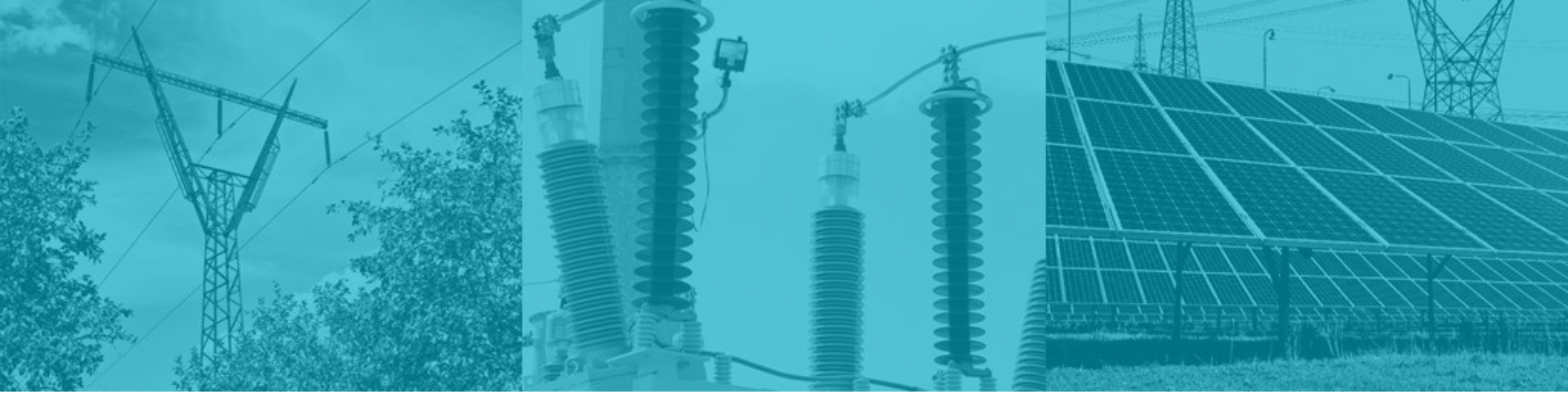


ERCOT Market Education

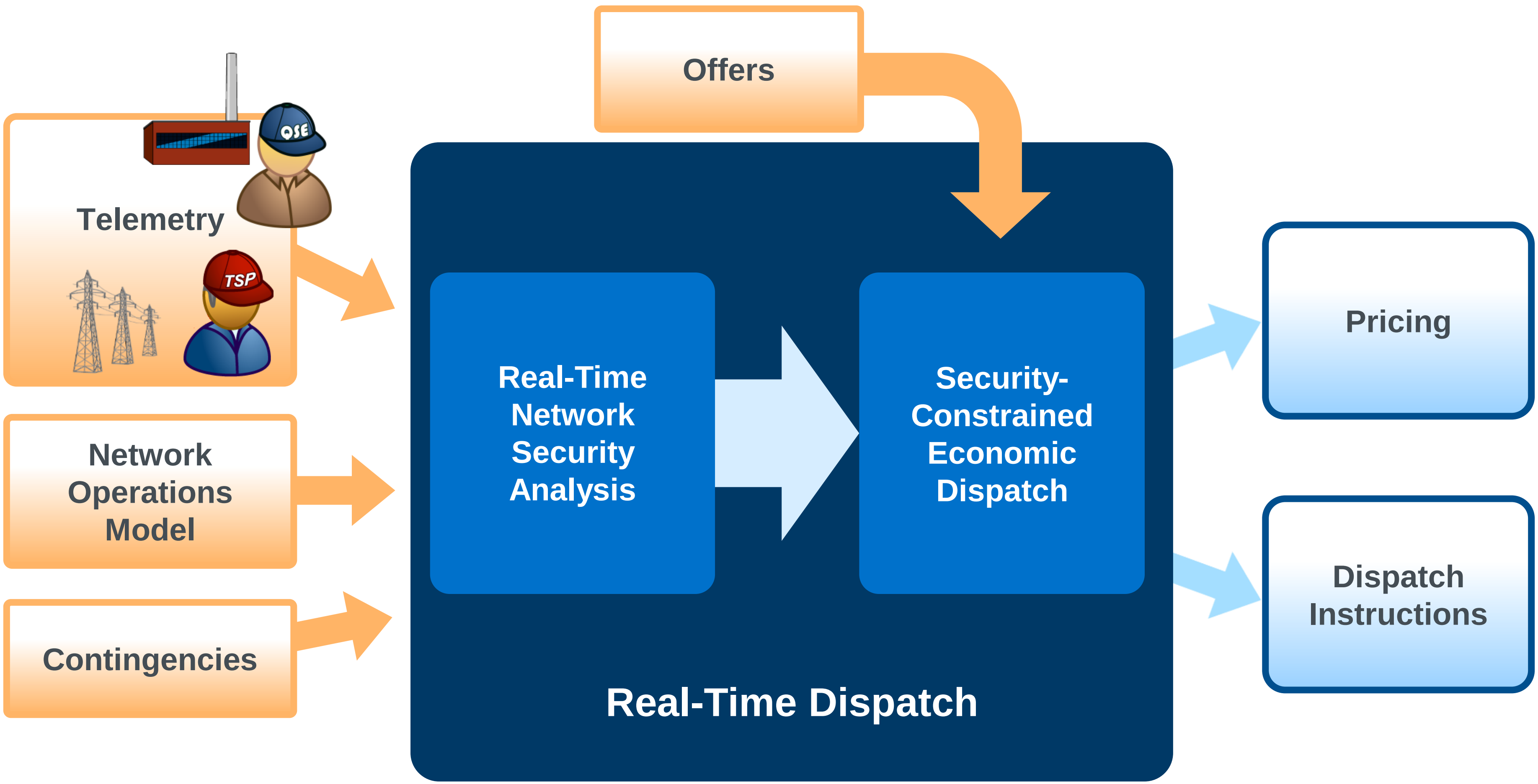
Settlements 301

Module 6: Real-Time Operations

Purpose of Real-Time Operations

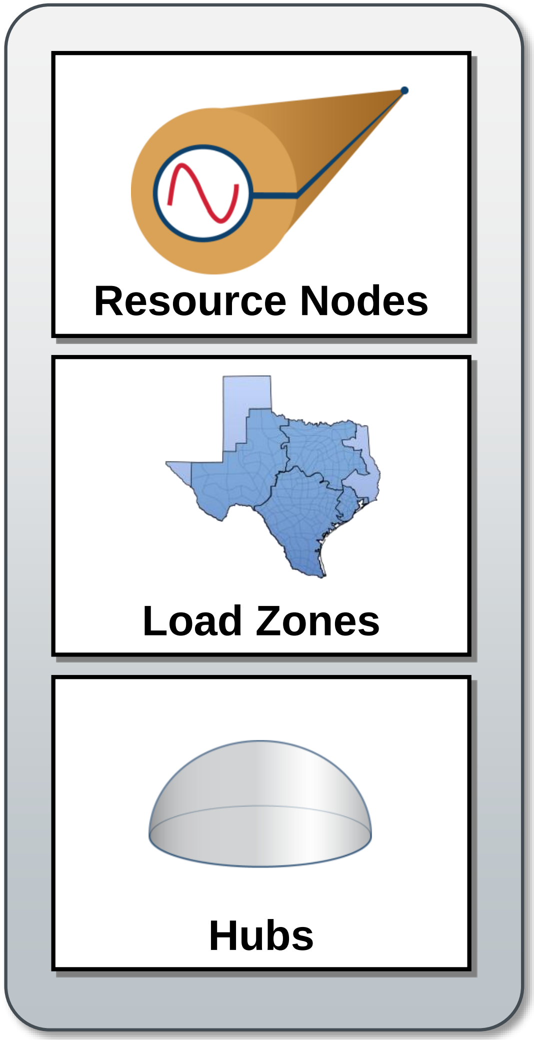
- Manage reliability
  - Match generation with demand
  - Operate transmission system within established limits
- Operate the system at least cost

Security Constrained Economic Dispatch



Locational Marginal Prices (LMPs)

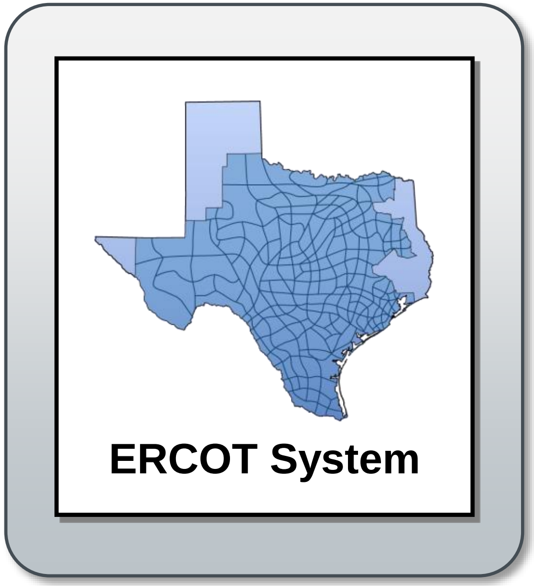
- Produced by SCED
- Combined with Reserve Price Adders to form Real-Time Settlement Point Prices



LMPs are location-specific. Reserve Price Adders represent the value of reserves ERCOT-wide.

Real-Time Reserve Price Adders

- Produced outside of SCED
- Two flavors:
  - **RTORPA** – On-line Reserves
  - **RTOFFPA** – Off-line Reserves



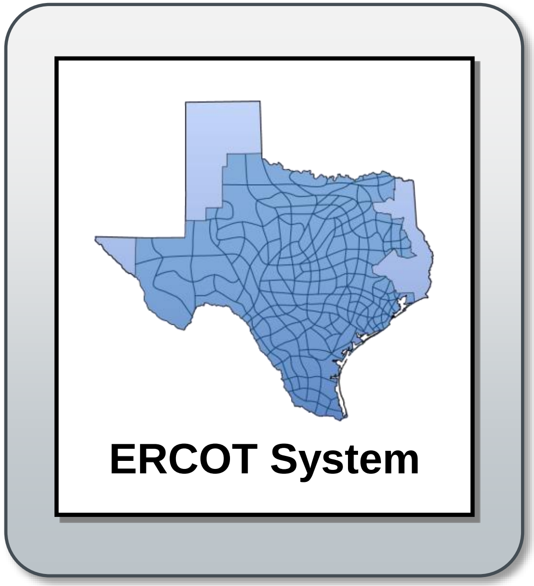
… for each SCED interval

RTORPA	**Real-Time On-Line Reserve Price Adder**
RTOFFPA	**Real-Time Off-Line Reserve Price Adder**

Real-Time Reserve Price Adders

RTRSVPOR = Time-Weighted Average (**RTORPAs**)

RTRSVPOFF = Time-Weighted Average (**RTOFFPAs**)



… for each 15-minute interval

RTRSVPOR	Real-Time Reserve Price for On-Line Reserves
RTRSVPOFF	Real-Time Reserve Price for Off-Line Reserves

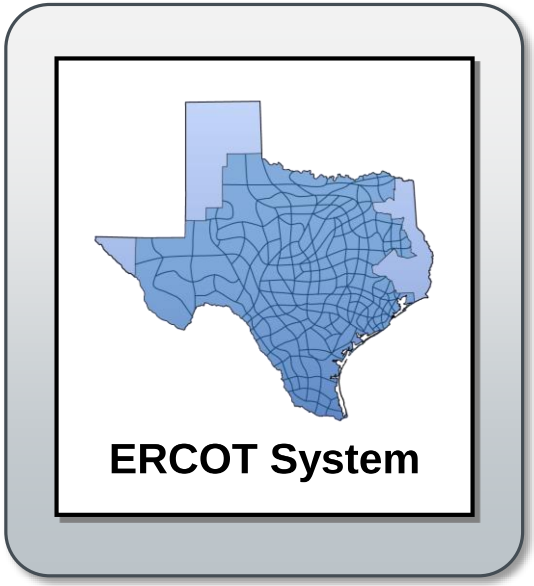
ERCOT added a Reliability Deployment Price Adder on June 1, 2015

- Reliability deployments suppress Real-Time prices
- Price Adder reverses price suppression

Reliability deployments include RUC, Emergency Response Service (ERS), RMR and Load Resources

Reliability Deployment Price Adder

RTORDPA – Captures impact of reliability deployments during SCED Interval



RTRDP = **Time-Weighted Average** (**RTORDPAs**)

… for each 15-minute interval

RTORDPA	**Real-Time On-Line Reliability Deployment Price Adder**
RTRDP	**Real-Time On-Line Reliability Deployment Price**

Settlement Point Prices:

Average (LMPs)

+

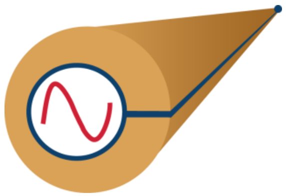
RTRSVPOR

+

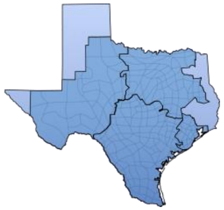
RTRDP

… for each 15-minute interval

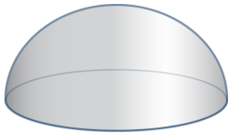
The way the LMPs are averaged varies by Settlement Point



Resource Nodes



Load Zones



Hubs

Real-Time

Real-Time Activities
- Imbalances
- Base Point Deviations
- Other odds & ends

Settlement of PTP Obligations purchased in the DAM

Real Time Ancillary Service Settlements

Revenue Neutrality

Real-Time

Real-Time Activities
- Imbalances
- Base Point Deviations
- Other odds & ends

Fundamentals of Real–Time Energy Imbalances

Who:	All QSEs that have Generation, Load, Trades, and DAM purchases or sales at any Settlement Point
What:	A charge or payment for the imbalance of Energy at a Settlement Point
Why:	To pay or charge a QSE for their injection or withdrawal at a Settlement Point

The basic idea at any Settlement Point:

$$(-1)\left[\left(\quad \textit{SUPPLIES} \quad\right)-\left(\textit{OBLIGATIONS}\right)\right] * \text{RTSPP}$$

Now, we simply fill in the appropriate elements for each Settlement Point

Real-Time Energy Imbalance at a Hub:

$$(-1)\left[\left(\begin{array}{c}\text{DAM Energy Purchases}\\ +\\ \text{Trade Energy Purchases}\end{array}\right)-\left(\begin{array}{c}\text{DAM Energy Sales}\\ +\\ \text{Trade Energy Sales}\end{array}\right)\right] * \text{RTSPP}$$

At a Hub

RTSPP is used to settle financial transactions

RTSPP = RTRSVPOR + RTRDP + Simple & Time-Weighted Average (LMPs)

RTSPP	Real-Time Settlement Point Price
RTRSVPOR	Real-Time Reserve Price for On-Line Reserves
RTRDP	Real-Time On-Line Reliability Deployment Price

Real-Time Energy Imbalance at a Load Zone:

$$(-1)\left[\left(\begin{array}{c}\text{DAM Energy Purchases}\\ +\\ \text{Trade Energy Purchases}\end{array}\right)-\left(\begin{array}{c}\text{DAM Energy Sales}\\ +\\ \text{Trade Energy Sales}\end{array}\right)\right] * \text{RTSPP}$$

$$+\ (-1)\left(\begin{array}{c}\text{Non-Modeled}\\ \text{Generation}\end{array} - \begin{array}{c}\text{Adjusted}\\ \text{Metered Load}\end{array}\right) * \text{RTSPPEW}$$

At a Load Zone,

RTSPP is used to settle financial transactions

RTSPP = RTRSVPOR + RTRDP + MW-Weighted & Time-Weighted Average (LMPs)

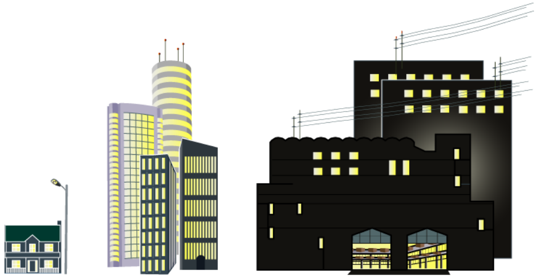
RTSPP	Real-Time Settlement Point Price
RTRSVPOR	Real-Time Reserve Price for On-Line Reserves
RTRDP	Real-Time On-Line Reliability Deployment Price

At a Load Zone,

RTSPPEW is used to settle physical energy consumption

$$RTSPPEW = RTRSVPOR + RTRDP + \underset{\text{Weighted Average}}{(MW * Time)} \left(LMPs \right)$$

