Basic Congestion Concepts and Calculating Project Benefits

MEPETF

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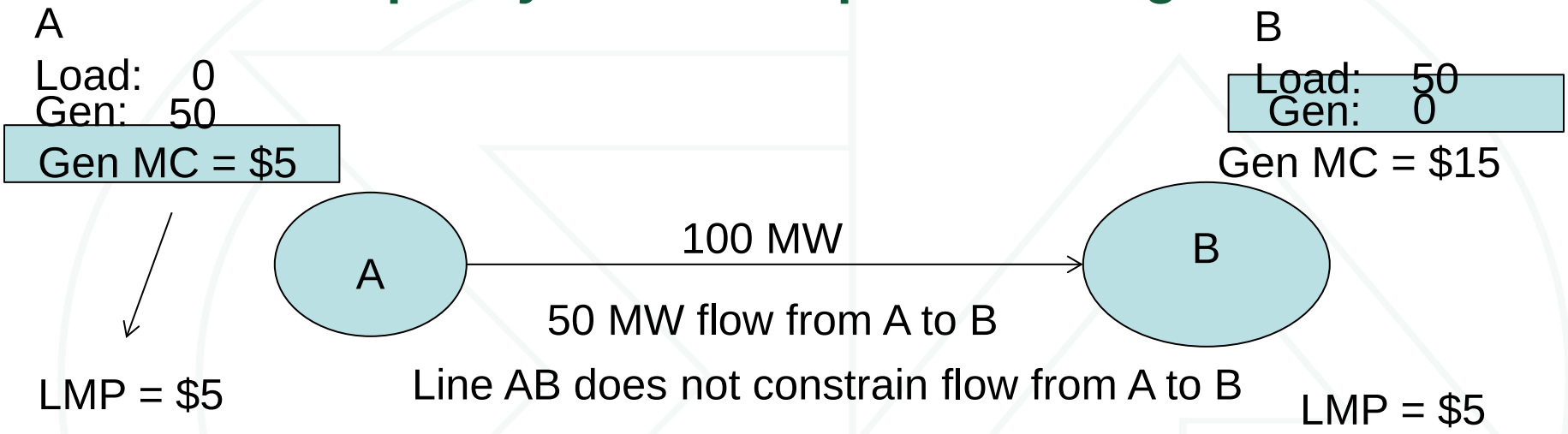
Monitoring Analytics

Congestion

- **Congestion = The difference between total charges to load and total payments to generation caused by binding transmission constraints.**
  - **Binding transmission constraints cause price differences on the system**
  - **With binding constraints, load pays more for energy than generation gets paid for energy**
  - **Generation upstream of a binding constraint is paid lower prices than generation downstream of a binding constraint**
  - **Load downstream of a binding constraint pays the higher (upstream price) for all of its energy**
  - **The difference in payments from load to generators is congestion**

Simple System Example: No Congestion



What are the LMPs at A and B?

	A	Constraint	B
LMP	$5	---->	$5

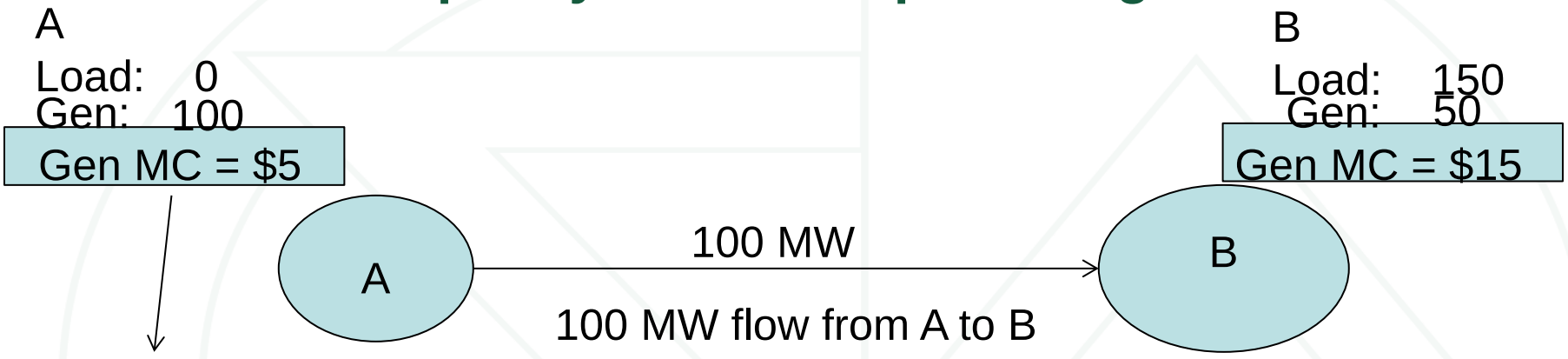
	Zone A	Zone B
Load MW	0	50
Marginal Price of Power	$5.00	$5.00

(LMP x MW)	Zone A	Zone B	Total
Load Charges	$0.00	$250.00	$250.00
Generation Credits	$250.00	$0.00	$250.00
Total Credits/Charges	($250.00)	$250.00	$0

Congestion= Load Charges – Gen Credits

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

Simple System Example: Congestion



	A	Constraint	B
LMP	$5	---->	$15

	Zone A	Zone B
Load MW	0	150
Marginal Price of Power	$5.00	$15.00

(LMP x MW)	Zone A	Zone B	Total
Load Charges	$0.00	$2,250.00	$2,250.00
Generation Credits	$500.00	$750.00	$1,250.00
Total Credits/Charges	($500.00)	$1,500.00	$1,000

