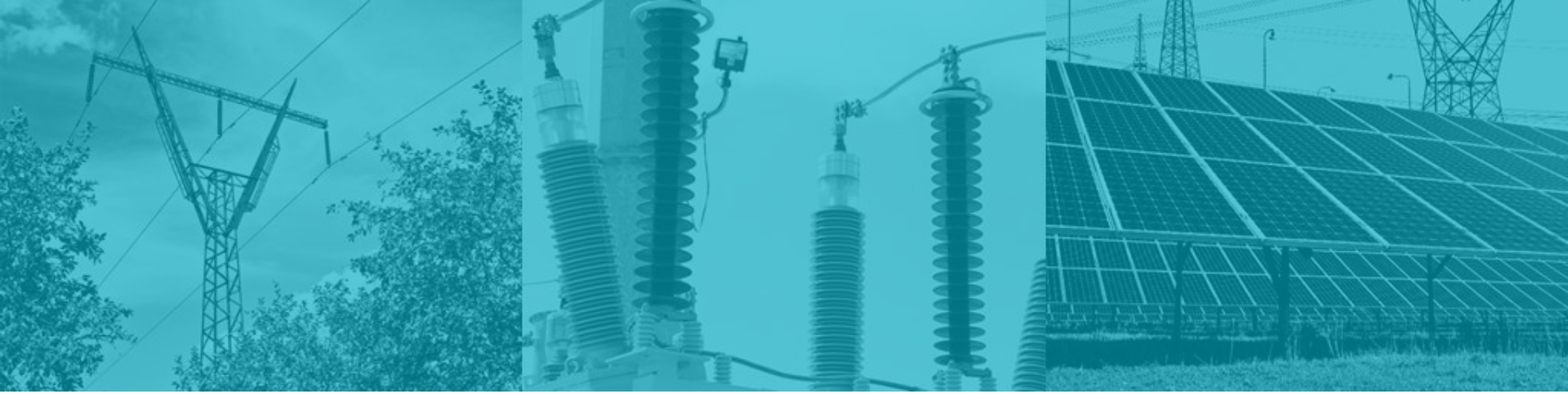


Wholesale Market Operations: Real-Time

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/

Suite of Wholesale Market Courses

Format	Title
WBT	Wholesale Markets Overview

Format	Title	Topic
ILT	Wholesale Market Operations: Day-Ahead	Day-Ahead Market Inputs
		Day-Ahead Market Clearing
		Day-Ahead Market Financial Impacts
		RUC and its Financial Impacts
	Wholesale Market Operations: Real-Time	The Adjustment Period
		Real-Time Dispatch and AS Deployments
		Real-Time Financial Impacts

WebEx Tips

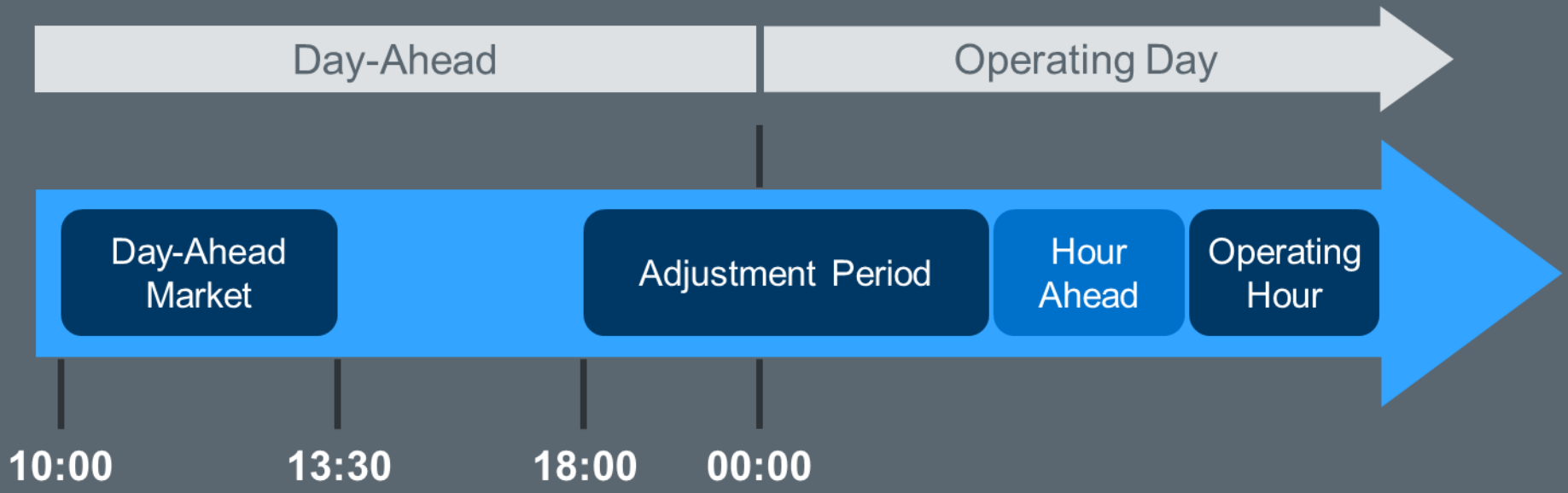
- Windows
- Buttons

Attendance

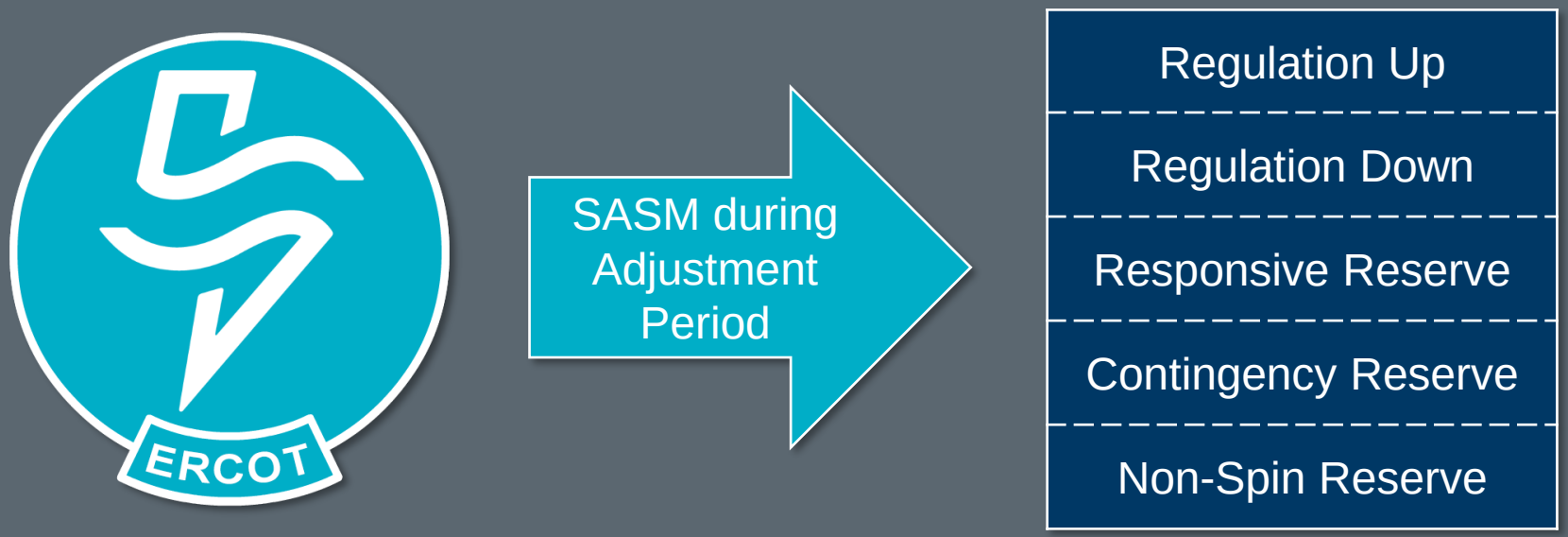
Questions / Chat

The Adjustment Period

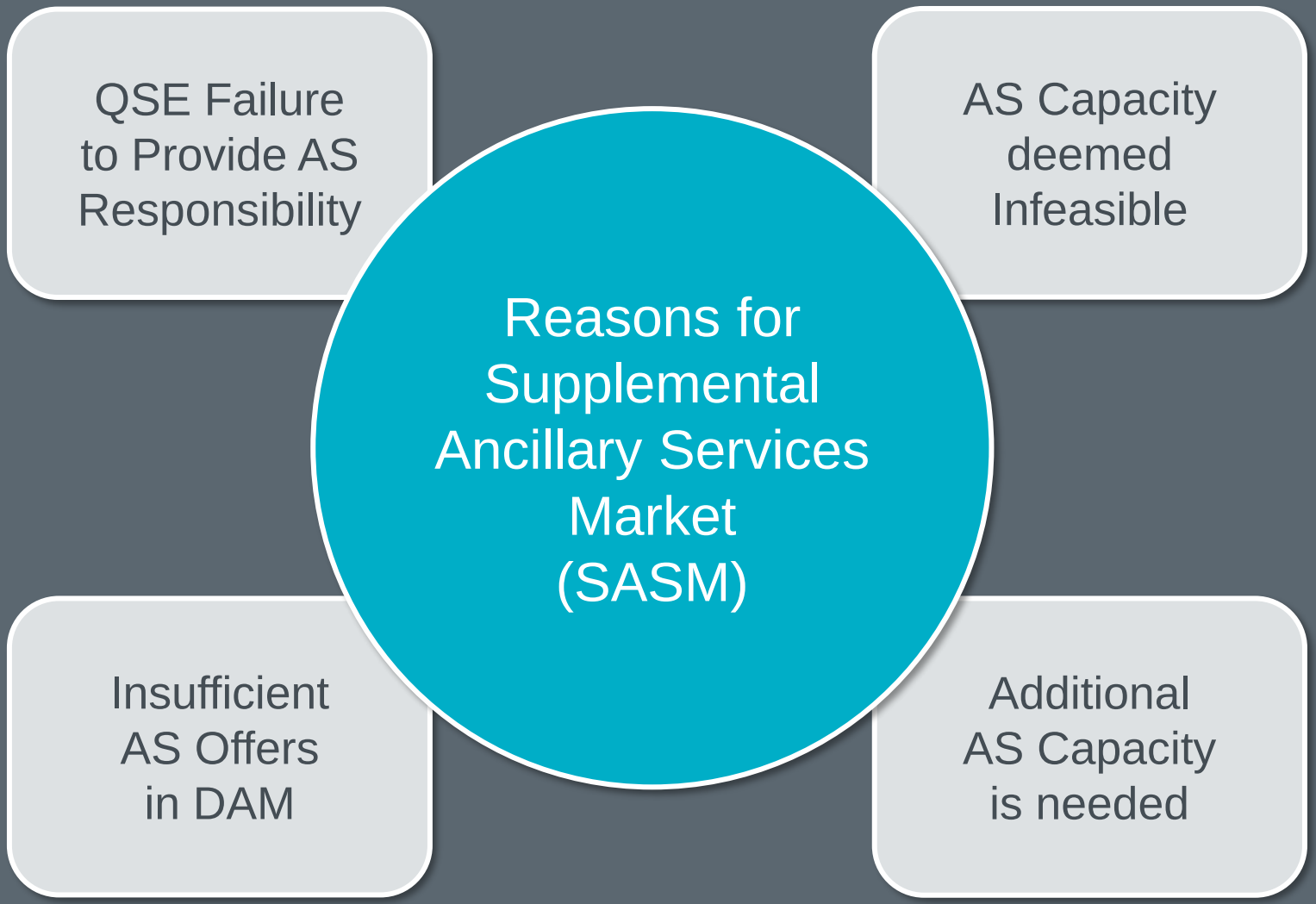
The Adjustment Period



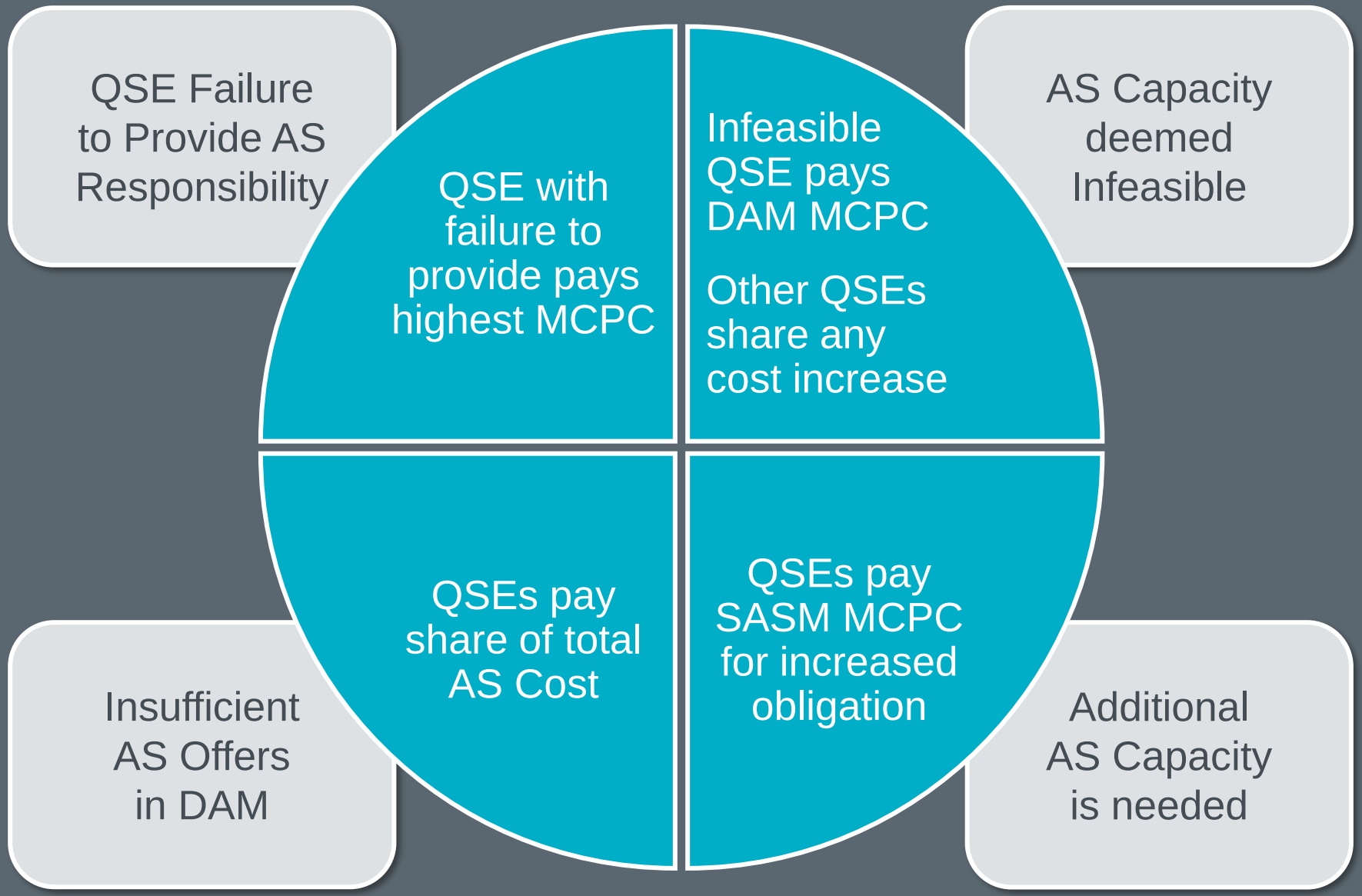
ERCOT may need additional Ancillary Services



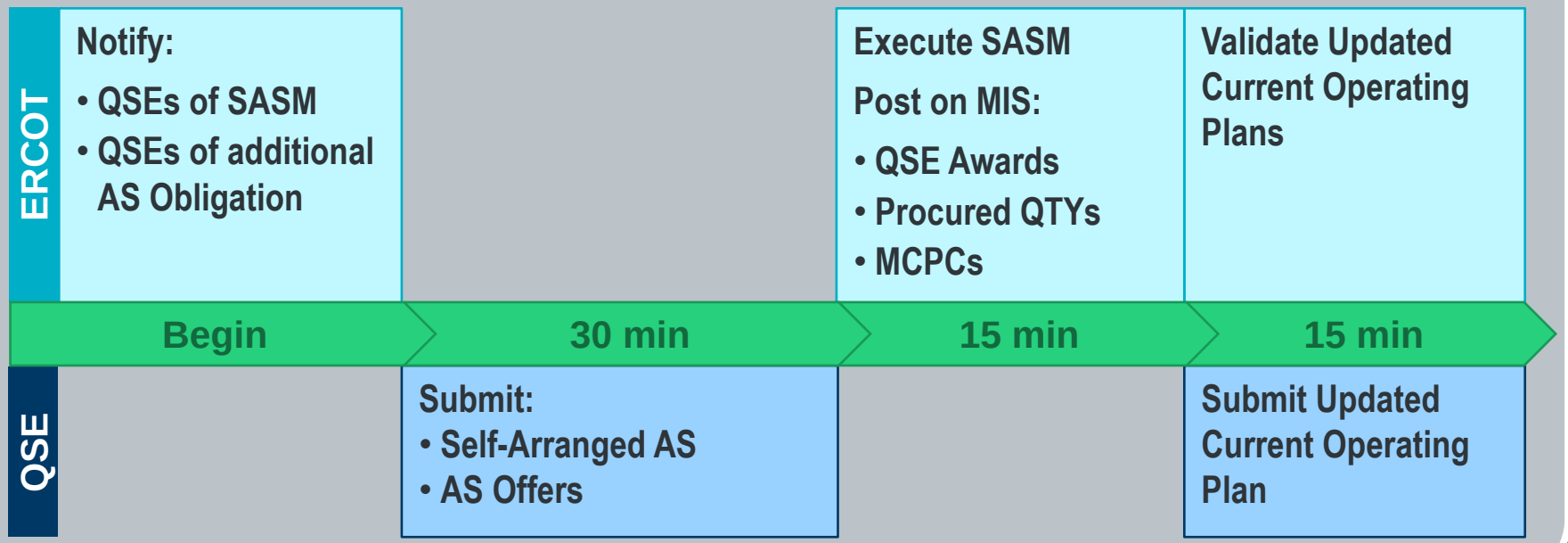
Why Have a SASM?



