Date: August 4, 2015
To: Board of Directors
From: Joel Mickey, Interim Director of Wholesale Market Operations
Subject: Other Binding Document, Methodology for Implementing Operating Reserve Demand Curve (ORDC) to Calculate Real-Time Reserve Price Adder

Issue for the ERCOT Board of Directors

ERCOT Board of Directors Meeting Date: August 11, 2015
Agenda Item No.: 2.2

Issue:

Consideration of revisions to the Other Binding Document, Methodology for Implementing Operating Reserve Demand Curve (ORDC) to Calculate Real-Time Reserve Price Adder consistent with ERCOT Staff's recommendation.

Background/History:

Section 6.5.7.3, Security Constrained Economic Dispatch, of the ERCOT Protocols requires Technical Advisory Committee (TAC) review and ERCOT Board of Directors (Board) approval of the methodology for implementing the ORDC to calculate the Real-Time Reserve Price Adder in the Other Binding Document, Methodology for Implementing Operating Reserve Demand Curve (ORDC) to Calculate Real-Time Reserve Price Adder (Methodology).

On May 27, 2015 ERCOT submitted Nodal Protocol Revision Request (NPRR) 710, Removal of ORDC Phase 2 Language and Modification to HASL Calculation. As Attachment 1 to this NPRR submission, ERCOT proposed revisions to the Methodology. NPRR710 and the proposed revisions to the Methodology remove ORDC Phase 2; change the High Ancillary Service Limit (HASL) calculation to remove Non-Frequency Responsive Capacity (NFRC) included in a Generation Resource's High Sustained Limit (HSL), thereby creating the opportunity for an ORDC payment for the NFRC capacity through Ancillary Service imbalance Settlement; and clarify the HASL definition between use in the Resource limit calculator, Reliability Unit Commitment (RUC) optimization, and the capacity shortfall ratio share.

Key Factors Influencing Issue:

At its July 30, 2015, TAC unanimously voted to endorse the revisions to the Methodology as set forth in the 7/8/15 ERCOT Comments – Attachment 1 (Attachment A hereto).

Conclusion/Recommendation:

ERCOT Staff recommends that the Board approve revision of the Other Binding Document, Methodology for Implementing Operating Reserve Demand Curve (ORDC) to Calculate Real-Time Reserve Price Adder, consistent with TAC's and ERCOT Staff's recommendation as set forth in Attachment A.

ELECTRIC RELIABILITY COUNCIL OF TEXAS, INC.
BOARD OF DIRECTORS RESOLUTION

WHEREAS, after due consideration of the alternatives, the Board of Directors (Board) of Electric Reliability Council of Texas, Inc. (ERCOT) deems it desirable and in the best interest of ERCOT to modify the Other Binding Document, Methodology for Implementing Operating Reserve Demand Curve (ORDC) to Calculate Real-Time Reserve Price Adder;

THEREFORE, BE IT RESOLVED, that the Other Binding Document, Methodology for Implementing Operating Reserve Demand Curve (ORDC) to Calculate Real-Time Reserve Price Adder is hereby modified to reflect the changes set forth in Attachment A to this Resolution.

CORPORATE SECRETARY'S CERTIFICATE

I, Vickie G. Leady, Assistant Corporate Secretary of ERCOT, do hereby certify that, at its August 11, 2015 meeting, the ERCOT Board passed a motion approving the above Resolution by _____.

IN WITNESS WHEREOF, I have hereunto set my hand this ___ day of August, 2015.

_____
Vickie G. Leady
Assistant Corporate Secretary

Attachment A

Methodology for Implementing Operating Reserve Demand Curve (ORDC) to Calculate Real-Time Reserve Price Adder

Version _0.~~7~~8

Document Revisions

Date Approved	Version	Description	Author(s)	Approved By	Effective Date
11/19/13	0.5	ERCOT Board approved NPRR568, Real-Time Reserve Price Adder Based on Operating Reserve Demand Curve, and associated OBD, Methodology for Implementing Operating Reserve Demand Curve (ORDC) to Calculate Real-Time Reserve Price Adder	ERCOT	ERCOT Board	Upon system implementation of NPRR568
4/8/14	0.6	Revisions proposed via NPRR598, Clarify Inputs to PRC and ORDC	ERCOT	ERCOT Board	Upon implementation of NPRR568
6/1/14	0.7	Partial un~~x~~boxing of NPRR568 due to system implementation of NPRR568 and NPRR555, Load Resource Participation in Security-Constrained Economic Dispatch	ERCOT		6/1/14
TBD	0.8	Synchronize the OBD with as built methodology, the removal of Phase 2, and the implementation of NPRR698~~595~~.	ERCOT		Upon system implementation of NPRR710