Congestion= Load Charges – Gen Credits

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

Allocation of congestion: Affect on Average Cost of Load

	A	Constraint	B
LMP	$5	---->	$15
SMP	$5		$5
CLMP	$0		$10
	Reference Bus	100	
Load MW	0		150
Gen MW	100		50

CLMP x MW	Zone Based A	Zone Based B	Total Congestion
Load Charges	$0	$1,500	$1,500
Gen Credits	$0	$500	$500
Total Charges	$0	$1,000	$1,000

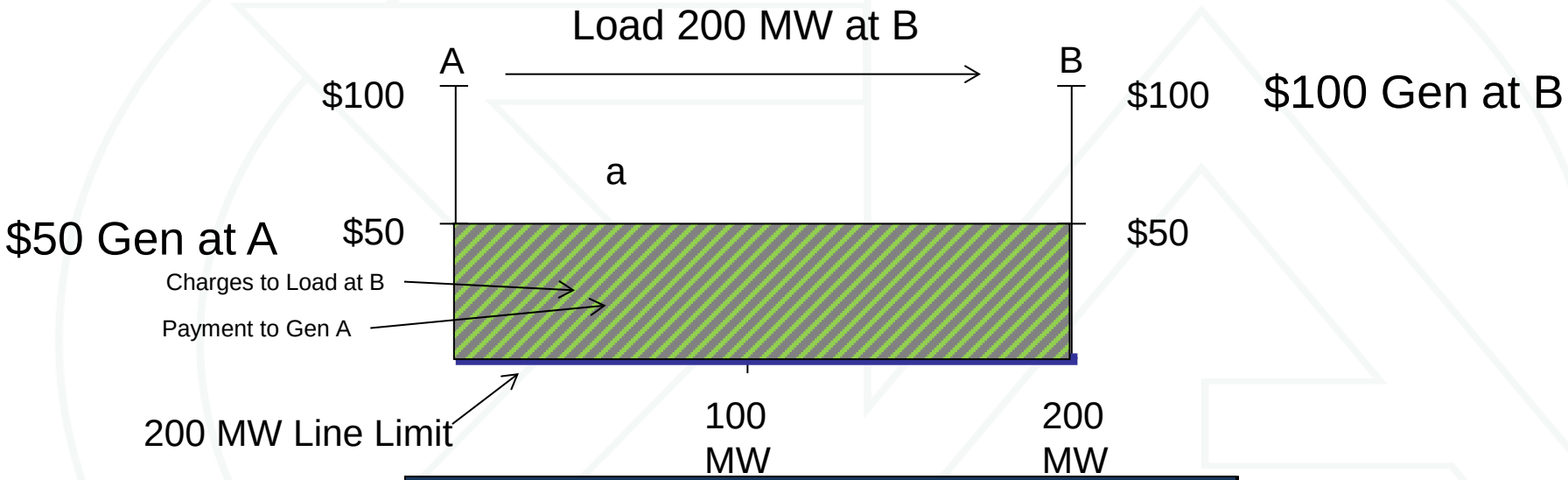
	Zone A	Zone B
Load MW	0	150
Marginal Price of Power	$5.00	$15.00
Total Load Charges	$0.00	$2,250.00
Average Cost of Power	$5.00	$15.00
Congestion Allocation	$0.00	$1,000.00
Net Load Charges	$0.00	$1,250.00
Marginal Price of Power	$5.00	$15.00
Average Cost of Power	NA	$8.33

Marginal Price does not change

With correct congestion allocation, average cost of power reflects actual average cost for serving zone

No constraints

Congestion

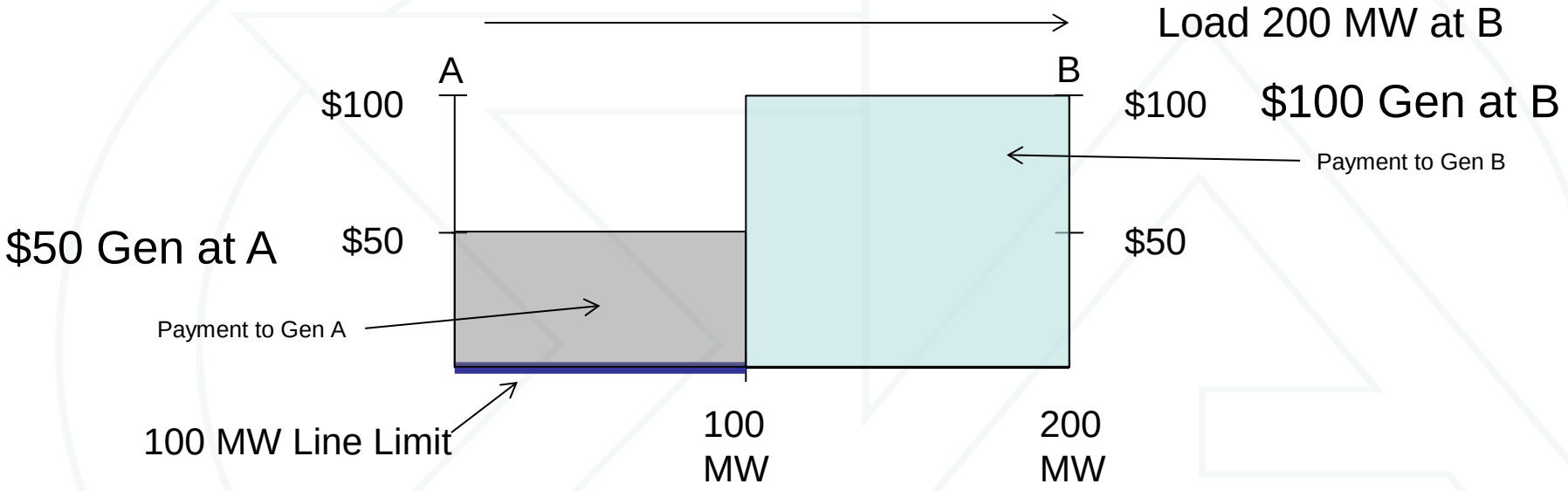


Day Ahead	Bus A	Transfer A to B	Bus B
Price	$50		$50
Load	-	→	200
Generation	200	200	-

