|  |  |  |  |
| --- | --- | --- | --- |
| NPRR Number | [1057](http://www.ercot.com/mktrules/issues/nprr1057) | NPRR Title | Modification to Real-Time Hub Price Formulas for Fully De-Energized Hubs |
|  |  |
| Date | December 28, 2020 |
|  |  |
| Submitter’s Information |
| Name | Dave Maggio |
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| Cell Number |  |
| Market Segment | Not Applicable |

|  |
| --- |
| Comments |

ERCOT submits these comments to Nodal Protocol Revision Request (NPRR) 1057 to correct some of the proposed Protocol language. These comments include minor language clarifications to some of the variables, and specifically update the following equations:

* Paragraph (4) of Sections 3.5.2.1 through 3.5.2.7 – clarify that the Hub Locational Marginal Price (HUBLMP) is used in each of the Real-Time Settlement Point Price (RTSPP) equations for each of the HUBs and remove redundant calculations.
* Paragraph (4) of Section 6.6.1.5 – add the calculation of the HUBLMP for the ERCOT Hub 345kV Bus Average.

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| Revised Proposed Protocol Language |

3.5.2.1 North 345 kV Hub (North 345)

(1) The North 345 kV Hub is composed of the following Hub Buses:

|  | ERCOT Operations |  |
| --- | --- | --- |
| No. | Hub Bus | kV | Hub |
| 1 | ANASW | 345 | NORTH |
| 2 | CN345 | 345 | NORTH |
| 3 | WLSH | 345 | NORTH |
| 4 | FMRVL | 345 | NORTH |
| 5 | LPCCS | 345 | NORTH |
| 6 | MNSES | 345 | NORTH |
| 7 | PRSSW | 345 | NORTH |
| 8 | SSPSW | 345 | NORTH |
| 9 | VLSES | 345 | NORTH |
| 10 | ALNSW | 345 | NORTH |
| 11 | ALLNC | 345 | NORTH |
| 12 | BNDVS | 345 | NORTH |
| 13 | BNBSW | 345 | NORTH |
| 14 | BBSES | 345 | NORTH |
| 15 | BOSQUESW | 345 | NORTH |
| 16 | CDHSW | 345 | NORTH |
| 17 | CNTRY | 345 | NORTH |
| 18 | CRLNW | 345 | NORTH |
| 19 | CMNSW | 345 | NORTH |
| 20 | CNRSW | 345 | NORTH |
| 21 | CRTLD | 345 | NORTH |
| 22 | DCSES | 345 | NORTH |
| 23 | EMSES | 345 | NORTH |
| 24 | ELKTN | 345 | NORTH |
| 25 | ELMOT | 345 | NORTH |
| 26 | EVRSW | 345 | NORTH |
| 27 | KWASS | 345 | NORTH |
| 28 | FGRSW | 345 | NORTH |
| 29 | FORSW | 345 | NORTH |
| 30 | FRNYPP | 345 | NORTH |
| 31 | GIBCRK | 345 | NORTH |
| 32 | HKBRY | 345 | NORTH |
| 33 | VLYRN | 345 | NORTH |
| 34 | JEWET | 345 | NORTH |
| 35 | KNEDL | 345 | NORTH |
| 36 | KLNSW | 345 | NORTH |
| 37 | LCSES | 345 | NORTH |
| 38 | LIGSW | 345 | NORTH |
| 39 | LEG  | 345 | NORTH |
| 40 | LFKSW | 345 | NORTH |
| 41 | LWSSW | 345 | NORTH |
| 42 | MLSES | 345 | NORTH |
| 43 | MCCREE | 345 | NORTH |
| 44 | MDANP | 345 | NORTH |
| 45 | ENTPR | 345 | NORTH |
| 46 | NCDSE | 345 | NORTH |
| 47 | NORSW | 345 | NORTH |
| 48 | NUCOR | 345 | NORTH |
| 49 | PKRSW | 345 | NORTH |
| 50 | KMCHI | 345 | NORTH |
| 51 | PTENN | 345 | NORTH |
| 52 | RENSW | 345 | NORTH |
| 53 | RCHBR | 345 | NORTH |
| 54 | RNKSW | 345 | NORTH |
| 55 | RKCRK | 345 | NORTH |
| 56 | RYSSW | 345 | NORTH |
| 57 | SGVSW | 345 | NORTH |
| 58 | SHBSW | 345 | NORTH |
| 59 | SHRSW | 345 | NORTH |
| 60 | SCSES | 345 | NORTH |
| 61 | SYCRK | 345 | NORTH |
| 62 | THSES | 345 | NORTH |
| 63 | TMPSW | 345 | NORTH |
| 64 | TNP\_ONE | 345 | NORTH |
| 65 | TRCNR | 345 | NORTH |
| 66 | TRSES | 345 | NORTH |
| 67 | TOKSW | 345 | NORTH |
| 68 | VENSW | 345 | NORTH |
| 69 | WLVEE | 345 | NORTH |
| 70 | W\_DENT | 345 | NORTH |
| 71 | WTRML | 345 | NORTH |
| 72 | WCSWS | 345 | NORTH |
| 73 | WEBBS | 345 | NORTH |
| 74 | WHTNY | 345 | NORTH |
| 75 | WCPP | 345 | NORTH |

(2) The North 345 kV Hub Price uses the aggregated Shift Factors of the Hub Buses for each hour of the Settlement Interval of the Day-Ahead Market (DAM) in the Day-Ahead and is the simple average of the time-weighted Hub Bus prices for each 15-minute Settlement Interval in Real-Time, for each Hub Bus included in this Hub.

(3) The Day-Ahead Settlement Point Price of the Hub for a given Operating Hour is calculated as follows:

**DASPP** *North345* **= DASL – (DAHUBSF***North345, c***\* DASP** *c***),**

 **if HBBC***North345***≠0**

**DASPP** *North345* **= DASPP** *ERCOT345Bus***, if HBBC***North345***=0**

Where:

DAHUBSF *North345, c =* (HUBDF *hb, North345, c* \* DAHBSF *hb, North345, c*)

DAHBSF *hb, North345, c =* (HBDF *pb, hb, North345, c* \* DASF *pb, hb, North345, c*)

HUBDF *hb, North345, c =* IF(HB*North345, c*=0, 0, 1 **/** HB *North345, c*)

HBDF *pb, hb, North345, c =* IF(PB*hb, North345, c*=0, 0, 1 **/** PB *hb, North345, c*)

The above variables are defined as follows:

| Variable | Unit | Definition |
| --- | --- | --- |
| DASPP *North345* | $/MWh | *Day-Ahead Settlement Point Price*⎯The DAM Settlement Point Price at the Hub, for the hour. |
| DASL | $/MWh | *Day-Ahead System Lambda*⎯The DAM Shadow Price for the system power balance constraint for the hour. |
| DASP *c* | $/MWh | *Day-Ahead Shadow Price for a binding transmission constraint*⎯The DAM Shadow Price for the constraint *c* for the hour. |
| DAHUBSF *North345,c* | none | *Day-Ahead Shift Factor of the Hub ⎯*The DAM aggregated Shift Factor of a Hub for the constraint *c* for the hour. |
| DAHBSF *hb,North345,c* | none | *Day-Ahead Shift Factor of the Hub Bus⎯*The DAM aggregated Shift Factor of a Hub Bus *hb* for the constraint *c* for the hour. |
| DASF *pb,hb,North345,c* | none | *Day-Ahead Shift Factor of the power flow bus⎯*The DAM Shift Factor of a power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour. |
| HUBDF *hb, North345,c* | none | *Hub Distribution Factor per Hub Bus in a constraint*⎯The distribution factor of Hub Bus *hb* for the constraint *c* for the hour.  |
| HBDF *pb, hb, North345,c* | none | *Hub Bus Distribution Factor per power flow bus of Hub Bus in a constraint*⎯The distribution factor of power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour.  |
| *pb* | none | An energized power flow bus that is a component of a Hub Bus for the constraint *c*. |
| PB *hb, North345,c* | none | The total number of energized power flow buses in Hub Bus *hb* for the constraint *c*. |
| *hb* | none | A Hub Bus that is a component of the Hub with at least one energized power flow bus for the constraint *c*. |
| HBBC *North345* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus in base case. |
| HB *North345,c* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus for the constraint *c*. |
| *c* | none | A DAM binding transmission constraint for the hour caused by either base case or a contingency. |

(4) The Real-Time Settlement Point Price of the Hub for a given 15-minute Settlement Interval is calculated as follows:

RTSPP *North345* = Max [-$251, (RTRSVPOR + RTRDP +

 (HUBLMP*, North345, y* \* RNWF *y*))]

Where:

RTRSVPOR = (RNWF *y* \* RTORPA *y*)

RTRDP = (RNWF *y* \* RTORDPA *y*)

