SPP Southwest Power Pool
MARKET MONITORING UNIT

TRANSMISSION CONGESTION RIGHT FUNDING IN SOUTHWEST POWER POOL

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INTRODUCTION

A key benefit of open-access, organized electricity markets is the ability to pool transmission, generation resources, and load in order to optimize dispatch to minimize total production cost across the bulk electric system. This optimization produces two main results: dispatch quantity and locational marginal prices. The locational marginal price is a function of marginal energy, marginal congestion, and marginal losses.[1] Marginal energy and marginal congestion are usually the material components of the locational marginal price. Marginal energy will be identical for every pricing node within the market, whereas marginal congestion often varies from pricing node to pricing node. The variance in marginal congestion brings about the material portion of the locational marginal price differences from pricing node to pricing node. This marginal pricing framework is preferred because it brings about the lowest production cost to serve the load. However, when congestion exists, the lowest production cost solution generates an over-collection, also referred to as congestion rent.

The load contributed the excess funds; therefore, it is reasonable to allocate the congestion rent over-collection back to the appropriate load. Furthermore, when load pays congestion, ratepayers can incur an additional charge over and above the charge tied to a transmission asset's regulated rate of return. Consequently, appropriate allocation of the congestion rent over-collection, can suitably adjust ratepayer cost, and as such, provides reasonable justification supporting the return of these funds back to the ratepayer. By extension, if the congestion rent allocation does not adequately true up this additional cost to load, ratepayer costs can exceed the regulated rate of return. In practice, congestion hedging processes can be effective in returning these funds back to ratepayers, especially if, among other things, transmission congestion rights approach perfect funding adequacy.[2] Therefore, funding adequacy is a crucial component in the utility of congestion hedging products to load.

[1] Integrated Marketplace Protocols, 4.5.4.1, LMP Calculations and LMP components
[2] In this paper, the terms: revenue adequacy, funding, underfunding, and overfunding are interchangeable.

ANALYSIS

FUNDING DRIVERS

1. Persistent modeling differences between the congestion hedging models and the day-ahead market models[3]
2. Material day-ahead market congestion

UNDERFUNDING ISSUE: MODELING

A model represents the topology of the transmission system. The transmission system's topology represents the energy transfer capability of the transmission system.[4] The system's energy transfer capability represents the collective operating limits of the individual transmission elements within the transmission system. The collective operating limits of the individual transmission elements within the transmission system manifest as modeled constraints.[5] The modeled constraints are respected in the day-ahead market's security constrained economic commitment and dispatch algorithms.[6] Following the commitment optimization, the day-ahead market's dispatch algorithm adjusts each generator's dispatch, among other things, to find the lowest-cost feasible solution.

Key takeaway: The day-ahead market models directly influence the day-ahead market commitment, dispatch, and locational marginal prices.

Similar to the day-ahead market's optimization the congestion hedging allocations and auctions employ a similar optimization, referred to as the simultaneous feasibility test.[7] In the congestion hedging optimizations, participants submit nominations, bids, and offers. These nominations,

[3] Inclusive of parallel flow
[4] Topology – the culmination of generators, lines, and other system elements both in and out of service
[5] Integrated Marketplace Protocols, 4.3.1.2.1, DA Market Execution
[6] Integrated Marketplace Protocols, 3.1, Energy and Operating Reserve Markets
[7] Integrated Marketplace Protocols, 5.3.3 Simultaneous Feasibility

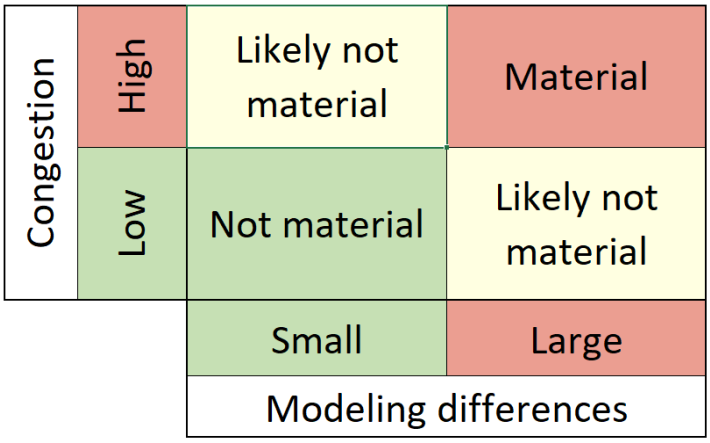
bids, and offers are workably comparable to the load bid and generation offered in the day-ahead market in that they too load and relieve constraints.

Key takeaway: The congestion hedging models directly influence the allocation awards, auction awards, and auction clearing prices.

MODELING DIFFERENCES AND FUNDING MAGNITUDE IN THEORY

The financial magnitude of underfunding, or overfunding, stems from both the differences in feasible transaction volume and the locational congestion prices assessed to the locational transaction volume.

Figure 1 Underfunding materiality grid



If congestion is low, and modeling differences are small, the transmission congestion right (TCR) settlements and the TCR underfunding will be immaterial. If congestion is low and modeling differences are large, the TCR settlements will be modest and the TCR underfunding will probably not be material. If congestion is high and modeling differences are small, the TCR settlements will be sizeable but the TCR underfunding will probably not be material. If congestion is high and modeling differences are large, the TCR settlements will be sizeable and the TCR underfunding or overfunding will be material. In recent years, the Southwest Power Pool funding, aggregately underfunding, is material.

