BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

COMMENTS OF THE CALIFORNIA INDEPENDENT SYSTEM OPERATOR CORPORATION

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I. Introduction

The California Independent System Operator Corporation (CAISO) hereby provides comments in response to the January 11, 2019 Administrative Law Judge's Ruling Seeking Comment on Proposed Preferred System Portfolio and Transmission Planning Process Recommendations (Ruling) and Attachments A (Attachment A) and B (Attachment B) thereto, issued in this proceeding. The CAISO appreciates the opportunity to formally file production modeling results and comments into the proceeding. The Ruling and associated attachments reflect many significant process improvements and greater transparency in the integrated resource planning (IRP) process. The CAISO's comments are divided into two main sections: 1) a summary and overview of the CAISO's production cost modeling and 2) specific recommendations and responses to the questions posed in the Ruling.

II. Discussion

A. CAISO Production Cost Modeling

1. Overview

To support the Commission's IRP proceeding, the CAISO conducted an independent assessment of the IRP hybrid conforming portfolio for 2030 and presented the results at the January 7, 2019 IRP workshop.[1] The CAISO's assessment is different than the Commission's SERVM production cost modeling in the following ways:

[1] *See* Appendix A. Appendix A also includes an additional slide prepared after the January 7, 2019 workshop comparing CAISO load and import supply.

- The CAISO used PLEXOS production cost modeling software. PLEXOS has more rigorous unit commitment and dispatch methodologies as compared to SERVM, and was used extensively in the Commission's long-term procurement plan proceedings; and
- The CAISO adopted enhanced modeling assumptions—including updated assumptions regarding the shapes of load, solar and wind generation, load-following and regulation requirements.

The CAISO's assessment focused on whether the hybrid conforming portfolio satisfies the CAISO system reliability and operating requirements. The CAISO's assessment found that the hybrid conforming portfolio is insufficient to reliably serve load and provide adequate reserves. The CAISO determined that the hybrid conforming portfolio would need to be augmented with approximately 1,077 MW of additional resources; either through retention of thermal resources past 40 years of age, or replacement with new resources that are capable of serving load and reserves during critical net load hours in order to maintain the reliability of the CAISO system and adequate reserves.

The CAISO's full PLEXOS model and output files can be accessed at http://12.200.60.146:990. Parties requiring access to the CAISO's PLEXOS database should request log-in and password information by emailing the CAISO via e-recipient@caiso.com.

2. Modeling Approach

The CAISO developed the PLEXOS models based on the knowledge and experience gained in previous Commission long-term procurement planning proceedings. The CAISO developed both a deterministic and a stochastic production cost model for its hybrid conforming portfolio assessment. The deterministic model simulations produce detailed results using the same core inputs—such as load and renewable energy forecasts—as the Commission Energy Division staff's SERVM modeling. The detailed deterministic results allow for deep-dive analyses into the causes of renewable curtailment, greenhouse gas (GHG) emissions, and capacity shortfalls. The stochastic model simulations examine a wide variety of system conditions and produce probabilistic results. The results are especially useful for identifying the likelihood and the magnitude of capacity shortfalls.

The stochastic model simulations use the reliability metrics specified in the September

23, 2016 Administrative Law Judge Ruling Directing Production Cost Modeling Requirements (Reliability Metric Ruling).[2] The reliability metrics define loss of load (LOL) event and the criteria for the loss of load expectation (LOLE).[3]

The CAISO's PLEXOS assessments do not explicitly enforce local capacity requirements and therefore do not identify reliability issues causes by local resource deficiencies.

3. Modeling Assumptions

The CAISO's deterministic and stochastic PLEXOS models have similar model structures and the same core inputs as the Commission's SERVM model. The core inputs include the California Energy Commission's (CEC) 2017 Integrated Energy Policy Report (IEPR) demand forecast, the resource portfolio specified in the hybrid conforming plan, and the WECC anchor data set production cost modeling dataset.[4]

The hybrid conforming portfolio differs significantly from the Commission's reference system plan issued based on the Commission's RESOLVE modeling, as discussed in more detail in Attachment A.[5] Compared to the reference system plan, the hybrid conforming portfolio has:

- A 949 MW reduction in battery storage resources, though the duration of the storage has increased;
- 3,227 MW of additional thermal generation resource retirement; and
- A 714 MW renewable generation capacity increase—with significant increases in solar and wind capacity—but a 1,197 MW reduction in geothermal capacity.

The increase in solar and behind-the-meter photovoltaic (BTM PV) resources results in both the net load (*i.e.*, load minus solar, BTM PV and wind generation) and the net sales peak (*i.e.*, load minus BTM PV) shifting to the early evening hours, specifically hour-ending 19 to 21 (HE 19-21) in the summer. At that time of day, grid connected solar generation is near zero and wind resources generate around 25% of installed capacity. Taking that into consideration, the capacity loss moving from the reference system plan to the hybrid conforming portfolio is actually about 4,995 MW.

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[2] http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442451199
[3] *See* Appendix A, Slide 31.
[4] *See* Appendix A, Slides 6-7.
[5] *See* Appendix A, Slide 9.

4. CAISO Modeling Results

The CAISO's deterministic model simulation of the hybrid conforming portfolio identified seven hours with observed capacity shortfalls in load-following up and non-spinning reserve. Detailed analysis of the capacity shortfall periods—such as hours 19 and 20 on August 31, 2030—show that all available capacity in the PLEXOS model has been fully utilized to serve the system load, with the exception of net import capacity.[6] Table 1 below shows total capacity usage and total available generation capacity during the August 31, 2030 net load peak.

Table 1: Generation Capacity During Peak Net Load Hours

August 31, 2030[7]

Hour	BTMPV	CCGT	CHP	DR	GT	Hydro	Pumped Storage	Renewable	ST	Storage	Net Import
Total Usage (MW)											
16	9,867	12,278	628	0	2,095	6,889	873	18,846	0	1,642	2,577
17	6,400	12,954	719	0	3,492	6,889	1,713	15,835	0	2,482	4,772
18	2,524	14,642	1,078	0	6,812	6,890	1,831	10,644	10	2,482	6,853
19	65	14,642	1,078	1,168	6,812	6,890	1,831	5,523	10	2,482	8,907
20	0	14,642	1,078	1,168	6,812	6,890	1,831	5,504	10	2,482	9,644
21	0	14,642	1,071	0	6,812	6,890	1,831	5,827	10	2,482	10,341
Total Available Capacity (MW)											
16	9,867	14,642	1,078	1,168	6,813	6,889	1,831	18,846	10	2,482	10,341
17	6,400	14,642	1,078	1,168	6,813	6,889	1,831	15,835	10	2,482	10,341
18	2,524	14,642	1,078	1,168	6,813	6,890	1,831	10,644	10	2,482	10,341
19	65	14,642	1,078	1,168	6,813	6,890	1,831	5,523	10	2,482	10,341
20	0	14,642	1,078	1,168	6,813	6,890	1,831	5,504	10	2,482	10,341
21	0	14,642	1,078	1,144	6,813	6,890	1,831	5,827	10	2,482	10,341

Based on the CAISO's operational experience, it is critical for the Commission and parties to note that import energy up to the maximum physical import capability is not always available, especially during peak load events. This is reflected in the CAISO's modeling and shown in Table 1. Specifically, note that the Total Usage (MW) for net imports is below the Total Available Capacity (MW) for net imports during the capacity shortfall period highlighted in red. This reflects supply constraints outside of California that should also be recognized in the Commission Energy Division staff's SERVM modeling.

The stochastic model results confirm the capacity shortfall identified in the deterministic modeling. The stochastic results show 202 LOL events in 500 iterations of full-year simulations with a 0.4 LOLE (day/year).[8] This exceeds the maximum acceptable 0.1 LOLE criteria specified in the September 23, 2016 ALJ ruling.[9] To achieve a 0.1. LOLE, at least 1,077 MW of effective

[6] *See* Appendix A, Slides 18-22.
[7] *See* Appendix A, Slide 22.
[8] *See* Appendix A, Slide 34.
[9] *See* Appendix A, Slide 31.

capacity (meaning 1,077 MW after taking into account outages) would need to be added to the hybrid conforming portfolio. This capacity could come from retention of thermal resources forecast to be retired by the 40-year rule, or replacement with new resources that are capable of serving load and reserves during the critical hours.

5. CAISO Conclusions

From the study results, the CAISO concludes that:

- The hybrid conforming portfolio does not have sufficient capacity to serve load and meet reserve requirements during critical net load hours;
- Unless there is adequate replacement capacity, less than 2,150 MW out of the 3,277 MW of 40 years and older gas-fired generation retired in the hybrid conforming portfolio can be retired without exceeding the 0.1 LOLE criteria;
- In order to achieve a 0.1 LOLE, at least 1,077 MW of effective capacity must be retained or replaced with new resources that are capable of serving load and reserves during the critical net load hours when solar output is effectively zero. A more diverse set of renewable resources, including storage and demand response, could allow for more retirement of 40-year-old thermal resources; and
- It is not appropriate to assume that import energy up to the maximum physical import capability is always available. Other states in the West are creating or increasing renewable integration targets, building renewable generation resources, and retiring thermal generation plants. In the future, the import market will become tighter and more competitive during critical periods. In recent years, the CAISO had import energy several thousand MWs below its physical import capability for some high load hours.[10] The CAISO expects this trend to continue and remains concerned by the overly optimistic assumptions in the Commission Energy Division staff's modeling.

B. CAISO Recommendations and Responses to Questions Posed in the Ruling

In this subsection, the CAISO responds to specific Commission questions posed in the Ruling. The CAISO first provides general recommendations regarding how the Commission, the CAISO, and parties can best use the hybrid conforming portfolio and the associated modeling

[10] *See* Appendix A, Slide 36.

results. Subsequently, the CAISO responds to the specific questions posed in the Ruling.

1. General Recommendations

The CAISO provides three main recommendations in response to the questions in the Ruling.

- **Recommendation 1: The Commission should not direct procurement based on the hybrid conforming portfolio but rather should take feedback from modeling parties and make needed improvements without delay in the 2019-2020 IRP cycle.** The CAISO's PLEXOS modeling shows that LOLE exceeds acceptable levels with the thermal generation retirement in the hybrid conforming portfolio. The CAISO also notes that its modeling shows that import supplies are limited during high net load periods. These findings indicate that the hybrid conforming portfolio may result in reliability issues, especially during net peak load hours when solar resources have declining levels of generation. It is not clear why the Energy Division staff's modeling results diverge from the CAISO's but the Commission should release the detailed SERVM modeling results for parties to analyze. Given these uncertainties and the numerous significant modeling improvements recommended for the 2019-2020 IRP cycle, the Commission should not use the hybrid conforming portfolio as the basis for procurement.
- **Recommendation 2: The Commission should transmit the hybrid conforming portfolio as the Preferred System Plan to the CAISO for analysis in the Transmission Planning Process (TPP).** The Commission should provide the same portfolio to the TPP as used to evaluate procurement. The TPP analysis will provide valuable feedback and the CAISO is not obligated to approve project solutions for every identified deficiency, especially in the first year the need is identified. Since there are some uncertainties around the level of thermal generation retirements between the analyses, the CAISO recommends that the Commission allow for some flexibility in how the hybrid conforming portfolio is studied in the TPP. For example, the Commission can specify that the level of thermal generation retirements to be studied under the TPP is *up to* the higher amount supported by Energy Division staff. The CAISO would need any portfolio transmitted by end of February in order to be considered in the upcoming TPP cycle.

