Basic Congestion Concepts and Calculating Project Benefits

MEPETF July 30, 2019 **Howard Haas**



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





What are the LMPs at A and B?

	А	Constraint	В	
LMP	\$5	>	\$5	
	Zone A		Zone B	
Load MW	0		50	
Marginal Price of Power	\$5.00		\$5.00	
(LMP × 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= L	3			

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



	А	Constraint	В	
LMP	\$5	>	\$15	
	Zone A		Zone B	
Load MW	0		150	
Marginal Price of Power	\$5.00		\$15.00	
(LMP × 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= I	oad Char	raes – G	en Credits	7

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

Allocation of congestion: Affect on Average Cost of Load

	А	Constraint	В	
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	5
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	K
Average Cost of Power	NA		\$8.33	\setminus \//ith c

> Marginal Price does not change

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

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No constraints





Congestion: Binding Constraints





Congestion Load 200 MW at B ≻ В А \$100 Gen at B \$100 \$100 Charges to load \$50 Gen at A \$50 \$50 100 200 100 MW Line Limit MW MW 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

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Congestion Load 200 MW at B В А \$100 Gen at B \$100 \$100 Congestion paid by load Payment to Gen B \$50 \$50 \$50 Gen at A Charges Load Charges \$20,000.00 Payment to Gen A **Congestion Allocation** \$5,000.00 \$15,000.00 Net Load Charges 100 200 100 MW Line Limit MW MW Day Ahead Bus A Transfer A to B Bus B \$50 Price \$100 Congestion **Total Load** Average Net Load Average LMP MW Cost Allocation Bill Charges Cost \$ 100 200 \$20,000.00 \$100.00 \$5,000.00 \$15,000.00 \$75.00 Load \$ \$20,000 Generation 5,000 \$10,000 \$ \$5,000 (\$5,000) \$10,000 Total



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Congestion: Constraint with Increased Line Limit







Congestion





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Calculating Benefits





Current Approach to Benefit Calculation

Day Ahead		Bus A	Transfer A to B	Bus B	
Price		\$50		\$100	
Load		-	\longrightarrow	200	
Generation		100	100 MW	100	
Day Ahead		Bus A		Bus B	Congestion
Day Ahead Load	\$	Bus A -		Bus B \$20,000	Congestion
Day Ahead Load Generation	\$ \$	Bus A - 5,000		Bus B \$20,000 \$10,000	Congestion

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

Day Ahead		Bus A	Transfer A to B	Bus B	
Price		\$50		\$100	
Load		-	\longrightarrow	200	
Generation		150	150 MW	50	
Day Ahead		Bus A		Bus B	Congestion
Day Ahead Load	\$	Bus A		Bus B \$ 20,000	Congestion
Day Ahead Load Generation	\$ \$	Bus A - 7,500		Bus B \$20,000 \$5,000	Congestion

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



- 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



- 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

- 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



- 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

	٦	Fransfer				Average			
Bus A	Bus A	Limit Bus B	Bus B	Total Charges	Average	Average	Renefit	Renefit	
LMP	\$50	100 LMP	\$100		Cost To	Cost Io	Colo		Not
Load	100	Load	200		Load	Load			net D
Gen (\$50): 1-300	200	Gen (\$100): 1-200	100		(System)	(System)	Regional	Local	Benefit
Gen (\$75): 1-100		Gen (\$200): 1-100			\$67	\$58	\$1,250	\$0	\$1,250
Load Charges	\$5,000	Load Charges	\$20,000	\$25,000			$\wedge \wedge$	1	A
Gen Credits	\$10,000	Gen Credits	\$10,000	\$20,000					1 15001 -4
Net Charges	-\$5,000	Net Charges	\$10,000	\$5,000					(50% Of
Total Congestion			\$5,000		Changes	Bus A	Bus B	Change	/ each)
Load Charges		Load Charges			IMP	\$0	\$0		
After Allocation of		After Allocation of			Load	0			/
Congestion	\$5,000	Congestion	\$15,000	\$20,000	Concretion	0		//	
Average Price for					Generation	0	-50	X //	Ronofit
Load	\$50.00		\$75.00		Generation	50	0	/	Derienti
Average Price for					Change in Load Charges	\$0	\$0	\ \$0 /	
Generation	\$50.00		\$100.00		Change in Gen Credits	\$2,500	-\$5,000	-\$2,500	v
	1	Fransfer			Change in Net Charges	-\$2,500	\$5,000	\$2,500	Net Load
Bus A	Bus A	Limit Bus B	Bus B	Total Charges	Change in Congestion	\$0	\$2,500	\$2,500	Charges
LMP	\$50	150 LMP	\$100		Change in net Load				(Congestion)
Load	100	Load	200		Charges After Congestion				\$2,500
Gen (\$50): 1-300	250	Gen (\$100): 1-200	50		Allocation	¢0	¢ 2 E 0 0	¢2 E00	>
Gen (\$75): 1-100	0	Gen (\$200): 1-100				\$U	-\$2,500	-\$2,500	
Load Charges	\$5,000	Load Charges	\$20,000	\$25,000	Change in Average Price for				
Gen Credits	\$12,500	Gen Credits	\$5,000	\$17,500	Load	\$0.00	-\$12.50		
Net Charges	-\$7,500	Net Charges	\$15,000	\$7,500	Charge in Average Price for				
		Load Chargos	\$7,500		Generation	\$12.50	\$0.00		
After Allocation of		After Allocation of							
Concestion	\$5,000	Congestion	\$12 500	\$17 500					
Average Price for	ψ0,000		ψ12,500	φ17,300					
Load	\$50.00		\$62.50						
Average Price for	¥00.00		<i>\\</i> 02.00						
Generation	\$50.00		\$100.00						
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50 MW Increased Transfer: Case 2