MODELING DIFFERENCES AND FUNDING MAGNITUDE IN PRACTICE

The underfunding is material, because congestion is frequently quite material, as are the differences in feasible transaction volume between the congestion hedging allocations and auctions and the day-ahead market. Figure 2 displays the daily congestion rent along with congestion hedging proxy constraint flows as a percentage of day-ahead market constraint flows.[8] The line is a reference line. It displays a perfect 100 percent match between congestion hedging proxy constraint flows and day-ahead market constraint flows.

Figure 2 Day-ahead congestion with TCR flows compared to day-ahead market flows, daily[9]

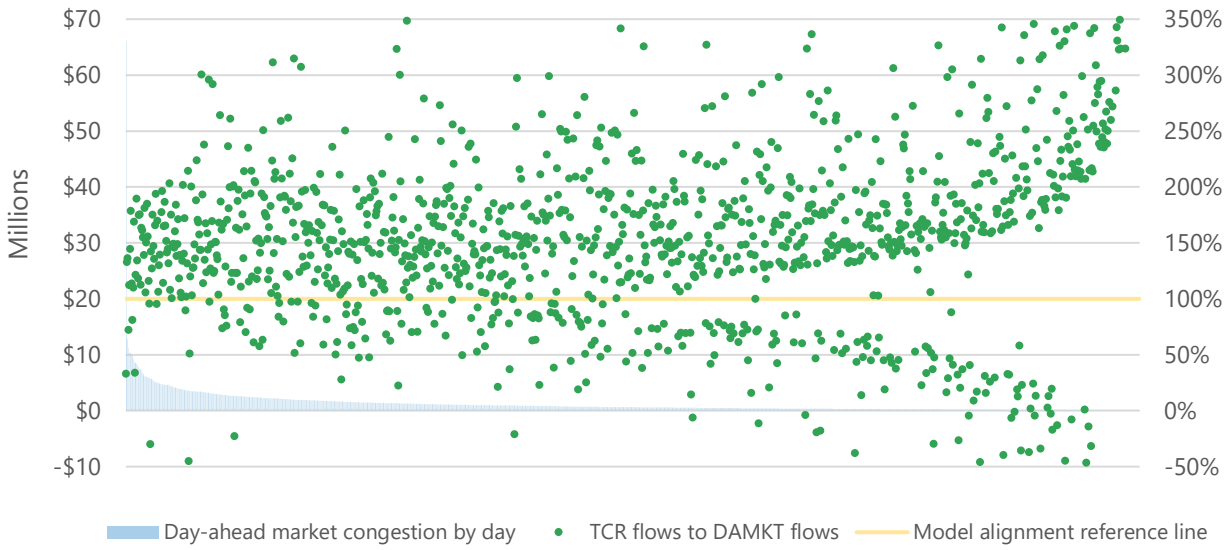


Figure 2 shows perfect model alignment between the congestion hedging models and day-ahead market models is extremely infrequent and day-ahead congestion is often material. The

[8] We calculate the TCR flows by translating the day-ahead constraints into TCR proxy constraints. Specifically, we use the day-ahead market constraint settled flows, the constraint level TCR funding dollars, and the day-ahead constraint prices to compute TCR proxy constraint flows. This calculation method is effective, even if the activated constraints differ between the congestion hedging models and the day-ahead market models.

[9] Date range January 2016 through May 2022. Data set includes daily funding by constraint that is greater than $10,000 or less than -$10,000, day-ahead market constraint flow > 10 MWh or < -10 MWh, and those constraints priced with the normal sign convention.

time between the congestion hedging processes and the relevant day-ahead markets essentially guarantees modeling inconsistencies. Because allocations and auctions can occur many days or months before the related day-ahead market hours occur, what is known about system capability at the time of the allocations and auctions can differ materially from that which may be known immediately prior to the relevant day-ahead market operating days.[10] Unknown future events can lead to awards that were feasible during the allocations and auctions at one level of transfer capability, but are no longer feasible in the day-ahead market at a lower transfer capability. The inconsistencies between these solutions manifest as modeling differences, and in this particular example, TCR underfunding.