- **Recommendation 3: The Commission should acknowledge that the Integrated Energy Policy Report demand forecast vintage used in the IRP will differ from the vintage used in the CAISO's Transmission Planning Process (TPP).** The Commission should clarify that this is necessary and acceptable because the IRP and the CAISO's TPP are completed serially.

2. CAISO Responses to Ruling Questions

In this subsection, the CAISO provides responses to selected questions from the Ruling. The relevant questions are reproduced prior to the CAISO response.

Question 1. Do you support the staff recommendation that the Commission adopt the hybrid conforming portfolio as the basis for the Preferred System Plan for the 2017-2018 IRP cycle? Why or why not?

The CAISO supports the use of the hybrid conforming portfolio as it likely reflects the best indication of current thinking. While many questions still remain to be addressed in the hybrid conforming portfolio, it is important for the IRP process to move forward so that the Commission can adopt a Preferred System Plan for the 2017-2018 IRP cycle and transmit the necessary cases to the CAISO for use in the Transmission Planning Process (TPP) without delay. As described in greater detail below in response to question 20, the TPP analysis can provide valuable feedback and identify any concerns and improvements that should be prioritized in the 2019-2020 IRP cycle.

Question 2. If you do not recommend the hybrid conforming portfolio form the basis for the PSP, what portfolio should the Commission utilize and why?

See response to question 1.

Question 3. Are there reasons for the Commission to utilize a different portfolio (or portfolios) for transmission infrastructure planning (in the TPP) as distinct from the portfolio describing procurement actions of LSEs? Discuss.

The CAISO generally believes the TPP and LSE procurement portfolios should be uniform because the TPP is the basis for approving transmission to support generation development that is ultimately derivative of procurement expectations. As described in greater detail in response to Questions 4 and 20, there is some flexibility in addressing uncertainty and

the CAISO is not obligated to approve project solutions for every identified deficiency, especially in the first year the need is identified. The CAISO expects that the hybrid conforming portfolio and the general IRP process will be improved upon and reworked in the 2019-2020 cycle and therefore does not consider the portfolio as a strong basis for directing procurement. However, transmitting the hybrid conforming portfolio to the CAISO for study in the TPP process can uncover issues and concerns for the Commission and parties to consider for future improvement.

Question 4. Comment on whether or not the hybrid conforming portfolio is likely to result in a reliable system in 2030.

The CAISO's PLEXOS modeling shows that LOLE exceeds acceptable levels with the thermal generation retirement in the hybrid conforming portfolio. The CAISO also notes that its modeling shows that import supplies are limited during high net load periods. These findings indicate that the hybrid conforming portfolio may result in reliability issues, especially during net peak load hours in which solar resources have declining levels of generation.

For the CAISO and parties to understand fully why these modeling results diverge and to more fully study the reliability of the hybrid conforming portfolio, the Commission should release Energy Division staff's detailed hourly SERVM modeling results, rather than averages, and related detailed modeling inputs and outputs. The Commission has requested modeling parties to provide this level of detail in this the proceeding and the same transparency standard should apply to Energy Division staff's modeling.

Because there are uncertainties regarding the level of thermal generation retirements that can be accommodated while maintaining reliability, the CAISO recommends that the Commission allow for flexibility in how the CAISO studies the hybrid conforming portfolio in the TPP. For example, the Commission can specify that the level of thermal generation retirements to be studied under the TPP is *up to* the higher amount supported by Energy Division staff. If there are any reliability concerns uncovered below that level, stakeholders can provide feedback via the CAISO's TPP stakeholder process, and the CAISO can identify the option to retain or replace generation resources as an alternative to transmission system improvements.

Question 5. Are the adjustments made by staff to the geographic resource allocations proposed by LSEs to develop the hybrid conforming

portfolio, as described in Section 2.1 above, warranted? What modifications would you make to these assumptions and why?

The CAISO believes that recognizing transmission limitations is a reasonable approach. However, the CAISO expects that the Commission is taking broader issues into account in addition to transmission limitations.

Question 6. Comment on the implications of the increased reliance on imports represented by the hybrid conforming portfolio.

As noted in the CAISO's summary of its PLEXOS modeling results, import energy up to the maximum physical import capability is not always available. The CAISO is generally concerned about the future reliance on imports, especially from hydroelectric generation. Historically, California has received a significant amount of imported energy, largely backed by hydroelectric generation. In the future, as the rest of the west grapples with growing baseload retirements, climate change impacts, and other pressures or preferences, the Commission should recognize that electric system conditions are changing throughout the west. This will impact both import energy and capacity available to California.

Question 9. Comment on the potential for WECC-wide resource shuffling and how the Commission should address it.

The CAISO asks for clarification on this question. Resource shuffling, as defined by the California Air Resources Board (CARB), is a "plan, scheme, or artifice undertaken by a First Deliverer of Electricity to substitute electricity deliveries from sources with relatively lower emissions for electricity deliveries from sources with relatively higher emissions to reduce its emissions compliance obligation."[11] The Commission should explain whether it is using the term "resource shuffling" based on CARB's definition.

Question 11. Comment on the calibrated LOLE study conducted for 2030. What are the implications or policy actions that should result, if any?

See response to question 4.

Question 14. Comment on the GHG emissions results from the hybrid conforming portfolio analysis in SERVM. What are the implications and what

[11] California Air Resources Board Cap and Trade Regulations, Subchapter 10, section 95802(a)

should the Commission change as a result? (presuming that a new RSP will be analyzed in 2019-2020 already.)

The CAISO is concerned about the increase in GHG emissions in the hybrid conforming portfolio compared to the original Reference System Plan. Based on the summary provided in the Ruling, GHG emissions in the CAISO footprint increased from 34 MMT under the Reference System Plan's RESOLVE-based analysis, to 38 MMT under the Reference System Plan's SERVM-based analysis, and then to 43 MMT under the hybrid conforming portfolio's SERVM-based analysis.[12] As noted in response to Question 4, it is difficult for the CAISO to comment fully without access to detailed modeling outputs of the hybrid conforming portfolio. However, the CAISO has stated in earlier comments that "the RESOLVE portfolios are not necessarily optimal, but rather arise from limiting or overly simplistic assumptions that results in a GHG Planning Price, which in turn is expected to drive to a particular portfolio."[13] This observation seems to be reflected in the Ruling's own conclusion that the 4 MMT increase between the RESOLVE and SERVM models of the Reference System Plan was "primarily due to more granular results of unit operations and generator data."[14] Specifically with regard to load serving entity (LSE) plans, the CAISO previously recommended the Commission require using mass-based GHG benchmark so that results would be more predictable.[15] To better understand the hybrid conforming portfolio GHG emissions, the CAISO recommends that the Commission provide detailed SERVM modeling results, address the numerous modeling improvements noted by parties in previous comments,[16] and use a mass-based GHG metric. The rise in GHG emissions reinforces the conclusion that the Commission should defer procurement decisions until significant improvements are made.

Question 16. Should the Commission place additional or tighter requirements on LSEs filing IRPs in the next IRP cycle? Suggest specific requirements and explain your rationale.

As the CAISO has noted in previous comments, the Commission should clarify how it will consider the LSE IRPs and the actions the Commission will take if LSE IRPs are insufficient

[12] Ruling, p. 15.
[13] CAISO opening comments, January 18, 2018, p. 4.
[14] Ruling, p. 15.
[15] CAISO opening comments, January 18, 2018, pp. 7-8.
[16] *See* for example CAISO opening comments, January 4, 2019.

to meet state GHG targets.[17] Using a mass-based GHG benchmark can help the Commission identify whether targets are achieved.

Question 17. Comment on any other aspects of the hybrid conforming portfolio analysis.

As the CAISO articulated in previous comments, the Commission should acknowledge that the Integrated Energy Policy Report (IEPR) demand forecast vintage used in the IRP will differ from the vintage used in the CAISO's TPP.[18] The Commission should clarify that this is necessary and acceptable because the IRP and the CAISO's TPP are completed serially.

Question 18. Should the hybrid conforming portfolio be analyzed as the reliability base case in the 2019-20 TPP? Why or why not? What changes would you recommend?

If the hybrid conforming portfolio is selected as the Preferred System Plan, the CAISO supports studying it as both the reliability base case and the policy-driven base case in the 2019-20 TPP (see also response to question 19). Per the CAISO's response to questions 1 and 3: (1) the hybrid conforming portfolio likely reflects the best indication of current thinking and should be the basis for the Preferred System Plan; (2) the portfolio studied in the TPP should be the same as the Preferred System Plan; and (3) the TPP analysis can uncover issues and concerns for the Commission and parties to consider for future improvement.

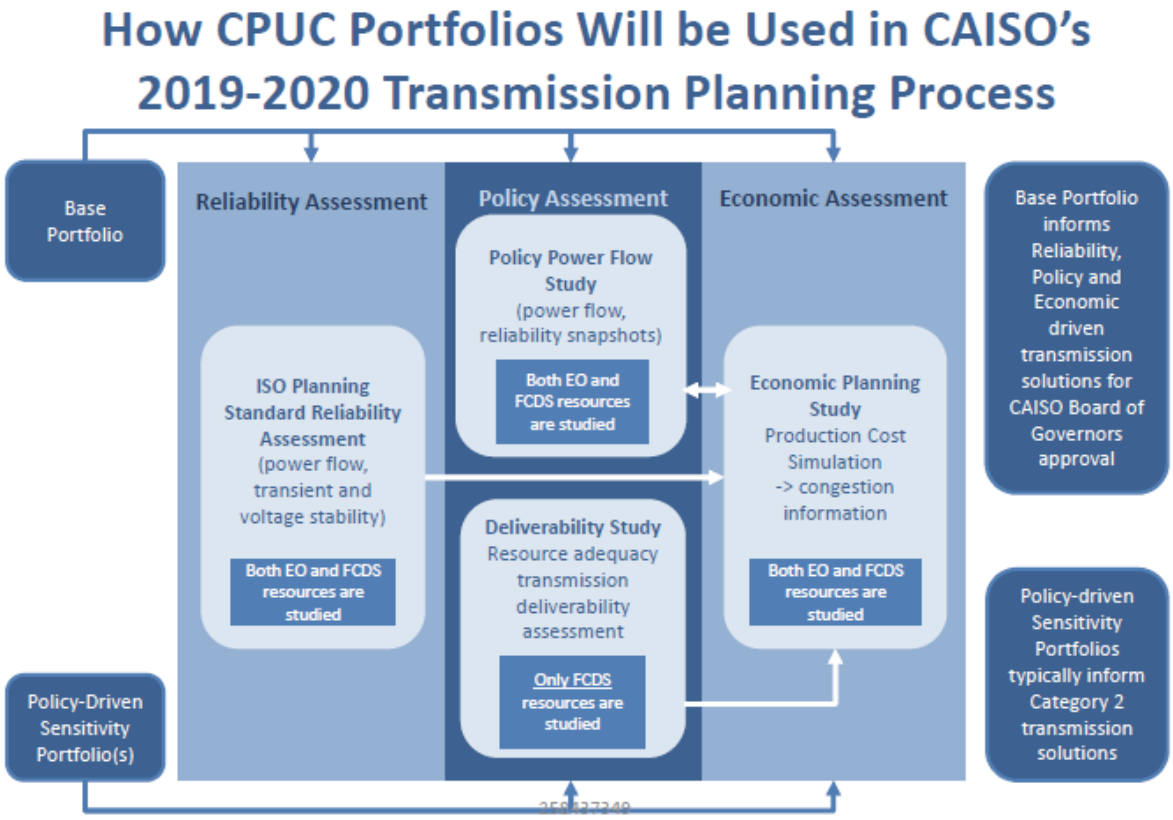
In terms of timing, the Commission must transmit any portfolios to the CAISO by end of February to be considered in the upcoming TPP cycle. After February, it will not be possible to make changes because model set up and development will be underway. See also response to question 19.

