower generation could be less than what was calculated based on SacWAM results. SacWAM results do not utilize flexibility in the Plan for adaptive management and local cooperative solutions, nor do they rely on fully developed long-term strategies. The Plan amendments allow for and encourage water users on tributaries to work together to meet the proposed flow and cold water habitat requirements in a manner that minimizes effects on hydropower generation to the extent possible. The program of implementation would allow two or more tributaries to work together to meet numeric requirements. Depending on specifics and approval, this approach could be a method for tributaries with significant interbasin diversions for hydropower production to reduce impacts on hydropower.

Compliance Points

Yuba Water Agency has expressed concern that the Plan amendments stand to affect power generation at Colgate Powerhouse disproportionately. Location of flow compliance points for the regulatory pathway will influence to what degree various hydropower facilities may be affected. A brief discussion below about compliance points provides background on the distribution of the Plan amendment effects on instream flows.

It is not an objective of the flow scenarios to affect hydropower generation. Nor is it an objective of the flow scenarios to create a greater percent decrease in hydropower generation in certain hydropower facilities or watersheds. Such decreases, however, may occur.

Hydropower effects of the Plan amendments on individual facilities will be influenced by the effect of existing infrastructure and operations on instream flows (i.e., how much do existing flows deviate from potential requirements). Hydropower effects will also be influenced by the compliance points for the unimpaired flow requirements under the regulatory pathway. Compliance points are generally located at the downstream ends of the larger tributaries. Initial compliance points include the confluence of Sacramento/Delta tributaries with the Sacramento River; the confluence with the Legal Delta for the Cosumnes, Calaveras, and Mokelumne Rivers; the mainstem of the Sacramento River at the confluence with the Delta; and, upstream locations on Sacramento/Delta tributaries at the confluence of every major fork, branch, and tributary of the tributaries subject to the inflow requirements unless determined through the implementation process that they are not needed or appropriate. Specific locations are listed in Table A1-2 of Appendix A1, *Sacramento Water Allocation Model Methods and Results*. There are multiple smaller tributaries that contribute flow to the compliance points that have unregulated flow that can contribute to meeting flow requirements at the compliance points.

Colgate Powerhouse and Yuba Water Agency

Similar to other hydropower facilities, Colgate Powerhouse would be expected to experience increases in spring hydropower generation and decreases in summer generation under the regulatory pathway. Several commenters expressed concern that on an annual basis, Colgate Powerhouse may experience greater annual reductions in generation than other hydropower facilities.

As simulated for the 2023 draft Staff Report and described in Section 7.8, *Energy*, the largest reductions in annual hydropower generation were estimated to occur at Colgate Powerhouse. The reason for this reduction is partially due to the specific location of the unimpaired flow requirement on the downstream end of the Middle Fork Yuba River. As described in Section A1.2.2, *Locations of New Instream Flow Requirements in Each Scenario*, in Appendix A1, *Sacramento Water Allocation Model Methods and Results,* SWRCB instream flow requirements were added above rim dam locations, below rim dam locations, and at the mouths of major tributaries to require upper watersheds to contribute to the new flow requirements, and to require large projects in the Sacramento/Delta region to bypass the percentage of unimpaired flow through the Delta. This general approach was applied to the Yuba River watershed and led to unimpaired flow requirements in the upper watershed on the North Fork Yuba River above New Bullards Bar Reservoir, on the South Fork Yuba River above Englebright Reservoir, and the Middle Fork Yuba River above the confluence with the North Fork Yuba River. New Bullards Bar Reservoir, which supplies Colgate Powerhouse, is located on the North Fork Yuba River, which supplies most of the water to the reservoir. However, the reservoir also receives water from the Middle Fork Yuba River imported through the Lohman Ridge and Camptonville Tunnels. The Middle Fork compliance point location has the effect of reducing the amount of water that can be diverted from the Middle Fork through the Lohman Ridge and Camptonville Tunnels to New Bullards Bar Reservoir. The long-term strategy plan to be developed for New Bullards Bar Reservoir as part of the cold water habitat objective and as mitigation for energy impacts could potentially demonstrate the temperature and energy benefits of moving this compliance point upstream, potentially as part of a local cooperative solution. If this compliance point were moved upstream of the Lohman Ridge diversion point on the Middle Fork Yuba River, Middle Fork diversions to New Bullards Bar Reservoir could potentially increase annual hydropower generation under the flow scenarios to become closer to baseline generation.

