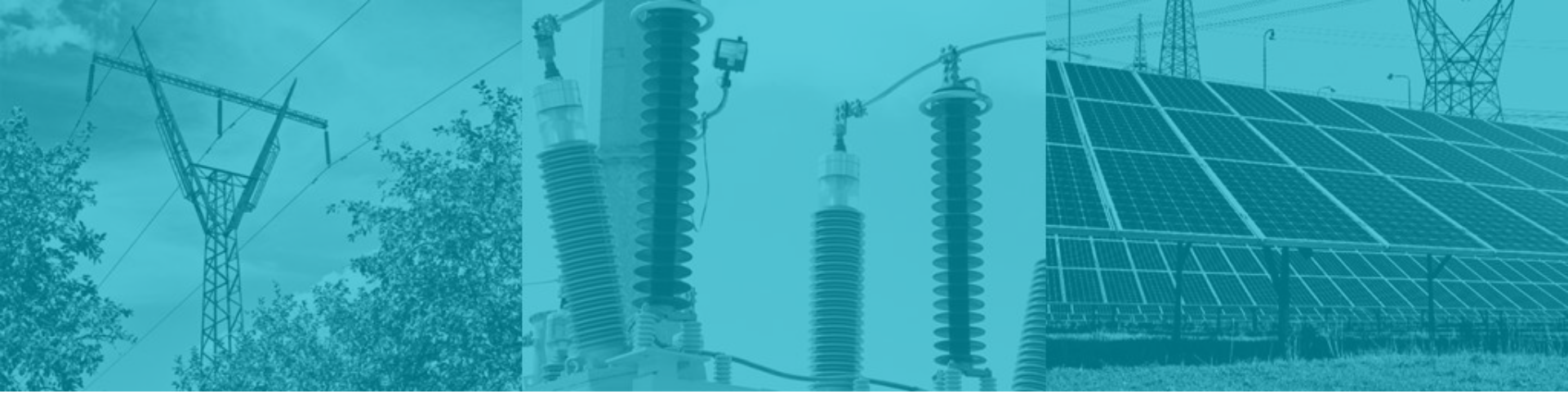


Settlement: Energy and PTP Obligations

Greetings and Introductions

WebEx Training Tips

- **Windows**
- **Buttons**

Attendance

Questions / Chat

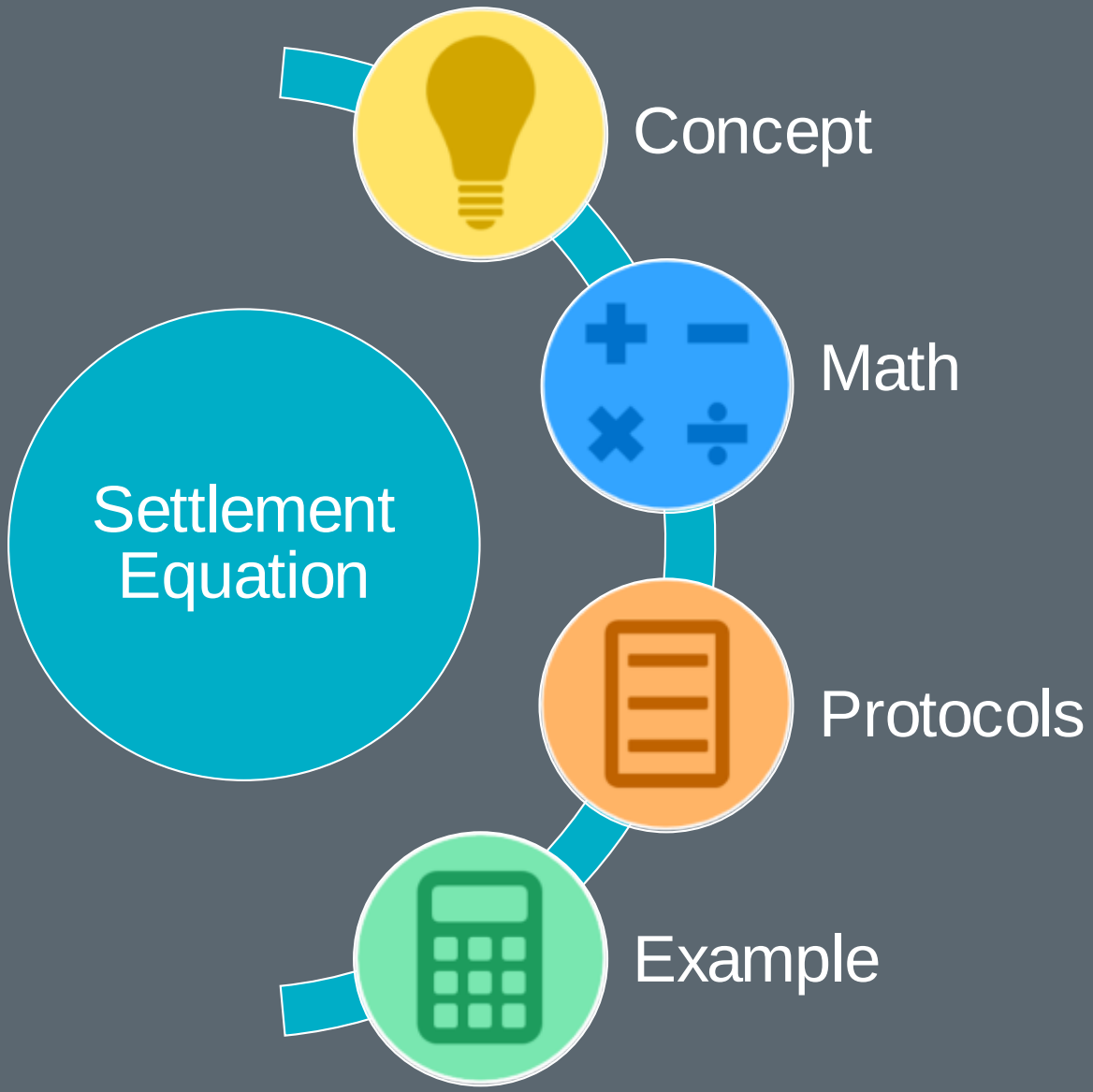
Please enable video & audio capabilities

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:

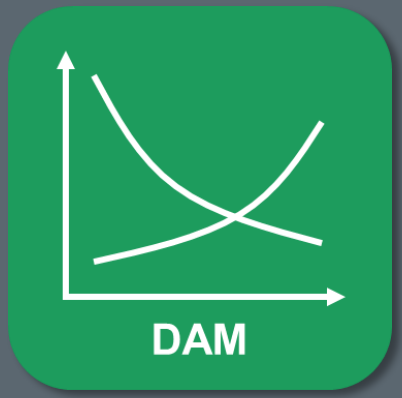
http://www.ercot.com/mktrules/nprotocols/

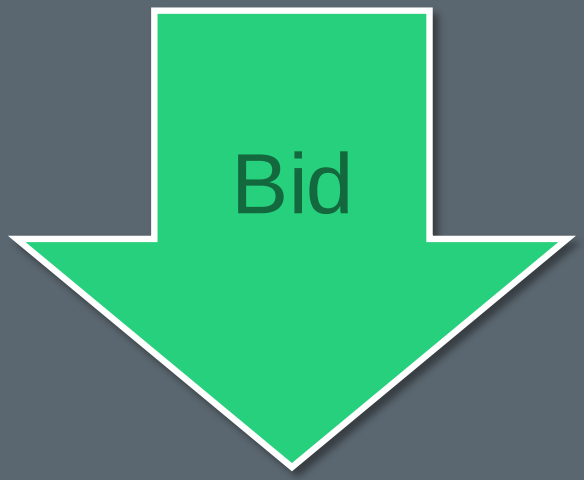

Concept
Math
Settlement Equation
Protocols
Example

Topics in this course include:

1. Energy Bids
2. Energy Offers
3. Real-Time Energy Imbalance
4. DC-Tie Import Transactions
5. PTP Obligation Bids
6. PTP Obligation Bids with Links to an Option

Which Markets & Which Participants?