Question 19. Should the hybrid conforming portfolio be analyzed as the policy-driven base case in the TPP? Why or why not? What changes would you recommend?

For the same reasons provided in response to question 18, the hybrid conforming portfolio should be analyzed as the policy-driven base case in the TPP. The 2018-2019 TPP has already studied the 42 MMT scenario from the Reference System Plan, which is similar to the hybrid conforming portfolio.

[17] CAISO opening comments, January 18, 2018, p. 8.
[18] CAISO opening comments, January 4, 2019, p. 3.

Though the Ruling notes that historically the Commission has transmitted different portfolios for the reliability base case and policy-driven base case, the CAISO prefers a single base case to be used for both purposes (as well as the economic assessment) as shown in Attachment B, page 3:



As noted in response to question 18, the CAISO needs to receive portfolios by end of February in order to be considered in the upcoming TPP cycle. After February, it will not be possible to make changes as model set up and development will be underway.

Question 20. What are the potential implications if the CAISO analyzes the hybrid conforming portfolio and takes transmission investments to the CAISO Governing Board, if the resource procurement by LSEs between now and 2030 turns out to be significantly different than the hybrid conforming portfolio suggests? If this is a concern, suggest potential remedies or other analysis or actions that could be taken.

The Commission should transmit the hybrid conforming portfolio to the CAISO for use in the 2019-20 TPP. There is flexibility in the TPP to address future procurement uncertainty. First, the TPP analysis will provide valuable feedback to the IRP process and will identify any

concerns and improvements for the 2019-2020 IRP cycle. It is critical to use the more granular reliability-based TPP analysis to identify any potential weaknesses and to address them specifically. Second, if there are any reliability concerns uncovered as a result of the hybrid conforming portfolio, this will be communicated to stakeholders via draft results in the TPP stakeholder process. In that process, there are opportunities for stakeholder engagement and feedback which can be used to identify any resource retention or replacement necessary to avoid transmission system improvements. Lastly, the CAISO is not obligated to approve transmission solutions for every deficiency identified in the TPP, especially in the first year a need is identified. When conditions are fluid, the CAISO has flexibility to wait until there is more information.

Question 21. Do you support the staff recommendation to transmit two policy-driven sensitivity scenarios (Case B and Case C) to the CAISO for further analysis as policy-drive sensitivity scenarios? Why or why not? What changes would you make?

The CAISO supports the Commission in the IRP process to the extent possible while balancing time and resource constraints in developing the annual TPP. The CAISO staff appreciates the collaboration with Commission Energy Division staff to ensure that the CAISO has the time and resource capability in the 2019-2020 TPP to analyze the two policy-driven sensitivity scenarios.

Although the CAISO supports the study of Case B and Case C, the rationale for Case C selection should be corrected. Attachment B states that "Case C is recommended over Case D in order to leverage existing OOS [out-of-state] mappings to busbars rather than create new mappings."[19] The CAISO clarifies that out-of-state resources will be modeled in a way such that it does not suggest a particular preference for any specific interregional transmission project. However, Case C is still preferred over Case D because Case C better leverages the geographical location of interregional transmission projects that have already been proposed, reflecting transmission commercial interest delivering wind resources from Wyoming and New Mexico to California.[20]

The CAISO has reviewed the policy-driven sensitivity portfolios and offers the following

[19] Attachment B, p. 17.
[20] *See*, for example, the projects submitted for evaluation in the 2016-2017 interregional coordination process available at: http://www.caiso.com/planning/Pages/InterregionalTransmissionCoordination/default.aspx

corrections in transmission capability limitations. The Kramer_Inyokern zone is part of the overarching Greater Kramer zone with only 600 MW capability for either full capacity delivery status (FCDS) or FCDS plus energy only. Likewise, the Southern CA desert and Southern NV zone is comprised of multiple zones such as Mountain Pass and Eldorado, Southern NV, Greater Imperial, Riverside East and Palm Springs. Collectively, the resource selection by individual zones cannot exceed the total capability estimate for "Southern CA desert and Southern NV" zone, which is 3,000 MW for FCDS or 9,600 MW for FCDS plus energy only. Generally, the resources in individual zones should not collectively exceed the total capability estimate for the overarching zone.

As noted in response to questions 18 and 19, the CAISO would need any portfolio transmitted by end of February in order to be considered in the upcoming TPP cycle. After February, it will not be possible to make changes as model set up and development work has already begun.

Question 22. Do you agree with the Commission staff assumptions used to development policy-driven sensitivities, with respect to electric vehicle load, GHG emissions constraints in 2030, etc? Explain in detail.

Per the CAISO's reply comments on the draft 2019 RESOLVE inputs and assumptions document, the CAISO supports analyzing a deep decarbonization scenario to identify the potential need for long-lead time or high capital cost resources (*e.g.*, large-scale pumped hydro storage, out-of-state wind, or geothermal resources).[21] The IRP should begin identifying and directing procurement of market resources that can help meet the greenhouse-gas emissions reductions required by Senate Bill 100.

Question 24. What further policy or procurement actions should the Commission take as a result of the analysis presented in this ruling? Explain your recommendations in detail.

At this point, the Commission should not direct procurement based on the hybrid conforming portfolio but rather should take feedback from modeling parties and make needed improvements without delay in the 2019-2020 IRP cycle. As noted above, additional analysis will be conducted on the hybrid conforming portfolio through the TPP which will also provide valuable feedback.

[21] CAISO opening comments, January 15, 2019, p. 2.

As the CAISO has noted in previous comments on out-of-state wind, the Commission should direct or encourage load serving entities to conduct a preliminary pricing analysis for commercial interest.[22] The goal of this analysis would be to garner more detailed information regarding the size and location of prospective generation resources.

Question 26. Acknowledging that near- and mid-term reliability issues have been addressed in comments in response to a separate ruling in this proceeding, should the Commission order any resource procurement in the context of the IRP proceeding at this time? How much? Explain your rationale.

As noted in response to questions 4, 20 and 24, the Commission should not direct procurement based on the hybrid conforming portfolio but rather should take feedback from modeling parties and make needed improvements without delay in the 2019-2020 IRP cycle. The Commission should transmit the hybrid conforming portfolio to the CAISO as the Preferred System Plan so that any concerns can be identified and provided back to the Commission.

III. Conclusion

Based on the CAISO's PLEXOS modeling of the hybrid conforming portfolio, the results show:

- The hybrid conforming portfolio does not have sufficient capacity to serve load and meet reserve requirements during critical net load hours;
- Unless there is adequate replacement capacity, less than 2,150 MW out of the 3,277 MW of 40 years and older gas-fired generation retired in the hybrid conforming portfolio can be retired without exceeding the 0.1 LOLE criteria;
- In order to achieve a 0.1 LOLE, at least 1,077 MW of effective capacity must be retained or replaced with new resources that are capable of serving load and reserves during the critical net load hours when solar output is effectively zero. A more diverse set of renewable resources, including storage and demand response, could allow for more retirement of 40-year-old thermal resources; and
- It is not appropriate to assume that import energy up to the maximum physical import capability is always available and the CAISO remains concerned by the overly optimistic

[22] CAISO reply comments, January 22, 2018, p. 2.

assumptions in the Commission Energy Division staff's modeling.

The CAISO provides three main recommendations in response to the questions in the Ruling:

- Recommendation 1: The Commission should not direct procurement based on the hybrid conforming portfolio but rather should take feedback from modeling parties and make needed improvements without delay in the 2019-2020 IRP cycle.
- Recommendation 2: The Commission should transmit the hybrid conforming portfolio as the Preferred System Plan to the CAISO for analysis in the Transmission Planning Process (TPP).
- Recommendation 3: The Commission should acknowledge that the Integrated Energy Policy Report demand forecast vintage used in the IRP will differ from the vintage used in the CAISO's Transmission Planning Process (TPP).

Respectfully submitted,

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APPENDIX A

California ISO

Reliability Assessment of the IRP Hybrid Conforming Plan

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Purposes of the CAISO's assessment

- To conduct an independent reliability assessment by
  - using production cost modeling software with some functions and methodologies different from SERVM, such as unit commitment and economic dispatch;
  - adopting some enhanced modeling assumptions, such as shapes of load, solar and wind profiles, load-following and regulation requirements; and
  - developing models based on the knowledge gained in the past CPUC Long Term Procurement Plan (LTPP) proceedings.

Purposes of the CAISO's assessment (cont.)

- To evaluate whether the Hybrid Conforming Plan (HCP) satisfies CAISO system reliability and operating requirements
- To provide feedback to the CPUC Integrated Resource Plan (IRP) proceeding
- To communicate with all parties in the IRP proceeding regarding the CAISO's view about operability of the HCP

Approaches of the CAISO's assessment

- Using both deterministic and stochastic production cost modeling for the assessment
  - Production cost modeling enforces operational constraints in optimizing generation unit commitment and dispatch
  - Deterministic simulations produce detail results for deep-diving analyses
  - Stochastic simulations examine a wide variety of system conditions and report the likelihood of capacity shortages

Approaches of the CAISO's assessment (cont.)

- Developing IRP models based on the models developed in the past LTPP proceedings that were:
  - discussed thoroughly with the involved parties;
  - made available to the public; and
  - used by many other parties for various studies.

References: CAISO testimonies about production cost modeling filed into the CPUC 2014 LTPP proceeding

1. http://www.caiso.com/Documents/Aug13_2014_InitialTestimony_ShuchengLiu_Phase1A_LTPP_R13-12-010.pdf
2. http://www.caiso.com/Documents/Nov20_2014_Liu_StochasticStudyTestimony_LTPP_R13-12-010.pdf

Approaches of the CAISO's assessment (cont.)

- Having a zonal model structure similar to the CPUC SERVM model
  - WECC-wide deterministic model and CAISO-wide stochastic model
  - 8 zones in California, 4 in CAISO
  - Transmission constraints between the zones

Approaches of the CAISO's assessment (cont.)

- Implementing the same core inputs as the SERVM model, including
  - Energy Commission (CEC) Integrated Energy Policy Report (IEPR) Mid Demand case load forecast;
  - Resource portfolio specified in the HCP; and
  - WECC ADS PCM dataset for non-CAISO regions.
- Running simulations chronologically in hourly interval for the whole year of 2030
  - Deterministic simulation for one iteration
  - Stochastic simulations for 500 iterations

Deterministic Modeling

From Reference System Plan (RSP) to HCP, the portfolio has changed significantly.

