**DC-Coupled Resources**

ERCOT Concept Paper

Battery Energy Storage Task Force (BESTF)

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# DC-Coupled Resource Draft Definition

One or more Energy Storage Systems (ESS) combined with one or more wind and/or solar generators behind a single point of interconnection (POI), where these combined technologies are interconnected within the site using direct current (DC) equipment. The combined technologies are then connected to the ERCOT grid using the same direct current-to-alternating current (DC-to-AC) inverter(s).

Note: To be classified as a DC-Coupled Resource, the ESS component of the Resource may need to meet a minimum percentage threshold requirement (nameplate MW and/or MWh rating) in relation to the nameplate MW rating of the solar/wind facility. In cases where the minimum threshold is not satisfied, the facility would be classified as a Wind or Solar Generation Resource.

For purposes of this concept paper and discussion at the Battery Energy Storage Task Force (BESTF), storage in DC-Coupled combination with any technologies other than wind and solar are out of scope.

# DC-Coupled Resource Registration with ERCOT

ERCOT systems will model and treat a DC-Coupled Resource as a sub-type of an Energy Storage Resource (ESR).

DC-Coupled Resources shall register as an ESR with a DC-Coupled attribute so that ERCOT systems can differentiate it from a stand-alone ESR. In addition, at Registration (RARF/RIOO), Resource Entities will be required to submit the same level of detail for both the generation facility (solar or wind) and the ESS as is required for stand-alone Generation Resources and ESRs.

# DC-Coupled Resource Characteristics (Based on ESR)

Similar to stand-alone battery Energy Storage Resources, DC-Coupled Resources:

1. Can smoothly transition from charging to discharging, and vice-versa, and there is no deadband around 0 MW; and
2. Have limited energy storage capability (<= 24 hours). This implies that the storage portion of the DC-Coupled Resource cannot discharge continuously at the ESS’s maximum rated MW, per its registration with ERCOT, for 24 hours.

## Modelling in ERCOT Systems:

1. For the “Combo Model ESR” era :
	1. Similar to a stand-alone combo-model ESR, ERCOT systems will treat a DC-Coupled Resource as a combination of a Generation Resource and a Controllable Load Resource, connected to the same node on the modeled AC electrical network that represents the connection of the common inverter of the solar/wind facility and the ESS. Thus, charging and discharging (withdrawal from and injection to the ERCOT grid) occurs on the same electrical pathway.
	2. The Generation Resource represents the injection (to the ERCOT grid) from both the solar/wind facility and the discharging side of the ESS.
		* The High Resource Limit (HRL) for the Generation Resource is set to the lesser of the AC MVA rating of the inverter or the sum of the AC-equivalent MW ratings of the solar/wind facility and the ESS.
2. The Controllable Load Resource represents the charging (withdrawal) side of the ESS.
	* + The HRL for the CLR is set to the lesser of the AC MVA rating of the inverter or the AC-equivalent MW rating of the ESS.
3. For the Single Model ESR era (beginning mid-2024):
	1. ERCOT systems will consider a DC-Coupled Resource as a single device with one electrical pathway to the modeled AC electrical network for both charging and discharging.
	2. The HRL for the ESR will be set to the lesser of the AC MVA rating of the inverter or the sum of the AC equivalent MW ratings of the solar-wind facility and the ESS.

Figure 1: Example Schematic of Solar + Storage DC-Coupled Resource

DC-DC Converter

**-**

**-**

meter

BKR-1

BKR-2

BKR-3

BKR-4

Rest of Grid

**+**

**-**

**-**

**+**

Battery

Power Electronics

**-**

**~**

Solar and battery are coupled on the DC side

Inverter Rating

+- 100 MW (MVA)

ESS (Battery) Rating

+- 20 MW

PVG Rating

+ 100 MW

BKR-5

AC Aux Load

DC Aux Load

# Combo Model DC-Coupled Resource Telemetry Requirements

This section describes the combo-model era telemetry requirements for the Generation Resource, which models the solar/wind facility plus the discharge portion of the ESS, and the CLR, which models the charging portion of the ESS. This additional telemetry will be required for forecasting and for enabling ERCOT Operator situational awareness.