Figure 3 TCR funding with TCR flows compared to day-ahead market flows, daily

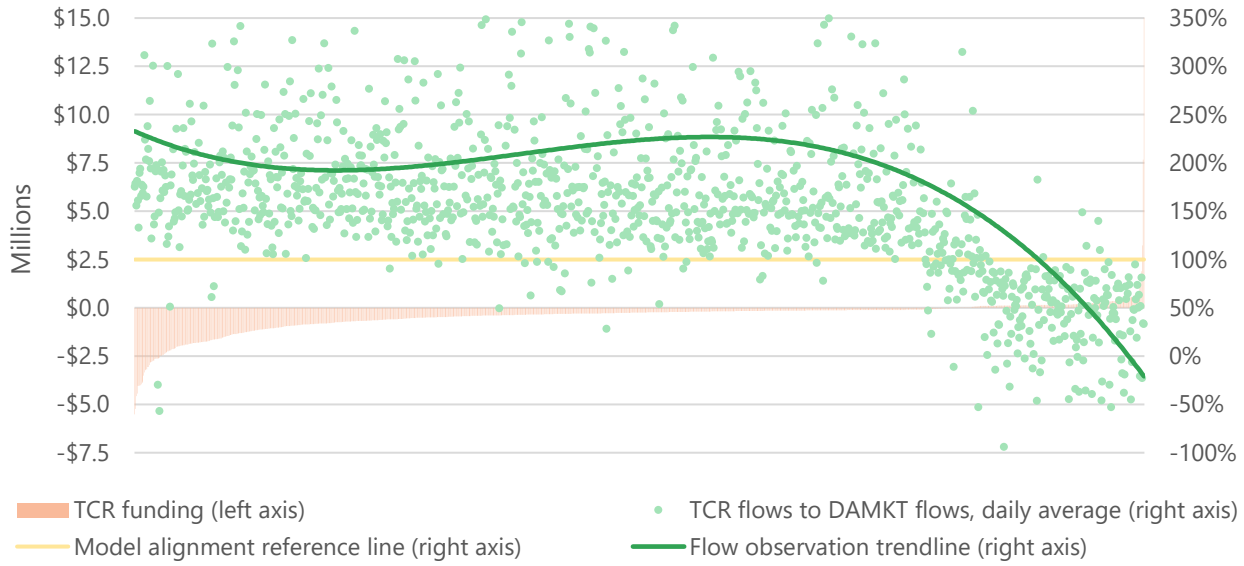


Figure 3 shows TCR funding in relation to the model alignment between the congestion hedging models and day-ahead market models. In general, as model alignment approaches 100 percent, the TCR funding becomes much less underfunded or overfunded.[11]

[10] Integrated Marketplace Protocols, Exhibit 5-1: LTCR/ARR Allocation and TCR Auction Processes Timeline
[11] The underfunding observations below 100% or overfunding observations above 100% are skewed into those ranges by other constraint level observations within the day.

Figure 4 TCR funding with TCR flows compared to day-ahead market flows, daily

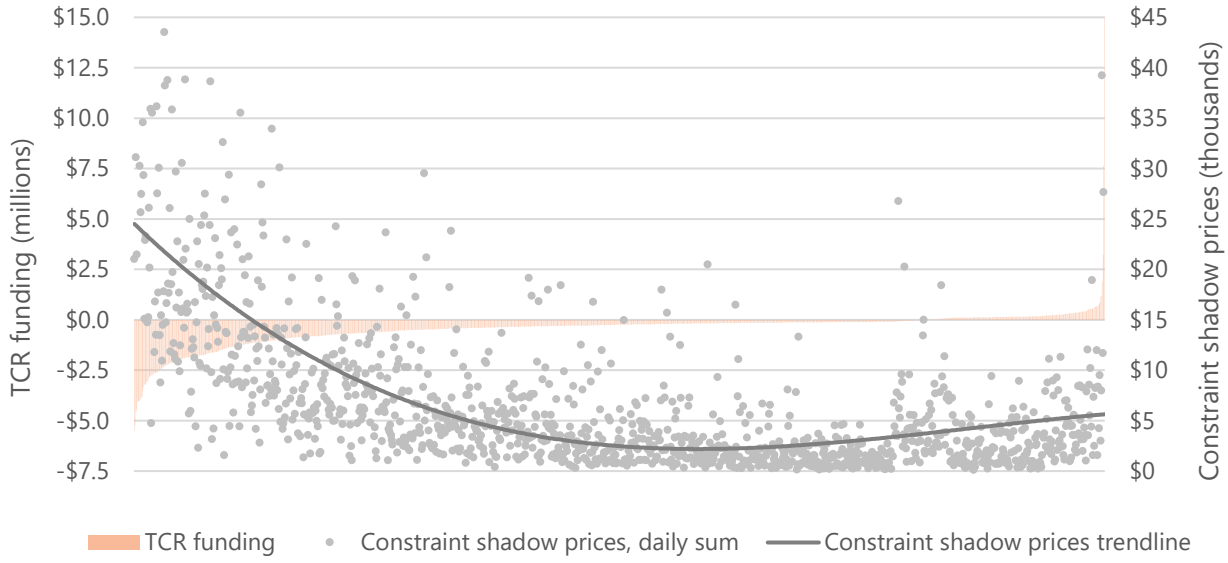


Figure 4 highlights the relationship between constraint prices and TCR funding. In instances where model alignment between congestion hedging and day-ahead market is relatively close, but underfunding or overfunding is material, correspond with periods of elevated congestion and constraint prices.

Examples of factors that are unknown at the time of allocation and auction but impact both feasible transaction volume and day ahead congestion are outages, rating changes, and parallel flow assumptions in the various optimizations.[12] When these types of events reduce the system's transfer capability in the day-ahead market, the congestion collected from the underlying day-ahead market transactions, will not be sufficient to fully settle the TCRs previously awarded.

ASSET VALUATION AND PARTICIPANT BEHAVIOR

TCR underfunding is a financial risk. This risk motivates participants to account for potential modeling inconsistencies and the resulting potential funding shortfalls in their participation. For

[12] 2020 Annual State of the Market Report, 5.2.2.3 Transmission outage modeling

example, when participants self-convert awarded auction revenue rights (ARRs), and as an example, estimate eighty-five percent TCR funding, participants must increase their awarded positions by roughly 18% to maintain the dollar equivalent of one hundred percent funding.[13]

Furthermore, when participants estimate future cash flows and discount those cash flows to their present value, they will account for a potential underfunded future cash flow. If auction participants' funding estimate is eighty-five percent, participants will likely pay fifteen percent less than they otherwise would under a one hundred percent funding assumption.

