Load Conformance Impact on the Resource Sufficiency Evaluation

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1 Executive Summary

As part of CAISO's Western Energy Imbalance Market (WEIM) Resource Sufficiency Evaluation Enhancements (RSEE) Phase 1b stakeholder initiative, the CAISO committed to further analyze the impact of load conformance on the resource sufficiency evaluation (RSE). This interim report covers the analysis conducted thus far focused on CAISO's balancing authority area (BAA). This is one of three analysis tracks of Phase 1B of the RSEE initiative. The CAISO is seeking stakeholders input on this interim report and will issue a final report in late May 2022.

Highlights of Findings -

- **Load conformance is consistently used in the real-time markets.** Historical use of load conformance shows that load conformance is significantly used in the hour ahead scheduling process (HASP) and the fifteen-minute (FMM) markets, mainly to position resources and secure additional intertie capacity. The hourly profile of load conformance exhibits a typical net load trend. The main use of load conformance in the real-time interval dispatch (RTD) is to manage real-time imbalances and does not show a marked hourly trend.

- **The findings in this analysis align with the CAISO finding in its preliminary analysis of July 9, 2021.** The preliminary analysis performed in the first phase of the RSEE stakeholder initiative was based on the peak hours of July 9, 2021. Because it was an extreme case of supply conditions, there was a concern that those findings would not be representative of the impact of load conformance during more general conditions. This recent analysis evaluates the implications of load conformance using over 650 FMM market cases and 170 HASP market cases, and reached the same conclusions. These cases covered 19 different trade dates for summer and winter conditions.

- **Load conformance causes changes in all types of supply.** The additional load requirements imposed by load conformance in HASP and FMM are met with increasing WEIM import transfers (or reducing WEIM export transfers), increasing of CAISO hourly intertie import schedules (or reducing of export schedules), and increasing schedules of CAISO's internal resources.

- **There is no evidence that load conformance causes a one-to-one increase in EIM import transfers.** A given load conformance value resulted in additional import transfers across a wide range of values, as low as no additional transfers and up to the full amount of load conformance. There is no straight relationship that can be defined *a priory* the market solution because the outcome is largely driven by the specific conditions and economics of that market interval.

- **The use of load conformance in HASP and FMM does not enhance the CAISO's BAA ability to pass the bid range capacity test.** The load conformance does not impact the capacity test requirements, nor does it not make available more supply in the capacity test . This is because by design, the capacity test explicitly excludes WEIM transfers in its assessment of incremental bid range. While the load conformance in HASP does in some cases result in clearing additional hourly intertie schedules, that additional supply is not a WEIM transfer and instead equates to the bilateral interchange reflected in WEIM BAA's base schedules.

- **The use of load conformance in HASP and FMM does not enhance the CAISO's ability to pass the flexible ramping test.** The analysis shows that load conformance does not impact the flex ramp requirements, and it reduces the ramp capability, making it more difficult for CAISO to pass the flexible ramping test. The concern that load conformance could create more headroom on CAISO resources by unloading internal resources with increasing transfers was not validated. On the contrary, load conformance cannibalizes flex ramp capability for the test because it already increases CAISO's internal resource dispatches in the FMM market.

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Load conformance effectively modifies the final load requirement the real-time markets need to clear against supply. Positive conformance effectively increases the load requirements and will alter the overall market solution, not only for the CAISO area but for the overall system-wide Western Energy Imbalance Market (WEIM) area because the real-time market optimizes across both the CAISO and WEIM areas together. The impact of load conformance on the volume of WEIM transfers into CAISO was widely discussed through the (RSE) enhancement. In a previous analysis of the interaction between load conformance and WEIM transfers, CAISO showed that load conformance applied to either the HASP or FMM had a limited impact on the WEIM import transfers coming into CAISO, and that only a fraction of the load conformance eventually drove additional WEIM import transfers, and in some cases the load conformance actually reduced the level of WEIM import transfers into the CAISO area.

The preliminary analysis was targeted at the most critical hours of July 9, 2021, for both the HASP and FMM markets. As part of CAISO's commitment to further explore the implications of the use of load conformance in the real-time markets as well as in the resource sufficiency test, CAISO is conducting an additional phase of this RSEE initiative, the RSE phase 1B, starting with an analysis phase. This analysis tracks the impact of load conformance more comprehensively than the preliminary analysis of the most critical hours of July 9. For this analysis, CAISO selected the top 16 days of 2021 based on the highest peak gross load. In addition, per stakeholder request the CAISO also analyzed three additional non-summer days selected from January 2022 based on the significant load conformance observed for HASP and FMM markets. These three days can complement the high-load days from 2021 and provide a broader reference of the dynamics under scenarios with light-load conditions.

Additionally, to better identify the dynamics between load conformance and changes of WEIM transfers, CAISO is assessing all intervals between hour ending (HE) 14 through 21, which covers the majority of peak load and upward ramping conditions. Over 650 FMM markets and 150 HASP market runs were analyzed. This is more comprehensive than the 10 intervals explored in the preliminary analysis.

3 Load Conformance

In all CAISO markets, except the IFM where demand is bid in, system operators can adjust either demand (through conformance) or supply (through Exceptional Dispatches, or EDs) based on expected system conditions. Changes to market inputs can influence market clearing prices. The adjustment to the load forecast in the day-ahead timeframe is referred as *RUC net short*, while in the real-time market it is referred to as *Load conformance*. These adjustments can effectively increase or decrease the overall demand requirements that the market optimization uses to clear against supply. Operators may use load adjustments to true up the market to the real-time system based on projected or observed system conditions.

Figures 1 to 3 illustrate the monthly distribution of load conformance in HASP, FMM and RTD markets from 2019 through 2022, organized by month. Because simple averages may not reflect the more complex dynamics of load conformance, these trends are shown as box-whisker overlapping with distribution curves. The box represents the 25th to the 75th percentile while the whiskers represent the 1.5 interquartile range; the dots represent the outliers. The horizontal line within the box shows the 50th percentile. This trends show that the real-time markets have frequently cleared with an adjustment to the load forecast; these adjustment effectively imposed additional demand requirements to meet with available supply. Overall, the load conformance tends to be positive.

Figure 4 to 6 show the same conformance organized by hourly profile for each year. Box plots are used to show this pattern; the blue mark inside the box shows the average values relative to the percentiles. The load conformance applied to HASP and FMM aligns very well and mimics the load profile. In contrast, the load conformance applied to the RTD market divergence from HASP and FMM and has a less defined hourly profile. The profile of the HASP and FMM conformance may suggest the main driver is to position these markets to the real-time conditions, while the RTD conformance serves more to manage the minute-to-minute imbalances in the real-time system. In each of the markets, the spread of the load conformance is wide, ranging from -2,500 MW to 3,000 MW.

These figures show that load conformance across markets is applied predominantly in the upward direction. RTD conformance tends to be smaller than load conformance in HASP and FMM. This means RTD buys back the flexibility gained in HASP and FMM due to the higher conformance in these markets. Since load conformance in HASP and FMM may result in additional WEIM transfers, and then such transfers are re-optimized in the RTD market, [1] these transfers are effectively advisory in the

[1]For a subset of WEIM entities, there is a concept of static and dynamic transfers; static transfers are optimized only in FMM but are not re-optimized in RTD; However, the dynamic portion of transfers

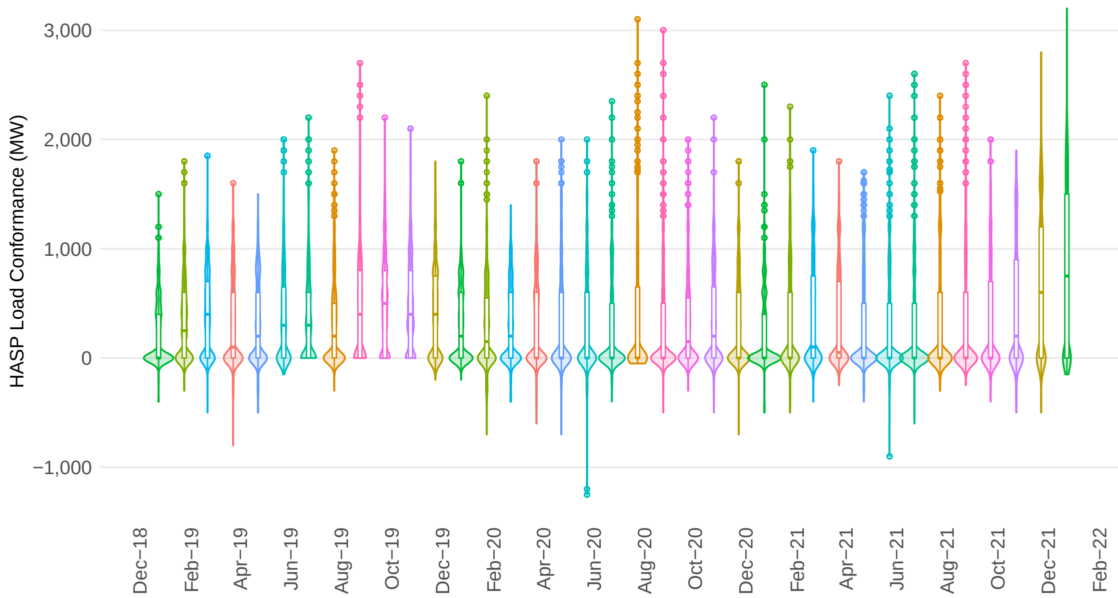

Figure 1: Monthly trend of historical HASP conformance.

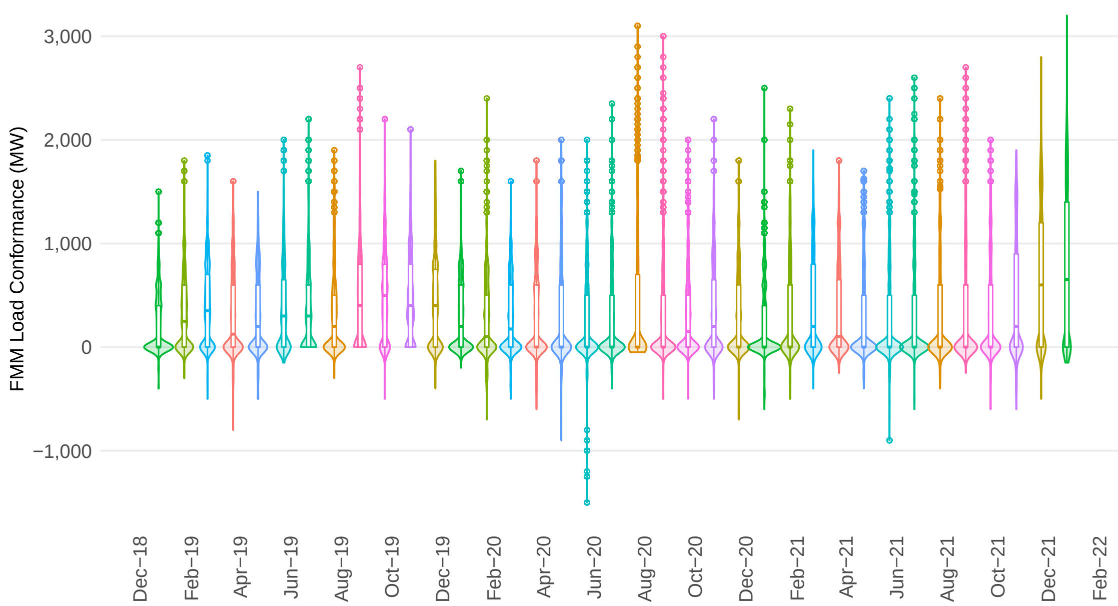

Figure 2: Monthly trend of historical FMM conformance.

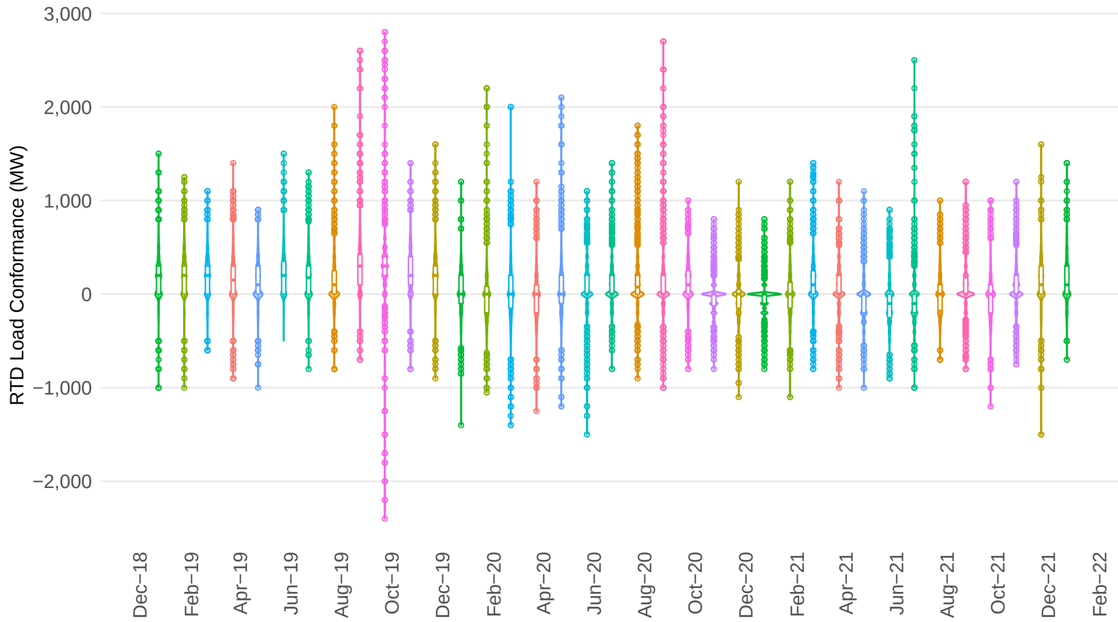

Figure 3: Monthly trend of historical RTD conformance.

HASP and FMM markets. There is no requirement under the current market rules to lock these transfers in RTD at the level of the transfers originally cleared in HASP and FMM. These HASP and FMM transfers have financial implications since FMM schedules are financially binding. From an operational perspective, however, only RTD transfers are meaningful since these are the transfers that translate from operational instructions for resources to follow.

are incremental to these static transfers.

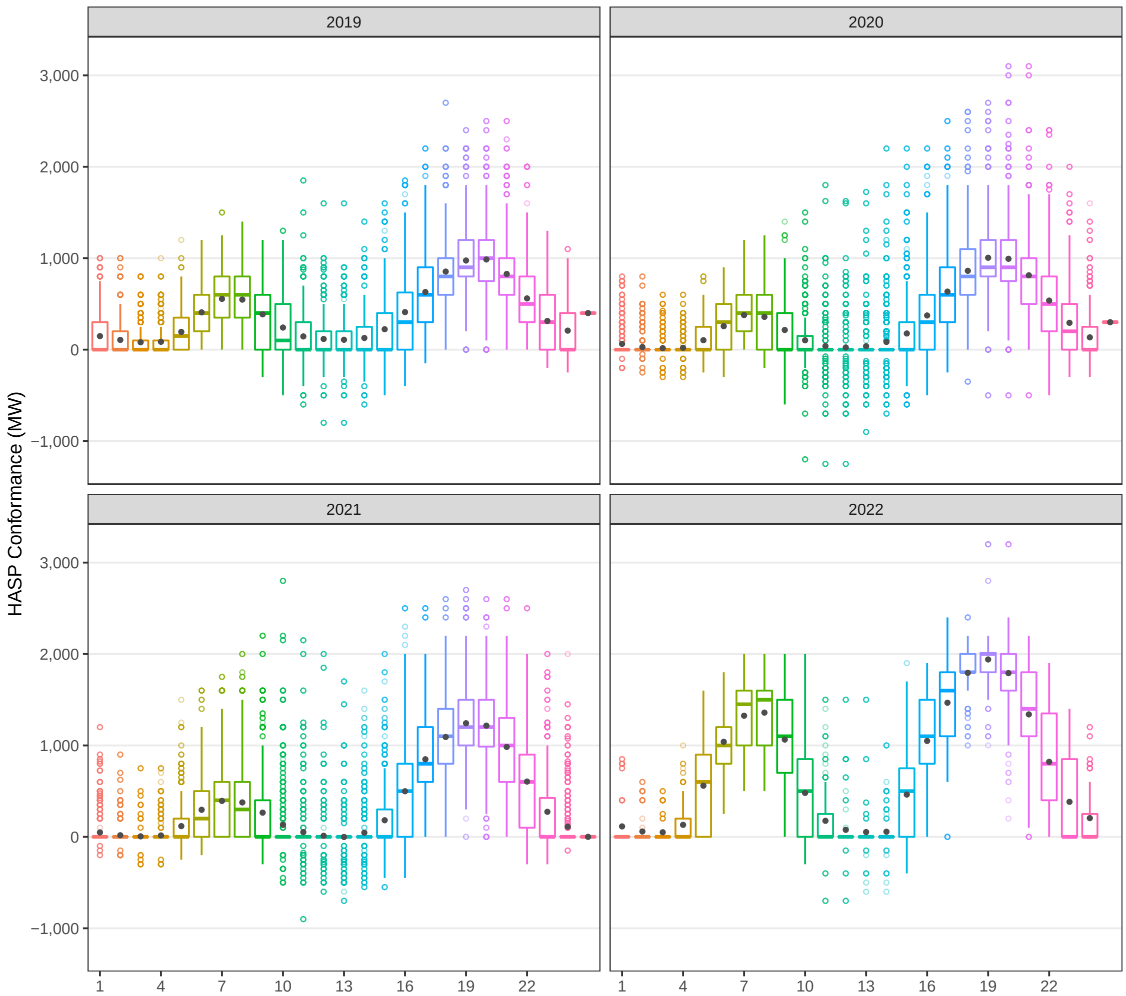

Figure 4: Hourly trend of historical HASP conformance.