Figure 2: Example Combo Model ESR Representation of
Solar + Storage DC-Coupled Resource

Controllable Load Resource:

ESS-Charge

MPC (max) = 20 MW

LPC (min) = 0 MW

Generation Resource:

PVG + ESS-Discharge

HRL = 100 MW

LRL = 0 MW

HSL <= 100 MW

LSL >= 0 MW

meter

BKR-1

BKR-2

BKR-3

BKR-4

Rest of Grid

BKR-5

AC Aux Load

## Generation Resource:

The Generation Resource represents the combined injection (to the ERCOT AC grid) from the solar/wind facility and the discharge side of the ESS.

### Telemetry from QSE to ERCOT:

|  |  |  |
| --- | --- | --- |
| **Telemetry item** | **Units** | **Comments** |
| Gross Megawatts | MW | Gross MW injection measured on AC side of shared/common DC-coupled Resource inverter.Gross MW >= 0 |
| Net Megawatts | MW | Net MW from GR injected as measured at POI..Net MW >= 0 |
| Gross Megavars | MVar | Gross MVar from GR (positive or negative) measured on AC side of shared/common DC-coupled Resource inverter. |
| Net Megavars | MW | Net MVar from GR (positive or negative) as measured at POI. |
| Resource Status | state | Per Nodal Protocols, Guides or Other Binding Documents applicable to a Generation Resource that is part of a combo-model ESR |
| Normal Ramp Rates (Up and Down) | MW/Min |
| Emergency Ramp Rates (Up and Down) | MW/Min |
| High and Low Emergency Limit (HEL, LEL) | MW |
| High and Low Sustained Limit (HSL, LSL) | MW |
| AS Qualifications (Reg-Up, Reg-Dn, RRS-PFR, RRS-FFR, ECRS, Non-Spin) | MW |
| Regulation Participation Factors (Up and Down) | number |
| AS Schedules (RRS-PFR, RRS-FFR, ECRS, Non-Spin) | MW |
| Raise/Lower Block Status | Flag |
| Voltage Regulator | Flag |
| Power System Stabilizer | Flag |
| Station: Breaker/Switch Status for AC equipment | Open/Close |
| Station: Branch flows for AC equipment | MW,MVAr |
| Station: Transformer tap position  | Flag (open/close) |
| Station: Reactor/Capacitor banks status | Flag (energized/de-energized) |

### Telemetry from ERCOT to QSE:

|  |  |  |
| --- | --- | --- |
| **Telemetry item** | **Units** | **Comments** |
| Updated Desired Generation | MW | Per Nodal Protocols, Guides or Other Binding Documents applicable to a Generation Resource that is part of a combo-model ESRPer Nodal Protocols, Guides or Other Binding Documents applicable to a Generation Resource that is part of a combo-model ESR |
| Base Point | MW |
| Locational Marginal Price for energy | $/MWh |
| Non-Spin Deployed flag | Flag |
| Curtailment flag | Flag |
| SCCT SCED Mitigation flag | Flag |
| Voltage KV at POI meter | KV |
| Desired Voltage Setpoint from TDSP | KV |

## Controllable Load Resource:

The Controllable Load Resource represents the charging (withdrawal) side of the ESS from the ERCOT AC Grid.

### Telemetry from QSE to ERCOT:

|  |  |  |
| --- | --- | --- |
| **Telemetry item** | **Units** | **Comments** |
|  |  |  |
| Net Load Megawatts | MW | Net MW withdrawal (charge) of CLR as measured at POI.Net MW >= 0 |
| Net Megavars | MW | Net MVar from CLR (positive or negative) as measured at POI. |
| Resource Status | state | Per Nodal Protocols, Guides or Other Binding Documents applicable to a CLR that is part of a combo-model ESR |
| Normal Ramp Rates (Up and Down) | MW/Min |
| Emergency Ramp Rates (Up and Down) | MW/Min |
| High and Low Emergency Limit (HEL, LEL) | MW |
| High and Low Sustained Limit (HSL/MPC, LSL/LPC) | MW |
| AS Responsibilities (RegUp, RegDn, RRS-PFR, RRS-FFR, ECRS, Non-Spin) | MW |
| Regulation Participation Factors (Up and Down) | number |
| AS Schedules (RRS-PFR, RRS-FFR, ECRS, Non-Spin) | MW |
| Raise/Lower Block Status | Flag |
| Voltage Regulator | Flag |
| Power System Stabilizer | Flag |
| Station: Breaker/Switch Status for AC equipment | Open/Close |
| Station: Branch flows for AC equipment | MW,MVAr |
| Station: Transformer tap position  | Flag (open/close) |
| Station: Reactor/Capacitor banks status | Flag (energized/de-energized) |