SASM Financial Impacts

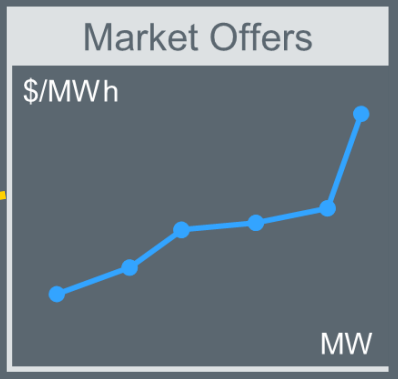


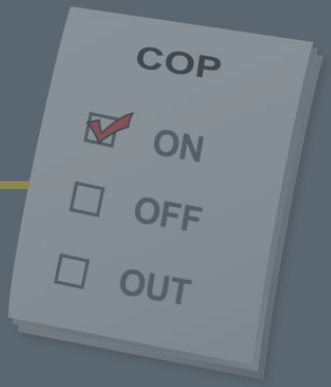
SASM Process Timeline



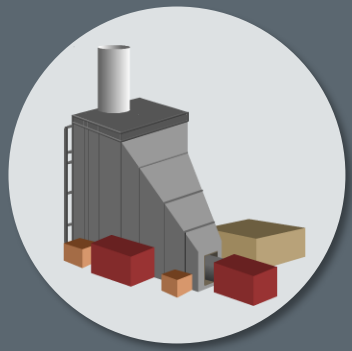
Notification occurs at least two hours before AS capacity is needed

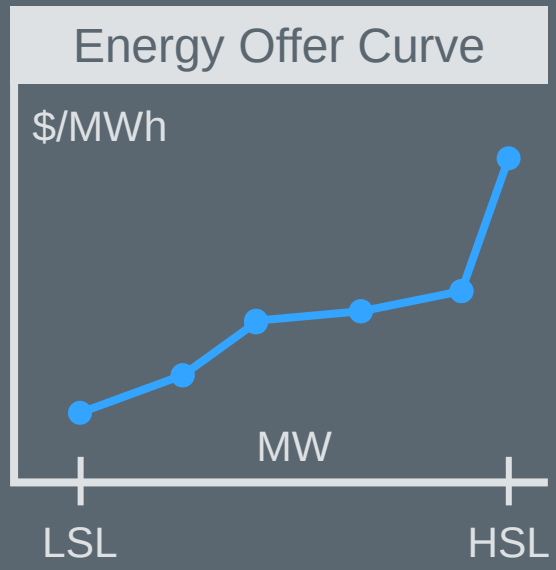
QSEs may update:





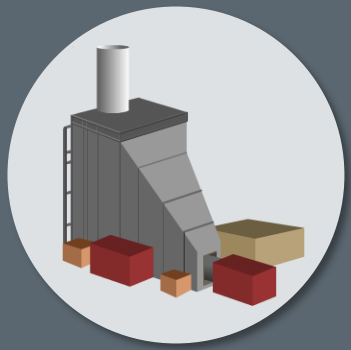
May be submitted or updated

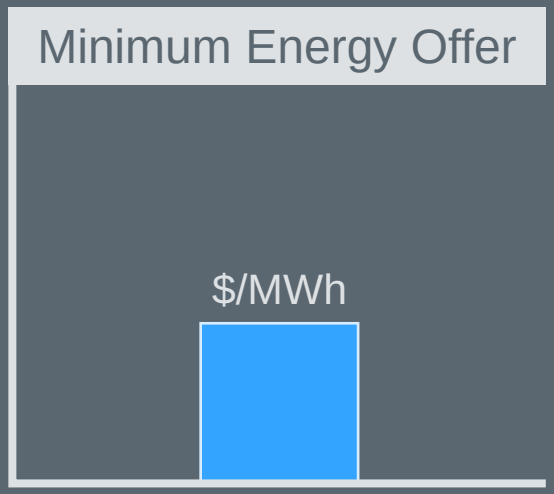


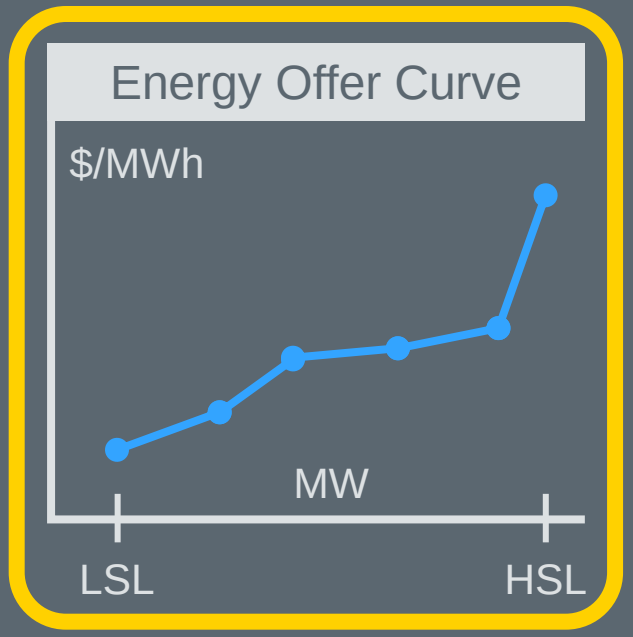


For hours not DAM-Committed or RUC-Committed

May be submitted or updated

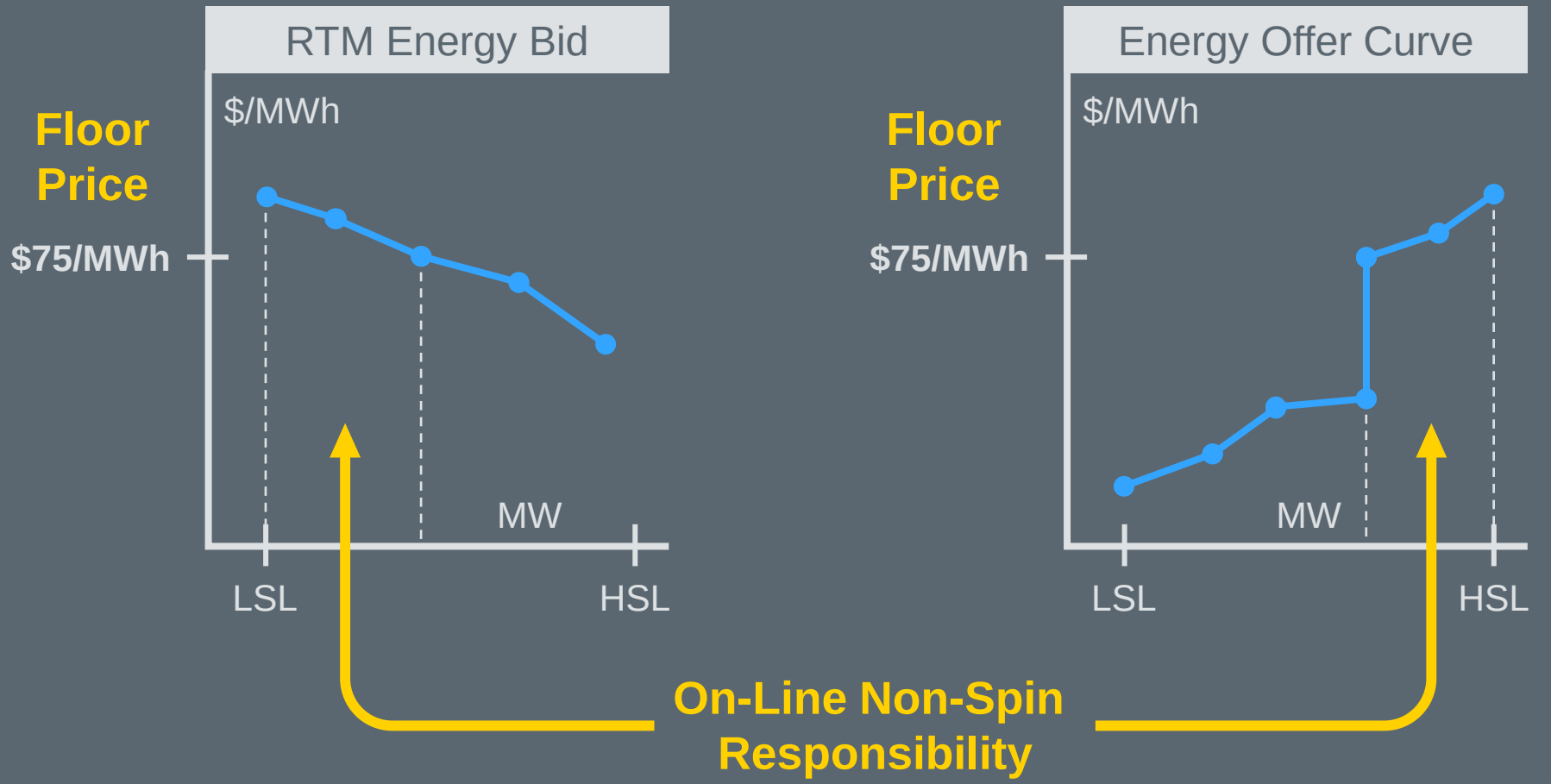




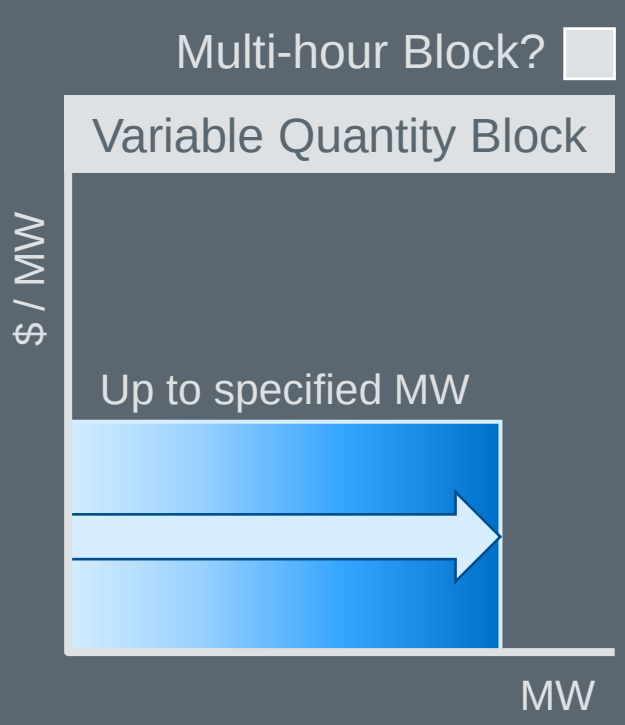


For any hours

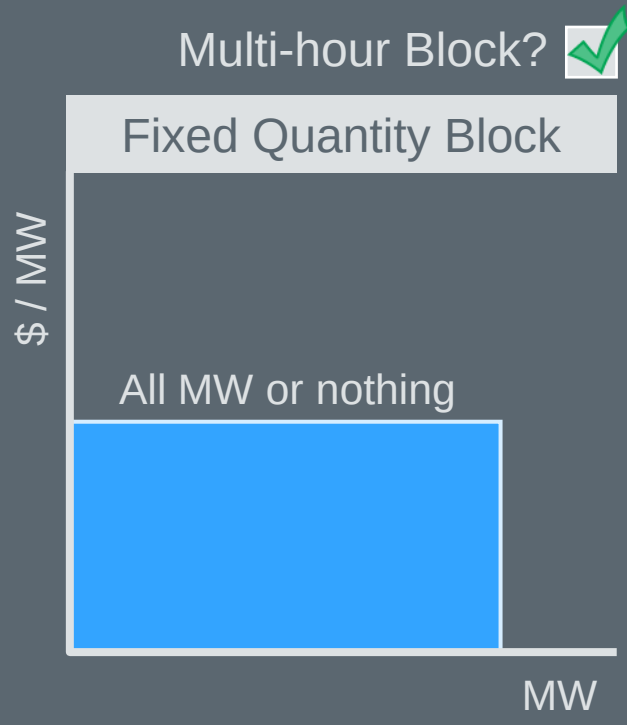
Must be updated during Adjustment Period



May be submitted or updated



Any qualified Resource

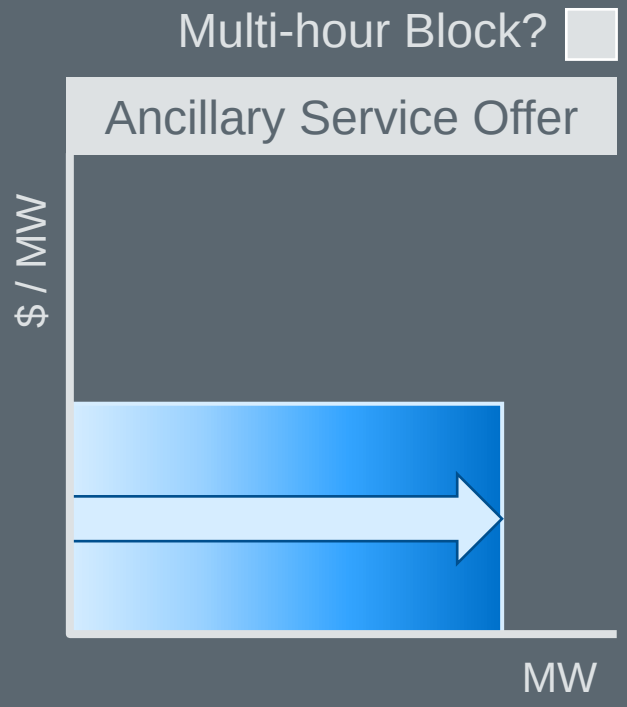


Load Resources Only

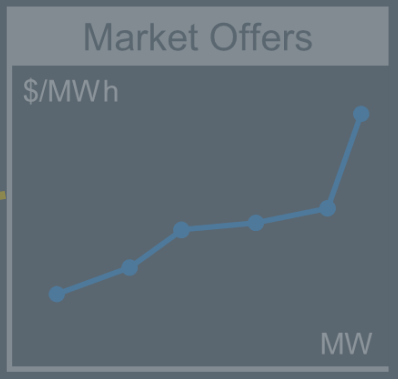
Discussion: Updating Ancillary Service Offers

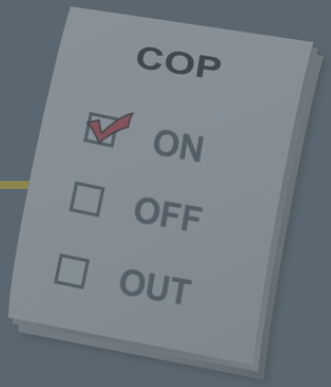
Why submit new Ancillary Service Offers after DAM?

Why update existing offers?



QSEs may update:





Bilateral Trades

Energy Trade

Impacts Real-Time Energy Settlement and RUC Settlement

Capacity Trade

Impacts only RUC Settlement

AS Trade

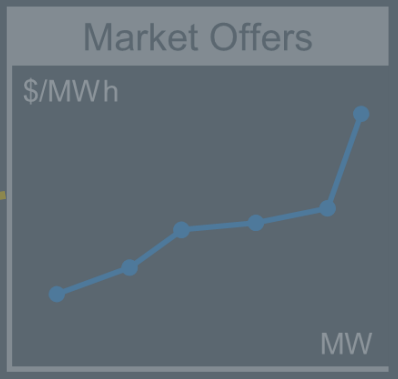
Impacts Ancillary Service Supply Responsibility

Buyer and Seller QSE must confirm Trades

One QSE reports

Other QSE confirms

QSEs may update:



Why would a QSE change the Status of a Resource?

Current Operating Plan								
Resource Name	Resource Status	Resource Limits		Ancillary Service Commitments				
		HSL	LSL	Reg-up	Reg-Dn	Responsive	ECRS	Non-Spin
ThisOne	ONREG	600	120	20	20	0	0	40
ThatOne	ON	400	75	0	0	20	80	0
OtherOne	OFF	100	25	0	0	0	0	0

QSE may start a Resource whenever they want

Current Operating Plan								
Resource Name	Resource Status	Resource Limits		Ancillary Service Commitments				
		HSL	LSL	Reg-up	Reg-Dn	Responsive	ECRS	Non-Spin
ThisOne	ONREG	600	120	20	20	0	0	40
ThatOne	ON	400	75	0	0	20	80	0
OtherOne	**ON**	100	25	0	0	0	0	0

Should update COP for all future hours they plan to run

QSE requires ERCOT approval for early shutdown

Current Operating Plan								
Resource Name	Resource Status	Resource Limits		Ancillary Service Commitments				
		HSL	LSL	Reg-up	Reg-Dn	Responsive	ECRS	Non-Spin
ThisOne	ONREG	600	120	20	20	0	0	40
ThatOne	**OFF**	400	75	0	0	0	0	0
OtherOne	ON	100	25	0	0	0	0	0

Next Hourly RUC will evaluate

Why would a QSE change AS Committments?

Current Operating Plan								
Resource Name	Resource Status	Resource Limits		Ancillary Service Commitments				
		HSL	LSL	Reg-up	Reg-Dn	Responsive	ECRS	Non-Spin
ThisOne	ONREG	600	120	20	20	0	0	40
ThatOne	ON	400	75	0	0	20	80	0
OtherOne	ON	100	25	0	0	0	0	0

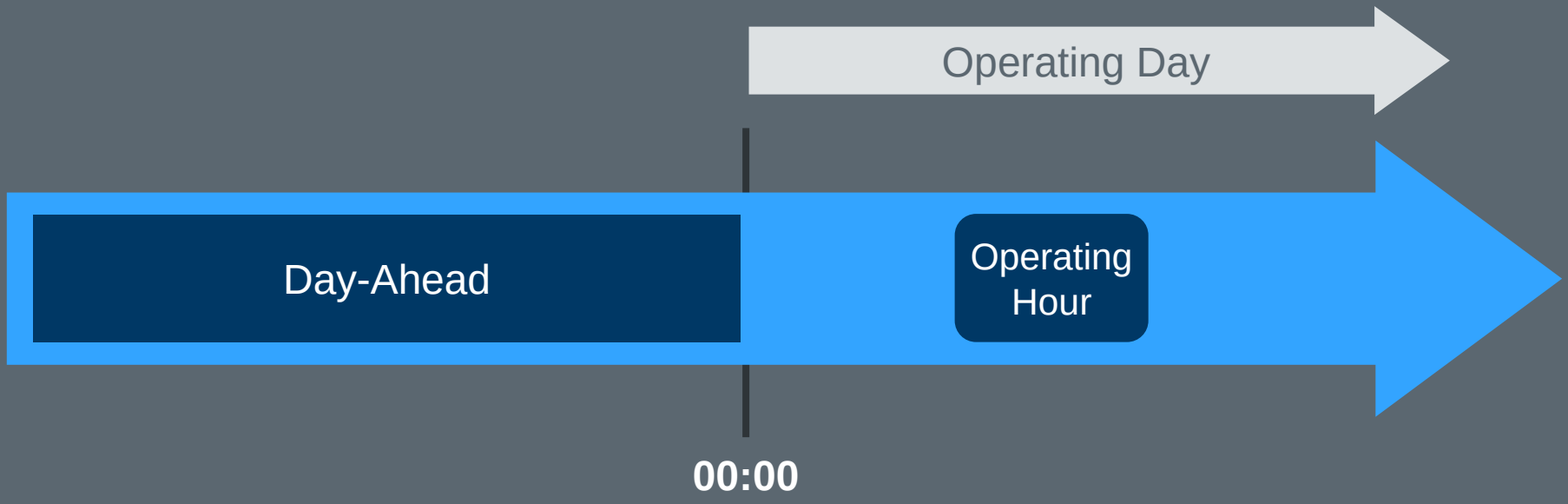
QSE requires ERCOT approval

Current Operating Plan								
Resource Name	Resource Status	Resource Limits		Ancillary Service Commitments				
		HSL	LSL	Reg-up	Reg-Dn	Responsive	ECRS	Non-Spin
ThisOne	ONREG	600	120	20	20	0	0	40
ThatOne	ON	400	75	0	0	**0**	**0**	0
OtherOne	ON	100	25	0	0	**20**	**80**	0