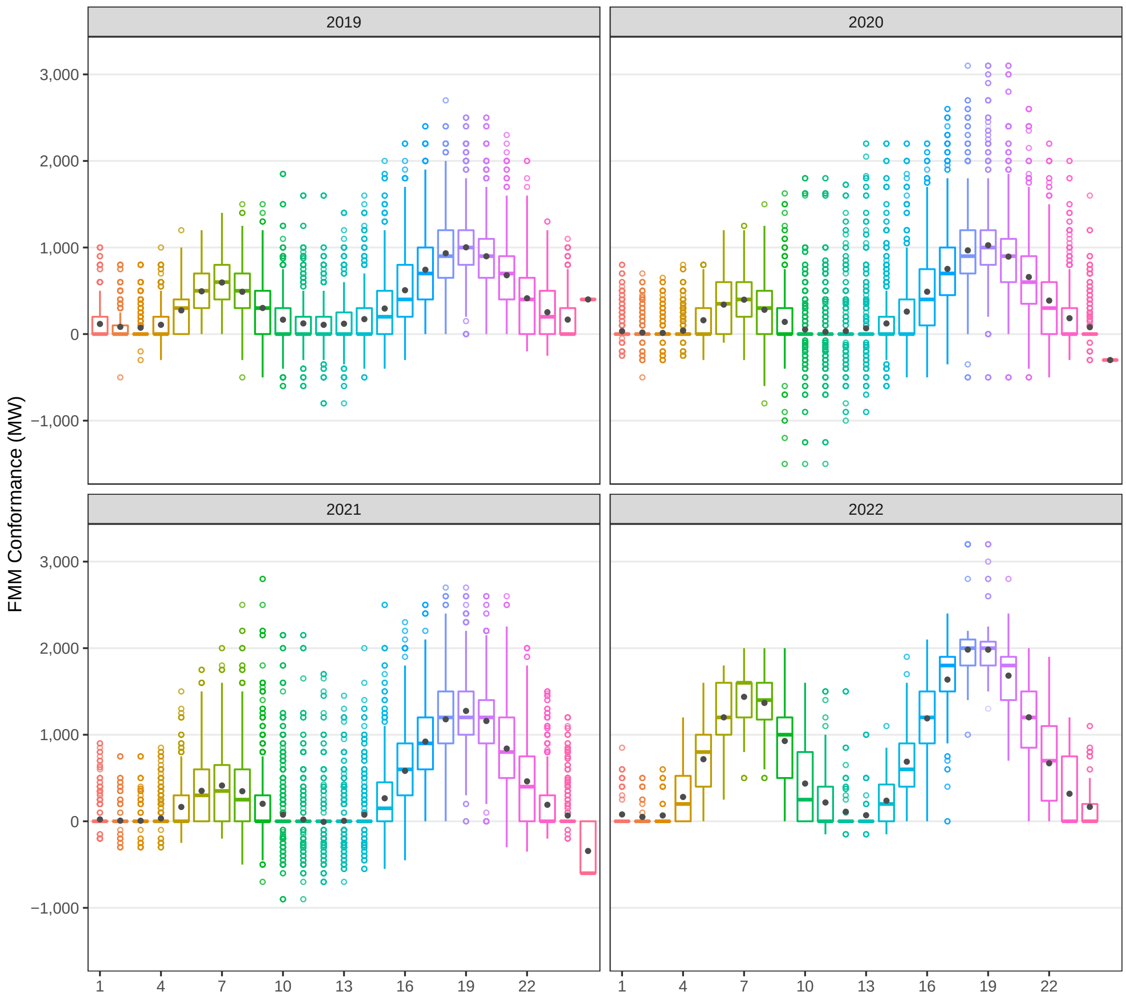

Figure 5: Hourly trend of historical FMM conformance.

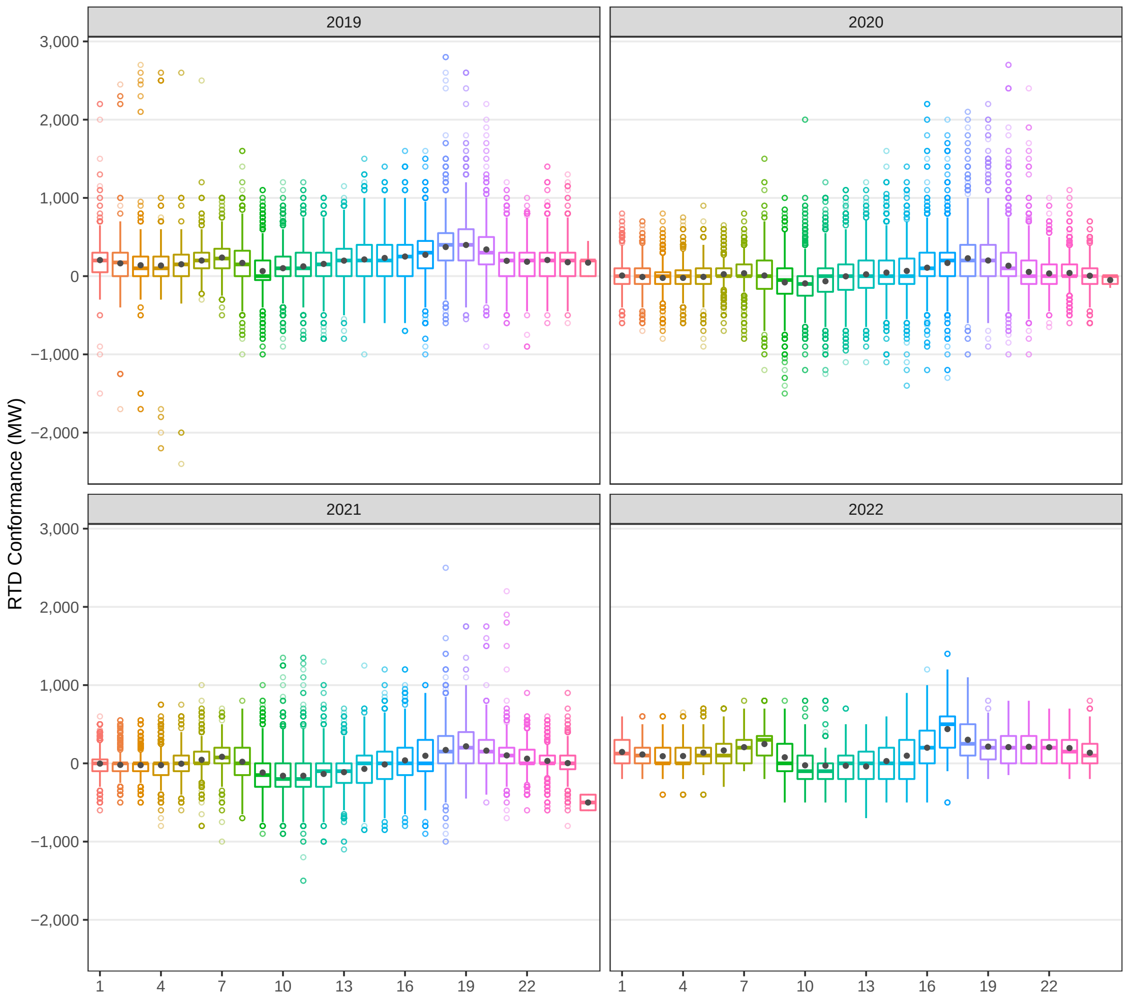

Figure 6: Hourly trend of historical RTD conformance.

4 Load Conformance and Energy Transfers

The objective of this analysis effort is to understand and evaluate the impact of load conformance in the RSE. The emphasis is on the CAISO balancing authority area (BAA) because the CAISO uses load conformance more systematically than other EIM BAAs.

The first metric is to quantify the amount of additional import transfers into CAISO BAA induced by using load conformance in both HASP and FMM markets. The focus is on HASP and FMM, instead of RTD, because these two markets might affect the inputs used in the RSE, which in turn may influence the outcome of the RSE. Figures 7 through 9 show the comparison between the level of load conformance used in the binding hour of the HASP process and the corresponding increase of WEIM import transfers into CAISO area due to the applied load conformance. The line in blue represents load conformance, while the bars in purple reflect the incremental WEIM import transfers. An incremental transfer represents the additional WEIM import transfer into CAISO induced by the load conformance, which most of the time is simply an increase of WEIM import transfers but in a few instances it can also be from the reduction of WEIM export transfers out of the CAISO area.

Likewise, Figures 10 through 12 show similar information for the FMM. These plots show a data granularity of 15 minutes and are based on the original market solutions of the 2021 and 2022 selected days. A consistent outcome of this analysis is that the increase of WEIM import transfers into the CAISO BAA is only a fraction of the total amount of load conformance.

The pattern over the different days is consistent with the increase of WEIM import transfers generally representing a fraction of the magnitude of load conformance. Take as a reference, June 17, 2021 in the HASP market, the load conformance of 2,000 MW resulted in no more than 1,000 MW of additional WEIM import transfer into CAISO area. This would represent a transfer increase in the order of 50 percent of the load conformance. [2] In contrast, on July 9, 2021, as described in the previous analysis reported, the load conformance indeed resulted in a reduction of WEIM import transfers into CAISO. This was an outcome in part due to the over-scheduling of intertie schedules in the real-time market during the derates of the Malin and NOB interties. When looking at other days with light load conditions, such as those of January 2022, a load conformance of 2,200 MW resulted in limited increases of WEIM import transfer as low as 500 MW, or about 23 percent of the load conformance. There are other hours through different days in which the increase of import transfers is basically nonexistent.

[2] HE 21 is missing and that's the reason it shows no records for additional transfers while the pattern of load conformance just connects the two adjacent hours. There are also a few other hours across other days in which the results are missing

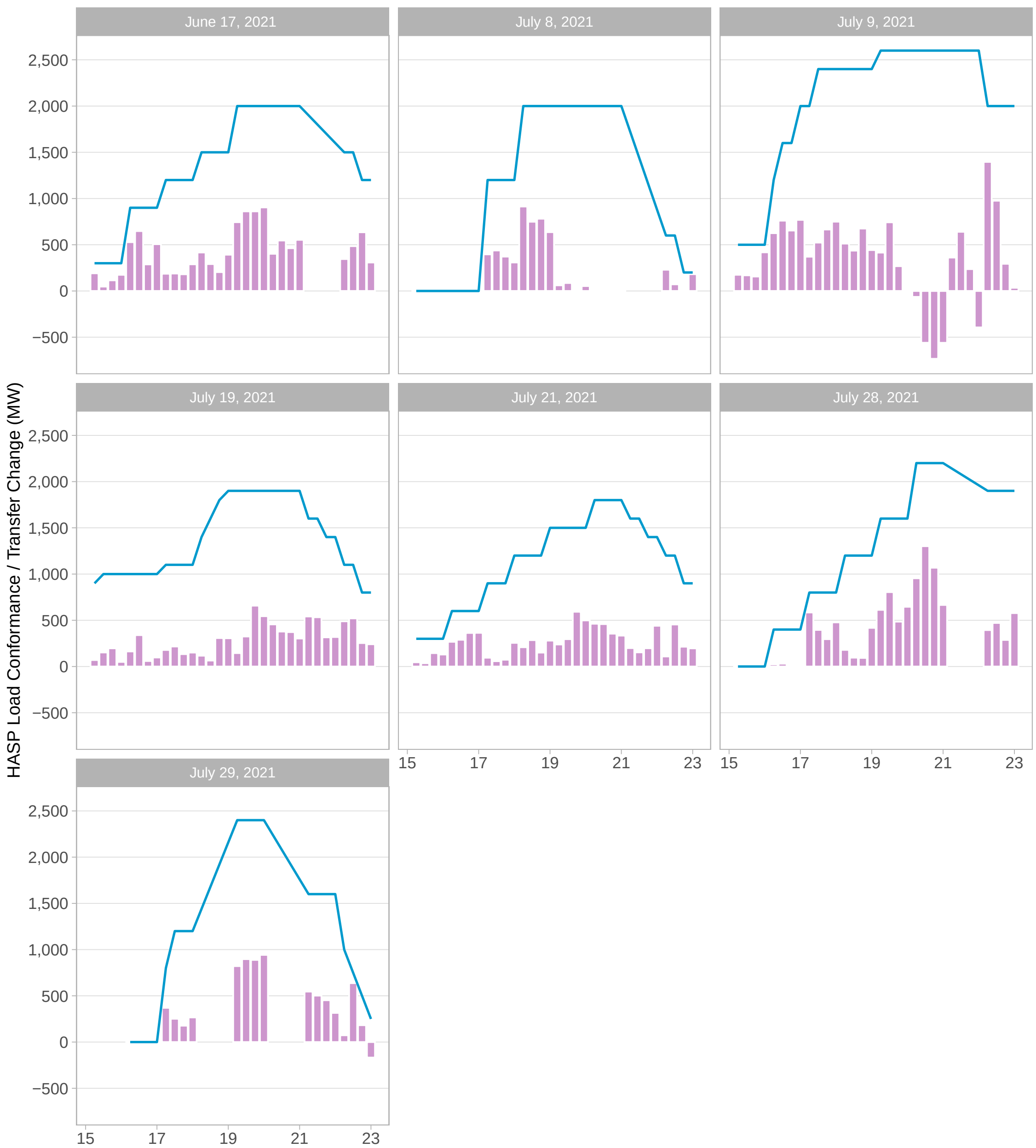

Figure 7: Additional import transfer induced by HASP load conformance 1-3.

Figure 8: Additional import transfer induced by HASP load conformance 2-3.

Figure 9: Additional import transfer induced by HASP load conformance 3-3.

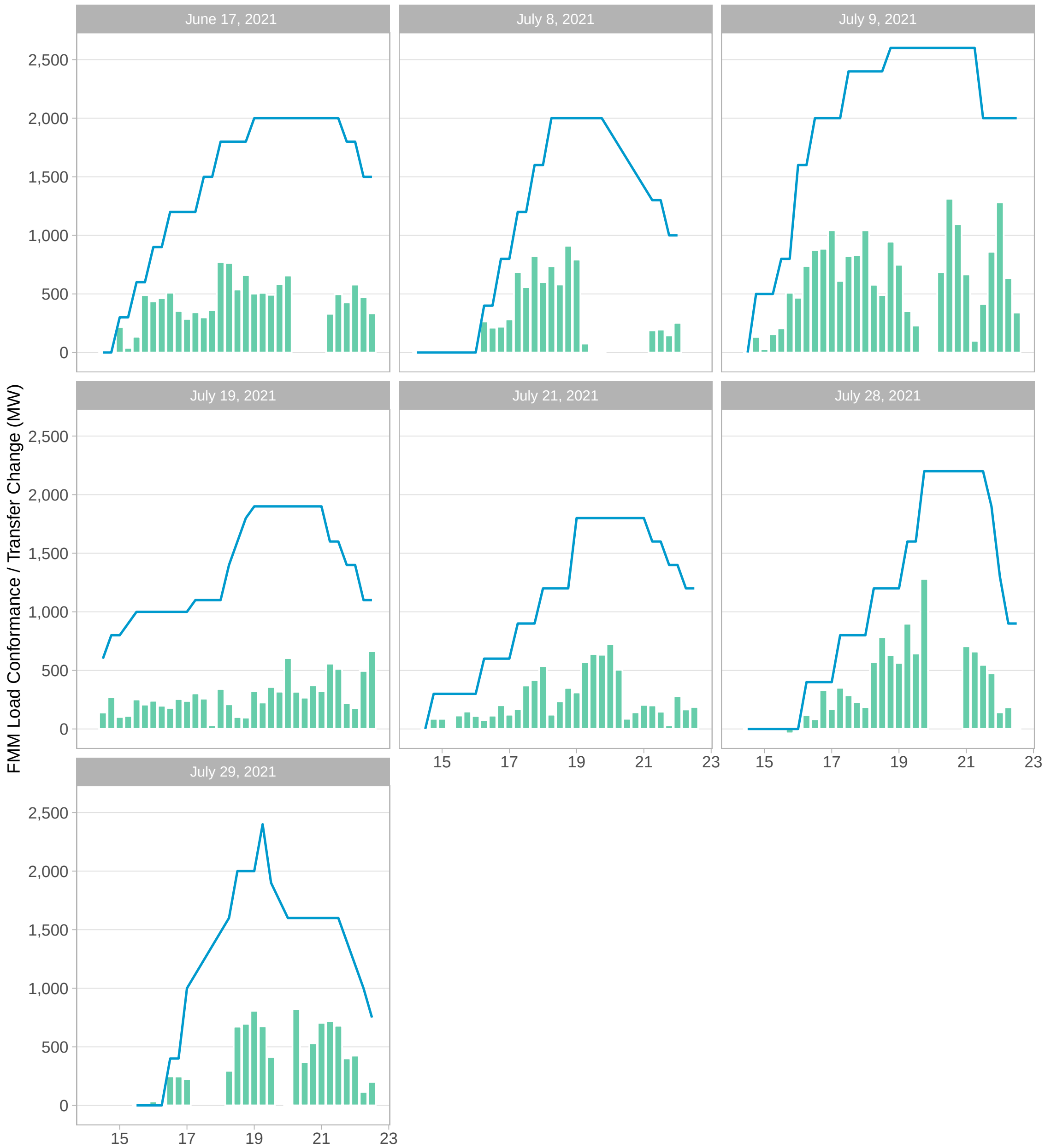

Figure 10: Additional import transfer induced by FMM load conformance 1-3.