As a result, participants opting to hold ARRs will receive less, and the ARR closeout[14] will be smaller given identical nomination and self-conversion behavior.[15] Furthermore, as underfunding becomes more volatile and negatively skewed, market participants will reduce their risk by reducing their bids. When participants collectively lower the prices they bid, the result is lower present value estimates, lower auction clearing prices, lower auction revenues, and lower excess auction revenues.

[13] 15 / 85 = 17.65%.
[14] The ARR closeout is often referred to as excess auction revenues
[15] Identical behavior here means the residual auctionable capacity is identical, only the price paid for the auctionable capacity would change

Figure 5 Auction clearing prices with identical gross margin in funding assumptions

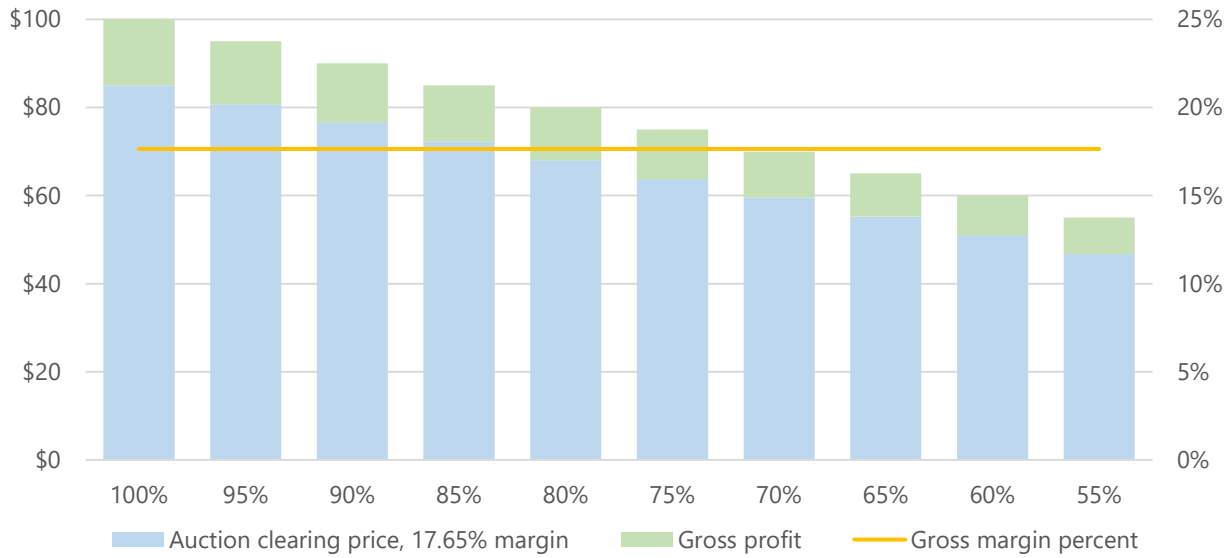
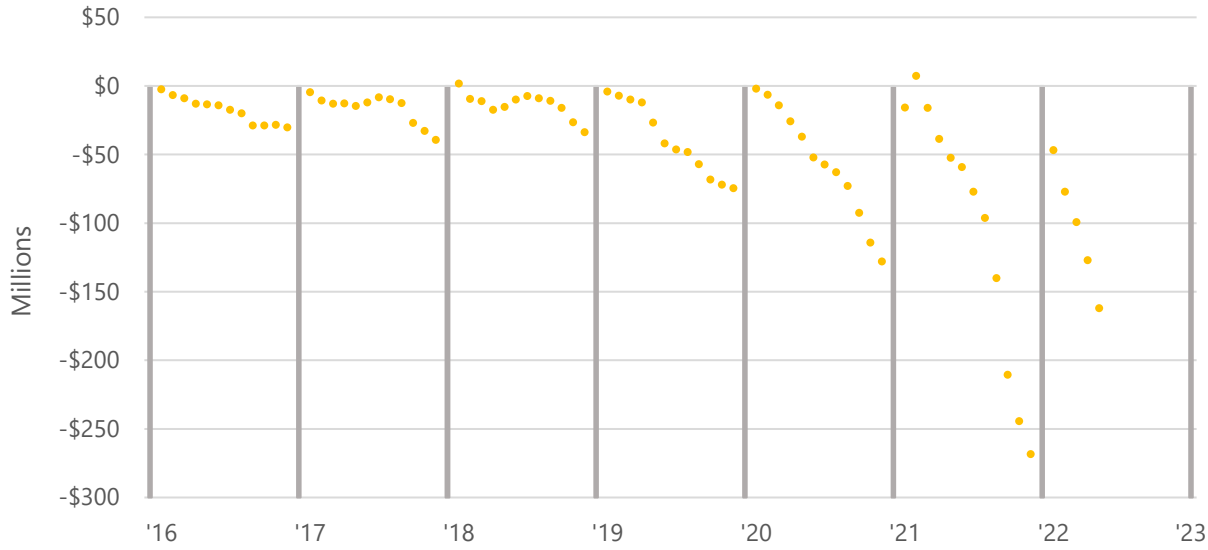


Figure 5 shows the potential auction clearing price given an identical risk premium adjusted for various underfunding assumptions. It also highlights the potential gross profit given a funding outcome identical to participants' expectations, all else equal. In these scenarios, the gross profit margin is unchanged.

