Settlement: Ancillary Services

2024_09 AS

Greetings
and
Introductions

WebEx Tips

- **Windows**

- **Buttons**

**Attendance**

Questions / Chat

PROTOCOL DISCLAIMER

This presentation provides a general overview of the Texas Nodal Market and is not intended to be a substitute for the ERCOT Protocols, as amended from time to time. If any conflict exists between this presentation and the ERCOT Protocols, the ERCOT Protocols shall control in all respects.

For more information, please visit:

http://www.ercot.com/mktrules/nprotocols/

Concept

Math

Protocols

Example

Settlement Equation
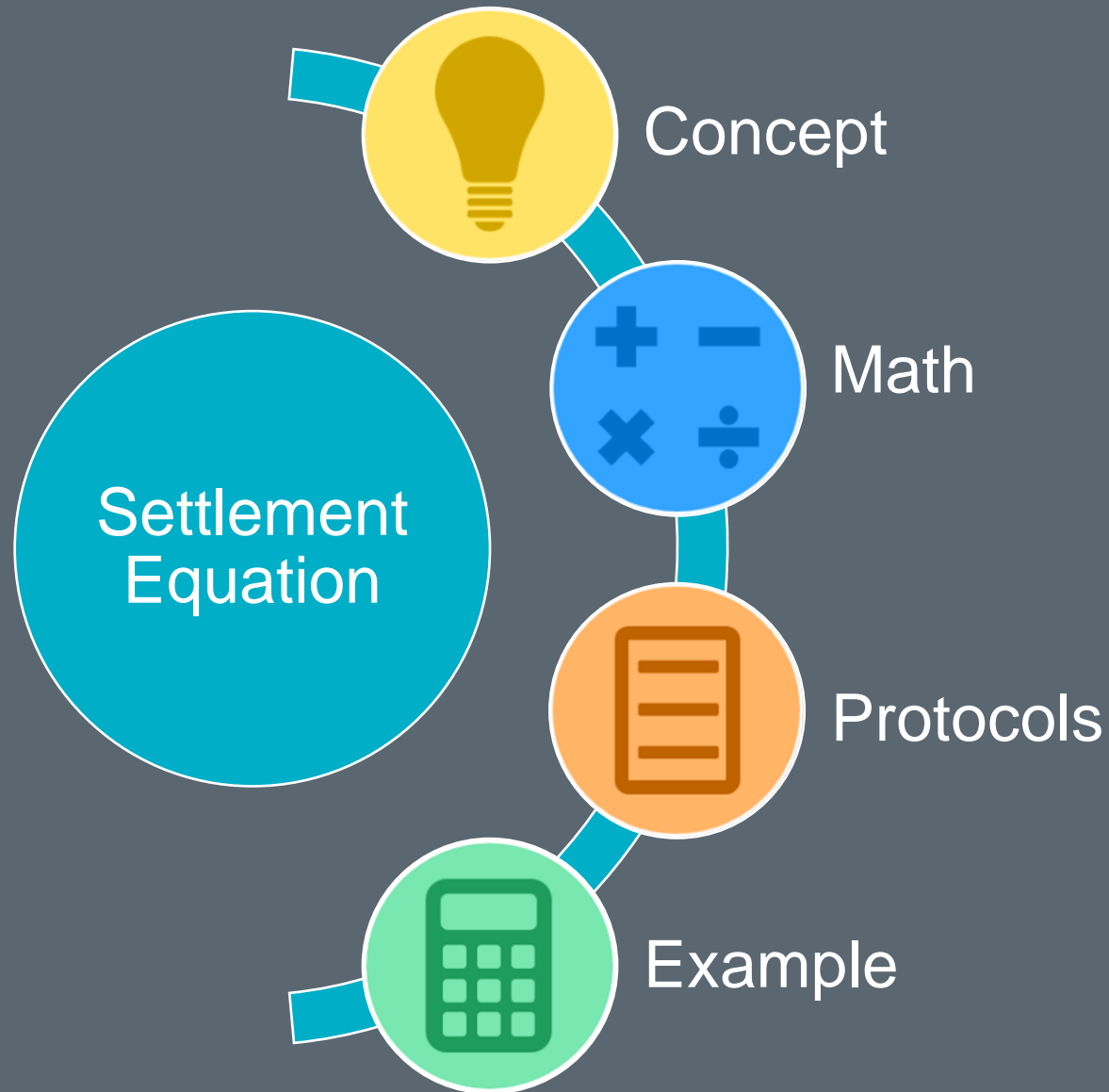
Topics in this course include:

1	Ancillary Service Procurement (DAM)
2	Ancillary Service Offer (DAM)
3	Supplemental Ancillary Services Market (SASM)
4	Ancillary Service Adjustment Costs
5	Real-Time Ancillary Service Imbalance

CRR Auction
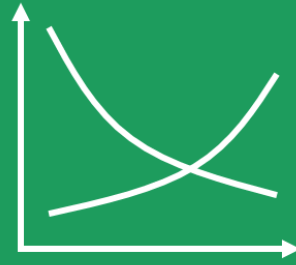
DAM

Real-Time

CRRAH

QSE

Five Ancillary Service (AS) Settlement Types:

RU – **Regulation Up**

RD – **Regulation Down**

RR – **Responsive Reserve**

ECR – **ERCOT Contingency Reserve**

NS – **Non-Spin Reserve**

ERCOT System
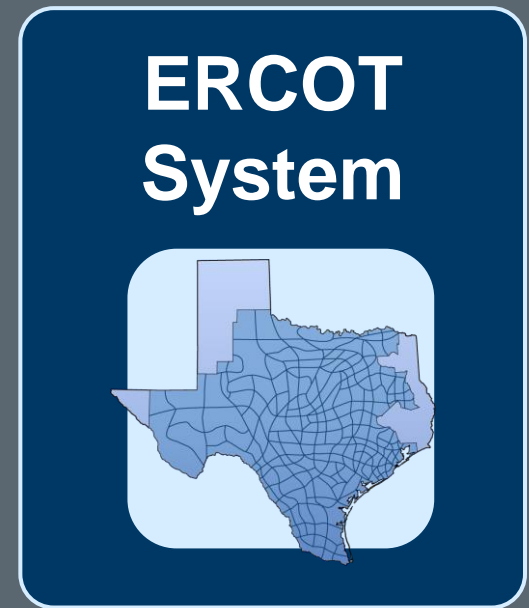
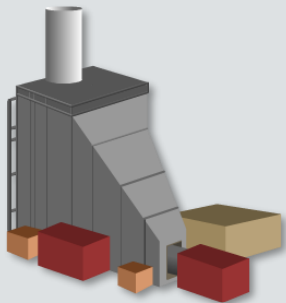# Where is the Payment or the Charge to the QSE (-/+)?
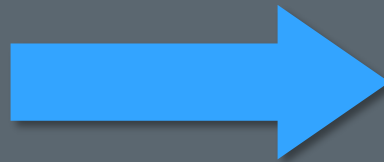
Ancillary Service Procurement