	RESOLVE	CAISO Plexos Model		
Capacity (MW)	RSP	RSP	HCP	Change
Battery	**3,429**	**3,429**	**2,480**	**-949**
1-hour	2,144	2,144	217	-1,927
4-hour	1,285	1,285	2,263	978
BTM PV	**19,992**	**19,295**	**19,295**	**0**
Renewable	**33,084**	**33,381**	**34,094**	**714**
Biomass	725	725	888	163
Geothermal	2,683	2,683	1,487	-1,197
Small Hydro	466	763	763	0
Solar	18,767	18,767	19,658	891
Wind	10,443	10,443	11,299	856
Thermal	**27,562**	**25,770**	**22,543**	**-3,227**
CCGT		15,720	14,642	-1,078
CHP	1,685	2,932	1,078	-1,854
GT		7,108	6,813	-295
ST		10	10	0
Gas	25,877			
Hydro	**7,844**	**6,890**	**6,890**	**0**
Pumped Storage	**1,832**	**1,831**	**1,831**	**0**
Demand Response	**1,752**	**1,752**	**1,752**	**0**
Net Import Limit	**10,068**	**10,341**	**10,341**	**0**

Notes:

- HCP battery has longer duration, but less capacity than RSP
- BTM PV capacity difference from RESOLVE is due to the shapes used to develop the profiles
- HCP has 714 MW more renewable capacity, but 5,649 GWh less renewable energy than RSP
- Geothermal capacity has 100% base load capacity factor
- Plexos thermal is based on Rated Capacity instead of Installed Capacity
- Thermal is after the retirement of all OTC and nuclear resources
- Demand Response availability varies over time

CAISO deterministic simulation case definitions

- Besides the HCP case, ISO ran 4 sensitivity cases of it to understand the impacts of some key assumptions
  - Lower net export capability in case the 5,000 MW capability is not achievable
  - 20% of the default CO2 intensity rate for Northwest import as California Air Resource Board suggested
  - The combination of the two above
  - Higher CO2 emission price as RSP suggested, which is sum of the default CO2 price and the shadow price of the CO2 emission constraint in RESOLVE for RSP

CAISO deterministic simulation case definitions (cont.)

Case	CO2 Intensity for Import from Northwest (MTon/MWh)	CAISO Net Export Capability (MW)	CO2 Emission Price ($/MTon)
RESOLVE Reference Plan	0.428	5,000	27.37
CAISO Plexos Hybrid Conforming Plan	0.428	5,000	27.37
CAISO Sensitivity 1	0.428	2,000	27.37
CAISO Sensitivity 2	0.086	5,000	27.37
CAISO Sensitivity 3	0.086	2,000	27.37
CAISO Sensitivity 4	0.428	5,000	217.58

More detail CO2 modeling of NW import reflected in optimization

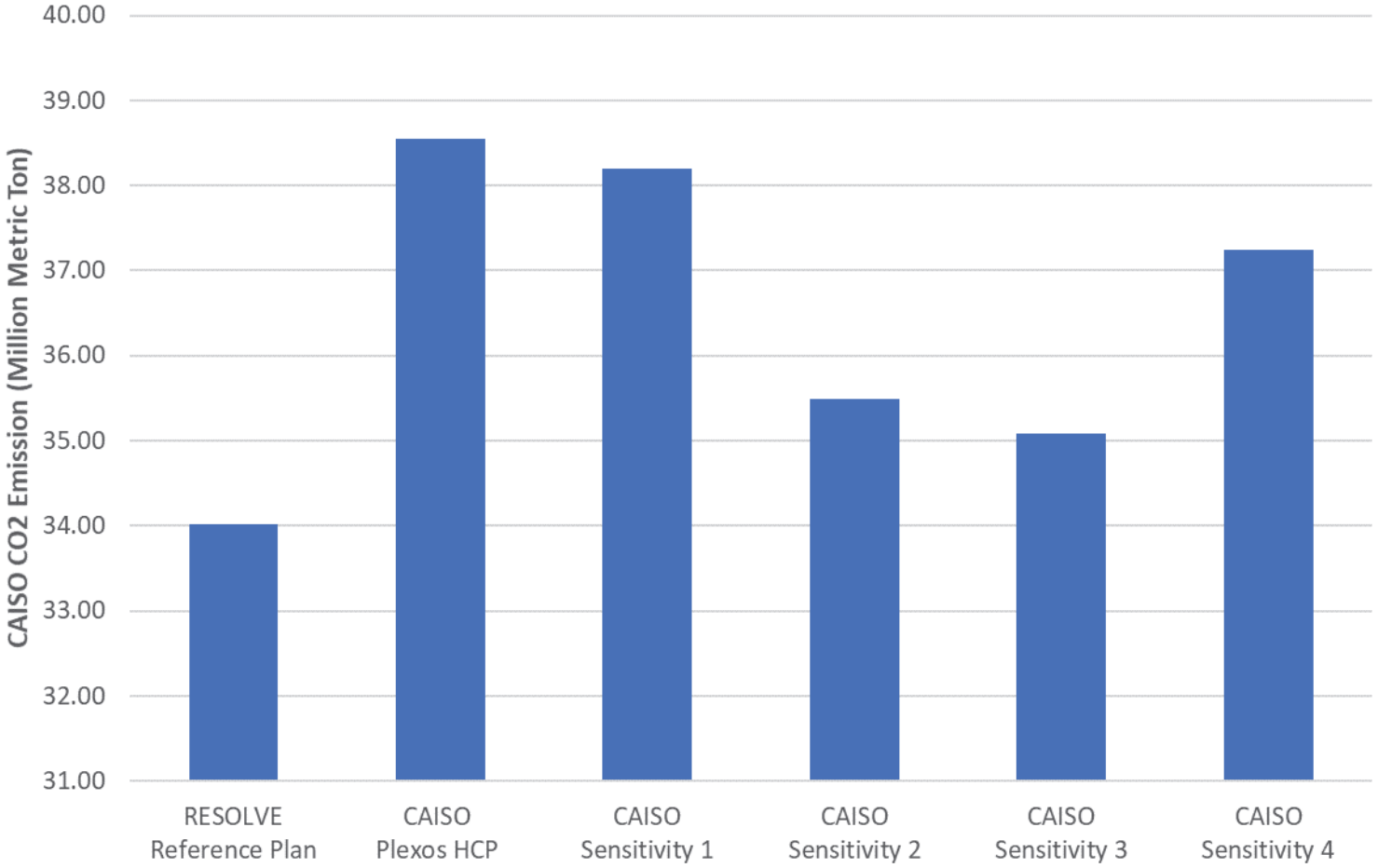
Tests what can be achieved without higher export capability

Tests if CO2 price determined in IRP achieves emission reduction target

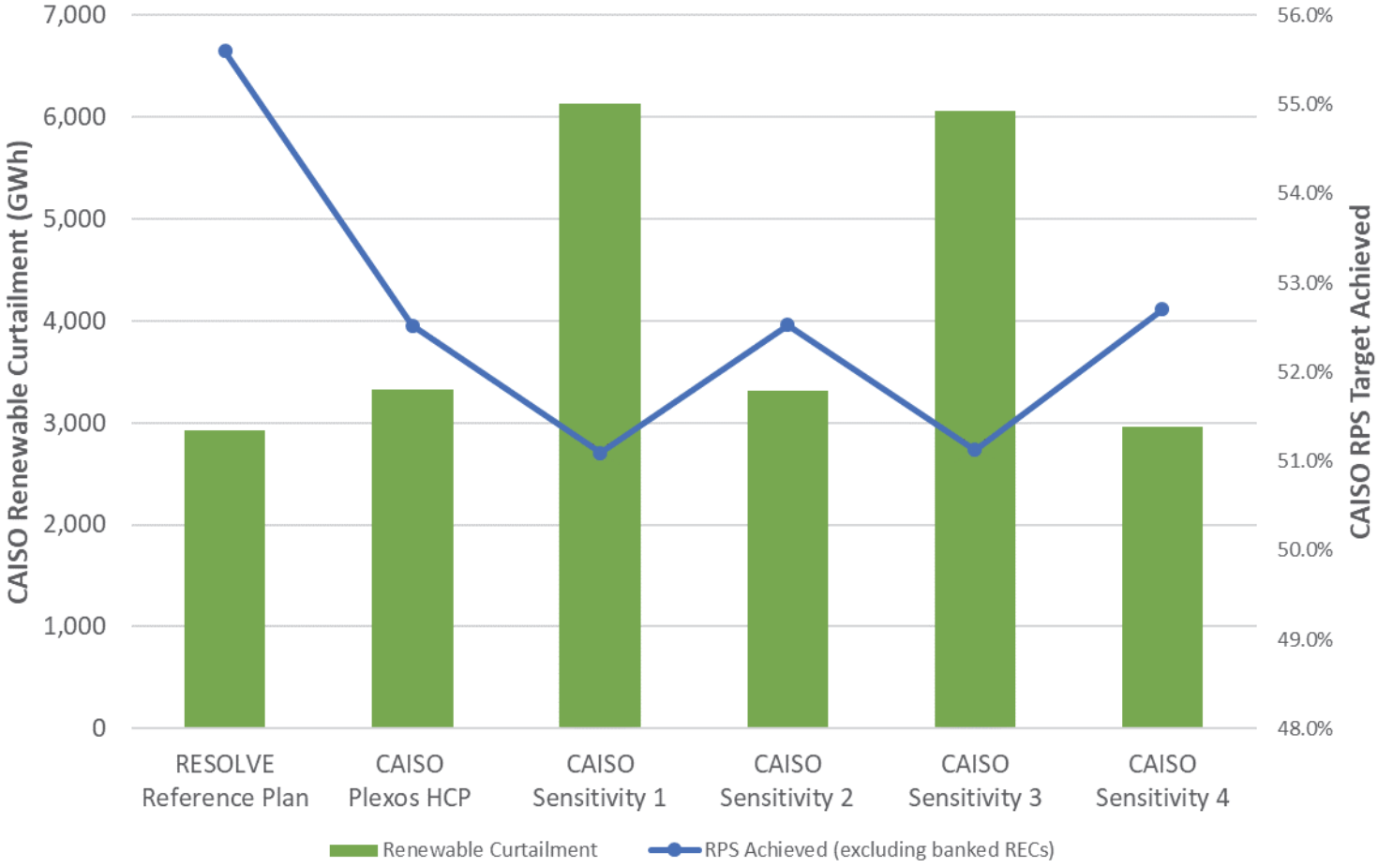
Summary of deterministic simulation annual results of HCP and sensitivity cases

	RESOLVE Reference Plan	CAISO Plexos HCP	CAISO Sensitivity 1	CAISO Sensitivity 2	CAISO Sensitivity 3	CAISO Sensitivity 4
Northwest Import CO2 Intensity (MTon/MWh)	0.428	0.428	0.428	0.086	0.086	0.428
CAISO Net Export Limit (MW)	5,000	5,000	2,000	5,000	2,000	5,000
CO2 Price ($/MTon in 2016 dollars)	27.37	27.37	27.37	27.37	27.37	217.58
CAISO CO2 Emission (MMTon)						
By In-CAISO Generation	31.38	23.43	22.88	22.69	22.13	23.62
From Import	5.44	17.92	18.11	12.79	12.96	16.43
Sum	36.82	41.35	41.00	35.49	35.09	40.05
CO2 Emission Offset	-2.80	-2.80	-2.80	0.00	0.00	-2.80
Total Emission	34.02	38.55	38.20	35.49	35.09	37.25
WECC-Wide CO2 Emission		303.67	305.63	304.23	306.18	303.22
CAISO Generation, Import and Export (GWh)						
CAISO Generation	237,407	205,532	201,242	203,488	199,208	207,259
Net Import	17,631	49,009	53,300	51,054	55,334	47,282
Renewable Generation, Curtailment and RPS Achieved						
Renewable Generation (GWh)	109,136	103,088	100,283	103,099	100,348	103,450
RPS Achieved (excluding banked RECs)	55.6%	52.5%	51.1%	52.5%	51.1%	52.7%
Renewable Curtailment (GWh)	2,923	3,322	6,127	3,311	6,062	2,961
Production Cost ($million)						
WECC		13,039	13,094	13,008	13,058	19,223
CAISO		2,866	2,827	2,786	2,744	7,497

