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Impact of Energy Storage Resource (ESR) State of Charge (SOC) and Ancillary Service Deployment Factors (ASDFs) on Recent Reliability Unit Commitment (RUC) Recommendations

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1. RUC commits capacity when forecast supply may not meet demand. ESRs are modeled as energy-limited resources through the Hour-Beginning SOC (HBSOC) values in their Current Operating Plan (COP) submissions.

2. On several recent high-risk evenings, RUC recommended large quantities of capacity. Stakeholders have questioned whether Ancillary Service Deployment Factors (ASDFs) are the cause.

3. This presentation answers the question, “What actually drives these RUC recommendations, and would changing ASDFs fix it?”

Flat HBSOC submissions, not ASDFs, drive recent RUC commitments

Key Takeaways of the RUC Sensitivity Analysis

- Constant or **'flat' Hour-Beginning State-of-Charge (HBSOC) submissions are inconsistent with actual operations** and regularly and directly contribute to the need for RUC.
- **Ancillary Service Deployment Factors (ASDFs) are not a materially contributing factor.** Even setting ASDFs to zero left RUC recommendations largely unchanged.
- **Replacing COP HBSOC with actual telemetered real-time SOC proxy substantially reduced or eliminated RUC** recommendations and AS shortages.

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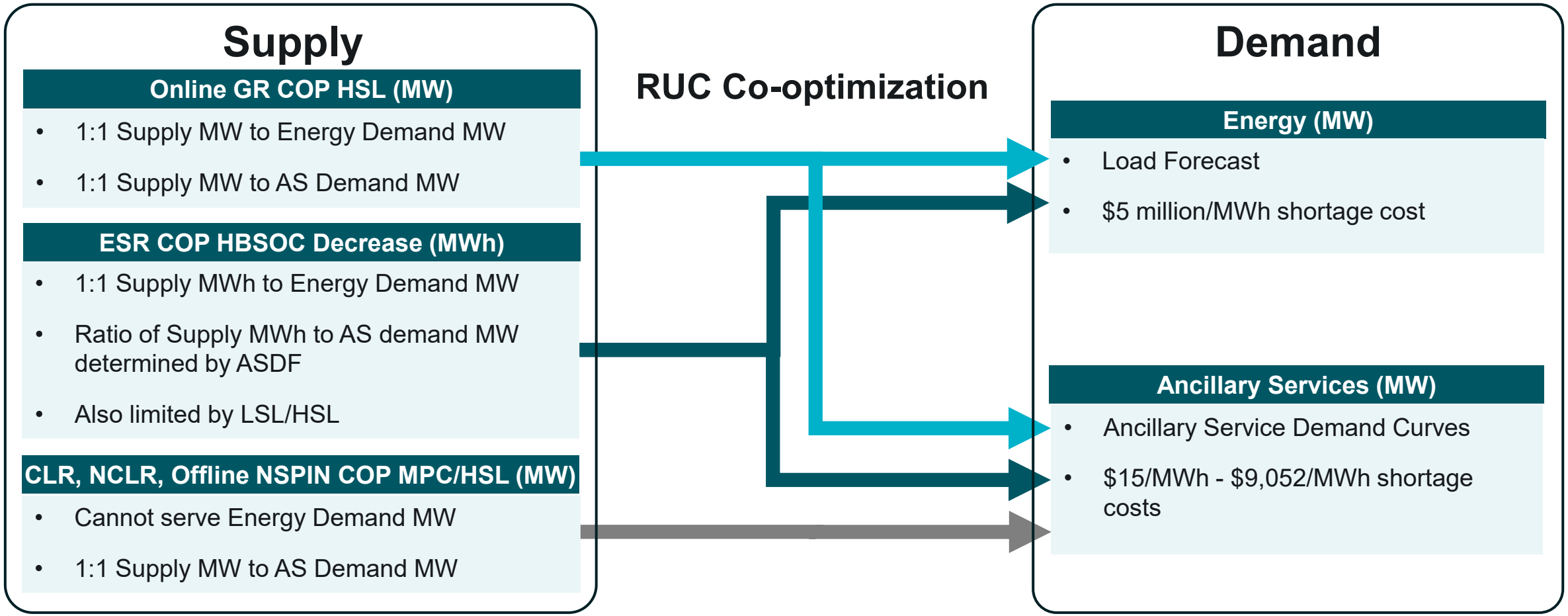
RUC co-optimization allocates supply to demand to minimize shortage costs



- ASDFs represent the likelihood and magnitude of SOC discharge that would be expected for an ESR AS Award
- ASDFs determine how much COP HBSOC Decrease (ESR energy) is required to serve each MW of AS Demand
- **ASDFs do not apply to Energy Awards;** HBSOC Decrease (MWh) to Energy Demand (MW) ratio is always 1:1

ESR SOC Constraints Differ Between SCED and RUC

	RUC (Look-Ahead)	SCED (Real-Time)
What dispatches the ESR	No bid/offer curve; RUC awards energy and AS to ESRs to follow the ESR SOC plan from COP	Dispatched economically based on bid/offer curves
Min/Max SOC Limit	Ensures energy and AS awards would not take the ESR outside of SOC operating range	Ensures energy and AS awards would not take the ESR outside of SOC operating range
HBSOC Limit	Ensures hour-to-hour charge/discharge in RUC follows the COP SOC plan	Not used
Takeaway	Only as good as the COP SOC Plan submitted by the QSE	Reflects what the ESR is doing right now

HBSOC and ASDFs shape ESR treatment in RUC

RUC treats ESRs as energy-limited resources (unlike conventional generators with unlimited fuel): COP HBSOC sets the SOC plan, and SOC constraints combined with ASDFs inside the RUC engine ensure that RUC gives each ESR energy and AS awards that follow its SOC plan.

