Transmission Penalty Factors

MIC
October 11, 2017

Joe Bowring
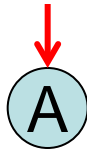Devendra Canchi
John Hyatt

Monitoring Analytics

Transmission Constraint Penalty Factors

- **In the PJM dispatch model, transmission constraints are violated under some conditions and flow exceeds the specified line limit**

- **Violated transmission constraints have defined penalty factors**

- **LMPs are affected by the penalty factors**

- **LMPs reflect the local scarcity**

Monitoring Analytics

A Simple Two Bus Example

Gen A
Offer: $25 per MWh
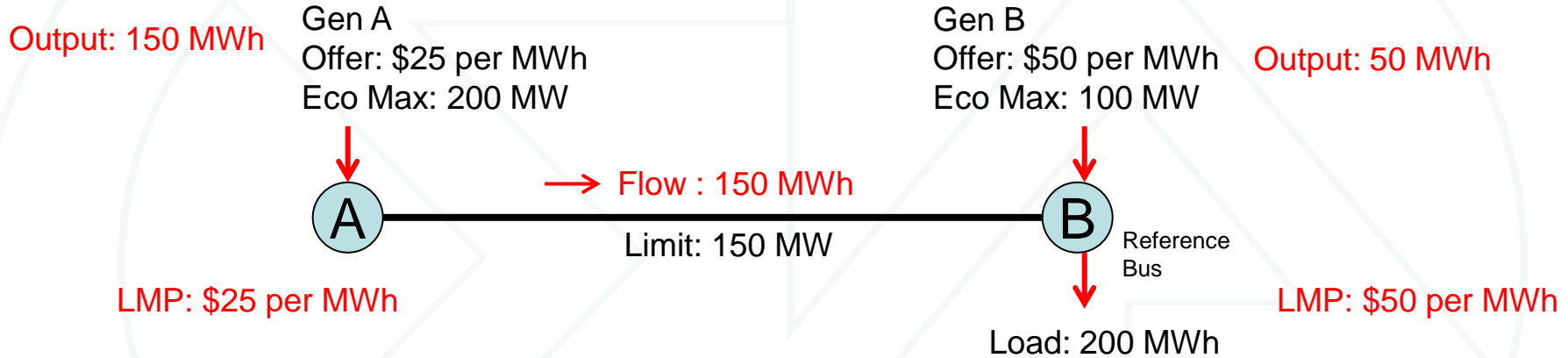Eco Max: 200 MW

Gen B
Offer: $50 per MWh
Eco Max: 100 MW

A ——————— Limit: 150 MW ——————— B   Reference
Bus

Load: 200 MWh

© 2017

Monitoring Analytics

A Simple Two Bus Example

Output: 150 MWh

Gen A
Offer: $25 per MWh
Eco Max: 200 MW

Gen B
Offer: $50 per MWh
Eco Max: 100 MW

Output: 50 MWh

Flow : 150 MWh

A ———————————————— **B**

Limit: 150 MW

Reference Bus

LMP: $25 per MWh

