KP 1.3

RTC Constraints

Working Document

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## Introduction

This document describes the proposed constraints used by RTC in the Real-Time optimization. This document will be revised based on feedback from stakeholders.

Status as of 6/21/2019:

Items not covered in this version

1. Synchronous Condenser participating in RRS (PFR) and ECRS
2. Storage Resources modeled as a combination of a Generation Resource and a Controllable Load Resource participating in FRRS, FFR and “blocky” ECR
3. Fast Load Resource participating in FFR

## Design Objective

In RTC, energy and Ancillary Service (AS) products are procured through a co-optimized clearing process that minimizes production costs. The results of the RTM (dispatch and prices) should not harm the Resource side i.e., energy dispatch and AS awards are feasible and there is no lost opportunity.

To achieve this, it is important to account for the physical operational characteristics of the Resources, viz. Ramp Rates, Forbidden Zones, High/Low output limits, transient temporal constraints due to combined cycle configuration transition, etc.

ERCOT stakeholders, in the design of the current RTM (SCED), adopted the use of a combination of mathematical modeling of the physical operational characteristics and Real-Time Resource telemetry in the clearing engine to allow maximum flexibility.

The same approach is taken for the design of RTC where, a combination of additional Real-Time Resource telemetry and enhancements to the mathematical models in the clearing engine have been adopted.

## Resource Status:

The Resource statuses (COP and Telemetry) will need to be reviewed. The table below lists the current Resource statuses (COP and/or Telemetry) being used.

Table 1: Resource Status

|  |  |  |
| --- | --- | --- |
| Resource Type | Resource Status | Under RTC |
| Generation Resource | ON | Available for energy and AS awards |
| ONOS | Energy participation same as today. Can participate in AS if offered |
| ONDSR | Energy participation same as today. Can participate in AS if offered |
| ONOPTOUT | Considered to be same as ON |
| ONRUC | Considered to be same as ON (will have special treatment, e.g., AS offer floors) |
| OFFQS | Considered to be same as ON for energy, ECRS and NSPIN. Cannot be awarded Regulation or PFR |
| OFF | Not available to for energy, Regulation, PFR, or ECRS awards. Available for NSPIN if qualified |
| ONREG | Status no longer needed |
| FRRSUP | Status no longer needed |
| ONOSREG | Status no longer needed |
| ONDSRREG | Status no longer needed |
| OFFNS | Status no longer needed |
| ONTEST | Energy participation same as today. Cannot be awarded AS |
| ONEMR | Considered to be same as ON, may appropriately set LSL and HSL to reflect operating limits |
| ONRR | More discussion required on both energy and AS participation |
| ONECRS | More discussion required on both energy and AS participation |
| ONFFRRRS | More discussion required on both energy and AS participation |
| OUT | Not available for energy or AS awards |
| EMR | Not available for energy or AS awards |
| STARTUP | Energy participation same as today. Cannot be awarded AS |
| SHUTDOWN | Energy participation same as today. Cannot be awarded AS |
| EMRSWGR | Not available for energy or AS awards |
|  |  |  |
| LR | ONRGL | Replace with ON |
| ONCLR | Replace with ON. Similar to GR with ON status |
| ONRL | Replace with ON. Not available for energy awards. Available for RRS and ECRS awards |
| ONECL | Replace with ON |
| ONFFRRRSL | Replace with ON |
| OUT | Not available for energy or AS |
| FRRSDN | Status no longer needed |
| FRRSUP | Status no longer needed |

**Feedback requested:**

1. **Please review table of Resource status and ERCOT comments and provide feedback**

## Telemetry Considerations

In this document new telemetry required for RTC are proposed. These new telemetry, in coordination with other existing telemetry and enhanced mathematical models will guide RTC in awarding energy and AS appropriately

**Existing Telemetry to manage physical operating conditions of Resources**

1. Resource status telemetry (STARTUP,SHUTDOWN), and
2. Resource Ramp Rate telemetry
3. Resource limits (HSL,LSL)

**New Resource Specific Telemetry**

$TelMxRegUp\_{i}$: Telemetry (MW value) to indicate maximum RegUp MW capability for *ith* Resource

$TelMxRegDn\_{i}$: Telemetry (MW value) to indicate maximum RegDn MW capability for *ith* Resource

$TelMxPFR\_{i}$: Telemetry (MW value) to indicate maximum PFR MW capability for *ith* Resource

$TelMxRRS\_{i}$: Telemetry (MW value) to indicate maximum RRS MW capability **excluding** self-provided amount for *ith* UFR type Load Resource

$TelMxECRS\_{i}$: Telemetry (MW value) to indicate maximum ECRS MW capability for *ith* Resource

$TelMxNSPIN\_{i}$: Telemetry (MW value) to indicate maximum NSPIN MW capability for *ith* Resource

**Additional New Combined Cycle Specific Telemetry to accommodate frequency and non-frequency capacity**

$RespFactor\_{i}$: Proportion of the Base Point $\left(MW\_{i}^{EnergyOfferAward}\right)$ provided by the frequency responsive capacity of the *ith* Combined Cycle Generation Resource

