

# Zone vs. Constraint Based Congestion

MMUAC

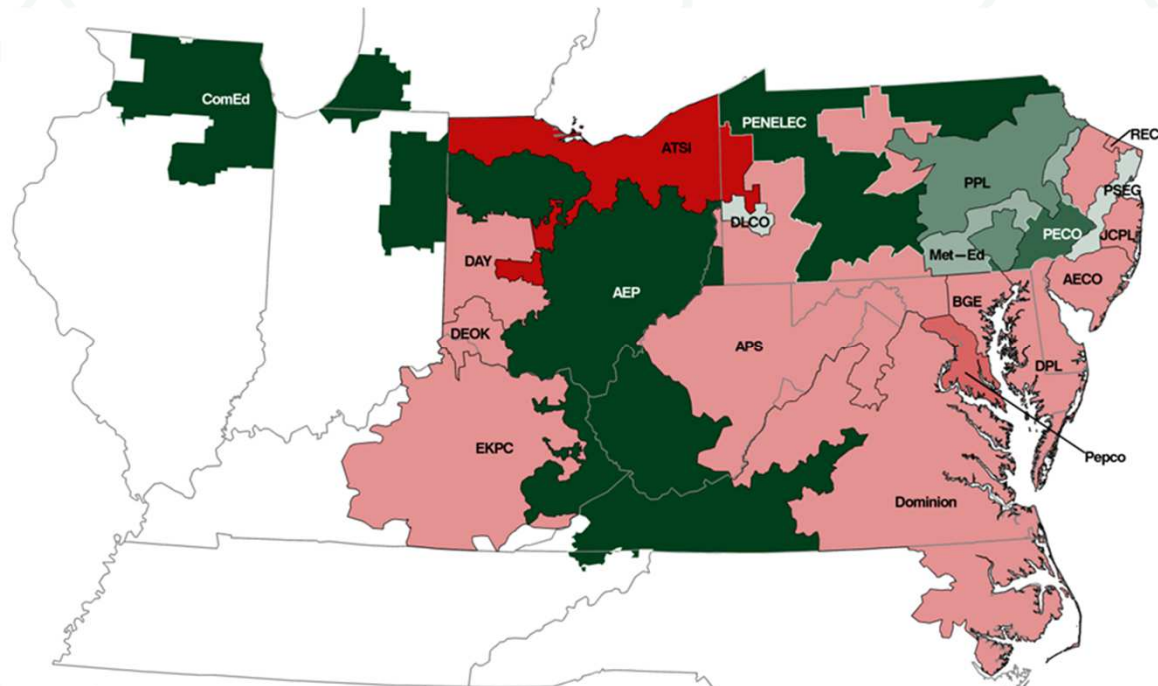
December 7, 2018

Howard Haas



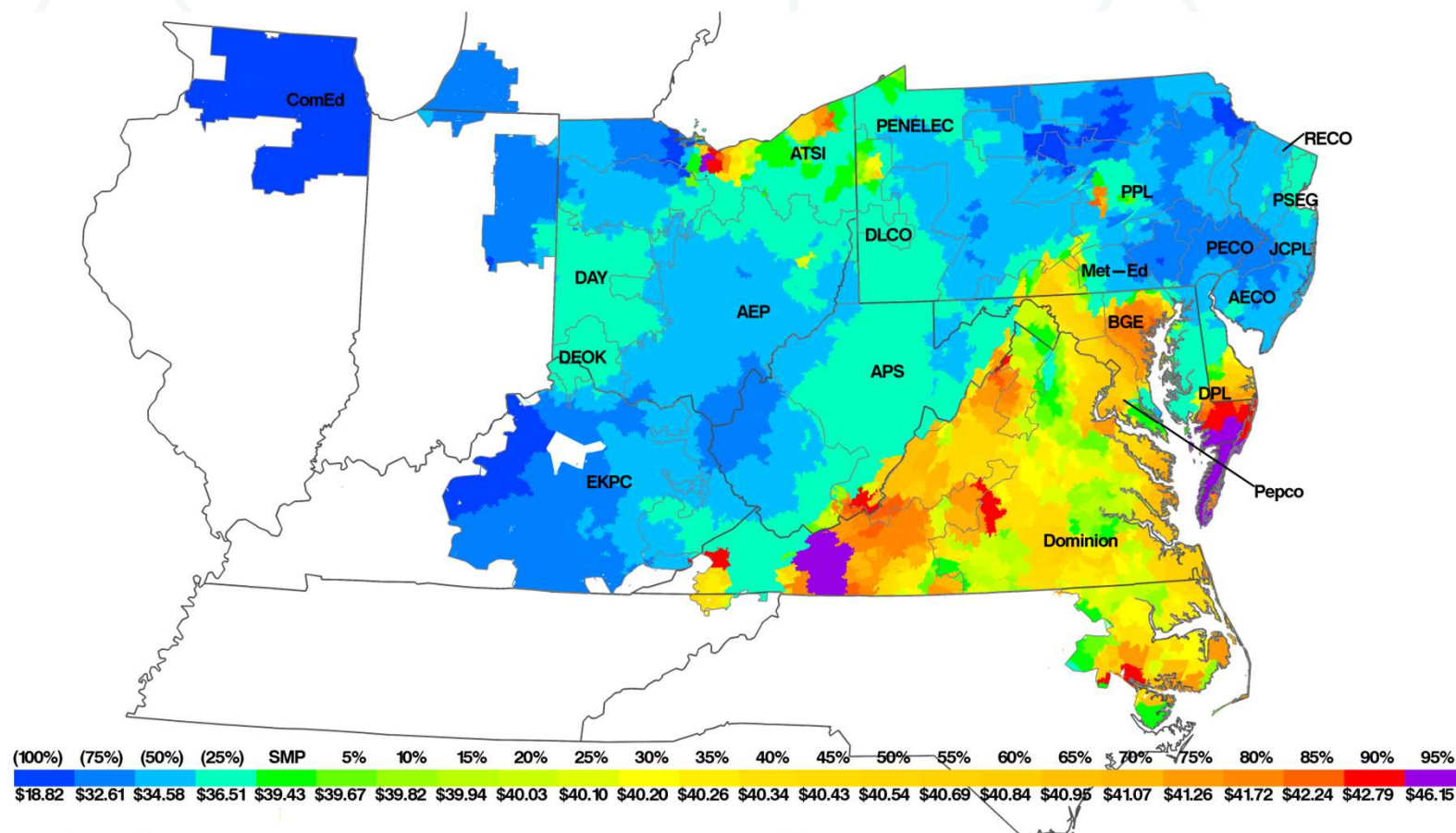
Monitoring Analytics

# Figure 3 18 Map of real-time generation, less real-time load, by zone: January through September, 2018

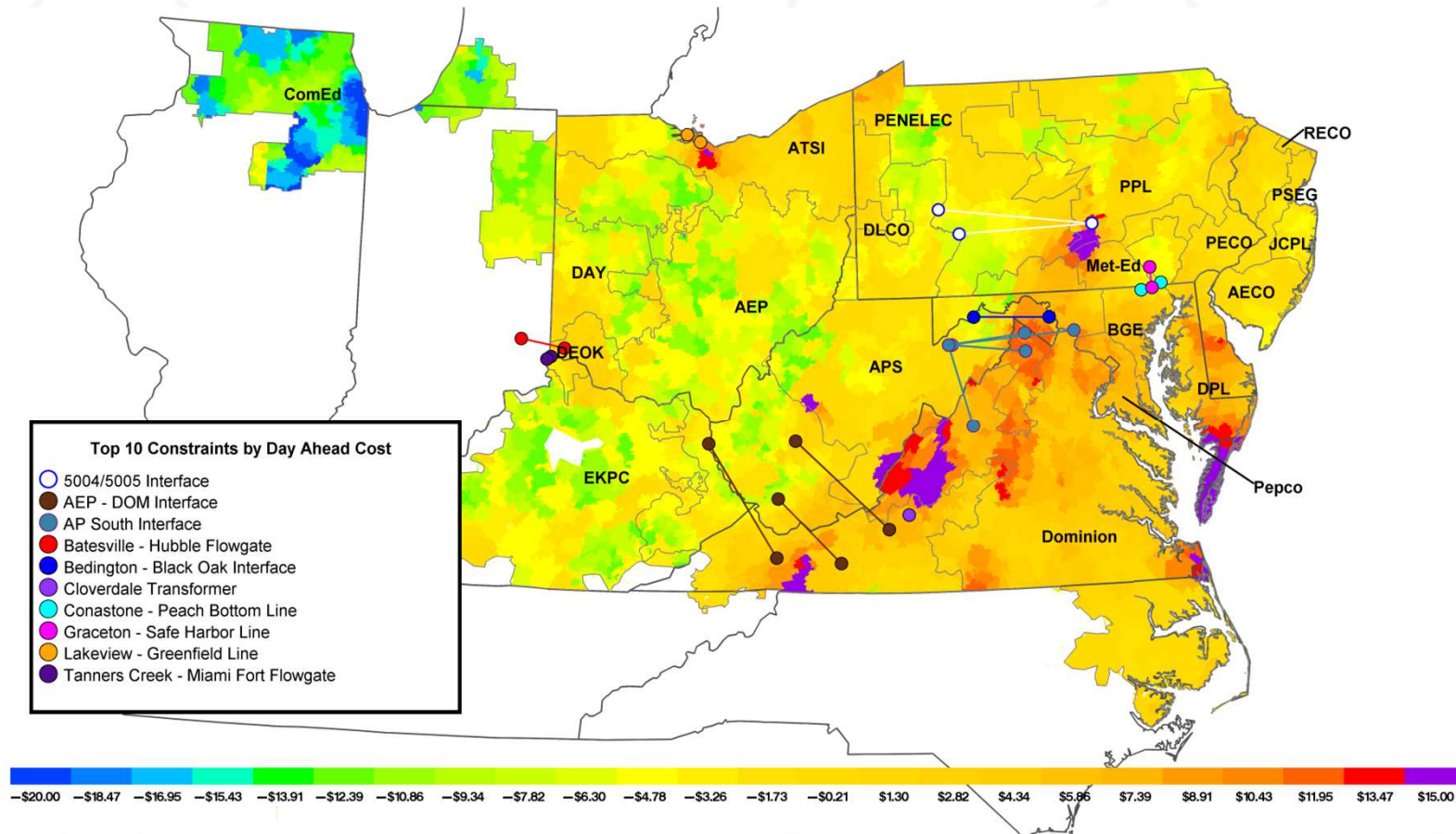


| Zone  | Net Gen Minus Load (GWh) | Zone     | Net Gen Minus Load (GWh) | Zone   | Net Gen Minus Load (GWh) | Zone    | Net Gen Minus Load (GWh) |
|-------|--------------------------|----------|--------------------------|--------|--------------------------|---------|--------------------------|
| AECO  | (3,625)                  | ComEd    | 25,724                   | DPL    | (9,321)                  | PENELEC | 19,980                   |
| AEP   | 25,755                   | DAY      | (8,769)                  | EKPC   | (2,963)                  | Pepco   | (13,669)                 |
| APS   | (1,915)                  | DEOK     | (7,742)                  | JCPL   | (4,762)                  | PPL     | 11,075                   |
| AT SI | (21,962)                 | DLCO     | 1,589                    | Met-Ed | 5,343                    | PSEG    | 1,770                    |
| BGE   | (7,982)                  | Dominion | (2,976)                  | PECO   | 19,548                   | RECO    | (1,153)                  |

# Figure 3-46 Real-time, load-weighted, average LMP: January through September, 2018



# Figure 11-4 Location of the top 10 constraints by PJM day-ahead congestion costs: January through September, 2018





**Table 11-4 Zonal and PJM real-time, load-weighted average LMP components (Dollars per MWh): January through September, 2017 and 2018**

