ORDC Workshop

ERCOT Market Training
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Housekeeping

- Restrooms
- Attendance sheet
- Questions
- Microphones

Please turn off cell phones & other electronics
Upon completion of this course...

...you will be able to:

- Describe the Purpose of ORDC
- Recognize the Methodology for Implementing ORDC
- Illustrate the Settlement Impacts of ORDC
Purpose of ORDC
Current Pricing Methodology in ERCOT

SCED can set Scarcity Pricing under the right conditions.
Brattle Report:

- At high reserve margins, scarcity-pricing events are rare
- Reserve margins would have to fall to ~8% to support new investment

Lack of new Resource investment could ultimately threaten reliability.
What changes are needed to ensure reliability?

- Lack of Resource investment could lead to more frequent load-shedding events
- There is value in avoiding load-shedding events
- Sufficient real-time reserves help avoid load-shedding events

Therefore, we may deduce . . .

Value of real-time reserves = Value of avoiding load-shed
The Operating Reserve Demand Curve (ORDC)

ERCOT will implement an Operating Reserve Demand Curve on June 1, 2014

- Creates a Real-time Price Adder to reflect the value of available reserves
- Reflects Value of Lost Load (VOLL)
- Based on Loss of Load Probability

Value of Lost Load (VOLL) is administratively set to $9000.
The Operating Reserve Demand Curve (ORDC)

Price of Reserves ($/MWh) vs Available Reserves (MWs)

VOLL
Revised Pricing Methodology in ERCOT

Price of Energy ($MwH)

- **VOLL**
- **SWCAP**

SCED can set Scarcity Pricing under the right conditions

Price Adder would improve Scarcity Pricing
Realizing the Reserve Price

**For Resources . . .**

- The Reserve price will be added to the LMP-based energy price the Resource is paid.
- An Ancillary Service Imbalance should make Resources indifferent to how their capacity is used.

**For Load . . .**

- The Reserve price will be added to the LMP-based energy price the Load is charged.
Methodology for Implementing ORDC
Methodology for Implementing ORDC

1. Constructing the ORDC
2. Constructing the Price Adders from ORDC
3. Price Modifications for Energy Offer Curves
Methodology for Implementing ORDC

1. Constructing the ORDC
2. Constructing the Price Adders from ORDC
3. Price Modifications for Energy Offer Curves
Constructing the Operating Reserve Demand Curve (ORDC)

Requirements for constructing an Operating Reserve Demand Curve (ORDC)

- Reflects Value of Lost Load (VOLL)
- Based on Loss of Load Probability
A Closer Look at the Price Component

- Overall goal is to *improve* scarcity pricing
- SCED may produce scarcity pricing
- Outside of any congestion impacts, price should not exceed VOLL

**The ORDC is then constructed from**

\[(VOLL - \text{System Lambda}) \times \text{Loss of Load Probability}\]
Loss of Load Probability (LOLP)

Now let’s turn to the Loss of Load Probability

*Where do we start?*
Loss of Load Probability (LOLP)

Calculate Historical Reserve Error

- Hour-Ahead (HA) Reserves
  \[ = \text{COP Capacities} - \text{Load Forecast} \]

- Real-Time (RT) Reserves (Hourly Average)
  \[ = \text{Telemetered Capacities} - \text{SCED Basepoints} \]

Reserve Error
\[ = \text{HA Reserves} - \text{RT Reserves} \]
Loss of Load Probability (LOLP)

Reserve Error

\[ \sigma \]

\[ \mu \]
Loss of Load Probability (LOLP)
Loss of Load Probability (LOLP)

Occurrences

Reserve Error

\[ R \]

\[ \mu \]

\[ \sigma \]

\[ \sigma \]
Loss of Load Probability (LOLP)

$$\mu$$

$$\sigma$$

$$\sigma$$

Reserve Error
LOLP Distributions are compiled and posted by season and time-of-day block.

(2011-2012 shown)