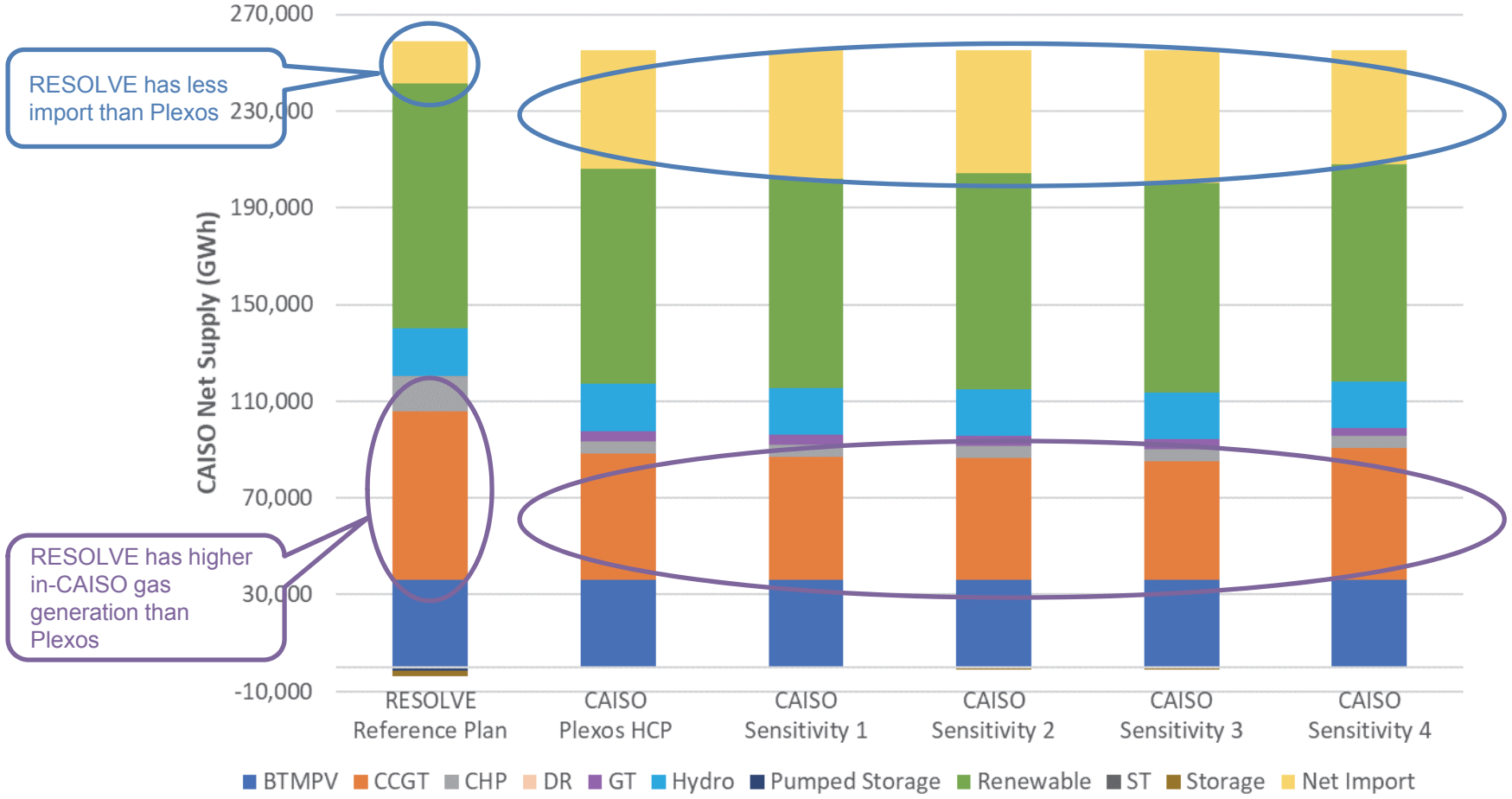
HCP portfolio does not achieve the 34 MMT CAISO CO2 emission target.



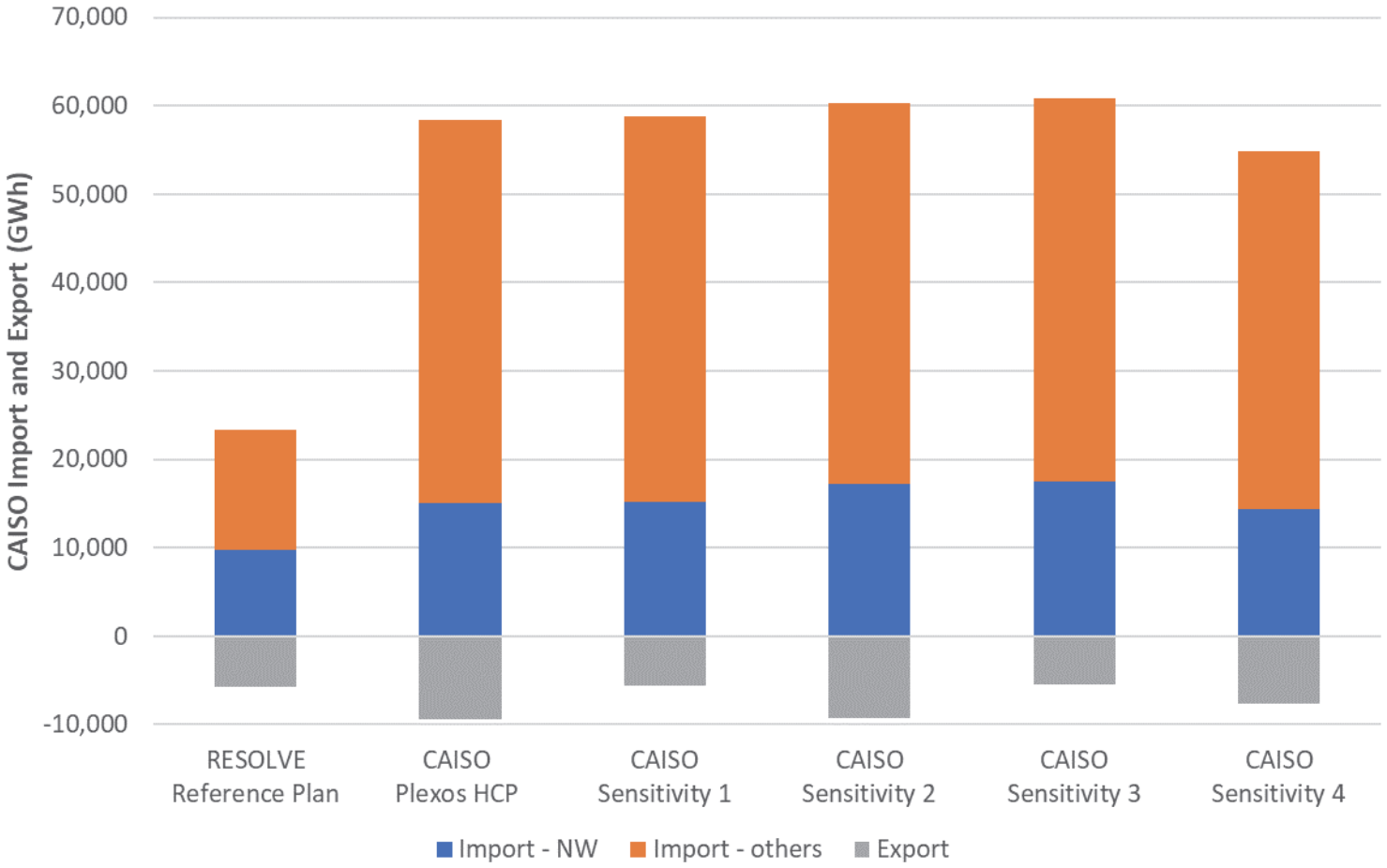
Renewable curtailment is sensitive to net export capability



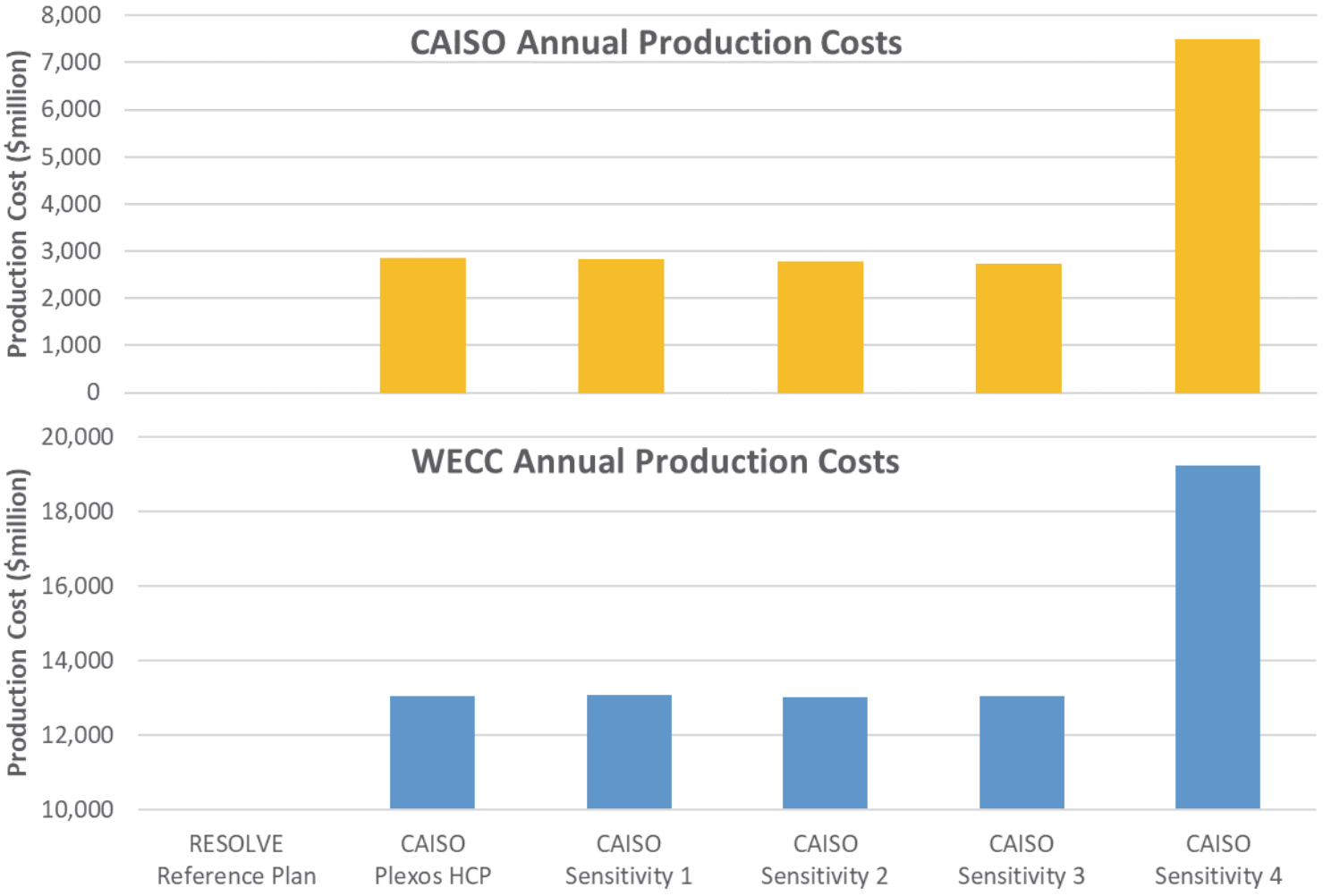
CAISO cases rely more on import and less on in-CAISO gas generation than the RESOLVE case.