|          | 2017 (Jan - Sep) |                  |                      |                | 2018 (Jan - Sep) |                  |                      |                |
|----------|------------------|------------------|----------------------|----------------|------------------|------------------|----------------------|----------------|
|          | Real-Time LMP    | Energy Component | Congestion Component | Loss Component | Real-Time LMP    | Energy Component | Congestion Component | Loss Component |
| AECO     | \$28.38          | \$30.48          | (\$2.49)             | \$0.39         | \$37.27          | \$38.62          | (\$2.30)             | \$0.95         |
| AEP      | \$30.15          | \$30.14          | \$0.27               | (\$0.26)       | \$38.79          | \$39.38          | (\$0.02)             | (\$0.57)       |
| APS      | \$30.56          | \$30.22          | \$0.33               | \$0.01         | \$41.51          | \$39.74          | \$1.51               | \$0.26         |
| ATSI     | \$31.19          | \$30.16          | \$0.46               | \$0.58         | \$41.48          | \$38.63          | \$2.31               | \$0.55         |
| BGE      | \$33.73          | \$30.56          | \$2.18               | \$0.99         | \$46.51          | \$40.19          | \$4.85               | \$1.47         |
| ComEd    | \$28.64          | \$30.30          | (\$0.67)             | (\$1.00)       | \$29.97          | \$38.39          | (\$6.42)             | (\$1.99)       |
| DAY      | \$31.14          | \$30.30          | \$0.32               | \$0.52         | \$39.98          | \$39.27          | \$0.11               | \$0.60         |
| DEOK     | \$30.68          | \$30.29          | \$1.07               | (\$0.68)       | \$40.56          | \$39.21          | \$2.38               | (\$1.04)       |
| DLOO     | \$30.58          | \$30.27          | \$0.43               | (\$0.11)       | \$41.19          | \$38.71          | \$2.38               | \$0.10         |
| Dominion | \$32.19          | \$30.49          | \$1.39               | \$0.32         | \$45.28          | \$40.45          | \$4.28               | \$0.54         |
| DPL      | \$30.36          | \$30.59          | (\$0.93)             | \$0.70         | \$44.03          | \$40.44          | \$1.76               | \$1.82         |
| EKPC     | \$29.25          | \$30.49          | (\$0.50)             | (\$0.74)       | \$36.98          | \$41.38          | (\$2.99)             | (\$1.41)       |
| JOPL     | \$29.72          | \$30.78          | (\$1.33)             | \$0.26         | \$38.10          | \$39.14          | (\$1.83)             | \$0.79         |
| Met-Ed   | \$30.32          | \$30.32          | (\$0.17)             | \$0.17         | \$37.97          | \$39.28          | (\$1.79)             | \$0.48         |
| PECO     | \$28.42          | \$30.40          | (\$2.01)             | \$0.04         | \$37.63          | \$39.24          | (\$2.16)             | \$0.55         |
| PENELEC  | \$29.28          | \$29.95          | (\$0.87)             | \$0.19         | \$38.83          | \$38.82          | (\$0.43)             | \$0.45         |
| Pepco    | \$32.63          | \$30.51          | \$1.50               | \$0.63         | \$44.76          | \$39.96          | \$3.82               | \$0.99         |
| PPL      | \$28.85          | \$30.23          | (\$1.35)             | (\$0.04)       | \$37.33          | \$39.63          | (\$2.46)             | \$0.15         |
| PSEG     | \$29.38          | \$30.36          | (\$1.23)             | \$0.25         | \$37.70          | \$38.56          | (\$1.61)             | \$0.75         |
| RECO     | \$30.02          | \$30.88          | (\$1.19)             | \$0.32         | \$38.30          | \$38.78          | (\$1.18)             | \$0.70         |
| PJM      | \$30.36          | \$30.32          | \$0.02               | \$0.01         | \$39.43          | \$39.37          | \$0.04               | \$0.02         |



