Interaction of Hourly Intertie Schedules and WEIM Transfers

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Market Analysis and Forecasting

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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 interaction between CAISO's hourly interties and WEIM transfers. 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 -

- **There is a robust volume of WEIM transfer for CAISO area in both import and export directions.** High volume of import transfers are observed during summer months while high volume of export transfers are observed during spring months. This level of transfers reflects to economical value of the WEIM.
- **WEIM import transfers into CAISO area are consistently unrealized from the HASP and FMM market to the RTD market.** The WEIM transfers in HASP are advisory in nature but can define the volume of cleared hourly inter-tie schedules. On a sample peak hour of July 9, the unrealized WEIM import transfers in RTD supported up to 1,500MW of real-time hourly exports.
- **The unrealized WEIM import transfers represent an additional last-minute requirement to CAISO's area supply to support the cleared hourly exports.** Real-time self schedule exports cleared at high volumes in multiple days of summer during tight supply conditions and a portion of that was supported by advisory HASP WEIM import transfers.
- **During peak hours in tight-supply summer days, the volume of WEIM import transfers were lower than the volume of scheduled hourly exports.** This represents a net export position for CAISO's area.
- **The majority of hourly exports bid-in and cleared in the HASP market were for real-time self schedules exports.** These are exports acting as price takers, which will drive the full utilization of any available economical supply in the system, including WEIM import transfers.

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2 Introduction

The centralized clearing process of the Western Energy Imbalance Market (WEIM) allows the market to attain an optimal solution across all balancing areas. Expensive generation internal to a balancing area can be economically displaced by cheaper generation from other areas. This economical displacement is reflected in WEIM transfers, which can be either imports or exports to other balancing areas. WEIM transfers are a by-product of a least-cost dispatch across all Balancing Authority Areas (BAAs). In each of the real-time-markets, namely hourly ahead scheduling process (HASP), fifteen-minute market (FMM) and real-time dispatch (RTD), the market clearing process attains optimal dispatches, which also determine WEIM transfers. In the HASP market, dispatches for all BAAS are optimized with resulting WEIM transfers. However, in the HASP market, only hourly intertie transaction schedules are binding. Any other dispatches for both CAISO internal resources and all other BAA internal resources are *advisory* because they do not represent a financially nor operationally binding schedule. WEIM transfers from HASP will also be *advisory* in nature since they are derived from resource dispatches that are also advisory. These advisory WEIM transfers have no bearing in the solution of subsequent FMM and RTD market solutions. The level of WEIM import transfers into the CAISO BAA cleared in the HASP and FMM markets are largely irrelevant to the level of import transfers eventually cleared in RTD. That is, the volume of HASP and FMM transfers do not determine the clearing values in RTD. Unlike the FMM and RTD markets, the HASP market is the last opportunity to optimize intertie transactions, which can be hourly or 15-minute transactions, although the large majority of intertie transactions are hourly. Once these hourly interties, either imports or exports, clear the HASP market, the subsequent FMM and RTD markets will considered them financially and operationally binding. The intertie schedules are binding and not advisory. As part of the overall optimization, the real-time markets will attain optimal solutions which will result in the utilization of all resources available in the market, including internal resources to each BAA as well as intertie transactions for the CAISO BAA. This optimization involves WEIM transfers as well. Given the centralized nature of the market clearing process, the interaction and relationship created among all these type of resources are inevitable. Some internal resource dispatches can support WEIM transfers, while some WEIM transfer may support hourly schedules, and vice versa. This paper presents the preliminary analysis performed to better understand the interaction between CAISO intertie transactions and WEIM transfers. The analysis focuses specifically on the CAISO's BAA. CAISO expect to publish a final report in late May 2022.

3 Western Energy Imbalance Transfers

Figures 1 through 3 show the monthly distribution of WEIM transfers for CAISO BAA. A positive value represents an import while a negative value represents an export. The violin plot shows the transfer distribution, while the internal dot within the violin represents the mean transfer for each month. The internal vertical line of each month within the violin represents one standard deviation of the transfer sample. This information provides clarity on the trends of the transfers [1].

Across all real-time submarkets, WEIM transfers for CAISO BAA are robust, reaching levels of up to 5,000 MW in both the import and export directions. The maximum import levels are attained during the summer months of July and August 2021 when supply conditions are the tightest. The maximum level of exports are attained during the shoulder months of April and May 2021, when there is plenty of supply from full production of renewable resources, hydro production is high and demands are still relatively low.

Figures 4 and 5 show the correlation of transfers between HASP and FMM and HASP and RTD, respectively. Overall, there is a strong correlation of transfers between markets as illustrated with the large volume of transfer scattered close to a 45 degree line. This is expected since market conditions may remain relatively similar across the various markets. Obviously, there are specific intervals in which the correlation is weaker. For instance, the third quadrant shows a region in which HASP exports were between 0 MW and 2,000 MW while the exports realized in RTD were higher than 3,000MW. Conversely, in the first quadrant, HASP transfer were between 2,000 MW and 3,000 MW while the realized transfers in RTD were approximately 1,000 MW. There are other extreme cases (fourth quadrant) in which transfers in HASP were between 1,000 and 2,000 MW of imports but the realized transfers in RTD were actually between 1,000 and 2,000 MW exports (flipping direction). Each dot represents a pair of (HASP, FMM) or (HASP, RTD) transfers while the color of the dots represent the trading year.

Figures 6 shows the same (HASP, RTD) comparison but the dots are color coded by trading hour to highlight any trend across the hourly profile. This shows that a higher quantity of purple dots, representing the later hours of the day, tends to be more predominantly below the interpolated line and clustered at higher level of transfer imports. This represents a high volume of import transfers in HASP that then are realized at lower volumes during the peak hours of the day in RTD.

These illustrations show an overall trend; however, for more critical days with high loads, as those of summer 2021, a more granular view is presented. Figures 7 through 10 introduce four sets of specific days with a five-minute granularity. These days are selected as they reflect high load conditions in July, August and September 2021, as well as one week in January 2022. These plots show the trends of WEIM transfers for CAISO area across the various real-time markets. Although the trends are very dynamic through the day, most of the time for these selected days, the RTD transfers materialize consistently below the WEIM transfers cleared in both the HASP and FMM markets (blue lines below the red and green lines). This is more pronounced during the peak hours when larger deviations can be observed.

The changes observed on the WEIM transfer for CAISO BAA can be driven by a variety of conditions, including the effect of load conformance. As explained in the previous CAISO's report for the interaction of load conformance and the WEIM market , the load conformance induced in both the HASP and FMM markets drive some level of additional imports into the CAISO BAA in the HASP and FMM markets. Once that level of conformance is no longer present in RTD, the need for meeting the additional requirement is no longer inducing the same levels of WEIM transfers and will tend to

[1] All transfer values are taken from the original market solution; this data sample does not filter out any potential values associated with market failures or issues

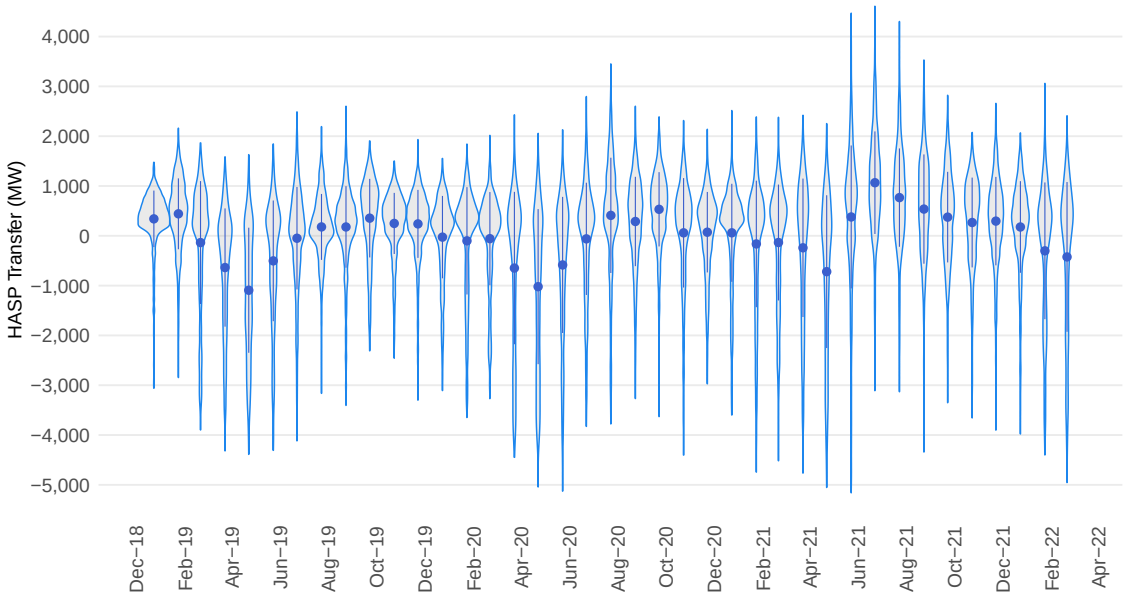

Figure 1: WEIM transfers in the HASP market for CAISO BAA.

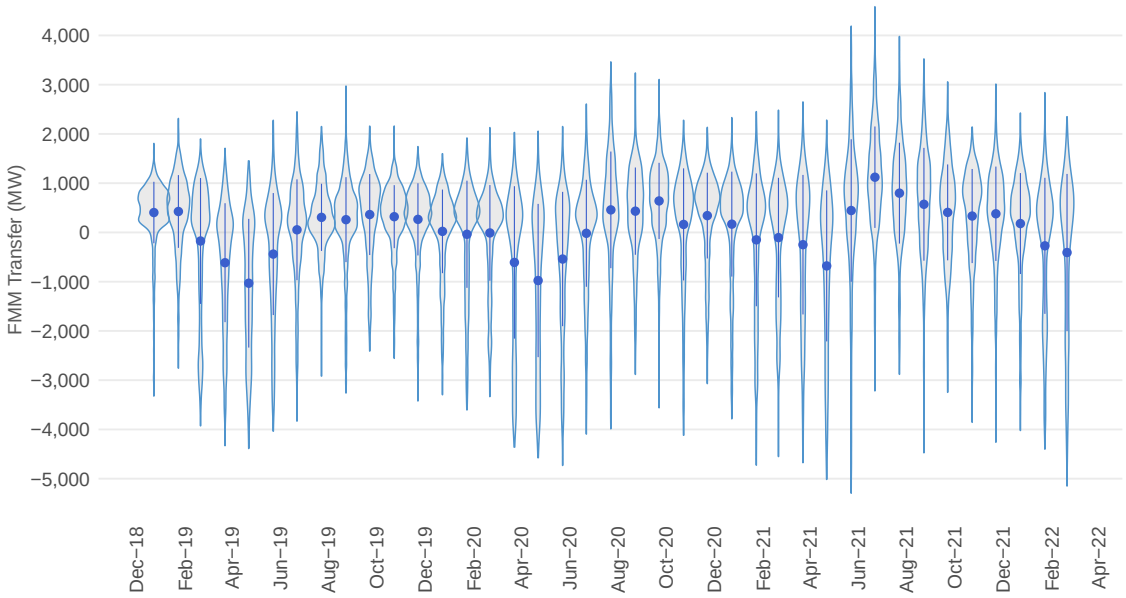

Figure 2: WEIM transfers in the FMM market for CAISO BAA.

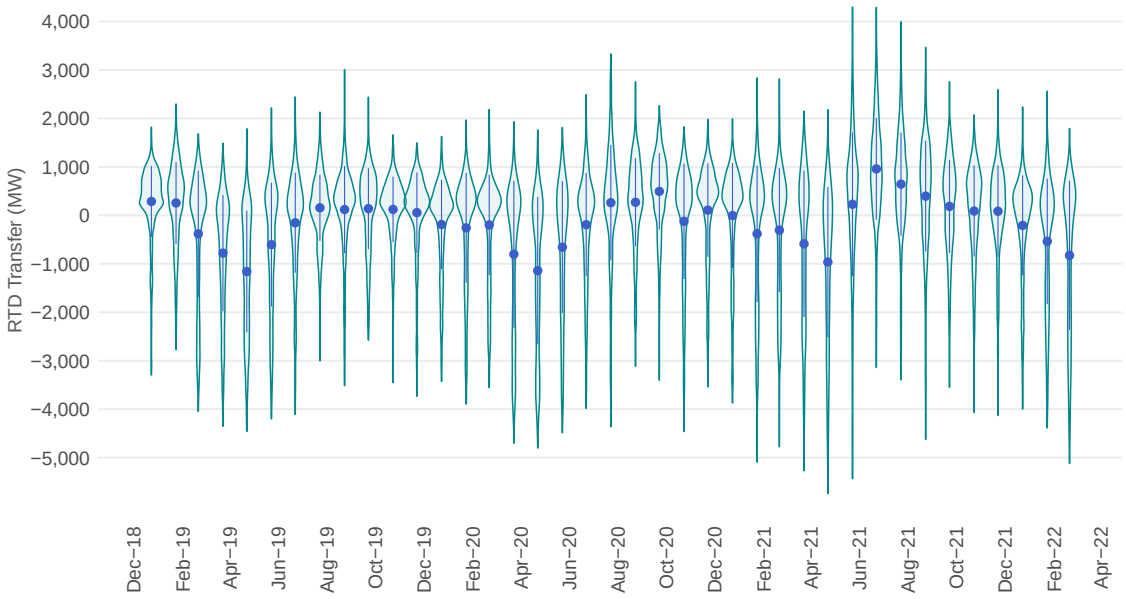

Figure 3: WEIM transfers in the RTD market for CAISO BAA.

