

Locational Based Marginal Pricing

Mathangi Srinivasan Kumar

Program Lead, Market Training, NYISO

New York Market Orientation Course (NYMOC) Webinar

December 3-6, 2024

Rensselaer, NY

Benefits to Understanding

- **Locational Based Marginal Pricing**
 - **Your Business Decisions**
 - **Be better informed for your bidding, forecasting, and investing decisions through understanding the price signals being sent**
 - **Your Financial Results**
 - **Understanding payments and charges on your invoice**

Locational Based Marginal Pricing

■ SESSION OBJECTIVES:

- Understand the Basics Behind LBMP
 - Definition
 - Show how LBMPs are Established
 - Name the Three Components of LBMP
- Complete Examples that Demonstrate LBMP Concepts
- Learn about the process of Price Validation

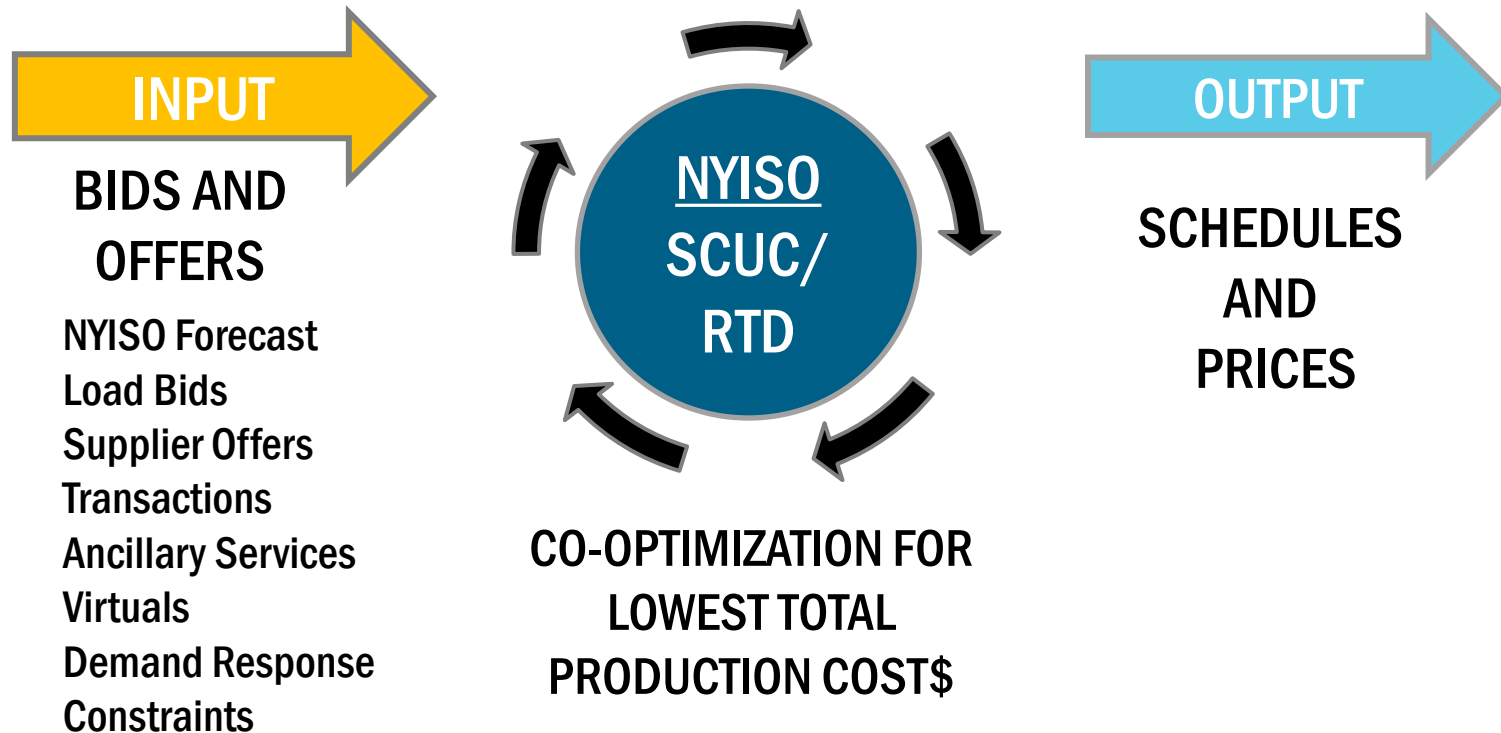
LBMP - Defined

- A methodology where the price of Energy at each location in the NYS Transmission System/NYCA is equivalent to the cost to supply the next increment of Load at that location.
- The cost to provide the next MW of Load at a specific location in the grid is the Marginal Price (LBMP)

LBMP – The Basics

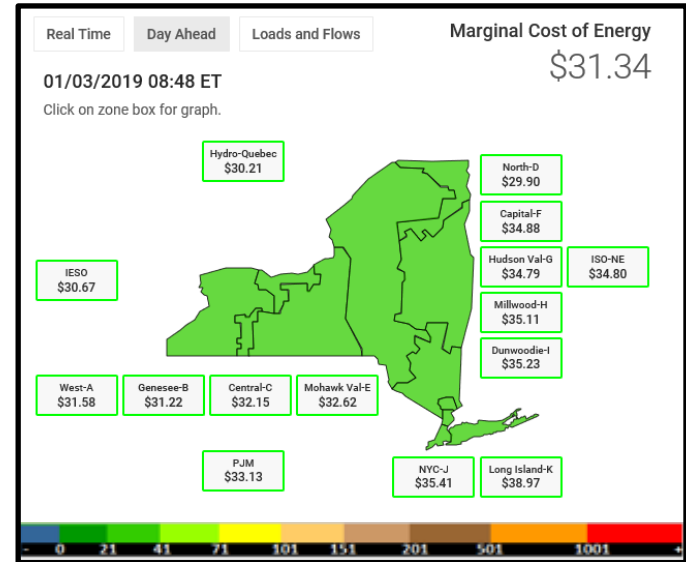
- **LBMP is established for the Day Ahead and the Real Time Markets**
 - **Day Ahead Market**
 - **Security Constrained Unit Commitment (SCUC)**
 - **Hourly Prices**
 - **Real Time Market**
 - **Real Time Dispatch (RTD)**
 - **5 Minute Interval Prices**

LBMP: Co-Optimized Based on Bids and Offers



LBMP - Established

- System is bid-based
 - Offers/Bids are Confidential
 - LBMPs are published, keeping market visible



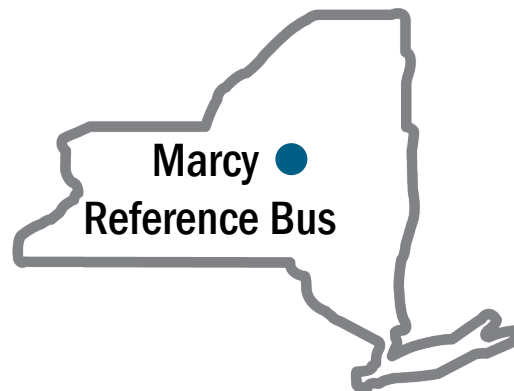
LBMP Components

- Three Components Comprise the LBMP
 - Marginal Energy Price Component
 - Marginal Loss Price Component
 - Marginal Congestion Price Component

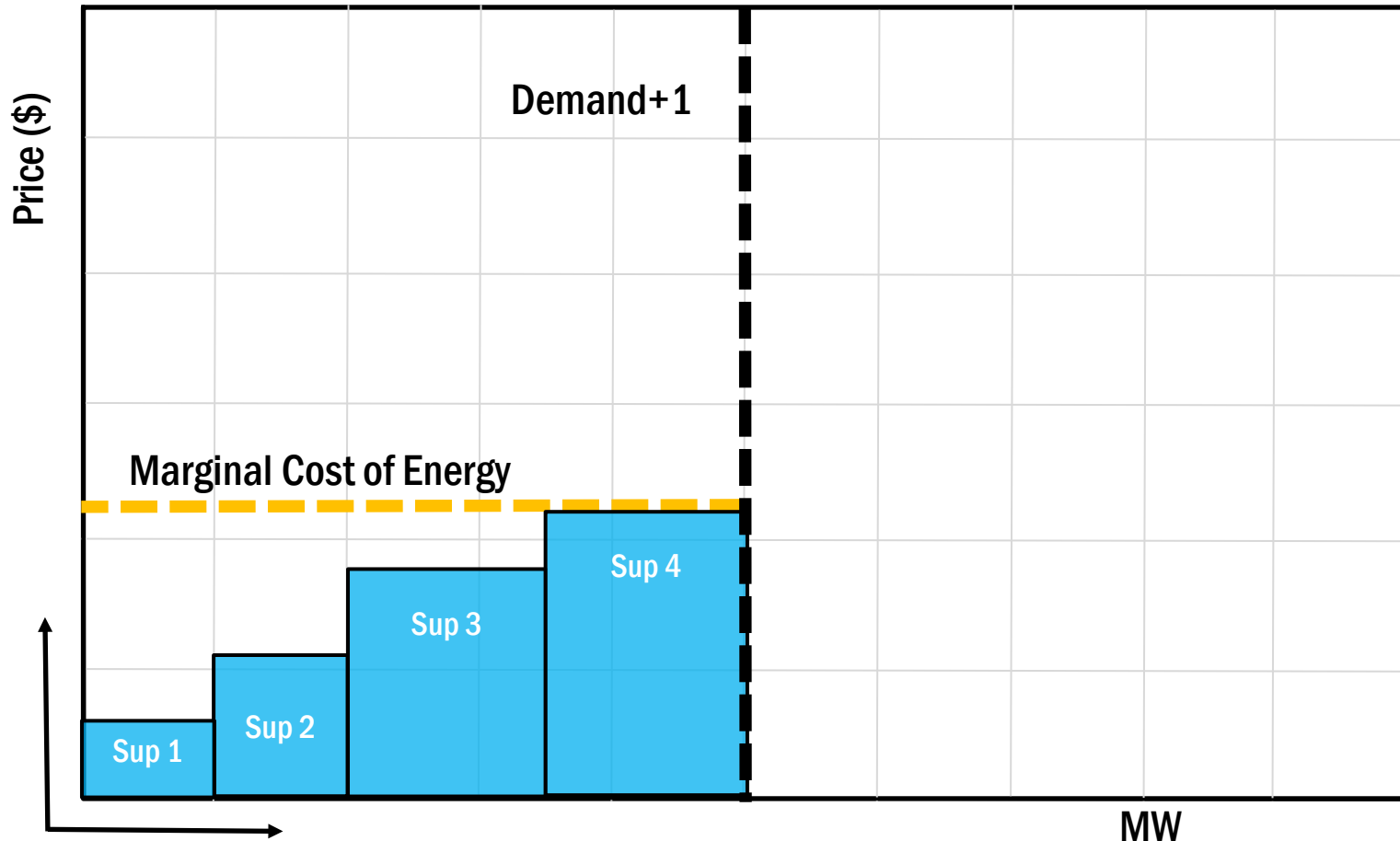
$$\text{LBMP} = \text{Energy} + \text{Loss} - \text{Congestion}$$

LBMP Components - Energy

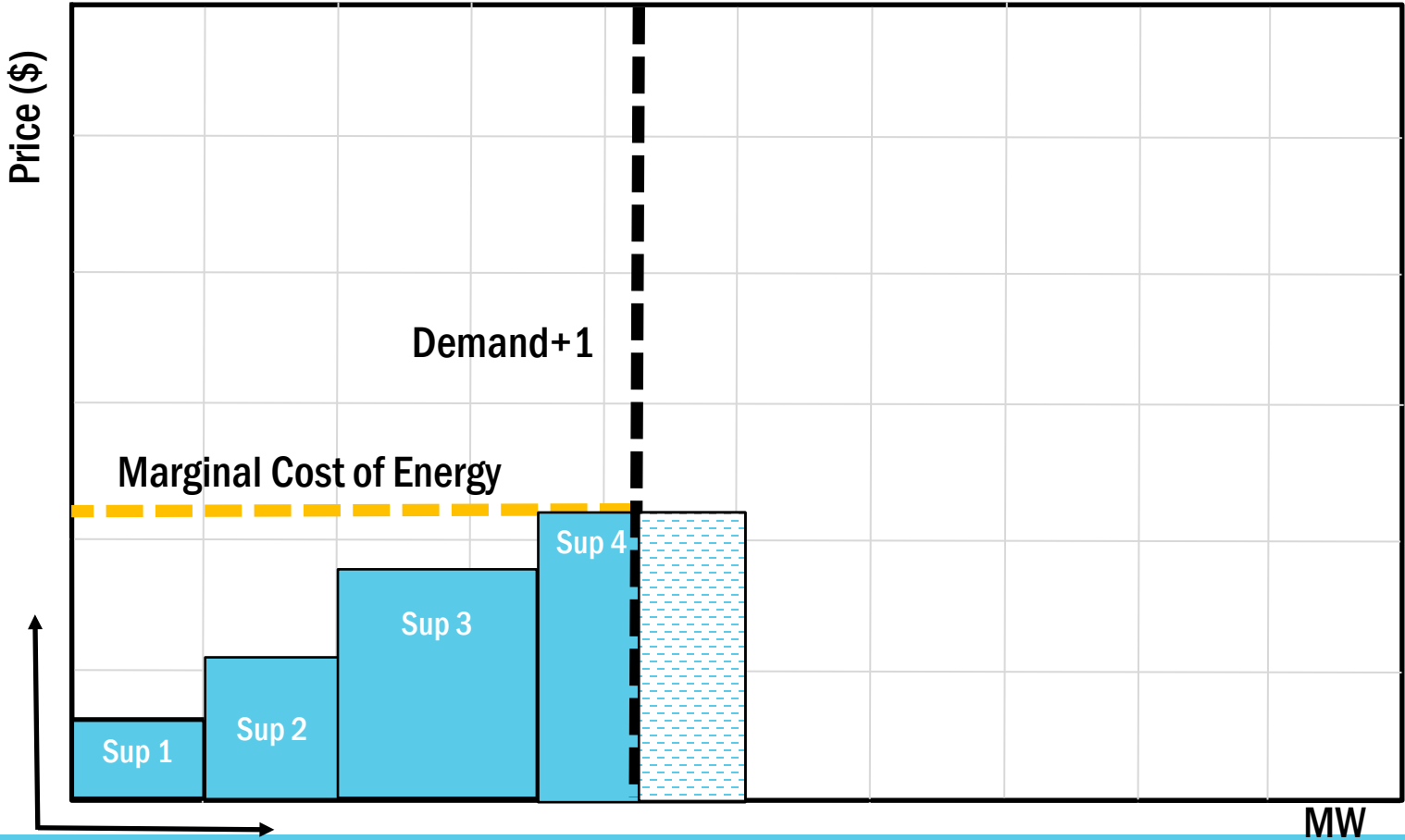
- **Marginal Energy Price Component**
 - Basic component of the LBMP at all buses in system – NYISO Reference Bus (Marcy), posted on NYISO site as: “NYISO_LBMP_Reference”