Next Hourly RUC will check for Infeasibility

Real-Time Dispatch and Ancillary Service Deployments

Real-Time Operations

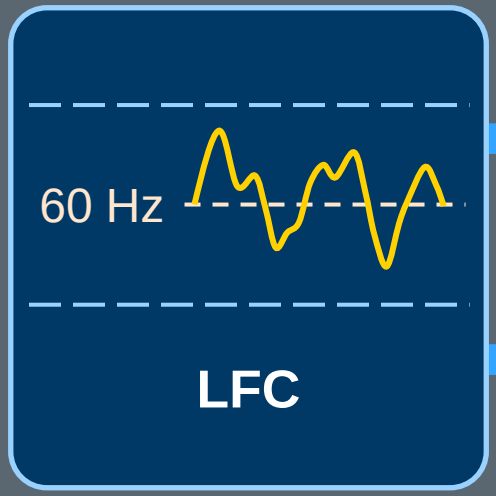


Two Main Real-Time Processes

Security Constrained Economic Dispatch

- Five-minute Dispatch
- Five-minute Prices

Load Frequency Control

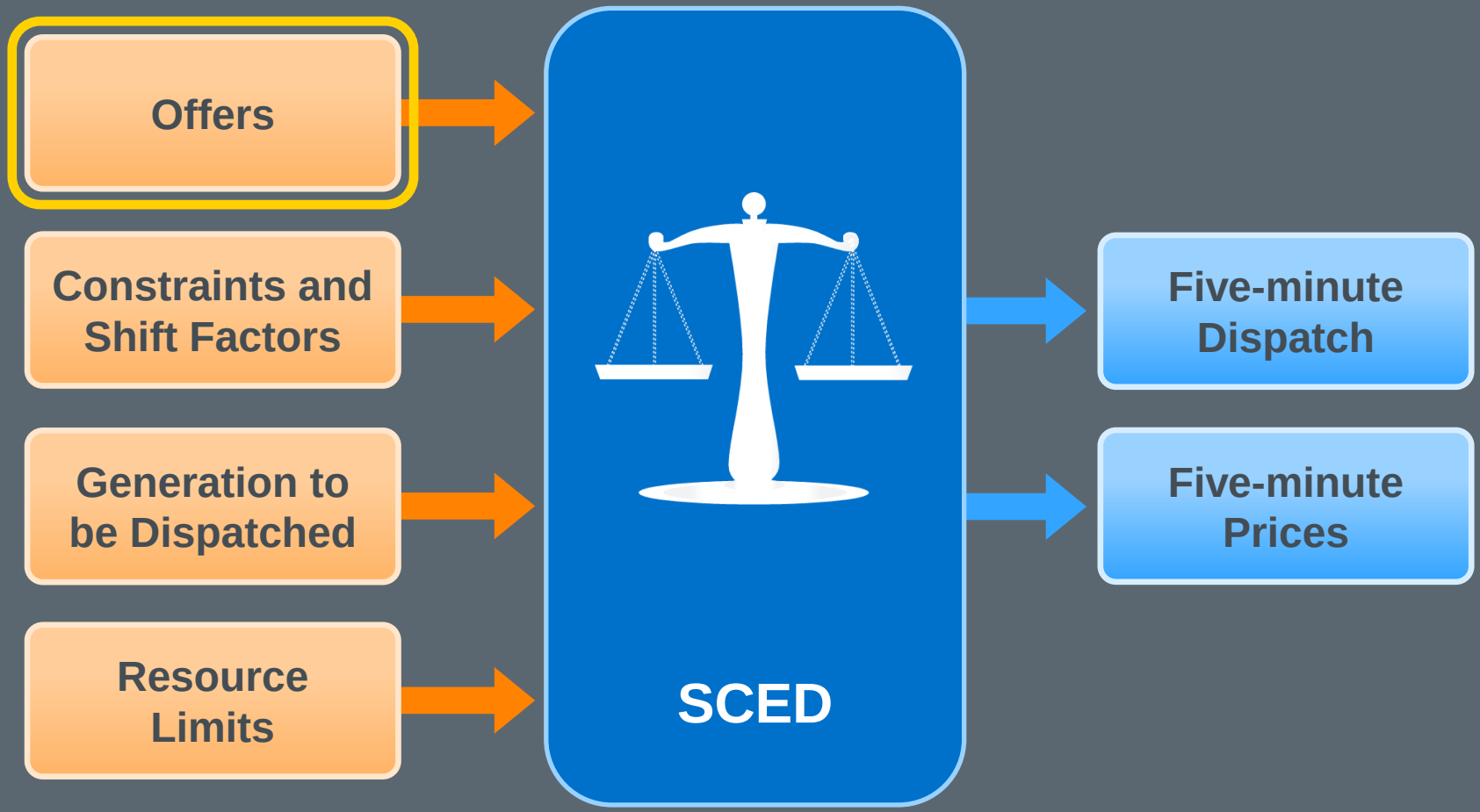


- Regulation
- Contingency Reserve (ECRS)