Day Ahead	Bus A	Bus B	Congestion
Load	$ -	$ 10,000	
Generation	$ 10,000	$ -	
Total	($10,000)	$10,000	$0

Congestion: Binding Constraints

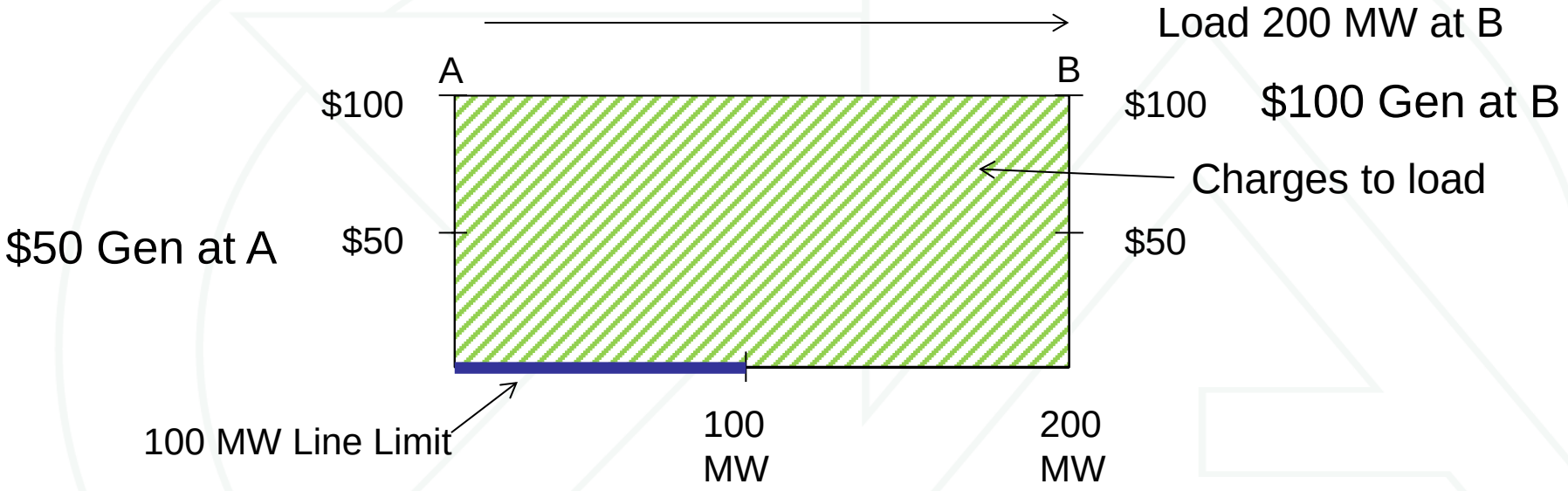
Congestion



Day Ahead	Bus A	Transfer A to B	Bus B	
Price	$50		$100	
Load	-	→	200	
Generation	100	100 MW	100	
Day Ahead	**Bus A**		**Bus B**	**Congestion**
Load	$ -		$ 20,000	
Generation	$ 5,000		$ 10,000	
Total	($5,000)		$10,000	$5,000