Proposal to buy

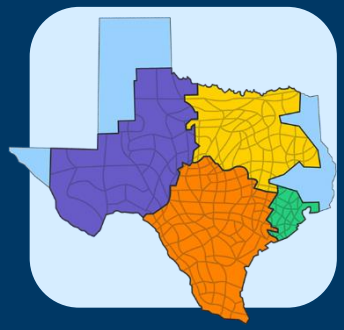
- A Product
- At a Location
- For a Max Price

Proposal to Sell

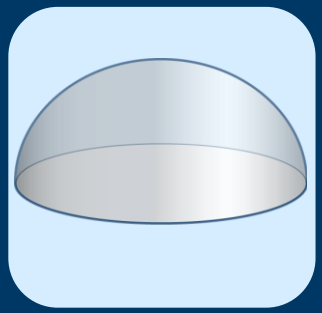
- A Product
- At a Location
- For a Min Price

Resource Node (RN)

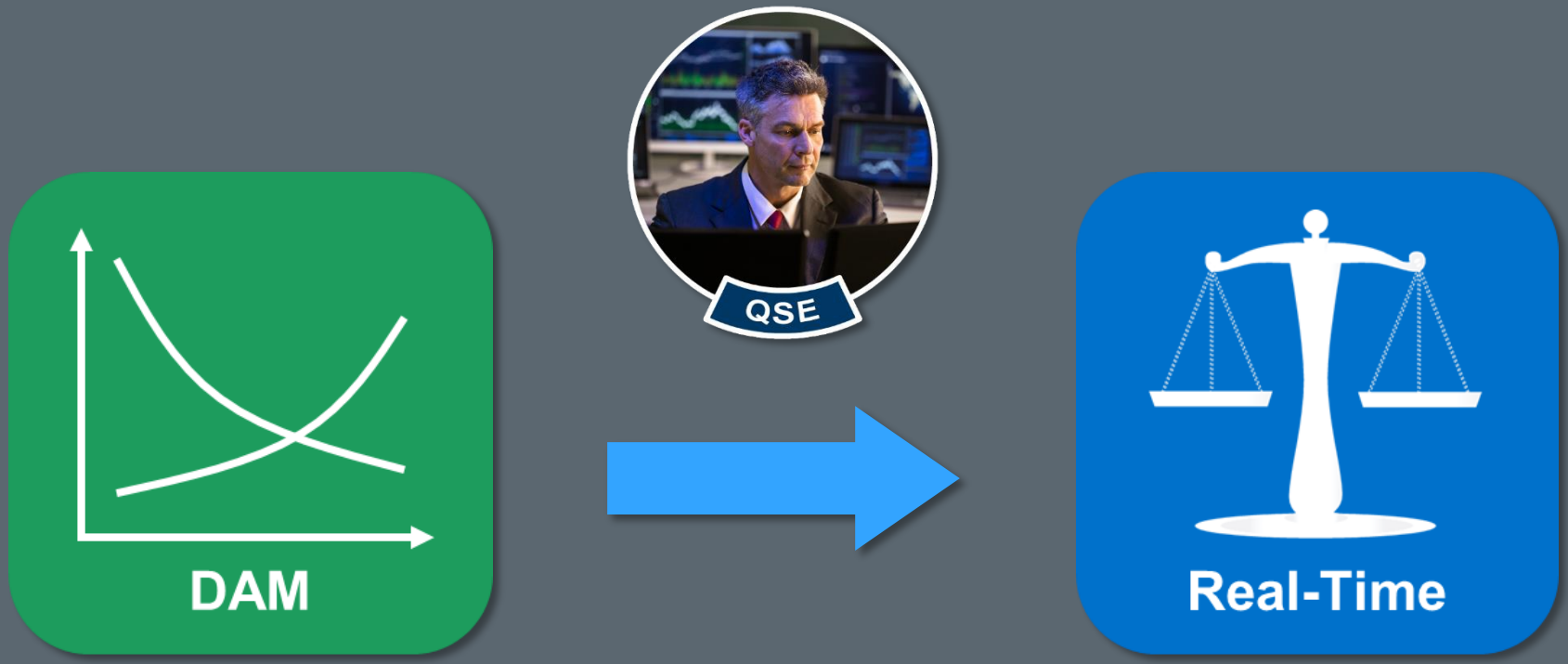
Load Zone (LZ)



Hub (HB)



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



Energy Bid

Energy Bid: Concept

Energy Bids

DAM

Hourly Awards

Hourly Prices

Energy Bid @ Load Zone 1

- Bid Price = $45/MWh
- Quantity = 68MW for one hour
- DAM clearing price is $40/MWh @ LZ1

Awarded Energy Bid = DAM Price * Quantity

Awarded Energy Bid = $40/MWh * 68MW

$2,720 for the hour @ LZ1

DAEPAMT = Day-Ahead Energy Purchase Amount

$$DAEPAMT_{q,p} = DASPP_{p} * DAEP_{q,p}$$

DASPP	Day-Ahead Settlement Point Price
DAEP	Day-Ahead Energy Purchase
q, p	QSE, Settlement Point

Example 1: Energy Bid

Settle Energy Bid @ Hub 1

- Bid Price = $38/MWh
- Quantity = 75MW for Hour 14
- DAM clearing price is $35MWh @ HB1

Energy Offer

Energy Offer: Concept

Energy-Only Offers

Three-Part Supply Offers

DAM

Hourly Awards

Hourly Prices

Three-Part Supply Offer @ Resource Node 1

- Energy Offer Curve Price = $16/MWh
- Quantity = 100MW for one hour
- DAM clearing price is $30/MWh @ RN1

Awarded Energy Offer = (-1) * DAM Price * Quantity

Awarded Energy Offer = (-1) * $30/MWh * 100MW

-$3,000 for the hour @ RN1

DAESAMT = Day-Ahead Energy Sale Amount

$$DAESAMT_{q,p} = (-1) * DASPP_{p} * DAES_{q,p}$$

DASPP	Day-Ahead Settlement Point Price
DAES	Day-Ahead Energy Sale
q, p	QSE, Settlement Point

Example 2: Energy Offer

Settle Energy-Only Offer @ Hub 1

- Offer Price = $30/MWh
- Quantity = 135MW for Hour 13 and Hour 14
- DAM price is $35/MWh @ HB1 for Hour 13
- DAM price is $38/MWh @ HB1 for Hour 14