LMP: $50 per MWh

Load: 200 MWh
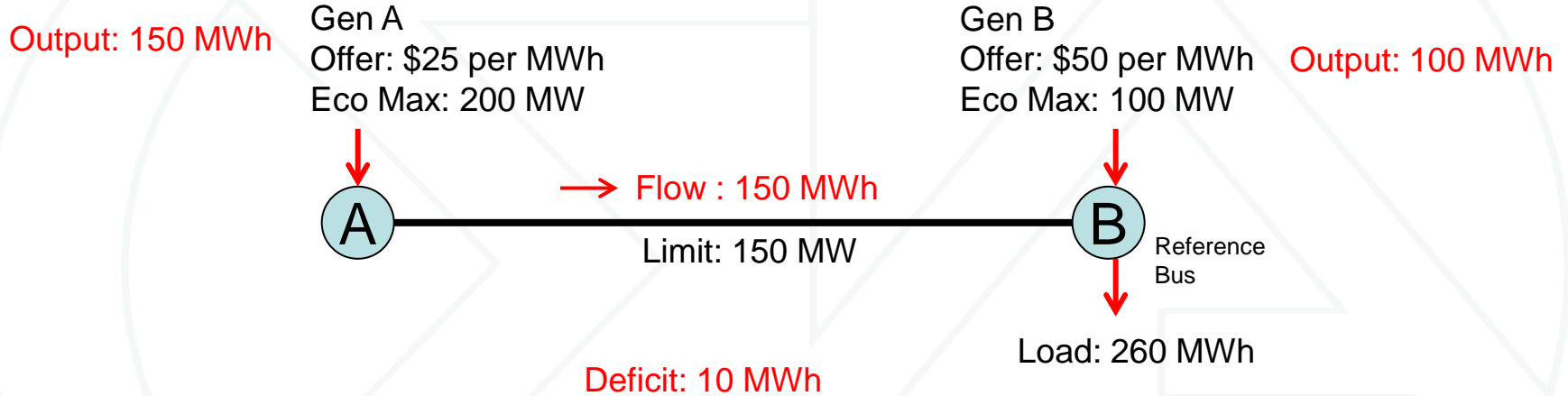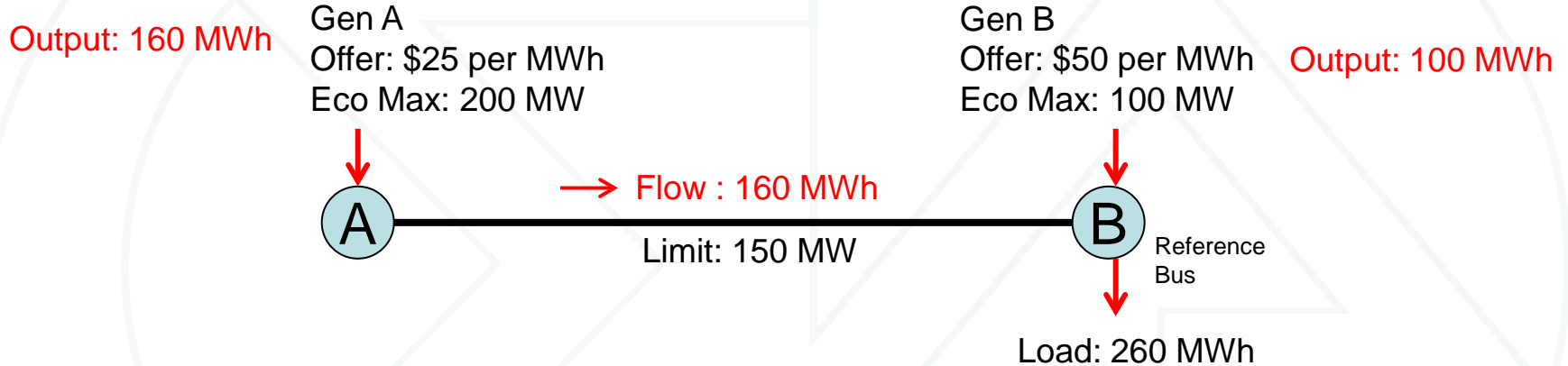
Shadow price is -$ 25 per MWh.
Shadow price represents the cost savings associated with increasing the transmission line limit by 1 MW

Monitoring Analytics

A Simple Two Bus Example

Output: 150 MWh

Gen A
Offer: $25 per MWh
Eco Max: 200 MW

Gen B
Offer: $50 per MWh
Eco Max: 100 MW

Output: 100 MWh

→ Flow : 150 MWh

A ——————— B

Limit: 150 MW

Reference Bus

Load: 260 MWh

Deficit: 10 MWh

The limit on the transmission line prevents extra generation to reach the load

Monitoring Analytics

A Simple Two Bus Example

Output: 160 MWh

Gen A
Offer: $25 per MWh
Eco Max: 200 MW

Gen B
Offer: $50 per MWh
Eco Max: 100 MW

Output: 100 MWh

→ Flow : 160 MWh

A —————————————— B

Limit: 150 MW

Reference Bus

Load: 260 MWh

Transmission constraint is violated
Every violation incurs a cost called transmission penalty factor
PJM currently values violations typically at $2,000 per MWh