ESR COP Inputs	RUC Engine	RUC Result	Reliability Outcome
COP snapshot circa the Hourly RUC (HRUC) execution time tells RUC where the ESR **plans** to be: • HBSOC • MinSOC / MaxSOC • LSL / HSL • Resource Status	• Power Balance • Network Constraints • Capacity Constraints (LSL / HSL) • HBSOC Constraint: $HBSOC_h$ ± *Energy Award* × *Duration* ± *AS Awards* × ***ASDF*** × *AS Duration* = $HBSOC_{h+1}$ • Min/Max SOC Constraint: $MinSOC \le HBSOC_h \pm$ *Energy Award* × *Duration* ± *AS Awards* × *AS Duration* ≤ *MaxSOC*	• Energy and AS schedules for resources • ESR dispatch follows SOC plan from COP • AS shortages • RUC may commit additional thermal capacity to reduce penalty costs	• RUC presents operators with a list of commitment options to maintain reliability • ESRs provide the energy/AS that their SOC plan supports • Prevents over-reliance on unavailable ESR energy • More accurate COP HBSOC = more accurate RUC results

- **Accurate HBSOC submissions are critical**: they directly affect how much ESR capability is available to RUC and whether RUC needs to commit additional thermal capacity.
- ASDFs determine how much reserve responsibility is treated as actual energy use in the RUC study; **but they use HBSOC as an input**.

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We tested three real RUC studies against three “what-if” scenarios to isolate the cause

We selected three HRUC studies where RUCs and large RUC AS shortages occurred, then ran three targeted scenarios to isolate how HBSOC and ASDF assumptions affect ESR treatment in RUC.

Select Operating Days

Days chosen because the issue occurred and RUC behavior could be compared consistently:

- Day 1: May 9, 2026 at 17:00-24:00
- Day 2: May 12, 2026 at 13:00-24:00
- Day 3: May 28, 2026 at 08:00-24:00

Run Sensitivity Scenarios

Methodology

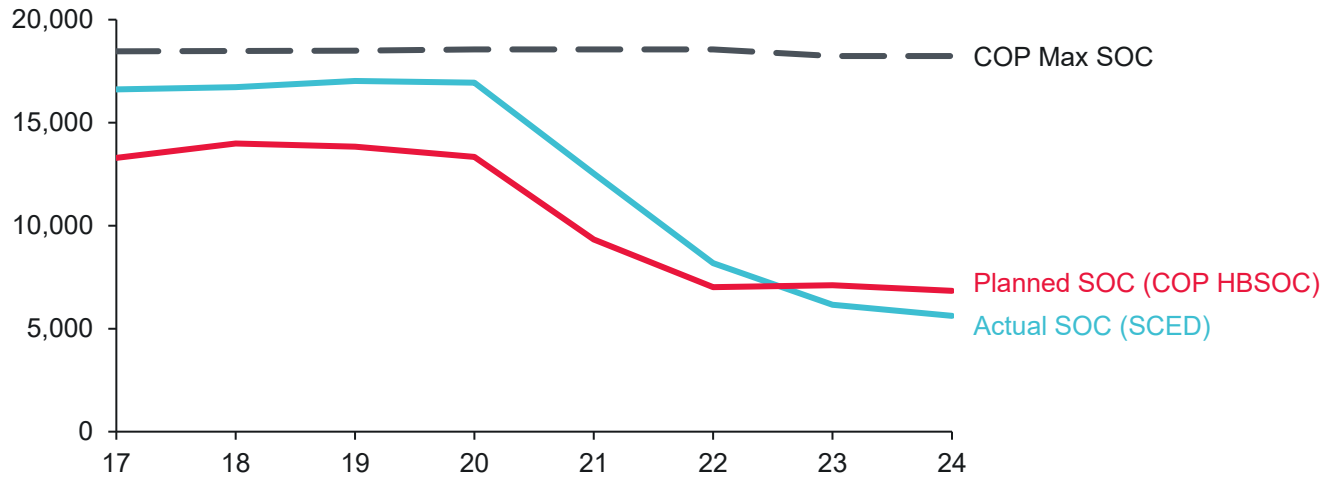
Rerun each HRUC study to isolate the effect of SOC trajectory and AS deployment assumptions:

- **Reference/as-submitted case**: use production inputs to establish **baseline** RUC behavior.
- **ASDF sensitivity**: modify **Ancillary Service Deployment Factors (ASDFs) to 0**.
- **HBSOC sensitivity**: modify ESR’s COP HBSOC input data to **actual telemetered Real-Time SCED SOC** data as a proxy.