		Transfer							
Bus A	Bus A	Limit Bus B	Bus B	Total Charges	Average	Average			
LMP	\$50	100 LMP	\$100			Cost To	Benefit	t Benefit	
Load	100	Load	200		$\sim \sim $	COSCIO	Calc	: Calc	Net
Gen (\$50): 1-200	200	Gen (\$100): 1-200	100		Load	Load	Regional	Local	Benefit
Gen (\$75): 1-100	0	Gen (\$200): 1-100	0		(System)	(System)	-\$1,875	5 \$0	-\$3,125
Load Charges	\$5,000	Load Charges	\$20,000	\$25,000	\$67	\$79			+=,.==
Gen Credits	\$10,000	Gen Credits	\$10,000	\$20,000					
Net Charges	-\$5,000	Net Charges	\$10,000	\$5,000					
Total Congestion			\$5,000					Change	-
Load Charges		Load Charges			Changes	Bus A	Bus B	in Totals	Benetit
After Allocation of		After Allocation of			LMP	\$25	\$0		2011011
Congestion	\$5,000	Congestion	\$15.000	\$20,000	Load	0	0		Net Loa
Average Drice for	,	0			Generation	0	-50		Charge
Average Frice for	¢E0.00		¢75.00		Generation	50	0		(Congestion
Ludu	\$50.00		\$75.00		Change in Load Charges	\$2,500	\$0	\$2,500	_\$3 75
Average Price for	¢50.00		¢100.00		Change in Gen Credits	\$8,750	-\$5.000	\$3.750	-40,10
Generation	\$30.00		\$100.00		Change in Net Charges	-\$6,250	\$5,000	-\$1,250	
	Г	Transfer			Change in Congestion	\$0	-\$1 250	-\$1 250	
Bus A	Bus A	Limit Bus B	Bus B	Total Charges		+0	<i><i><i></i></i></i>	<i><i><i></i></i></i>	
LMP	\$75	150 LMP	\$100		Change in net Load				
Load	100	Load	200		Charges After Congestion	l			
Gen (\$50): 1-200	200	Gen (\$100): 1-200	50		Allocation	\$2,500	\$1,250	\$3,750	
Gen (\$75): 1-100	50	Gen (\$200): 1-100							
Load Charges	\$7,500	Load Charges	\$20,000	\$27,500	Average Price for Load	\$25.00	\$6.25		
Gen Credits	\$18,750	Gen Credits	\$5,000	\$23,750	Average Price for				
Net Charges	-\$11,250	Net Charges	\$15,000	\$3,750	Constation	¢ 40 75	¢0.00		
Total Congestion			\$3,750		Generation	\$43.75	\$0.00		
Load Charges		Load Charges							
After Allocation		After Allocation of							
of Congestion	\$7,500	Congestion	\$16,250	\$23,750					
Average Price for									
Load	\$75.00		\$81.25		0.1			Monitoria	a Analytics
Average Price for					24			Monitorii	ig Analytics
Generation	\$93.75		\$100.00						