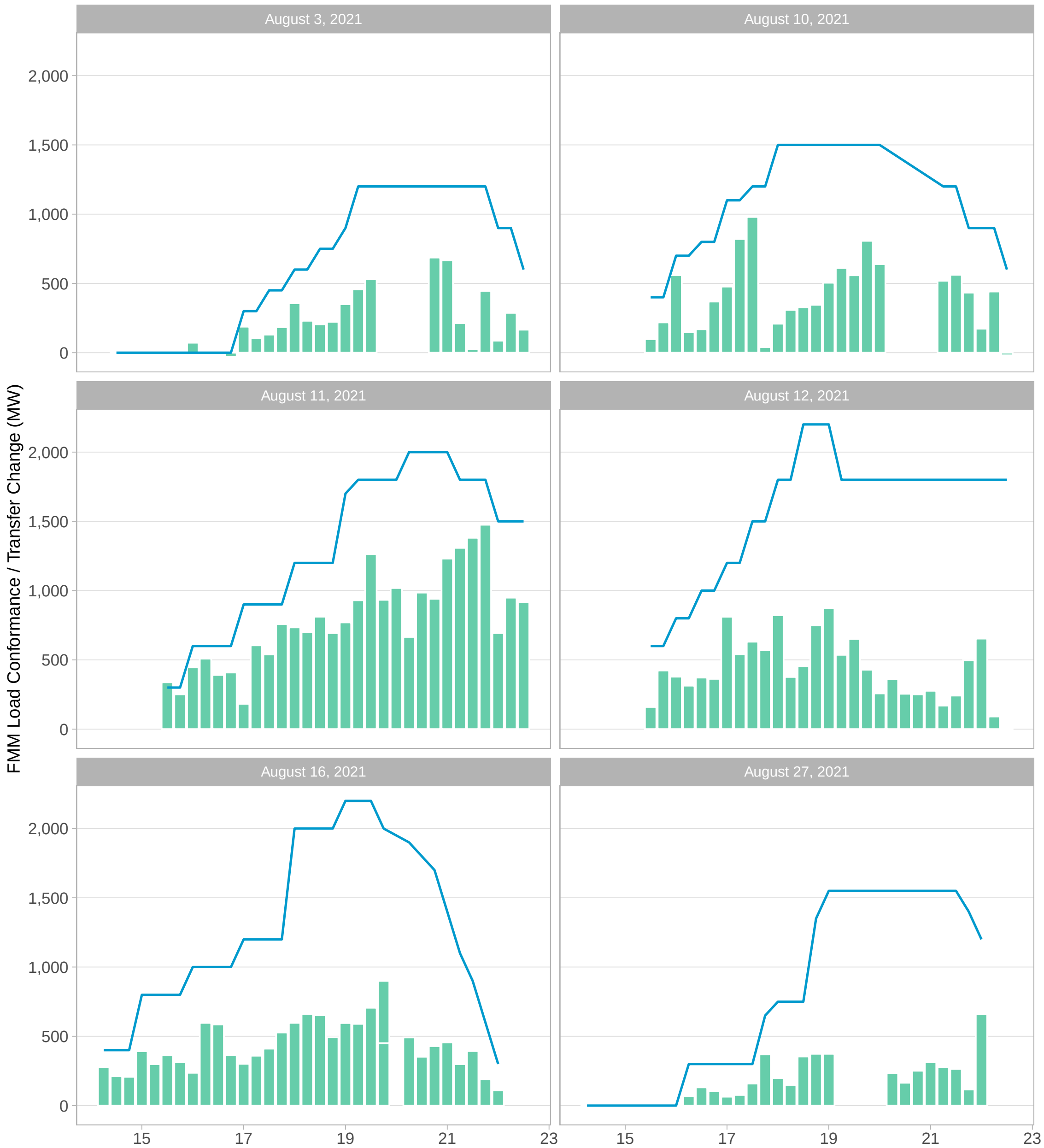

Figure 11: Additional import transfer induced by FMM load conformance 2-3.

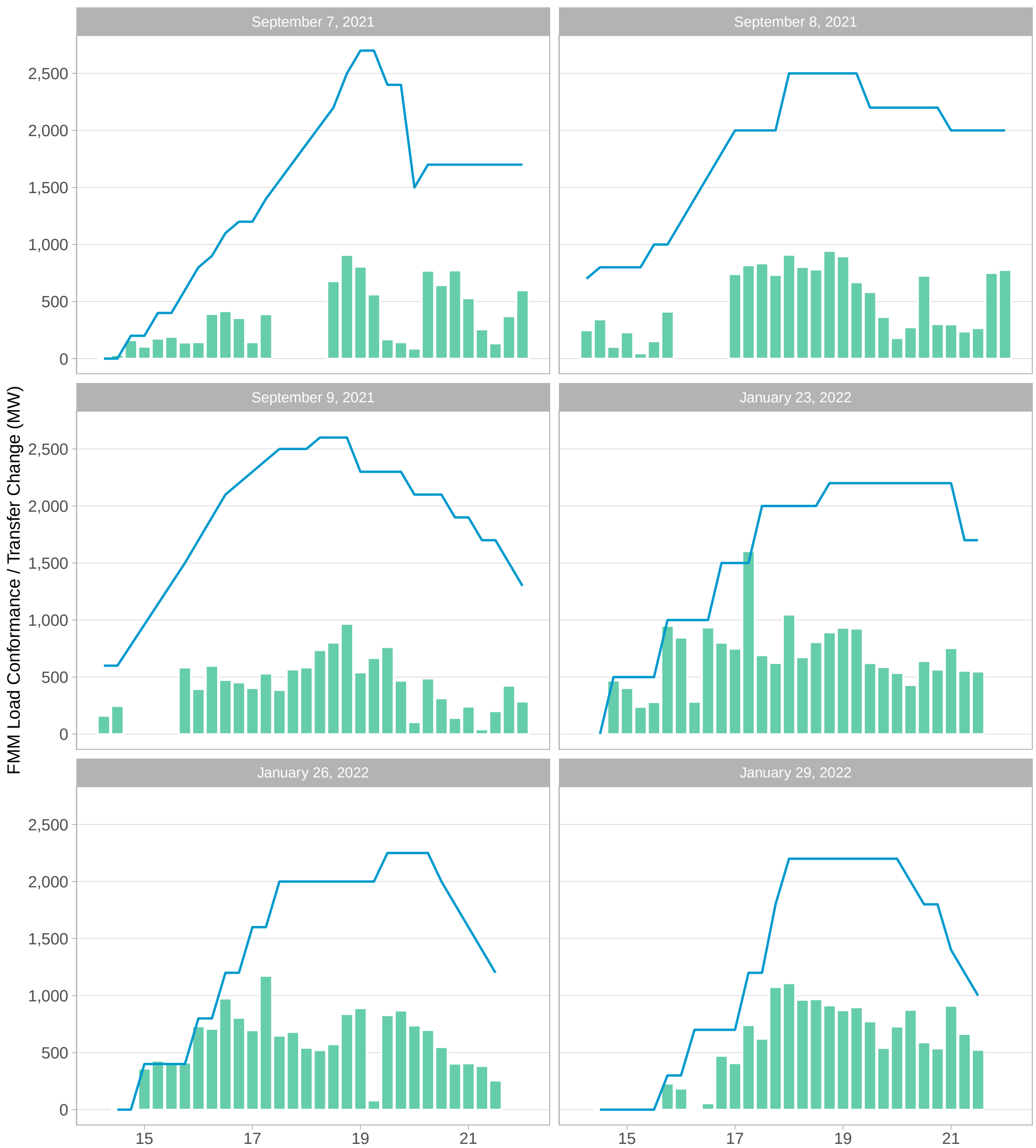

Figure 12: Additional import transfer induced by FMM load conformance 3-3.

Figure 13 shows all data together by comparing the load conformance against the amount of increase for import transfers. Since the load conformance utilized in the market is coarse and in discrete values, the x-axis values are lumpy in nature. In contrast, the corresponding increase of import transfers can take a wide range of values for the same applicable load conformance level. For instance, for a load conformance of approximately 1,500 MW, the increase of import transfers can vary anywhere between 200 MW and 1,400 MW. For a load conformance of 2,000 MW, the corresponding import transfer can be anywhere between 0 MW to 1,400 MW. This reflects the inherent dynamic conditions and highlight the challenge of trying to associate a WEIM import transfer value to a corresponding load conformance value. ***For a given load conformance value, there is no precise way to identify a priori what level of import transfers will be induced in the market.*** This challenge is root on the inherent centralized clearing process of the WEIM. The transfers are not *per se* variables optimized in the WEIM, they are the by-product of the overall dispatches of all internal resources of each BAA, which in turn are based on the overall economics and constraints of the system-wide market. Transfers internalize hourly imports and exports, resource bids, resource and system constraints, such as ramp rate and transfer capabilities, and the overall system load conditions. Therefore, the pattern of EIM transfers will not inherently behave linearly; *i.e.*, there is no basis to expect that a 1 MW change of system load will result in 1 MW of additional transfers. On the contrary and as shown by hard data, an increase of system load (induced by load conformance) can result in either,

1. increase of hourly imports, or reduction of hourly exports,

2. upward dispatches of the area's internal resources,

3. relaxation of power balance constraint,

4. increase of import transfer or reduction of export transfers, or

5. any combination of all above changes.

In Figure 13, the blue line represents a smooth regression used to identify any trend in the data and any relationship between the magnitude of the load conformance and the resulting increase of import transfers. This line is derived using a locally weighted least square regression, which is a common technique to smoothen the regression for localized subsets of load conformance and is an appropriate technique when the load conformance is bounded within a finite range. Historically, the load conformance is within certain range and in discrete and coarse changes. The gray band associated with the regression line represents the 95 percent confidence interval. This regression exhibits a nonlinear relationship between load conformance and the resulting increase of import transfers.

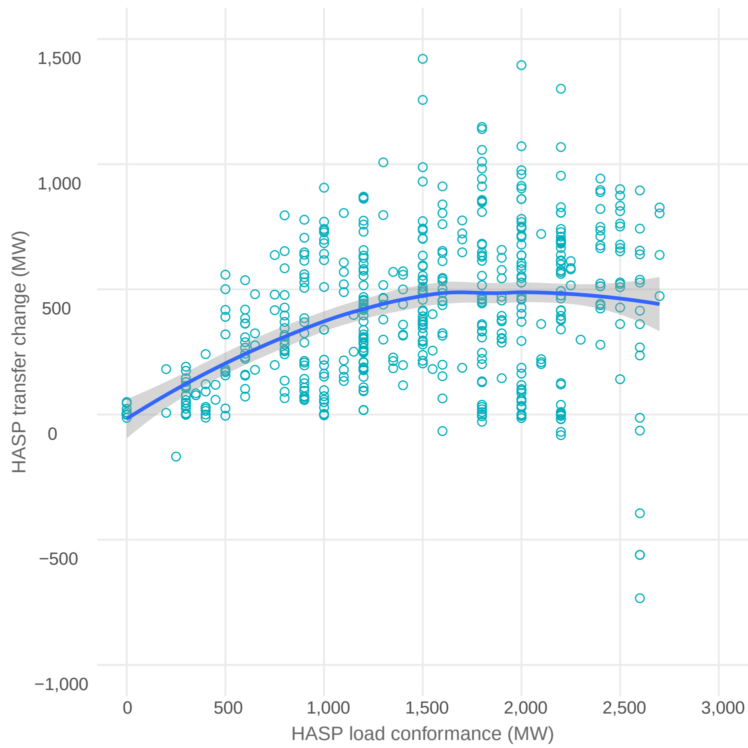

Figure 13: HASP load conformance *vs.* import transfers.

The decreasing pattern at the high end of the trend is largely influenced by the events of July 9, 2021, when load bias resulted in a reduction of import transfers. Th ese data points are presented in the set because they were indeed reflective of the actual market solution. [3] Given the wide range of import transfer changes for a corresponding load conformance value, the regression shows that the typical increase of imports due to conformance would be no more than 500 MW.

Figure 14 compares the load conformance level against the increase of import transfers as a percent of the load conformance. For instance, a value of 20 percent will mean that the import transfer increase represents 20 percent of the load conformance utilized in that market; *i.e.*, 20 percent of the load conformance translated into an increase of the import transfer. This relationship shows that as the magnitude of the load conformance increases, the increase of import transfer tends to represent a lower percentage of the load conformance. In relative terms, overall the load conformance translates into no more than 40 percent of additional import transfers.

The same analysis was performed for the FMM market, which unlike HASP, the FMM market does not clear hourly interties and thus the use of load conformance may result in a different WEIM transfer results than what is observed in HASP., Figures 15 and 16 show the relationship between load conformance and the increase of import

[3]Figure 35 in the Appendix shows the adjusted metric if the extreme cases of July 9, 2021, when over-scheduling occurred are removed.

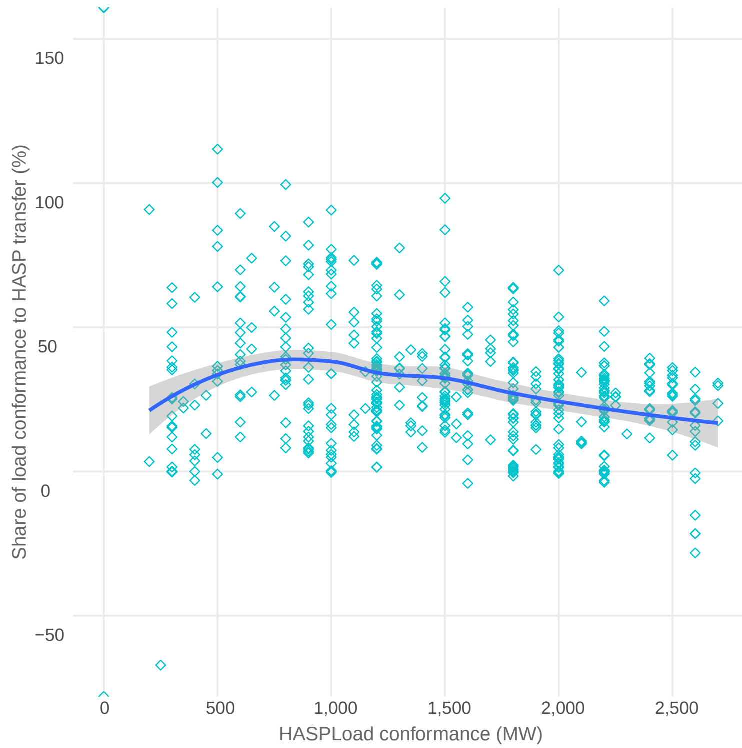

Figure 14: HASP load conformance *vs.* share of load conformance.

transfers (absolute in MW or relative in percent) for the FMM market. This uses the same days and hours used for the HASP analysis. Similar to HASP, for a given load conformance value, it shows that there is a wide range of import transfer increases; *e.g.*, for a load conformance of 2,000 MW, the corresponding WEIM import transfer increase can be anywhere between 0 MW and 1,300 MW. This again reflects that load conformance does not exhibit a straight one-to-one relationship to changes of WEIM import transfers. This conclusion aligns with the conclusions attained earlier in the preliminary analysis of load conformance using a very limited set of data. The larger set of data in this analysis, spanning over 650 data points and 19 different days and conditions, leads to the same conclusion and eliminates any concern over the preliminary analysis using a very limited data set. It also highlights the inherent difficulty and potential inaccuracies of attempting to create a direct relationship based on offline studies or a rule of thumb relationship that could be utilized in the RSE.

Figures 15 exhibit an increasing trend as the load conformance is larger; this is mainly due to not having reduction of import transfers in the critical day of July 9, 2021. The interpolated value for import transfer increase can be as high as 700 MW, which is larger than those observed in HASP. Figure 16 also shows similar trend where the percent of load conformance translated into import transfers reduces as the load conformance increases, like the HASP trend.

Figures 17 and 18 provide the same information for HASP and FMM, respectively,

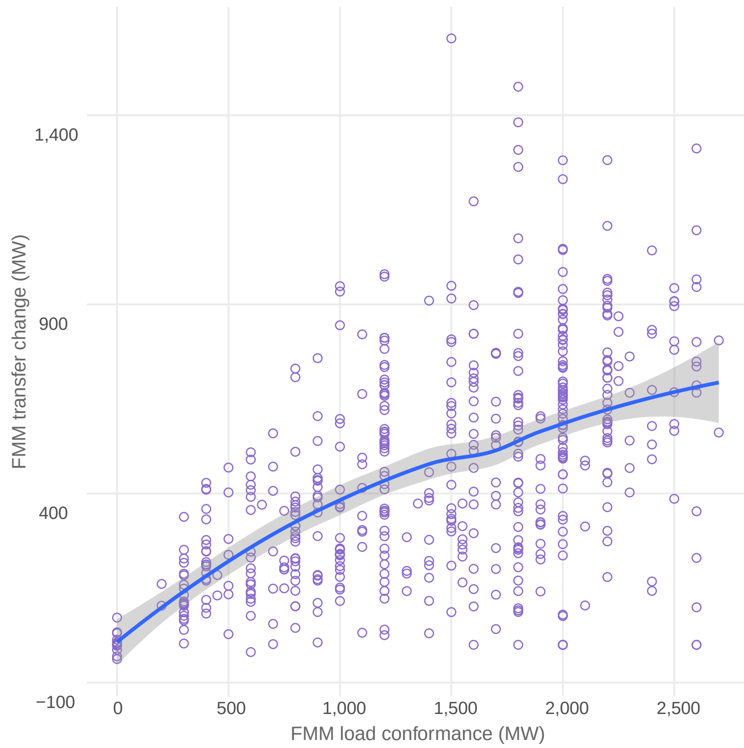

Figure 15: FMM load conformance *vs.* import transfers.

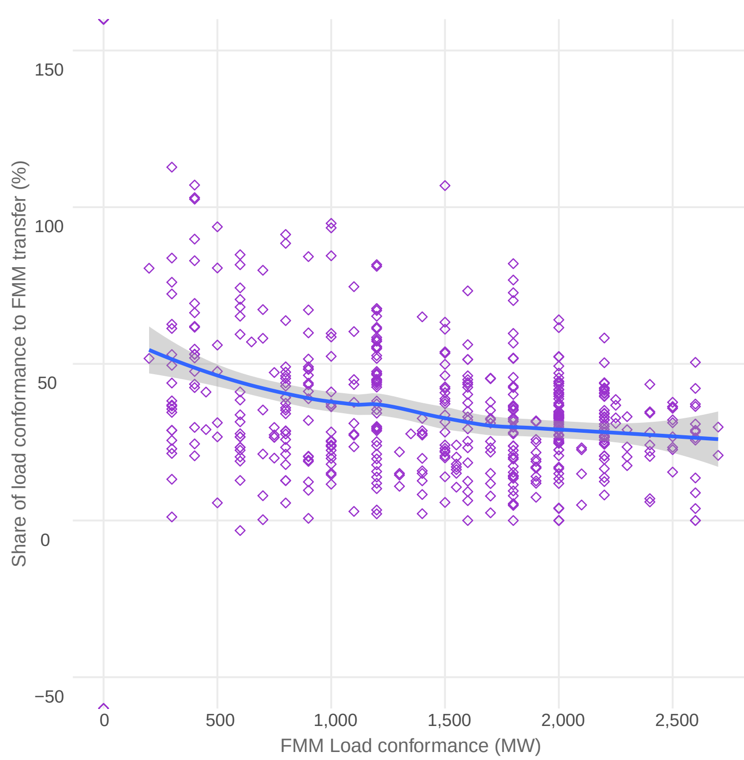

Figure 16: FMM load conformance *vs.* share of load conformance.

showing the relationship between load conformance and the level of import transfer increases organized by trading hour. This can help identify the different trends that hold for different times, and loading conditions. Generally, different hours of the day exhibit similar trends as the overall set, which suggest that no specific hour may have a more defined conclusion of a stronger relationship between load conformance and import transfers.

This section has shown the relationship between WEIM import transfer increase and load conformance using a comparison between accounting for the full amount of load conformance versus the instance where there is no load conformance at all. Figures 19 through 22 uses a different approach, with a single HASP or FMM market used as a reference. In addition to having the estimation of the import transfer increases between the two extremes cases of full load conformance and no-load conformance, these are estimations for gradual load conformance increases in 10 percent step-size. This assessment highlights the pattern of import transfer variations as load conformance changes, while all other conditions remain the same since it is done for the same HASP or FMM run.

