RTC+B: ESR SOC Accounting

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# Objective

This document is intended to provide a high-level overview of system changes required to account for State of Charge (SOC) of Energy Storage Resource (ESR) under the RTC+B Project.

For the RTC+B project, ESR SOC accounting is limited to RTC versions of RUC and SCED.

# Summary of proposed ESR SOC accounting changes

## Interim Period changes (NPRR 1186) carried over into the RTC+B Project

Additional fields in COP (MinSOC, MaxSOC, HourBeginningPlannedSOC) (used by RTC-RUC)

## Day-Ahead Market (DAM)

There are no changes proposed to RTC-DAM as part of the RTC+B project.

## RTC+B Reliability Unit Commitment

RTC-RUC will be the tool ERCOT will rely on to ensure that there is sufficient capacity (MW) and energy from ESRs (MWh), to meet demand (load forecast), Ancillary Service requirements and manage congestion.

The energy sufficiency checks on ESRs uses COP submissions of minSOC, maxSOC and Hour beginning planned SOC and includes the use of AS deployment factors.

The AS deployment factors are hourly parameters for each AS type that are values between 0 and 1 (or 0% to 100%) that indicate the expectation of deployment based on system conditions as new forecasts for demand and renewables are input to RUC.

For example, the AS deployment factor for Non-Spin may be set to a high value for time periods when the expected net load forecasted ramp over certain hours exceeds a certain MW/hour threshold.

RTC-RUC, will use the following new COP values and AS deployment factors to ensure that MW dispatch to an ESR for energy and AS are such that:

1. There is sufficient energy (SOC, MWh) available in the ESR to sustain the MW dispatch for energy and AS for their respective time durations and does not violate the COP values of minimum and maximum SOC for any given hour.
2. The study/simulated dispatch for energy and AS for a given hour are such that the resulting SOC accounting for the end of the given hour will be equal to the HourBeginningPlannedSOC of the next hour. In effect, RTC RUC will dispatch an ESR for energy and AS such that the ESR’s SOC accounting will track the submitted HourBeginningPlannedSOC for each hour as closely as possible (depending on violation costs).

The COP values related to SOC are;

1. Target SOC for the beginning of the Operating Hour for the ESR, (HourBeginningPlannedSOC), MWh
2. Minimum Operating State of Charge for the Operating Hour, (MinSOC), MWh and
3. Maximum Operating State of Charge for the Operating Hour (MaxSOC) MWh

With COP validation rules:

Check that the following condition is satisfied for given Hour Ending

1. MaxSOC is less than or equal to registered MaxSOC (similar to HSL check against HRL)
2. MinSOC is greater than or equal to registered MinSOC (similar to LSL check against LRL)

### RTC RUC setup

1. Input to Mid Term Load Forecast (MTLF) is setup such that MTLF does not include ESR charging load.
2. RUC study/simulation for ESR will be dispatched in RUC for both charging and discharging (change from current RUC where only ESR-GR is dispatched)
3. QSE: the QSE shall ensure that the Hour Beginning Planned SOC for any two consecutive hours shall be such that these values are operationally feasible.
4. In the single model representation of an ESR under approved RTC+B Protocols, LSL is normally a negative MW quantity.
5. RTC RUC preprocessing shall process the COP data and flag any ESR identified by hour(s) and amount where two consecutive Hour Beginning Planned SOC are not operationally feasible i.e., with a maximum basepoint (charging or discharging) in one hour, the next hour’s Hour Beginning Planned SOC in COP cannot be achieved.

For these ESRs, RTC RUC preprocessing will modify the COP submitted Hour Beginning Planned SOC value to a feasible value if the Hour Beginning Planned SOC value is not feasible.