Another reason that the reduction in hydropower generation at Colgate Powerhouse is relatively large is that Colgate Powerhouse is large and generates substantial electrical energy, so any reduction would be relatively large in terms of GWh. Based on the analysis performed as described in Appendix A5, *Hydropower, Energy Grid, and Export Energy Analyses*, the estimated average annual baseline electricity generation at Colgate Powerhouse is 1,289 GWh. The average annual reduction in generation under the 55 Scenario of 143 GWh represents approximately 11.1 percent of the total. Yuba Water Agency operates Colgate Powerhouse and the Narrows 1&2 Powerhouses. The estimated average annual baseline generation at the Narrows Powerhouses is 277 GWh and the estimated change in generation under the 55 Scenario is an increase of 8 GWh. The estimated combined effect on the three major Yuba Water Agency facilities under the 55 scenario is an average annual reduction in generation of 8.6 percent, allowing for substantial continued revenue from hydropower generation.

Effect on Hydropower Facilities in Upper Watersheds

Some commenters expressed concern about the effects of the Plan amendments on hydropower generation in the upper watersheds, such as some facilities operated by Pacific Gas and Electric Company (PG&E), Nevada Irrigation District (NID), South Feather Power Project, and Sacramento Municipal Utility District (SMUD).

In many tributaries, the flow requirements would allow operations in the upper watersheds to continue as they do under existing conditions because there is sufficient flow at the downstream ends of upper watershed tributaries to meet flow requirements at compliance points. Effects at individual upper watershed facilities are described for Impact EN-c in Section 7.8, *Energy*, and Appendix A5, *Hydropower, Energy Grid, and Export Energy Analyses*, Section A5.2.5.2, *Effects at Individual Facilities*.

As described for impact EN-c, upper watershed facilities most likely to be affected by flow requirements are those located in tributaries that are affected by substantial interbasin diversions under existing conditions. For these facilities, local cooperative solutions could be used to reduce hydropower effects as described for Mitigation Measure EN-a–e. Water users would be encouraged to work together to tailor approaches to meet flow requirements of the regulatory pathway in a manner that minimizes disruptions to other important beneficial uses, including hydropower.

Commenter Estimates of Local Effects

Some commenters presented their own evaluation of local hydropower effects and claimed larger hydropower effects than were calculated based on the SacWAM results for the Staff Report. The results from the commenter simulations differed from the Staff Report simulations due to differences in modeling assumptions.

For example, differences in assumptions for reservoir operations contributed to some discrepancies between hydropower effects estimated in the Staff Report and hydropower effects estimated by commenters. Some modelers assumed that the specified percentage of unimpaired flow would be bypassed at all reservoirs, when in fact many reservoirs would be able to operate as they do under existing conditions without affecting whether the flow requirements are met. Other operational differences are related to carryover (end-of-September) storage assumptions. Carryover storage in SacWAM depends on multiple controls that vary between reservoirs including operational priorities and storage buffers. This results in a range of carryover storage values from SacWAM that vary from year to year based on hydrology, which is similar to how reservoirs are actually operated. Other reasons for differences between the Staff Report and commenter estimates of hydropower effects are differences in hydrology, such as years selected for evaluation.

Another reason for differences in results is related to differences in assumptions regarding points of compliance. Local hydropower effects are dependent on the locations selected for implementation of the Delta inflow requirements. Initial compliance points, which are described above under *Compliance Points*, do not include every reach, reservoir discharge, or small stream within a watershed. As described above in the compliance points and upper watershed sections, in many tributaries, the flow requirements would allow operations in the upper watersheds to continue as they do under existing conditions because existing flow at compliance points would be sufficient to meet flow requirements. Hydropower effects based on SacWAM results were often less than what was estimated by commenters.

Nevada Irrigation District Example

Multiple comments expressed concern that reduction in hydropower generation by NID's Yuba-Bear project would be substantial.

Most of NID's hydropower generating capacity comes from the three main facilities of the Yuba-Bear project: Dutch Flat 2, Chicago Park, and Rollins powerhouses. Changes in hydropower generation at these powerhouses represent possible effects on NID hydropower generation. Based on the SacWAM flows used for the analysis presented in Appendix A5, *Hydropower, Energy Grid, and Export Energy Analyses*, reduction in hydropower generation at these powerhouses could vary between approximately 11 percent for the 45 Scenario and 35 percent for the 65 scenario (Figures A5-17 through A5-19). These reductions in hydropower generation are lower than those estimated by NID.