For this more targeted analysis, the cases of September 7, 2021 hour ending 19, interval three is used for FMM, while HE 20 is used for HASP. The second set uses the same FMM and HASP time frames for January 23, 2022. These two days are analyzed to have a reference of a typical high-load summer-type peak hour, and a reference of a light-load winter day. Both days had over 2,000 MW of load conformance in the original market solution, reflecting the need to use a sizable load conformance to handle system conditions. For the HASP cases, there are four trends, one per each HASP interval of the hour. The darker line represents the first interval of the hour while the lighter color stands for the fourth interval of the hour.

In the September 7, 2021 HASP case, CAISO had robust WEIM import transfers ranging between 2,000 MW and 3,000 MW; this occurred with a load conformance of 2,400 MW. This level of import transfers was not driven fully by the load conformance. If there were no load conformance, CAISO would still observe sizable import transfers between 1,700 MW and 2,200 MW. The first interval of HASP sees an increase of import transfers of about 280 MW, going from 1,785 MW to 2,065 MW. This first intervals shows an interesting scenario in which import transfers increase as the load conformance increases, but after the load conformance reaches 50 percent of the original level used in the market $(1,250MW)$, the import transfers remain constant at 2065 even when load conformance increases from 1,250 through 2,500 MW. This outcome reflects the condition in which the there is no more capability to support additional import transfers into CAISO; increasing load conformance will be reflected in other market changes rather than an increase in transfers. The last HASP interval observed an import transfer increase of 735 MW, from 2,224 MW to 2,959 MW.

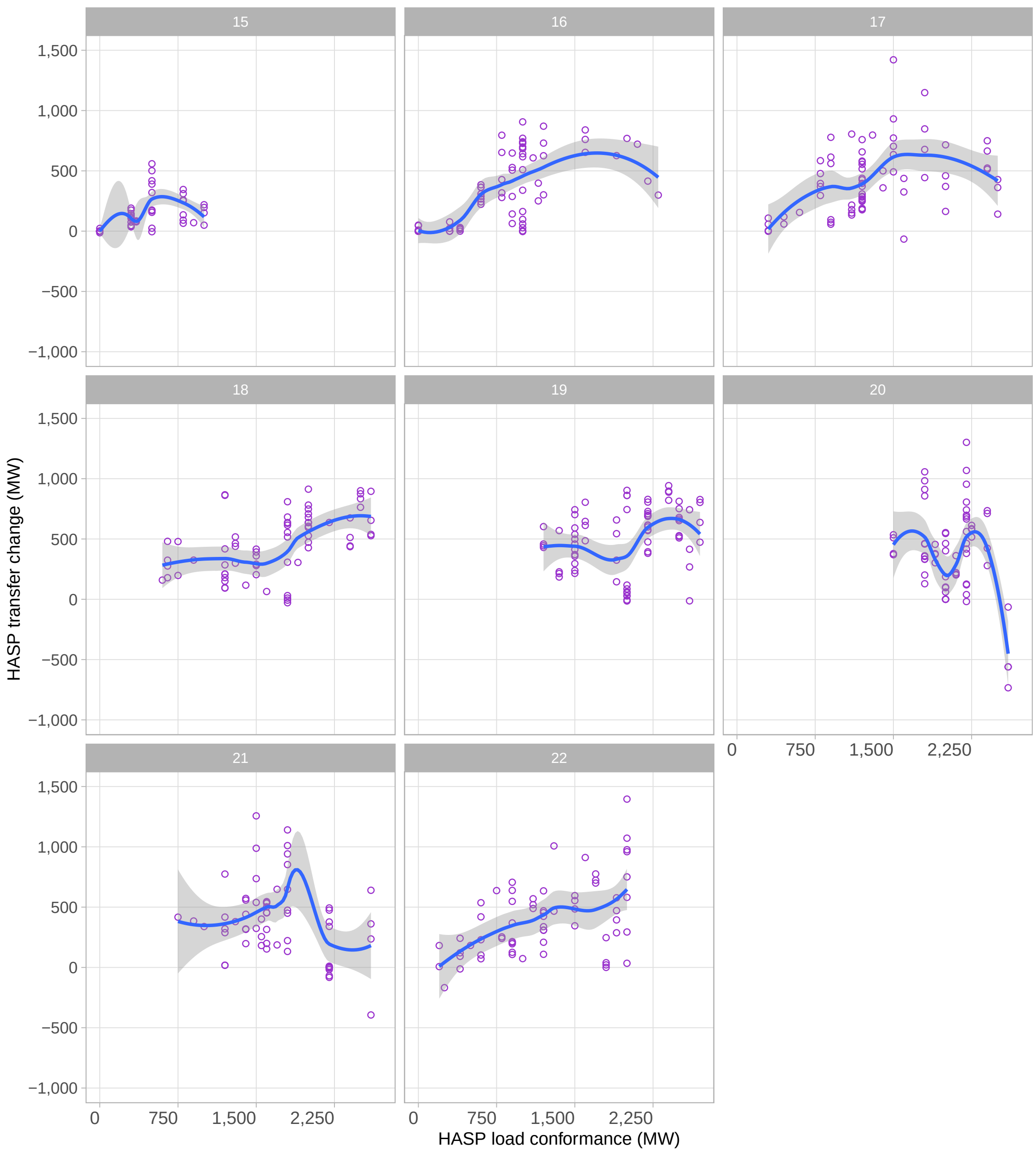

Figure 17: Hourly HASP load conformance *vs.* import transfers.

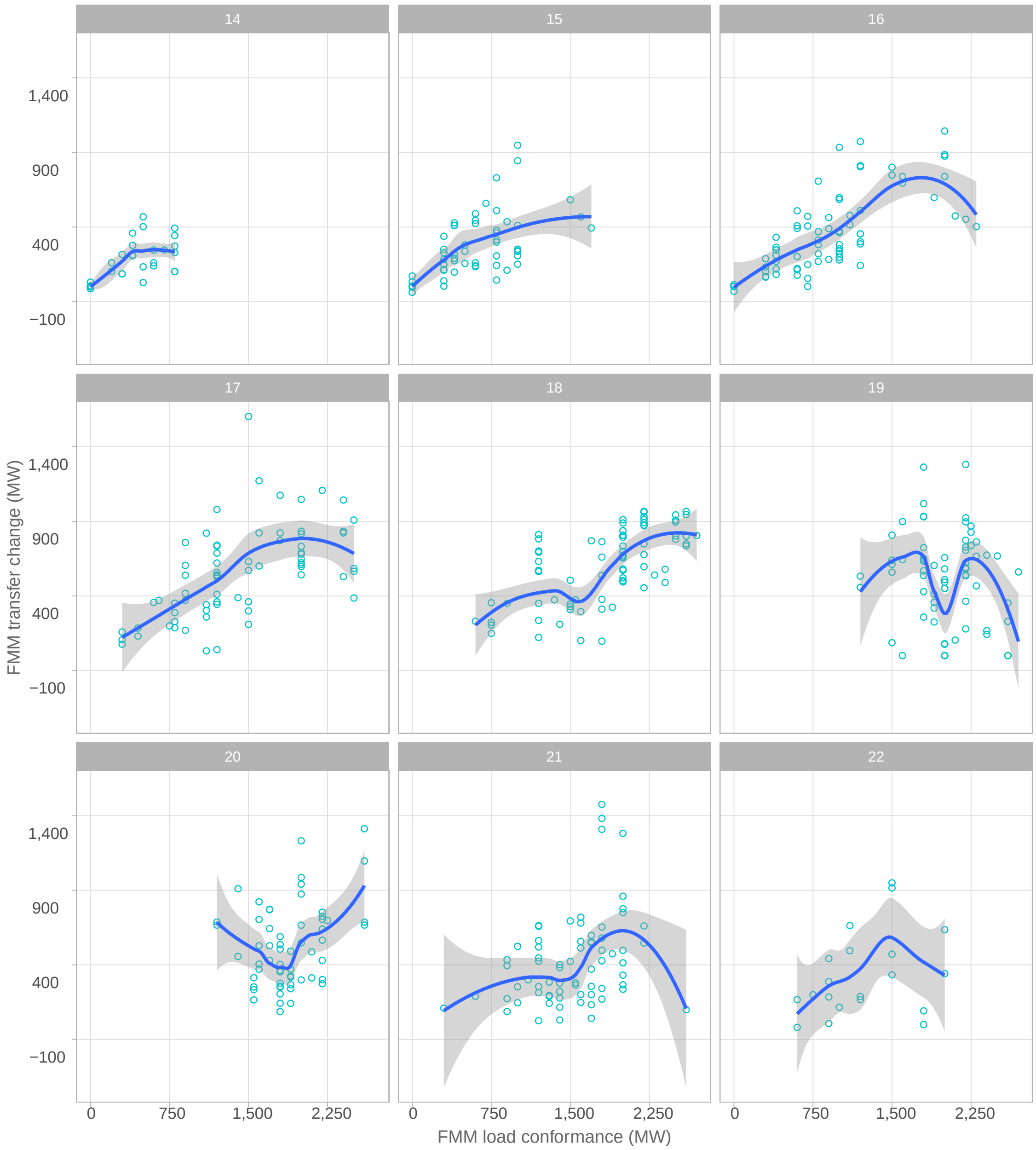

Figure 18: Hourly FMM load conformance *vs.* imports transfers.

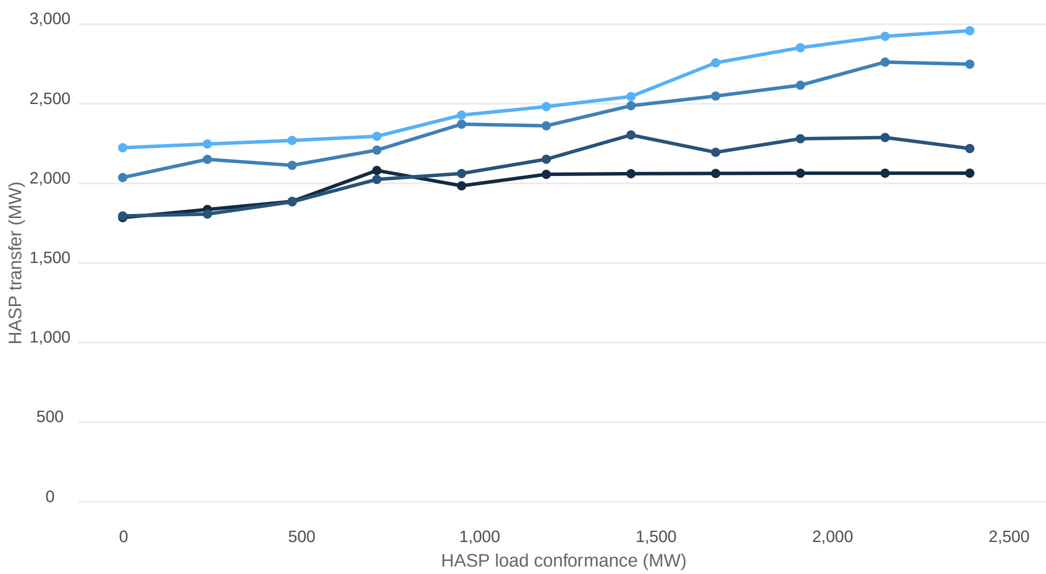

Figure 19: HASP Import transfers as a function of applied load conformance. HE19, September 7, 2021.

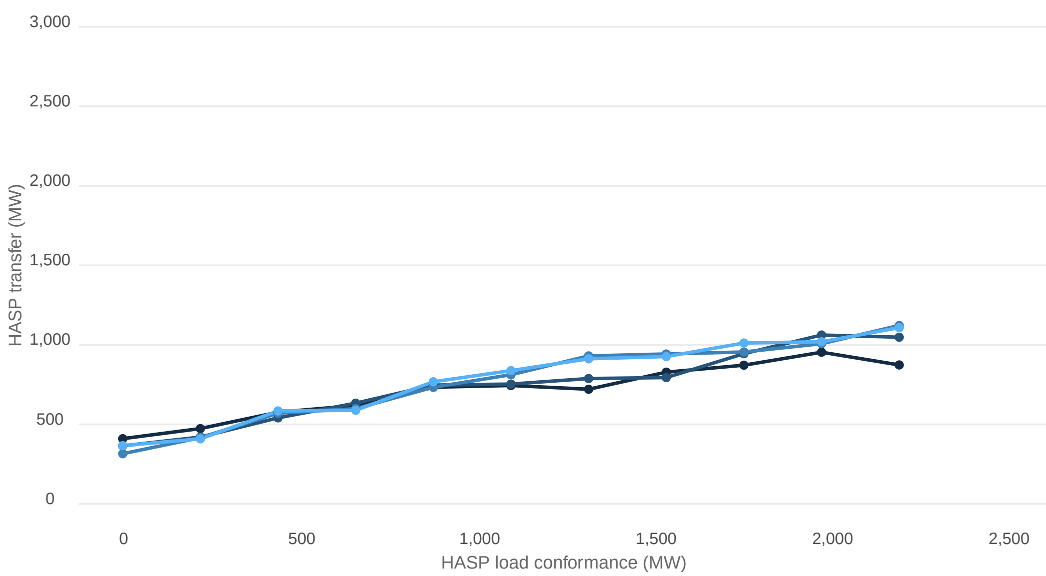

Figure 20: HASP Import transfers as a function of applied load conformance. HE23, January 23, 2022.

The January 23, 2022 HASP case is reflective of a typical winter day when CAISO loads are low and under 30,000 MW. However, there was significant load conformance used in the HASP and FMM markets. The import transfers into CAISO were significantly lower at about 1,040 MW, while the load conformance was 2,200 MW. This result shows that the load conformance does not result in a straight increase of import transfer since the volume of transfers is less than a half of the load conformance volume. Similar to the case of September 7, 2021, only a fraction of this WEIM import transfer was driven by load conformance. For the first HASP interval, the WEIM import transfers increased by 460 MW, from 410 MW to 873 MW. The last HASP interval observed an increase of import transfers of 741 MW, from 367MW to 1,108 MW.

In both HASP cases analyzed, it is expected that the first HASP interval will see a lower WEIM import transfer that progressively increases through the end of the hour. This is because for the first interval the changes are influenced by the results of previous hours which are already treated as fix for the current HASP, thus there is less flexibility to re-dispatch resources. As the hour progresses, more capability is accessible as resources have more time to ramp.

The same assessment was performed on the FMM case. Only one interval is analyzed since FMM relies only on one binding interval per market. For the case of September 7, 2021, the WEIM import transfer into CAISO was 2,360 MW while the load conformance was 2,400 MW. This import transfer was bounded by above due to a test failure. This case also shows that the WEIM import transfer was largely unrelated to the load conformance applied; *i.e.*, the import transfers were not driven by load conformance. This can be observed by the WEIM import transfer change as the load conformance is adjusted from 0MW to 2,400 MW and the import transfer increased by 142 MW. The load conformance could have resulted potentially in higher import transfer but was bounded by the transfer cap imposed by the test failure.

For the FMM case of January 23, 2022, the import transfers were 1,011 MW while the load conformance was 2,200 MW. Figure 22 shows the gradual increase of import transfers as load conformance is adjusted. Overall, the import transfers increased by 741 MW going from 424 MW to 1,011 MW. This means 33 percent of the load conformance translated into an import transfer. The trajectory of the import increases follows an upward trend but it is not smooth nor linear, reflecting the complexity of the market dynamics not having a one-to-one linear relationship.

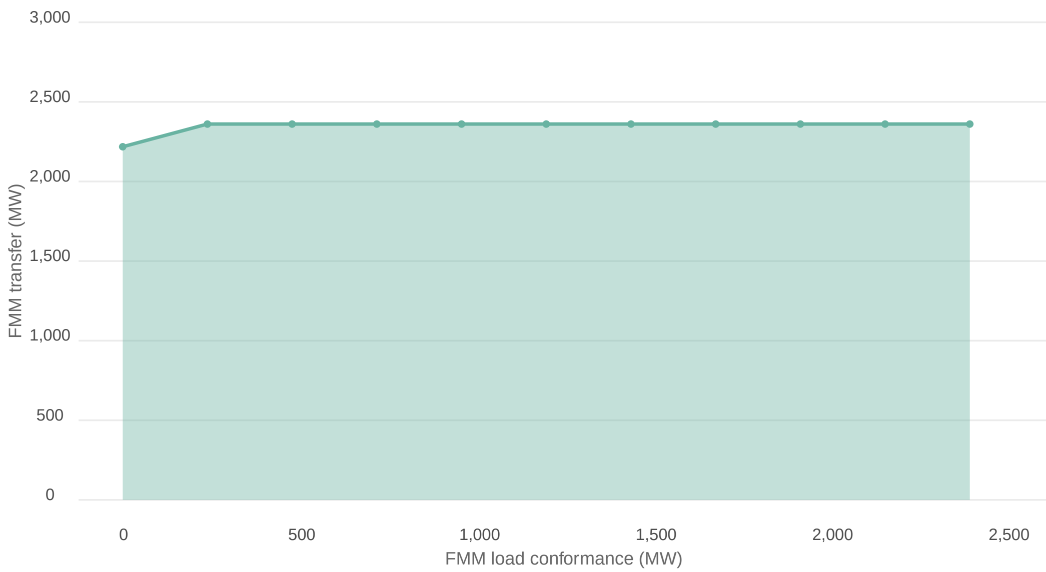

Figure 21: FMM Import transfers as a function of applied load conformance. September 7.

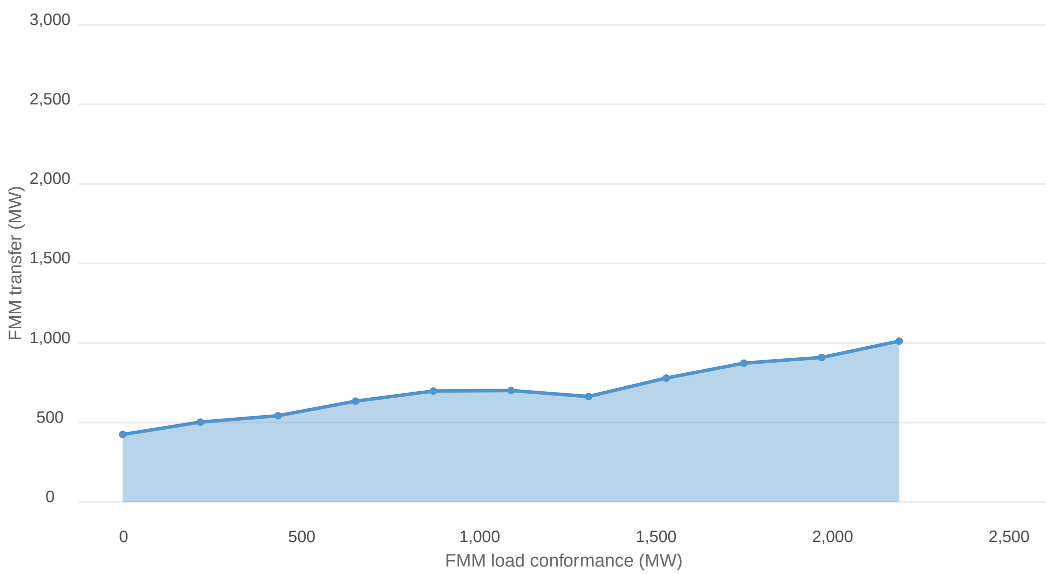

Figure 22: FMM Import transfers as a function of applied load conformance. January 23.