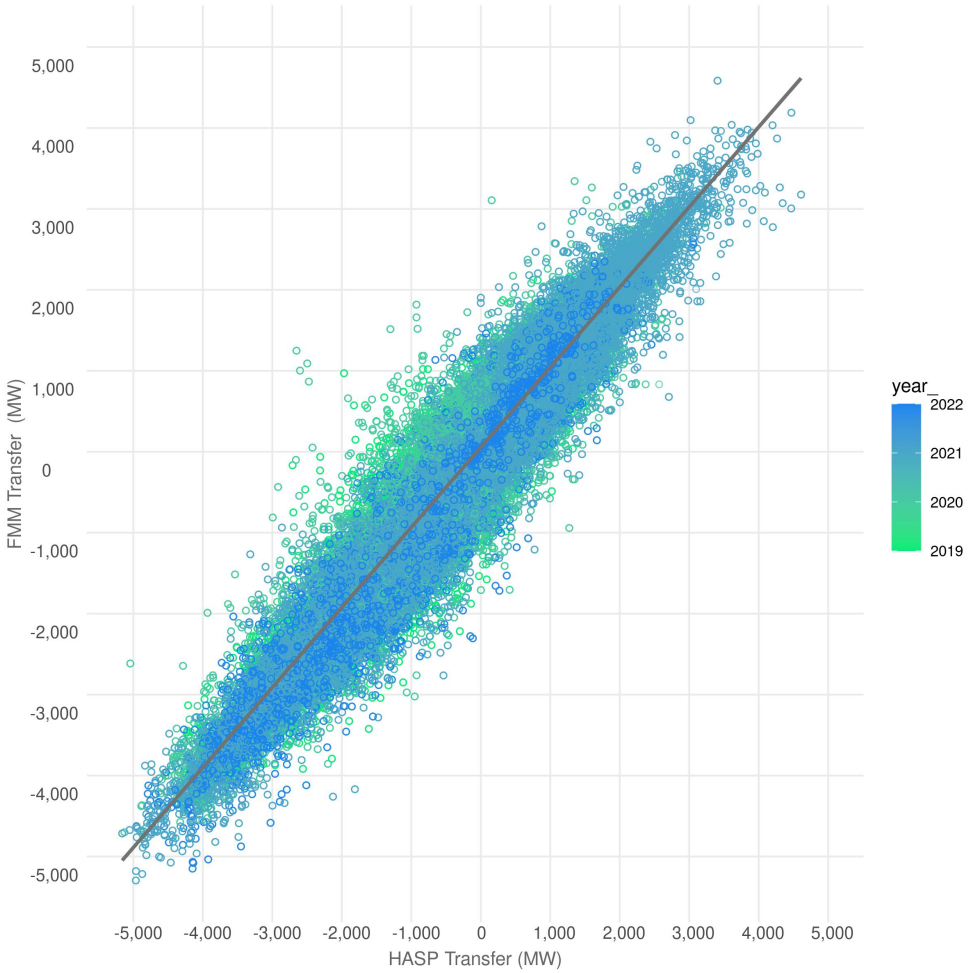

Figure 4: WEIM transfers for CAISO BAA, FMM *vs.* HASP by year.

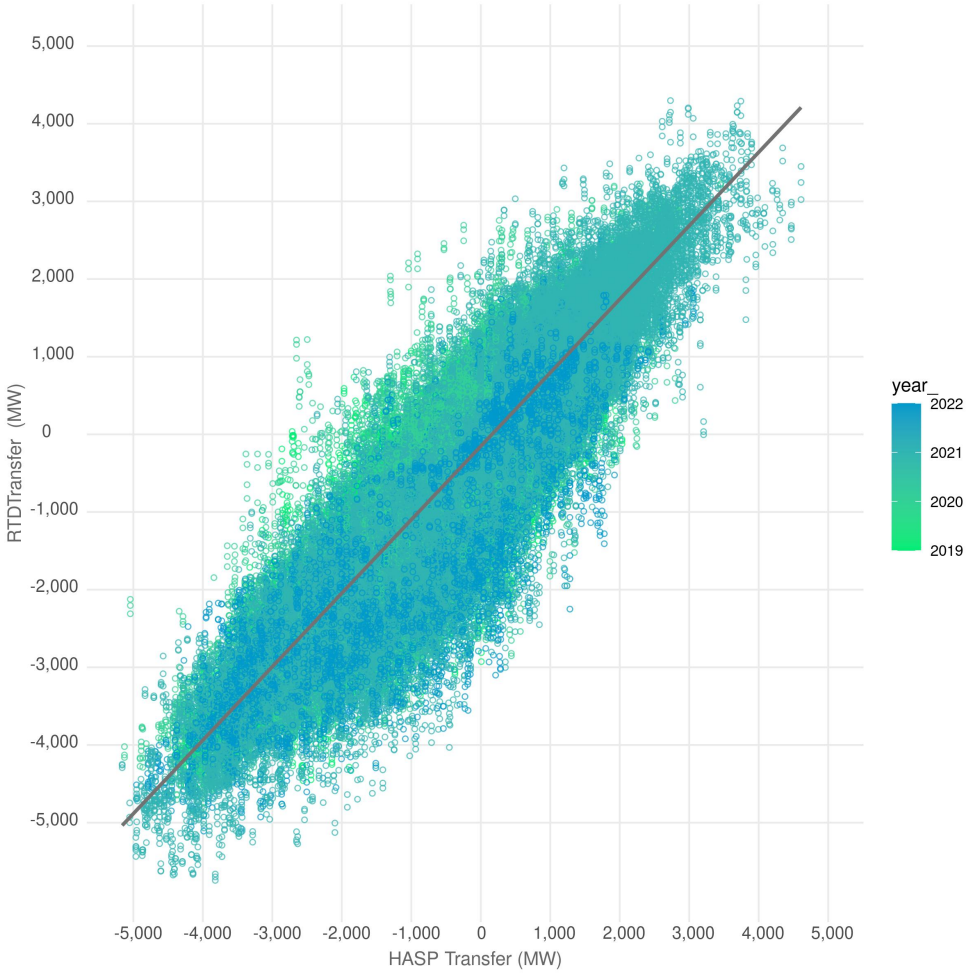

Figure 5: WEIM transfers for CAISO BAA, RTD *vs.* HASP by year.

Figure 6: WEIM transfers for CAISO BAA, RTD *vs.* HASP by hour.

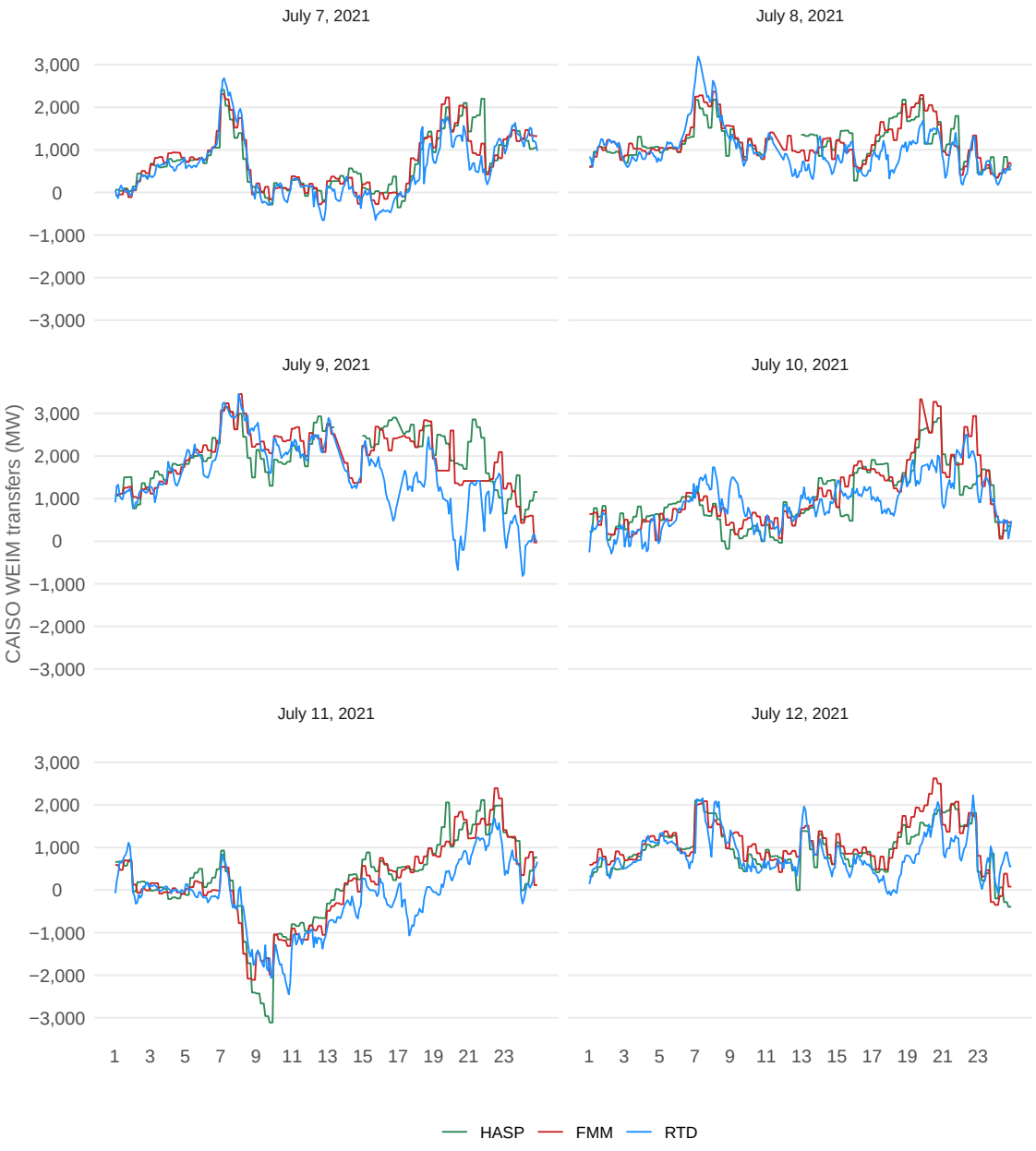

Figure 7: CAISO WEIM transfers across markets. July 2021 sample.

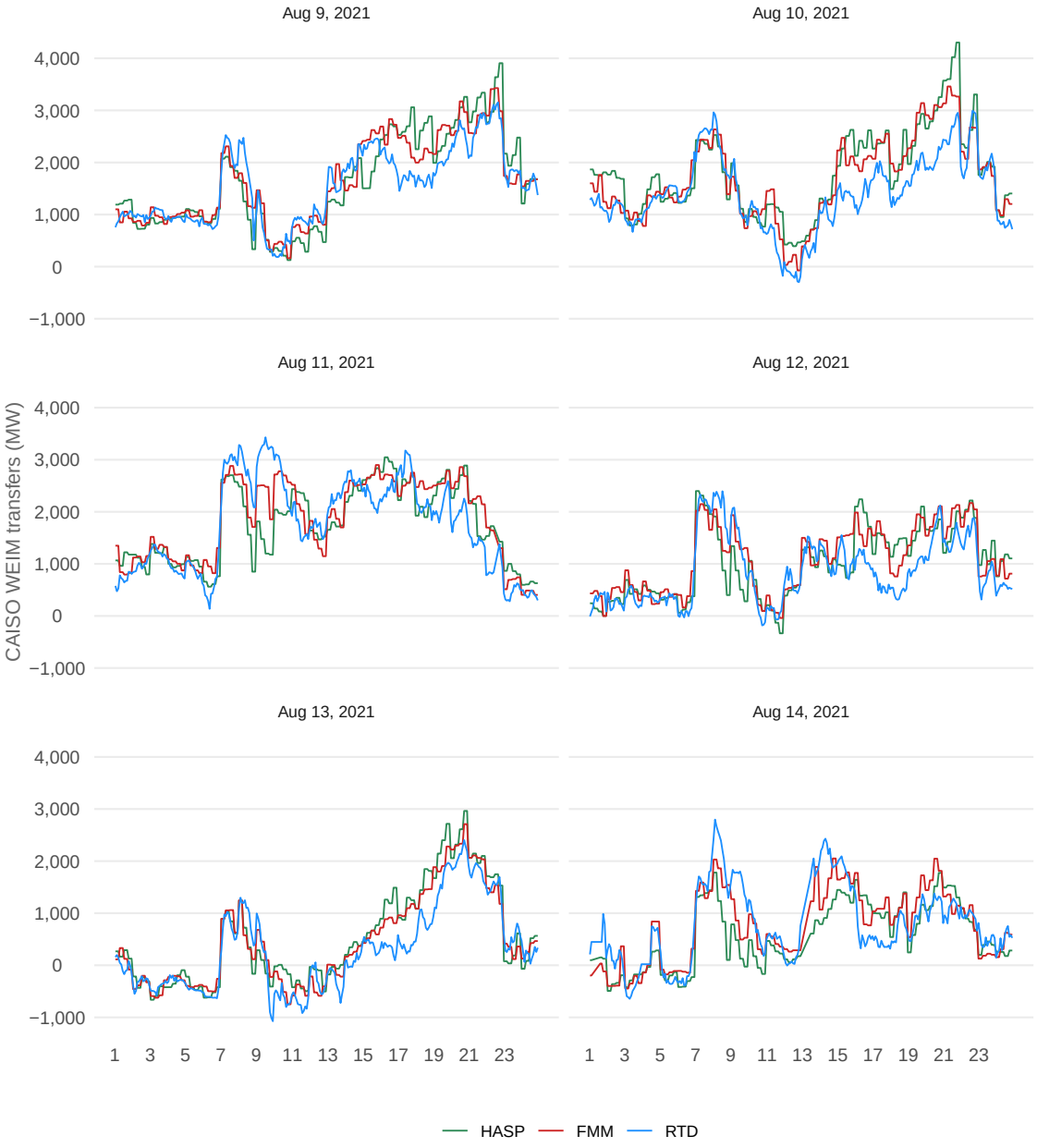

Figure 8: CAISO WEIM transfers across markets. August 2021 sample.