ERCOT allocates Ancillary Service Plan

QSE chooses how to fulfill

Self-Arrange

Allow ERCOT to procure

Regulation Up Procurement

- **DAM Obligation = 5MW RU for one hour**
- **Self Arranged = 2MW RU for the same hour**
- **Regulation Up Price = $14/MW**

AS Procurement = RU Price * Net Quantity

AS Procurement = $14/MW * (5MW – 2MW)

AS Procurement = $14/MW * 3MW

$42 for Regulation Up for the hour

DAM

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DA<u>RU</u>AMT = Day-Ahead Reg-Up Amount

$$DA\underline{RU}AMT_q = DA\underline{RU}PR * DA\underline{RU}Q_q$$

$$\text{Where: } DA\underline{RU}Q_q = DA\underline{RU}O_q - DASA\underline{RU}Q_q$$

|	
DA<u>RU</u>PR	Day-Ahead Reg-Up Price
DA<u>RU</u>Q	Day-Ahead Reg-Up Quantity
DA<u>RU</u>O	Day-Ahead Reg-Up Obligation
DASA<u>RU</u>Q	Day-Ahead Self-Arranged Reg-Up Quantity
q	QSE

DAM

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Settle Regulation Down Procurement

- **DAM Obligation = 8MW RD for Hour 17**
- **Self Arranged = 1.5MW RD for Hour 17**
- **Regulation Down Price = $38/MW**

DAM

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Ancillary Service Offer

Ancillary Service Offers → **DAM** → **Hourly Awards**

Hourly Prices
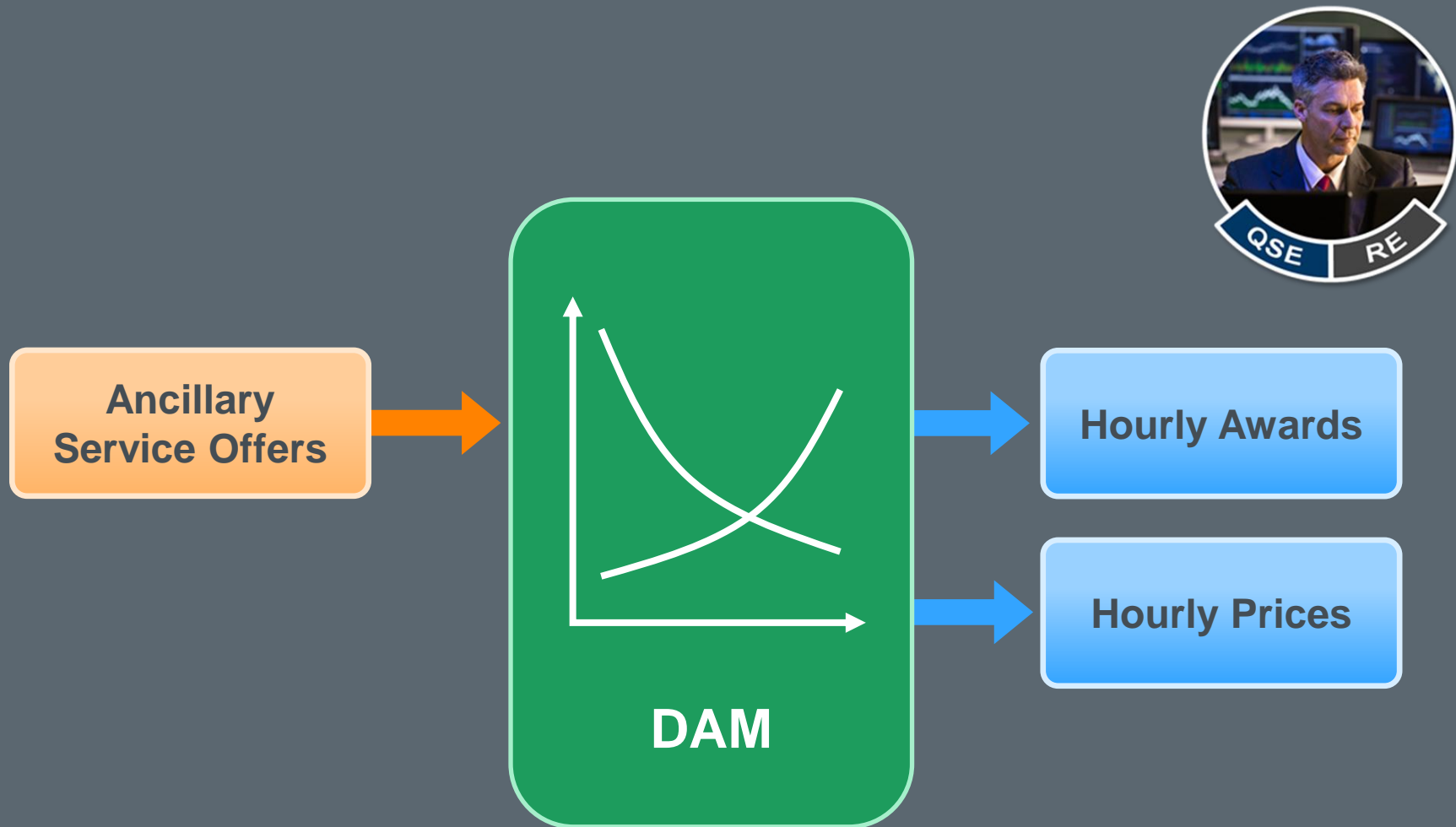
Awarded ERCOT Contingency Reserve Offer

- **DAM Quantity = 90MW ECR for one hour**
- **ERCOT Contingency Reserve Price = $23/MW**

AS Award = (-1) * ECR Price * Quantity

AS Award = (-1) * $23/MW * 90MW

-$2,070 for ERCOT Contingency Reserve for the hour

DAM

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PCECRAMT = Procured Capacity for ERCOT Contingency Reserve Service Amount