5 Resource Sufficiency Evaluation

The design of the WEIM includes a resource sufficiency evaluation process, with the last pass run forty minutes prior to the upcoming hour's real-time market to ensure each participating balancing area has sufficient resources, capacity and flexibility to serve its load needs prior to participating in the real time market . The RSE includes

1. Balancing test
2. Capacity (bid range) test
3. Feasibility evaluation
4. Flexible ramping test

The CAISO area is assessed for the bid range capacity test and the flexible ramp sufficiency test.

The objective of the capacity test is to assess whether participating areas have sufficient bid-range capacity in their corresponding area to meet the imbalance requirements. The goal of the flexible ramp sufficiency test is to assess whether participating areas have sufficient ramping capability among all area's resources to meet the forecasted demand changes across intervals plus the uncertainty estimated on historical uncertainty. The RSE consists of three passes at T-75, T-55 and T-40, relative to the start of the assessed hour. The first two passes are advisory and enable balancing areas to adjust their schedules in order to pass the last pass at T-40. A BAA fails the test if they failed either the bid-range capacity or flexibility ramping sufficiency test at T-40. For CAISO, there is no expectation of making adjustment in the first two passes since CAISO area relies on the capacity made available through the resource adequacy program and the day-ahead market solution. CAISO operators do not actively take actions on resources to change the outcome of the first two passes of the test process. If a BAA fails the bid-range capacity test under test, it automatically fails the flexible ramp sufficiency test up test.

5.1 Capacity test

The capacity test simply assesses if there is sufficient supply capacity to meet the load obligation. The inputs for the capacity test include:

1. fifteen-minute load forecast
2. imports and exports; for CAISO's test at T-40, only the fifteen-minute imports and exports bids are considered because they can be optimized in the FMM market and consequently can provide bid-range capacity.

3. hourly next schedule interchange schedules. For CAISO these are the inter-tie schedules cleared in the HASP process

4. bids for all internal resources

5. resources derates and rerates

6. historical intertie deviation adder

In the simplest terms, the capacity test can be expressed as follows

$$S_k > LF_k \ \forall k \tag{1}$$

where S is the supply capacity and LF is the load forecast; since supply capacity can be provided not only by internal resources but also by imports, this expression can be expressed with its underlying components

$$\sum_i G_{i,k} + \sum_j I_{j,k} - \sum_j E_{j,k} > LF_k \ \forall k \tag{2}$$

where G_i, I_j and E_j stand for the capacity provided by internal resource i, and the j-the Imports and Exports for BAA k, respectively. Exports act similar to demand and reduce the supply capacity; the imports and exports can be netted out to yield the net schedule interchange NSI_j

$$\sum_i G_{i,k} + \sum_j NSI_{j,k} > LF_k \ \forall k \tag{3}$$

This can be visualized in Figure 23, in which the supply capacity is compared relative to the loaf forecast.

The bid range capacity is the summation of the individual bid range capacity of all resources. The logic behind this design was that in some instances resources can be offline due to economics as the market finds optimal to not have them on but if conditions arise, then they can be started up. This design was changed during the RSE enhancements. New enhancements proposed for implementation during the summer of 2022 will only count resources that can be started up within the real-time market horizon in the bid range capacity test.

The bid range capacity test is a capacity test, which means that the overall capacity of a resources is counted regardless of its current operating point or ramp capability. The flexible ramping capacity test complements the capacity test with more stringent assessment of ramp capability. Under this construct, the resources individual capacity range is based on the available capacity once derates/rerates, outages, spin and regulation capacity are discounted since these use up certain range of the resource capacity, as illustrated in Figure 24. Only the range in dark blue is the bid range effectively utilized in the capacity test.

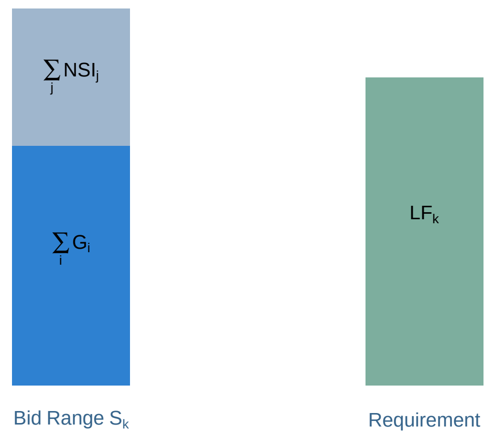

Figure 23: Supply capacity *vs.* capacity requirements

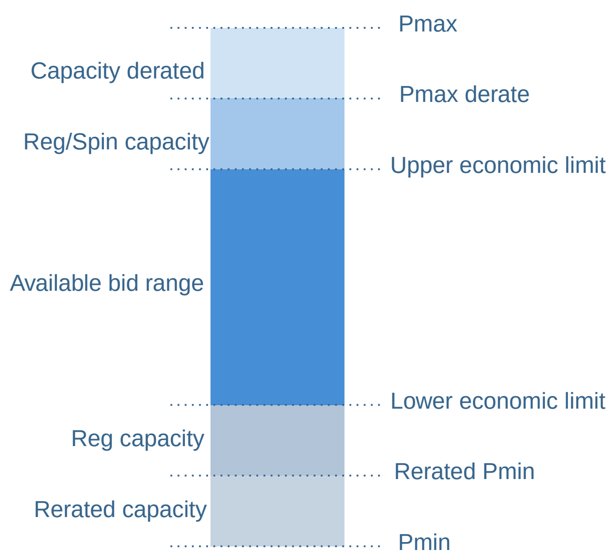

Figure 24: Resource capacity breakdown

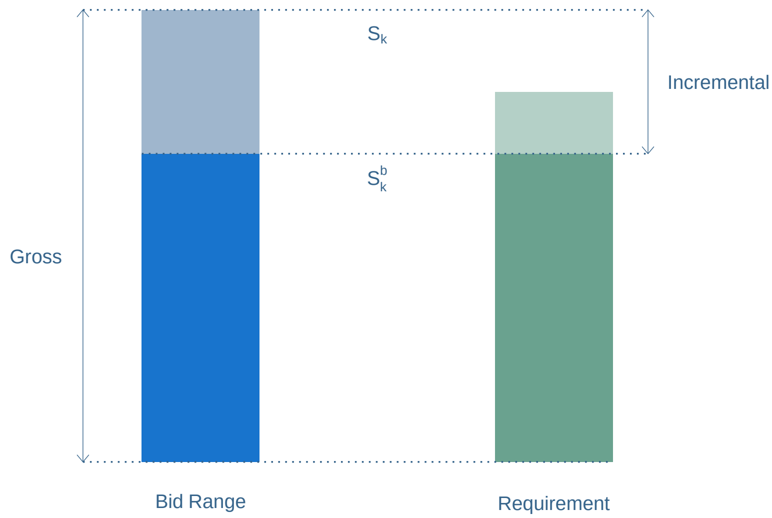

Figure 25: Gross *vs.* incremental resource capacity breakdown

EIM BAAs make capacity available through base scheduling and bid-in resources. For the hourly balancing process, it is expected that base schedules for supply and demand balance are within a 1 percent tolerance band. Then EIM BAAs make bid-in capacity available to manage imbalances (upwards or downwards) that will inherently happen in the real-time market. This allows them to make capacity available in the real-time market for economic displacement in the wider WEIM foot print. The imbalance is intuitively associated with higher or lower demand levels relative to the base schedules. Therefore, the base schedules become a relative reference to estimate imbalances for capacity test. Consider the illustration from Figure 25 where now a reference line is drawn for the level of base schedules. Higher or lower bases schedules will only make the incremental bid range larger or smaller, but it will not materially change the overall bid range capacity test available to the balancing area.

For CAISO's BAA, there are no base schedules since the CAISO utilizes its market to position resources for upcoming intervals; consequently, instead, the concept of incremental bid range is based on the last FMM market solution available. There are two components that will impact the capacity test based on this construct,

1. The FMM solution will not change the bid range capacity available for CAISO because the solution will only determine the composition of the range between base capacity and incremental capacity. For instance, if a resource with Pmax of 100 MW is dispatched at either 50 MW or 90 MW it will still result in the bid range of that resource to be 100 (50 MW+50 MW or 90M W+10 MW).

2. The net schedule interchange component for CAISO resources is based on the preceding HASP solution and not on the latest FMM solution. In the FMM

solution the hourly inter-tie schedules are modeled as given and will not be re-optimized. When load conformance is applied to the HASP load forecast, as a consequence more hour inter-ties may clear. This effectively increases the capacity made available to the capacity test as the NSI_{CAISO} will be higher by the incremental imports induced by load conformance. This is appropriate because it reflects the additional capacity gained for CAISO's BAA through its hourly process.

From this overall description, it can be seen that *cleared WEIM transfer for imports or exports related to CAISO in the FMM market have no impact on the bid range capacity test*. WEIM transfers are not counted as internal resources to CAISO as part of hourly intertie schedules cleared in the HASP process; WEIM transfers are not FMM resources cleared in the FMM market. However, WEIM import transfer could potentially displace hour intertie schedules. In the HASP process, hourly interties together with the WEIM transfers will be considered for an optimal HASP solution; under the HASP economics, the market may consider more optimal to clear certain level of WEIM import transfers rather than clearing additional hourly inter-ties.

A HASP solution influenced by the additional load conformance can indeed result in WEIM transfers displacing hourly inter-ties, which in turn will result in a smaller net schedule interchange (NSI) that can contribute to the CAISO bid range capacity test. Therefore, CAISO may have less bid range capacity test given a lower volume of hourly NSI due to foregoing block hourly offers at the interties. The only impact to CAISO in the capacity test due to WEIM import transfers, is the potential for level of NSI. If load conformance applied to the HASP market results in additional import transfers into CAISO, this may be at the expense of displacing hourly inter-ties, which will further reduce the NSI, which consequently will reduce the bid range capacity available for CAISO to account for in the test, exposing CAISO to fail more frequently [4].

The load conformance applied to the HASP market can result in some level of either additional hourly intertie imports cleared or less exports cleared. Based on the same set of days analyzed and presented in previous sections, Figures 26 to 28 illustrate the volume of intertie import increases or intertie export reductions in the HASP process resulted from applying load conformance to the HASP process. The days are organized in three group, one per figure. The bars in the positive range represent import increases while the bars in the negative range represent export reductions. Either change will result in effectively larger NSI, which provides more capacity to CAISO area in both the capacity test and in the real-time markets. The line in purple shows the pattern of HASP load conformance.

[4] CAISO is further analyzing the interaction of WEIM transfers and hourly intertie schedules as part of the third track of the analysis effort in RSE Phase 1B

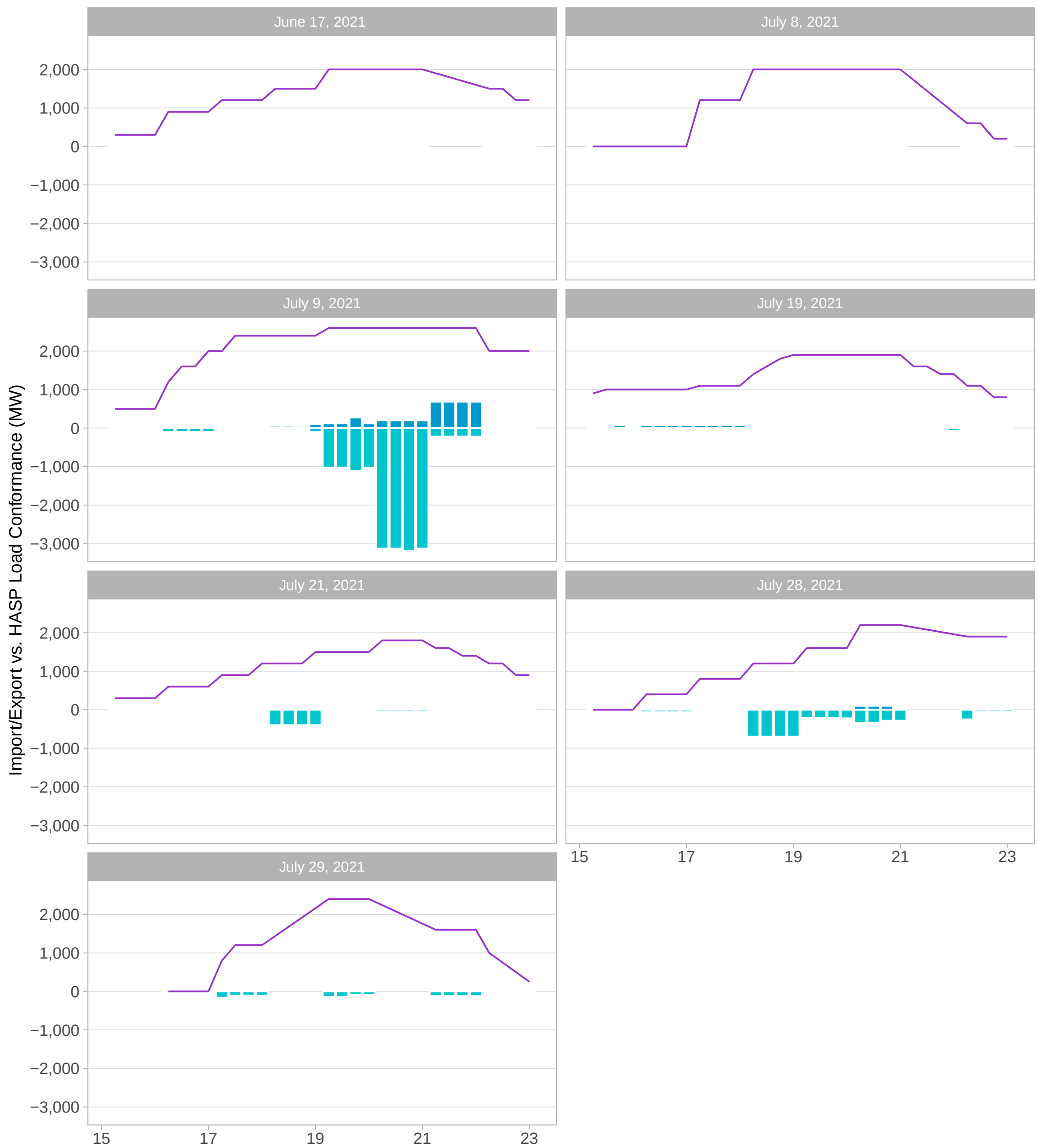

Figure 26: Additional intertie schedules induced by HASP load conformance 1-3.