DAEPAMTQSETOT = Day-Ahead Energy Purchase Amount QSE Total

$$DAEPAMTQSETOT_q = \sum_p DAEPAMT_{q,p}$$

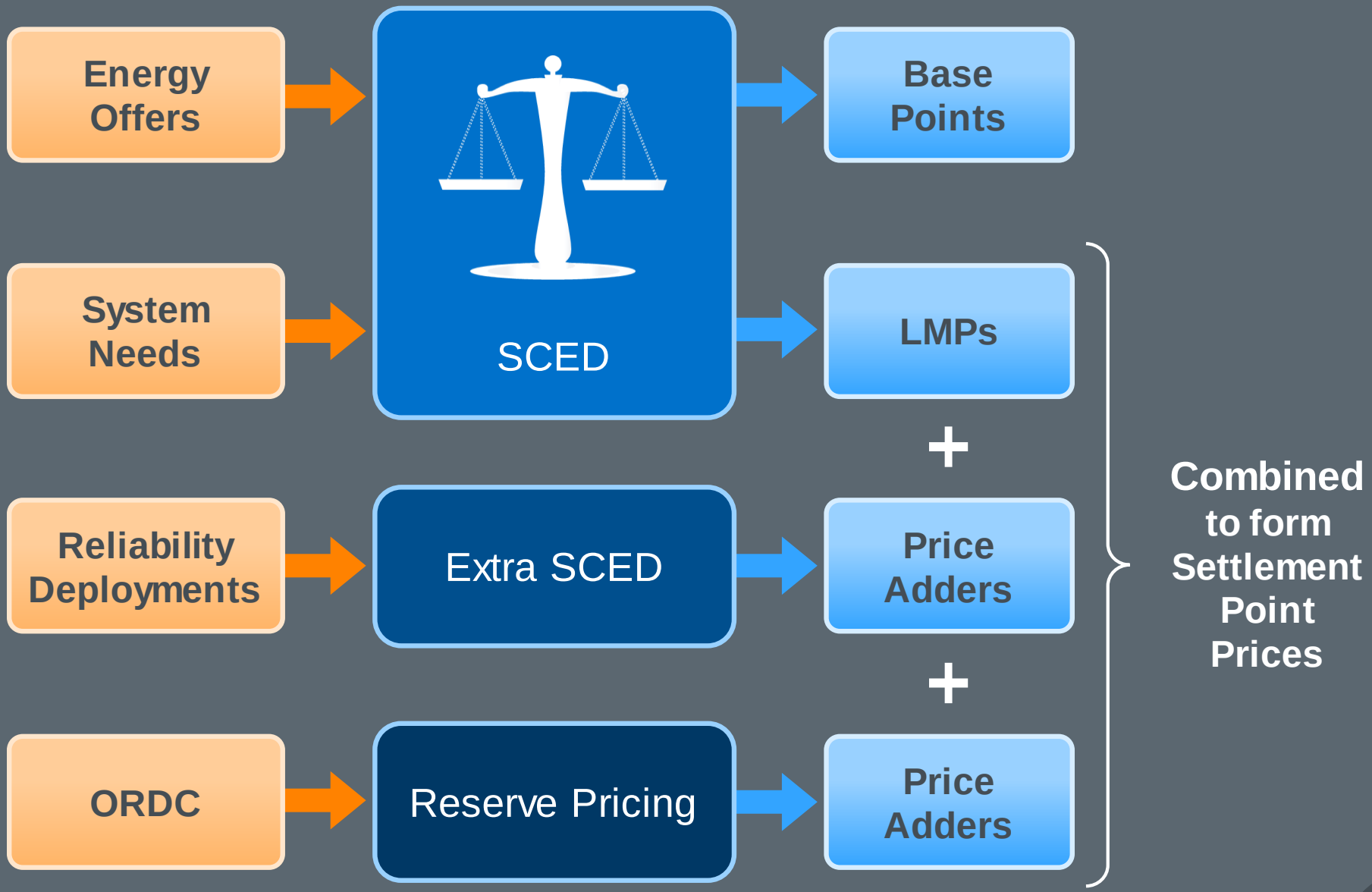
DAESAMTQSETOT = Day-Ahead Energy Sale Amount QSE Total

$$DAESAMTQSETOT_q = \sum_p DAESAMT_{q,p}$$

q, p	QSE, Settlement Point

Real-Time Settlement Point Prices

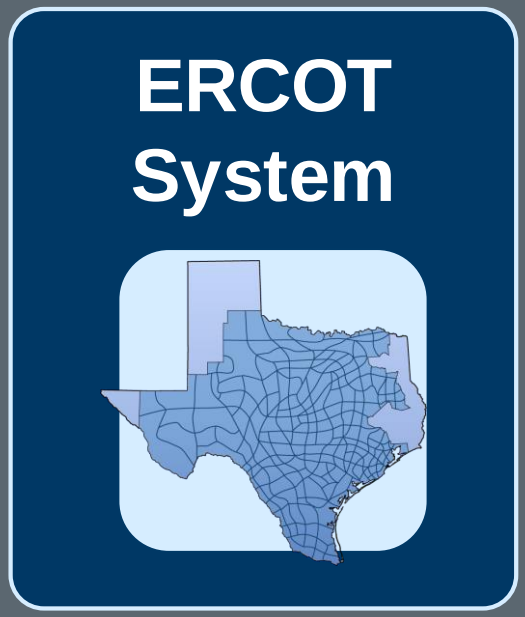
Real-Time Pricing: Concept



RTORPA = Real-Time On-Line Reserve Price Adder

RTOFFPA = Real-Time Off-Line Reserve Price Adder

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

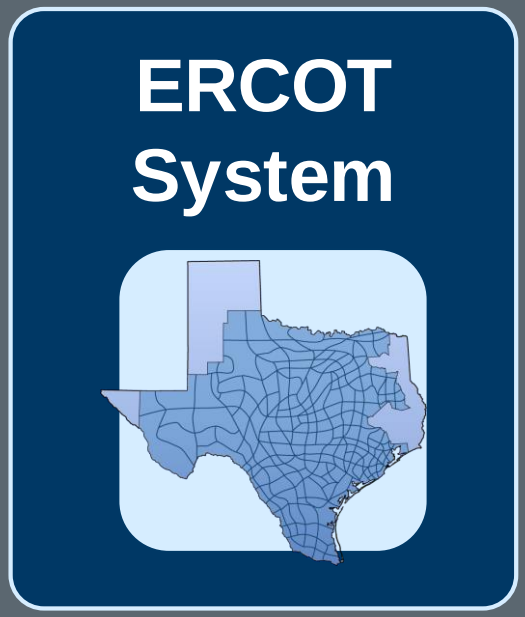


Adders are produced for each SCED interval

RTRSVPOR = Real-Time Reserve Price for On-Line Reserves

RTRSVPOFF = Real-Time Reserve Price for Off-Line Reserves

RTRDP = Real-Time On-Line Reliability Deployment Price



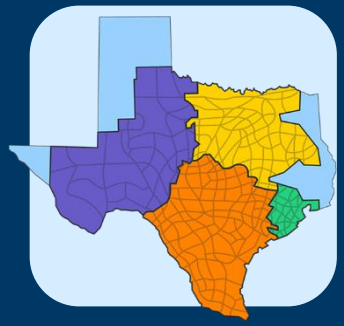
Time-Weighted Average for each 15-minute interval

