Settlement: Ancillary Services

2023_06 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

Settlement Equation

Protocols

Example
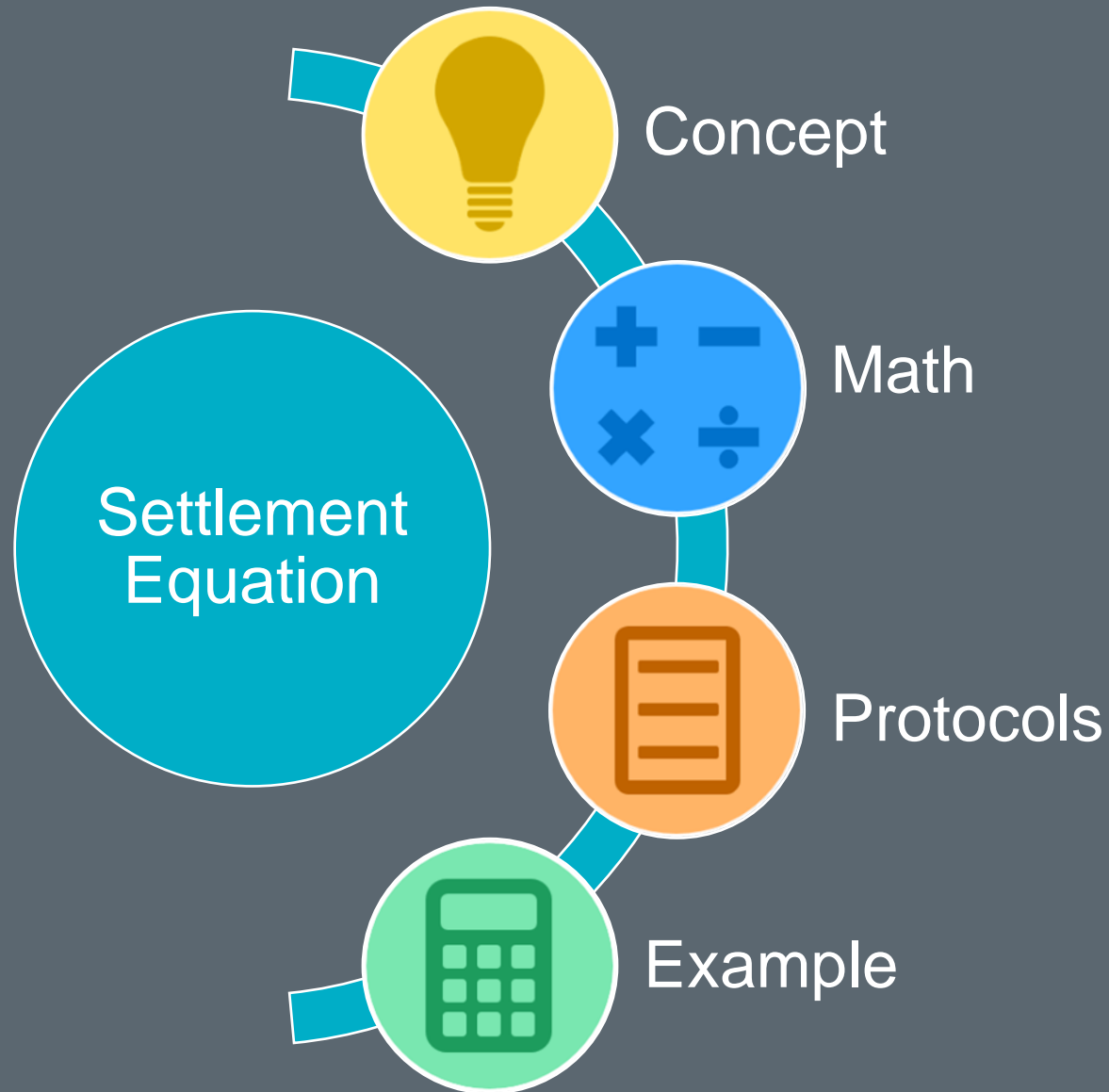
Topics in this course include:
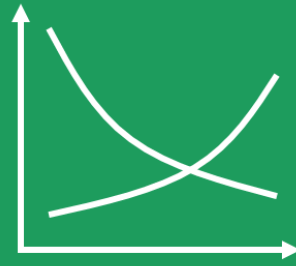
1	Ancillary Service Procurement (DAM)
2	Ancillary Service Offer (DAM)
3	Supplemental Ancillary Services Market (SASM)
4	Ancillary Service Adjustment Costs
5	Real-Time Ancillary Service Imbalance