$$PCECRAMT_q = (-1) * MCPCECR_{DAM} * PCECR_{q,DAM}$$

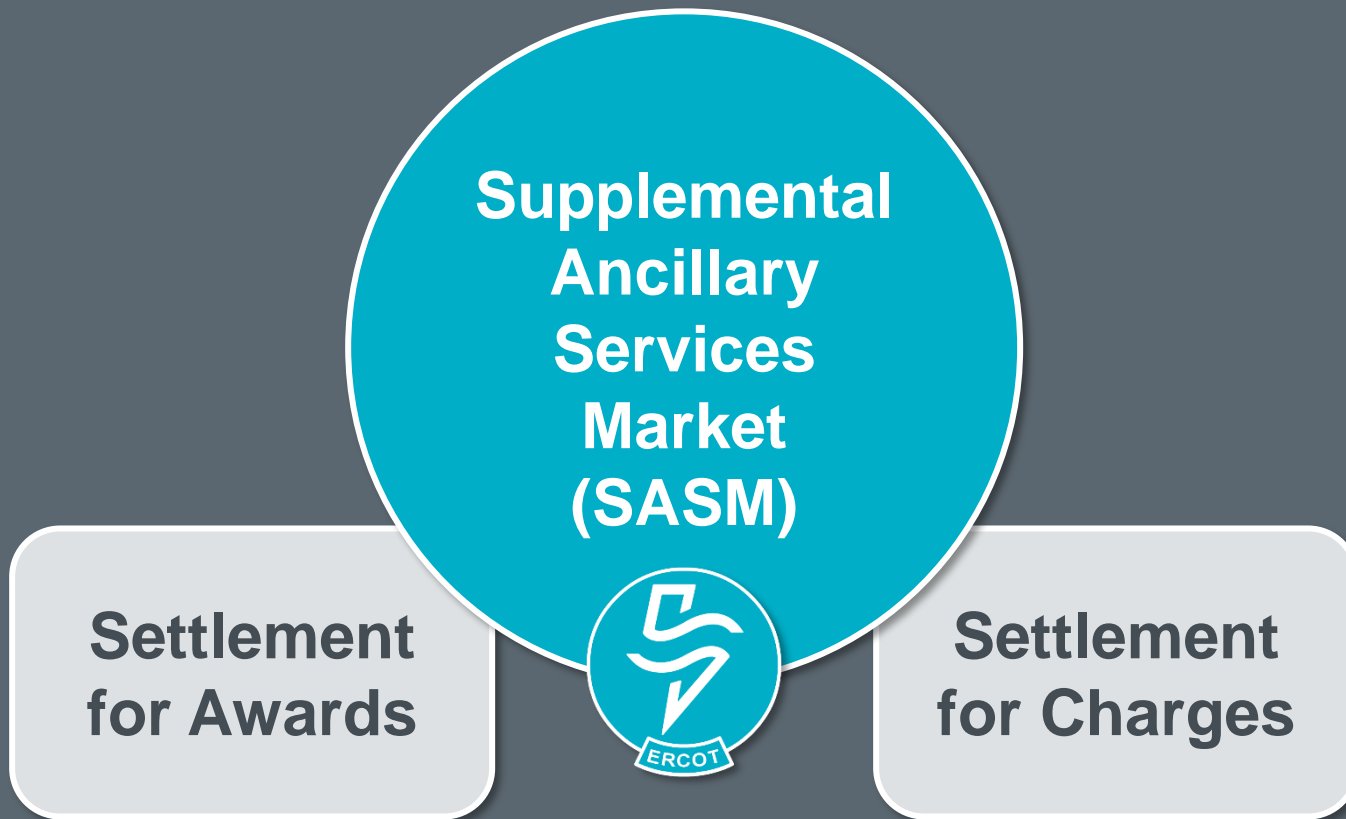|	
MCPCECR	Market Clearing Price Capacity ERCOT Contingency Reserve
PCECR	Procured Capacity ERCOT Contingency Reserve
q, DAM	QSE, Day-Ahead Market

DAM

Settle Awarded Responsive Reserve Offer

- **DAM Quantity = 55MW RR for Hour 16**
- **Responsive Reserve Price = $77/MW**

DAM

Supplemental Ancillary Services Market (SASM) Offer

Ancillary Service changes during Adjustment Period

Supplemental Ancillary Services Market (SASM)

Settlement for Awards

Settlement for Charges

Awards Settle in Real-Time Market

Ancillary Service Offers → **Supplemental Ancillary Services Market (SASM)**

→ **Hourly Awards**

→ **Hourly Prices**

Real-Time

QSE **RE**

Awarded Regulation Down Offer

- **SASM Quantity = 12MW RD for one hour**
- **Regulation Down Price = $450/MW**

SASM Award = (-1) * RD Price * Quantity

SASM Award = (-1) * $450/MW * 12MW

-$5,400 for Regulation Down for the hour

Real-Time

RTPC<u>RD</u>AMT = Procured Capacity for Reg-Down Amount

$$RTPC\underline{RD}AMT_{q,m} = (-1) * MCPC\underline{RD}_m * RTPC\underline{RD}_{q,m}$$

MCPC<u>RD</u>	Market Clearing Price Capacity Reg-Down
RTPC<u>RD</u>	Procured Capacity Reg-Down
q, m	QSE, AS Market (SASM)

Real-Time

Settle Awarded Regulation Up Offer

- **SASM Quantity = 9MW RU for last 12 hours of the day**

- **Reg-Up Price (Hour 13 through Hour 20) = $111/MW**

- **Reg-Up Price (Hour 21 through Hour 24) = $46/MW**

Real-Time

Failure to Provide an Ancillary Service

Resource is <u>unable</u> to provide AS

Charge = Max of AS Market Prices or Average Real-Time AS Imbalance Price

RTRSVPOR = **R**eal-**T**ime **R**eserve **P**rice for **O**n-Line **R**eserves

RTRDP = **R**eal-**T**ime On-Line **R**eliability **D**eployment **P**rice

ERCOT System
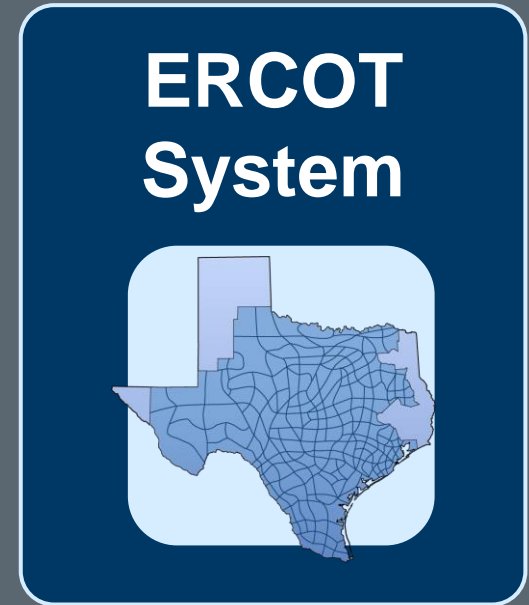
Average of the sum of both Prices for the hour

Real-Time

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Non-Spin Reserve Failure

- **Quantity = 25MW NS for one hour**

- **NS Price for the hour in DAM = $30/MW**

- **NS Price for the hour in 1st SASM = $300/MW**

- **NS Price for the hour in 2nd SASM = $3,000/MW**

- **Average Real-Time AS Imbalance Price for the hour = $900/MW**

NS Failure = Max (Price) * Quantity

NS Failure = $3000/MW * 25MW

**$75,000 for NS Failure Quantity
for the hour**

Real-Time

NSFQAMT = Non-Spin Failure Quantity Amount

$$\text{NSFQAMT}_q = \text{Max}(\text{MCPCNS}_m, \text{AVGRTASIP}) * (\text{NSFQ}_q + \text{TNSFQ}_q)$$

$$\text{Where: AVGRTASIP} = \sum(\text{RTRSVPOR} + \text{RTRDP}) / 4$$

MCPCNS	Market Clearing Price Capacity Non-Spin
AVGRTASIP	Average Real-Time Ancillary Service Imbalance Price
NSFQ	Non-Spin Failure Quantity
TNSFQ	Telemetered Non-Spin Failure Quantity
RTRSVPOR	Real-Time Reserve Price for On-Line Reserves
RTRDP	Real-Time On-Line Reliability Deployment Price
q, m	QSE, AS Market (DAM or SASM)