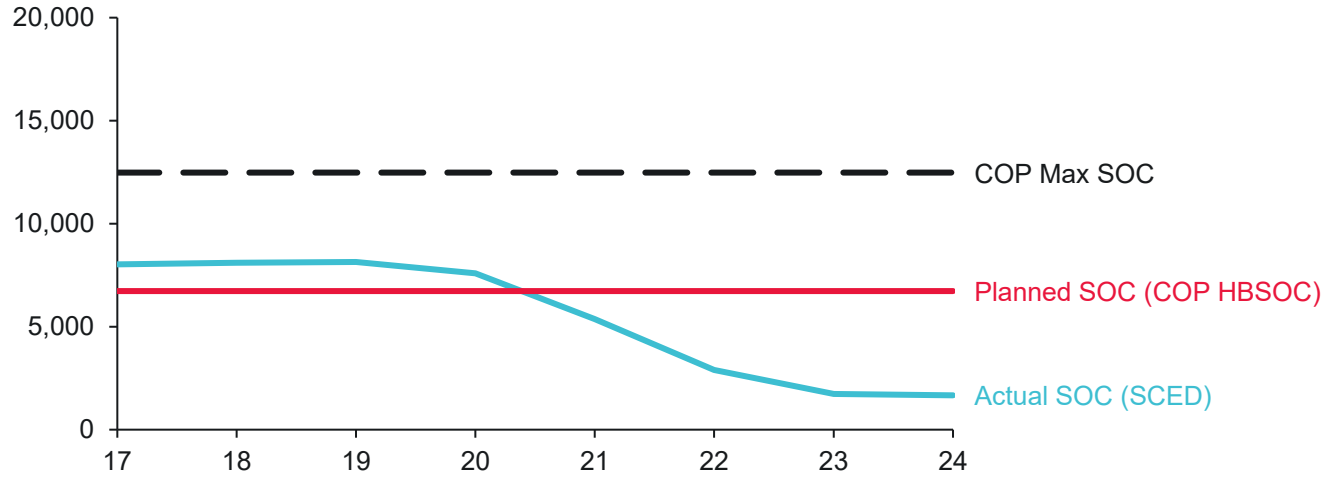
Day 1

HBSOC in COP is inconsistent with Real-Time SOC, hides energy from RUC that the ESR actually discharges

SOC for ESRs Submitting Dynamic HBSOC (MWh)



SOC for ESRs Submitting Constant or 'Flat' HBSOC (MWh)

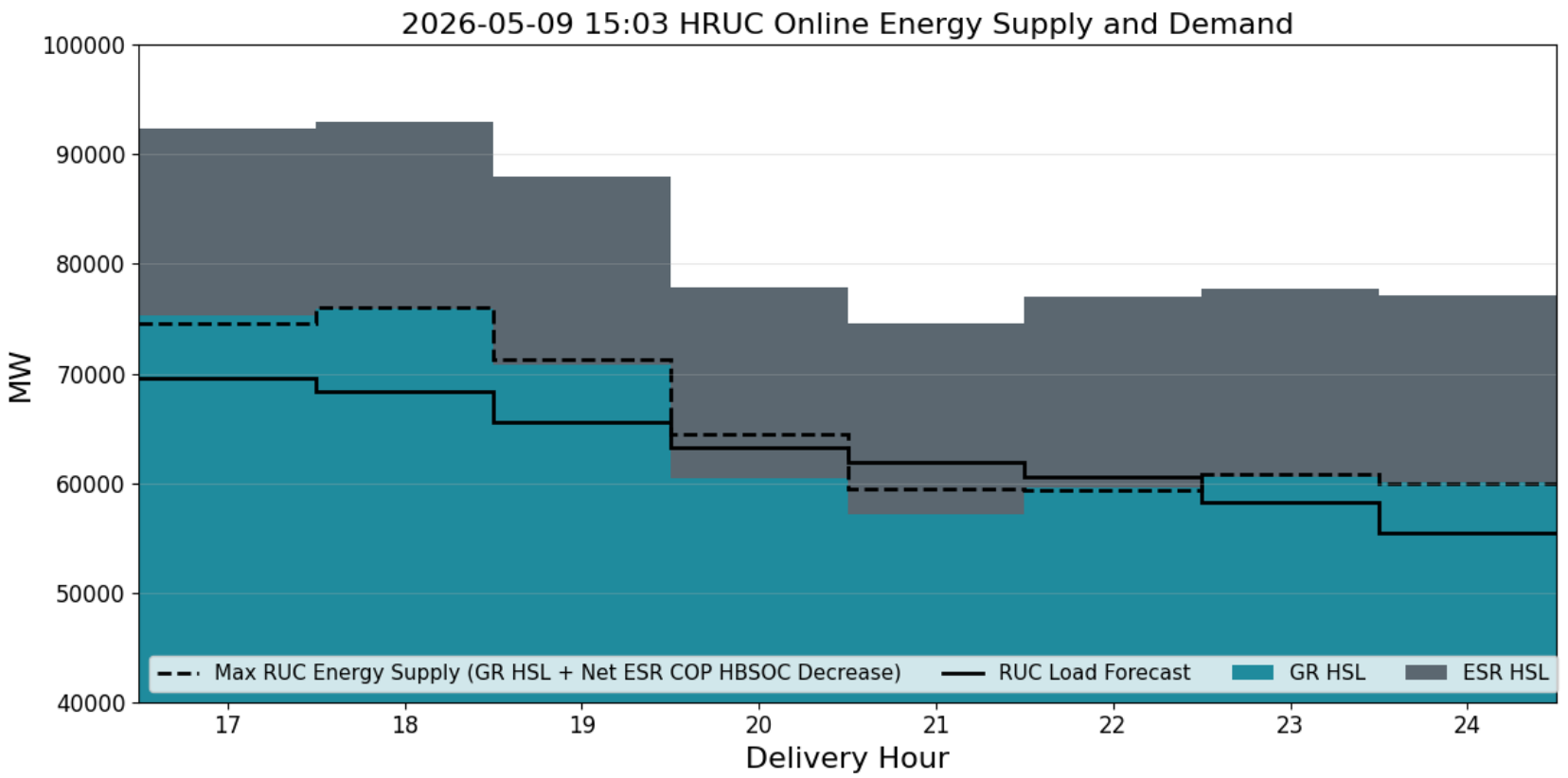


Delivery Hour on May 9, 2026

Takeaway

- HRUC execution from 15:00 ahead of the evening operating hours.
- Dynamic HBSOC resources showed some SOC trajectory movement, but real-time SOC declined more sharply after HE20.
- Flat HBSOC resources did not reflect the evening discharge, preventing RUC from using this ESR energy.