# Area Based and Constraint Based Total Day Ahead and Total Balancing Congestion by Zone (Dollars (Millions)): January through September, 2018

| Control Zone | Congestion Costs (Millions) |           |           |                  |           |           |
|--------------|-----------------------------|-----------|-----------|------------------|-----------|-----------|
|              | Area Based                  |           |           | Constraint Based |           |           |
|              | Day-Ahead                   | Balancing | Total     | Day-Ahead        | Balancing | Total     |
| AECO         | (\$1.1)                     | (\$2.4)   | (\$3.5)   | \$9.6            | (\$0.6)   | \$9.0     |
| AEP          | \$335.8                     | (\$31.2)  | \$304.6   | \$187.1          | \$1.0     | \$188.1   |
| APS          | \$51.2                      | (\$1.4)   | \$49.9    | \$51.6           | \$1.9     | \$53.5    |
| ATSI         | \$80.1                      | (\$19.0)  | \$61.1    | \$81.0           | (\$0.3)   | \$80.7    |
| BGE          | \$52.0                      | (\$0.7)   | \$51.3    | \$61.9           | \$1.7     | \$63.6    |
| ComEd        | \$157.7                     | \$44.0    | \$201.7   | \$62.2           | (\$47.0)  | \$15.2    |
| DAY          | \$13.1                      | (\$1.4)   | \$11.7    | \$33.2           | \$0.7     | \$33.9    |
| DEOK         | \$70.7                      | (\$9.3)   | \$61.5    | \$120.4          | \$6.5     | \$126.9   |
| DLCO         | \$5.4                       | \$0.9     | \$6.3     | \$15.6           | \$1.1     | \$16.7    |
| Dominion     | \$80.1                      | (\$5.0)   | \$75.0    | \$199.4          | \$7.2     | \$206.6   |
| DPL          | \$31.6                      | \$3.0     | \$34.6    | \$61.6           | \$1.2     | \$62.8    |
| EKPC         | (\$17.2)                    | \$4.7     | (\$12.5)  | \$11.7           | (\$2.0)   | \$9.7     |
| EXT          | (\$1.6)                     | (\$4.5)   | (\$6.1)   | \$0.7            | (\$0.0)   | \$0.7     |
| JCPL         | \$22.9                      | (\$13.6)  | \$9.2     | \$23.0           | (\$1.4)   | \$21.6    |
| Met-Ed       | \$27.8                      | (\$5.1)   | \$22.7    | \$30.3           | (\$1.3)   | \$28.9    |
| PECO         | \$81.6                      | \$0.7     | \$82.3    | \$34.8           | (\$1.7)   | \$33.1    |
| PENELEC      | \$61.6                      | (\$4.0)   | \$57.6    | \$21.3           | \$0.7     | \$22.0    |
| Pepco        | \$44.3                      | \$3.8     | \$48.1    | \$50.6           | \$1.5     | \$52.1    |
| PPL          | \$10.9                      | \$11.7    | \$22.6    | \$39.1           | (\$3.2)   | \$36.0    |
| PSEG         | \$45.4                      | (\$6.0)   | \$39.4    | \$53.3           | (\$1.2)   | \$52.0    |
| RECO         | (\$0.7)                     | (\$0.6)   | (\$1.2)   | \$3.2            | (\$0.0)   | \$3.2     |
| Total        | \$1,151.7                   | (\$35.5)  | \$1,116.2 | \$1,151.7        | (\$35.5)  | \$1,116.2 |



# Area Based and Constraint Based Total Day Ahead and Total Balancing Congestion by Zone (Dollars (Millions)): January through September, 2017