For HRUC:

1. For RUC study hours (h=1,2,3,4, … last hour) initialize:
2. For 1st hour of RUC study (h=1):

Evaluate feasibility of ESR achieving the HourBeginngingPlannedSOC for the first hour of the RUC study using the telemetered ESR HSL, LSL and SOC at time of HRUC execution:

Check if the value of HourBeginningPlannedSOC is between the achievable min and max SOC. If not the RUC study will use the closest feasible value and potentially set the min and max SOC values to the closest feasible value (if needed):

1. For RUC study hours (h=2,3,4,… last hour):

From the 2nd hour till the last hour, evaluate sequentially (daisy chain), if the HourBeginningPlannedSOC for hour x is achievable from the previous hours SOC value that will be used by the RUC study. If the HourBeginngingPlannedSOC for an hour is not achievable, then the RUC study will use the closest feasible value for that hour and potentially set the min and max SOC values to the closest feasible value (if needed):

For DRUC and WRUC, the preprocessing check is the same as for HRUC with the exception that the first hour of the DRUC or WRUC study will assume that the COP SOC data is valid and no feasibility checks are required.

SOC accounting related parameters:

 : Time duration required to sustain MW energy dispatch (analogous to Real-Time Base Point)

 : Time duration required to sustain MW Regulation Up/Down dispatch (analogous to Real-Time Regulation Up/Down MW award )

 : Time duration required to sustain MW RRS-PFR dispatch (analogous to Real-Time RRS-PFR MW award )

 : Time duration required to sustain MW RRS-FFR dispatch (analogous to Real-Time RRS-FFR MW award )

 : Time duration required to sustain MW ECRS dispatch (analogous to Real-Time ECRS MW award )

 : Time duration required to sustain MW Non-Spin dispatch (analogous to Real-Time Non-Spin MW award )

 : Deployment Factor for Regulation Up in hour *h*

 : Deployment Factor for Regulation Down in hour *h*

 : Deployment Factor for RRS-PFR in hour *h*

 : Deployment Factor for RRS-FFR in hour *h*

 : Deployment Factor for ECRS in hour *h*

 : Deployment Factor for Non-Spin in hour *h*

 : Deployment Factor Time duration for energy dispatch

 : Deployment Factor Time duration for Regulation Up/Down dispatch

 : Deployment Factor Time duration for RRS-PFR dispatch

 : Deployment Factor Time duration for RRS-FFR dispatch

 : Deployment Factor Time duration for ECRS dispatch

 : Deployment Factor Time duration for Non-Spin dispatch

###  RTC RUC: Objective function change related to ESR

ESR energy dispatch costs (Bid/Offer) and AS offer costs not included in the RTC-RUC objective function. i.e., ignore energy dispatch costs and AS offer costs of ESR. The SOC constraint violation costs are included in the objective function. *(Note that ERCOT is open to feedback on whether AS Offer costs should be included or not in the objective function)*

### RTC RUC: Additional SOC accounting related constraints

RTC-RUC will attempt to track the COP HourBeginningPlannedSOC for each hour of the RUC study period. As written below, there is no coupling between intervals as the violations of target SOC in one interval do not influence the starting SOC of the next interval. With this approach the penalty costs for violating the target SOC become important. With no temporal coupling, the performance of RTC RUC should not be adversely impacted by the introduction of binary variables due to SOC accounting.

Note that the equations below use RUCHourBeginningPlannedSOC, RUCMinSOC, RUCMaxSOC. If the COP submitted values for HourBeginningPlannedSOC, MinSOC and MaxSOC are feasible, then the values used in the RUC study are the same as the values in COP.

Shams comment:

This approach is very conservative mainly because RUC is still contemplated to have hourly intervals instead of 5-minute intervals. would need to be 1-hour since RUC interval is 1 hour long. Take the example of an ESR at MinSOC at the beginning. In SCED, the ESR could charge the first two SCED intervals while providing UpAS. Once adequately charged, it could provide UpAS and Reg-Down for the remainder of the hour and even discharge for some portion of the hour. Some of that flexibility and the fact that AS typically is not continuously deployed at max for the whole hour may be accounted for by having Δt of 5 minutes (or at most 15 minutes) for all AS.