Day 1 Flat HBSOC Impacts on RUC: Online energy supply was less than energy demand during some study hours



Takeaway

- During HE21-22 of the 05/09/26 15:00 HRUC study, even if all online GR COP HSL (with no RUCs) and net ESR COP HBSOC decrease (available ESR energy) was allocated to energy, it still would have been less than the load forecast, meaning there was an **energy shortage**.
- The penalty cost for energy shortages is large ($5 million/MWh). RUC will recommend at least enough capacity to eliminate energy shortages.
- During HE21, the **energy shortage** peaked at 2400 MW and RUC recommended 2700 MW for commitment.
- ASDFs and AS shortages would not impact 2400 MW of these HE21 RUC recommendations.

*GRs include dispatchable resources and intermittent renewable resources but not ESRs.

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Day 1

Removing ASDFs had a negligible effect on RUC commitments; using real-time SOC eliminated all of them

Takeaway

- In the 05/09/26 15:00 HRUC study, COP HBSOC understated the actual HE20-22 ESR SOC decrease: 6.2 GWh modeled versus 16.6 GWh actual.
- Setting ASDFs to zero reduced RUC recommendations, but short-start recommendations and Non-Spin shortfall remained.
- Using telemetered RT SOC proxy exposed additional ESR energy and eliminated RUC recommendations and shortfall in the study.

*Short Start resources have a cold startup time <= 1 hr
*Actual SOC profile would be impacted by accepted RUCs that were online in real-time

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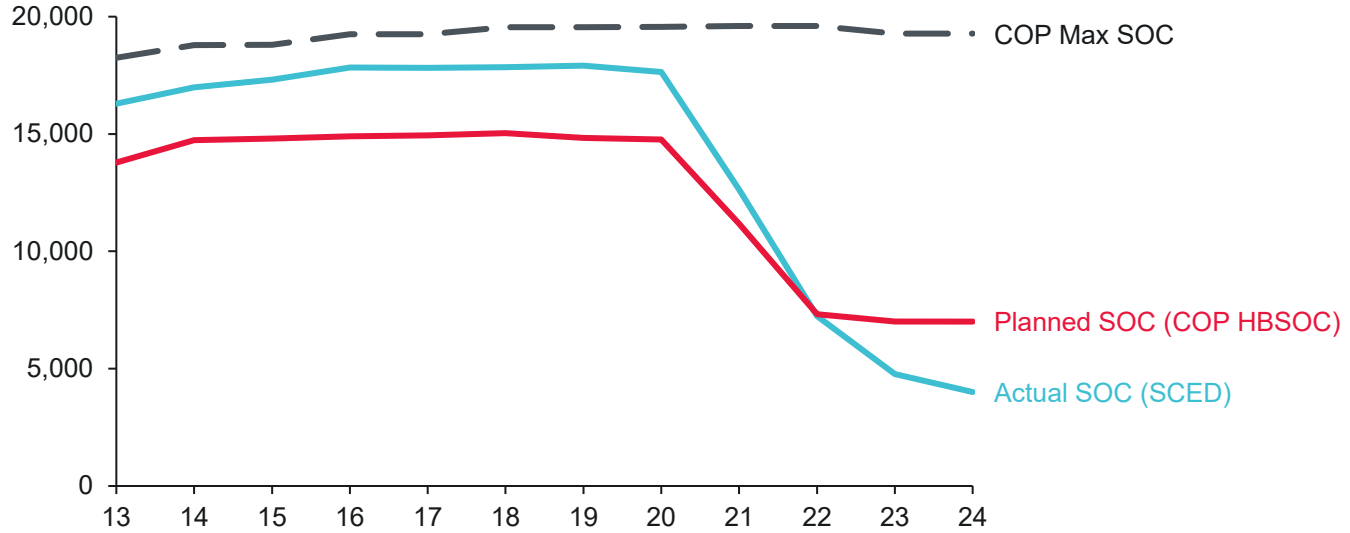
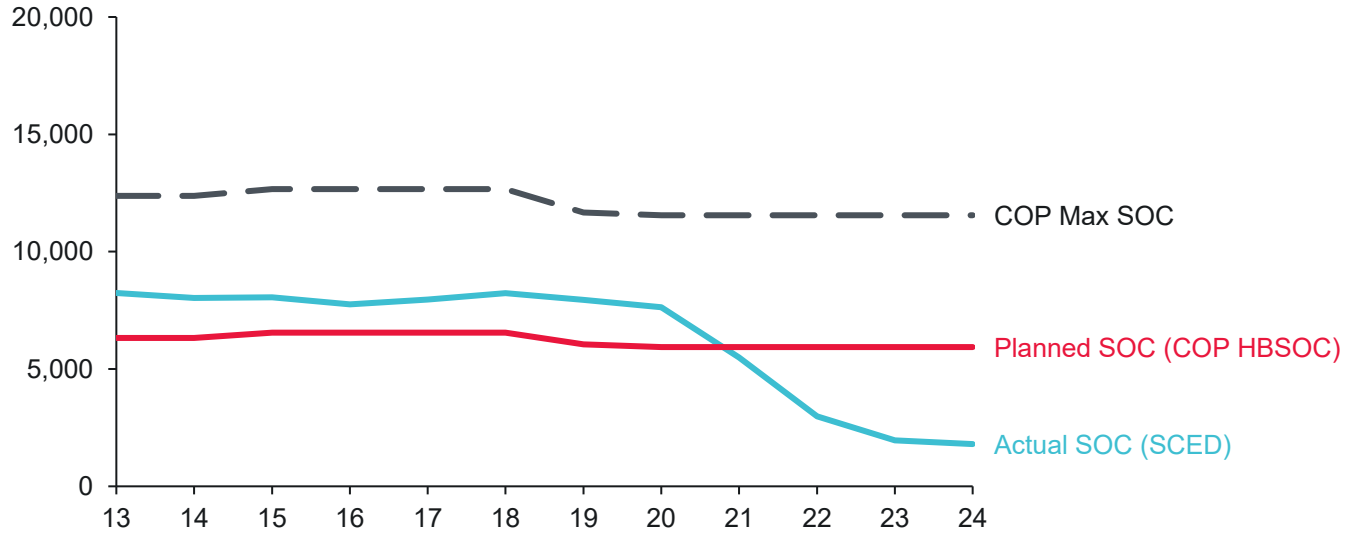
Day 2