The greater effect estimated by NID relative to the SacWAM results is due to differences in modeling approach. Common Response 6.1, *Sacramento Water Allocation Model and Changes in Hydrology and Water Supply,* provides detail comparing SacWAM to hydrologic modeling by commenters for the

Yuba River watershed, including a description of concerns regarding NID modeling of effects on Yuba River operations. Some of the concerns are inclusion of unnecessary compliance points in the NID modeling and changes in modeling assumptions between baseline and the 55 scenario that are not related to the regulatory pathway (i.e., climate change and increased level of demand).

Grid Reliability

There were multiple comments expressing concern about effects of changes in hydropower generation on the reliability of the electrical grid, with some expressing concern about the grid in general, some expressing concern about local grid effects, and others commenting on the methodology that was used to evaluate grid reliability.

Power Flow Analysis

In general, electricity can be moved from one location to another, and local effects become important for grid reliability only if there is a limitation on total available supply or there is a restriction point in moving electricity from generating sources to users. As a result, changes in hydropower generation do not by themselves indicate whether local or regional energy supplies would be affected. As long as the electric grid can move sufficient energy to where it is needed, there is no need for additional generation. The ability of the electric grid to handle reductions in hydropower generation at facilities depends on generation capacity at other facilities and on the ability of the grid infrastructure to convey electricity from those facilities.

Local effects on the electrical grid were evaluated with a power flow analysis. The power flow analysis incorporated changes in hydropower generation at each of the 47 facilities that were evaluated in detail. The methodology for this analysis is described in the Appendix A5 section titled *Power Flow Assessment Methods*. While the power flow modeling covers a large area (the multi-state Western Interconnection), the model includes, by necessity, detailed representation of local power infrastructure.

The power flow analysis was performed using Power Gem's Transmission Adequacy and Reliability Assessment (TARA) software. The TARA Load Flow model uses inputs developed by the California Independent System Operator (CAISO) to represent 2021 electric grid conditions under heavy summer demand for the entire Western Interconnection, including detailed representation of the California electric grid. The model relied on transmission system data obtained from the 2021–2022 CAISO Reliability Assessment Base Case. ICF staff obtained the case through the Critical Energy/Electric Infrastructure Information process. The power flow modeling includes all types of electricity-generating facilities, including natural gas, solar, hydropower (including all CVP and SWP hydropower), coal, and wind. The electrical demand is modeled at each substation, and it includes all types of demands: residential, industrial, agricultural, and institutional (e.g., energy to move SWP and CVP Delta exports).

In the power flow analysis, grid reliability for the 75 scenario was compared with baseline conditions. The power flow analysis evaluated the ability of the electric grid to compensate for the 75 scenario under a range of contingencies. To assess grid reliability, loading on transmission facilities—including transmission lines and transformers as well as bus voltages—was evaluated to identify any thermal violations (i.e., power overload) or voltage violations under both normal and contingency conditions. Under normal conditions, all generation and transmission facilities were assumed to be in service. The contingency scenarios were ones defined by CAISO for reliability assessments. These CAISO contingency scenarios specify single and multiple outages.

For the power flow analysis, the estimated peak power generated by the 47 facilities represented in the analysis was approximately 3,552 MW for baseline conditions and 2,118 MW for the 75 scenario. To compensate for this difference in power, generation at existing natural gas facilities was scaled up proportionally in the 75 scenario analysis. Peak power generated under the other flow scenarios was higher than for the 75 scenario, indicating the conservative nature of the power flow analysis (2,449 MW for the 65 scenario, 2,872 MW for the 55 scenario, 3,218 MW for the 45 scenario, and 3,428 MW for the 35 scenario).

As described in Appendix A5, *Hydropower, Energy Grid, and Export Energy Analyses,* even with the 75 scenario, which would result in substantially larger changes in hydrology than the 55 with water supply adjustments (w/WSA) scenario being suggested as the starting point for the regulatory pathway of the revised proposed Plan amendments, modeled generation at other facilities was able to increase to compensate for reductions in hydropower generation and provide sufficient electricity to maintain reliability of the electrical grid.

In the power flow analysis, the grid remained reliable even with the multiple contingency scenarios that were evaluated, although the power flow analysis did not cover the specific series of extenuating circumstances that led to the rolling blackouts of 2020. The Staff Report includes consideration of the effect of the Plan amendments on rolling blackouts in Section 7.8, *Energy*, Impact EN-c: *The effects of the project on local and regional energy supplies and requirements for additional capacity*. Rolling blackouts are considered further in the section below titled *Consideration of Rolling Blackouts*.