RTSPPEW	Real-Time Settlement Point Price Energy-Weighted
RTRSVPOR	Real-Time Reserve Price for On-Line Reserves
RTRDP	Real-Time On-Line Reliability Deployment Price



Real-Time Energy Imbalance at a Resource Node:

$$(-1)\left[\begin{pmatrix}\text{DAM Energy Purchases}\\ +\\ \text{Trade Energy Purchases}\end{pmatrix} - \begin{pmatrix}\text{DAM Energy Sales}\\ +\\ \text{Trade Energy Sales}\end{pmatrix}\right] * \text{RTSPP}$$

$$+ \; (-1)\left(\text{Metered Generation}\right) * \text{RTRMPR}$$

At a Resource Node,

RTSPP is used to settle financial transactions

$$\text{RTSPP} = \text{RTRSVPOR} + \text{RTRDP} + \underset{\text{Average}}{\text{Time-Weighted}} \left(\text{LMPs} \right)$$

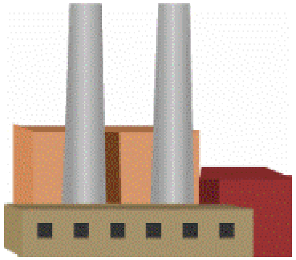
RTSPP	Real-Time Settlement Point Price
RTRSVPOR	Real-Time Reserve Price for On-Line Reserves
RTRDP	Real-Time On-Line Reliability Deployment Price

At a Resource Node,

RTRMPR is used to settle physical energy production

RTRMPR = RTRSVPOR + RTRDP + (Base-Point * Time) Weighted Average [LMPs]

RTRMPR	Real-Time Resource Meter Price
RTRSVPOR	Real-Time Reserve Price for On-Line Reserves
RTRDP	Real-Time On-Line Reliability Deployment Price

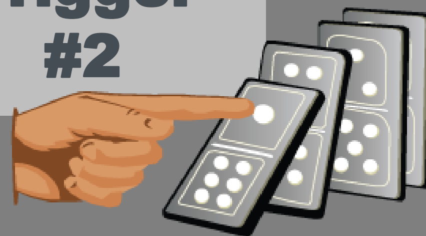


Real-Time Energy: Triggers

Trigger #1

A QSE has Trades, DAM bids or DAM offers at a Hub

Trigger #2



A QSE has Generation, Load, Trades, DAM bids or DAM offers at a Load Zone

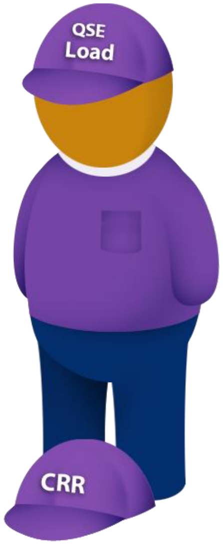
Trigger #3

A QSE has Generation, Trades, DAM bids or DAM offers at a Resource Node

Outcome #1

QSE3

- 8MW DAM Energy Sale (2MWh)
- 12 MW DAM Energy Purchase (3MWh)
- Settlement Point Price is $40/MWh at Hub1



(-1) * Price * (Supplies – Obligations)

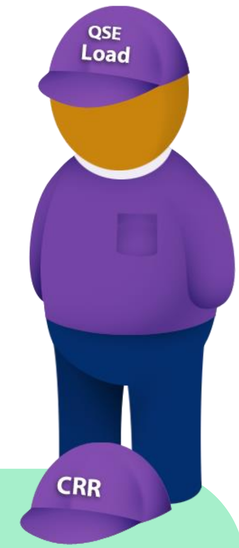
(-1) * $40/MWh * (3MWh – 2MWh) = -$40

Supplies		Obligations	
DAEP	**D**AM **E**nergy **P**urchase	DAES	**D**AM **E**nergy **S**ale
RTQQEP	**R**eal-Time **Q**SE to **Q**SE **E**nergy **P**urchase (Trade)	RTQQES	**R**eal-Time **Q**SE to **Q**SE **E**nergy **S**ale (Trade)

Outcome #1

QSE3

- 8MW DAM Energy Sale (2MWh)
- 12 MW DAM Energy Purchase (3MWh)
- Settlement Point Price is $40/MWh at Hub1



$$\mathrm{RTEIAMT}_{q,\,p} = (-1) * \mathrm{RTSPP}_{p} * \{(\mathrm{DAEP}_{q,\,p} * \tfrac{1}{4})) + (\mathrm{RTQQEP}_{q,\,p} * \tfrac{1}{4}) - (\mathrm{DAES}_{q,\,p} * \tfrac{1}{4}) - (\mathrm{RTQQES}_{q,\,p} * \tfrac{1}{4})\}$$

$$-\$40 = (-1) * \$40/\mathrm{MWh} * \{(12\mathrm{MW} * \tfrac{1}{4})\ ) + (0\mathrm{MW} * \tfrac{1}{4}) - (8\mathrm{MW} * \tfrac{1}{4}) - (0\mathrm{MW} * \tfrac{1}{4})\}$$

Refer to your Settlements Workbook

In a small group, respond to the questions that relate to Scenario #RT1.

You have 5 minutes to complete your questions.

If you cannot complete all questions, don’t worry – all questions will be reviewed as a class.

Trigger #1

A QSE has Trades, DAM bids or DAM offers at a Hub

Trigger #2

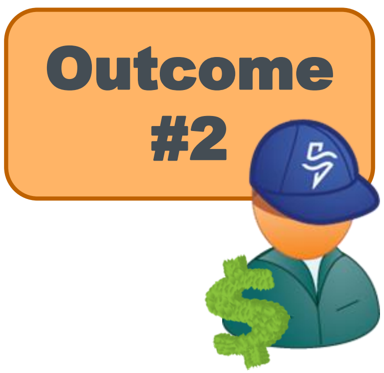
A QSE has Generation, Load, Trades, DAM bids or DAM offers at a Load Zone

Trigger #3

A QSE has Generation, Trades, DAM bids or DAM offers at a Resource Node

At a Load Zone a QSE may have:

- Metered Load
- Non-Modeled Generation
- Trades
- DAM Bids & DAM Offers



If a QSE has…	The QSE will receive…
Net Supply	**Payment**
Net Obligation	**Charge**

Don't forget: *Load Zone has two prices*

Translated into a Settlement Equation,

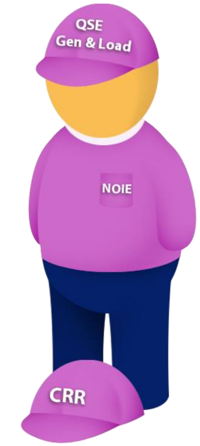
$$\mathrm{RTEIAMT}_{q,p} = (-1) * \{[\mathrm{RTSPP}_{p} * [(\mathrm{DAEP}_{q,p} * ¼) + (\mathrm{RTQQEP}_{q,p} * ¼) - (\mathrm{DAES}_{q,p} * ¼) - (\mathrm{RTQQES}_{q,p} * ¼)]] + [\mathrm{RTSPPEW}_{p} * (\mathrm{RTMGNM}_{q,p} - \mathrm{RTAML}_{q,p})]\}$$

Supplies		Obligations	
DAEP	**DA**M **E**nergy **P**urchase	DAES	**DA**M **E**nergy **S**ale
RTQQEP	**R**eal-**T**ime **Q**SE to **Q**SE **E**nergy **P**urchase (Trade)	RTQQES	**R**eal-**T**ime **Q**SE to **Q**SE **E**nergy **S**ale (Trade)
RTMGNM	**R**eal-**T**ime **M**etered **G**eneration **N**on-**M**odeled	RTAML	**R**eal-**T**ime **A**djusted **M**etered **L**oad

Outcome #2

QSE4

- Has a 12MW DAM Energy Purchase (3MWh)
- Purchased 20MW through a Trade (5MWh)
- Has Load at LZ3 of 10MWh
- The RTSPP is $100/MWh at LZ3
- The RTSPPEW is $101/MWh at LZ3



$$\mathrm{RTEIAMT}_{q,\,p} = (-1) * \{[\mathrm{RTSPP}_{p} * [(\mathrm{DAEP}_{q,\,p} * ¼) + (\mathrm{RTQQEP}_{q,\,p} * ¼) - (\mathrm{DAES}_{q,\,p} * ¼) - (\mathrm{RTQQES}_{q,\,p} * ¼)]] + [\mathrm{RTSPPEW}_{p} * (\mathrm{RTMGNM}_{q,\,p} - \mathrm{RTAML}_{q,\,p})]\}$$

$$\$210 = (-1) * \{[\$100/\mathrm{MWh} * [(12\mathrm{MW} * ¼) + (20\mathrm{MW} * ¼) - (0\mathrm{MW} * ¼) - (0\mathrm{MW} * ¼)]] + [\$101/\mathrm{MWh} * (0\mathrm{MW} - 10\mathrm{MWh})]\}$$

Refer to your Settlements Workbook

In a small group, respond to the questions that relate to Scenario #RT2.

You have 10 minutes to complete your questions.

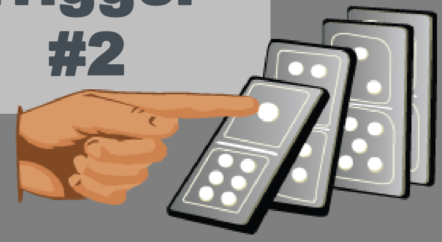
If you cannot complete all questions, don’t worry – all questions will be reviewed as a class.

Real-Time Energy: Triggers

Trigger #1

A QSE has Trades, DAM bids or DAM offers at a Hub

Trigger #2



A QSE has Generation, Load, Trades, DAM bids or DAM offers at a Load Zone

Trigger #3

A QSE has Generation, Trades, DAM bids or DAM offers at a Resource Node

Trigger #3

At a Resource Node A QSE may have:

- Metered Generation
- Trades
- DAM Bids & DAM Offers

Outcome #3

If a QSE has…	The QSE will receive…
Net Supply	**Payment**
Net Obligation	**Charge**

Don't forget: *Resource node has multiple prices*

If all Generation Sites were simple . . .

Real-Time Energy Imbalance at a Resource Node =

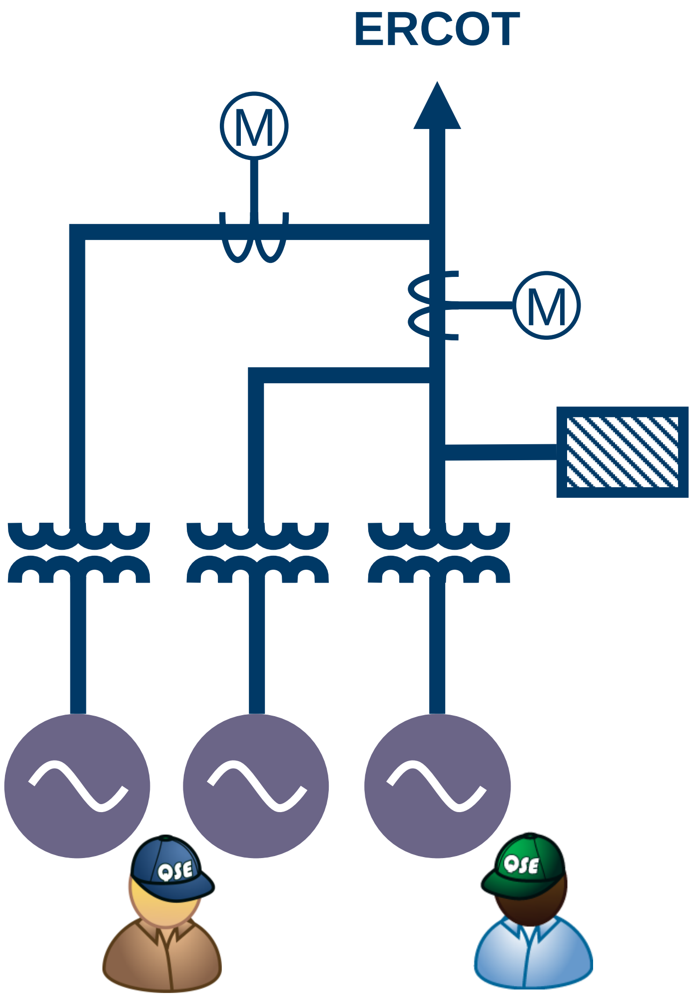
$$(-1)\left[\left(\begin{array}{c}\text{DAM Energy Purchases}\\+\\\text{Trade Energy Purchases}\end{array}\right)-\left(\begin{array}{c}\text{DAM Energy Sales}\\+\\\text{Trade Energy Sales}\end{array}\right)\right]*\ \text{RTSPP}$$

$$+\ (-1)\left(\text{Metered Generation}\right)*\ \text{RTRMPR}$$

But in reality . . .

Many Generation Sites are complex

- Multiple generators per meter
- Multiple owners
- Load and generation
- Combined Cycle Resources



ERCOT uses a single methodology to settle all Generation Sites

Introducing Net Metering . . .

Real-Time Energy Imbalance at a Resource Node =

$$(-1)\left[\begin{pmatrix}\text{DAM Energy Purchases}\\+\\\text{Trade Energy Purchases}\end{pmatrix}-\begin{pmatrix}\text{DAM Energy Sales}\\+\\\text{Trade Energy Sales}\end{pmatrix}\right]*\ \text{RTSPP}$$

$$+\ (-1)\left(\text{Splitting Percentage} * \text{Total Site Payment}\right)$$

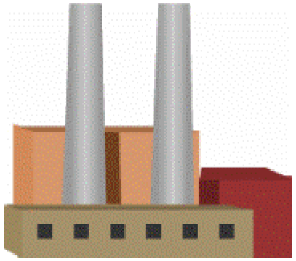
$$\text{RESREV}_{q,r} = \left(\text{Splitting Percentage} * \text{Total Site Payment} \right)$$

Splitting Percentage: GSPLITPER

- QSE's per Resource share of Total Site Payment
- Calculated from SCADA telemetry

Total Site Payment: NMSAMTTOT

- For all Resources at Site
- For all QSEs at Site

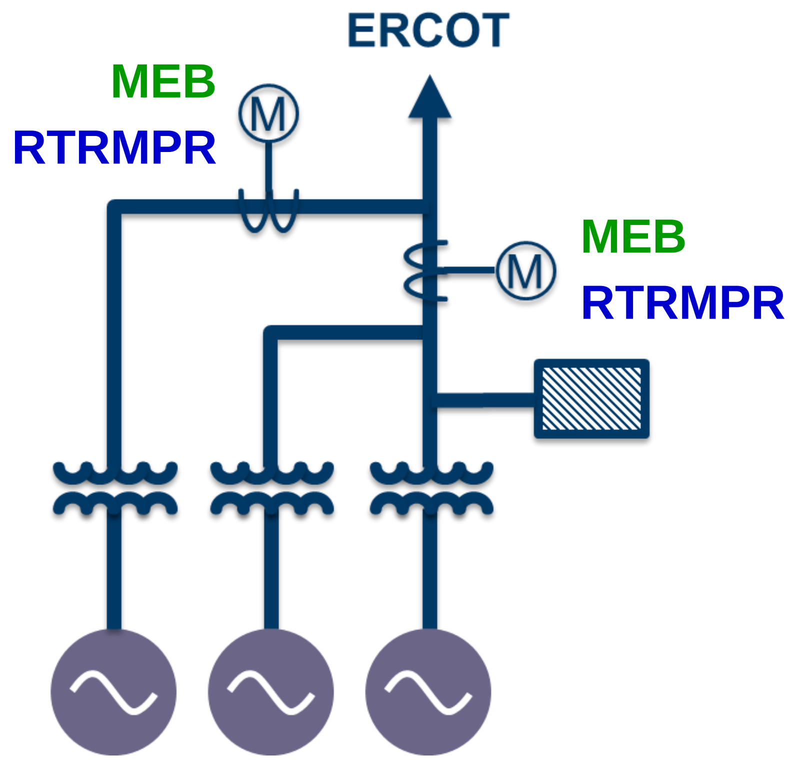


GSPLITPER	Generation Resource SCADA Splitting Percentage
NMSAMTTOT	Net Metering Site Amount Total
RESREV	Resource Share Revenue Settlement Payment for QSE

Total Site Payment:

NMSAMTTOT = ∑ (RTRMPR * MEB)

Net negative energy is settled at a Load Zone.