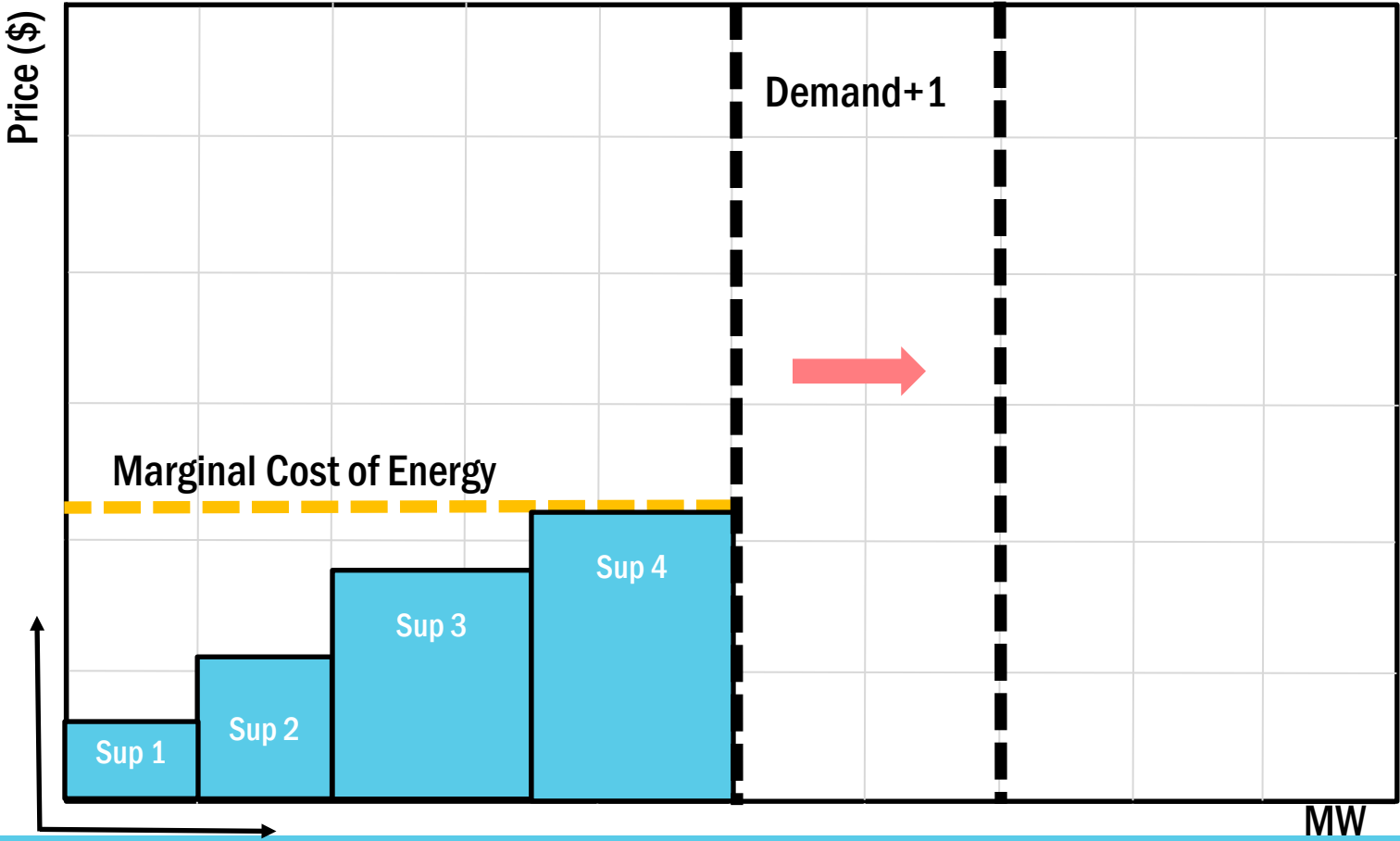
Determining the Marginal Energy Price



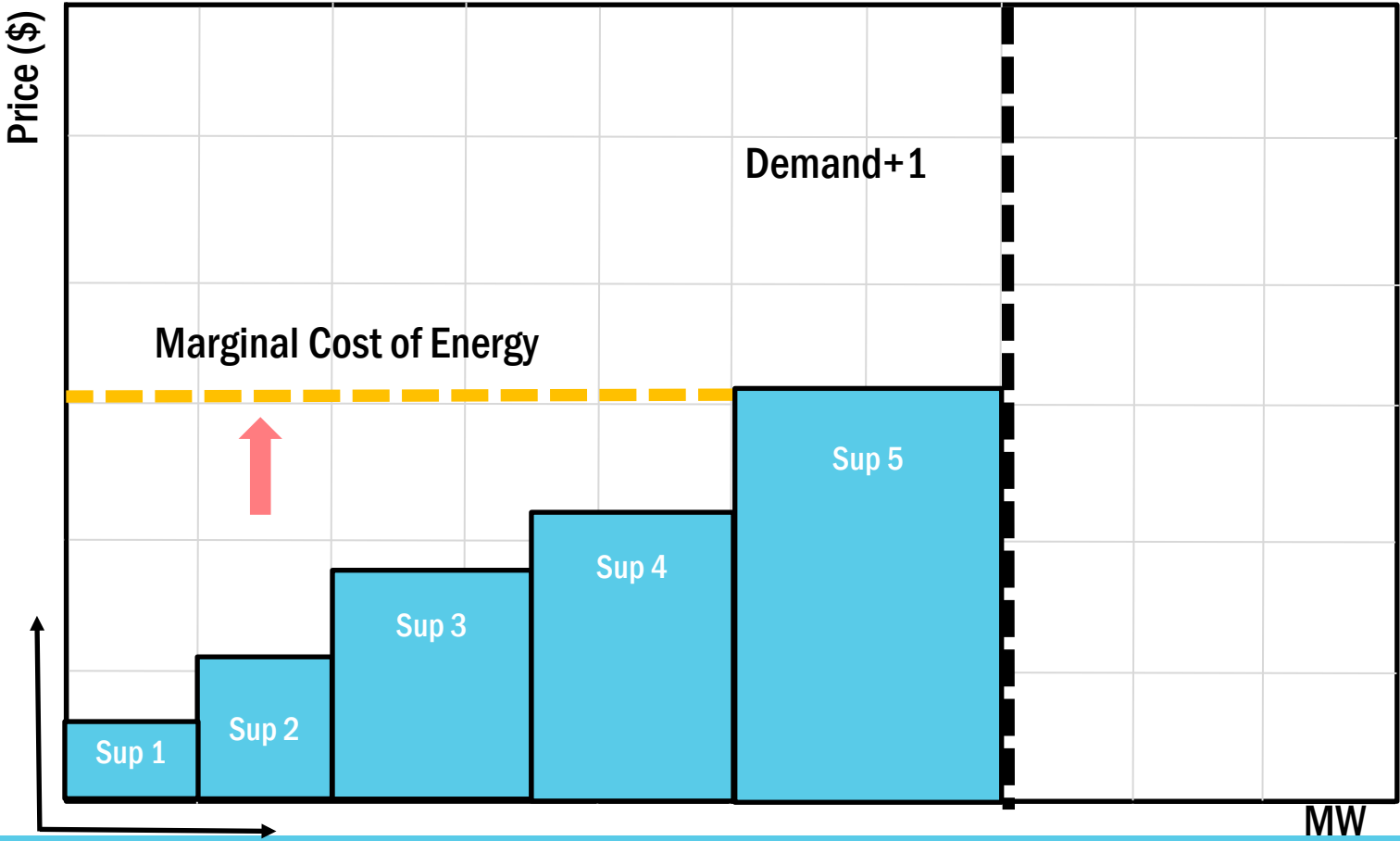
Determining the Marginal Energy Price



Determining the Marginal Energy Price



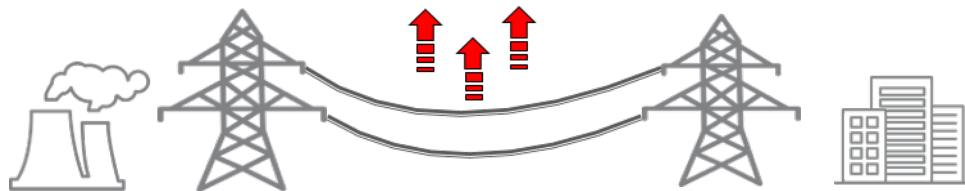
Determining the Marginal Energy Price



LBMP Components - Losses

■ Marginal Loss Price Component

- Some amount of generation will be lost along path to load due to heat dissipation
 - Transmission Losses
 - Approx. 2.5% of Energy is consumed by Losses in NYCA
- Marginal Loss Component takes this into account
- If Losses were zero, Loss \$ Component would be zero as well



LBMP Components - Losses

- **Marginal Loss Price Component**
 - **Factors used to determine losses**
 - **Delivery Factor**
 - **Energy Price Component at NYISO Reference Bus**
 - **Delivery Factor**
 - **Impact on Overall System Losses (+/-) when power injected at a Specific Generator Bus**

LBMP Components - Losses

- **Marginal Loss Price Component**

- Factors used to determine losses
 - Delivery Factor
 - Energy Price Component at NYISO Reference Bus
- Delivery Factor
 - Impact on Overall System Losses (+/-) when power injected at a Specific Generator Bus

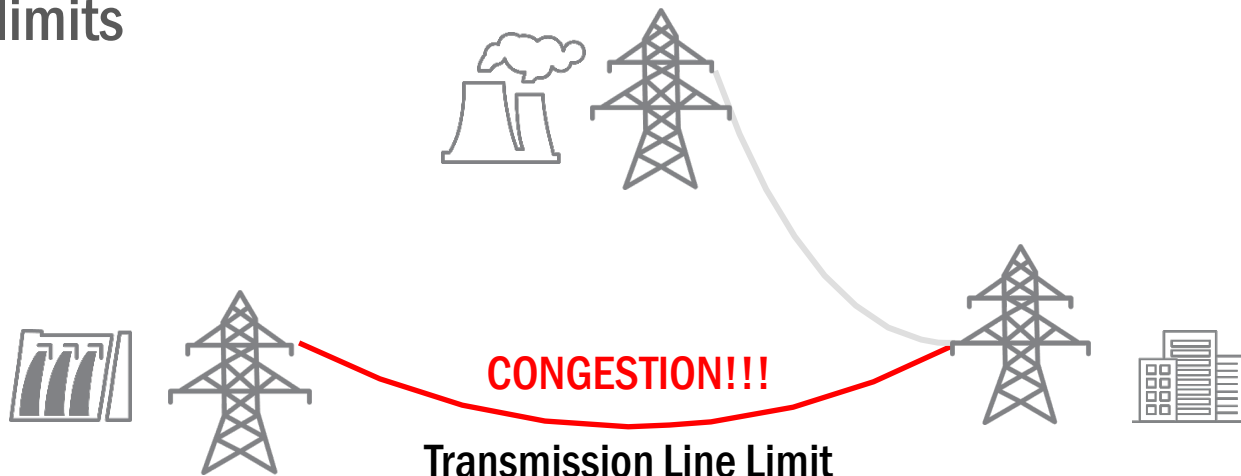
Delivery Factor	Impact on system Loss	Marginal Loss Price Component
Positive	Decreases System Loss	Positive
Negative	Increases System Loss	Negative

LBMP Components - Losses

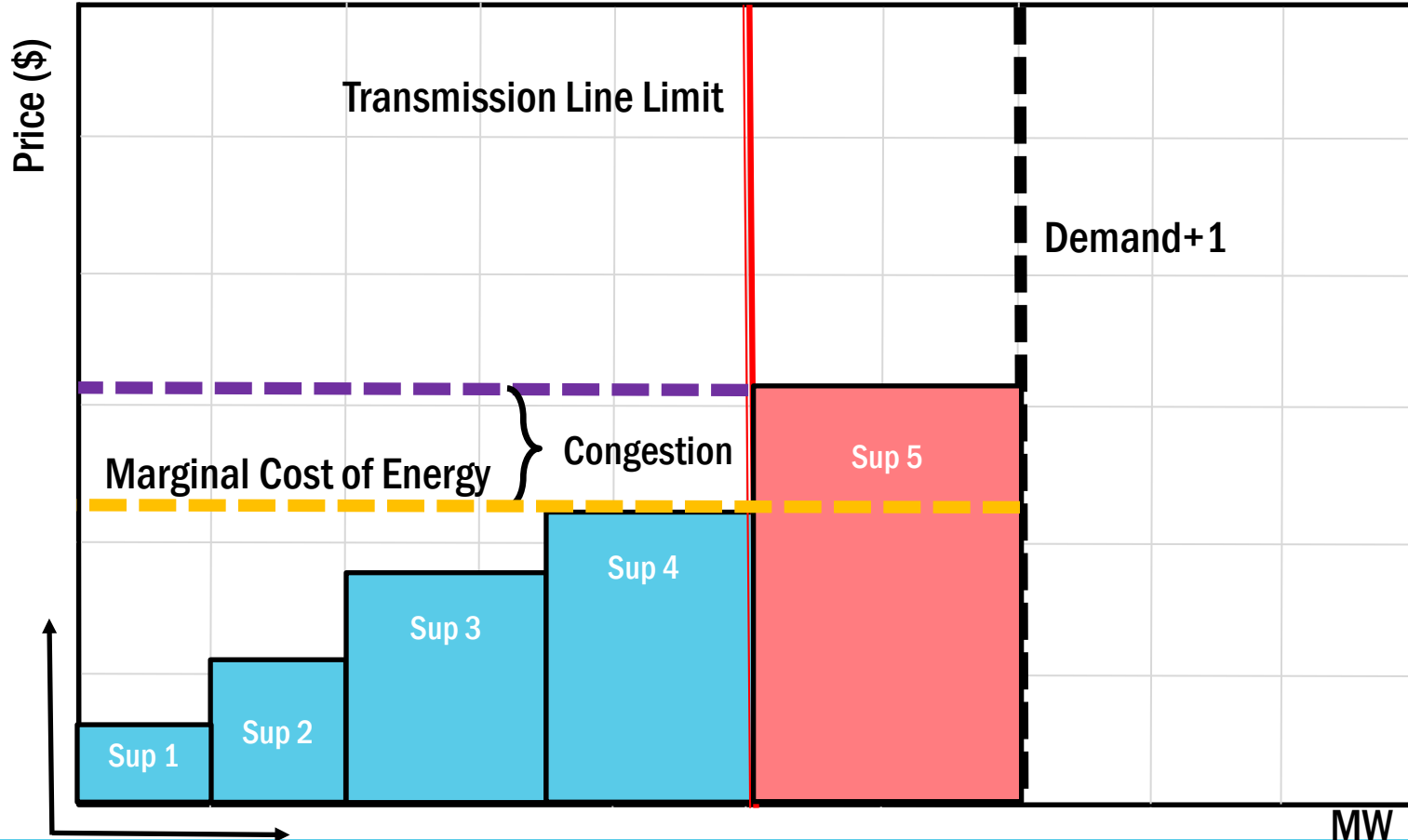
- **Marginal Loss Price Component**
 - For Detailed Information see OATT Attachment J or MST Attachment B
 - Market Participant User's Guide 3.3.1