Detailed results from the power flow analysis, including specific pieces of infrastructure likely to be most affected by the Plan amendments are presented in the Appendix A5 section titled *Power Flow Assessment Results*.

Peaking Power and Drought Conditions

As described in Appendix A5, *Hydropower, Energy Grid, and Export Energy Analyses,* and Section 7.8, *Energy*, demand for electricity fluctuates on a daily and annual basis, with peak demand tending to occur during the late afternoon or early evening in the summer. The ability to ramp power generation up and down during the day is an important tool to compensate for variations in demand and generation of electricity. Typically, increased generation from natural gas facilities and hydropower is used to meet the daily peak demand. This peaking ability is becoming more important due to increasing use of solar and wind power, which fluctuates daily and seasonally in a way that does not match demand.

Several commenters said the flow scenarios would affect the ability of hydropower plants to provide peaking power. They claimed that the flow scenarios would cause substantial reduction in the ability to increase generation during energy shortages and that the peaking analysis was inadequate because it did not consider drought conditions.

This discussion considers two different types of hydropower peaking operations: typical daily peaking and emergency peaking.

- Typical daily peaking – is an increase in hydropower generation that occurs on a daily basis to increase generation during the time of day when demand is high relative to supply.

- Emergency peaking – is an increase in hydropower generation in response to an energy shortage due to heat waves and/or contingencies. During emergency peaking, reservoir operators can release more water than they would typically.

Typical Daily Peaking

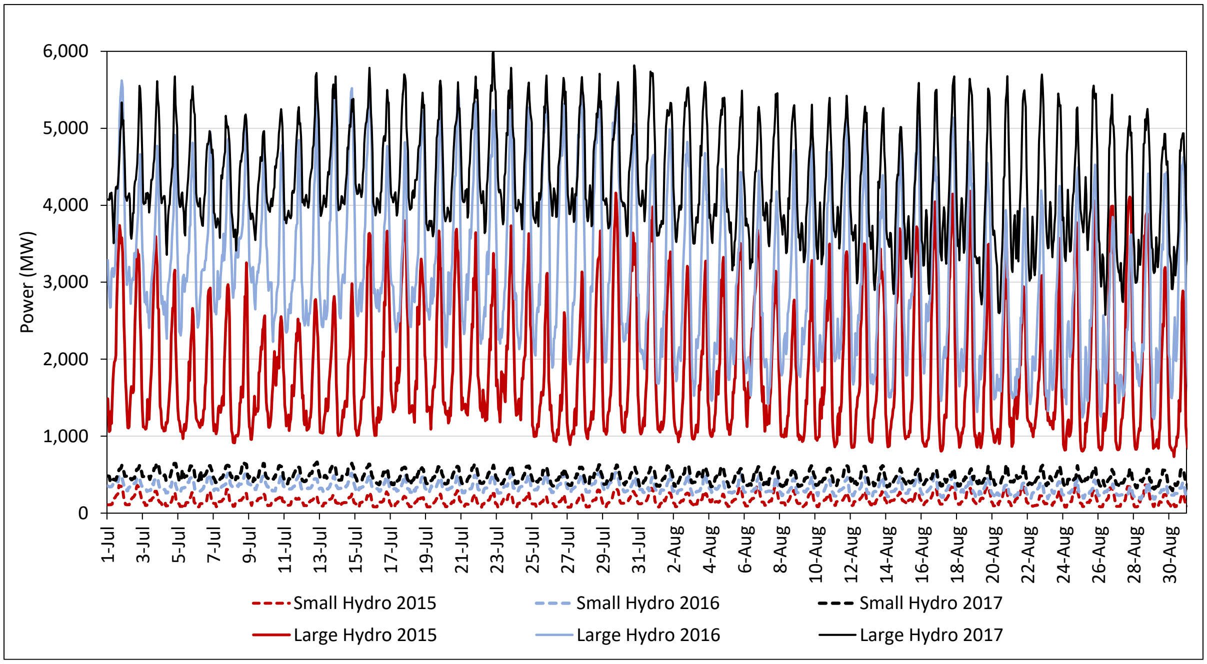
Some commenters suggested that the analysis should have used the peaking fraction from 2015, a critical water year, instead of the peaking fraction from 2016, a below normal water year. The following paragraphs describe the peaking fraction methodology and explain why it is appropriate to use the value from 2016. Other commenters claimed the peaking fraction methodology was faulty because it was not calculated separately for each hydropower facility.

