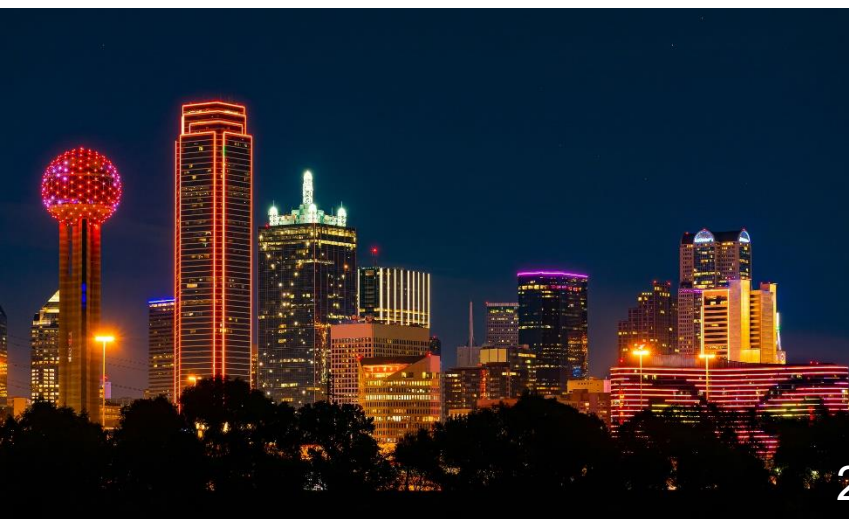




Resources in ERCOT Market Operations



Greetings and Introductions

Attendance

Questions

Presentation materials

Recording for internal purposes



PROTOCOL DISCLAIMER

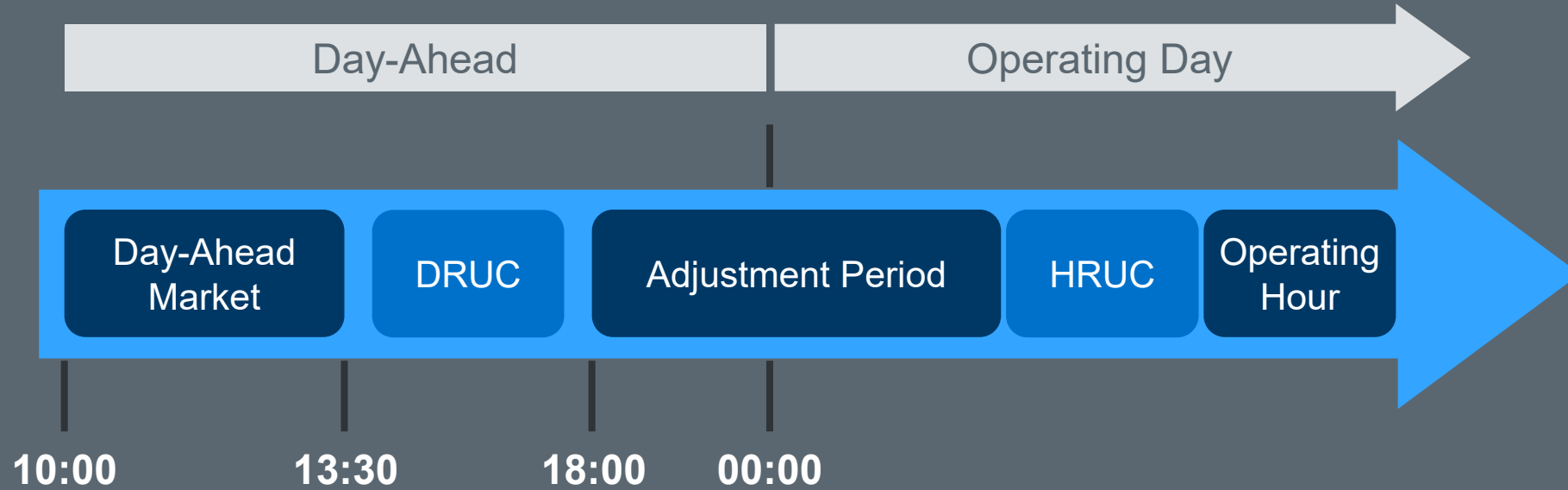
This presentation provides a general overview of the Texas Nodal Market and is not intended to be a substitute for the ERCOT Protocols, as amended from time to time. If any conflict exists between this presentation and the ERCOT Protocols, the ERCOT Protocols shall control in all respects.

For more information, please visit:

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

Purpose	Format	Title
Pre-requisite	WBT	✓ Resources in ERCOT
		✓ Resource Responsibilities in ERCOT
Core Courses	ILT	∧ Resources in ERCOT Market Operations
		ERCOT Market Operations >
		Resources in the Day-Ahead Market >
		Resources in the Real-Time Market >
		✓ Energy Storage Resources
		✓ Intermittent Renewable Resources
		✓ Combined Cycle Generation Resources
Post-requisite	WBT	✓ IRR Forecasting
		✓ Quick Start Generation Resources

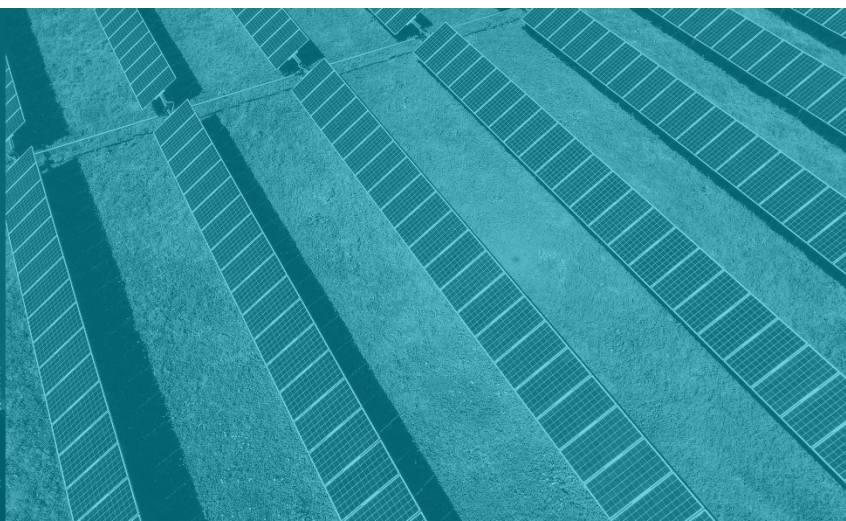
In general, . . .



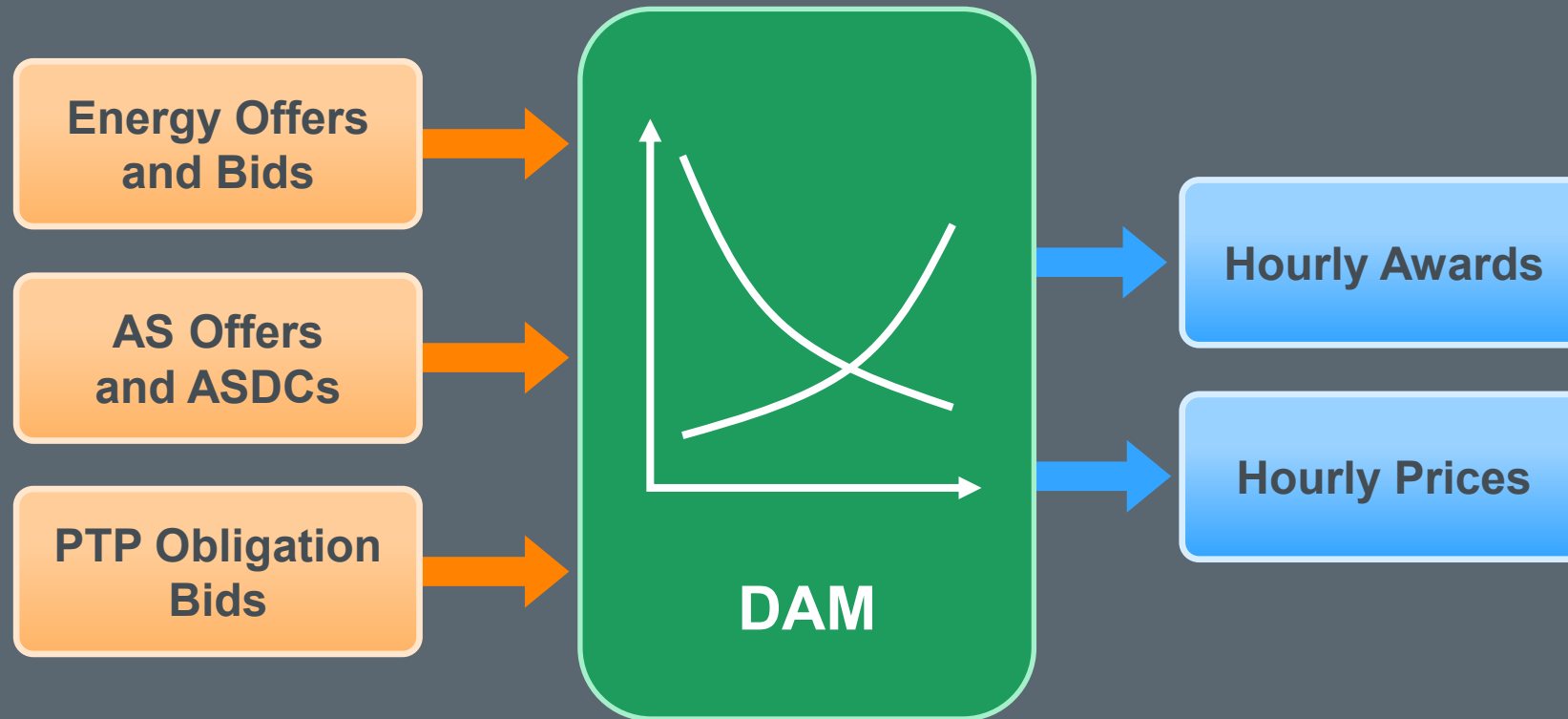




Resources in the Day-Ahead Market



Economically optimized subject to constraints



Topics in this module include:

1

Resource Offers in DAM

2

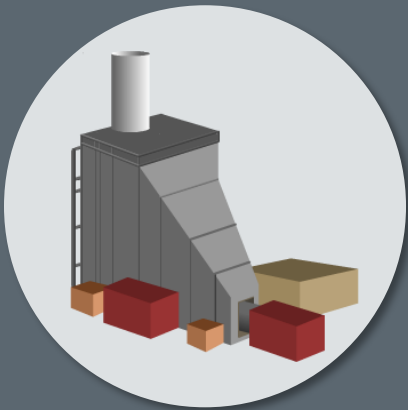
Resource Limits in DAM Clearing

3

Post DAM Activities



Resource may be offered for Energy Inclusive or Exclusive of Ancillary Service Offers



Three Part Supply Offer

Start-Up

Minimum Energy

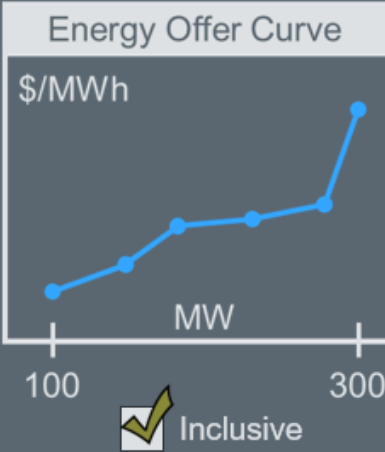
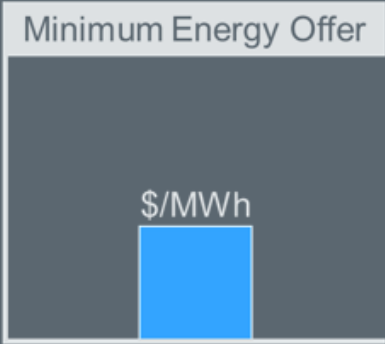
Energy Offer Curve

☒ Inclusive
☐ Exclusive

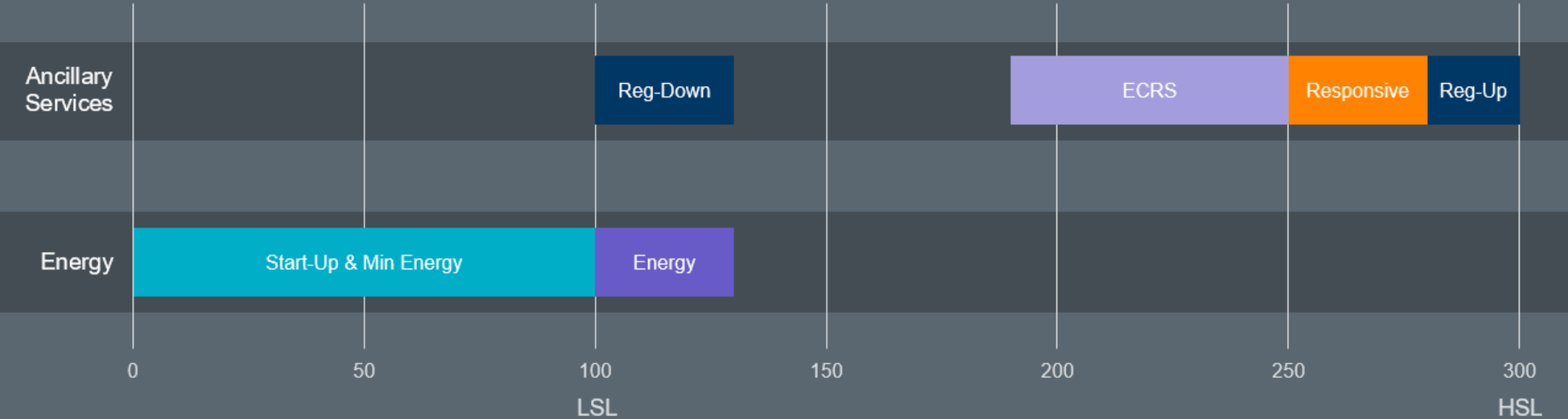
AS Type	Offer	
Reg-Up	MW	\$ / MW
Reg-Down	MW	\$ / MW
Responsive	MW	\$ / MW
ECRS	MW	\$ / MW
Non-Spin	MW	\$ / MW



Ancillary Service Offers with Inclusive Energy Offer Curve

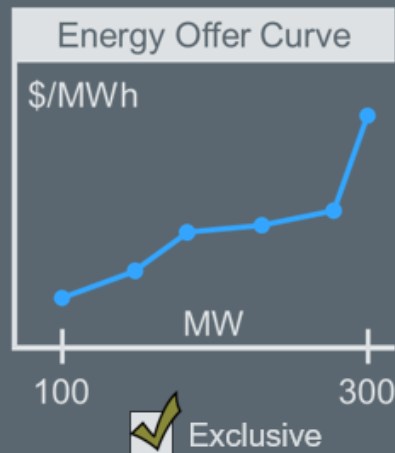


AS Type	Offer	
Reg-Up	30 MW	\$ / MW
Reg-Down	30 MW	\$ / MW
Responsive	60 MW	\$ / MW
ECRS	120 MW	\$ / MW
Off-Line Non-Spin	300 MW	\$ / MW