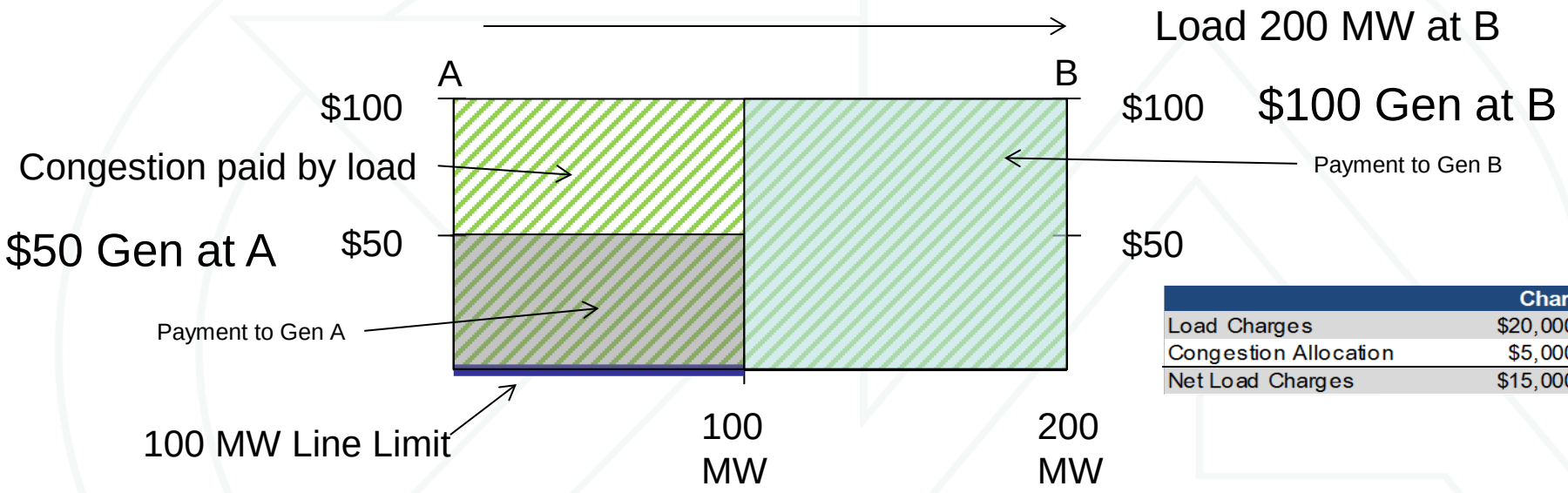
Monitoring Analytics

Congestion



Day Ahead	Bus A	Transfer A to B	Bus B	
Price	$50		$100	
Load	-	→	200	
Generation	100	100 MW	100	
Day Ahead	**Bus A**		**Bus B**	**Congestion**
Load	$ -		$20,000	
Generation	$ 5,000		$10,000	
Total	($5,000)		$10,000	$5,000

Congestion



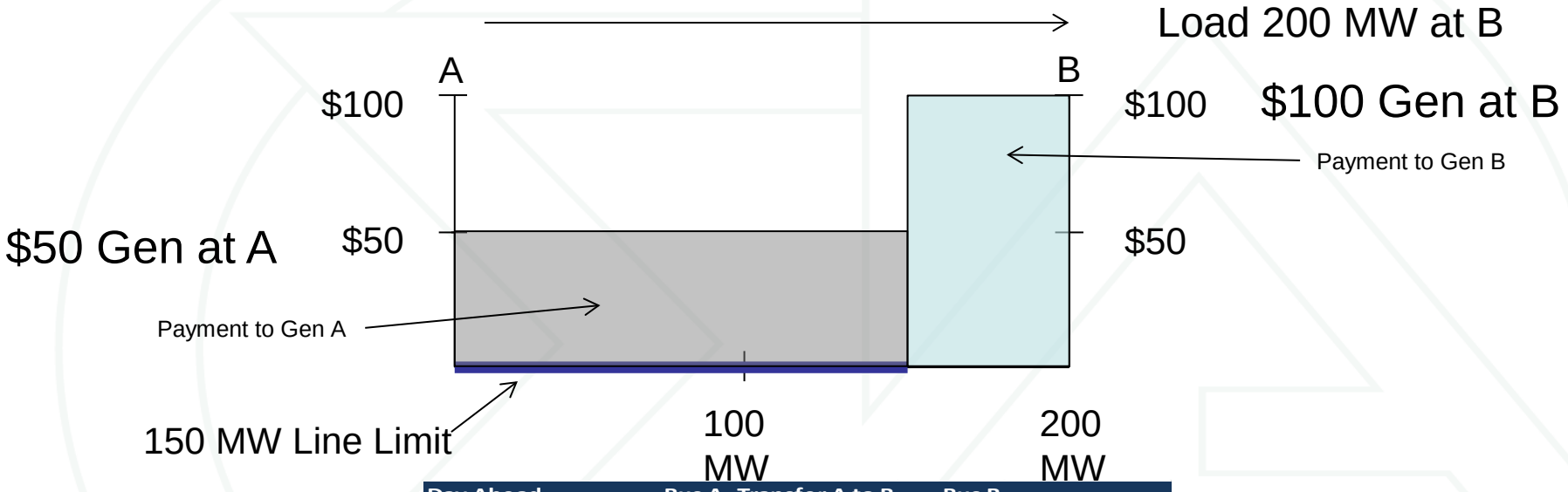
	Charges
Load Charges	$20,000.00
Congestion Allocation	$5,000.00
Net Load Charges	$15,000.00

Day Ahead	Bus A	Transfer A to B	Bus B
Price	$50		$100

LMP	MW	Total Load Charges	Average Cost	Congestion Allocation	Net Load Bill	Average Cost
$ 100	200	$20,000.00	$100.00	$5,000.00	$15,000.00	$75.00
Load		$ -		$20,000		
Generation		$ 5,000		$10,000		
Total		($5,000)		$10,000	$5,000	

