



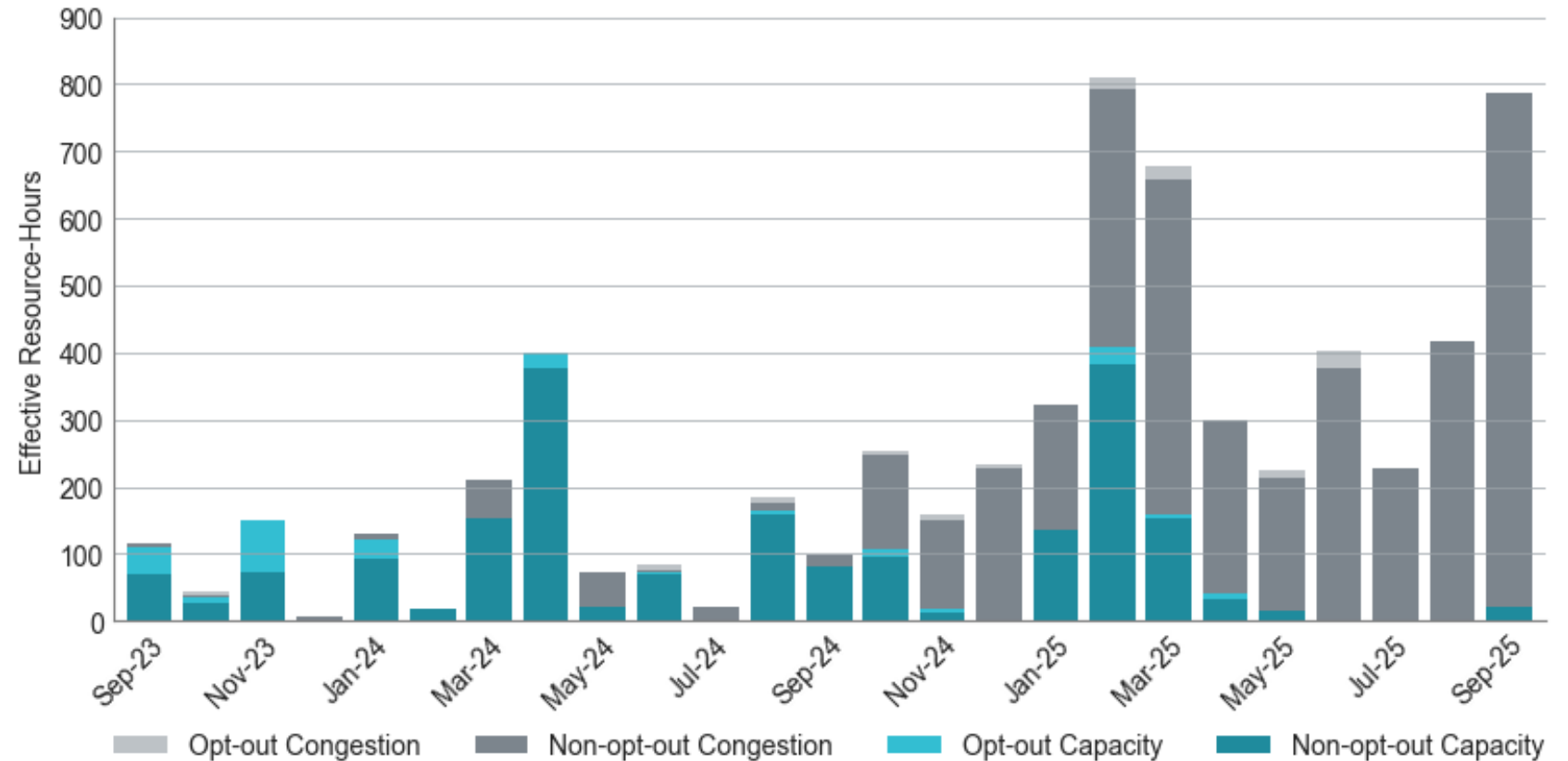
Discussion on Recent Trends in Reliability Unit Commitment (RUC)

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Recent Trends in Reliability Unit Commitment (RUC) Activity

- RUC Activity has increased over the past year and has been mostly attributed managing congestion



Stakeholder Questions

Why is a Resource being committed by RUC when it has a small shift factor for the constraint?

Why is a Resource being committed by RUC if the constraint is not overloaded or congested in real-time?

Key Takeaways Today

There can be multiple simultaneous factors leading to a single RUC commitment in the optimization. Many RUCs nominally “for congestion” may also be driven by interdependent capacity needs.

The shift factor (SF) for the RUC-instructed resource is not particularly relevant on its own for managing congestion. What matters is that the SF for the RUC-instructed resource is **less hurting** than the SFs for the generators it is replacing.

RUC solves the system for future hours using the key input of **Resource plans** indicated by the Current Operating Plan (COP) snapshot **at the time that RUC executes**. QSE COP submissions which do not accurately reflect future resource availability plans can lead to discrepancies between what RUC ‘sees’ in future hours v. what occurs in real-time (including future Resource availability and State-of-Charge (SOC))

Discussion Items

Understanding the RUC Process

RUCs for Capacity *and* Congestion

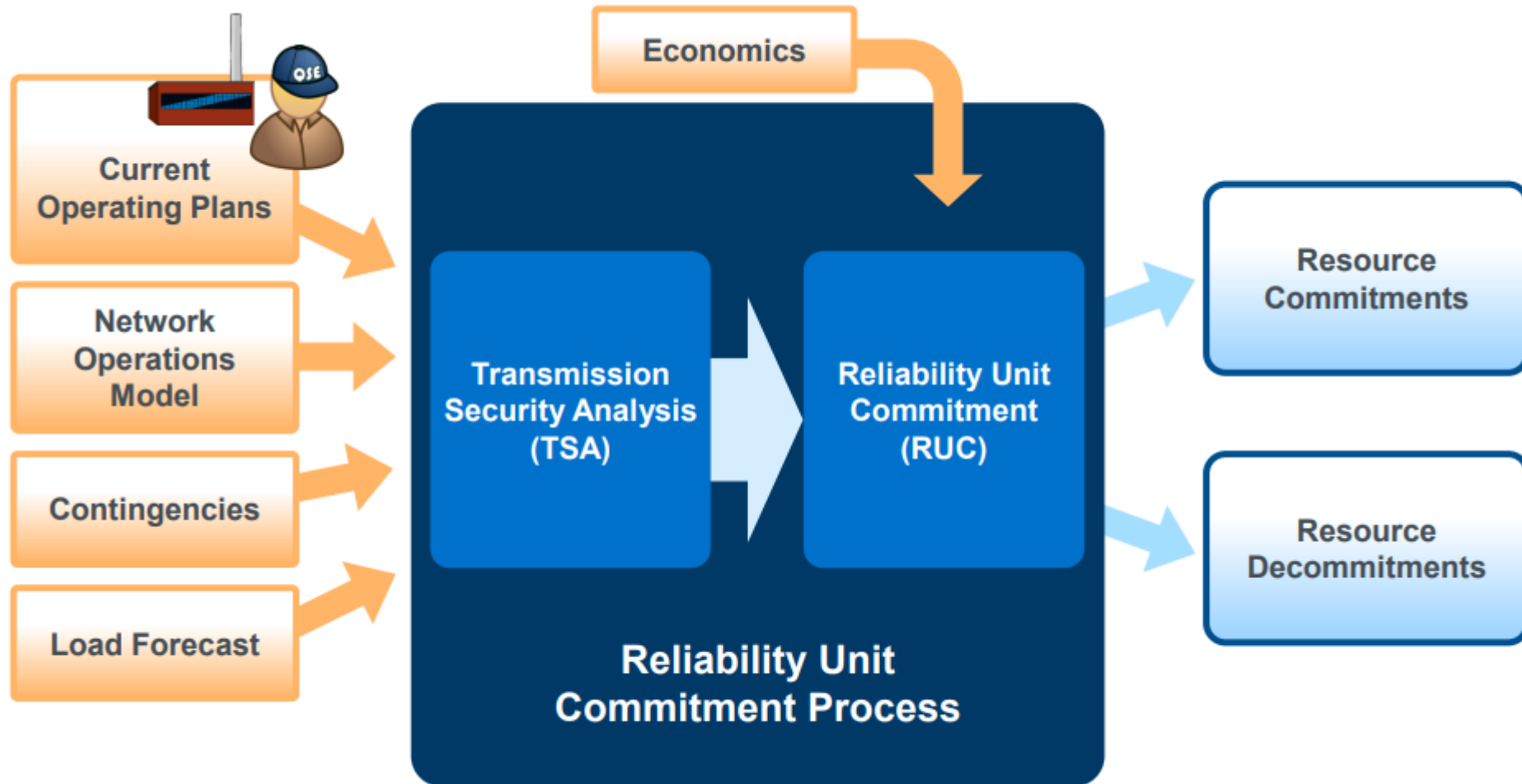
- High Ancillary Service Limit (HASL) Margin
- Understanding application of Shift Factors

Current Operation Plans and RUC

- Energy Storage Resource (ESR) SOC under NPRR 1186
- Dispatchable Resource Availability/Plans for Future Hours

Summary, Discussion and Next Steps

Understanding the RUC Process



Understanding the RUC Process

There is often not a single reason why the RUC engine is recommending certain units based on the optimization outputs

- A RUC dispatch will curtail generation in the South to manage congestion while **simultaneously** committing units in the North to achieve power balance.
- Operator decisions to select/deselect units recommended for commitment and attribute a reason for the RUC are based on deep operational experience and heuristic analysis of shift factors.
- The Operations log may show a single reason e.g. 'capacity', 'constraint name', however in reality there could be multiple simultaneous factors leading to the RUC commitment.