### Telemetry from ERCOT to QSE:

|  |  |  |
| --- | --- | --- |
| **Telemetry item** | **Units** | **Comments** |
| Updated Desired Generation | MW | Per Nodal Protocols, Guides or Other Binding Documents applicable to a CLR that is part of a combo-model ESR |
| Base Point | MW |
| Locational Marginal Price for energy | $/MWh |
| Non-Spin Deployed flag | Flag |
| Voltage KV at POI meter | KV |
| Desired Voltage Setpoint from TDSP | KV |

## Solar/Wind Facility and ESS-Discharge Specific Telemetry

Telemetered data to be provided from the solar/wind facility and the ESS for forecasting and enabling ERCOT operator situational awareness:

### Telemetry from QSE to ERCOT:

|  |  |  |
| --- | --- | --- |
| **Telemetry item** | **Units** | **Comments** |
| Gross solar/wind facility Megawatts (AC equivalent)(*TotACMWirr*) *NEW* | MW | AC equivalent of Gross MW output of the solar/wind facility. Includes the portion of the solar/wind facility output used to charge the ESS on the DC side of the inverter, and/or Auxiliary Loads.*TotACMWirr* >= 0 |
| Gross solar/wind facility Megawatt Capability (AC equivalent)(*TotACCapMWirr*) *NEW* | MW | AC equivalent of Gross MW capability of the solar/wind facility, based on Real-Time conditions. Represents total uncurtailed AC MW capability. *TotACCapMWirr* >= 0 |
| Barometric Pressure | Same as current | Per Nodal Protocols, Guides or Other Binding Documents applicable to a Generation Resource that is part of a combo-model ESR |
| Wind Direction | Same as current |
| Wind Speed | Same as current |
| Temperature, in degree C | Centigrade |
|  |  |
| For Solar IRR |
| Number of Inverters Online | Number | Per Nodal Protocols, Guides or Other Binding Documents applicable to a Generation Resource that is part of a combo-model ESR |
| Number of Inverters Offline | Number |
| Number of Inverters with unknown status | Number |
| Back Panel Temp, in degrees C | Centigrade |
| Plane of Array Irradiance, w/m2 | Watts/M2 |
|  |  |
| For Wind IRR |
| Number of Turbines Online | Number | Per Nodal Protocols, Guides or Other Binding Documents applicable to a Generation Resource that is part of a combo-model ESR |
| Number of Turbines Offline | Number |
| Number of Turbines with unknown status | Number |
|  |  |
| For storage (ESS discharge) | MW (injection or withdrawal AC equivalent)(*TotMWstorage*) *NEW* | MW | AC equivalent of Net MW injection or withdrawal from storage as measured at DC terminals of storage. Can be positive or negative |
| Maximum Operating State Of Charge | MWh | Per Nodal Protocols, Guides or Other Binding Documents applicable to a Generation Resource that is part of a combo-model ESR |
| Minimum Operating State Of Charge | MWh |
| Current State Of Charge | MWh |
| Maximum Operating Discharge Power Limit | MW |
| Minimum Operating Discharge Power Limit | MW |

# Single Model DC-Coupled Resource Telemetry Requirements

This section describes the telemetry requirements for the single model ESR that models the DC-Coupled Resource and the additional telemetry from the IRR and storage for forecasting and enabling ERCOT Operator situational awareness.