PROTOCOL DISCLAIMER

This document describes ERCOT systems and the response of these systems to Market Participant submissions incidental to the conduct of operations in the ERCOT Texas Nodal Market and is not intended to be a substitute for the ERCOT Protocols (available at http://www.ercot.com/mktrules/nprotocols/current), as amended from time to time. If any conflict exists between this document and the Protocols, the Protocols shall control in all respects.

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1. PURPOSE

~~Protocol Section 6.5.7.3, Security Constrained Economic Dispatch, requires the ERCOT Board to approve ERCOT's methodology for implementing the Operating Reserve Demand Curve (ORDC) to calculate the Real-Time reserve price adders. Additionally, the ERCOT Board must approve the parameters to be used in the methodology.~~

For each Security-Constrained Economic Dispatch (SCED) process, ERCOT calculates a Real-Time On-Line Reserve Price Adder (RTORPA) and a Real-Time Off-Line Reserve Price Adder (RTOFFPA) based on the On-Line and Off-Line available reserves in the ERCOT System and the ORDC. ~~The On-Line Reserve Price Adder is added to the Real-Time Locational Marginal Prices (LMPs) to determine the Real-Time Settlement Point Prices.~~ The price after the addition of RTORPA to LMPs approximates the pricing outcome of Real-Time energy and Ancillary Service co-optimization since RTORPA captures the value of the opportunity cost of reserves based on the defined ORDC. Additionally, the Real-Time Off-Line Reserve Capacity (RTOFFCAP) shall be administratively set to zero when the SCED snapshot of the Physical Responsive Capability (PRC) is less than or equal to the PRC MW at which Energy Emergency Alert (EEA) Level 1 is initiated. An Ancillary Service imbalance Settlement is done based on Protocol Section 6.7.4, Real-Time Ancillary Service Imbalance Payment or Charge, to make Resources indifferent to the utilization of their capacity for energy or Ancillary Service reserves.

This document describes:

- T~~t~~he ERCOT Board-approved methodology that ERCOT uses for determining the Real-Time reserve price adders based on ORDC.
- T~~t~~he ERCOT Board-approved parameters for ~~determining the Real-Time reserve price adders and~~implementing ORDC ~~effective date~~.

2. METHODOLOGY FOR IMPLEMENTING ORDC

~~The maximum price on the Power Balance Penalty Curve (PBPC) would be set to the System-Wide Offer Cap (SWCAP) + 1. The Real-Time spot market clearing process uses the SCED application to dispatch Resources and set prices.~~ For each execution of SCED, the System Lambda of the power balance constraint will be determined and the ORDC will be constructed as probability of reserves falling below the minimum contingency level (PBMCL) multiplied by the difference between Value of Lost Load (VOLL) and System Lambda. ~~Since the System Lambda in this equation is not a fixed value and could vary for each SCED execution, the Real-Time ORDC could vary for each SCED execution as well. In short,~~ T~~t~~his approach is needed with the current rules in order to ensure that power balance is given the highest priority and~~.~~ ~~This approach, which uses a modified ORDC for each SCED execution,~~ can result in a reserve price that is near zero ~~and~~ with an energy price near SWCAP under scarcity conditions.

Determining the following values is a major part of implementing ORDC to calculate Real-Time Reserve Price Adder:

1. VOLL~~;~~
2. PBMCL~~, defined as the probability of reserves falling below the minimum contingency level; and~~

3. ~~The Real-Time On-Line Reserve Price Adder (~~RTORPA and ~~) and Real-Time Off-Line Reserve Price Adder (~~RTOFFPA~~).~~

2.1. Determine VOLL

The VOLL is a parameter for implementing the ORDC and shall be approved by ERCOT Board.