HBSOC in COP is inconsistent with Real-Time SOC, hides energy from RUC that the ESR actually discharges

SOC for ESRs Submitting Dynamic HBSOC (MWh)



SOC for ESRs Submitting Constant or 'Flat' HBSOC (MWh)*



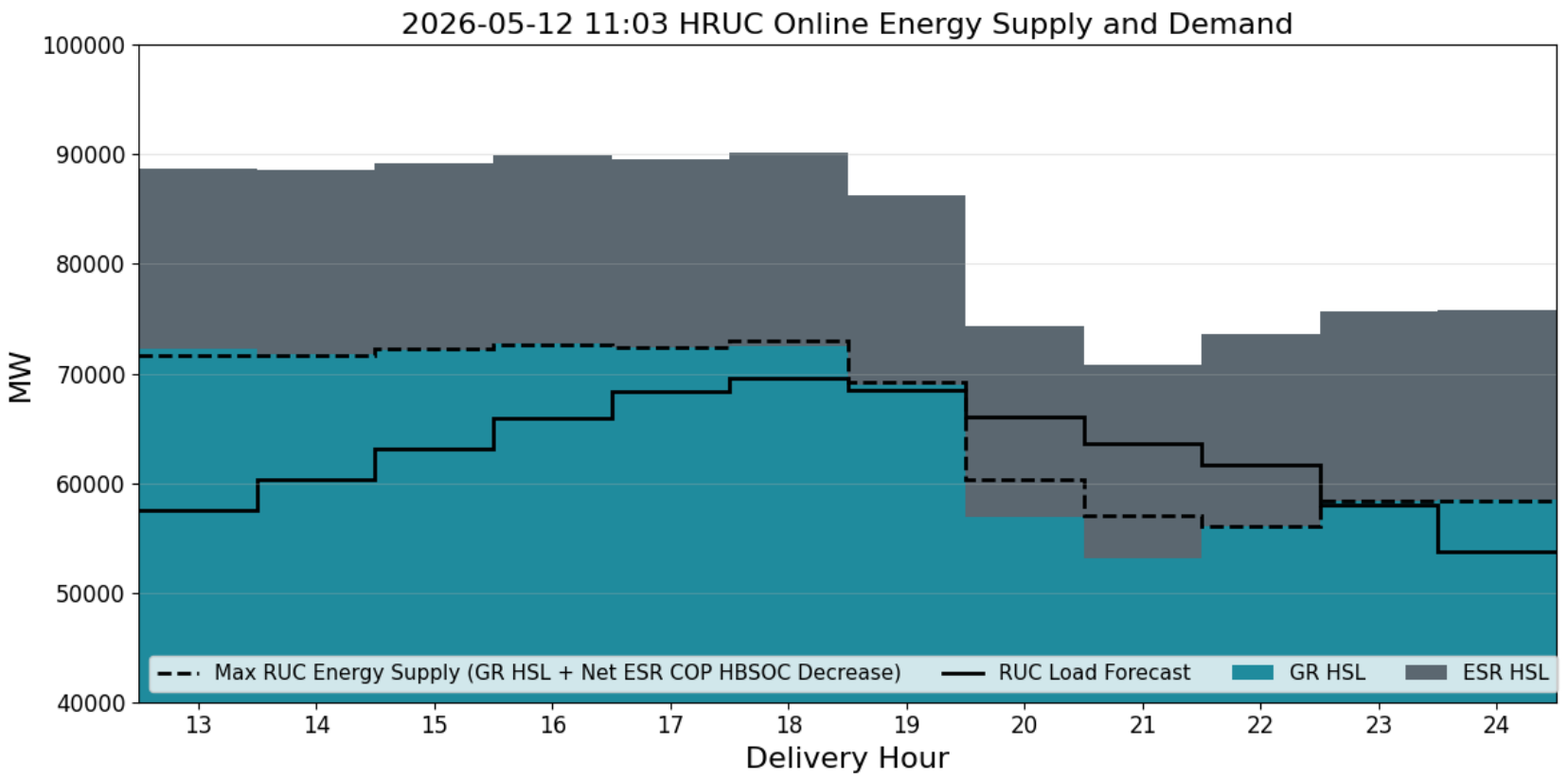
Delivery Hour on May 12, 2026

Takeaway

- HRUC execution at 11:00 before the evening risk window.
- Dynamic HBSOC remained relatively high until HE20, while HBSOC and RT SOC fell sharply from HE20 onward.
- Flat HBSOC resources again failed to reflect the magnitude of actual ESR discharge during the evening hours.