Figure 3: Example Single Model ESR Representation of Solar + Storage DC-Coupled Resource

ESR modeling construct

HRL = 100 MW

LRL = - 20 MW

HSL <= 100 MW

LSL >= - 20 MW

BKR-5

meter

BKR-1

BKR-2

BKR-3

BKR-4

Rest of Grid

AC Aux Load

## Single Model ESR used to represent DC-Coupled Resource

### Telemetry from QSE to ERCOT:

|  |  |  |
| --- | --- | --- |
| Telemetry item | Units | Comments |
| Gross Megawatts | MW | Gross MW injection/withdrawal measured on AC side of shared/common DC-coupled Resource inverter.Gross MW can be positive or negative |
| Net Megawatts | MW | Net MW from DC-Coupled Resource (modeled as ESR) injected or withdrawn, as measured at POI..Net MW can be positive or negative |
| Gross Megavars | MVar | Gross MVar (positive or negative) measured on AC side of shared/common DC-coupled Resource inverter. |
| Net Megavars | MW | Net MVar from Single model ESR used to model DC-Coupled Resource (positive or negative) as measured at POI. |
| Resource Status | state | per protocols or other binding documents as applicable to ESR |
| Normal Ramp Rates (Up and Down) | MW/Min | Separate telemetry for energy, regulation, ECRS and Non-Spin. See RTCTF NPRRs |
| RRS Capabilities (RRS-PFR, RRS-FFR) | MW | With NPRR 863, a DC-Coupled Resource may be qualified to provide both RRS-PFR and RRS-FFR |
| Emergency Ramp Rates (Up and Down) | MW/Min | Not used under RTC? ERCOT can declare emergency and have all the normal ramp rate reflect emergency capability. |
| High and Low Emergency Limit (HEL, LEL) | MW | Per Nodal Protocols, Guides or Other Binding Documents applicable to Single Model ESRs (under development) |
| High and Low Sustained Limit (HSL, LSL) | MW |
| Raise/Lower Block Status | Flag |
| Voltage Regulator | Flag |
| Power System Stabilizer | Flag |
| Station: Breaker/Switch Status for AC equipment | Open/Close |
| Station: Branch flows for AC equipment | MW,MVAr |
| Station: Transformer tap position  | Flag (open/close) |
| Station: Reactor/Capacitor banks status | Flag (energized/de-energized) |

### Telemetry from ERCOT to QSE:

|  |  |  |
| --- | --- | --- |
| Telemetry item | Units | Comments |
| Updated Desired Set Point | MW | See RTC NPRRs,For DC-Coupled Resources modeled as ESRs, this value can be positive or negative |
| Base Point | MW | See RTC NPRRs,For DC-Coupled Resources modeled as ESRs, this value can be positive or negative |
| Locational Marginal Price for energy | $/MWh | See RTC NPRRs |
| AS Awards (RegUp,RegDn, RRS-PFR, RRS-FFR, ECRS, Non-Spin) | MW | See RTC NPRRs |
| AS MCPC (RegUp,RegDn, RRS-PFR, RRS-FFR, ECRS, Non-Spin) | $/MW/h | See RTC NPRRs |
| Non-Spin Deployed flag | Flag | Per Nodal Protocols, Guides or Other Binding Documents applicable to Single Model ESRs (under development) |
| Curtailment flag | Flag |
| SCCT SCED Mitigation flag | Flag |
| Voltage KV at POI meter | KV |
| Desired Voltage Setpoint from TDSP | KV |

## Solar/Wind Facility and ESS-discharge Specific Telemetry:

Information to be provided from the solar/wind facility and ESS for forecasting and enabling ERCOT operator situational awareness.