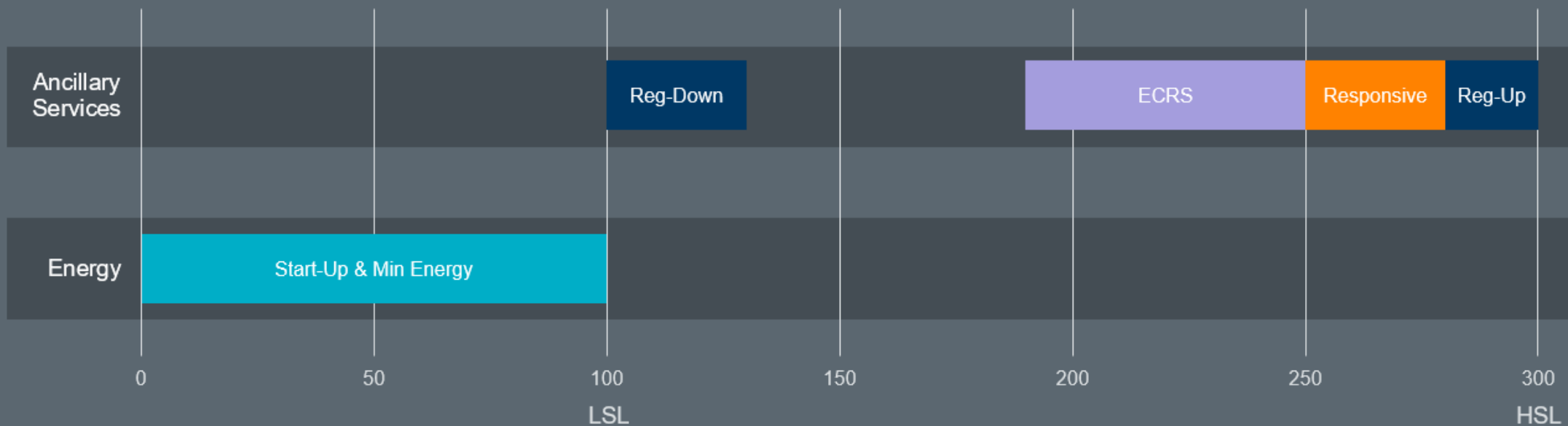


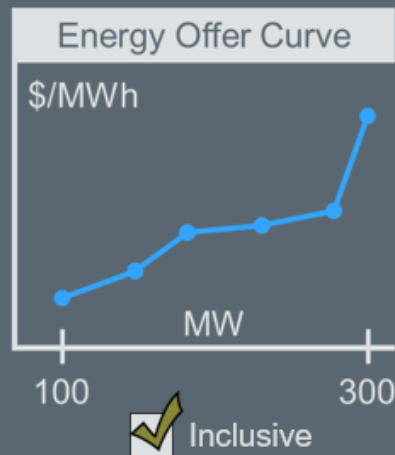
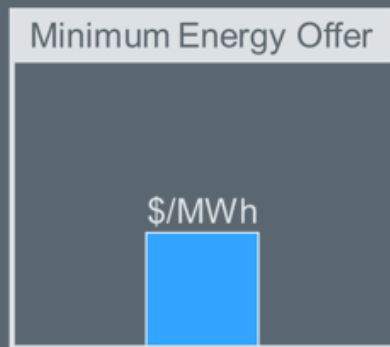


Ancillary Service Offers with Exclusive Energy Offer Curve

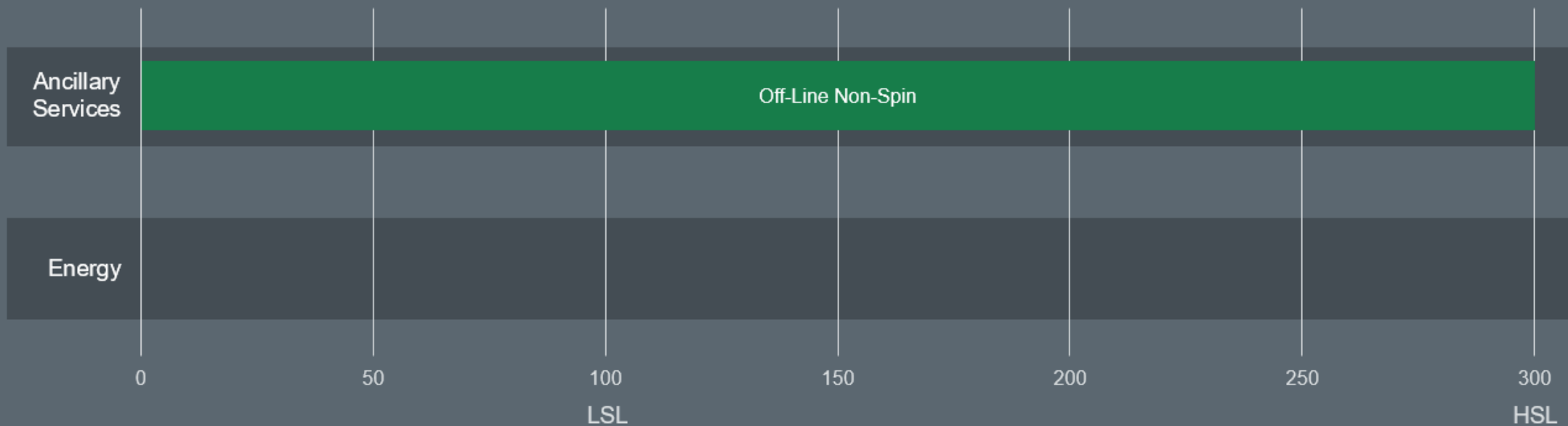


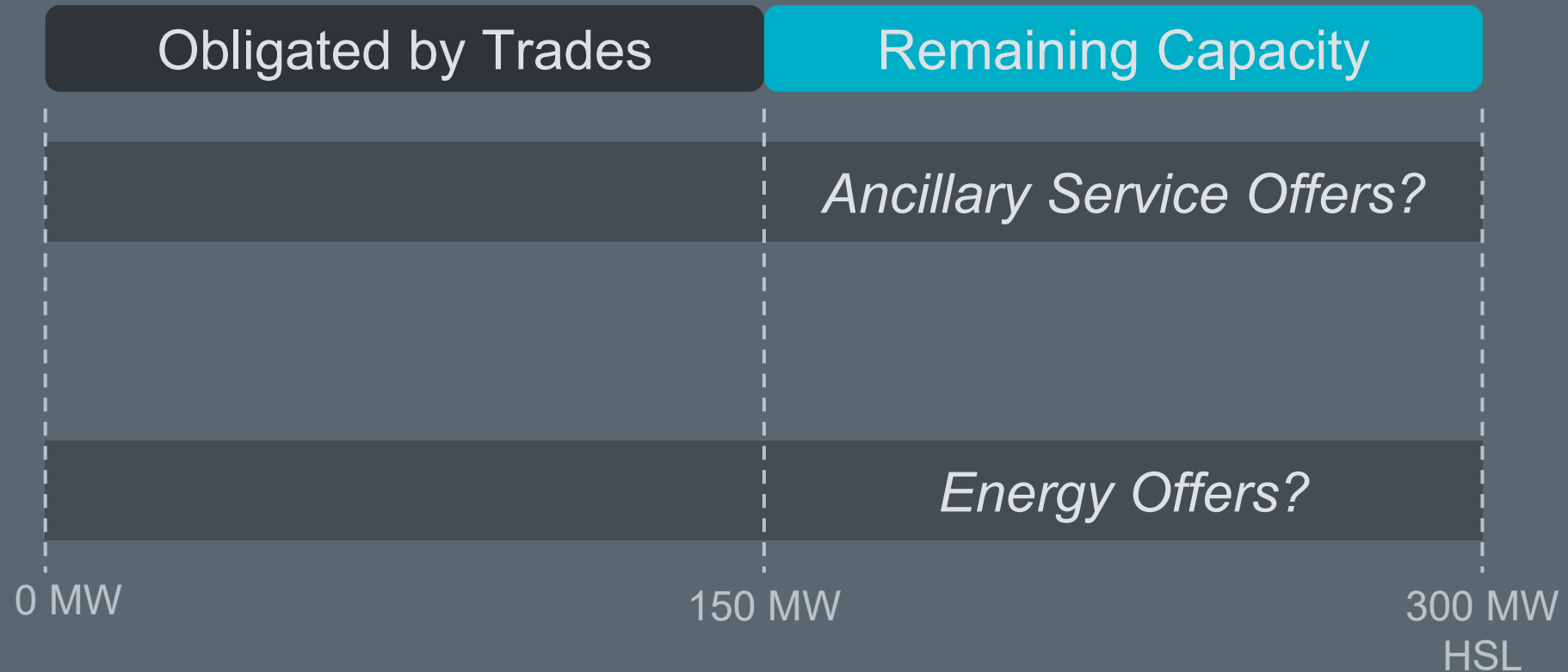
AS Type	Offer	
Reg-Up	30 MW	\$ / MW
Reg-Down	30 MW	\$ / MW
Responsive	60 MW	\$ / MW
ECRS	120 MW	\$ / MW
On-Line Non-Spin	200 MW	\$ / MW

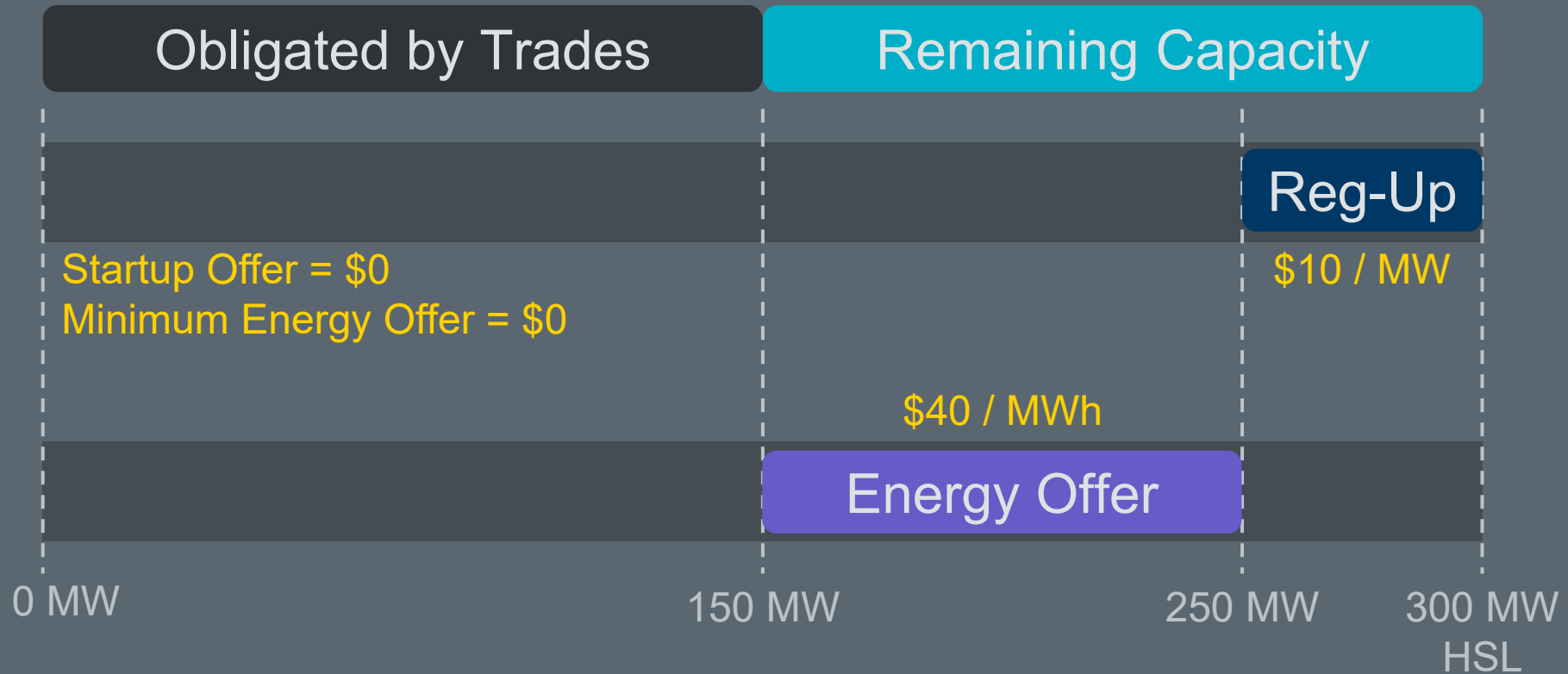




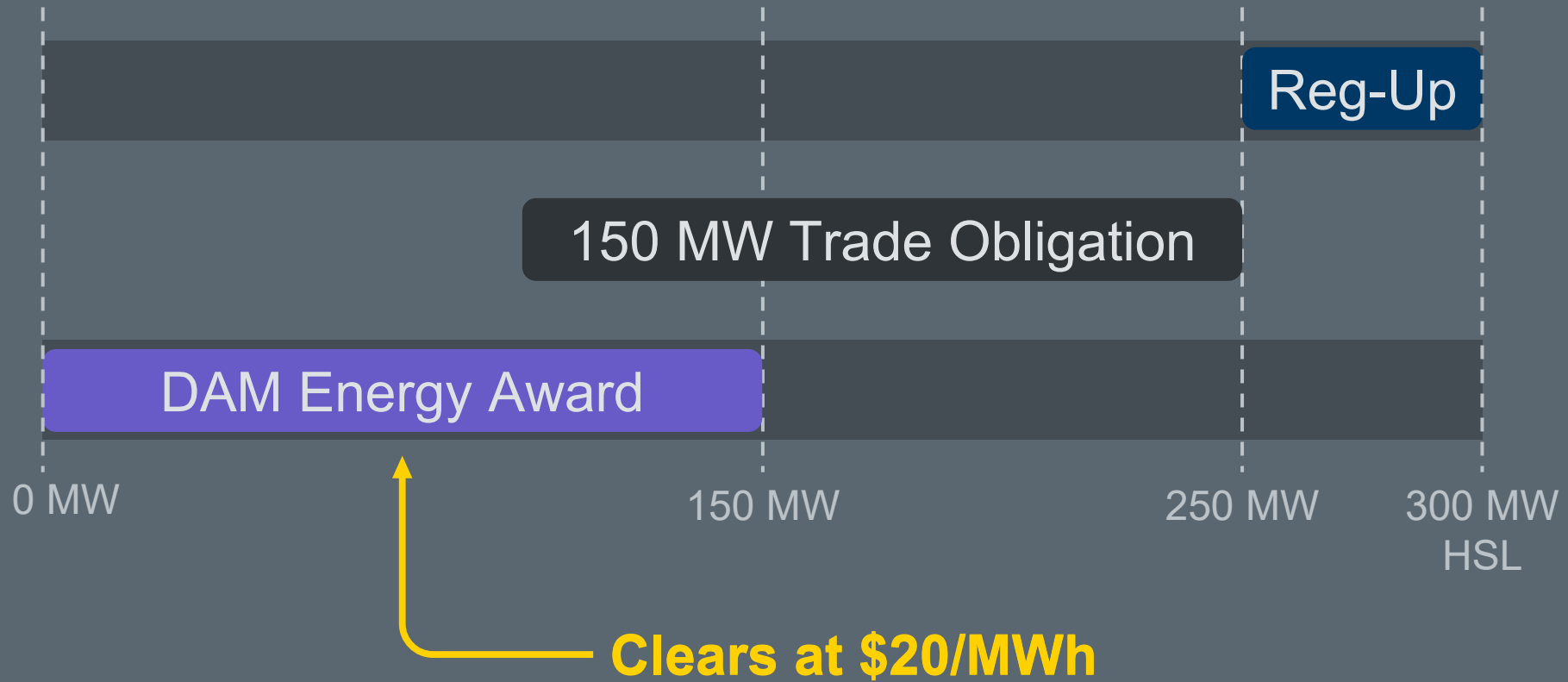
AS Type	Offer	
Reg-Up	30 MW	$\$/\text{MW}$
Reg-Down	30 MW	$\$/\text{MW}$
Responsive	60 MW	$\$/\text{MW}$
ECRS	120 MW	$\$/\text{MW}$
Off-Line Non-Spin	300 MW	$\$/\text{MW}$