$LowRespLim\_{i}$: Minimum amount of the total Base Point $\left(MW\_{i}^{EnergyOfferAward}\right)$ provided by the frequency responsive capacity of the *ith* Combined Cycle Generation Resource

$HiRespLim\_{i}$ : Maximum amount of the total Base Point $\left(MW\_{i}^{EnergyOfferAward}\right)$ provided by the frequency responsive capacity of the *ith* Combined Cycle Generation Resource

**Additional New UFR Type Load Resource Specific Telemetry to accommodate self-provision of RRS and ECRS**

$TelSelfRRS\_{i}$: Telemetry to indicate RRS MW amount self-provided by *ith* On-Line UFR type Load Resource

$TelSelfECRS\_{i}$: Telemetry to indicate ECRS MW amount self-provided by *ith* On-Line UFR type Load Resource

**Feedback requested:**

**Is the flexibility of using telemetry to address operational constraints is adequate (e.g. awarding of Regulation, PFR considering only frequency responsive capacity, handling of forbidden zones, avoiding award of AS while Resource is transitioning through “dead zones”, etc.) adequate?**

## Nomenclature

$Ng$: The number of On-Line Generation Resources

$Noffqs$: The number of Generation Resources with status of OFFQS

$Nclr$: The number of On-Line Controllable Load Resources

$Nfg$: The number of On-Line “fast” Generation Resource part of Storage Resource

$Nfclr$: The number of On-Line “fast” Controllable Load Resource part of Storage Resource

$Nufr$: The number of On-Line UFR type Load Resources

$Nflr$: The number of On-Line “fast” Load Resources that are qualified for FFR

$Noff$: The number of Off-Line Generation Resources that are qualified for NSPIN

$MW\_{i}^{EnergyOfferAward}$: Energy Base Point to *ith* Generation Resource (supply-generation)

$MW\_{i}^{EnergyBidAward}$ : Energy Base Point to *ith* Controllable Load Resource (demand - consumption)

$MW\_{i}^{PowerBalanceMW}$: Cleared MW segment of the Power Balance Penalty Curve

$MW\_{i}^{RegUpAward}$: RegUp MW capacity award to *ith* Resource

$MW\_{i}^{FRRSUpAward}$: FRRSUp MW capacity award to *ith* Resource

$MW\_{i}^{RegDnAward}$: RegDn MW capacity award to *ith* Resource

$MW\_{i}^{FRRSDnAward}$: FRRSDn MW capacity award to *ith* Resource

$MW\_{i}^{PFRAward}$: RRS (PFR) MW capacity award to *ith* Resource

$MW\_{i}^{RRSAward}$: RRS (UFR) MW capacity award to *ith* UFR type Load Resource

$MW\_{i}^{FFRAward}$: RRS (FFR) MW capacity award to *ith* “fast” Resource (Storage or Fast Load Resource)

$MW\_{i}^{ECRSAward}$: ECRS MW capacity award to *ith* Resource

$MW\_{i}^{NSPINAward}$: NSPIN MW award to *ith* Resource

$MW\_{i}^{RegUpDemandAward}$: Cleared RegUp MW segment of RegUp ASDC

$MW\_{i}^{RegDnDemandAward}$: Cleared RegDn MW segment of RegDn ASDC

$MW\_{i}^{RRSDemandAward}$: Cleared RRS MW segment of RRS ASDC

$MW\_{i}^{ECRSDemandAward}$: Cleared ECRS MW segment of ECRS ASDC

$MW\_{i}^{NSPINDemandAward}$: Cleared NSPIN MW segment of NSPIN ASDC

**Resource Specific Telemetry Values input to RTC**

$TelemMW\_{i}$: Telemetered MW of *ith* Resource (supply side – generation, demand side - consumption)

$LSL\_{i}$: Low Sustained Limit of *ith* Generation Resource

$HSL\_{i}$: High Sustained Limit of *ith* Generation Resource

$LPC\_{i}$: Low Power Consumption Limit of *ith* Load Resource

$MPC\_{i}$: Maximum Power Consumption Limit of *ith* Load Resource

$NRRUp\_{i}$: Blended Normal Ramp Rate Up (value, when multiplied by 5 shows the 5 minute MW output change capability) of *ith* Resource

$ERRUp\_{i}$: Blended Emergency Ramp Rate Up (value, when multiplied by 5 shows the 5 minute MW output change capability using the emergency ramp rate) of *ith* Resource

$NRRDn\_{i}$: Blended Normal Ramp Rate Down (value, when multiplied by 5 shows the 5 minute MW output change capability) of *ith* Resource

**Calculated Values input to RTC**

$LDL\_{i}$: Low Dispatch Limit of *ith* Resource

$HDL\_{i}$: High Dispatch Limit of *ith* Resource

**Other Inputs**

$ScalingFactorUp$: Value between 0 and 1. Determines amount of ramp sharing between Base Point (energy) and RegUp. Value of 1 indicates no ramp sharing.

$ScalingFactorDn$: Value between 0 and 1. Determines amount of ramp sharing between Base Point (energy) and RegDn. Value of 1 indicates no ramp sharing.