2.2. Determine PBMCL

The key part of the concept is the determination of the ~~probability of reserves falling below the minimum contingency level (~~PBMCL~~)~~. PBMCL is derived from Loss of Load Probability curve (LOLP), which depends on many factors, including the probability of forced outages, probability of Load forecast error and probability of wind forecast error. ~~It could also be different for different times of the day and for different months of the year.~~ LOLP at a given reserve level can be interpreted as the probability of the occurrence of an event with a magnitude greater than that reserve level. A minimum contingency level (X) is chosen in order to send an appropriate scarcity price signal to maintain reliability and stability of the system. The PBMCL is constructed by shifting the curve to the right by the minimum contingency level (X) amount~~,~~ ~~since ERCOT is at a higher risk of shedding firm Load when reserves fall near or below the minimum contingency reserve level,~~ and setting the value to one for reserve levels below the minimum contingency level (X). The PBMCL curve for a given reserve level (R) is given as follows:

$$\pi(R) = \begin{cases} LOLP(R - X), & R - X > 0 \\ 1 & , R - X \le 0 \end{cases}$$

LOLP is determined by analyzing historic events defined as the difference between the hour-ahead forecasted reserves with the reserves that were available in Real-Time during the Operating Hour. These events are split into twenty-four groups, comprising of four seasons and six time-of-day blocks per day. These groups are used to determine twenty-four distinct normal probability distributions of the events, which will determine the LOLP for the corresponding season and time block. The detailed logic for determining LOLP is described as below:

1) For each Operating Hour in the study period, calculate the system-wide Hour-Ahead (HA) reserve using the snapshot of last Hourly Reliability Unit Commitment (HRUC) for the Operating Hour (at the end of Adjustment Period):

   HA Reserve = RUC On-Line Gen COP HSL - (RUC Load Forecast + RUC DCTIE Load) ~~*+ RUC Off-Line Gen COP OFFNS Responsibility*~~ *+ RUC On-Line Load COP Non-Spin Responsibility + RUC On-Line Load COP Reg-Up Responsibility + RUC On-Line Load COP RRS Responsibility* *+ RUC On-Line Non-Controllable Load COP Additional Available Capacity +* ~~*+ OFF10 from COP + OFF30 from COP*~~ *+ RUC Off-Line Gen COP OFFNS HSL + RUC Off-Line Gen COP CST30HSL*

   The calculation above excludes the following Generation Resources:

(a) Intermittent Renewable Resources (IRRs) other than Wind-powered Generation Resources (WGRs);

(b) Nuclear Resources; and

(c) Resources with ONTEST COP Status.

2) For each SCED interval in the study period, calculate the system-wide available SCED reserve using SCED telemetry and solution as:

SCED Reserve = SCED On-Line Gen HSL – SCED Gen Base Point + ~~SCED Off-Line Gen OFFNS Schedule +~~ SCED On-Line Load Telemetry RRS Schedule +SCED On-Line Non-Controllable Load Additional Available Capacity + SCED On-Line Load Telemetry Reg-Up Responsibility + SCED On-Line Load Telemetry Non-Spin Schedule + ~~OFF10 + OFF30~~ SCED Off-Line Gen OFFNS HSL + SCED Off-Line RTCST30HSL - SCED under-generation Power Balance MW

The calculation above excludes the following Generation Resources:

(a) Intermittent Renewable Resources (IRRs) other than Wind-powered Generation Resources (WGRs);

(b) Nuclear Resources;

(c) Resources with telemetered net real power (in MW) less than 95% of their telemetered LSL; and

(d) Resources with a telemetered status of:

(i) ONTEST;

(ii) STARTUP (except Resources with Non-Spin Ancillary Service Resource Responsibility greater than zero); or

(iii) SHUTDOWN.

3) For each Operating Hour in the study period, calculate the hourly average system-wide SCED reserve by averaging the interval SCED reserve in step 2).