*Change in HBSOC for 'Flat' HBSOC ESRs is the result of switching between online and offline status and does not reflect energy available to RUC

Day 2 Flat HBSOC Impacts on RUC: Online energy supply was less than energy demand during some study hours



Takeaway

- During HE20-22 of the 05/12/26 11:00 HRUC study, there were **energy shortages**.
- During HE21, the **energy shortage** peaked at 6700 MW and RUC recommended 8400 MW for commitment.
- ASDFs and AS shortages would not impact 6700 MW of these HE21 RUC recommendations.

Day 2 Removing ASDFs had a negligible effect on RUC commitments; using real-time SOC reduced them significantly

Takeaway

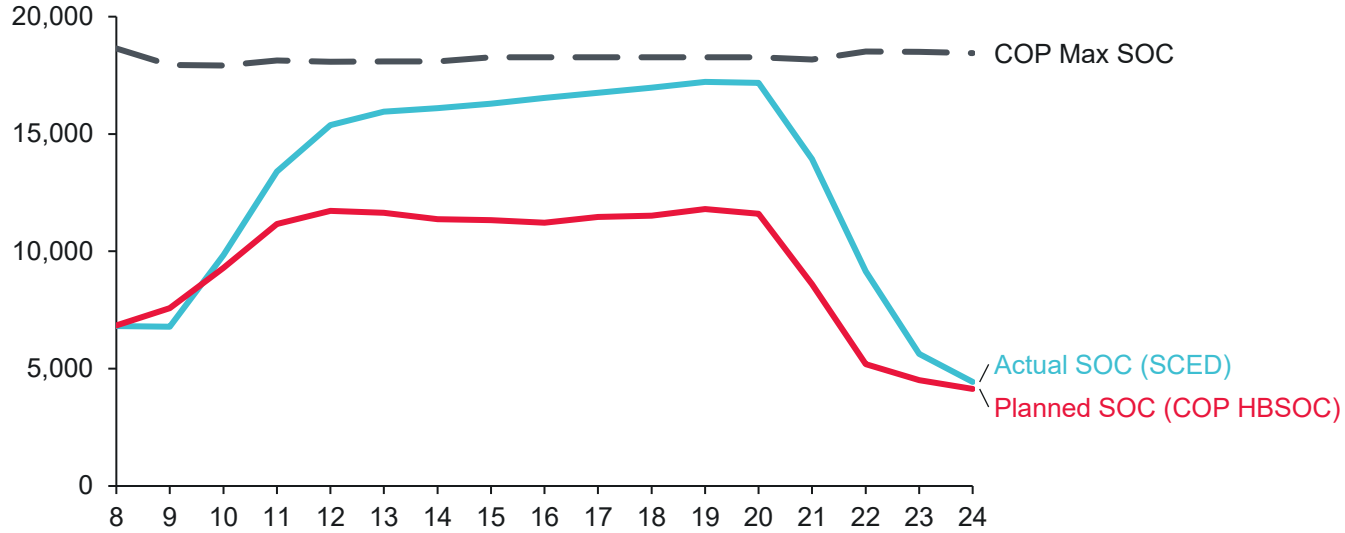
- In the 05/12/26 11:00 HRUC study, COP HBSOC understated the actual HE20-22 ESR SOC decrease: 7.8 GWh modeled versus 18.5 GWh actual.
- Setting ASDFs to zero shifted the timing of RUC recommendations but did not materially reduce the total recommendation level.
- Using telemetered RT SOC proxy reduced both RUC recommendations and AS shortfall.

*Short Start resources have a cold startup time <= 1 hr
*Actual SOC profile would be impacted by accepted RUCs that were online in real-time