## RTC optimization Objective

Maximize bid based costs (energy bids and AS Demand Curves) minus offer based revenue (energy offers and AS offers)

## Power Balance Constraint

$$\sum\_{i=1}^{Ng+Noffqs}MW\_{i}^{EnergyOfferAward}-\sum\_{i=1}^{Nclr}MW\_{i}^{EnergyBidAward}+\sum\_{i=1}^{Nclr}TelemMW\_{i}+\sum\_{i=1}^{NPB}MW\_{i}^{PowerBalanceMW}-GTBD=0$$

## System-Wide Regulation Up Procurement Constraint

$$\sum\_{i=1}^{Ng+Nclr}MW\_{i}^{RegUpAward}+\sum\_{i=1}^{Nfg+Nfclr}MW\_{i}^{FRRSUpAward}-\sum\_{i=1}^{NregUpDemand}MW\_{i}^{RegUpDemandAward}=0$$

1. FRRS-Up maximum procurement limit

$$MaxFRRSUp-\sum\_{i=1}^{Nfg+Nfclr}MW\_{i}^{FRRSUpAward}\geq 0$$

## System-Wide Regulation Down Procurement Constraint

$$\sum\_{i=1}^{Ng+Nclr}MW\_{i}^{RegDnAward}+\sum\_{i=1}^{Nfclr}MW\_{i}^{FRRSDnAward}-\sum\_{i=1}^{NregDnDemand}MW\_{i}^{RegDnDemandAward}=0$$

1. FRRS-Down maximum procurement limit:

$$MaxFRRSDn-\sum\_{i=1}^{Nfclr}MW\_{i}^{FRRSDnAward} \geq 0$$

## System-Wide RRS Procurement

$$\sum\_{i=1}^{Ng+Nclr}MW\_{i}^{PFRAward}+\sum\_{i=1}^{Nufr}MW\_{i}^{RRSAward}+\sum\_{i=1}^{Nfg+Nfclr+Nflr}MW\_{i}^{FFRAward}-\sum\_{i=1}^{NRRSDemand}MW\_{i}^{RRSDemandAward}=0$$

1. PFRsys-min, RRS+FFR and FFR maximum procurement

NPRR 863 stipulates that:

1. Minimum amount of PFR shall be procured (1150 MW)
2. The Maximum amount of RRS and FFR from UFR Load Resources and fast resources is limited to 60% of the total RRS requirement
3. The maximum amount of FFR procured cannot exceed 420MW

One way of representing these requirements as constraints in the RTC optimization are shown below:

$$\sum\_{i=1}^{Ng+Nclr}MW\_{i}^{PFRAward}\geq PFR\_{sys-min}$$

$$MaxRRS- \sum\_{i=1}^{Nufr}MW\_{i}^{RRSAward}-\sum\_{i=1}^{Nfg+Nfclr+Nflr}MW\_{i}^{FFRAward}\geq 0$$

$$MaxFFR- \sum\_{i=1}^{Nfg+Nfclr+Nflr}MW\_{i}^{FFRAward}\geq 0$$

## System-Wide ECRS Procurement

$$\sum\_{i=1}^{Ng+Nclr+Noffqs}MW\_{i}^{ECRSAward}+\sum\_{i=1}^{Nufr}MW\_{i}^{ECRSAward}-\sum\_{i=1}^{NECRSDemand}MW\_{i}^{ECRSDemandAward}=0$$

## System-Wide NSPIN Procurement

$$\sum\_{i=1}^{Ng+Nclr+Noffqs+Noff}MW\_{i}^{NSPINAward}-\sum\_{i=1}^{NNSPINDemand}MW\_{i}^{NSPINDemandAward}=0$$

## On-Line Generation Resource

Generation Resources that are Combined Cycle Generation Resources, WGRs , PVGRs, and Storage Resources modeled as a combination of a Generation Resource and a Controllable Load Resource that participates in conventional Regulation, PFR, ECRS, and NSPIN ( Storage Resource participating in FRRS, and FFR are described in a later section)

1. Resource Status is one of (ON, ONOS, ONDSR, ONOPTOUT, ONRUC, ONEMR)
2. For each On-Line Generation Resource ($i=1,2,3…N\_{g}$):

$$LSL\_{i}\leq LDL\_{i}\leq TelemMW\_{i}\leq HDL\_{i}\leq HSL\_{i}$$

$$HDL\_{i}=Min\left(HSL\_{i},\left(TelemMW\_{i}+NRRUp\_{i}\*5\right)\right)$$

$$LDL\_{i}=Max\left(LSL\_{i},\left(TelemMW\_{i}-NRRDn\_{i}\*5\right)\right)$$

LSL

LDL

HDL

HSL

TelemMW

1. Upward AS Offer constraints (RegUp, RRS PFR, ECRS, On-Line NSPIN): Assume full utilization of available AS Offer structure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| AS Offer MW | RegUp $/MWh(Conventional) | RRS (PFR) $/MWh | ECRS $/MWh(RTC Dispatchable) | On-Line NSPIN $/MWh(RTC Dispatchable) |
| ASMW1 | Yes | Yes | Yes | Yes |
| ASMW2 | Yes | Yes | Yes | Yes |
| ASMW3 | Yes | Yes | Yes | Yes |
| ASMW4 | Yes | Yes | Yes | Yes |
| ASMW5 | Yes | Yes | Yes | Yes |