LBMP Components - Congestion

- **Marginal Congestion Price Component**
 - In some instances, dispatching least costly generation may exceed line limitations
 - More costly units may subsequently be dispatched to avoid exceeding those limits

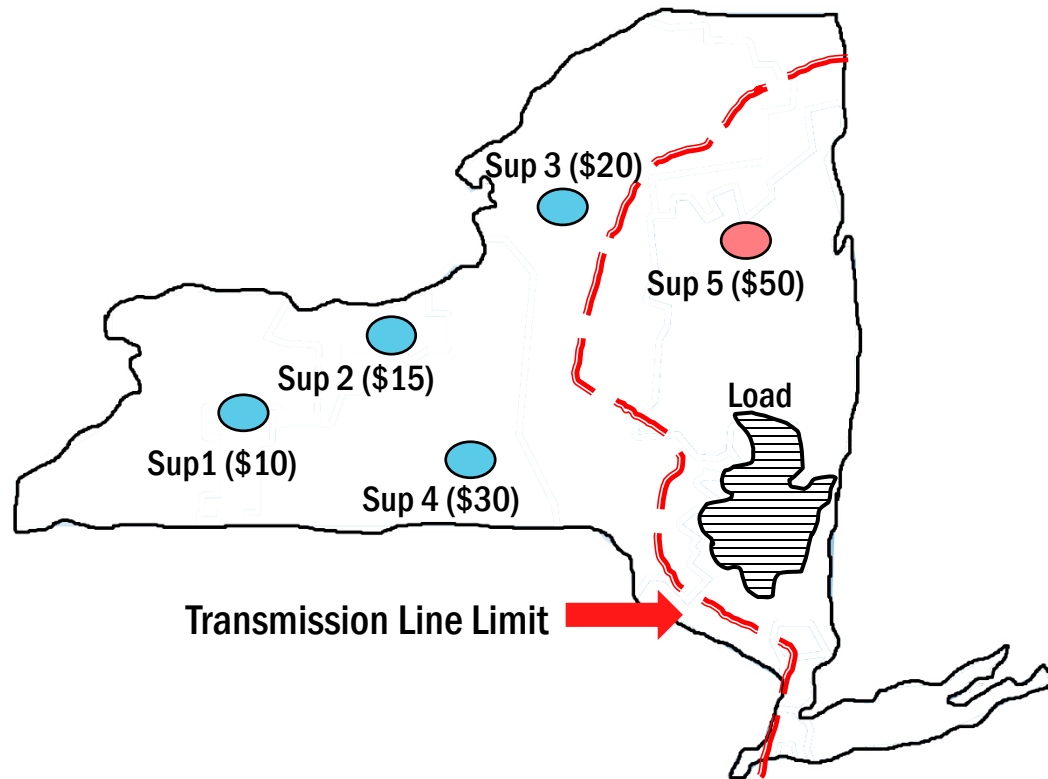


Determining the Marginal Congestion Price



LBMP - Congestion

- Marginal Congestion Price Component
 - Difference between 2 marginal prices creates congestion component



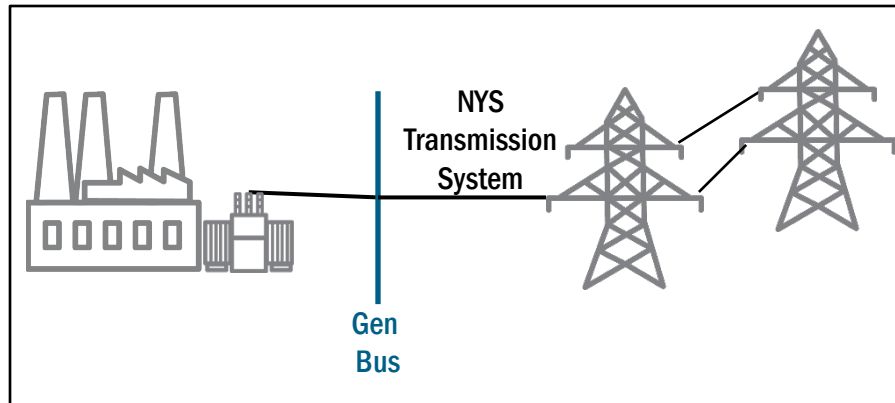
LBMP Components

- Three Components of LBMP
 - Marginal Energy Price Component
 - Marginal Loss Price Component
 - Marginal Congestion Price Component

$$\text{LBMP} = \text{Energy} + \text{Loss} - \text{Congestion}$$

Generators – Gen Bus LBMP

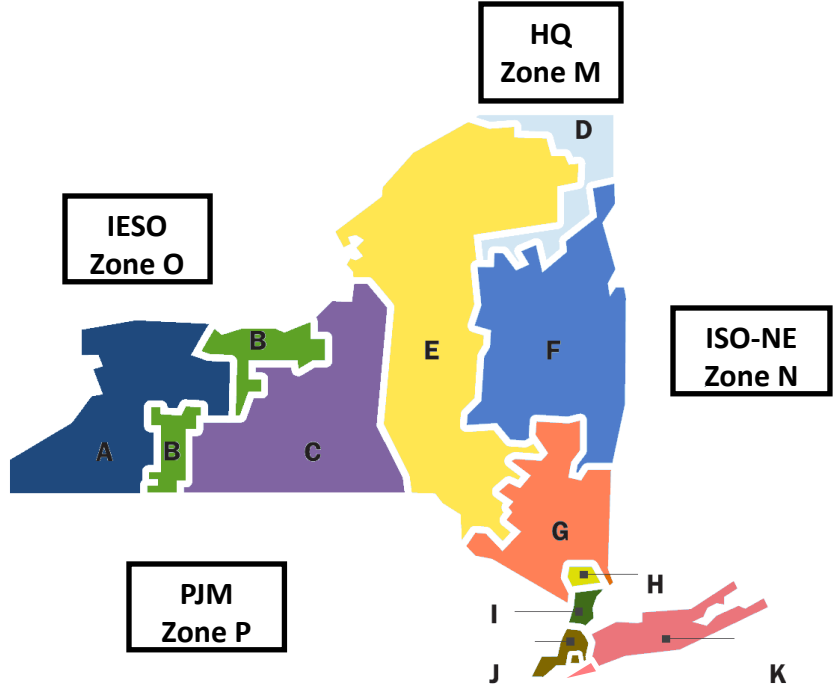
- LBMP for Generators
 - Based on Generator Bus
 - LBMP calculated at Bus where Generator injects power



Load Serving Entity – Zonal LBMP

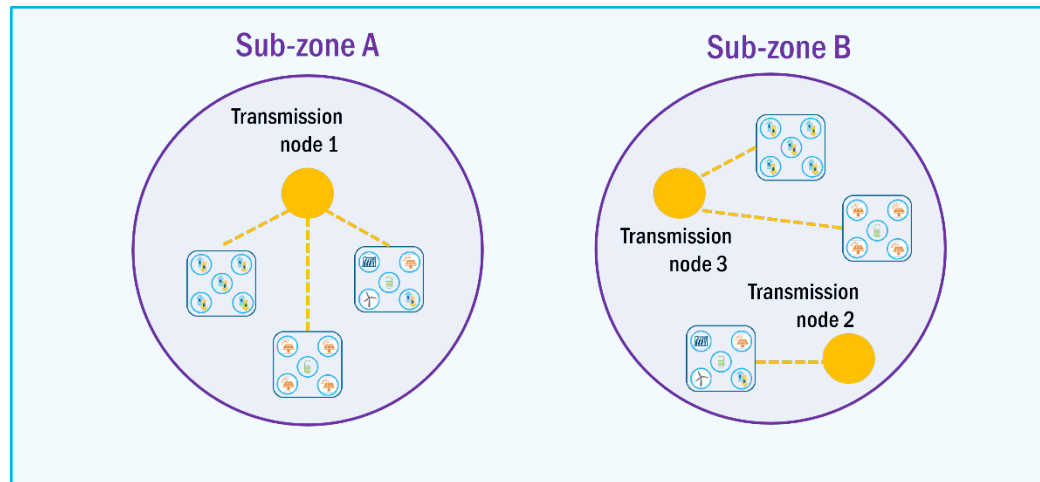
- **LBMP for Load**
 - Based on Zone where Load is Located
 - One Zonal LBMP for entire Zone
 - Load Weighted Average

NYCA Load Zones		
A- West	E- Mohawk Valley	I- Dunwoodie
B- Genesee	F- Capital	J- NYC
C- Central	G- Hudson Valley	K- Long Island
D- North	H- Millwood	



Aggregations – Transmission Node LBMP

- **LBMP for Aggregations**
 - Based on Transmission Node
 - Transmission Nodes reflect a collection of designated load buses on which individual DER are located and may participate together in an Aggregation