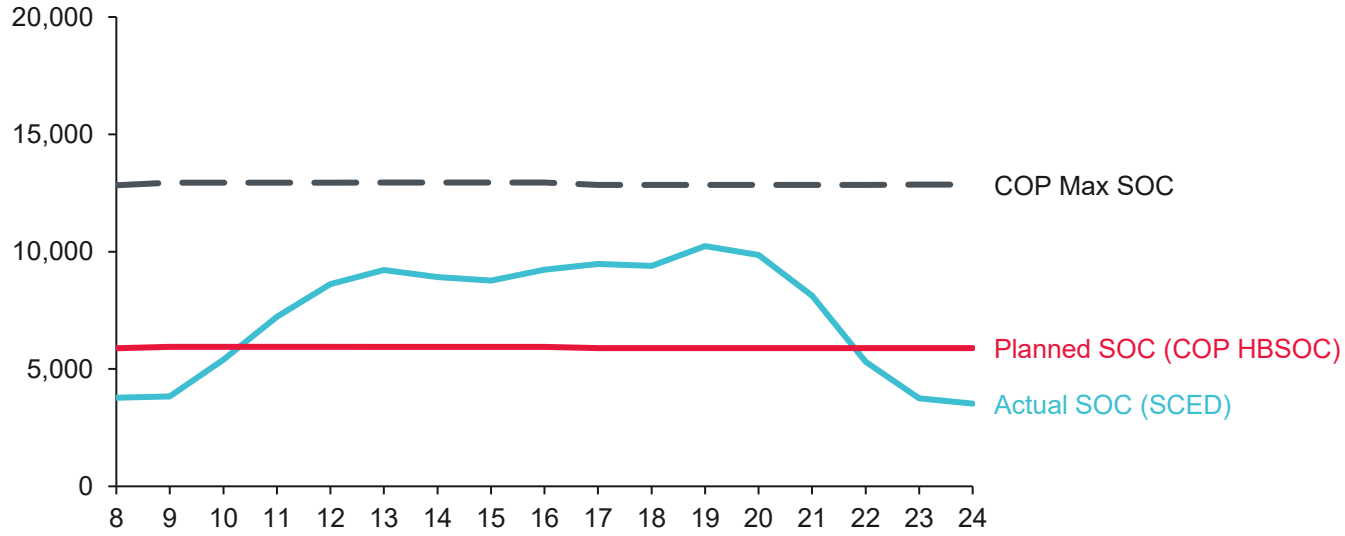
Day 3

HBSOC in COP is inconsistent with Real-Time SOC, hides energy from RUC that the ESR actually discharges

SOC for ESRs Submitting Dynamic HBSOC (MWh)



SOC for ESRs Submitting Constant or 'Flat' HBSOC (MWh)



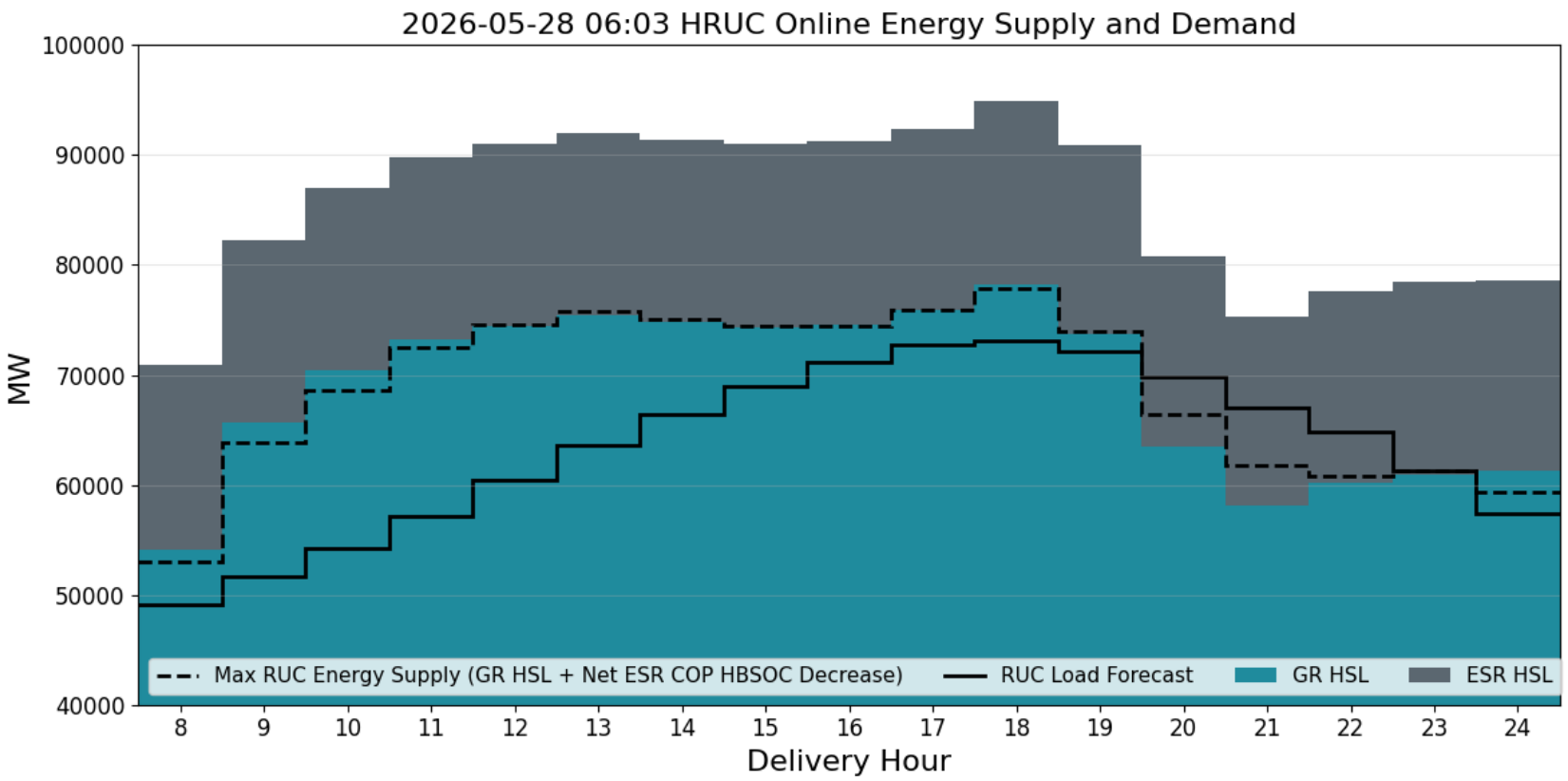
Delivery Hour on May 28, 2026

Takeaway

- HRUC execution at 06:00 well ahead of the evening risk window.
- Real-time SOC increased materially during the day, then declined sharply starting at HE20.
- COP HBSOC, especially for flat-submitters, did not fully reflect the actual charge-discharge profile.