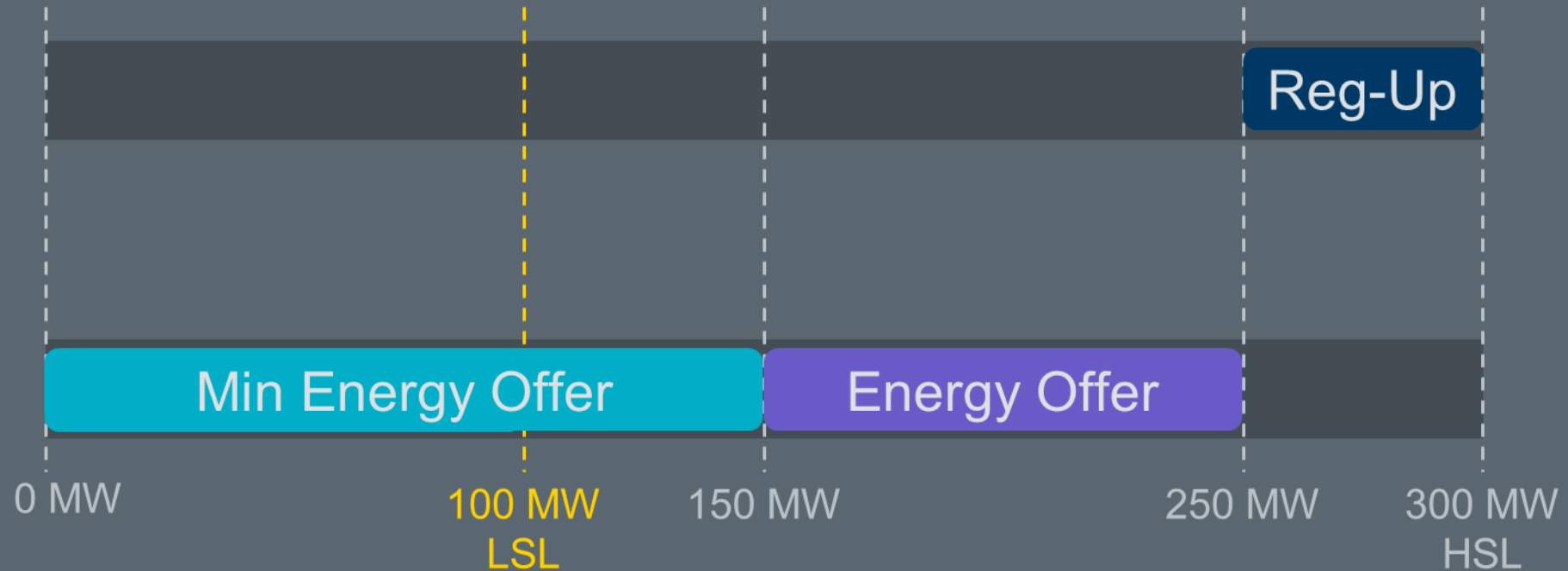


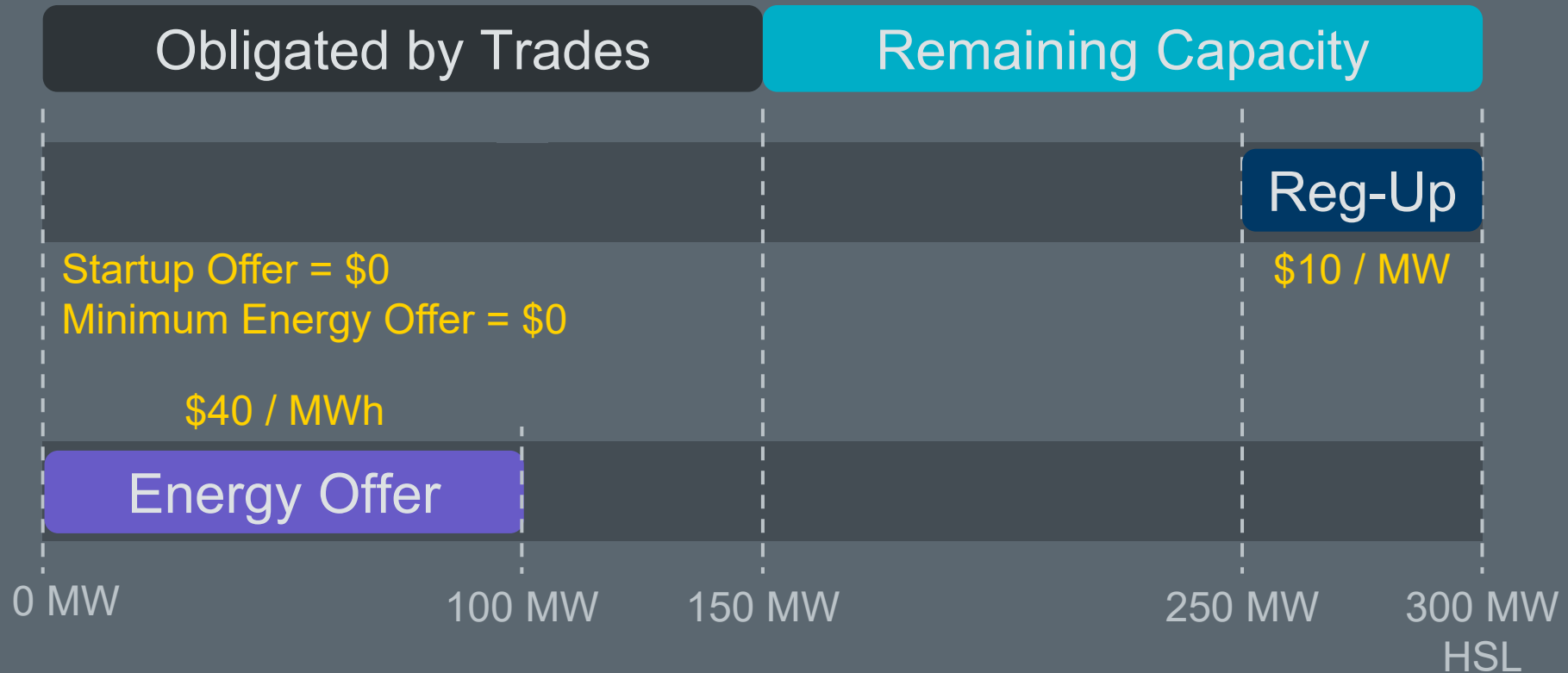


Possible outcome:

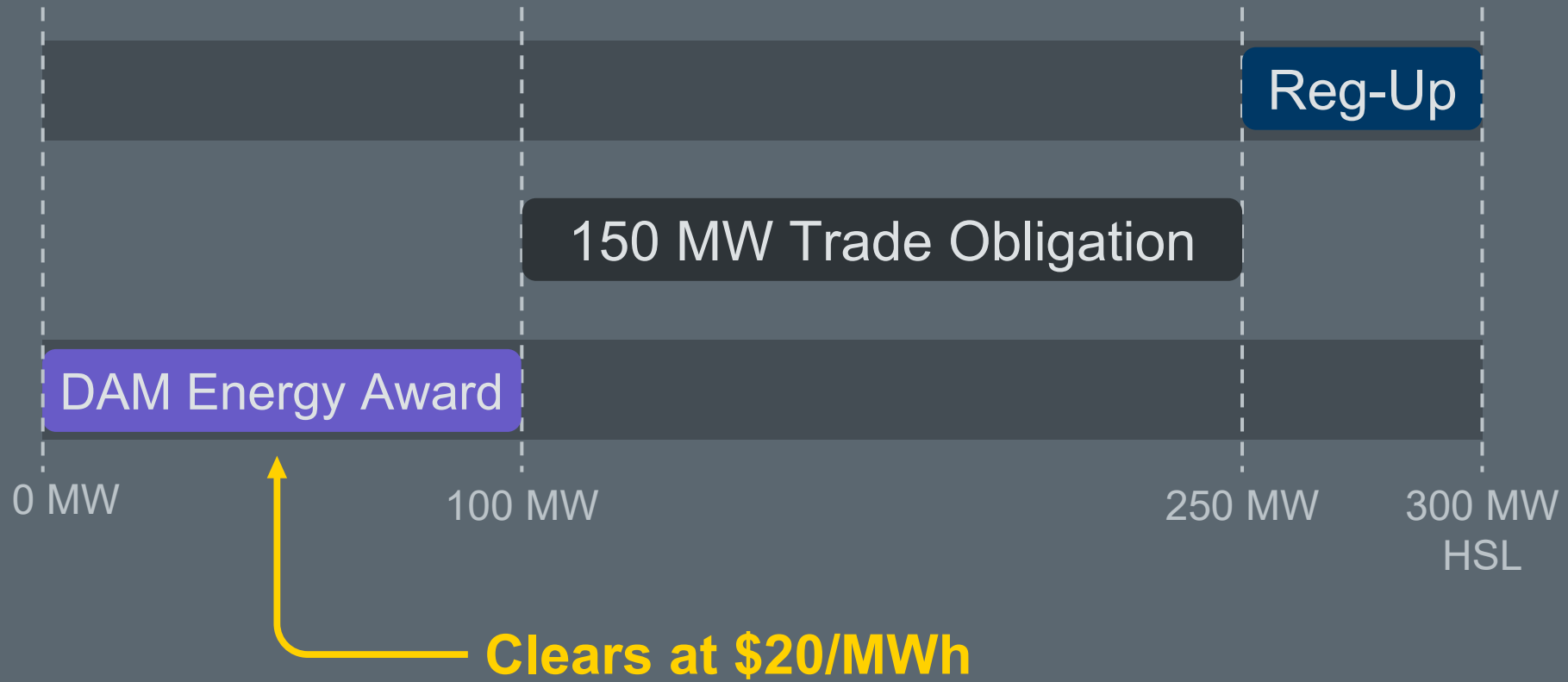


What DAM actually saw:

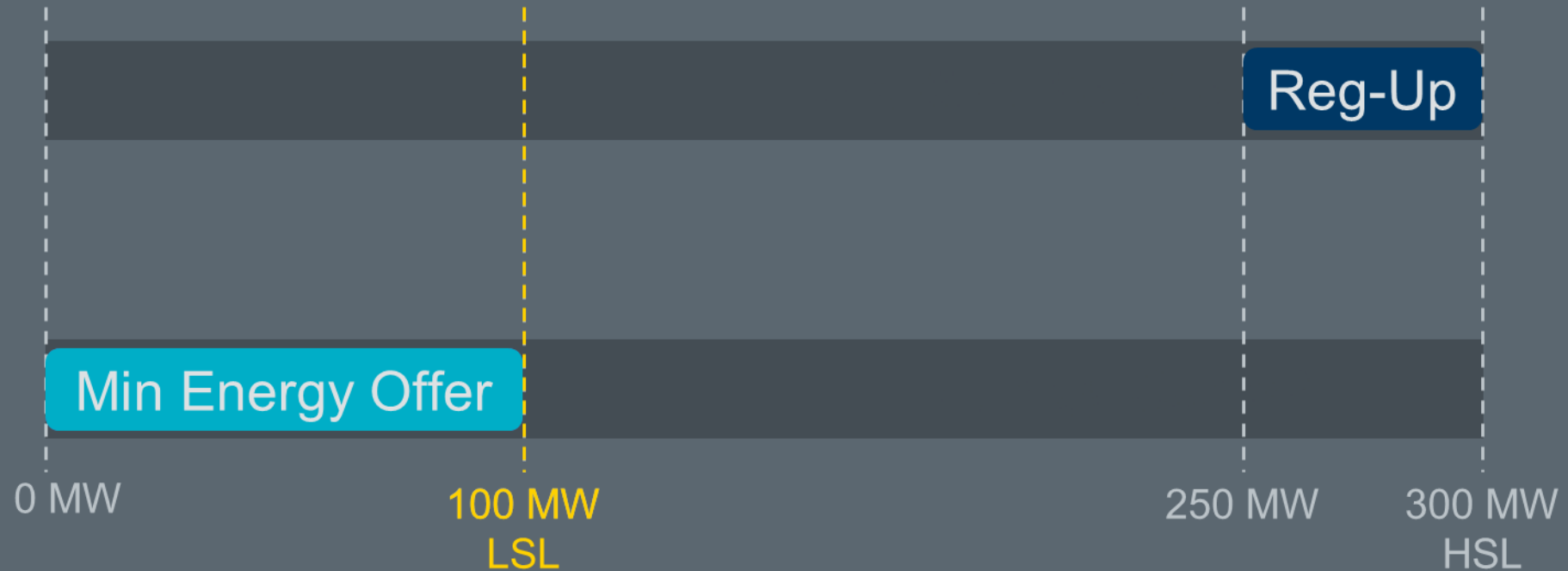


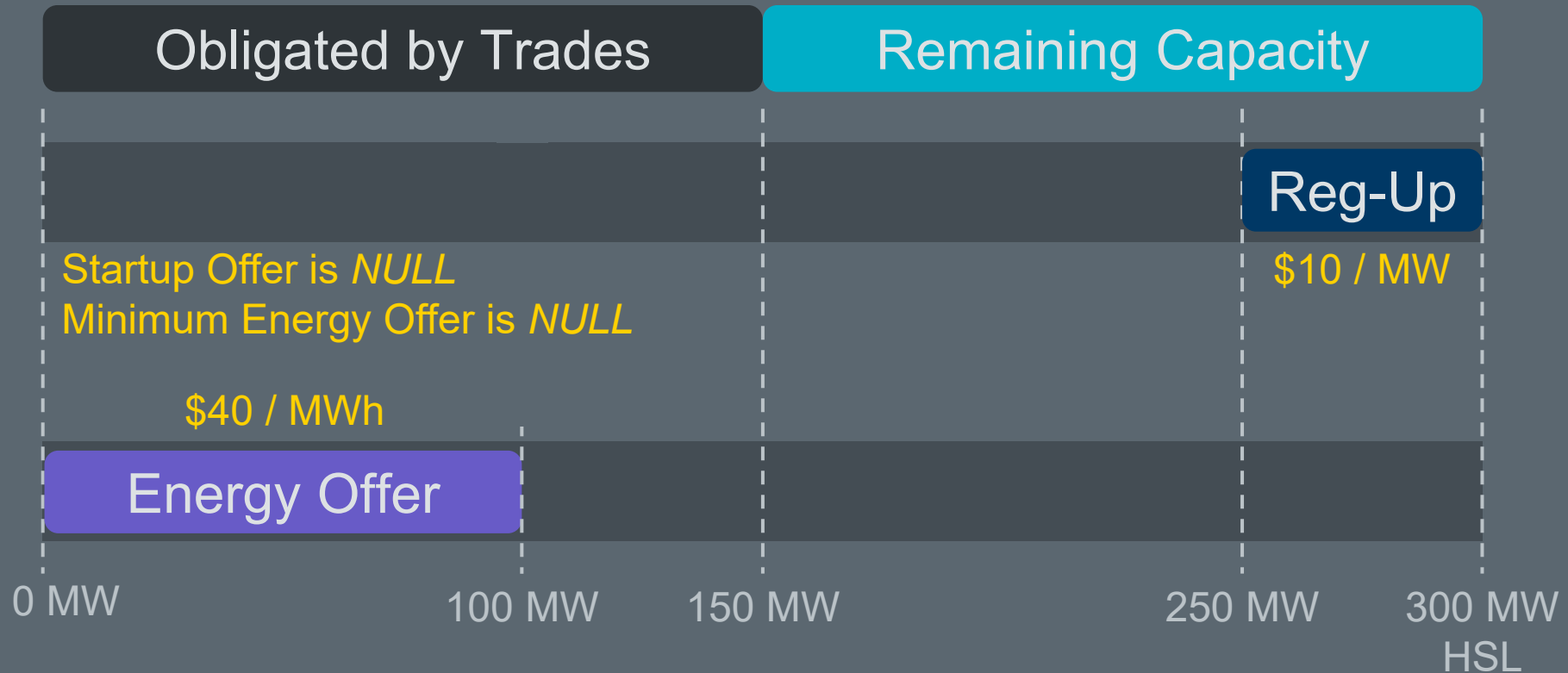


Possible outcome:

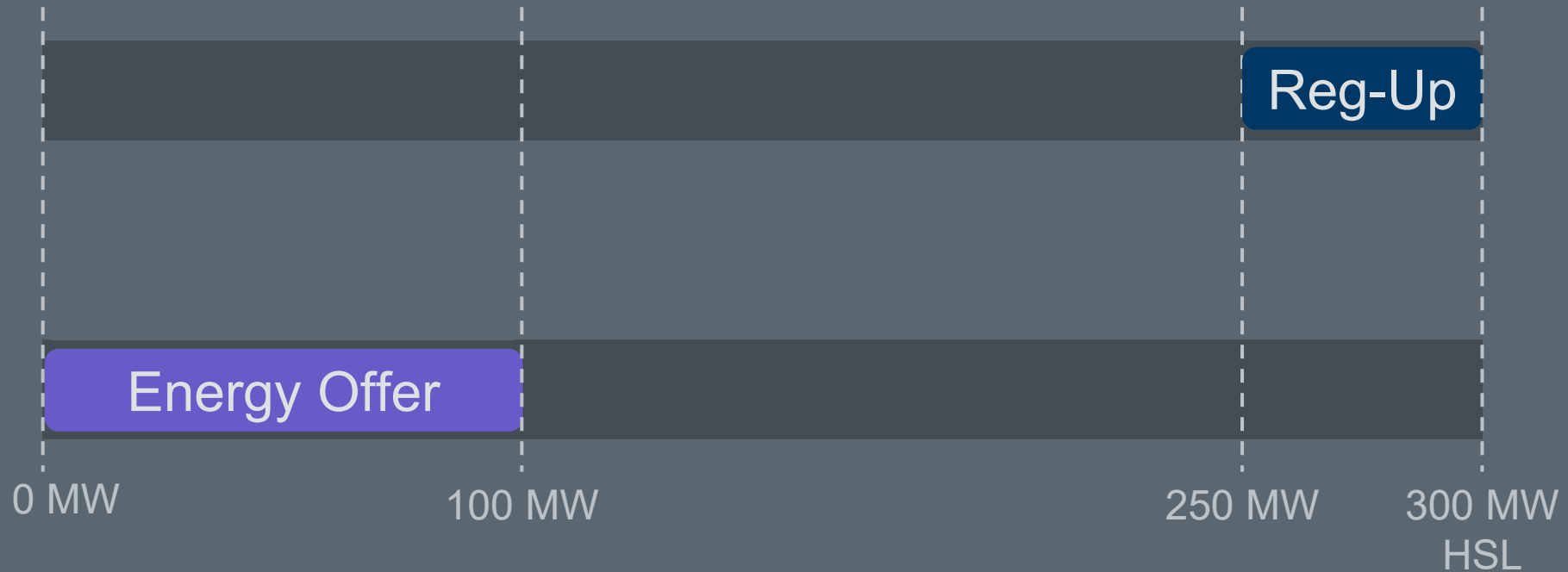


What DAM actually saw:



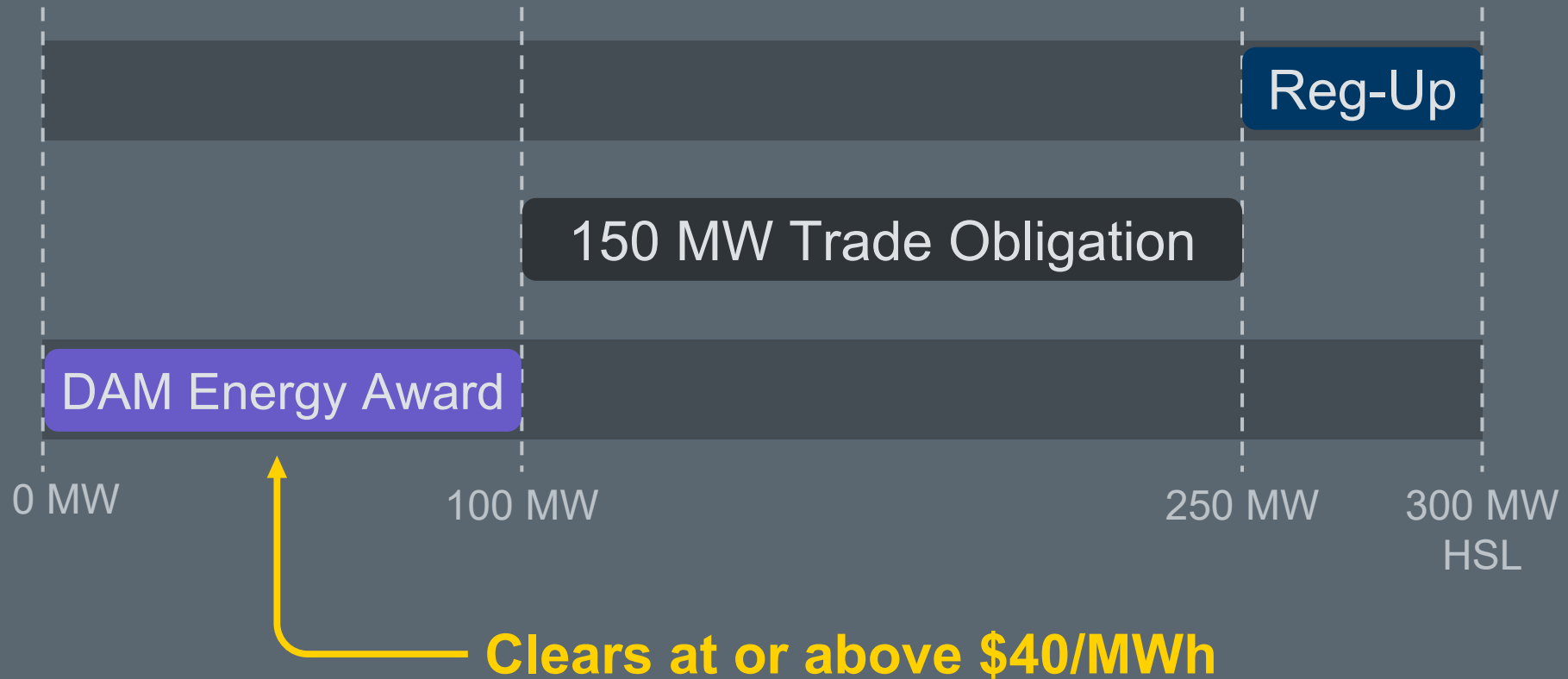


What DAM actually sees:



LSL constraint ignored

Possible outcome:



Topics in this module include:

1

Resource Offers in DAM

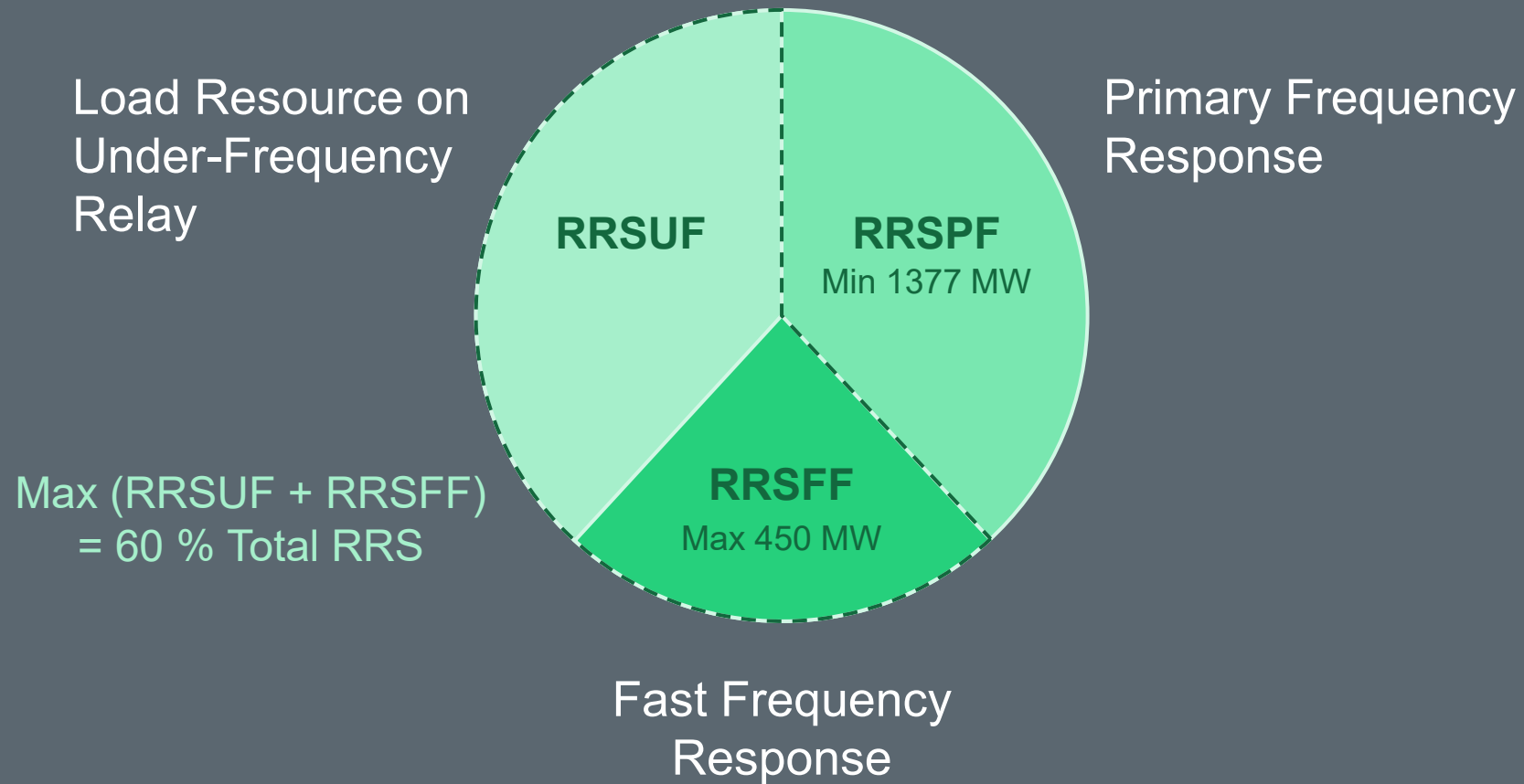
2

Resource Limits in DAM Clearing

3

Post DAM Activities

Responsive Reserve Service Subtypes



Communicates Resource Capabilities

Current Operating Plan															
Resource Name	Resource Status	Resource Limits				ESR SOC Limits			Ancillary Service Capabilities						
		HEL	HSL	LSL	LEL	Min	Max	Hour Beginning	Reg-Up	Reg-Dn	RRSPF	RRSFF	RRSUF	ECRS	NSRS
GEN1	ON	620	600	120	120	-	-	-	20	20	40	0	0	40	120
GEN2	OFF	100	90	25	20	-	-	-	0	0	0	0	0	0	90
LR1	ONL	30	30	0	0	-	-	-	0	0	0	0	30	0	0
ESR1	ON	40	40	-40	-40	0	40	40	40	0	0	40	0	40	10

Used to limit DAM awards

Limits enforced by Day-Ahead Market:

Generation Resources	Responsive Reserve (RRSPF subtype)	Award $\leq$ RRSPF% of HSL (20% or Proven)
	Responsive Reserve (RRSFF subtype)	Award $\leq$ 15-minute capacity (Proven)
	ERCOT Contingency Reserve Service (ECRS)	Award $\leq 10 * \text{Emergency Ramp Rate}$
	Energy and AS Capacity	Total Award $\leq$ HSL
Load Resources	Responsive Reserve	Award $\leq$ HSL - LSL

Topics in this module include:

1

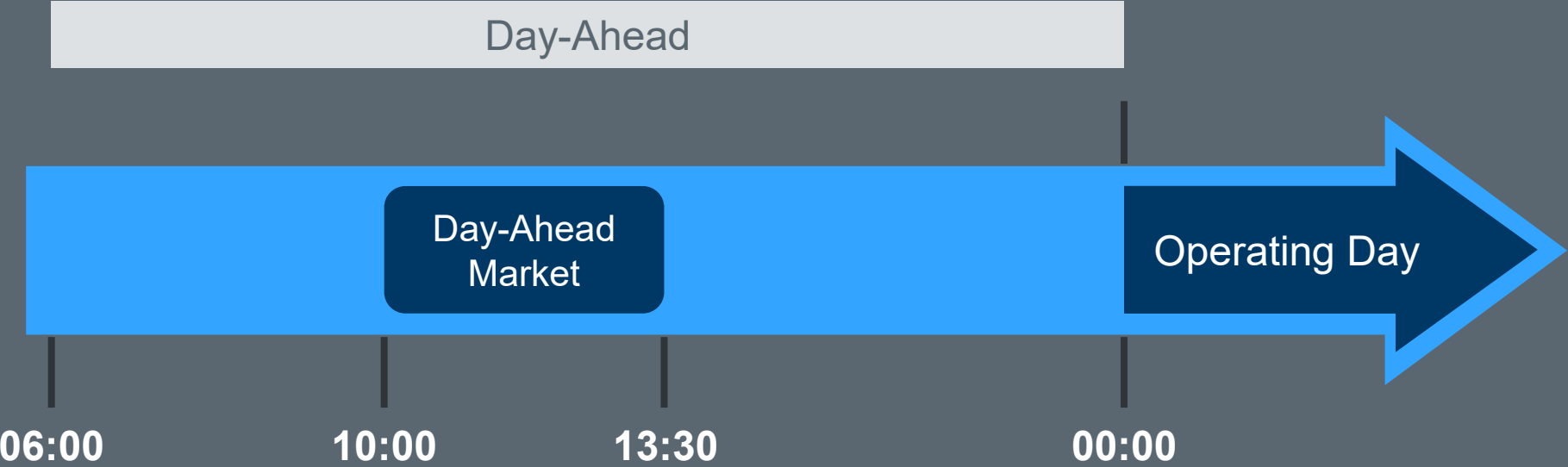
Resource Offers in DAM

2

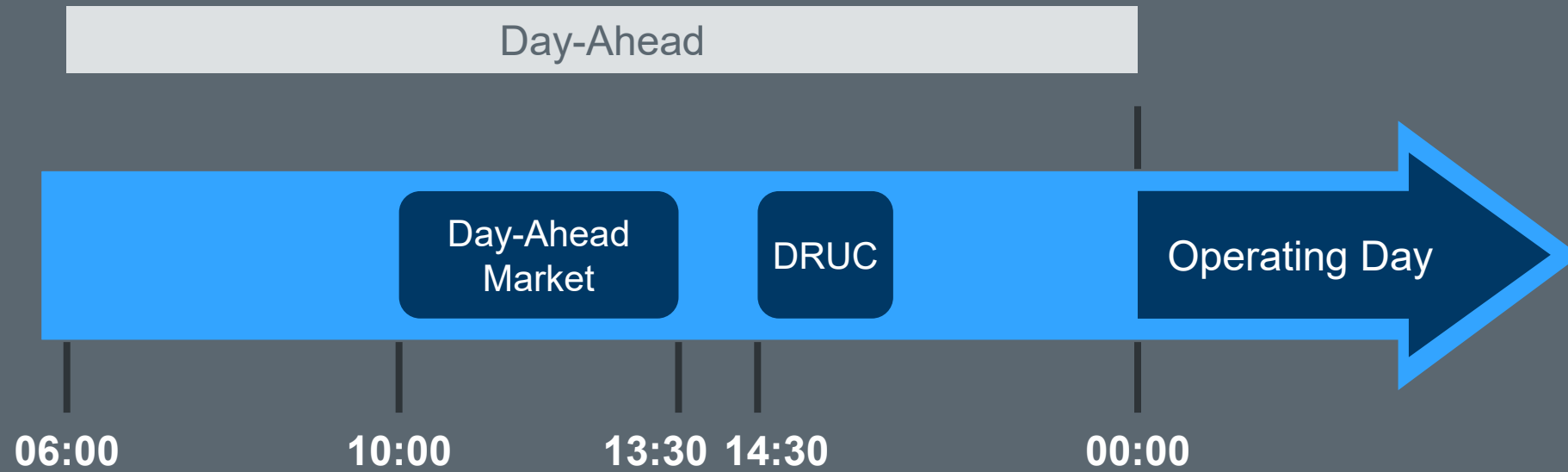
Resource Limits in DAM Clearing

3

Post DAM Activities



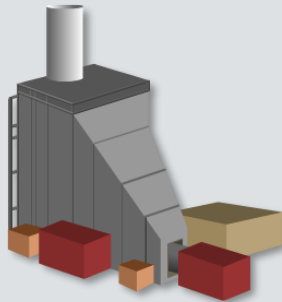
ERCOT Posts Results
by 13:30



 **QSE may need to
act on DAM Results**

Self-Arranged Ancillary Services

Self-Arranged AS Quantities

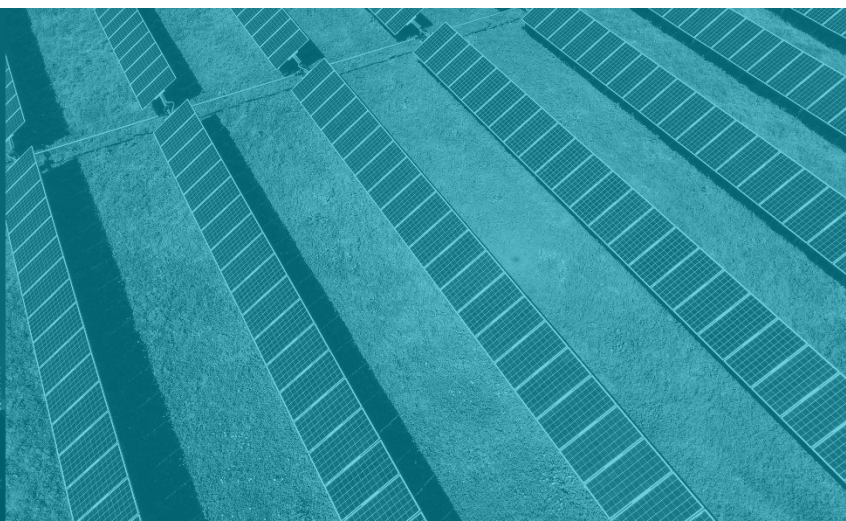


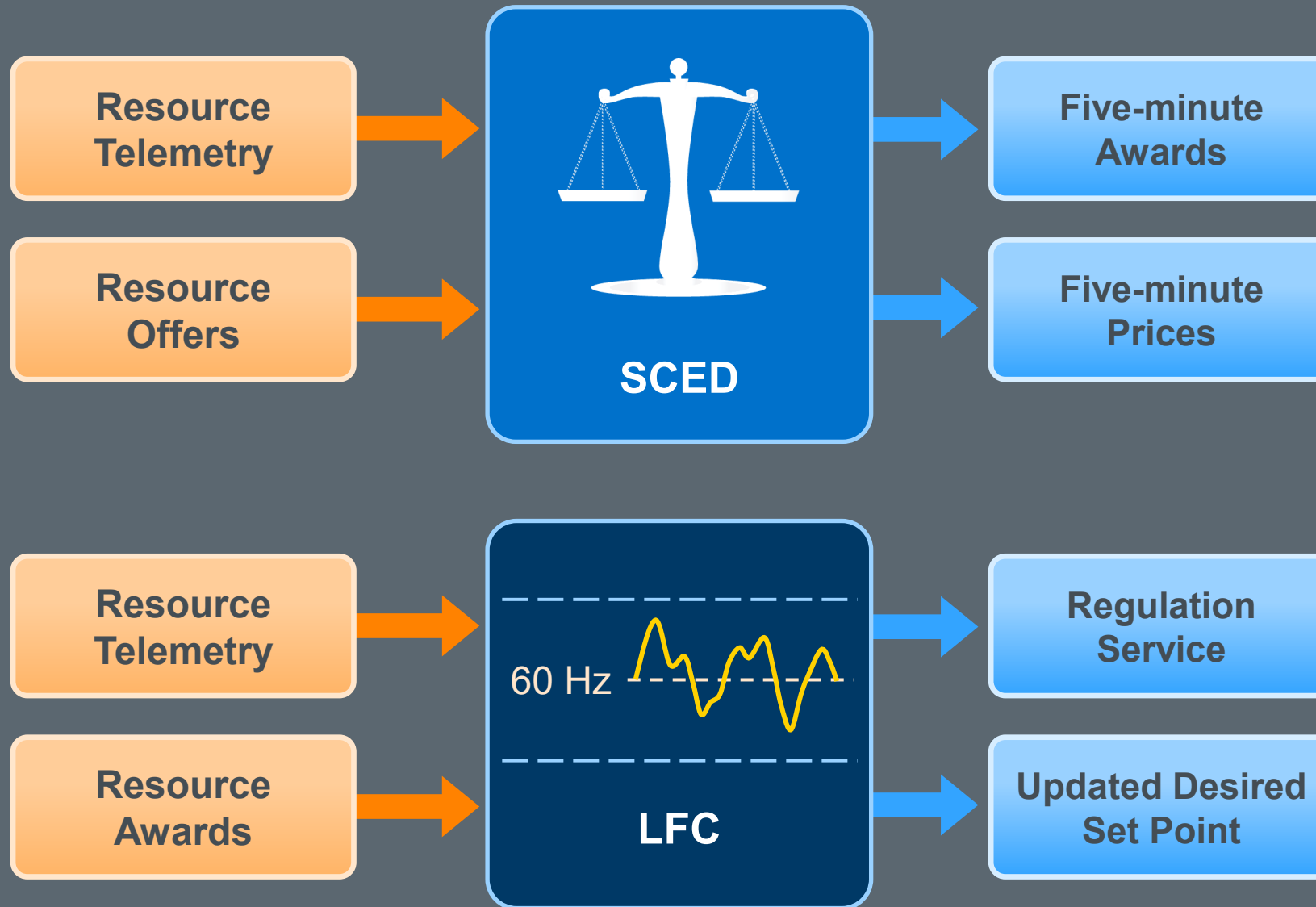
... must be arranged by 14:30

Current Operating Plan															
Resource Name	Resource Status	Resource Limits				ESR SOC Limits			Ancillary Service Capabilities						
		HEL	HSL	LSL	LEL	Min	Max	Hour Beginning	Reg-Up	Reg-Dn	RRSPF	RRSFF	RRSUF	ECRS	NSRS
GEN1	ON	620	600	120	120	-	-	-	20	20	40	0	0	40	120
GEN2	OFF	100	90	25	20	-	-	-	0	0	0	0	0	0	90
LR1	ONL	30	30	0	0	-	-	-	0	0	0	0	30	0	0
ESR1	ON	40	40	-40	-40	0	40	40	40	0	0	40	0	40	10



Resources in the Real-Time Market





Topics in this module include:

1

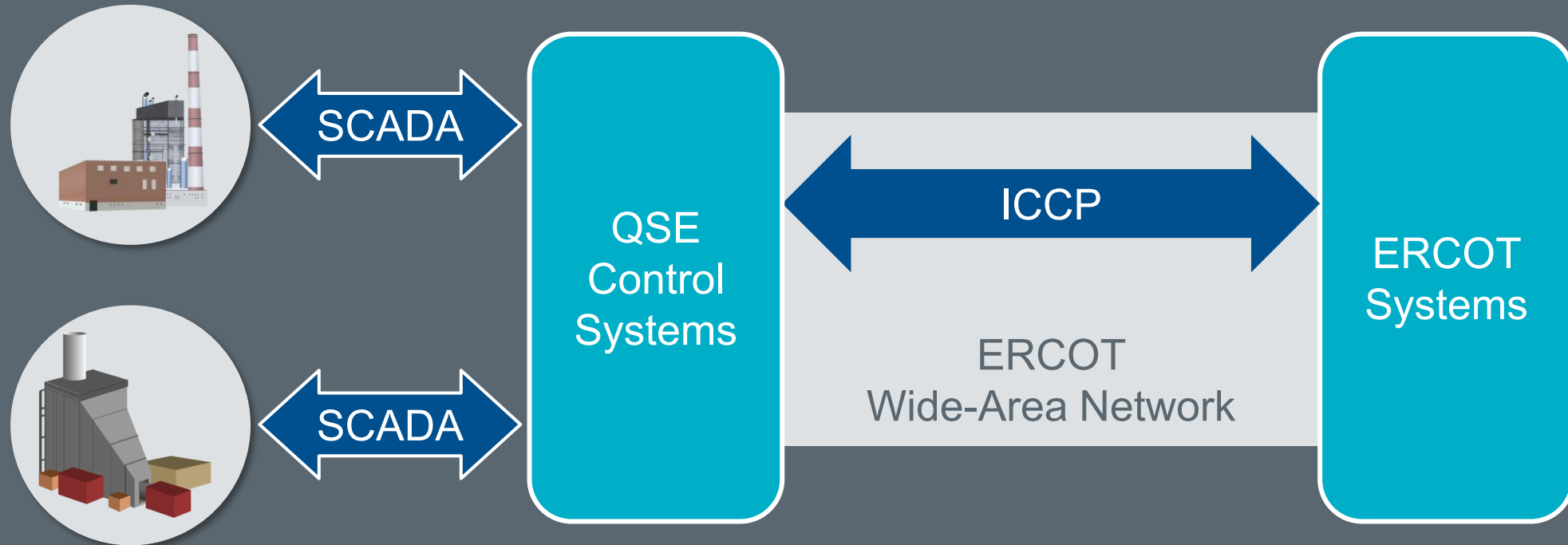
Resource Telemetry

2

Resource Offers in SCED

3

Load Frequency Control and Primary Frequency Response



Communicates Real-Time Resource Capabilities:

- Operational Status and Limits
- Ramp Rates
- AS Capabilities
- Self-Provided Ancillary Services
- SOC data for ESRs (more in ESR class)



ICCP Resource Telemetry													
Name	Operational Status and Limits						Ancillary Service Capabilities						
	Status (Code)	Power (MW)	HSL (MW)	LSL (MW)	Up Ramp (MW/Min)	Dn Ramp (MW/min)	Reg-Up (MW/min)	Reg-Dn (MW/min)	RRSPF (MW)	RRSFF (MW)	RRSUF (MW)	ECRS (MW/min)	NSRS (MW/min)
GEN1	ON	455	600	120	4	4	4	4	40	0	0	4	4
GEN2	OFF	0	90	25	-	-	0	0	0	0	0	0	3
LR1	ONL	30	30	0	-	-	0	0	0	0	30	0	0
ESR1	ON	0	40	-40	8	4	8	0	0	40	0	4	.33



Multiple
Ramp Rates?



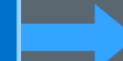
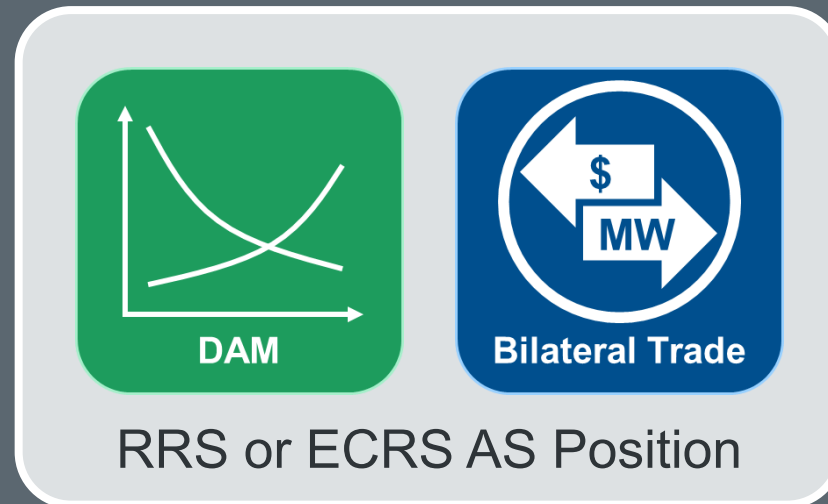
Multiple
Ramp Rates?