ERCOT response:

The constraint that RUC dispatch for energy and Ancillary Services has the granularity of an hour is not a function of being conservative. It’s a function of the fact that that is the smallest time interval within the optimization. As a result, it’s also worth noting that the inputs are hourly average values or other values that are static across the hour (hourly average load, static Resource Status, static Energy Curves, etc.). For the RTC+B project, smaller time intervals for RUC studies is not in scope. Exploring the feasibility of smaller intervals that make up the RUC study is a potential future endeavor. If one of the objectives of going to smaller intervals is to mimic Real-Time SCED, then the RUC dispatch engine would have to be redone to use submitted offer/bids with mitigation (two step) and use the same penalty values for power balance and transmission constraints, etc. This is in addition to all the inputs that would need to change. There are a lot of policy issues to be resolved and it should not be assumed that having smaller time intervals will make the RUC solution less conservative.

Regarding the Deployment Factors, the setting of AS Deployment Factors is the expectation of deployment and should be able to account for the amount of continuous deployment or the potential lack thereof. The expectation is also that these values can have some variation, where they can vary by AS type, time of day, etc.

1. For hour h of RTC-RUC Study:
2. *(ESR has discharge energy dispatch)*

Ensure that, with a discharging energy dispatch, if all upward AS (RegUp, RRS-PFR, RRS-FFR, ECRS, NonSpin) are fully deployed (duration requirements for energy and AS), that there is sufficient SOC so that the ESR is not discharged below its COP minimum operating SOC value:

Ensure that, with a discharging energy dispatch, if downward AS (RegDown) is fully deployed (duration requirements for energy and AS), that the ESR’s calculated SOC is not above its COP maximum operating SOC value:

The starting SOC for the next interval (hour h) is known beforehand from COP (HourBeginningPlannedSOCi,h+1) (or closest feasible value). The energy and AS awards for the current interval must be such that the ESR SOC trajectory from one interval to the next will track as closely as possible (subject to violation penalty costs) the COP SOC values. Also, the change in SOC during an interval is based on how much SOC was depleted due to discharging energy dispatch and likely RegUp deployment and boosted by likely RegDown deployment (taking into account regulation deployment factors).

 and are the Regulation Up and Regulation Down deployment factors respectively (value between 0 and 1 for the interval/hour h). In addition, RRS-PFR, RRS-FFR, ECRS and NSPIN deployment factors are considered. and are the RRS-PFR, RRS-FFR, ECRS and NSPIN deployment factors respectively (value between 0 and 1 for the interval/hour h).

This constraint ensures that this calculated change in SOC matches the difference between the COP SOC values in adjacent intervals as closely as possible (HourBeginningPlannedSOCi,h+1 - HourBeginningPlannedSOCi,h):

Shams comment:

This constraint is again very conservative since it allows only charging for the whole hour or only discharging for the whole hour with no changes for each 5-minute interval within the hour. However, this conservativeness may be necessary to make the RUC problem tractable (quantum computing would change this). Since this is an accounting of the SOC for AS provided over the whole hour and the variables take into account the expected deployment of energy for each AS, Dt would be 1 hour for all AS – even FFR (FFR would be very close to 0 if not 0).

ERCOT response:

The constraint that RUC dispatch for energy and Ancillary Services has the granularity of an hour is not a function of being conservative. It’s a function of the fact that that is the smallest time interval within the optimization. As a result, it’s also worth noting that the inputs are hourly average values or other values that are static across the hour (hourly average load, static Resource Status, static Energy Curves, etc.). For the RTC+B project, smaller time intervals for RUC studies is not in scope. Exploring the feasibility of smaller intervals that make up the RUC study is a potential future endeavor. If one of the objectives of going to smaller intervals is to mimic Real-Time SCED, then the RUC dispatch engine would have to be redone to use submitted offer/bids with mitigation (two step) and use the same penalty values for power balance and transmission constraints, etc. This is in addition to all the inputs that would need to change. There are a lot of policy issues to be resolved and it should not be assumed that having smaller time intervals will make the RUC solution less conservative.