Real-Time

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Settle ERCOT Contingency Reserve Failure

- **ECRFQ + TECRFQ = 29MW for Hour 18**

- **ECR Price for Hour 18 in DAM = $45/MW**

- **ECR Price for Hour 18 in SASM = $98/MW**

- **Average Real-Time AS Imbalance Price for Hour 18 = $3/MW**

Real-Time

Infeasible Ancillary Service

Resource is <u>not allowed</u> to provide AS

Real-Time

Charge = DAM Price

Infeasible Regulation Up

- **Quantity = 16MW RU for one hour**
- **Reg-Up Price for the hour in DAM = $42/MW**
- **Reg-Up Price for the hour in SASM = $4,200/MW**

Infeasible RU = RU Price$_{DAM}$ * Quantity

Infeasible RU = $42/MW * 16MW

$672 for Infeasible Reg-Up for the hour

Real-Time

RUINFQAMT = Reg-Up Infeasible Quantity Amount

$$\text{RUINFQAMT}_q = \text{MCPCRU}_{DAM} * \text{RUINFQ}_q$$

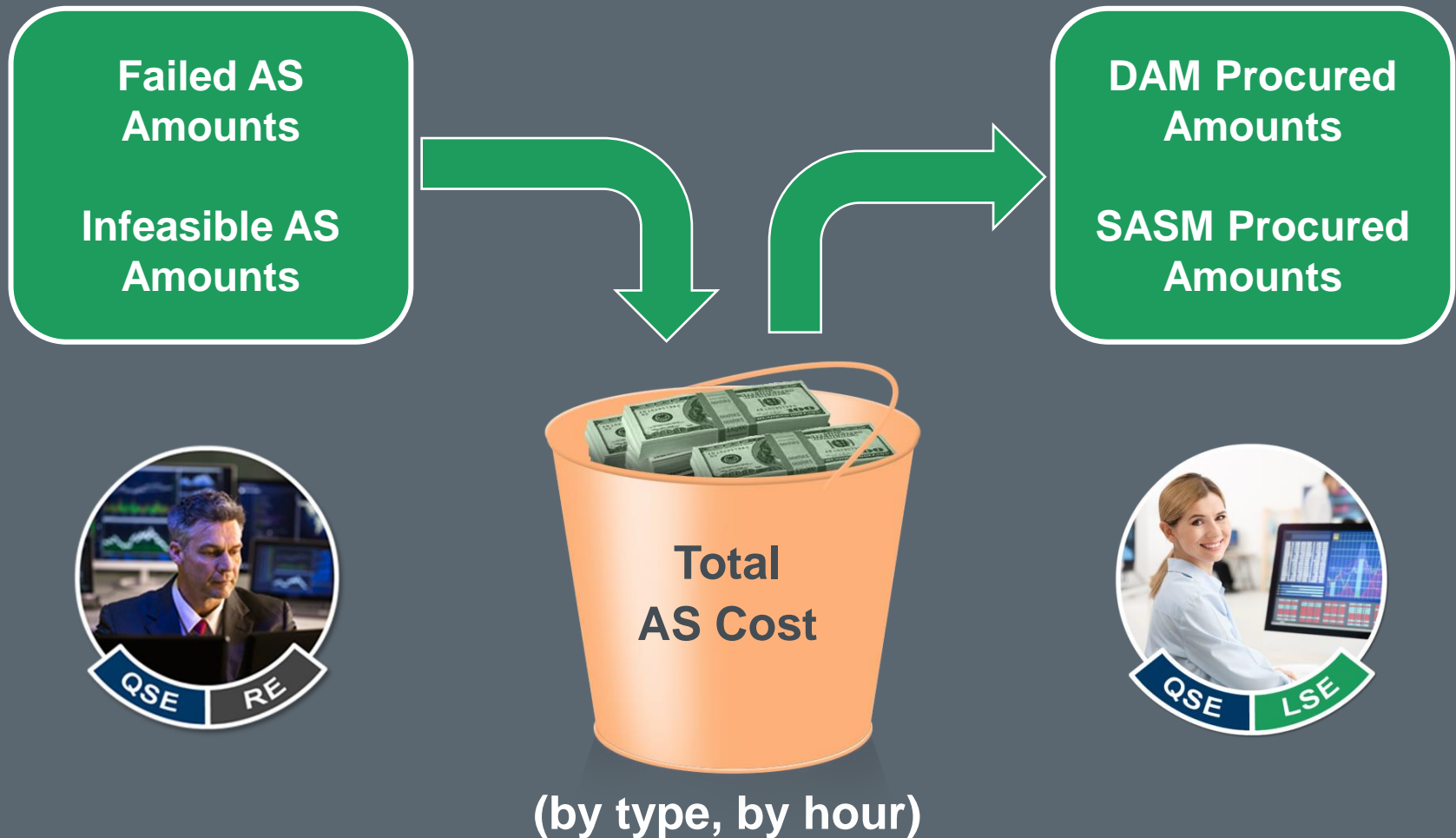| MCPCRU	Market Clearing Price Capacity Reg-Up
RUINFQ	Reg-Up Infeasible Quantity
q, DAM	QSE, Day-Ahead Market

Real-Time

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Settle Infeasible Regulation Down

- **Quantity = 14MW RD for last 10 hours of the day**
- **DAM RD Price (Hour 15 through Hour 19) = $55/MW**
- **DAM RD Price (Hour 20 through Hour 24) = $23/MW**

Real-Time

Total Ancillary Service Cost Allocation

Failed AS Amounts

Infeasible AS Amounts

DAM Procured Amounts

SASM Procured Amounts

Total AS Cost

(by type, by hour)

Net Total AS Cost Allocated (by type, by hour)

Real-Time

QSE **LSE**

$$\text{Charge} = \text{AS Price} * \left[\left(\text{QSE Obligation}\right) - \left(\text{Self-Arranged Qty}\right)\right]$$

$$\textit{Where ...} \quad \text{AS Price} = \left(\frac{\text{Total Ancillary Service Cost}}{\text{Total Procurement not self-arranged}}\right)$$

Real-Time

Obligation Allocated
(by type, by hour)

QSE   LSE

Where …

$$\text{QSE Obligation} = \sum_{\text{All QSEs}} \left[\begin{array}{c} \text{Self-Arranged Qty in all Markets} \\ + \\ \text{AS Procured in Real-Time} \\ + \\ \text{AS Procured in DAM} \\ - \\ \text{AS Failed Quantities} \end{array} \right] * \text{Hourly Load Ratio Share}$$

Total Responsive Reserve Costs

- **RR Quantities for one hour:**
  - This QSE Self-Arranged 100MW
  - This QSE has 5% of the ERCOT Load
  - All QSEs Self-Arranged 900MW
  - ERCOT procured 2000MW in DAM
  - ERCOT procured 10MW in SASM (Failed Quantity)
  - Total Procurement is 2000MW (not Self Arranged, 2000 + 10 – 10)
- **RR Costs for the same hour:**
  - DAM Cost = $16,000
  - SASM Cost = $600
  - Failed Quantity Charge = $600
  - Net Total Cost is $16,000 ($16,000 + $600 - $600)