1. New telemetry to limit individual AS awards:
	1. $TelMxRegUp\_{i}$: Telemetry (MW value) to indicate maximum RegUp MW capability.
2. $TelMxPFR\_{i}$: Telemetry (MW value) to indicate maximum PFR MW capability.
3. $TelMxECRS\_{i}$: Telemetry (MW value) to indicate maximum ECRS MW capability.
4. $TelMxNSPIN\_{i}$: Telemetry (MW value) to indicate maximum NSPIN MW capability.

**Feedback requested:**

1. **Is the provision of the additional new telemetry acceptable?**
2. **Are there other alternatives to inform ERCOT of reduced AS capability for use by RTC?**
3. Individual AS Offer MW constraints ($k=1,2,3,4,5$):

$$MW\_{k}^{RegUpAward}+MW\_{k}^{PFRAward}+MW\_{k}^{ECRSAward}+MW\_{k}^{NSPINAward}\leq ASMW\_{k}$$

1. Checks on allowable total RegUp Award for On-Line Generation Resource ($i=1,2,3…N\_{g}$):

$$MW\_{i}^{RegUpAward}=\sum\_{k=1}^{k=5}MW\_{k}^{RegUpAward}$$

$$MW\_{i}^{RegUpAward}\leq Min\left( TelMxRegUp\_{i},RegUpQualifiedMW\_{i},\left(NRRUp\_{i}\*5\right)\right)$$

1. Checks on allowable total PFR Award for On-Line Generation Resource ($i=1,2,3…N\_{g}$):

$$MW\_{i}^{PFRAward}=\sum\_{k=1}^{k=5}MW\_{k}^{PFRAward}$$

$$MW\_{i}^{PFRAward}\leq Min\left(TelMxPFR\_{i},PFRQualifiedMW\_{i}\right)$$

1. Checks on allowable total ECRS Award for On-Line Generation Resource ($i=1,2,3…N\_{g}$):

$$MW\_{i}^{ECRSAward}=\sum\_{k=1}^{k=5}MW\_{k}^{ECRSAward}$$

$$MW\_{i}^{ECRSAward}\leq Min\left(TelMxECRS\_{i},ECRSQualifiedMW\_{i},\left(ERRUp\_{i}\*10\right)\right)$$

1. Checks on allowable total NSPIN Award for On-Line Generation Resource ($i=1,2,3…N\_{g}$):

$$MW\_{i}^{NSPINAward}=\sum\_{k=1}^{k=5}MW\_{k}^{NSPINAward}$$

$$MW\_{i}^{NSPINAward}\leq Min\left(TelMxNSPIN\_{i},NSPINQualifiedMW\_{i},\left(NRRUp\_{i}\*30\right)\right)$$

1. RegDn AS Offer constraints: Assume full utilization of available AS Offer structure

|  |  |
| --- | --- |
| RegDnAS Offer MW | RegDn $/MWh(Conventional) |
| ASMW1 | Yes |
| ASMW2 | Yes |
| ASMW3 | Yes |
| ASMW4 | Yes |
| ASMW5 | Yes |

1. New Resource telemetry to limit RegDn AS awards:
	1. $TelMxRegDn\_{i}$: Telemetry (MW value) to indicate maximum RegDn MW capability.

**Feedback requested:**

1. **Is the provision of the additional new telemetry acceptable?**
2. **Are there other alternatives to inform ERCOT of reduced AS capability for use by RTC?**
3. Individual RegDn AS Offer MW constraints ($k=1,2,3,4,5$):

$$MW\_{k}^{RegDnAward}\leq ASMW\_{k}$$

1. Checks on allowable total RegDn Award for On-Line Generation Resource ($i=1,2,3…N\_{g}$):

$$MW\_{i}^{RegDnAward}=\sum\_{k=1}^{k=5}MW\_{k}^{RegDnAward}$$

$$MW\_{i}^{RegDnAward}\leq Min\left(TelMxRegDn\_{i},RegDnQualifiedMW\_{i},\left(NRRDn\_{i}\*5\right)\right)$$