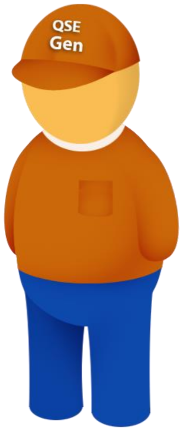


RTRMPR	**Real-Time Resource Meter Price**
MEB	**Metered Energy at Bus**

Trigger #3

QSE1

- Has one Resource with 60% of the generation at this site
- The metered energy at Bus 1 is 10MWh
- The metered energy at Bus 2 is 20MWh
- The Real Time Resource Meter Price is $30/MWh at both Bus 1 & Bus 2.



Outcome #3

Total Site Payment:

NMSAMTTOT = ∑ (RTRMPR * MEB)

= $30/MWh * (10MWh + 20MWh)

= $900

QSE1 RESREV = GSPLITPER * NMSAMTTOT

= 60% * $900

= $540

Don't forget: The Resource Node can have other transactions

$$\text{RTEIAMT}_{q,p} = (-1) * \{ \sum_{r}(\text{RESREV}_{q,r}) + \text{RTSPP}_{p} * [(\text{DAEP}_{q,p} * \tfrac{1}{4}) + (\text{RTQQEP}_{q,p} * \tfrac{1}{4}) - (\text{DAES}_{q,p} * \tfrac{1}{4}) - (\text{RTQQES}_{q,p} * \tfrac{1}{4})] \}$$

Supplies		Obligations	
DAEP	**D**AM **E**nergy **P**urchase	DAES	**D**AM **E**nergy **S**ale
RTQQEP	**R**eal-Time **Q**SE to **Q**SE **E**nergy **P**urchase (Trade)	RTQQES	**R**eal-Time **Q**SE to **Q**SE **E**nergy **S**ale (Trade)
RESREV	**Res**ource Share **Rev**enue Settlement Payment for QSE		

Refer to your Settlements Workbook

In a small group, respond to the questions that relate to Scenario #RT3.

You have 5 minutes to complete your questions.

If you cannot complete all questions, don’t worry – all questions will be reviewed as a class.

Volumetric determinants for Real-Time Energy Imbalance:

$RESMEB_q$ = GSPLITPER * ∑ MEB for Generation Site

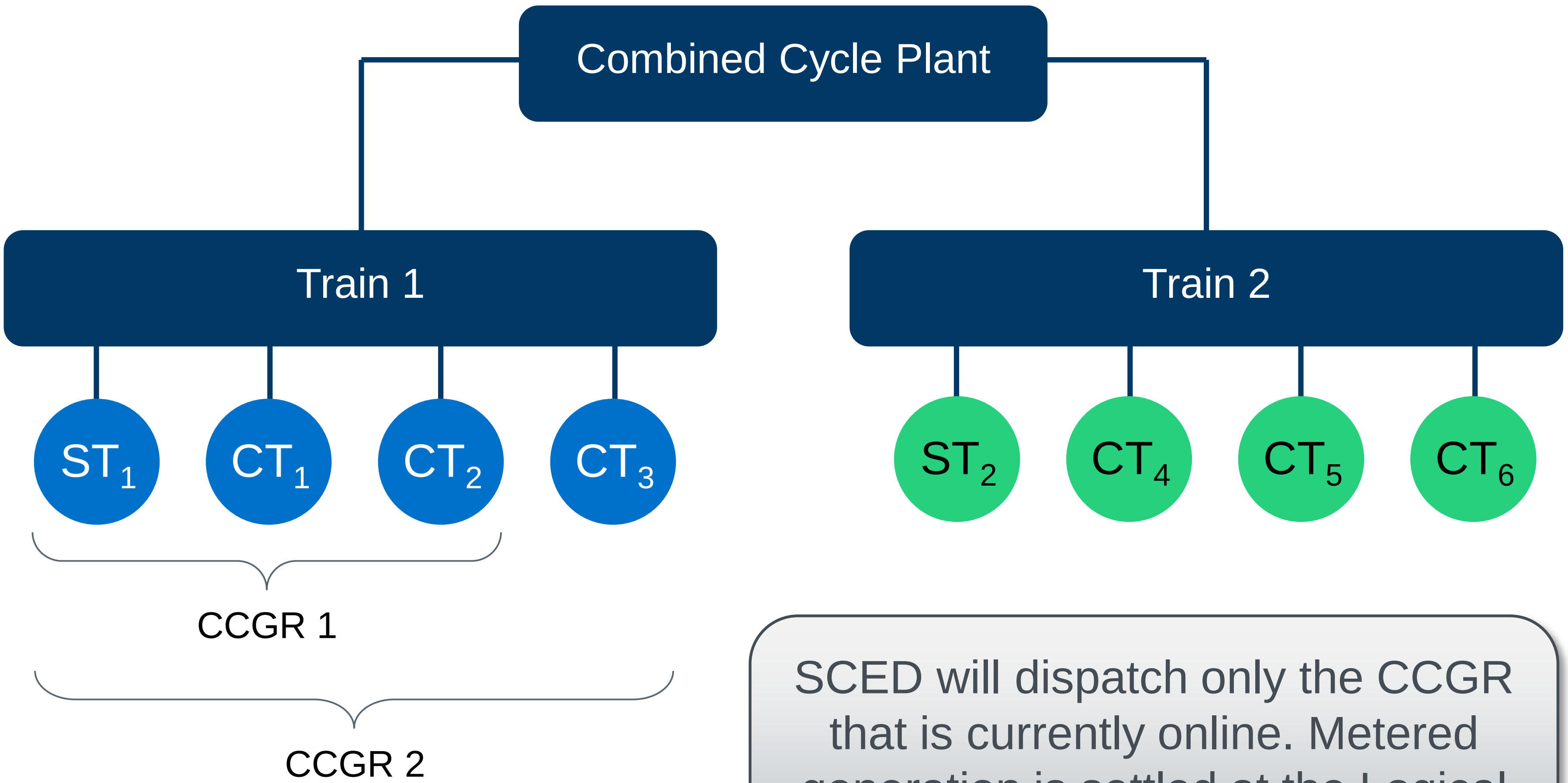
$RNIMBAL_q$ = MWh Imbalance for all transactions at Resource Node

$LZIMBAL_q$ = MWh Imbalance for all transactions at Load Zone

$HBIMBAL_q$ = MWh Imbalance for all transactions at Hub

For information only; not used in Settlements

RESMEB	Resource Share of total Metered Energy at Bus for QSE
RNIMBAL	Resource Node Energy Imbalance per QSE
LZIMBAL	Load Zone Energy Imbalance per QSE
HBIMBAL	Hub Energy Imbalance per QSE



SCED will dispatch only the CCGR that is currently online. Metered generation is settled at the Logical Resource Node.

Real-Time Energy Settlements - Combined Cycle Resources

		Resource Node	
Bill Determinant	**Description**	**Logical Resource Node**	**Physical Resource Node**
RTEIAMT	Real Time Energy Imbalance	**X**	
DAES	Day Ahead Energy Sales	**X (3PO)**	
GSPLITPER	Generation Unit Splitting Percentage	**X**	
RTEIAMT	Real Time Energy Imbalance		**X**
DAEP	Day Ahead Energy Purchase		**X**
DAES	Day Ahead Energy Sales		**X (Energy only)**
RTQQEP	Real Time QSE to QSE Purchase		**X**
RTQQES	Real Time QSE to QSE Sale		**X**

Real-Time Energy Payment for DC Tie Import

Real-Time

Real-Time Activities
- Imbalances
- Base Point Deviations
- Other odds & ends

Fundamentals of Payment for DC Tie Import

Who:	A QSE that has a DC Tie import
What:	A Payment for the Energy that is imported into the ERCOT grid through a DC Tie
Why:	When a QSE brings Power into the ERCOT grid they need to receive a payment for it

DC Tie Import Payment: Triggers

Trigger #1

A QSE Schedules a DC Tie to import power into ERCOT area

- A QSE Schedules a DC Tie to import energy into ERCOT area

- The QSE receives a payment for the injection of energy

Outcome #1

A QSE1

- Schedules 100 MW import on DC Tie one
- The Settlement Point Price is $50/MWh at DCTIE1

$$\mathrm{RTDCIMPAMT}_{q,\,p} = (-1) * \mathrm{RTSPP}_{p} * (\mathrm{RTDCIMP}_{q,\,p} * \tfrac{1}{4})$$

$$\$-1250 = (-1) * \$50 * (100\mathrm{MW} * \tfrac{1}{4})$$

Real-Time

Real-Time Activities
- Imbalances
- Base Point Deviations
- Other odds & ends

Fundamentals of Real–Time Ancillary Service Imbalances

Who:	All QSEs that have Resource Capacity available to ERCOT during Real-Time
What:	A charge or payment based on the imbalance between available Capacity and Ancillary Service Reserves
Why:	To make Resources indifferent to the utilization of their capacity for energy or Ancillary Service reserves

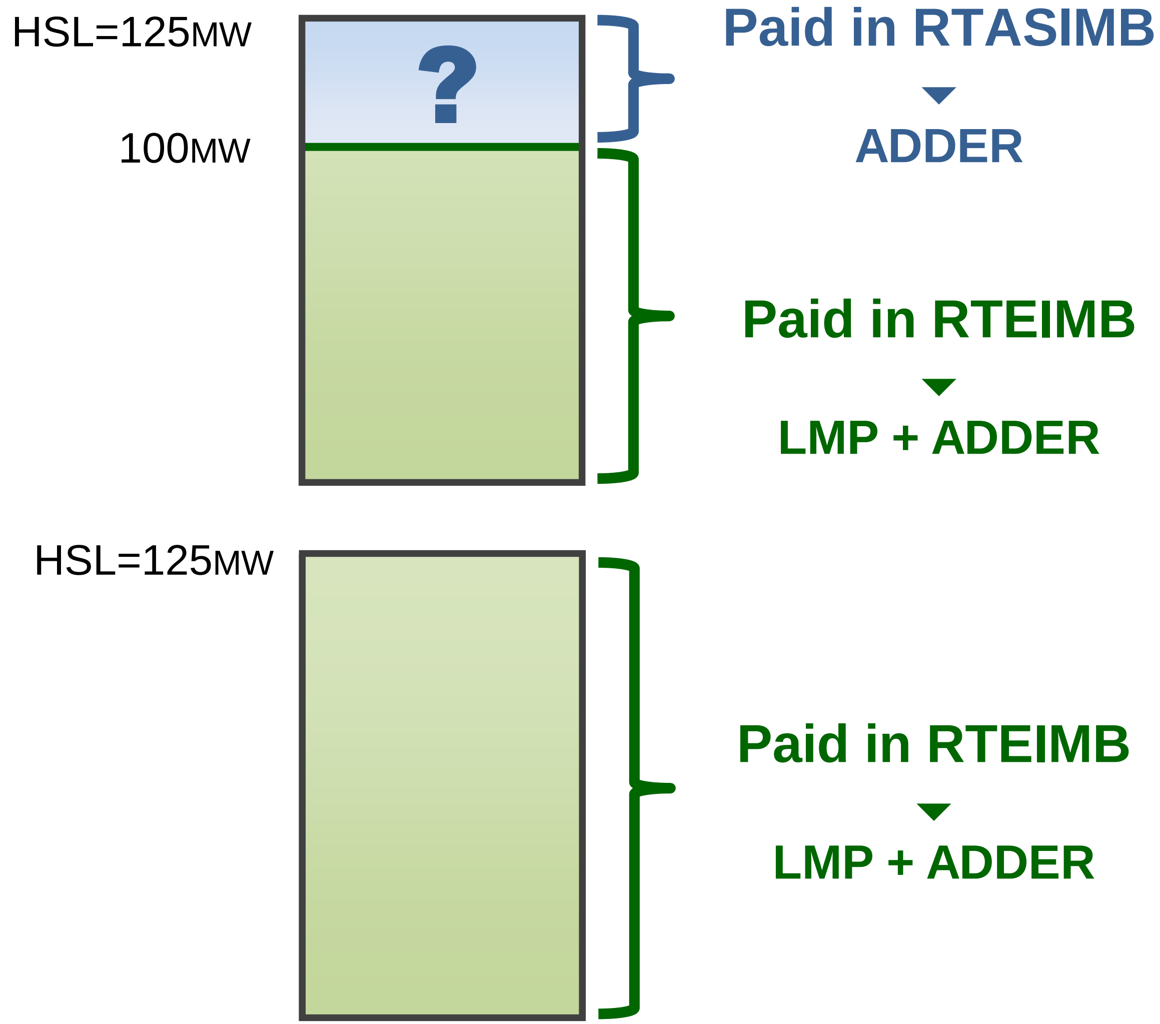
The Basic Idea:

(-1) [(*On-Line Reserve SUPPLIES* – *On-Line Reserve OBLIGATIONS*) * On-line Reserve Price

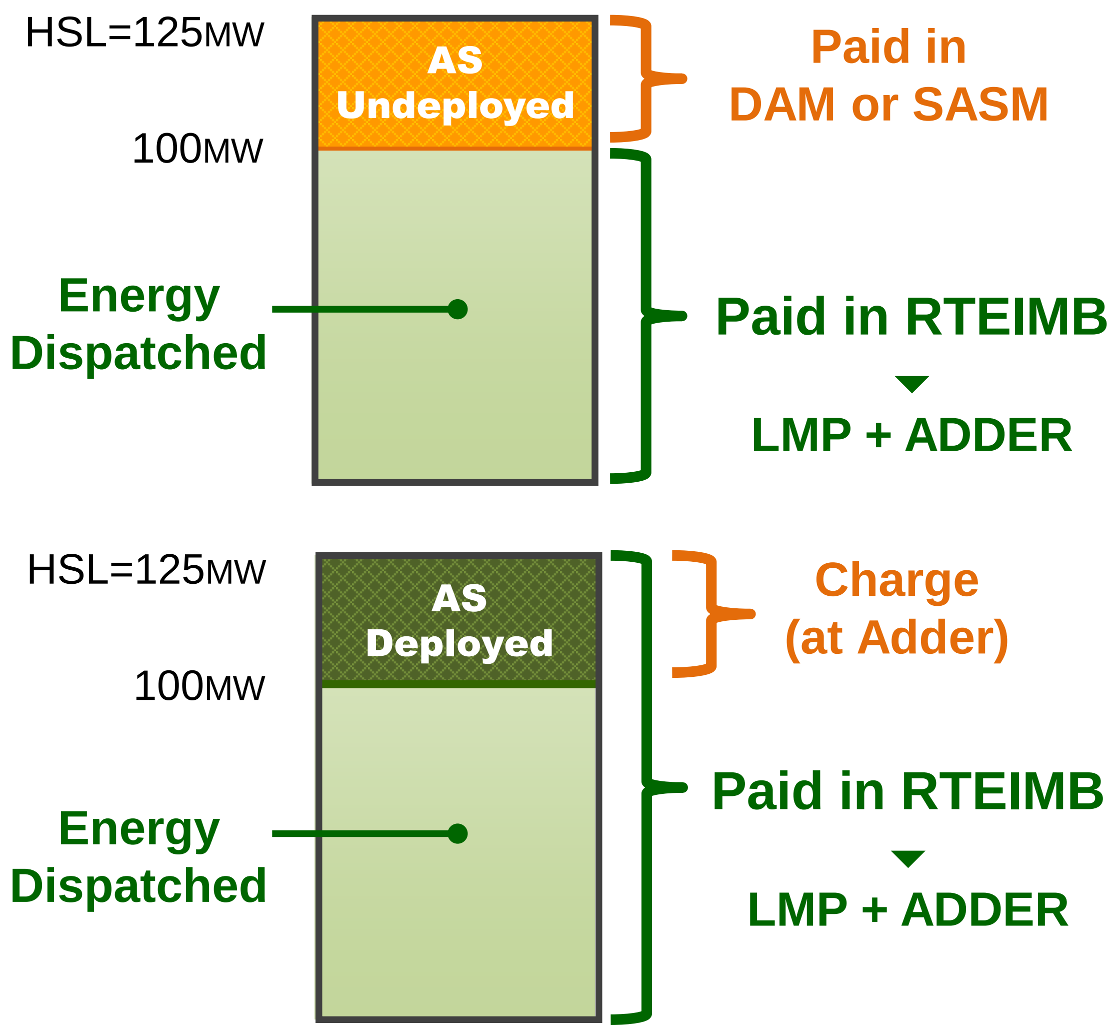
\+ (*Off-Line Reserve SUPPLIES* – *Off-Line Reserve OBLIGATIONS*) * Off-line Reserve Price]