<table>
<thead>
<tr>
<th>Season</th>
<th>For Hours</th>
<th>( \mu )</th>
<th>( \sigma )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>1-2 and 23-24</td>
<td>185.14</td>
<td>1217.89</td>
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<tr>
<td></td>
<td>3-6</td>
<td>76.28</td>
<td>1253.93</td>
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<tr>
<td></td>
<td>7-10</td>
<td>136.32</td>
<td>1434.64</td>
</tr>
<tr>
<td></td>
<td>11-14</td>
<td>-218.26</td>
<td>1441.00</td>
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<tr>
<td></td>
<td>15-18</td>
<td>-53.67</td>
<td>1349.52</td>
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<tr>
<td></td>
<td>19-22</td>
<td>-183.00</td>
<td>1129.31</td>
</tr>
<tr>
<td>Spring</td>
<td>1-2 and 23-24</td>
<td>245.76</td>
<td>1174.61</td>
</tr>
<tr>
<td></td>
<td>3-6</td>
<td>460.41</td>
<td>1313.46</td>
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<td></td>
<td>7-10</td>
<td>348.16</td>
<td>1292.36</td>
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<td>-491.91</td>
<td>1332.05</td>
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<td></td>
<td>15-18</td>
<td>-253.77</td>
<td>1382.60</td>
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<td></td>
<td>19-22</td>
<td>-436.09</td>
<td>1280.47</td>
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<td>Summer</td>
<td>1-2 and 23-24</td>
<td>374.88</td>
<td>1503.97</td>
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<td></td>
<td>3-6</td>
<td>1044.81</td>
<td>1252.25</td>
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<td></td>
<td>7-10</td>
<td>339.01</td>
<td>1679.70</td>
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<td>-695.94</td>
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<td>-270.54</td>
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<td>19-22</td>
<td>-730.33</td>
<td>1331.49</td>
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<tr>
<td>Fall</td>
<td>1-2 and 23-24</td>
<td>15.90</td>
<td>1044.88</td>
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<td>3-6</td>
<td>478.97</td>
<td>1014.02</td>
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<td>7-10</td>
<td>322.65</td>
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<tr>
<td></td>
<td>19-22</td>
<td>-177.76</td>
<td>1231.14</td>
</tr>
</tbody>
</table>
But what we really seek . . .

- Probability that reserves will fall below the Minimum Contingency Level (PBMCL)
- Minimum Contingency Level (X) currently set at 2000MW

\[
PBMCL(R) = \begin{cases} 
\text{LOLP}(R - X), & R - X > 0 \\
1, & R - X \leq 0 
\end{cases}
\]

*For a given reserve level of R and the appropriate \( \mu \) and \( \sigma \) values*
Constructing the Operating Reserve Demand Curve (ORDC)

Putting everything together so far . . .

Our ORDC is constructed as

\[(\text{VOLL} - \text{System Lambda}) \times \text{PBMCL}\]

where

\[
\text{PBMCL}(R) = \begin{cases} 
\text{LOLP}(R - X), & R - X > 0 \\
1, & R - X \leq 0
\end{cases}
\]
Methodology for Implementing ORDC

1. Constructing the ORDC
2. Constructing the Price Adders from ORDC
3. Price Modifications for Energy Offer Curves
Calculating Reserve Price Adders

But first . . .

We must clarify one thing about our Real-Time Reserve Level, $R$
Calculating Reserve Price Adders

Not all reserves are created equal . . .

- Some are available to SCED immediately
- Some could be made available to SCED in 30 minutes

\[ R_S = \text{Reserves that are available to SCED immediately} \]

\[ R_{SNS} = R_S \text{ plus the reserves that could be made available to SCED in 30 minutes} \]
Reserves Available to SCED Immediately

\[ R_S = \sum \left( \begin{array}{l} \text{HSLs for all Generation Resources} \\ - \text{SCED Base Points for all Generation Resources} \\ + \text{Capacity from Controllable Load Resources} \\ + \text{Non-Controllable Load Resources} \\ + \text{RR Schedules} \\ \text{Capacity Available in 10 minutes} \\ (\text{Phase 2 new telemetry}) \\ - \text{Online Non-Spin AS Schedules} \end{array} \right) \]
Reserves Available to SCED Immediately

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

\[
R_s = RTOLCAP
\]

\[
RTOLCAP = RTOLHSL - RTBP + RTCLRCAP + RTNCLRRRS + RTOFF10 - RTOLNSRS
\]

\[
RTCLRCAP = RTCLRBP - RTCLRLSL - RTCLRNS + RTCLRREG
\]

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTOLCAP</td>
<td>Online Reserve capacity</td>
</tr>
<tr>
<td>RTOLHSL</td>
<td>HSLs for all Online Generation Resources</td>
</tr>
<tr>
<td>RTBP</td>
<td>SCED Base Points for all Generation Resources</td>
</tr>
<tr>
<td>RTCLRCAP</td>
<td>Capacity from Controllable Load Resources</td>
</tr>
<tr>
<td>RTNCLRRRS</td>
<td>Non-Controllable Load Resources RR Schedules</td>
</tr>
<tr>
<td>RTOFF10</td>
<td>Capacity Available in 10 minutes (Phase 2 new telemetry)</td>
</tr>
<tr>
<td>RTOLNSRS</td>
<td>Online Non-Spin AS Schedules</td>
</tr>
<tr>
<td>RTCLRBP</td>
<td>Controllable Load Base Point (Loads in SCED)</td>
</tr>
<tr>
<td>RTCLRLSL</td>
<td>Controllable Load LSL (Loads in SCED)</td>
</tr>
<tr>
<td>RTCLRNS</td>
<td>Non-Spin Schedule for CLRs</td>
</tr>
<tr>
<td>RTCLRREG</td>
<td>Reg-Up Schedule for CLRs with Primary Frequency Response</td>
</tr>
</tbody>
</table>
Reserves Available to SCED During the Hour

\[ R_{SNS} = \sum \left( \text{On-Line Reserve capacity} + \right. \]
\[ \left. \text{Capacity Available in 30 minutes} + \right. \]
\[ \left. \text{Non-Spin Schedule} \right. \]
\[ + \]
\[ \text{Controllable Load Resources} \]
\[ + \]
\[ \text{On-Line Non-Spin AS Schedule} \]
Reserves Available to SCED During the Hour