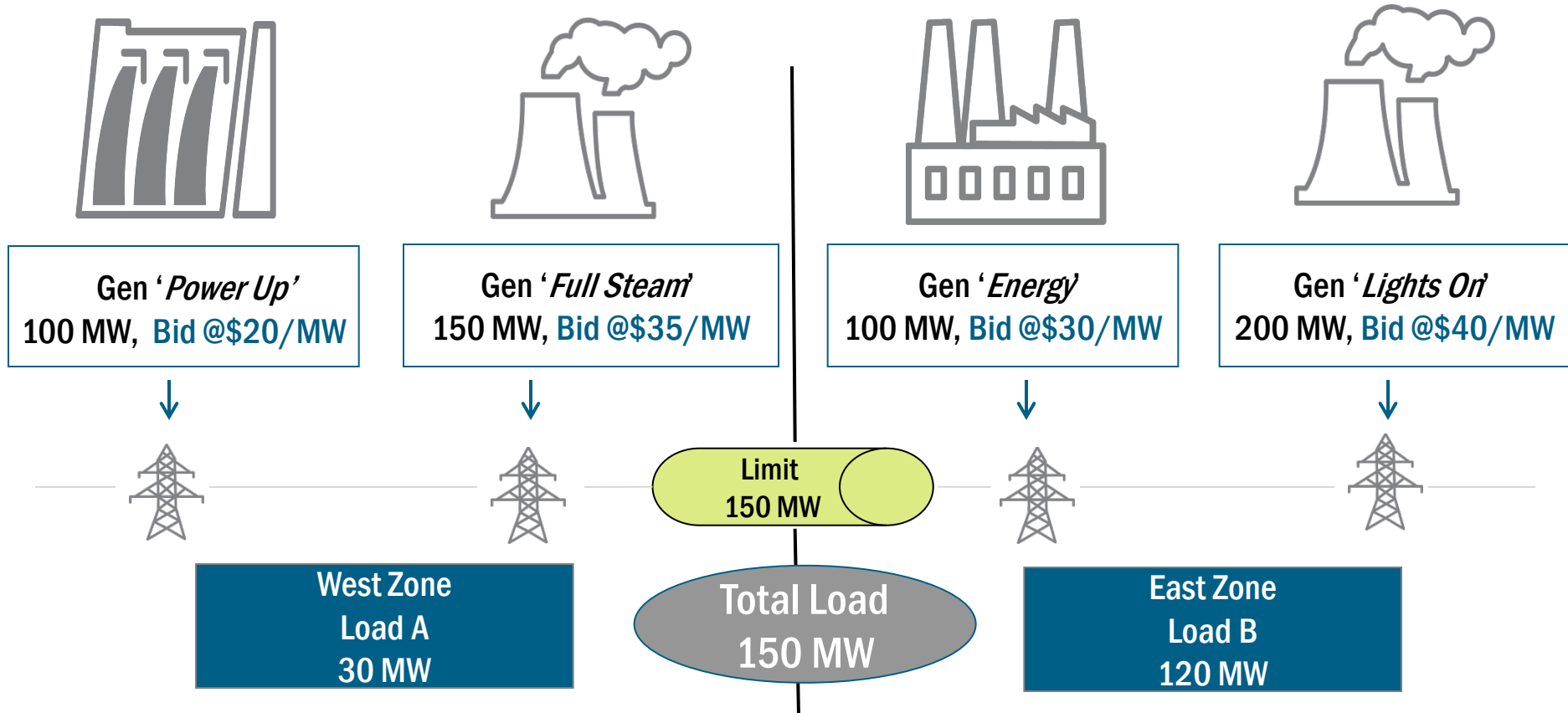
Example 1: Energy Only

No Losses and No Congestion

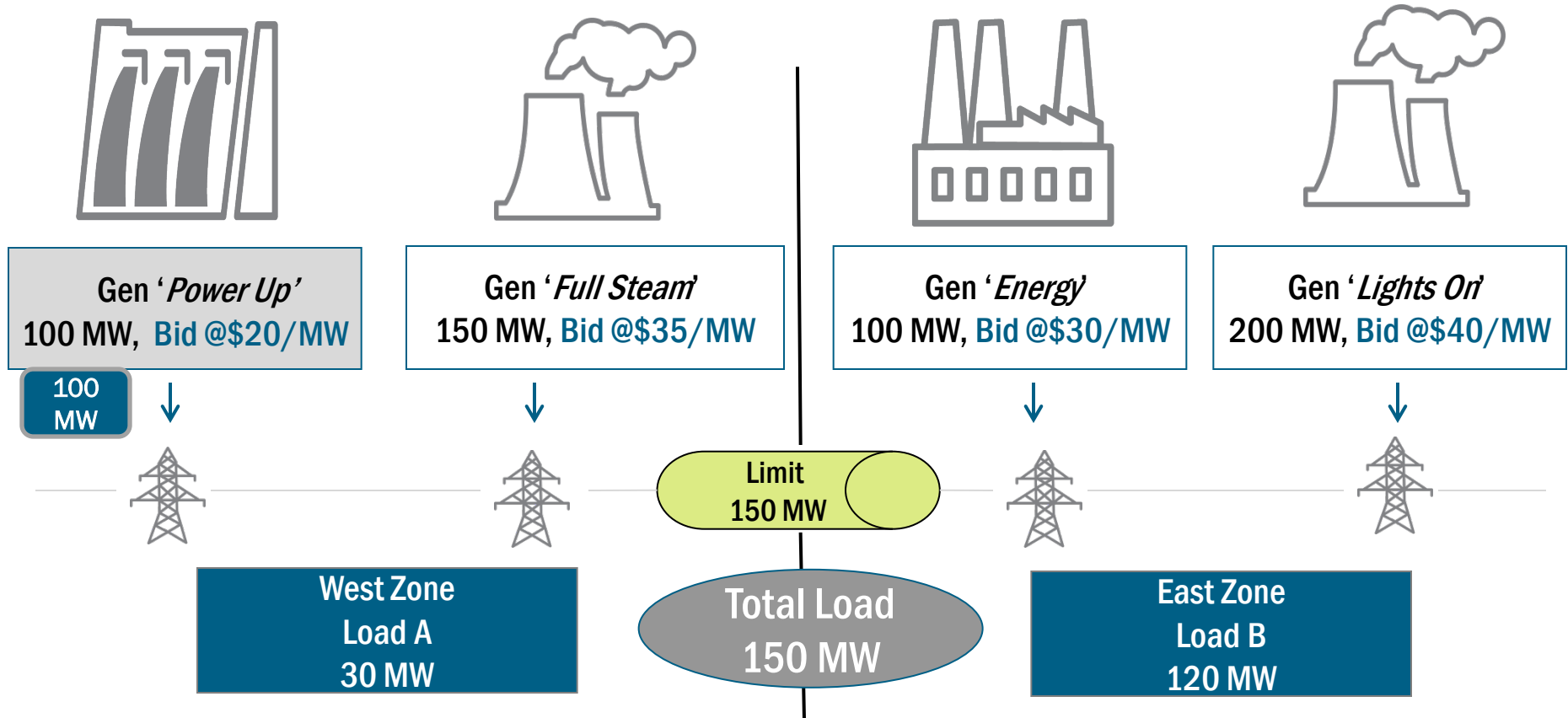


Total Load = 150 MW

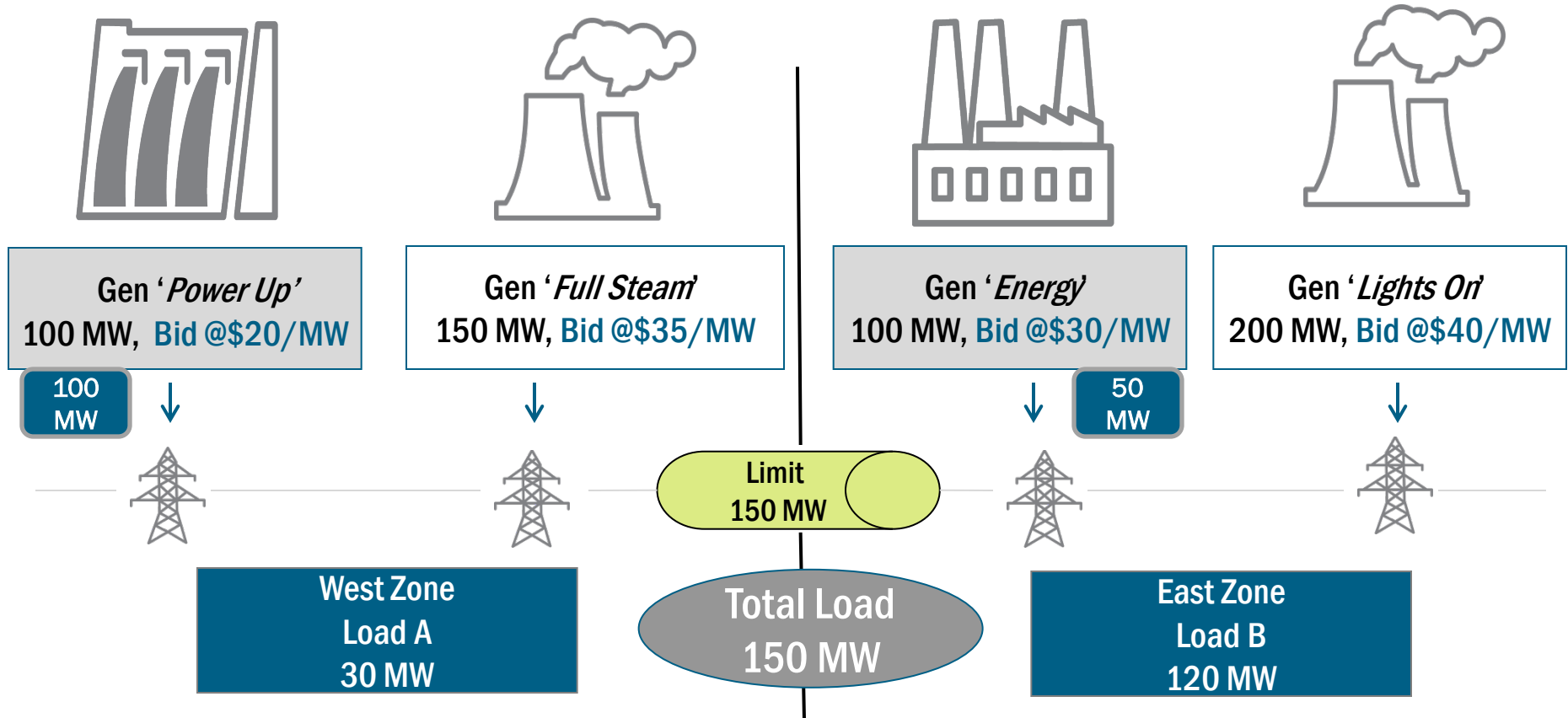
Example 1: Energy Only



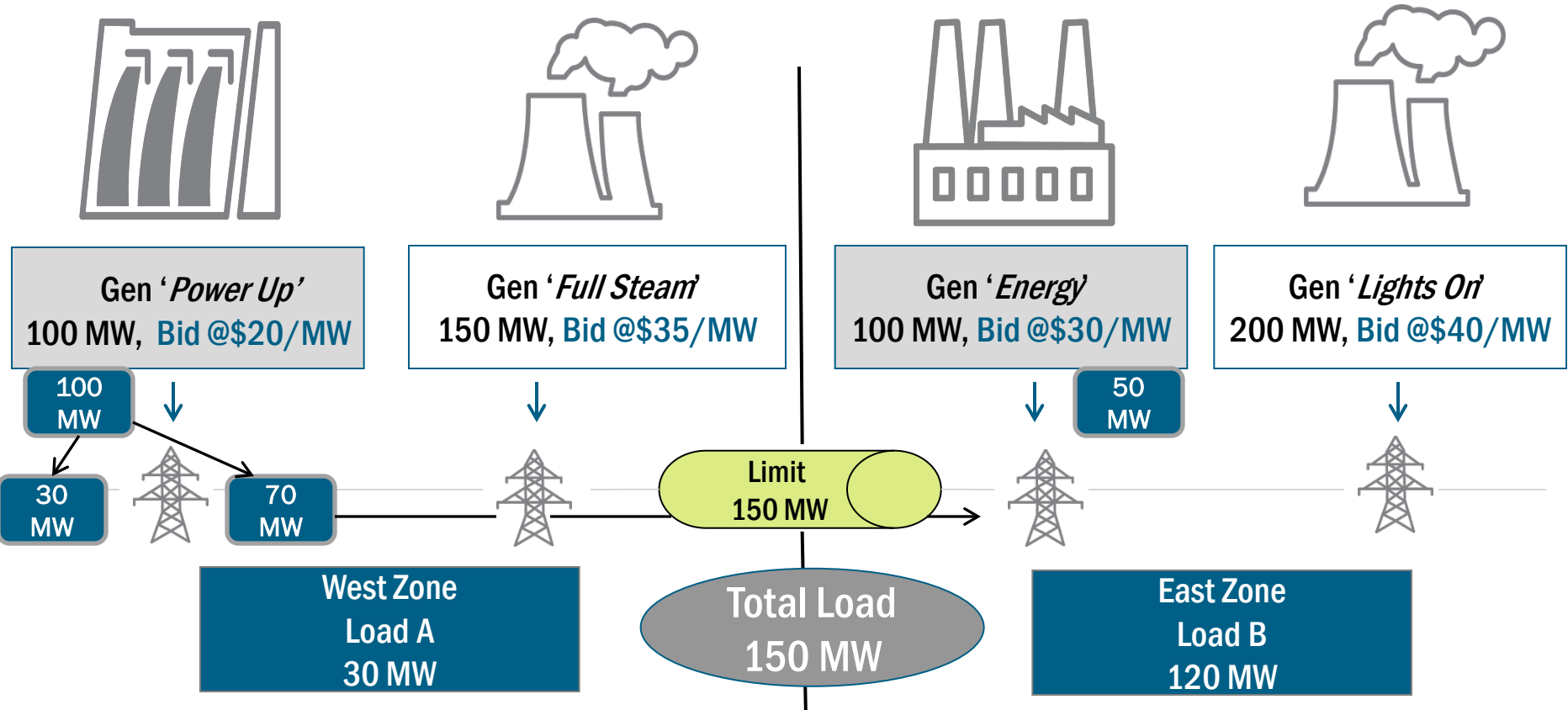
Example 1: Energy Only



Example 1: Energy Only



Example 1: Energy Only



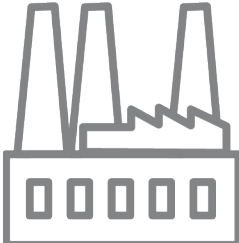
Example 1: Energy Only - Results



Gen 'Power Up'
100 MW, Bid @\$20/MW



Gen 'Full Steam'
150 MW, Bid @\$35/MW



Gen 'Energy'
100 MW, Bid @\$30/MW



Gen 'Lights On'
200 MW, Bid @\$40/MW

Energy \$30.00
Loss \$0.00
Congestion -\$0.00
LBMP \$30.00

West Zone
Load A
30 MW

West Zone LBMP \$30/MW



Limit
150 MW

Total Load
150 MW



East Zone
Load B
120 MW

East Zone LBMP \$30/MW

Energy \$30.00
Loss \$0.00
Congestion -\$0.00
LBMP \$30.00

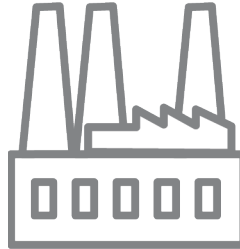
Example 1: Energy Only - Results



Gen '*Power Up*', 100 MW
Bid \$20, Paid \$30



Gen '*Full Steam*', 150 MW
Bid \$35, Paid \$0



Gen '*Energy*', 100 MW
Bid \$30, Paid \$30



Gen '*Lights On*', 200 MW
Bid \$40, Paid \$0

West Zone

East Zone

Generators receive \$30/MW (LBMP)

Example 1: Energy Only - Results

Loads Charged \$30/MW (LBMP)



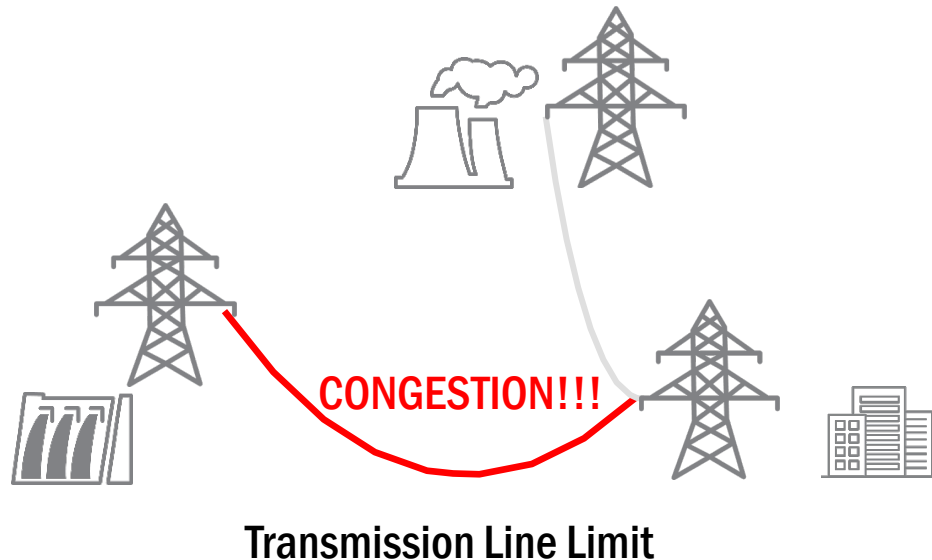
West Zone
Load A
30 MW



East Zone
Load B
120 MW

Congestion

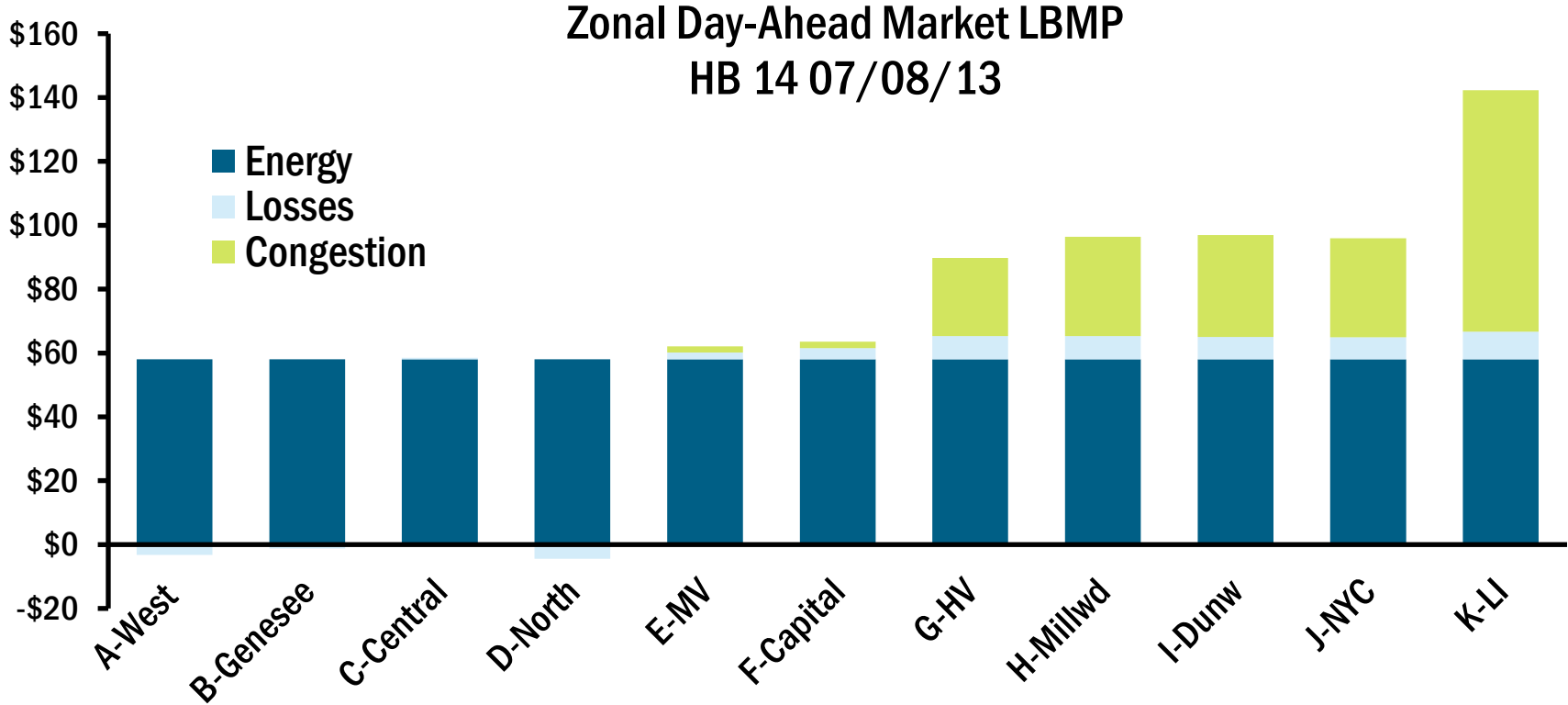
- Congestion occurs when the Power flow reaches the Transmission Limit
- To maintain efficient and reliable Transmission system
 - Transmission limits cannot be exceeded
 - When Transmission limits reached, generators from different buses are dispatched to meet load
- When there is congestion, LBMPs can differ between buses