RNWF *y* = TLMP *y* / TLMP *y*

The above variables are defined as follows:

|  |  |  |
| --- | --- | --- |
| Variable | Unit | Description |
| RTSPP *North345* | $/MWh | *Real-Time Settlement Point Price*⎯The Real-Time Settlement Point Price at the Hub, for the 15-minute Settlement Interval. |
|  |  |  |
| RTRSVPOR | $/MWh | *Real-Time Reserve Price for On-Line Reserves*⎯The Real-Time Reserve Price for On-Line Reserves for the 15-minute Settlement Interval. |
| RTORPA*y* | $/MWh | *Real-Time On-Line Reserve Price Adder per interval*⎯The Real-Time price adder for On-Line Reserves for the SCED interval *y*. |
| RTRDP | $/MWh | *Real-Time On-Line Reliability Deployment Price*⎯The Real-Time price for the 15-minute Settlement Interval, reflecting the impact of reliability deployments on energy prices that are calculated from the Real-Time On-Line Reliability Deployment Price Adder.  |
| RTORDPA *y* | $/MWh | *Real-Time On-Line Reliability Deployment Price Adder*⎯The Real-Time price adder that captures the impact of reliability deployments on energy prices for the SCED interval *y.*  |
| HUBLMP*Hub, y* | $/MWh | *Hub Locational Marginal Price*⎯The Hub LMP for the Hub for the SCED Interval *y*. |
| RNWF *y* | none | *Resource Node Weighting Factor per interval*⎯The weight used in the Resource Node Settlement Point Price calculation for the portion of the SCED interval *y* within the Settlement Interval. |
|  |  |  |
| TLMP *y* | second | *Duration of SCED interval per interval*⎯The duration of the portion of the SCED interval *y* within the 15-minute Settlement Interval |
|  |  |  |
|  |  |  |
| *y* | none | A SCED interval in the 15-minute Settlement Interval. The summation is over the total number of SCED runs that cover the 15-minute Settlement Interval. |
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3.5.2.2 South 345 kV Hub (South 345)

(1) The South 345 kV Hub is composed of the following Hub Buses:

|  | ERCOT Operations |  |
| --- | --- | --- |
| No. | Hub Bus | kV | Hub |
| 1 | AUSTRO | 345 | SOUTH |
| 2 | BLESSING | 345 | SOUTH |
| 3 | CAGNON | 345 | SOUTH |
| 4 | COLETO | 345 | SOUTH |
| 5 | CLEASP | 345 | SOUTH |
| 6 | NEDIN | 345 | SOUTH |
| 7 | FAYETT | 345 | SOUTH |
| 8 | FPPYD1 | 345 | SOUTH |
| 9 | FPPYD2 | 345 | SOUTH |
| 10 | GARFIE | 345 | SOUTH |
| 11 | GUADG | 345 | SOUTH |
| 12 | HAYSEN | 345 | SOUTH |
| 13 | HILLCTRY | 345 | SOUTH |
| 14 | HOLMAN | 345 | SOUTH |
| 15 | KENDAL | 345 | SOUTH |
| 16 | LA\_PALMA | 345 | SOUTH |
| 17 | LON\_HILL | 345 | SOUTH |
| 18 | LOSTPI | 345 | SOUTH |
| 19 | LYTTON\_S | 345 | SOUTH |
| 20 | MARION | 345 | SOUTH |
| 21 | PAWNEE | 345 | SOUTH |
| 22 | RIOHONDO | 345 | SOUTH |
| 23 | RIONOG | 345 | SOUTH |
| 24 | SALEM | 345 | SOUTH |
| 25 | SANMIGL | 345 | SOUTH |
| 26 | SKYLINE | 345 | SOUTH |
| 27 | STP | 345 | SOUTH |
| 28 | CALAVERS | 345 | SOUTH |
| 29 | BRAUNIG | 345 | SOUTH |
| 30 | WHITE\_PT | 345 | SOUTH |
| 31 | ZORN | 345 | SOUTH |

(2) The South 345 kV Hub Price uses the aggregated Shift Factors of the Hub Buses for each hour of the Settlement Interval of the DAM in the Day-Ahead and is the simple average of the time-weighted Hub Bus prices for each 15-minute Settlement Interval in Real-Time, for each Hub Bus included in this Hub.

(3) The Day-Ahead Settlement Point Price of the Hub for a given Operating Hour is calculated as follows:

**DASPP** *South345* **= DASL – (DAHUBSF***South345, c***\* DASP** *c***),**

 **if HBBC***South345***≠0**

**DASPP** *South345* **= DASPP** *ERCOT345Bus***, if HBBC***South345***=0**

Where:

DAHUBSF *South345, c =* (HUBDF *hb, South345, c* \* DAHBSF *hb, South345, c*)

DAHBSF *hb, South345, c =* (HBDF *pb, hb, South345, c* \* DASF *pb, hb, South345, c*)

HUBDF *hb, South345, c =* IF(HB*South345, c*=0, 0, 1 **/** HB *South345, c*)

HBDF *pb, hb, South345, c =* IF(PB*hb, South345, c*=0, 0, 1 **/** PB *hb, South345, c*)

The above variables are defined as follows:

| Variable | Unit | Definition |
| --- | --- | --- |
| DASPP *South345* | $/MWh | *Day-Ahead Settlement Point Price*⎯The DAM Settlement Point Price at the Hub, for the hour. |
| DASL | $/MWh | *Day-Ahead System Lambda*⎯The DAM Shadow Price for the system power balance constraint for the hour. |
| DASP *c* | $/MWh | *Day-Ahead Shadow Price for a binding transmission constraint*⎯The DAM Shadow Price for the constraint *c* for the hour. |
| DAHUBSF *South345,c* | none | *Day-Ahead Shift Factor of the Hub ⎯*The DAM aggregated Shift Factor of a Hub for the constraint *c* for the hour. |
| DAHBSF *hb,South345,c* | none | *Day-Ahead Shift Factor of the Hub Bus⎯*The DAM aggregated Shift Factor of a Hub Bus *hb* for the constraint *c* for the hour. |
| DASF *pb,hb,South345,c* | none | *Day-Ahead Shift Factor of the power flow bus⎯*The DAM Shift Factor of a power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour. |
| HUBDF *hb, South345,c* | none | *Hub Distribution Factor per Hub Bus in a constraint*⎯The distribution factor of Hub Bus *hb* for the constraint *c* for the hour.  |
| HBDF *pb, hb, South345,c* | none | *Hub Bus Distribution Factor per power flow bus of Hub Bus in a constraint*⎯The distribution factor of power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour.  |
| *pb* | none | An energized power flow bus that is a component of a Hub Bus for the constraint *c*. |
| PB *hb, South345,c* | none | The total number of energized power flow buses in Hub Bus *hb* for the constraint *c*. |
| *hb* | none | A Hub Bus that is a component of the Hub with at least one energized power flow bus for the constraint *c*. |
| HBBC *South345* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus in base case. |
| HB *South345,c* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus for the constraint *c*. |
| *c* | none | A DAM binding transmission constraint for the hour caused by either base case or a contingency. |

(4) The Real-Time Settlement Point Price of the Hub for a given 15-minute Settlement Interval is calculated as follows:

RTSPP *South345* = Max [-$251, (RTRSVPOR + RTRDP +

 (HUBLMP *South345, y* \* RNWF *y*))]

Where:

RTRSVPOR = (RNWF  *y* \* RTORPA *y*)

RTRDP = (RNWF*y* \* RTORDPA*y*)

RNWF *y* = TLMP *y* / TLMP *y*

The above variables are defined as follows:

|  |  |  |
| --- | --- | --- |
| Variable | Unit | Description |
| RTSPP *South345* | $/MWh | *Real-Time Settlement Point Price*⎯The Real-Time Settlement Point Price at the Hub, for the 15-minute Settlement Interval. |
|  |  |  |
| RTRSVPOR | $/MWh | *Real-Time Reserve Price for On-Line Reserves*⎯The Real-Time Reserve Price for On-Line Reserves for the 15-minute Settlement Interval. |
| RTORPA*y* | $/MWh | *Real-Time On-Line Reserve Price Adder per interval*⎯The Real-Time On-Line Reserve Price Adder for the SCED interval *y*. |
| RTRDP | $/MWh | *Real-Time On-Line Reliability Deployment Price-*⎯The Real-Time price for the 15-minute Settlement Interval, reflecting the impact of reliability deployments on energy prices that are calculated from the Real-Time On-Line Reliability Deployment Price Adder.  |
| RTORDPA *y* | $/MWh | *Real-Time On-Line Reliability Deployment Price Adder –*The Real-Time price adder that captures the impact of reliability deployments on energy prices for the SCED interval *y.*  |
| HUBLMP*Hub, y* | $/MWh | *Hub Locational Marginal Price*⎯The Hub LMP for the Hub for the SCED Interval *y*. |
| RNWF *y* | none | *Resource Node Weighting Factor per interval*⎯The weight used in the Resource Node Settlement Point Price calculation for the portion of the SCED interval *y* within the Settlement Interval. |
|  |  |  |
| TLMP *y* | second | *Duration of SCED interval per interval*⎯The duration of the portion of the SCED interval *y* within the 15-minute Settlement Interval. |
|  |  |  |
|  |  |  |
| *y* | none | A SCED interval in the 15-minute Settlement Interval. The summation is over the total number of SCED runs that cover the 15-minute Settlement Interval. |
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3.5.2.3 Houston 345 kV Hub (Houston 345)