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
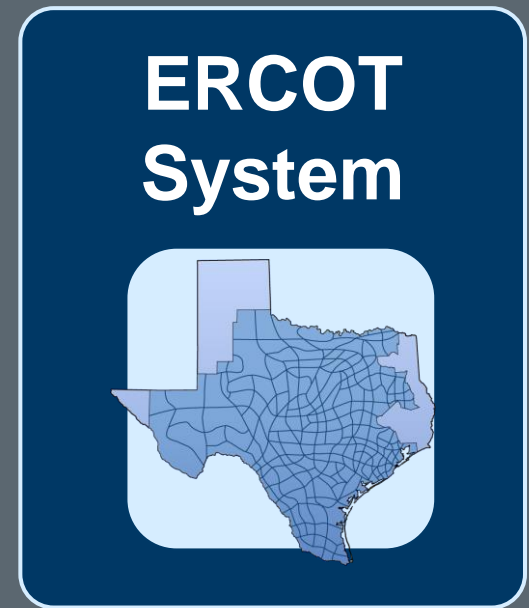
Where is the Payment or the Charge to the QSE (-/+)?
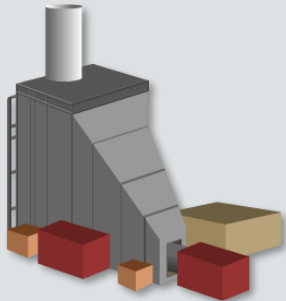

DAM

QSE

Real-Time
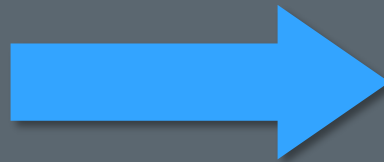
Ancillary Service Procurement

ERCOT allocates Ancillary Service Plan
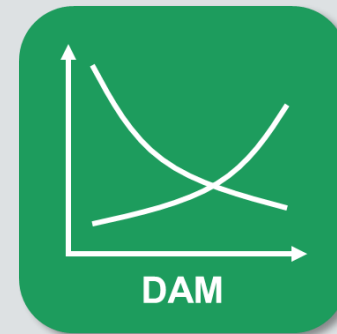
QSE chooses how to fulfill

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

DA<u>RU</u>AMT = **D**ay-**A**head **R**eg-**U**p **Am**oun**t**

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

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

|	
DA<u>RU</u>PR	**D**ay-**A**head **R**eg-**U**p **P**rice
DA<u>RU</u>Q	**D**ay-**A**head **R**eg-**U**p **Q**uantity
DA<u>RU</u>O	**D**ay-**A**head **R**eg-**U**p **O**bligation
DASA<u>RU</u>Q	**D**ay-**A**head **S**elf-**A**rranged **R**eg-**U**p **Q**uantity
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**

Ancillary Service Offer

Ancillary Service Offers

DAM

Hourly Awards

Hourly Prices
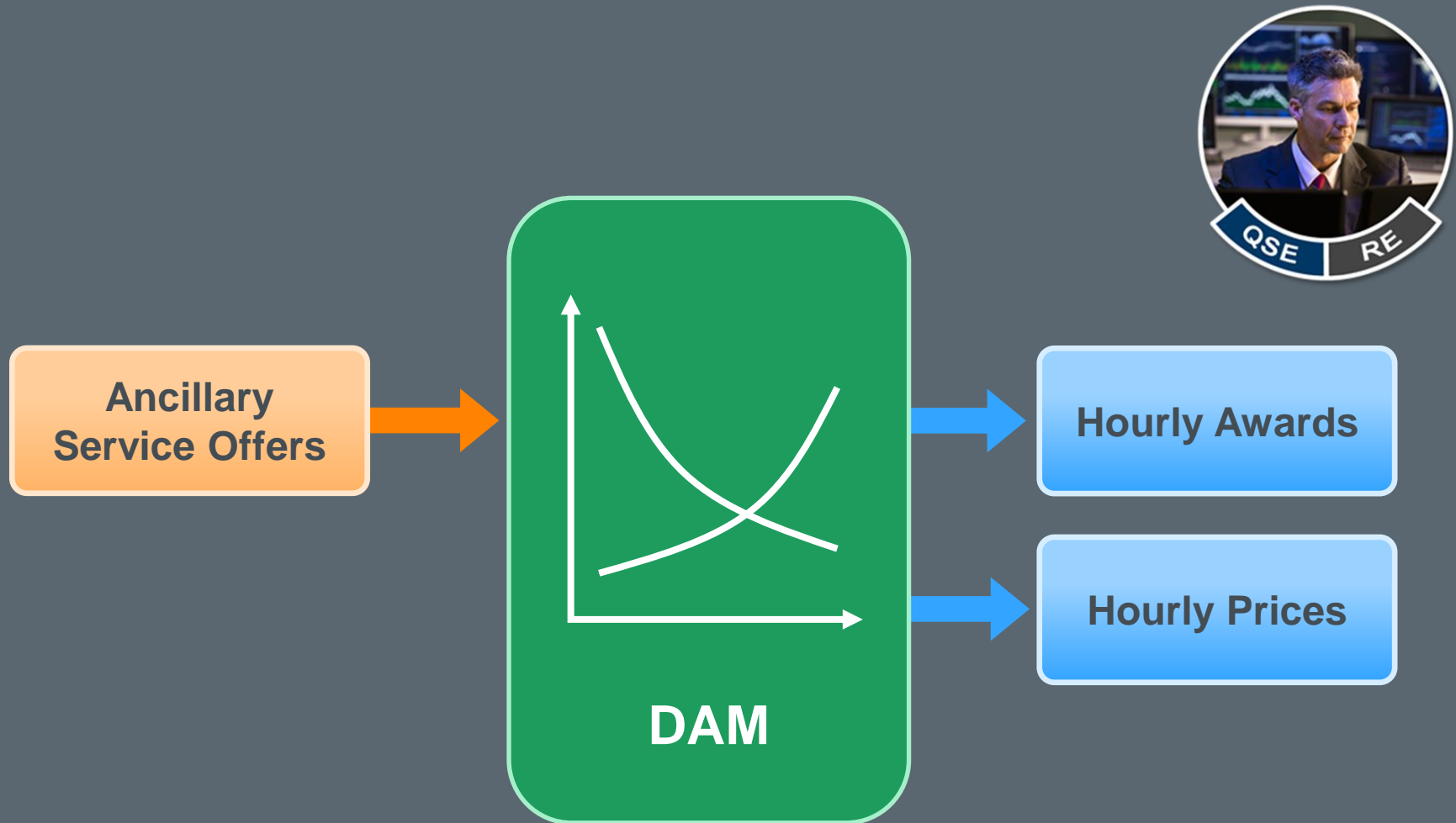
Awarded ERCOT Contingency Reserve Offer