Real-Time Settlement Point Prices =

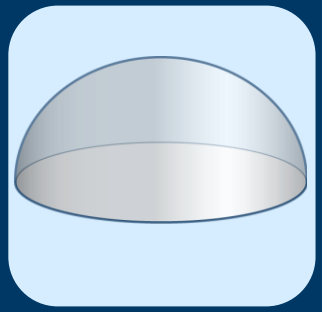
RTRSVPOR + RTRDP + Ave (LMPs)

Resource Node

Load Zone



Hub



Real-Time

… for each 15-minute interval

Real-Time Energy Imbalance Concept

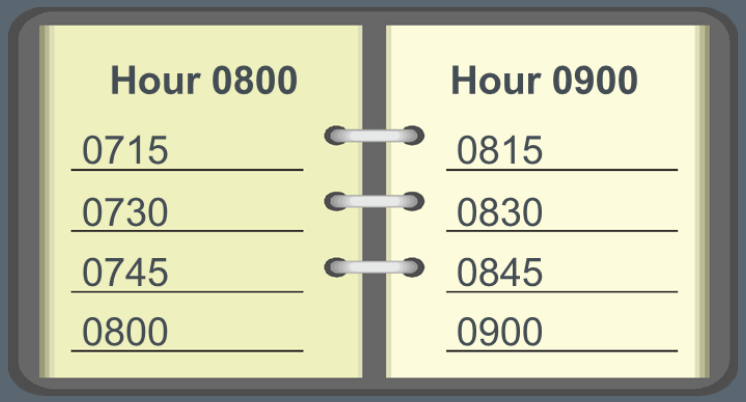
The basic idea at any Settlement Point:

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

Now, fill in the elements

Supplies & Obligations includes DAM & Trade Energy

- DAM Energy settled in hourly MWs
- Trade Energy reported in hourly MWs
- Real-Time Energy Imbalance settles in 15-minute MWhs

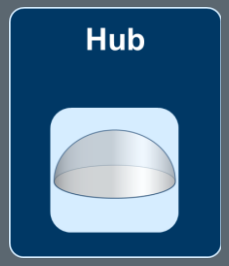


Multiply DAM & Trade Energy by ¼ hour

Real-Time

Real-Time Energy Imbalance at a Hub

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

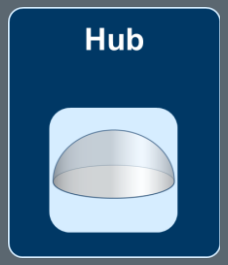


Each Settlement Point settled separately

RTSPP = Real-Time Settlement Point Price

Settles Financial Transactions

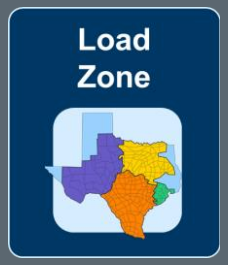
RTSPP = RTRSVPOR + RTRDP +
Simple & Time-Weighted Average (LMPs)



Real-Time Energy Imbalance at a Load Zone

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

$$+ (-1)\left[\text{Settlement Only Generation (SOG)} - \text{Adjusted Metered Load}\right] * \text{RTSPPEW}$$

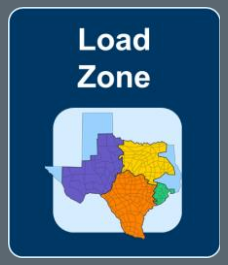


Each Settlement Point settled separately

RTSPP = Real-Time Settlement Point Price

Settles Financial Transactions

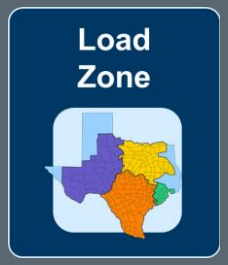
RTSPP = RTRSVPOR + RTRDP +
MW-Weighted & Time-Weighted Average (LMPs)



RTSPPEW = Real-Time Settlement Point Price Energy-Weighted

Settles Physical Energy Consumption

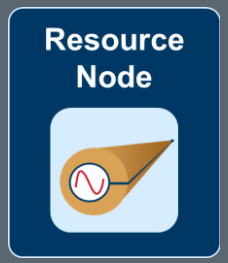
RTSPPEW = RTRSVPOR + RTRDP + (MW * Time)-Weighted Average (LMPs)



Real-Time Energy Imbalance at a Resource Node

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

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

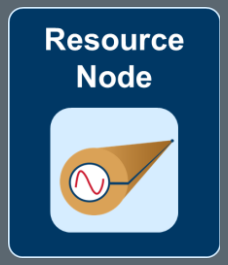


Each Settlement Point settled separately

RTSPP = Real-Time Settlement Point Price

Settles Financial Transactions

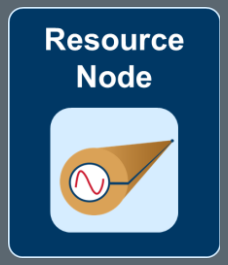
RTSPP = RTRSVPOR + RTRDP + Time-Weighted Average (LMPs)



RTRMPR = Real-Time Resource Meter Price

Settles Physical Energy Production

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



Real-Time Energy Imbalance Hub

Supplies & Obligations @ Hub 2

- DAM Energy Purchase = 128MW for one hour
- DAM Energy Sale = 80MW for the same hour
- RTSPP = $41/MWh @ HB2

Imbal. = (-1) * **RTSPP** * (**Supplies** * ¼ – **Obligations** * ¼)

Imbal. = (-1) * **$41/MWh** * (**32MWh** – **20MWh**)

-$492 for the interval @ HB2

RTEIAMT = Real-Time Energy Imbalance Amount

$$RTEIAMT_{q,p} = (-1) * RTSPP_{p} * \{(DAEP_{q,p} * \tfrac{1}{4}) + (RTQQEP_{q,p} * \tfrac{1}{4}) - (DAES_{q,p} * \tfrac{1}{4}) - (RTQQES_{q,p} * \tfrac{1}{4})\}$$

RTSPP	Real-Time Settlement Point Price
DAE(P/S)	Day-Ahead Energy (Purchase or Sale)
RTQQE(P/S)	Real-Time QSE to QSE Energy (Purchase or Sale)
q, p	QSE, Settlement Point

Example 3: Real-Time Energy Imbalance (HB)

Settle Energy Imbalance @ Hub 4

- DAM Energy Purchase = 20MW for Hour 9
- Trade Energy Sale = 40MW for Hour 9
- RTSPP = $40/MWh @ HB4 for Interval 0830

Real-Time Energy Imbalance Load Zone

Supplies & Obligations @ Load Zone 2

- DAM Energy Purchase = 120MW for one hour
- Trade Energy Purchase = 200MW for the same hour
- Adjusted Metered Load = 100MWh for the interval
- RTSPP = $90/MWh & RTSPPEW = $91/MWh @ LZ2

Imbal. = (-1) * **RTSPP** * (**Supplies** * ¼ – **Obligations** * ¼)
+ (-1) * **RTSPPEW** * (**SOG** – **AML**)

Imbal. = (-1) * **$90/MWh** * (**30MWh** + **50MWh** – **0**)
+ (-1) * **$91/MWh** * (**0** – **100MWh**)