Calculated ERCOT-wide per QSE

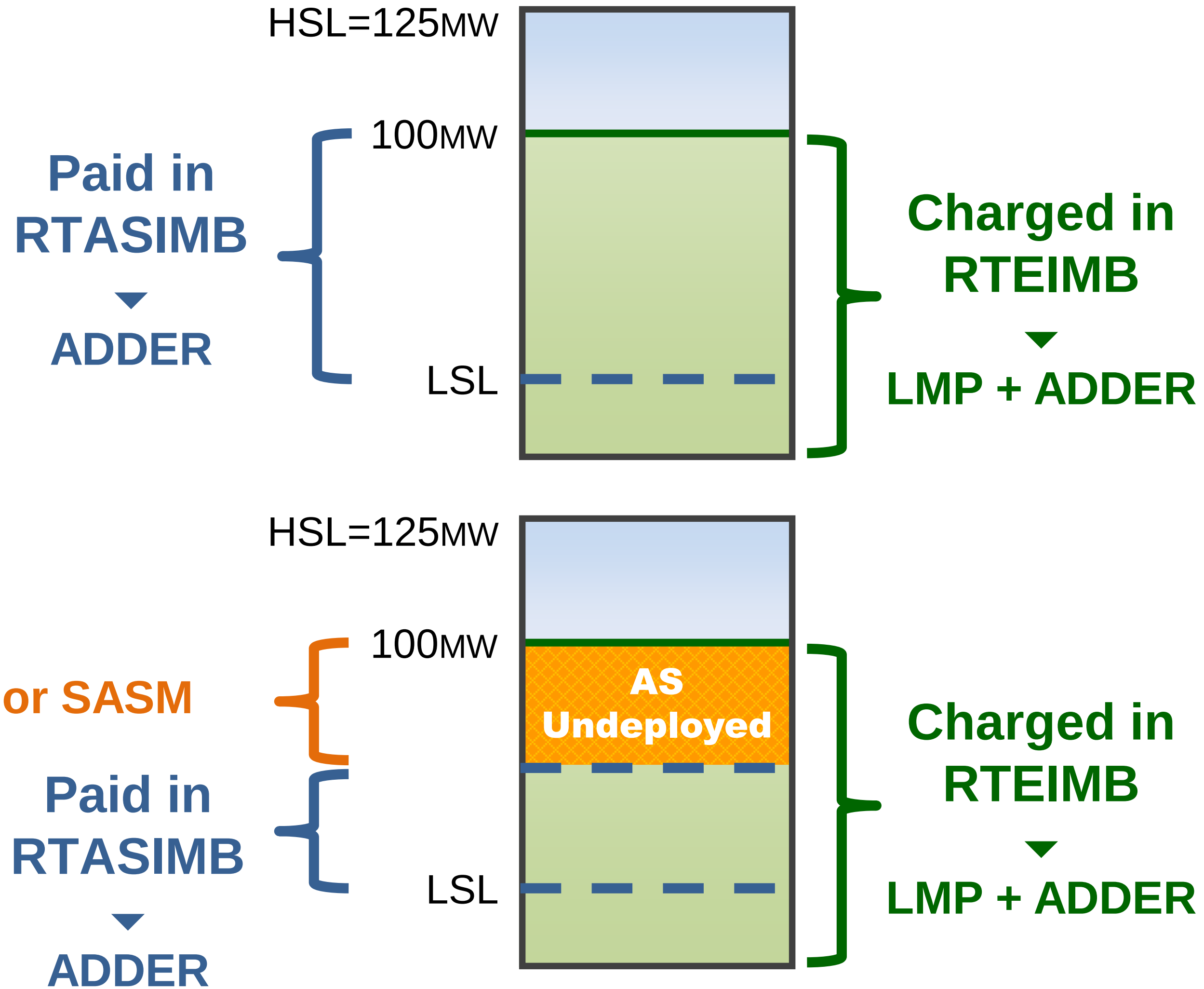
For Generation Resources:



For Generation Resources:



For Load Resources:



Ancillary Service Imbalance Details:

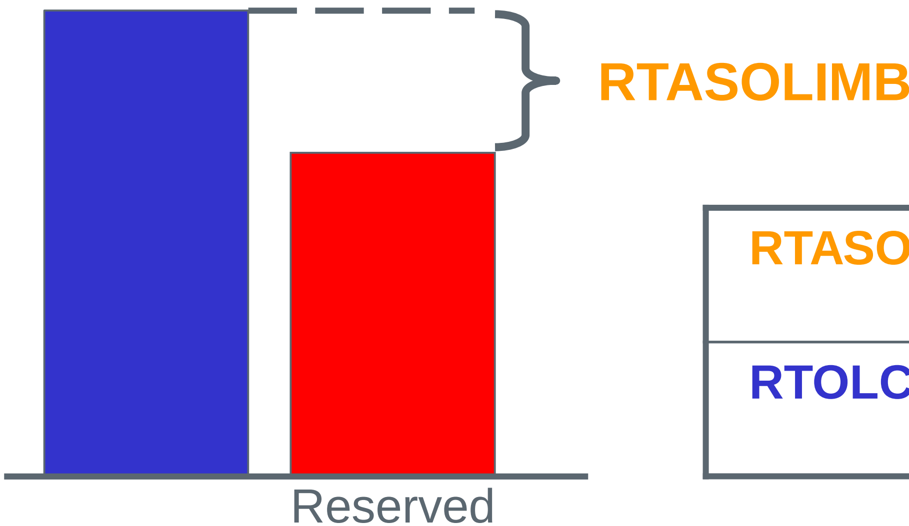
(-1) [(***Ancillary Service On-Line Reserve Imbalance***) * **On-line Reserve Price**

\+ (***Ancillary Service Off-Line Reserve Imbalance***) * **Off-line Reserve Price**]

Ancillary Service On-Line Reserve Imbalance

$$RTASOLIMB_q = RTOLCAP_q - [\text{Online Capacity already reserved}]$$

Online Capacity in Real-Time:

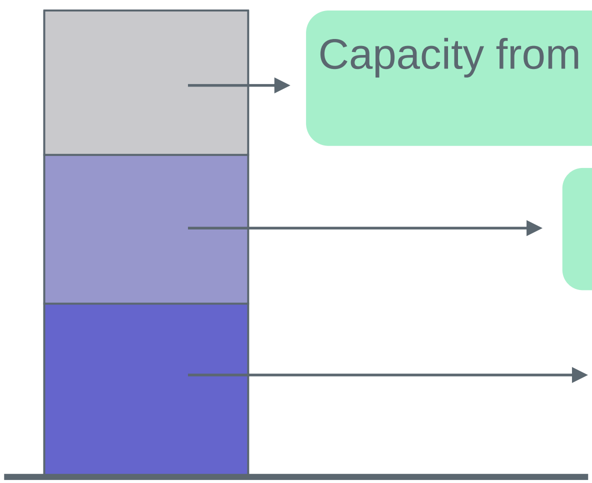


RTASOLIMB	**Real Time Ancillary Service On-Line Reserve Imbalance**
RTOLCAP	**Real-Time On-Line Reserve Capacity**

Ancillary Service On-Line Reserve Imbalance

$$RTASOLIMB_q = RTOLCAP_q - [\text{Online Capacity already reserved}]$$

Online Capacity in Real-Time:



Capacity from Non-Controllable Load Resources Carrying Responsive Reserve (RTNCLRCAP)

Capacity from Controllable Load Resources (RTCLRCAP)

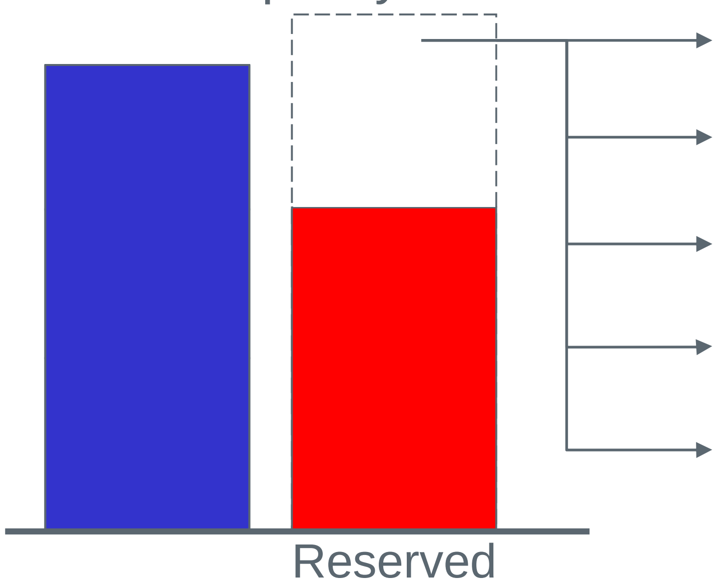
High Sustained Limits – Metered Generation (RTOLHSL - RTGMQ)

Telemetered and Integrated to 15-minutes

Ancillary Service On-Line Reserve Imbalance

$$\text{RTASOLIMB}_q = \text{RTOLCAP}_q - [\text{Online Capacity already reserved}]$$

Online Capacity in Real-Time:



- Ancillary Service Supply Responsibility
- – RUC Ancillary Service Supply Responsibility
- – Ancillary Service Schedule for Off-line Generation
- – Controllable Load Resource Non-Spin Responsibility
- – Ancillary Service Supply Responsibility for RMR Units

Ancillary Service On-Line Reserve Imbalance

$$RTASOLIMB_q = RTOLCAP_q - [(RTASRESP_q * 1/4) - RTASOFF_q - RTRUCNBBRESP_q - RTCLRNSRESP_q - RTRMRRESP_q]$$

RTASRESP	Real-Time Ancillary Service Supply Responsibility
RTASOFF	Real-Time Ancillary Service Schedule for the Off-Line Generation Resource
RTRUCNBBRESP	Real-Time RUC Ancillary Service Supply Responsibility in Non-Buy-Back hours
RTCLRNSRESP	Real-Time Controllable Load Resource Non-Spin Responsibility
RTRMRRESP	Real-Time Ancillary Service Supply Responsibility for RMR Units

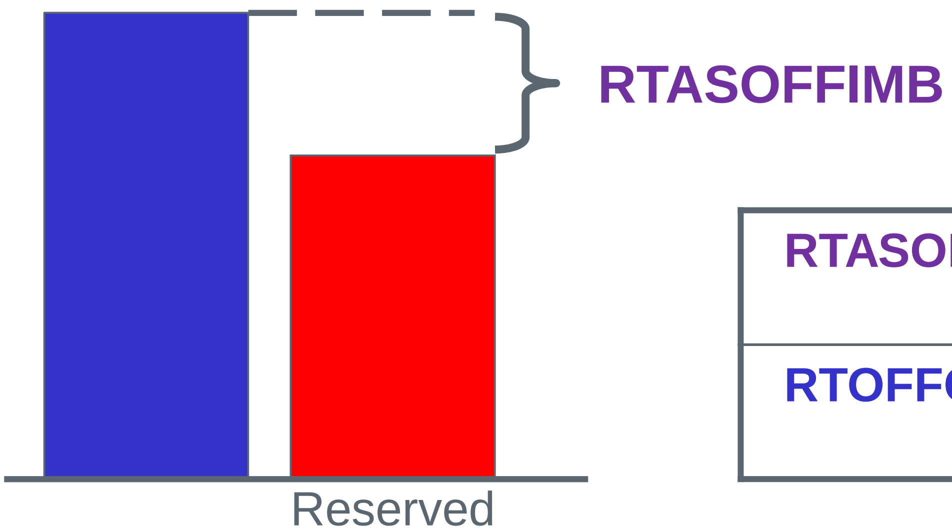
Ancillary Service Imbalance Details:

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

Ancillary Service Off-Line Reserve Imbalance

$\mathbf{RTASOFFIMB}_q = \mathbf{RTOFFCAP}_q$ – [Offline Capacity already reserved]

Offline Capacity in Real-Time:

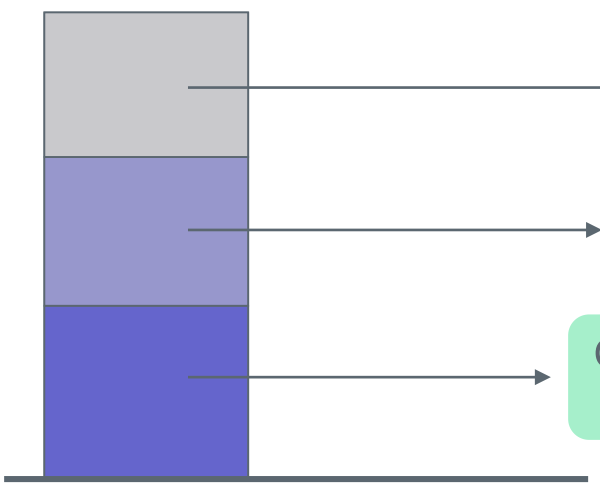


RTASOFFIMB	**Real Time Ancillary Service Off-Line Reserve Imbalance**
RTOFFCAP	**Real-Time Off-Line Reserve Capacity**

Ancillary Service Off-Line Reserve Imbalance

$$RTASOFFIMB_q = RTOFFCAP_q - [\text{Offline Capacity already reserved}]$$

Offline Capacity in Real-Time:



Non-Spin Schedule for Controllable Load Resources (RTCLRNS)

Generation Resources with Off-Line Non-Spin Schedule (RTOFFNSHSL)

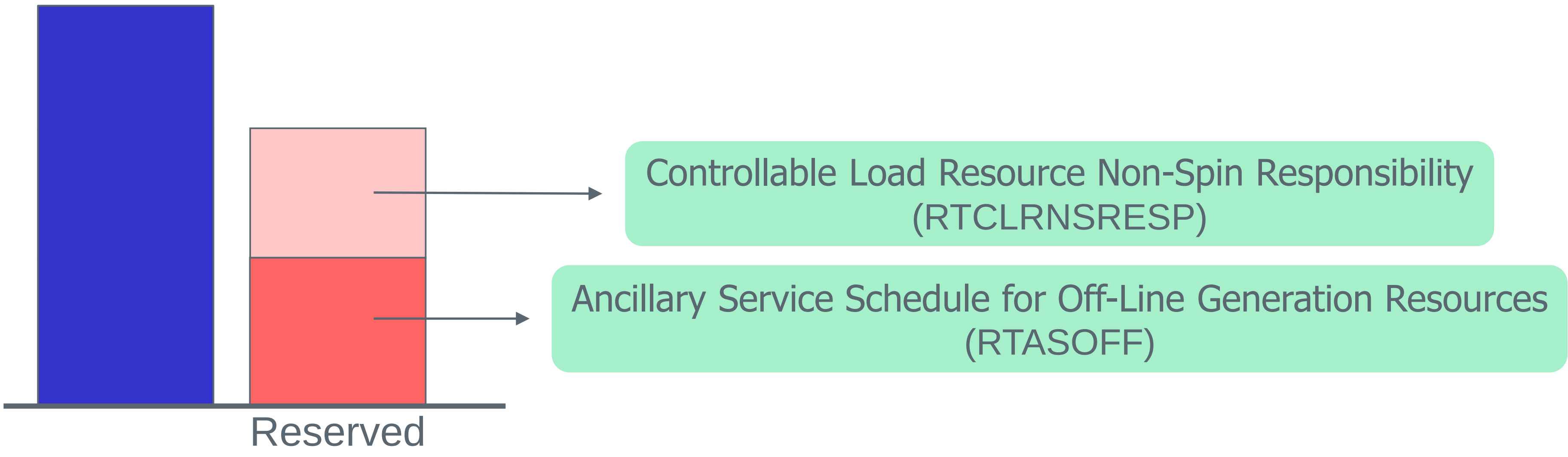
Generation Resources with Cold Start Available in 30 Minutes (RTCST30HSL)

Converted to 15-minutes

Ancillary Service Off-Line Reserve Imbalance

$\mathbf{RTASOFFIMB}_q = \mathbf{RTOFFCAP}_q$ – [Offline Capacity already reserved]

Offline Capacity in Real-Time:



Putting it all back together . . .

