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| Key Topic Concept (KTC) Number | 11 | KTC Title | DC-Coupled Resources |
| Date Posted | February 28, 2020 |
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| Executive Summary | This KTC establishes how DC-Coupled Resources register and participate in the Combo Model era and the Single Model era. It covers a wide range of topics including registration, market operations and settlements. |
| Recommendation Description | This KTC describes a path forward for how ERCOT can accommodate DC-Coupled Resources. Specifically, the KTC addresses the following concepts for DC-Coupled Resources:1. Resource Definition and Registration
2. Resource participation model (EMS and MMS)
3. Forecasting Photo-Voltaic/Wind production from a DC Coupled Resource and Current Operating Plan (COP)
4. Resource Performance Measurement (Base-Point Deviation and ESREDP)
5. Resource Mitigation treatment in SCED
6. WSL Treatment & Renewable Energy Credits
7. Data Requirements from QSEs
8. Resource treatment in Operations and Planning Studies
9. Resource treatment Resource Adequacy Reporting
10. Proxy Offer Curve and Bid to Buy for DC Coupled Resources
11. DC Coupled Resource RUC Capacity Short Calculations
12. DC Coupled Resource Physical Responsive Reserve (PRC) and Real-Time On-Line Capacity (RTOLCAP) Calculation
13. Charging an ESS portion of DC Coupled Resource under ERCOT Emergency Conditions
14. DC-Coupled Resource Statuses
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| BESTF Discussion  | On 1/17/20 and 02/25/2020, ERCOT staff presented a presentations on the concepts listed above.  |
| TAC Action Requested | None at this time. |
| TAC Action Summary |  |

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| Proposed KTC Recommendation Language |

# *Key Topic/Concept recommendation Language for TAC Approval*

None.

# *Key Topic/Concept recommendation Language Previously APProved by tac*

None.

# *Key Topic/Concept recommendation Language IN DISCUSSION AT BESTF*

1. DC-Coupled Resource Definition and Registration
	1. Definition of DC-Coupled Resource: 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).
		1. 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.
	2. For purposes of this KTC document and discussion at the Battery Energy Storage Task Force (BESTF), an ESS in DC-Coupled combination with any technologies other than wind and solar is out of scope.
	3. ERCOT systems will model and treat a DC-Coupled Resource as a sub-type of an Energy Storage Resource (ESR).
	4. 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.
2. DC-Coupled Resource participation model (EMS and MMS)
	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.
		3. 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.
		4. The Controllable Load Resource represents the charging (withdrawal) side of the ESS.
		5. 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.
		6. 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)
		7. ESS charging portion of the DC-Coupled Resource: QSE will submit an RTM Energy Bid.
		8. 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.
		9. The timeline for updating energy Offers and RTM Energy Bids will be the same as those in place for other ESRs.
	2. For the Single Model ESR (together with RTC Go-live)
		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.
		3. 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
		4. 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.
		5. The timeline for updating Energy Bid/Offers will be the same as that for other ESRs.
3. Forecasting Photo-Voltaic/Wind production from a DC-Coupled Resource and 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.
4. DC-Coupled Resource Performance Measurement (Base-Point Deviation and ESREDP)
	1. Combo Model:
		1. A DC-Coupled Resource will be required to follow ERCOT Dispatch Instructions at all times, similar to Energy Storage 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 ESS portion of the DC-Coupled Resource. During all other SCED/Settlement intervals, a DC-Coupled Resource would be treated like an IRR when calculating Base Point Deviation and ESREDP performance metrics.
		2. New performance threshold variables, V % and W MW, will be initially set to 3% and 3 MW for DC-Coupled Resources when their performance (Base Point Deviation and ESREDP) is measured like an ESR, all other times their performance is measured like an IRR and existing performance thresholds will continue to apply when calculating Base Point Deviation and ESREDP performance metrics.
	2. Single Model:
		1. A DC-Coupled Resource will be required to follow ERCOT Dispatch Instructions at all times similar to ESRs when the DC-Coupled Resource has received an Ancillary Service award or/and its net injection/withdrawal into/from ERCOT grid includes non-zero telemetered MW from the ESS portion of the DC-Coupled Resource. During all other SCED/Settlement intervals, a DC-Coupled Resource would be treated like an IRR when calculating Base Point Deviation and ESREDP performance metrics.
		2. New performance threshold variables, V % and W MW, will be initially set to 3% and 3 MW for DC Coupled Resources when their performance (Base Point Deviation and ESREDP) is measured like an ESR, all other times their performance is measured like an IRR and existing performance thresholds will continue to apply when calculating Base Point Deviation and ESREDP performance metrics.
5. DC-Coupled Resource Mitigation treatment in SCED
	1. DC-Coupled ESR Offers include the same opportunity cost issues addressed in NPRR 986 (for ESRs not sharing an inverter with a non-ESR). Currently, non-ESR resources (solar), on a stand-alone basis, could be subject to mitigation at 14.5 \* FIP.
	2. Propose to extend the ESR mitigation approach in NPRR 986 to DC-coupled ESRs with the same review deadline of Dec. 31, 2023.
6. DC Coupled Resource ---- WSL Treatment & Renewable Energy Credits
	1. EPS Metering is required for Wholesale Storage Load (WSL) treatment
	2. WSL must be separately metered from all other Facilities
	3. 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. WSL treatment for the ESS portion of a DC-Coupled Resource is dependent upon ANSI certified DC Metering
	4. Commission filings by an Entity must include details on all generation at a facility and a representation of how the output of the renewable resource is metered.
	5. Metering must be installed in a location to only record energy from generation certified by the PUCT to receive RECs.
	6. Only MWh produced by generators certified by the commission as a renewable generator are eligible to earn RECs. This may include generation from a certificed renewable generator used to charge the ESS portion of a DC-Coupled Resource with sufficient metering in place per requirement (e) above.
7. Data Requirements from QSEs
	1. Combo-Model Era
		1. Provide telemetry consistent with the requirement today for Generation Resource and Controllable Load Resource so that DC-Coupled Resource.
		2. Additional telemetry to be provided for Photo-Voltaic/Wind and ESS portion of the DC-Coupled Resource to support forecasting, and additional visibility of each technology type.
	2. Single Model ESR
		1. Provide telemetry consistent with the requirement for single model ESR.
		2. Additional telemetry to be provided for Photo-Voltaic/Wind and ESS portion of the DC Coupled Resource to support forecasting, and additional visibility of each technology type.
8. DC-Coupled Resource treatment in Operations and Planning Studies
	1. Real-Time and Next Day Studies will use COPs.
	2. Operational Planning Horizon Studies will use the expected operational behavior of an IRR to build these singular time point study case and build upon ESS assumptions as applicable.
	3. Outage Coordination Studies will use the expected operational behavior of an IRR consistent with current practice.
	4. Planning studies – Build baseline studies based on existing PVGR/WGR practices and build additional ESS assumptions.
9. DC-Coupled Resource treatment Resource Adequacy Reporting
	1. Resource Adequacy reporting should consider installed technology (wind/PV and ESS) behind the inverter and consider physical capability (inverter rating, self-limiting etc.) of a DC-Coupled Resource to inject into the ERCOT grid.
	2. QSE shall provide DC-Coupled Resource’s limitation (Inverter rating, installed capacity, and self-limiting Pmax).
10. Proxy Offer Curve and Bid to Buy for DC Coupled Resources
	1. Combo-Model Era
		1. Proxy Energy Offer Curve creation for the solar/wind facility and ESS discharge portion of an ESR when an Energy Offer Curve has not been submitted, or proxy RTM Energy Bid creation for the ESS charge portion of an ESR when an RTM Energy Bid has not been submitted, will follow the same rules as those in place for other ESRs.
		2. 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.
	2. Single Model ESR
		1. 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.
		2. 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.
11. DC-Coupled Resource RUC Capacity Short Calculations (Two options are described below.)