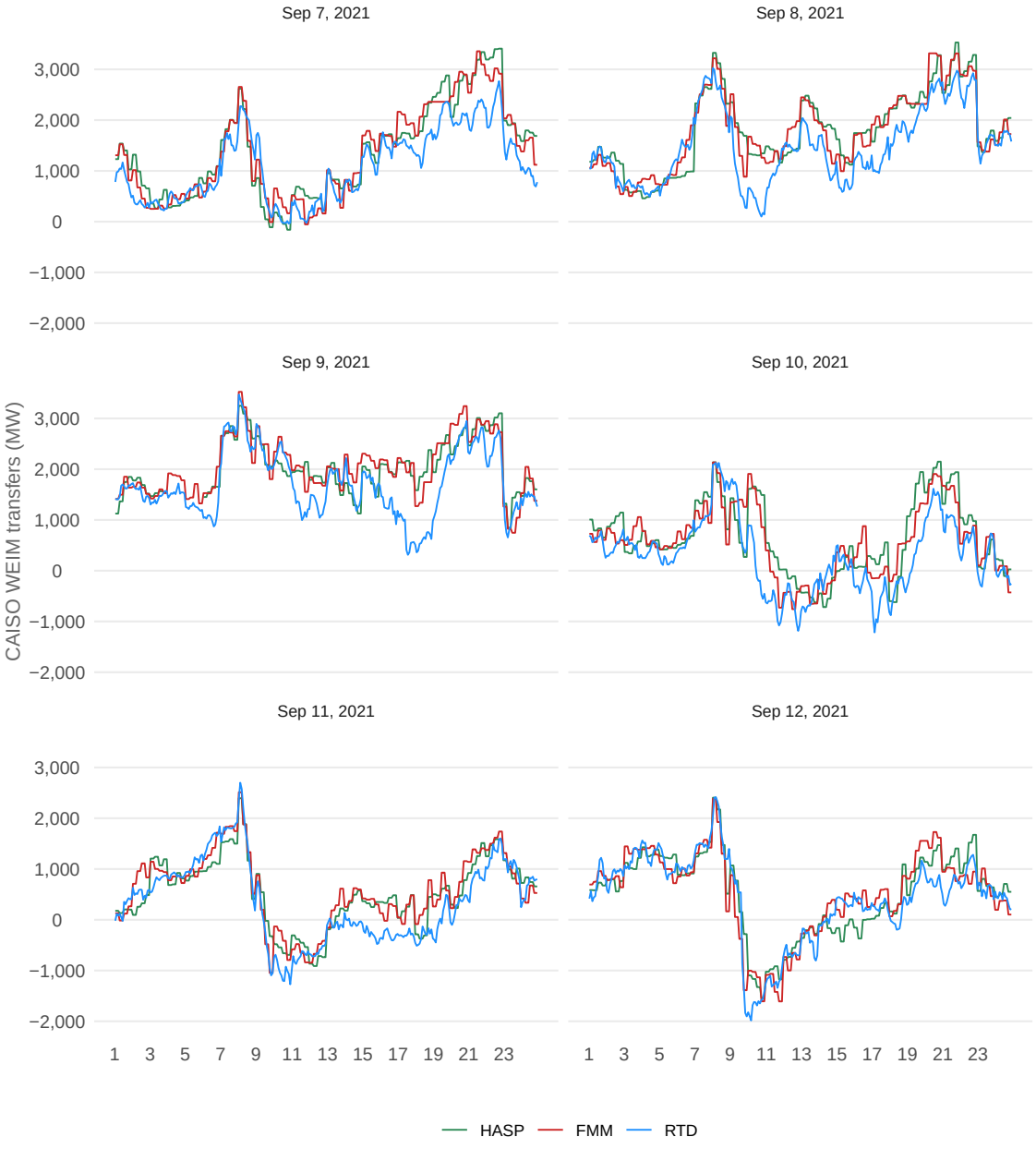

Figure 9: CAISO WEIM transfers across markets. September 2021 sample.

Figure 10: CAISO WEIM transfers across markets. January 2022 sample.

result in lower level of WEIM import transfers.

Figures 11 through 14 show more explicitly the changes observed in WEIM transfers across markets by depicting the delta between markets: one delta from HASP to FMM and another from FMM to RTD. A negative value reflects a reduction of transfers from one market to the subsequent one. Effectively, negative values of these delta represent the buyback of WEIM transfers happening for CAISO BAA across two markets. The black line represents the net of the two deltas since in some cases the deltas can be additive or offsetting. For several of days selected, a certain volume of WEIM transfers cleared in HASP, which is advisory in nature, then were consistently bought back towards the RTD market, which is the market producing operationally and financially binding WEIM transfers. This condition is not advantageous to the CAISO BAA because the advisory WEIM transfers bought in HASP and FMM at typically higher prices (since load conformance will command higher requirements that will push higher clearing prices) will be bought back in RTD at lower prices because of the load conformance is no longer present at that higher level. Based on these daily trends, the majority of buyback of WEIM transfers happen from FMM to RTD.

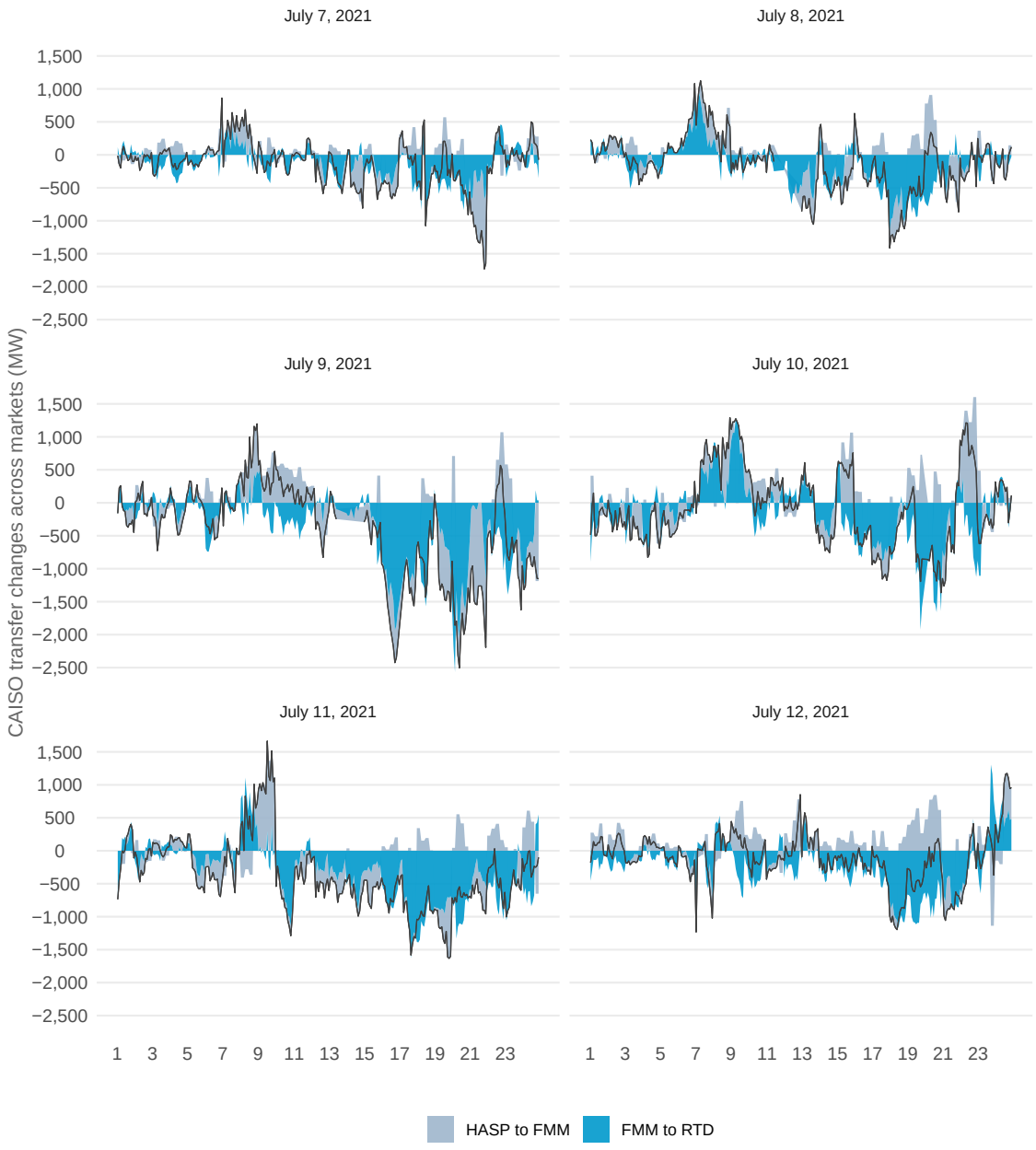

Figure 11: Rebalancing of EIM transfers. July 2021 sample.

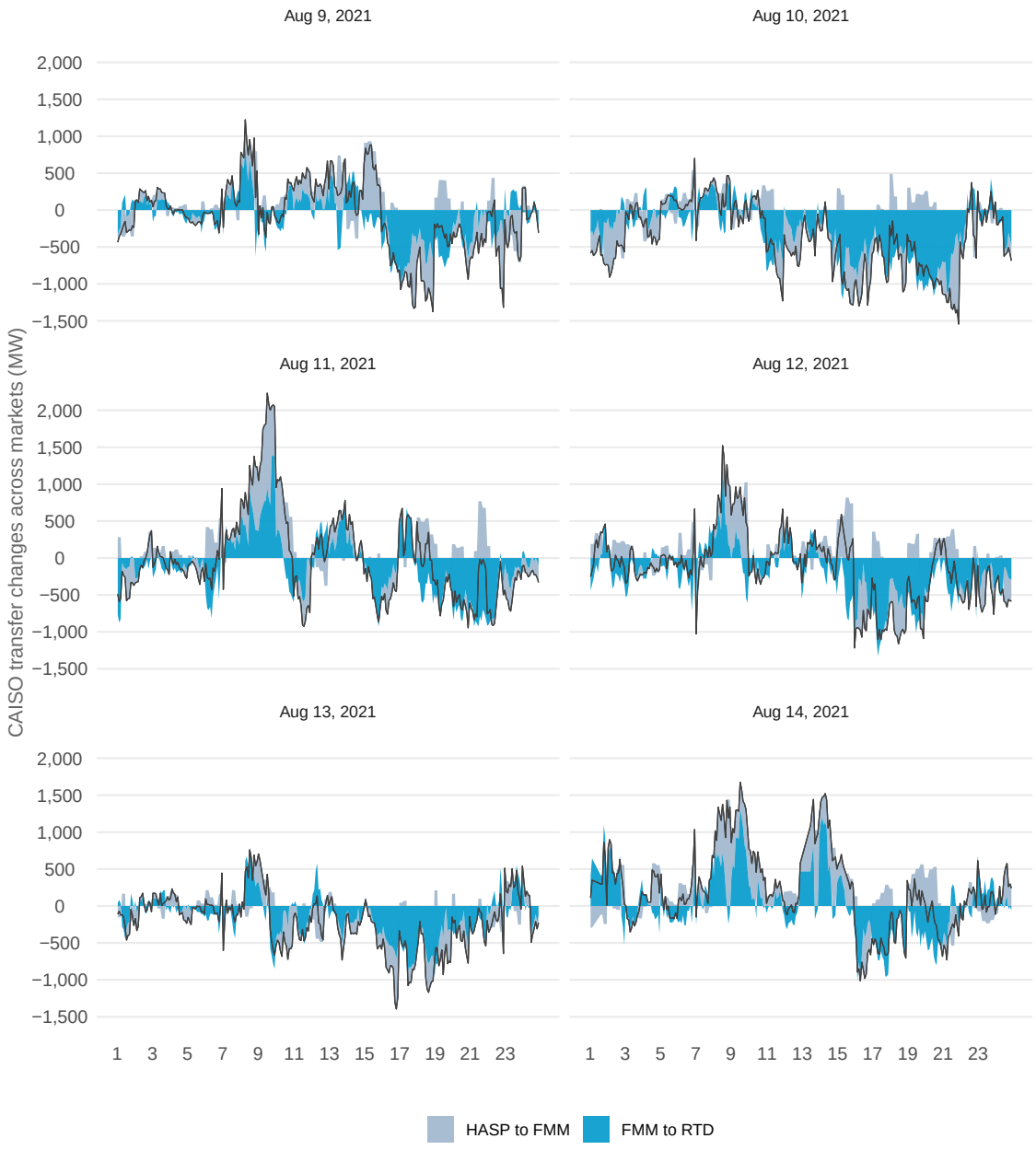

Figure 12: Rebalancing of EIM transfers. August 2021 sample.

Figure 13: Rebalancing of EIM transfers. September 2021 sample.