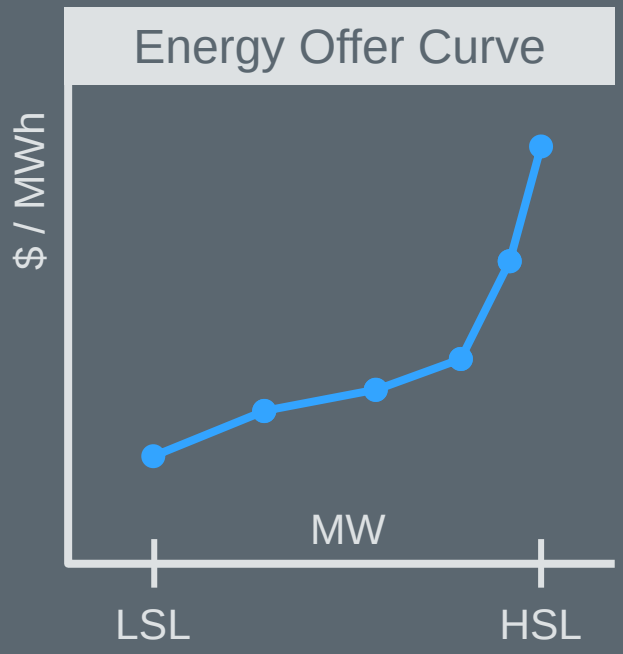
Balancing Reliability and Economics

SCED

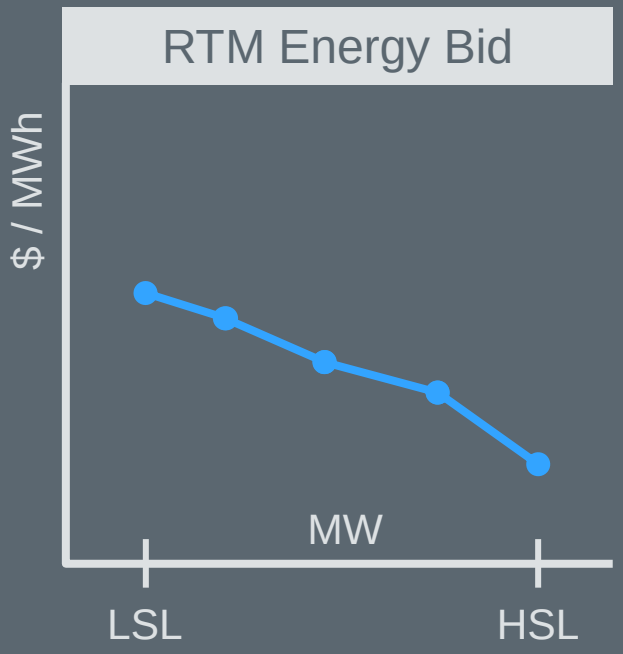
Manage Reliability at Least Cost



Generation Resources



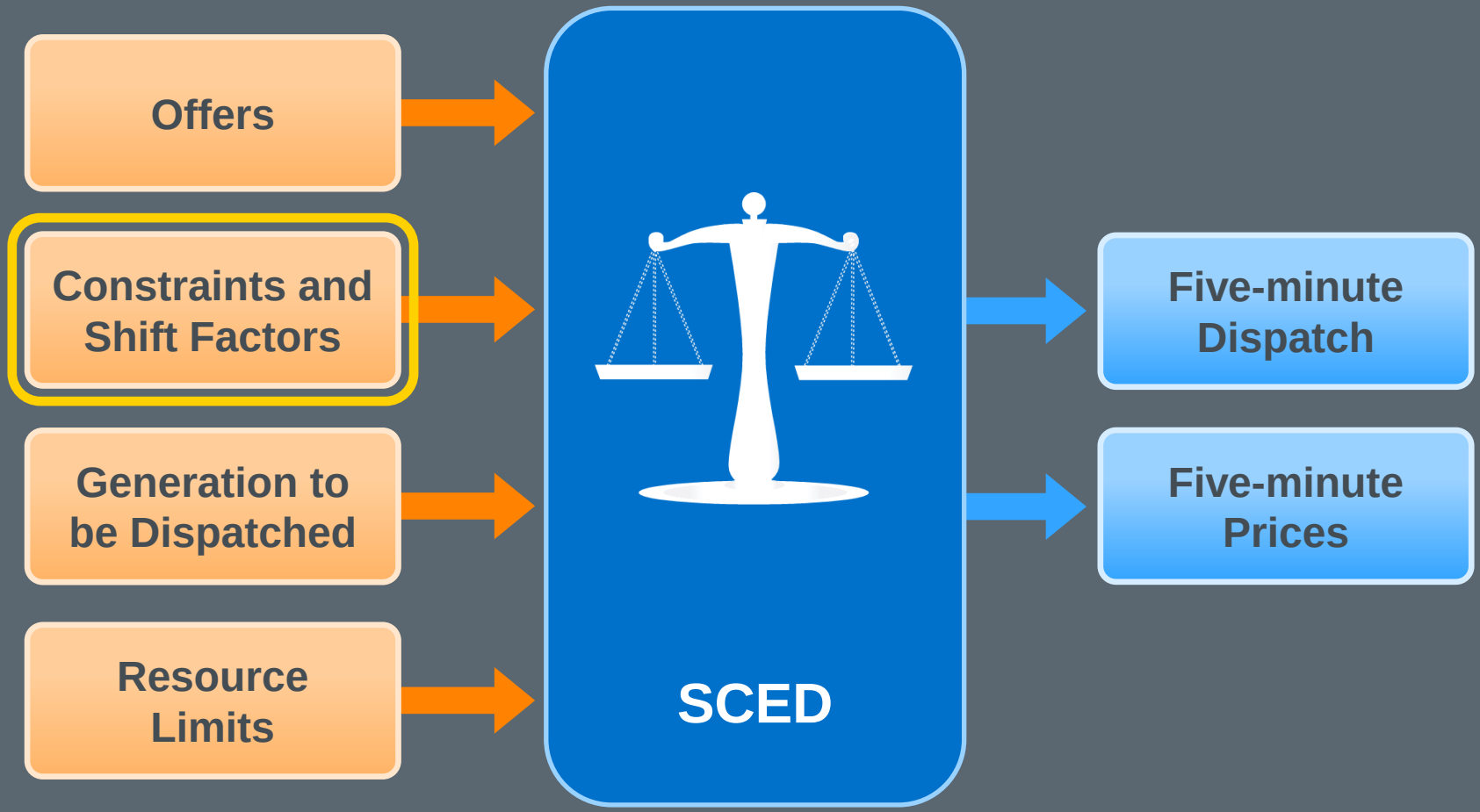
Controllable Load Resources



LSL – Low Sustained Limit

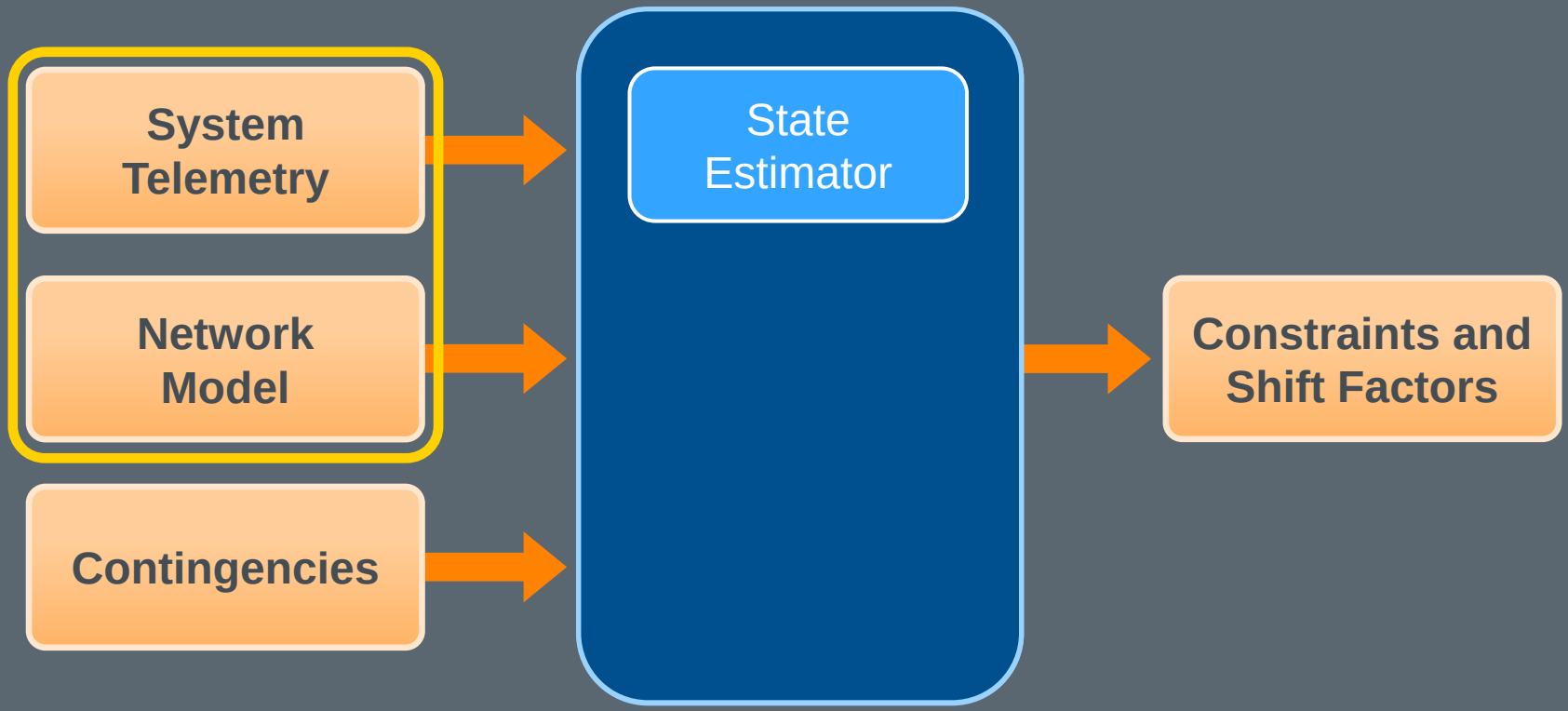
HSL – High Sustained Limit

Network Constraints determined by Security Analysis

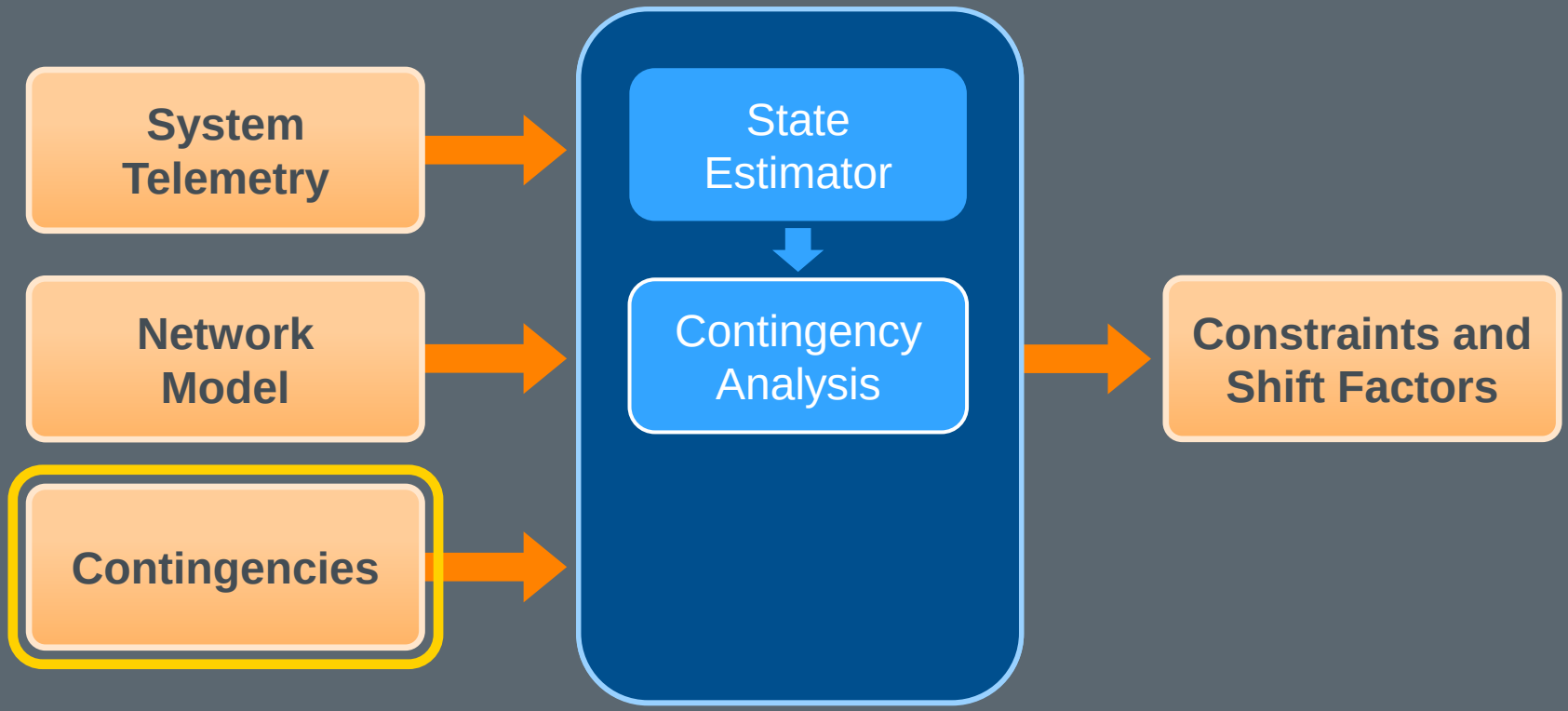


Runs just before each SCED cycle

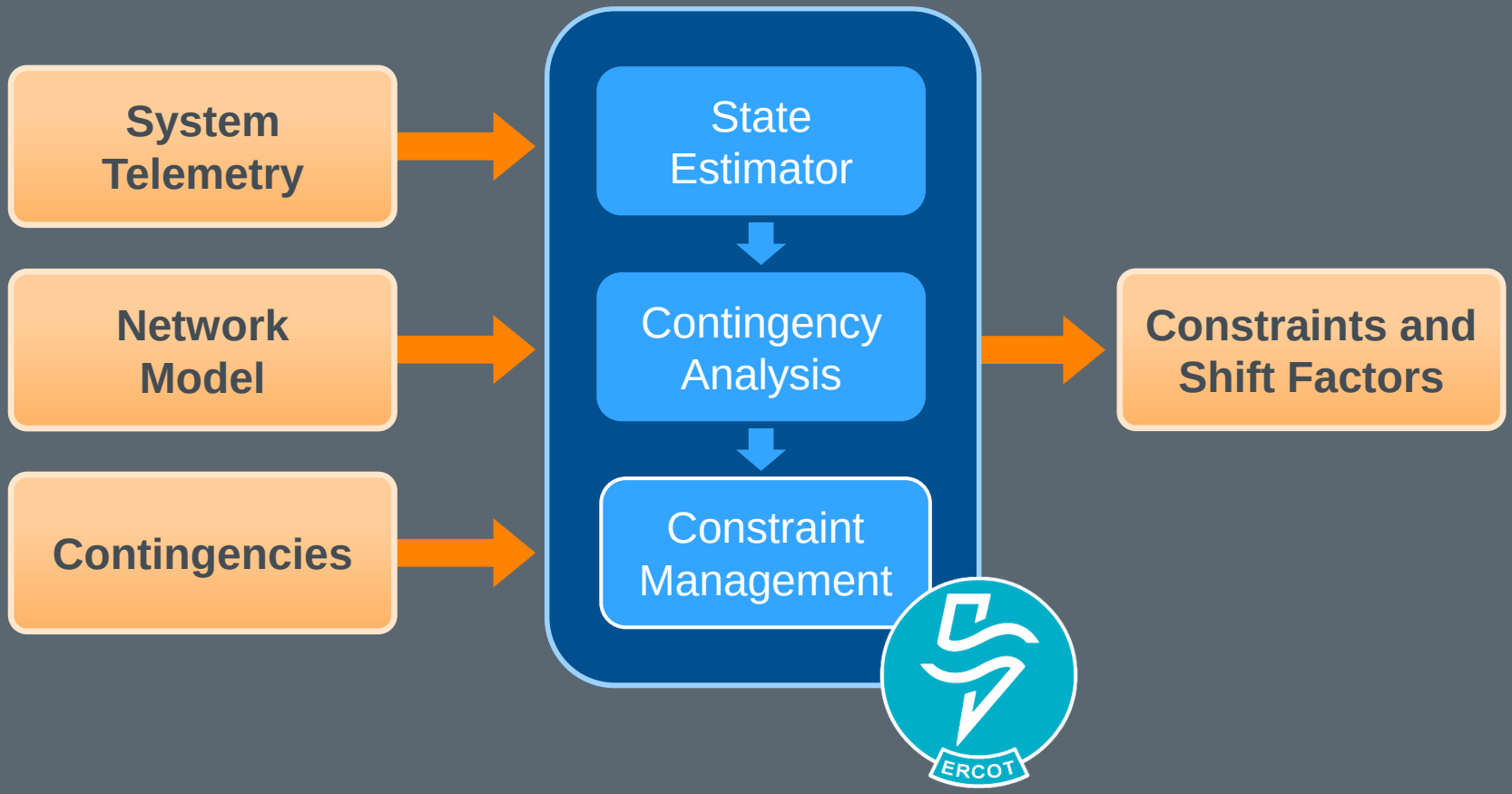
Assembles current grid conditions



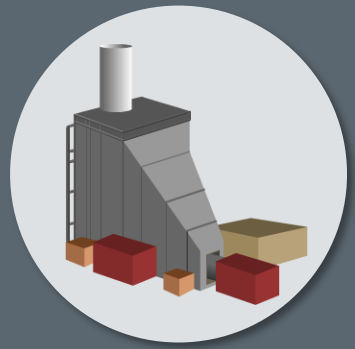
Performs n-1 Security Analysis

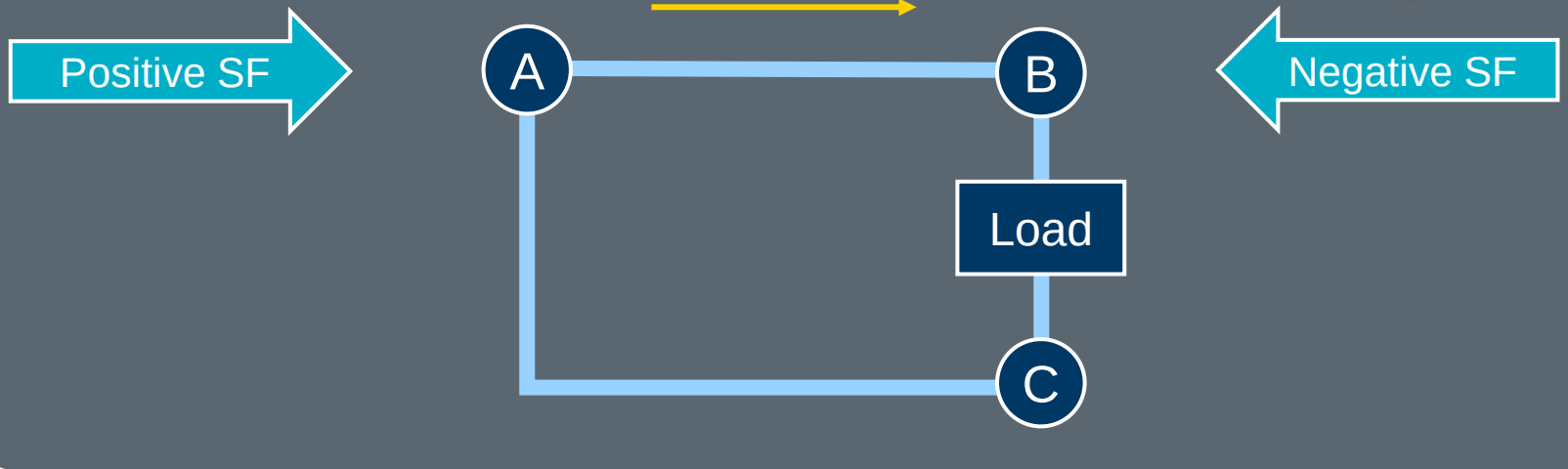


Constraints must be “activated” before going to SCED

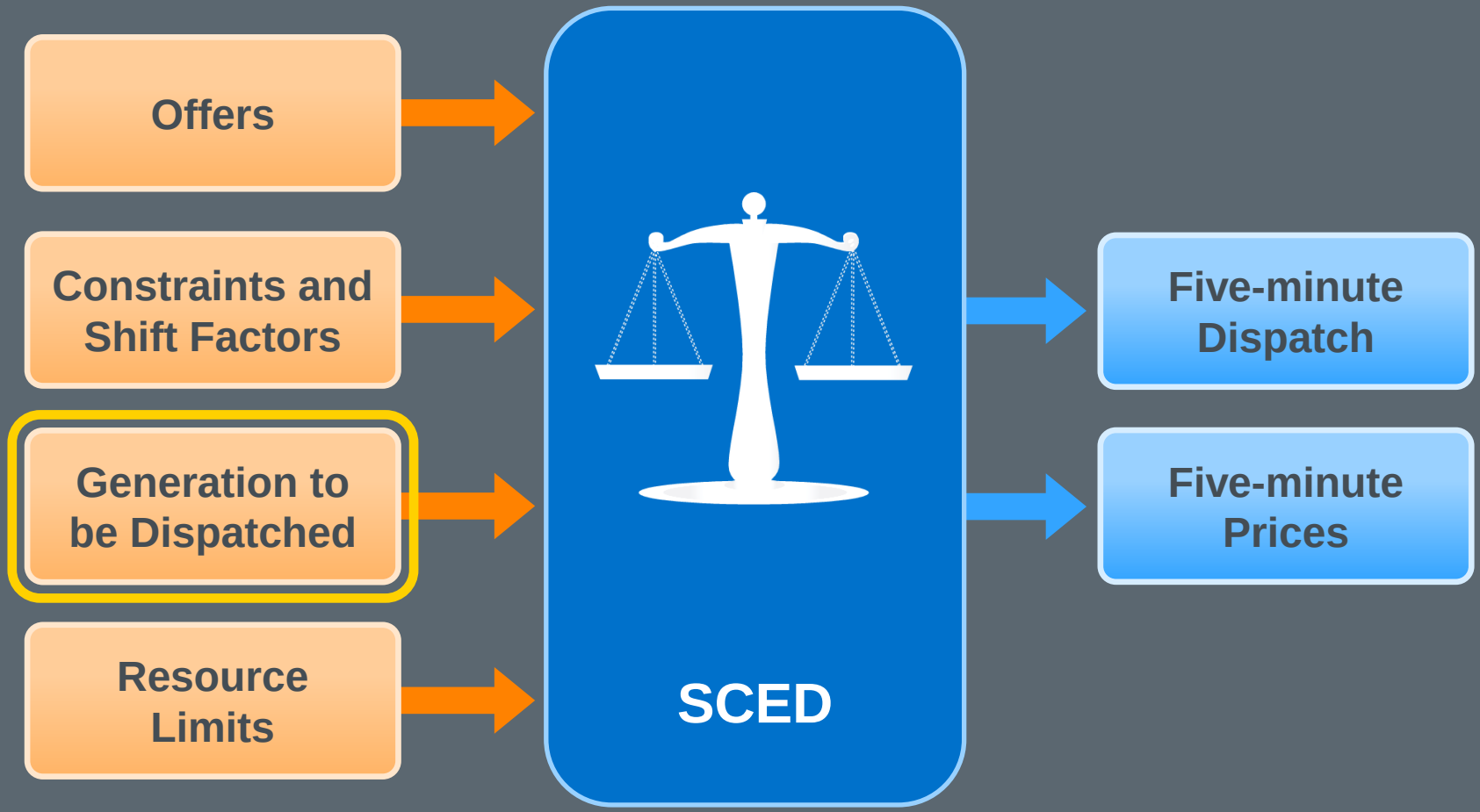


How does a Resource impact a Constraint?

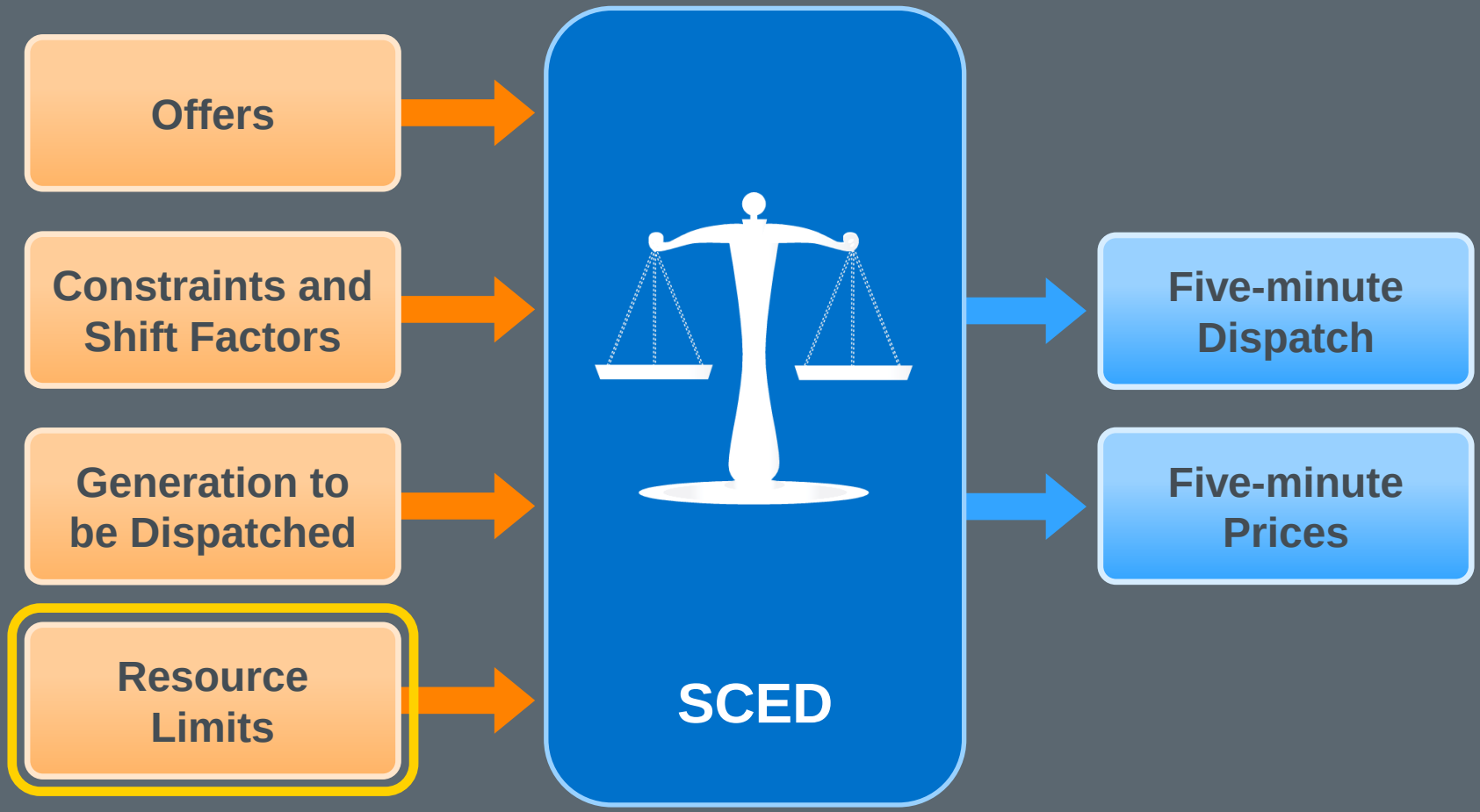




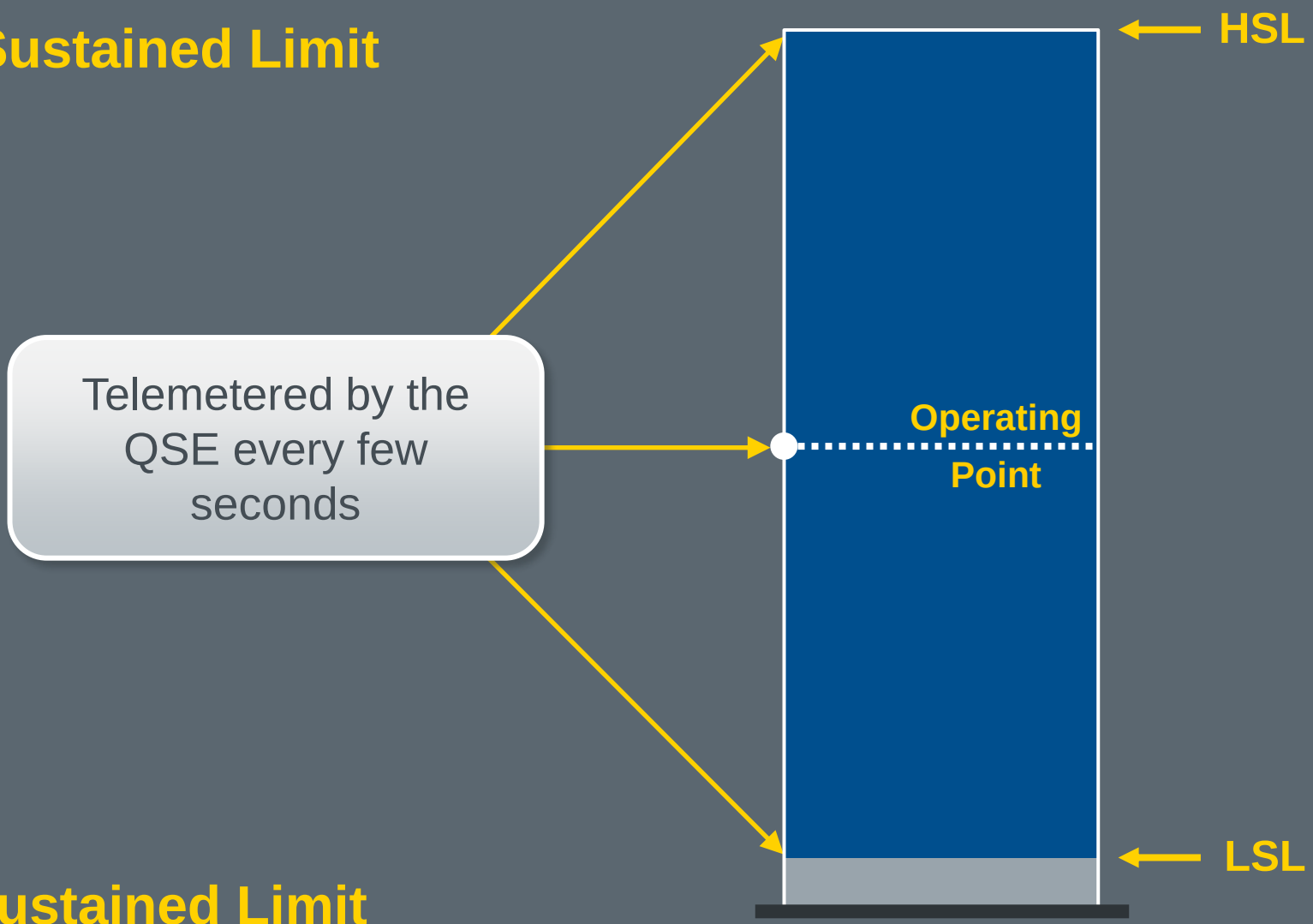
Total Generation must project expected demand



Dispatch Solution must honor Resource capabilities



High Sustained Limit

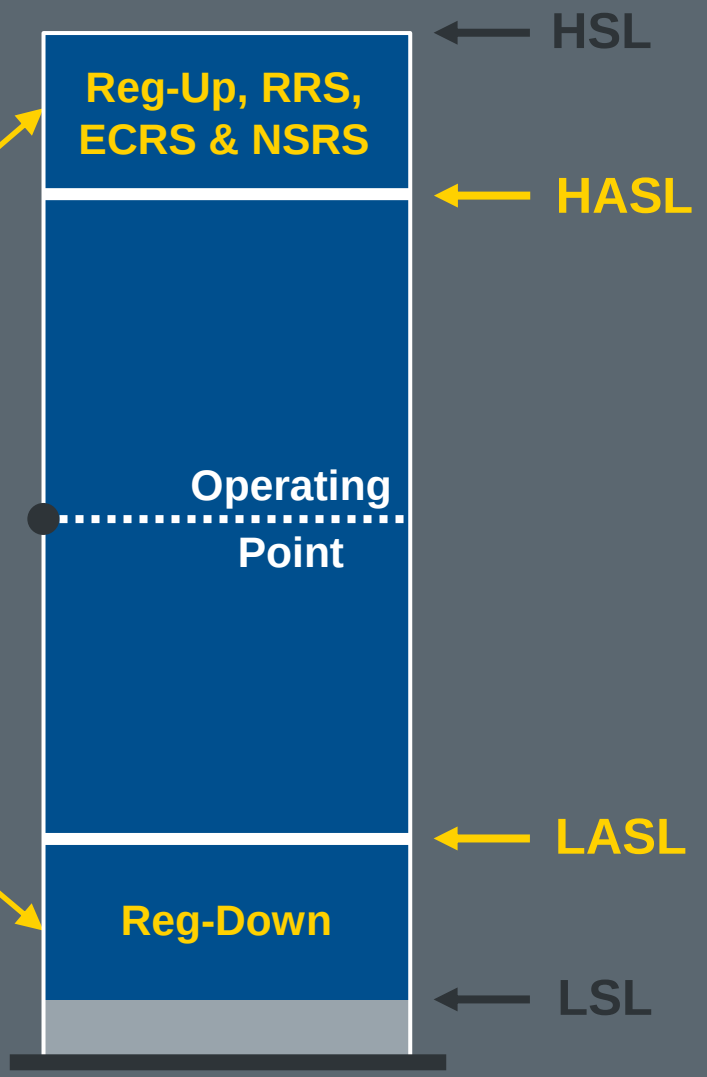


Low Sustained Limit

High Ancillary Service Limit

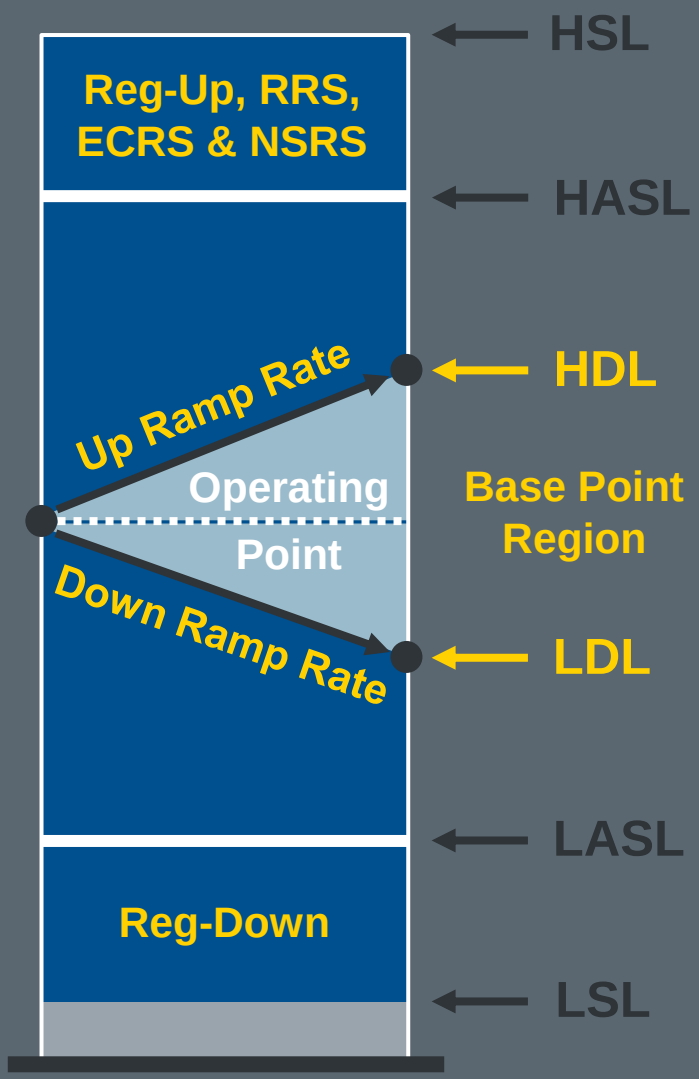
Telemetered by the QSE every few seconds