### Telemetry from QSE to ERCOT:

|  |  |  |
| --- | --- | --- |
| Telemetry item | Units | Comments |
| Gross IRR Megawatts (AC equivalent)(*TotMWirr*) *NEW* | MW | AC equivalent of Gross MW output of IRR. Includes the portion of IRR output used to charge storage on the DC side of inverter and/or Aux Loads.*TotMWirr* >= 0 |
| Gross IRR Megawatts Capability (AC equivalent)(*TotCapMWirr*) *NEW* | MW | AC equivalent of Gross MW capability of IRR based on Real-Time conditions. Represents total MW (AC) uncurtailed MW capability. *TotCapMWirr* >= 0 |
| Barometric Pressure | Same as current | Per Nodal Protocols, Guides or Other Binding Documents applicable to Single Model ESRs (under development) |
| Wind Direction | Same as current |
| Wind Speed | Same as current |
| Temperature | Degrees C |
|  |  |
| For Solar IRR |
| Number of Inverters Online | Number | Per Nodal Protocols, Guides or Other Binding Documents applicable to Single Model ESRs (under development) |
| Number of Inverters Offline | Number |
| Number of Inverters with unknown status | Number |
| Back Panel Temp, in degrees C | Centigrade |
| Plane of Array Irradiance, w/m2 | Watts/M2 |
|  |  |
| For Wind IRR |
| Number of Turbines Online | Number | Per Nodal Protocols, Guides or Other Binding Documents applicable to Single Model ESRs (under development) |
| Number of Turbines Offline | Number |
| Number of Turbines with unknown status | Number |
|  |  |
| For storage |
| MW (injection or withdrawal AC equivalent)(*TotMWstorage*) *NEW* | MW | AC equivalent of Net MW injection or withdrawal from storage as measured at DC terminals of storage. Can be positive or negative |
| Maximum Operating State Of Charge | MWh | Per Nodal Protocols, Guides or Other Binding Documents applicable to Single Model ESRs (under development) |
| Minimum Operating State Of Charge | MWh |
| Current State Of Charge | MWh |
| Maximum Operating Discharge Power Limit | MW |
| Minimum Operating Discharge Power Limit | MW |

# DC-Coupled Resource Rules (Based on ESR)

## Temporal Constraints

ERCOT systems/software assume that ESRs, including DC-Coupled Resources, have no temporal constraints (StartTime, MinUpTime, MinDownTime, etc.) and also assume that there is no transition times between charging and discharging. QSEs may submit Resource-specific information (limits, ramp rates, etc.) to ERCOT via telemetry or XML submissions to account for any temporal constraints and transition times

## Start-Up and Minimum energy Costs

ESRs including DC-Coupled Resources do not have Startup, Shutdown or Transition costs.

## Participation for SCED energy Dispatch:

* 1. Combo Model Era:
		1. Solar/wind facility and ESS discharging portion of the DC-Coupled Resource: QSE will submit an Energy Offer Curve or a Three Part Supply Offer (with startup and minimum energy costs set to zero)
		2. ESS charging portion of the DC-Coupled Resource: QSE will submit an RTM Energy Bid.
			1. Note: In the DAM, DAM Energy Only Bids can be submitted by the QSE at the Resource Node for the GR to represent Bid-to-Buy energy for the CLR. This is an interim solution that will be in place only during the combo model era, until RTC go-live; it has the drawback of not enabling DAM to co-optimize a CLR’s Resource-specific Bids-to-buy energy and/or AS offers.
		3. The timeline for updating energy Offers and RTM Energy Bids will be the same as those in place for other ESRs.
		4. The Mitigated Offer Cap (MOC) for energy Offers from DC-Coupled Resources will be the same as that in place for other ESRs.
		5. Proxy Energy Offer Curve creation for the solar/wind facility and ESS discharge portion of an ESR when Energy Offer Curve not submitted, or proxy RTM Energy Bid creation for the ESS charge portion of an ESR when an RTM Energy Bid is not submitted, will follow the same rules as those in place for other ESRs.
		6. Proxy Energy Offer Curve extension for the solar/wind facility and ESS discharge portion of an ESR when the Energy Offer Curve does not cover the full range from LSL to HSL, or proxy RTM Energy Bid creation for the ESS charge portion of an ESR when the RTM Energy Bid does not cover the full range from LPC to MPC, will follow the same rules as those in place for other ESRs.
1. Single Model ESR:
	* 1. QSEs will submit a single incremental Energy Bid/Offer Curve from charging (Bid-To-Buy) to discharging (Offer-To-Sell) that is monotonically non-decreasing from the ESR’s negative MW (charging) to positive MW (discharging) range
		2. Start-Up and Minimum Energy costs are zero. In DAM, RUC and RTC there is no commitment cost — i.e. the optimization engine sees a Single Model ESR as an On-line Resource available for Dispatch.
		3. The timeline for updating Energy Bid/Offers will be the same as that for other ESRs.
		4. The MOC for the offer (discharge) portion of the Energy Bid/Offer Curve from DC-Coupled Resources will be the same as those in place for other ESRs.
		5. Proxy Energy Bid/Offer Curve creation for DC-Coupled Resources, when an Energy Bid/Offer Curve not submitted, will follow the same rules as those in place for other ESRs.
		6. Proxy Energy Bid/Offer Curve extension for DC-Coupled Resources when the Energy Bid/Offer Curve does not cover the full range, from LSL (can be negative) to HSL, will follow the same rules as that of an Single Model ESR.