Real-Time

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Total Responsive Reserve Costs

AS Price = Total Cost / Total Procurement
AS Price = $16,000 / 2000MW = $8/MW

QSE Obligation
$= \sum_{\textbf{QSEs}}$ **(Self-Arranged + SASM + DAM – Failed Qty) * Ratio**
= (900MW + 10MW + 2000MW – 10MW) * 5%
= 2900MW * 0.05 = 145MW

RR Cost = AS Price * (Obligation – Self Arranged)
RR Cost = $8/MW * (145MW – 100 MW)
RR Cost = $8/MW * 45MW = $360 for the hour

Real-Time

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RRCOST = Responsive Reserve Cost

$$RRCOST_q = RRPR * RRQ_q$$

Where: $RRPR = RRCOSTTOT / RRQTOT$ & $RRQ_q = RRO_q - SARRQ_q$

Where: $RRO_q = \sum_q (SARRQ_q + RTPCRR_q + PCRR_q - RRFQ_q) * HLRS_q$

RRPR	Responsive Reserve Price
RRQ(TOT), RRO	RR Quantity (Total), RR Obligation
RRCOSTTOT	Responsive Reserve Cost Total
SARRQ, RRFQ	Self-Arranged RR Quantity, RR Failure Quantity
RTPCRR, PCRR	Procured Capacity RR (SASMs & DAM)
HLRS, q	Hourly Load Ratio Share, QSE

Real-Time

Settle Total Non-Spin Reserve Costs

- **NS Quantities for Hour 7:**
  - This QSE Self-Arranged 80MW
  - This QSE has 10% of the ERCOT Load
  - All QSEs Self-Arranged 810MW
  - ERCOT procured 990MW in DAM
  - ERCOT procured 10MW in SASM (Infeasible)
  - Total Procurement is 1000MW (not Self Arranged, 990 + 10)
- **NS Costs for the same hour:**
  - DAM Cost = $9,900
  - SASM Cost = $1,200
  - Infeasible Charge = $100
  - Net Total Cost is $11,000 ($9,900 + $1,200 - $100)

Real-Time

Settle Total Non-Spin Reserve Costs

Real-Time

Ancillary Service Procurement Adjustment Costs

DAM AS Amounts compared to Total AS Costs

Estimate   **vs.**   **Actuals**

RTM AS Amount = Total AS Cost – DAM AS Amount

Real-Time Responsive Reserve Amount

- RR Cost for QSE = $360 for one hour
- DAM RR Amount for QSE = $240 for one hour

RTM RR Amount = RR Cost – DAM RR Amount

RTM RR Amount = $360 – $240

$120 Real-Time RR Amount
for the hour

RT<u>RR</u>AMT = Real-Time Responsive Reserve Amount

$$RT\underline{RR}AMT_q = \underline{RR}COST_q - DA\underline{RR}AMT_q$$

<u>RR</u>COST	Responsive Reserve Cost
DA<u>RR</u>AMT	Day-Ahead Responsive Reserve Amount
q	QSE

Real-Time

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Settle Real-Time Non-Spin Reserve Amount

- **NS Cost for QSE = $1111 for Hour 7**
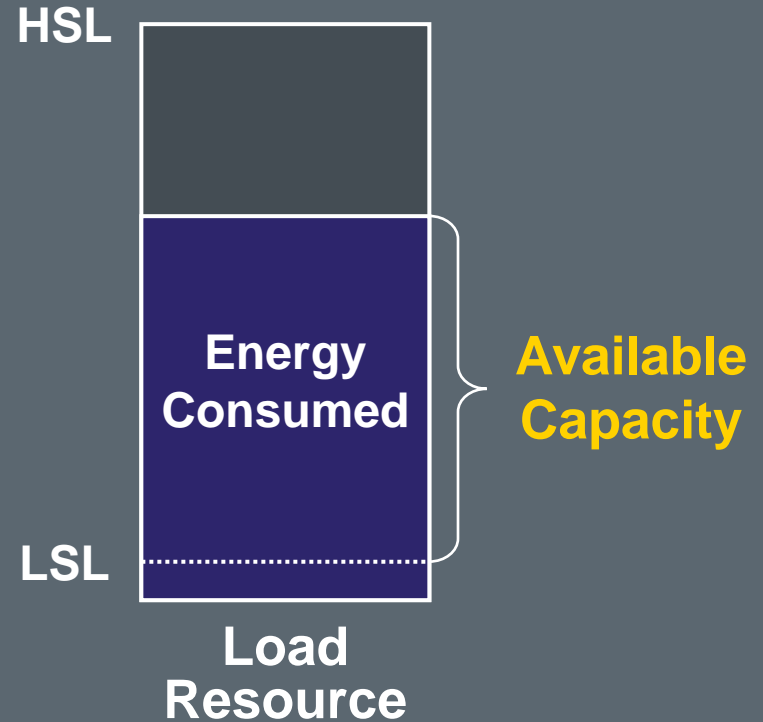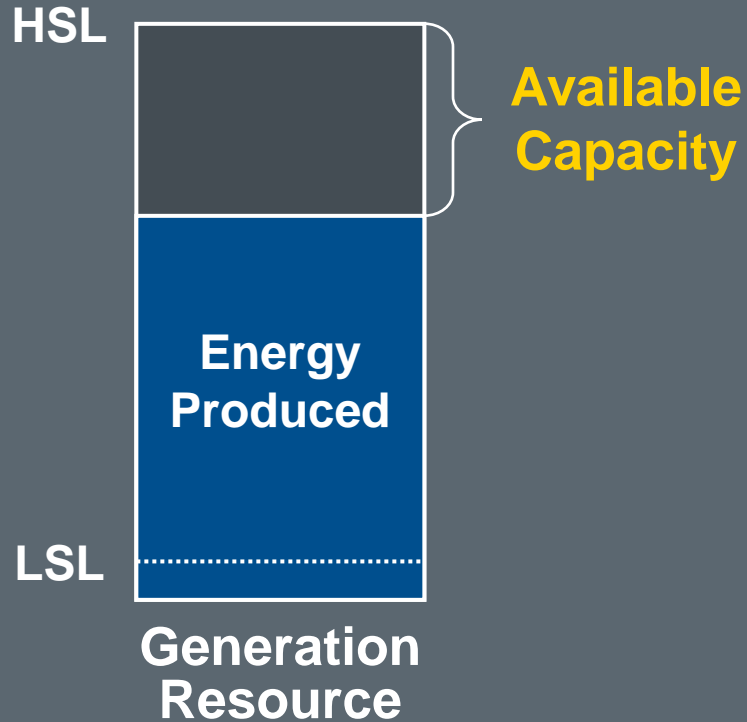- **DAM NS Amount for QSE = $1300 for Hour 7**