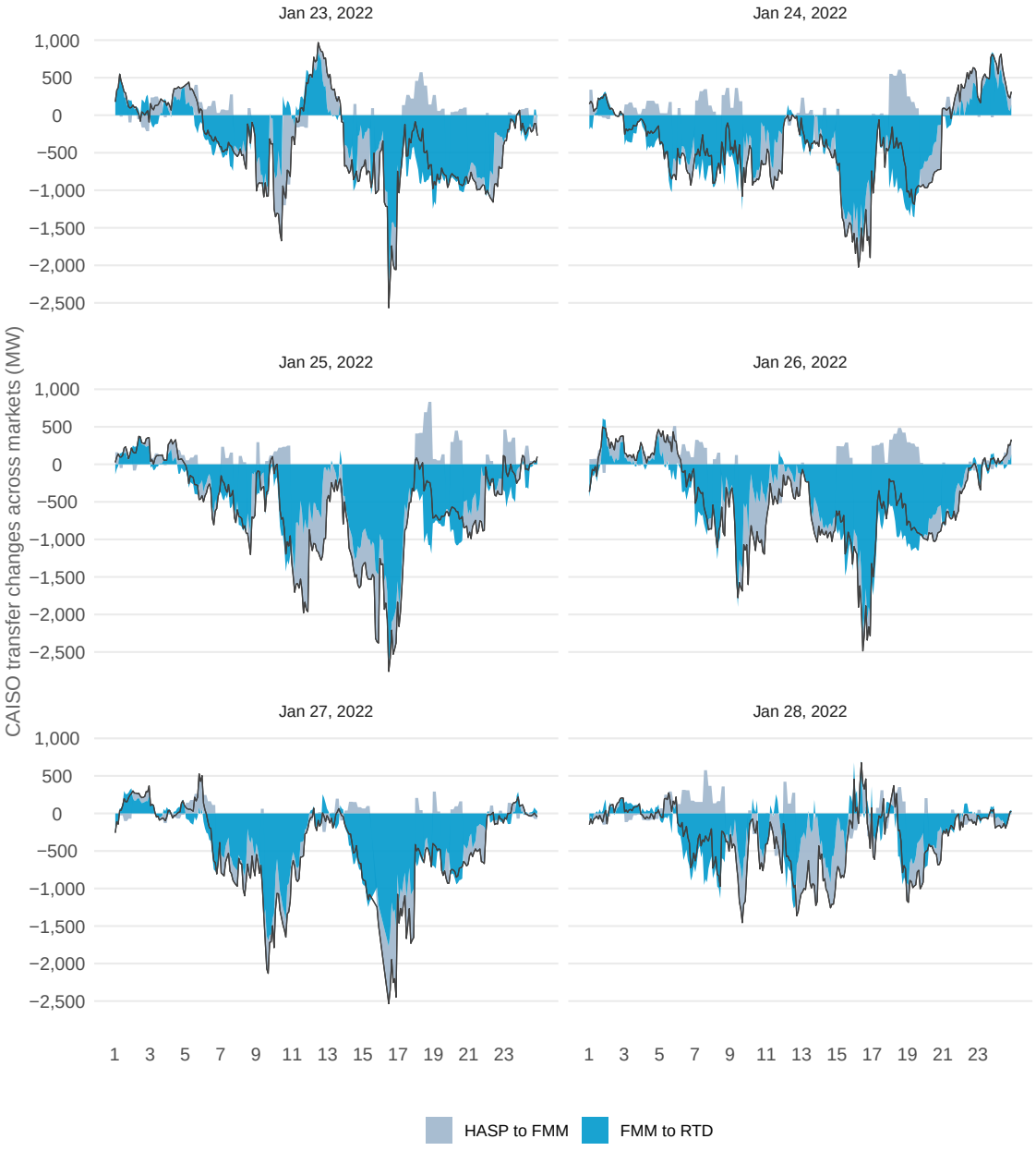

Figure 14: Rebalancing of EIM transfers. January 2022 sample.

4 Hourly Intertie Transactions

The CAISO's system relies on imports that come into the balancing authority area through various interties. Imports can come through Malin and NOB from the Northwest, and Paloverde and Mead from the Southwest, among others. Interties are generally grouped into static imports and exports, or dynamic and pseudo tie resources, which are generally resource-specific. Like internal supply resources, interties can participate in both the day-ahead and real-time markets through bids and self-schedules. Additionally, the CAISO's markets offer the flexibility to organize pair-wise imports and exports to define a wheel. This transaction defines a static import and export at given intertie scheduling point which are paired into the system to ensure both parts of the transaction will always clear at the same level. Wheel transactions must be balanced, thus they do not add or subtract supply or demand to the overall CAISO system, regardless of the cleared level. However, they utilize scheduling capacity on interties and transmission capacity on CAISO's internal transmission system. All intertie transactions compete for scheduling and transmission capacity via scheduling priority and economic bids.

Like internal resources, Intertie transactions have the option to self-schedule. The CAISO's market utilizes a series of self-schedules which have higher priorities than economical bids based on the attributes applicable to such resources. Participants with transmission entitlements can submit intertie self-schedules using transmission ownership rights (TORs) or Existing Transmission Contracts (ETCs). Additionally, interties can use high- and lower-priority self-schedules. Economical bids for imports are treated similarly to internal supply bids, while exports are treated similarly to demand bids (or fixed load in the real-time). These bids are bounded between the bid floor (-$150/MWh) and bid cap ($1,000/MWh or $2,000/MWh). Each part of a wheel is also treated accordingly as supply or demand but its net bid position is defined as the spread between its import and export legs prices.

CAISO's markets will clear intertie transactions utilizing its least-cost optimization process in each market. Bids and self-schedules are considered in a merit order to determine the clearing schedules, and all resource bids and characteristics, as well as system conditions, are considered. In the upward direction, when supply capacity is limited, imports with self-schedules clear first, followed by economic bids from cheapest to most expensive, up to the level of the market clearing price. Conversely, exports will clear first for ETC/TORs, then high priority, followed by low priority exports and lastly economic bids from most expensive to cheapest.

In the HASP market, intertie transactions compete with internal CAISO resources as well as with other WEIM resources by means of WEIM transfers. An import transaction will be considered in merit order under the same basis as WEIM resources to meet CAISO's demand. When the WEIM resource is cheaper, that generation will economically displace more expensive intertie resources and will meet CAISO's demand by means of an economical import transfer into the CAISO area. Additionally, export intertie resources can be supported with internal CAISO resources, import intertie resources, and WEIM import transfers.

Figures 15 through 17 provide the import bid composition for three sets of days during the summer of 2021. The import volumes are organized by type of bids [2]. The bars in purple show the volume of imports associated with TORs and ETCs. This volume remained relatively constant through the sample days and exhibit two block profiles, one for each time of use (off- and on-peak hours). TORs and ETCs are a type of self-schedule and have the highest priority in the market. They are followed by day-ahead self-schedules and real-time self-schedules, shown by the bars in blue and green, respectively. The bars in red represent the volume of economical bids with a bid price between the bid floor and cap. The majority of the import interties come into the market with some type of self-schedule and

[2]This volume only reflects static intertie; dynamic resources or pseudo resources are not included here, neither are the import side of wheel-through transactions

only a small portion of those import interties participate economically with price-sensitive bids. These economical bids typically do not clear in the early hours of the day when demand is low, even during summer conditions. However, they tend to clear in the evening peak hours when supply is the tightest. The black dotted line represents the total volume of imports cleared in the market.

Similarly, Figures 18 through 20 provide similar information for export interties. Exports come into the HASP process with different type of priorities, including TOR/ETC, day-ahead and real-time self-schedules, as well as economical bids. Like imports, the vast majority of exports during summer days came into HASP with some type of self-schedule. A very small volume of exports participated with economical bids. Since all self-schedules have a higher priority than any economical bids, even real-time self-schedules which are willing to take any real-time price, these self-schedules will push supply (either internal CAISO generation, hourly interties or WEIM internal resources) through as WEIM transfers- to clear since they can take high prices. It is these self-schedule exports that will drive the utilization of any available supply across the real-time market, including the utilization of WEIM internal resources.

The volume of exports throughout the sample days is markedly different even when sampling a relatively small portion of the month. This is consistent with the high-load conditions which can change rapidly from day to day within the same month.

To highlight the economics of the price-responsive import bids, Figures 21 through 23 show the volume of economical imports organized by price bins between the bid floor and cap. The volume of imports made available in the market through economical bids is quite variable from day to day and hour to hour. The black dotted line represents the volume of economical bids cleared in HASP. In July, some high-priced imports were bid in the range of (750−1,000) and did not clear. In August and September, imports were generally bid at more expensive levels ($> \$ 500$) and did not clear either.

Correspondingly, for exports, Figures 24 through 26 show the volume of economical exports bid-in to the HASP market organized by price bins; the dotted line in black represents the cleared volume of economical exports. The price bins are stacked from the most expensive to the cheapest to illustrate the range that would typically clear [3] based on merit order. There is still some level of economical exports cleared in the HASP process even during tight supply conditions.

[3] This illustration holds as long as the clearing of exports are driven only by supply-demand conditions since congestion may break the natural in-merit clearing of exports

Figure 15: Bid-in volume of Imports. July sample.

Figure 16: Bid-in volume of Imports. August sample.

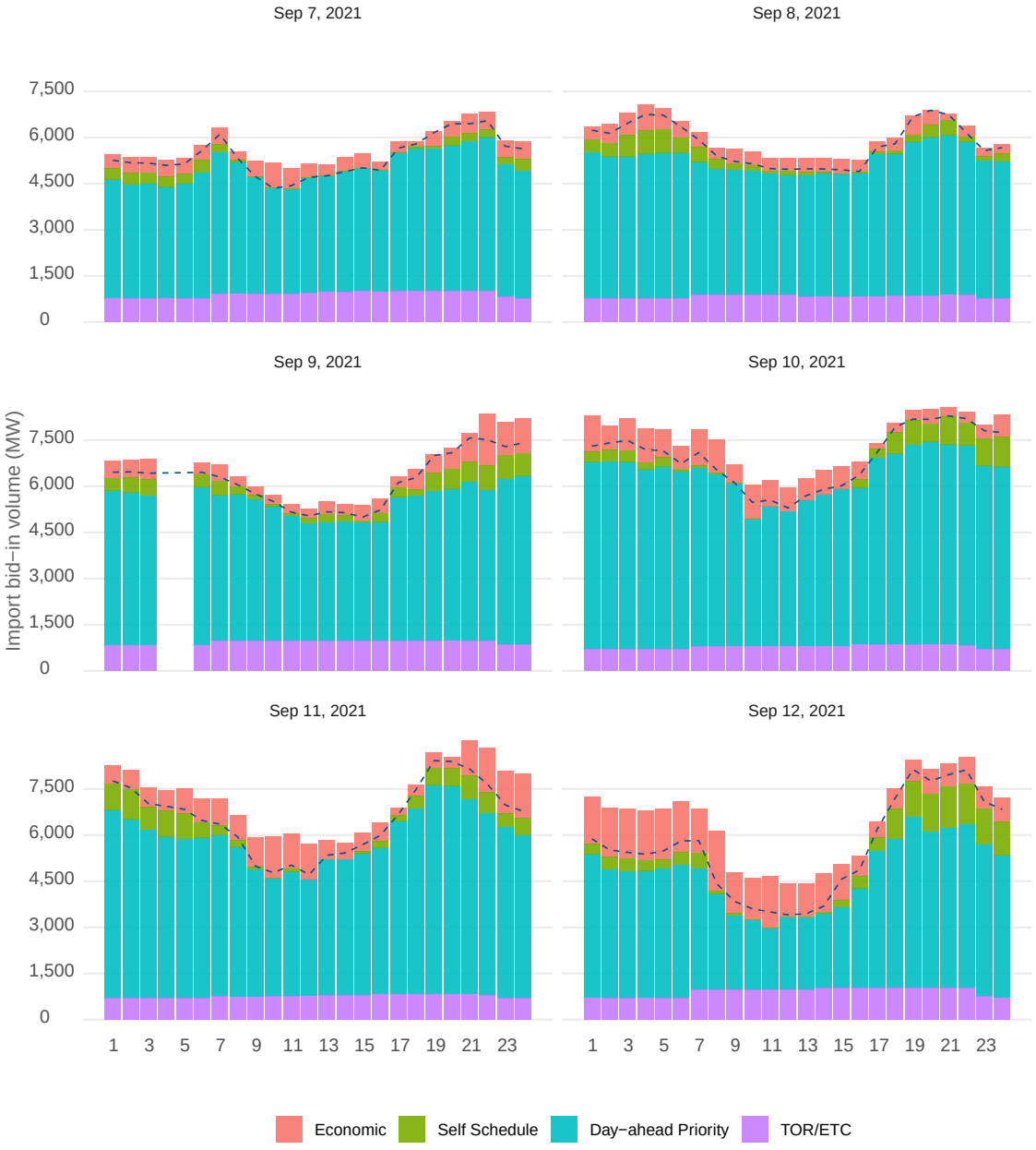

Figure 17: Bid-in volume of Imports. September sample.