4) For each Operating Hour in the study period, calculate the system-wide Reserve Error as:

Reserve Error = HA Reserve – SCED Reserve (Hourly Average) + Firm_Load_Shed (Hourly Average)

~~6)~~5) For each Operating Hour in the study period, allocate it to the corresponding season and time block. All the hours will be split into 24 distribution groups ~~developed for the analysis~~ based on the Season and the time of day:

- 4 Seasons of
  - Winter (Months 12,1, 2),
  - Spring (Months 3,4,5),

- Summer (Months 6,7,8) ~~and~~
- Fall (Months 9,10,11)

- 6 time-of-day blocks each consisting of 4 hours

~~7)~~6) Calculate the mean (μ) and standard deviation (σ) for each of the twenty-four distinct LOLP distributions using the calculated Reserve Error in step 4). The current values can be found at ERCOT.com on the Real-Time Market page.~~The detail results for 2011 and 2012 are illustrated in Table 1.~~ This hourly error is normally distributed and hence LOLP for a given value reserve level R can be calculated:

$$LOLP(\mu, \sigma, R) = 1 - CDF(\mu, \sigma, R)$$

Where CDF is the Cumulative Distribution Function of the normal distribution with mean μ and standard deviation σ.

Table 1 LOLP distributions by season and time-of-day block for 2011 and 2012

Season	For Hours	μ	σ
Winter (Month 12, 1, 2)	1-2 and 23-24	185.14	1217.89
	3-6	76.28	1253.93
	7-10	136.32	1434.64
	11-14	-218.26	1441.00
	15-18	-53.67	1349.52
	19-22	-183.00	1129.31
Spring (Month 3,4,5)	1-2 and 23-24	245.76	1174.61
	3-6	460.41	1313.46
	7-10	348.16	1292.36
	11-14	-491.91	1332.05
	15-18	-253.77	1382.60
	19-22	-436.09	1280.47
Summer (Month 6,7,8)	1-2 and 23-24	374.88	1503.97
	3-6	1044.81	1252.25
	7-10	339.01	1679.70
	11-14	-695.94	1251.05
	15-18	-270.54	1284.96
	19-22	-730.33	1331.49
Fall (Month 9, 10,11)	1-2 and 23-24	15.90	1044.88
	3-6	478.97	1014.02
	7-10	322.65	1036.07
	11-14	-473.16	1293.83
	15-18	-422.21	1246.49
	19-22	-177.76	1231.14

~~2.2.113.~~2.2.1. *Calculation of R_s and R_{sns}*

R_s is the reserves from Resources participating in SCED plus the Reg-Up ~~and RRS~~ and RRS from Load Resources and the ~~Net Power Consumption minus the Low Power Consumption~~additional available capacity from Load Resources other than Controllable Load Resources with a validated Real-Time RRS Schedule. ~~and validated Real-Time telemetered OFF10 capacity~~. R_{sns} is equal to R_s plus the reserves from Resources that are not currently available to SCED but could be available in 30 minutes.

1) R_s is calculated based on SCED telemetry and solution as:

$R_s = RTOLCAP = RTOLHSL – RTBP + RTCLRCAP + RTNCLRCAP + RTNCLRRRS + RTOLNSRS - RTPBPC$

Where
$RTCLRCAP = RTCLRBP – RTCLRLSL RTCLRLPC – RTCLRNS + RTCLRREG$
$RTNCLRCAP = RTNCLRNPC - RTNCLRLPC$

~~***[NPRR568: Replace paragraph (1) above with the following upon Phase 2 implementation:]***~~

~~R_s is calculated based on SCED telemetry and solution as:~~

~~$R_s = RTOLCAP = RTOLHSL – RTBP + RTCLRCAP + RTNCLRRRS + RTOFF10 - RTOLNSRS$~~

~~*Where*~~
~~$RTCLRCAP = RTCLRP – RTCLRLSL – RTCLRNS + RTCLRREG$~~

Where

- *RTOLCAP* is the system total Real-Time On-Line reserve capacity of all On-Line Resources for the SCED interval.
- *RTOLHSL* is the system total Real-Time telemetered High Sustained Limits (HSLs) for all Generation Resources (excluding non-Wind-powered Generation Resource (WGR) Intermittent Renewable Resources (IRRs), Nuclear Resources, Resources with a telemetered ONTEST, STARTUP (except Resources with Non-Spin Ancillary Service Resource Responsibility greater than zero), or SHUTDOWN Resource Status and Resources with telemetered net real power (in MW) less than 95% of their telemetered LSL) available to SCED for the SCED interval discounted by the system-wide ~~seasonal~~ discount factor.
- *RTBP* is the system total SCED Base Points for all Generation Resources (excluding all IRRs other than WGRs, nuclear Resources, Resources with a telemetered ONTEST, STARTUP (except Resources with Non-Spin Ancillary Service Resource Responsibility greater than zero), or SHUTDOWN Resource Status and Resources

with telemetered net real power (in MW) less than 95% of their telemetered LSL) for the SCED interval discounted by the system-wide seasonal discount factor.