Contributing Congestion Factors

- Generator Derates
- Line Outages
- Transaction Curtailments
- TSA – Severe Weather Conditions
- Reserve Shortage
- Alert State
- OOM & SRE Request
- Forecast Load vs. Actual RT Load

Day Ahead LBMP- Zonal pattern for 1 hour

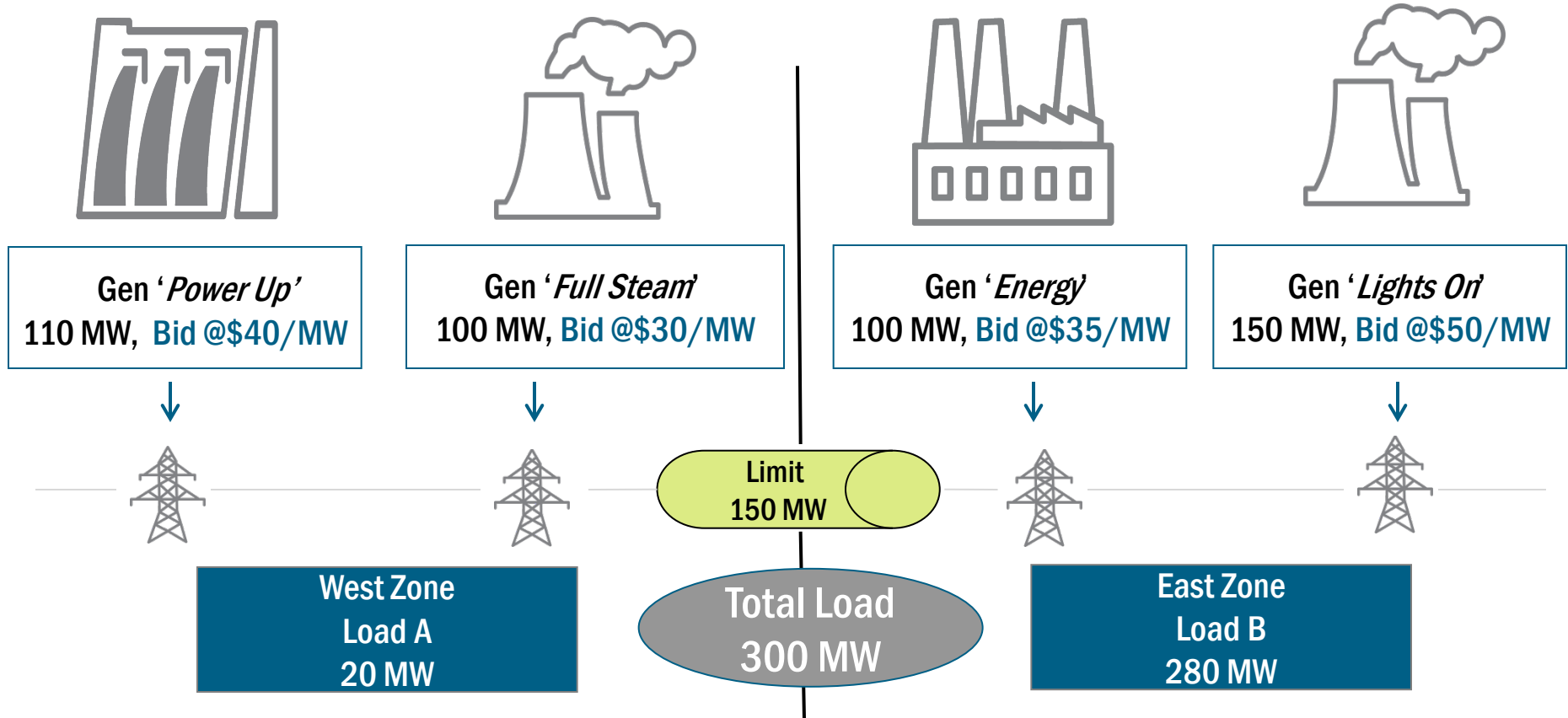


Example 2: Energy and Congestion, No Losses

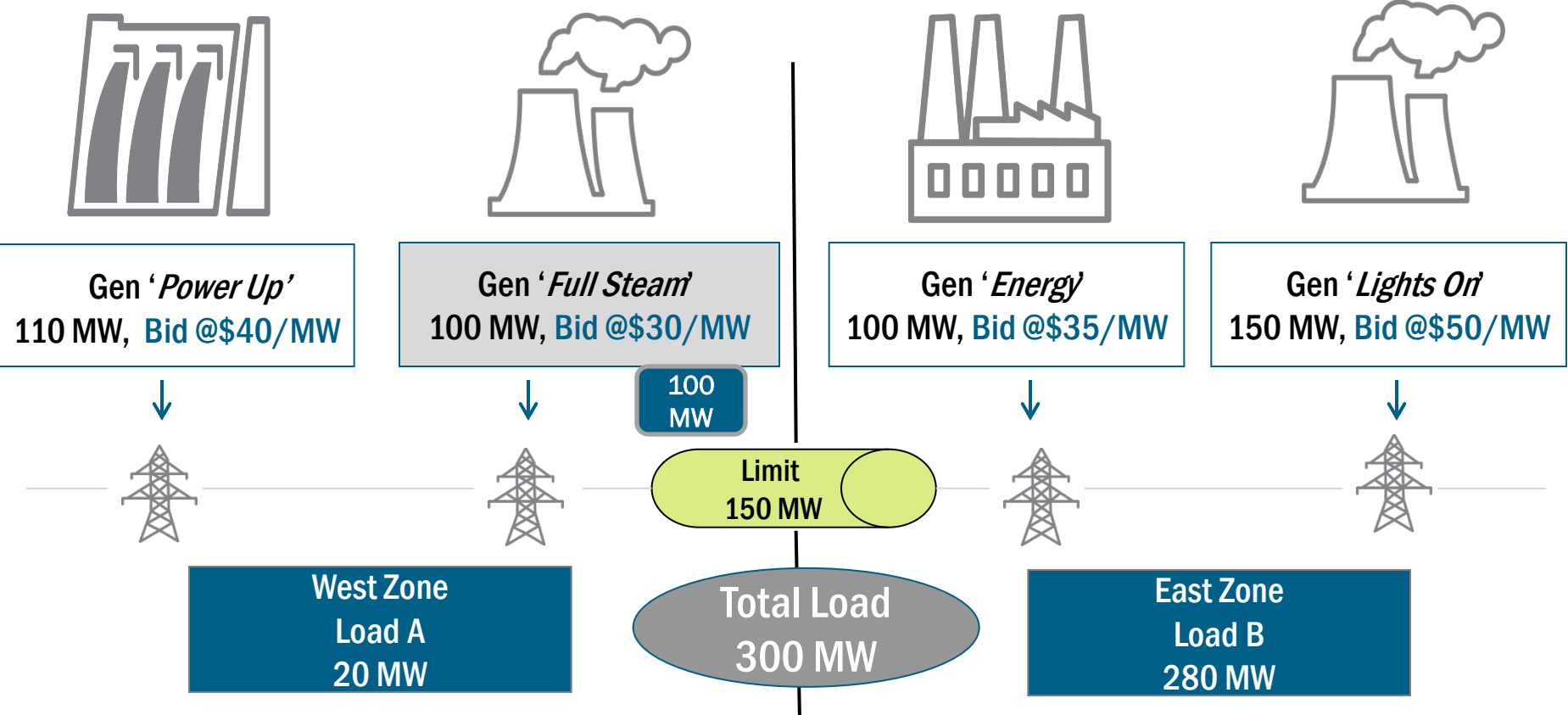


Total Load = 300 MW

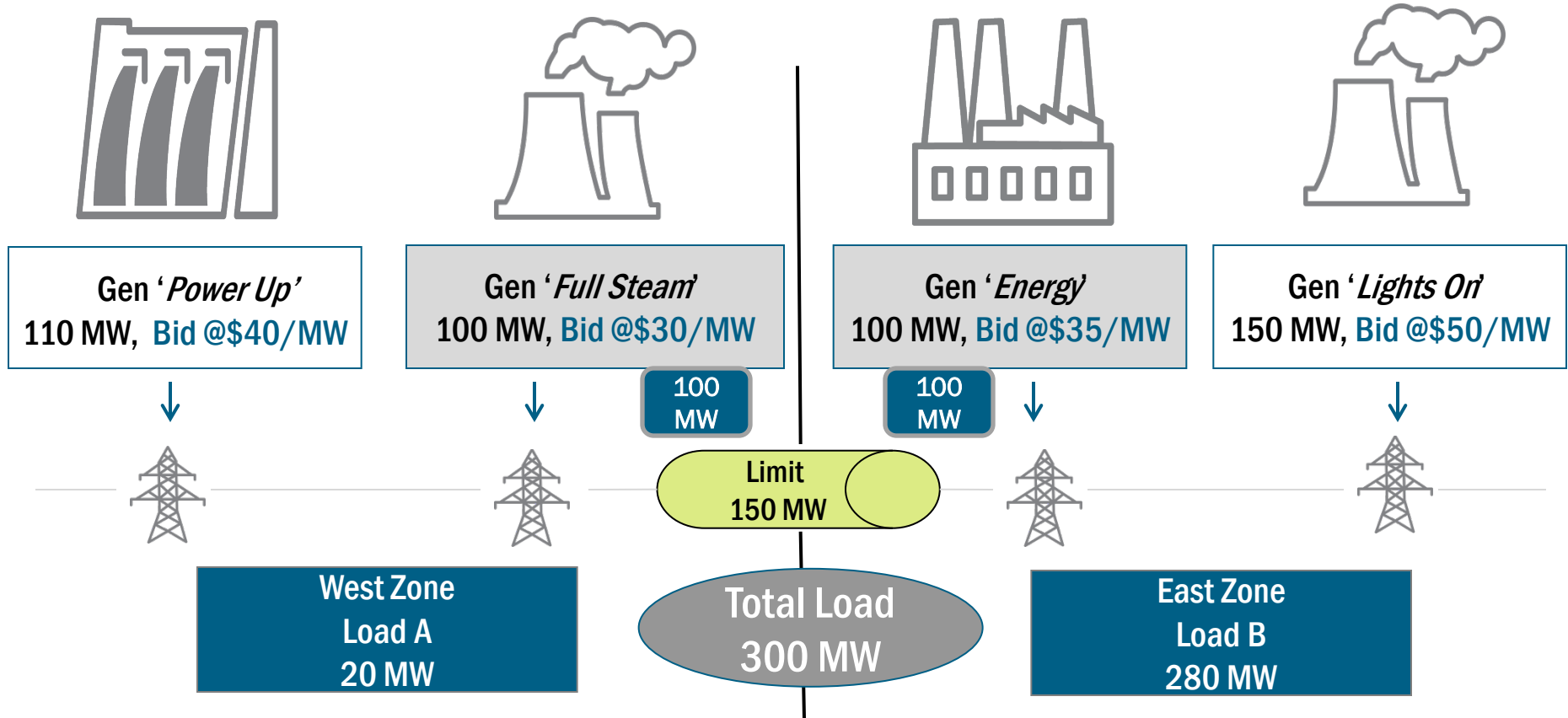
Example 2: Energy and Congestion



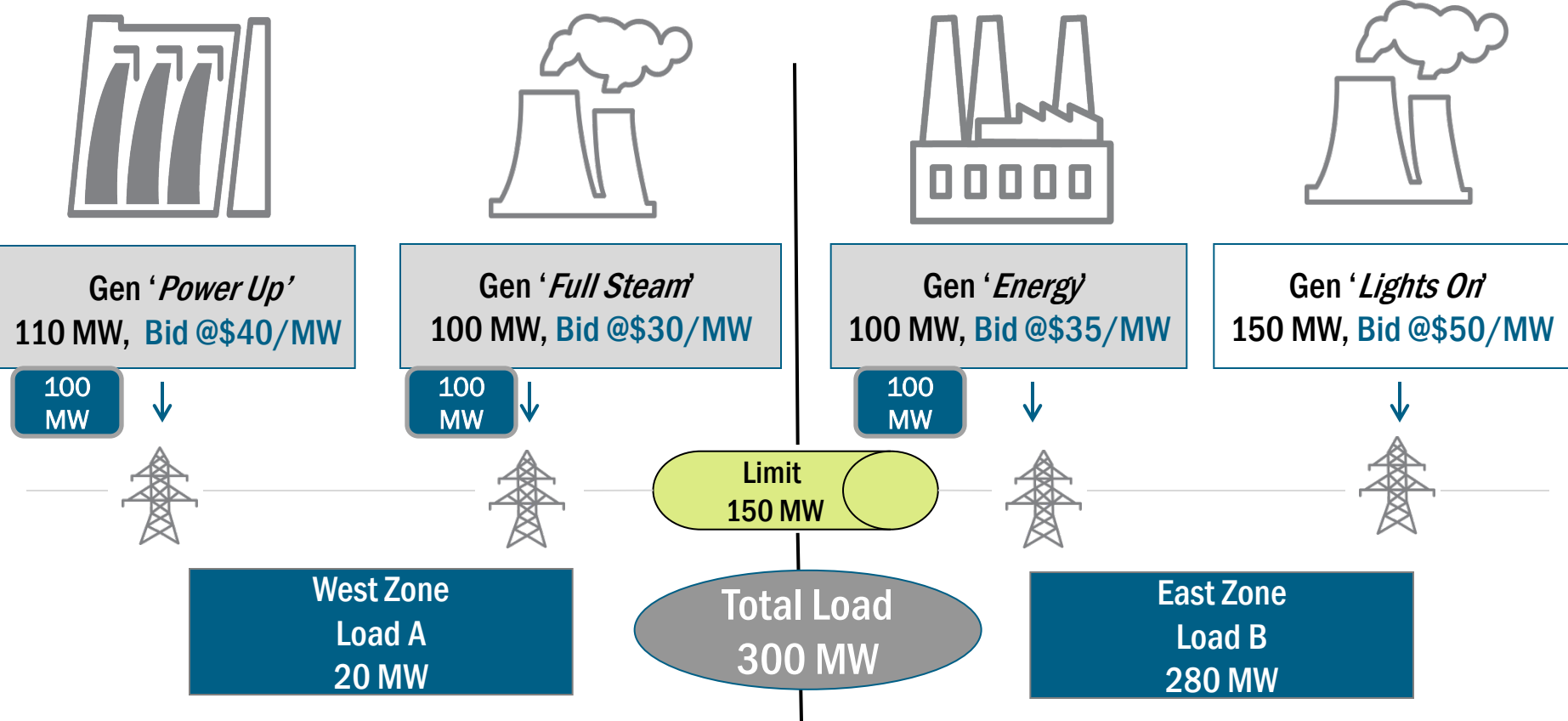
Example 2: Energy and Congestion



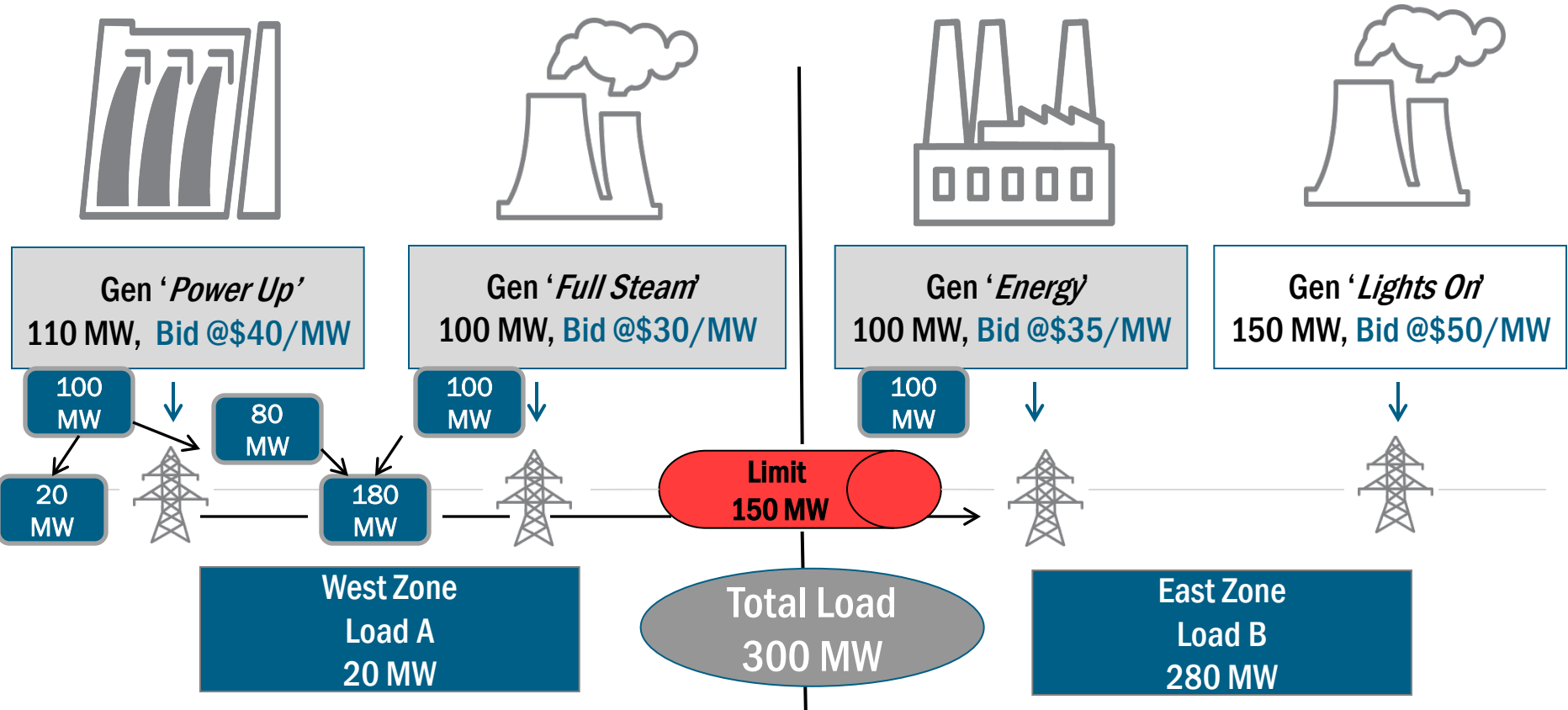
Example 2: Energy and Congestion



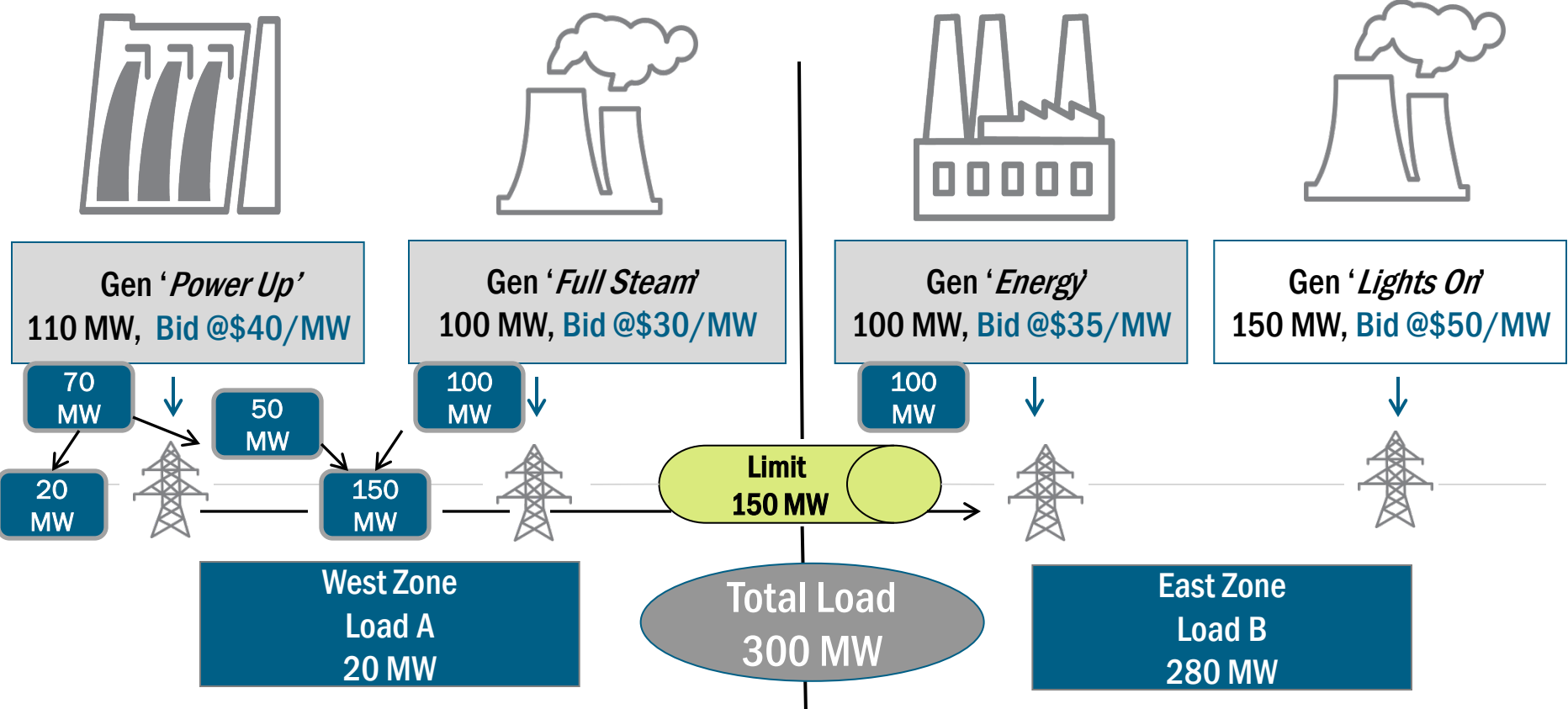
Example 2: Energy and Congestion



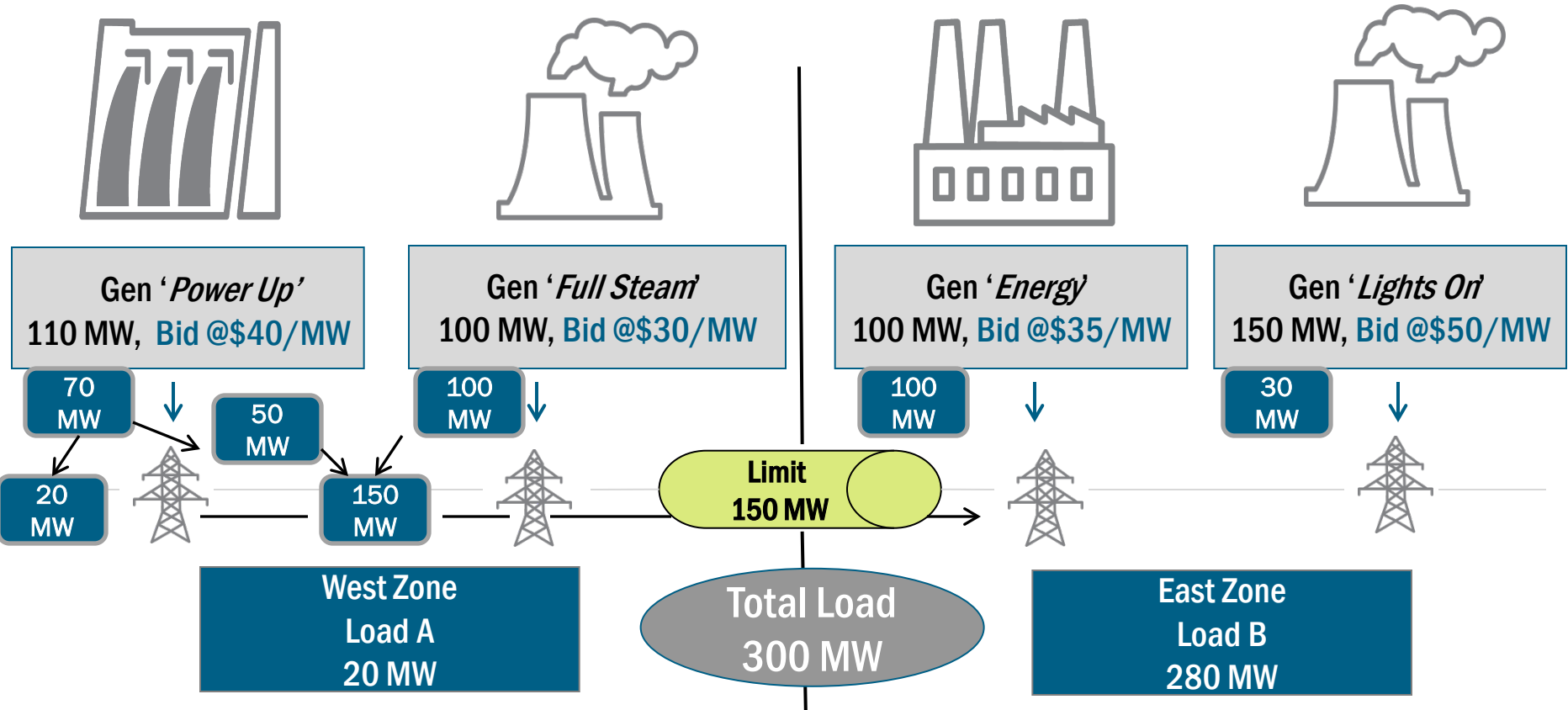
Example 2: Energy and Congestion



Example 2: Energy and Congestion



Example 2: Energy and Congestion



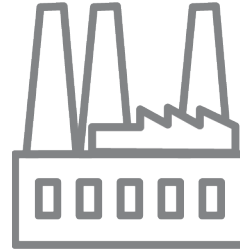
Example 2: Energy and Congestion - Results



Gen '*Power Up*'
110 MW, Bid @\$40/MW



Gen '*Full Steam*'
100 MW, Bid @\$30/MW



Gen '*Energy*'
100 MW, Bid @\$35/MW



Gen '*Lights On*'
150 MW, Bid @\$50/MW

Energy \$40.00
Loss \$0.00
Congestion -\$0.00
LBMP \$40.00

West Zone
Load A
20 MW

West Zone LBMP \$40/MW



Limit
150 MW

Total Load
300 MW



East Zone
Load B
280 MW

East Zone LBMP \$50/MW

Energy \$40.00
Loss \$0.00
Congestion -\$10.00
LBMP \$50.00

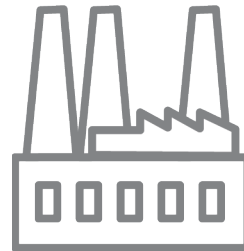
Example 2: Energy and Congestion -Results



Gen '*Power Up*', 110 MW
Bid \$40, Paid \$40



Gen '*Full Steam*', 100 MW
Bid \$30, Paid \$40