## AS market participation

A DC-Coupled Resource may offer to provide any Ancillary Service where it has demonstrated the appropriate qualifications.

## QSE Responsibility for Maintaining State of Charge

QSEs have the responsibility for maintaining State Of Charge and reflecting energy capability to ERCOT via telemetry, COP, etc.

1. Combo Model:
	* 1. The QSE is responsible for submitting appropriate data on both the Generation Resource (solar/wind facility and ESS discharge) and the CLR (ESS charge) side of the DC-Coupled Resource, including telemetry, Energy Offers, RTM Energy Bids, AS Offers to ensure feasible awards for energy and AS for the DC-Coupled Resource.
2. Single Model:
	* 1. The QSE will be responsible for submitting appropriate data on the single model ESR representing the DC-Coupled Resource, including telemetry, Energy Bid/Offers, and AS Offers to ensure feasible awards for energy and AS.

## Energy Awards (DAM) / Base Points (RTC)

1. Combo Model:
	1. For both the Generation Resource and the CLR, any energy Awards will be positive MW.
2. Single Model:
	1. Energy Awards will be a single number (in MW) that can be positive MW (discharge) or negative MW (charge).

## Ancillary Service Awards (DAM or RTC) will be positive MW

1. Combo Model:
	1. For both the GR and CLR, any AS Awards will be positive MW.
2. Single Model:
	1. AS Awards will be positive MW.

## Physical Responsive Capability (PRC) Calculation

PRC will be calculated consistent with droop and dead-band settings limited by energy injections that can be sustained for a minimum of 15 minutes, similar to that for a stand-alone ESR.

1. Combo Model:

$$PRC=Min\left(X\% of \left(HSL\_{GR-dcR}+HSL\_{CLR-dcR}\right) based on droop, \left(HSL\_{GR-dcR}-NetMW\_{dcR}\right),PRC\_{irr+storage} \right)$$

$$PRC\_{irr+storage}=\left(TotMWCap\_{irr}-TotMW\_{irr}\right)+Max\left(0,-NetMW\_{dcR}\right)+\left(\frac{SOC\_{storage}^{Telem}-SOC\_{storage}^{OperMin}}{∆t}\right)$$

Where,

 $HSL\_{GR-dcR}$ is the HSL for the GR portion of DC-Coupled Resource (>=0),

$HSL\_{CLR-dcR}$ is the HSL/MPC for the CLR portion of DC-Coupled Resource (>=0),

$NetMW\_{dcR}$ is the Net MW for GR minus the Net MW for CLR of the DC-Coupled Resource (both >=0, the result can be positive or negative),

$SOC\_{storage}^{Telem}$ is the telemetered current state of charge in MWh (>=0),

$SOC\_{storage}^{Telem}$ is the telemetered current state of charge in MWh (>=0),

$SOC\_{storage}^{OperMin}$ is the telemetered Minimum Operating state of charge in MWh (>=0), and

 $∆t=\frac{1}{4} hour$

1. Single Model:

$$PRC=Min\left(X\% of \left(HSL\_{dcR}-LSL\_{dcR}\right) based on droop,\left(HSL\_{dcR}-NetMW\_{dcR}\right),PRC\_{irr+storage} \right)$$

$$PRC\_{irr+storage}=\left(TotMWCap\_{irr}-TotMW\_{irr}\right)+Max\left(0,-NetMW\_{dcR}\right)+\left(\frac{SOC\_{storage}^{Telem}-SOC\_{storage}^{OperMin}}{∆t}\right)$$