Because the power flow model simulates electricity during the daily period of peak demand, the monthly hydropower values estimated from SacWAM results were scaled up to represent the monthly average of daily peak power. Under both baseline conditions and the 75 scenario, hydropower peaking operations would occur to maximize hydropower during the daily time of peak demand. Daily peak hydropower generation was estimated as the monthly hydropower derived from the SacWAM results increased by a fraction (the peaking fraction) to represent typical peaking operations that would occur in the absence of a contingency.

The typical peaking fraction was included in the power flow analysis as described in the Appendix A5 section titled *Selection and Modification of Estimated Hydropower Values for Power Flow Modeling*. Average typical peaking pattern data for all CAISO hydropower facilities combined can be calculated from data available from CAISO. To estimate the summer peaking fraction, hourly CAISO data for July and August in 2015, 2016, and 2017 were evaluated to assess conditions during a range of hydrologic conditions (CAISO 2017). The peaking fraction does not represent the maximum possible generation that could occur during grid emergencies, but instead represents what typically occurs during the summer, absent an emergency.

CAISO does not provide (and the State Water Board does not have) data for peaking operations at individual facilities. The use of the aggregated values is sufficient for evaluating the ability of electric power supply to maintain grid reliability. While hydropower generation at some facilities may be more affected by the flow requirements than others, the percentage increase in peaking operations is less likely to be affected. In addition, the use of average typical peaking patterns in the analysis approximates the average effect of the Plan amendments on overall peaking operations due to the large number of facilities that were evaluated (i.e., actual peaking operations will be higher than the average at some facilities and will be lower at other facilities).

As described in Appendix A5, *Hydropower, Energy Grid, and Export Energy Analyses*. Regional, under wet conditions, hydropower facilities may operate close to full capacity throughout the day; during dry conditions, reductions in water availability may limit the ability to generate maximum power during periods of peak demand. However, flexibility persists under both dry and wet hydrologic conditions. Hourly hydropower values for 2015 (a critically dry year) and for 2017 (a wet year) show that substantial peaking operations occur during both wet and dry years (Figure CR 7.8-3).



Source: CAISO 2017 .
MW = megawatt

Figure CR 7.8-3. Hourly Power from Small and Large California Independent System Operator Hydropower Facilities during Summer 2015, 2016, and 2017 (copy of Figure A5-26 from Appendix A5, *Hydropower, Energy Grid, and Export Energy Analyses*

The evaluation of peaking fractions during 2015 – 2017 showed that as a percentage of average hydropower generation, the peaking fraction was greatest during the dry conditions of 2015 and smallest during the wet conditions of 2017. During dry years, operators optimize hydropower by increasing the typical amount of peaking generation compared to average daily generation and the peaking fraction is higher. According to CAISO, during drought conditions "hydro resource operators typically strive to conserve their more limited water to provide peaking energy, which helps mitigate the adverse impact of limited hydro" (CAISO 2022). For the power flow assessment, the peaking fraction was assumed to be equal to the peaking fraction of 2016, a below normal water year (see Table A5-12, Average July-to-August California Independent System Operator Hydropower Peaking).

Use of the peaking fraction from 2015 (81%) would have resulted in higher calculated values for peak summer hydropower generation compared to the peaking fraction that was used, the value from 2016 (54%). Use of the 2015 value would have resulted in a less conservative analysis than use of the 2016 value because it would have resulted in an increase in the calculated hydropower generation, which would help maintain reliability of the electric grid. However, even with use of the lower 2016 peaking fraction, the electric grid remained reliable in the power flow analysis.

Emergency Peaking

The California electrical grid is most likely to become unreliable when contingency events occur during heat waves. The reservoir releases that supply some hydropower facilities can be increased on a short-term basis to maximize power and alleviate reliability violations that may occur under contingency conditions during periods of peak demand. When these events occur, increased hydropower generation may help prevent rolling blackouts through emergency peaking. When this occurs, hydropower facilities may temporarily increase hydropower generation beyond what would be expected with typical operations.