Congestion: Constraint with Increased Line Limit

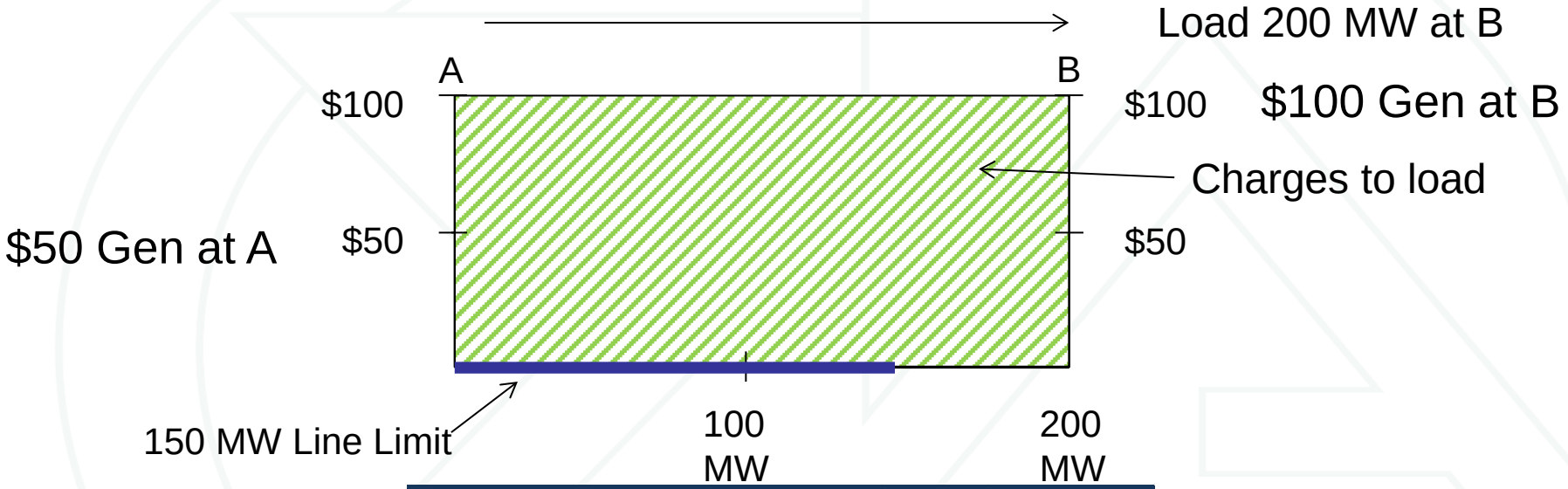
Congestion



Day Ahead	Bus A	Transfer A to B	Bus B	
Price	$50		$100	
Load	-	→	200	
Generation	150	150 MW	50	
Day Ahead	**Bus A**		**Bus B**	**Congestion**
Load	$ -		$20,000	
Generation	$ 7,500		$ 5,000	
Total	($7,500)		$15,000	$7,500

Monitoring Analytics

Congestion

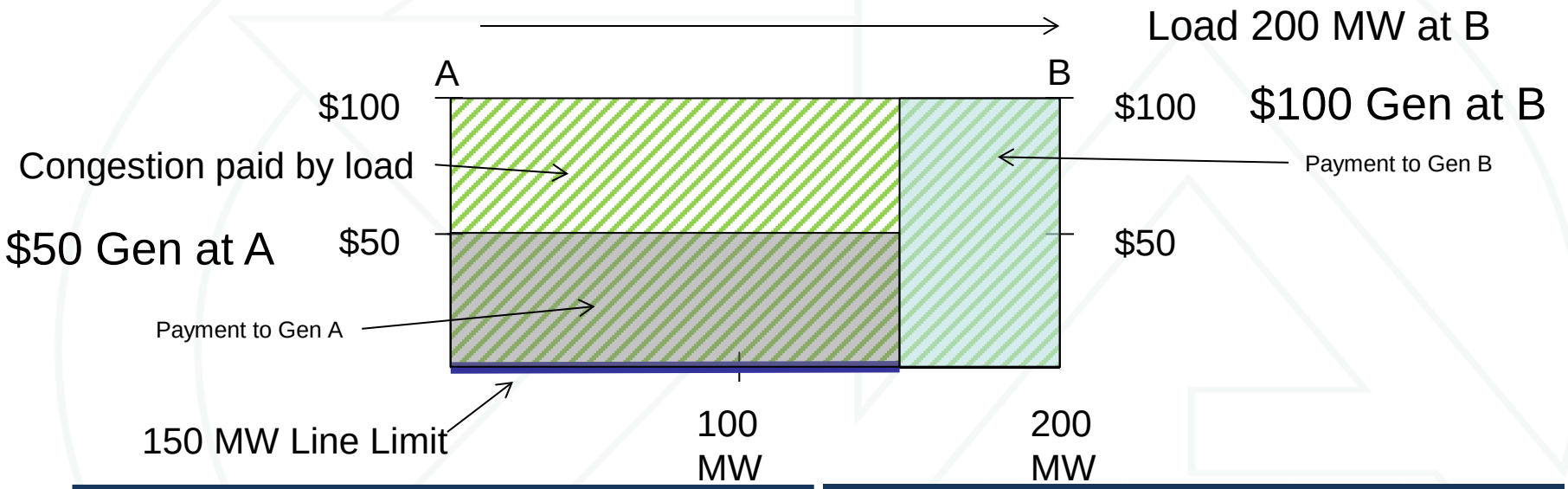


Day Ahead	Bus A	Transfer A to B	Bus B
Price	$50		$100
Load	-	→	200
Generation	150	150 MW	50

Day Ahead	Bus A	Bus B	Congestion
Load	$ -	$20,000	
Generation	$ 7,500	$ 5,000	
Total	($7,500)	$15,000	$7,500

Monitoring Analytics

Congestion



Day Ahead	Bus A	Transfer A to B	Bus B
Price	$50		$100
Load	-	→	200
Generation	100	100 MW	100