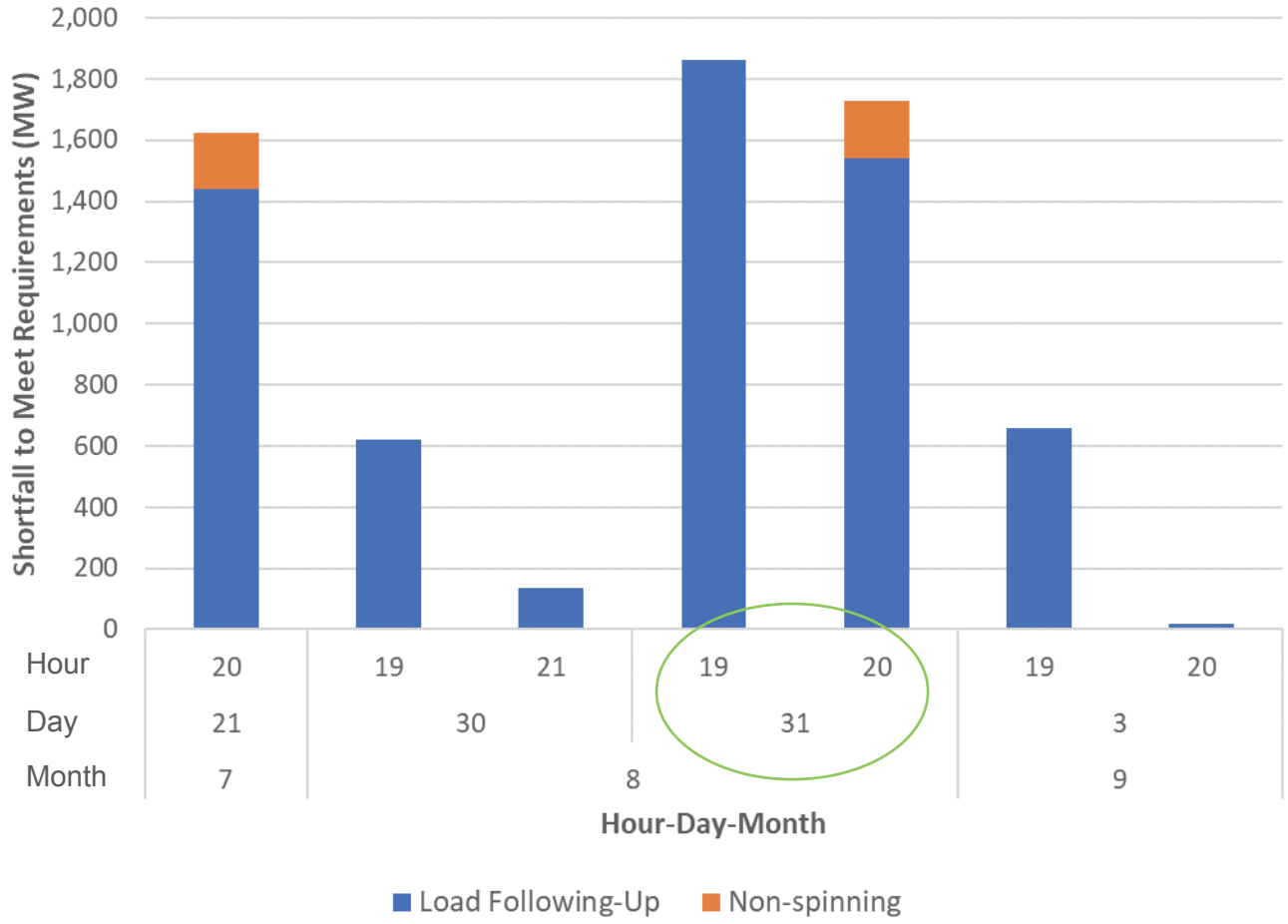
Imports and exports are affected by modelling assumptions.



High CO2 price causes significant increase in production costs.



CAISO supply becomes insufficient in the HCP case.



Capacity Changes (MW)	
Battery	**-949**
1-hour	-1,927
4-hour	978
BTM PV	**0**
Renewable	**714**
Biomass	163
Geothermal	-1,197
Small Hydro	0
Solar	891
Wind	856
Thermal	**-3,227**
CCGT	-1,078
CHP	-1,854
GT	-295

CAISO hourly load and generation balance of the HCP case on August 31, 2030

Hour	Load (MW)	Generation (MW)											Net Import (MW)	Reserve Shortfall	
		Total Generation	BTMPV	CCGT	CHP	DR	GT	Hydro	Pumped Storage	Renewable	ST	Storage		Load Following-Up	NonSpin Reserve
1	32,447	22,227	0	6,683	616	0	335	6,894	84	5,252	0	2,363	10,221	0	0
2	30,705	20,510	0	6,096	590	0	335	6,894	0	5,231	0	1,363	10,195	0	0
3	29,396	19,055	0	6,027	590	0	335	6,894	0	5,205	0	4	10,341	0	0
4	28,802	19,006	0	6,055	573	0	335	6,894	0	5,149	0	0	9,796	0	0
5	28,843	18,830	0	6,125	573	0	335	6,894	0	4,903	0	0	10,013	0	0
6	28,891	19,283	71	6,197	580	0	332	6,894	0	4,483	0	726	9,608	0	0
7	31,436	26,035	2,822	5,370	543	0	252	6,161	0	10,886	0	0	5,402	0	0
8	32,316	28,820	6,722	5,471	516	0	252	1,041	0	14,819	0	0	3,496	0	0
9	37,093	35,585	10,446	5,471	523	0	252	2,039	0	16,853	0	0	1,508	0	0
10	41,783	40,473	13,504	5,507	516	0	252	2,125	0	18,571	0	0	1,310	0	0
11	43,973	42,656	15,255	5,585	516	0	252	1,245	0	19,804	0	0	1,317	0	0
12	46,472	45,079	15,763	5,720	523	0	252	2,834	0	19,987	0	0	1,393	0	0
13	48,735	47,412	15,953	6,014	523	0	252	4,037	0	20,632	0	0	1,323	0	0
14	48,994	47,732	14,578	6,310	533	0	252	5,587	0	20,472	0	0	1,262	0	0
15	49,024	47,812	12,815	6,881	554	0	252	6,891	0	20,419	0	0	1,212	0	0
16	48,525	45,948	9,867	9,187	628	0	332	6,889	199	18,846	0	0	2,577	0	0
17	47,619	42,847	6,400	10,878	719	0	1,312	6,889	813	15,835	0	0	4,772	0	0
18	45,953	39,100	2,524	12,667	1,078	0	3,456	6,890	1,831	10,644	10	0	6,853	0	0
19	44,635	35,729	65	13,493	1,078	1,168	3,811	6,890	1,831	5,523	10	1,858	8,907	1,862	0
20	45,811	36,167	0	13,609	1,078	1,168	3,866	6,890	1,831	5,504	10	2,210	9,644	1,538	189
21	43,689	33,348	0	13,393	1,071	0	3,772	6,890	1,831	5,827	10	554	10,341	0	0
22	40,204	30,019	0	12,537	747	0	2,189	6,890	1,831	5,821	4	0	10,185	0	0
23	36,718	27,724	0	11,198	734	0	1,949	6,891	1,340	5,609	4	0	8,995	0	0
24	33,472	24,919	0	10,034	695	0	1,061	6,891	581	5,657	0	0	8,552	0	0

- Renewable and BTM PV generation drops quickly in early evening
- Net import in hour 19 and 20 is below the CAISO net import limit
- Supply is insufficient to meet load-following up and non-spinning reserve requirements in hour 19 and 20

Breakdown of renewable generation on August 31, 2030 (MW)

Hour	Biogas	Biomass	Geothermal	Small Hydro	Solar PV	Solar Thermal	Wind	Total
1	187	690	1,329	227	0	0	2,819	5,252
2	187	690	1,329	222	0	0	2,803	5,231
3	187	690	1,329	198	0	0	2,801	5,205
4	187	690	1,329	200	0	0	2,743	5,149
5	187	690	1,329	219	0	0	2,478	4,903
6	187	690	1,329	253	99	22	1,902	4,483
7	187	690	1,329	282	6,800	279	1,319	10,886
8	187	690	1,329	359	11,091	628	534	14,819
9	187	690	1,329	384	13,029	1,022	212	16,853
10	187	690	1,329	401	14,504	1,319	141	18,571
11	187	690	1,329	415	15,511	1,498	173	19,804
12	187	690	1,329	399	15,465	1,633	284	19,987
13	187	690	1,329	431	15,704	1,586	704	20,632
14	187	690	1,329	441	15,179	1,393	1,252	20,472
15	187	690	1,329	444	15,010	1,230	1,529	20,419
16	187	690	1,329	454	13,274	943	1,967	18,846
17	187	690	1,329	440	10,613	566	2,009	15,835
18	187	690	1,329	453	5,976	164	1,844	10,644
19	187	690	1,329	456	4	0	2,857	5,523
20	187	690	1,329	457	0	0	2,841	5,504
21	187	690	1,329	443	0	0	3,177	5,827
22	187	690	1,329	388	0	0	3,227	5,821
23	187	690	1,329	312	0	0	3,091	5,609
24	187	690	1,329	211	0	0	3,239	5,657

Load forecast and modifiers during peak net load hours on August 31, 2030

CAISO Load Forecast and Load Modifiers (MW)

Hour	Load Forecast	AAEE	Pump Load	EV	TOU	Load with Modifiers
16	51,565	4,596	1,158	681	-282	48,525
17	50,532	4,532	1,160	759	-299	47,619
18	48,486	4,194	1,159	795	-292	45,953
19	46,750	3,892	1,274	794	-292	44,635
20	45,791	3,714	1,394	2,630	-289	45,811
21	42,970	3,468	1,424	2,636	127	43,689

- August 31, 2030 is a Saturday. Compared to weekdays of the same week
  - AAEE is about 2,000 MW lower;
  - Pump load is about doubled
  - EV charging load is higher
  - TOU is in the same range

Generation capacity usage during peak net load hours on August 31, 2030

Generation and Import (MW)

Hour	BTMPV	CCGT	CHP	DR	GT	Hydro	Pumped Storage	Renewable	ST	Storage	Net Import
16	9,867	9,187	628	0	332	6,889	199	18,846	0	0	2,577
17	6,400	10,878	719	0	1,312	6,889	813	15,835	0	0	4,772
18	2,524	12,667	1,078	0	3,456	6,890	1,831	10,644	10	0	6,853
19	65	13,493	1,078	1,168	3,811	6,890	1,831	5,523	10	1,858	8,907
20	0	13,609	1,078	1,168	3,866	6,890	1,831	5,504	10	2,210	9,644
21	0	13,393	1,071	0	3,772	6,890	1,831	5,827	10	554	10,341

Provision of Upward Load-following and Reserves (MW)