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

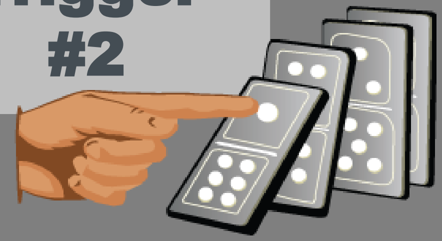
RTASIAMT	Real-Time Ancillary Service Imbalance Amount
RTASOLIMB	Real Time Ancillary Service On-Line Reserve Imbalance
RTRSVPOR	Real-Time Reserve Price for On-Line Reserves
RTASOFFIMB	Real Time Ancillary Service Off-Line Reserve Imbalance
RTRSVPOFF	Real-Time Reserve Price for Off-Line Reserves

Real-Time Ancillary Service Imbalance: Triggers

Trigger #1

A QSE has On-Line Reserves in Real-Time

Trigger #2

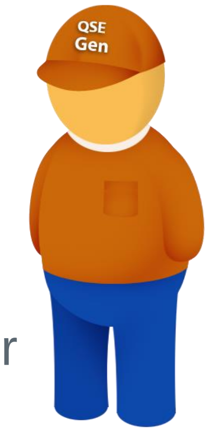


A QSE has Off-Line Reserves in Real-Time

Trigger #1

QSE1

- One Generation Resource online
- HSL is 200 MW (50MWh for 15 minutes)
- Metered Generation is 40 MWh
- No Ancillary Service commitments
- No other Resources available within the hour
- On-line Reserve Price is $20/MWh
- Off-line Reserve Price is $5/MWh



Outcome #1

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

Outcome #1

$$RTASOLIMB_q = RTOLCAP_q - [\text{Capacity already reserved}]$$
$$= (RTOLHSL - RTMGQ) - [\ 0\ ]$$
$$= 50\text{MWh} - 40\text{MWh}$$
$$= 10\ \text{MWh}$$

$$RTASIAMT_q = (-1) * [(RTASOLIMB_q * RTRSVPOR) + (RTASOFFIMB_q * RTRSVPOFF)]$$
$$= (-1) * [(10\text{MWh} * \$20/\text{MWh}) + (0 * \$5/\text{MWh})]$$
$$= -\$200$$

Real-Time Ancillary Service Imbalance: Triggers

Trigger #1

A QSE has On-Line Reserves in Real-Time

Trigger #2

A QSE has Off-Line Reserves in Real-Time

Trigger #2

QSE4

- No Resources online
- One Generation Resource offline and available within the hour
- HSL is 100 MW (25MWh for 15 minutes)
- Entire Resource is reserved for Non-Spin
- No other Resources available within the hour
- On-line Reserve Price is $20/MWh
- Off-line Reserve Price is $5/MWh

Outcome #2

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

Outcome #2

$$RTASOLIMB_q = RTOLCAP_q - [\text{Capacity already reserved}]$$
$$= 0 - [(RTASRESP * 1/4) - RTASOFF]$$
$$= 0 - [(100MW * 1/4h) - 25MWh]$$
$$= 0\ MWh$$

$$RTASOFFIMB_q = RTOFFCAP_q - [\text{Reserved Capacity}]$$
$$= RTOFFNSHSL - [RTASOFF]$$
$$= 25MWh - [25MWh]$$
$$= 0\ MWh$$

$$RTASIAMT_q = (-1) * [(RTASOLIMB_q * RTRSVPOR) + (RTASOFFIMB_q * RTRSVPOFF)]$$
$$= (-1) * [(0 * \$20/MWh) + (0 * \$5/MWh)]$$
$$= \$0$$

Refer to your Settlements Workbook

In a small group, respond to the questions that relate to Scenario #RT4.

You have 10 minutes to complete your questions.

If you cannot complete all questions, don’t worry – all questions will be reviewed as a class.

Real-Time Reliability Deployment AS Imbalance

Real-Time

Real-Time Activities
- Imbalances
- Base Point Deviations
- Other odds & ends

Fundamentals of Real–Time Reliability Deployment Ancillary Service Imbalances

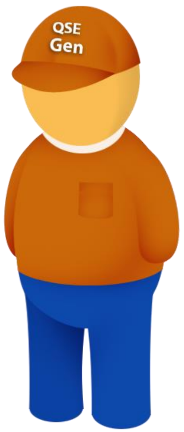
Who:	All QSEs that have Resource Capacity available to ERCOT during Reliability Deployments in Real-Time
What:	A charge or payment based on the imbalance between available Capacity and Ancillary Service Reserves
Why:	To make Resources indifferent to the utilization of their capacity for energy or Ancillary Service reserves

A QSE has On-Line Reserves in Real-Time

Trigger #1

QSE1

- Had a Real-Time Ancillary Service Online Reserve Imbalance



Outcome #1

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

RTRDASIAMT	Real-Time Reliability Deployment Ancillary Service Imablance Amount
RTASOLIMB	Real Time Ancillary Service On-Line Reserve Imbalance
RTRDP	Real-Time On-Line Reliability Deployment Price

Generation Resource Base Point Deviation Charge

Real-Time

Real-Time Activities
- Imbalances
- Base Point Deviations
- Other odds & ends

Fundamentals of Base Point Deviation Charge

Who:	QSEs that have Resources that do not follow Base Points as dictated by SCED
What:	A charge for over generation or under generation – May not receive this charge when helping frequency
Why:	The Resource did not follow Dispatch Instructions and Ancillary Services deployments within defined tolerances

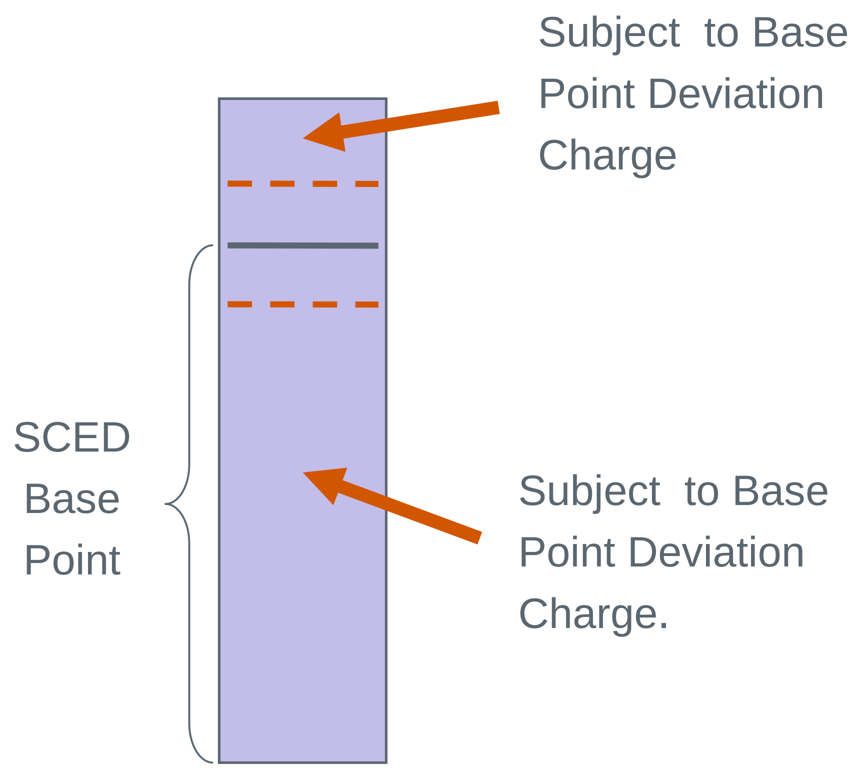
Base Point Deviation Charge

- Resource did not follow Dispatch Instructions and Ancillary Services Deployments within defined tolerances

- Tolerances

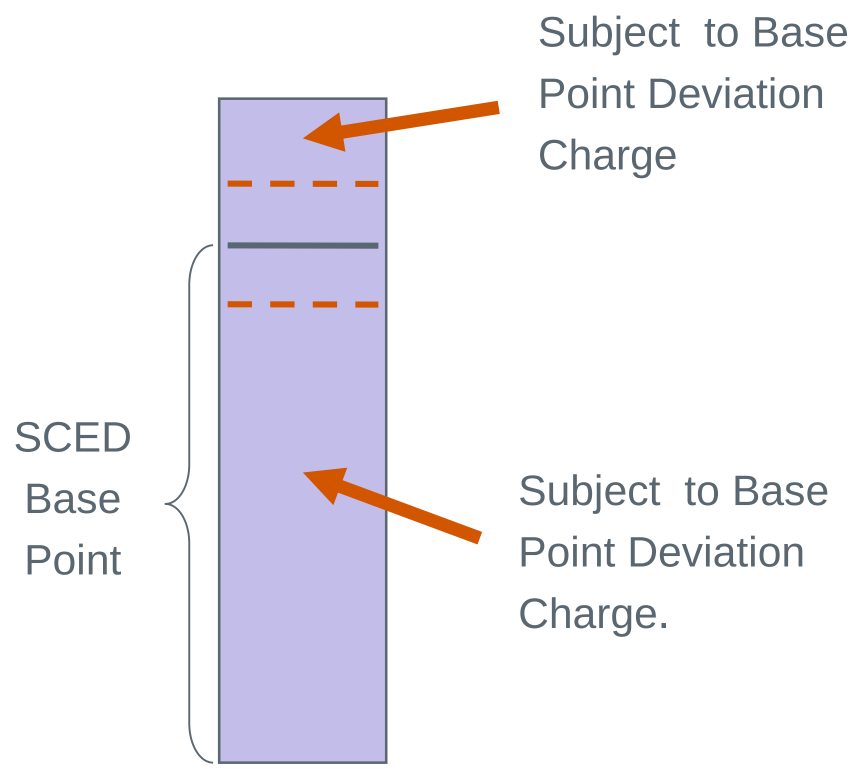
  ± 5% or ± 5MW, whichever is greater

  + 10% for Intermittent Renewable Resources (when curtailed)



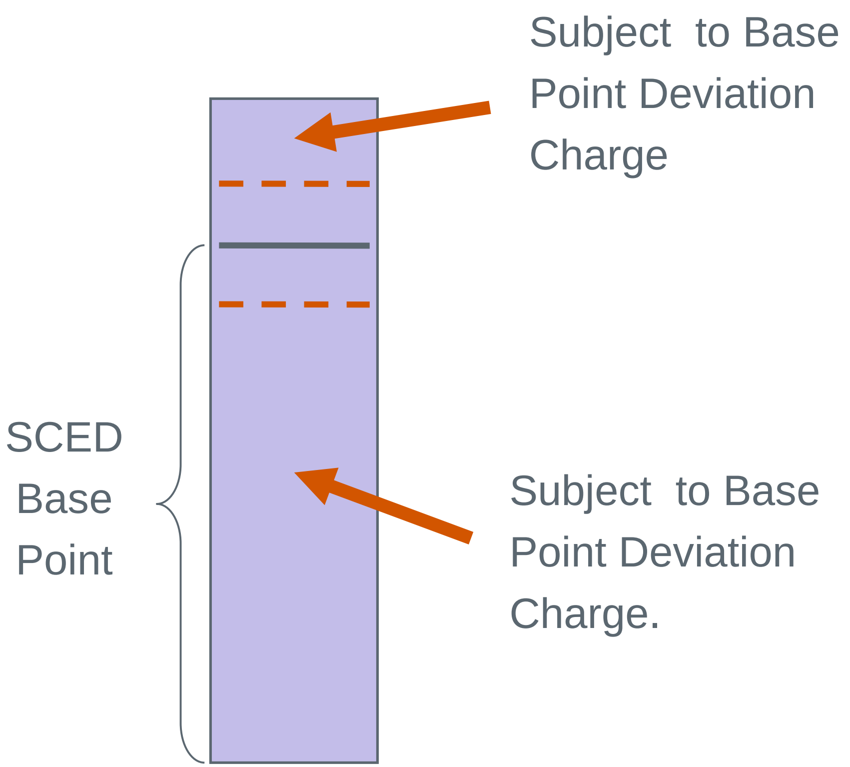
Base Point Deviation Charge

- Exclusions
  - No charge during a Frequency deviation greater than 0.05 Hz if the QSEs deviation helps frequency
  - No charge for any intervals with Responsive Reserve deployments



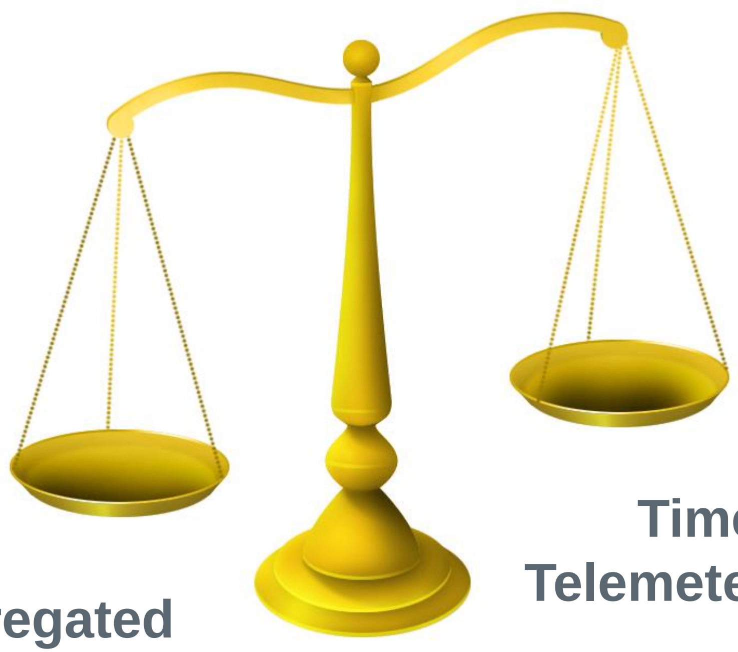
Base Point Deviation Charge

- Exemptions
  - RMR Units
  - Qualifying Facilities (QFs) that do not submit Energy Offer Curves
  - Quick Start Generation Resources (QSGRs) exempt for the first Settlement Interval in which they are deployed



Determining Basepoint Deviation Charges

ERCOT compares Adjusted Aggregated Base Points to the Time-Weighted Telemetered Generation.



Time-Weighted Telemetered Generation

Adjusted Aggregated Base Point

Calculating Adjusted Aggregated Base Point

Adjusted Aggregated Base Point = Average Base Point + Average Regulation

15 Minute Value

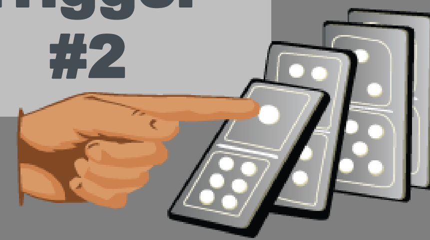
Considers Ramping

Base Point Deviation Charge: Triggers

Trigger #1

Resource did not follow Dispatch Instructions and OVER Generated

Trigger #2



Resource did not follow Dispatch Instructions and UNDER Generated

Base Point Deviation Charge – Over Generation

Trigger #1

- Resource did not follow Dispatch Instructions and OVER Generated
- The Over Generation is outside of the 5% or 5 MW tolerance

Outcome #1

- QSE is charged:

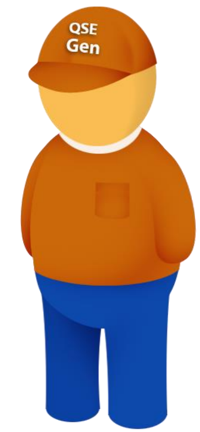
  Settlement Point Price * the MW above Tolerance

If system frequency dipped below 59.95 Hz during the settlement interval, then the QSE would not be charged.

Outcome #1

QSE1 unit 5

- Adjusted Aggregated Base Point of 40MW
- Time Weighted Telemetered Generation of 12MWh (Operated at 48MW)
- Tolerances are 5% or 5MW
- Settlement Point Price is $20/MWh at RN5



Base Point Deviation Charge

= Price * (Generation – ¼h * Max (AABP + 5% or AABP + 5MW))

= $20/MWh * (12MWh – ¼h * Max (42MW or 45MW))

= $20/MWh * (12MWh – 11.25MWh)

= $15

Translated into Settlement Equations,

$$BPDAMT = \text{Max}\,(PR1,\ RTSPP) * OGEN$$

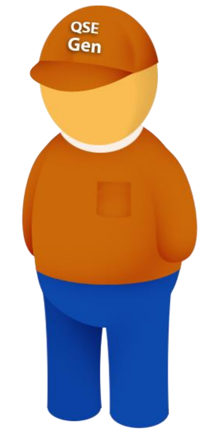
$$OGEN = \text{Max}\left(0,\ \left(TWTG - \tfrac{1}{4} * \text{Max}\left((1 + K1) * AABP,\ (AABP + Q1)\right)\right)\right)$$

BPDAMT $_{q,\, r,\, p}$	**B**ase **P**oint **D**eviation **Am**ount
OGEN	**O**ver **Gen**eration Volume
TWTG $_{q,\, r,\, p}$	**T**ime **W**eighted **T**elemetered **G**eneration
AABP $_{q,\, r,\, p}$	**A**djusted **A**ggregated **B**ase **P**oint
PR1	Minimum price for over-generation, $20.
K1	The percentage tolerance for over-generation, 5%.
Q1	The MW tolerance for over-generation, 5 MW.