Real-Time

Real-Time Ancillary Service Imbalance

Calculated ERCOT-wide per QSE
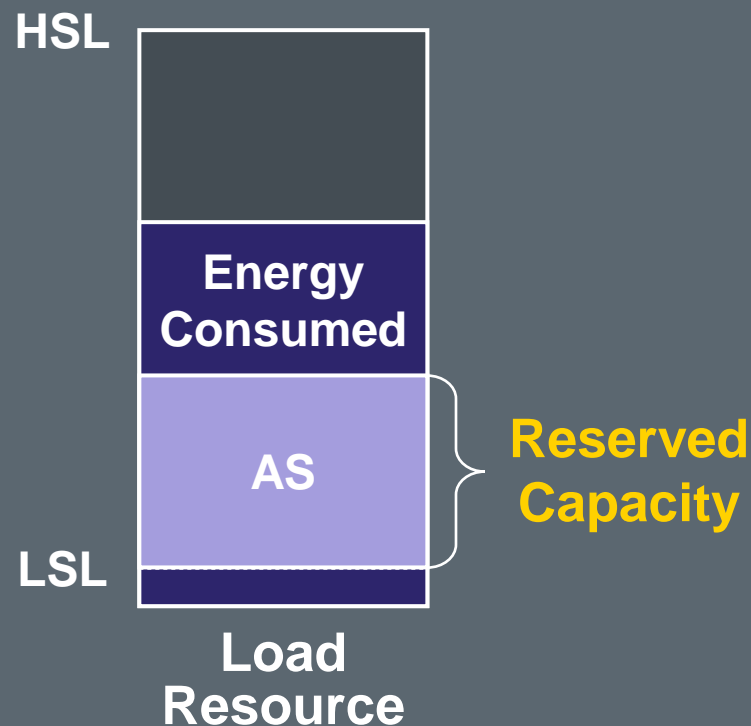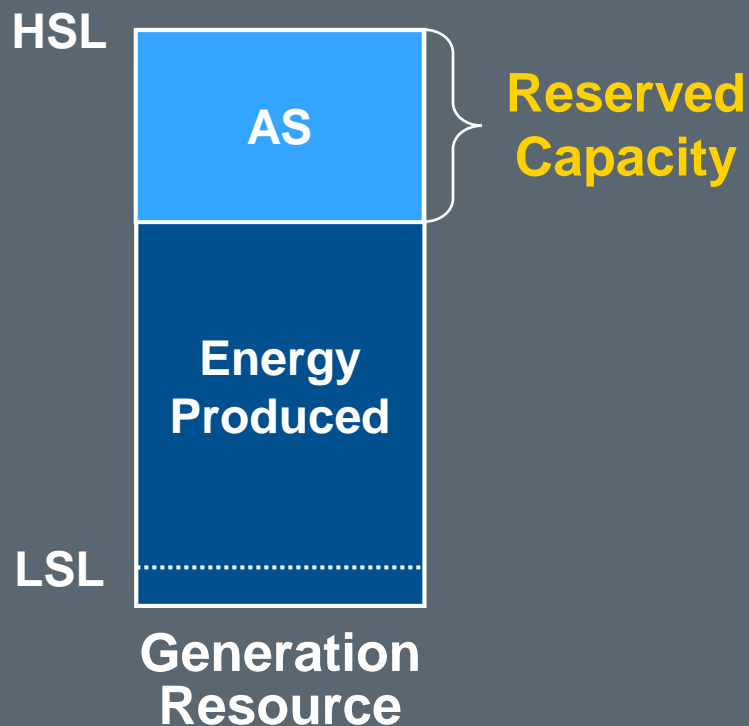
$$= (-1) \left[\left[\text{On-Line Reserve SUPPLIES} - \text{On-Line Reserve OBLIGATIONS} \right] * \text{On-line Reserve Price} \right.$$

$$\left. + \left[\text{Off-Line Reserve SUPPLIES} - \text{Off-Line Reserve OBLIGATIONS} \right] * \text{Off-line Reserve Price} \right]$$
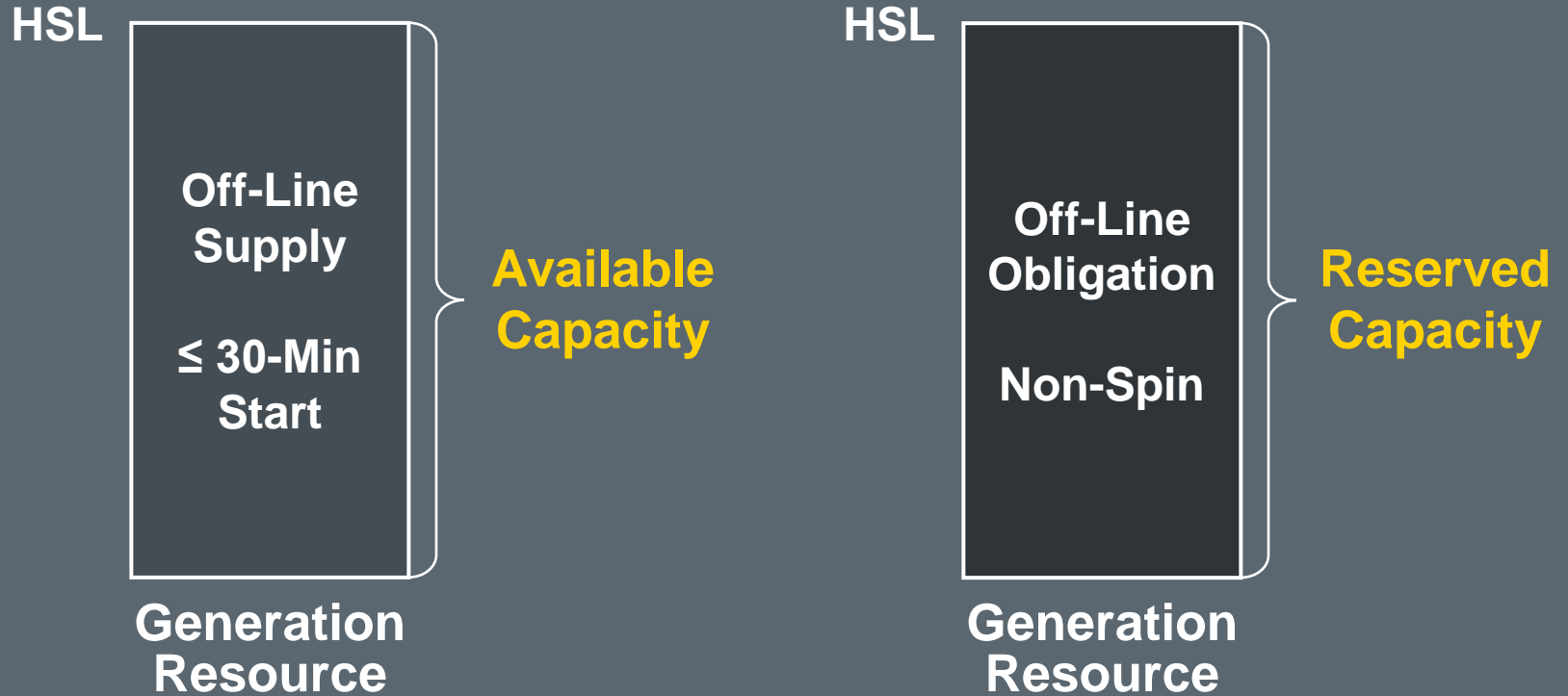
Real-Time