\( R_{SNS} \) is calculated based on SCED telemetry and solution as:

\[
R_{SNS} = RTOLCAP + RTOFFCAP
\]

\[
RTOFFCAP = RTOFF30 + RTCLRNS + RTOLNSRS
\]

<table>
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<tr>
<th></th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td><strong>RTOLCAP</strong></td>
<td>On-Line Reserve capacity</td>
</tr>
<tr>
<td><strong>RTOFFCAP</strong></td>
<td>Off-Line Reserve capacity</td>
</tr>
<tr>
<td><strong>RTOFF30</strong></td>
<td>Capacity Available in 30 minutes (Phase 2 new telemetry)</td>
</tr>
<tr>
<td></td>
<td>In phase 1 implementation, it is the sum of ( RTCST30HSL ) and ( RTOFFNSHSL )</td>
</tr>
<tr>
<td><strong>RTCLRNS</strong></td>
<td>Non-Spin Schedule Controllable Load Resources</td>
</tr>
<tr>
<td><strong>RTOLNSRS</strong></td>
<td>On-Line Non-Spin AS Schedule</td>
</tr>
<tr>
<td><strong>RTCST30HSL</strong></td>
<td>HSLs of “OFF” Generation can be started from cold in 30 minutes</td>
</tr>
<tr>
<td><strong>RTOFFNSHSL</strong></td>
<td>HSLs of Generation with “OFFNS” status</td>
</tr>
</tbody>
</table>

If Physical Responsive Capability drops below 2300MW, \( RTOFFCAP \) will be set to 0.
Calculating Reserve Price Adders

Calculate separate adders for each level of Reserves

• $R_{SNS}$ gives us the Real-Time Off-line Reserve Price Adder

$$R_{TOFFPA} = 0.5 \times (VOLL - \lambda) \times LOLP(R_{SNS} - X)$$

• $R_{S}$ gives us the Real-Time On-line Reserve Price Adder

$$R_{TORPA} = R_{TOFFPA} + 0.5 \times (VOLL - \lambda) \times LOLP(R_{S} - X)$$
Calculating Reserve Price Adders

Calculate separate adders for each level of Reserves

- Note that for the on-line price adder, we must scale the values from our LOLP distributions, since they represent hourly values.

\[
R_{TOFFPA} = 0.5 \times (VOLL - \lambda) \times LOLP(R_{SNS} - X)
\]

*Using* \(\mu\) and \(\sigma\) *from LOLP table*

\[
RT_{ORPA} = R_{TOFFPA} + 0.5 \times (VOLL - \lambda) \times LOLP(R_{S} - X)
\]

*Using* 0.5\(\mu\) and 0.707\(\sigma\) *from LOLP table*
Price Adder vs. System Lambda for Various Reserve Levels

Using Spring HE7-10 LOLP values

- MW

Reserves MW

$ Energy

$ Adder
Methodology for Implementing ORDC

1. Constructing the ORDC
2. Constructing the Price Adders from ORDC
3. Price Modifications for Energy Offer Curves
Protocol Price Requirements

Since 2012 QSEs providing Ancillary Services have been subject to price floors for their AS Responsibility on each Resource

- Responsive Reserve at SWCAP
- On-line Non-Spin at $120/MWh
- Off-line Non-Spin at $180/MWh

The floors for Responsive Reserve and Off-line Non-Spin are removed with ORDC implementation
Protocol Price Requirements

QSEs providing On-line Non-Spin are still subject to price floors for their AS Responsibility on each Resource

- On-Line Non-Spin priced at or above $75/MWh
Protocol Price Requirements

If a Resource is committed by the Reliability Unit Commitment (RUC) process, the QSE is still subject to a price floor

- All energy priced at or above $1000
- Applies only to RUC Hours
Settlement Impacts for ORDC
Settlement Impacts for ORDC

1. Modifications to Settlement Point Prices
2. Real-Time Ancillary Service Imbalance
3. RUC-Committed Ancillary Services
4. Revenue Neutrality
Settlement Impacts for ORDC

1. Modifications to Settlement Point Prices
2. Real-Time Ancillary Service Imbalance
3. RUC-Committed Ancillary Services
4. Revenue Neutrality
For each Settlement Point,

$$RTSPP = \text{Ave (Reserve Price Adders)} + \text{Ave (LMPs)}$$

... for each 15-minute interval

*Note: The way the LMPs are averaged varies by Settlement Point*
Reserve Price Adders

\[ \text{RTRSVPOR} = \sum_y (\text{RTORPA}_y \times \frac{\text{TLMP}_y}{\sum_y \text{TLMP}_y}) \]

**Summary of Symbols**

- **RTRSVPOR**: Real-Time On-Line Reserve Price
- **RTORPA\_y**: Real-Time On-Line Reserve Price Adder per interval
- **TLMP\_y**: Duration of SCED interval per interval
Real-Time Settlement Point Price for a Resource Node