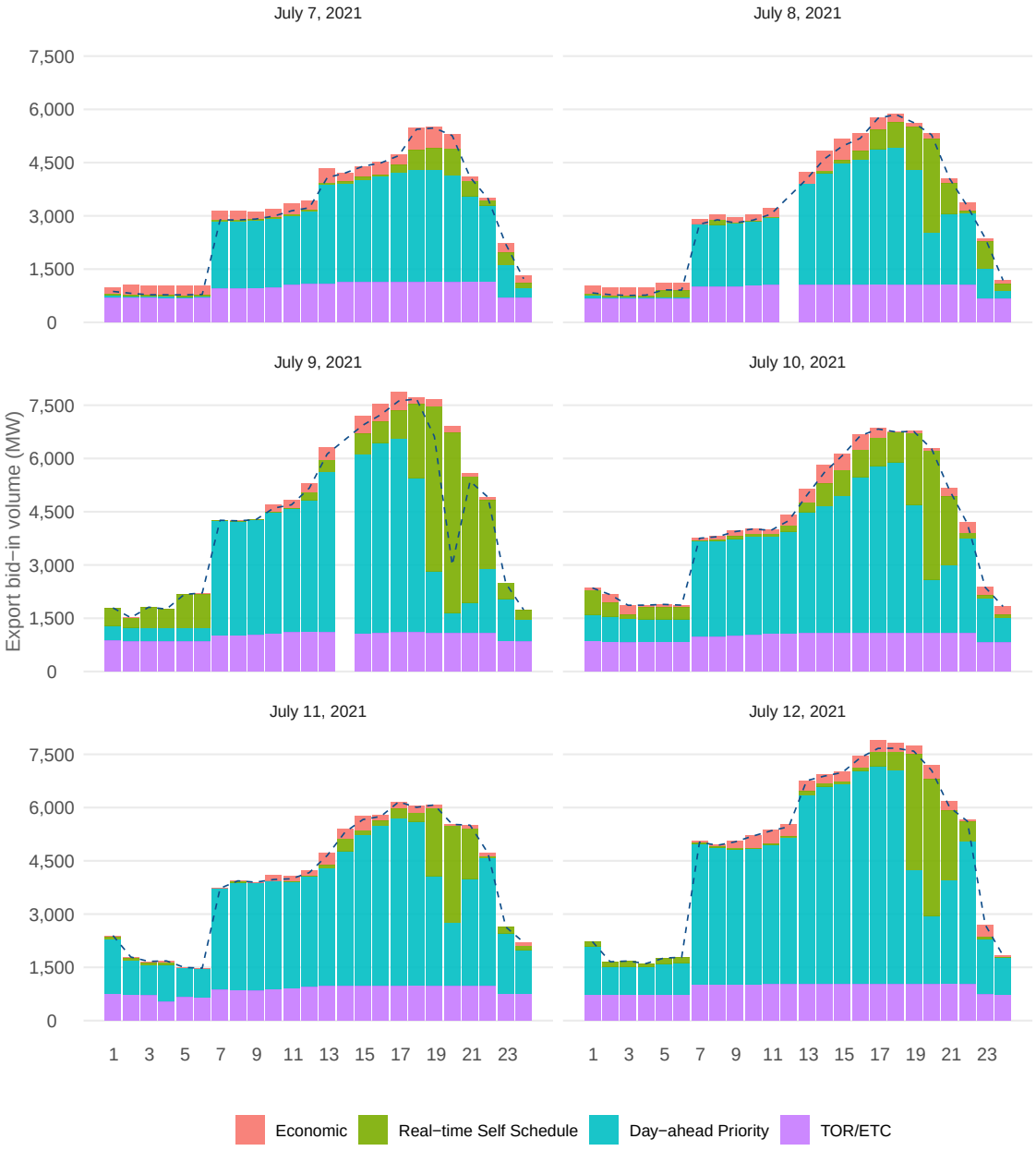

Figure 18: Bid-in volume of Exports. July sample.

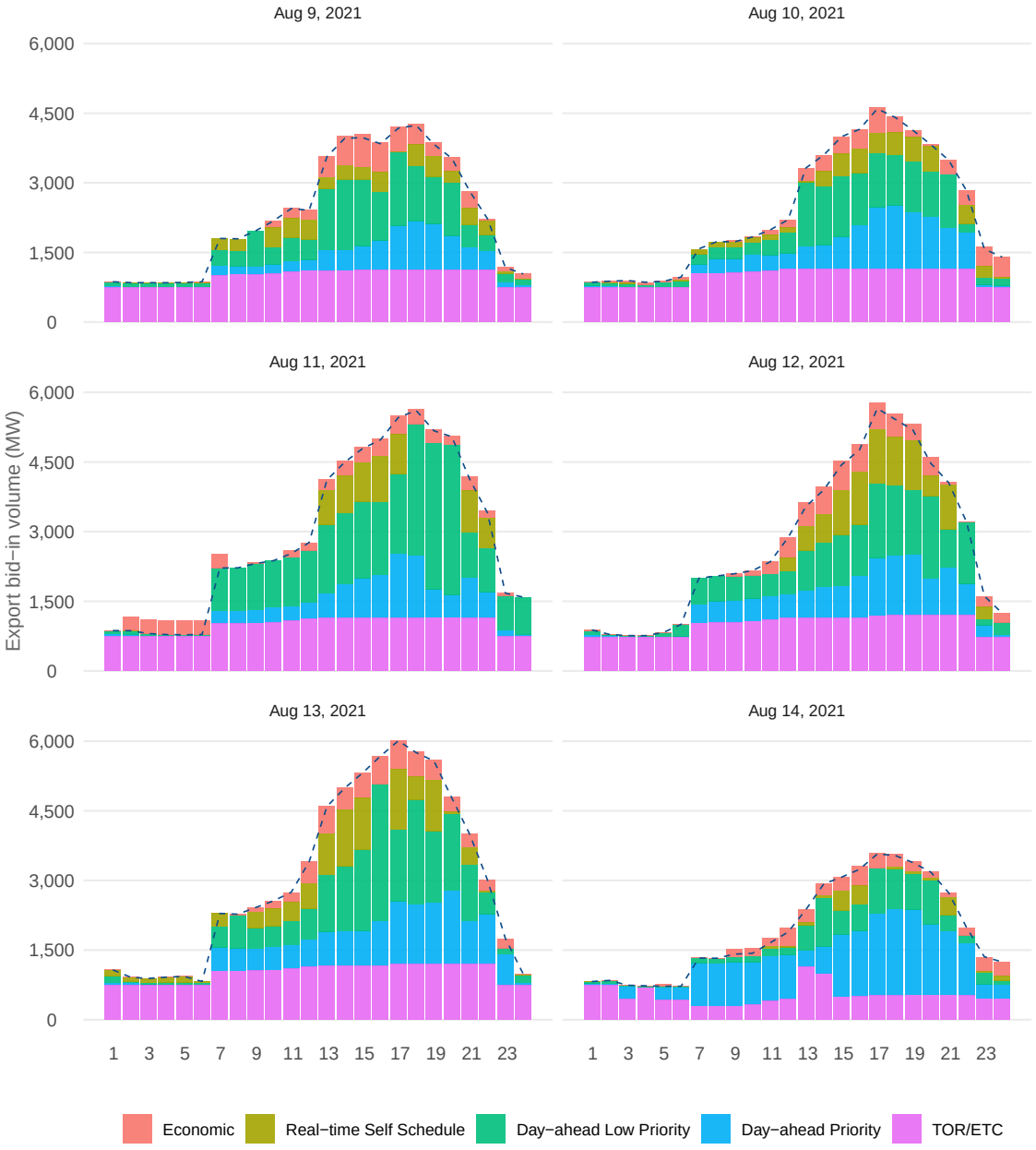

Figure 19: Bid-in volume of Exports. August sample.

Figure 20: Bid-in volume of Exports. September sample.

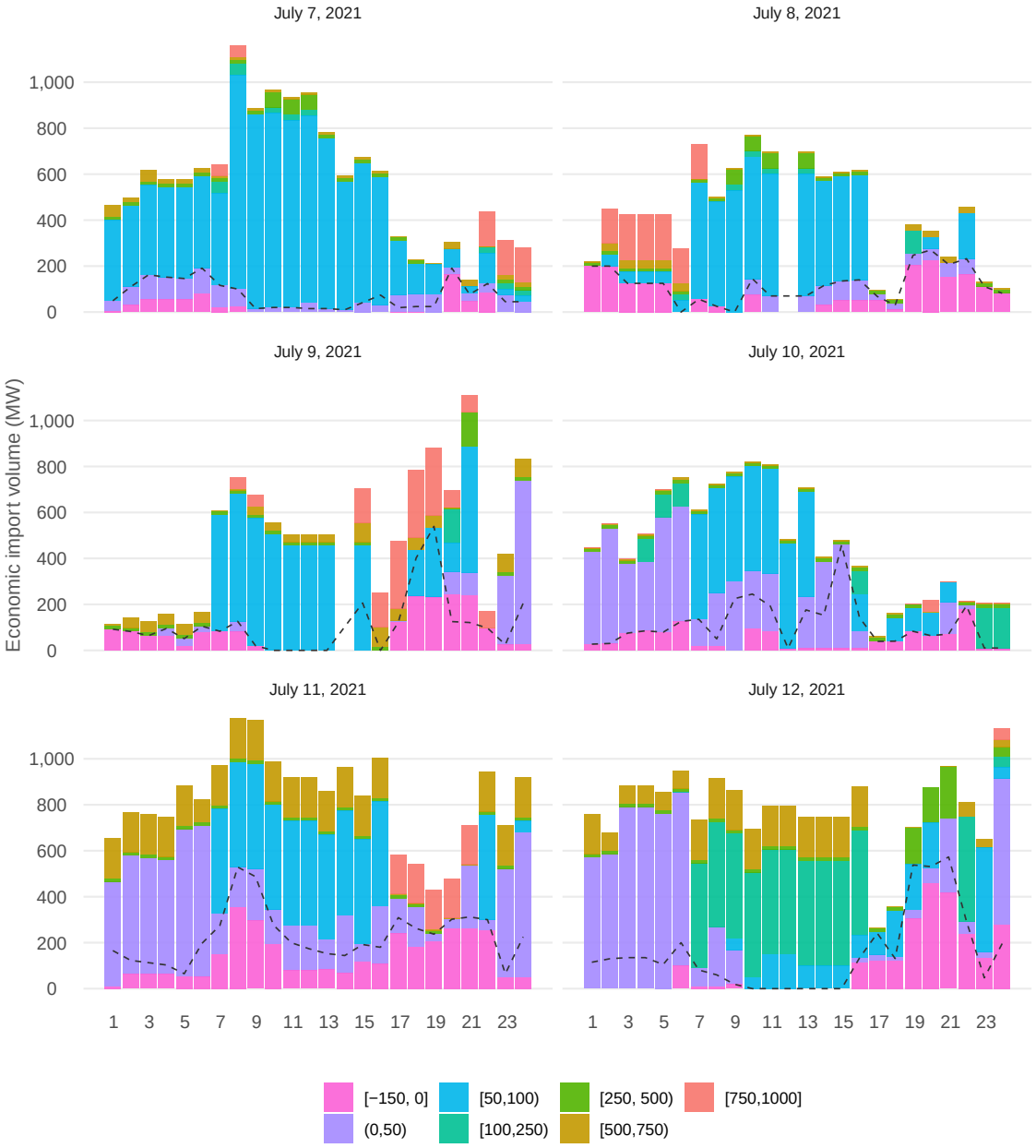

Figure 21: Economical bid-in volume of imports. July sample.

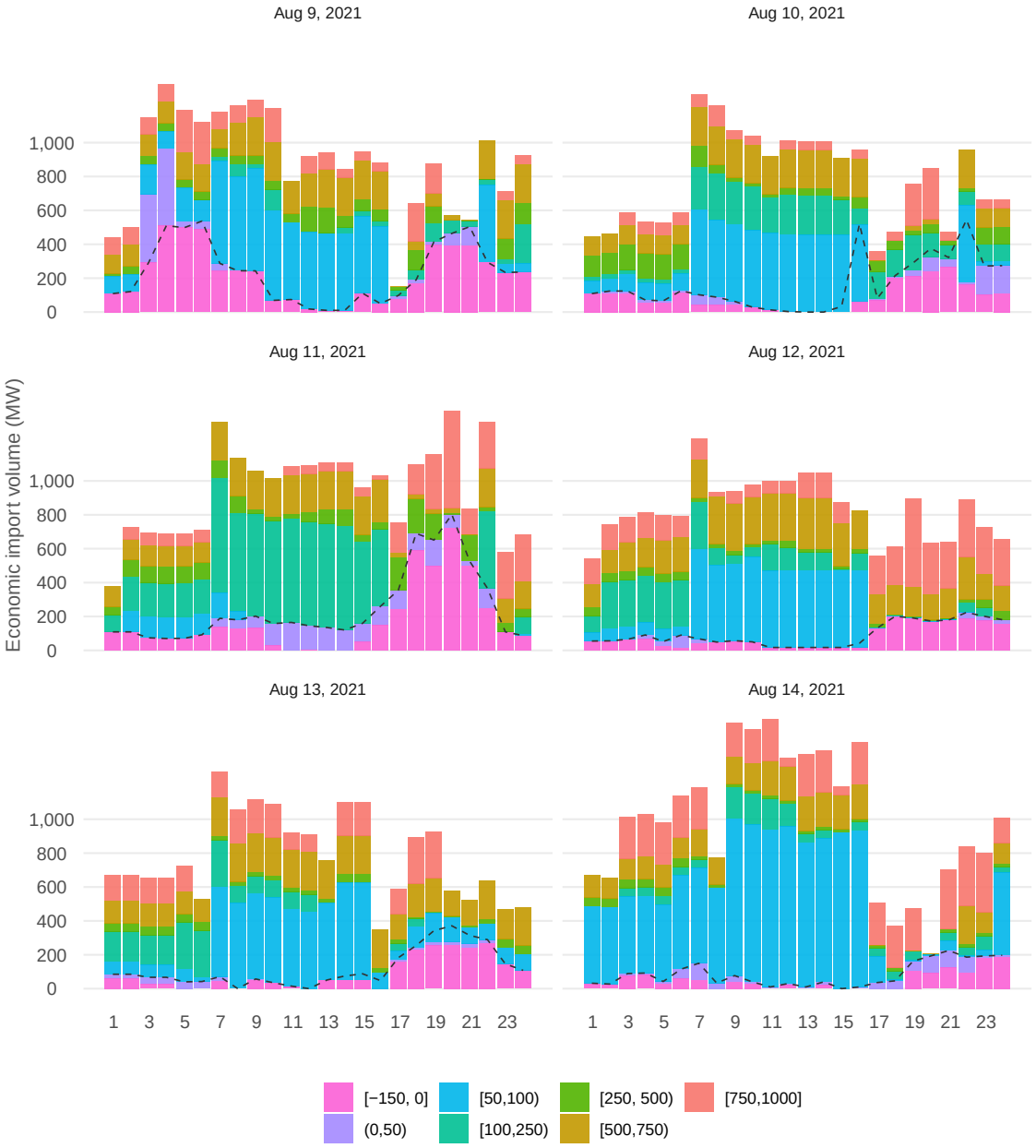

Figure 22: Economical bid-in volume of imports. August sample.