(1) The Houston 345 kV Hub is composed of the following listed Hub Buses:

|  | ERCOT Operations |  |
| --- | --- | --- |
| No. | Hub Bus | kV | Hub |
| 1 | ADK | 345 | HOUSTON |
| 2 | BI | 345 | HOUSTON |
| 3 | CBY | 345 | HOUSTON |
| 4 | CTR | 345 | HOUSTON |
| 5 | CHB | 345 | HOUSTON |
| 6 | DPW | 345 | HOUSTON |
| 7 | DOW | 345 | HOUSTON |
| 8 | RNS | 345 | HOUSTON |
| 9 | GBY | 345 | HOUSTON |
| 10 | JN | 345 | HOUSTON |
| 11 | KG | 345 | HOUSTON |
| 12 | KDL | 345 | HOUSTON |
| 13 | NB | 345 | HOUSTON |
| 14 | OB | 345 | HOUSTON |
| 15 | PHR | 345 | HOUSTON |
| 16 | SDN | 345 | HOUSTON |
| 17 | SMITHERS | 345 | HOUSTON |
| 18 | THW | 345 | HOUSTON |
| 19 | WAP | 345 | HOUSTON |
| 20 | WO | 345 | HOUSTON |

(2) The Houston 345 kV Hub Price uses the aggregated Shift Factors of the Hub Buses for each hour of the Settlement Interval of the DAM in the Day-Ahead and is the simple average of the time-weighted Hub Bus prices for each 15-minute Settlement Interval in Real-Time, for each Hub Bus included in this Hub.

(3) The Day-Ahead Settlement Point Price of the Hub for a given Operating Hour is calculated as follows:

**DASPP** *Houston345* **= DASL – (DAHUBSF***Houston345, c***\* DASP** *c***),**

 **if HBBC***Houston345***≠0**

**DASPP** *Houston345* **= DASPP** *ERCOT345Bus***, if HBBC***Houston345***=0**

Where:

DAHUBSF *Houston345, c =* (HUBDF *hb, Houston345, c* \* DAHBSF *hb, Houston345, c*)

DAHBSF *hb, Houston345, c =* (HBDF *pb, hb, Houston345, c* \* DASF *pb, hb, Houston345, c*)

HUBDF *hb, Houston345, c =* IF(HB*Houston345, c*=0, 0, 1 **/** HB *Houston345, c*)

HBDF *pb, hb, Houston345, c =* IF(PB*hb, Houston345, c*=0, 0, 1 **/** PB *hb, Houston345, c*)

The above variables are defined as follows:

| Variable | Unit | Definition |
| --- | --- | --- |
| DASPP *Houston345* | $/MWh | *Day-Ahead Settlement Point Price*⎯The DAM Settlement Point Price at the Hub, for the hour. |
| DASL | $/MWh | *Day-Ahead System Lambda*⎯The DAM Shadow Price for the system power balance constraint for the hour. |
| DASP *c* | $/MWh | *Day-Ahead Shadow Price for a binding transmission constraint*⎯The DAM Shadow Price for the constraint *c* for the hour. |
| DAHUBSF *Houston345,c* | none | *Day-Ahead Shift Factor of the Hub ⎯*The DAM aggregated Shift Factor of a Hub for the constraint *c* for the hour. |
| DAHBSF *hb,Houston345,c* | none | *Day-Ahead Shift Factor of the Hub Bus⎯*The DAM aggregated Shift Factor of a Hub Bus *hb* for the constraint *c* for the hour. |
| DASF *pb,hb,Houston345,c* | none | *Day-Ahead Shift Factor of the power flow bus⎯*The DAM Shift Factor of a power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour. |
| HUBDF *hb, Houston345,c* | none | *Hub Distribution Factor per Hub Bus in a constraint*⎯The distribution factor of Hub Bus *hb* for the constraint *c* for the hour.  |
| HBDF *pb, hb, Houston345,c* | none | *Hub Bus Distribution Factor per power flow bus of Hub Bus in a constraint*⎯The distribution factor of power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour.  |
| *pb* | none | An energized power flow bus that is a component of a Hub Bus for the constraint *c*. |
| PB *hb, Houston345,c* | none | The total number of energized power flow buses in Hub Bus *hb* for the constraint *c*. |
| *hb* | none | A Hub Bus that is a component of the Hub with at least one energized power flow bus for the constraint *c*. |
| HBBC *Houston345* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus in base case. |
| HB *Houston345,c* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus for the constraint *c*. |
| *c* | none | A DAM binding transmission constraint for the hour caused by either base case or a contingency. |

(4) The Real-Time Settlement Point Price of the Hub for a given 15-minute Settlement Interval is calculated as follows:

RTSPP *Houston345* = Max [-$251, (RTRSVPOR + RTRDP +

 (HUBLMP*Houston345, y* \* RNWF *y*))]

Where:

RTRSVPOR = (RNWF *y* \* RTORPA *y*)

RTRDP = (RNWF *y* \* RTORDPA *y*)

RNWF *y* = TLMP *y* / TLMP *y*

The above variables are defined as follows:

| Variable | Unit | Description |
| --- | --- | --- |
| RTSPP *Houston345* | $/MWh | *Real-Time Settlement Point Price*⎯The Real-Time Settlement Point Price at the Hub, for the 15-minute Settlement Interval. |
|  |  |  |
| RTRSVPOR | $/MWh | *Real-Time Reserve Price for On-Line Reserves*⎯The Real-Time Reserve Price for On-Line Reserves for the 15-minute Settlement Interval. |
| RTORPA*y* | $/MWh | *Real-Time On-Line Reserve Price Adder per interval*⎯The Real-Time On-Line Reserve Price Adder for the SCED interval *y*. |
| RTRDP | $/MWh | *Real-Time On-Line Reliability Deployment Price*⎯The Real-Time price for the 15-minute Settlement Interval, reflecting the impact of reliability deployments on energy prices that are calculated from the Real-Time On-Line Reliability Deployment Price Adder.  |
| RTORDPA *y* | $/MWh | *Real-Time On-Line Reliability Deployment Price Adder*⎯The Real-Time price adder that captures the impact of reliability deployments on energy prices for the SCED interval *y.*  |
| HUBLMP*Hub, y* | $/MWh | *Hub Locational Marginal Price*⎯The Hub LMP for the Hub for the SCED Interval *y*. |
| RNWF *y* | none | *Resource Node Weighting Factor per interval*⎯The weight used in the Resource Node Settlement Point Price calculation for the portion of the SCED interval *y* within the Settlement Interval. |
|  |  |  |
| TLMP *y* | second | *Duration of SCED interval per interval*⎯The duration of the portion of the SCED interval *y* within the 15-minute Settlement Interval |
|  |  |  |
|  |  |  |
| *y* | none | A SCED interval in the 15-minute Settlement Interval. The summation is over the total number of SCED runs that cover the 15-minute Settlement Interval. |
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3.5.2.4 West 345 kV Hub (West 345)

(1) The West 345 kV Hub is composed of the following listed Hub Buses:

|  |  |  |
| --- | --- | --- |
|  | ERCOT Operations |  |
| No. | Hub Bus | kV | Hub |
| 1 | MULBERRY | 345 | WEST |
| 2 | BOMSW | 345 | WEST |
| 3 | OECCS | 345 | WEST |
| 4 | BITTCR | 345 | WEST |
| 5 | FSHSW | 345 | WEST |
| 6 | FLCNS | 345 | WEST |
| 7 | GRSES | 345 | WEST |
| 8 | JCKSW | 345 | WEST |
| 9 | MDLNE | 345 | WEST |
| 10 | MOSSW | 345 | WEST |
| 11 | MGSES | 345 | WEST |
| 12 | DCTM | 345 | WEST |
| 13 | ODEHV | 345 | WEST |
| 14 | OKLA | 345 | WEST |
| 15 | REDCREEK | 345 | WEST |
| 16 | SWESW | 345 | WEST |
| 17 | TWINBU | 345 | WEST |

(2) The West 345 kV Hub Price uses the aggregated Shift Factors of the Hub Buses for each hour of the Settlement Interval of the DAM in the Day-Ahead and is the simple average of the time weighted Hub Bus prices for each 15-minute Settlement Interval in Real-Time, for each Hub Bus included in this Hub.