| Control Zone | Congestion Costs (Millions) |           |          |                  |           |         |
|--------------|-----------------------------|-----------|----------|------------------|-----------|---------|
|              | Area Based                  |           |          | Constraint Based |           |         |
|              | Day-Ahead                   | Balancing | Total    | Day-Ahead        | Balancing | Total   |
| AECO         | (\$3.3)                     | (\$1.1)   | (\$4.3)  | \$2.3            | (\$0.3)   | \$2.0   |
| AEP          | \$52.4                      | \$5.7     | \$58.0   | \$73.3           | (\$1.9)   | \$71.4  |
| APS          | \$10.6                      | \$0.3     | \$10.9   | \$15.2           | (\$2.0)   | \$13.2  |
| ATSI         | \$21.7                      | (\$6.6)   | \$15.1   | \$19.6           | \$0.7     | \$20.3  |
| BGE          | \$32.6                      | (\$2.5)   | \$30.1   | \$27.6           | (\$0.4)   | \$27.2  |
| ComEd        | \$159.2                     | (\$10.9)  | \$148.4  | \$129.7          | (\$22.1)  | \$107.6 |
| DAY          | \$0.7                       | \$0.8     | \$1.4    | \$5.0            | (\$0.1)   | \$5.0   |
| DEOK         | \$11.5                      | \$2.6     | \$14.2   | \$17.6           | \$1.7     | \$19.3  |
| DLCO         | (\$0.4)                     | (\$0.3)   | (\$0.7)  | \$3.1            | (\$0.2)   | \$2.9   |
| Dominion     | \$35.0                      | (\$7.2)   | \$27.8   | \$60.8           | (\$3.6)   | \$57.2  |
| DPL          | (\$4.3)                     | \$4.7     | \$0.4    | \$18.6           | \$4.6     | \$23.3  |
| EKPC         | (\$2.4)                     | \$1.4     | (\$0.9)  | \$3.2            | (\$1.8)   | \$1.3   |
| EXT          | (\$13.3)                    | (\$11.5)  | (\$24.8) | (\$0.2)          | \$0.0     | (\$0.2) |
| JCPL         | \$3.2                       | \$0.0     | \$3.2    | \$8.8            | (\$0.2)   | \$8.6   |
| Met-Ed       | \$12.7                      | \$1.3     | \$14.0   | \$11.9           | \$1.7     | \$13.6  |
| PECO         | \$59.5                      | (\$4.5)   | \$55.0   | \$13.5           | (\$0.9)   | \$12.6  |
| PENELEC      | \$37.4                      | (\$7.3)   | \$30.1   | \$10.3           | (\$1.6)   | \$8.8   |
| Pepco        | \$22.4                      | \$3.3     | \$25.7   | \$20.1           | (\$0.8)   | \$19.3  |
| PPL          | \$21.0                      | \$3.5     | \$24.5   | \$17.6           | \$0.3     | \$17.8  |
| PSEG         | \$27.5                      | \$0.9     | \$28.5   | \$23.6           | (\$0.4)   | \$23.2  |
| RECO         | (\$1.3)                     | \$0.1     | (\$1.2)  | \$0.8            | (\$0.0)   | \$0.7   |
| Total        | \$482.5                     | (\$27.1)  | \$455.4  | \$482.5          | (\$27.1)  | \$455.4 |



# System Example

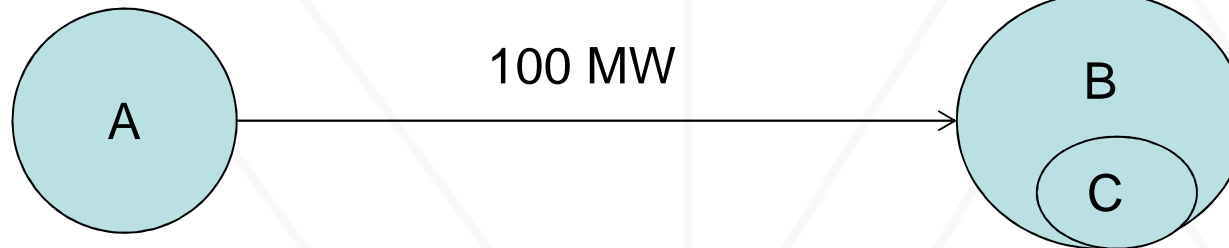
A  
Load: 800  
Gen: 900

LMP = \$5

| Type | Total MW |
|------|----------|
| Load | 1,600    |
| Gen  | 1,600    |

B  
Load: 400  
Gen: 650

LMP = \$15



|      | A     | Constraint | B    | C    |
|------|-------|------------|------|------|
| LMP  | \$5   |            | \$15 | \$15 |
| SMP  | \$10  | \$10       | \$10 | \$10 |
| CLMP | (\$5) | ---->      | \$5  | \$5  |