RUCs for Capacity *and* Congestion

When HASL Margin is positive

- The power balance constraint is **satisfied**
- RUC can manage *some* congestion by curtailing capacity ‘stuck’ behind binding constraints and replacing it with excess HASL from other online units

When HASL Margin is negative

- The power balance constraint is **violated**, even before factoring in congestion
- There is likely some capacity ‘stuck’ behind congestion. RUC will need to curtail that capacity and replace it with RUC-instructed capacity

- HASL Margin (MW) compares forecasted load and HASL (MW) for online units.
- The RUC optimization will recommend the lowest cost combination of units that resolves both the:
 1. power balance constraint violation, and
 2. network constraint violation

RUC by Reason in 2025

- **From January 1 to October 31 there were 821 total HRUC Commitments and HRUC Manual Overrides**
 - 657 (80%) of the HRUC Commitments and HRUC Manual Overrides were labeled as actions taken to relieve congestion
 - 553 (67%) of the HRUC Commitments and HRUC Manual Overrides were labeled as actions taken to relieve congestion on the South Texas GTCs, specifically E_PATA or E_PASP
- **79% of HRUC Commitments and HRUC Manual Overrides attributed to congestion spanned an hour when the HASL Margin was negative (i.e. HASL was less than Load Forecast)**
 - Many of these RUCs were driven by capacity needs, in part or entirely.
- *Next slides will help explain the evaluation of Shift Factors in RUC*

Shift Factor (SF) Overview

Single Reference SFs

- Used in DAM and RUC
- Single Reference SF for a Resource A – Constraint B pair represents the change in power flow through Constraint B if 1 MW is injected at Resource Node A and entirely consumed at the reference bus (Comanche Peak).
- Not intuitive – the Single Reference SF for the Comanche Peak Nuclear Power Plant is zero for all constraints.
- What matters is **the relative difference** between the single reference SF for Resource A and the SFs for other resources or electrical buses on the system.

Load Distributed SFs

- Used in SCED
- Same methodology as Single Reference SFs, except that 1 MW injection is consumed at all network nodes weighted by the actual load at the nodes at the time of interest, rather than being entirely consumed at Comanche Peak.
- Magnitude and sign of Load Distributed SFs can be more intuitive than Single Reference SFs when interpreting the data.

- **While shift factors are informative and Load Distributed SFs can be more helpful than Single Reference SFs in this context, considered in isolation they will not give us the whole picture.**

Using SFs to Analyze RUC Commitments

- When the RUC optimization recommends a resource to help resolve a violation of a network constraint, it is curtailing the generators that were overloading the constraint and replacing that curtailed generation with the RUC-instructed resource.
- Neither the Single Reference SF or the Load Distributed SF for the RUC-instructed resource are particularly relevant on their own. **What matters is that the SF for the RUC-instructed resource is *less* hurting than the SFs for the generators it is replacing.**
- **Example:** To reduce power flow South to North on E_PASP and E_PATA, RUC would curtail generators south of E_PASP and E_PATA and replace that generation with RUC instructions to units north of E_PASP and E_PATA.

Current Operating Plans and RUC

COP Snapshot Impacts

- RUC engine solves the system for future hours according to resource availability indicated by the COP snapshot from the moment in time that RUC executes.
 - e.g. The HRUC execution at 07:00 solves for hour ending 1900 (HE19) using forecasted resource availability from the COP records circa 07:00.
- COP records submitted by QSEs can consistently underrepresent resource availability for future hours, which may lead to the need for additional RUCs of thermal generation resources (GRs). The drivers of COP impacts include:
 1. SOC data in ESR COPs may **underrepresent future ESR discharge** and availability compared to what materializes in real-time.
 2. Resource statuses, High System Limit (HSL), and other data from dispatchable resource COPs may **underrepresent future availability** compared to what materializes in real-time.

State of Charge (SOC) Data From COP

Pre-NPRR1186

- ESR-GR component was treated like any other dispatchable generator i.e., no accounting for state of charge.
- The HASL calculation for an ESR-GR was strictly a function of HSL and the COP Ancillary Service (AS) responsibilities.
- The calculation did not check if available stored energy was sufficient to cover the ESR-GR's AS responsibilities.
- **So long as the HASL > 0, then the ESR-GR could be dispatched for energy across multiple hours. RUC was overstating capacity available for energy dispatch from ESRs.**

Post-NPRR1186 (Pre-RTC+B)

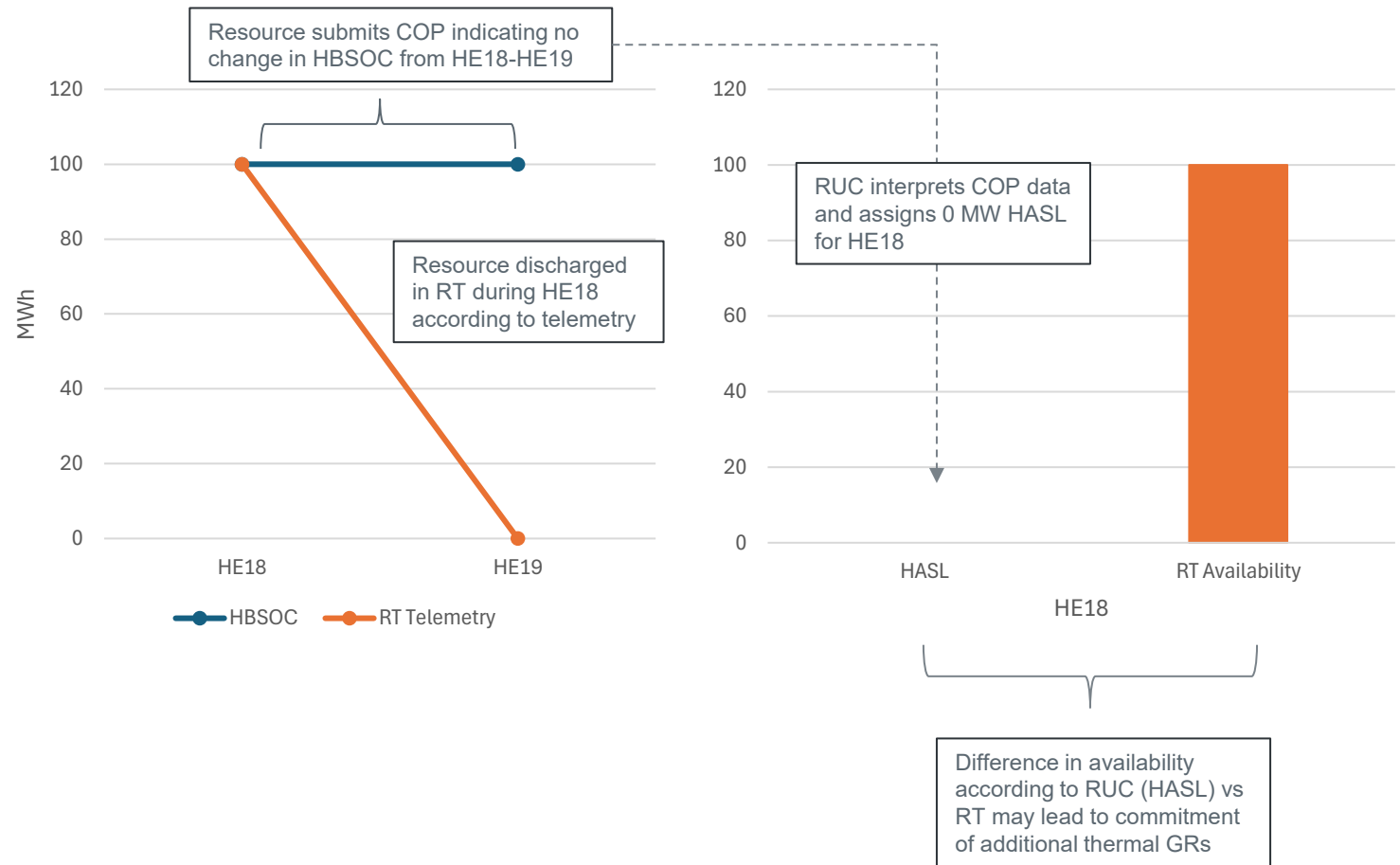
- RUC checks if Hour Beginning State of Charge (HBSOC) minus minimum SOC (minSOC) from COP is sufficient to cover the QSE-submitted AS responsibilities for that ESR-GR, for that hour.
 - **Only the remaining stored energy is made available to RUC for energy dispatch.***
- RUC compares the QSE-submitted SOC expectation (HBSOC) **across two consecutive hours** to see if the QSE intends to discharge the ESR-GR.
 - If **HBSOC does not decrease across two consecutive hours**, RUC prevents the ESR from discharging for the first hour by setting all energy costs to the SOC protection price.

*This is accomplished by modifying the HASL calculations and setting the energy cost above the new calculated HASL to the SOC protection price (\$10,000/MWh).

Constant COP HBSOC Scenario

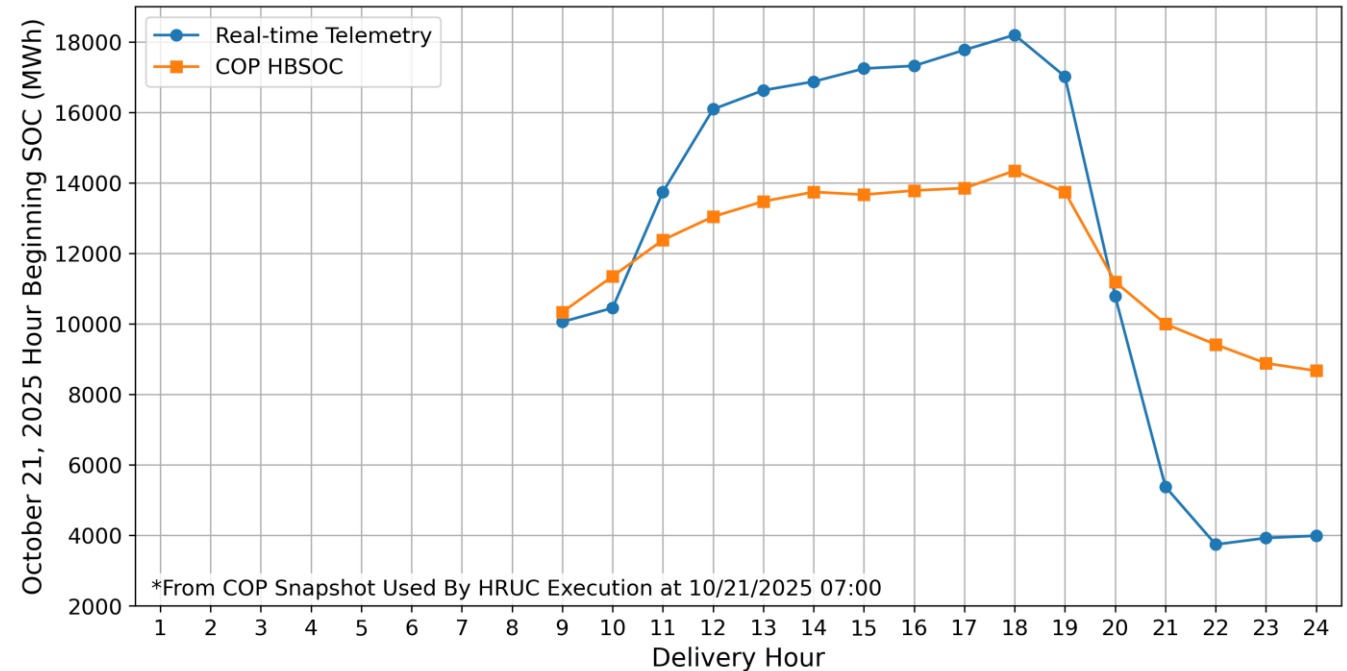
- Many ESR-GRs, for all hours, submit 100% HBSOC, 0% HBSOC, or 50% HBSOC.
- Some ESR-GRs submit “shaped” HBSOC profiles across the hours to cover their energy and AS positions and attempt to show the periods where they intend or can expect to charge or discharge.
- The flat (i.e. unchanging) HBSOC data is processed by RUC and **leads to situations where the ESR-GR is seen as unavailable to RUC for energy dispatch** which may lead to additional RUC commitments.