1. LDL/LSL constraint: Ensures that the energy (Base Point) and Regulation Down awards are feasible with respect to the LDL and LSL of the Resource ($i=1,2,3…N\_{g}$):

$$MW\_{i}^{EnergyOfferAward}-ScalingFactorDn×MW\_{i}^{RegDnAward}-LDL\_{i} \geq 0$$

$$MW\_{i}^{EnergyOfferAward}-MW\_{i}^{RegDnAward}-LSL\_{i} \geq 0$$

$$MW\_{i}^{RegDnAward}$$

LSL

LDL

HDL

HSL

$$MW\_{i}^{EnergyOfferAward}$$

1. HDL constraint: Ensures that the energy (Base Point) and Regulation Up awards are feasible with respect to the HDL of the Resource:

$$HDL\_{i}-MW\_{i}^{EnergyOfferAward}-ScalingFactorUp×MW\_{i}^{RegUpAward} \geq 0$$

$$MW\_{i}^{RegUpAward}$$

LSL

LDL

HDL

HSL

$$MW\_{i}^{EnergyOfferAward}$$

1. HSL constraint: Ensures that the energy (Base Point), Regulation Up, Responsive Reserve (PFR), ECRS and On-line NSPIN awards are feasible with respect to the High Sustained Limit (HSL) of the Resource:

$$HSL\_{i}-MW\_{i}^{EnergyOfferAward}-MW\_{i}^{RegUpAward}-MW\_{i}^{PFRAward}-MW\_{i}^{ECRSAward}-MW\_{i}^{NSPINAward}\geq 0$$

$$MW\_{i}^{RegUpAward}$$

LSL

LDL

HDL

HSL

$$MW\_{i}^{EnergyOfferAward}$$

$$MW\_{i}^{PFRAward}$$

$$MW\_{i}^{ECRAward}$$

$$MW\_{i}^{NSPINAward}$$

1. Combined Cycle Generation Resource: Checks on ensuring awards for RegUp, RegDn and PFR are feasible.

Conditional Constraint: If the sum of RegUp and PFR award is greater than zero, then enforce additional constraint:

If ($MW\_{i}^{RegUpAward}+MW\_{i}^{PFRAward}>0$) then additionally enforce these two constraints:

$$RespFactor\_{i}×MW\_{i}^{EnergyOfferAward}-MW\_{i}^{RegDnAward}-LowRespLim\_{i} \geq 0$$

$$HiRespLim\_{i}-RespFactor\_{i}×MW\_{i}^{EnergyOfferAward}+MW\_{i}^{RegUpAward}+MW\_{i}^{PFRAward} \geq 0$$

Where,

$RespFactor\_{i}$: Proportion of the Base Point $\left(MW\_{i}^{EnergyOfferAward}\right)$ provided by the frequency responsive capacity of the Combined Cycle Generation Resource

$LowRespLim\_{i}$: Minimum amount of the total Base Point $\left(MW\_{i}^{EnergyOfferAward}\right)$ provided by the frequency responsive capacity of the Combined Cycle Generation Resource

$HiRespLim\_{i}$ : Maximum amount of the total Base Point $\left(MW\_{i}^{EnergyOfferAward}\right)$ provided by the frequency responsive capacity of the Combined Cycle Generation Resource

ST3 and/or duct burner

CT1

CT2

|  |  |  |  |
| --- | --- | --- | --- |
| CC component | Capacity | Frequency Responsive? | MW output |
| CT1 | 100 | Yes | 80 |
| CT2 | 100 | Yes | 80 |
| ST3 no duct burner | 200 | No | 160 |
| ST3 with duct burner | 250 | No | 30 |

In this example for a 2x1 configuration, a sample value for new telemetry could be:

$RespFactor\_{i}$ = 0.45

$LowRespLim\_{i}$=150 MW

$HiRespLim\_{i}$=200 MW

**Proposal is to have QSE provide these additional data inputs (**$RespFactor\_{i}$**,**$LowRespLim\_{i}$**,**$HiRespLim\_{i}$**) via telemetry**

**Feedback requested:**

1. **Review proposal. ERCOT staff available to walk through the concept in detail**
2. **Is the provision of the additional new telemetry acceptable?**
3. **Are there other alternatives to better model the constraints to consider the non-frequency responsive capacity of the combined cycle configuration in RTC?**

## QSGR Generation Resource with Resource Status of OFFQS

QSGR qualification requires a Generation Resource to be On-Line in 10 minutes and be capable of providing a certain minimum amount of energy as determined during qualification tests.

1. LSL=LDL=0; For each Generation Resource with Resource Status of OFFQS ($i=1,2,3…N\_{g}^{OFFQS}$):

$$LSL\_{i}=LDL\_{i}=0\leq TelemMW\_{i}\leq HDL\_{i}\leq HSL\_{i}$$

$$HDL\_{i}=Min\left(HSL\_{i},\left(TelemMW\_{i}+NRRUp\_{i}\*5\right)\right)$$

1. Upward AS Offer constraints (ONLY ECRS and NSPIN): Assume full utilization of available AS Offer structure

|  |  |  |
| --- | --- | --- |
| AS Offer MW | ECRS $/MWh(RTC Dispatchable) | On-Line NSPIN $/MWh(RTC Dispatchable) |
| ASMW1 | Yes | Yes |
| ASMW2 | Yes | Yes |
| ASMW3 | Yes | Yes |
| ASMW4 | Yes | Yes |
| ASMW5 | Yes | Yes |

1. New Resource telemetry to limit individual AS awards:
2. $TelMxECRS\_{i}$: Telemetry (MW value) to indicate maximum ECRS MW capability.
3. $TelMxNSPIN\_{i}$: Telemetry (MW value) to indicate maximum NSPIN MW capability.