As part of the hydropower calculations for the Staff Report described in Appendix A5, *Hydropower, Energy Grid, and Export Energy Analyses,* emergency peaking capability at the Shasta, Folsom, Oroville, and Colgate Powerhouses was estimated for baseline conditions and the flow scenarios. These estimates were based on reservoir water surface elevation simulated by SacWAM and maximum possible flow through the powerhouses. These estimates of emergency peaking capability could have been included in the power flow modeling assessment if the inclusion of those estimates were needed for maintaining grid reliability. This was not necessary, however, because increases in natural gas generation were sufficient to prevent reliability criteria violations, even when the 75 scenario was combined with contingencies.

Emergency peaking requires adequate reservoir storage. It is expected that adequate storage would continue to be available for emergency peaking with implementation of the Plan amendments. Adequate storage would be protected through implementation of the cold water habitat objective, which would prevent reservoirs from being drained under the regulatory pathway. The lowest storage levels typically occur during Septembers of critical water years or later in the fall following critical water years. Estimated carryover (end-of-September) storage during critical water year types indicates availability of water at a time when storage levels might be of concern. As indicated by SacWAM results for the staff report, storage would remain high enough that power generation could be ramped up in response to reduced availability of electricity.

For most reservoirs, carryover storage during critical water years is expected to be similar to or higher than under baseline conditions. For example, as simulated for the 2023 draft Staff Report and presented in Table 6.3-9, under the 55 scenario, average critical water year carryover storage at Shasta, Oroville, New Bullards Bar, and Folsom Reservoirs (the Sacramento/Delta reservoirs with the largest hydropower facilities) would change relative to baseline by +30%, -2%, -12%, and +4%, respectively. Under the 55 w/ WSA scenario of the revised proposed Plan amendments, average critical water year carryover storage simulated for Shasta, Oroville, New Bullards Bar, and Folsom Reservoirs would change relative to baseline by +45%, +28%, -9%, and +5%, respectively (Section 13.4, *Changes in Hydrology and Water Supply*).

Drought Conditions

Some commenters thought that the power flow analysis should have been based on the hydropower calculations for critical water years or should have represented conditions during extended drought instead of being based on changes in hydropower generation estimated for below-normal water years. During critical water years, several things occur that would reduce the effect of the Plan amendments on hydropower generation. The cold water habitat objective has provisions for maintaining carryover storage for protection of cold water habitat, which would limit the effect of the Plan amendments on reservoir storage during the late summer and early fall, particularly under dry conditions. During times of drought, water availability for powerhouse flow is low and hydropower generation is depressed regardless of implementation of the Plan amendments. Under these circumstances, the electrical grid must operate with less hydropower and other sources of energy must increase, but hydropower generation can still assist in meeting demand during emergencies. For example, during the 2022 drought year, the electrical grid was able to compensate for an electrical emergency that was associated with an extreme heat wave from August 31 through

September 9. During this time, CAISO's grid reached record demands on September 6 with an instantaneous gross peak load of 52,061 megawatts (MW) and an hourly average load of 51,479 MW (CAISO 2022). Despite this high load and lower levels of hydropower generation due to the drought, rolling blackouts were avoided (CAISO 2022).

As described in Appendix A5, *Hydropower, Energy Grid, and Export Energy Analyses,* for the power flow analysis, the 2016 peaking fraction of 54% was applied to the calculated average July power values for baseline and the 75 scenario for below-normal years. While hydropower generation during critical water years is less than during below-normal years, the peaking fraction for critical years can be higher (e.g., 81% during 2015), and the difference between baseline conditions and the flow scenarios is expected to be greater during below-normal years. CEQA analysis considers project-related changes relative to baseline conditions. Below-normal years were chosen for evaluation because they showed the largest change relative to baseline.

Consideration of Rolling Blackouts

Several commenters implied that the environmental analysis did not consider possible contributions of the Plan amendments to rolling blackouts or that the analysis needed to include an evaluation of the heat-wave induced energy shortage of 2022.

As evidenced by history, unexpected situations may cause rare outages. Multiple contingencies were considered as part of the power flow analysis, but under extenuating circumstances, such as what occurred in 2020, rolling blackouts could occur even without implementation of the Plan amendments. To further consider grid reliability, the circumstances that led to brief periods of electrical energy shortages that resulted in power curtailments, or blackouts, during August 14 and 15, 2020, were considered in the grid reliability analysis discussed in Section 7.8, *Energy*. As described in Section 7.8, the Plan amendments could have a small incremental effect on power outages.