Regarding the Deployment Factors, the setting of AS Deployment Factors is the expectation of deployment. Specifically, for FFR, this is a frequency response product that is self-deployed due to an event (e.g. unit trip). As these kinds of events may happen any time, the AS Deployment Factor for FFR may have a floor value which may be very close to 0. The expectation is also that these values can have some variation, where they can vary by AS type, time of day, etc.

1. *(ESR has a charge energy dispatch)*

Ensure that, with a charging energy dispatch, if all upward AS (RegUp, RRS-PFR, RRS-FFR, ECRS, NonSpin) are fully deployed (duration requirements for energy and AS), that there is sufficient SOC so that the ESR is not discharged below its COP minimum operating SOC value:

Ensure that, with a charging energy dispatch, if downward AS (RegDown) is fully deployed (factoring safety margin, duration requirements for energy and AS), that the ESR’s calculated SOC is not above its COP maximum operating SOC value:

The starting SOC for the next interval (hour h) is known beforehand from COP (TargetBeginSOCi,h+1). The energy and AS awards for the current interval must be such that the ESR SOC trajectory from one interval to the next will match as closely as possible (subject to violation penalty costs) the COP target begin SOC values. Also, the change in SOC during an interval is based on how much SOC was boosted due to charging energy Base Point and likely RegDown deployment and depleted by likely RegUp deployment (taking into account statistical regulation deployment factors).

 and are the Regulation Up and Regulation Down deployment factors respectively (value between 0 and 1 for the interval/hour h). In addition, RRS-PFR, RRS-FFR, ECRS and NSPIN deployments must be factored in. and are the RRS-PFR, RRS-FFR, ECRS and NSPIN deployment factors respectively (value between 0 and 1 for the interval/hour h).

This constraint ensures that this calculated change in SOC matches the difference between the COP target begin SOC values in adjacent intervals as closely as possible (HourBeginningPlannedSOCi,h+1 - HourBeginningPlannedSOCi,h):

Simultaneous upward and downward AS deployment scenario is not considered for either charging or discharging scenarios as the above constraints are more conservative and will ensure that the COP minimum and maximum operating SOC values are not violated with simultaneous upward and downward AS deployment.

### RTC+B RUC: RUC Capacity Short Calculations

The RUC capacity short calculations will factor in the COP value of HourBeginningPlannedSOC for each hour of the RUC study horizon to determine capacity available to meet the QSE’s energy and AS position.

Shams comment:

Since ASDCs and bids/offers set the AS quantities in DAM (e.g., in scarcity situations no Non-Spin and little ECRS could be awarded in DAM), having ASDCs in RUC where energy scarcity values are not taken into account (due to EOC discounting) may lead to thousands of MWs of Non-Spin/ECRS additional “award” compare to DAM. There will always be a mismatch between DAM and RUC AS quantities for each RUC. This becomes impossible to hedge. So, maybe we don’t have ASDCs in RUC but use the DAM awarded and self-arranged quantities as the fixed quantities that RUC must re-award.

To determine AS quantity shortfall, use the DAM AS obligations and AS Resource Responsibilities and Trades to determine any shortfall – no need to consider SOC since AS can be provided while charging if necessary. To determine energy capacity shortfall, don’t count Resource capacity tied to UpAS Resource Responsibility and use the remaining capacity to determine capacity available for energy. For ESRs, remaining capacity for which there is enough SOC to sustain a 1-hour deployment should be credited towards capacity available for energy. E.g., 100MW ESR with 25MWh SOC and 50MW of UpAS Resource Responsibility will get credit for 25MW as counting towards capacity available for energy. If that ESR has 90MW UpAS Resource Responsibility, then only 10MW will count towards capacity available for energy.

ERCOT response:

The RTC RUC ASDC parameters will be a later discussion item and the above comments should be considered then.

We assume the UpAS Resource Responsibility in the comment above refers to the QSE portfolio Up AS position (from DAM and Trades) and not the RUC dispatch values for AS. ERCOT does not understand the example. RUC dispatch for energy and AS on individual Resources should not be used. This is because RUC sets up the offer/bids based on MOC and we do not have the same RT-SCED implementation (two steps, transmission constraint penalty, power balance constraint penalty, etc.) when determining the dispatch for energy and AS.