Where,

 $HSL\_{dcR}$ is the HSL of the single model ESR representing the DC-Coupled Resource (can be positive or negative),

$LSL\_{dcR}$ is the LSL of the single model ESR representing the DC-Coupled Resource (can be positive or negative),

$NetMW\_{dcR}$ is the Net MW of the single model ESR representing the DC-Coupled Resource (can be positive or negative),

$SOC\_{storage}^{Telem}$ is the telemetered current state of charge in MWh (>=0),

$SOC\_{storage}^{Telem}$ is the telemetered current state of charge in MWh (>=0),

$SOC\_{storage}^{OperMin}$ is the telemetered Minimum Operating state of charge in MWh (>=0), and

 $∆t=\frac{1}{4} hour$

## Real-Time On-Line Capacity (RTOLCAP) Calculation

This calculation is for the period (prior to RTC go-live and is therefore applicable to the combo model only.

RTOLCAP will be calculated consistent with limits in place for energy injections that can be sustained for a minimum of 15 minutes, similar to that for a stand-alone ESR.

Combo Model:

$$RTOLCAP=Min\left(\left(HSL\_{GR-dcR}-NetBasePoint\_{dcR}\right),PRC\_{irr+storage} \right)$$

$$PRC\_{irr+storage}=\left(TotMWCap\_{irr}-TotMW\_{irr}\right)+Max\left(0,-NetMW\_{dcR}\right)+\left(\frac{SOC\_{storage}^{Telem}-SOC\_{storage}^{OperMin}}{∆t}\right)$$

Where,

 $HSL\_{GR-dcR}$ is the HSL for the GR portion of DC-Coupled Resource (>=0),

$NetBasePoint\_{dcR}$ is the BasePoint MW for GR minus the BasePoint MW for CLR of the DC-Coupled Resource (both >=0, the result can be positive or negative),

$SOC\_{storage}^{Telem}$ is the telemetered current state of charge in MWh (>=0),

$SOC\_{storage}^{Telem}$ is the telemetered current state of charge in MWh (>=0),

$SOC\_{storage}^{OperMin}$ is the telemetered Minimum Operating state of charge in MWh (>=0), and

 $∆t=\frac{1}{4} hour$

## Current Operating Plan (COP)

1. Combo Model:
	1. ERCOT will populate the Generation Resource’s COP HSL with the forecasted output of the solar/wind facility and the discharge side of the ESS. QSEs will have the ability to modify (lower or raise) the Generation Resource’s COP HSL; for example, raise the HSL if the ESS (but not the solar/wind facility) is capable of increasing discharge and the QSE intends to inject additional MW, without violating the inverter rating.
2. Single Model:
	1. ERCOT will populate the single model ESR’s COP HSL with the forecasted output of the solar/wind facility and the discharge side of the ESS. QSEs will have the ability to modify (lower or raise) the ESR COP HSL; for example, raise the HSL if the ESS (but not the solar/wind facility) is capable of and the QSE intends to inject additional MW without violating the inverter rating.

## Use of State Of Charge Telemetry

In both the Combo Model era and Single Model era, State of Charge (SOC) and State of Charge Operational Limits (min, max) will not be used in the optimization engines of DAM, RUC, and Real-Time Market (RTC).

1. SOC-related telemetry will be used for:
	1. Calculation of contribution to PRC (and RTOLCAP before RTC go-live), and
	2. ERCOT Operator situational awareness displays.

## Charging an ESS under ERCOT Emergency Conditions

During all levels of an Energy Emergency Alert, the ESS charge portion of a DC-Coupled Resource shall suspend charging (directly from the IRR behind the common inverter or from the ERCOT grid) unless instructed otherwise by ERCOT. Such instructions may be in the form of, but not limited to, SCED Base Points, Load Frequency Control deployment, manual Dispatch including Verbal Dispatch Instruction, and Primary Frequency Response.

One exception to this provision is a DC-Coupled Resource behind a POI with excess capacity from onsite generation that otherwise would be incapable of exporting to the ERCOT grid; in this case the storage asset may continue to charge as long as maximum output to the grid is maintained.