At a Resource Node,

**RTSPP** is used to settle financial transactions

\[
RTSPP = RTRSVPOR + \text{Time-Weighted Average} \left( \text{LMPs} \right)
\]

<table>
<thead>
<tr>
<th>RTSPP</th>
<th>Real-Time Settlement Point Price for the 15-minute Settlement Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTRSVPOR</td>
<td>Real-Time On-Line Reserve Price Adder</td>
</tr>
</tbody>
</table>
Real-Time Settlement Point Price for a Resource Node

At a Resource Node, 

**RTRMPR** is used to settle physical energy production

\[
RTRMPR = RTRSVPOR + \left( \text{Base-Point} \times \text{Time} \right) \left( \text{Weighted Average} \right) \left( \text{LMPs} \right)
\]

- **RTRMPR** subscripts:
  - **RTRMPR** subscripts: Real-Time Price for the Energy Metered for each Resource meter at bus
  - **RTRSVPOR**: Real-Time On-Line Reserve Price Adder
At a Load Zone,

**RTSPP** is used to settle financial transactions

\[
RTSPP = RTRSVPOR + \text{MW-Weighted & Time-Weighted Average LMPs}
\]

<table>
<thead>
<tr>
<th>RTSPP</th>
<th>Real-Time Settlement Point Price for the 15-minute Settlement Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTRSVPOR</td>
<td>Real-Time On-Line Reserve Price Adder</td>
</tr>
</tbody>
</table>
At a Load Zone,

**RTSPPEW** is used to settle physical energy consumption

\[
RTSPP = RTRSVPOR + \left( MW \times Time \right) \left( \text{Weighted Average} \left( LMPs \right) \right)
\]

**RTSPPEW**  Real-Time Settlement Point Price Energy-Weighted

**RTRSVPOR**  Real-Time On-Line Reserve Price Adder
At a Hub,

**RTSPP** is used to settle financial transactions

\[
RTSPP = RTRSVPOR + \left( \text{Simple & Time-Weighted Average LMPs} \right)
\]

<table>
<thead>
<tr>
<th><strong>RTSPP</strong></th>
<th>Real-Time Settlement Point Price for the 15-minute Settlement Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RTRSVPOR</strong></td>
<td>Real-Time On-Line Reserve Price Adder</td>
</tr>
</tbody>
</table>
1. Modifications to Settlement Point Prices
2. Real-Time Ancillary Service Imbalance
3. RUC-Committed Ancillary Services
4. Revenue Neutrality
Ancillary Service Imbalance Overview

HSL=125MW

100MW

Paid in RTEIMB

LMP + ADDER

Paid in RTASIMB

ADDER

HSL=125MW

Paid in RTEIMB

LMP + ADDER

Paid in RTEIMB

LMP + ADDER
Ancillary Service Imbalance Overview

HSL=125MW
100MW

Energy Dispatched

AS Undeployed
Paid in DAM or SASM
LMP + ADDER

Charge (at Adder)

Paid in RTEIMB
LMP + ADDER

AS Deployed

Energy Dispatched

HSL=125MW
100MW
Real-Time Ancillary Service Imbalance Amount

\[
(-1) \left[ \left( \text{Real Time Ancillary Service On-Line Reserve Imbalance} \right) \times \left( \text{Real-Time Reserve Price for On-Line Reserves} \right) \right] + \left( \text{Real-Time Ancillary Service Off-Line Reserve Imbalance} \right) \times \left( \text{Real-Time Reserve Price for Off-Line Reserves} \right)
\]
RTASIAMT_q = (-1) * [(RTASOLIMB_q * RTRSVPOR) + (RTASOFFIMB_q * RTRSVPOFF)]

<table>
<thead>
<tr>
<th>RTASIAMT_q</th>
<th>Real-Time Ancillary Service Imbalance Amount</th>
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</thead>
<tbody>
<tr>
<td>RTASOLIMB_q</td>
<td>Real Time Ancillary Service On-Line Reserve Imbalance</td>
</tr>
<tr>
<td>RTRSVPOR</td>
<td>Real-Time Reserve Price for On-Line Reserves</td>
</tr>
<tr>
<td>RTASOFFIMB_q</td>
<td>Real-Time Ancillary Service Off-Line Reserve Imbalance</td>
</tr>
<tr>
<td>RTRSVPOFF</td>
<td>Real-Time Reserve Price for Off-Line Reserves</td>
</tr>
</tbody>
</table>
Ancillary Service Imbalance

\[ \text{RTASIAMT}_q = (-1) \left[ (\text{RTASOLIMB}_q \times \text{RTRSVPOR}) + (\text{RTASOFFIMB}_q \times \text{RTRSVPOFF}) \right] \]

Where

\[ \text{RTASOLIMB}_q = \text{RTOLCAP}_q - [(\text{RTASRESP}_q \times \frac{1}{4}) - \text{RTASOFF}_q - \text{RTRUCNBBRESP}_q - \text{RTCLRNSRESP}_q - \text{RTRMRRESP}_q] \]

Items in red above represent the QSE AS Responsibility in the equation which will offset the capacity creating the over or under imbalance.