The determination of RUC capacity short is done on a QSE portfolio basis.

ERCOT is still working on the RUC capacity short calculations. Suggest that we wait for ERCOT to present the changes to the current grey box RTC protocols.

We disagree with the above comment that the COP SOC should not be used to verify whether the QSE portfolio Up AS position can be satisfied. If RUC commits a thermal Resource due to QSEs having insufficient SOC to cover its portfolio AS position, then these QSEs should have a RUC capacity shortfall. Note that RTC RUC will dispatch energy and AS on ESRs to follow their submitted COP SOC from hour to hour.

## RTC+B Real-Time Market

In Real-Time, for an ESR, RTC-SCED will use the currently SOC related telemetered values (that became required telemetry for ESRs in 2018)

1. Telemetered State of Charge [SOC\_Telem], “SOC”, MWh
2. Telemetered Minimum Operating State of Charge ([SOC\_OperMin], “MNOS”, MWh; and
3. Telemetered Maximum Operating State of Charge [SOC\_OperMax], MXOS”,MWh

to:

1. perform telemetry validation to ensure telemetered min, max, and current SOC values are within bounds, i.e.,
2. Modify RTC-SCED to incorporate SOC related constraints such that there is sufficient energy to sustain the MW awards for energy (Base Points) and AS for their respective time duration and does not violate the telemetered minimum and maximum SOC values.

### RTC SCED: Additional SOC related constraints

This section describes the proposed additional RTC SCED constraints for SOC accounting. The purpose of these constraints is to ensure that there is sufficient stored energy (MWh) available to sustain RTC-SCED MW awards for energy and AS.

SOC accounting related parameters:

 : Time duration required to sustain MW energy award (Base Point)

 : Time duration required to sustain MW Regulation Up/Down award

 : Time duration required to sustain MW RRS-PFR award

 : Time duration required to sustain MW RRS-FFR award

 : Time duration required to sustain MW ECRS award

 : Time duration required to sustain MW Non-Spin award

1. ESR with status of ON, ONOS, ONEMR
2. (ESR has a Base Point to Discharge)

Ensure that, with a discharging Base Point, if all upward AS (RegUp, RRS-PFR, RRS-FFR, ECRS, NonSpin) are fully deployed (duration requirements for energy and AS), that there is sufficient SOC so that the ESR is not discharged below is telemetered minimum operating SOC value:

Shams comment:

These equations are assuming ESR discharging/charging immediately with Energy MW (Base Point) Award – which would be good. However, UDSP would then also need to reflect this for ESRs and not ramp to Base Point over 4 minutes. Currently, ESRs, when deployed for Energy and required to ramp over 4 minutes, are not able to supply the needed Energy faster and get paid more during scarcity intervals. Without implementing shorter SCED durations, can UDSP calculations mimic what a 1-minute SCED would dispatch thereby address any frequency issues? If not and all UDSPs ramp over 4 minutes, then the first term needs to be multiplied by a fraction slightly greater than 0.5 based on UDSP Energy over the SCED interval (say 0.6). Also, since SCED awards and AS responsibilities are over 5 minutes, is 5 minutes for proper SOC accounting and all other Δt need to be the same 5 minutes to avoid stranded SOC.

ESRs can provide only online (not offline) ECRS and Non-Spin. Online ECRS (not held behind HASL in RTC) and Non-Spin awards for a SCED interval are not deployed for energy during that SCED interval. So, there is no SOC required to provide ECRS and Non-Spin – these AS have limited RT reliability value except to provide market price signals for the value of 10-minute and 30-minute capacity to induce self-commitment and future investment. However, since capacity providing ECRS and Non-Spin could potentially be issued Emergency Base Points outside the SCED process, it’s reasonable to require 5-minutes worth of SOC.