Gen '*Energy*', 100 MW
Bid \$35



Gen '*Lights On*', 150 MW
Bid \$50

West Zone

East Zone

Generators in the West receive \$40/MW (LBMP)

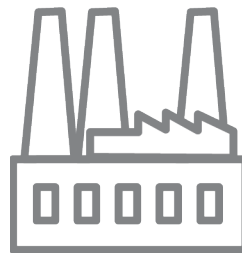
Example 2: Energy and Congestion -Results



Gen '*Power Up*', 110 MW
Bid \$40, Paid \$40



Gen '*Full Steam*', 100 MW
Bid \$30, Paid \$40



Gen '*Energy*', 100 MW
Bid \$35, Paid \$50



Gen '*Lights Out*', 150 MW
Bid \$50, Paid \$50

West Zone

East Zone

Generators, East of the interface receive \$50/MW (LBMP)

Example 2: Energy and Congestion - Results

Loads in West Zone
Charged \$40/MW (LBMP)



West Zone
Load A
20 MW

Loads in East Zone
Charged \$50/MW (LBMP)



East Zone
Load B
280 MW

Price Validation

Price Validation – Procedures for Correcting Erroneous Prices

- **Price Validation – Review and Correction of Day Ahead and Real Time Energy and Ancillary Services prices and price components**
 - In accordance with the rules set forth in Section 20, Attachment E of the Market Services Tariff (MST)
 - To ensure accurate and transparent market signals, and to ensure market certainty
 - Timely review of prices for accuracy and release or correction of prices in a tariff defined timeframe

Prices Validated

Energy Prices

DAM, RTC and RTD LBMPs at
Zonal and Gen Bus level

Ancillary Services Prices

Regulation and Reserves by Reserve
product type and location

Price Component Inputs



Marginal Energy Price



Loss factors (relative to Ref. Bus)



Shift Factors



Shadow Prices



NYCA Regulation

- Regulation Capacity
- Regulation Movement (RTC & RTD only)