Must be updated every 2 seconds

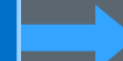


Load Resources on
Under-Frequency
Relays (UFR)

QSE may
Self-Provide



SCED must
Award



Five-minute
Prices



ICCP

*What are
the Benefits?*

Topics in this module include:

1

Resource Telemetry

2

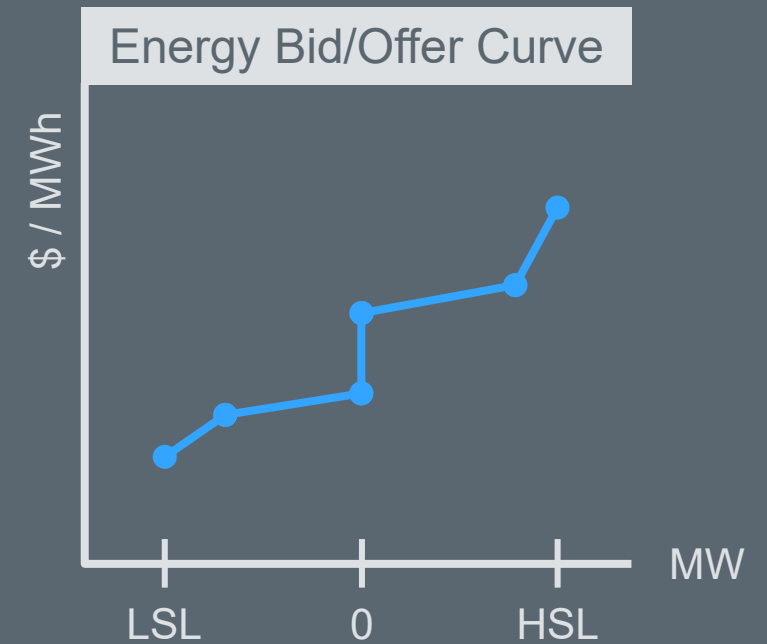
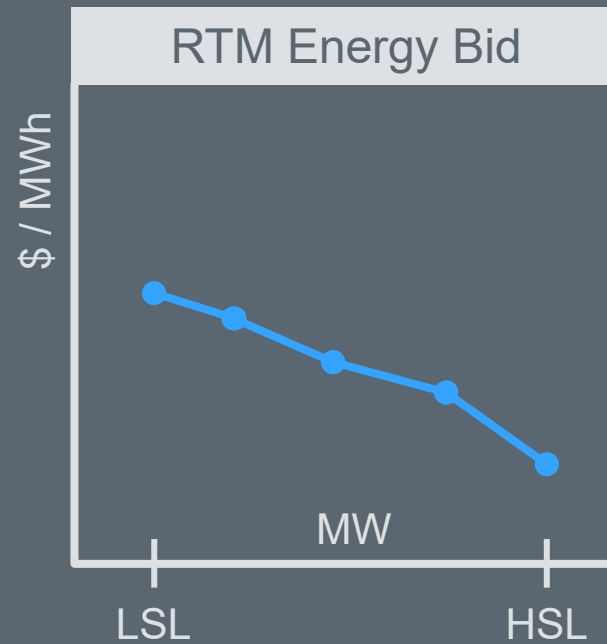
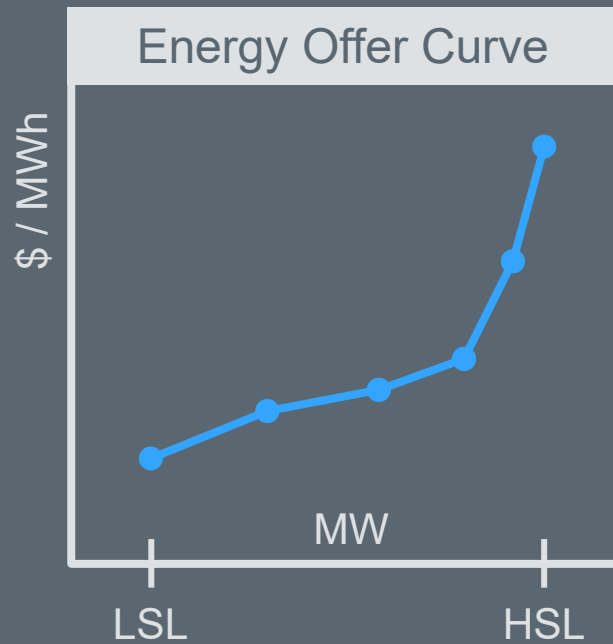
Resource Offers in SCED

3

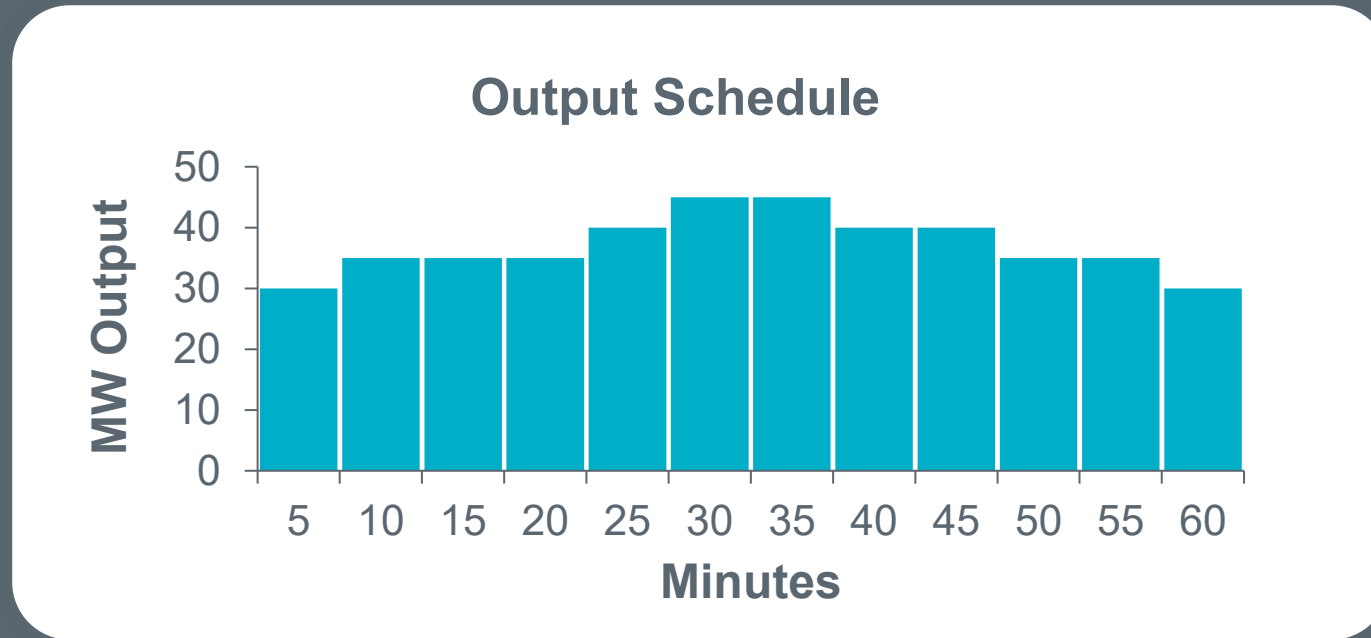
Load Frequency Control and Primary Frequency Response

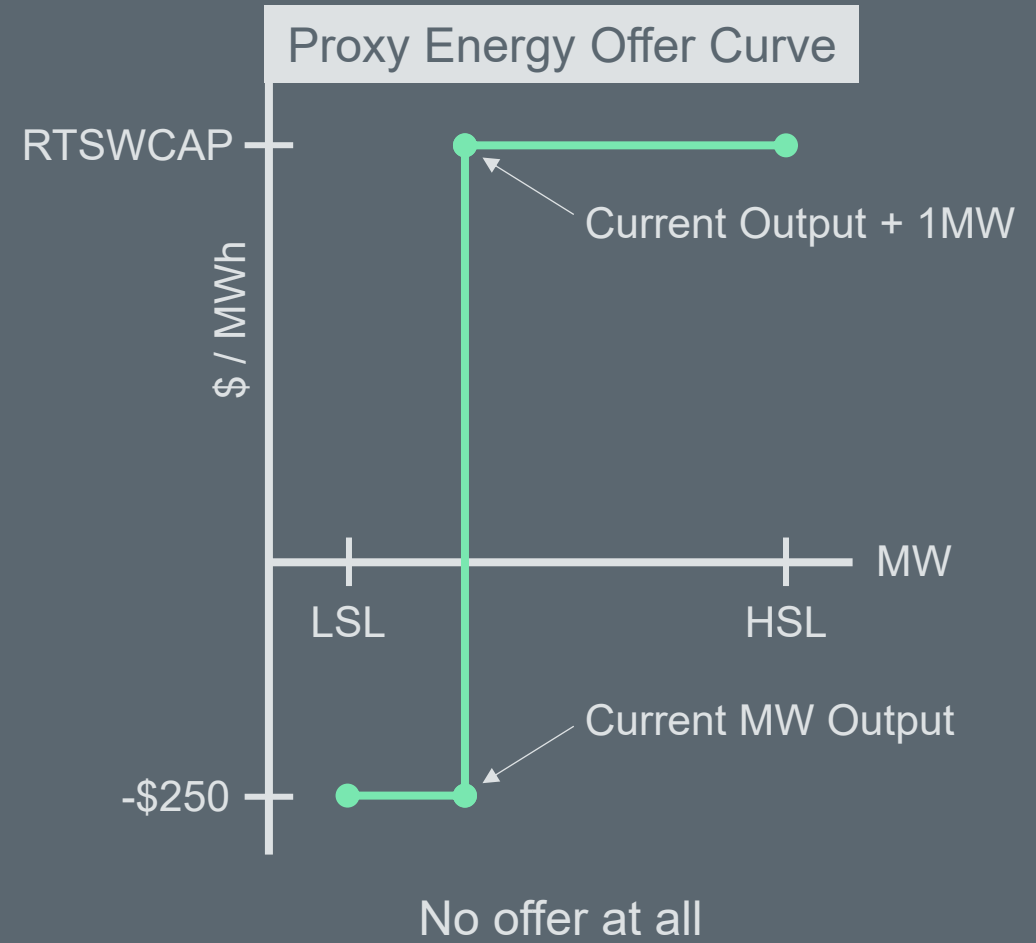
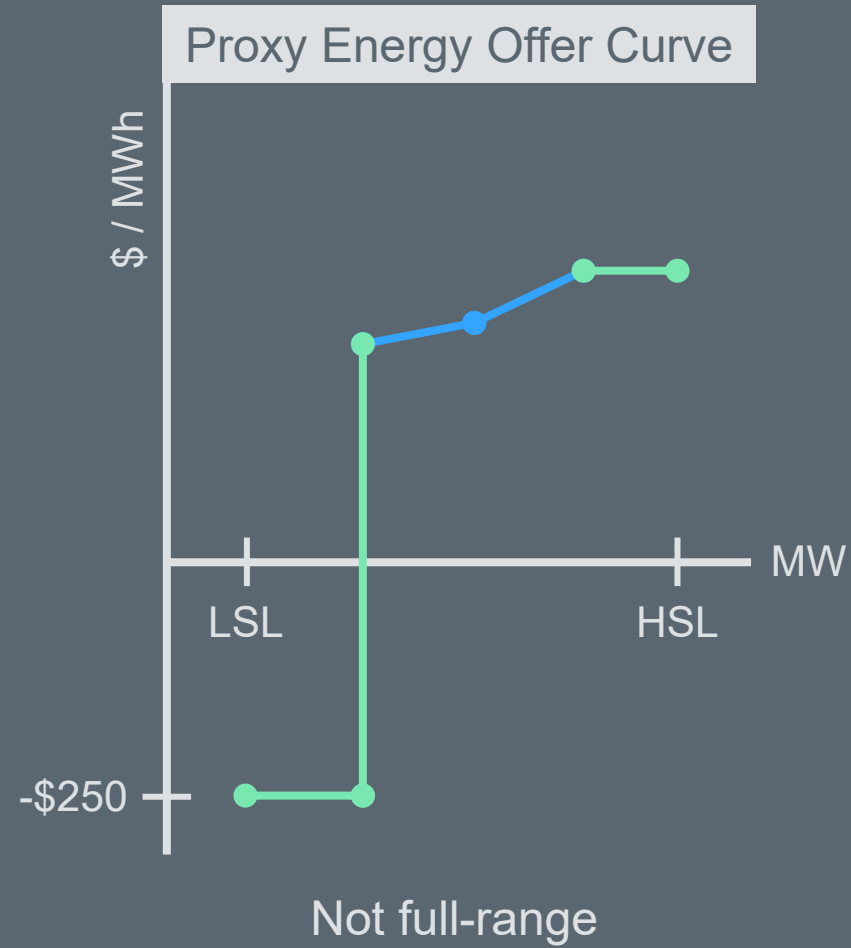


Name that Resource!



“Offer” to be a Price Taker





Resource-Specific Offers for Each Qualified Service

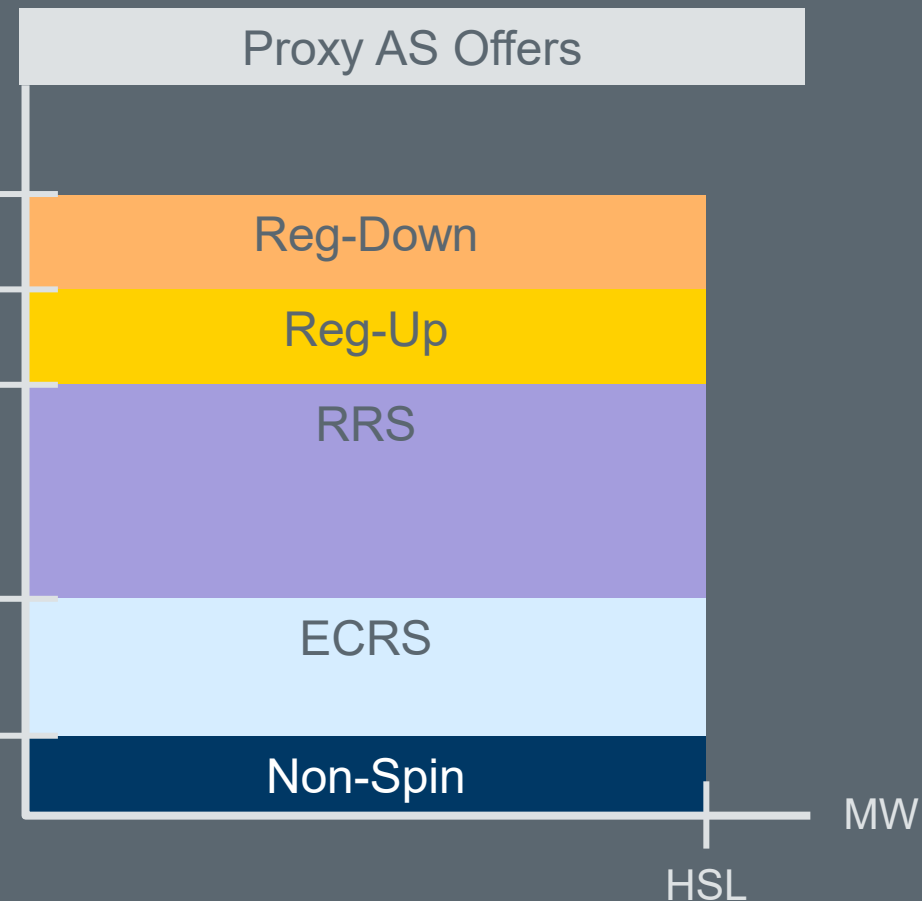
Type of Service	Offer	
Regulation Up	MW	\$ / MW
Regulation Down	MW	\$ / MW
Responsive Reserve	MW	\$ / MW
ERCOT Contingency Reserve	MW	\$ / MW
Non-Spinning Reserve	MW	\$ / MW