Imbal. = **-$7,200** + **$9,100**

$1,900 for the interval @ LZ2

RTEIAMT = Real-Time Energy Imbalance Amount

$$RTEIAMT_{q,p} = (-1) * RTSPP_{p} * [(DAEP_{q,p} * ¼) + (RTQQEP_{q,p} * ¼) – (DAES_{q,p} * ¼) – (RTQQES_{q,p} * ¼)] + (-1) * RTSPPEW_{p} * (RTMGNM_{q,p} – RTAML_{q,p})$$

RTSPP	Real-Time Settlement Point Price
RTSPPEW	Real-Time Settlement Point Price Energy-Weighted
DAE(P/S)	Day-Ahead Energy (Purchase or Sale)
RTQQE(P/S)	Real-Time QSE to QSE Energy (Purchase or Sale)
RTMGNM	Real-Time Metered Generation from SOG
RTAML	Real-Time Adjusted Metered Load
q, p	QSE, Settlement Point

Example 4: Real-Time Energy Imbalance (LZ)

Settle Energy Imbalance @ Load Zone 3

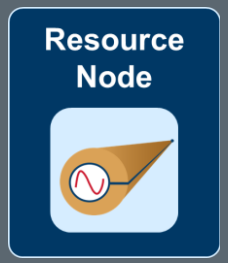
- DAM Energy Purchase = 60MW for Hour 9
- Trade Energy Sale = 20MW for Hour 9
- Adjusted Metered Load = 8MWh for Interval 0830
- RTSPP = $51/MWh & RTSPPEW = $50/MWh @ LZ3

Real-Time Energy Imbalance Resource Node

Real-Time Energy Imbalance at a Resource Node: Concept

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

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

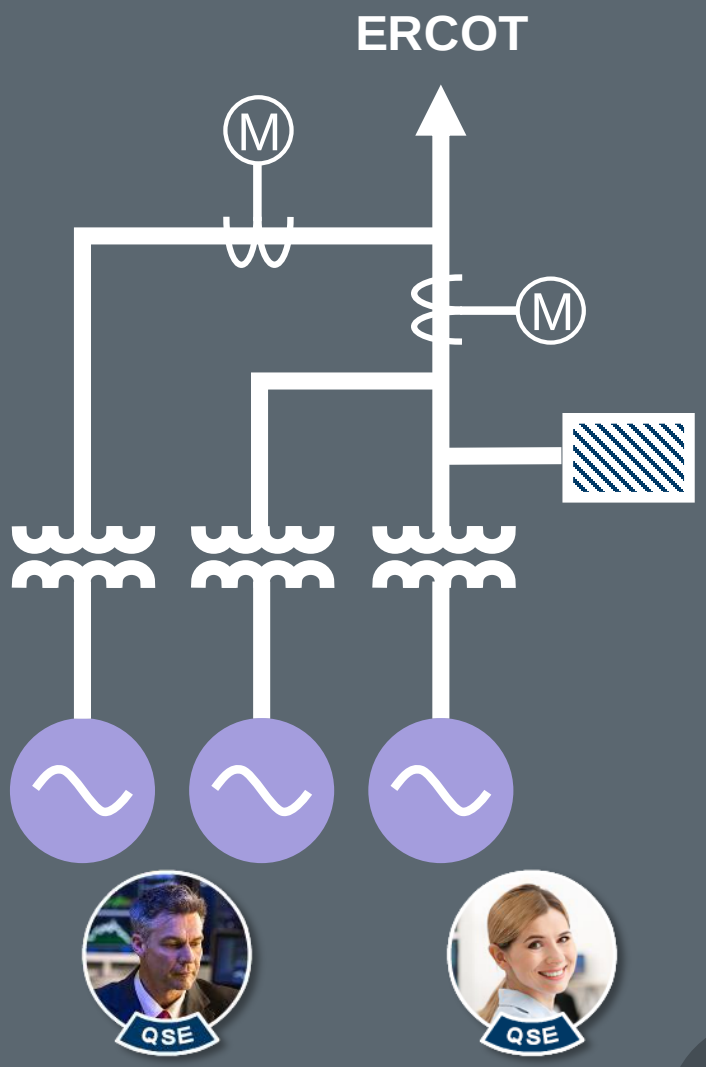


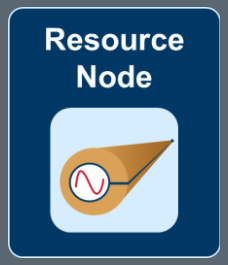
If all Generation Sites were simple …

But in reality …

Many Generation Sites are complex

- Multiple generators per meter
- Multiple owners
- Load and generation





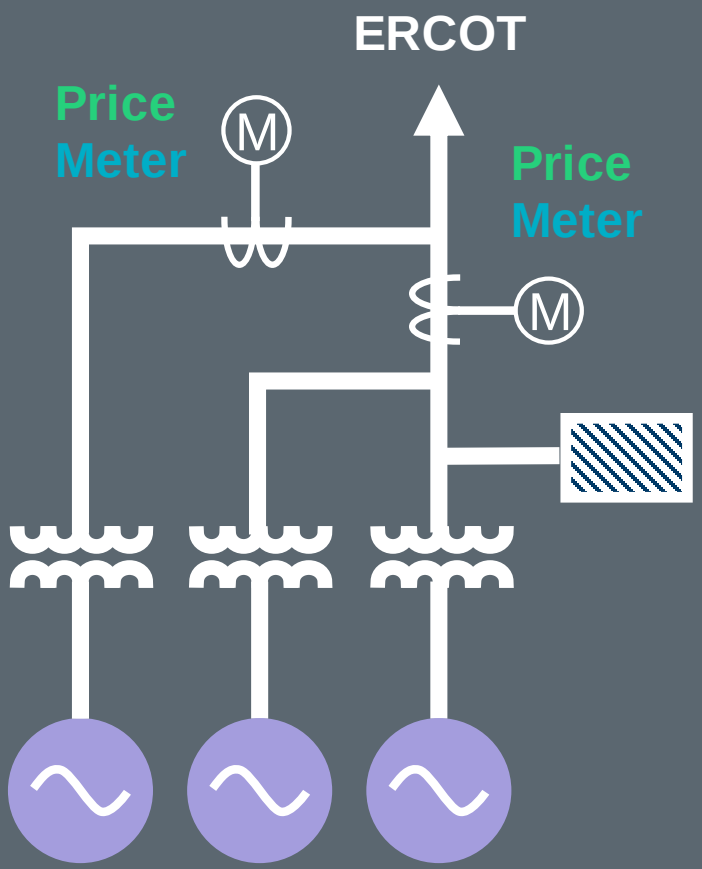
Resource Share = Splitting Percentage * Site Payment

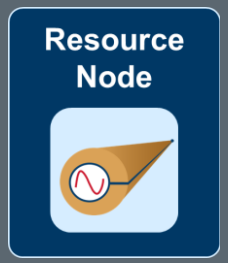
Splitting Percentage

- QSE Share per Resource
- Calculated from telemetry

Site Payment = ∑(Price * Meter)

- For all Resources at Site
- For all QSE at Site

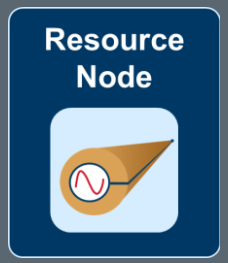




Real-Time Energy Imbalance at a Resource Node: Concept

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

$$+ (-1)\left[\text{Resource Share of Revenue}\right]$$



Methodology for all Generation Sites

Supplies & Obligations @ Resource Node 12

- DAM Energy Sale = 200MW for one hour
- Trade Energy Sale = 200MW for the same hour
- RTSPP = $30/MWh for the interval
- QSE owns 50% of Resource 12
- Meter Energy at Bus = 150MWh for the interval
- Resource Meter Price = $31 for the interval