<table>
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<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>\text{RTOLCAP}_q</td>
<td>Real-Time On-Line Reserve Capacity</td>
</tr>
<tr>
<td>\text{RTASRESP}_q</td>
<td>Real-Time Ancillary Service Supply Responsibility</td>
</tr>
<tr>
<td>\text{RTASOFF}_q</td>
<td>Real-Time Ancillary Service Schedule for the Off-Line Generation Resource</td>
</tr>
<tr>
<td>\text{RTRUCNBBRESP}_q</td>
<td>Real-Time RUC Ancillary Service Supply Responsibility in Non-Buy-Back hours</td>
</tr>
<tr>
<td>\text{RTCLRNSRESP}_q</td>
<td>Real-Time Controllable Load Resource Non-Spin Responsibility</td>
</tr>
<tr>
<td>\text{RTRMRRESP}_q</td>
<td>Real-Time Ancillary Service Supply Responsibility for RMR Units</td>
</tr>
</tbody>
</table>
Ancillary Service Imbalance – Phase 1

\[
\text{RTASIAMT}_q = (-1) \left[ (\text{RTASOLIMB}_q \times \text{RTRSVPOR}) + (\text{RTASOFFIMB}_q \times \text{RTRSVPOFF}) \right]
\]

Where

\[
\text{RTASOLIMB}_q = \text{RTOLCAP}_q - \left[ (\text{RTASRESP}_q \times \frac{1}{4}) - \text{RTASOFF}_q - \text{RTRUCNBRESP}_q - \text{RTCLRNSRESP}_q - \text{RTRMRRESP}_q \right]
\]

\[
\text{RTOLCAP}_q = (\text{RTOLHSL}_q - \text{RTMGQ}_q) + \text{RTCLRCAP}_q + \text{RTNCLRRRS}_q + \text{RTOFF10}_q
\]

<table>
<thead>
<tr>
<th>\text{RTOLHSL}_q</th>
<th>Real-Time On-Line High Sustained Limit</th>
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</thead>
<tbody>
<tr>
<td>\text{RTMGQ}_q</td>
<td>Real-Time Metered Generation</td>
</tr>
<tr>
<td>\text{RTCLRCAP}_q</td>
<td>Real-Time Capacity from Controllable Load Resources</td>
</tr>
<tr>
<td>\text{RTNCLRRRS}_q</td>
<td>Real-Time Non-Controllable Load Resources Responsive Reserve Schedule</td>
</tr>
<tr>
<td>\text{RTOFF10}_q</td>
<td>Real-Time Reserve Capacity Available in Ten Minutes</td>
</tr>
</tbody>
</table>
RTASIAMT\(_q\) = (-1) [(RTASOLIMB\(_q\) * RTRSVPOR) + (RTASOFFIMB\(_q\) * RTRSVPOFF)]

Where

RTASOLIMB\(_q\) = RTOLCAP\(_q\) – [(RTASRESP\(_q\) * ¼) – RTASOFF\(_q\) – RTRUCNBBRESP\(_q\) – RTCLRNSRESP\(_q\) – RTRMRRESP\(_q\)]

RTOLCAP\(_q\) = (RTOLHSL\(_q\) – RTMGQ\(_q\)) + RTCLRCAP\(_q\) + RTNCLRRRS\(_q\) + RTOFF10\(_q\)

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<td>Real-Time Capacity from Controllable Load Resources</td>
</tr>
<tr>
<td>RTNCLRRRS(_q)</td>
<td>Real-Time Non-Controllable Load Resources Responsive Reserve Schedule</td>
</tr>
<tr>
<td>RTOFF10(_q)</td>
<td>Real-Time Reserve Capacity Available in Ten Minutes</td>
</tr>
</tbody>
</table>
Ancillary Service Imbalance

\[ \text{RTASIAMT}_q = (-1) \left[ (\text{RTASOLIMB}_q \times \text{RTRSVPOR}) + (\text{RTASOFFIMB}_q \times \text{RTRSVPOFF}) \right] \]

Where

\[ \text{RTASOFFIMB}_q = \text{RTOFFCAP}_q - (\text{RTASOFF}_q + \text{RTCLRNSRESP}_q) \]

Items in red above represent the QSE Responsibility in the equation which will offset the capacity creating the over or under imbalance.