- **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

PCECRAMT = Procured Capacity for ERCOT Contingency Reserve Service Amount

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

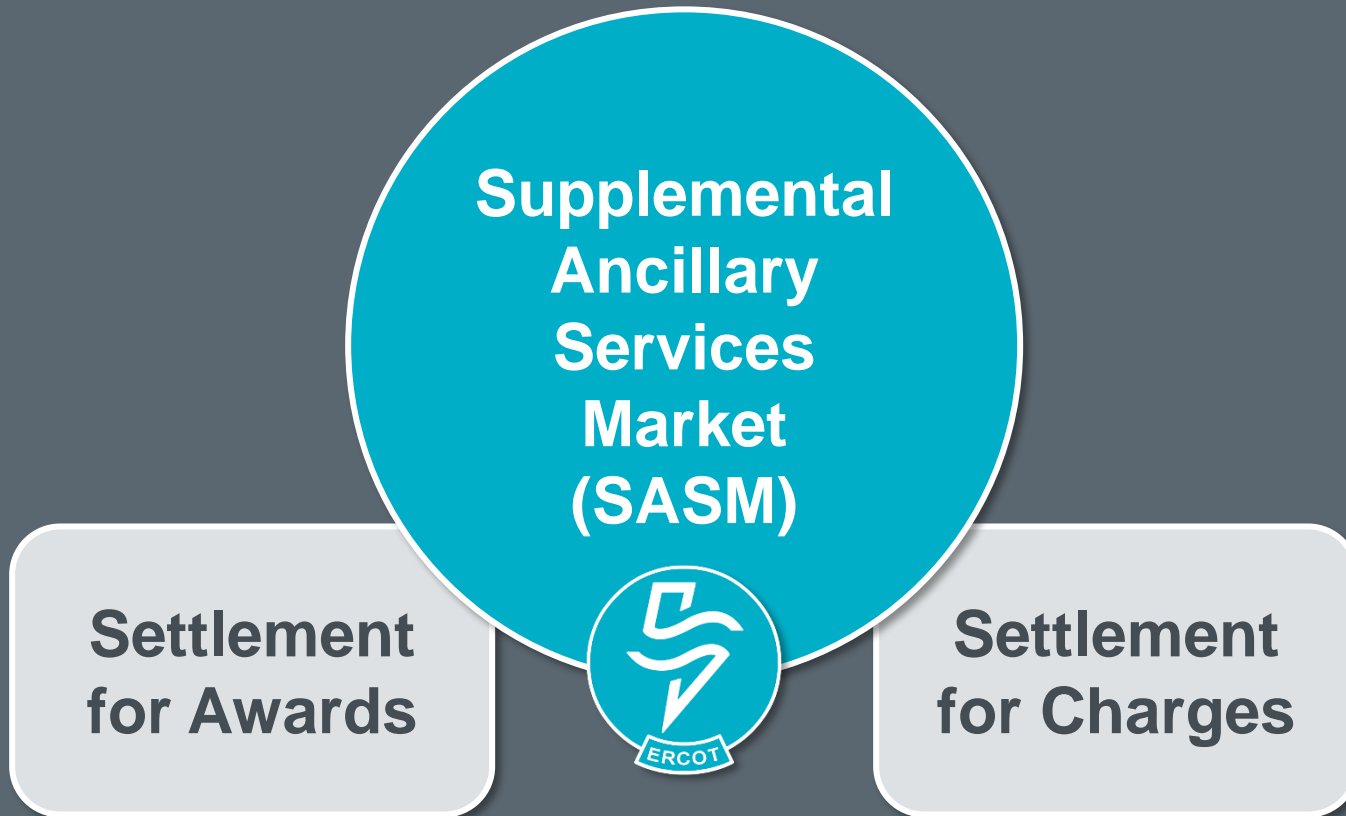|	
MCPCECR	Market Clearing Price Capacity ERCOT Contingency Reserve
PCECR	Procured Capacity ERCOT Contingency Reserve
q, DAM	QSE, Day-Ahead Market