16	0	3,063	0	0	1,462	0	300	0	0	1,642	0
17	0	1,459	0	0	1,882	0	900	0	0	2,481	0
18	0	1,358	0	0	3,058	0	0	0	0	2,481	0
19	0	533	0	0	2,667	0	0	0	0	623	0
20	0	416	0	0	2,624	0	0	0	0	272	0
21	0	633	0	0	2,718	0	0	0	0	1,927	0

Outages (MW)

16	0	28	0	0	301	0	374	0	0	0	0
17	0	616	0	0	298	0	0	0	0	0	0
18	0	616	0	0	298	0	0	0	0	0	0
19	0	616	0	0	333	0	0	0	0	0	0
20	0	616	0	0	321	0	0	0	0	0	0
21	0	616	0	0	321	0	0	0	0	0	0

Total Usage (MW)

16	9,867	12,278	628	0	2,095	6,889	873	18,846	0	1,642	2,577
17	6,400	12,954	719	0	3,492	6,889	1,713	15,835	0	2,482	4,772
18	2,524	14,642	1,078	0	6,812	6,890	1,831	10,644	10	2,482	6,853
19	65	14,642	1,078	1,168	6,812	6,890	1,831	5,523	10	2,482	8,907
20	0	14,642	1,078	1,168	6,812	6,890	1,831	5,504	10	2,482	9,644
21	0	14,642	1,071	0	6,812	6,890	1,831	5,827	10	2,482	10,341

Total Available Capacity (MW)

16	9,867	14,642	1,078	1,168	6,813	6,889	1,831	18,846	10	2,482	10,341
17	6,400	14,642	1,078	1,168	6,813	6,889	1,831	15,835	10	2,482	10,341
18	2,524	14,642	1,078	1,168	6,813	6,890	1,831	10,644	10	2,482	10,341
19	65	14,642	1,078	1,168	6,813	6,890	1,831	5,523	10	2,482	10,341
20	0	14,642	1,078	1,168	6,813	6,890	1,831	5,504	10	2,482	10,341
21	0	14,642	1,078	1,144	6,813	6,890	1,831	5,827	10	2,482	10,341

Notes

- Some demand response programs are not available on weekend
- BTM PV and renewable generation drops quickly starting hour 16, solar has almost no contribution from hour 19 on
- Storage provides a large portion of upward load-following and reserves
- 4.2% CCGT and 4.9% GT forced outages
- At hour 19 and 20 all available generation capacity is fully utilized, but import is below the maximum import limit

Findings from CAISO's deterministic production cost simulations

- CAISO supply is insufficient in the HCP case
  - Capacity shortfalls in meeting load-following up and non-spinning reserve requirements are found in 7 peak net load hours
  - It is mostly due to retirement of thermal resource and loss of effective capacity of battery and geothermal
  - Import up to the 10,341 MW maximum limit is not always available. During the hours with capacity shortfall, import is below the limit. That is consistent with the trend observed in the CAISO market operation today.

Findings from CAISO's deterministic production cost simulations (cont.)

- CAISO HCP case achieves lower RPS target than RESOLVE for RSP because
  - Plexos and RESOLVE serve different purposes and have different optimization methodologies and objectives
  - In Plexos model more renewable energy is curtailed than in RESOLVE model
  - HCP portfolio has less renewable energy than RSP portfolio

Findings from CAISO's deterministic production cost simulations (cont.)

- CAISO HCP case does not achieve the 34 MMT CO2 emission target set by RESOLVE for RSP because of
  - More stringent operational constraints in Plexos model
  - Lower renewable generation in HCP
  - Differences in other modeling assumptions between RESOLVE and CAISO Plexos models

Findings from CAISO's deterministic production cost simulations (cont.)

- CAISO net export limit has significant impact on achieving RPS target. The assumption needs to be assessed carefully.
- Lower Northwest import CO2 intensity results in much lower total emission, though still higher than 34 MMT. The -2.8 MMT after-the-fact offset is a mismatch of the impact of the lower CO2 intensity.
- The case of $217.58/MTon CO2 emission price also does not achieve the 34 MMT emission target

Stochastic Modeling

The stochastic model is developed based on the HCP deterministic model.

- The purpose of CAISO stochastic modeling is to identify the likelihood and magnitude of capacity shortages in HCP after the 40-year thermal retirement rule is applied
- The stochastic model has a CAISO-focused scope, including PG&E_BAY, PG&E_VALLEY, SCE, SDG&E zones, and an outside zone
- Inside the CAISO footprint, the stochastic model has the same inputs as in the deterministic model, except the stochastic variables

The outside zone represents the regions outside CAISO.

- The outside zone holds
  - Out-of-state RPS resources
  - Non-RPS dedicated import resources (Hoover, Palo Verde, etc.)
  - A “market station” representing other outside resources and load for economic import and export
- The same net import and export limits between CAISO and the outside zone, as in the deterministic model, are enforced

Stochastic variables in the model

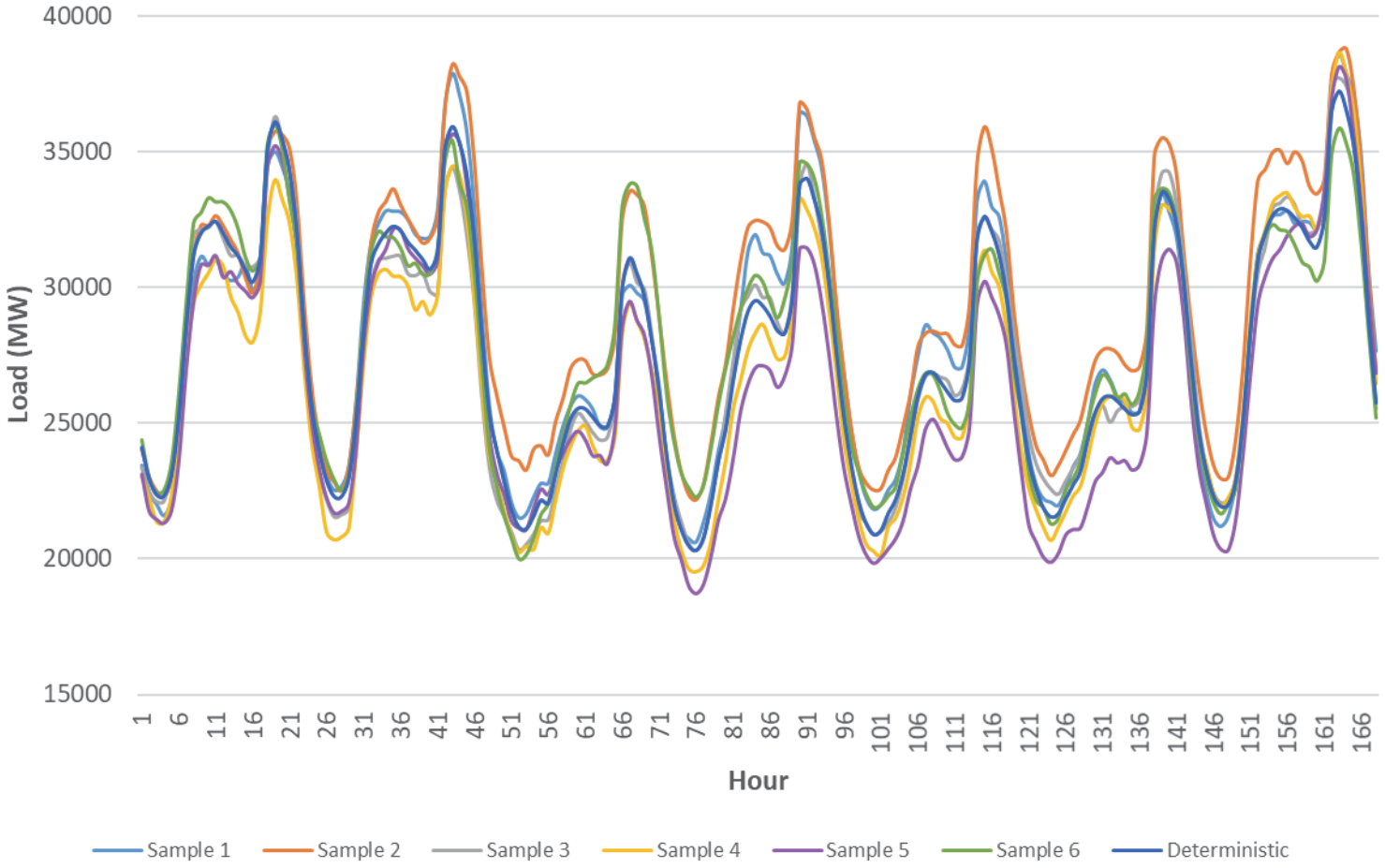
- The model has four stochastic variables
  - Forced outage, load, solar and wind generation
- Forced outages are generated randomly and independently for each generation resource in each iteration
- Load, solar and wind stochastic samples of 500 iterations are generated
  - Randomly with built-in cross-correlations among them
  - Chronologically by hour for the whole year of each iteration

Reliability metrics for stochastic simulations

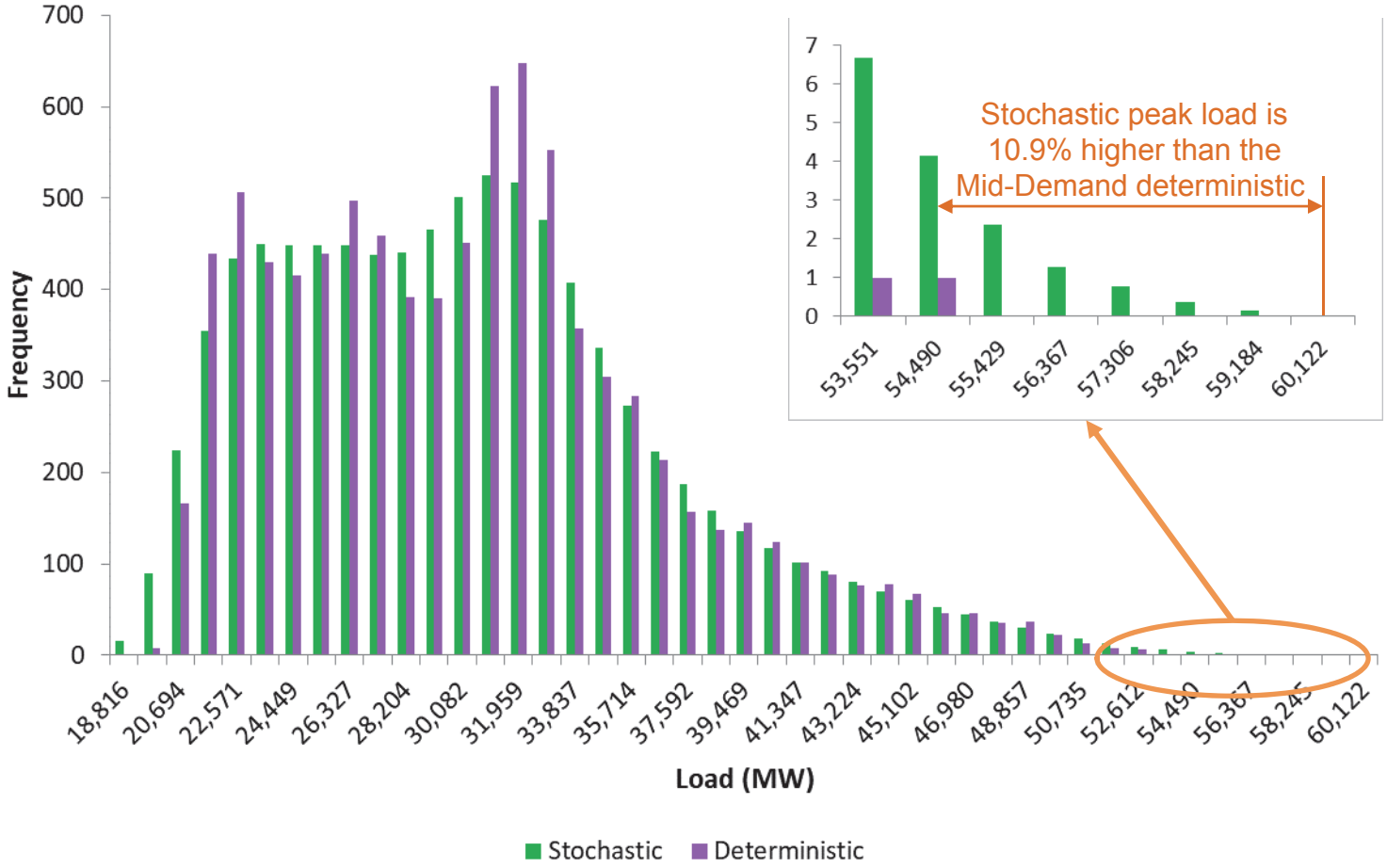
- Use the same metrics as defined in the IRP ALJ ruling*
  - A loss of load (LOL) event: a day with insufficient capacity to meet the sum of load and requirements for regulation, frequency response, and spinning reserve for at least one hour
  - Loss of load expectation (LOLE) criterion: the average of LOL events of all iterations of full-year simulations should be no higher than 0.1 (day/year)
  - For 500 iterations (500 years), up to 50 LOL events are allowed to meet the LOLE criterion