Example: COP HBSOC vs Real-time (RT) Telemetered SOC for ESR



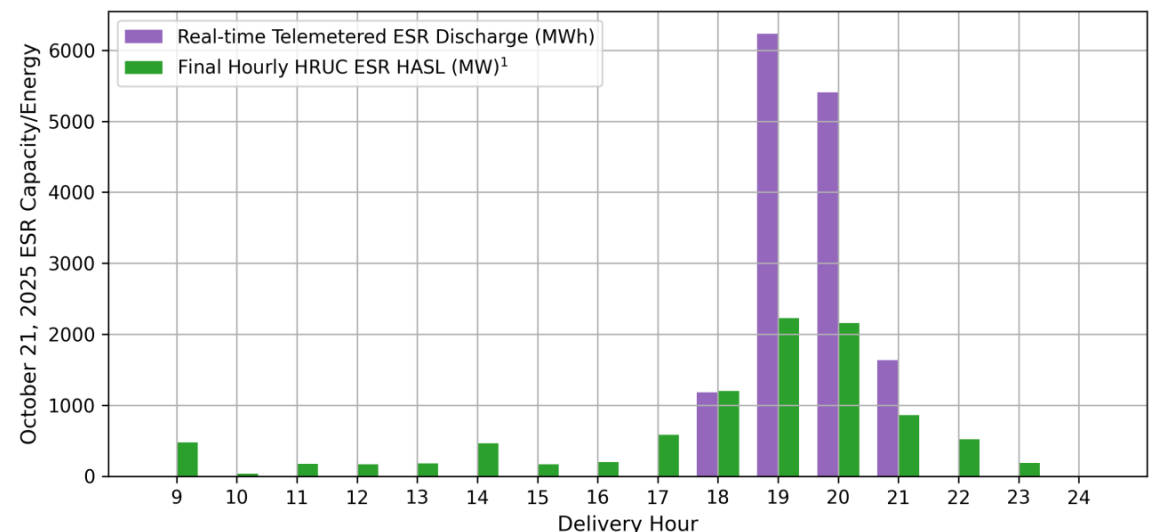
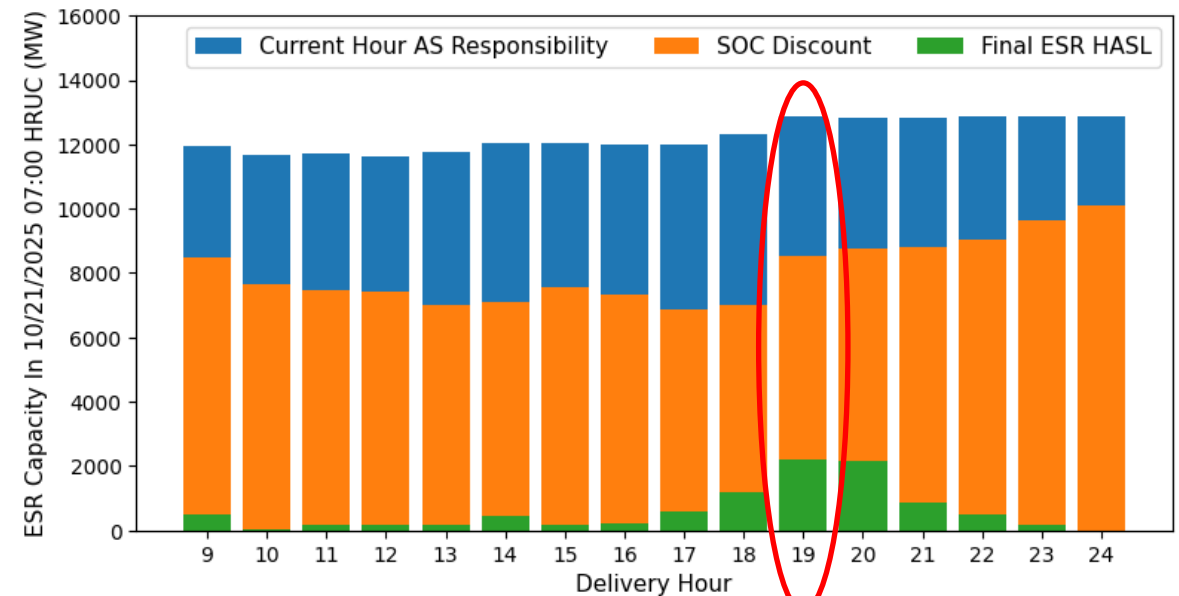
Example: 10/21/2025

- The amount of ESR capacity considered as available to RUC for energy dispatch is discounted based on HBSOC and minSOC from COP.
 - In the COP Snapshot used for the HRUC execution at 10/21/25 07:00, System-wide COP HBSOC generally did not decrease from HE9-17.
 - HRUC considered zero HASL for any ESRs that did not have decreasing HBSOC.
 - System-wide COP HBSOC decreased between HE18 and HE19.
 - For any ESRs that had decreasing HBSOC between HE18 and HE19, the remaining stored energy after discounting for HE18 AS responsibilities and minSOC was considered by HRUC to be available for energy dispatch during HE18.



Example Con'd

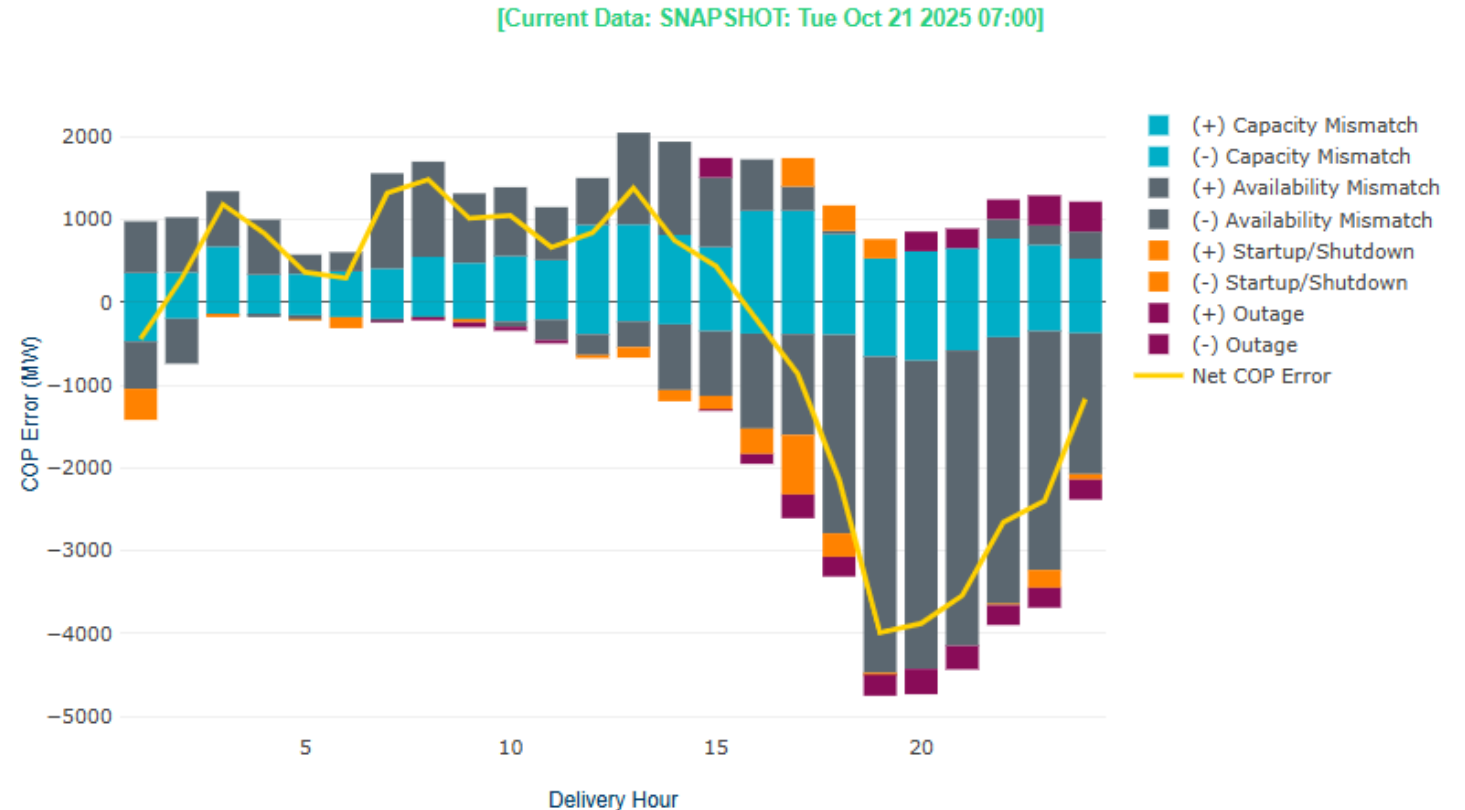
- According to COP data used by the 10/21/25 07:00 HRUC, there was ~12,800 MW of online ESR HSL during HE19.
 - ~4300 MW of this capacity was reserved for Current Hour AS Responsibility (blue)
 - ~6300 MW was discounted based on SOC limitations (orange)
 - ~2200 MW was the Final ESR HASL available to RUC for energy dispatch (green)
- The Final HRUC ESR HASL compared to real-time telemetered ESR discharge in the bottom chart **shows a marked difference** between what RUC saw and what occurred in real-time for HE19.
- *Next slides will consider a second COP issue related to **dispatchable Resource availability***