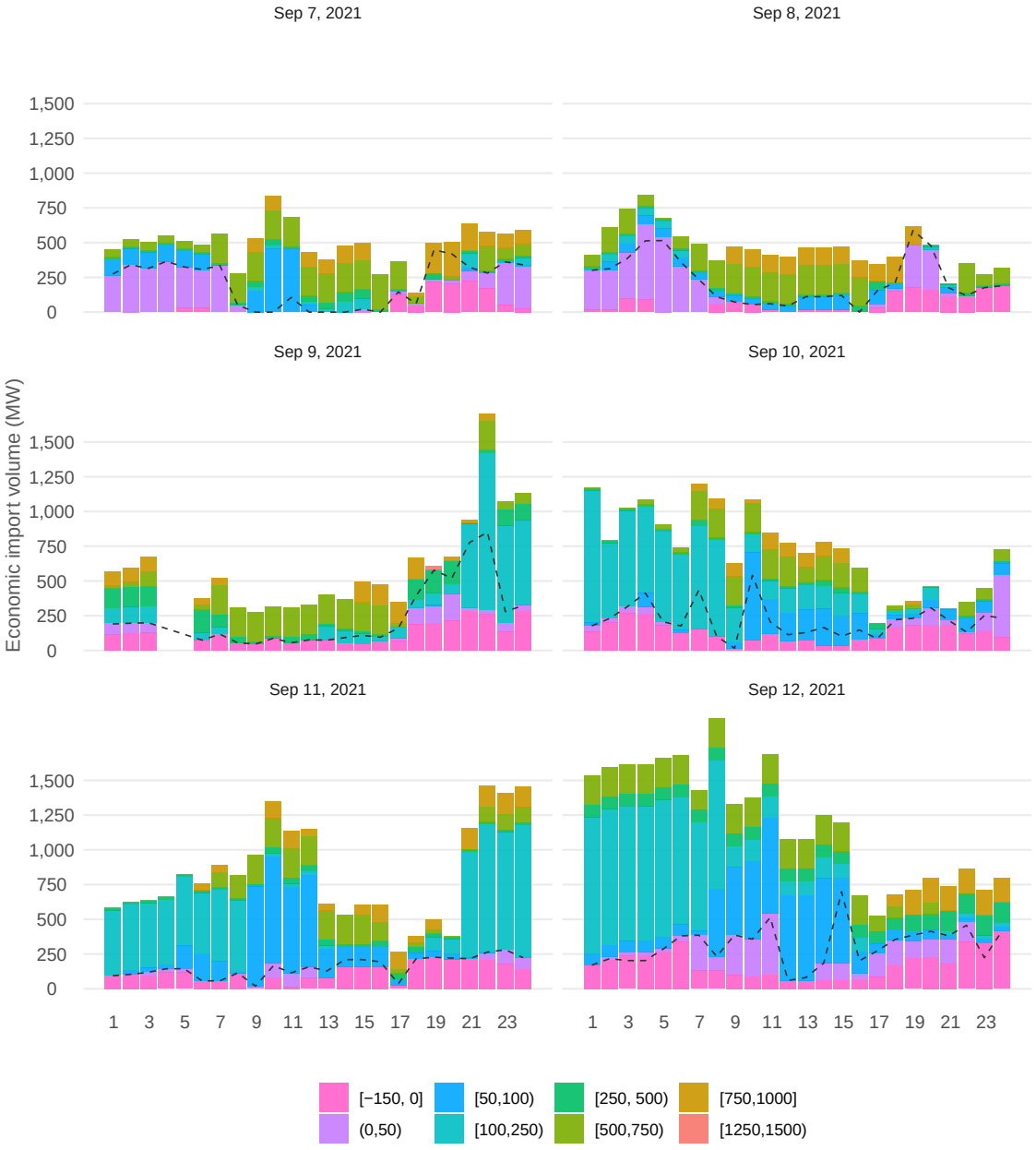

Figure 23: Economical bid-in volume of imports. September sample.

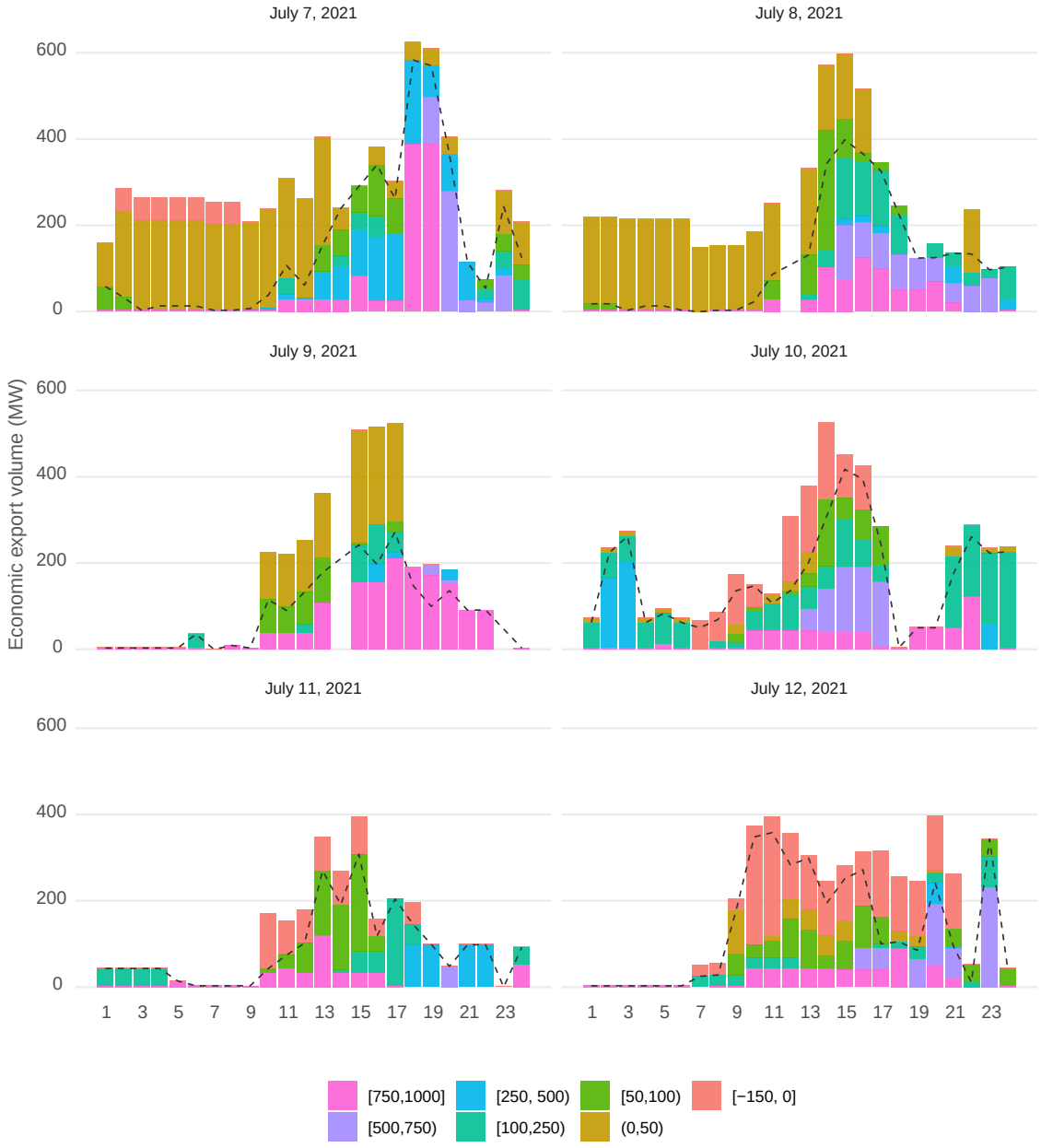

Figure 24: Economical bid-in volume of exports. July sample.

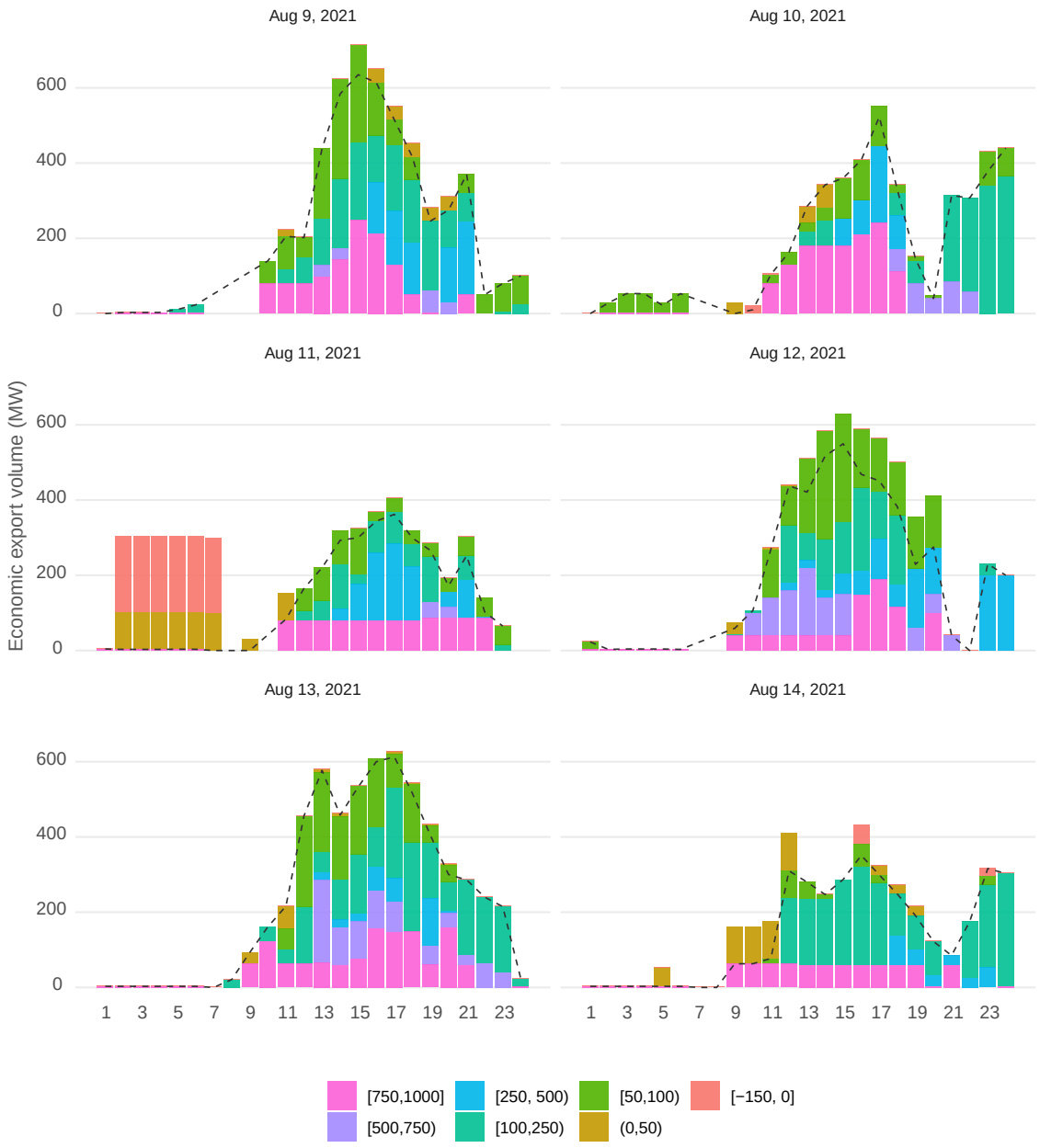

Figure 25: Economical bid-in volume of exports. August sample.