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**

Supplemental Ancillary Services Market (SASM) → **Hourly Prices**

Real-Time

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

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

Real-Time

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

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

Real-Time

Charge = Max Price of AS Markets

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**

NS Failure = Max (NS Price) * Quantity

NS Failure = $3000/MW * 25MW

$75,000 for NS Failure Quantity for the hour

Real-Time

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NSFQAMT = Non-Spin Failure Quantity Amount

$$NSFQAMT_q = Max_m (MCPCNS_m) * NSFQ_q$$

Real-Time

MCPCNS	Market Clearing Price Capacity Non-Spin
NSFQ	Non-Spin Failure Quantity
q, m	QSE, AS Market (DAM or SASM)

Settle ERCOT Contingency Reserve Failure

- **Quantity = 29MW ECR for Hour 18**

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

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

Real-Time

Infeasible Ancillary Service

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

Charge = DAM Price

Real-Time

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

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RUINFQAMT = Reg-Up Infeasible Quantity Amount

$$RUINFQAMT_q = MCPCRU_{DAM} * RUINFQ_q$$

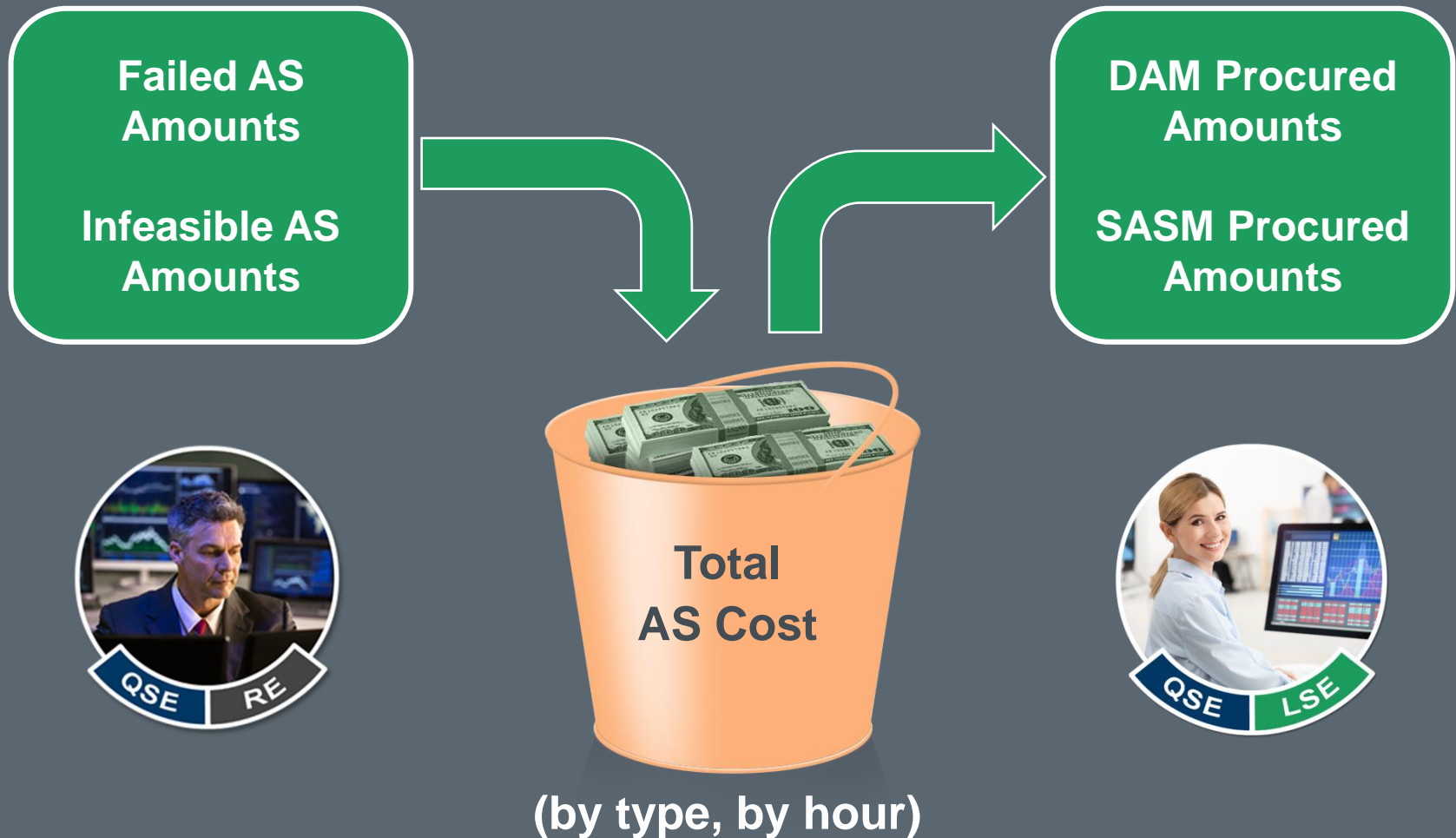| MCPCRU	Market Clearing Price Capacity Reg-Up
RUINFQ	Reg-Up Infeasible Quantity
q, DAM	QSE, Day-Ahead Market

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)