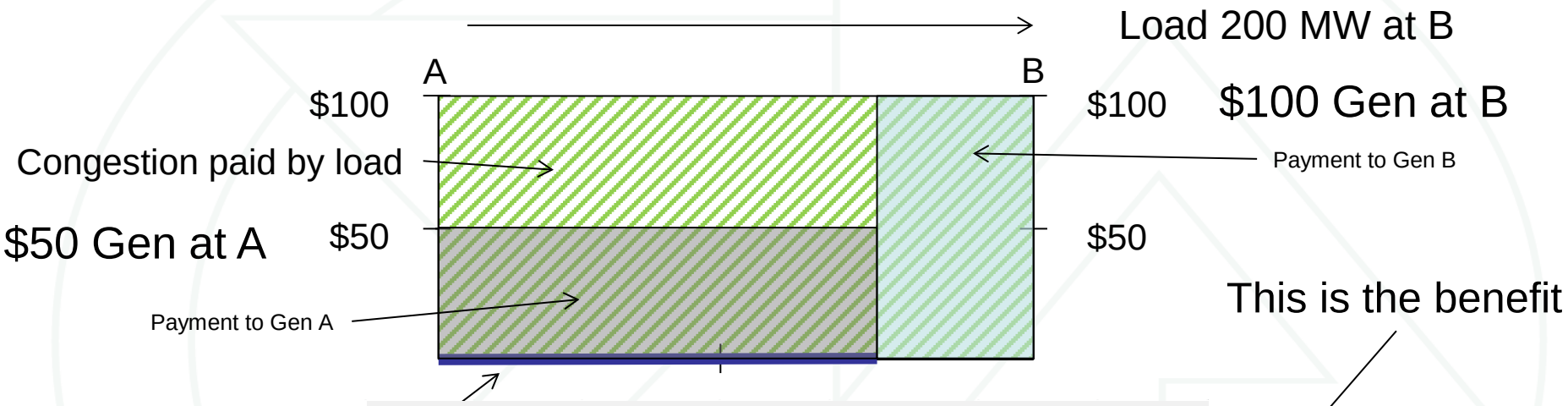
Day Ahead		Bus A	Bus B	Congestion
Load	$	-	$ 20,000	
Generation	$	5,000	$ 10,000	
Total		($5,000)	$10,000	$5,000

Day Ahead	Bus A	Transfer A to B	Bus B
Price	$50		$100
Load	-	→	200
Generation	150	150 MW	50

Day Ahead		Bus A	Bus B	Congestion
Load	$	-	$ 20,000	
Generation	$	7,500	$ 5,000	
Total		($7,500)	$15,000	$7,500

Calculating Benefits

Congestion



This is the benefit

With 100 MW Transmission

LMP	MW	Total Load Charges	Average Cost	Congestion Allocation	Net Load Bill	Average Cost
$ 100	200	$20,000.00	$100.00	$5,000.00	$15,000.00	$75.00

With 150 MW Transmission

LMP	MW	Total Load Charges	Average Cost	Congestion Allocation	Net Load Bill	Average Cost
$ 100	200	$20,000.00	$100.00	$7,500.00	$12,500.00	$62.50

Change in congestion allocation available	Change in Net Bill	Change in Average Cost
$2,500.00	-$2,500.00	-$12.50

Compare this to cost (Change * -1)

Current Approach to Benefit Calculation

Day Ahead	Bus A	Transfer A to B	Bus B	
Price	$50		$100	
Load	-	→	200	
Generation	100	100 MW	100	
Day Ahead	**Bus A**		**Bus B**	**Congestion**
Load	$ -		$ 20,000	
Generation	$ 5,000		$ 10,000	
Total	($5,000)		$10,000	$5,000

Day Ahead	Bus A	Transfer A to B	Bus B	
Price	$50		$100	
Load	-	→	200	
Generation	150	150 MW	50	
Day Ahead	**Bus A**		**Bus B**	**Congestion**
Load	$ -		$ 20,000	
Generation	$ 7,500		$ 5,000	
Total	($7,500)		$15,000	$7,500

	Total Generation Credits	Total Load Charges
Before	$15,000.00	$20,000.00
After	$12,500.00	$20,000.00
Change	-$2,500.00	$0.00

Regional Benefit Calculation	Subregional Benefit Calculation	Net Benefits
(Net gen + Load Savings Only)	(Load Savings Only)	Net gen + net load savings
$ 1,250.00	$0.00	$ 1,250.00

Things to Consider

- **Overall concept: Total Net Benefit > Total Cost**
  - **In closed system benefits can be shared**

- **Load Charges, both positive and negative**
  - **Who benefits?**
  - **Downstream load benefits**
  - **Upstream load loses**
    - **Will only benefit in closed system with average cost allocation**
    - **Within utility zone upgrade**

Things to Consider

- **Generation Credits (Production Costs), both positive and negative**
  - **Who saves generation production charges?**
  - **Downstream load "benefits"**
  - **Upstream load does not benefit**
    - **Only benefits in a closed system with average cost allocation**
    - **Within utility zone upgrade**
  - **Upstream generation wins**
  - **Downstream generation loses**

Things to Consider

- **Benefit calculations are very sensitive to LMP estimates/assumptions**
- **Current approach does not examine benefit on the basis of whole system**
- **Would be more correct if run by a single utility that had a cost minimization goal**
  - **Should include the consideration of generation alternatives to project**
  - **Current approach ignores generation competitive alternatives**

Things to Consider

- **Current regional approach does not allocate cost solely to beneficiaries**
  - **Socializes cost to those helped and hurt by project**
  - **50% to socialized to system and 50% assigned to winners**
    - **Regardless of proportion that is generation production savings or load energy savings**

50 MW Increased Transfer: Case 1

Bus A	Bus A	Transfer Limit	Bus B	Bus B	Total Charges
LMP	$50	100	LMP	$100	
Load	100		Load	200	
Gen ($50): 1-300	200		Gen ($100): 1-200	100	
Gen ($75): 1-100			Gen ($200): 1-100		
Load Charges	$5,000		Load Charges	$20,000	$25,000
Gen Credits	$10,000		Gen Credits	$10,000	$20,000
Net Charges	-$5,000		Net Charges	$10,000	$5,000
Total Congestion				$5,000	
Load Charges After Allocation of Congestion	$5,000		Load Charges After Allocation of Congestion	$15,000	$20,000
Average Price for Load	$50.00			$75.00	
Average Price for Generation	$50.00			$100.00	