NATURE AND MAGNITUDE OF THE FUNDING PROBLEM

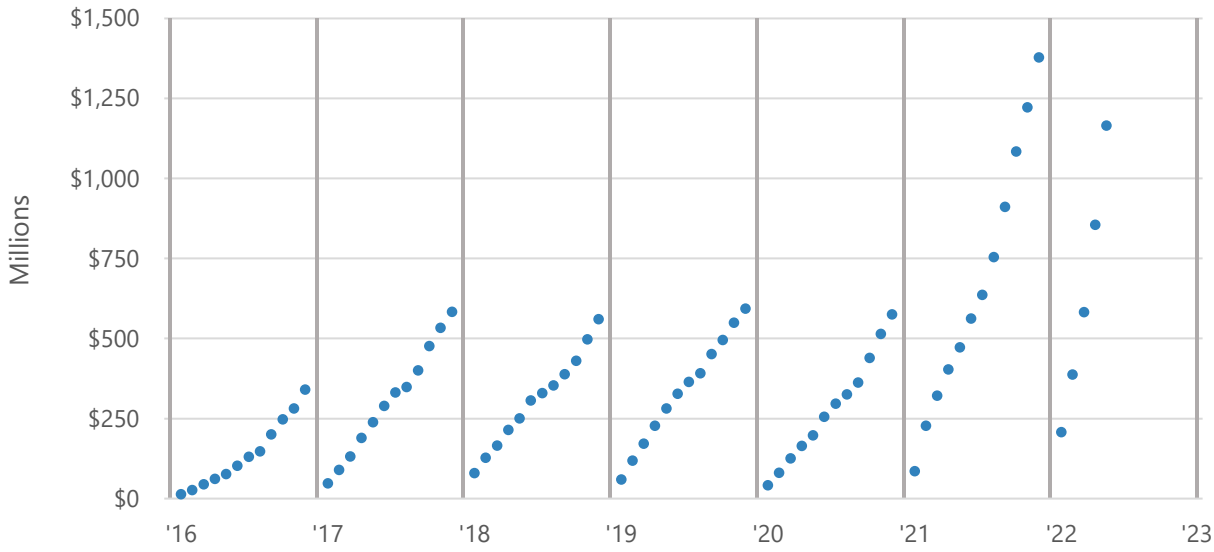
The nature of the underfunding problem has not changed. Modeling differences and congestion drove funding outcomes at the start of the Integrated Marketplace and still do so today. However, the magnitude of the problem has materially increased over time. The increase in the problem's financial magnitude can be largely attributed to the increase in congestion.

Figure 6 Cumulative TCR funding, calendar year[16]



Comparing Figure 6 to Figure 7, the relationship between congestion and TCR funding appears strong, and inversely related. To that end, the correlation between congestion and TCR funding is roughly -0.73. In SPP, as congestion increases, underfunding also tends to increase.

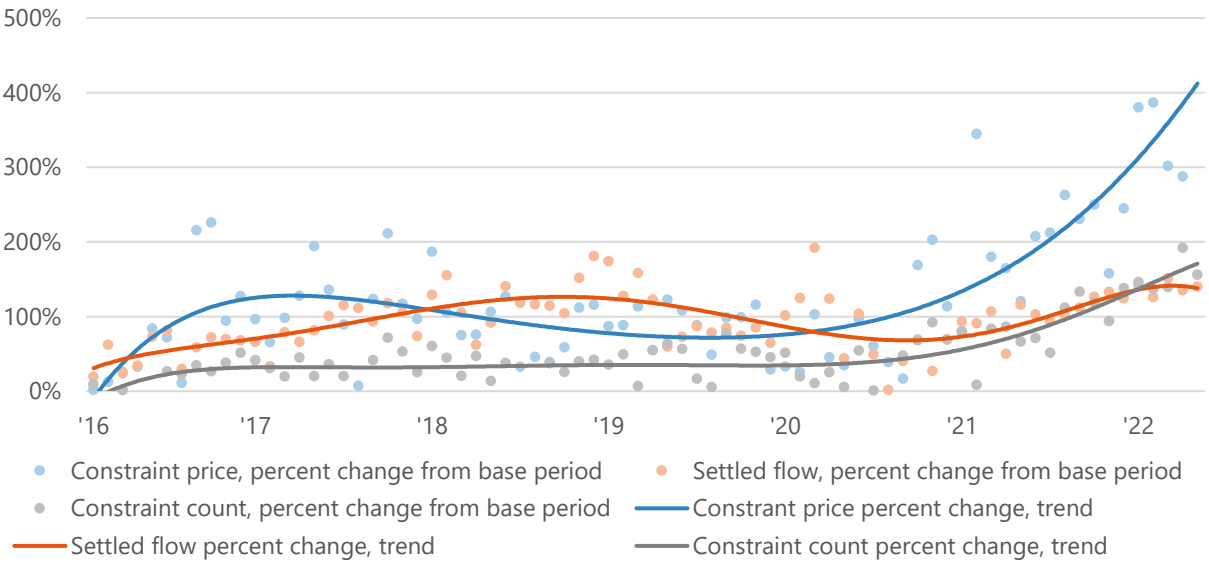
Figure 7 Cumulative day-ahead market congestion, calendar year[17]



[16] Data through May 2022.
[17] Data through May 2022.