QSE RE

QSE LSE

Real-Time

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

QSE LSE

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

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

Real-Time

Obligation Allocated
(by type, by hour)

QSE LSE

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

Where …

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

Total Responsive Reserve Costs

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

QSE Obligation
$= \sum_{\text{QSEs}}$ **(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

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

RTRRAMT = Real-Time Responsive Reserve Amount

$$RTRRAMT_q = RRCOST_q - DARRAMT_q$$

Real-Time

RRCOST	Responsive Reserve Cost
DARRAMT	Day-Ahead Responsive Reserve Amount
q	QSE

Settle Real-Time Non-Spin Reserve Amount

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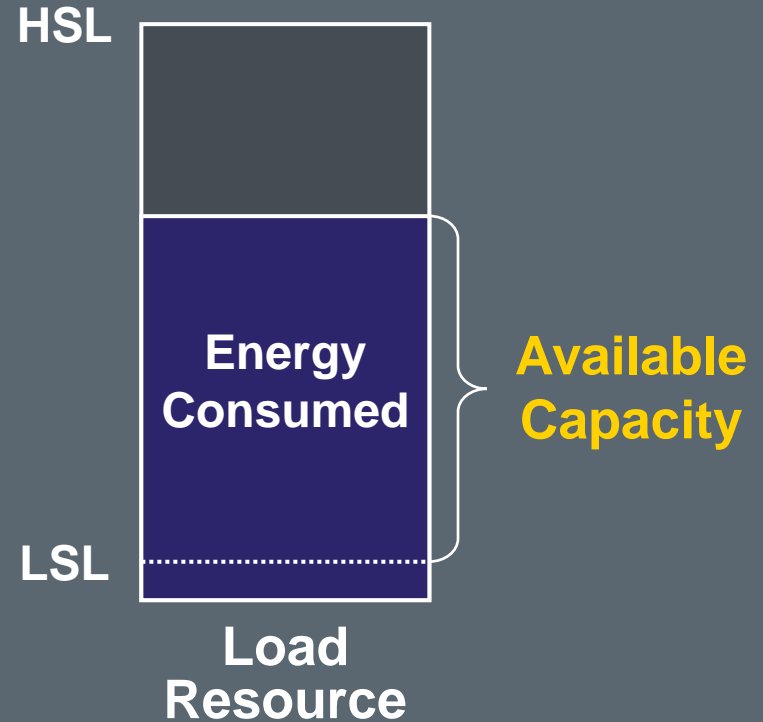- **DAM NS Amount for QSE = $1300 for Hour 7**