Outcome #1

QSE1 unit 5

- Adjusted Aggregated Base Point of 40MW
- Time Weighted Telemetered Generation of 12MWh (Operated at 48MW)
- Tolerances are 5% or 5MW
- Settlement Point Price is $20/MWh at RN5



$$\text{BPDAMT} = \text{Max}\,(\text{PR1}, \text{RTSPP}) * \text{OGEN}$$

$$\text{OGEN} = \text{Max}\left[0, \left[\text{TWTG} - \tfrac{1}{4} * \text{Max}\left[(1 + \text{K1}) * \text{AABP}, (\text{AABP} + \text{Q1})\right]\right]\right]$$

$$\text{OGEN} = \text{Max}\,(0, (12\text{MWh} - \tfrac{1}{4}\text{h} * \text{Max}\,(42\ \text{MW}, 45\text{MW}))) = 0.75\ \text{MWh}$$

$$\text{BPDAMT} = \text{Max}\,(\$20/\text{MWh}, \$20/\text{MWh}) * \text{OGEN} = \$15$$

Key Differences between Intermittent Renewable Resources (IRRs) & Conventional Resources

IRR must be Curtailed

- Curtailment Flag

IRR must be Over-Generating

- Telemetered Generation
- Instructed Base Point

Wider tolerance for deviation from Base Point

When are IRRs exposed to deviation charges?

	IRR output ***within*** 10% acceptable range	IRR output ***exceeds*** 10% acceptable range
Curtailment Flag is not set	No Charge	No Charge
Curtailment Flag *is* set	No Charge	***Charge***

Translated into Settlement Equations,

If **SBPBHDLFLAG = 1**, then

$$\mathbf{BPDAMT} = \mathrm{Max}\,(\mathbf{PR1}, \mathbf{RTSPP}) * \mathbf{OGENIRR}$$

$$\mathbf{OGENIRR} = \mathrm{Max}\left[0, \left(\mathbf{TWTG} - \tfrac{1}{4} * \mathbf{AABP} * (1 + \mathbf{KIRR})\right)\right]$$

SBPBHDLFLAG	**S**CED **B**ase **P**oint **B**elow **HDL FLAG**
BPDAMT $_{q, r, p}$	**B**ase **P**oint **D**eviation **Am**oun**t**
OGENIRR	**O**ver **Gen**eration Volume per **IRR** Generation Resource
TWTG $_{q, r, p}$	**T**ime **W**eighted **T**elemetered **G**eneration
AABP $_{q, r, p}$	**A**djusted **A**ggregated **B**ase **P**oint
PR1	Minimum price for over-generation, $20.
KIRR	The percentage tolerance for IRRs, 10%.

Activity: Now it’s your turn!

Refer to your Settlements Workbook

In a small group, respond to the questions that relate to Scenario #RT5.

You have 5 minutes to complete your questions.

If you cannot complete all questions, don’t worry – all questions will be reviewed as a class.

Base Point Deviation Charge: Triggers

Trigger #1

Resource did not follow Dispatch Instructions and OVER Generated

Trigger #2

Resource did not follow Dispatch Instructions and UNDER Generated

Base Point Deviation Charge – Under Generation

Trigger #2

- Resource did not follow Dispatch Instructions and UNDER Generated
- The Under Generation is outside of the 5% or 5 MW tolerance

Outcome #2

- QSE is charged:

  Settlement Point Price * the MW below Tolerance

If system frequency rose above 60.05 Hz during the settlement interval, then the QSE would not be charged.

Base Point Deviation Charge – Under Generation

Outcome #2

QSE4 unit 8

- Adjusted Aggregated Base Point of 40MW
- Time Weighted Telemetered Generation of 8MWh (Operated at 32MW)
- Tolerances are 5% or 5MW
- Settlement Point Price is -$20/MWh at RN8

Base Point Deviation Charge

= (-1) * Price * (¼h * Min (AABP – 5% or AABP – 5MW) – Generation)

= (-1) * -$20/MWh * (¼h * Min (38MW or 35MW) – 8MWh)

= (-1) * -$20/MWh * (8.75MWh – 8MWh)

= $15

Translated into Settlement Equations,

$$\mathrm{BPDAMT} = (-1) * \mathrm{Min}\,(\mathrm{PR2}, \mathrm{RTSPP}) * \mathrm{Min}(1, \mathrm{KP}) * \mathrm{UGEN}$$

$$\mathrm{UGEN} = \mathrm{Max}\left[0, \left[\mathrm{Min}\left[(1 - \mathrm{K2}) * \tfrac{1}{4}\,\mathrm{AABP}, \tfrac{1}{4}\,(\mathrm{AABP} - \mathrm{Q2})\right] - \mathrm{TWTG}\right]\right]$$

$\mathrm{BPDAMT}_{q, r, p}$	Base Point Deviation Amount
UGEN	Under Generation Volume
$\mathrm{TWTG}_{q, r, p}$	Time Weighted Telemetered Generation
$\mathrm{AABP}_{q, r, p}$	Adjusted Aggregated Base Point
PR2	Minimum price for under-generation, -$20.
K2	The percentage tolerance for under-generation, 5%.
Q2	The MW tolerance for under-generation, 5 MW.
KP	Settlement Point Price coefficient, (1.0, for now)

Base Point Deviation Charge – Under Generation

Outcome #2

QSE4 unit 8

- Adjusted Aggregated Base Point of 40MW
- Time Weighted Telemetered Generation of 8MWh (Operated at 32MW)
- Tolerances are 5% or 5MW
- Settlement Point Price is -$20/MWh at RN8

$$BPDAMT = (-1) * \text{Min}(PR2, RTSPP) * \text{Min}(1, KP) * UGEN$$

$$UGEN = \text{Max}\left[0, \left[\text{Min}\left[(1 - K2) * \tfrac{1}{4} AABP, \tfrac{1}{4}(AABP - Q2)\right] - TWTG\right]\right]$$

$$UGEN = \text{Max}(0, \text{Min}(9.5MWh, 8.75MWh) - 8MWh) = 0.75MWh$$

$$BPDAMT = (-1) * \text{Min}(-\$20/MWh, -\$20/MWh) * \text{Min}(1, 1) * UGEN = \$15$$

Real-Time

Real-Time Activities
- Imbalances
- Base Point Deviations
- Other odds & ends

Fundamentals of Base Point Deviation Payment

Who:	QSEs that have load
What:	Distributes the funds collected from Base Point Deviation Charges.
Why:	To keep ERCOT revenue neutral

Charges for Base Point Deviations are collected

- Resources Over or Under Generated
- ERCOT charges the QSEs representing the Resources

- Sum Base Point Deviation charges for the interval
- Calculate each QSE’s Load Ratio Share
- Pay each QSE their portion of the revenue

Outcome #1

For interval one ERCOT charged for deviation

- Total Charges $255

QSE 5 has thirty percent of Load

- QSE 5 is paid for 30 percent of the $255

$$LABPDAMT_q = (-1) * BPDAMTTOT * LRS_q$$

$$\$-76.50 = (-1) * \$255 * 0.30$$

$LABPDAMT_q$	Load-Allocated Base Point Deviation Amount
BPDAMTTOT	Base Point Deviation Amount Total
LRS_q	Load Ratio Share

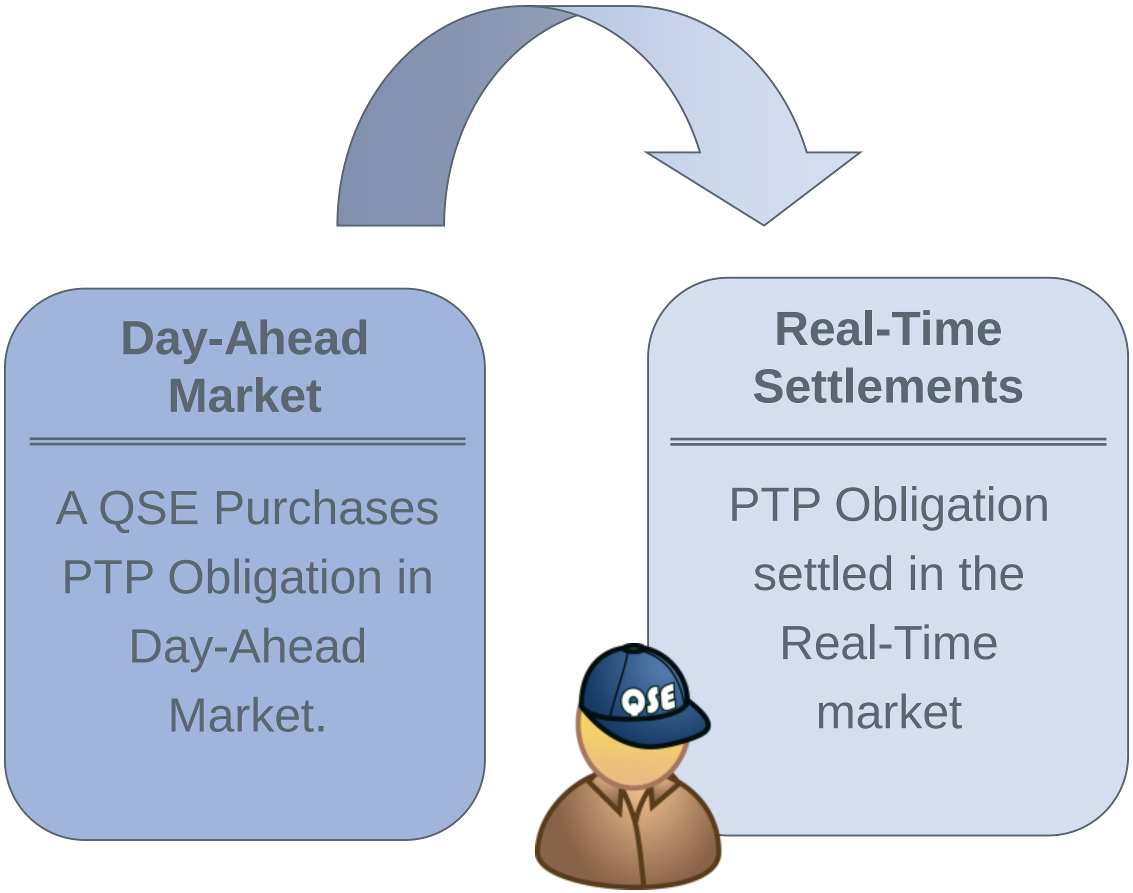
Real-Time

Settlement of PTP Obligations purchased in DAM

Fundamentals of PTP Obligations Settled in Real-Time

Who:	QSEs that have purchased PTP obligations in the DAM
What:	A Charge or Payment based on Real-Time Congestion
Why:	To Hedge the Cost of congestion in Real-Time

Payments or Charges for PTP Obligations in Real-Time



Payments or Charges for PTP Obligations in Real-Time

Trigger #1

A QSE buys a PTP obligation in the DAM

- A QSE buys a PTP obligation in the Day-Ahead Market.

- The Price is the Difference between the RTSPP of the Source and Sink
- If Sink price is higher, the QSE is paid
- If Source price is higher, the QSE is charged

Settlement for DAM PTP Obligations

Real-Time

Settlement of PTP Obligations purchased in DAM

$$\text{RTOBLAMT}_{q,\,(j,\,k)} = (-1) * \text{RTOBLPR}_{(j,\,k)} * \text{RTOBL}_{q,\,(j,\,k)}$$

$$\text{RTOBLPR}_{(j,\,k)} = \Sigma\,(\text{RTSPP}_{k} - \text{RTSPP}_{j})\ /\ 4$$

q = QSE
j = Source Settlement Point
k = Sink Settlement Point

Determinants
Real-Time Obligation Amount
Real-Time Obligation Price
Real-Time Obligation
Real-Time Settlement Point Price

Payments or Charges for PTP Obligations in Real-Time

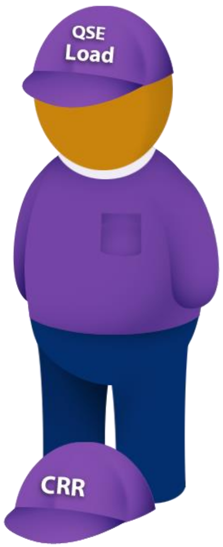
Trigger #1

- QSE3 bought 40 MW of PTP obligations in the Day-Ahead Market.
- RT Settlement Point Prices during the hour

Interval	Source	Sink
0415	$17	$21
0430	$17	$22
0445	$16	$21
0500	$15	$21

Outcome #1

- QSE3 receives a payment



Outcome #1

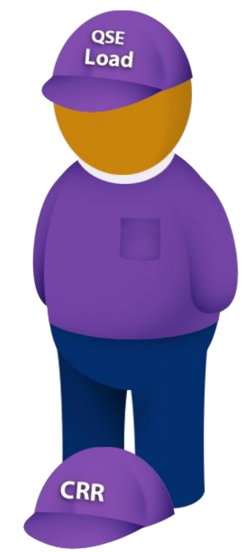
$$RTOBLPR_{(j,\,k)} = \Sigma\,(RTSPP_{k,\,i} - RTSPP_{j,\,i})\;/\;4$$

$$\begin{aligned}\$5/MW_{(j,\,k)} = \;&[\,(\$21/MWh - \$17/MWh)\\ &+(\$22/MWh - \$17/MWh)\\ &+(\$21/MWh - \$16/MWh)\\ &+(\$21/MWh - \$15/MWh)]\;/\;4\end{aligned}$$

QSE3 receives a payment

$$RTOBLAMT_{q,\,(j,\,k)} = (-1) * RTOBLPR_{(j,\,k)} * RTOBL_{q,\,(j,\,k)}$$

$$-\$200 = (-1) * \$5/MW * 40\ MW$$



Real-Time

Settlement of PTP Obligations purchased in DAM

Real-time Settlement of DAM PTP Obligations with Links to Option

Who:	NOIE that owns PTP Options before DAM and buys PTP Obligations in DAM linked to those Options
What:	A Payment based on Real-Time Congestion
Why:	To Hedge the Cost of congestion in Real-Time

Payments for PTP Obligations with Links to Options

Trigger #1

NOIE buys DAM PTP Obligations based on PTP Options they own

Settlement for DAM PTP Obligations with Links to Options

Real-Time

Settlement of PTP Obligations purchased in DAM

$$\text{RTOBLLOAMT}_{q,(j,k)} = (-1) * \text{Max}(0, \text{RTOBLPR}_{(j,k)}) * \text{RTOBLLO}_{q,(j,k)}$$

$$\text{RTOBLPR}_{(j,k)} = \Sigma\,(\text{RTSPP}_{k} - \text{RTSPP}_{j}) / 4$$

Determinants
Real-**T**ime **Obl**igation with **L**inks to an **O**ption **Am**oun**t**
Real-**T**ime **Obl**igation **Pr**ice
Real-**T**ime **Obl**igation with **L**inks to an **O**ption
Real-**T**ime **S**ettlement **P**oint **P**rice

q = QSE
j = Source Settlement Point
k = Sink Settlement Point

Real-Time

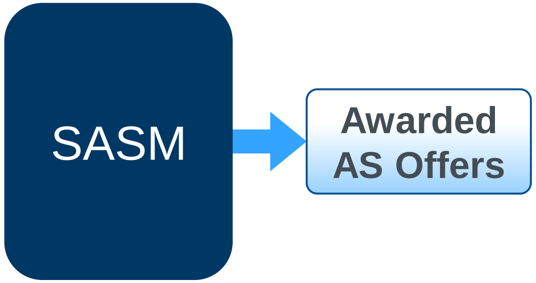
Real-Time Ancillary Service Settlements

Fundamentals of Payments for Services Sold in SASM

Who:	QSEs that sold Reg-Up, Reg-Down, Responsive, or Non-Spin in a SASM
What:	A Payment for the services sold in a SASM
Why:	To cover the costs of a services to ensure ERCOT reliability

Reasons ERCOT may procure Ancillary Services in the Adjustment Period

- Failure to Provide by a QSE
- Infeasible due to Transmission Constraints
- Increased need after DAM
- Insufficient Ancillary Service Offers in DAM