Low Ancillary Service Limit

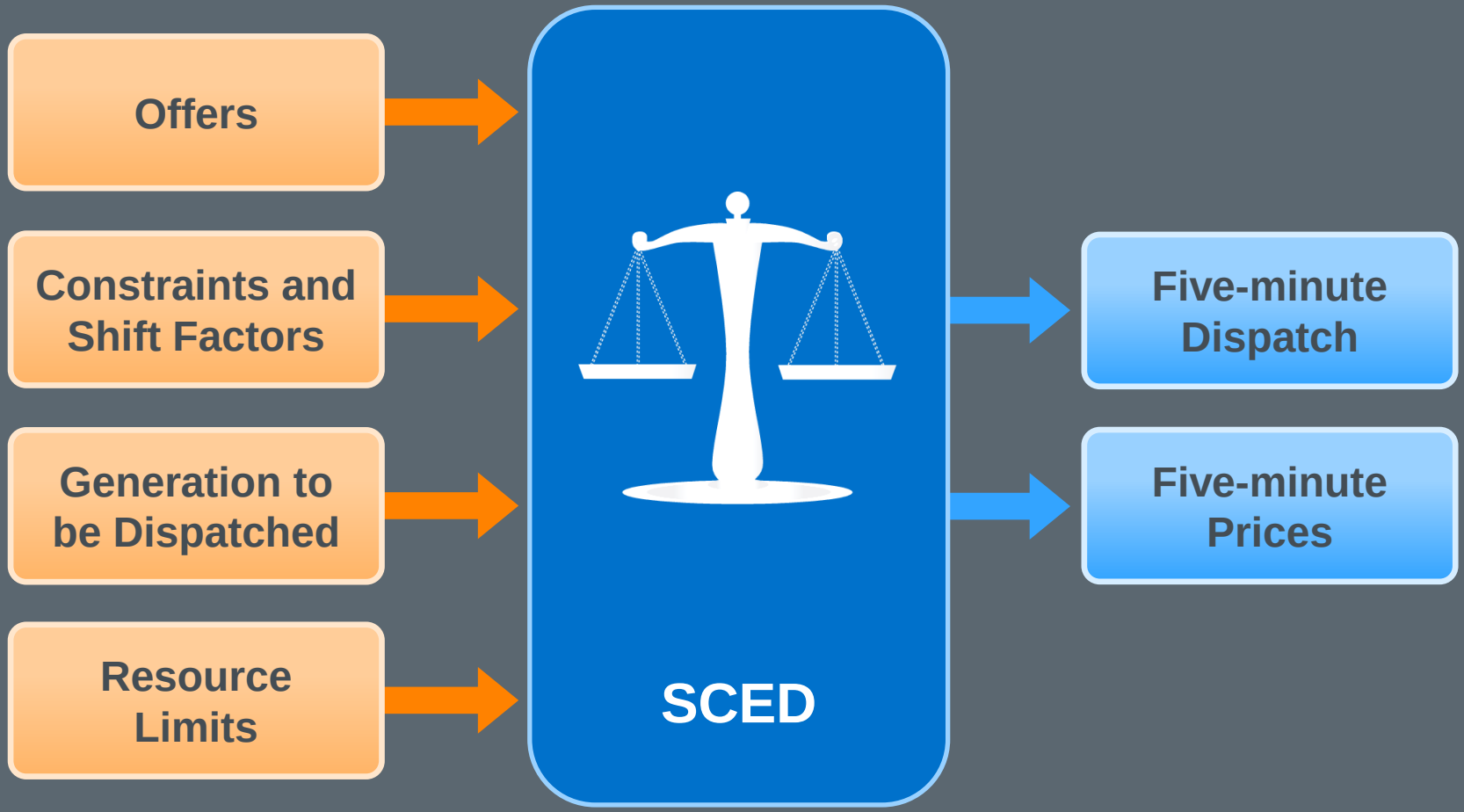


High Dispatch Limit

Low Dispatch Limit



So what does SCED do with all this stuff?



The Texas Two Step

SCED Two Step Process

SCED executes twice each cycle

- Reduces Market Power
- Allows high prices under the right circumstances

Scenario: Another "Power" Product

Demand	Bakery	QTY	Price
	1	35	$2.99
	2	15	$6.98
		50	$15.75

Alligator Infested Waters

Constraints must be classified*

Competitive?

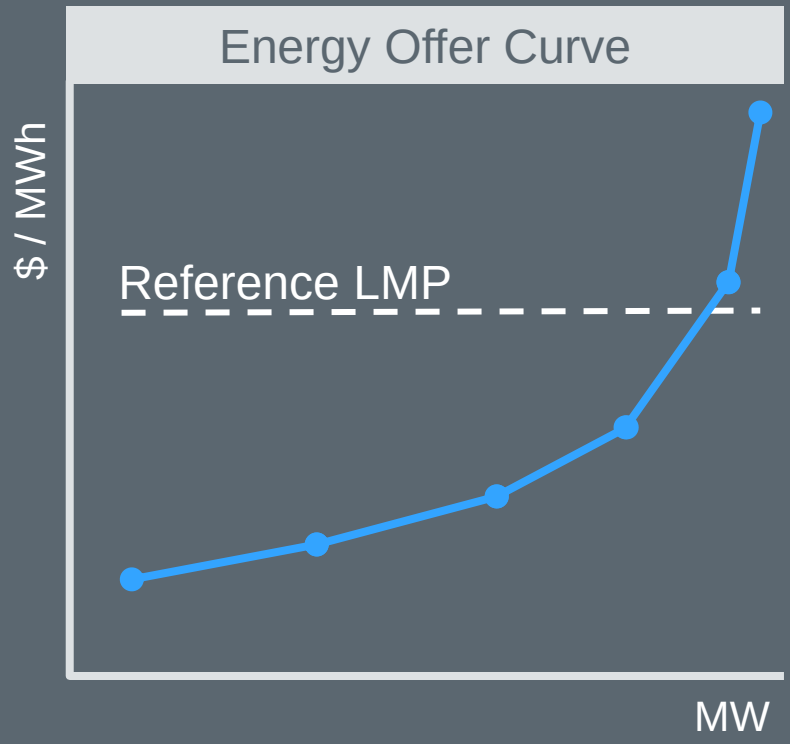
-- or --

Non-Competitive?

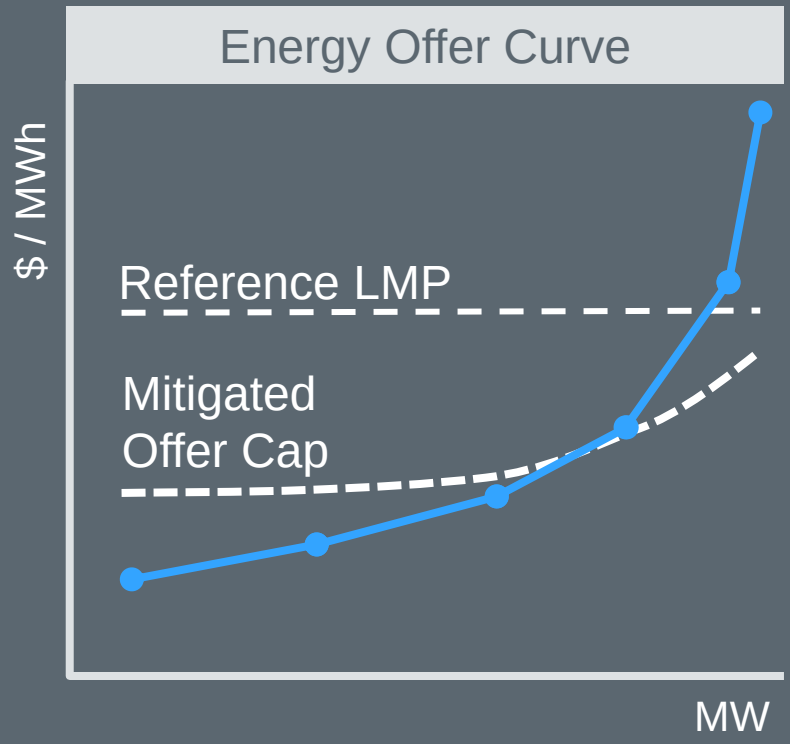
*See Protocol Section 3.19.4 for details

Step One


Two-Step
Competitive Constraints Only


Energy Offer Curve
$ / MWh
Reference LMP
MW

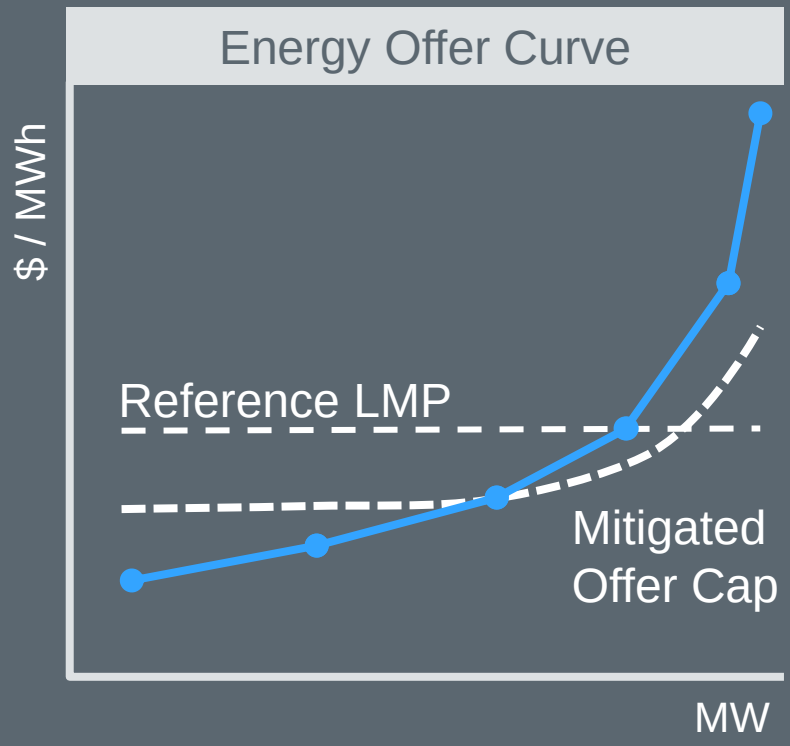
Step Two



Offer capped at greater of Reference LMP or Mitigated Offer Cap

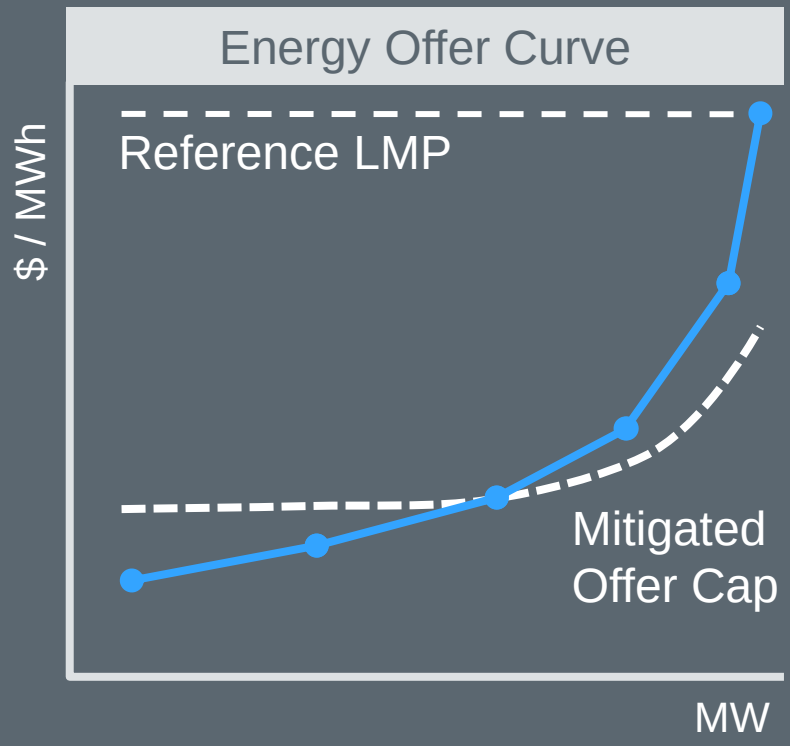
SCED has completed Step One

How will this Energy Offer Curve look in STEP Two?

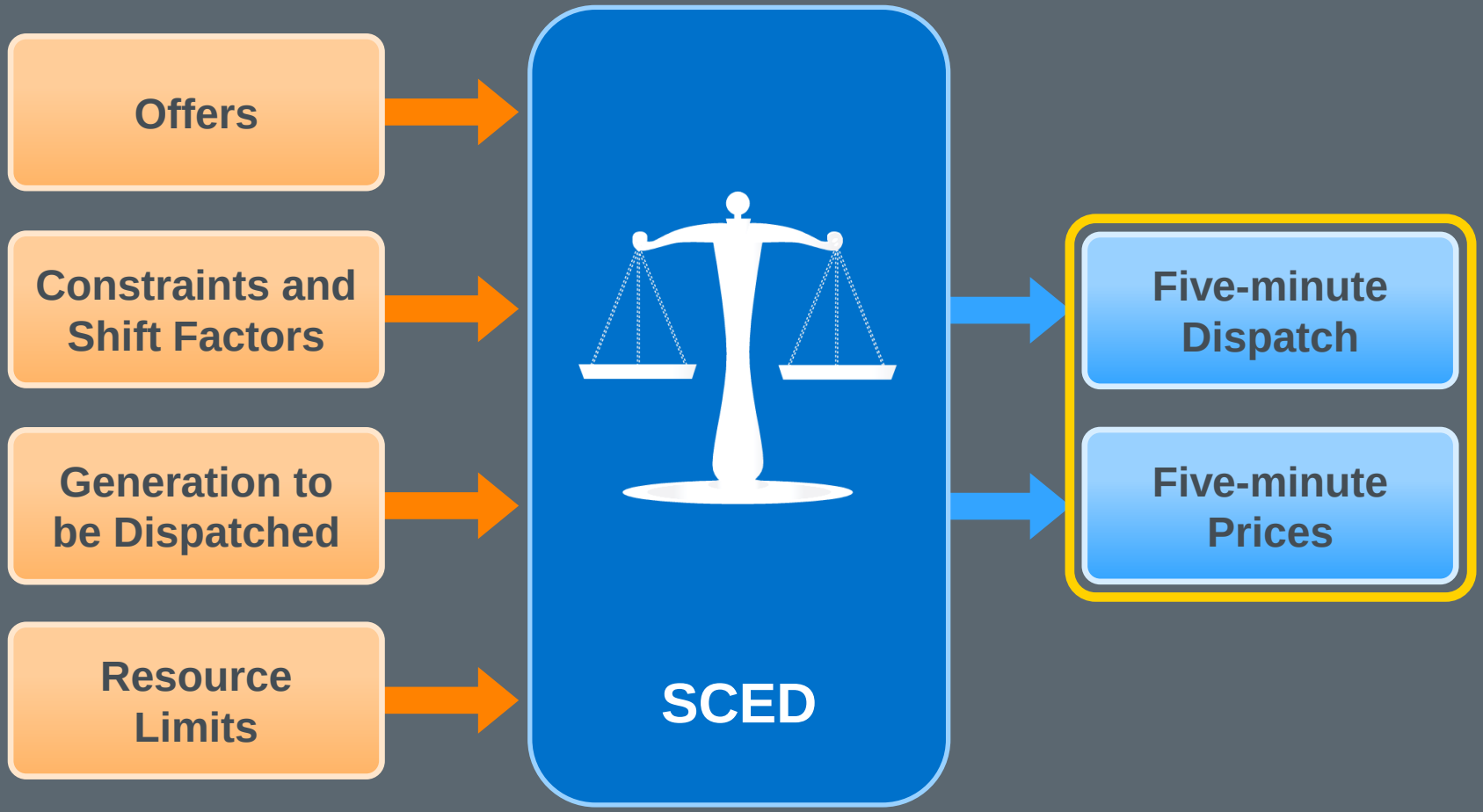


SCED has completed Step One

How will this Energy Offer Curve look in STEP Two?