* Administrative Law Judge Ruling Directing Production Cost Modeling Requirements, September 23, 2016 (http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442451199)

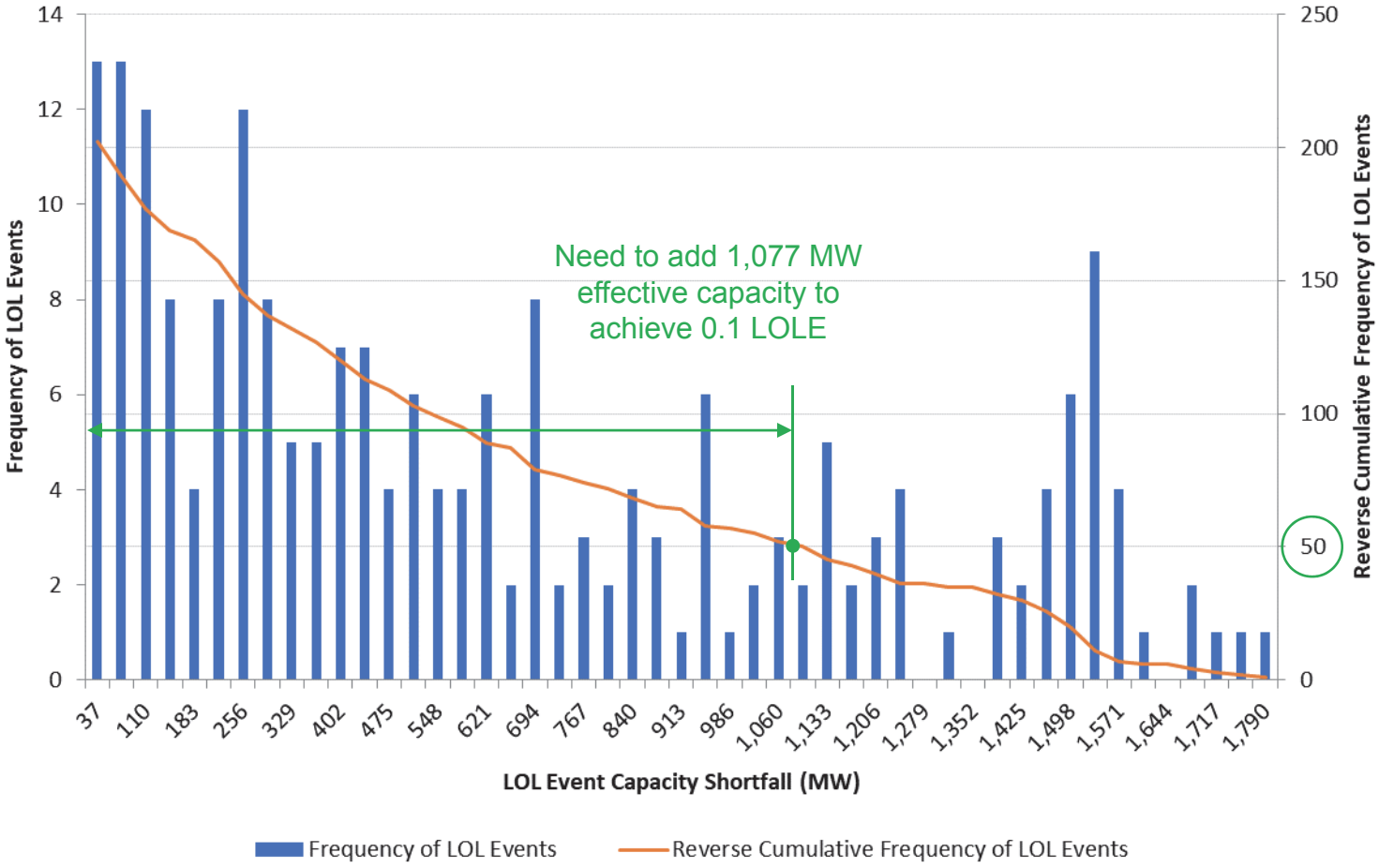
Hourly load of one week: load of the deterministic model vs. 6 stochastic samples



Histogram of 2030 hourly load: deterministic vs. 500-iteration stochastic values



Stochastic simulation results: histogram of loss of load events in 500 iterations

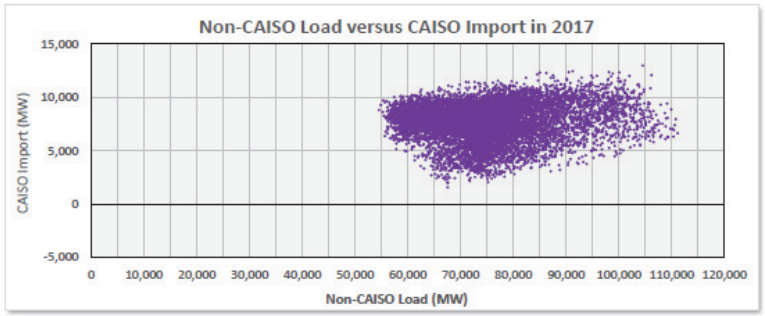


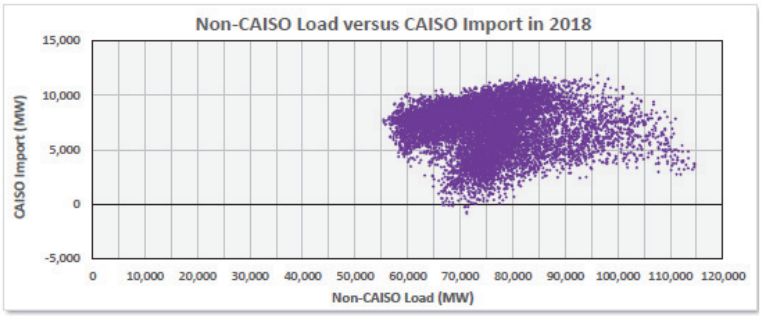
CAISO supply insufficiency is confirmed through stochastic simulations.

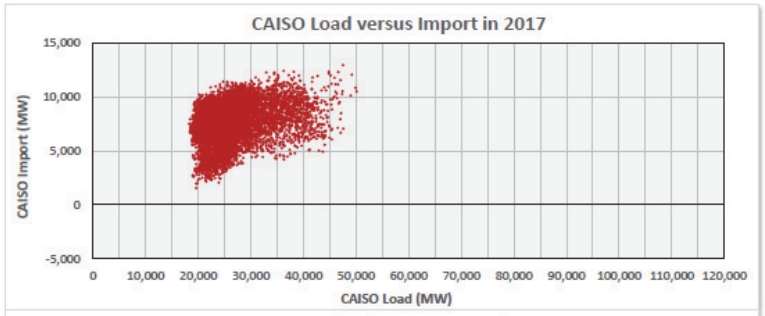
- Stochastic simulations confirmed the capacity insufficiency found in the deterministic simulation
- To meet the 0.1 LOLE criterion, it needs to
  - reinstall 1,077 MW* of the 3,227 MW thermal resources retired by the 40-year rule, i.e., allow retirement of less than 2,150 MW of it; or
  - add new resources with equivalent capability to serve load and reserves during critical periods.

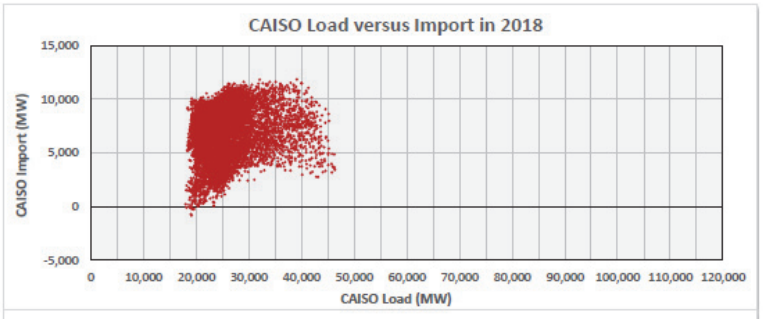
* It will need about 4.5% more capacity to count for forced outages.

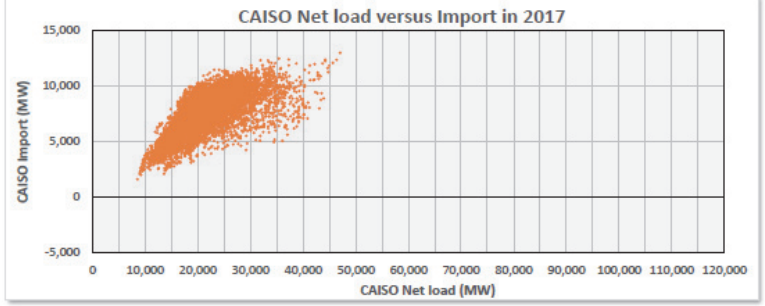
Appendix: 2017-2018 CAISO load vs. import

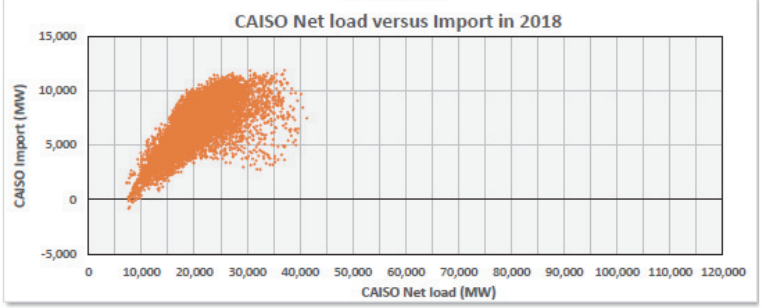












Thank you!