C  
Load: 400  
Gen: 50

LMP = \$15

Shadow price of constraint = \$10



## System Example

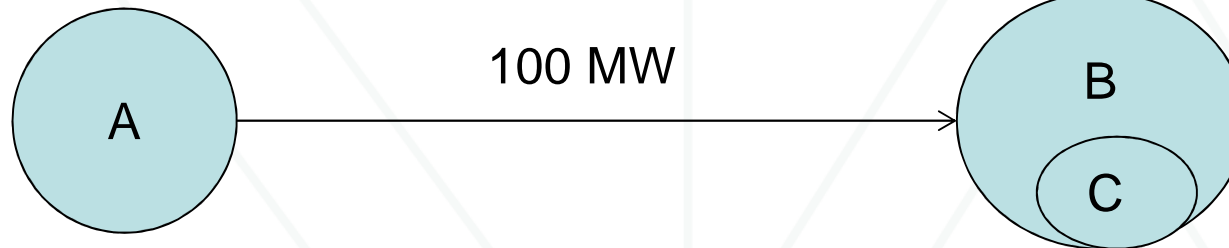
A  
Load: 800  
Gen: 900

LMP = \$5

| Type | Total MW |
|------|----------|
| Load | 1,600    |
| Gen  | 1,600    |

B  
Load: 400  
Gen: 650

LMP = \$15



|      | A     | Constraint | B    | C    |
|------|-------|------------|------|------|
| LMP  | \$5   |            | \$15 | \$15 |
| SMP  | \$10  | \$10       | \$10 | \$10 |
| CLMP | (\$5) | ---->      | \$5  | \$5  |

C  
Load: 400  
Gen: 50

LMP = \$15

Shadow price of constraint = \$10  
Total congestion = \$10 x 100 MW  
Total congestion = \$1,000

Congestion = The difference between total charges to load and total payments to generation caused by binding transmission constraints.

# System Example

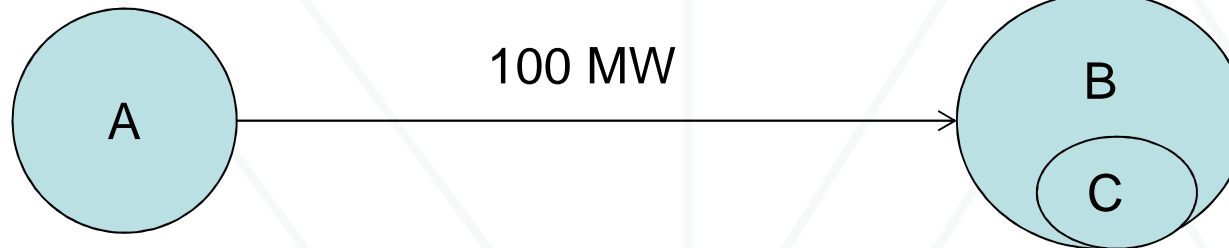
A  
Load: 800  
Gen: 900

LMP = \$5

| Type | Total MW |
|------|----------|
| Load | 1,600    |
| Gen  | 1,600    |

B  
Load: 400  
Gen: 650

LMP= \$15



C  
Load: 400  
Gen: 50

LMP= \$15

|      | A     | Constraint | B    | C    |
|------|-------|------------|------|------|
| LMP  | \$5   |            | \$15 | \$15 |
| SMP  | \$10  | \$10       | \$10 | \$10 |
| CLMP | (\$5) | ---->      | \$5  | \$5  |

|                  |           | 100                            |              |              |
|------------------|-----------|--------------------------------|--------------|--------------|
| Load MW          | 800       | Load Weighted<br>Reference Bus | 400          | 400          |
| Gen MW           | 900       |                                | 650          | 50           |
| Zone Based A     |           |                                | Zone Based B | Zone Based C |
| Congestion Load  | (\$4,000) |                                | \$2,000      | \$2,000      |
| Congestion Gen   | (\$4,500) |                                | \$3,250      | \$250        |
| Total Congestion | \$500     |                                | (\$1,250)    | \$1,750      |

|  |
|--|
| Total Zone<br>Congestion<br>(Area Method)<br>For B and C |
| \$500  |

|                                |
|--------------------------------|
| Total Congestion<br>for system |
| \$1,000                        |