- Up to 5 Offers per service per Resource
- Subject to \$0 floor price

Applies to all AS Qualified Resources

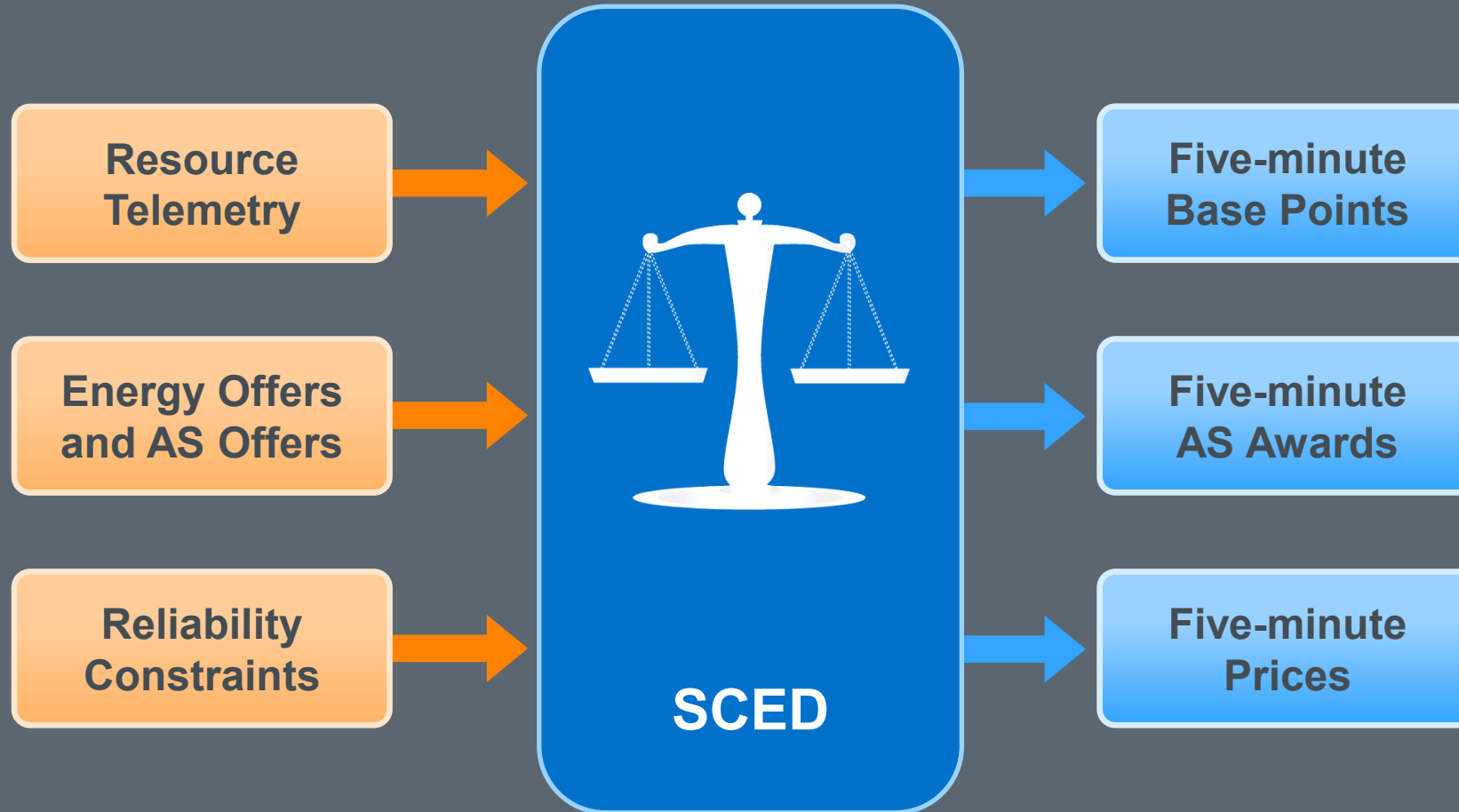
Priced from each
Ancillary Service Demand Curve
at 95% of AS Plan MW
(up to \$2000)

\$ / MWh



Award still constrained by Resource Capabilities

Manages Reliability at Least Cost



Topics in this module include:

1

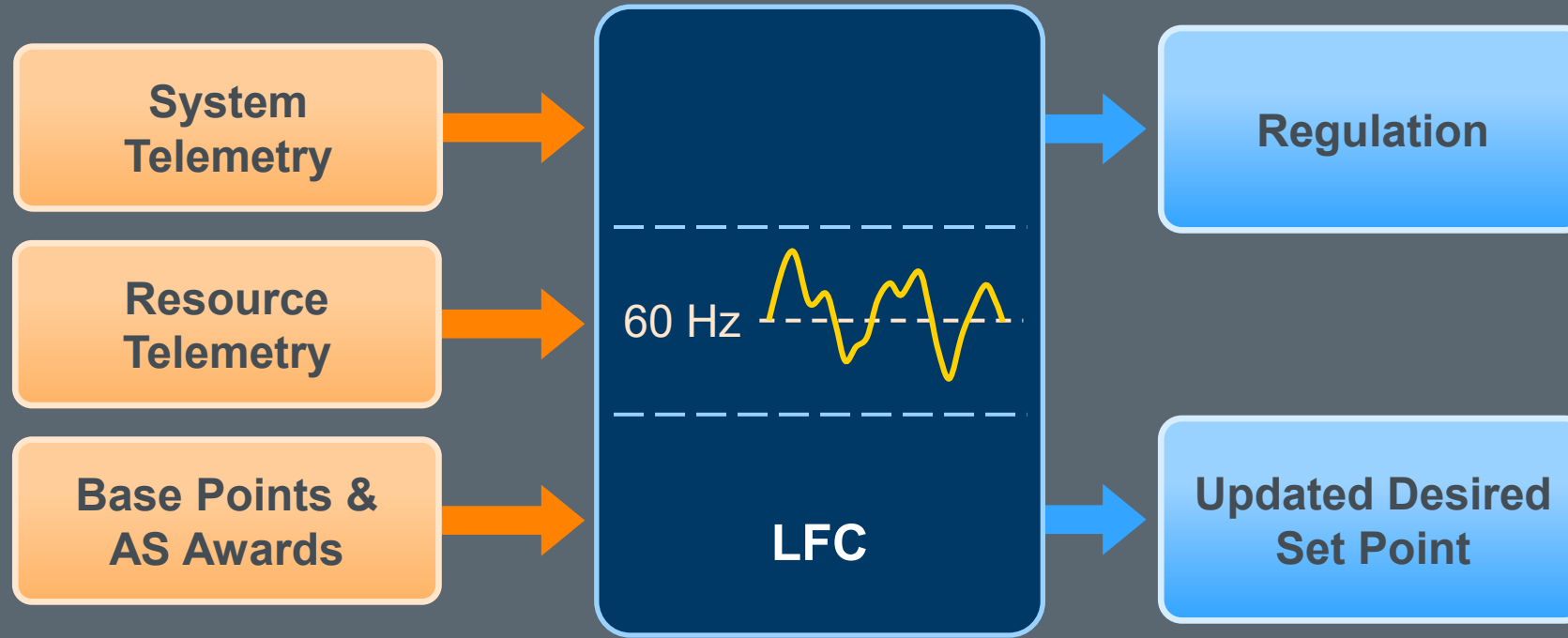
Resource Telemetry

2

Resource Offers in SCED

3

Load Frequency Control and Primary Frequency Response



Runs every 4 seconds!