50 MW Increased Transfer: Case 3

					Average	Average			
		Iransfer			Cost To	Cost To	Bene	fit Benefit	
Bus A	Bus A	Limit Bus B	Bus B	Total Charges	\downarrow load \rightarrow	Load	Ca	lc Calc	Net
LMP	\$50	100 LMP	\$200		(System)	(Systom)	Pogior		Bonofit
Load	100	Load	200				Region		
Gen (\$50): 1-300	200	Gen (\$100): 1-60	60		\$100	\$58	\$16,2	50 \$20,000	\$16,250
Gen (\$75): 1-100	+=	Gen (\$200): 1-100	40	+ 15 000					
Load Charges	\$5,000	Load Charges	\$40,000	\$45,000					
Gen Credits	\$10,000	Gen Credits	\$20,000	\$30,000	Changes	Bus A	Bus B	Change	
Net Charges	-\$5,000	Net Charges	\$20,000	\$15,000	IMP	02	\$100	onango	
Total Congestion			\$15,000			\$U	-\$100		
Load Charges		Load Charges			Load	0	0		Renefitl
After Allocation of		After Allocation of			Generation	50	-10		Denena
Congestion	\$5,000	Congestion	\$25,000	\$30,000	Generation	0	-40		
Average Price for					Change in Load Charges	02	\$20,000	000 002	
Load	\$50.00		\$125.00			¢0 مەر	-\$20,000	-\$20,000	Not Lood
Average Price for					Change in Gen Credits	\$2,500	-\$15,000	-\$12,500	Net Load
Generation	\$50.00		\$200.00		Change in Net Charges	-\$2,500	-\$5,000	-\$7,500	Charges
		Transfor			Change in Congestion	\$0	-\$7,500	-\$7,500	(Congestion)
Βιις Δ			Rue R	Total Charges	Change in net Load				\$12,500
LMP	\$50		\$100	rotar charges	Charges After Congestion	,			
Load	100	Load	200						
Gen (\$50) [.] 1-300	250	Gen (\$100) [.] 1-60	50		Allocation	\$0	-\$12,500	-\$12,500	
Gen (\$75): 1-100	0	Gen (\$200): 1-200			Change in Average Price for	r			
Load Charges	\$5,000	Load Charges	\$20,000	\$25,000	Load	00.02	-\$62.50		
Gen Credits	\$12,500	Gen Credits	\$5,000	\$17,500		\$0.00	-\$02.50		
Net Charges	-\$7,500	Net Charges	\$15,000	\$7,500	Charge in Average Price for				
Total Congestion			\$7,500		Generation	\$0.00	-\$100.00		
Load Charges		Load Charges							
After Allocation of		After Allocation of							
Congestion	\$5,000	Congestion	\$12,500	\$17,500					
Average Price for									
Load	\$50.00		\$62.50						
Average Price for									
Generation	\$50.00		\$100.00		l l				