**Feedback requested:**

1. **Is the provision of the additional new telemetry acceptable?**
2. **Are there other alternatives to inform ERCOT of reduced AS capability for use by RTC?**
3. Individual AS Offer MW constraints ($k=1,2,3,4,5$):

$$MW\_{k}^{ECRSAward}+MW\_{k}^{NSPINpAward}\leq ASMW\_{k}$$

1. Checks on allowable total ECRS Award for OFFQS Generation Resource ($i=1,2,3…N\_{g}^{OFFQS}$):

$$MW\_{i}^{ECRSAward}=\sum\_{k=1}^{k=5}MW\_{k}^{ECRSAward}$$

$$MW\_{i}^{ECRSAward}\leq Min\left(TelMxECRS\_{i},ECRSQualifiedMW\_{i},\left(ERRUp\_{i}\*10\right)\right)$$

1. Checks on allowable total NSPIN Award for OFFQS Generation Resource ($i=1,2,3…N\_{g}^{OFFQS}$):

$$MW\_{i}^{NSPINAward}=\sum\_{k=1}^{k=5}MW\_{k}^{NSPINAward}$$

$$MW\_{i}^{NSPINAward}\leq Min\left(TelMxNSPIN\_{i},NSPINQualifiedMW\_{i},\left(NRRUp\_{i}\*30\right)\right)$$

1. LDL/LSL constraint: Ensures that the energy (Base Point) award is feasible with respect to the LDL and LSL of the Resource ($i=1,2,3…N\_{g}$):

$$MW\_{i}^{EnergyOfferAward} \geq LDL\_{i}=0$$

$$MW\_{i}^{EnergyOfferAward} \geq LSL\_{i}=0$$

1. HDL constraint: Ensures that the energy (Base Point) award is feasible with respect to the HDL of the Resource:

$$HDL\_{i}-MW\_{i}^{EnergyOfferAward} \geq 0$$

1. HSL constraint: Ensures that the energy (Base Point), ECRS and On-line NSPIN awards are feasible with respect to the High Sustained Limit (HSL) of the Resource:

$$HSL\_{i}-MW\_{i}^{EnergyOfferAward}-MW\_{i}^{ECRSAward}-MW\_{i}^{NSPINAward}\geq 0$$

## Off-Line Generation Resource Qualified to provide Non-Spin, with Resource Status of OFF

Can only be ONLY awarded NSPIN

1. Off-Line NSPIN AS Offer constraints (ONLY Off-Line NSPIN):

|  |  |
| --- | --- |
| AS Offer MW | Off-Line NSPIN $/MWh(RTC Dispatchable) |
| ASMW1 | Yes |
| ASMW2 | Yes |
| ASMW3 | Yes |
| ASMW4 | Yes |
| ASMW5 | Yes |

1. New Resource telemetry to limit individual AS awards:
2. $TelMxNSPIN\_{i}$: Telemetry (MW value) to indicate maximum NSPIN MW capability.

**Feedback requested:**

1. **Is the provision of the additional new telemetry acceptable?**
2. **Are there other alternatives to inform ERCOT of reduced AS capability for use by RTC?**
3. Individual AS Offer MW constraints ($k=1,2,3,4,5$):

$$MW\_{k}^{NSPINpAward}\leq ASMW\_{k}$$

1. Checks on allowable total NSPIN Award for On-Line Generation Resource ($i=1,2,3…N\_{g}^{off}$):

$$MW\_{i}^{NSPINpAward}=\sum\_{k=1}^{k=5}MW\_{k}^{NSPINAward}$$

$$MW\_{i}^{NSPINAward}\leq Min\left(TelMxNSPIN\_{i},NSPINQualifiedMW\_{i},\left(NRRUp\_{i}\*30\right),HSL\right)$$

## UFR type Load Resource self-providing RRS and/or ECRS based on DAM awards, AS Trades

Proposal is to allow self-provision of RRS and/or ECRS based on DAM awards and AS Trades for the QSE at the portfolio level

**Issues that need more discussion:**

**Validation of self-provided telemetered RRS and ECRS amounts:**

**During scarcity conditions when total PFR amount procured is less than 1150 MW, the sum of self-provided RRS and ECRS amounts can be greater than 60% of Total RRS procured.**

Constraints:

1. For each On-Line UFR type Load Resource ($i=1,2,3…N\_{UFR}^{ON}$):

$$LPC\_{i}\leq TelemMW\_{i}\leq MPC\_{i}$$

1. New Resource telemetry indicating self-provided AS MW amounts
2. $TelSelfRRS\_{i}$: Telemetry to indicate RRS MW amount self-provided by On-Line UFR type Load Resource
3. $TelSelfECRS\_{i}$: Telemetry to indicate ECRS MW amount self-provided by On-Line UFR type Load Resource
4. Validation of self-provision of RRS and ECRS 🡨 **TBD**

$$TelSelfRRS\_{i}+TelSelfECRS\_{i} \leq TelemMW\_{i}-LPC\_{i}$$

If this validation fails, the discounting of the self-provided amounts will decrement the self-provided ECRS before decrement the self-provided amounts of RRS.