ERCOT response:

Need clarification on the UDSP comments. Is the question on UDSP suggesting to use the shape (trapezoid) of the 4 minute ramp to calculate the energy requirement when discharging? If so, the same will apply for both charging and discharging Base Points. It should also be pointed out that UDSP needs to be coordinated across all Resources responding to SCED Base Points. Frequency imbalances will be created if we don’t have uniform ramp periods for UDSP base ramp across the whole system. To the degree we see frequency deviations and we want to certain Resources to move more quickly to balance them, that will already be reflected in Ancillary Service deployments, primarily Regulation. Allowing different base ramp rates for UDSP will simply lead to increased frequency deviations and more dependency on Regulation and other Ancillary Services.

There will be further discussions on the energy and AS duration requirements for both RUC and Real-Time. At present would like consensus on the proposed concepts in this document.

For the AS duration comment for ECRS and Non-Spin, we disagree. It is not just a price formation issue but ensuring that there is sufficient energy preserved that can be used later if required. Note that under RTC, there is no concept of HASL and during scarcity events RTC SCED will go short on procuring ECRS and Non-Spin. If the energy required for ECRS and Non-Spin is not preserved in prior SCEDs, then a scarcity event can quickly lead to firm load shed.

Ensure that, with a discharging Base Point, if downward AS (RegDown) is fully deployed (duration requirements for energy and AS), that the ESR is not in a state where the calculated SOC is not above its telemetered maximum operating SOC value:

1. *(ESR has a Base Point to Charge)*

Ensure that, with a charging Base Point, if all upward AS (RegUp, RRS-PFR, RRS-FFR, ECRS, NonSpin) are fully deployed (duration requirements for energy and AS), that there is sufficient SOC so that the ESR is not discharged below is telemetered minimum operating SOC value:

Shams comment:

These constraints also assume immediate charging with no ramp period – if ramp required, then adjustments similar to the ones described above should be made. When charging at say 10MW, the ESR can provide 10MW of UpAS by simply ceasing to charge. Then, should the adjustment be applied to all the terms in this constraint? It may be okay to not apply that term to be more conservative. Same issue with ECRS and Non-Spin as described above.

ERCOT response:

The optimization engine requires linear constraints. What is proposed in the comments above would lead to non-linear constraints. Modifying the above example, if the ESR was awarded a 7 MW charging Base Point and a 10 MW UpAS, then the constraint would have terms using min or max and the use of Min/Max functions results in the constraints becoming non-linear.

Ensure that, with a charging Base Point, if downward AS (RegDown) is fully deployed (duration requirements for energy and AS), that the ESR is not in a state where the calculated SOC is not above its telemetered maximum operating SOC value:

Simultaneous upward and downward AS deployment scenario is not considered as the above constraints (for discharging and charging) are more conservative and will ensure that the telemetered minimum and maximum operating SOC values are not violated with simultaneous upward and downward AS deployment.

Where;

 is the roundtrip efficiency (dimensionless) value being between 0 and 1

1. ESR with status of ONTEST, ONHOLD

Do not enforce SOC constraints.

### RTC SCED: Preprocessing

To eliminate the use of penalty variables in SCED SOC constraints, perform preprocessing to ensure feasibility of SOC constraints. If LDL<0 and HDL >0, then there is no issue of SOC constraint infeasibility. However, there are infeasibilities that can occur when LDL and HDL are such that RTC-SCED cannot give a ESR Base Point of 0.

The assumptions are:

1. The system that calculates LDL and HDL, will always provide LDL, HDL values such that LDL<=HDL.
2. RTC-SCED can always give an AS award =0

Below are the preprocessing rules:

1. LDL>0: If giving a minimum discharge energy Base Point of LDL violates MinSOC limit then:
2. Do not enforce SOC constraints.
3. Constrain Base Point to LDL
4. Do not award any AS

1. HDL<0: : If giving a maximum charge energy Base Point of HDL violates MaxSOC limit then:
2. Do not enforce SOC constraints.
3. Constrain Base Point to HDL
4. Do not award any AS