Monitoring Analytics

A Simple Two Bus Example

Output: 160 MWh

Gen A
Offer: $25 per MWh
Eco Max: 200 MW

Gen B
Offer: $50 per MWh
Eco Max: 100 MW

Output: 100 MWh

Flow : 160 MWh

Limit: 150 MW

A

B

Reference Bus

LMP: $25 per MWh

LMP: $2,025 per MWh

Load: 260 MWh
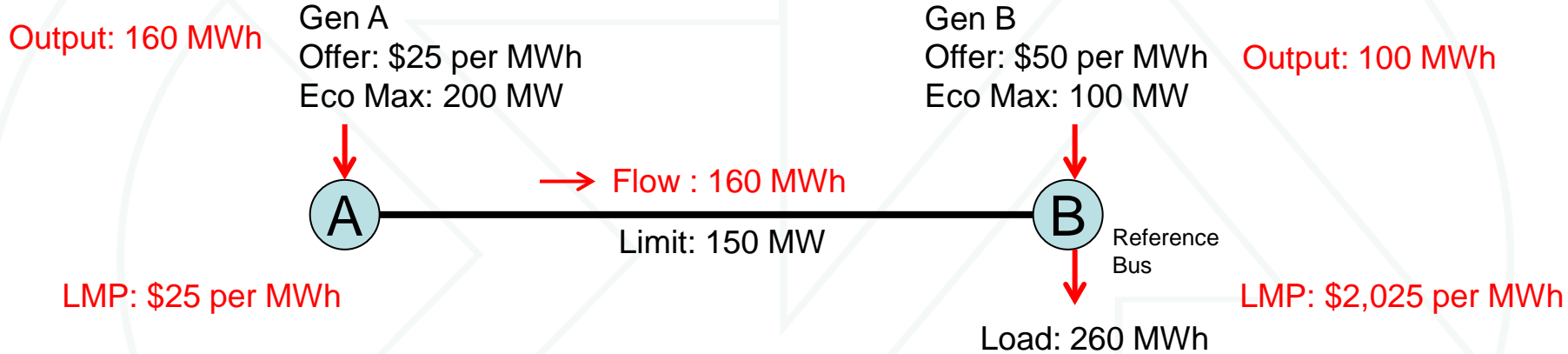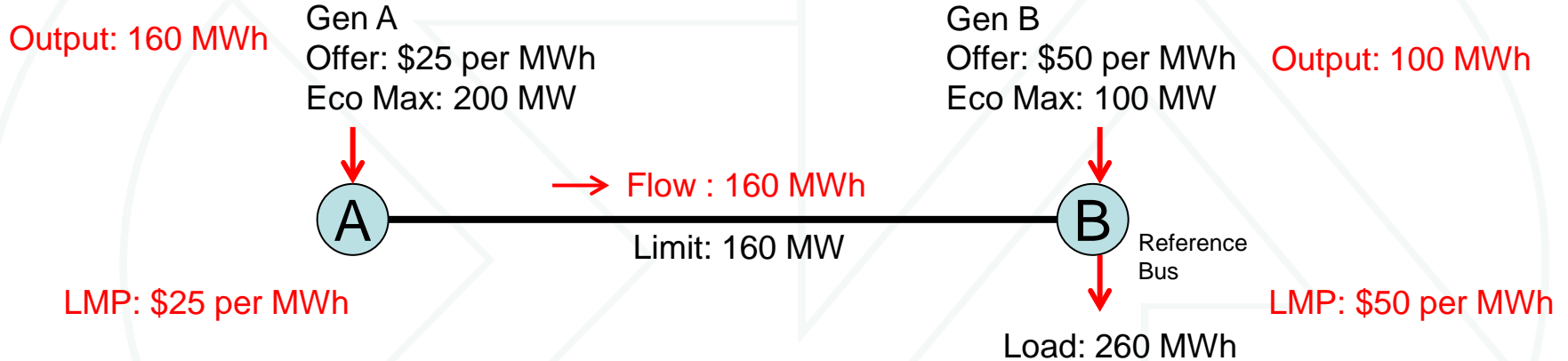
Shadow price: -$2,000 per MWh
Shadow price = Cost of Violation (Transmission Penalty Factor)

Monitoring Analytics

Constraint Relaxation Logic

- **The shadow price of a violated constraint should equal the transmission penalty factor**

- **PJM uses a method called "constraint relaxation logic" to affect shadow prices of violated transmission constraints**

- **The logic typically results in reducing the shadow prices to be slightly below the defined constraint violation penalty factor**

- **LMP is not related to marginal unit offers**

Monitoring Analytics

A Simple Two Bus Example

Output: 160 MWh

Gen A
Offer: $25 per MWh
Eco Max: 200 MW

Gen B
Offer: $50 per MWh
Eco Max: 100 MW

Output: 100 MWh

→ Flow : 160 MWh

A ———————————— B

Limit: 160 MW

Reference
Bus

LMP: $25 per MWh

LMP: $50 per MWh

Load: 260 MWh

Constraint Relaxation logic increases the line limit such that the constraint is not violated
Shadow price: -$50 per MWh

© 2017

Monitoring Analytics

Historical Data

	2013			2014			2015		
	Number of Constraints	Percent	Average Shadow price	Number of Constraints	Percent	Average Shadow price	Number of Constraints	Percent	Average Shadow price
PJM Internal Binding Transmission Constraints	60,538	49%	($172.93)	131,348	62%	($172.52)	140,545	66%	($159.27)
PJM Internal Violated Transmission Constraints	17,948	15%	($531.84)	32,398	15%	($640.62)	20,255	10%	($957.49)
Market to Market Transmission Constraints	45,210	37%	($299.24)	48,418	23%	($445.51)	51,680	24%	($281.89)
All Transmission Constraints	123,696	100%	($271.17)	212,164	100%	($306.30)	212,480	100%	($265.19)

	2016			2017 (Jan-Sep)		
	Number of Constraints	Percent	Average Shadow price	Number of Constraints	Percent	Average Shadow price
PJM Internal Binding Transmission Constraints	130,855	64%	($120.13)	62,893	60%	($112.11)
PJM Internal Violated Transmission Constraints	19,536	10%	($643.04)	7,071	7%	($605.87)
Market to Market Transmission Constraints	54,848	27%	($264.34)	34,239	33%	($347.48)
All Transmission Constraints	205,239	100%	($208.44)	104,203	100%	($222.95)

Monitoring Analytics

Monitoring Analytics, LLC

2621 Van Buren Avenue

Suite 160

Eagleville, PA

19403

(610) 271-8050

MA@monitoringanalytics.com

www.MonitoringAnalytics.com

Monitoring Analytics