In the case of an ERCOT-declared local transmission emergency, ERCOT may instruct one or more DC-Coupled Resources to suspend charging if ERCOT determines that this action is capable of mitigating transmission emergency.

## DC-Coupled Resource Statuses

1. Combo Model:
	1. The allowed Resource Statuses for a DC-Coupled Resource will be the same as that for an ESR modeled as a combination of GR and CLR.
2. Single Model:
	1. The allowed Resource Statuses for a DC-Coupled Resource will be the same as that for a single model ESR
3. ON
4. ONOS
5. ONTEST
6. ONEMR
7. OUT
8. EMR
9. EMRSWGR
10. ONHOLD (More discussion needed whether this status should be treated the same way as that for an ESR or that for Generator Resource)

## Constraints in the Optimization Engine for DAM, RUC and SCED (current and RTC)

1. Combo Model:
2. Same as that for other ESRs (modeled as a combination of a Generation Resource and CLR)
	* + 1. No temporal constraints, Start-Up or Minimum Energy Costs
3. HRL of the Generation Resource is set to the minimum of the inverter rating or combined export (solar/wind facility + ESS discharge) rating
4. HRL of the CLR is set to the minimum of the inverter rating or charge rating of the ESS
5. Single Model:
6. Same as that as other ESRs that are modeled as a single device. Limits (HSL/LSL) and BasePoints can be positive or negative.
	* + 1. No temporal constraints, Start-Up or Minimum Energy Costs
7. HRL of a DC-Coupled Resource modeled as single model ESR is set to the minimum of inverter rating or the combined export (solar/wind facility + ESS discharge) rating
8. LRL (negative) of a DC-Coupled Resource modeled as single model ESR is set to the maximum of the negative of the inverter rating or the charge rating of the ESS.

## Performance metrics (GREDP and base Point Deviation)

1. Combo Model:
	1. A DC-Coupled Resource will be required to follow ERCOT Dispatch Instructions at all times, similar to conventional Generation Resources, when the DC-Coupled Resource is carrying an Ancillary Service responsibility or its net injection/withdrawal into/from the ERCOT grid includes non-zero telemetered MW from the CLR portion of the DC-Coupled Resource. During all other SCED/Settlement intervals, a DC-Coupled Resource could be treated like a WGR and PVGR when calculating Base Point Deviation and GREDP performance metrics.
2. Single Model:
	1. A DC-Coupled Resource will be required to follow ERCOT Dispatch Instructions at all times similar to thermal units when the DC-Coupled Resource has received an Ancillary Service award or its net injection/withdrawal into/from ERCOT grid includes non-zero telemetered MW from the ESS charge portion of the DC-Coupled Resource. During all other SCED/Settlement intervals, a DC-Coupled Resource could be treated like a WGR and PVGR when calculating Base Point Deviation and GREDP performance metrics.

## Studies

1. COP if available, otherwise forecast/best engineering judgment as per BESTF Key Topic/Concept 10.
2. Real-Time and Next Day Studies will use COPs.
3. Operational Planning Horizon Studies will use the expected operational behavior of an IRR to build these singular time point study cases.
4. Outage Coordination Studies will use the expected operational behavior of an IRR consistent with current practice.
5. Planning studies – Build baseline studies based on existing PVGR/WGR practices and build additional ESS assumptions.

## Outage Scheduler

1. Will follow same pattern as that of a conventional Generation Resource for both outages and derates
2. Derate type outage requests shall be accompanied by additional information (in requestor notes) indicating whether the IRR or storage or some other equipment is the source of the deration

## Wholesale Storage Load (WSL) Treatment for the ESS component of a DC-Coupled Resource (combo and single model), and Renewable Energy Credits (RECs)

1. EPS Metering is required for Wholesale Storage Load (WSL) treatment
	1. This applies to all ESRs, including the ESS portion of a DC-Coupled Resource.
	2. WSL must be separately metered from all other Facilities
2. EPS Metering equipment must be certified to ANSI Standards
	1. There is no ANSI Standard for DC metering
	2. ANSI C12 SC32 DC Metering Working Group has been formed to address DC meter, DC voltage sensor and DC current sensor performance criteria
3. More discussion needed
4. See PowerPoint presentation (2/25/20) on RECs