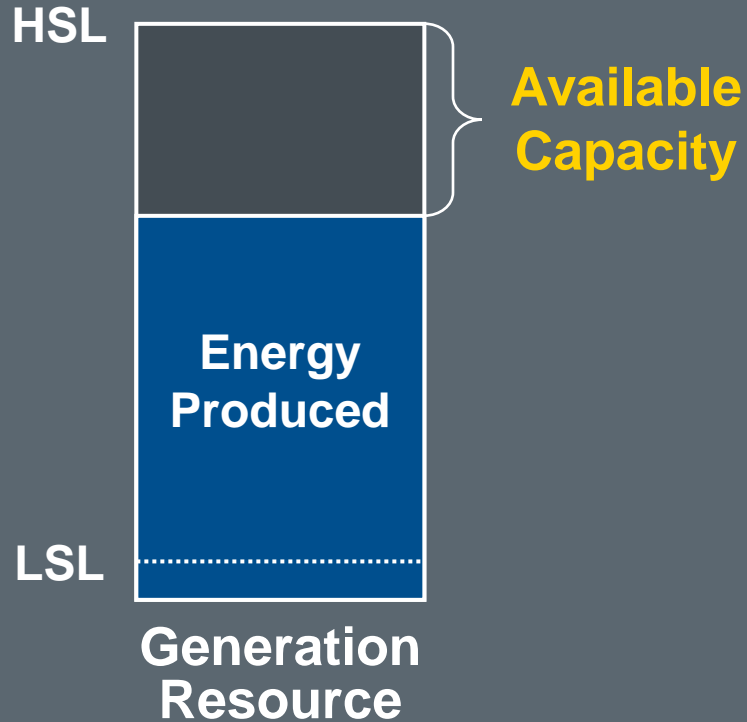# Real-Time Ancillary Service Imbalance

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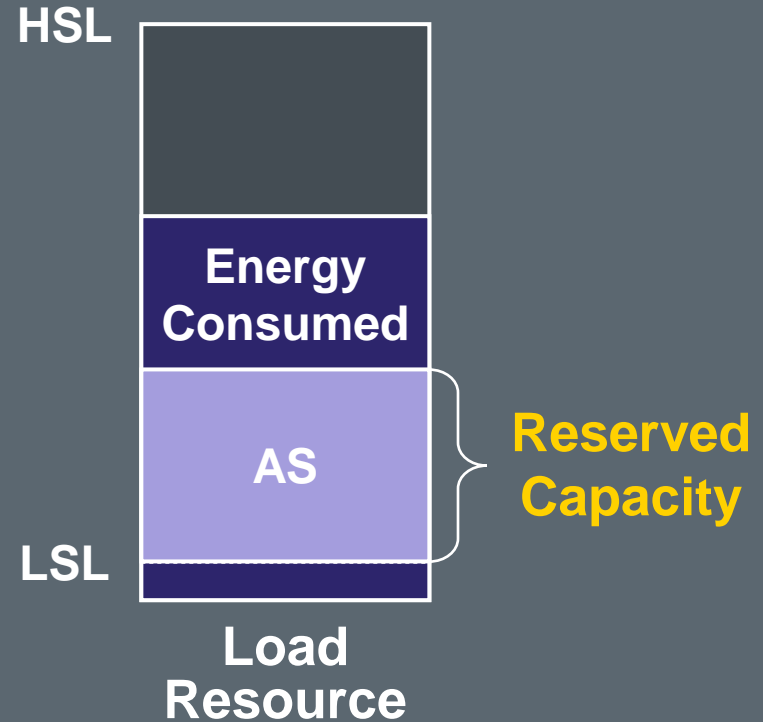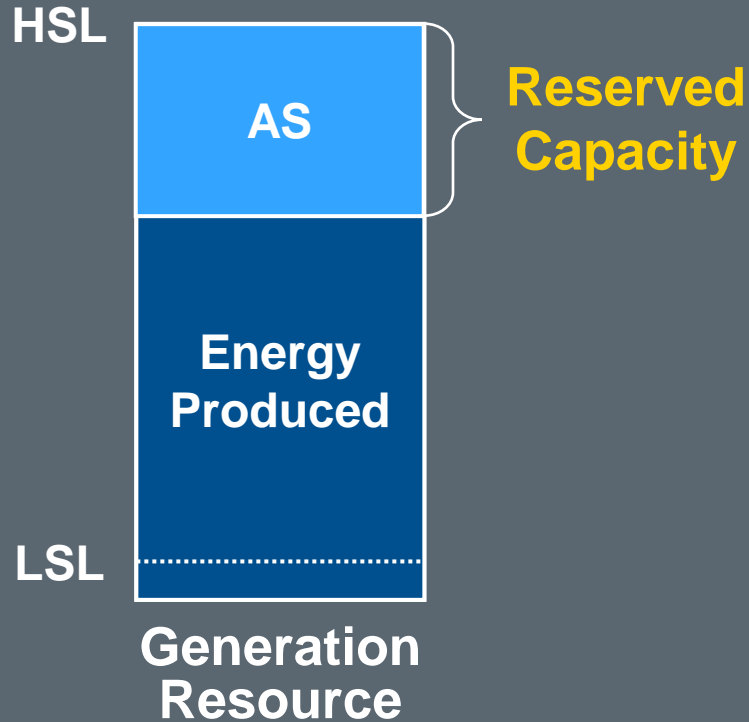
$$= (-1) \left[\left(\text{On-Line Reserve SUPPLIES} - \text{On-Line Reserve OBLIGATIONS} \right) * \text{On-line Reserve Price} \right.$$

$$\left. + \left(\text{Off-Line Reserve SUPPLIES} - \text{Off-Line Reserve OBLIGATIONS} \right) * \text{Off-line Reserve Price} \right]$$