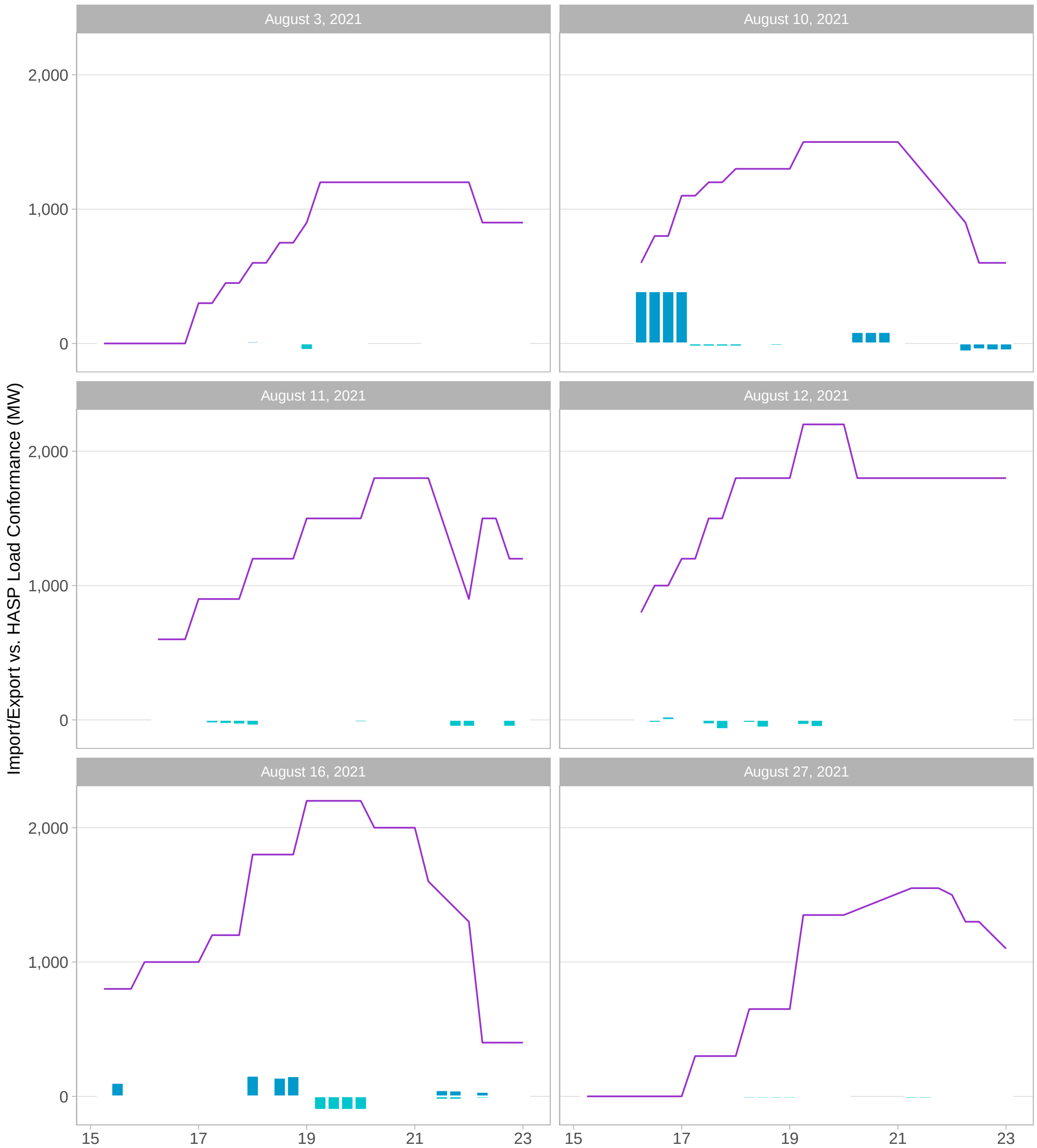

Figure 27: Additional intertie schedules induced by HASP load conformance 2-3

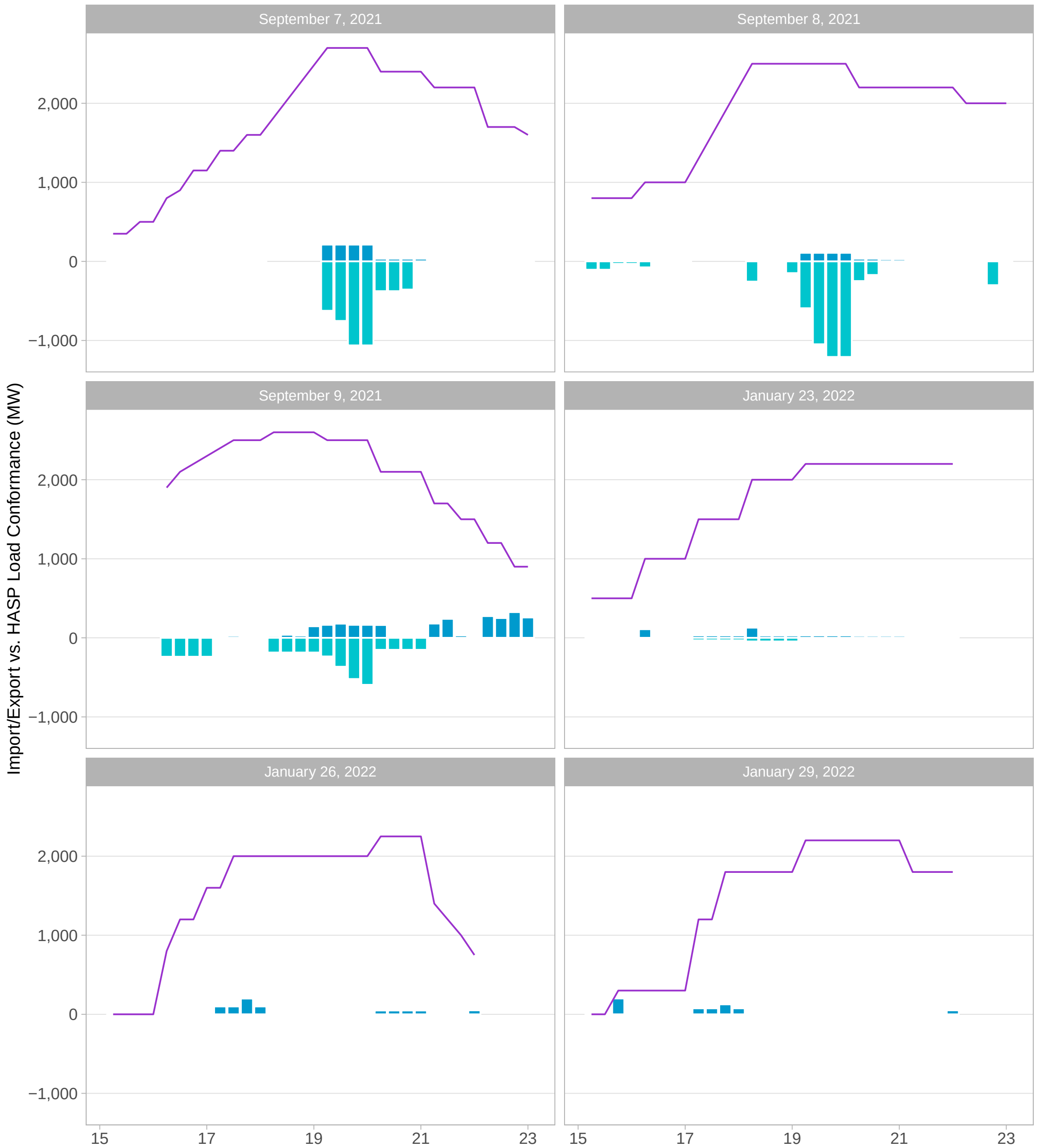

Figure 28: Additional intertie schedules induced by HASP load conformance 3-3

Overall, the additional hourly intertie supply induced by the HASP load conformance is minimum throughout the days. Indeed, reduction of hourly exports was more significant in the studied period. This is due to load conformance increasing the load that has higher priority than economic and low priority exports. Reducing exports is equivalent to increasing imports since either one increases the NSI for the CAISO area. July 9, 2021 observed export reduction of up to 3,000 MW when load conformance was applied. This specific day was impacted by heavy derates on Malin and NOB interties and it is when overscheduling was observed on these interties. This specific day is more of an outlier. An extensive analysis of the events of July 9 is available in the Summer performance reports. Since the preliminary analysis of load conformance relied on that day, this was largely a reason to perform a more comprehensive analysis of the implications of load conformance using other days for analysis.

These trends show effectively the additional capacity gained in the HASP process to be used eventually in the capacity test as part of a higher NSI. The additional NSI induced by load conformance does not create a disconnect between the capacity test and the real-time capacity available because these are effectively hourly intertie additional schedules gained through the HASP process. In this case there is no detrimental implications of the use of load conformance in the HASP process to the capacity test for CAISO area.

5.2 Flexible ramp capacity test

The flexible ramping sufficiency test (FRST) is part of the RSE. When an entity fails the capacity test, it automatically fails the flexible ramping sufficiency test. The objective of the FRST is to assess whether there is sufficient ramping capability among all resources in the balancing area to meet the forecast demand changes across intervals plus the historical net load uncertainty. The system performs the FRST for each 15-minute interval of the hour assessed in both the upward and downward directions. If a BAA fails the upward FRST for a given 15-minute interval, then its import EIM transfers are capped for that specific interval. A BAA can pass the FRST if the summation of the flexible ramp capacity from all its resources is greater than the flexible ramp requirement [5].

The flexible ramp requirement consists of five components:

1. Forecasted change in demand ($\Delta LF_{k,t}$).The forecasted change in demand from the starting point at T-7.5 to each of the corresponding 15-minute intervals of the hour assessed, namely T+7.5, T+22.5, T+37.5, or T+52.5

2. FRP uncertainty ($FRU_{k,t}^{max}$), which is the net load uncertainty calculated with

[5] A 1% or 1 MW tolerance band threshold is applied to the flexible ramping uncertainty requirement

the histogram methodology for each BAA

3. Diversity benefit ($DB_{k,t}$), which is calculated as the share of the uncertainty relative to WEIM footprint uncertainty

$$DB_{k,t} = FRU_{k,t}^{max} \left(1 - \frac{FRU_{k,t}^{max}}{FRU_{WEIM,t}^{max}}\right) \tag{4}$$

4. Flexible ramp credit ($FRC_{k,t}$), which is the incremental export transfer for a BAA

5. Net import/export capability, which reflects the transfer capability a BAA can count to bring or send out capability from and to other BAAs,

$$NIC_{k,t} = \sum_{i \in Dyn} IX_{i,t+7.5}^{max} + \sum_{j \in Dyn} (EX_{i,t-7.5} - IX_{i,t-7.5}) \tag{5}$$

where i is the index for the set of ETSR, the time reference (t-7.5) and (t+7.5) represent the applicable values for the fifteen-minute interval prior to and the first fifteen-minute interval of the assessed hour, respectively; $IX_{i,t+7.5}^{max}$ is the import ETSR limit, while and $IX_{i,t-7.5}$ and $EX_{i,t-7.5}$ are the import and export, respectively, transfer schedules from the latest FMM run for the 15-minute interval prior to the hour assessed.

With these components, the FRST can be denoted as

$$\sum_n FR_{k,n,t+m} \geq \Delta LF_{k,t} + \max\left(FRU_{k,t+m}^{max} - NIC_{k,t+m},\ FRU_{k,t+m}^{max} - DB_{k,t+m} - FRC_{k,t+m}\right) \forall k \tag{6}$$

where $m \in (7.5, 22.5, 37.5, 52.5)$ stands for each of the four intervals of the hour assessed. If this inequality holds, then the BAA passes the FRST, which simply means the BAA's resource capability is sufficient to meet the requirement. The second term right-hand side of the test in Equation 6 defines the flexible ramp requirement for the uncertainty components, which in turn consists of two components. Only one of them, which produces the largest requirement, will set the requirements used in the FRST for the BAAs in a given interval. The first component is driven by the offset of the transfer capability on the uncertainty requirement. If a BAA has a large net import capability (NIC), this component will be negative and will generally not set the requirement. The second component is driven by the relative share of the BAA requirement relative to the overall uncertainty and is also offset by any export transfer in the BAA. This is considered a credit to reduce the requirement since an export transfer may be recalled if needed.

From Equation 5, the requirement for the FRST can be set by the volume of import transfer cleared in the last FMM market run. The more import transfers clear in the FMM market that is used as a reference in the FRST, the larger the offset for the requirements and therefore the smaller the FRST requirement used to pass the test. This only applies when the second component of the FRST requirement is the one setting the FRST requirement. For this scenario to trigger, the NIC component must be relative smaller than the nominal uncertainty requirement, and also relatively smaller than the diversity benefit.

As described in previous sections, one effect of using load conformance in the CAISO BAA in the FMM market is the increase of WEIM import transfers. A potential concern is that these additional transfers from the use of load conformance could reduce the NIC value used in the FRST, effectively reducing the FRST requirements. If the FRST requirements in turn are lower, CAISO may have a less stringent test, and potentially the CAISO BAA may be passing the FRST more easily and frequently. Therefore, the use of load conformance could allow CAISO BAA to pass the FRST more easily.

In theory this might happen given how the FRST requirement is constructed (Equation 6). As shown with this analysis, in practice this does not happen. As defined in Equation 5-**??**, the NIC is largely set by the inherent transfer capabilities of a BAA, which is directly defined by all the transfers with other BAAs. In the specific case of the CAISO BAA, the transfer capability is significantly higher than the uncertainty requirement due to the multiple transfers with all adjacent BAAs. This means that the first component of the FRST requirement will generally be negative and smaller than the second component. [6] Figure 29 shows the historical NIC values for CAISO BAA for the period January 2021 through January 2022. The tails of the boxes indicate the maximum and minimum values of NIC observed. The minimum NIC value is consistently over 8,000MW. [7] By looking into the incremental import transfers induced by load conformance shown in Figure 16, even when considering the highest increase of about 1,500MW import transfer would not make any difference to the FRST requirement. If we take the lowest NIC value of about 19,000 MW observed in July 2021, this NIC already factored in the increase import transferred induced by load conformance (original market solution had the load conformance applied, and the counterfactual assesses the resulting import transfers without load conformance), this means the outcome without load conformance had resulted in a NIC higher by 1,400 MW, which would be 20,500

[6]For a simple illustration, if the uncertainty requirement for CAISO BAA is 1,500MW but the NIC is about 9,000 MW, the first component will be -7,500 MW=1,500 MW -9,000 MW, which in turn will not set the requirements for CAISO

[7]There is a cap value set to 30,000 MW for the upper values to ensure the illustration of the distributions can be shown. Also, there is a significant change in the NIC ranges starting in April 2021 which was driven by the addition of new entities to the WEIM. These entities have direct transfers with CAISO and consequently increase the transfer capability for CAISO BAA.

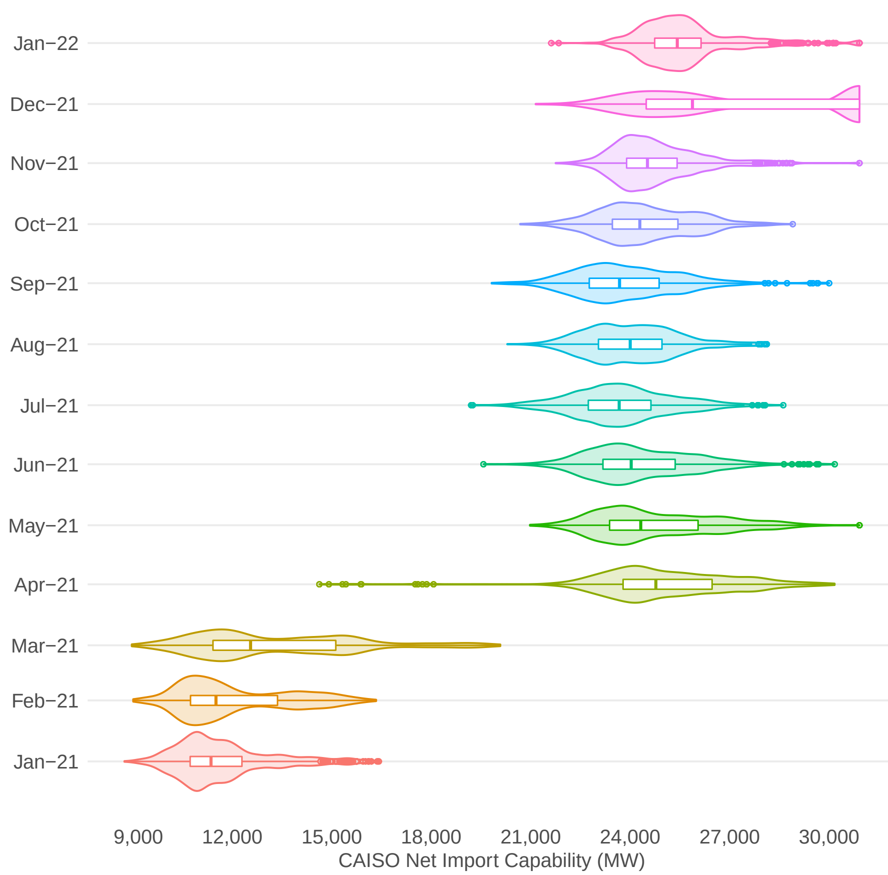

Figure 29: Monthly distribution of historical NIC values for CAISO BAA

MW; the outcome would be the same with and without load conformance, in which NIC is sufficiently large to make the first component largely negative and not set the FRST requirement.

For the flex ramp sufficiency test, all resources in the BAA may contribute. The ramp capability is assessed at the resource level and considers resources' inter-temporal constraints, such ramp rates. Only the capacity that is ramp accessible within the timeframe tested can contribute to the flex ramp test. Consider Figure 30 as a reference to illustrate the concept. As previously described, the FRST calculates each resource's flex ramp capability between two points. The starting point is the last FMM schedule available by the time the FRST is done, this is denoted by T-7.5 because it is the last FMM interval available prior to the timeframe of the assessed hour. Then the flexibility is assessed from that starting point to the mid-point of each of the four FMM intervals (T+m) that make up the hour assessed. If the calculation is for the first interval, then the ramp capability is at T+7.5; if it is for the fourth interval, then it is calculated for T+52.5. The highest level the resource can ramp up is denoted as *Ramped limit*,

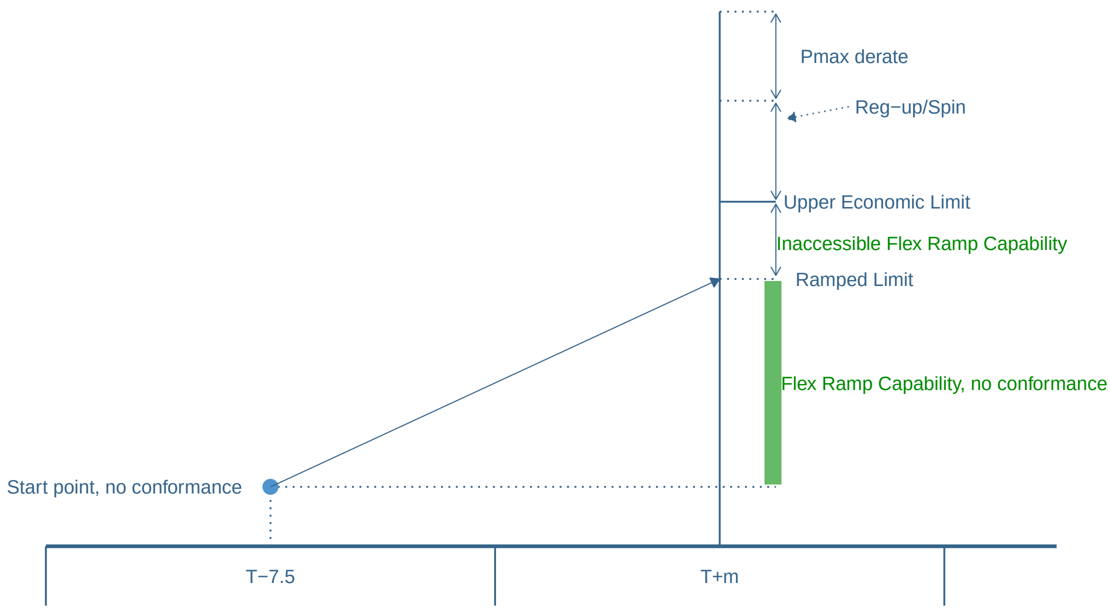

Figure 30: Flex ramp capability assessed for a given resource

which may be at or below the upper economic limit of the resource [8]. The difference of MW level between that ramped limit and the starting point quantifies the flex ramp capability for a given resource, which is depicted with the bar in green. Depending on the available bid range and how fast a resource can ramp, in some cases the ramped limit may not be able to reach the upper economic limit; thus, the difference between the ramped limit and the upper economic limit is the ramp capability that is available but cannot be accessed in the FMM interval being assessed.

The flexible ramp capability calculated for a given resource is based on the starting point, which is determined by the last resource's schedule in the FMM market prior to the start of the FRST. If that FMM market schedules the resource higher, the starting point for the FRST will be higher and since the bid range of the resource made available in the test remains the same, it simply means the flexible ramp capability will be lower. The opposite holds true.