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Case 4

						0	Average				
		Transfer				Average	Cost To	Bei	nefit E	Benefit	
Bus A	Bus A	Limit Bus B	Bus B	Total Charges		Cost To	Load		Calc	Calc	Net
LMP	\$50	50 LMP	\$200			Load	(System)	Regi	onal	Local	Benefit
Load	500	Load	150			(System)		Q¢	275 \$	18 000	\$2,025
Gen (\$50): 1-600	550	Gen (\$80): 1-60	60			\$73	\$75	φ υ	,210 ¢	10,000	<i>\\</i> 2,020
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	Changes		Bus A	Bus B	Change	<u>م</u>	
Total Congestion			\$7,500				¢25	\$120	Change	~	Net Load
Load Charges		Load Charges					\$20 Q	-\$120			Charges
After Allocation of		After Allocation of			Load		0	0			(Congostion)
Congestion	\$25,000	Congestion	\$22,500	\$47,500	Generatio	n	50	-20			
Average Price for					Generatio	n	10	-40			-\$1,450
Load	\$50.00		\$150.00		Change in	Load Charges	\$12,500	-\$18,000	-\$5,500	C	
Average Price for					Change in	Gen Credits	\$18,250	-\$16,800	\$1,450)	
Generation	\$50.00		\$200.00		Change in	Net Charges	-\$5,750	-\$1 200	-\$6 950)	Donofita
	-	Transfor			Change in	Congestion	\$0	-\$6 950	-\$6,950	<u>)</u>	Denemi
Bus A	Bus A	Limit Bus B	Bus B	Total Charges	Change in	netLoad	+0	<i><i><i></i></i></i>	<i><i><i>q</i>0770</i></i>	_	
LMP	\$75	110 LMP	\$80	gee	Charges A	After Concestion					
Load	500	Load	150			aller congestion	¢10 500	¢11.0F0	¢1 454	`	
Gen (\$50): 1-600	600	Gen (\$100): 1-60	40		Allocation		\$12,500	-\$11,050	\$1,450	<u> </u>	
Gen (\$75): 1-100	10	Gen (\$200): 1-200			Change in	Average Price for					
Load Charges	\$37,500	Load Charges	\$12,000	\$49,500	Load		\$25.00	-\$73.67			
Gen Credits	\$45,750	Gen Credits	\$3,200	\$48,950	Charge in A	Average Price for					
Net Charges	-\$8,250	Net Charges	\$8,800	\$550	Generation	1	\$26.25	-\$120.00			
Total Congestion			\$550		Generation		Ψ20.25	\$120.00		_	
Load Charges		Load Charges									
After Allocation of		After Allocation of									
Congestion	\$37,500	Congestion	\$11,450	\$48,950							
Average Price for											
Load	\$75.00		\$76.33								
Average Price for											
Generation	\$76.25		\$80.00		26				Mor	nitorin	g Analytics

Case 5

		Transfer			- E	-	_				
Bus A	Bus A	Limit Bus B	Bus B	Total Charges		Average	Average				
LMP	\$50	50 LMP	\$200		_	Cost To	Cost To	Benefi	t Benefit		
Load	1000	Load	150			Load	Load	Calo	c Calc	Net	
Gen (\$50): 1-1100	1050	Gen (\$80): 1-60	60			(System)	(System)	Regiona	I Local	Benefit	
Gen (\$75): 1-100		Gen (\$200): 1-100	40			\$63	\$76	\$2,02	5 \$18,000	-\$10,475	
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	Chan	a 00			Due D	Change	
Total Congestion			\$7,500		Chang	yes		BUS A	BUS B	Change	
Load Charges		Load Charges			LIMP			\$25	-\$120		
After Allocation of		After Allocation of			Load			0	0		
Congestion	\$50,000	Congestion	\$22,500	\$72,500	Gene	ration		50	-20		Donofit?
Average Price for					Gene	ration		10	-40		Deneiii (
Load	\$50.00		\$150.00		Chang	ge in Load C	harges	\$25,000	-\$18,000	\$7,000	
Average Price for					Chang	ge in Gen Cr	edits	\$30,750	-\$16,800	\$13,950	Net Load
Generation	\$50.00		\$200.00		Chan	ge in Net Cha	arges	-\$5,750	-\$1,200	-\$6,950	Charges
		T			Chanc	ge in Conges	stion	\$0	-\$6,950	-\$6,950	(Congestion)
			Due D	Total Charges	Chan	ge in net Loa	d				-\$13,950
	\$75		Bus B 088	Total Charges	Charg	es After Con	gestion				
Load	1000	Load	150		Alloca	ation	5	\$25,000	-\$11.050	\$13,950	
Gen (\$50) [.] 1-1100	1100	Gen (\$80) [,] 1-60	40		Chanc		Prico for	<i>\\</i> 20,000	¢11,000	\$10,700	
Gen (\$75): 1-100	10	Gen (\$200): 1-200					i nce ioi	¢ 2 Γ 0 0	¢70/7		
Load Charges	\$75,000	Load Charges	\$12,000	\$87,000	Load		~	\$25.00	-\$/3.0/		
Gen Credits	\$83,250	Gen Credits	\$3,200	\$86,450	Charg	e în Average I	Price for				
Net Charges	-\$8,250	Net Charges	\$8,800	\$550	Gener	ration		\$25.68	-\$120.00		
Total Congestion			\$550								
Load Charges		Load Charges									
After Allocation of		After Allocation of									
Congestion	\$75,000	Congestion	\$11,450	\$86,450							
Average Price for											
Load	\$75.00		\$76.33								
Average Price for					27				Mc Mc	nitoring	Analytics
Generation	\$75.68		\$80.00						-		

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