Spinning Reserve



Non-Synchronous Reserve

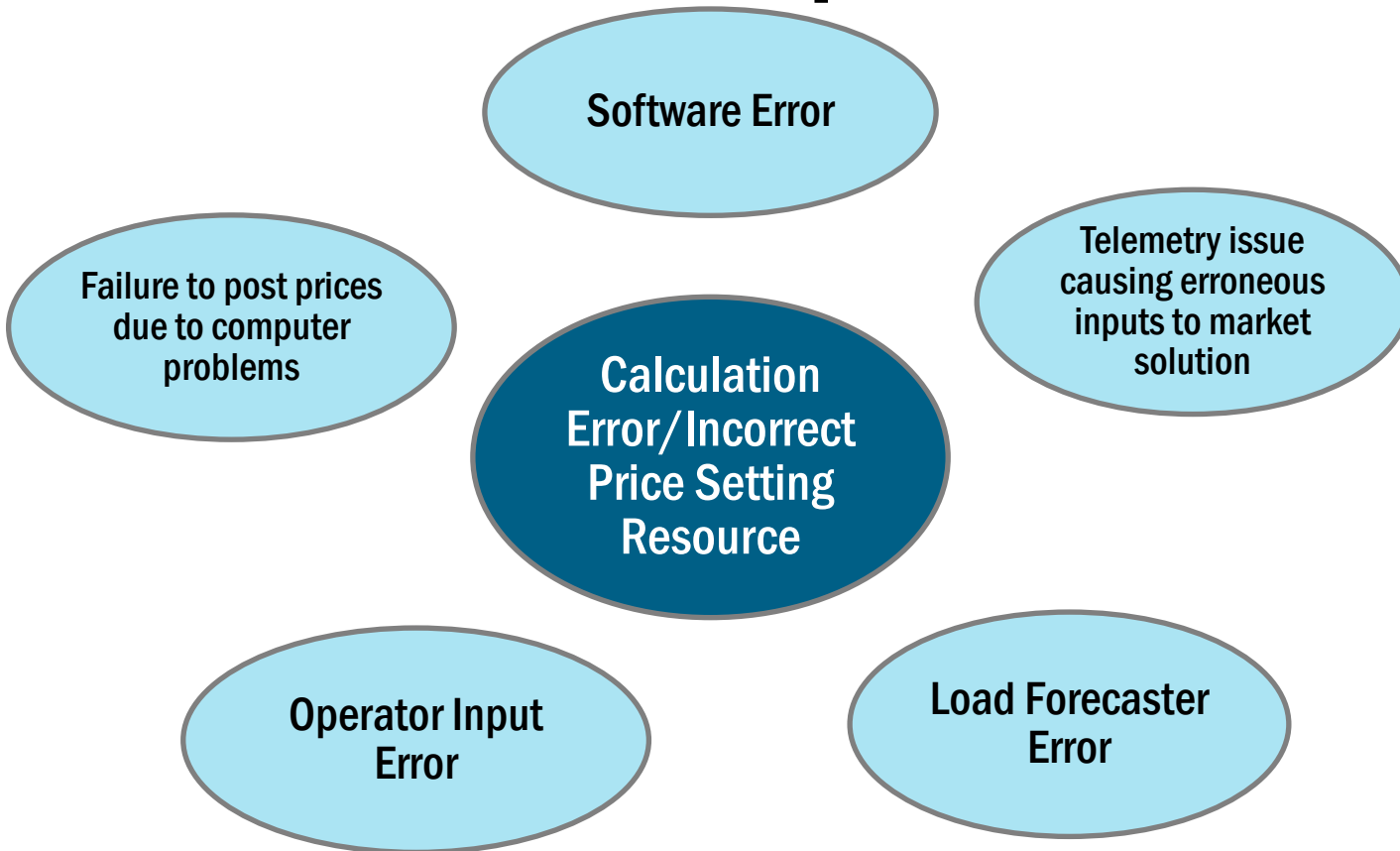
What Makes a Price Accurate?

- An accurate price is one which is:
 - Correctly calculated per the rules defined in NYISO's tariff
 - Based on the appropriate price setting resource
 - Posted to OASIS correctly

- Fewer than 0.10 % (one tenth of one percent) of all Real-Time intervals have resulted in a price correction since 2009



Price Errors: Some Examples



Price Validation Process

1. Identify Suspects

- Evaluate of all intervals through set of automated business rule comparisons by the Price Validation Rules Engine; intervals failing a rule tests flagged as suspects

2. Evaluate Suspects

- Determine if suspect interval is correct, analyzing variety of data such as Load and DNI, Operator logs, constraints and limits, etc.

3. Dismiss, Reserve, Correct/Release Suspects

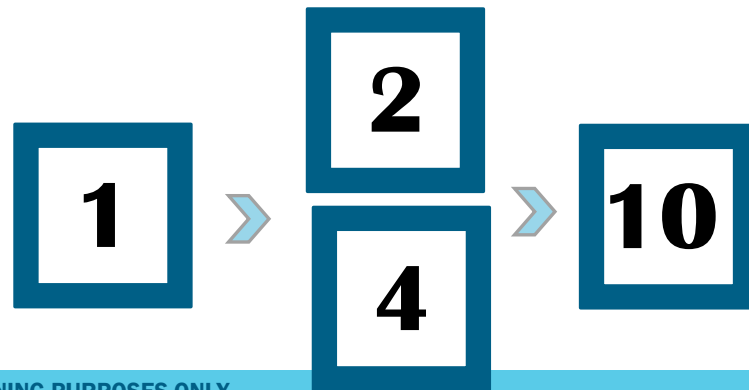
- Reserve intervals that need further review correct or release prices before tariff-defined deadlines
 - 2 business days after market day for DAM prices, 4 business days after market day for RT prices

4. Correction Modes

- Replace with surrounding interval price, RTD level advisory prices, similar bus prices, or prices from other markets (RTC or DAM)
- Recalculate
- Re-post

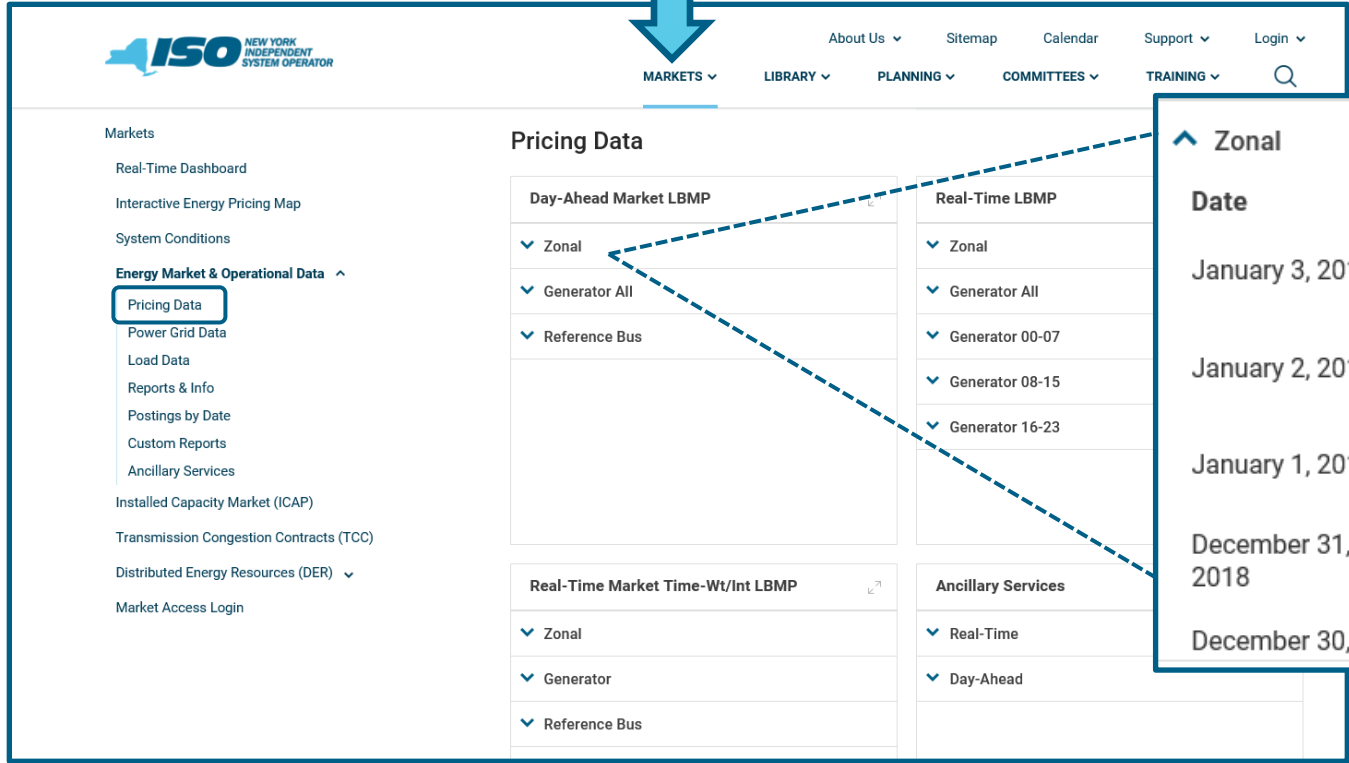
Price Validation Timeline

- Market participants are notified in a timely manner
 - One day to reserve potentially erroneous prices
 - Business days after the market day to correct or release reserved prices
 - 2 business days (Day Ahead prices)
 - 4 business days (RT prices)
 - Ten calendar days, following the price correction, to report the cause and type of correction applied



LBMP and Price Validation – NYISO Website Data

LBMP Data Files



ISO NEW YORK INDEPENDENT SYSTEM OPERATOR

MARKETS ▾ LIBRARY ▾ PLANNING ▾ COMMITTEES ▾ TRAINING ▾

About Us ▾ Sitemap Calendar Support ▾ Login ▾


Markets

- Real-Time Dashboard
- Interactive Energy Pricing Map
- System Conditions
- Energy Market & Operational Data ▾
 - Pricing Data**
 - Power Grid Data
 - Load Data
 - Reports & Info
 - Postings by Date
 - Custom Reports
 - Ancillary Services
- Installed Capacity Market (ICAP)
- Transmission Congestion Contracts (TCC)
- Distributed Energy Resources (DER) ▾
- Market Access Login

Pricing Data

Day-Ahead Market LBMP	Real-Time LBMP
<ul style="list-style-type: none"> ▼ Zonal ▼ Generator All ▼ Reference Bus 	<ul style="list-style-type: none"> ▼ Zonal ▼ Generator All ▼ Generator 00-07 ▼ Generator 08-15 ▼ Generator 16-23
Real-Time Market Time-Wt/Int LBMP	Ancillary Services
<ul style="list-style-type: none"> ▼ Zonal ▼ Generator ▼ Reference Bus 	<ul style="list-style-type: none"> ▼ Real-Time ▼ Day-Ahead

^ Zonal



Date	Download	Last Updated
January 3, 2019	csv pdf htm	01/02/19 09:35 EST
January 2, 2019	csv pdf htm	01/01/19 09:35 EST
January 1, 2019	csv pdf htm	12/31/18 09:34 EST
December 31, 2018	csv pdf htm	12/30/18 09:35 EST
December 30,	csv pdf	12/29/18 09:35

LBMP Components Data Files

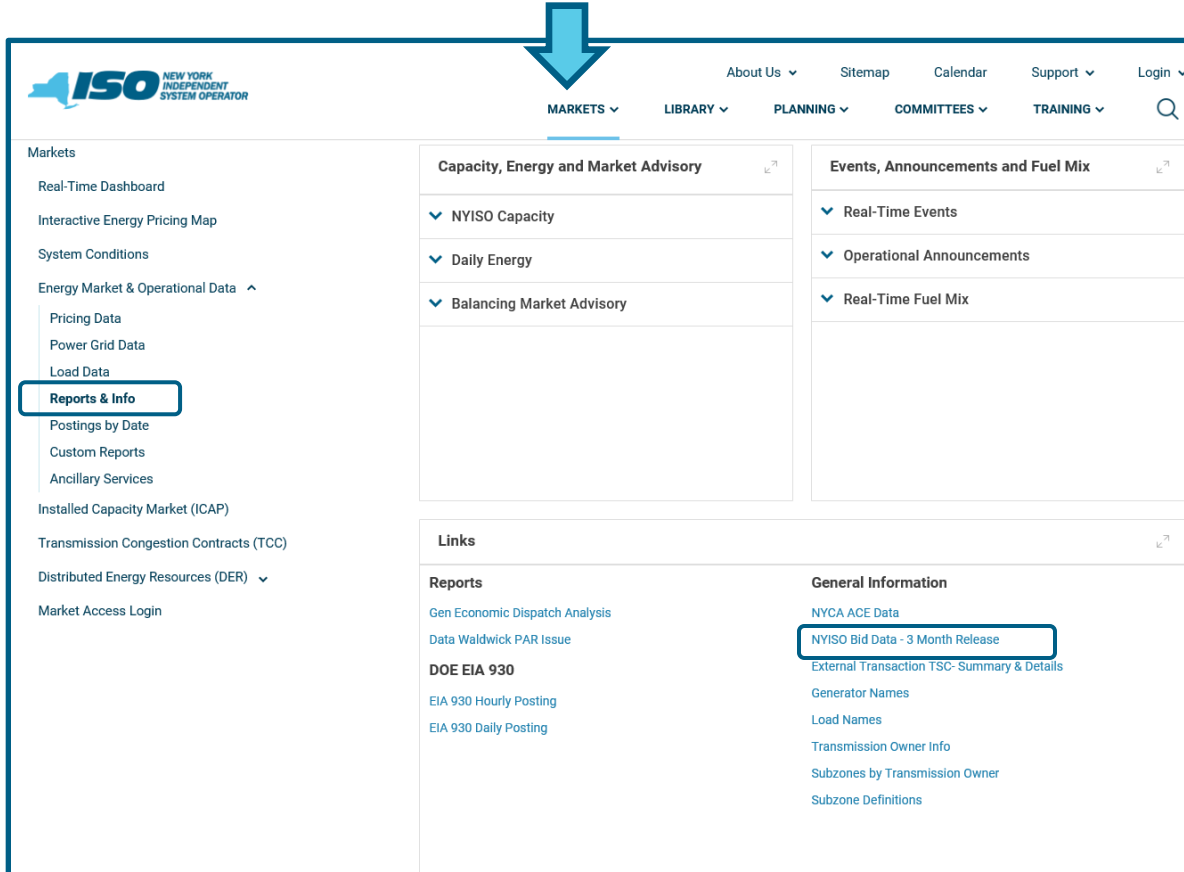
Day Ahead Market Zonal LBMP

		--- LBMP \$				--- Marginal Cost of Losses				--- Marginal Cost of Congestion														
Zonal Data																								12/05/2017
Name	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
PTID	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST
CAPITL 61757	29.72	25.19	25.98	23.15	24.45	22.61	27.54	28.15	27.81	31.93	31.91	27.75	28.93	28.11	28.85	28.06	34.82	38.63	34.29	32.65	31.82	26.66	25.41	24.62
	0.28	0.27	0.27	0.27	0.27	0.37	0.83	1.38	1.73	1.69	1.63	1.68	1.67	1.65	1.51	1.65	1.97	2.71	2.35	2.23	1.97	1.58	0.99	0.40
	-25.19	-20.68	-21.48	-18.63	-19.95	-16.96	-14.55	-5.94	-2.13	-6.40	-6.33	-2.40	-3.81	-2.94	-6.07	-3.56	-5.89	0.24	0.20	0.09	-2.45	-2.77	-9.35	-17.78
CENTRL 61754	6.88	6.40	6.46	6.19	6.30	7.13	13.94	21.78	24.28	24.59	24.65	23.99	23.90	23.86	22.00	23.34	27.73	36.19	32.14	30.60	27.71	22.57	16.07	8.37
	0.03	0.02	0.01	0.03	0.01	0.10	0.27	0.39	0.34	0.31	0.26	0.29	0.26	0.24	0.23	0.28	0.30	0.40	0.29	0.22	0.17	0.07	0.11	0.09
	-2.60	-2.14	-2.22	-1.92	-2.06	-1.75	-1.51	-0.54	0.01	-0.44	-0.43	-0.04	-0.19	-0.09	-0.49	-0.21	-0.47	0.36	0.29	0.13	-0.14	-0.20	-0.90	-1.84