Resource Share = Splitting Percentage * Site Payment

Resource Share = Splitting Percentage * ∑(Price * Meter)

Resource Share = 50% * $31 * 150MWh

$2325 for the interval @ RN12

Supplies & Obligations @ Resource Node 12

- DAM Energy Sale = 200MW for one hour
- Trade Energy Sale = 200MW for the same hour
- RTSPP = $30/MWh for the interval
- Resource Share = $2,325

Imbal. = (-1) * {Resource Share + RTSPP * [Supplies * ¼ – Obligations * ¼]}

Imbal. = (-1) * {$2,325 + $30/MWh * [0 – (50MWh + 50MWh)]}

Imbal. = (-1) * {$2,325 + $30/MWh * [-100MWh]}

Imbal. = (-1) * {$2,325 + -$3,000}

$675 for the interval @ RN12

Real-Time

RTEIAMT = Real-Time Energy Imbalance Amount

$$RTEIAMT_{q,p} = (-1) * \{\sum_r(RESREV) + RTSPP_p * [(DAEP_{q,p} * ¼) + (RTQQEP_{q,p} * ¼) – (DAES_{q,p} * ¼) – (RTQQES_{q,p} * ¼)]\}$$

RESREV	Resource Share Revenue Settlement Payment
RTSPP	Real-Time Settlement Point Price
DAE(P/S)	Day-Ahead Energy (Purchase or Sale)
RTQQE(P/S)	Real-Time QSE to QSE Energy (Purchase or Sale)
q, p, r	QSE, Settlement Point, Generation Resource

RESREV = Resource Share Revenue Settlement Payment

$$\text{Where: } RESREV_{q,r,s,p} = GSPLITPER_{q,r,p} * NMSAMTTOT_{s}$$

$$\text{Where: } NMSAMTTOT_{s} = \sum(RTRMPR_{b} * MEB_{s,b})$$

GSPLITPER	Generation Resource SCADA Splitting Percentage
NMSAMTTOT	Net Metering Settlement
RTRMPR	Real-Time Resource Meter Price
MEB	Metered Energy at Bus
b, q, p	Electrical Bus, QSE, Settlement Site
r, s	Generation Resource, Generation Site

Example 5: Real-Time Energy Imbalance (RN)

Settle Energy Imbalance @ Resource Node 32

- DAM Energy Sale = 80MW for Hour 9
- RTSPP = $25/MWh for Interval 0830
- QSE owns 100% of Resource 32
- Resource Share Revenue = $1,040

Volumetric Determinates (informational)

$RESMEB_q$ = GSPLITPER * $\sum_s$(MEB)

$RNIMBAL_q$ = MWh Imbalance for all transactions (RN)

$LZIMBAL_q$ = MWh Imbalance for all transactions (LZ)

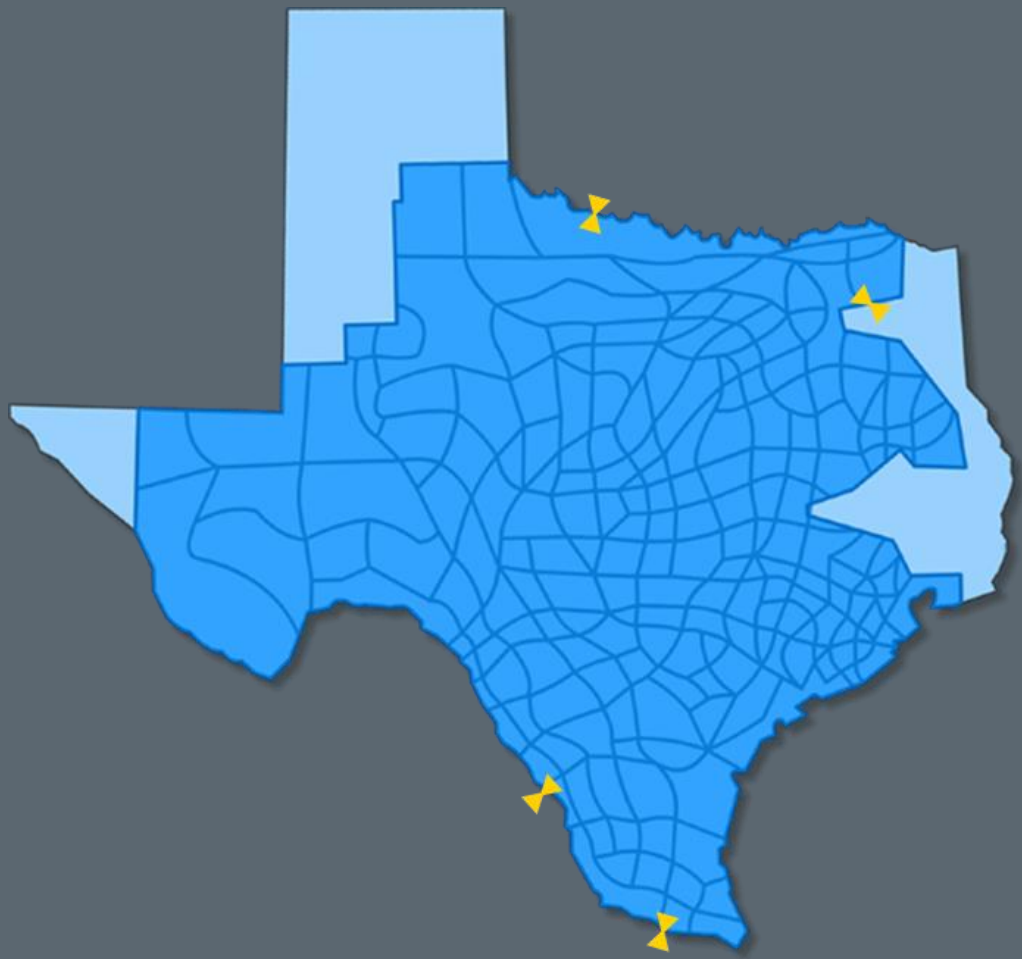
$HBIMBAL_q$ = MWh Imbalance for all transactions (HB)

RESMEB	Resource Share of total Metered Energy at Bus
RNIMBAL	Resource Node Energy Imbalance
LZIMBAL	Load Zone Energy Imbalance
HBIMBAL	Hub Energy Imbalance
q, s	QSE, Generation Site

DC Tie Import

Export = Load

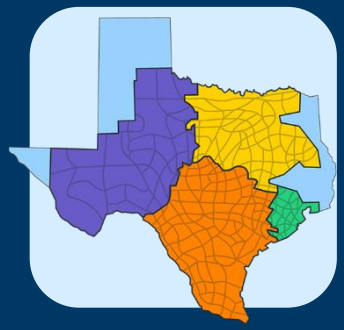
Import = Generation



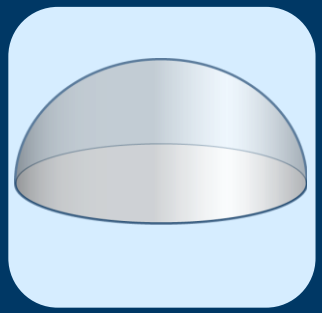
Financial and Physical Export Transactions