¹HRUC ESR HASL is MW availability by hour in 10/21/2025 07:00 HRUC Execution and is equivalent to MWh

Dispatchable Resource COP Error (not including ESRs)

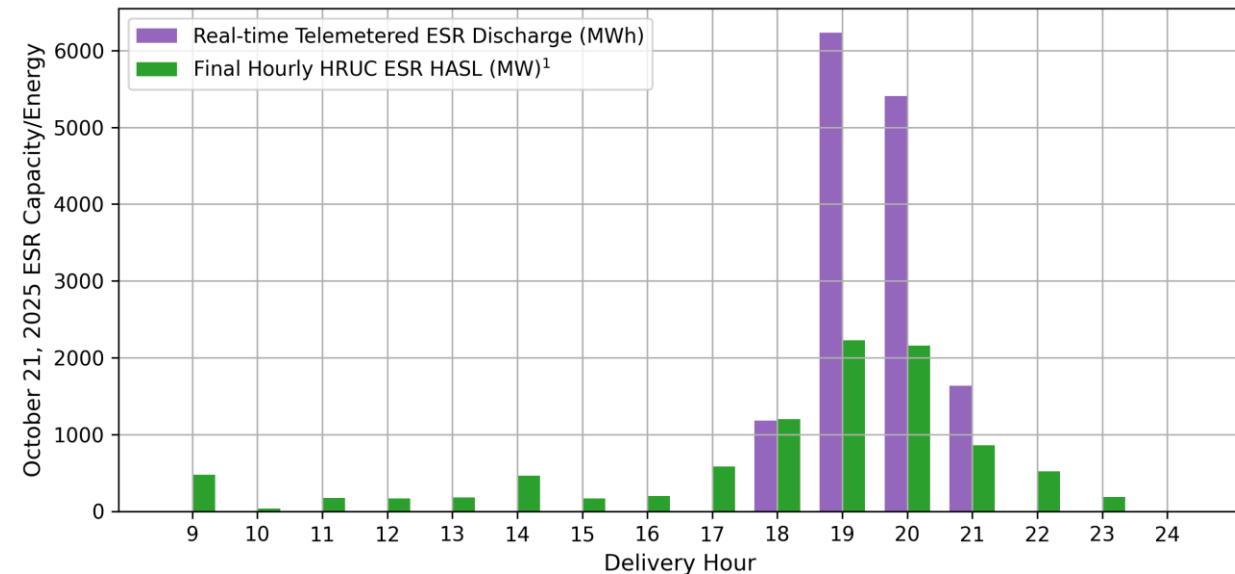
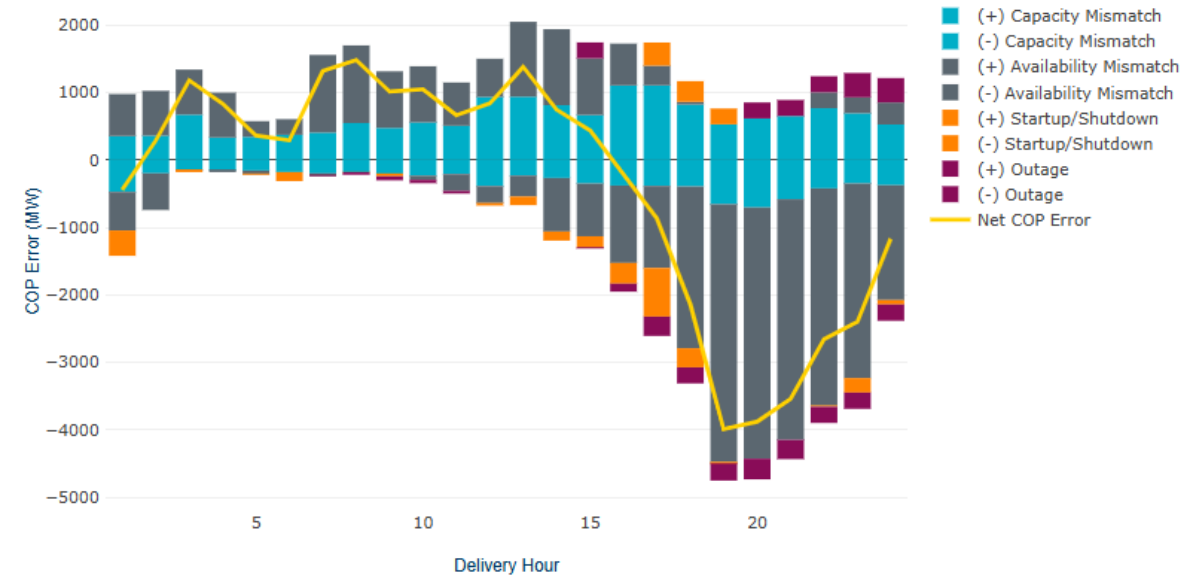
- COP records for dispatchable resources have **underrepresented capacity availability for future hours** via inaccurate resource statuses (Availability Mismatch), HSL (Capacity Mismatch), startup/shutdown information (Startup/Shutdown) and outage information (Outage).
- The COP snapshot used by HRUC on 10/21/25 at 07:00 **showed ~4000 MW less dispatchable capacity** would self-commit during 10/21/25 HE19 **than materialized in real-time.**



Net COP Error = COP Snapshot Dispatchable HSL – Realtime Telemetered Dispatchable HSL

COP Error Impacts

- The COP snapshot used by the 10/21/25 07:00 HRUC underrepresented HE19 dispatchable resource availability by ~4 GW and HE19 ESR availability by ~4 GW.
- Consequently, the HASL Margin for HE19 in this HRUC study was very low (-8400 MW).
- The engine responded by recommending every resource it could for commitment during HE19 which amounted to ~3500 MW HSL, of which the operators accepted 87 MW HSL.
- Operators accepted only a small fraction of the RUC-recommended MW, highlighting that RUC engine results are only recommendations and operators rely on operational experience to decide which recommendations to accept.



¹HRUC ESR HASL is MW availability by hour in 10/21/2025 07:00 HRUC Execution and is equivalent to MWh

Summary

- ERCOT analyzed a number of historical RUC days to shed light on drivers for these commitments in response to stakeholder questions
 - RUC optimization is working as designed and must solve for congestion and capacity
 - Most RUCs nominally attributed to congestion in 2025 spanned hours with a negative HASL Margin, meaning that many of these RUCs were also driven by capacity needs, in part or entirely.
 - SFs for the RUC-instructed resource are not particularly relevant on their own. What matters is that the SF for the RUC-instructed resource are *less* hurting than the SFs for the generators it is replacing.
 - QSE COP submission data is a key input into what RUC ‘sees’ and influences commitments
 - Resource status, HSL, and other data in dispatchable resource COPs can underrepresent future resource availability.
 - SOC data in ESR COPs can also underrepresent future ESR discharge and availability.

Next Steps

- Further discussion at CMWG and/or WMWG based on today's analysis and questions
- Further analysis and planned outreach to QSEs around COP submission issues identified
- Implementation of RTC+B will incorporate ESR SOC data in RUC Capacity Shortfall Charges