	CAPITL	CENTRL	NYISO_LBMP_REFERENCE
	61757	61754	24008

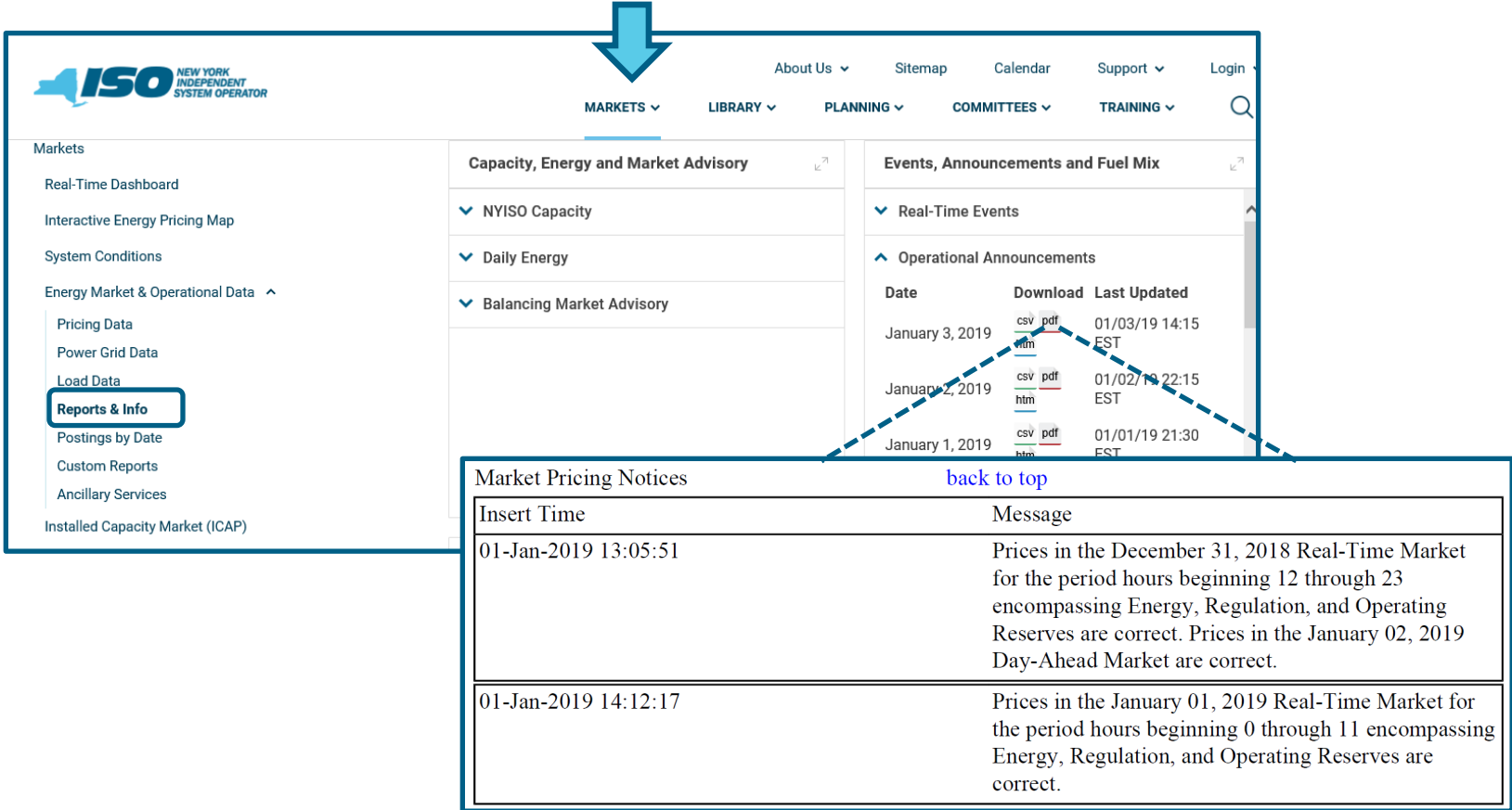
LBMP	27.54	13.94	12.16
Loss	0.83	0.27	0.00
Congestion	-14.55	-1.51	0.00

NYISO Bid Data – 3 Month Release



The screenshot shows the NYISO website interface. A large blue arrow points to the 'MARKETS' dropdown menu. In the left sidebar, the 'Reports & Info' menu item is highlighted with a red box. In the main content area, the 'Capacity, Energy and Market Advisory' section is expanded, showing 'NYISO Capacity', 'Daily Energy', and 'Balancing Market Advisory'. The 'Events, Announcements and Fuel Mix' section is also expanded, showing 'Real-Time Events', 'Operational Announcements', and 'Real-Time Fuel Mix'. In the 'Links' section, the 'Reports' sub-section is expanded, and the 'NYISO Bid Data - 3 Month Release' link is highlighted with a red box. The 'General Information' sub-section is also expanded, showing various links like 'NYCA ACE Data', 'External Transaction TSC- Summary & Details', 'Generator Names', 'Load Names', 'Transmission Owner Info', 'Subzones by Transmission Owner', and 'Subzone Definitions'.

Market Price Validation Notices



The screenshot shows the NYISO website interface. A blue arrow points to the 'MARKETS' menu item in the top navigation bar. A dashed blue arrow points from the 'MARKETS' menu to a table titled 'Market Pricing Notices'.

MARKETS


- Capacity, Energy and Market Advisory
 - NYISO Capacity
 - Daily Energy
 - Balancing Market Advisory
- Events, Announcements and Fuel Mix
 - Real-Time Events
 - Operational Announcements

Date	Download	Last Updated
January 3, 2019	csv pdf htm	01/03/19 14:15 EST
January 2, 2019	csv pdf htm	01/02/19 22:15 EST
January 1, 2019	csv pdf htm	01/01/19 21:30 EST

Insert Time	Message
01-Jan-2019 13:05:51	Prices in the December 31, 2018 Real-Time Market for the period hours beginning 12 through 23 encompassing Energy, Regulation, and Operating Reserves are correct. Prices in the January 02, 2019 Day-Ahead Market are correct.
01-Jan-2019 14:12:17	Prices in the January 01, 2019 Real-Time Market for the period hours beginning 0 through 11 encompassing Energy, Regulation, and Operating Reserves are correct.

Price Correction Reports





[About Us](#) ▾ [Sitemap](#) [Calendar](#) [Support](#) ▾ [Login](#) ▾

MARKETS ▾ LIBRARY ▾ PLANNING ▾ COMMITTEES ▾ TRAINING ▾ 🔍

Markets

- Real-Time Dashboard
- Interactive Energy Pricing Map
- System Conditions
- Energy Market & Operational Data ▾
 - Pricing Data
 - Power Grid Data
 - Load Data
 - Reports & Info**
 - Postings by Date
 - Custom Reports
 - Ancillary Services
- Installed Capacity Market (ICAP)
- Transmission Congestion Contracts (TCC)
- Distributed Energy Resources (DER) ▾
- Market Access Login

Price Correction Reports
↗

Name	Published
^ 2019 January 20, 2019	2019/01/30
v 2018	
v 2017	
v 2016	
v 2007-2015	
Price Correction Report Reference Document	2016/06/29

Reports
↗

Name	Published
v Major Emergency Events	
Capacity Report Explanation	2015/11/11
Notice of Discretionary Acts	2019/01/18
Price Validation Quarterly Report	2019/01/22

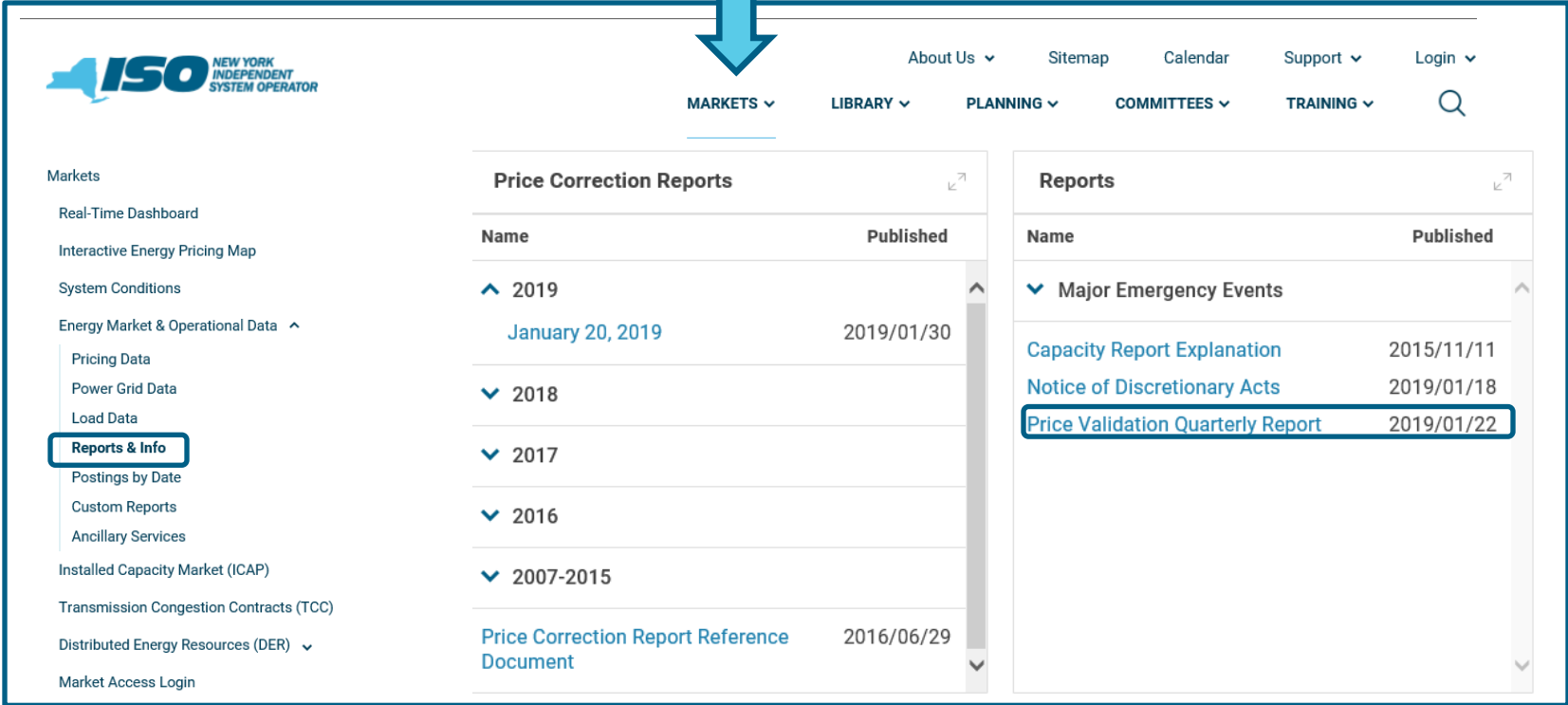
RT Price Correction Report Cont'd

- Report data includes:
 - Timestamps
 - Error Type
 - Error Description
 - Correction Mode
 - Affected Zones/External Proxies
 - Affected Ancillary Services
 - Additional Comments

Interval: 01/20/2019 19:15:00
 Error Type: Incorrect Price Setting Resource
 Error Description: Operator Input
 Correction Mode: Replace w/Subsequent Interval
 Comments: Issue resulted from an incorrect interface limit input for CENTRAL EAST - VC.

Zone / Proxy	Energy	10 Min Spin	10 Min Non-Spin	30 Min	Reg Capacity	Reg Movement
CAPITL	C					
CENTRL	C					
DUNWOD	C					
GENESE	C					
HUD VL	C					
LONGIL	C					
MHK VL	C					
MILLWD	C					
N.Y.C.	C					
NORTH	C					
WEST	C					
HQ_GEN_CEDA						
RS_PROXY	C					
HQ_GEN_IMPO						
RT	C					
HQ_GEN_WHE						
EL	C					
N.E._GEN_SAN						
DY PD	C					
NPX_GEN_1385						
_PROXY	C					
NPX_GEN_CSC	C					
O.H._GEN_BRU						
CE	C					
PJM_GEN_HTP						
_PROXY	C					
PJM_GEN_KEYS						
TONE	C					
PJM_GEN_NEP						
TUNE_PROXY	C					
PJM_GEN_VFT						
_PROXY	C					

Price Validation Quarterly Reports



The screenshot shows the NYISO website interface. The top navigation bar includes links for About Us, Sitemap, Calendar, Support, and Login. Below this is a secondary navigation bar with dropdown menus for MARKETS, LIBRARY, PLANNING, COMMITTEES, and TRAINING. A search icon is also present. The left sidebar contains a list of menu items, with 'Reports & Info' highlighted in a red box. The main content area is divided into two columns. The left column is titled 'Price Correction Reports' and contains a table with columns 'Name' and 'Published'. The right column is titled 'Reports' and contains a table with columns 'Name' and 'Published'. In the 'Reports' table, the 'Price Validation Quarterly Report' is highlighted in a red box.

Price Correction Reports

Name	Published
2019	
January 20, 2019	2019/01/30
2018	
2017	
2016	
2007-2015	
Price Correction Report Reference Document	2016/06/29

Reports

Name	Published
Major Emergency Events	
Capacity Report Explanation	2015/11/11
Notice of Discretionary Acts	2019/01/18
Price Validation Quarterly Report	2019/01/22

Locational Based Marginal Pricing

■ SESSION OBJECTIVES:

- Understand the Basics Behind LBMP
 - Definition
 - Show how LBMPs are Established
 - Name the Three Components of LBMP
- Complete Examples that Demonstrate LBMP Concepts
- Learn about the process of Price Validation

Additional Resources

- Tariffs - OATT & MST
- Day Ahead Scheduling Manual
- Transmission and Dispatching Operations Manual
- Market Participant User's Guide
- Technical Bulletins