Resource Node

Load Zone



Hub



Real-Time

Scheduled Import @ DC Tie 1

- Quantity = 100MW for one hour
- RTSPP = $50/MWh @ DC1 for the interval

DC Tie Import = (-1) * RTSPP * (Quantity * ¼)

DC Tie Import = (-1) * $50/MWh * 25MWh

-$1,250 for the interval @ DC1

RTDCIMPAMT = Real-Time DC Import Amount

$$RTDCIMPAMT_{q,p} = (-1) * RTSPP_{p} * (RTDCIMP_{q,p} * ¼)$$

RTSPP	Real-Time Settlement Point Price
RTDCIMP	Real-Time DC Import
q, p	QSE, Settlement Point

Example 6: DC Tie Import

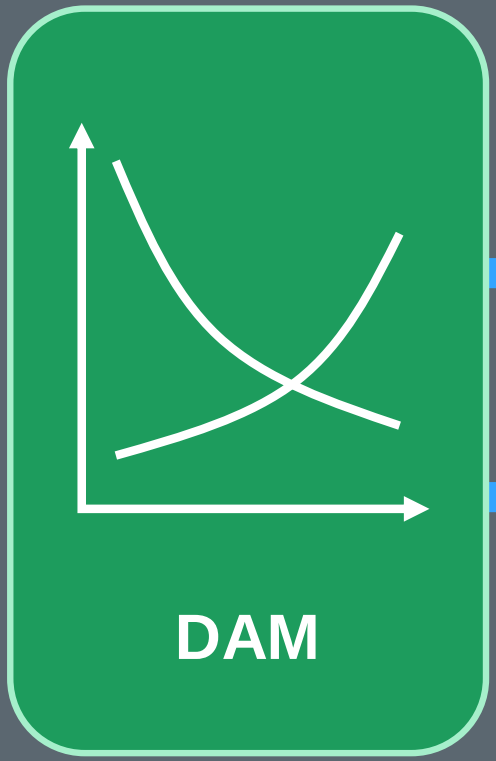
Settle Scheduled Import @ DC Tie 2

- Quantity = 136MW for Hour 17
- RTSPP = $47/MWh @ DC2 for Interval 1645

Day-Ahead Market
PTP Obligation Bid

DAM PTP Obligation Bid: Concept

PTP Obligation Bids

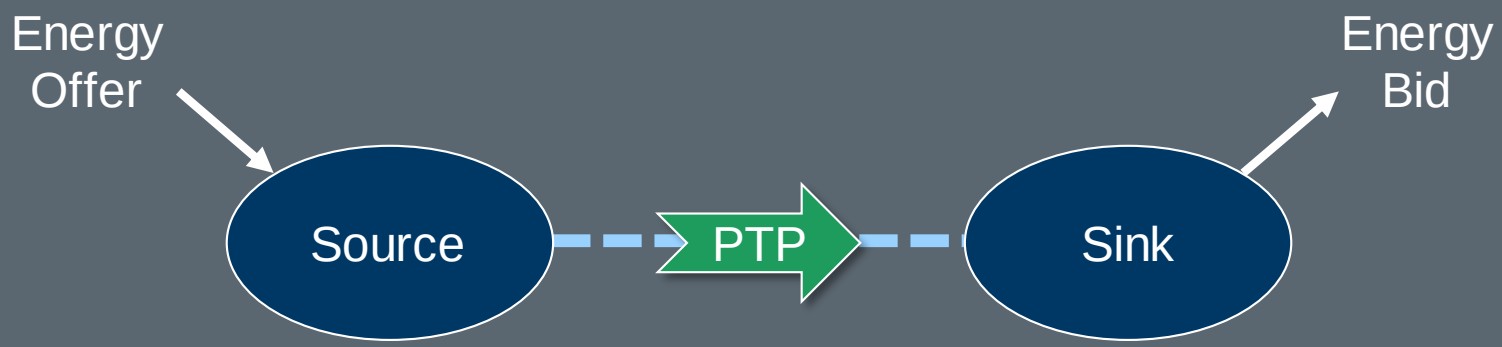


Hourly Awards

Hourly Prices

Like a coupled Offer and Bid

Purchase Price = Sink – Source



PTP Obligation Bid

- Bid Price = $26/MWh
- Quantity = 50MW for Hour 5
- Resource Node 1 (Source) / Load Zone 1 (Sink)
- DAM Prices are RN1 = $14/MWh & LZ1 = $18/MWh

Awarded PTP = Price * Quantity

Awarded PTP = (Sink Price – Source Price) * Quantity

Awarded PTP = ($18/MWh – $14/MWh) * 50MW

Awarded PTP = $4/MWh * 50MW

$200 for the hour (RN1 to LZ1)

DARTOBLAMT = Day-Ahead Real-Time Obligation Amount

$$DARTOBLAMT_{q,(j,k)} = DAOBLPR_{(j,k)} * RTOBL_{q,(j,k)}$$

Where: $DAOBLPR_{(j,k)} = DASPP_k - DASPP_j$

DAOBLPR	Day-Ahead Obligation Price
DASPP	Day-Ahead Settlement Point Price
RTOBL	Real-Time Obligation
q, j & k	QSE, Source & Sink Settlement Point

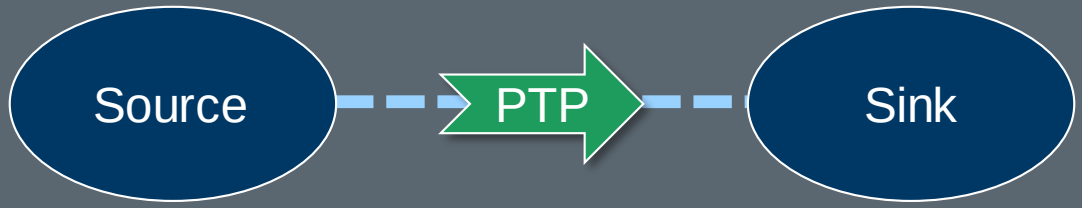
Settle PTP Obligation Bid

- Bid Price = $37/MWh
- Quantity = 75MW for Hour 12
- Hub 3 (Source) / Load Zone 3 (Sink)
- DAM Prices are HB3 = $27/MWh & LZ3 = $62/MWh

Day-Ahead Market
PTP Obligation Ownership

Hourly product settled with 15-minute prices

- Settled Price = Average of Sink – Source
- If Sink Price > Source Price, QSE is paid



Owned PTP Obligation (RN1 to LZ1)

- **Quantity = 50MW for Hour 5**
- **Average RTSPPs**

Interval	LZ1 $	RN1 $	Spread $
0415	$21/MWh	$17/MWh	$4/MWh
0430	$22/MWh	$17/MWh	$5/MWh
0445	$21/MWh	$16/MWh	$5/MWh
0500	$21/MWh	$15/MWh	$6/MWh

Average Price = ∑(Sink RTSPP – Source RTSPP) / 4

Average Price = ($4 + $5 + $5 + $6) / 4 =

Average Price = ($20/MWh) / 4 = $5/MW

Owned PTP Obligation (RN1 to LZ1)