(3) The Day-Ahead Settlement Point Price of the Hub for a given Operating Hour is calculated as follows:

**DASPP** *West345* **= DASL – (DAHUBSF***West345, c***\* DASP** *c***),**

 **if HBBC***West345***≠0**

**DASPP** *West345* **= DASPP** *ERCOT345Bus***, if HBBC***West345***=0**

Where:

DAHUBSF *West345, c =* (HUBDF *hb, West345, c* \* DAHBSF *hb, West345, c*)

DAHBSF *hb, West345, c =* (HBDF *pb, hb, West345, c* \* DASF *pb, hb, West345, c*)

HUBDF *hb, West345, c =* IF(HB*West345, c*=0, 0, 1 **/** HB *West345, c*)

HBDF *pb, hb, West345, c =* IF(PB*hb, West345, c*=0, 0, 1 **/** PB *hb, West345, c*)

The above variables are defined as follows:

| Variable | Unit | Definition |
| --- | --- | --- |
| DASPP *West345* | $/MWh | *Day-Ahead Settlement Point Price*⎯The DAM Settlement Point Price at the Hub, for the hour. |
| DASL | $/MWh | *Day-Ahead System Lambda*⎯The DAM Shadow Price for the system power balance constraint for the hour. |
| DASP *c* | $/MWh | *Day-Ahead Shadow Price for a binding transmission constraint*⎯The DAM Shadow Price for the constraint *c* for the hour. |
| DAHUBSF *West345,c* | none | *Day-Ahead Shift Factor of the Hub ⎯*The DAM aggregated Shift Factor of a Hub for the constraint *c* for the hour. |
| DAHBSF *hb,West345,c* | none | *Day-Ahead Shift Factor of the Hub Bus⎯*The DAM aggregated Shift Factor of a Hub Bus *hb* for the constraint *c* for the hour. |
| DASF *pb,hb,West345,c* | none | *Day-Ahead Shift Factor of the power flow bus⎯*The DAM Shift Factor of a power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour. |
| HUBDF *hb, West345,c* | none | *Hub Distribution Factor per Hub Bus in a constraint*⎯The distribution factor of Hub Bus *hb* for the constraint *c* for the hour.  |
| HBDF *pb, hb, West345,c* | none | *Hub Bus Distribution Factor per power flow bus of Hub Bus in a constraint*⎯The distribution factor of power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour.  |
| *pb* | none | An energized power flow bus that is a component of a Hub Bus for the constraint *c*. |
| PB *hb, West345,c* | none | The total number of energized power flow buses in Hub Bus *hb* for the constraint *c*. |
| *hb* | none | A Hub Bus that is a component of the Hub with at least one energized power flow bus for the constraint *c*. |
| HBBC *West345* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus in base case. |
| HB *West345,c* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus for the constraint *c*. |
| *c* | none | A DAM binding transmission constraint for the hour caused by either base case or a contingency. |

 (4) The Real-Time Settlement Point Price of the Hub for a given 15-minute Settlement Interval is calculated as follows:

RTSPP *West345* = Max [-$251, (RTRSVPOR + RTRDP +

 (HUBLMP*West345, y* \* RNWF *y*))]

Where:

RTRSVPOR = (RNWF *y* \* RTORPA *y*)

RTRDP = (RNWF *y* \* RTORDPA *y*)

RNWF *y* = TLMP *y* / TLMP *y*

The above variables are defined as follows:

| Variable | Unit | Description |
| --- | --- | --- |
| RTSPP *West345* | $/MWh | *Real-Time Settlement Point Price*⎯The Real-Time Settlement Point Price at the Hub, for the 15-minute Settlement Interval. |
| RTRSVPOR | $/MWh | *Real-Time Reserve Price for On-Line Reserves*⎯The Real-Time Reserve Price for On-Line Reserves for the 15-minute Settlement Interval. |
| RTORPA*y* | $/MWh | *Real-Time On-Line Reserve Price Adder per interval*⎯The Real-Time On-Line Reserve Price Adder for the SCED interval *y*. |
| RTRDP | $/MWh | *Real-Time On-Line Reliability Deployment Price*⎯The Real-Time price for the 15-minute Settlement Interval, reflecting the impact of reliability deployments on energy prices that are calculated from the Real-Time On-Line Reliability Deployment Price Adder.  |
| RTORDPA *y* | $/MWh | *Real-Time On-Line Reliability Deployment Price Adder*⎯The Real-Time price adder that captures the impact of reliability deployments on energy prices for the SCED interval *y.*  |
| HUBLMP*Hub, y* | $/MWh | *Hub Locational Marginal Price*⎯The Hub LMP for the Hub for the SCED Interval *y*. |
| RNWF *y* | none | *Resource Node Weighting Factor per interval*⎯The weight used in the Resource Node Settlement Point Price calculation for the portion of the SCED interval *y* within the Settlement Interval. |
|  |  |  |
|  |  |  |
| TLMP *y* | second | *Duration of SCED interval per interval*⎯The duration of the portion of the SCED interval *y* within the 15-minute Settlement Interval. |
|  |  |  |
|  |  |  |
| *y* | none | A SCED interval in the 15-minute Settlement Interval. The summation is over the total number of SCED runs that cover the 15-minute Settlement Interval. |
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**3.5.2.5 Panhandle 345 kV Hub (Pan 345)**

(1) The Panhandle 345 kV Hub is composed of the following listed Hub Buses:

|  |  |  |
| --- | --- | --- |
|  | ERCOT Operations |  |
| No. | Hub Bus | kV | Hub |
| 1 | ABERNATH | 345 | PAN |
| 2 | AJ\_SWOPE | 345 | PAN |
| 3 | ALIBATES | 345 | PAN |
| 4 | CTT\_CROS | 345 | PAN |
| 5 | CTT\_GRAY | 345 | PAN |
| 6 | OGALLALA | 345 | PAN |
| 7 | RAILHEAD | 345 | PAN |
| 8 | TESLA | 345 | PAN |
| 9 | TULECNYN | 345 | PAN |
| 10 | W\_CW\_345 | 345 | PAN |
| 11 | WHIT\_RVR | 345 | PAN |
| 12 | WINDMILL | 345 | PAN |

(2) The Panhandle 345 kV Hub Price uses the aggregated Shift Factors of the Hub Buses for each hour of the Settlement Interval of the DAM in the Day-Ahead and is the simple average of the time weighted Hub Bus prices for each 15-minute Settlement Interval in Real-Time, for each Hub Bus included in this Hub.

(3) The Day-Ahead Settlement Point Price of the Hub for a given Operating Hour is calculated as follows:

**DASPP** *Pan345* **=**  **DASL – (DAHUBSF***Pan345, c***\* DASP** *c***),**

 **if HBBC***Pan345***≠0**

**DASPP** *Pan345* **=**  **DASPP** *ERCOT345Bus***, if HBBC***Pan345***=0**

Where:

DAHUBSF *Pan345, c =* (HUBDF *hb, Pan345, c* \* DAHBSF *hb, Pan345, c*)

DAHBSF *hb, Pan345, c =* (HBDF *pb, hb, Pan345, c* \* DASF *pb, hb, Pan345, c*)

HUBDF *hb, Pan345, c =* IF(HB*Pan345, c*=0, 0, 1 **/** HB *Pan345, c*)

HBDF *pb, hb, Pan345, c =* IF(PB*hb, Pan345, c*=0, 0, 1 **/** PB *hb, Pan345, c*)

The above variables are defined as follows:

| Variable | Unit | Definition |
| --- | --- | --- |
| DASPP *Pan345* | $/MWh | *Day-Ahead Settlement Point Price*⎯The DAM Settlement Point Price at the Hub, for the hour. |
| DASL | $/MWh | *Day-Ahead System Lambda*⎯The DAM Shadow Price for the system power balance constraint for the hour. |
| DASP *c* | $/MWh | *Day-Ahead Shadow Price for a binding transmission constraint*⎯The DAM Shadow Price for the constraint *c* for the hour. |
| DAHUBSF *Pan345,c* | none | *Day-Ahead Shift Factor of the Hub ⎯*The DAM aggregated Shift Factor of a Hub for the constraint *c* for the hour. |
| DAHBSF *hb,Pan345,c* | none | *Day-Ahead Shift Factor of the Hub Bus⎯*The DAM aggregated Shift Factor of a Hub Bus *hb* for the constraint *c* for the hour. |
| DASF *pb,hb,Pan345,c* | none | *Day-Ahead Shift Factor of the power flow bus⎯*The DAM Shift Factor of a power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour. |
| HUBDF *hb, Pan345,c* | none | *Hub Distribution Factor per Hub Bus in a constraint*⎯The distribution factor of Hub Bus *hb* for the constraint *c* for the hour.  |
| HBDF *pb, hb, Pan345,c* | none | *Hub Bus Distribution Factor per power flow bus of Hub Bus in a constraint*⎯The distribution factor of power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour.  |
| *pb* | none | An energized power flow bus that is a component of a Hub Bus for the constraint *c*. |
| PB *hb, Pan345,c* | none | The total number of energized power flow buses in Hub Bus *hb* for the constraint *c*. |
| *hb* | none | A Hub Bus that is a component of the Hub with at least one energized power flow bus for the constraint *c*. |
| HBBC *Pan345* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus in base case. |
| HB *Pan345,c* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus for the constraint *c*. |
| *c* | none | A DAM binding transmission constraint for the hour caused by either base case or a contingency. |