The rolling blackouts that occurred in 2020 were the result of a series of unfortunate circumstances that are described in Section 7.8, *Energy*. The rolling blackout events that occurred during August 14 and 15, 2020, indicate there are some extreme circumstances that can cause California's electric grid to become unreliable due to inadequate supply of electricity, leading to the need for rotating power outages. If such rotating outages occur again, changes in hydrology could cause an incremental exacerbation of the outages.

During the August 14, 2020, period of rolling power outages, demand for CAISO power peaked at 46,777 MW. As described in Appendix A5, *Hydropower, Energy Grid, and Export Energy Analyses,* the summer peak hydropower generated in the Sacramento/Delta is approximately 3,600 MW for baseline conditions, 3,200 MW for the 45 scenario, 2,900 MW for the 55 scenario, and 2,400 MW for the 65 scenario, with most of the reduction due to reduction in flow. The estimated 700 MW reduction in power generation associated with the 55 scenario represents approximately 1.5 percent of the CAISO peak energy demand during the August 14, 2020, rolling blackouts. The percentage would be even smaller with implementation of emergency increases in hydropower generation, which were not considered in the analysis of rolling blackouts. Under the Plan amendments, incremental effects due to changes in hydrology on power outages would be rare and would represent a relatively small effect on the state as a whole but could represent a significant temporary impact on the affected communities.

Several commenters described the 2022 extreme heat event as another energy emergency worthy of detailed evaluation. The 2022 extreme heat event and electrical emergency was not more severe than the 2020 event because no rolling blackouts were required. Several commenters described emergency responses that were taken in 2022, including emergency hydropower generation that helped prevent the need for rolling blackouts in 2022. Inclusion of the 2022 heat emergency in the Staff Report would not alter the conclusions in the Staff Report that are based on assessment of the 2020 rolling blackouts. Under the Plan amendments, it is expected that emergency hydropower generation could still occur, but in the event of rolling blackouts, there could be local incremental effects.

Future of the California Electrical Grid

Several commenters expressed concern that reduction in hydropower generation would be problematic for meeting California's increasing need for electricity, particularly carbon-free electricity. As described in Section 7.8, *Energy*, hydropower facilities generate a relatively small percentage of the electricity in California (e.g., large hydropower generation contributed 9.2 percent to California's electrical energy generation in 2021). However, Section 7.8 also acknowledges hydropower's additional benefits of being a flexible renewable source of energy that can be scaled up to provide more electricity when supply is low relative to demand.

Demand for electrical energy in the state of California is expected to increase due to

- Increasing electrification of transportation, homes, and businesses,
- Increases in data center use of electricity, and
- Climate change, which will result in increased use of air conditioning.

Enactment of SB100, which requires carbon-free supply of electricity by 2045, will necessitate substantial increases in carbon-neutral electricity to meet increasing demand and replace existing fossil-fuel based generation.

CAISO has evaluated the 2045 demand for electricity and possible scenarios for generating this electricity in a carbon-neutral manner (CAISO 2024). CAISO estimated that during the afternoon period of peak consumption, peak electrical load may be 77,430 MW. During this time, a substantial portion of electricity may come from solar energy. The more problematic portion of the day, however, would occur in the early evening when demand for electricity is still high, but no solar power is available. In this circumstance, peak electrical load was estimated to be 64,923 MW. These two load estimates, 77,430 MW and 64,923 MW, are 49 percent and 25 percent higher than the September 6, 2022, peak load of 52,061 MW.

In the 2045 scenarios evaluated by CAISO, during the period of the day when solar electricity is not available, future load is expected to be met with substantial increases in power from wind and battery storage, with battery storage potentially providing between 19,000 MW and 51,000 MW. In contrast, traditional hydropower (i.e., not generated through pumped storage) was assumed to provide only 5,574 MW. (CAISO 2024).

As described above in the section titled *Consideration of Rolling Blackouts*, the 55 Scenario could reduce summer peak hydropower generation by approximately 700 MW. This represents approximately 1.1 percent of the estimated peak early evening load of 64,923 MW estimated by CAISO for 2045.

In the short-term, under typical operating conditions, reductions in summer hydropower generation associated with the Plan amendments would likely be replaced with natural gas generation, but in the long-term, other technologies will be greatly augmented to meet California's energy goals. Reductions in hydropower generation would be small compared to the new energy generation needed to replace electricity generated through fossil fuel consumption and meet the increasing demand for electricity.