<table>
<thead>
<tr>
<th>\text{RTOFFCAP}_q</th>
<th>Real-Time Off-Line Reserve Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{RTASOFF}_q</td>
<td>Real-Time Ancillary Service Schedule for Off-Line Generation Resources</td>
</tr>
<tr>
<td>\text{RTCLRNSRESP}_q</td>
<td>Real-Time Controllable Load Resource Non-Spin Responsibility</td>
</tr>
</tbody>
</table>
Ancillary Service Imbalance – Phase 1

\[ RTASIAMT_q = (-1) \left[ (RTASOLIMB_q \times RTRSVPOR) + (RTASOFFIMB_q \times RTRSVPOFF) \right] \]

Where

\[ RTASOFFIMB_q = RTOFFCAP_q - (RTASOFF_q + RTCLRNSRESP_q) \]

\[ RTOFFCAP_q = RTOFF30_q + RTCST30HSL_q + RTOFFNSHSL_q + RTCLRNS_q \]

<table>
<thead>
<tr>
<th>( RTOFF30_q )</th>
<th>Real-Time Reserve Capacity Available in 30 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>( RTCST30HSL_q )</td>
<td>Real-Time Generation Resources with Cold Start Available in 30 Minutes</td>
</tr>
<tr>
<td>( RTOFFNSHSL_q )</td>
<td>Real-Time Generation Resources with Off-Line Non-Spin Schedule</td>
</tr>
<tr>
<td>( RTCLRNS_q )</td>
<td>Real-Time Non-Spin Schedule for Controllable Load Resources</td>
</tr>
</tbody>
</table>
Ancillary Service Imbalance – Phase 2

\[ RTASIAMT_q = (-1) \left[ (RTASOLIMB_q \times RTRSVPOR) + (RTASOFFIMB_q \times RTRSVPOFF) \right] \]

*Where*

\[ RTASOFFIMB_q = \text{RTOFFCAP}_q - (\text{RTASOFF}_q + \text{RTCLRNSRESP}_q) \]

\[ \text{RTOFFCAP}_q = \text{RTOFF30}_q + \text{RTCST30HSL}_q + \text{RTOFFNSHSL}_q + \text{RTCLRNS}_q \]

<table>
<thead>
<tr>
<th>\text{RTOFF30}_q</th>
<th>Real-Time Reserve Capacity Available in 30 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{RTCST30HSL}_q</td>
<td>Real-Time Generation Resources with Cold Start Available in 30 Minutes</td>
</tr>
<tr>
<td>\text{RTOFFNSHSL}_q</td>
<td>Real-Time Generation Resources with Off-Line Non-Spin Schedule</td>
</tr>
<tr>
<td>\text{RTCLRNS}_q</td>
<td>Real-Time Non-Spin Schedule for Controllable Load Resources</td>
</tr>
</tbody>
</table>
How does this impact a Generation Resource?

Assume the following inputs …

- DAM MCPC = $10
- DAM SPP = $30
- RT LMP = $30
- RT ADDER = $5
- RT SPP = $35
- HSL = 125 MW
# Generation Resource: DAM AS awarded, not deployed

<table>
<thead>
<tr>
<th>Settlement Type</th>
<th>Inputs</th>
<th>Price</th>
<th>Qty</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day-Ahead</strong></td>
<td>DAM AS Award</td>
<td>$10</td>
<td>25</td>
<td>$-250</td>
</tr>
<tr>
<td><strong>Real-Time Energy</strong></td>
<td>Real-Time Metered Generation (RTMG)</td>
<td>$35</td>
<td>100</td>
<td>$-350</td>
</tr>
<tr>
<td><strong>AS Imbalance</strong></td>
<td>Online Reserves Available: RTOLCAP (HSL 125 – RTMG 100)</td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Online Reserves Responsibility: RTASRESP</td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AS Imbalance: (RTOLCAP - RTASRESP) x RTRSVPOR</td>
<td>$5</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td><strong>QSE Net for Operating Day</strong></td>
<td></td>
<td></td>
<td></td>
<td>$-3750</td>
</tr>
</tbody>
</table>
## Generation Resource: DAM AS awarded and deployed

<table>
<thead>
<tr>
<th>Settlement Type</th>
<th>Inputs</th>
<th>Price</th>
<th>Qty</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day-Ahead</td>
<td>DAM AS Award</td>
<td>$10</td>
<td>25</td>
<td>-$250</td>
</tr>
<tr>
<td>Real-Time Energy</td>
<td>RTMG</td>
<td>$35</td>
<td>125</td>
<td>-$4375</td>
</tr>
<tr>
<td>AS Imbalance</td>
<td>Online Reserves Available: RTOLCAP (HSL 125 – RTMG 125)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Online Reserves Responsibility: RTASRESP</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AS Imbalance: (RTOLCAP - RTASRESP) x RTRSVPOR</td>
<td>$5</td>
<td>-25</td>
<td>$125</td>
</tr>
</tbody>
</table>

**QSE Net for Operating Day**

-$4500
## Generation Resource: DAM AS and Energy awards

<table>
<thead>
<tr>
<th>Settlement Type</th>
<th>Inputs</th>
<th>Price</th>
<th>Qty</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day-Ahead</strong></td>
<td>DAM AS Award</td>
<td>$10</td>
<td>25</td>
<td>-$250</td>
</tr>
<tr>
<td></td>
<td>DAM Energy Sales (DAES)</td>
<td>$30</td>
<td>100</td>
<td>-$3000</td>
</tr>
<tr>
<td><strong>Real-Time</strong></td>
<td>RTMG</td>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>(RTMG – DAES) x RT SPP</td>
<td>$35</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td><strong>AS Imbalance</strong></td>
<td>Online Reserves Available: RTOLCAP</td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(HSL 125 – RTMG 100)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Online Reserves Responsibility: RTASRESP</td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AS Imbalance: (RTOLCAP - RTASRESP) x RTRSVPOR</td>
<td>$5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>QSE Net for Operating Day</strong></td>
<td></td>
<td></td>
<td></td>
<td>-$3250</td>
</tr>
</tbody>
</table>
Non-Controllable Resource Example

How does this impact a Non-Controllable Resource?