(4) The Real-Time Settlement Point Price of the Hub for a given 15-minute Settlement Interval is calculated as follows:

**RTSPP** *Pan345* **= Max [-$251, (RTRSVPOR + RTRDP +**

**(HUBLMP***Pan345, y* **\* RNWF *y*))]**

Where:

RTRSVPOR = (RNWF *y* \* RTORPA *y*)

RTRDP = (RNWF *y* \* RTORDPA *y*)

RNWF *y* = TLMP *y* / TLMP *y*

The above variables are defined as follows:

| **Variable** | **Unit** | **Description** |
| --- | --- | --- |
| RTSPP *Pan345* | $/MWh | *Real-Time Settlement Point Price*⎯The Real-Time Settlement Point Price at the Hub for the 15-minute Settlement Interval. |
| RTRSVPOR | $/MWh | *Real-Time Reserve Price for On-Line Reserves*⎯The Real-Time Reserve Price for On-Line Reserves for the 15-minute Settlement Interval. |
| RTORPA*y* | $/MWh | *Real-Time On-Line Reserve Price Adder per interval*⎯The Real-Time On-Line Reserve Price Adder for the SCED interval *y*. |
| RTRDP | $/MWh | *Real-Time On-Line Reliability Deployment Price*⎯The Real-Time price for the 15-minute Settlement Interval, reflecting the impact of reliability deployments on energy prices that are calculated from the Real-Time On-Line Reliability Deployment Price Adder.  |
| RTORDPA *y* | $/MWh | *Real-Time On-Line Reliability Deployment Price Adder*⎯The Real-Time price adder that captures the impact of reliability deployments on energy prices for the SCED interval *y.*  |
| HUBLMP*Hub, y* | $/MWh | *Hub Locational Marginal Price*⎯The Hub LMP for the Hub for the SCED Interval y. |
| RNWF *y* | none | *Resource Node Weighting Factor per interval*⎯The weight used in the Resource Node Settlement Point Price calculation for the portion of the SCED interval *y* within the Settlement Interval. |
|  |  |  |
|  |  |  |
| TLMP *y* | second | *Duration of SCED interval per interval*⎯The duration of the portion of the SCED interval *y* within the 15-minute Settlement Interval. |
|  |  |  |
|  |  |  |
| *y* | none | A SCED interval in the 15-minute Settlement Interval. The summation is over the total number of SCED runs that cover the 15-minute Settlement Interval. |
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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***[NPRR941: Insert Section 3.5.2.6 below upon system implementation and renumber accordingly:]*****3.5.2.6 Lower Rio Grande Valley Hub (LRGV 138/345)**(1) The Lower Rio Grande Valley Hub 138/345 kV Hub is composed of the following listed Hub Buses:

|  |  |  |  |
| --- | --- | --- | --- |
|  | ERCOT Operations |  |  |
| No. | Hub Bus | kV | Hub |
| 1 | AIRPORT | 138 | LRGV |
| 2 | ALBERTA | 138 | LRGV |
| 3 | BATES | 138 | LRGV |
| 4 | FRONTERA | 138 | LRGV |
| 5 | GARZA | 138 | LRGV |
| 6 | HARLNSW | 138 | LRGV |
| 7 | HEC | 138 | LRGV |
| 8 | KEY\_SW | 138 | LRGV |
| 9 | LA\_PALMA\_345 | 345 | LRGV |
| 10 | LA\_PALMA\_138 | 138 | LRGV |
| 11 | LASPULGA | 138 | LRGV |
| 12 | LISTON | 138 | LRGV |
| 13 | LOMA\_ALT | 138 | LRGV |
| 14 | MARCONI | 138 | LRGV |
| 15 | MILHWY | 138 | LRGV |
| 16 | MILITARY | 138 | LRGV |
| 17 | MV\_WEDN4 | 138 | LRGV |
| 18 | N\_MCALLN | 138 | LRGV |
| 19 | NEDIN\_345 | 345 | LRGV |
| 20 | NEDIN\_138 | 138 | LRGV |
| 21 | OLEANDER | 138 | LRGV |
| 22 | P\_ISABEL | 138 | LRGV |
| 23 | PALMHRTP | 138 | LRGV |
| 24 | PALMITO\_345 | 345 | LRGV |
| 25 | PALMITO\_138 | 138 | LRGV |
| 26 | PAREDES | 138 | LRGV |
| 27 | PHARMVEC | 138 | LRGV |
| 28 | PHARR | 138 | LRGV |
| 29 | PRICE\_RD | 138 | LRGV |
| 30 | RAILROAD | 138 | LRGV |
| 31 | RAYMND2 | 138 | LRGV |
| 32 | REDTAP | 138 | LRGV |
| 33 | RIO\_GRAN | 138 | LRGV |
| 34 | RIOHONDO\_345 | 345 | LRGV |
| 35 | RIOHONDO\_138 | 138 | LRGV |
| 36 | ROMA\_SW | 138 | LRGV |
| 37 | S\_MCALLN | 138 | LRGV |
| 38 | SCARBIDE | 138 | LRGV |
| 39 | SILASRAY | 138 | LRGV |
| 40 | STEWART | 138 | LRGV |
| 41 | WESLACO | 138 | LRGV |

(2) The Lower Rio Grande Valley 138/345 kV Hub Price uses the aggregated Shift Factors of the Hub Buses for each hour of the Settlement Interval of the DAM in the Day-Ahead and is the simple average of the time weighted Hub Bus prices for each 15-minute Settlement Interval in Real-Time, for each Hub Bus included in this Hub.(3) The Day-Ahead Settlement Point Price of the Hub for a given Operating Hour is calculated as follows: **DASPP** *LRGV 138/345* **= DASL – (DAHUBSF***LRGV 138/345, c***\* DASP** *c***),**  **if HBBC***LRGV138/345***≠0****DASPP** *LRGV138/345* **= DASPP** *ERCOT345Bus***, if HBBC***LRGV138/345***=0**Where:DAHUBSF *LRGV138/345, c =* (HUBDF *hb, LRGV138/345, c* \* DAHBSF *hb, LRGV138/345, c*)DAHBSF *hb, LRGV138/345, c =* (HBDF *pb, hb, LRGV138/345, c* \* DASF *pb, hb, LRGV138/345, c*)HUBDF *hb, LRGV138/345, c =* IF(HB*LRGV138/345, c*=0, 0, 1 **/** HB *LRGV138/345, c*)HBDF *pb, hb, LRGV138/345, c =* IF(PB*hb, LRGV138/345, c*=0, 0, 1 **/** PB *hb, LRGV138/345, c*)The above variables are defined as follows:

| Variable | Unit | Definition |
| --- | --- | --- |
| DASPP *LRGV138/345* | $/MWh | *Day-Ahead Settlement Point Price*⎯The DAM Settlement Point Price at the Hub, for the hour. |
| DASL | $/MWh | *Day-Ahead System Lambda*⎯The DAM Shadow Price for the system power balance constraint for the hour. |
| DASP *c* | $/MWh | *Day-Ahead Shadow Price for a binding transmission constraint*⎯The DAM Shadow Price for the constraint *c* for the hour. |
| DAHUBSF *LRGV138/345,c* | none | *Day-Ahead Shift Factor of the Hub ⎯*The DAM aggregated Shift Factor of a Hub for the constraint *c* for the hour. |
| DAHBSF *hb, LRGV138/345,c* | none | *Day-Ahead Shift Factor of the Hub Bus⎯*The DAM aggregated Shift Factor of a Hub Bus *hb* for the constraint *c* for the hour. |
| DASF *pb,hb, LRGV138/345,c* | none | *Day-Ahead Shift Factor of the power flow bus⎯*The DAM Shift Factor of a power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour. |
| HUBDF *hb, LRGV138/345,c* | none | *Hub Distribution Factor per Hub Bus in a constraint*⎯The distribution factor of Hub Bus *hb* for the constraint *c* for the hour.  |
| HBDF *pb, hb, LRGV138/345,c* | none | *Hub Bus Distribution Factor per power flow bus of Hub Bus in a constraint*⎯The distribution factor of power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour.  |
| *pb* | none | An energized power flow bus that is a component of a Hub Bus for the constraint *c*. |
| PB *hb, LRGV138/345,c* | none | The total number of energized power flow buses in Hub Bus *hb* for the constraint *c*. |
| *hb* | none | A Hub Bus that is a component of the Hub with at least one energized power flow bus for the constraint *c*. |
| HBBC *LRGV138/345* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus in base case. |
| HB *LRGV138/345,c* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus for the constraint *c*. |
| *c* | none | A DAM binding transmission constraint for the hour caused by either base case or a contingency. |