- Quantity = 50MW for Hour 5
- Average Settlement Point Price = $5/MW

Owned PTP = (-1) * Average Price * Quantity

Owned PTP = (-1) * $5/MW * 50MW

-$250 for Hour 5 (RN1 to LZ1)

RTOBLAMT = Real-Time Obligation Amount

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

$$\text{Where: } RTOBLPR_{(j,k)} = \sum(RTSPP_k - RTSPP_j) / 4$$

RTOBLPR	Real-Time Obligation Price
RTSPP	Real-Time Settlement Point Price
RTOBL	Real-Time Obligation
q, j & k	QSE, Source & Sink Settlement Point

Example 8: DAM PTP Obligation Ownership

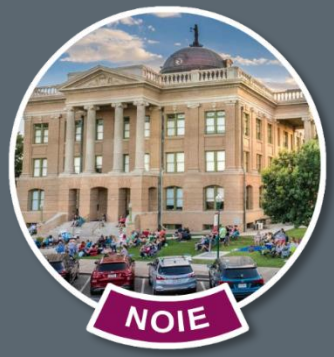
Settle Owned PTP Obligation (HB3 to LZ3)

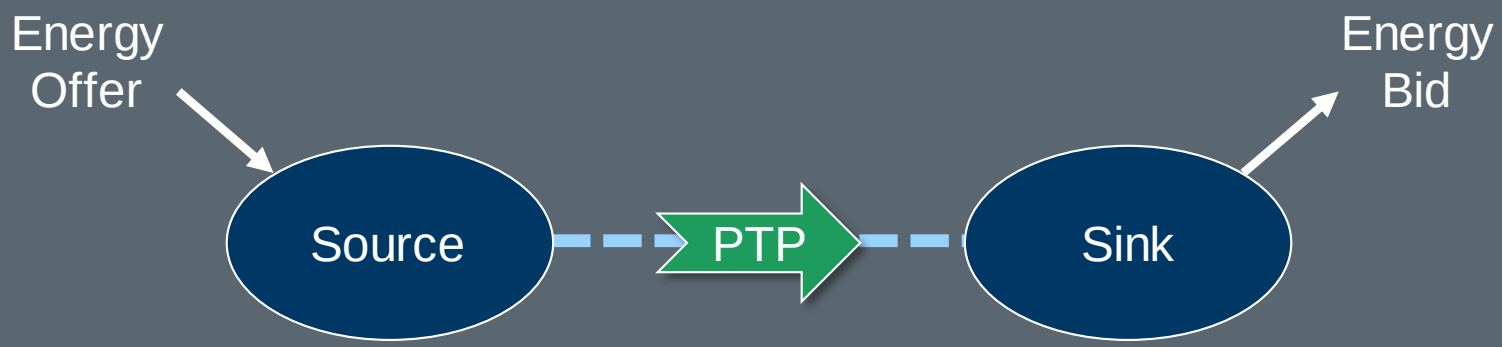
- Quantity = 75MW for Hour 12
- Average RTSPPs = $50/MW
  LZ3($/MWh) = $75, $74, $76, $75
  HB3($/MWh) = $25, $24, $26, $25

Day-Ahead Market PTP Obligation with Links to an Option Bid

Special Product for NOIEs

- **Must Own CRR Option**
- **Buy like quantity DAM PTP Obligation**





Settles like Option in Real-Time

PTP Obligation Bid (w/ Link to Option)

- Bid Price = $26/MWh
- Quantity = 50MW for one hour
- Resource Node 1 (Source) / Load Zone 1 (Sink)
- DAM Prices are RN1 = $16/MWh & LZ1 = $40/MWh

Awarded PTP (LO) = Price * Quantity

Awarded PTP (LO) = (Sink Price – Source Price) * Quantity

Awarded PTP (LO) = ($40/MWh – $16/MWh) * 50MW

Awarded PTP (LO) = $24/MWh * 50MW

$1,200 for the hour (RN1 to LZ1)

DARTOBLLOAMT = Day-Ahead Real-Time Obligation with Links to an Option Amount

$$DARTOBLLOAMT_{q,(j,k)} = Max(0, DAOBLPR_{(j,k)}) * RTOBLLO_{q,(j,k)}$$

Where: $DAOBLPR_{(j,k)} = DASPP_k - DASPP_j$

DAOBLPR	Day-Ahead Obligation Price
DASPP	Day-Ahead Settlement Point Price
RTOBLLO	Real-Time Obligation with Links to an Option
q, j & k	QSE, Source & Sink Settlement Point

Example 9: PTP Obligation w/ Links to Option Bid

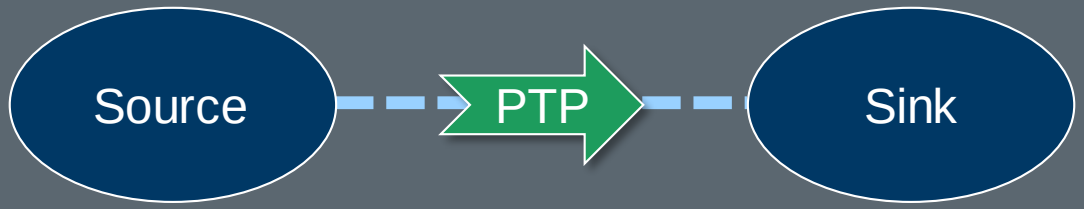
Settle PTP Obligation Bid (w/ Link to Option)

- Bid Price = $40/MWh
- Quantity = 50MW for Hour 12
- Resource Node 7 (Source) / Load Zone 4 (Sink)
- DAM Prices are RN7 = $55/MWh & LZ4 = $50/MWh

Day-Ahead Market
PTP Obligation with
Links to an Option Ownership

Special Product for NOIEs

- Only results in Real-Time Payments
- Real-Time Charges are waived



Owned PTP Obligation (w/ Link to Option)

- Quantity = 50MW for one hour
- Resource Node 1 (Source) / Load Zone 1 (Sink)
- Average RTSPPs = $29/MW
  LZ1($/MWh) = $50, $49, $41, $39
  RN1($/MWh) = $13, $14, $16, $20

Owned PTP (LO) = (-1) * Average Price * Quantity

Owned PTP (LO) = (-1) * $29/MW * 50MW

-$1,450 for the hour (RN1 to LZ1)

RTOBLLOAMT = Real-Time Obligation with Links to an Option Amount

$$RTOBLLOAMT_{q,(j,k)} = (-1) * Max(0, RTOBLPR_{(j,k)}) * RTOBLLO_{q,(j,k)}$$

Where: $RTOBLPR_{(j,k)} = \sum(RTSPP_k - RTSPP_j) / 4$

RTOBLPR	Real-Time Obligation Price
RTSPP	Real-Time Settlement Point Price
RTOBLLO	Real-Time Obligation with Links to an Option
q, j & k	QSE, Source & Sink Settlement Point

Example 10: PTP Obligation w/ Option Ownership

Settle Owned PTP Obligation (w/ Link to Option)

- Quantity = 50MW for Hour 12
- Resource Node 7 (Source) / Load Zone 4 (Sink)
- LZ4($/MWh) = $50, $55, $60, $59
  RN7($/MWh) = $60, $60, $60, $60

Topics in this course included:

1. Energy Bids
2. Energy Offers
3. Real-Time Energy Imbalance
4. DC-Tie Import Transactions
5. PTP Obligation Bids
6. PTP Obligation Bids with Links to an Option

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