Assume the following inputs ...

- DAM MCPC = $10
- DAM SPP = $30
- RT LMP = $30
- RT ADDER = $5
- RT SPP = $35
Non-Controllable Load Resource: DAM AS awarded, not deployed

<table>
<thead>
<tr>
<th>Settlement Type</th>
<th>Inputs</th>
<th>Price</th>
<th>Qty</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day-Ahead</td>
<td>DAM AS Award</td>
<td>$10</td>
<td>20</td>
<td>-$200</td>
</tr>
<tr>
<td>Real-Time Energy</td>
<td>RTAML x RTSPP</td>
<td>$35</td>
<td>20</td>
<td>$700</td>
</tr>
<tr>
<td>AS Imbalance</td>
<td>RT NCL RR Schedule (RTNCLRRRS)</td>
<td></td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>AS Imbalance</td>
<td>Online Reserves Available: RTOLCAP (RTNCLRRRS)</td>
<td></td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>AS Imbalance</td>
<td>Online Reserves Responsibility: RTASRESP</td>
<td></td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>AS Imbalance</td>
<td>AS Imbalance: (RTOLCAP - RTASRESP) x RTRSVPOR</td>
<td></td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>QSE Net for Operating Day</td>
<td></td>
<td></td>
<td></td>
<td>$500</td>
</tr>
</tbody>
</table>
Non-Controllable Load Resource: DAM AS award and Energy Purchase, AS not deployed

<table>
<thead>
<tr>
<th>Settlement Type</th>
<th>Inputs</th>
<th>Price</th>
<th>Qty</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day-Ahead</td>
<td>DAM Energy Purchase (DAEP)</td>
<td>$30</td>
<td>20</td>
<td>$600</td>
</tr>
<tr>
<td></td>
<td>DAM AS Award</td>
<td>$10</td>
<td>20</td>
<td>-$200</td>
</tr>
<tr>
<td>Real-Time Energy</td>
<td>RTAML</td>
<td></td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(DAEP – RTAML) x RTSPP</td>
<td>$35</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>AS Imbalance</td>
<td>RT NCL RR Schedule (RTNCLRRRS)</td>
<td></td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Online Reserves Available: RTOLCAP (RTNCLR)</td>
<td></td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Online Reserves Responsibility: RTASRESP</td>
<td></td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AS Imbalance: (RTOLCAP - RTASRESP) x RTR</td>
<td>$5</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td></td>
<td>QSE Net for Operating Day</td>
<td></td>
<td></td>
<td>$400</td>
</tr>
</tbody>
</table>
Non-Controllable Load Resource: DAM AS award and Energy Purchase, with AS deployed

<table>
<thead>
<tr>
<th>Settlement Type</th>
<th>Inputs</th>
<th>Price</th>
<th>Qty</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day-Ahead</strong></td>
<td>DAM Energy Purchase (DAEP)</td>
<td>$30</td>
<td>20</td>
<td>$600</td>
</tr>
<tr>
<td></td>
<td>DAM AS Award</td>
<td>$10</td>
<td>20</td>
<td>-$200</td>
</tr>
<tr>
<td><strong>Real-Time Energy</strong></td>
<td>RTAML</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(DAEP – RTAML) x RTSPP</td>
<td>$35</td>
<td>20</td>
<td>-$700</td>
</tr>
<tr>
<td><strong>AS Imbalance</strong></td>
<td>RT NCL RR Schedule (RTNCLRRRS)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Online Reserves Available: RTOLCAP (RTNCLRRRS)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Online Reserves Responsibility: RTASRESP</td>
<td></td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AS Imbalance: (RTOLCAP - RTASRESP) x RTRSVPOR</td>
<td>$5</td>
<td>-20</td>
<td>$100</td>
</tr>
<tr>
<td><strong>QSE Net for Operating Day</strong></td>
<td></td>
<td></td>
<td></td>
<td>-$200</td>
</tr>
</tbody>
</table>
## Controllable Load Resource: No AS responsibility

<table>
<thead>
<tr>
<th>Settlement Type</th>
<th>Inputs</th>
<th>Price</th>
<th>Qty</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Real-Time Energy</strong></td>
<td>Real-Time Adjusted Metered Load (RTAML)</td>
<td>$35</td>
<td>50</td>
<td>$1750</td>
</tr>
<tr>
<td></td>
<td>Net Power Flow</td>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LSL</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Online Reserves Available: RTOLCAP (NPF – LSL)</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Online Reserves Responsibility: RTASRESP</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AS Imbalance: (RTOLCAP-RTASRESP) x RTRSVPOR</td>
<td>$5</td>
<td>50</td>
<td>-$250</td>
</tr>
<tr>
<td><strong>AS Imbalance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>QSE Net for Operating Day</strong></td>
<td></td>
<td></td>
<td><strong>$1500</strong></td>
</tr>
</tbody>
</table>