Real-Time
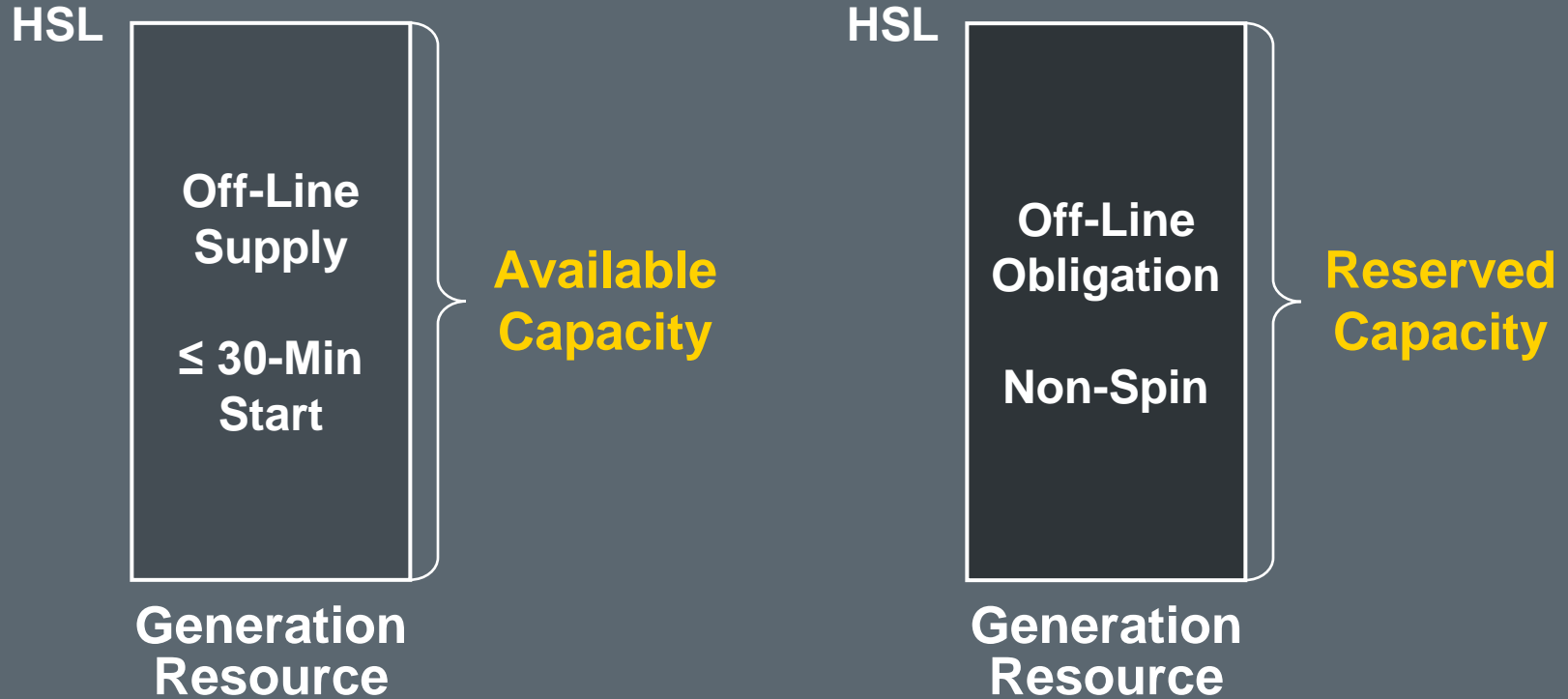
Online Reserve Supplies

HSL

Available Capacity

Energy Produced

LSL

Generation Resource

HSL

Energy Consumed

Available Capacity

LSL

Load Resource

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
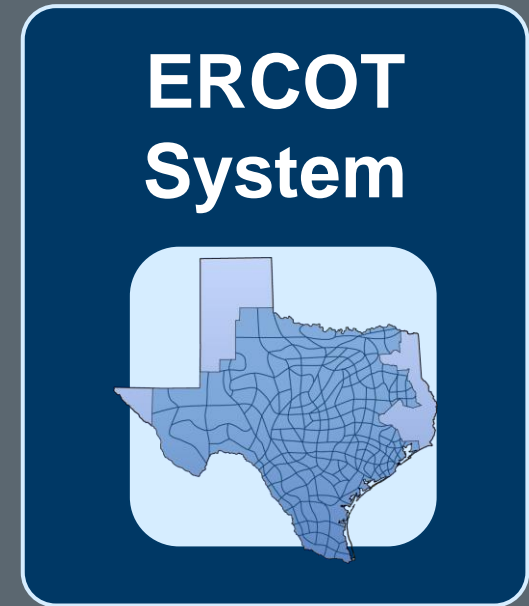
ERCOT System

Adders are produced for each SCED interval

Real-Time

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 **Of**f-Line Reserves

ERCOT System

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

Real-Time
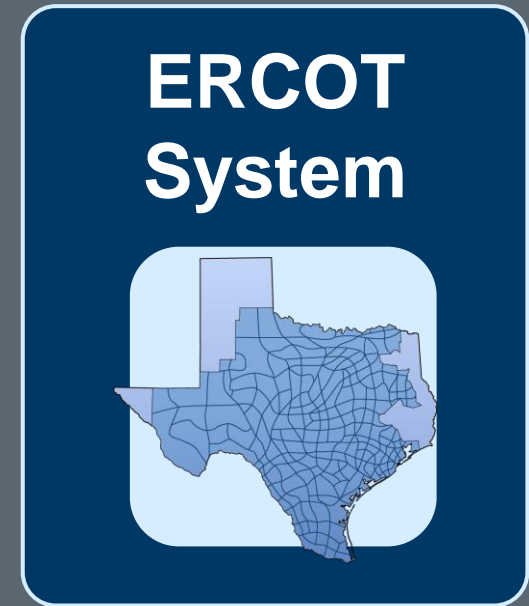
Calculated ERCOT-wide per QSE

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

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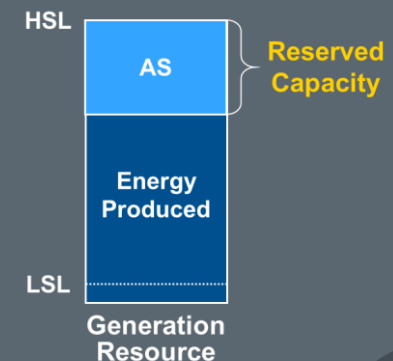
Real-Time

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On-Line Supply = On-Line Capacity

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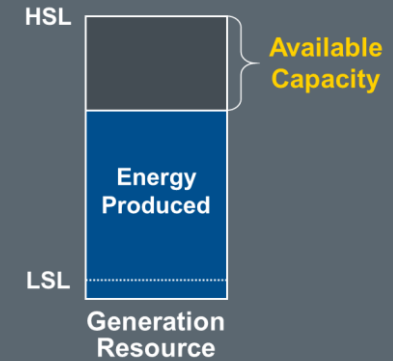
On-Line Obligations = On-Line AS