Option 1:

* 1. The capacity credit for DC-Coupled Resources be based on their COP HSL similar to how it is calculated for other Energy Storage Resources (ESRs).
	2. The COP HSL values for DC-Coupled Resources shall be set to the Short-Term Photo Voltaic Power Forecast (STPPF) [50% probability of exceedance forecast], or the Short-Term Wind Power Forecast (STWPF) [50% probability of exceedance forecast], with the option for the QSE to increase or decrease the HSL values. The HSL values of the DC-Coupled Resource could be decreased due to the QSE’s lower expectation from the WGR or PVGR or it could be increased due to the QSE’s expectation of the battery’s availability and capability to inject power to the grid.

Option 2:

* 1. For each RUC snapshot, and at the end of the adjustment period, identify how much (if any) the QSE increased the COP HSL above the Short-Term Photo Voltaic Power Forecast (STPPF) or the Short-Term Wind Power Forecast (STWPF) [50% probability of exceedance forecast].
	2. For the purposes of determining the capacity credit of the DC-Coupled Resource for the RUC Capacity Short calculation, add the quantity from step 1 above to the Wind-powered Generation Resource Production Potential (WGRPP) [80% probability of exceedance], or the Photovoltaic Generation Resource Production Potential (PVGRPP) [80% probability of exceedance forecast].
	3. Unlike the treatment of Intermittent Renewable Resources (IRRs), whose Resource capacity is only determined at the RUC snapshot, the capacity credit for DC-Coupled Resources will be determined at both the snapshot and the end of adjustment period.

Energy Storage Resources must adhere to the following guidelines when submitting their COP HSL values.

* + 1. The hourly COP HSL values for future hours shall represent a reasonable expectation of how the energy (MWh) storage capability of the battery will be managed,
		2. At all times the COP HSL value shall be no greater than the Maximum Operating Discharge Power Limit (MW),
		3. For a battery in which the Maximum Operating State of Charge (MWhs) is less than the quantity required to operate at its Maximum Operating Discharge Power Limit (MW) for a full hour; the QSE shall limit the hourly COP HSL value to no more than what could be sustained for a full hour, and
		4. For a battery in which the Maximum Operating State of Charge (MWhs) is more than the quantity required to operate at its Maximum Operating Discharge Power Limit (MW) for an hour; the QSE shall limit the hourly COP HSL values over a rolling 24 hour period to a “schedule” that could be reasonably met with charging and discharging.
1. DC-Coupled Resource Physical Responsive Reserve (PRC) and Real-Time On-Line Capacity (RTOLCAP) Calculation
	1. 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.
	2. 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. This calculation is for the period (prior to RTC go-live and is therefore applicable to the combo model only.
2. Charging an ESS portion of DC-Coupled Resource under ERCOT Emergency Conditions
	1. 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.
	2. 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.
	3. 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.
3. DC-Coupled Resource Statuses
	1. **Combo Model:** 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:** The allowed Resource Statuses for a DC-Coupled Resource will be the same as that for a single model ESR
		1. ON
		2. ONOS
		3. ONTEST
		4. ONEMR
		5. OUT
		6. EMR
		7. EMRSWGR
		8. ONHOLD (More discussion needed whether this status should be treated the same way as that for an ESR or that for Generator Resource)

# *Future Decision Points and Issues for Developing Key topic/Concept recommendation Language*

None.

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| Applicable Protocol Section(s) |  |
| Impacted System(s) / Application(s) |  |