**Generation
Resources**



**Energy Storage
Resources**



**Controllable
Load
Resources**



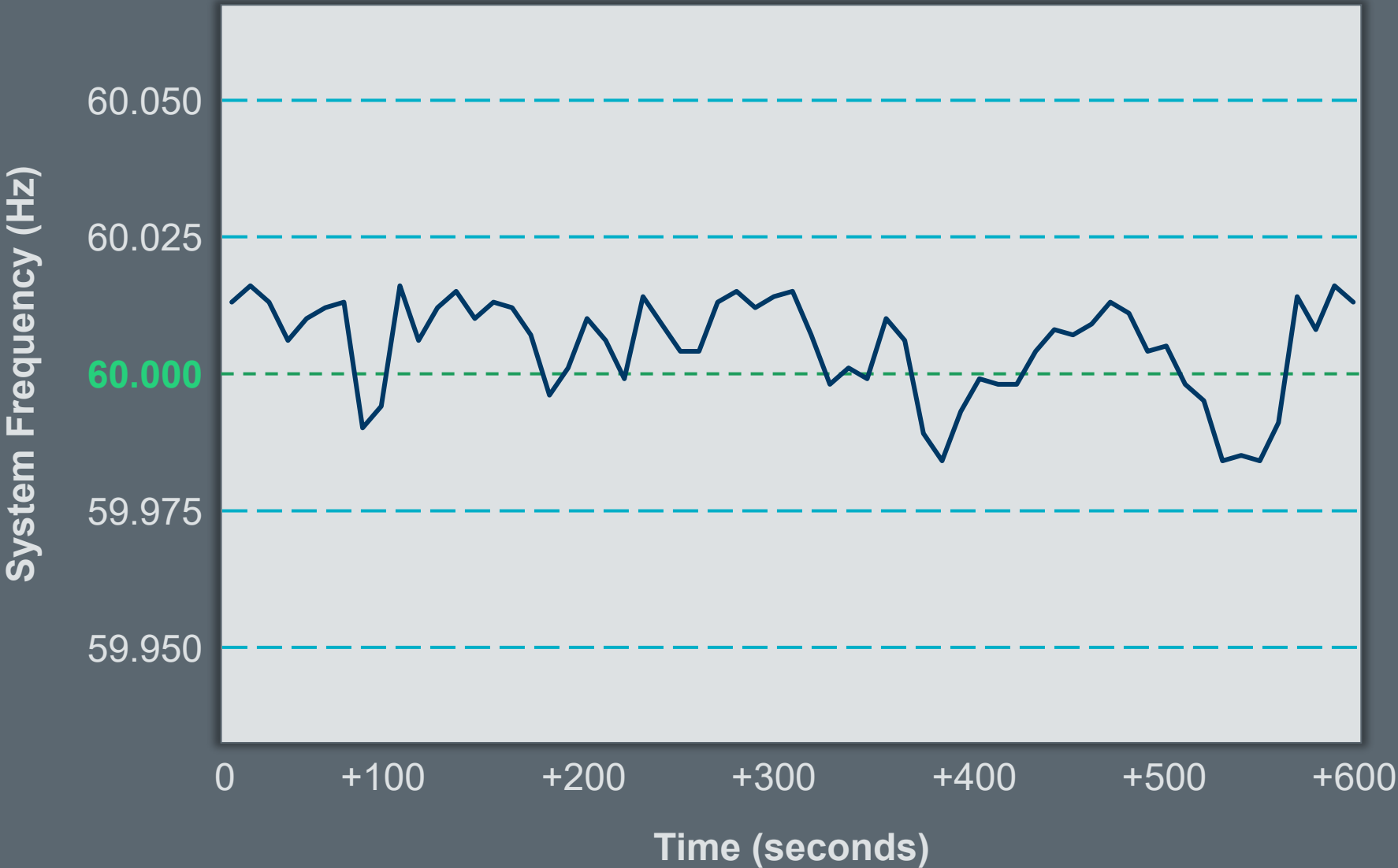
**Settlement Only
Generators**

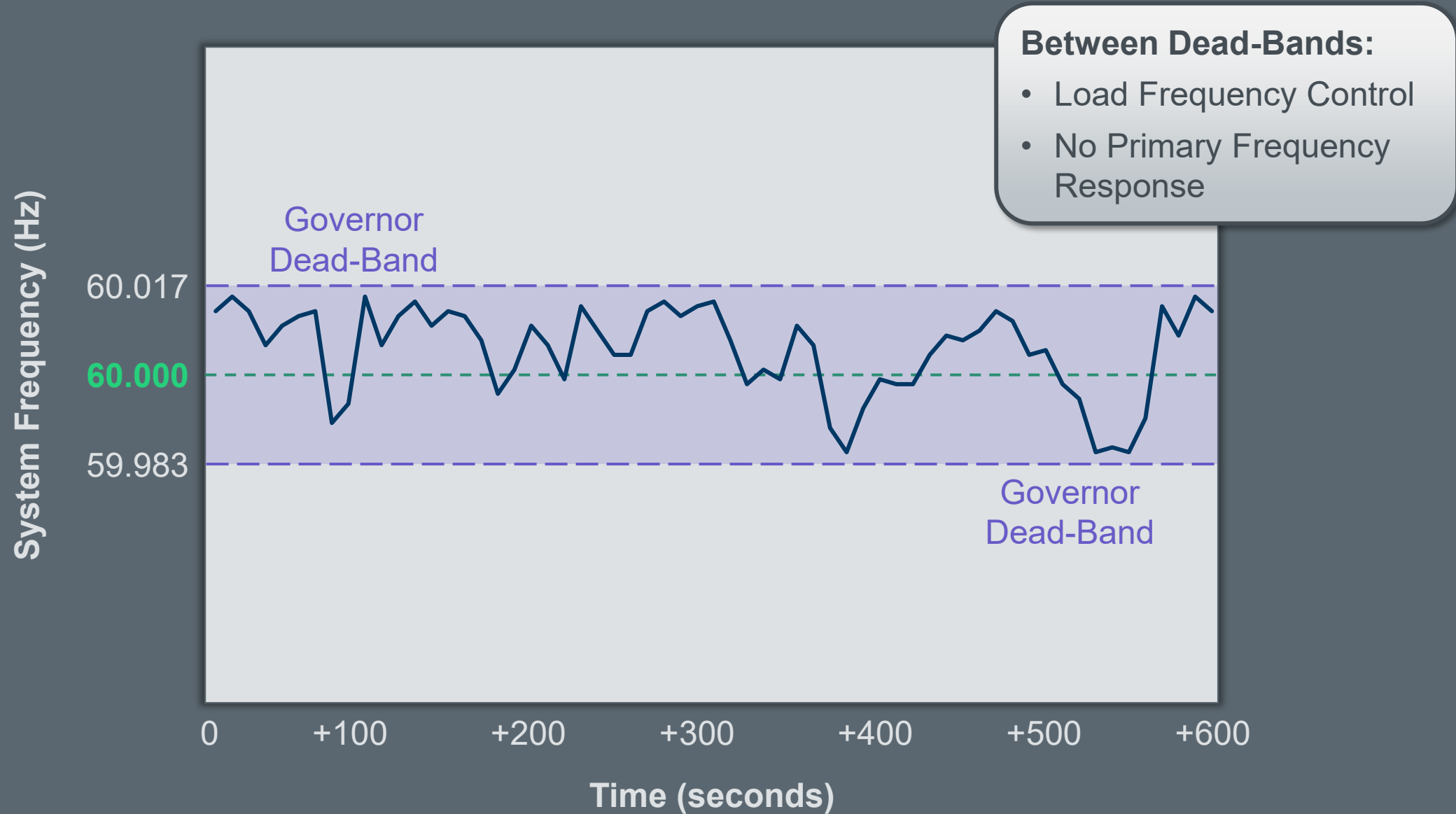


Governors must respond to changes in system frequency

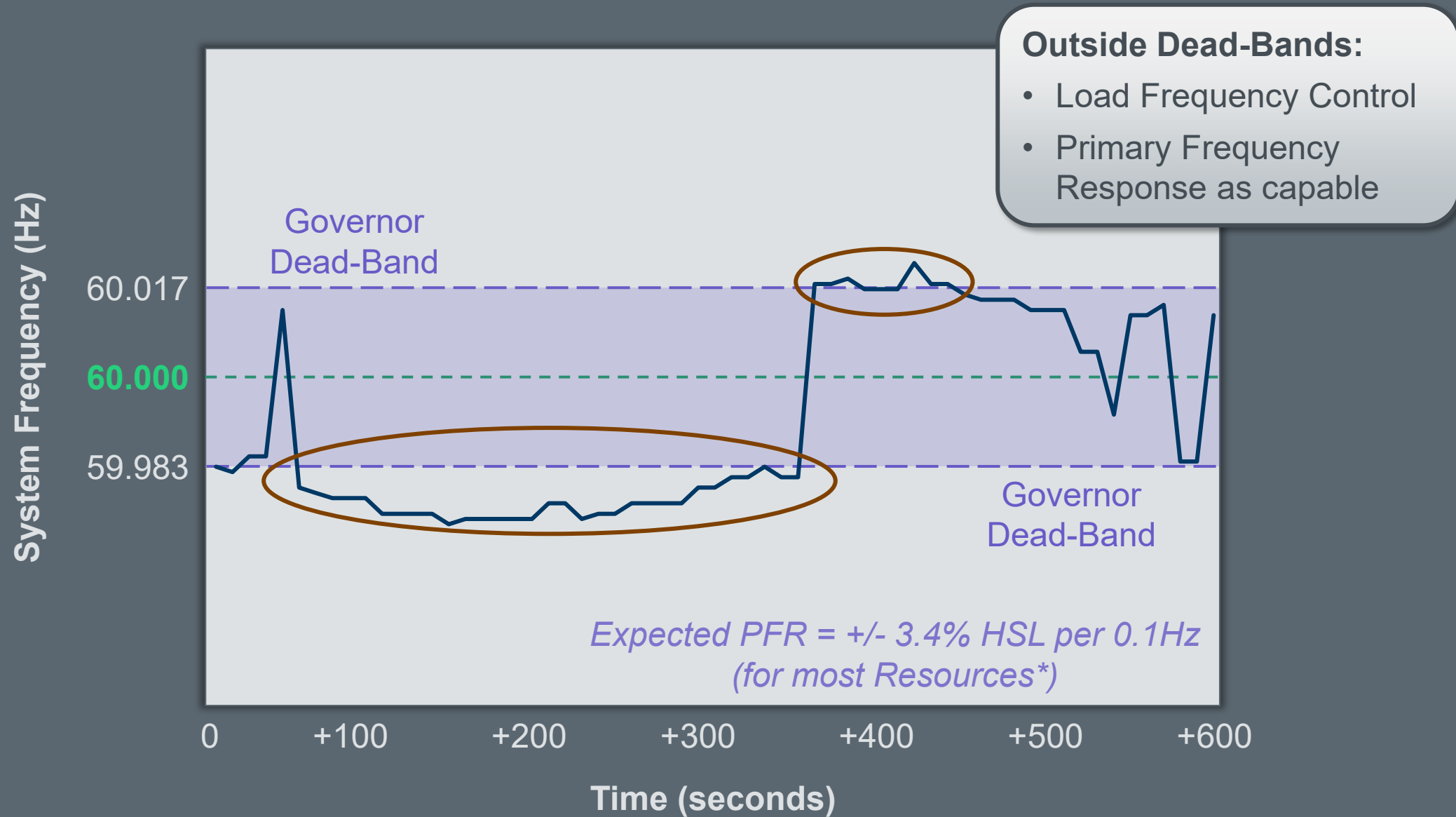
... after a point







* See Nodal Operating Guide
Sections 2 and 8 for more details



* See Nodal Operating Guide
Sections 2 and 8 for more details

System response depends on Frequency Deviation



Proportion of HSL



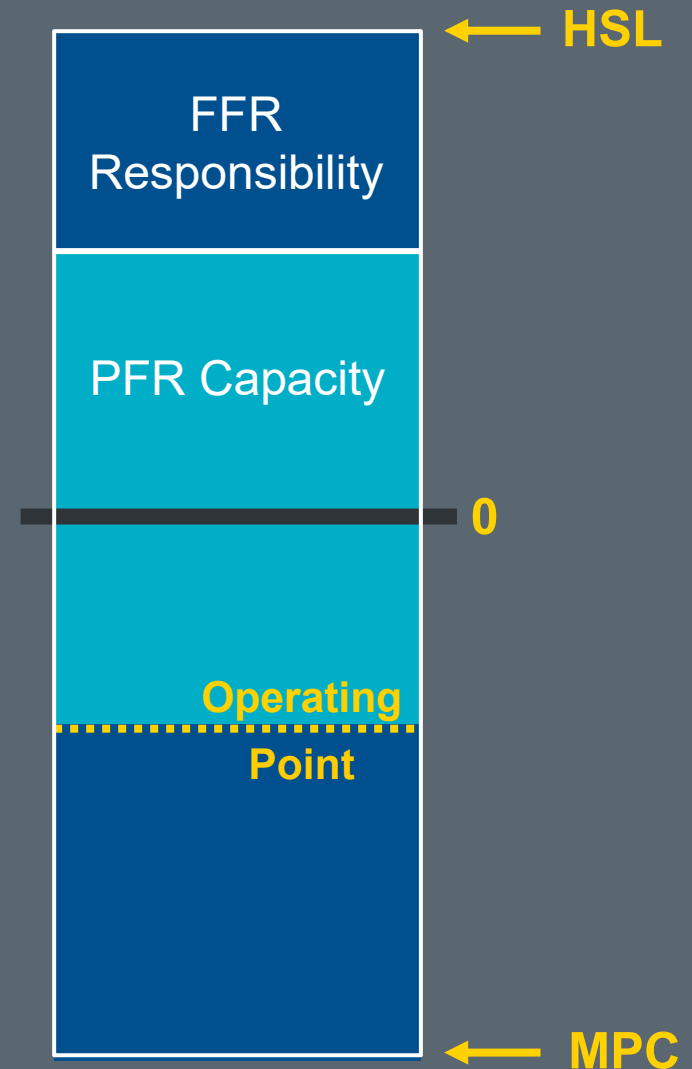
Proportion of Primary
Frequency Responsive Capacity



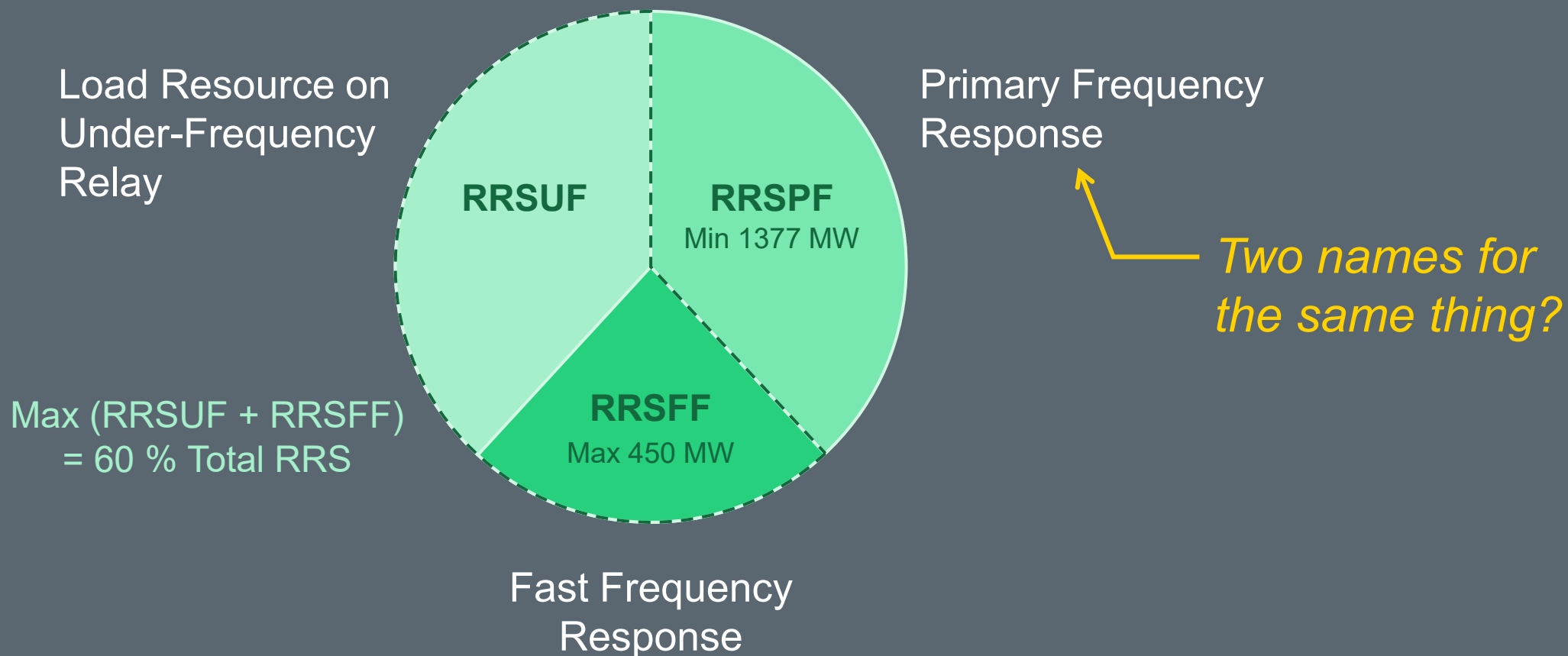
Low Frequency?

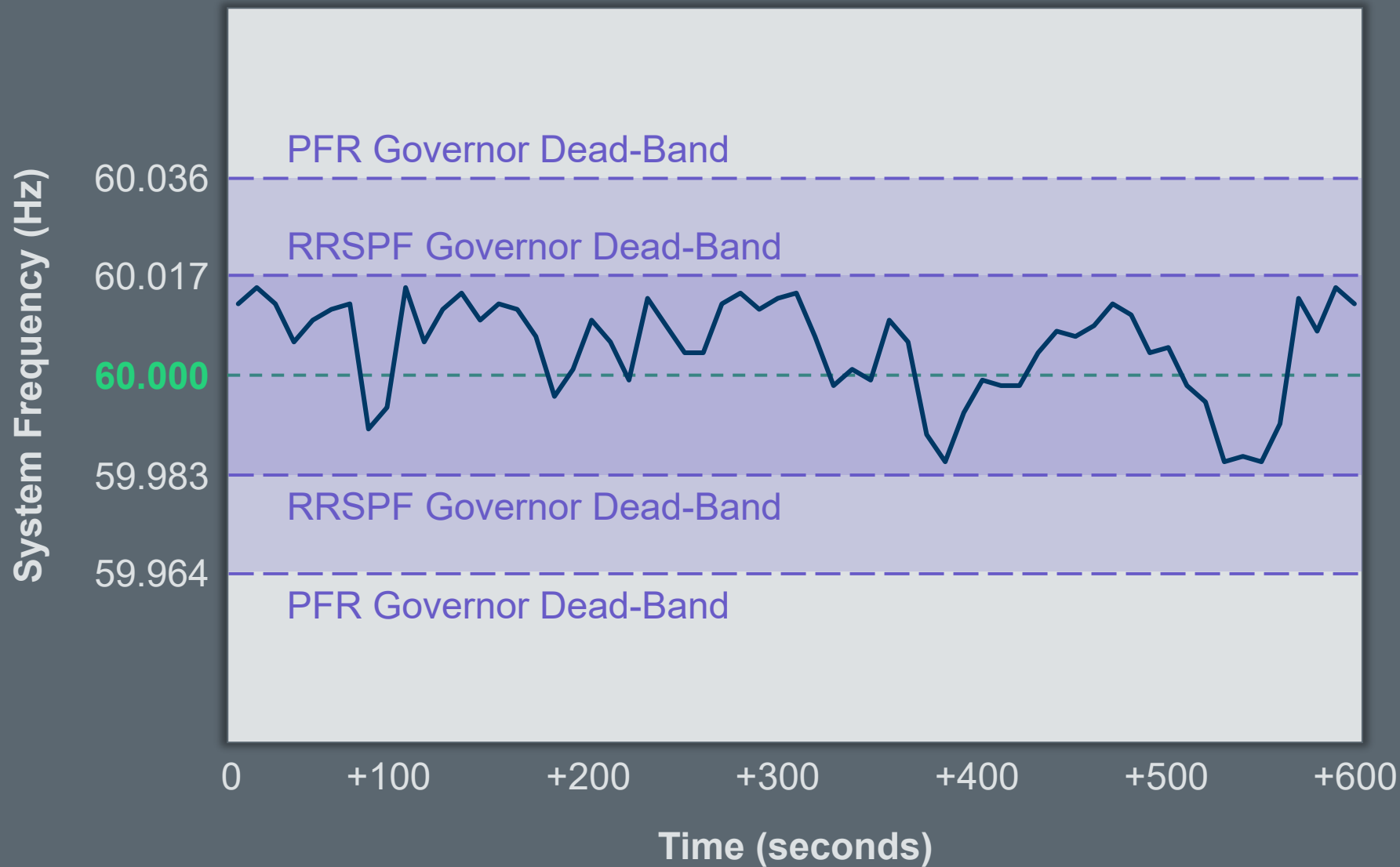


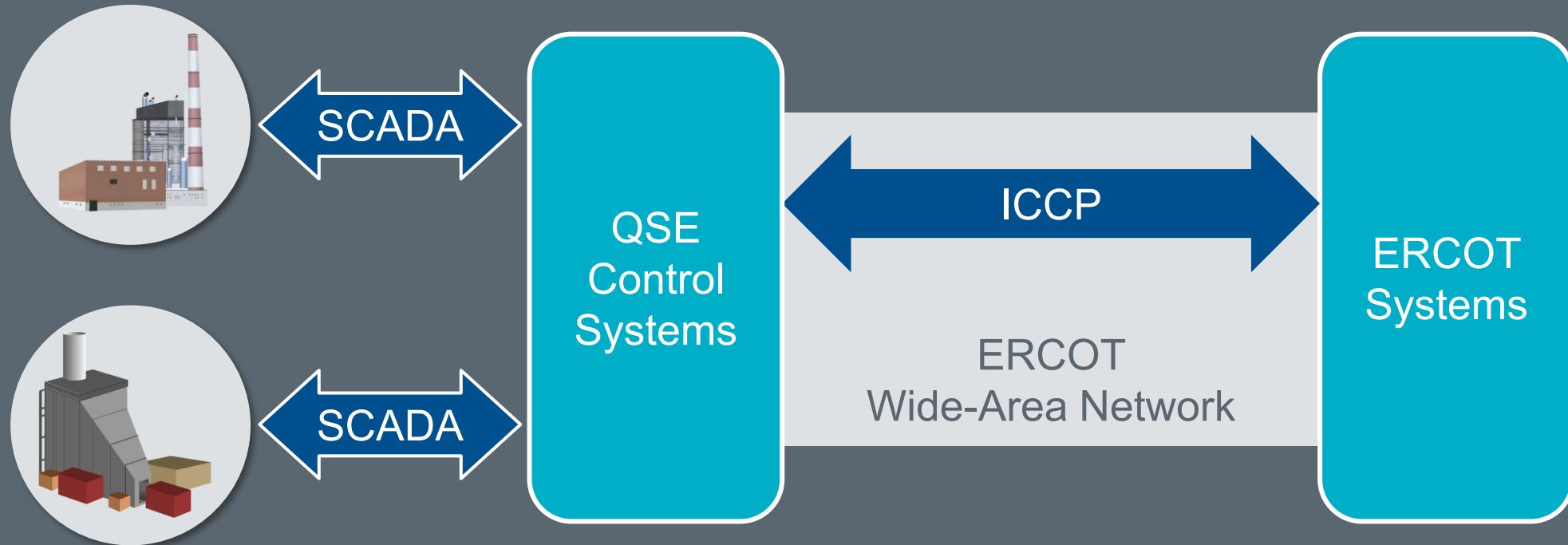
HSL = High Sustained Limit
MPC = Max Power Consumption



Responsive Reserve Service Subtypes







Communicates Real-Time Resource instructions:

- Five-minute Base Points
- Five-minute AS Awards
- Five-minute Prices
- Regulation Deployments
- Updated Desired Set Point

See ICCP Handbook for complete list

Purpose	Format	Title
Pre-requisite	WBT	✓ Resources in ERCOT
		✓ Resource Responsibilities in ERCOT
Core Courses	ILT	^ Resources in ERCOT Market Operations
		ERCOT Market Operations >
		Resources in the Day-Ahead Market >
		Resources in the Real-Time Market >
		✓ Energy Storage Resources
		✓ Intermittent Renewable Resources
		✓ Combined Cycle Generation Resources
Post-requisite	WBT	✓ IRR Forecasting
		✓ Quick Start Generation Resources

ERCOT Training Information

<http://www.ercot.com/services/training/>

Course Recommendations

<https://www.ercot.com/services/training/recommendations>

Market Education Contact

Training@ercot.com

ERCOT Client Services Contact

Clientservices@ercot.com

ERCOT Mailing Lists

<http://lists.ercot.com/>

Scan this QR code to take the course survey!

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