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

Off-Line Supply = Off-Line Capacity

- **Generation Resources with 30-Min Cold Start**

- **Generation Resources with NS Schedule**

- **Load Resources with NS Schedule**

HSL

Off-Line Supply

≤ 30-Min Start

Available Capacity

Generation Resource
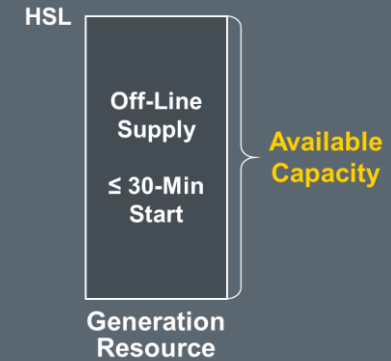
Off-Line Obligations = Off-Line AS

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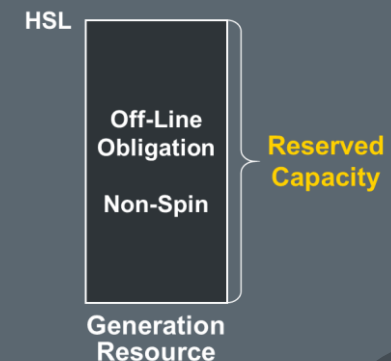
- **Load Resources with NS Responsibility**

HSL

Off-Line Obligation

Non-Spin

Reserved Capacity

Generation Resource

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 On-Line Imbalance = HSL – Metered Gen

AS On-Line Imbalance = 50MWh – 40MWh

10MWh for the interval

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

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

Where: $RTASOLIMB_q = RTOLCAP_q - [(RTASRESP_q * \frac{1}{4})$
$- RTASOFF_q - RTCLRNSRESP_q - RTNCLRNSRESP_q]$

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
RTCLRNSRESP	Real-Time Controllable Load Resource NS Responsibility
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$_q$ + RTCLRNSRESP$_q$ + RTNCLRNSRESP$_q$)

Where: RTOFFCAP$_q$ = RTCST30HSL$_q$ + RTOFFNSHSL$_q$ + RTCLRNS$_q$ + RTNCLRNSCAP$_q$

RTOFFCAP	Real-Time Off-Line Reserve Capacity
RTASOFF	Real-Time AS Schedule for Off-Line Generation Resource
RTCLRNSRESP	Real-Time Controllable Load Resource NS Responsibility
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
RTCLRNS	Real-Time Controllable Load Resource NS Schedule
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
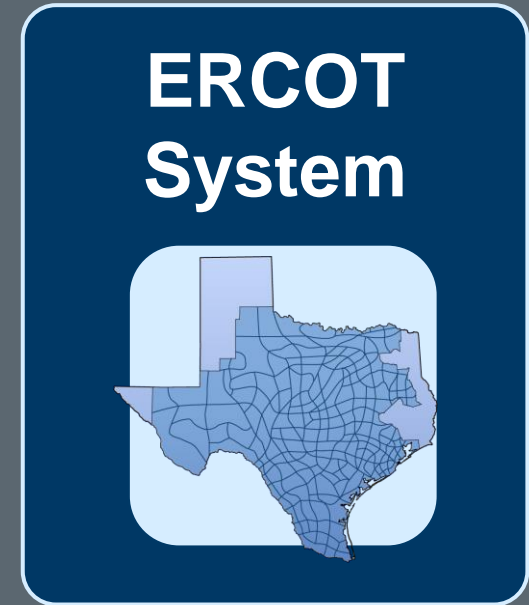- RR commitment of 20MW for Hour 9
- On-line Reserve Price = $25/MWh

Real-Time

Real-Time Reliability Deployment Ancillary Service Imbalance

Calculated ERCOT-wide per QSE

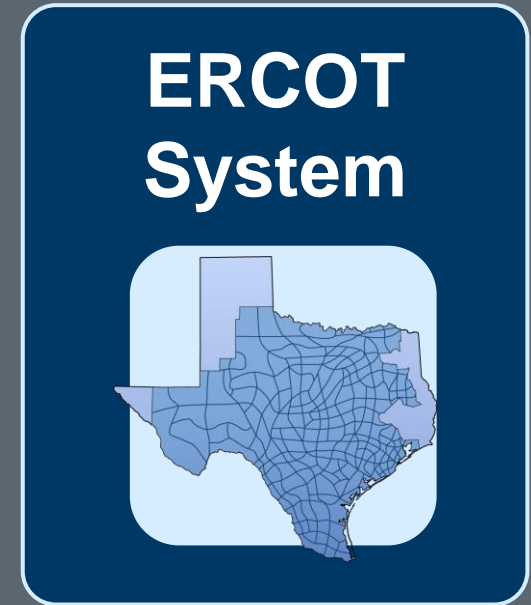$$= (-1) * \left[\textit{Ancillary Service On-Line Reserve Imbalance} \right] * \textbf{On-line Reliability Price}$$

Real-Time

RTORDPA = Real-Time On-Line Reliability Deployment Price Adder

ERCOT System

Adders are produced for each SCED interval

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

ERCOT System

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

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RTRDASIAMT = Real-Time Reliability Deployment Ancillary Service Imbalance Amount

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

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
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