During future electrical emergencies, emergency hydropower peaking operations could still occur, as described above in the section titled *Emergency Peaking,* even with the Plan amendments. Furthermore, as indicated in the CAISO study, battery storage will likely provide a substantial portion of early evening power generation in the future (>19,000 MW in 2045). Because battery storage can be used in a flexible, dispatchable, manner to a degree even greater than hydropower, and because batteries are expected to eventually provide much more energy during early evening periods of peak demand as compared to traditional hydropower, batteries will likely augment future-grid reliability to a greater degree than the role currently played by hydropower in today's electrical grid (i.e., hydropower may play less of a role in the flexible response to future fluctuations in energy supply than it does now).

Possible Energy Expenditure to Replace Surface Water Supplies, including Increased Groundwater Pumping

Some commenters stated that the energy analysis should evaluate the energy required for increased groundwater pumping that could occur as a result of reductions in Sacramento/Delta surface water supply, and that this possible energy expenditure should be included in the analysis of all potential impacts including the power flow analysis.

Energy requirements of groundwater pumping are discussed in several locations in Section 7.8, *Energy*. In particular, the evaluation of Impact EN-e, *Energy requirements and energy use efficiencies by amount and fuel type for each stage of the project*, considers energy that could be expended to replace reductions in Sacramento/Delta water supply. It also considers the net effect of reductions in energy needed to transport Sacramento/Delta water supply and increases in energy used to replace reductions in Sacramento/Delta water supply.

Energy required for groundwater pumping is part of the evaluation of potential energy expenditures needed for replacing reductions in surface water supply as discussed for Impact EN-e. The extent to which water users may increase groundwater pumping is uncertain and the energy cost associated with that pumping is also uncertain and depends on the depth of the groundwater and the efficiency of the system. Groundwater pumping is less likely to occur in areas where groundwater supply is limited. In addition, groundwater subbasins in many parts of the San Joaquin Valley are overdrafted and are subject to the Sustainable Groundwater Management Act, which could limit groundwater use in the future.

Estimates of average regional energy costs for groundwater pumping are presented for Impact EN-e in terms of kilowatt-hours per acre-foot (kWh/AF) and vary from 350 kWh/AF to 650 kWh/AF. These are compared to estimates of regional energy savings associated with reduced deliveries of

Sacramento/Delta water supply, which vary from 0 kWh/AF to 3,240 kWh/AF. Energy savings would also be associated with water conservation. The most energy intensive method for replacing reductions in surface water supplies would be desalination of seawater, estimated to require 4,100 kWh/AF to 5,100 kWh/AF. (Table 7.8-5).

The evaluation for impact EN-e ultimately concludes that, depending on how water users respond to decreased water deliveries, the energy used to replace reduced Sacramento/Delta water supply potentially could exceed the energy saved by conveying less Sacramento/Delta water to end users.

One commenter mentioned that implementation of the Plan amendments might cause extra energy to be expended to increase pumping out of the Delta. This increased pumping would take place to meet water demand adjacent to the Delta that is currently supplied by another Sacramento/Delta source of water. If this were to occur, it likely would require less energy than other potential responses to reduction in water supply that are evaluated for impact EN-e. For example, pumping water out of the Delta for local use would likely use less energy than groundwater pumping due to the greater depth of groundwater relative to surface water in the Delta. Consequently, this response mechanism would not cause an effect greater than what is already evaluated for impact EN-e.

Under some combinations of scenarios, it is possible that energy expended to replace reductions in Sacramento/Delta surface water supplies may be greater than energy savings associated with reduced water conveyance, but this is not certain. To include this possibility in the analysis of all potential impacts including the power flow analysis would be highly speculative. Aside from the possibility of no net increase in energy consumption, there are additional reasons the effect of increased groundwater pumping on the electrical grid would be limited. As described in Section 7.10, *Greenhouse Gas Emissions*, some groundwater pumping is performed by electric pumps and some by nonelectric fuel-powered pumps. Increased use of electric pumps powered by the electric grid could be minimized during the late afternoon period of peak energy demand, which is a time of day when pumping for agriculture may already be low due to high rates of evaporation. Groundwater pumping can also occur without support from the electrical grid through use of either diesel-powered pumps or pumps powered by local renewable energy sources. Renewable energy sources, including energy obtained from wind turbines, windmills, and solar arrays, can be used to pump groundwater without reliance on the electric grid. Solar-powered pumping systems have been used in the United States for more than 30 years. As photovoltaic modules become more affordable and the energy efficiency of both the modules and solar-powered pumps increases, it will become a leading technology in remote areas.

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