- *RTCLRCAP* is the system total Real-Time capacity from Controllable Load Resources for the SCED interval. It is the sum of SCED Base Points less the telemetered CLR LSL and Non-Spin Schedule for all Controllable Load Resources.
- *RTNCLRCAP* is the system total Real-Time capacity for all Load Resources other than Controllable Load Resources that have a validated Real-Time RRS Ancillary Service Schedule integrated over thefor the SCED Iinterval.
- *RTPBPC* is the system total SCED under-generation Power Balance MW violated for the SCED interval.
- *RTNCLRNPC*RRS is the system total Real-Time net real power consumption from all Load Resources other than Controllable Load Resources that have a validated Real-Time RRS Ancillary Service Schedule for the SCED interval integrated over the SCED Interval discounted by the system-wide discount factor.. validated Real-Time telemetered RRS Ancillary Service Schedule from Load Resources other than Controllable Load Resources for the SCED interval discounted by the system-wide seasonal discount factor.
- *RTNCLRLPC* is the system total Real-Time Low Power Consumption (LPC) from all Load Resources other than Controllable Load Resources that have a validated Real-Time RRS Ancillary Service Schedule integrated overfor the SCED Iinterval discounted by the system-wide discount factor.
-

[NPRR568: Insert the following upon Phase 2 implementation:]

- *RTOFF10* is the system total validated Real-Time reserve capacity available in ten minutes for all Resources for the SCED interval discounted by the system widesystem-wide seasonal discount factor.

  - The telemetered OFF10 capacity shall be capped at the ERCOT-calculated maximum MW the Resource can provide in ten minutes based on the Resource asset registration information, COP and telemetry information.

  - For a an Off-Line Generation Resource providing OFF10 capacity, other than a Combined Cycle Train, ERCOT shall capverify the telemetered OFF10 capacity based on the amount qualified pursuant to Section 8.1.1.2.1.6, OFF10 Reserve Qualification. is viable in ten minutes based on the current warmth state and the corresponding start-up time of the Resource. For a Combined Cycle Train providing OFF10 capacity, ERCOT shall verify that the transition from the current configuration to the telemetered configuration providing OFF10 capacity is viable in ten minutes based on the transition times and transition matrix communicated via Resource asset registration information and the warmth state of the current configuration.

- *RTOLNSRS* is the system total Real-Time telemetered On-Line Non-Spin Ancillary Service Schedule for all On-Line Generation Resources for the SCED interval discounted by the system-wide seasonal discount factor.

- *RTCLRBP* is the system total SCED Base Points from Controllable Load Resources for the SCED interval discounted by the system-wide seasonal discount factor.
- *RTCLRLSL RTCLRLPC* is the system total Real-Time telemetered LSL Low Power Consumption from Controllable Load Resources for the SCED interval discounted by the system-wide seasonal discount factor.
- *RTCLRREG* is the system total validated capacity from Controllable Load Resources with Primary Frequency Response (not SCED qualified) Regulation-Up Ancillary Service Schedule discounted by the system-wide seasonal discount factor.
- *RTCLRNS* is the system total validated Real-Time telemetered Non-Spin Ancillary Service Schedules from Controllable Load Resources for the SCED interval discounted by the system-wide seasonal discount factor.

The Resource reserve discount factors are the seasonal system level parameters calculated based on average seasonal temperature and can be different for different Resource type reserves.