*Change in HBSOC for 'Flat' HBSOC ESRs is the result of switching between online and offline status and does not reflect energy available to RUC

Day 3 Flat HBSOC Impacts on RUC: Online energy supply was less than energy demand during some study hours



Takeaway

- During HE20-23 of the 05/28/26 06:00 HRUC study, there were **energy shortages**.
- During HE21, the **energy shortage** peaked at 5200 MW and RUC recommended every available offline unit for commitment (4600 MW) but was still short on energy.
- ASDFs and AS shortages would not impact any of these HE21 RUC recommendations.

Day 3

Removing ASDFs had a negligible effect on RUC commitments; using real-time SOC reduced them significantly

Takeaway

- In the 05/28/26 06:00 HRUC study, COP HBSOC understated the actual HE20-22 ESR SOC decrease: 7.1 GWh modeled versus 17.7 GWh actual.
- Zero ASDFs reduced shortfall but left RUC recommendations largely similar to the base case.
- Using telemetered RT SOC proxy significantly reduced RUC recommendations and shortfall.

*Short Start resources have a cold startup time <= 1 hr
*Actual SOC profile would be impacted by accepted RUCs that were online in real-time

Improve HBSOC submission and most RUC commitments become unnecessary

What We Learned

- COP HBSOC accuracy is the primary driver of ESR availability in the May 2026 HRUC studies.
- ASDF assumptions matter at the margin, but flat HBSOC submissions drove far more of the result.
- The RUC engine is consistently short on energy and will recommend enough capacity for commitment to eliminate the energy shortages, regardless of ASDFs and AS shortages.
- RUC recommendations reduce substantially when SOC inputs better reflect real-time ESR conditions.

Next Steps

- ERCOT will review problematic COP HBSOC submissions with QSEs and monitor going forward.
- Further discussion of this issue planned for WMS and TAC.
- Consider additional next steps, including tool and/or protocol changes, if behavior is not corrected.

Appendix

SOC Constraints for ESRs with Discharge Energy Dispatch Differ Between SCED and RUC

RUC		SCED
MinSOC Constraint	**Hour Beginning SOC (HBSOC) Constraint**	**MinSOC Constraint**
$RUCHourBeginningPlannedSOC_{i,h}$ $-MW_{i,h}^{EnergyBidOfferAward} \times \Delta t_{ene}^{ruc}$ $-MW_{i,h}^{RegUpAward} \times \Delta t_{Reg}^{ruc}$ $-MW_{i,h}^{RRSPFAward} \times \Delta t_{RPF}^{ruc}$ $-MW_{i,h}^{RRSFFAward} \times \Delta t_{RFF}^{ruc}$ $-MW_{i,h}^{ECRSSAward} \times \Delta t_{ecr}^{ruc}$ $-MW_{i,h}^{NSPINAward} \times \Delta t_{nsp}^{ruc}$ $\geq RUCMinSOC_{i,h} + MinSOCViolationAmount$	$RUCHourBeginningPlannedSOC_{i,h+1}$ $- RUCHourBeginningPlannedSOC_{i,h} =$ $-MW_{i,h}^{EnergyBidOfferAward} \times \Delta t_{ene-DF}^{ruc}$ $-\kappa_h^{RegUp} MW_{i,h}^{RegUpAward} \times \Delta t_{Reg-DF}^{ruc}$ $+\eta_{rt}\kappa_h^{RegDn} MW_{i,h}^{RegDnAward} \times \Delta t_{Reg-DF}^{ruc}$ $-\kappa_h^{RPF} MW_{i,h}^{RRSPFAward} \times \Delta t_{RPF-DF}^{ruc}$ $-\kappa_h^{RFF} MW_{i,h}^{RRSFFAward} \times \Delta t_{RFF-DF}^{ruc}$ $-\kappa_h^{ecr} MW_{i,h}^{ECRSSAward} \times \Delta t_{ecr-DF}^{ruc}$ $-\kappa_h^{nsp} MW_{i,h}^{NSPINAward} \times \Delta t_{nsp-DF}^{ruc}$ $+UnderSOCViolationAmount_{i,h}$ $- OverSOCViolationAmount_{i,h}$	$TelemSOC_i$ $-MW_i^{EnergyBidOfferAward} \times \Delta t_{ene}^{sced}$ $-MW_i^{RegUpAward} \times \Delta t_{Reg}^{sced}$ $-MW_i^{RRSPFAward} \times \Delta t_{RPF}^{sced}$ $-MW_i^{RRSFFAward} \times \Delta t_{RFF}^{sced}$ $-MW_i^{ECRSSAward} \times \Delta t_{ecr}^{sced}$ $-MW_i^{NSPINAward} \times \Delta t_{nsp}^{sced}$ $\geq TelemMinSOC_i$
Where: $\Delta t_{Award\ Type}^{RUC}$: *Time duration required to sustain MW Award dispatch* $\Delta t_{Award\ Type-DF}^{RUC}$: *Deployment Factor Time duration for Award dispatch* κ_h^{AS}: *RUC Deployment Factor for AS in hour h (value between 0 and 1)* η_{rt}: *ESR roundtrip efficiency*		Where: $\Delta t_{Award\ Type}^{SCED}$: *Time duration required to sustain MW Award*