Validated self-provided RRS and ECRS are $MW\_{i}^{RRSSelf}$and $MW\_{i}^{ECRSSelf}$.

**Feedback requested:**

1. **Timeline for submission of AS trades – has impact on RTC performance**
2. **How are the limits on system-wide RRS provided by UFR, FFR to be checked?**
3. AS Offer constraints (RRS, ECRS): Assume full utilization of available AS Offer structure

|  |  |  |
| --- | --- | --- |
| AS Offer MW | RRS $/MWh | ECRS $/MWh(RTC Dispatchable) |
| ASMW1 | Yes | Yes |
| ASMW2 | Yes | Yes |
| ASMW3 | Yes | Yes |
| ASMW4 | Yes | Yes |
| ASMW5 | Yes | Yes |

1. New telemetry to limit individual AS awards:
2. $TelMxRRS\_{i}$: Telemetry (MW value) to indicate maximum RRS MW capability **excluding** self-provided amount
3. $TelMxECRS\_{i}$: Telemetry (MW value) to indicate maximum ECRS MW capability **excluding** self-provided amount

**Feedback requested:**

1. **Is the provision of the additional new telemetry acceptable?**
2. **Are there other alternatives to inform ERCOT of reduced AS capability for use by RTC?**
3. Individual AS Offer MW constraints ($k=1,2,3,4,5$):

$$MW\_{k}^{RRSOfferAward}+MW\_{k}^{ECROfferAward}\leq ASMW\_{k}$$

1. Checks on allowable total RRS Award for On-Line UFR type Load Resource ($i=1,2,3…N\_{UFR}^{ONRL}$):

$$MW\_{i}^{RRSOfferAward}=\sum\_{k=1}^{k=5}MW\_{k}^{RRSOfferAward}$$

$$MW\_{i}^{RRSOfferAward}\leq Min\left(TelMxRRS\_{i},RRSQualifiedMW\_{i},\left(TelemMW\_{i}-MW\_{i}^{RRSSelf}-LPC\_{i}\right)\right)$$

1. Checks on allowable total ECRS Award for On-Line UFR type Load Resource ($i=1,2,3…N\_{g}$):

$$MW\_{i}^{ECRSOfferAward}=\sum\_{k=1}^{k=5}MW\_{k}^{ECRSOfferAward}$$

$$MW\_{i}^{ECRSOfferAward}\leq Min\left(TelMxECRS\_{i},ECRSQualifiedMW\_{i},\left(TelemMW\_{i}-MW\_{i}^{ECRSSelf}-LPC\_{i}\right)\right)$$

1. Checks on allowable total RRS and ECRS Award for On-Line UFR type Load Resource ($i=1,2,3…N\_{UFR}^{ON}$):

$$MW\_{UFRi}^{RRS}=MW\_{i}^{RRSOfferAward}+MW\_{i}^{RRSSelf}$$

$$MW\_{UFRi}^{ECRS}=MW\_{i}^{ECRSOfferAward}+MW\_{i}^{ECRSSelf}$$

1. Maximum total AS (RRS+ECRS) that can be provided from On-Line UFR type Load Resource is:

$$ MW\_{UFRi}^{RRS}+MW\_{UFRi}^{ECRS}\leq TelemMW\_{i}-LPC\_{i}$$

## On-Line Controllable Load Resource

1. For each On-Line Controllable Load Resource ($i=1,2,3…N\_{CLR}^{ON}$):

$$LPC\_{i}\leq LDL\_{i}\leq TelemMW\_{i}\leq HDL\_{i}\leq MPC\_{i}$$

$$HDL\_{i}=Min\left(MPC\_{i},\left(TelemMW\_{i}+NRRDn\_{i}\*5\right)\right)$$

$$LDL\_{i}=Max\left(LPC\_{i},\left(TelemMW\_{i}-NRRUp\_{i}\*5\right)\right)$$

1. Upward AS Offer constraints (RegUp, PFR, ECRS, On-Line NSPIN): Assume full utilization of available AS Offer structure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| AS Offer MW | RegUp $/MWh(Conventional) | RRS (PFR) $/MWh | ECRS $/MWh(RTC Dispatchable) | On-Line NSPIN $/MWh(RTC Dispatchable) |
| ASMW1 | Yes | Yes | Yes | Yes |
| ASMW2 | Yes | Yes | Yes | Yes |
| ASMW3 | Yes | Yes | Yes | Yes |
| ASMW4 | Yes | Yes | Yes | Yes |
| ASMW5 | Yes | Yes | Yes | Yes |

1. New telemetry to limit individual AS awards:
	1. $TelMxRegUp\_{i}$: Telemetry (MW value) to indicate maximum RegUp MW capability.
2. $TelMxPFR\_{i}$: Telemetry (MW value) to indicate maximum PFR MW capability.
3. $TelMxECRS\_{i}$: Telemetry (MW value) to indicate maximum ECRS MW capability.
4. $TelMxNSPIN\_{i}$: Telemetry (MW value) to indicate maximum NSPIN MW capability.