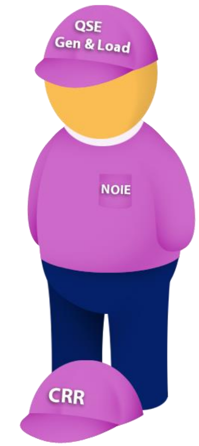
Trigger #1

ERCOT executes a SASM and Ancillary Services are sold

Outcome #1

In SASM1

- QSE1, 50 MW of Regulation Up at $8/MW
- QSE4, 10 MW of Regulation Down at $4/MW
- QSE4, 20 MW of Responsive Reserve at $8/MW
- QSE1, 40 MW of Non-Spin at $12/MW



$$\mathrm{RTPCRUAMT}_{q,\,M} = (-1) * \mathrm{MCPCRU}_{M} * \mathrm{RTPCRU}_{q,\,M}$$
$$\mathrm{RTPCRDAMT}_{q,\,M} = (-1) * \mathrm{MCPCRD}_{M} * \mathrm{RTPCRD}_{q,\,M}$$
$$\mathrm{RTPCRRAMT}_{q,\,M} = (-1) * \mathrm{MCPCRR}_{M} * \mathrm{RTPCRR}_{q,\,M}$$
$$\mathrm{RTPCNSAMT}_{q,\,M} = (-1) * \mathrm{MCPCNS}_{M} * \mathrm{RTPCNS}_{q,\,M}$$

$$-\$400_{q,\,M} = (-1) * \$\,8/\mathrm{MW} * 50\mathrm{MW}_{q,\,M}$$
$$-\$40_{q,\,M} = (-1) * \$\,4/\mathrm{MW} * 10\mathrm{MW}_{q,\,M}$$
$$-\$160_{q,\,M} = (-1) * \$\,8/\mathrm{MW} * 20\mathrm{MW}_{q,\,M}$$
$$-\$480_{q,\,M} = (-1) * \$12/\mathrm{MW} * 40\mathrm{MW}_{q,\,M}$$

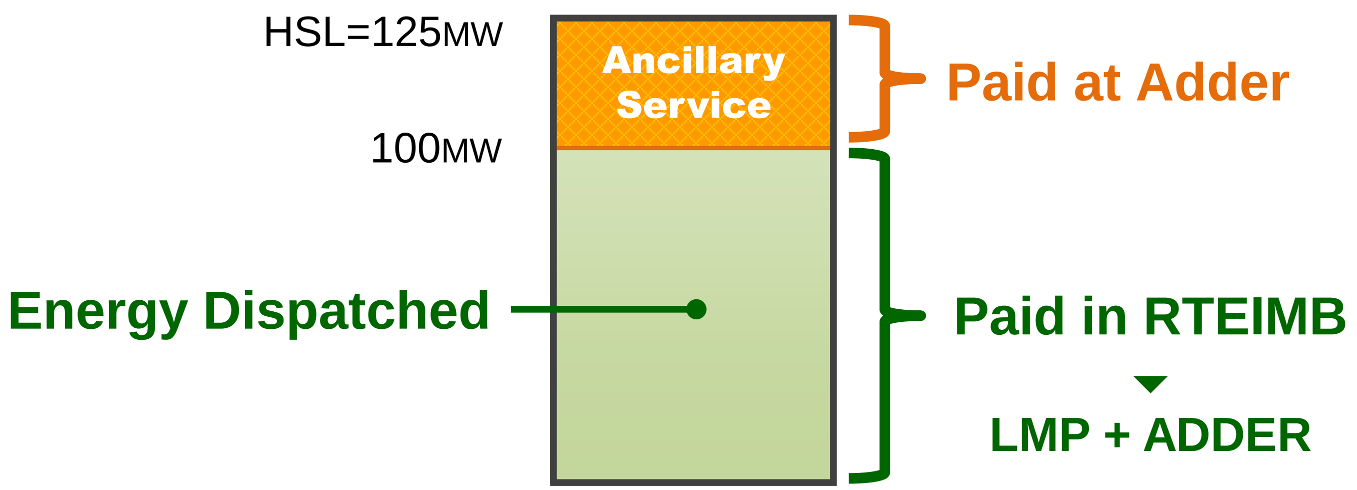
Real-Time

Real-Time Ancillary Service Settlements

Fundamentals of Payments for AS Procured through RUC

Who:	QSEs who were committed to provide AS through RUC *and Opted out of the RUC commitment*
What:	A Payment for the reserved capacity
Why:	To cover the value of the reserved capacity

Payments for Ancillary Services Procured through RUC



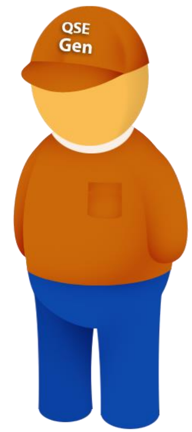
Available only for QSEs who opt out of RUC

Payments for Ancillary Services Procured through RUC

Trigger #1

QSE1

- Was committed to provide Ancillary Services on several Resources
- Opted out of RUC commitment



Outcome #1

$$RTRUCRSVAMT_q = (-1) * (RTRUCRESP_q * RTRSVPOR)$$

Where $$RTRUCRESP_q = \sum_r RTRUCASA_{q,r} * 1/4$$

RTRUCRSVAMT	**R**eal-**T**ime **RUC** Ancillary Service **R**eser**v**e **Am**oun**t**
RTRUCRESP	**R**eal-**T**ime **RUC** Ancillary Service Supply **Resp**onsibility
RTRSVPOR	**R**eal-**T**ime **R**e**s**er**v**e **P**rice for **O**n-Line **R**eserves
RTRUCASA	**R**eal-**T**ime **RUC** **A**ncillary **S**ervice **A**wards

Trigger #2

QSE1

- Was committed to provide Ancillary Services on several Resources
- Opted out of RUC commitment before the end of the Adjustment Period

Outcome #2

Also,

$$RTRDRUCRSVAMT_q = (-1) * (RTRUCRESP_q * RTRDP)$$

RTRDRUCRSVAMT	**R**eal-**T**ime **R**eliability **D**eployment **RUC** Ancillary Service **Res**er**v**e **Am**oun**t**
RTRUCRESP	**R**eal-**T**ime **RUC** Ancillary Service Supply **Resp**onsibility
RTRDP	**R**eal-**T**ime On-Line **R**eliability **D**eployment **P**rice

Real-Time

Real-Time Ancillary Service Settlements

Fundamentals of Charges for Failure to Provide

Who:	QSEs that fail to provide their Ancillary Service Supply Responsibility
What:	A charge for the Failure to Provide Ancillary Service Capacity
Why:	To ensure costs are met in order to replace Failed Ancillary Service Capacity

Outcome #1

Charge for Failure to Provide

Max Price of AS Markets * Failed Quantity

$$RUFQAMT_{q} = Max(MCPCRU_{m}) * RUFQ_{q,}$$

$$RDFQAMT_{q} = Max(MCPCRD_{m}) * RDFQ_{q,}$$

$$RRFQAMT_{q} = Max(MCPCRR_{m}) * RRFQ_{q,}$$

$$NSFQAMT_{q} = Max(MCPCNS_{m}) * NSFQ_{q,}$$

Similar for other AS Types

RUFQAMT	Reg-Up Failure Quantity Amount
MCPCRU	Market Clearing Price for Capacity for Reg-Up
RUFQ	Reg-Up Failure Quantity

Outcome #2

Charge for Failure to Provide

Reconfiguration SASM Price * Failed Quantity

$$RRUFQAMT_{q} = MCPCRU_{rs} * RRUFQ_{q,}$$
$$RRDFQAMT_{q} = MCPCRD_{rs} * RRDFQ_{q,}$$
$$RRRFQAMT_{q} = MCPCRR_{rs} * RRRFQ_{q,}$$
$$RNSFQAMT_{q} = MCPCNS_{rs} * RNSFQ_{q,}$$

Similar for other AS Types

RRUFQAMT	**R**econfiguration **R**eg-**U**p **F**ailure **Q**uantity **Am**ount
$MCPCRU_{rs}$	**M**arket **C**learing **P**rice for **C**apacity for **R**eg-**U**p by RSASM
RRUFQ	**R**econfiguration **R**eg-**U**p **F**ailure **Q**uantity

Charges for Infeasibility

Real-Time

Real-Time Ancillary Service Settlements

Fundamentals of Charges for Infeasibility

Who:	QSEs with Ancillary Service Supply Responsibility that is deemed infeasible by ERCOT
What:	A charge for the Infeasible Ancillary Service Capacity
Why:	To recover payments made for Ancillary Service Capacity in the DAM

Outcome #1

Charge for Infeasibility

DAM Price of AS Markets * Infeasible Quantity

$$RUINFQAMT_{q} = MCPCRU_{DAM} * RUINFQ_{q,}$$
$$RDINFQAMT_{q} = MCPCRD_{DAM} * RDINFQ_{q,}$$
$$RRINFQAMT_{q} = MCPCRR_{DAM} * RRINFQ_{q,}$$
$$NSINFQAMT_{q} = MCPCNS_{DAM} * NSINFQ_{q,}$$

Similar for other AS Types

RUINFQAMT	Reg-Up Infeasible Quantity Amount
$MCPCRU_{DAM}$	Market Clearing Price for Capacity for Reg-Up in DAM
RUINFQ	Reg-Up Infeasible Quantity

Real-Time

Real-Time Ancillary Service Settlements

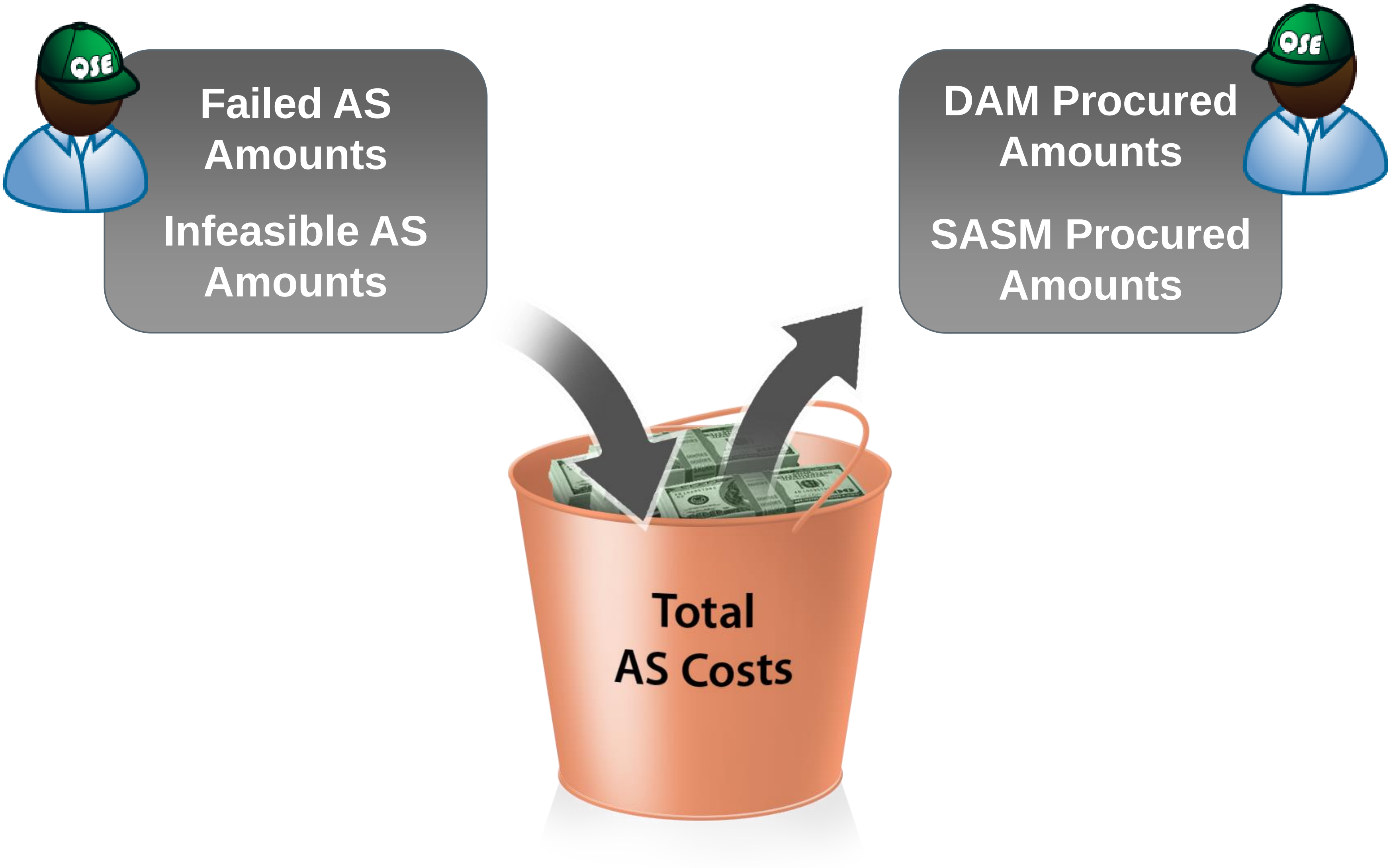
Fundamentals of Adjustments to Cost for Ancillary Service

Who:	QSEs that have Ancillary Service obligations
What:	A charge to the QSE for its share of the net total costs incurred in both DAM and SASMs less its DAM charge
Why:	To cover the costs of a services to ensure ERCOT reliability

Trigger #1

ERCOT has net costs for AS that must be collected from the market

Adjustments to Costs for Ancillary Services Procurement



A QSE's share of the net total cost for an Ancillary Service for an Operating Hour is simply

$$(\text{AS Price}) * (\text{AS Quantity}_q)$$

$$\text{AS Price} = \left(\frac{\text{Total Ancillary Service Costs}}{\text{Total Ancillary Service Quantity}}\right)$$

$$\text{Total AS Quantity} = \sum_{\text{All QSEs}} \text{AS Quantity}_q$$

$$\text{AS Quantity}_q = \text{AS Obligation}_q - \text{Self-Arranged Quantity}_q$$

Finding the Ancillary Service Obligation for a QSE

$$\text{Ancillary Service Obligation}_{q} = \sum_{\text{All QSEs}} \left(\begin{array}{c} \text{Self-Arranged Qty in all Markets} \\ + \\ \text{AS Procured in Real-Time} \\ + \\ \text{AS Procured in DAM} \\ - \\ \text{AS Failed Quantities} \end{array} \right) * \text{HLRS}$$

Now, the QSE’s Ancillary Service Cost is simply

AS Price * (AS Obligation $_{q}$ – Self-Arranged Quantity $_{q}$)

Is this what the QSE pays for each Ancillary Service in Real-Time?

Adjustments to Costs for Ancillary Services Procurement

The QSE already paid part of this AS Cost in the Day-Ahead Market.

DAM

Participation in DAM
- **Energy**
- **AS**
- **PTP Obligations**

In Real-Time, the QSE pays or is paid for any difference between their AS Cost and their Day-Ahead AS Charge

RT AS Amount = AS Cost – Day-Ahead AS Amount

Real-Time

Supplemental Ancillary Services Market SASM)

Activity: Now it's your turn!

Refer to your Settlements Workbook

In a small group, respond to the questions that relate to Scenario #RT6.

You have 15 minutes to complete your questions.

If you cannot complete all questions, don't worry – all questions will be reviewed as a class.