Online Reserve Obligations

Offline Reserve Supplies & Obligations

HSL

Off-Line Supply

≤ 30-Min Start

Available Capacity

Generation Resource

HSL

Off-Line Obligation

Non-Spin

Reserved Capacity

Generation Resource

Real-Time

RTORPA = **R**eal-**T**ime **O**n-Line **R**eserve **P**rice **A**dder

RTOFFPA = **R**eal-**T**ime **Off**-Line Reserve **P**rice **A**dder

ERCOT System
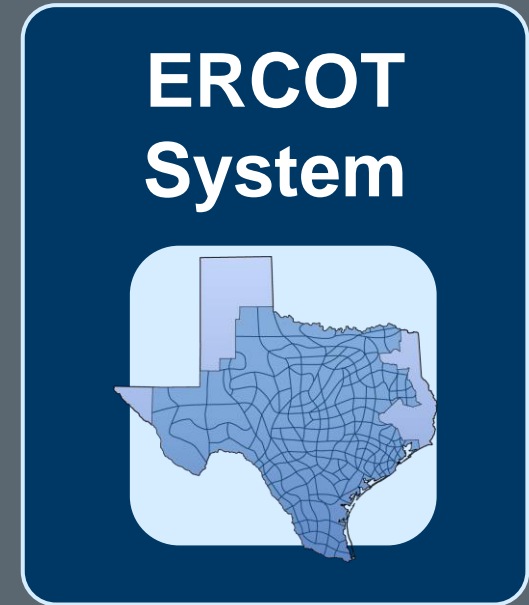
Adders are produced for each SCED interval

RTRSVPOR = **R**eal-**T**ime **R**eserve **P**rice for **O**n-Line **R**eserves

RTRSVPOFF = **R**eal-**T**ime **R**eserve **P**rice for **Off**-Line Reserves

**ERCOT System**
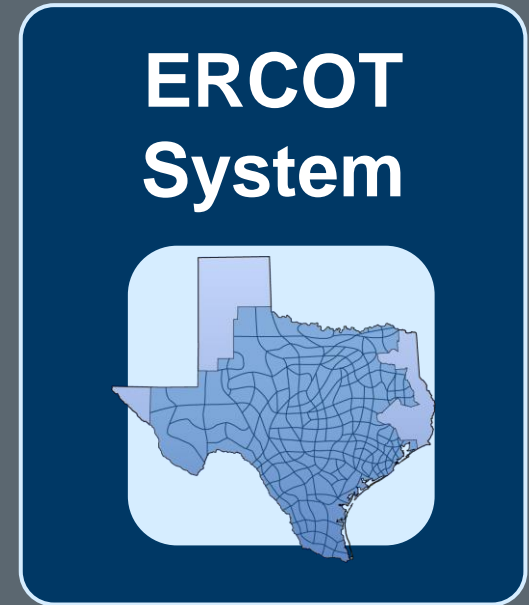
Time-Weighted Average for each 15-minute interval

Calculated ERCOT-wide per QSE

$$= (-1) \left[\left[\textit{Ancillary Service On-Line Reserve Imbalance} \right] * \textbf{On-line Reserve Price} \right.$$

$$\left. + \left[\textit{Ancillary Service Off-Line Reserve Imbalance} \right] * \textbf{Off-line Reserve Price} \right]$$
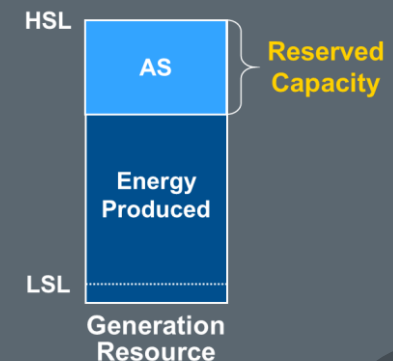
Real-Time

On-Line Supply = On-Line Capacity

- **Generation Resources (HSL – Metered Generation)**
- **Controllable Load Resources**
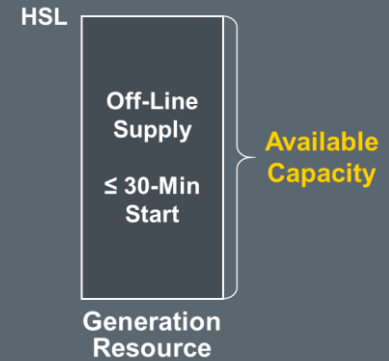- **Non-Controllable Load Resources**
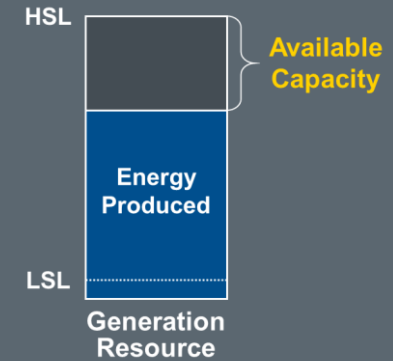
On-Line Obligations = On-Line AS

- **Ancillary Service Supply Responsibility**
- **Excluding Off-Line Generation Resources with NS Schedule**
- **Excluding Non-Controllable Load Resources with NS Responsibility**

HSL

Available Capacity

Energy Produced

LSL

Generation Resource

HSL

AS — Reserved Capacity
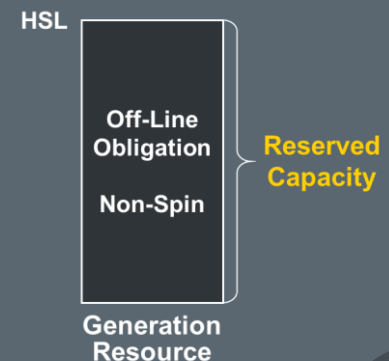
Energy Produced

LSL

Generation Resource

Real-Time

Off-Line Supply = Off-Line Capacity

- **Generation Resources with 30-Min Cold Start**
- **Generation Resources with NS Schedule**
- **Non-Controllable Load Resources with NS Schedule**

Off-Line Obligations = Off-Line AS

- **Off-Line Generation Resources with NS Schedule**
- **Non-Controllable Load Resources with NS Responsibility**

AS Supplies & Obligations

- QSE has One Generation Resource (On-Line)
- HSL is 200MW (50MWh for the interval)
- Metered Generation is 40MWh for the interval
- No AS commitments
- On-line Reserve Price = $20/MWh, Off-line Reserve Price = $5/MWh

AS On-Line Imbalance = HSL – Metered Gen

AS On-Line Imbalance = 50MWh – 40MWh

10MWh for the interval

Real-Time

AS Supplies & Obligations

- QSE has One Generation Resource (On-Line)
- HSL is 200MW (50MWh for the interval)
- Metered Generation is 40MWh for the interval
- No AS commitments
- On-line Reserve Price = $20/MWh, Off-line Reserve Price = $5/MWh

AS Imbalance = (-1) * [(**AS On-Line Imbalance** * **On-line Reserve Price**) + (**AS Off-Line Imbalance** * **Off-Line Reserve Price**)]