2) R_{sns} is calculated based on SCED telemetry and solution as

$R_{sns} = RTOLCAP + RTOFFCAP$

$RTOFFCAP = RTCST30HSL + RTOFFNSHSL + RTCLRNS + RTOLNSRS$

[NPRR568: Replace paragraph (2) above with the following upon Phase 2 implementation:]

2) R_{sns} is calculated based on SCED telemetry and solution as:

$R_{sns} = RTOLCAP + RTOFFCAP$

$RTOFFCAP = RTOFF30 + RTCLRNS + RTOLNSRS + RTOFFNSHSL$

Where

- *RTOLCAP* is the system total Real-Time On-Line reserve capacity of all On-Line Resources for the SCED interval.
- *RTOFFCAP* is the system total Real-Time Off-Line reserve capacity for the SCED interval.
- *RTCST30HSL* is the system total Real-Time telemetered HSLs of Generation Resources, excluding IRRs, that have telemetered an OFF Resource Status and can be started from a cold temperature state in 30 minutes and discounted by the system-wide seasonal discount factor.

~~***[NPRR568: Replace the above variable (RTCST30HSL) with the following upon Phase 2 implementation:]***~~

- ~~*RTOFF30* is the system total validated Real-Time reserve capacity available in 30 minutes for all the Resources for the SCED interval discounted by the system wide~~system-wide ~~seasonal discount factor.~~
  - ~~The telemetered OFF30 capacity shall be capped at the ERCOT-calculated maximum MW the Resource can provide in 30 minutes based on the Resource asset registration information, COP and telemetry information.~~
  - ~~For an Off-Line Generation Resource providing OFF30 capacity other than a Combined Cycle Train, ERCOT shall verify the telemetered OFF30 capacity is viable in 30 minutes based on the current warmth state and the corresponding start-up time of the Resource. For a Combined Cycle Train providing OFF30 capacity, ERCOT shall verify that the transition from the current configuration to the telemetered configuration providing OFF30 capacity is viable in 30 minutes based on the transition times and transition matrix communicated via the Resource asset registration information and the warmth state of the current configuration.~~

- *RTCLRNS* is the system total validated Real-Time telemetered Non-Spin Ancillary Service Schedules from Controllable Load Resources for the SCED interval discounted by the system-wide ~~seasonal~~ discount factor.
- *RTOLNSRS* is the system total validated Real-Time telemetered On-Line Non-Spin Ancillary Service Schedule for all On-Line Generation Resources for the SCED interval discounted by the system-wide ~~seasonal~~ discount factor.
- *RTOFFNSHSL* is the system total telemetered HSLs of Generation Resources that have telemetered an OFFNS Resource Status and discounted by the system-wide discount factor.

~~***[NPRR568: Remove the above variable RTOFFNSHSL upon Phase 2 implementation:]***~~

~~The Resource reserve discount factors are the seasonal system level parameters calculated based on average seasonal temperature and can be different for different Resource type reserves.~~

The system-wide discount factor used to discount inputs is calculated for each Season based on the average of the Reserve Discount Factors (RDFs) for that Season from the year prior.

~~2.2.114.~~2.2.2. *Calculation of* $\pi_S(R_S)$ *and* $\pi_{NS}(R_{SNS})$

$\pi_S(R_S)$ and $\pi_{NS}(R_{SNS})$ are functions that describe the PBMCL at various reserve levels.

1) Calculation of Curve $\pi_S(R_S)$:

$\pi_S(R_S)$ is a function of the Real-Time reserves that should be available in the first 30 minutes of the hour and is intended to capture the PBMCL for that level of reserves. The general equation for $\pi_S(R_S)$ is:

$$\pi_S(R_S) = \begin{cases} LOLP_S(R_S - X), & R_S - X > 0 \\ 1, & R_S - X \le 0 \end{cases}$$

Where

- *X in this equation is the~~a~~ minimum contingency level ~~and represents a level of reserves at which ERCOT may need to begin to shed firm Load.~~*
- *$LOLP_S$ is the LOLP function for the spinning reserve.*