Outcome #1

QSE's Net Cost for Reg-Up is calculated as

$$RUCOST_q = RUPR * RUQ_q$$

Where:

Net price for Reg-Up

$$RUPR = RUCOSTTOT / RUQTOT$$

A QSE's net quantity for Reg-Up

$$RUQ_q = RUO_q – SARUQ_q$$

Outcome #1

QSE's Net Cost for Reg-Up is calculated as

$$RUCOST_{q} = RUPR * RUQ_{q}$$

Where:

A QSE's obligation for Reg-Up

$$RUO_{q} = \sum_{q} (SARUQ_{q} + \sum_{m} (RTPCRU_{q,\,m}) + PCRU_{q} - RUFQ_{q} - RRUFQ_{q}) * HLRS_{q}$$

Outcome #1

Finally, the QSE is charged the difference between their net Reg-Up Cost and their Day-Ahead Reg-Up Charge

The Real-Time Reg-Up Amount for a QSE

$$\mathbf{RTRUAMT}_{q} = \mathbf{RUCOST}_{q} - \mathbf{DARUAMT}_{q}$$

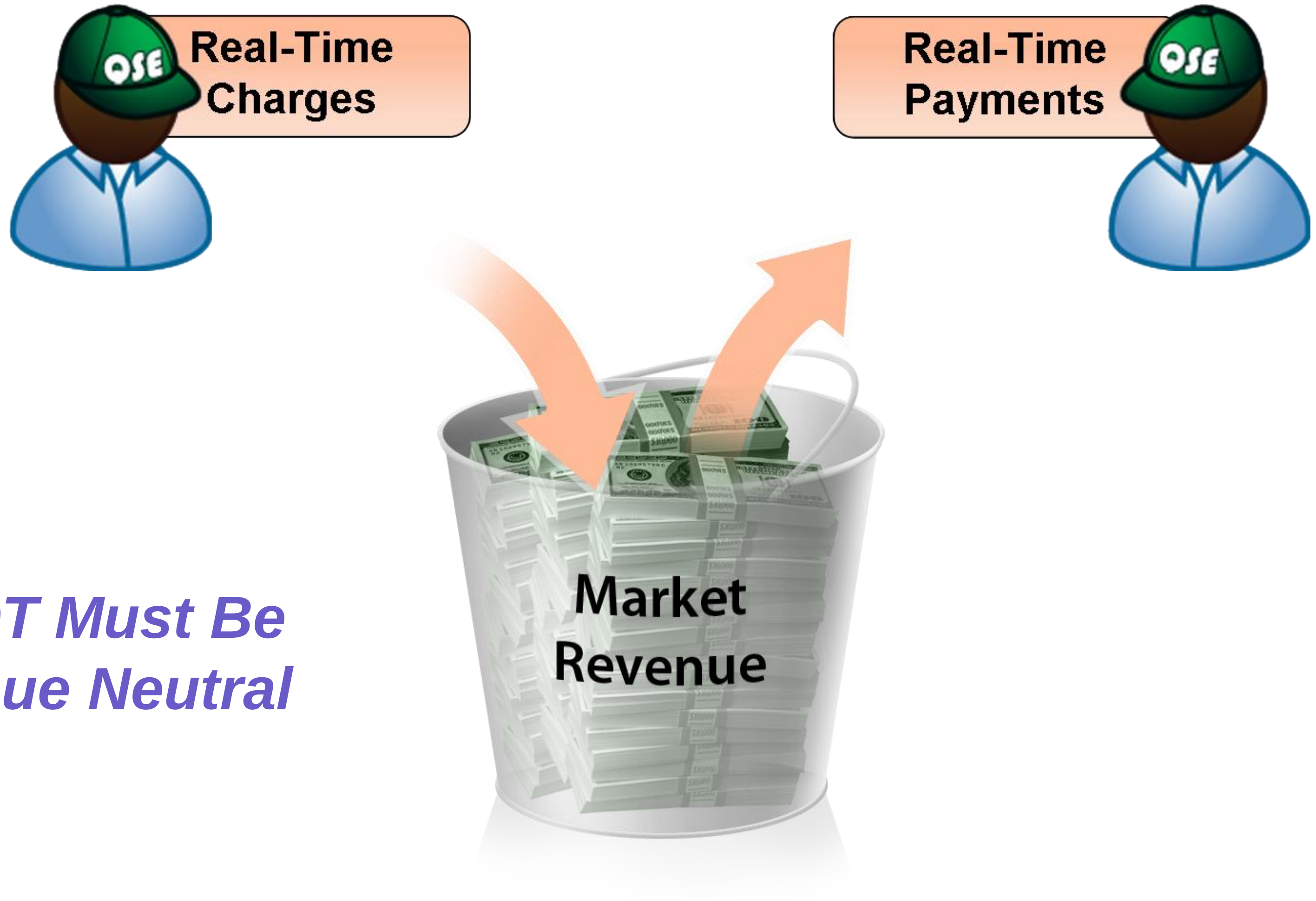
There is a similar Charge Type for each Ancillary Service Type

Real-Time

Revenue Neutrality

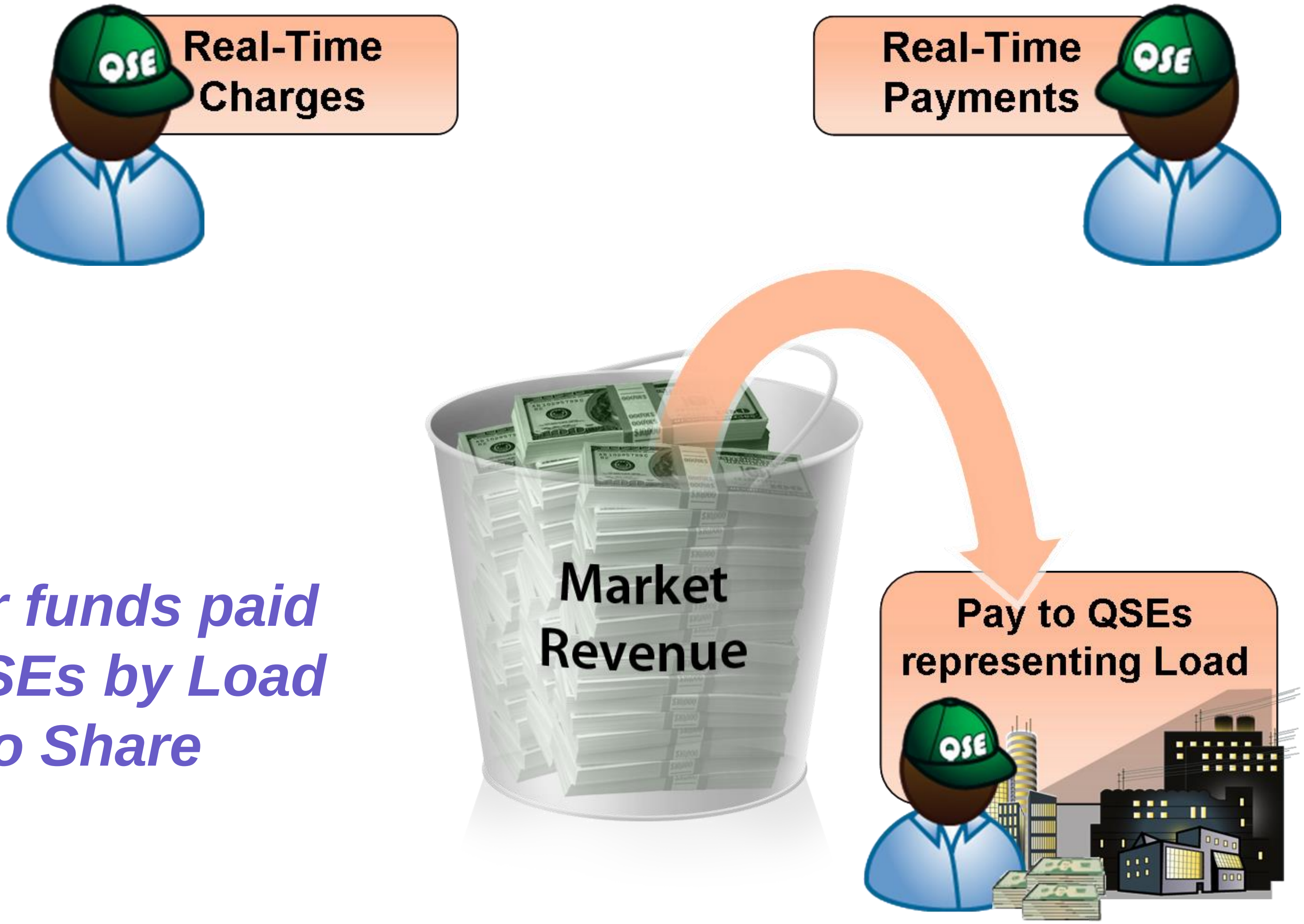
Fundamentals of Real-Time Revenue Neutrality Allocation

Who:	QSEs that have load
What:	An Allocation on of a QSEs Load Ratio Share
Why:	To keep ERCOT revenue neutral



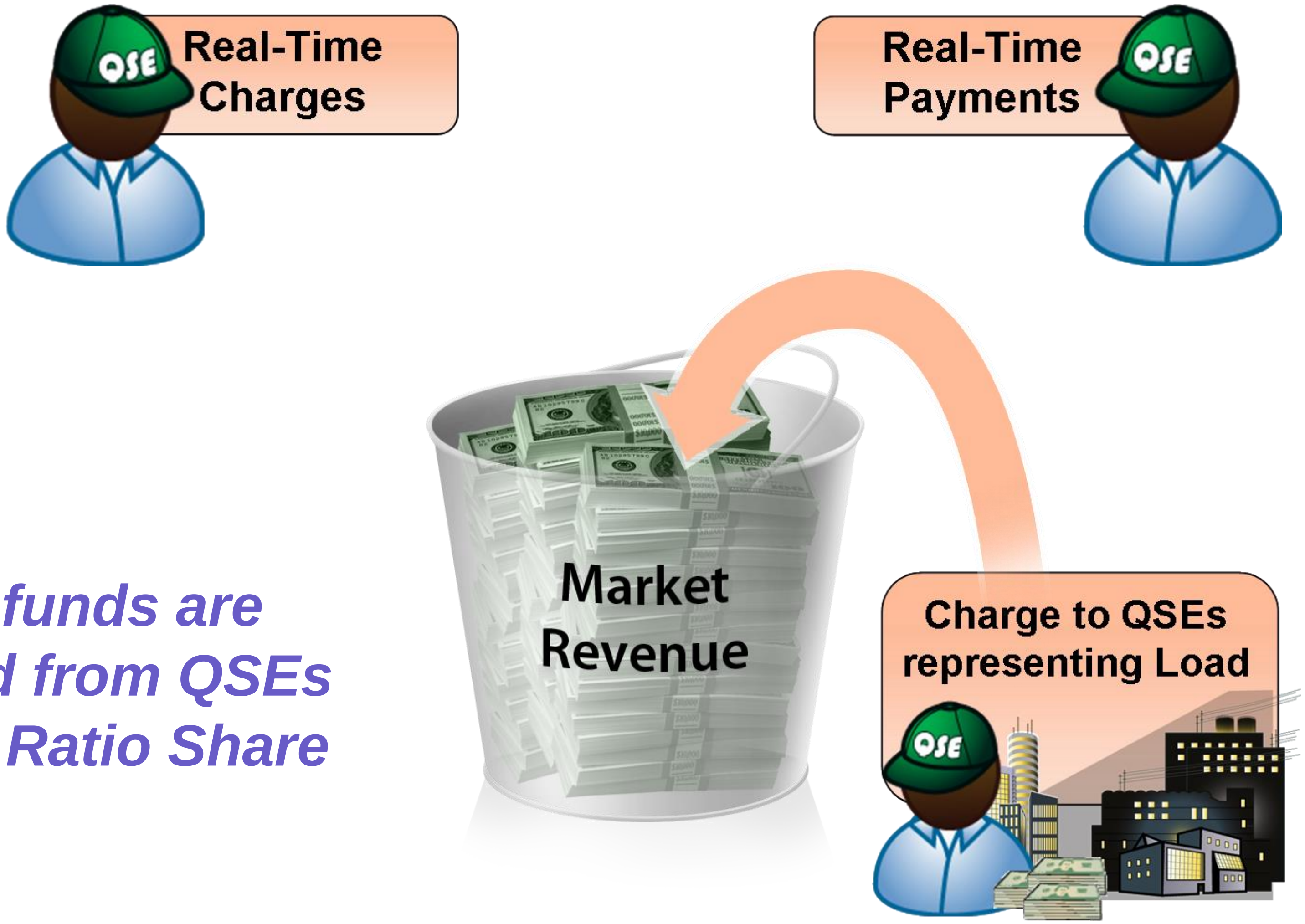
ERCOT Must Be Revenue Neutral

Revenue Neutrality



Left over funds paid out to QSEs by Load Ratio Share

Revenue Neutrality



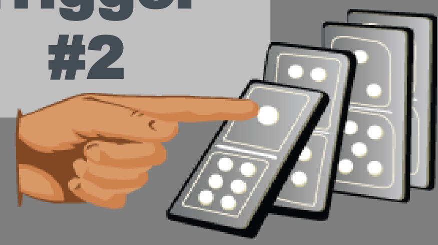
Short funds are collected from QSEs by Load Ratio Share

Revenue Neutrality: Triggers

Trigger #1

ERCOT has issued energy-related charges and payments and must achieve Revenue Neutrality

Trigger #2



ERCOT has issued AS Imbalance charges and payments and must achieve Revenue Neutrality

- All charges and payments related to energy are summed
- Allocated to QSEs with Load

RTEIAMTTOT	Real-Time Energy Imbalance Amount Total
BLTRAMTTOT	Block Load Transfer Resource Amount Total
RTDCIMPAMTTOT	Real-Time DC Import Amount Total
RTDCEXPAMTTOT	Real-Time DC Export Amount Total (*Oklaunion*)
RTCCAMTTOT	Real-Time Energy Congestion Cost Amount Total
RTOBLAMTTOT	Real-Time Obligation Amount Total
RTOBLLOAMTTOT	Real-Time Obligation with Links to an Option Amount Total

Outcome #1

- Hourly values must be divided by 4
- Allocated based on Load Ratio Share

$$LARTRNAMT_{q} = (-1) * \left(\begin{array}{l} RTEIAMTTOT + BLTRAMTTOT \\ + RTDCIMPAMTTOT + RTDCEXPAMTTOT \\ + RTCCAMTTOT \\ + RTOBLAMTTOT/4 + RTOBLLOAMTTOT/4 \end{array} \right) * LRS_{q}$$

Outcome #1

- RT Energy Imbalance Total = $1500
- DC Tie Import Amount Total = -$400
- RT Obligation Amount Total = -$1200
- QSE 4 has **20%** of the load

$$LARTRNAMT_{q} = (-1) * \left(\begin{array}{l} RTEIAMTTOT + BLTRAMTTOT \\ + RTDCIMPAMTTOT + RTDCEXPAMTTOT \\ + RTCCAMTTOT \\ + RTOBLAMTTOT/4 + RTOBLLOAMTTOT/4 \end{array} \right) * LRS_{q}$$

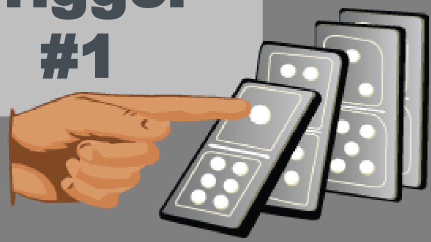
$$= (-1) * (\$1500 - \$400 - \$1200/4) * 0.20$$

$$= (-1) * (\$800) * 0.20$$

$$= -\$160$$

Revenue Neutrality: Triggers

Trigger #1



ERCOT has issued energy-related charges and payments and must achieve Revenue Neutrality

Trigger #2

ERCOT has issued AS Imbalance charges and payments and must achieve Revenue Neutrality

Real-Time AS Imbalance Revenue Neutrality Allocation

Outcome #2

- All charges and payments related to AS Imbalance are summed
- Allocated to QSEs with Load

$$LAASIRNAMT_{q} = (-1) * [(RTASIAMTTOT + RTRUCRSVAMTTOT) * LRS_{q}]$$

LAASIRNAMT	Load-Allocated Ancillary Service Imbalance Revenue Neutrality Amount
RTASIAMTTOT	Real-Time Ancillary Service Imbalance Market Total Amount
RTRUCRSVAMTTOT	Real-Time RUC Ancillary Service Reserve Market Total Amount

Outcome #2

- RT AS Imbalance Total = \$1200
- RT RUC AS Reserve Total = -\$300
- QSE 5 has **30%** of the load

$$\mathrm{LAASIRNAMT}_{q} = (-1) * [(\mathrm{RTASIAMTTOT} + \mathrm{RTRUCRSVAMTTOT}) * \mathrm{LRS}_{q}]$$

$$= (-1) * [(\$1200 - \$300) * 0.30]$$

$$= (-1) * [\$900 * 0.30]$$

$$= -\$270$$

Outcome #2

But wait, there's more!

- All charges and payments related to Reliability Deployment AS Imbalance are summed
- Allocated to QSEs with Load

$$LARDASIRNAMT_{q} = (-1) * [(RTRDASIAMTTOT + RTRDRUCRSVAMTTOT) * LRS_{q}]$$

LARDASIRNAMT	Load-Allocated Reliability Deployment Ancillary Service Imbalance Revenue Neutrality Amount
RTRDASIAMTTOT	Real-Time Reliability Deployment Ancillary Service Imbalance Market Total Amount
RTRDRUCRSVAMTTOT	Real-Time Reliability Deployment RUC Ancillary Service Reserve Market Total Amount

CRR Auction

Charges & Payments for CRRs

Revenue Distribution

CRR Balancing Account

Reconcile CRR Short payments

DAM

Participation in DAM
- Energy
- AS
- PTP Obligations

DAM Commitment
- Make-Whole

Settlement of CRRs purchased in the Auction

RUC

Commitment
- Make-Whole
- Clawback

Decommitment

Real-Time

Real-Time Activities
- Imbalances
- Base Point Deviations
- Other odds & ends

Settlement of PTP Obligations purchased in the DAM

Real Time Ancillary Service Settlements

Revenue Neutrality