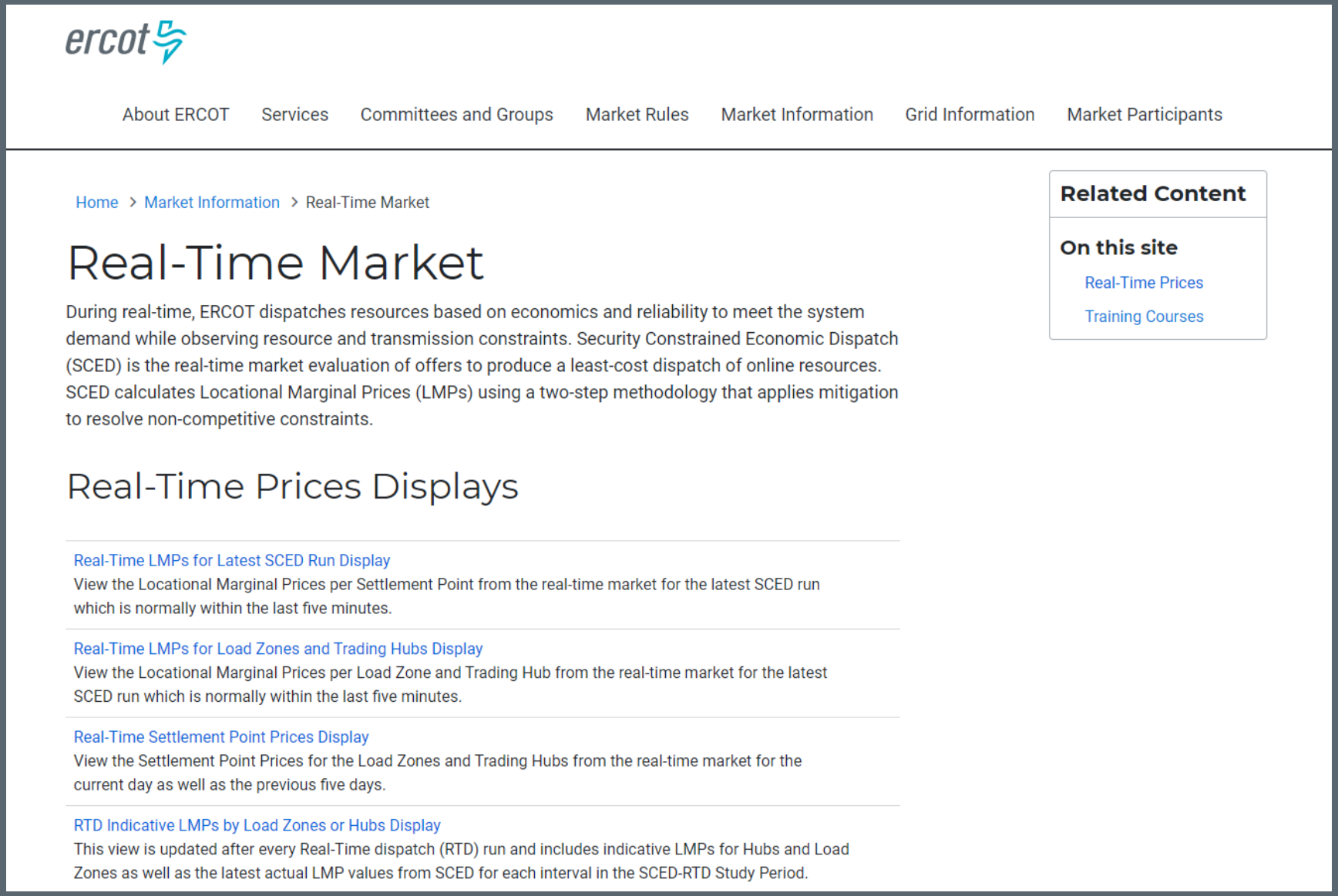


SCED Results



Resource-specific Base Points sent to QSEs

ICCP = Inter-Control Center Protocol



ercot

About ERCOT | Services | Committees and Groups | Market Rules | Market Information | Grid Information | Market Participants

Home > Market Information > Real-Time Market

Real-Time Market

During real-time, ERCOT dispatches resources based on economics and reliability to meet the system demand while observing resource and transmission constraints. Security Constrained Economic Dispatch (SCED) is the real-time market evaluation of offers to produce a least-cost dispatch of online resources. SCED calculates Locational Marginal Prices (LMPs) using a two-step methodology that applies mitigation to resolve non-competitive constraints.

Real-Time Prices Displays

Real-Time LMPs for Latest SCED Run Display
View the Locational Marginal Prices per Settlement Point from the real-time market for the latest SCED run which is normally within the last five minutes.

Real-Time LMPs for Load Zones and Trading Hubs Display
View the Locational Marginal Prices per Load Zone and Trading Hub from the real-time market for the latest SCED run which is normally within the last five minutes.

Real-Time Settlement Point Prices Display
View the Settlement Point Prices for the Load Zones and Trading Hubs from the real-time market for the current day as well as the previous five days.

RTD Indicative LMPs by Load Zones or Hubs Display
This view is updated after every Real-Time dispatch (RTD) run and includes indicative LMPs for Hubs and Load Zones as well as the latest actual LMP values from SCED for each interval in the SCED-RTD Study Period.

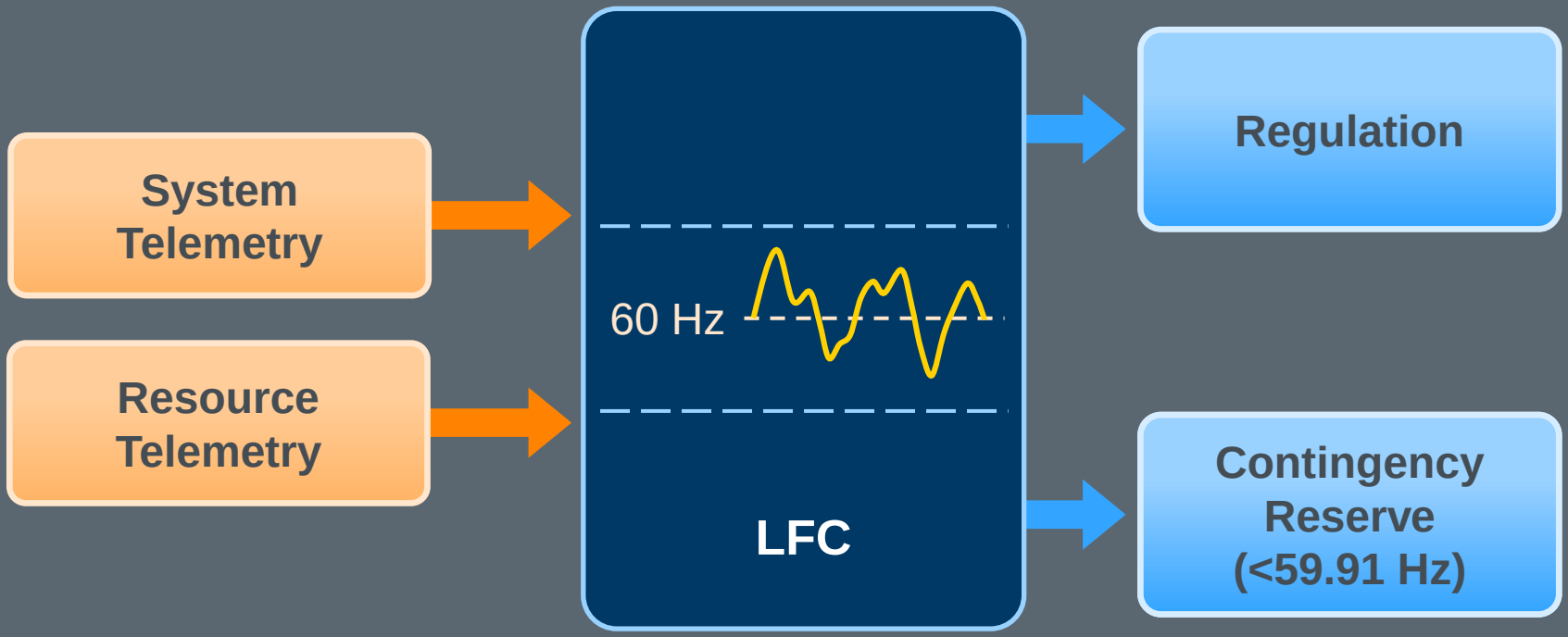
Related Content

On this site

Real-Time Prices

Training Courses

Load Frequency Control (LFC)

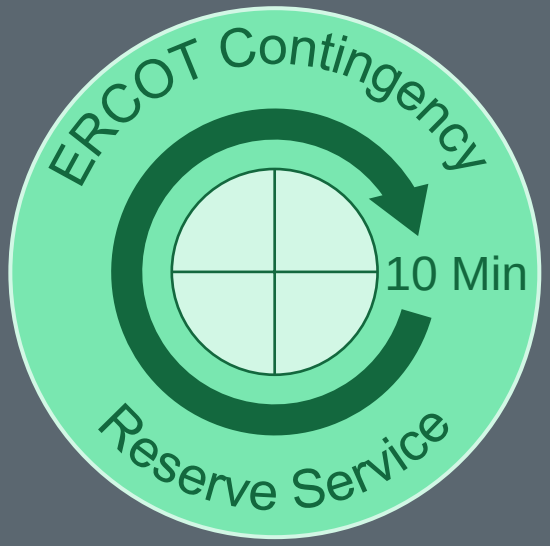


Runs every 4 seconds!

Proportional by QSE Share

- Not Resource-specific
- No price consideration

QSE receives MW deployment signal



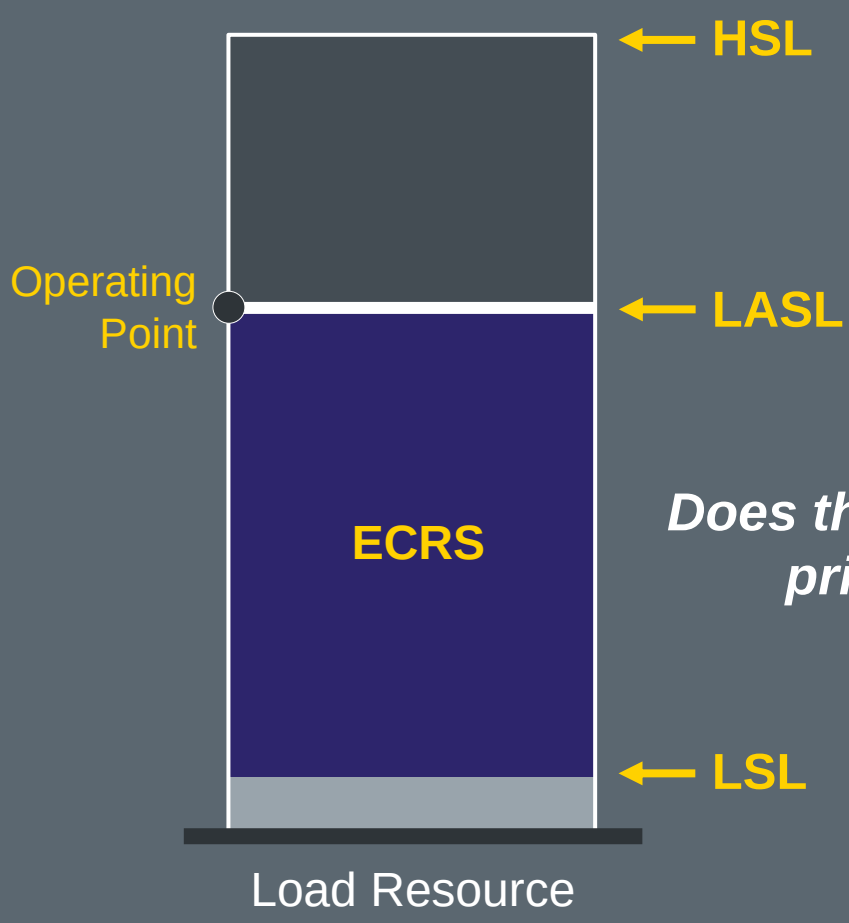
May be deployed manually or by Load Frequency Control

- Releases reserves to system
- Process varies by Resource Type

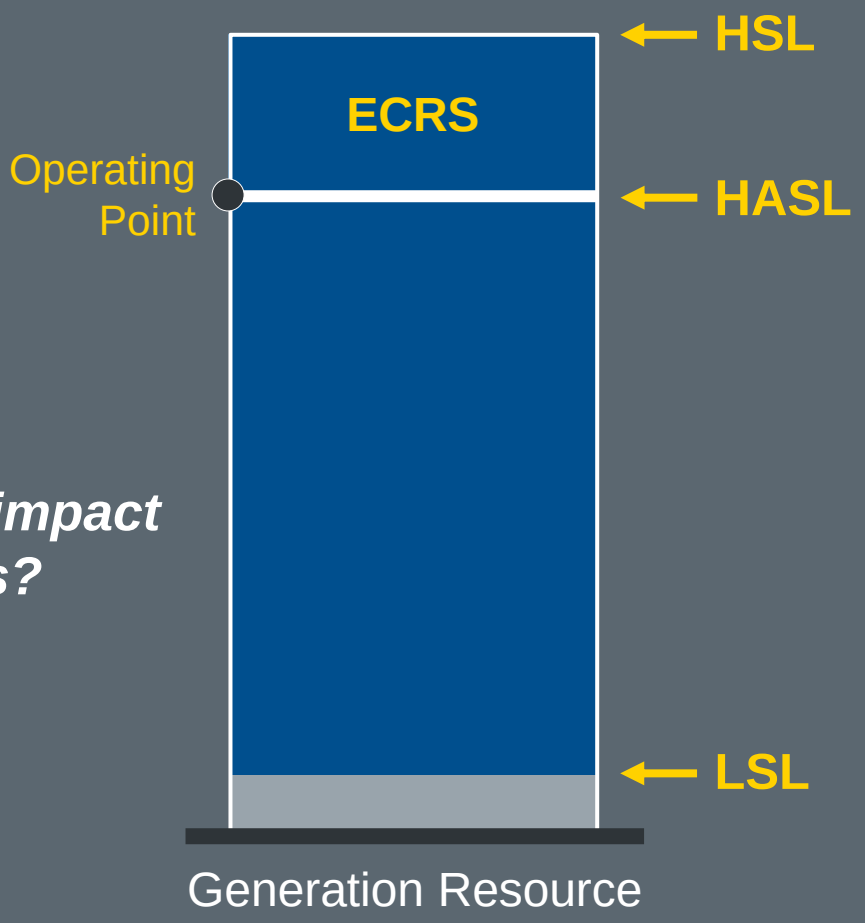
QSE receives MW deployment signal

. . . QSE releases capacity to SCED

QSE releases reserved capacity to SCED



Does this impact prices?



Responsive Reserve is frequency responsive

RRSPF – Primary Frequency Response

- Automatic Response at 59.983 Hz
- May be deployed manually

RRSFF – Fast Frequency Response

- Auto-deployed at 59.85 Hz
- Responds within 15 Cycles

RRSUF – Load Resource on Under-Frequency Relay

- Auto-deployed at 59.70 Hz
- Trips within 30 cycles

Non-Spinning Reserve Service

Resource-specific deployment

- Releases reserves to SCED
- Methodology varies by Resource type

Non-Spin Deployments

Resource Type	Deployment Methodology
On-Line Generation Resource	Standing Deployment with $75 Floor Price
Controllable Load Resource	Standing Deployment with $75 Floor Price
Off-Line Generation Resource	Operator Dispatch Instruction
Non-Controllable Load Resource	Operator Dispatch Instruction

System Ancillary Service Capacity Monitor

http://www.ercot.com/content/cdr/html/as_capacity_monitor.html

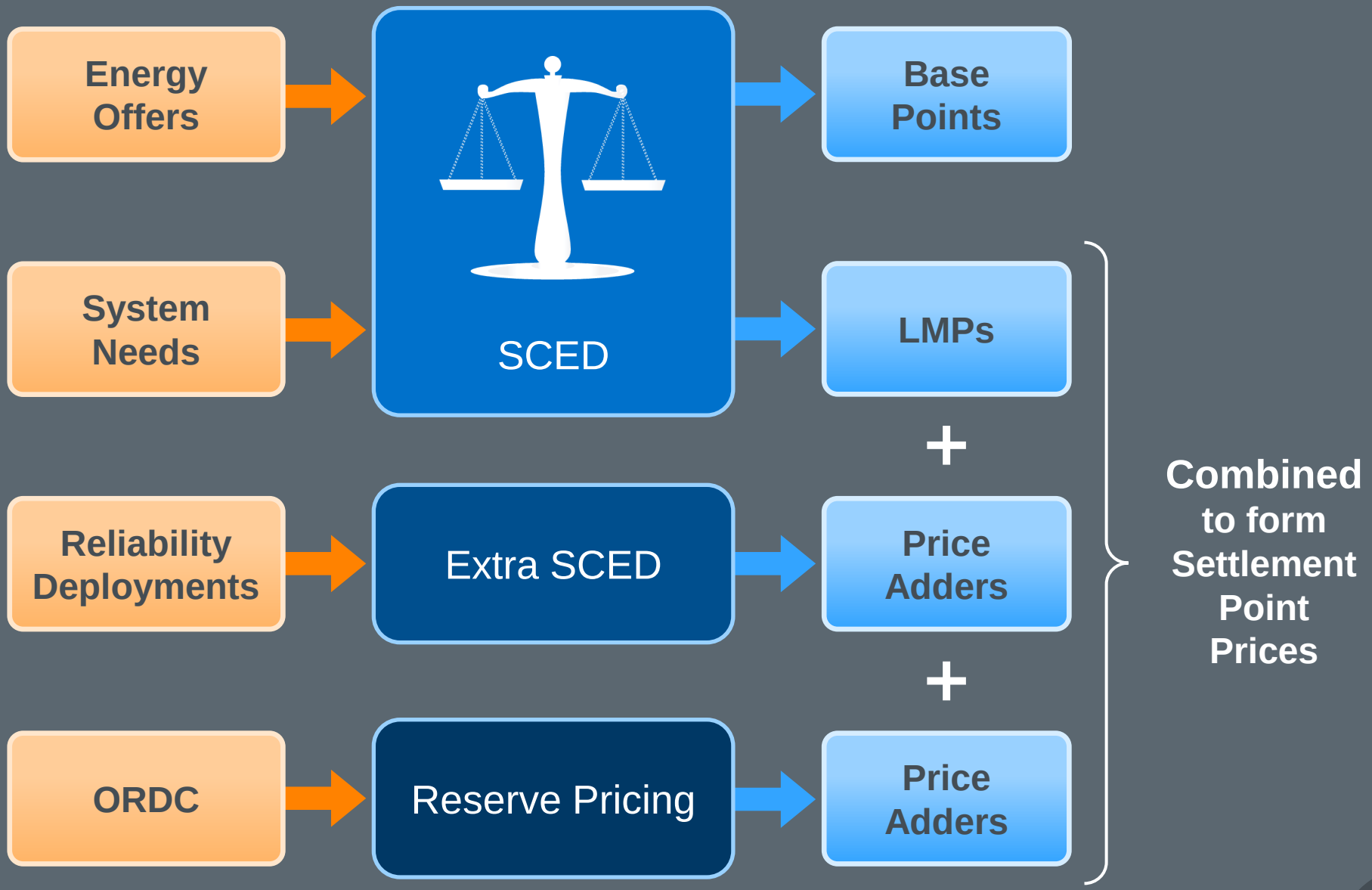
Responsive Reserve Capacity (MW)	
Generation Resources	1,343
Load Resources excluding Controllable Load Resources	1,280
Unprocured additional capacity from Load Resources excluding Controllable Load Resources	596
Controllable Load Resources	0
Resources capable of Fast Frequency Response	112
Deployed Generation Resources and Controllable Load Resources	0
Responsive Reserve Responsibility (MW)	
Generation Resources	1,388
Load Resources excluding Controllable Load Resources	1,294
Resources capable of Fast Frequency Response	115
Controllable Load Resources	4
ERCOT Contingency Reserve Capacity (MW)	
Generation Resources	919
Load Resources excluding Controllable Load Resources	184
Controllable Load Resources	60
Quick Start Generation Resources	938
Deployed Generation Resources and Load Resources	0
ERCOT Contingency Reserve Responsibility (MW)	
Generation Resources	960
Load Resources excluding Controllable Load Resources	185
Controllable Load Resources	61
Quick Start Generation Resources	938

Real-Time
Financial Impacts

Real-Time Financial Impacts

1. Real-Time Pricing
2. Real-Time Energy Settlement
3. Real-Time Reserve Settlement
4. Base Point Deviation

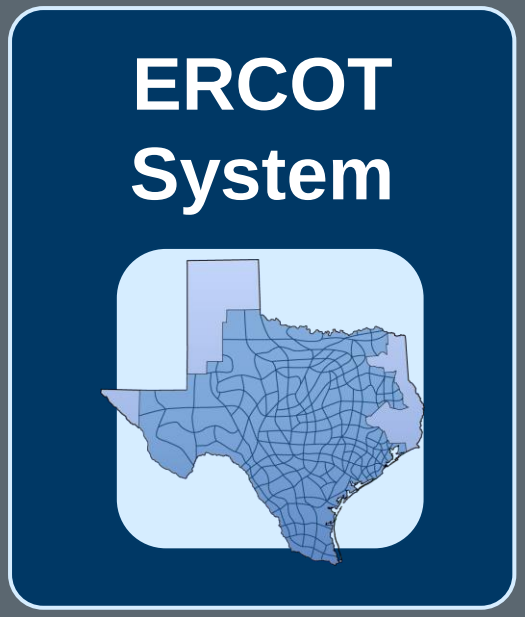
1. Real-Time Pricing
2. Real-Time Energy Settlement
3. Real-Time Reserve Settlement
4. Base Point Deviation