Congestion has increased significantly over the last eighteen months for three primary reasons: the average number of day-ahead market priced constraints increased, the average day-ahead market constraint prices increased, and the average day-ahead market constraint flows increased. The driving factors behind these trends include increased wind generation, increased wind generation on the margin, and higher fossil fuel prices. With respect to each contributing factor over the full study period: constraint prices and priced constraints increased materially from their previous peaks. However, settled flows have not exceeded their previous peak.

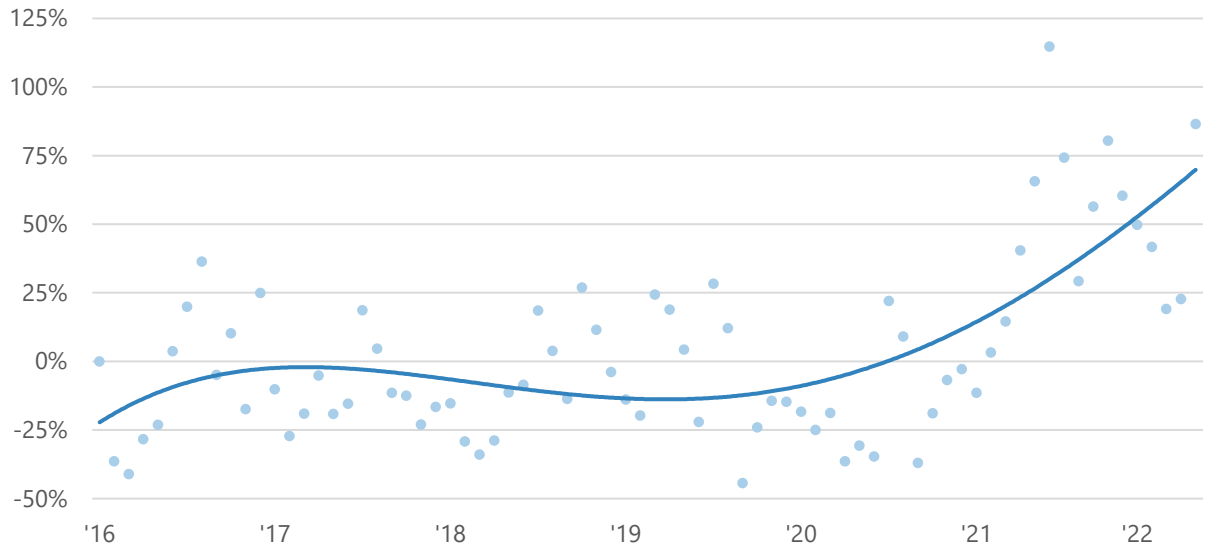
Figure 8 Percent change, average monthly constraint price, and average monthly settled flow by year



The similarities in monitored element voltages for the most frequently activated and priced constraints drive the relatively narrow variance in settled flows. Similar monitored element voltages generally translate into similar constraint limits. Furthermore, these constraint limits represent power flow capability, and by extension effectively place a cap on settled flows. Constraint count increases tend to trend with periods of increased renewable penetration prior to increases of similar magnitude, in the system's regional transfer capability. A constraint's price represents the cost difference to serve load, if that constraint's limit is increased by one megawatt. This cost difference is commonly referred to as redispatch cost. When system assets can be redispatched, the constraint price represents the difference in each injection's shift

factor[18] adjusted flow on the constraint, multiplied by the respective locational marginal price. Said another way, if load could have been served through nodal injections with lower locational marginal prices, in place of nodal injections with higher locational marginal prices, given a one-megawatt increase in constraint limits, there will be positive congestion.

Figure 9 Marginal price difference between the highest and lowest marginal cost fuels, weighted by marginal time, by month[19]



The key takeaway from Figure 9 is this: the difference between high marginal cost and low marginal cost resources, adjusted for time on the margin, increased materially over the last 18 months. These marginal cost differences and these resources' time on the margin affect constraint prices, and by extension congestion rent.

Specifically, periods of elevated wind penetration often coincide with increases in the number of priced constraints, as well as the magnitude and volatility of constraint flows. Areas well-suited for wind development often do not reside in close proximity to load. These geographical relationships cause some regions to have material excess dispatchable online generation. The

[18] Integrated Marketplace Protocols, 4.5.4.1.2 Marginal Congestion Component Calculation, specifically determinant $Sens_{ik}$ as shift factor.
[19] Due to the effects of the winter weather event, February 2021 has been omitted because it materially skews the data.

excess power will flow toward the load centers, but cannot always serve the load due to limited transmission capacity. To protect the transmission system, wind units and other generation types in generation rich regions, will often be dispatched below their interval specific production capability. The redispatched generation is frequently wind, and the common replacement for 'wind lost' is natural gas.

ADDRESS ROOT CAUSES: IMPROVE MODEL ALIGNMENT AND REDUCE SYSTEM CONGESTION

As demonstrated, funding adequacy problems stem from modeling inconsistencies between the TCR auction and the day-ahead market. To be clear, the MMU acknowledges perfect model alignment is a practical impossibility. However, it is the MMU's opinion that a material improvement over the current model alignment is achievable. Over the study period, roughly 95 percent of the day-ahead market outages were not included the TCR auction models. Material improvements in model alignment can be accomplished through modification of the ARR/TCR market structure and/or the outage coordination process.