(4) The Real-Time Settlement Point Price of the Hub for a given 15-minute Settlement Interval is calculated as follows:**RTSPP** *LRGV138/345* **= Max [-$251, (RTRSVPOR + RTRDP +**  **(HUBLMP** *LRGV138/345, y* **\* RNWF** *y***))]**Where:RTRSVPOR = (RNWF *y* \* RTORPA *y*)RTRDP = (RNWF *y* \* RTORDPA *y*)RNWF *y* = TLMP *y* / TLMP *y*The above variables are defined as follows:

| **Variable** | **Unit** | **Description** |
| --- | --- | --- |
| RTSPP *LRGV138/345kV* | $/MWh | *Real-Time Settlement Point Price*⎯The Real-Time Settlement Point Price at the Hub for the 15-minute Settlement Interval. |
| RTRSVPOR | $/MWh | *Real-Time Reserve Price for On-Line Reserves*⎯The Real-Time Reserve Price for On-Line Reserves for the 15-minute Settlement Interval. |
| RTORPA*y* | $/MWh | *Real-Time On-Line Reserve Price Adder per interval*⎯The Real-Time On-Line Reserve Price Adder for the SCED interval *y*. |
| RTRDP | $/MWh | *Real-Time On-Line Reliability Deployment Price*⎯The Real-Time price for the 15-minute Settlement Interval, reflecting the impact of reliability deployments on energy prices that are calculated from the Real-Time On-Line Reliability Deployment Price Adder.  |
| RTORDPA *y* | $/MWh | *Real-Time On-Line Reliability Deployment Price Adder*⎯The Real-Time price adder that captures the impact of reliability deployments on energy prices for the SCED interval *y.*  |
| HUBLMP*Hub, y* | $/MWh | *Hub Locational Marginal Price*⎯The Hub LMP for the Hub for the SCED Interval y. |
| RNWF *y* | none | *Resource Node Weighting Factor per interval*⎯The weight used in the Resource Node Settlement Point Price calculation for the portion of the SCED interval *y* within the Settlement Interval. |
|  |  |  |
|  |  |  |
| TLMP *y* | second | *Duration of SCED interval per interval*⎯The duration of the portion of the SCED interval *y* within the 15-minute Settlement Interval. |
|  |  |  |
|  |  |  |
| *y* | none | A SCED interval in the 15-minute Settlement Interval. The summation is over the total number of SCED runs that cover the 15-minute Settlement Interval. |
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3.5.2.7 ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus)

(1) The ERCOT Bus Average 345 kV Hub is composed of the Hub Buses listed in Section 3.5.2.1, North 345 kV Hub (North 345); Section 3.5.2.2, South 345 kV Hub (South 345); Section 3.5.2.3, Houston 345 kV Hub (Houston 345); and Section 3.5.2.4, West 345 kV Hub (West 345). The Panhandle 345 kV Hub is not included in the ERCOT Bus Average 345 kV Hub price.

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| ***[NPRR941: Replace paragraph (1) above upon system implementation:]***(1) The ERCOT Bus Average 345 kV Hub is composed of the Hub Buses listed in Section 3.5.2.1, North 345 kV Hub (North 345); Section 3.5.2.2, South 345 kV Hub (South 345); Section 3.5.2.3, Houston 345 kV Hub (Houston 345); and Section 3.5.2.4, West 345 kV Hub (West 345). The Panhandle 345 kV Hub and the Lower Rio Grande Valley 138/345 kV Hub are not included in the ERCOT Bus Average 345 kV Hub price. |

(2) The ERCOT Bus Average 345 kV Hub uses the aggregated Shift Factors of the Hub Buses for each hour of the Settlement Interval of the DAM in the Day-Ahead and is the simple average of the time weighted Hub Bus prices for each 15-minute Settlement Interval in Real-Time, for each Hub Bus included in this Hub.

(3) The Day-Ahead Settlement Point Price of the Hub for a given Operating Hour is calculated as follows:

**DASPP** *ERCOT345Bus* **= DASL – (DAHUBSF***ERCOT345Bus, c***\* DASP** *c***),**

 **if HBBC***ERCOT345Bus***≠0**

**DASPP** *ERCOT345Bus* **= 0, if HBBC***ERCOT345Bus***=0**

Where:

DAHUBSF *ERCOT345Bus, c =* (HUBDF *hb, ERCOT345Bus, c* \* DAHBSF *hb, ERCOT345Bus, c*)

DAHBSF *hb, ERCOT345Bus, c  =* (HBDF *pb, hb, ERCOT345Bus, c* \* DASF *pb, hb, ERCOT345Bus, c*)

HUBDF *hb, ERCOT345Bus, c =* IF(HB*ERCOT345Bus, c*=0, 0, 1 **/** HB *ERCOT345Bus, c*)

HBDF *pb, hb, ERCOT345Bus, c =* IF(PB*hb, ERCOT345Bus, c*=0, 0, 1 **/** PB *hb, ERCOT345Bus, c*)

The above variables are defined as follows:

| Variable | Unit | Definition |
| --- | --- | --- |
| DASPP *ERCOT345Bus* | $/MWh | *Day-Ahead Settlement Point Price*⎯The DAM Settlement Point Price at the Hub, for the hour. |
| DASL | $/MWh | *Day-Ahead System Lambda*⎯The DAM Shadow Price for the system power balance constraint for the hour. |
| DASP *c* | $/MWh | *Day-Ahead Shadow Price for a binding transmission constraint*⎯The DAM Shadow Price for the constraint *c* for the hour. |
| DAHUBSF *ERCOT345Bus,c* | none | *Day-Ahead Shift Factor of the Hub ⎯*The DAM aggregated Shift Factor of a Hub for the constraint *c* for the hour. |
| DAHBSF *hb,ERCOT345Bus,c* | none | *Day-Ahead Shift Factor of the Hub Bus⎯*The DAM aggregated Shift Factor of a Hub Bus *hb* for the constraint *c* for the hour. |
| DASF *pb,hb,ERCOT345Bus,c* | none | *Day-Ahead Shift Factor of the power flow bus⎯*The DAM Shift Factor of a power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour. |
| HUBDF *hb,ERCOT345Bus,c* | none | *Hub Distribution Factor per Hub Bus in a constraint*⎯The distribution factor of Hub Bus *hb* for the constraint *c* for the hour.  |
| HBDF *pb, hb, ERCOT345Bus,c* | none | *Hub Bus Distribution Factor per power flow bus of Hub Bus in a constraint*⎯The distribution factor of power flow bus *pb* that is a component of Hub Bus *hb* for the constraint *c* for the hour.  |
| *pb* | none | An energized power flow bus that is a component of a Hub Bus for the constraint *c*. |
| PB *hb, ERCOT345Bus,c* | none | The total number of energized power flow buses in Hub Bus *hb* for the constraint *c*. |
| *hb* | none | A Hub Bus that is a component of the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus) with at least one energized power flow bus for the constraint *c*. The Hub “ERCOT 345 Bus” includes any Hub Bus defined in the Hub “North 345”, “South 345”, “Houston 345” and “West 345”.  |
| HBBC *ERCOT345Bus* | none | The total number of Hub Buses in the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus) with at least one energized component in each Hub Bus in base case. The Hub “ERCOT 345 Bus” includes any Hub Bus defined in the Hub “North 345”, “South 345”, “Houston 345” and “West 345”. |
| HB *ERCOT345Bus,c* | none | The total number of Hub Buses in the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus) with at least one energized component in each Hub Bus for the constraint *c*. The Hub “ERCOT 345 Bus” includes any Hub Bus defined in the Hub “North 345”, “South 345”, “Houston 345” and “West 345”. |
| *c* | none | A DAM binding transmission constraint for the hour caused by either base case or a contingency. |

 (4) The Real-Time Settlement Point Price of the Hub for a given 15-minute Settlement Interval is calculated as follows:

RTSPP *ERCOT345Bus* = Max [-$251, (RTRSVPOR + RTRDP +

 (HUBLMP*ERCOT345Bus* \* RNWF *y*))]

Where:

RTRSVPOR = (RNWF *y* \* RTORPA *y*)

RTRDP = (RNWF *y* \* RTORDPA *y*)