Appendix

04/04/2025

RUC Block: 04/04/25 HE8-11

Resource: HLSES_UNIT5

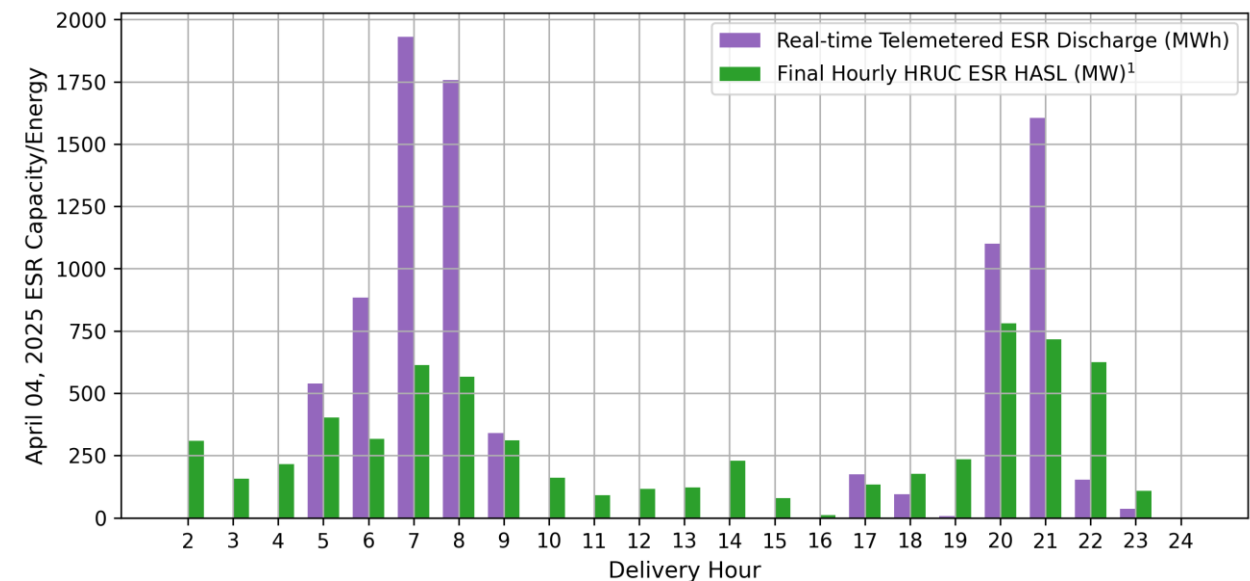
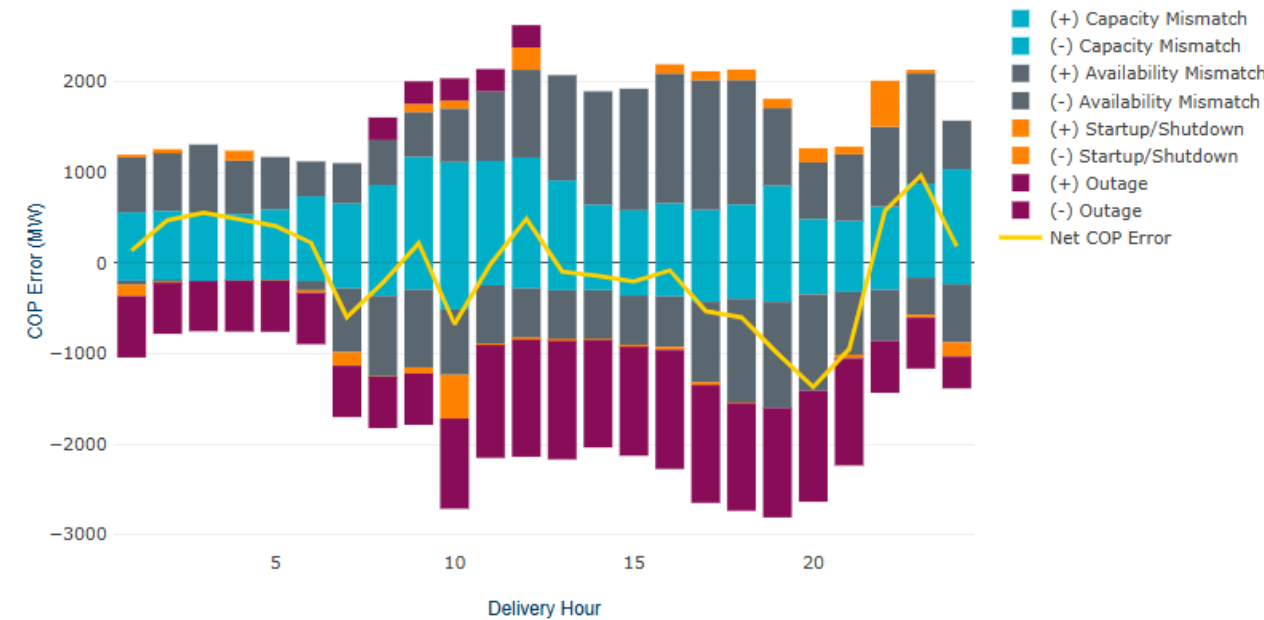
Listed Constraint: E_PATA

Commit Time: 4/4/2025 12:03:04 AM

Minimum HASL Margin: -585 MW (HE10)

Dispatchable COP Error: ~(-)200 MW during HE8

ESR COP HBSOC Error: ~(-)1200 MW during HE8



¹HRUC ESR HASL is MW availability by hour in 04/04/2025 00:00 HRUC Execution and is equivalent to MWh

06/15/2025

RUC Blocks: 06/15/25 HE17-23

Resource: 11 unique units

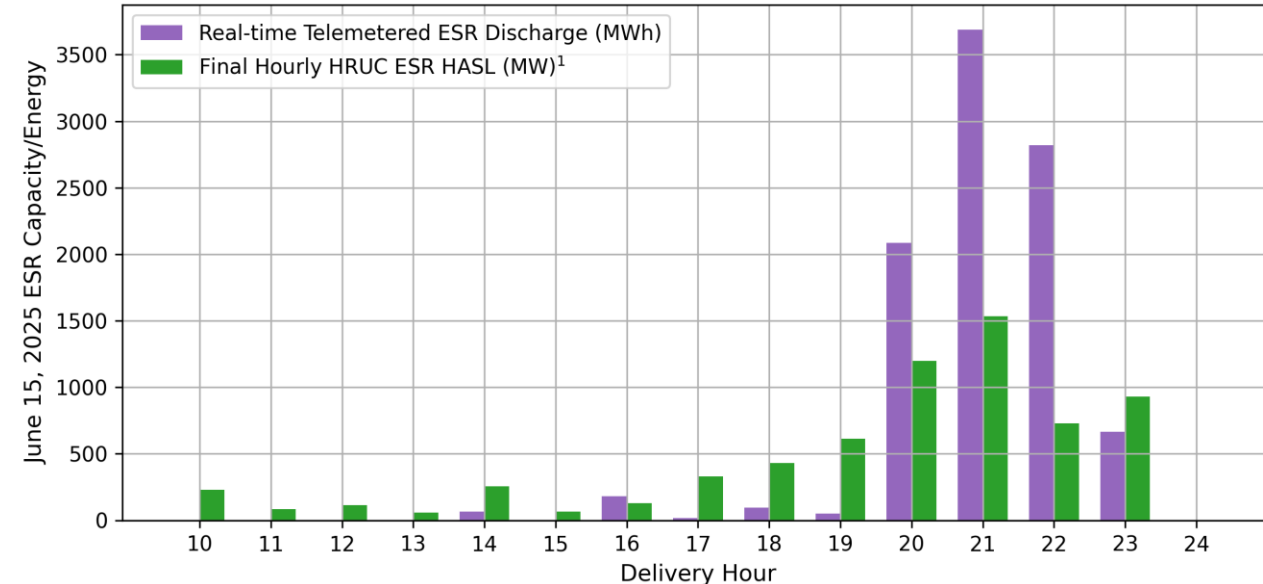
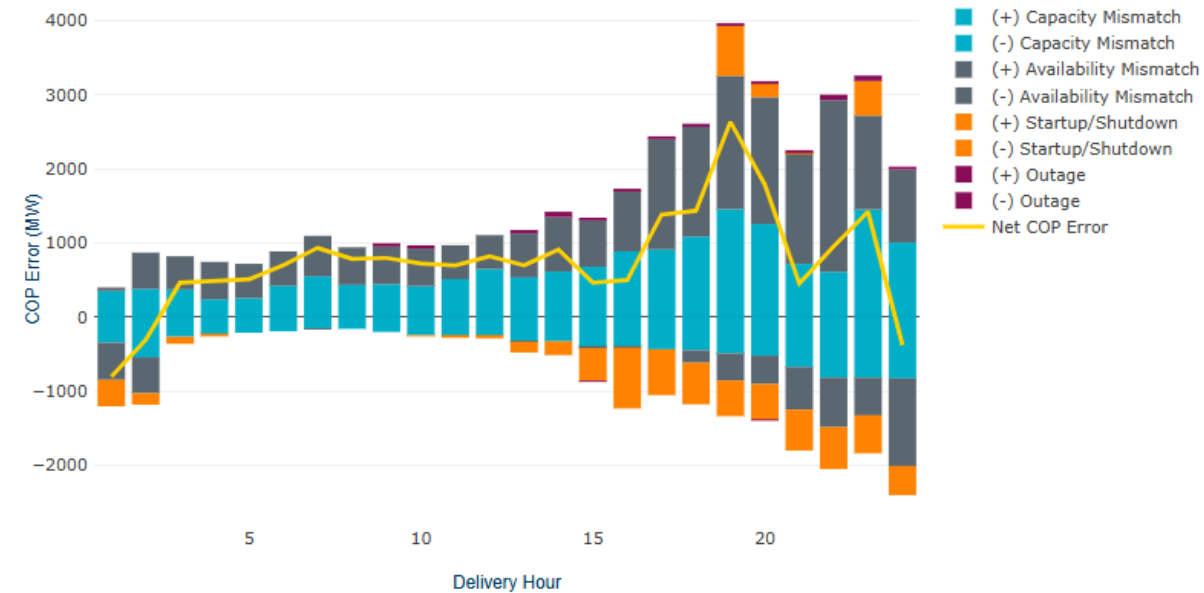
Listed Constraint: E_PASP

Commit Time: 6 HRUC studies

Minimum HASL Margin: Every RUC had a negative HASL Margin during its RUC block.

Dispatchable COP Error: ~(+500 MW during HE21

ESR COP HBSOC Error: ~(-2200 MW during HE21



¹HRUC ESR HASL is MW availability by hour in 06/15/2025 08:00 HRUC Execution and is equivalent to MWh