IMPROVE MODEL ALIGNMENT: REDUCE TIME BETWEEN AUCTIONS AND DAY-AHEAD MODEL

The current market design, with both annual and monthly auctions, attempts to account for the uncertainty in the future system's transfer capability. Currently, the full system capability known at the time of the annual allocation and auction is not fully allocated or sold in those processes. Additional capacity is reserved for subsequent monthly allocations and auctions.[20] This staggered approach helps to account for the possibility of a future event, or series of events, which may create inconsistencies between the congestion hedging models and the related day-ahead market models.

[20] Integrated Marketplace Protocols, Exhibit 5-2, ACR Auction Process Summary

Recommendation: Reduce the time between the congestion hedging solutions and the related day-ahead market solutions.

IMPROVE MODEL ALIGNMENT: SHORTEN PRODUCT DURATION[21]

In addition to shortening the time between auctions and related day-ahead markets, a shorter product duration could also help the funding problem. For example, next day TCR products would be much more likely to align with the next day-ahead market model. The Integrated Marketplace's other primary hedging mechanism, virtual energy, has this same timeline. In addition to the improvement in modeling alignment with the next day market cases, alignment in product duration between virtual energy and TCRs could aid participants in achieving more tailored and focused hedges. While many participants tend to prefer longer-term congestion hedges, insufficient funding offsets the utility of those hedges. Because short product tenors are likely to result in improved funding, participants may be willing to substitute longer tenors for shorter tenors for some portion of their portfolio.

Recommendation: Enhance the current market design by preserving a material amount of capacity for new shorter duration congestion hedging products.

IMPROVE MODEL ALIGNMENT: BALANCE OF PLANNING PERIOD MARKET DESIGN[22]

Balance of planning period market design takes the current annual and monthly structure a step further. This market design increases the number of auctions for the same product duration. Additionally, balance of planning period auctions systematically release system capacity to be auctioned during each of the more frequent auctions. This market design increases the

[21] Duration used here is better defined as tenor, but is less commonly known and used. Tenor refers to the length of time remaining before a financial contract expires.
[22] A balance of planning period market design is most effective for products whose settlement is tied to events, which occur materially after the initial allocation and auction date.

probability of model alignment because more of the system's capacity is sold closer to the underlying day-ahead markets. When capacity is held back for these later allocations and auctions, the uncertainty regarding the future day-ahead market topology decreases, which increases the probability of model alignment.

Recommendation: Implement a balance of planning period market design.

IMPROVE MODEL ALIGNMENT: CREDIT POLICY CONSIDERATIONS

Additional benefits associated with balance of planning period market design carry over into other SPP functions. Specifically, the credit policy generally associated with this market design differs from the current credit policy. Under the current policy, the financial security required to participate in the TCR auctions is based, among other things, on historical market settlement. [23] In contrast, mark-to-auction in conjunction with a balance of planning period market design, incorporates participants' collective assessment of the expected future settlement by using the most recent clearing prices to update the previously effective financial security requirements. By increasing the frequency of allocations and auctions, for the same product period, auction participants more frequently estimate the future value of TCRs.

These updates in future value expectations aid the SPP credit department, and market participants, in calibrating exposure estimates. In turn, these exposure estimates will trigger fluctuations in the required financial security. These changes in required financial security may aid in collecting additional financial security prior to a default. Additionally, this policy framework may help participants post financial security in a magnitude more closely resembling the market's collective valuation assessment. Furthermore, due to participants collectively accounting for known information in their auction participation, the SPP credit department's use of this information in setting financial security requirements would satisfy an outstanding

[23] SPP Tariff, Attachment X

Annual State of the Market recommendation.[24] In addition to satisfying the recommendation, the lack of a mark-to-auction credit policy framework was identified as a contributing factor to a large default in another region.[25] For these reasons, the SPP credit policy would be materially improved by implementing mark-to-auction in conjunction with a balance of planning period market design.

Recommendation: Incorporate information from the balance of planning period TCR auctions into the SPP credit policy.

REDUCE SYSTEM CONGESTION: OUTAGE INCENTIVES

The MMU acknowledges zero congestion as a practical impossibility. However, there are several ways to relieve congestion, which have been previously supported by the membership. For example, there are numerous examples where the membership has willingly upgraded the transmission system to increase transfer capability and alleviate congestion. Some of the best examples include the more than $10 billion in transmission buildout, the Woodward phase-shifting transformer, and the Integrated Transmission Planning cost/benefit threshold.[26]