Energy Offers
System Needs
Reliability Deployments
ORDC
SCED
Extra SCED
Reserve Pricing
Base Points
LMPs
+
Price Adders
+
Price Adders
Combined to form Settlement Point Prices

RTORPA – On-Line Reserve Price Adder

RTOFFPA – Off-Line Reserve Price Adder

RTORDPA – On-Line Reliability Deployment Price Adder



… for each SCED interval

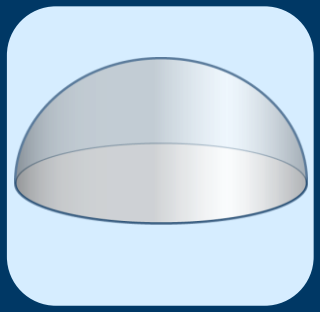
Real-Time Settlement Point Prices (RTSPPs)

= Ave (LMPs) + Ave (RTORPA) + Ave (RTORDPA)

Resource Nodes

Load Zones

Hubs



… for each 15-minute interval

1. Real-Time Pricing
2. Real-Time Energy Settlement
3. Real-Time Reserve Settlement
4. Base Point Deviation

Real-Time Energy Imbalance

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

Real-Time Energy Imbalance at Load Zone

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

Each Settlement Point settled separately

Real-Time Energy Imbalance at Resource Node

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

Each Settlement Point settled separately

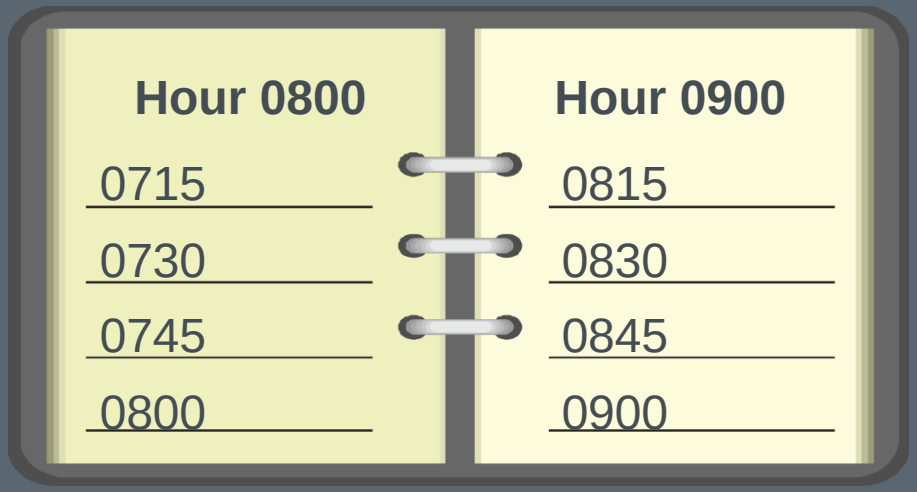
Real-Time Energy Imbalance at Hub

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

Each Settlement Point settled separately

DAM Awards & Trades in Real-Time Energy Settlements

- DAM awards and settles *hourly MWs*
- Energy Trades reported as *hourly MWs*
- Real-Time settles *15-minute MWhs*



Multiply DAM awards and Trades by ¼ hour

QSE has Generation during Interval 1445

At the GENRUS Resource Node

- Metered Generation = 150 MWh
- DAM Energy Sale = 200 MW
- RTSPP = $30/MWh

At GENRUS Resource Node

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

$$= (-1) \left(\left(\quad \right) - \left(\quad \right) \right) * \$30/\text{MWh}$$

$$=$$

QSE has Load and Energy Trades during Interval 1445

At the Houston Hub

- Trade Purchase = 200 MW
- RTSPP = $35/MWh

At the Houston Load Zone

- Metered Load = 40 MWh
- RTSPP = $40/MWh

At Houston Hub

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

$$= (-1) \left[\left(\quad \right) - \left(\quad \right) \right] * \$35/\text{MWh}$$

$$=$$

At Houston Load Zone

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

$$= (-1) \left[\left(\quad \right) - \left(\quad \right) \right] * \$40/\text{MWh}$$

$$=$$

Net Real-Time Energy Imbalance

Houston Hub	Houston Load Zone	Net Amount

QSE has neither Generation nor Load for Interval 1445

At the Houston Load Zone

- 32 MW Awarded DAM Energy Offer
- RTSPP = $40/MWh

At Houston Load Zone

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

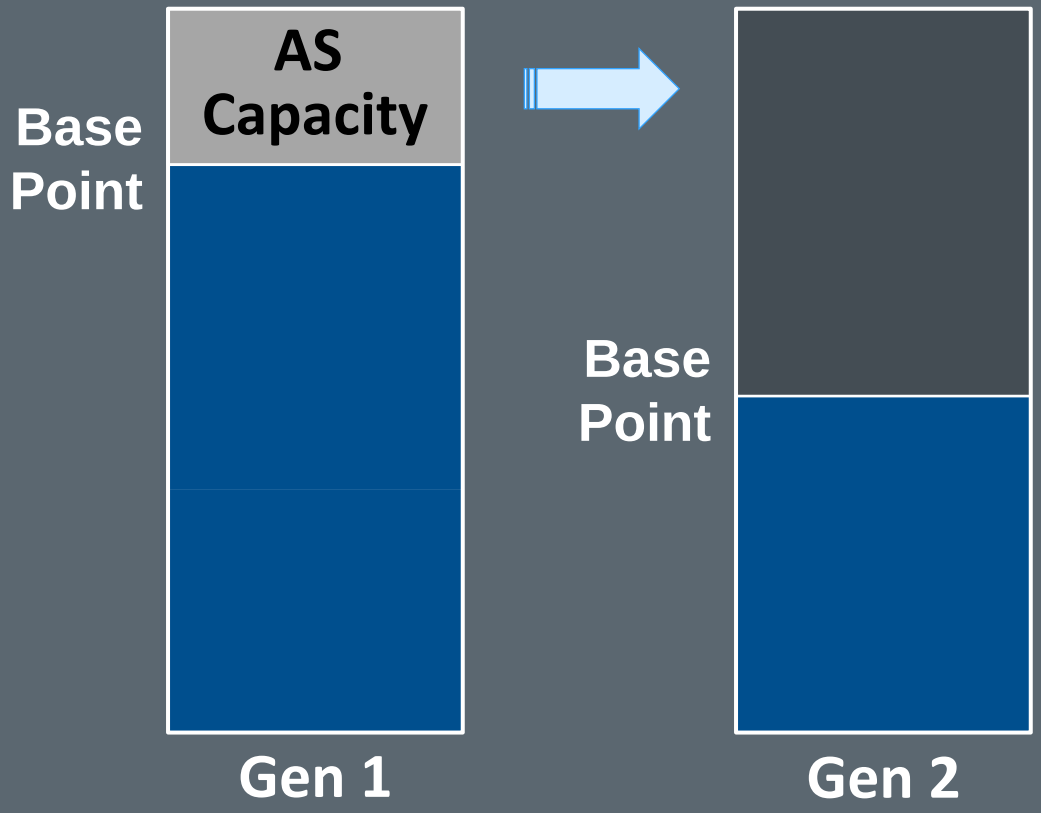
$$= (-1) \left[\left(\quad \right) - \left(\quad \right) \right] * \$40/\text{MWh}$$

$$=$$

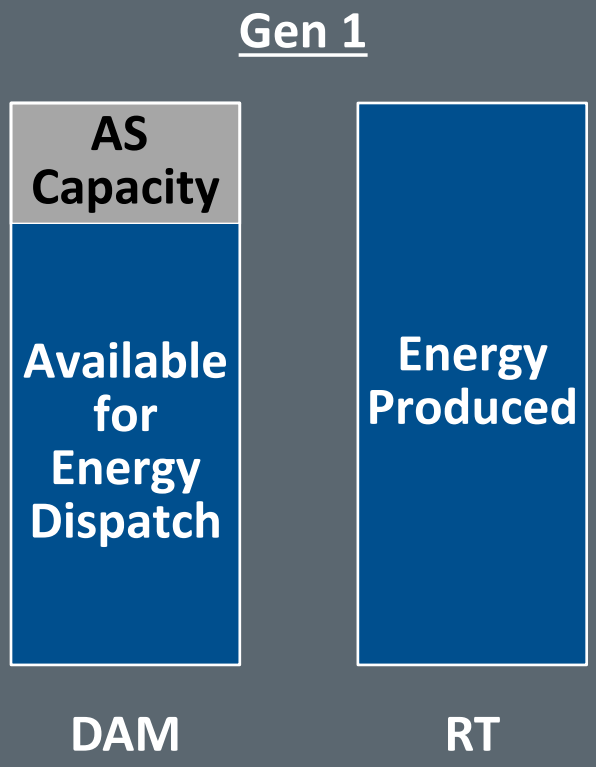
1. Real-Time Pricing
2. Real-Time Energy Settlement
3. Real-Time Reserve Settlement
4. Base Point Deviation

What if we could shift the AS from Gen 1 to Gen 2?

$255.67



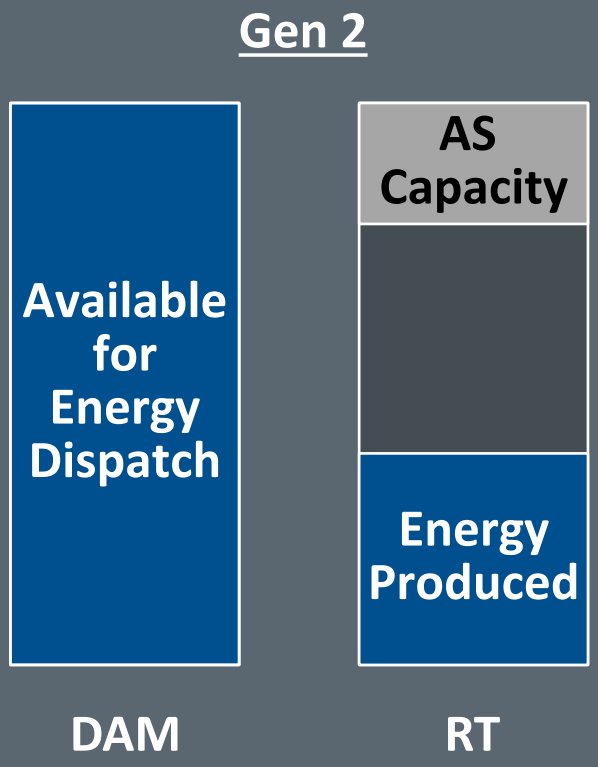
What if we could shift the AS from Gen 1 to Gen 2?



QSE Real-Time Settlement:

- Paid RTSPP for energy produced in Real-Time
- Buy back AS Capacity at some Real-Time Price

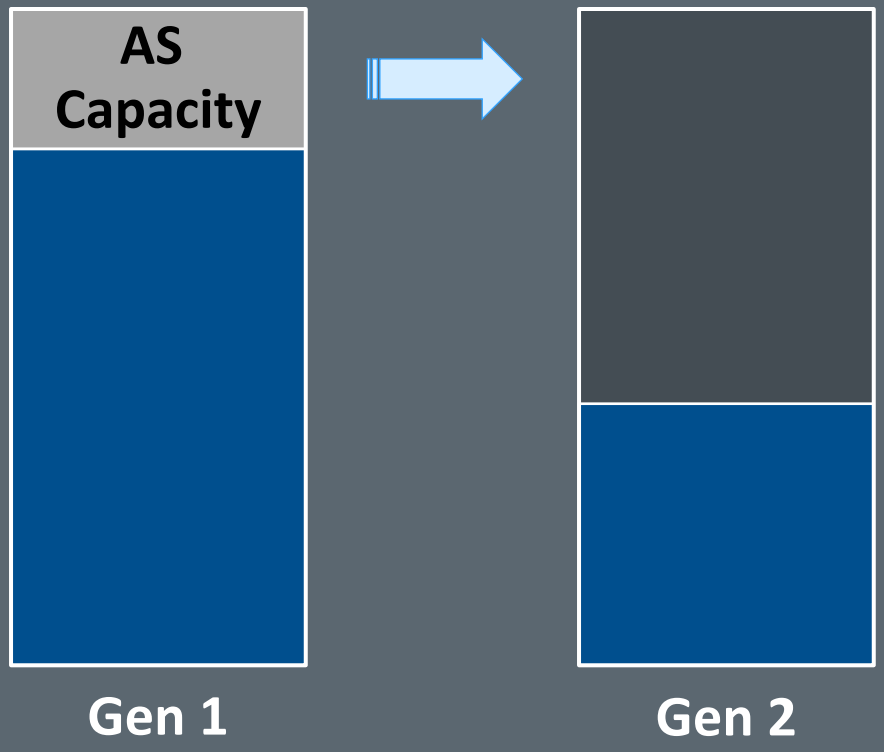
What if we could shift the AS from Gen 1 to Gen 2?



QSE Real-Time Settlement:

- Paid RTSPP for energy produced in Real-Time
- Paid for AS Capacity at some Real-Time Price

Real-Time Ancillary Service Imbalance



. . . approximates Real-Time Co-optimization

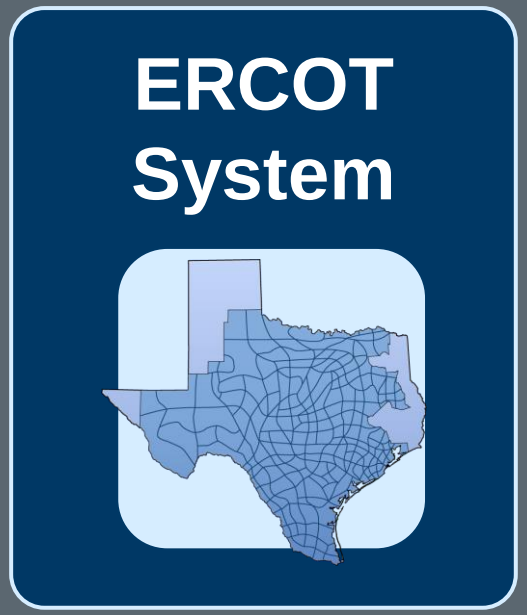
Real-Time Ancillary Service Imbalance:

$$= (-1)\left[\left(\text{On-Line Reserve SUPPLIES} - \text{On-Line Reserve OBLIGATIONS}\right) * \text{On-line Reserve Price} + \left(\text{Off-Line Reserve SUPPLIES} - \text{Off-Line Reserve OBLIGATIONS}\right) * \text{Off-line Reserve Price}\right]$$

Calculated ERCOT-wide per QSE

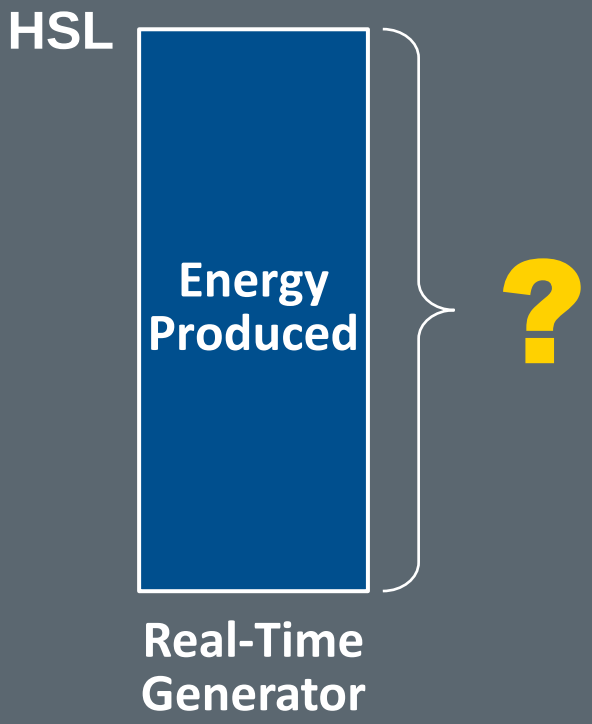
On-line Reserve Price = Ave (RTORPA)

Off-line Reserve Price = Ave (RTOFFPA)

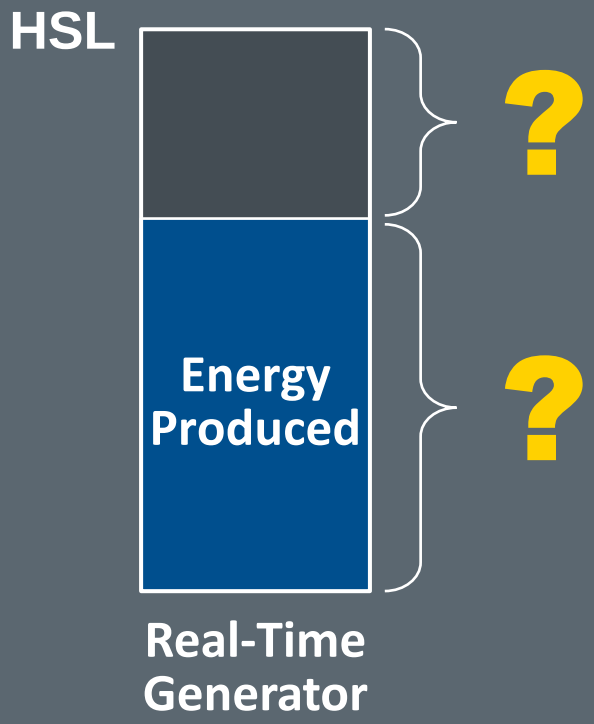


… for each 15-Minute interval

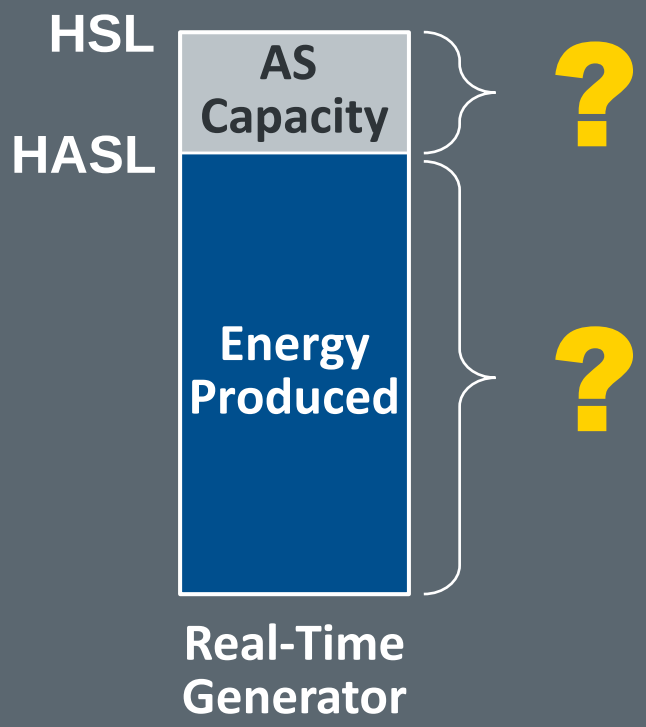
Scenario 1: How's it Settled?