06/26/2025

RUC Block: 06/26/25 HE1-24

Resource: HLSES_UNIT3

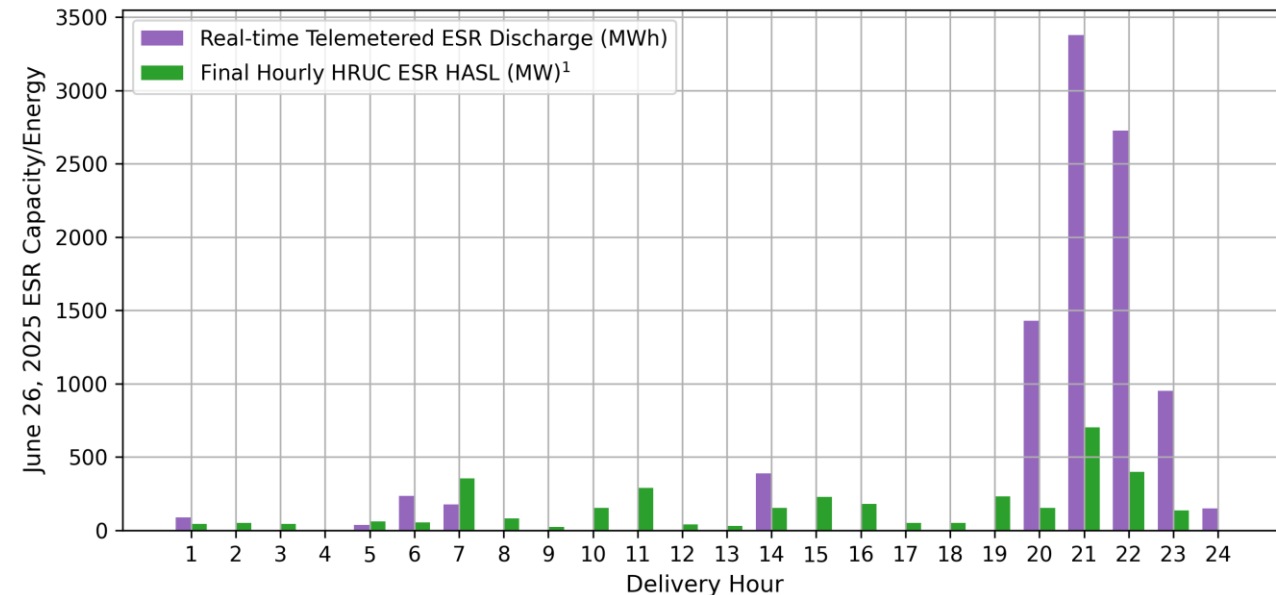
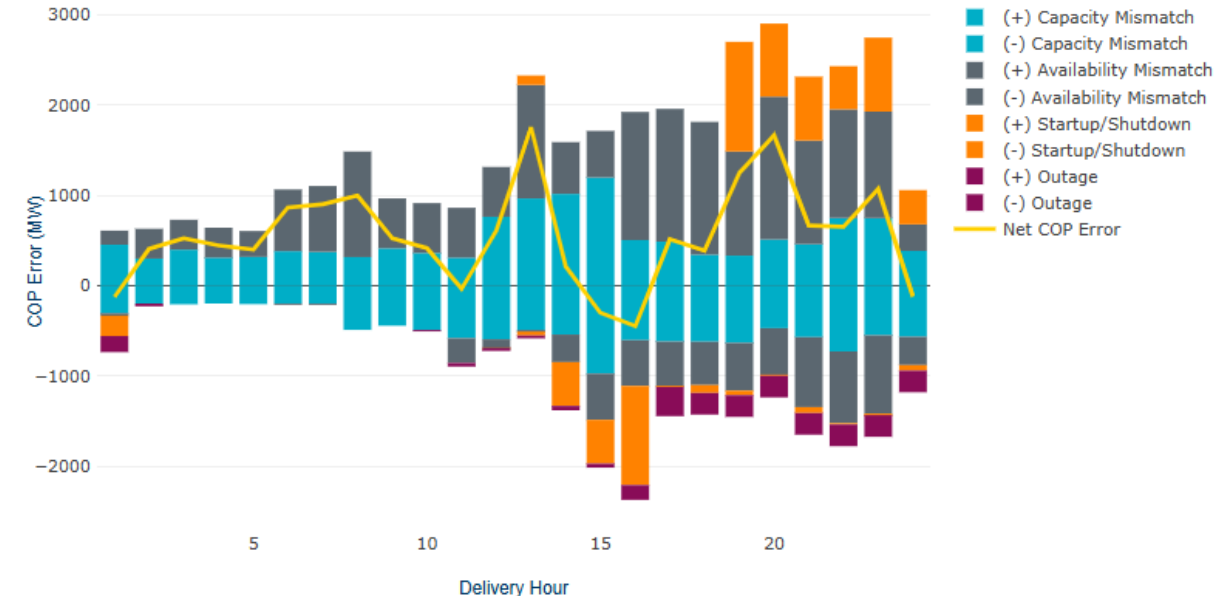
Listed Constraint: E_PASP

Commit Time: 6/25/2025 4:03:04 PM

Minimum HASL Margin: -3667 MW (HE21)

Dispatchable COP Error: ~(+)700 MW during HE21

ESR COP HBSOC Error: ~(-)2700 MW during HE21



¹HRUC ESR HASL is MW availability by hour in 06/25/2025 16:00 HRUC Execution and is equivalent to MWh

06/26/2025

RUC Block: 06/26/25 HE19-22

Resource: HLSES_UNIT5

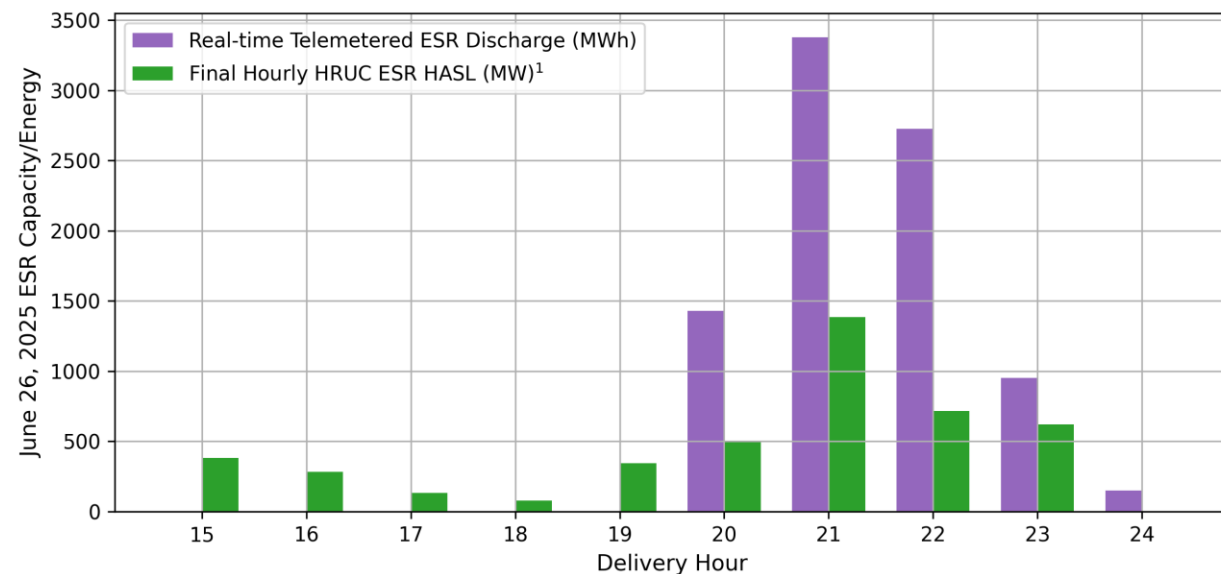
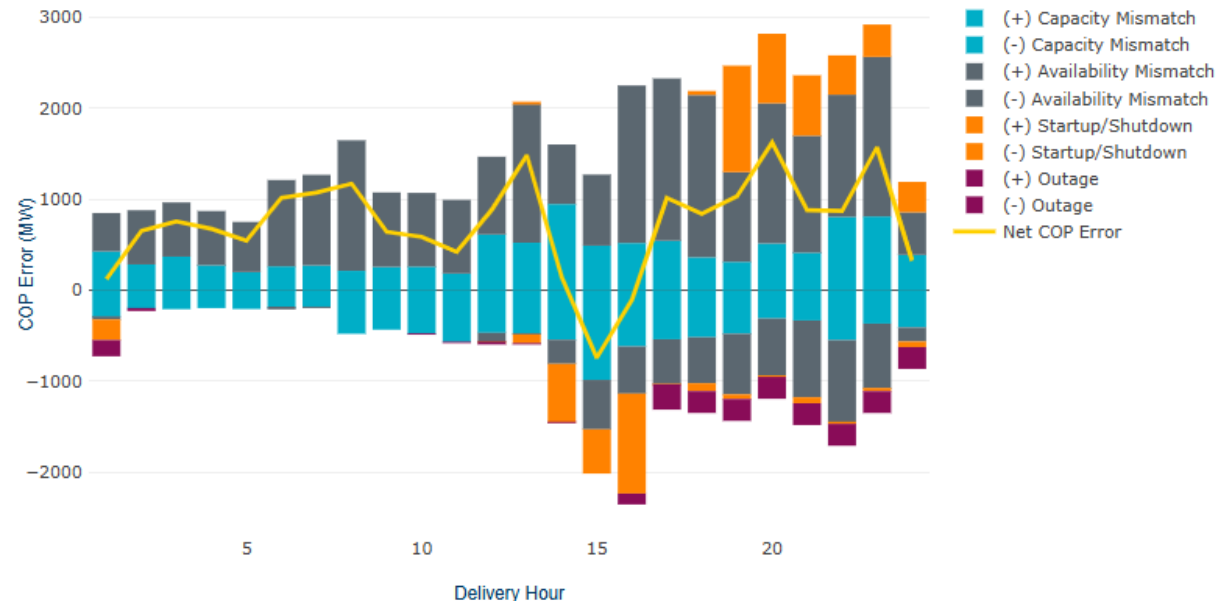
Listed Constraint: E_PASP

Commit Time: 6/26/2025 1:03:03 PM

Minimum HASL Margin: -2131 MW (HE21)

Dispatchable COP Error: ~(+)900 MW
during HE22

ESR COP HBSOC Error: ~(-)2000 MW
during HE22



¹HRUC ESR HASL is MW availability by hour in 06/26/2025 13:00 HRUC Execution and is equivalent to MWh