$LOLP_S$ is different from the 60 minutes *LOLP* in Table 1, which is calculated based on the hourly error analysis. The reserves are classified into two categories; those that are being provided by Resources in SCED and Load Resources providing Reg-Up and RRS and those that are being provided by Resources that are not currently available to SCED but could be made available in 30 minutes. Since the first reserve type is available immediately, those reserves are the only ones considered to be available to respond to any event that happens in the first 30 minutes of the hour. All reserve types are then considered to be available to respond to events that happen in the second 30 minutes of the hour. From the hourly error analysis, a mean (μ) and standard deviation (σ) for the 60 minute *LOLP* ~~are~~ is determined for each of the different seasons and time blocks. Because the error analysis is hourly, to capture the events within the first 30 minutes for $\pi_S(R_S)$, the μ and σ needs to be scaled to reflect the 30 minute timeframe, with $\delta = 0.5$ hour:

$$\mu' = \delta * \mu = 0.5\mu$$

$$\sigma' = \frac{\delta}{\sqrt{\delta^2 + (1-\delta)^2}} * \sigma = 0.707\sigma$$

So the *$LOLP_S$* can be calculated based on the 60 minute *LOLP* as follows:

$$LOLP_S(\mu', \sigma', R) = LOLP(0.5\mu, 0.707\sigma, R) = 1 - CDF(0.5\mu, 0.707\sigma, R)$$

24 $\pi_S(R_S)$ curves are developed based on the season and the time of day.

2) Calculation of Curve $\pi_{NS}(R_{SNS})$:

$\pi_{NS}(R_{SNS})$ is a function of all the Real-Time reserves that can be expected to be available within the hour and is intended to capture the PBMCL for that level of reserves ~~based on events that happen in an hour~~. The general equation for $\pi_{NS}(R_{SNS})$ is:

$$\pi_{NS}(R_{SNS}) = \begin{cases} LOLP(R_{SNS} - X), R_{SNS} - X > 0 \\ 1 \qquad\qquad , R_{SNS} - X \le 0 \end{cases}$$

This is similar to $\pi_S(R_S)$ but the key differences here are the types of reserves considered and the μ and σ ~~μ and σ~~ that are used in calculating LOLP

- *The total On-Line and Off-Line applies for the full change in net Load over the hour and there is no scaling adjustments needed for* μ and σ ~~μ and σ~~ *in the* $\pi_{NS}(R_{SNS})$ *calculations*
- ~~*Again,*~~ *X in this equation is* ~~*a*~~ *the minimum contingency level*

~~Like $\pi_S(R_S)$, twenty four~~24 $\pi_{NS}(R_{SNS})$ curves are developed based on the season and the time of day. ~~individual curves are created for $\pi_{NS}(R_{SNS})$.~~

2.3. Determination of Price Adders (RTORPA and RTOFFPA)

Once PBMCL is determined, the Real-Time On-Line Reserve Price Adder (RTORPA) and Real-Time Off-Line Reserve Price Adder (RTOFFPA) for each SCED interval can be calculated. RTORPA (a.k.a. P_S) and RTOFFPA (a.k.a. P_{NS}) are functions of the PBMCL at various levels of Real-Time reserves, the net value of Load curtailment, and time duration during which the reserves are available. RTORPA and RTOFFPA are determined as follows:

$$RTORPA = P_S = v * 0.5 * \pi_S(R_S) + P_{NS}$$
$$RTOFFPA = P_{NS} = v * (1 - 0.5) * \pi_{NS}(R_{SNS})$$

where

$v = \max(0, VOLL - SystemLambda)$

$R_S = RTOLCAP$

$R_{SNS} = RTOLCAP + RTOFFCAP$

Where *v* represents the net value of Load curtailment and is calculated as the VOLL minus the SCED System Lambda. System Lambda is subtracted from VOLL to reflect the scarcity value of the marginal dispatch capacity and to ensure that the final cost of energy does not go above the VOLL. The Off-Line Available Reserves (RTOFFCAP) will be set to zero when the SCED snapshot of the PRC is equal to or below the PRC MW at which EEA Level 1 is initiated

3. METHODOLOGY REVISION PROCESS

Revisions to this document, and the parameters to be used in the methodology, shall be made according to the approval process as prescribed in Protocol Section 6.5.7.3, Security Constrained Economic Dispatch, which requires TAC review and ERCOT Board approval.

4. ~~APPENDIX 1:~~ PARAMETERS FOR IMPLEMENTING ORDC

The definition and values of the parameters used in implementing ORDC are as follows:

Parameter	Definition	Unit	Value
VOLL	Value of Lost Load	$/MWh	9000
X	Minimum contingency reserve level ~~at which ERCOT may need to begin shedding firm Load~~	MW	2000