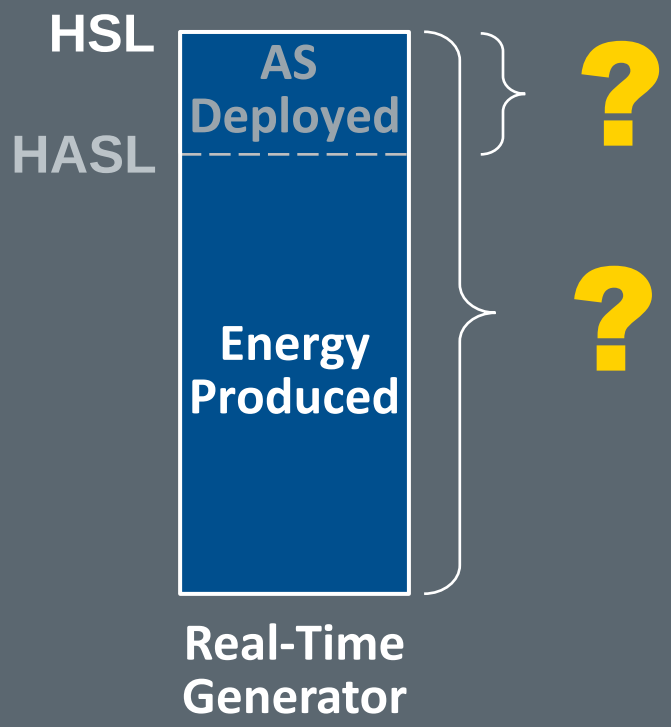
Scenario 2: How's it Settled?



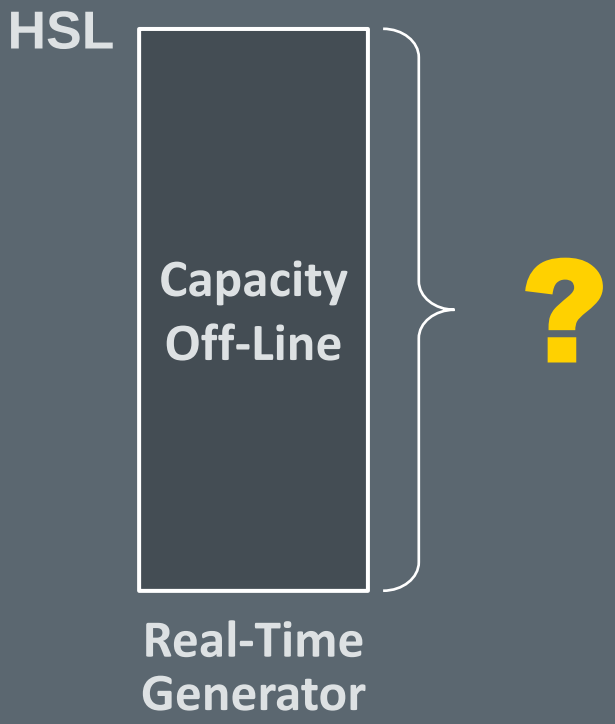
Scenario 3: How's it Settled?



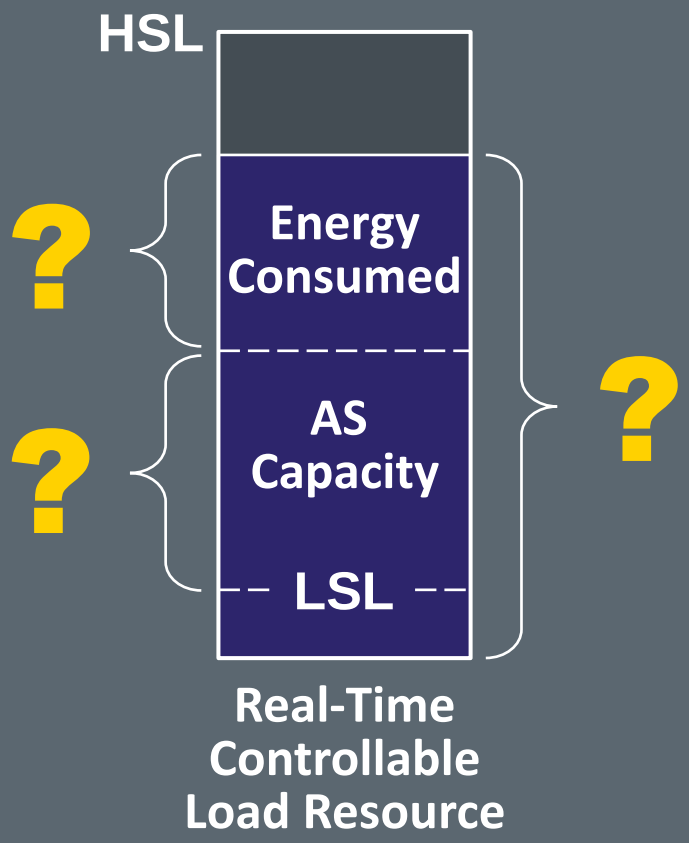
Scenario 4: How's it Settled?



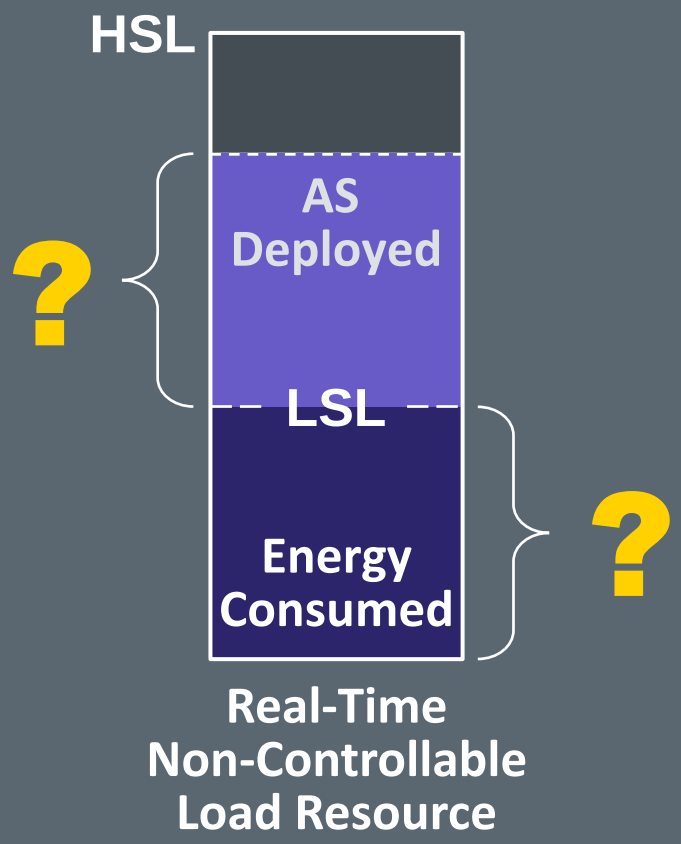
Scenario 5: How's it Settled?



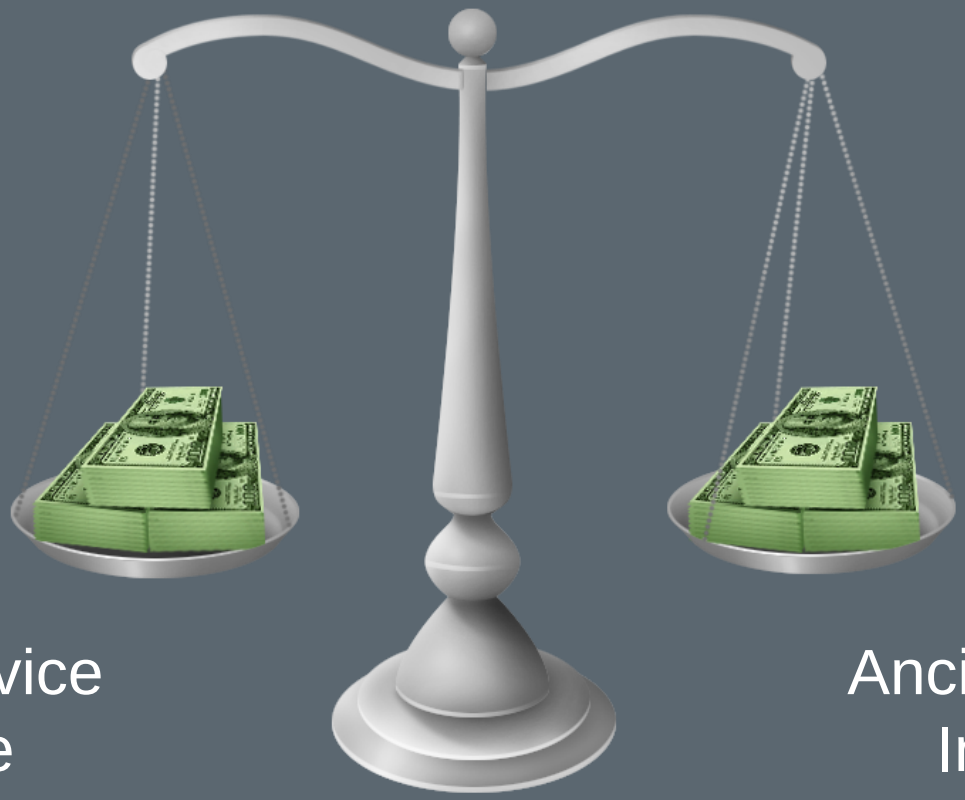
Scenario 6: How's it Settled?



Scenario 7: How's it Settled?



Real-Time AS Imbalance Revenue Neutrality Allocation



Ancillary Service Imbalance Net

Ancillary Service Imbalance Uplift

1 Real-Time Pricing

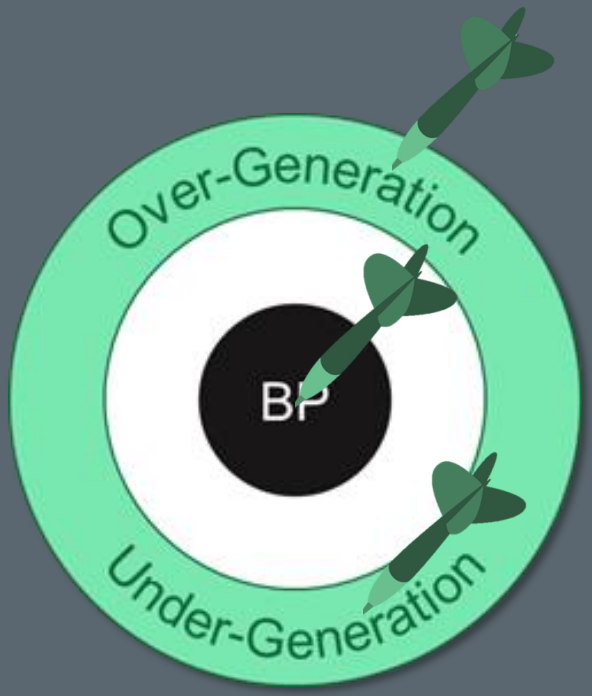
2 Real-Time Energy Settlement

3 Real-Time Reserve Settlement

4 Base Point Deviation

Resource is expected to follow Base Point instructions

QSE's may be charged if Resource outside tolerance



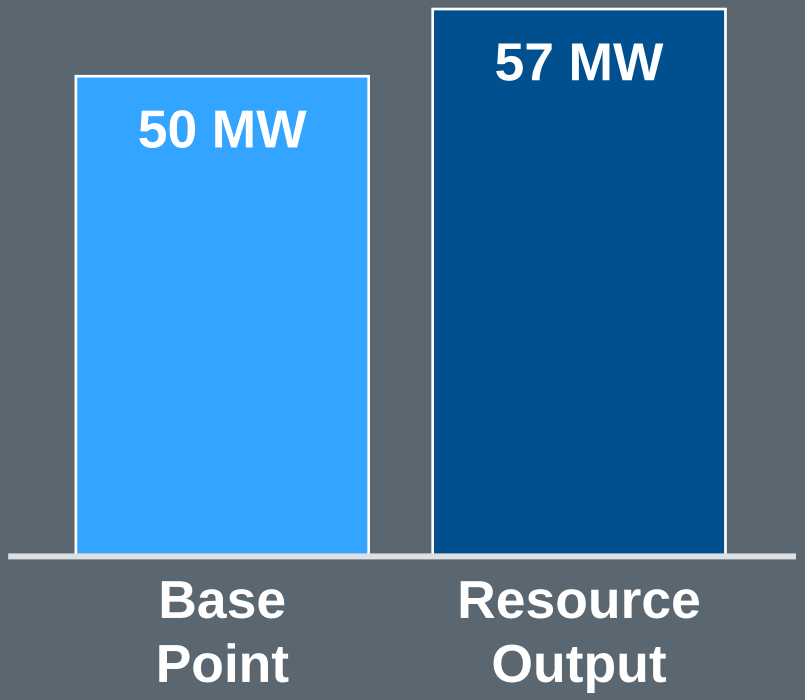
Protocol Tolerances

- Greater of ± 5% or ± 5MW
- IRRs allowed 5%

Waived if two conditions are met

1. Frequency deviation greater than 0.05Hz
2. Resource's deviation helps correct frequency

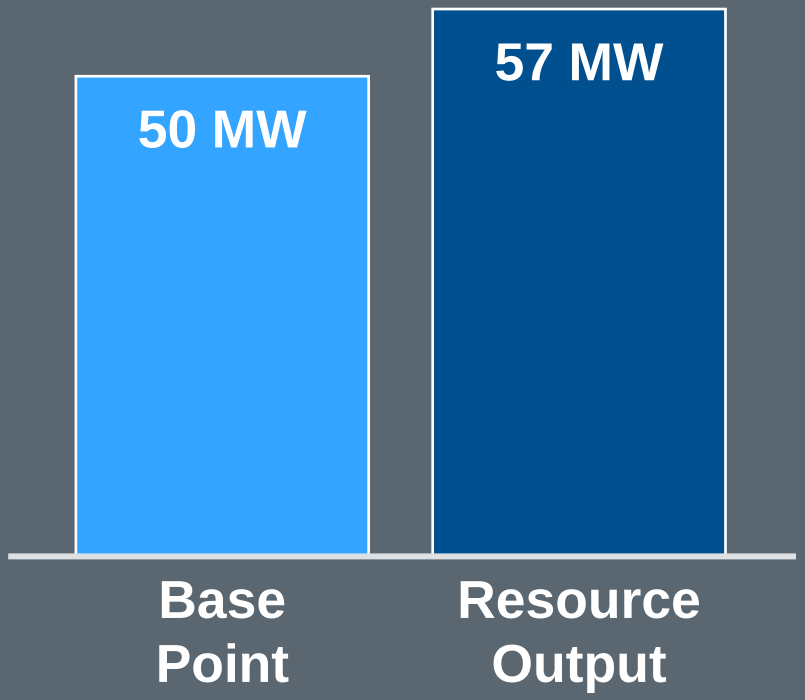
Does the QSE incur a Base Point Deviation Charge?



59.940

Frequency at max deviation during interval

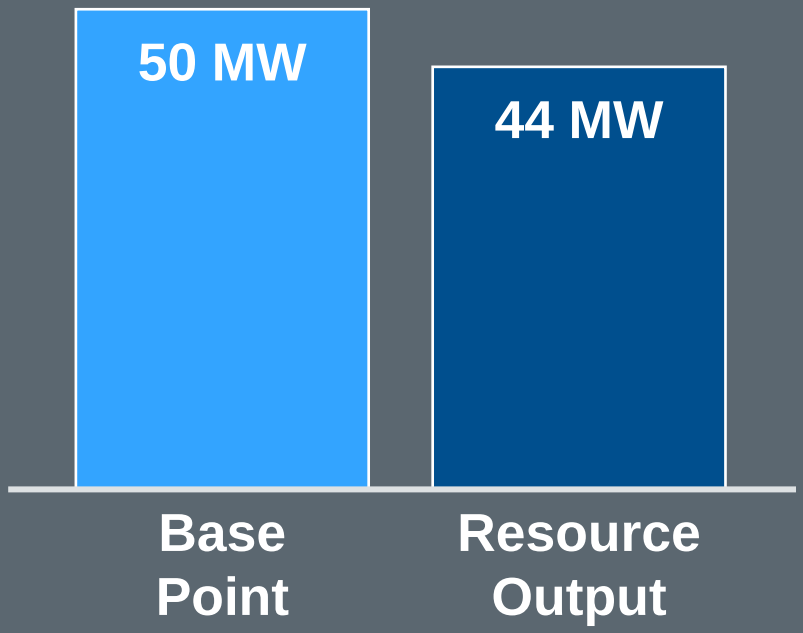
Does the QSE incur a Base Point Deviation Charge?



60.020

Frequency at max deviation during interval

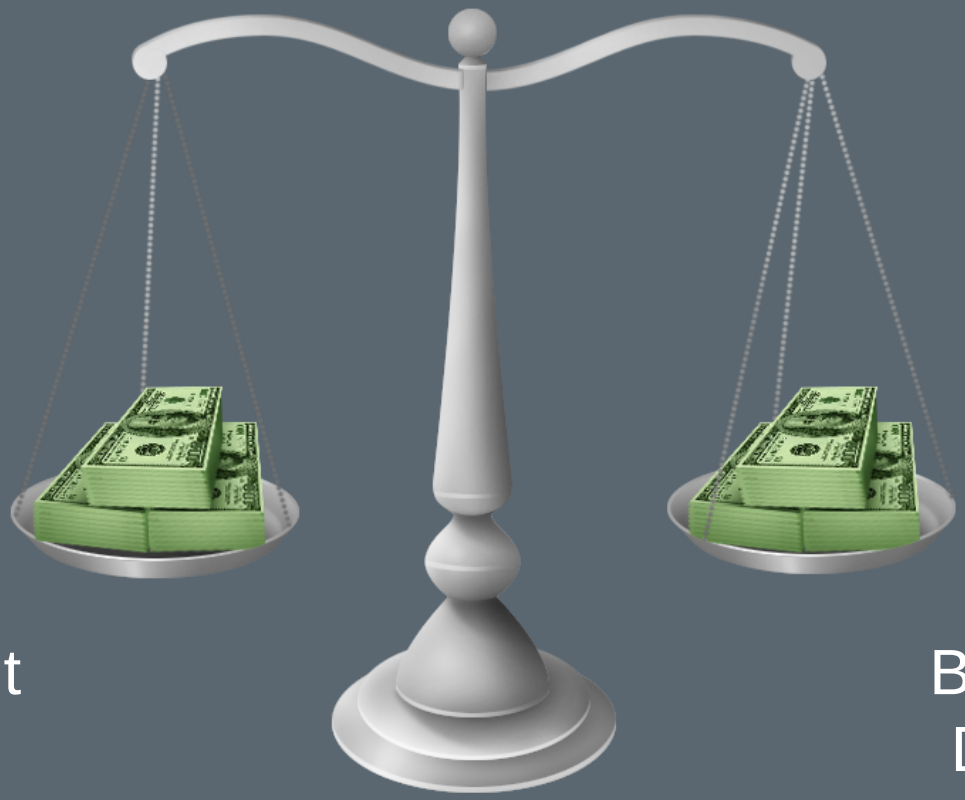
Does the QSE incur a Base Point Deviation Charge?



60.020

Frequency at max deviation during interval

Base Point Deviation Payment



Base Point Deviation Charges

Base Point Deviation Payments

Course Wrap-Up

Suite of Wholesale Market Courses

Format	Title
WBT	Wholesale Markets Overview

Format	Title	Topic
ILT	Wholesale Market Operations: Day-Ahead	Day-Ahead Market Inputs
		Day-Ahead Market Clearing
		Day-Ahead Market Financial Impacts
		RUC and its Financial Impacts
	Wholesale Market Operations: Real-Time	The Adjustment Period
		Real-Time Dispatch and AS Deployments
		Real-Time Financial Impacts

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