Bus A	Bus A	Transfer Limit	Bus B	Bus B	Total Charges
LMP	$50	150	LMP	$100	
Load	100		Load	200	
Gen ($50): 1-300	250		Gen ($100): 1-200	50	
Gen ($75): 1-100	0		Gen ($200): 1-100		
Load Charges	$5,000		Load Charges	$20,000	$25,000
Gen Credits	$12,500		Gen Credits	$5,000	$17,500
Net Charges	-$7,500		Net Charges	$15,000	$7,500
Total Congestion				$7,500	
Load Charges After Allocation of Congestion	$5,000		Load Charges After Allocation of Congestion	$12,500	$17,500
Average Price for Load	$50.00			$62.50	
Average Price for Generation	$50.00			$100.00	

Average Cost To Load (System)	Average Cost To Load (System)	Benefit Calc Regional	Benefit Calc Local	Net Benefit
$67	$58	$1,250	$0	$1,250

Changes	Bus A	Bus B	Change
LMP	$0	$0	
Load	0	0	
Generation	0	-50	
Generation	50	0	
Change in Load Charges	$0	$0	$0
Change in Gen Credits	$2,500	-$5,000	-$2,500
Change in Net Charges	-$2,500	$5,000	$2,500
Change in Congestion	$0	$2,500	$2,500
Change in net Load Charges After Congestion Allocation	$0	-$2,500	-$2,500
Change in Average Price for Load	$0.00	-$12.50	
Charge in Average Price for Generation	$12.50	$0.00	

(50% of each)

Benefit!

Net Load Charges (Congestion)
$2,500

50 MW Increased Transfer: Case 2

Bus A	Bus A	Transfer Limit	Bus B	Bus B	Total Charges
LMP	$50	100	LMP	$100	
Load	100		Load	200	
Gen ($50): 1-200	200		Gen ($100): 1-200	100	
Gen ($75): 1-100	0		Gen ($200): 1-100	0	
Load Charges	$5,000		Load Charges	$20,000	$25,000
Gen Credits	$10,000		Gen Credits	$10,000	$20,000
Net Charges	-$5,000		Net Charges	$10,000	$5,000
Total Congestion				$5,000	
Load Charges After Allocation of Congestion	$5,000		Load Charges After Allocation of Congestion	$15,000	$20,000
Average Price for Load	$50.00			$75.00	
Average Price for Generation	$50.00			$100.00	

Bus A	Bus A	Transfer Limit	Bus B	Bus B	Total Charges
LMP	$75	150	LMP	$100	
Load	100		Load	200	
Gen ($50): 1-200	200		Gen ($100): 1-200	50	
Gen ($75): 1-100	50		Gen ($200): 1-100		
Load Charges	$7,500		Load Charges	$20,000	$27,500
Gen Credits	$18,750		Gen Credits	$5,000	$23,750
Net Charges	-$11,250		Net Charges	$15,000	$3,750
Total Congestion				$3,750	
Load Charges After Allocation of Congestion	$7,500		Load Charges After Allocation of Congestion	$16,250	$23,750
Average Price for Load	$75.00			$81.25	
Average Price for Generation	$93.75			$100.00	

Average Cost To Load (System)		Average Cost To Load (System)	Benefit Calc Regional	Benefit Calc Local	Net Benefit
$67	→	$79	-$1,875	$0	-$3,125

Changes	Bus A	Bus B	Change in Totals
LMP	$25	$0	
Load	0	0	
Generation	0	-50	
Generation	50	0	
Change in Load Charges	$2,500	$0	$2,500
Change in Gen Credits	$8,750	-$5,000	$3,750
Change in Net Charges	-$6,250	$5,000	-$1,250
Change in Congestion	$0	-$1,250	-$1,250
Change in net Load Charges After Congestion Allocation	$2,500	$1,250	$3,750
Average Price for Load	$25.00	$6.25	
Average Price for Generation	$43.75	$0.00	

Benefit?

Net Load Charges (Congestion)
-$3,750

50 MW Increased Transfer: Case 3

Bus A	Bus A	Transfer Limit	Bus B	Bus B	Total Charges
LMP	$50	100	LMP	$200	
Load	100		Load	200	
Gen ($50): 1-300	200		Gen ($100): 1-60	60	
Gen ($75): 1-100			Gen ($200): 1-100	40	
Load Charges	$5,000		Load Charges	$40,000	$45,000
Gen Credits	$10,000		Gen Credits	$20,000	$30,000
Net Charges	-$5,000		Net Charges	$20,000	$15,000
Total Congestion				$15,000	
Load Charges After Allocation of Congestion	$5,000		Load Charges After Allocation of Congestion	$25,000	$30,000
Average Price for Load	$50.00			$125.00	
Average Price for Generation	$50.00			$200.00	

Bus A	Bus A	Transfer Limit	Bus B	Bus B	Total Charges
LMP	$50	150	LMP	$100	
Load	100		Load	200	
Gen ($50): 1-300	250		Gen ($100): 1-60	50	
Gen ($75): 1-100	0		Gen ($200): 1-200		
Load Charges	$5,000		Load Charges	$20,000	$25,000
Gen Credits	$12,500		Gen Credits	$5,000	$17,500
Net Charges	-$7,500		Net Charges	$15,000	$7,500
Total Congestion				$7,500	
Load Charges After Allocation of Congestion	$5,000		Load Charges After Allocation of Congestion	$12,500	$17,500
Average Price for Load	$50.00			$62.50	
Average Price for Generation	$50.00			$100.00	

Average Cost To Load (System)	→	Average Cost To Load (System)	Benefit Calc Regional	Benefit Calc Local	Net Benefit
$100		$58	$16,250	$20,000	$16,250

Changes	Bus A	Bus B	Change
LMP	$0	-$100	
Load	0	0	
Generation	50	-10	
Generation	0	-40	
Change in Load Charges	$0	-$20,000	-$20,000
Change in Gen Credits	$2,500	-$15,000	-$12,500
Change in Net Charges	-$2,500	-$5,000	-$7,500
Change in Congestion	$0	-$7,500	-$7,500
Change in net Load Charges After Congestion Allocation	$0	-$12,500	-$12,500
Change in Average Price for Load	$0.00	-$62.50	
Charge in Average Price for Generation	$0.00	-$100.00	

Benefit!