AS Imbalance = (-1) * [(**10MWh** * **$20/MWh**) + (0 * **$5/MWh**)]

-$200 Real-Time AS Imbalance for the interval

Real-Time

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RTASIAMT = Real-Time Ancillary Service Imbalance Amount

$$RTASIAMT_q = (-1) * [(RTASOLIMB_q * RTRSVPOR) + (RTASOFFIMB_q * RTRSVPOFF)]$$

RTASOLIMB	Real-Time Ancillary Service On-Line Reserve Imbalance
RTASOFFIMB	Real-Time Ancillary Service Off-Line Reserve Imbalance
RTRSVPOR	Real-Time Reserve Price for On-Line Reserves
RTRSVPOFF	Real-Time Reserve Price for Off-Line Reserves
q	QSE

Real-Time

Where: $RTASOLIMB_q = RTOLCAP_q - [(RTASRESP_q * ¼) - RTASOFF_q - RTNCLRNSRESP_q]$

Where: $RTOLCAP_q = (RTOLHSL_q - RTGMQ_q) + RTCLRCAP_q + RTNCLRCAP_q$

RTOLCAP	Real-Time On-Line Reserve Capacity
RTASRESP	Real-Time Ancillary Service Supply Responsibility
RTASOFF	Real-Time AS Schedule for Off-Line Generation Resource
RTNCLRNSRESP	Real-Time Non-Controllable Load Resource NS Responsibility
RTOLHSL	Real-Time On-Line High Sustained Limit
RTGMQ	Real-Time Generation Metered Quantity
RTCLRCAP	Real-Time Controllable Load Resource Capacity
RTNCLRCAP	Real-Time Non-Controllable Load Resource Capacity

Real-Time

Where: $RTASOFFIMB_q = RTOFFCAP_q - (RTASOFF_q + RTNCLRNSRESP_q)$

Where: $RTOFFCAP_q = RTCST30HSL_q + RTOFFNSHSL_q + RTNCLRNSCAP_q$

RTOFFCAP	Real-Time Off-Line Reserve Capacity
RTASOFF	Real-Time AS Schedule for Off-Line Generation Resource
RTNCLRNSRESP	Real-Time Non-Controllable Load Resource NS Responsibility
RTCST30HSL	Real-Time Cold Start Generation Resource (≤ 30 min) @ HSL
RTOFFNSHSL	Real-Time Generation Resource Off-Line NS Schedule @ HSL
RTNCLRNSCAP	Real-Time Non-Controllable Load Resource NS Capacity

Real-Time

Settle AS Supplies & Obligations

- QSE has One Generation Resource (On-Line)
- HSL is 400MW (100MWh for Interval 0845)
- Metered Generation is 50MWh for Interval 0845
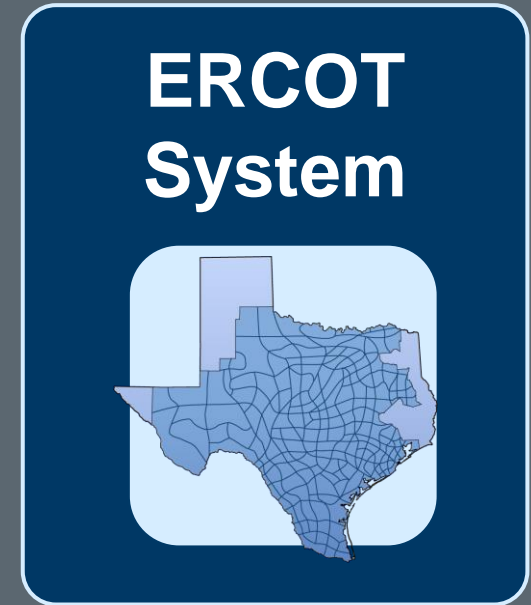- RR commitment of 20MW for Hour 9
- On-line Reserve Price = $25/MWh

Real-Time

Real-Time Reliability Deployment Ancillary Service Imbalance

Calculated ERCOT-wide per QSE

$$= (-1) * [\text{Ancillary Service On-Line Reserve Imbalance}] * \text{On-line Reliability Price}$$

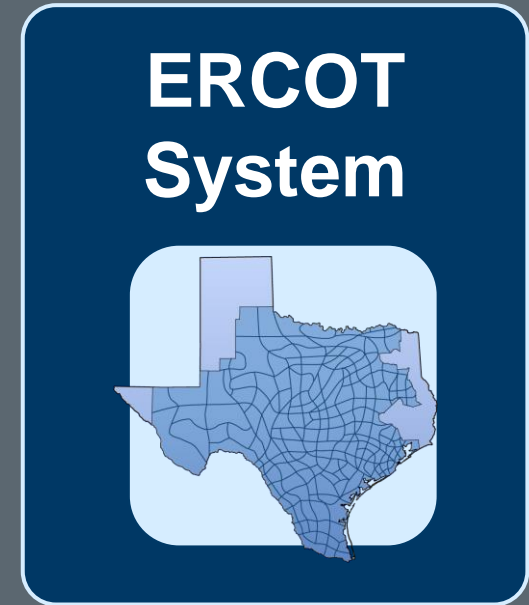**Real-Time**

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RTORDPA = **R**eal-**T**ime **O**n-Line
Reliability **D**eployment
Price **A**dder

**ERCOT
System**

**Adders are produced
for each SCED interval**

Real-Time

RTRDP = **R**eal-**T**ime On-Line **R**eliability **D**eployment **P**rice

ERCOT System

Real-Time

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Time-Weighted Average for each 15-minute interval

AS Supplies & Obligations

- **AS On-Line Imbalance = 451MWh for the interval**

- **Reliability Deployment Price = $14/MWh**

Reliability Imbalance = (-1) * (AS On-Line Imbalance * Reliability Price)

Reliability Imbalance = (-1) * (451MWh * $14/MWh)

-$6,314 Reliability Imbalance for the interval

Real-Time

RTRDASIAMT = **R**eal-**T**ime **R**eliability **D**eployment **A**ncillary **S**ervice **I**mbalance **Am**oun**t**

$$RTRDASIAMT_q = (-1) * (RTASOLIMB_q * RTRDP)$$

RTASOLIMB	Real-Time Ancillary Service On-Line Reserve Imbalance
RTRDP	Real-Time On-Line Reliability Deployment Price
q	QSE

Real-Time

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Settle AS Supplies & Obligations

- **AS On-Line Imbalance = -50MWh for Interval 1115**
- **Reliability Deployment Price = $22/MWh**

Real-Time

Topics in this course included:

1	Ancillary Service Procurement (DAM)
2	Ancillary Service Offer (DAM)
3	Supplemental Ancillary Services Market (SASM)
4	Ancillary Service Adjustment Costs
5	Real-Time Ancillary Service Imbalance

ERCOT Client Services
Clientservices@ercot.com

ERCOT Mailing Lists
http://lists.ercot.com/

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

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

Market Education Contact
Training@ercot.com

Scan this QR code to take the course survey!

https://www.surveymonkey.com/r/ERCOTILT