- Net Power Flow
- LSL
- Online Reserves Available: RTOLCAP (NPF – LSL)
- Online Reserves Responsibility: RTASRESP
- AS Imbalance: (RTOLCAP-RTASRESP) x RTRSVPOR

- Total QSE Net for Operating Day: $1500
1. Modifications to Settlement Point Prices
2. Real-Time Ancillary Service Imbalance
3. RUC-Committed Ancillary Services
4. Revenue Neutrality
RUC-Committed Ancillary Services

HSL=125MW

100MW

Energy Dispatched

Ancillary Service

Paid at Adder

Paid in RTEIMB

LMP + ADDER
Real-Time RUC Ancillary Service Reserve Amount

\[
\begin{align*}
\text{Real-Time RUC Ancillary Service Reserve Amount} & = \left( -1 \right) \times \left( \text{Real-Time RUC Ancillary Service Supply Responsibility} \times \text{Real-Time Reserve Price for On-Line Reserves} \right) \\
\end{align*}
\]

Available only for QSEs who opt out of RUC
### RUC-Committed Ancillary Services

The formula for **Real-Time RUC Ancillary Service Reserve Amount** is:

\[
RTRUCRSVAMT_q = (-1) \times (RTRUCRESP_q \times RTRSVPOR)
\]

Where

\[
RTRUCRESP_q = \sum_r RTRUCASA_{q,r} \times \frac{1}{4}
\]

<table>
<thead>
<tr>
<th><strong>RTRUCRSVAMT</strong> (_q)</th>
<th>Real-Time RUC Ancillary Service Reserve Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RTRUCRESP</strong> (_q)</td>
<td>Real-Time RUC Ancillary Service Supply Responsibility</td>
</tr>
<tr>
<td><strong>RTRSVPOR</strong></td>
<td>Real-Time Reserve Price for On-Line Reserves</td>
</tr>
<tr>
<td><strong>RTRUCASA</strong> (_{q,r})</td>
<td>Real-Time RUC Ancillary Service Awards</td>
</tr>
</tbody>
</table>

*Available only for QSEs who opt out of RUC*
Settlement Impacts for ORDC

1. Modifications to Settlement Point Prices
2. Real-Time Ancillary Service Imbalance
3. RUC-Committed Ancillary Services
4. Revenue Neutrality
We have charged or paid QSEs through Ancillary Service Imbalance

… but ERCOT must be Revenue Neutral

Real-Time AS Imbalance Amount
RUC AS Reserve Amount

Real-Time AS Imbalance Revenue Neutrality Allocation
Load-Allocated Ancillary Service Imbalance

Revenue Neutrality Amount

\[ (-1) \left( \left( \text{Real-Time Ancillary Service Imbalance Market Total Amount} \right) + \left( \text{Real-Time RUC Ancillary Service Reserve Market Total Amount} \right) \right) \times \left( \text{The LRS calculated for QSE q for the 15-minute Settlement Interval} \right) \]
LAASIRNAMT\(_q\) = (-1) * [(RTASIAMTTOT + RTRUCRSVAMTTOT) * LRS\(_q\)]

Where

RTASIAMTTOT = \(\sum \) RTASIAMT\(_q\)

RTRUCRSVAMTTOT = \(\sum \) RTRUCRSVAMT\(_q\)

<table>
<thead>
<tr>
<th><strong>LAASIRNAMT(_q)</strong></th>
<th>Load-Allocated Ancillary Service Imbalance Revenue Neutrality Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RTASIAMTTOT</strong></td>
<td>Real-Time Ancillary Service Imbalance Market Total Amount</td>
</tr>
<tr>
<td><strong>RTRUCRSVAMTTOT</strong></td>
<td>Real-Time RUC Ancillary Service Reserve Market Total Amount</td>
</tr>
<tr>
<td><strong>LRS(_q)</strong></td>
<td>The LRS calculated for QSE q for the 15-minute Settlement Interval</td>
</tr>
<tr>
<td><strong>RTASIAMT(_q)</strong></td>
<td>Real-Time Ancillary Service Imbalance Amount</td>
</tr>
<tr>
<td><strong>RTRUCRSVAMT(_q)</strong></td>
<td>Real-Time RUC Ancillary Service Reserve Amount</td>
</tr>
</tbody>
</table>
You should now be able to …

• Describe the Purpose of ORDC
• Recognize the Methodology for Implementing ORDC
• Illustrate the Settlement Impacts of ORDC

All in a day’s work!
Additional Resources

ERCOT Nodal Market Protocols
http://www.ercot.com/mktrules/nprotocols/

ERCOT Training
http://www.ercot.com/services/training/

Nodal Market Education Contact
Training@ercot.com

ORDC Job Aid
http://www.ercot.com/services/training/course/107#materials