RNWF *y* = TLMP *y* / TLMP *y*

The above variables are defined as follows:

| Variable | Unit | Description |
| --- | --- | --- |
| RTSPP *ERCOT345Bus* | $/MWh | *Real-Time Settlement Point Price*⎯The Real-Time Settlement Point Price at the Hub, for the 15-minute Settlement Interval. |
| RTRSVPOR | $/MWh | *Real-Time Reserve Price for On-Line Reserves*⎯The Real-Time Reserve Price for On-Line Reserves for the 15-minute Settlement Interval. |
| RTORPA*y* | $/MWh | *Real-Time On-Line Reserve Price Adder per interval*⎯The Real-Time On-Line Reserve Price Adder for the SCED interval *y*. |
| RTRDP | $/MWh | *Real-Time On-Line Reliability Deployment Price*⎯The Real-Time price for the 15-minute Settlement Interval, reflecting the impact of reliability deployments on energy prices that are calculated from the Real-Time On-Line Reliability Deployment Price Adder.  |
| RTORDPA *y* | $/MWh | *Real-Time On-Line Reliability Deployment Price Adder*⎯The Real-Time price adder that captures the impact of reliability deployments on energy prices for the SCED interval *y.*  |
| HUBLMP *ERCOT345Bus* | $/MWh | *Hub Locational Marginal Price for the ERCOT345Bus*⎯The Hub LMP for the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus), for the SCED Interval *y*. |
| RNWF *y* | none | *Resource Node Weighting Factor per interval*⎯The weight used in the Resource Node Settlement Point Price calculation for the portion of the SCED interval *y* within the Settlement Interval. |
|  |  |  |
|  |  |  |
| TLMP *y* | second | *Duration of SCED interval per interval*⎯The duration of the portion of the SCED interval *y* within the 15-minute Settlement Interval. |
|  |  |  |
|  |  |  |
| *y* | none | A SCED interval in the 15-minute Settlement Interval. The summation is over the total number of SCED runs that cover the 15-minute Settlement Interval. |
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6.6.1.5 Hub LMPs

(1) The Hub LMPs shall be posted on the MIS Public Area.

(2) For each defined Hub except for the ERCOT Hub Average 345 kV Hub and the ERCOT Bus Average 345 kV Hub, the Hub LMP is the arithmetic average of the Real-Time LMPs of the Hub Buses included in the Hub. The Hub LMP for a SCED Interval is calculated as follows:

HUBLMP *Hub, y* = (HUBDF *hb, Hub* \* RTHBP *hb, Hub, y*), if HB*Hub* ≠ 0

HUBLMP *Hub, y* = HUBLMP*ERCOT345Bus*, if HB*Hub* = 0

Where:

RTHBP *hb, Hub, y* = (HBDF *b, hb, Hub* \* RTLMP *b, hb, Hub, y*)

HUBDF *hb, Hub* = 1 **/** HB *Hub*, if HB*Hub* ≠ 0

HUBDF *hb, Hub*  = 0, if HB*Hub* = 0

HBDF *b, hb, Hub*  = 1 **/** B *hb, Hub*, if B *hb, Hub* ≠ 0

HBDF *b, hb, Hub*  = 0, if B *hb, Hub* = 0

The above variables are defined as follows:

|  |  |  |
| --- | --- | --- |
| Variable | Unit | Description |
| HUBLMP*Hub, y* | $/MWh | *Hub Locational Marginal Price*⎯The Hub LMP for the Hub for the SCED Interval *y*. |
|  |  |  |
| RTHBP *hb, Hub, y* | $/MWh | *Real-Time Hub Bus Price at Hub Bus per SCED interval*⎯The Real-Time energy price at Hub Bus *hb* for the SCED interval *y*. |
| HUBLMP *ERCOT345Bus,y* | $/MWh | *Hub Locational Marginal Price for the ERCOT345Bus*⎯The Hub LMP for the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus), for the SCED Interval *y*. |
| RTLMP *b, hb, Hub, y* | $/MWh | *Real-Time Locational Marginal Price at Electrical Bus of Hub Bus per interval*⎯The Real-Time LMP at Electrical Bus *b* that is a component of Hub Bus *hb*, for the SCED interval *y*. |
| HUBDF *hb, Hub* | none | *Hub Distribution Factor per Hub Bus*⎯The distribution factor of Hub Bus *hb*.  |
| HBDF *b, hb, Hub* | none | *Hub Bus Distribution Factor per Electrical Bus of Hub Bus*⎯The distribution factor of Electrical Bus *b* that is a component of Hub Bus *hb*.  |
| B *hb, Hub* | none | The total number of energized Electrical Buses in Hub Bus *hb*. |
| HB*Hub* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus. |
| *Hub* | none | One of the following Hubs: North 345 kV Hub, South 345 kV Hub, Houston 345 kV Hub, West 345 kV Hub, or the Panhandle 345 kV Hub. |
| *hb* | none | A Hub Bus that is a component of the Hub with at least one energized component. |
| *y* | none | A SCED interval. |
| *b* | none | An energized Electrical Bus that is a component of a Hub Bus. |

(3) The Hub LMP for the ERCOT Hub Average 345 kV Hub (ERCOT 345) for a SCED Interval is calculated as follows:

HUBLMP *ERCOT345, y* = (HUBLMP*NORTH345, y* + HUBLMP*SOUTH345, y +* HUBLMP*HOUSTON345, y +* HUBLMP*WEST345, y*) / 4

The above variables are defined as follows:

|  |  |  |
| --- | --- | --- |
| Variable | Unit | Description |
| HUBLMP*ERCOT345, y* | $/MWh | *Hub Locational Marginal Price for the ERCOT345*⎯The Hub LMP for the ERCOT Hub Average 345 kV Hub (ERCOT 345), for the SCED Interval *y*. |
| HUBLMP*NORTH345, y* | $/MWh | *Hub Locational Marginal Price for the NORTH345*⎯The Hub LMP for the North 345 kV Hub (NORTH 345), for the SCED Interval *y*. |
| HUBLMP*SOUTH345, y* | $/MWh | *Hub Locational Marginal Price for the SOUTH345*⎯The Hub LMP for the South 345 kV Hub (SOUTH 345), for the SCED Interval *y*. |
| HUBLMP*HOUSTON345, y* | $/MWh | *Hub Locational Marginal Price for the HOUSTON345*⎯The Hub LMP for the Houston 345 kV Hub (HOUSTON 345), for the SCED Interval *y*. |
| HUBLMP*WEST345, y* | $/MWh | *Hub Locational Marginal Price for the WEST345*⎯The Hub LMP for the West 345 kV Hub (WEST 345), for the SCED Interval *y*. |

(4) The Hub LMP for the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus) for a SCED Interval is calculated as follows:

HUBLMP *ERCOT345Bus, y* =(HUBDF *hb,ERCOT345Bus* \* RTHBP *hb, ERCOT345Bus, y*), if HB*ERCOT345Bus* ≠ 0

HUBLMP *ERCOT345Bus, y* = 0, if HB*ERCOT345Bus* = 0

Where:

RTHBP *hb, ERCOT345Bus, y* = (HBDF *b, hb, ERCOT345Bus* \* RTLMP *b, hb, ERCOT345Bus, y*)

HUBDF *hb, ERCOT345Busc =* IF(HB*ERCOT345Bus* =0, 0, 1 **/** HB *ERCOT345Bus*)

HBDF *b, hb, ERCOT345Bus =* IF(B*hb, ERCOT345Bus* =0, 0, 1 **/** B *hb, ERCOT345Bus*)