## System Example

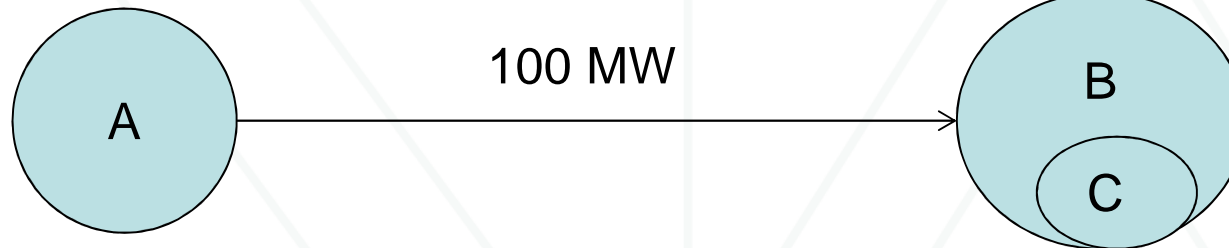
A  
Load: 800  
Gen: 900

LMP = \$5

| Type | Total MW |
|------|----------|
| Load | 1,600    |
| Gen  | 1,600    |

B  
Load: 400  
Gen: 650

LMP = \$15



|      | A     | Constraint | B    | C    |
|------|-------|------------|------|------|
| LMP  | \$5   |            | \$15 | \$15 |
| SMP  | \$10  | \$10       | \$10 | \$10 |
| CLMP | (\$5) | ---->      | \$5  | \$5  |

|         |     |                                |     |     |
|---------|-----|--------------------------------|-----|-----|
|         |     | 100                            |     |     |
| Load MW | 800 | Load Weighted<br>Reference Bus | 400 | 400 |
| Gen MW  | 900 |                                | 650 | 50  |

C  
Load: 400  
Gen: 50

LMP = \$15

| Total Congestion<br>for system |
|--------------------------------|
| \$1,000                        |

Load is paying more for energy than gen is being paid for energy due to constraints.

Load downstream of constraints pay congestion.

# System Example

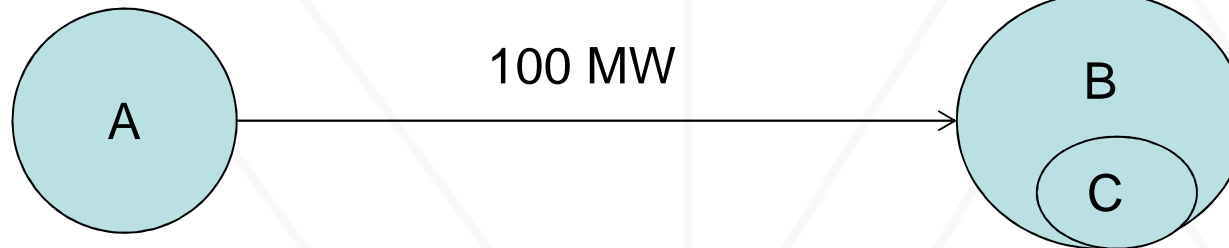
A  
Load: 800  
Gen: 900

LMP = \$5

| Type | Total MW |
|------|----------|
| Load | 1,600    |
| Gen  | 1,600    |

B  
Load: 400  
Gen: 650

LMP= \$15



C  
Load: 400  
Gen: 50

LMP= \$15

|      | A     | Constraint | B    | C    |
|------|-------|------------|------|------|
| LMP  | \$5   |            | \$15 | \$15 |
| SMP  | \$10  | \$10       | \$10 | \$10 |
| CLMP | (\$5) | ---->      | \$5  | \$5  |

|         |     |                                |     |     |
|---------|-----|--------------------------------|-----|-----|
|         |     | 100                            |     |     |
| Load MW | 800 | Load Weighted<br>Reference Bus | 400 | 400 |
| Gen MW  | 900 |                                | 650 | 50  |

| Constraint Specific     | Zone B  | Zone C  |
|-------------------------|---------|---------|
| Load Congestion Charges | \$2,000 | \$2,000 |
| Proportion of Charges   | 50%     | 50%     |
| Total Congestion        | \$1,000 | \$500   |

| Total Congestion<br>for system |
|--------------------------------|
| \$1,000                        |



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