06/24/2025

RUC Blocks: 06/24/25 HE20-24

Resource: 7 unique units

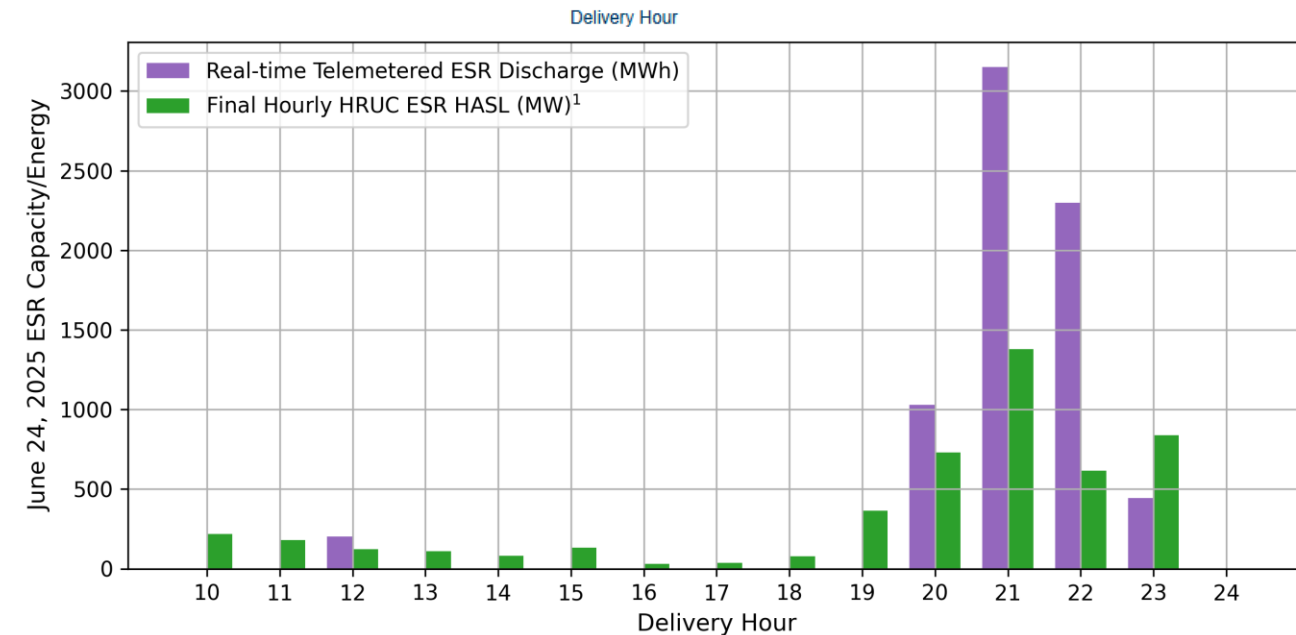
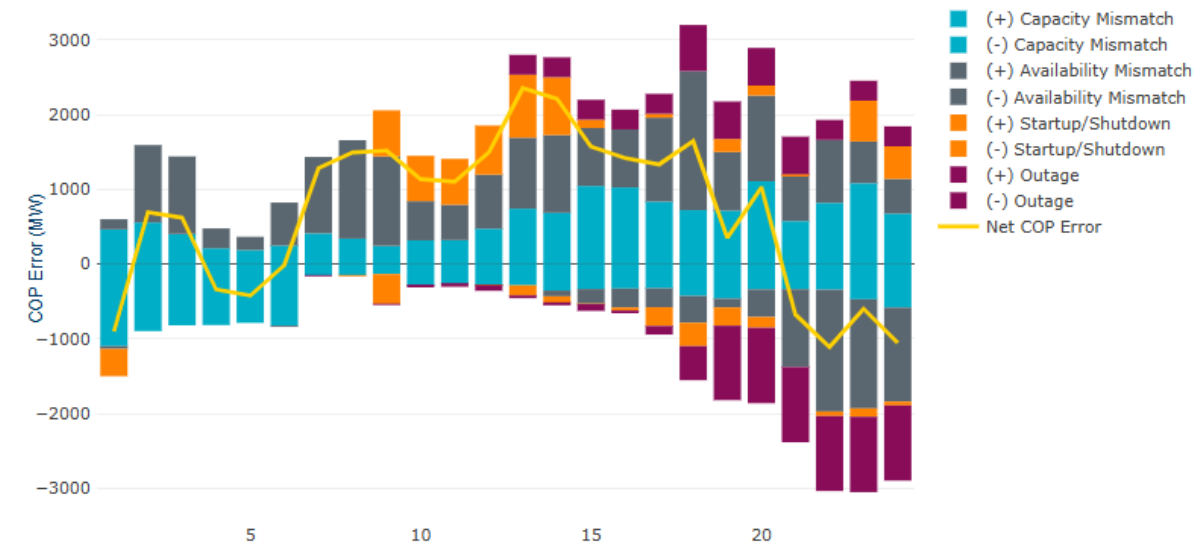
Listed Constraint: E_PASP

Commit Time: 6 HRUC studies

Minimum HASL Margin: All 7 RUCs spanned an HE22 that had a negative HASL Margin.

Dispatchable COP Error: ~(-)1100 MW during HE22

ESR COP HBSOC Error: ~(-)1700 MW during HE22



¹HRUC ESR HASL is MW availability by hour in 06/24/2025 08:00 HRUC Execution and is equivalent to MWh

06/26/2025

RUC Block: 06/26/25 HE20-23

Resource: HLSES_UNIT4

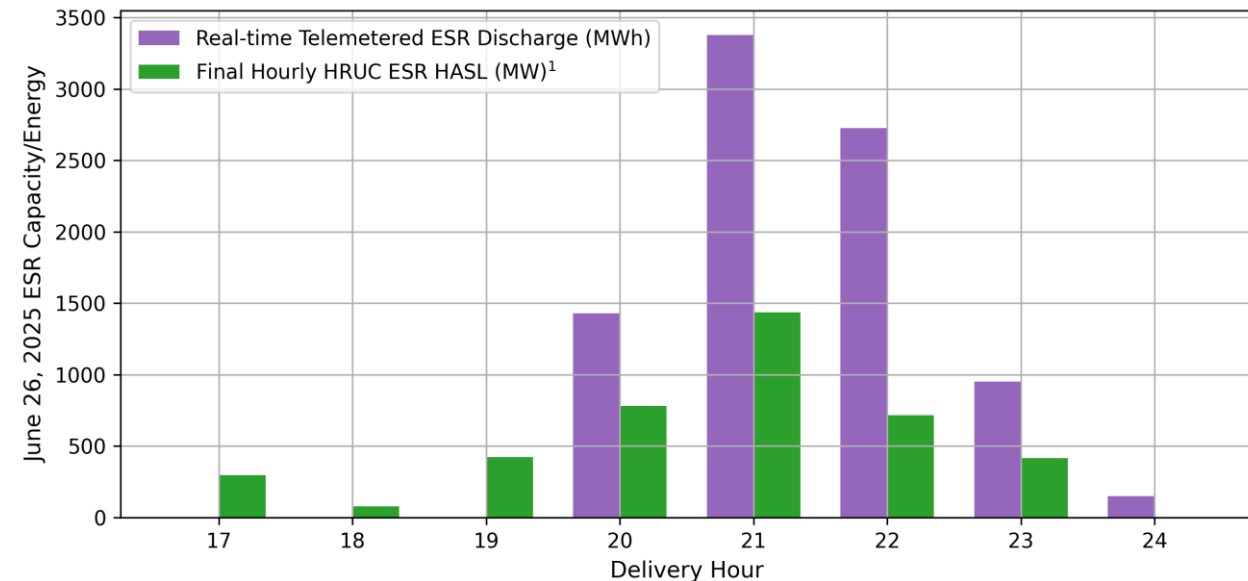
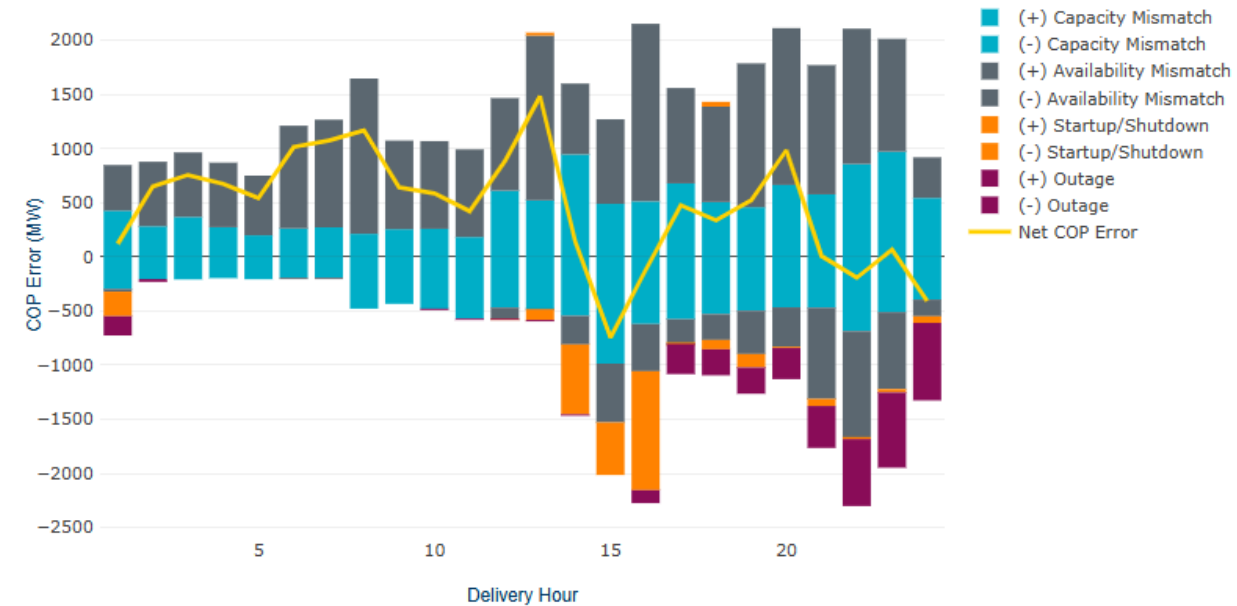
Listed Constraint: E_PASP

Commit Time: 6/26/2025 3:03:03 PM

Minimum HASL Margin: -3334 MW (HE21)

Dispatchable COP Error: ~(-)200 MW during HE22

ESR COP HBSOC Error: ~(-)2000 MW during HE22



¹HRUC ESR HASL is MW availability by hour in 06/26/2025 15:00 HRUC Execution and is equivalent to MWh

09/14/2025

RUC Block: 09/14/25 HE2-24

Resource:

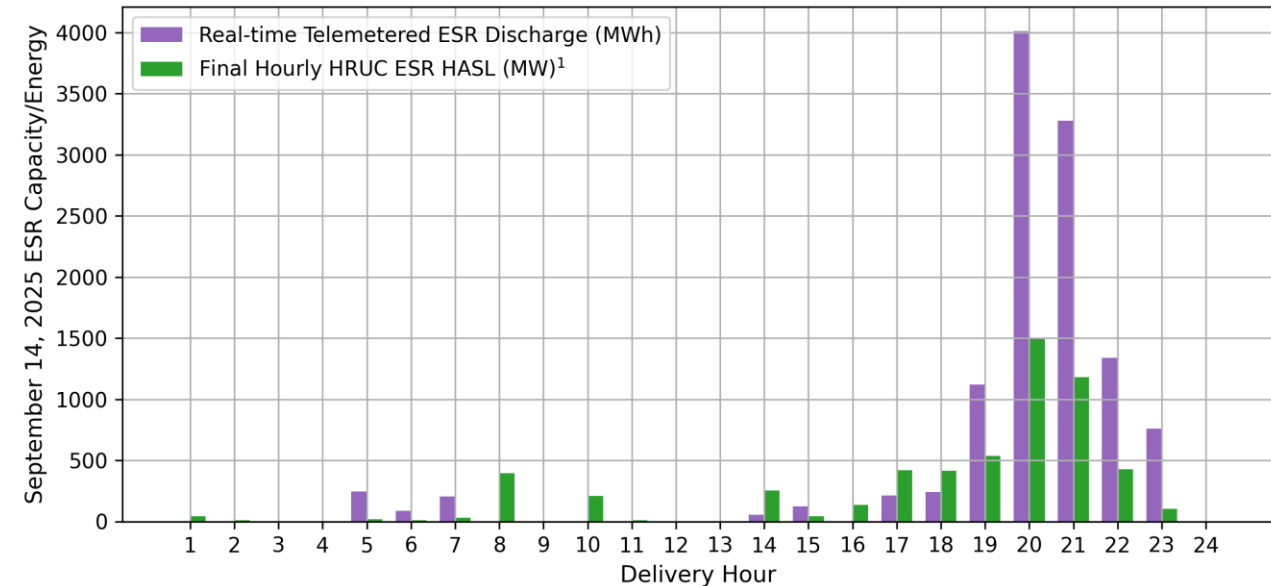
Listed Constraint: E_PASP

Commit Time: 9/13/2025 5:03:03 PM

Minimum HASL Margin: -8530 MW (HE20)

Dispatchable COP Error: ~(-)3400 MW during HE20

ESR COP HBSOC Error: ~(-)2500 MW during HE20



¹HRUC ESR HASL is MW availability by hour in 09/13/2025 17:00 HRUC Execution and is equivalent to MWh

09/14/2025

RUC Block: 09/14/25 HE19-22

Resource:

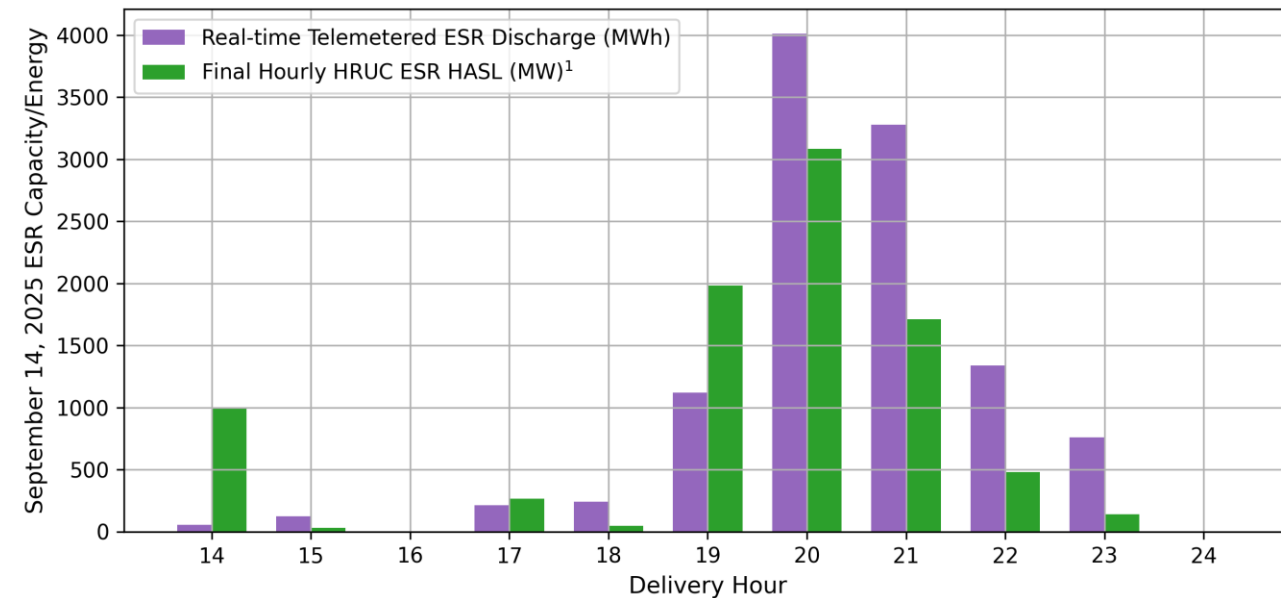
Listed Constraint: E_PASP

Commit Time: 9/14/2025 12:03:03 PM

Minimum HASL Margin: -4654 MW (HE20)

Dispatchable COP Error: ~(-)1000 MW during HE20

ESR COP HBSOC Error: ~(-)900 MW during HE20



¹HRUC ESR HASL is MW availability by hour in 09/14/2025 12:00 HRUC Execution and is equivalent to MWh

05/24/2025

RUC Blocks: 05/24/25 HE16-22

Resource: 7 unique units

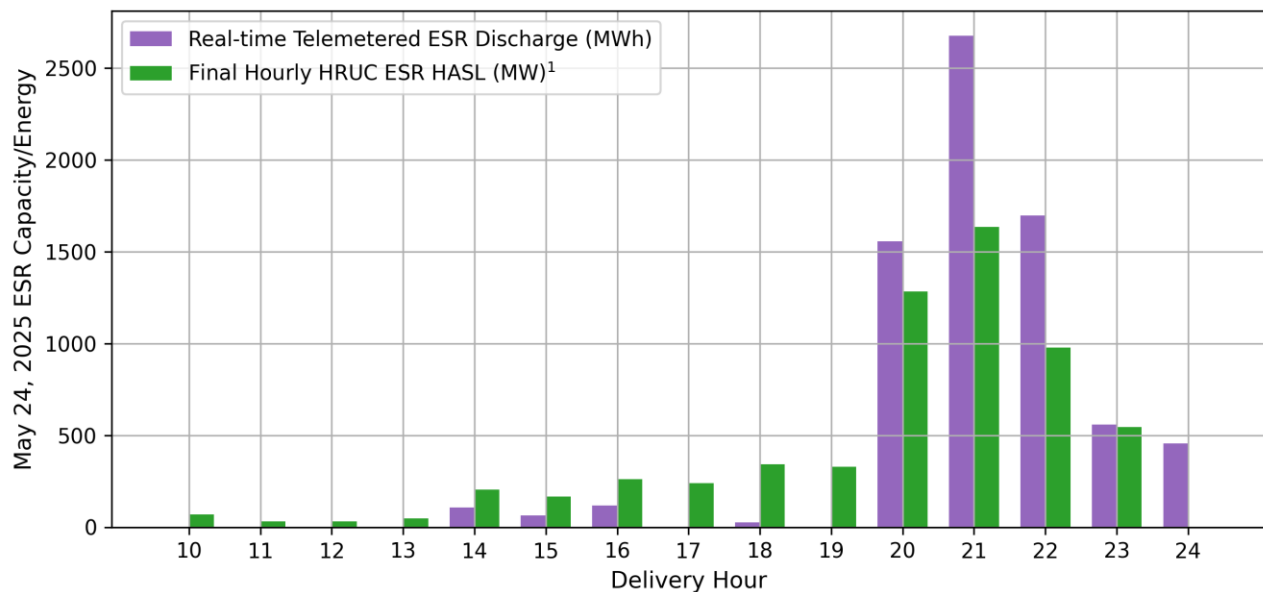
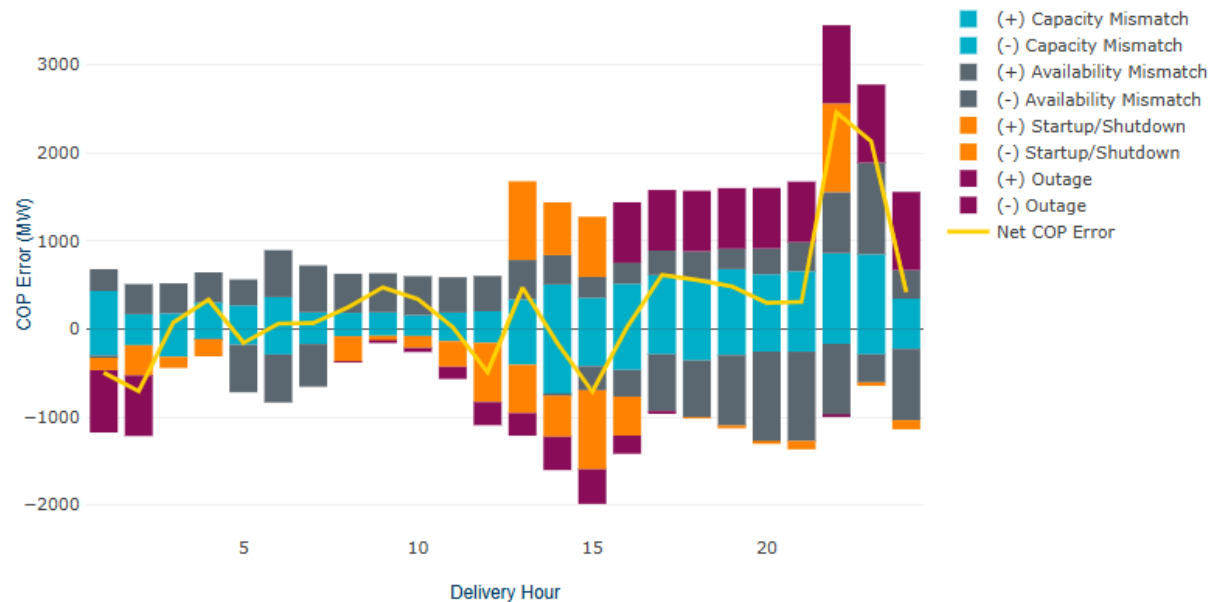
Listed Constraint: E_PASP

Commit Time: 5 HRUC studies

Minimum HASL Margin: One RUC had a negative HASL Margin during its RUC block. The other 8 RUCs had all positive HASL margins during the RUC blocks.

Dispatchable COP Error: ~(+300 MW during HE21

ESR COP HBSOC Error: ~(-1000 MW during HE21



¹HRUC ESR HASL is MW availability by hour in 05/24/2025 08:00 HRUC Execution and is equivalent to MWh