Net Load Charges (Congestion)
$12,500

Case 4

Bus A	Bus A	Transfer Limit	Bus B	Bus B	Total Charges
LMP	$50	50	LMP	$200	
Load	500		Load	150	
Gen ($50): 1-600	550		Gen ($80): 1-60	60	
Gen ($75): 1-100			Gen ($200): 1-100	40	
Load Charges	$25,000		Load Charges	$30,000	$55,000
Gen Credits	$27,500		Gen Credits	$20,000	$47,500
Net Charges	-$2,500		Net Charges	$10,000	$7,500
Total Congestion				$7,500	
Load Charges After Allocation of Congestion	$25,000		Load Charges After Allocation of Congestion	$22,500	$47,500
Average Price for Load	$50.00			$150.00	
Average Price for Generation	$50.00			$200.00	

Bus A	Bus A	Transfer Limit	Bus B	Bus B	Total Charges
LMP	$75	110	LMP	$80	
Load	500		Load	150	
Gen ($50): 1-600	600		Gen ($100): 1-60	40	
Gen ($75): 1-100	10		Gen ($200): 1-200		
Load Charges	$37,500		Load Charges	$12,000	$49,500
Gen Credits	$45,750		Gen Credits	$3,200	$48,950
Net Charges	-$8,250		Net Charges	$8,800	$550
Total Congestion				$550	
Load Charges After Allocation of Congestion	$37,500		Load Charges After Allocation of Congestion	$11,450	$48,950
Average Price for Load	$75.00			$76.33	
Average Price for Generation	$76.25			$80.00	

Average Cost To Load (System)
$73

→

Average Cost To Load (System)
$75

Benefit Calc Regional	Benefit Calc Local	Net Benefit
$8,275	$18,000	$2,025

Changes	Bus A	Bus B	Change
LMP	$25	-$120	
Load	0	0	
Generation	50	-20	
Generation	10	-40	
Change in Load Charges	$12,500	-$18,000	-$5,500
Change in Gen Credits	$18,250	-$16,800	$1,450
Change in Net Charges	-$5,750	-$1,200	-$6,950
Change in Congestion	$0	-$6,950	-$6,950
Change in net Load Charges After Congestion Allocation	$12,500	-$11,050	$1,450
Change in Average Price for Load	$25.00	-$73.67	
Charge in Average Price for Generation	$26.25	-$120.00	

Net Load Charges (Congestion)
-$1,450

Benefit?

Case 5

Bus A	Bus A	Transfer Limit	Bus B	Bus B	Total Charges
LMP	$50	50	LMP	$200	
Load	1000		Load	150	
Gen ($50): 1-1100	1050		Gen ($80): 1-60	60	
Gen ($75): 1-100			Gen ($200): 1-100	40	
Load Charges	$50,000		Load Charges	$30,000	$80,000
Gen Credits	$52,500		Gen Credits	$20,000	$72,500
Net Charges	-$2,500		Net Charges	$10,000	$7,500
Total Congestion				$7,500	
Load Charges After Allocation of Congestion	$50,000		Load Charges After Allocation of Congestion	$22,500	$72,500
Average Price for Load	$50.00			$150.00	
Average Price for Generation	$50.00			$200.00	

Bus A	Bus A	Transfer Limit	Bus B	Bus B	Total Charges
LMP	$75	110	LMP	$80	
Load	1000		Load	150	
Gen ($50): 1-1100	1100		Gen ($80): 1-60	40	
Gen ($75): 1-100	10		Gen ($200): 1-200		
Load Charges	$75,000		Load Charges	$12,000	$87,000
Gen Credits	$83,250		Gen Credits	$3,200	$86,450
Net Charges	-$8,250		Net Charges	$8,800	$550
Total Congestion				$550	
Load Charges After Allocation of Congestion	$75,000		Load Charges After Allocation of Congestion	$11,450	$86,450
Average Price for Load	$75.00			$76.33	
Average Price for Generation	$75.68			$80.00	

Average Cost To Load (System)	Average Cost To Load (System)	Benefit Calc Regional	Benefit Calc Local	Net Benefit
$63	$76	$2,025	$18,000	-$10,475

Changes	Bus A	Bus B	Change
LMP	$25	-$120	
Load	0	0	
Generation	50	-20	
Generation	10	-40	
Change in Load Charges	$25,000	-$18,000	$7,000
Change in Gen Credits	$30,750	-$16,800	$13,950
Change in Net Charges	-$5,750	-$1,200	-$6,950
Change in Congestion	$0	-$6,950	-$6,950
Change in net Load Charges After Congestion Allocation	$25,000	-$11,050	$13,950
Change in Average Price for Load	$25.00	-$73.67	
Charge in Average Price for Generation	$25.68	-$120.00	

Benefit?

Net Load Charges (Congestion)
-$13,950

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