**Feedback requested:**

1. **Is the provision of the additional new telemetry acceptable?**
2. **Are there other alternatives to inform ERCOT of reduced AS capability for use by RTC?**
3. Individual AS Offer MW constraints ($k=1,2,3,4,5$):

$$MW\_{k}^{RegUpAward}+MW\_{k}^{PFRAward}+MW\_{k}^{ECRSAward}+MW\_{k}^{NSPINAward}\leq ASMW\_{k}$$

1. Checks on allowable total RegUp Award for On-Line Controllable Load Resource ($i=1,2,3…N\_{CLR}^{ON}$):

$$MW\_{i}^{RegUpAward}=\sum\_{k=1}^{k=5}MW\_{k}^{RegUpAward}$$

$$MW\_{i}^{RegUpAward}\leq Min\left( TelMxRegUp\_{i},RegUpQualifiedMW\_{i},\left(NRRUp\_{i}\*5\right)\right)$$

1. Checks on allowable total PFR Award for On-Line Controllable Load Resource ($i=1,2,3…N\_{CLR}^{ON}$):

$$MW\_{i}^{PFRAward}=\sum\_{k=1}^{k=5}MW\_{k}^{PFRAward}$$

$$MW\_{i}^{PFRAward}\leq Min\left(TelMxRegUp\_{i},PFRQualifiedMW\_{i}\right)$$

1. Checks on allowable total ECRS Award for On-Line Controllable Load Resource ($i=1,2,3…N\_{CLR}^{ON}$):

$$MW\_{i}^{ECRAward}=\sum\_{k=1}^{k=5}MW\_{k}^{ECRAward}$$

$$MW\_{i}^{ECRSAward}\leq Min\left(TelMxECRS\_{i},ECRSQualifiedMW\_{i},\left(ERRUp\_{i}\*10\right)\right)$$

1. Checks on allowable total NSPIN Award for On-Line Controllable Load Resource ($i=1,2,3…N\_{CLR}^{ON}$):

$$MW\_{i}^{NSPINpAward}=\sum\_{k=1}^{k=5}MW\_{k}^{NSPINpAward}$$

$$MW\_{i}^{NSPINpAward}\leq Min\left(TelMxNSPIN\_{i},NSPINQualifiedMW\_{i},\left(NRRUp\_{i}\*30\right)\right)$$

1. RegDn AS Offer constraints: Assume full utilization of available AS Offer structure

|  |  |
| --- | --- |
| RegDnAS Offer MW | RegDn $/MWh(Conventional) |
| ASMW1 | Yes |
| ASMW2 | Yes |
| ASMW3 | Yes |
| ASMW4 | Yes |
| ASMW5 | Yes |

1. New Resource telemetry to limit RegDn AS awards:
	1. $TelMxRegDn\_{i}$: Telemetry (MW value) to indicate maximum RegDn MW capability.

**Feedback requested:**

1. **Is the provision of the additional new telemetry acceptable?**
2. **Are there other alternatives to inform ERCOT of reduced AS capability for use by RTC?**
3. Individual RegDn AS Offer MW constraints ($k=1,2,3,4,5$):

$$MW\_{k}^{RegDnAward}\leq ASMW\_{k}$$

1. Checks on allowable total RegDn Award for On-Line Controllable Load Resource ($i=1,2,3…N\_{CLR}^{ON}$):

$$MW\_{i}^{RegDnAward}=\sum\_{k=1}^{k=5}MW\_{k}^{RegDnAward}$$

$$MW\_{i}^{RegDnAward}\leq Min\left(RegDnQualifiedMW\_{i},\left(NRRDn\_{i}\*5\right)\right)$$

1. LDL/LPC constraint: Ensures that the energy (Base Point) and Regulation Up awards are feasible with respect to the LDL and LPC of the Controllable Load Resource ($i=1,2,3…N\_{CLR}^{ON}$):

$$MW\_{i}^{EnergyBidAward}-ScalingFactorDn×MW\_{i}^{RegUpAward}-LDL\_{i} \geq 0$$

$$MW\_{i}^{EnergyBidAward}-MW\_{i}^{RegUpAward}-LPC\_{i} \geq 0$$

1. HDL constraint: Ensures that the energy (Base Point) and Regulation Down awards are feasible with respect to the HDL of the Controllable Load Resource ($i=1,2,3…N\_{CLR}^{ON}$):

$$HDL\_{i}-MW\_{i}^{EnergyBidAward}-ScalingFactorUp×MW\_{i}^{RegDnAward} \geq 0$$

1. LPC constraint: Ensures that the energy (Base Point), Regulation Up, Responsive Reserve (PFR), ECRS and On-line NSPIN awards are feasible with respect to the Low Power Consumption Limit (LPC) of the Controllable Load Resource:

$$MW\_{i}^{EnergyBidAward}-MW\_{i}^{RegUpAward}-MW\_{i}^{PFRAward}-MW\_{i}^{ECRSAward}-MW\_{i}^{NSPINAward}-LPC\_{i}\geq 0$$

## Storage Resources modeled as a combination of Generation Resource and Controllable Load Resource participating in FRRS, FFR and “blocky” ECR

To be discussed later

## Fast Load Resources participating in FFR

To be discussed later