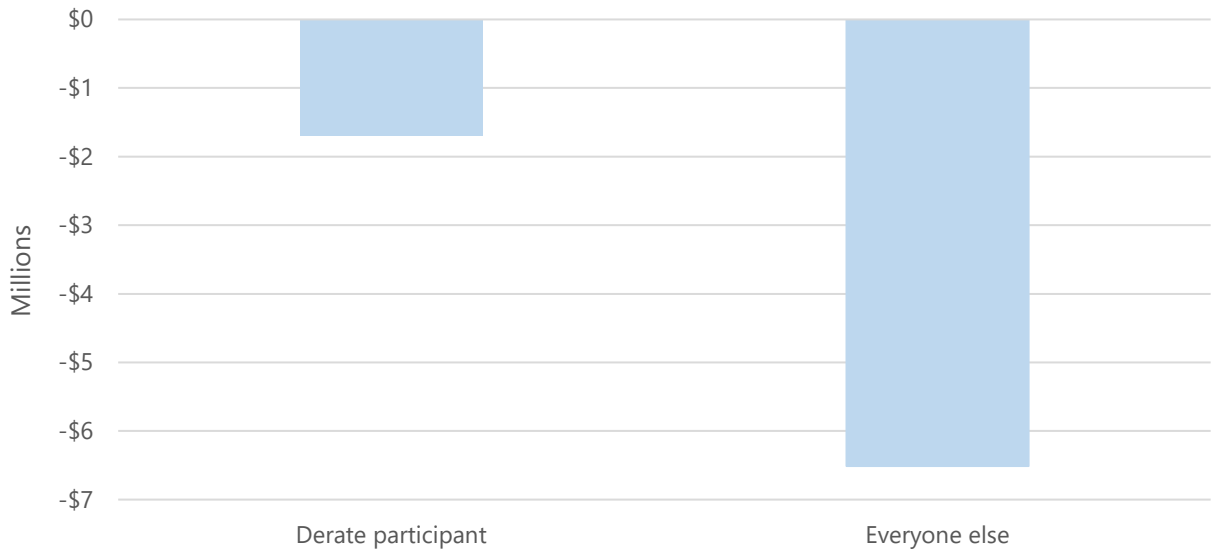
As mentioned previously, the transmission system's topology represents the energy transfer capability of the transmission system. The topology stems from the collective group of in-service transmission elements, accounting for outages and derates. In addition to contributing to model alignment issues, outages and derates materially contribute to the location and magnitude of system congestion. Additionally, because funding is levered to modeling differences through congestion, any congestion resulting from an outage or derate, can have a significant impact on funding quality. Furthermore, outages and derates stem from individual

[24] 2020 Annual State of the Market Report, Recommendation 2018.2, Enhance credit rules to account for known information in assessments
[25] https://www.pjm.com/-/media/library/reports-notices/special-reports/2019/report-of-the-independent-consultants-on-the-greenhat-default.pdf
[26] SPP Integrated Transmission Planning Manual, Section 5.3.1

rather than collective action, but underfunding is socialized among all market participants holding TCR positions.[27]

For example, the MMU has observed a single derate as the root cause of more than $8 million dollars of underfunding over roughly 60 days.

Figure 10 TCR underfunding breakdown associated with a derate



To be clear, this derate was not driven by physics, but by a participant's unilateral policy change. The participant who submitted the derate bore roughly $2 million of this underfunding, but benefited overall from the action. Whereas, the more than $6 million residual underfunding was borne by the group of TCR holders who did not submit the derate.

One way to address these issues is to create incentives within the outage coordination process and the day-ahead market. Ideally, these incentives would motivate participants to evaluate their behavior in the context of their own cost/benefit along with the cost/benefit to the market more broadly. More simply, if a participant's behavior creates a market externality, that participant should perhaps be financially responsible for all, or part, of that externality's financial impact. In support of this approach, other wholesale electricity markets have similar policy

[27] SPP Integrated Marketplace Protocols, 4.5.8.15, Transmission Congestion Rights Daily Uplift Amount

frameworks.[28] While a policy of this type would complicate the outage coordination process in addition to other SPP processes, the potential for congestion alleviation and improved model alignment will very likely dwarf the additional cost and complication. Additionally, an outage incentive framework would serve to satisfy an outstanding Annual State of the Market recommendation.[29]

Recommendation: Create and implement an outage incentive framework, which motivates participants to consider the system wide impacts in outage decisions.

REDUCE SYSTEM CONGESTION: CREDIT BENEFITS

TCR total potential credit exposure decreases as product duration and position size decreases. Said another way, a TCR position with one-day exposure carries significantly less risk than the same TCR position with a year of exposure. Regardless of the product duration, reducing congestion decreases the risk inherent in all ARR and TCR products. Just as funding financial magnitude is levered to congestion, the magnitude of TCR credit exposure is also levered to congestion. In the extreme case of no current or future congestion, ARRs and TCRs of all durations and position sizes would carry no credit risk.

It is reasonable to anticipate a decrease in congestion rent with enhanced outage incentives. In terms of potential benefit, had outage incentives changed the timing and duration of those implemented, and if those actions had resulted in as little as a five percent reduction in day-ahead market congestion rent, the calendar year 2021 day-ahead congestion would have declined by nearly $69 million.

Recommendation: Continue to increase the transfer capability and resiliency of the transmission system to reduce congestion. While there are multiple ways this can be accomplished, the MMU supports implementing dynamic line ratings, evaluating the benefits of

[28] NYISO Tariff, Attachment N – Congestion Settlements Related to the Day-Ahead Market and TCC Auction Settlements
[29] SPP Annual State of the Market Report – 2021, Recommendation 2020.1

system reconfiguration, and improving the Integrated Transmission Planning process to enhance assumptions and scenarios to account for a broader range of outcomes.

CONCLUSION

For these reasons, funding adequacy is a crucial component in the utility of congestion hedging products to load. While the market monitor acknowledges systematically achieving perfect funding is not possible, we believe systematically achieving material funding improvements is possible. These recommended market designs and policy frameworks are ways to bring about that improvement. Given revenue adequacy's importance, the MMU strongly recommends the implementation of these, or workably similar policies. The MMU further recommends SPP consider including these recommendations into the initiatives road map as a high priority.