As previously explained, load conformance also results in resource schedule changes. However, contrary to previous beliefs expressed by stakeholders in the RSE enhancement discussions, the load conformance is actually detrimental to CAISO passing the FRST. As part of the analysis of load conformance, Figures 31 through 33 show the impact of load conformance on CAISO's internal resources schedules. These figures show the total schedule changes for internal resources for the last FMM market solution. It shows that the load conformance consistently results in CAISO's internal resources

[8] Refer to Figure 25 to understand the concept of *Upper economic limit*

scheduled at higher output levels relative to the solution where there is no load conformance applied to the FMM market. It also shows a significant share of the load conformance is absorbed by increases of internal resources schedules. [9]. This trend and conclusion hold not only for critical summer days of July 9, 2021 but it is also exhibited for days of August and September under less stressed conditions, and even for days of January 2022 which reflects a different supply/demand condition.

For each day analyzed, the bars represent the internal resource changes, with positive bars indicating an increase of schedules and negative bars reflecting a reduction of FMM schedules. The blue dots are a reference of the level of load conformance used in the original production market. This provides a reference on the relative magnitude of the resource schedule increases relative to the load conformance applied. In multiple days and intervals, the increases of resource schedules represent over 80 % of the load conformance applied. The schedule changes are also broken out by the main type of resources, which shows that the majority of the schedule increases are supported by gas resources, including peakers and muti-stage generators.

The increases of internal resource FMM schedules due to load conformance have a negative and detrimental implication for the FRST assessed for the CAISO BAA. Let's consider Figure 34 to illustrate this dynamic. This figure is the expansion of Figure 30, obtained by adding the flex ramp capability under the scenario that there is an increase of the resource FMM schedule due to load conformance. Because of load conformance, the starting point for the flex ramp capability is moving up from the blue dot to the purple dot. This higher starting point means that the ramp capability assessed for the m interval will no reached a higher MW point at T+m; in some cases, it may reach prematurely the upper economic limit given the reduced capacity that is now available. Under this scenario, the flex ramp capability will be less relative to the capability assessed with no load conformance (compare the length of the green bar *vs.* the purple bar). The difference is the lost flex ramp capability (bar in red) due to the higher FMM schedule induced by the load conformance.

The load conformance that translated into higher FMM schedules is effectively already being counted in the FRST by having the flex ramp capability quantified from the higher FMM schedule. The increase of internal resource dispatches is effectively and already reducing the flex ramp capability that is no longer available in the FRST. This means that the effect of load conformance applied to the FMM market is already factored in the FRST for CAISO through the consideration of the increased FMM

[9]This is consistent with the conclusion from the preliminary analysis the CAISO reached based on a very limited sample of the FMM market and FRST. Since that sample relied only on the critical day of July 9, 2021, there were additional concerns that the results could be a reflection of an outlier condition rather than more typical conditions. The additional analysis performed here, including over 650 FMM runs an 150 HASP runs, results in the same conclusion.

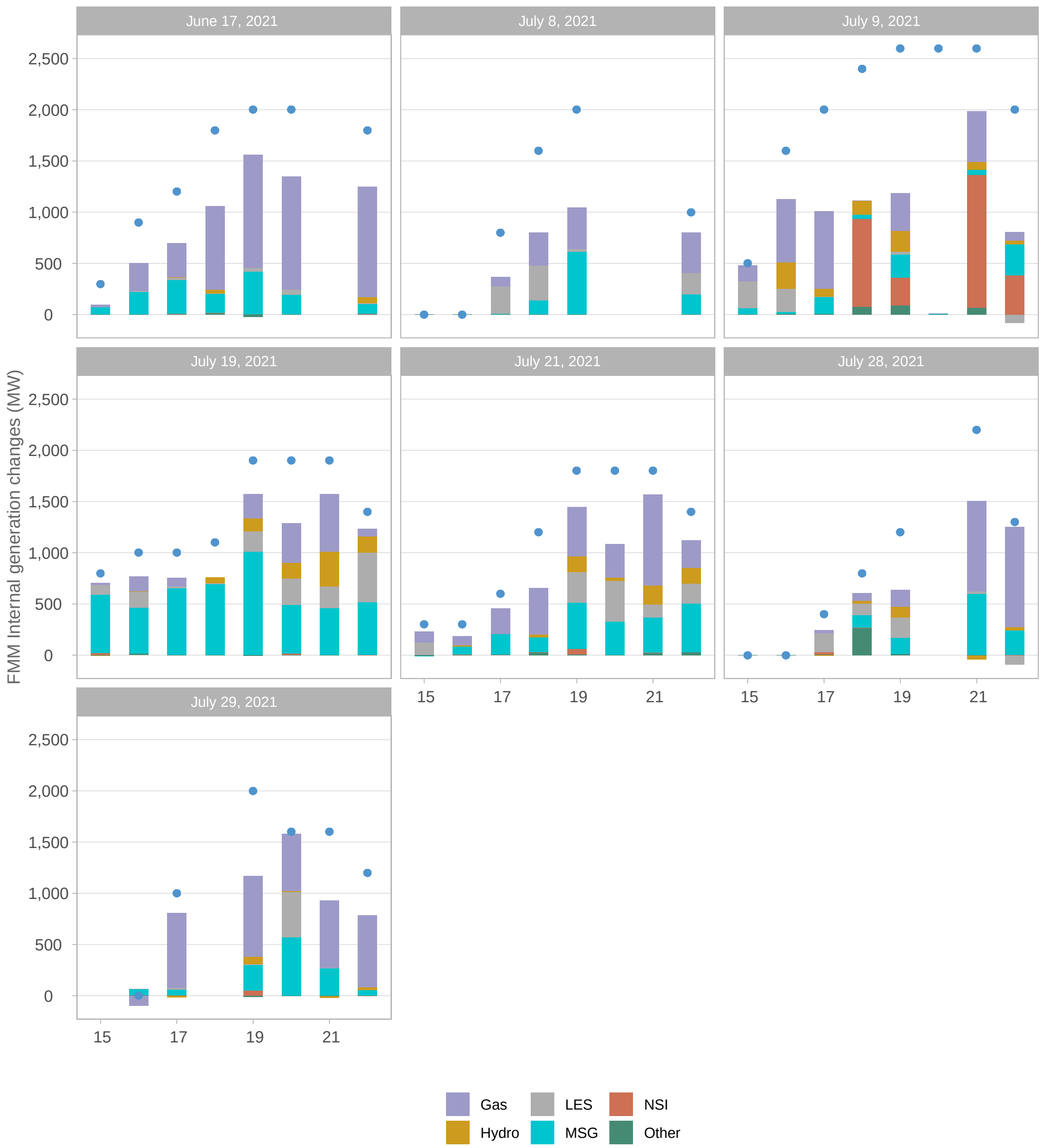

Figure 31: Changes of CAISO's internal resource schedules due to load conformance 1-3

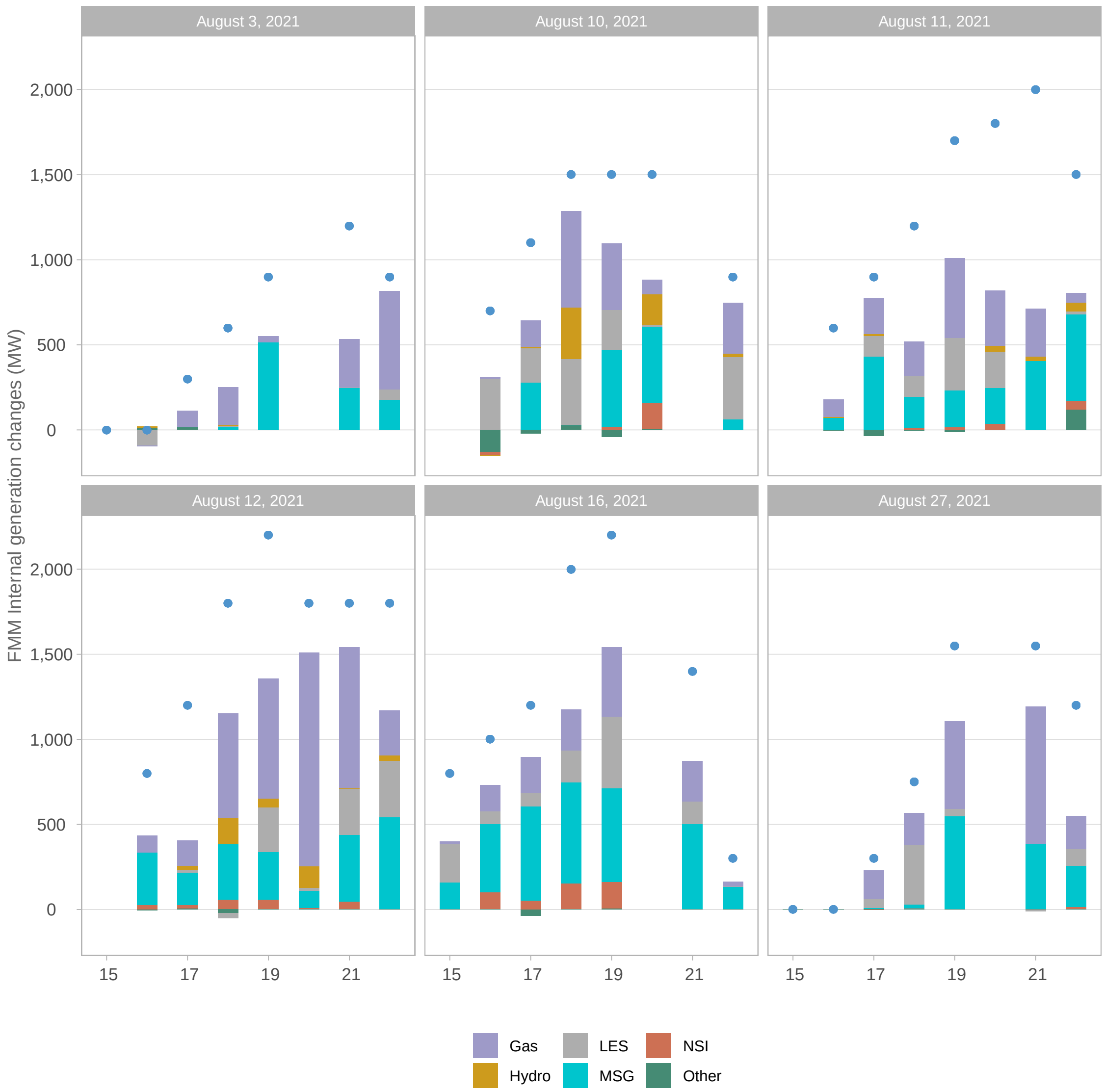

Figure 32: Changes of CAISO's internal resource schedules due to load conformance 2-3

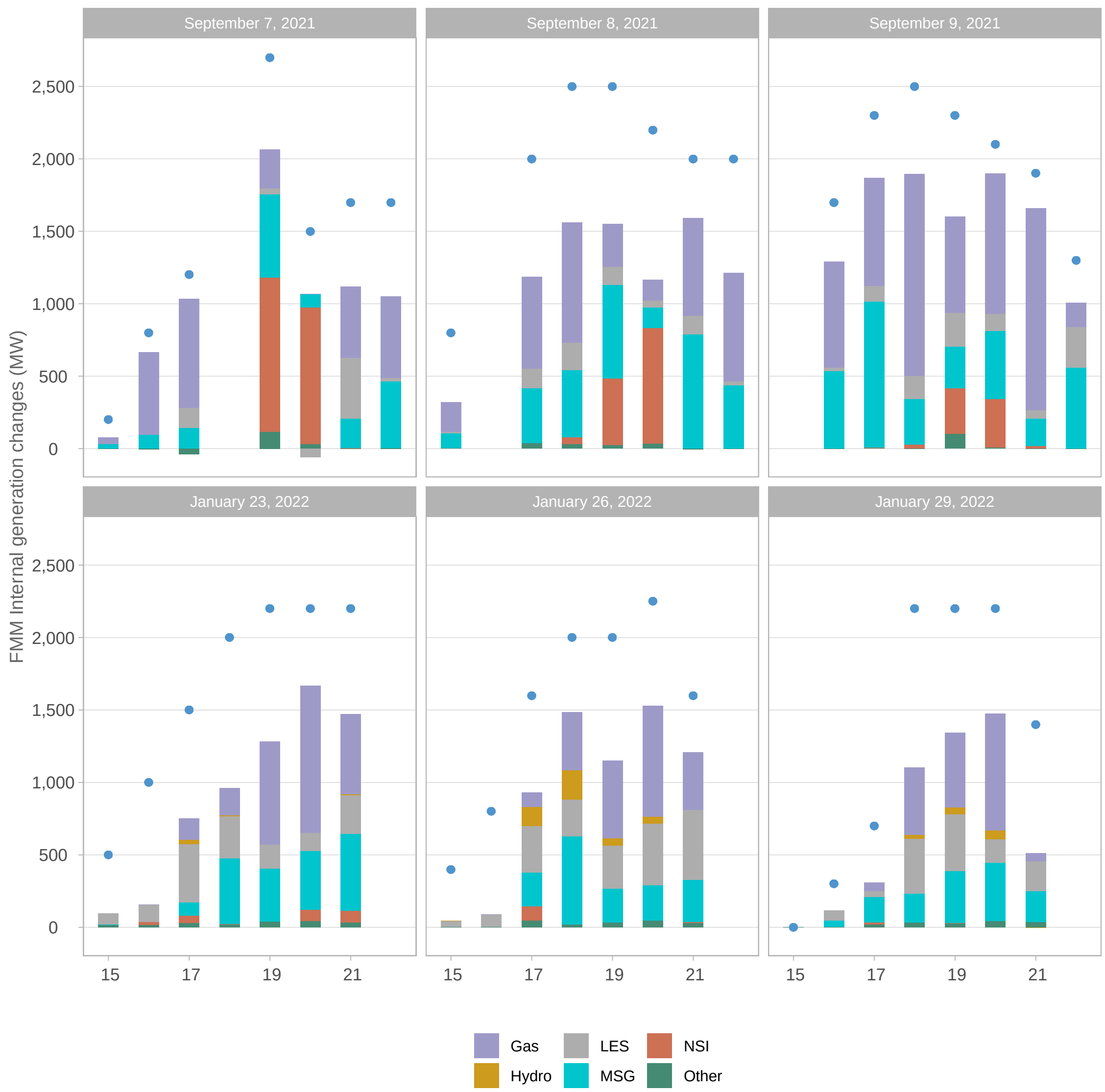

Figure 33: Changes of CAISO's internal resource schedules due to load conformance 3-3

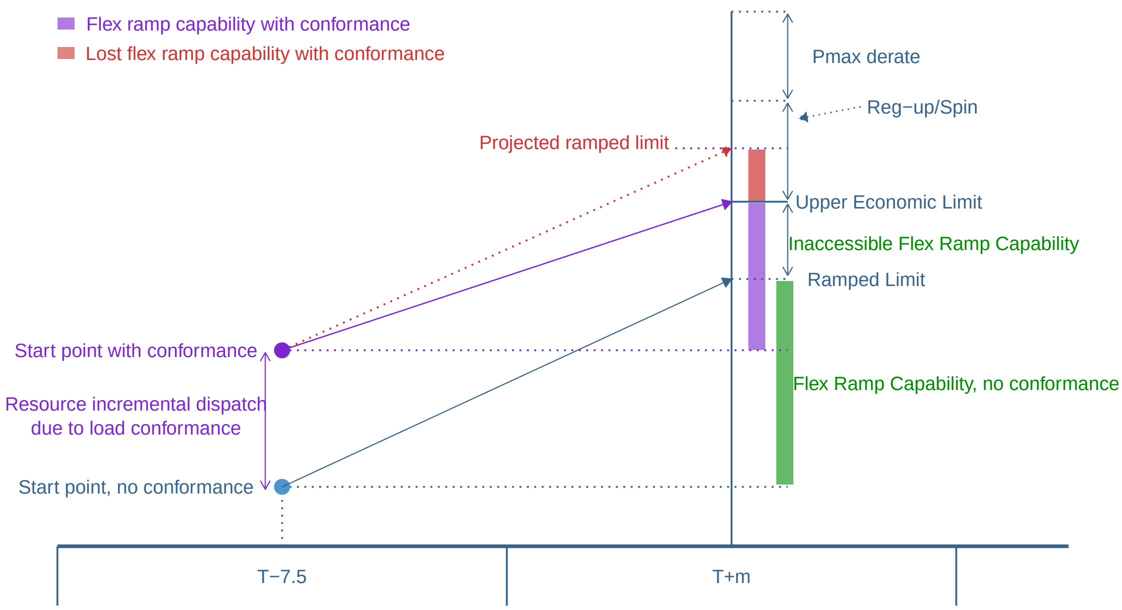

Figure 34: HASP load conformance *vs.* share of load conformance.

schedules used as the starting point in the FRST.