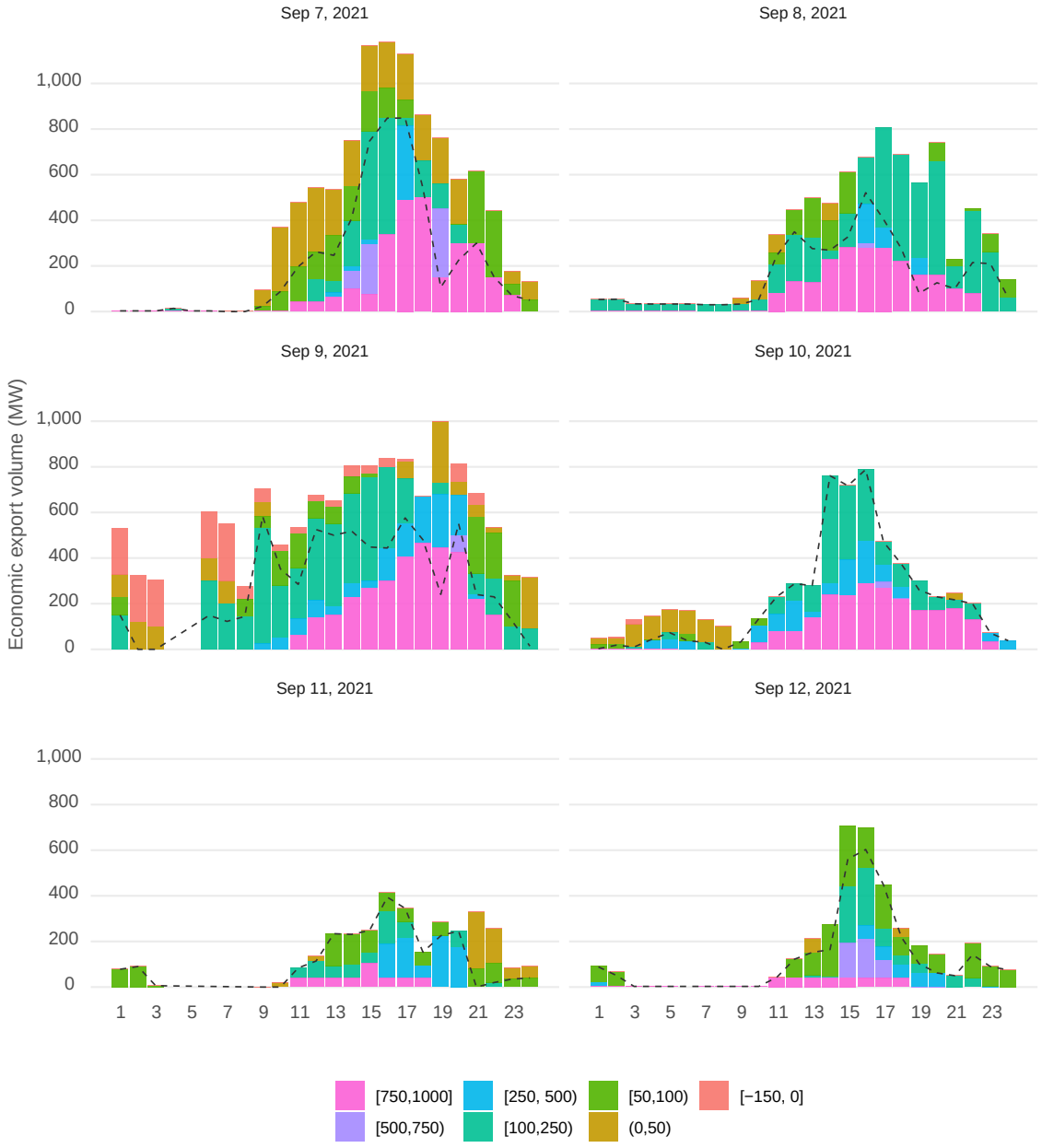

Figure 26: Economical bid-in volume of exports. September sample.

5 Intertie Exports and WEIM Transfers

A concern expressed in previous cycles of analysis regarding the resource sufficiency evaluation and the performance of CAISO interties refers to the scenario in which the advisory WEIM import transfers cleared in HASP are supporting hourly exports. Since these import transfers are advisory in nature and are consequentially reassessed in FMM and RTD, when the operationally-binding WEIM import transfers are eventually cleared in RTD, they may be lower than the level originally cleared in HASP. However, the hourly WEIM exports cleared in HASP hold despite the unrealized portion of transfer imports. As seen in previous section, it is quite frequent that HASP and FMM transfers are reduced (bought back) in RTD. Therefore, there are conditions for this scenario to happen.

On the other hand, there is also a concern that the CAISO area may have been leaning on WEIM imports to meet its load obligations, mainly during tight supply conditions, by relying on WEIL import transfers into CAISO area. These two concerns drive at the core of how the CAISO real-time market works and highlights the complex interactions between hourly intertie and WEIM transfers. In the HASP process, hourly intertie schedules and WEIM transfers are attained as part of an overall market solution based on least-cost dispatch. Energy from either hourly intertie imports or WEIM imports contribute to the overall supply pool that is the reference to the level of exports that can clear in HASP.

To further assess these implications, consider Figures 27 through 29. These figures show the volume of hourly intertie exports cleared in the HASP process for the CAISO area versus the net WEIM transfers coming into the system cleared in the RTD market. The exports are organized in two groups, i) real-time self-schedules, and ii) economical bids, and are shown with a negative sign convention. This aligns with the sign convention of positive values for WEIM import transfer into CAISO, and negative values for WEIM exports transfers out of CAISO. The black trend line represents the net between exports and WEIM transfers. Like the metrics in previous sections, the information is provided in three sample sets of days for July, August, and September 2021.

The sample for July 2021 exhibits a common trend across the different days in which real-time exports cleared at high volumes with mainly with self-schedule exports. These are exports that came into real-time at the last minute with no supporting resources but with the willingness to take any clearing price. These are exports that did not come through the day-ahead market first; they came directly into the real-time market. With real-time self-schedules, these exports put themselves higher in the bid stack and increase the likelihood of clearing since they are willing take clearing prices as high as the bid cap. These self-schedules will drive the market to clear any capacity available across the WEIM and can consequently drive higher level of import transfers into CAISO. These WEIM imports may be perceived as serving CAISO but can be very well pass through the CAISO area since they may be serving hourly intertie exports. Clearing hourly exports, even if they are last-minute real-time self-schedules, represents a more certain approach for Scheduling Coordinators to secure exports because i) they are cleared in the CAISO hourly process, and ii) Scheduling Coordinators can utilize self-schedules to price their willingness to acquire exports as pricy as possible. The WEIM counterpart approach is uncertain as a balancing area cannot directly influence the level of export transfers that can clear in RTD and these transfer exports are uncertain and dynamically assessed in the RTD market. The clearing of advisory WEIM transfers in HASP and FMM do not provide BAAs with any certainty that these transfers will eventually materialize in the operationally-binding RTD market.

For the critical peak hours in the July 2021 sample set of days, the volume of real-time exports cleared in HASP were higher than the volume of WEIM import transfers cleared for CAISO in the RTD market. Consequently, the net position for CAISO is indeed a net export condition. For instance, on July 9, real-time exports cleared at about 3,800 MW in hour ending 19 while the CAISO received as low as 640 MW of WEIM transfer imports; the net position for CAISO was still a net exporter of about 3,150 MW.

These RTD transfer imports were much lower than what was projected by the advisory HASP WEIM transfer imports, which resulted in CAISO having to honor these real-time exports even though the WEIM import transfers did not fully realize. This dynamic was also observed on September 7 and 8[4], as well as on August 12 and 13, when real-time exports cleared higher in HASP than what CAISO eventually received as WEIM transfer imports. This condition changed significantly for the other sample days of August and September when CAISO experienced high loads but conditions were not that tight.

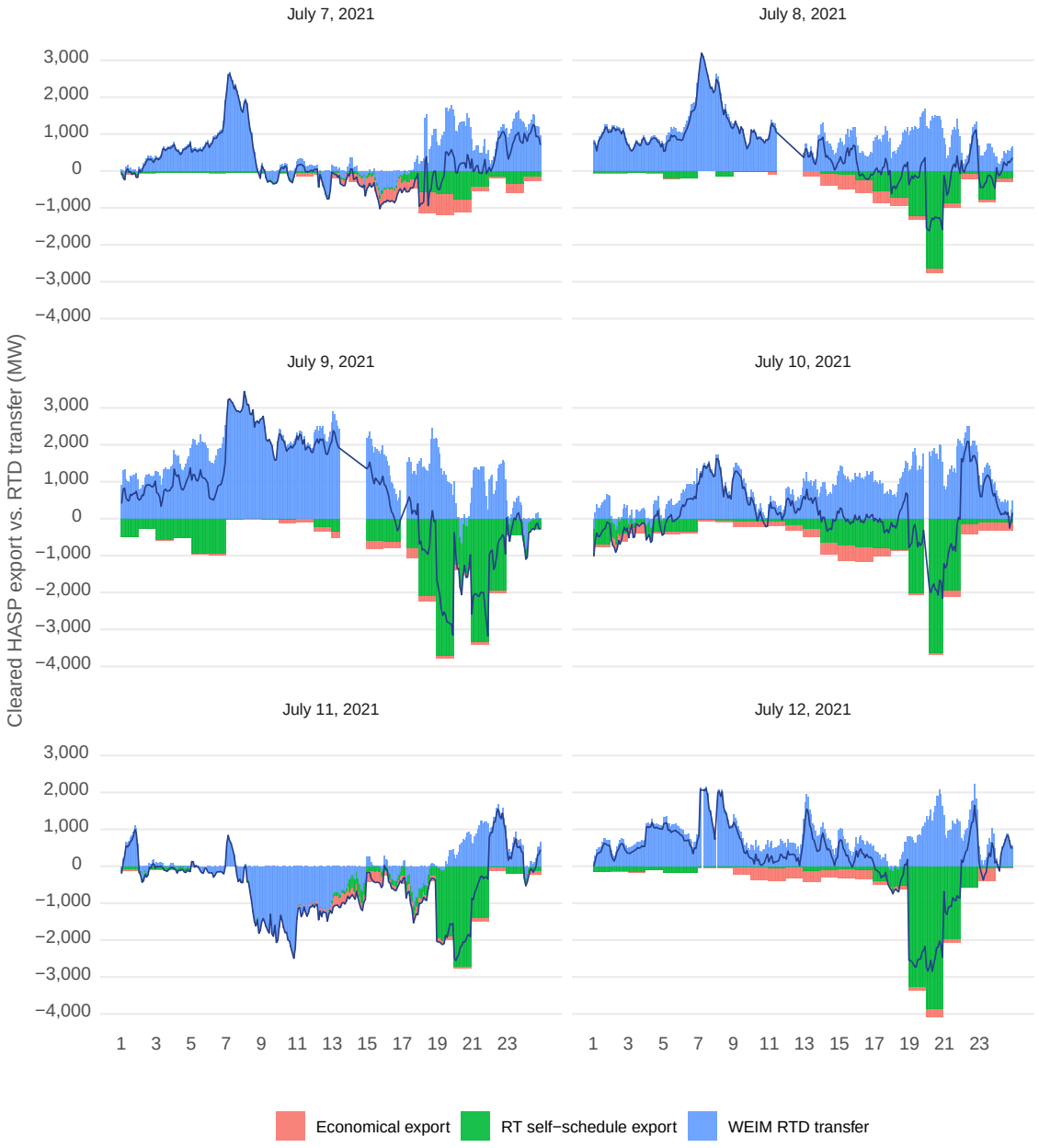

Figure 27: Hourly exports *vs.* WEIM RTD transfers. July sample.

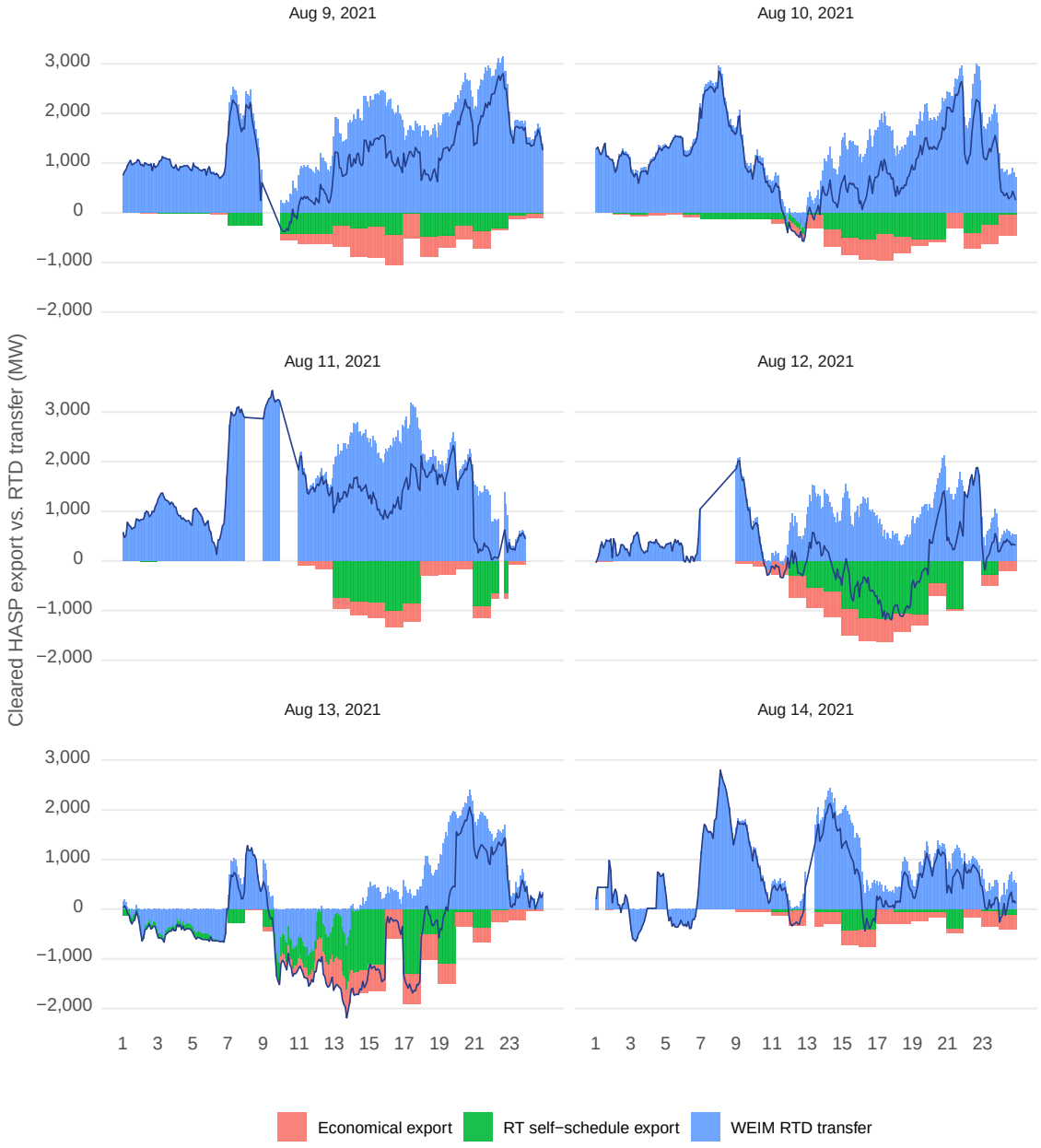

Figure 28: Hourly exports *vs.* WEIM RTD transfers. August sample.