| Variable | Unit | Description |
| --- | --- | --- |
| HUBLMP *ERCOT345Bus, y* | $/MWh | *Hub Locational Marginal Price for the ERCOT345Bus*⎯The Hub LMP for the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus), for the SCED Interval *y*. |
| RTHBP *hb, ERCOT345Bus, y* | $/MWh | *Real-Time Hub Bus Price at Hub Bus per SCED interval*⎯The Real-Time energy price at Hub Bus *hb* in ERCOT 345 Bus, for the SCED interval *y*. |
| RTLMP *b, hb, ERCOT345Bus, y* | $/MWh | *Real-Time Locational Marginal Price at Electrical Bus of Hub Bus per interval*⎯The Real-Time LMP at Electrical Bus *b* that is a component of Hub Bus *hb* in ERCOT 345 Bus, for the SCED interval *y*. |
| HUBDF *hb, ERCOT345Bus* | none | *Hub Distribution Factor per Hub Bus*⎯The distribution factor of Hub Bus *hb*.  |
| HBDF *b, hb, ERCOT345Bus* | none | *Hub Bus Distribution Factor per Electrical Bus of Hub Bus*⎯The distribution factor of Electrical Bus *b* that is a component of Hub Bus *hb*.  |
| HB*ERCOT345Bus* | none | The total number of Hub Buses in the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus) with at least one energized component in each Hub Bus . The Hub “ERCOT 345 Bus” includes any Hub Bus defined in the Hub “North 345”, “South 345”, “Houston 345” and “West 345”. |
| B *hb, ERCOT345Bus* | none | The total number of energized Electrical Buses in Hub Bus *hb* that is a component of “ERCOT 345 Bus”. |
| *hb* | none | A Hub Bus that is a component of the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus) with at least one energized component. The Hub “ERCOT 345 Bus” includes any Hub Bus defined in the Hub “North 345”, “South 345”, “Houston 345” and “West 345”. |
| *y* | none | A SCED interval in the 15-minute Settlement Interval. The summation is over the total number of SCED runs that cover the 15-minute Settlement Interval. |
| *b* | none | An energized Electrical Bus that is a component of a Hub Bus. |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***[NPRR1057: Replace Section 6.6.1.5 above upon system implementation of NPRR941:]***6.6.1.5 Hub LMPs(1) The Hub LMPs shall be posted on the ERCOT website.(2) For each defined Hub except for the ERCOT Hub Average 345 kV Hub and the ERCOT Bus Average 345 kV Hub, the Hub LMP is the arithmetic average of the Real-Time LMPs of the Hub Buses included in the Hub. The Hub LMP for a SCED Interval is calculated as follows:HUBLMP *Hub, y* = (HUBDF *hb, Hub* \* RTHBP *hb, Hub, y*), if HB*Hub* ≠ 0HUBLMP *Hub, y* = HUBLMP*ERCOT345Bus*, if HB*Hub* = 0Where:RTHBP *hb, Hub, y* = (HBDF *b, hb, Hub* \* RTLMP *b, hb, Hub, y*)HUBDF *hb, Hub* = 1 **/** HB *Hub*, if HB*Hub* ≠ 0HUBDF *hb, Hub*  = 0, if HB*Hub* = 0HBDF *b, hb, Hub*  = 1 **/** B *hb, Hub*, if B *hb, Hub* ≠ 0HBDF *b, hb, Hub*  = 0, if B *hb, Hub* = 0The above variables are defined as follows:

|  |  |  |
| --- | --- | --- |
| Variable | Unit | Description |
| HUBLMP*Hub, y* | $/MWh | *Hub Locational Marginal Price*⎯The Hub LMP for the Hub for the SCED Interval *y*. |
| RTHBP *hb, Hub, y* | $/MWh | *Real-Time Hub Bus Price at Hub Bus per SCED interval*⎯The Real-Time energy price at Hub Bus *hb* for the SCED interval *y*. |
| HUBLMP *ERCOT345Bus,y* | $/MWh | *Hub Locational Marginal Price for the ERCOT345Bus*⎯The Hub LMP for the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus), for the SCED Interval *y*. |
| RTLMP *b, hb, Hub, y* | $/MWh | *Real-Time Locational Marginal Price at Electrical Bus of Hub Bus per interval*⎯The Real-Time LMP at Electrical Bus *b* that is a component of Hub Bus *hb*, for the SCED interval *y*. |
| HUBDF *hb, Hub* | none | *Hub Distribution Factor per Hub Bus*⎯The distribution factor of Hub Bus *hb*.  |
| HBDF *b, hb, Hub* | none | *Hub Bus Distribution Factor per Electrical Bus of Hub Bus*⎯The distribution factor of Electrical Bus *b* that is a component of Hub Bus *hb*.  |
| B *hb, Hub* | none | The total number of energized Electrical Buses in Hub Bus *hb*. |
| HB*Hub* | none | The total number of Hub Buses in the Hub with at least one energized component in each Hub Bus. |
| *Hub* | none | One of the following Hubs: North 345 kV Hub, South 345 kV Hub, Houston 345 kV Hub, West 345 kV Hub, the Panhandle 345 kV Hub, or the Lower Rio Grande Valley 138/345 kV Hub. |
| *hb* | none | A Hub Bus that is a component of the Hub with at least one energized component. |
| *y* | none | A SCED interval. |
| *b* | none | An energized Electrical Bus that is a component of a Hub Bus. |

(3) The Hub LMP for the ERCOT Hub Average 345 kV Hub (ERCOT 345) for a SCED Interval is calculated as follows: HUBLMP *ERCOT345, y* = (HUBLMP*NORTH345, y* + HUBLMP*SOUTH345, y +* HUBLMP*HOUSTON345, y +* HUBLMP*WEST345, y*) / 4The above variables are defined as follows:

|  |  |  |
| --- | --- | --- |
| Variable | Unit | Description |
| HUBLMP*ERCOT345, y* | $/MWh | *Hub Locational Marginal Price for the ERCOT345*⎯The Hub LMP for the ERCOT Hub Average 345 kV Hub (ERCOT 345), for the SCED Interval *y*. |
| HUBLMP*NORTH345, y* | $/MWh | *Hub Locational Marginal Price for the NORTH345*⎯The Hub LMP for the North 345 kV Hub (NORTH 345), for the SCED Interval *y*. |
| HUBLMP*SOUTH345, y* | $/MWh | *Hub Locational Marginal Price for the SOUTH345*⎯The Hub LMP for the South 345 kV Hub (SOUTH 345), for the SCED Interval *y*. |
| HUBLMP*HOUSTON345, y* | $/MWh | *Hub Locational Marginal Price for the HOUSTON345*⎯The Hub LMP for the Houston 345 kV Hub (HOUSTON 345), for the SCED Interval *y*. |
| HUBLMP*WEST345, y* | $/MWh | *Hub Locational Marginal Price for the WEST345*⎯The Hub LMP for the West 345 kV Hub (WEST 345), for the SCED Interval *y*. |

(4) The Hub LMP for the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus) for a SCED Interval is calculated as follows: HUBLMP *ERCOT345Bus, y* =(HUBDF *hb,ERCOT345Bus* \* RTHBP *hb, ERCOT345Bus, y*), if HB*ERCOT345Bus* ≠ 0HUBLMP *ERCOT345Bus, y* = 0, if HB*ERCOT345Bus* = 0Where:RTHBP *hb, ERCOT345Bus, y* = (HBDF *b, hb, ERCOT345Bus* \* RTLMP *b, hb, ERCOT345Bus, y*)HUBDF *hb, ERCOT345Busc =* IF(HB*ERCOT345Bus* =0, 0, 1 **/** HB *ERCOT345Bus*)HBDF *b, hb, ERCOT345Bus =* IF(B*hb, ERCOT345Bus* =0, 0, 1 **/** B *hb, ERCOT345Bus*)

| Variable | Unit | Description |
| --- | --- | --- |
| HUBLMP *ERCOT345Bus, y* | $/MWh | *Hub Locational Marginal Price for the ERCOT345Bus*⎯The Hub LMP for the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus), for the SCED Interval *y*. |
| RTHBP *hb, ERCOT345Bus, y* | $/MWh | *Real-Time Hub Bus Price at Hub Bus per SCED interval*⎯The Real-Time energy price at Hub Bus *hb* in ERCOT 345 Bus, for the SCED interval *y*. |
| RTLMP *b, hb, ERCOT345Bus, y* | $/MWh | *Real-Time Locational Marginal Price at Electrical Bus of Hub Bus per interval*⎯The Real-Time LMP at Electrical Bus *b* that is a component of Hub Bus *hb* in ERCOT 345 Bus, for the SCED interval *y*. |
| HUBDF *hb, ERCOT345Bus* | none | *Hub Distribution Factor per Hub Bus*⎯The distribution factor of Hub Bus *hb*.  |
| HBDF *b, hb, ERCOT345Bus* | none | *Hub Bus Distribution Factor per Electrical Bus of Hub Bus*⎯The distribution factor of Electrical Bus *b* that is a component of Hub Bus *hb*.  |
| HB*ERCOT345Bus* | none | The total number of Hub Buses in the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus) with at least one energized component in each Hub Bus . The Hub “ERCOT 345 Bus” includes any Hub Bus defined in the Hub “North 345”, “South 345”, “Houston 345” and “West 345”. |
| B *hb, ERCOT345Bus* | none | The total number of energized Electrical Buses in Hub Bus *hb* that is a component of “ERCOT 345 Bus”. |
| *hb* | none | A Hub Bus that is a component of the ERCOT Bus Average 345 kV Hub (ERCOT 345 Bus) with at least one energized component. The Hub “ERCOT 345 Bus” includes any Hub Bus defined in the Hub “North 345”, “South 345”, “Houston 345” and “West 345”. |
| *y* | none | A SCED interval in the 15-minute Settlement Interval. The summation is over the total number of SCED runs that cover the 15-minute Settlement Interval. |
| *b* | none | An energized Electrical Bus that is a component of a Hub Bus. |

 |