This can also be seen from the perspective of the FRST requirement (demand side). To illustrate this consider the FRST equation 6, and drop the uncertainty component requirement (or just assume uncertainty happens to be 0MW for that given interval) since uncertainty has no interplay to supply and demand of the FRST. This yields the following relationship:

$$\sum_n FR_{k,n,t+m} \geq \Delta LF_{k,t} \, \forall k \tag{7}$$

This indicates the flex ramp capability of a given BAA has to be equal to or greater than the load forecast movement (delta between load forecast at the starting point and the assessed interval of the hour); relying on Figure 34, this equation can be expanded into its underlying terms

$$\sum_n (MW_{k,n,t+m} - MW_{k,n,t-7.5}) \geq (LF_{k,t+m} - LF_{k,t-7.5}) \, \forall k \tag{8}$$

where $LF_{k,t+m}$ is the load forecast at the interval being tested and $LF_{k,t-7.5}$ is the load forecast in the last interval preceding the tested hour. The term $MW_{k,n,t+m}$ is the ramped limit calculated in the FRST. The term $MW_{k,n,t-7.5}$ is the schedule at starting point at T-7.5, which is the last available FMM solution for the interval prior to the hour assessed in the FRST. When the FMM had a load conformance, that term is the purple dot in Figure 34. This point can be decomposed into the original FMM schedules produced in FMM with no load conformance $MW^{*}_{k,n,t-7.5}$ (blue dot in Figure 34) and the increase induced by applying load conformance in the FMM market $\Delta MW^{lc}_{k,n,t-7.5}$ (distance between Purple and blue dots in Figure 34), such that

$$\sum_{n} MW_{k,n,t-7.5} = \sum_{n} MW^{*}_{k,n,t-7.5} + \sum_{n} \Delta MW^{lc}_{k,n,t-7.5} \tag{9}$$

Substituting (9) into (8) yields the following expression

$$\sum_{n} \left\{ MW_{k,n,t+m} - (MW^{*}_{k,n,t-7.5} + \Delta MW^{lc}_{k,n,t-7.5}) \right\} \geq (LF_{k,t+m} - LF_{k,t-7.5}),\ \forall k \tag{10}$$

Similarly, the ramped limit assessed for interval $t+m$ can be decomposed into the ramped limit assessed without the load conformance and the delta introduced by load conformance, yielding the following expression

$$\sum_{n} MW_{k,n,t+m} = \sum_{n} MW^{*}_{k,n,t+m} + \sum_{n} \Delta MW^{lc}_{k,n,t+m} \tag{11}$$

Substituting Equation 11 into 10 shows the overall relationship of the ramp capability with the changes induced by load conformance in the FMM market

$$\sum_{n} \left\{ (MW^{*}_{k,n,t+m} + \Delta MW^{lc}_{k,n,t+m}) - (MW^{*}_{k,n,t-7.5} + \Delta MW^{lc}_{k,n,t-7.5}) \right\} \geq (LF_{k,t+m} - LF_{k,t-7.5}),\ \forall k \tag{12}$$

The left-hand side can be reorganized to have a term for the ramp capability in terms of no load conformance plus a second term that tracks the delta in the ramp capability driven by the load conformance,

$$\sum_{n} \left\{ (MW^{*}_{k,n,t+m} - MW^{*}_{k,n,t-7.5}) + (\Delta MW^{lc}_{k,n,t+m} - \Delta MW^{lc}_{k,n,t-7.5}) \right\} \geq (LF_{k,t+m} - LF_{k,t-7.5}),\ \forall k \tag{13}$$

The term of the delta in ramp capability can be moved to the right hand side, yielding

$$\sum_{n} (MW^{*}_{k,n,t+m} - MW^{*}_{k,n,t-7.5}) + \geq (LF_{k,t+m} - LF_{k,t-7.5}) + \sum_{n} (\Delta MW^{lc}_{k,n,t-7.5} - \Delta MW^{lc}_{k,n,t+m}),\ \forall k \tag{14}$$

Since the ramp capability in the FRST is consistently assessed at the maximum ramp speed, the following relationship holds

$$\sum_{n} \Delta MW^{lc}_{k,n,t-7.5} \geq \sum_{n} \Delta MW^{lc}_{k,n,t+m},\ \forall k \tag{15}$$

When the deltas from both sides are equal (the constraints hold strictly), the load conformance has no impact on the ramp capability. This will happen when resources are schedule in the last FMM at relatively low levels such that there is sufficient rmp capability that evn when moving the starting point up, there is sufficient head room from above. This is expected for cases when there is plenty of supply available which can happen under mild load levels in seasons with relatively light loading conditions, or in early hours of the day.

However, under tight supply conditions or ramping hours like those of summer or evening ramps, the constraint will not hold strictly because it is very likely that the ramp limit capability will reach the upper economic limit prematurely. This represents a loss of flexible ramping capability in the FRST due to the impact of load conformance. In Figure 34 this is illustrated with the ramp capability range in red.

Let's define that loss in the following terms:

$$\kappa LC_{k,t-7.5} = \sum_n \Delta MW^{lc}_{k,n,t-7.5} - \sum_n \Delta MW^{lc}_{k,n,t+m} \geq 0, \ \forall k \tag{16}$$

The term $\kappa LC_{k,t-7.5}$ reflects a portion of the load conformance realized as resources schedule increases due to the use of load conformance in the FMM market; thus, it can be stated as a fraction κ of the load conformance LC applied to the load forecast at (t-7.5). As analyzed throughout this report, the fraction of load conformance translated into increase of resources schedules is not a one-to-one relationship nor a value that remains constant from market to market.

With this association, the FRST reflecting the effect of load conformance can be defined as follows:

$$\sum_n \left\{MW_{k,n,t+m} - MW^{*}_{k,n,t-7.5}\right\} \geq (LF_{k,t+m} - LF_{k,t-7.5}) + \kappa LC_{k,t-7.5}, \ \forall k \tag{17}$$

This simple relationship shows that the increase in schedules is effectively an adder to the load forecast movement used in the flexible ramping requirement. The left-hand side is the flexible ramping capability assessed at the starting point without the effect of load conformance, while the right hand side is the incremental load forecast requirement plus an additional requirement induced by the load conformance on the FMM solution for the last interval available prior to the assessed hour, which is the starting point for the FRST.

This shows that the load conformance used in the FMM market is effectively already reflected as an additional requirement in the flexible ramping test. Conversely, the effect of load conformance is already reflected in the FRST as a reduction of the resources' ramp capability.

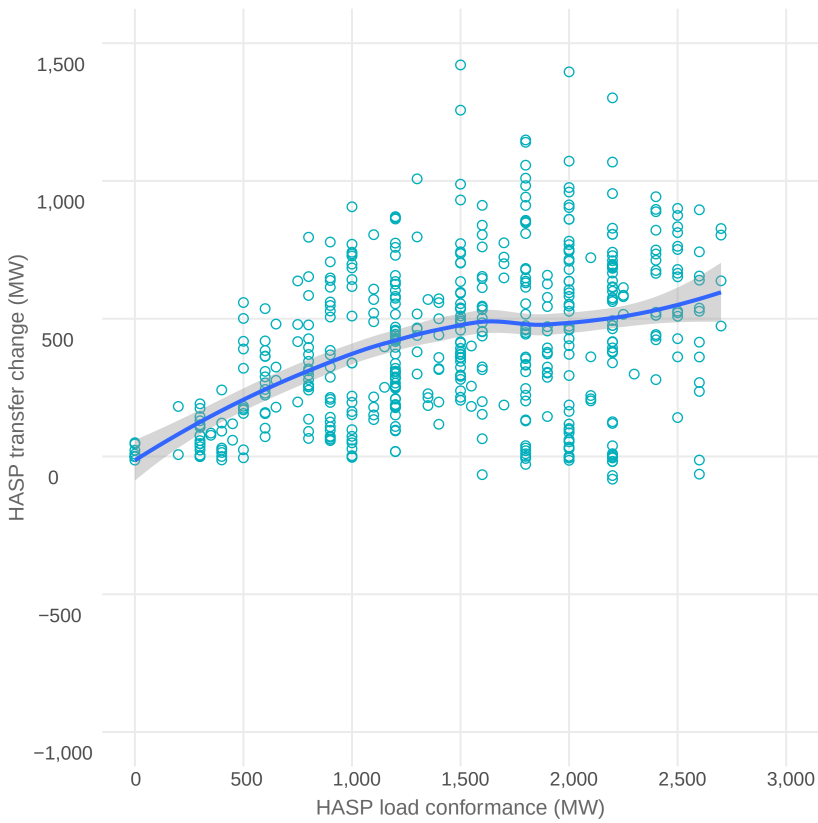

Figure 35: HASP load conformance *vs.* share of load conformance.

6 Appendix

This section provides additional metrics and trends of items described throughout this paper.

Figure 36: Incremental dispatches for CAISO's area resources due to HASP load conformance 1-3.

Figure 37: Incremental dispatches for CAISO's area resources due to HASP load conformance 2-3.

Figure 38: Incremental dispatches for CAISO's area resources due to HASP load conformance 3-3.

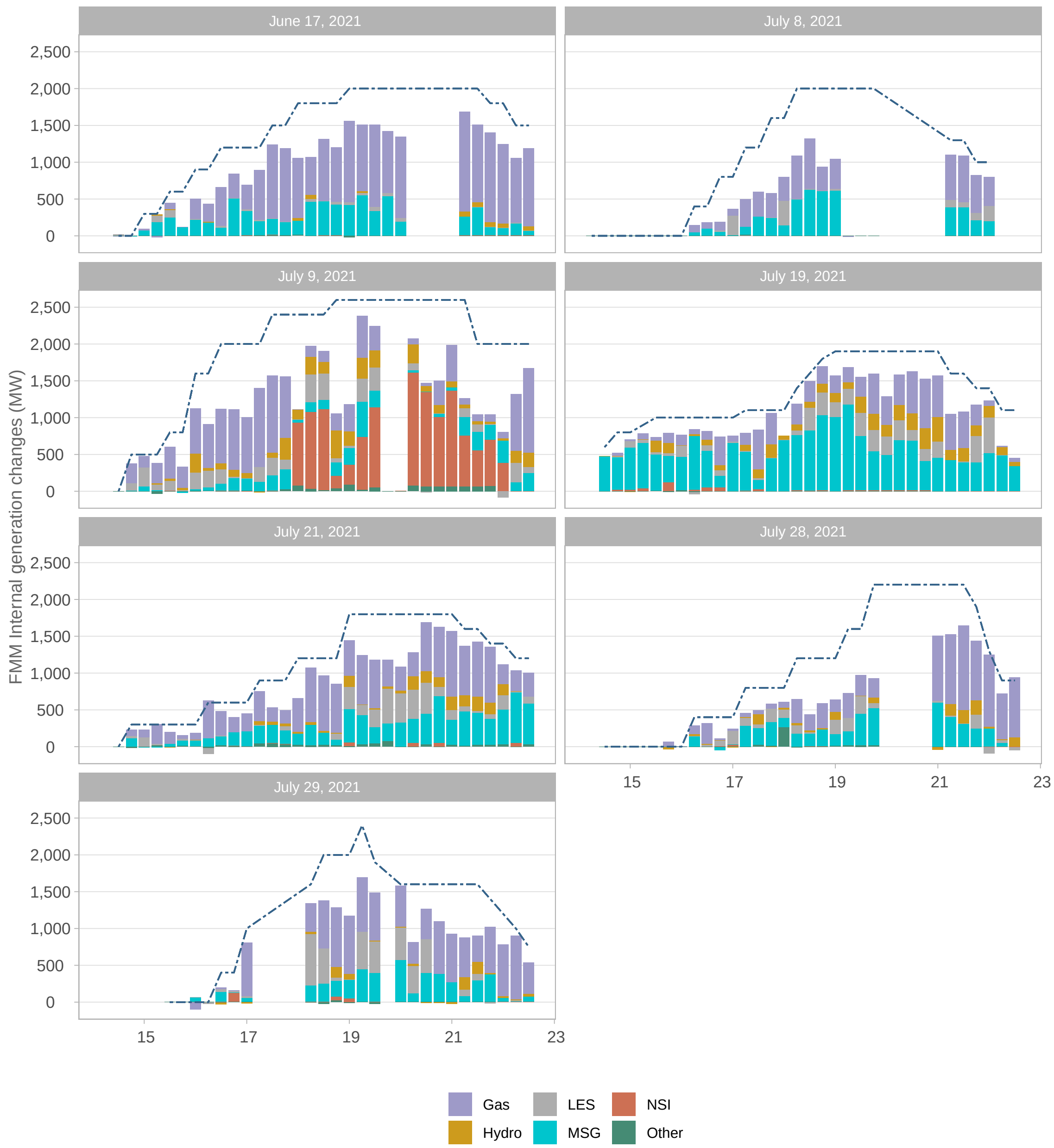

Figure 39: Incremental dispatches for CAISO's area resources due to FMM load conformance 1-3.

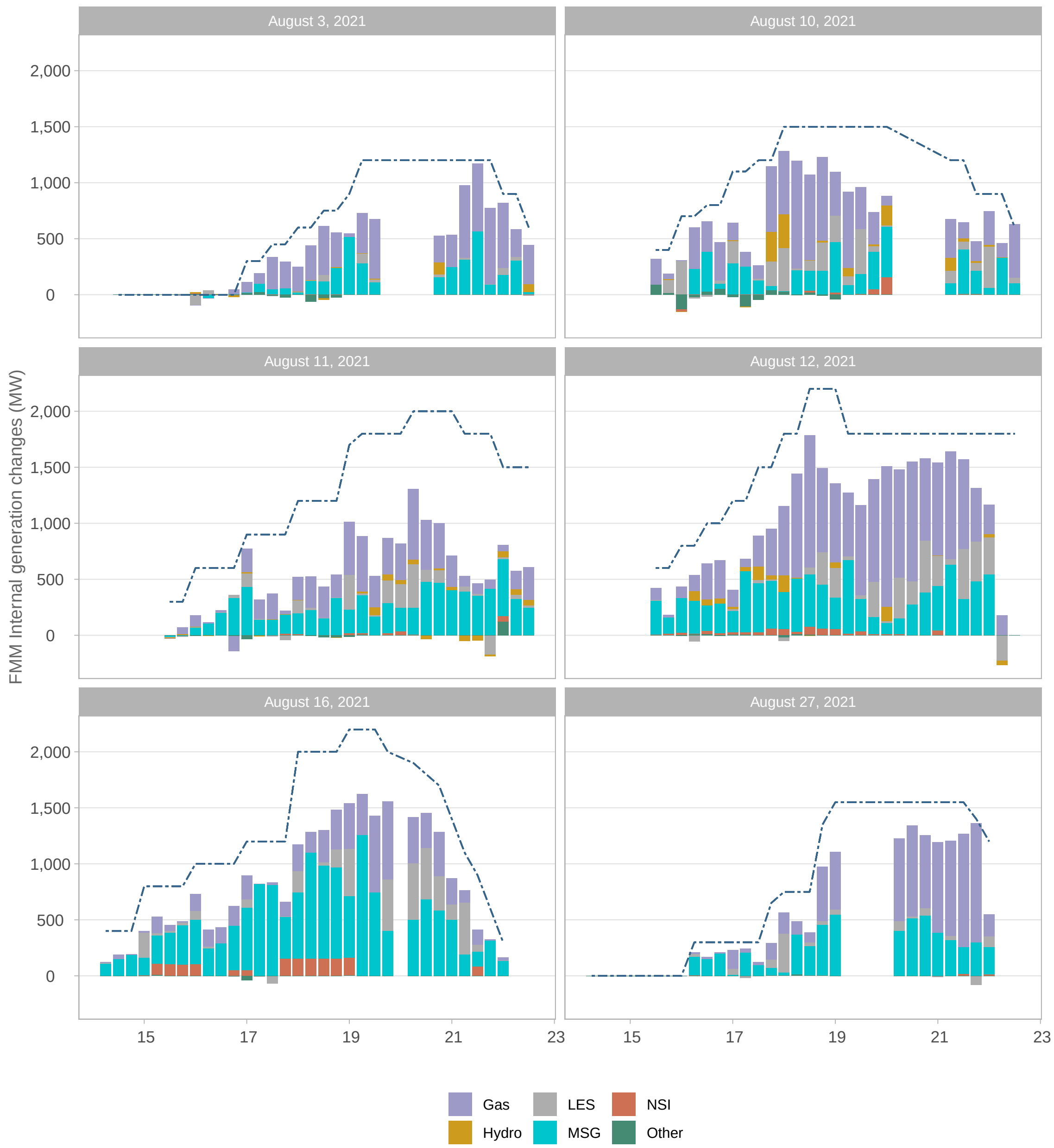

Figure 40: Incremental dispatches for CAISO's area resources due to FMM load conformance 2-3.

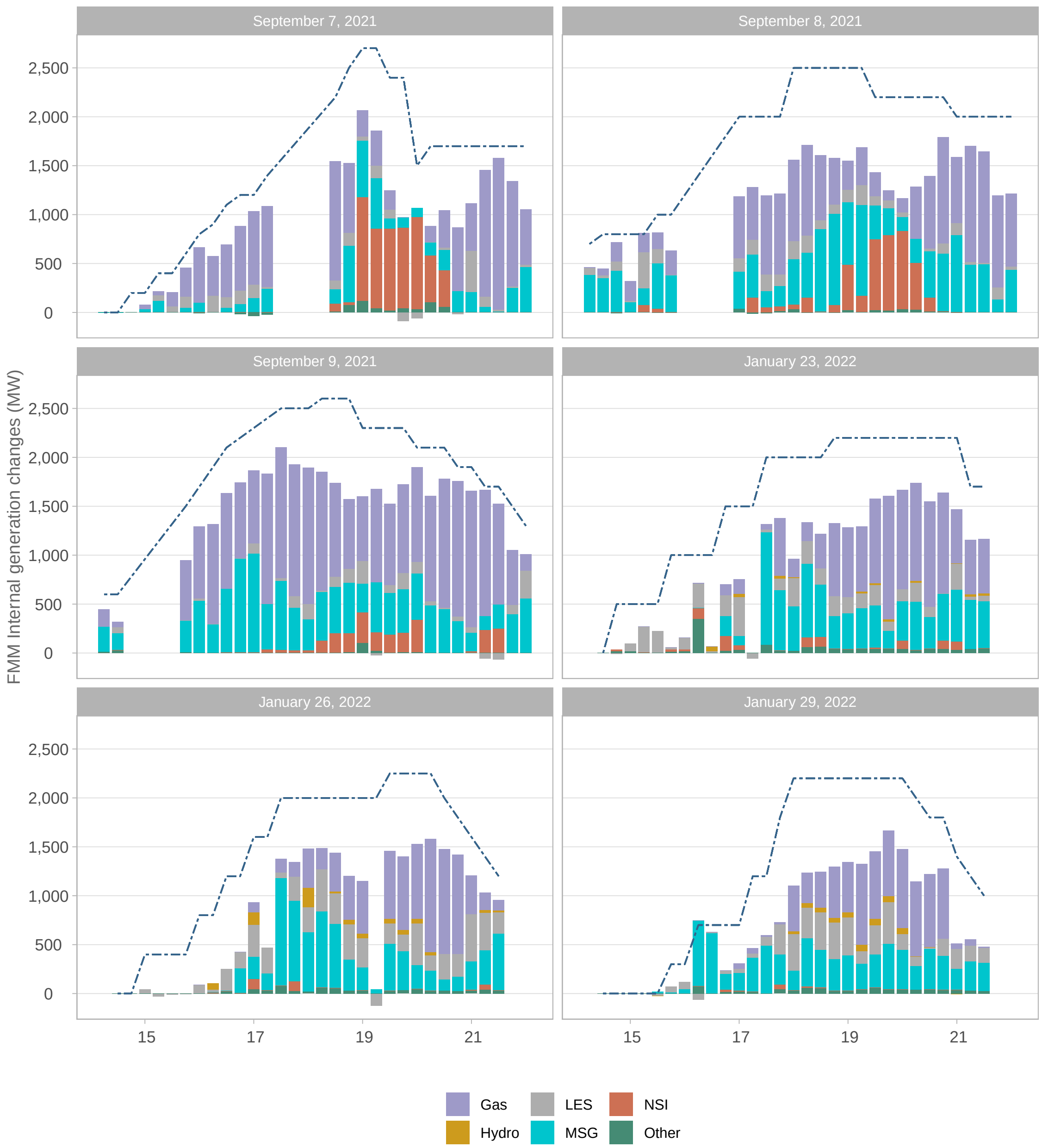

Figure 41: Incremental dispatches for CAISO's area resources due to FMM load conformance 3-3.