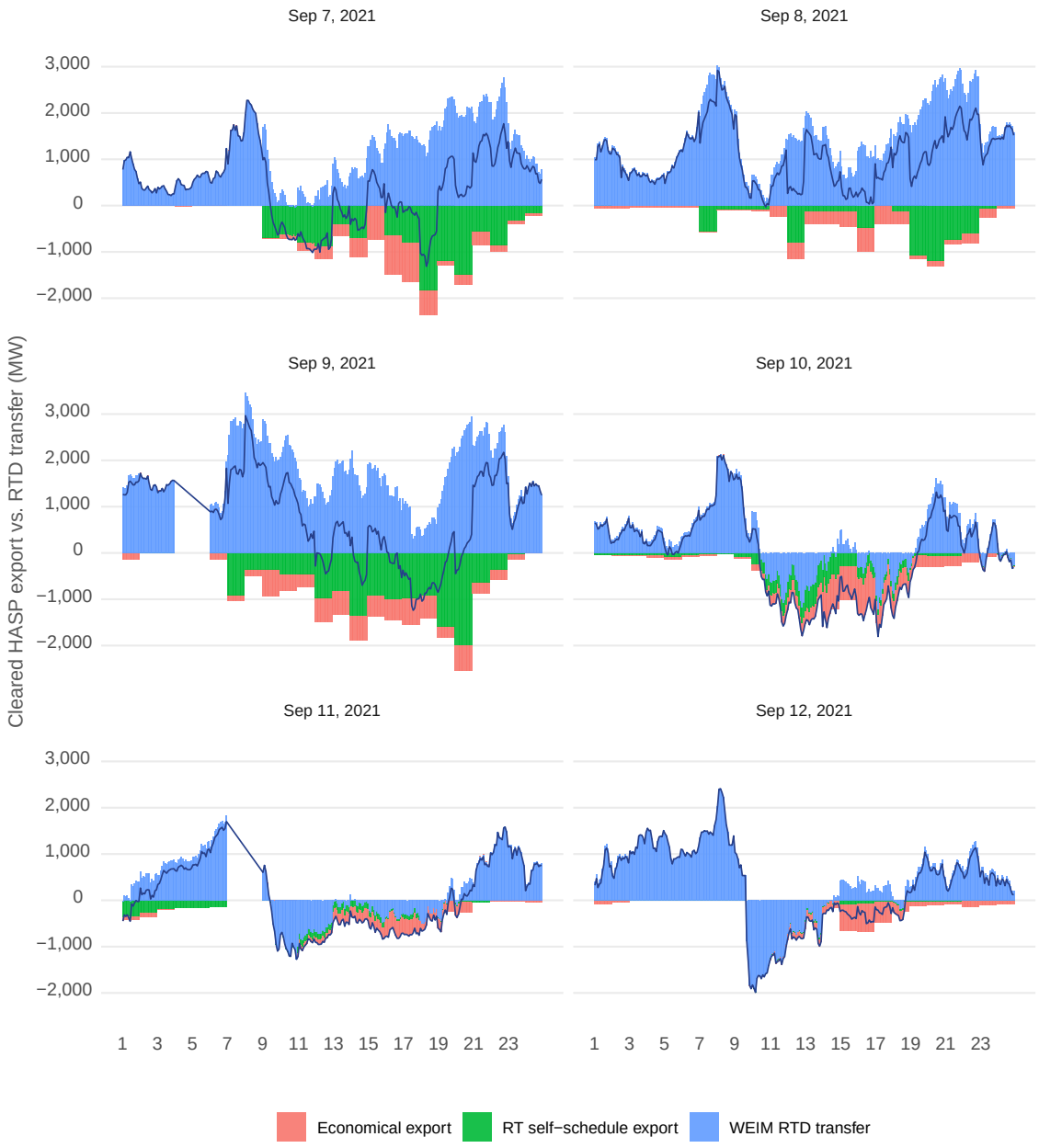

Figure 29: Hourly exports *vs.* WEIM RTD transfers. September sample.

6 Sampled Analysis for July 9 and August 11

With the WEIM utilizing a centralized least-cost dispatch, each BAA's internal resources as well as hourly intertie resources for CAISO are decision variables to determine the most optimal solution across the entire WEIM footprint. The WEIM transfers are the by-product of dispatch imbalances between areas. An excess of supply in one area enables export transfer out of that area, while a deficit of supply in another area represents a WEIM import transfer into that area. It is not feasible to color code what supply is utilized to specifically meet a BAA's load or exports. Aiming to quantifying the interaction between WEIM import transfers and CAISO hourly exports, *i.e.*, what volume of hourly exports are supported by the advisory HASP transfer imports, CAISO designed a counterfactual analysis. The proof of concept is outlined in the following steps.

1. Identify an instance in which the WEIM import transfer into the CAISO BAA saw a reduction from the advisory WEIM HASP transfer into the operationally-binding RTD WEIM transfer in the import direction.

2. Quantify the volume of buyback WEIM import transfers from HASP to RTD. Since RTD transfers are on a five-minute basis while hourly exports are on an hourly basis, take the average transfer of the 12 RTD intervals to have an hourly EIM import transfer associated with RTD. An average for the hour is taken for simplicity, but the minimum or the mid-point value or other variation could be utilized as a representation of five-minute transfers to an hourly basis.

3. Adjust the transfer limits in the HASP market to match the average cleared transfer derived from the RTD market.

4. Rerun the HASP market to achieve a new market solution. This will reflect the new market solution while complying with the reduced WEIM transfer imports into the CAISO BAA. It's important to consider that by imposing reduced transfer limits, the HASP market will attain a different market solution that will change not only the volume of WEIM transfer into the CAISO BAA but will effectively change the dispatch profile across the larger WEIM footprint, including the resource dispatches for the CAISO area.

5. Based on this new HASP solution, estimate the change in hourly exports, as well as any other supply changes, relative to the original HASP solution. This delta in hourly exports effectively represents the level of hourly exports supported by the unrealized WEIM transfer imports from HASP to RTD.

This proof of concept was used with two HASP hours on July 9, 2021 hour-ending (HE) 19 and August 11, 2021 HE19. July 9 is a reference point for the most critical supply conditions observed in 2021, while August 11 represents another summer day with high load but with less critical conditions as the day in July. HE19 was used since it is a good representation of peaking conditions. CAISO expects to run this methodology for a larger data sample similar to the counterfactual analysis done for the load conformance impact analysis and the results will be introduced in the next round of analysis in late may 2022.

Figures 31 and 31 illustrate the summary results of this counterfactual analysis. The dotted line with markers represents the volume of buyback happening for WEIM transfer imports into CAISO from HASP to RTD. For July 9, HASP transfers were on average about 2,280 MW while they were on average about 1,232 MW in RTD. Thus, for each HASP interval, the marker represents the difference of that specific HASP transfer relative to the RTD average of 1,232 MW. The largest buyback happened in the second HASP interval at an amount of 1,660 MW. This represents 1,660 MW less of WEIM

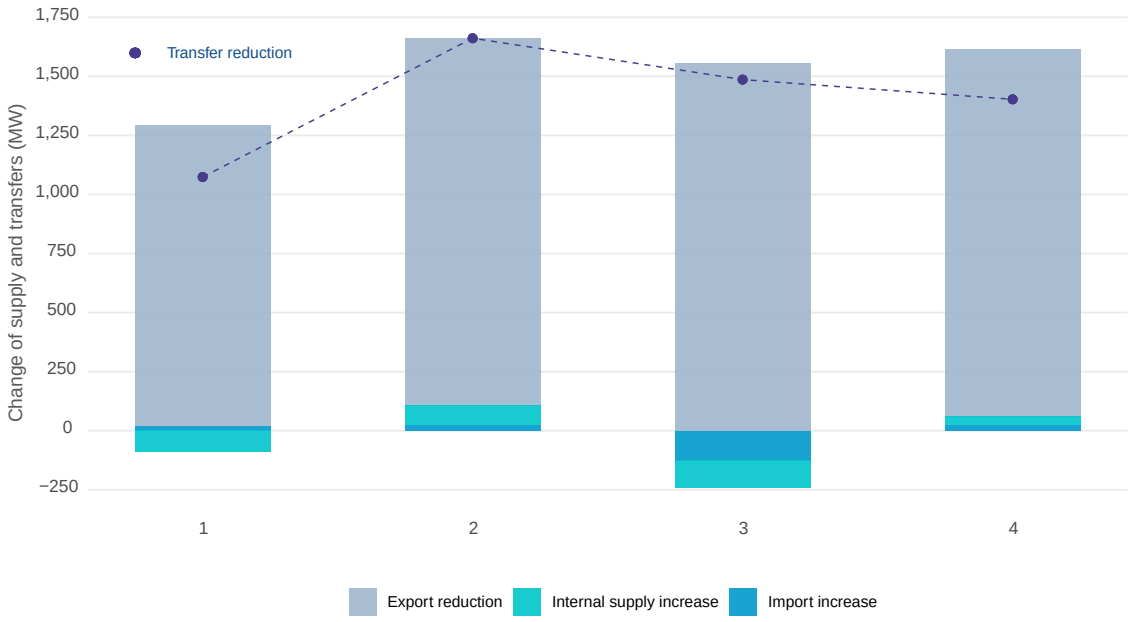

Figure 30: Changes of exports and supply relative to changes in WEIM transfer -July 9, 2021, HE19.

transfer imports that did not realize in RTD but were considered as available supply when clearing hourly exports in HASP. By reducing the transfer limits to match the volume cleared in RTD, the HASP market realizes the solution that can be supported with less WEIM transfer imports into CAISO. For this specific hour, the reduction of WEIM transfer imports into CAISO was largely offset by a reduction of real-time exports. On average, the reduction of WEIM transfers resulted in a reduction of 1,500 MW of real-time hourly exports. That is, the unrealized (buyback) WEIM import transfers from HASP to RTD resulted in CAISO having to support 1,500 MW hourly and real-time exports that were originally intended to be supported by WEIM transfers that did not realize operationally. July 9, 2021 HE19 reflected very tight supply conditions, thus it is expected that by reducing WEIM import transfers, the only solution for the market is to reduce real-time exports since there is no other supply available.

For August 11, 2021 HE19, the outcome is fairly different. WEIM transfers were on average about 2,500 MW in HASP while they were about 2,033 MW in RTD. Figure 31 shows with the dotted line the change in WEIM transfer from the original HASP transfer relative to the hourly RTD transfer average; that change was as high as 1,300 MW in the second HASP interval. The reduction of WEIM transfers imposed in HASP is largely compensated by increasing CAISO's internal resource dispatches. This outcome represents a condition in which CAISO's area still has supply available and reflects economical displacement of supply between WEIM transfer for internal supply. These internal resources are dispatched even if relatively expensive because it is to meet real-time self-schedule exports.

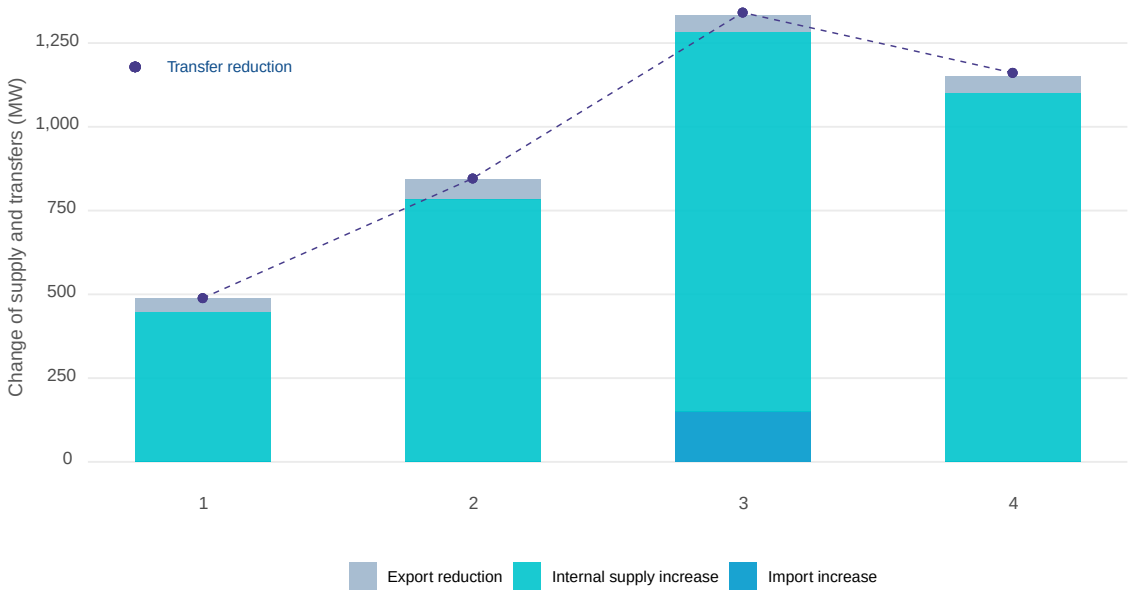

Figure 31: Changes of exports and supply relative to changes in WEIM transfer -August 11, 2021, HE19.