

Elements of Transmission Congestion

2-bus example

ESPWG meeting
November 17, 2003

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NYISO Transmission Congestion Metrics

Impact On	Description	Measures
Bid Production Costs	Difference between transmission-constrained and -unconstrained bid production costs	Efficiency
Load Payments	Difference between transmission-constrained and -unconstrained load payments	Bills Impact
Congestion Payments	Difference between transmission-constrained and -unconstrained congestion payments	Money Flows
Physical Flows	Flow duration curves vs. limit for significant flowgates	Network Usage



Simple numerical example

- Two bus model
 - West bus (reference) and East bus
 - East bus has 400 MW of load and 500 MW of (expensive) generation
 - West bus has 100 MW of load and 850 MW of (cheap) generation
 - 350 MW @ \$4 and 500 MW @ \$6 (example 1)
 - 450 MW @ \$4 and 400 MW @ \$6 (example 2)
 - Single line between the two buses
 - 1000 MW capacity in unconstrained example
 - 300 MW capacity in constrained example



Example 1



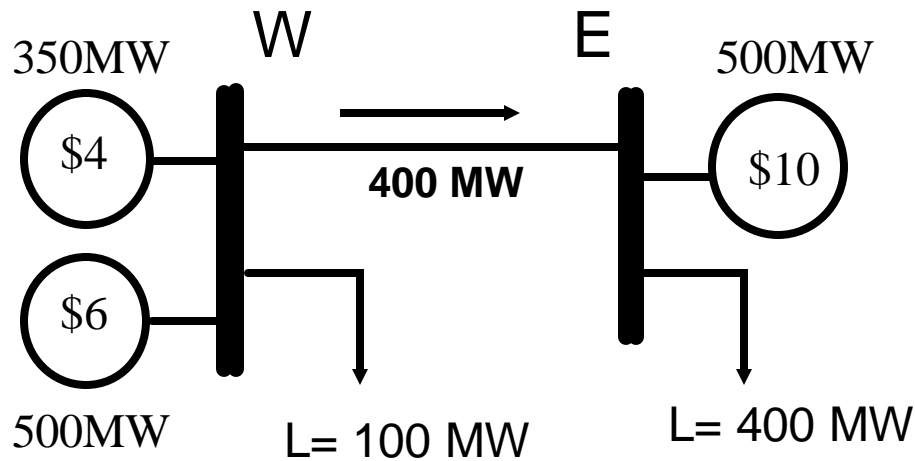
Unconstrained 2-bus system

Bid production cost = $(350\text{MW} \times \$4) + (150\text{MW} \times \$6) = \$2300$

Load payment = $500\text{MW} \times \$6 = \3000

Generation payment = $500\text{MW} \times \$6 = \3000

Flow = 400 MW



Production cost	\$2300
Load payment	\$3000
Generation payment	\$3000
Congestion payment	\$0
Interface flow	400 MW



Constrained 2-bus system

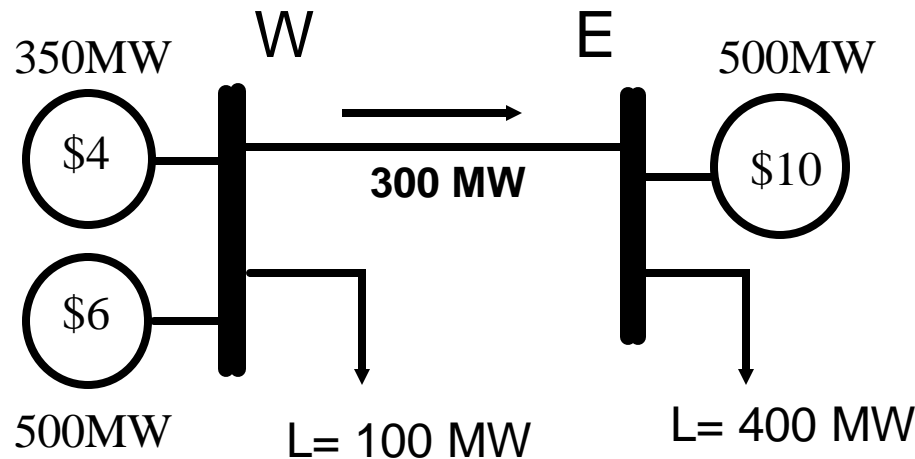
Transmission line limited at 300 MW

Bid production cost = $(350\text{MW} \times \$4) + (50\text{MW} \times \$6) + (100\text{MW} \times \$10) = \$2700$

Load payment = $400\text{MW} \times \$10 + 100\text{MW} \times \$6 = \$4600$

Generation payment = $400\text{MW} \times \$6 + 100\text{MW} \times \$10 = \$3400$

Flow = 300 MW



Production cost	\$2700
Load payment	\$4600
Generation payment	\$3400
Congestion payment	
Interface flow	300 MW



Constrained 2-bus system (cont'd)

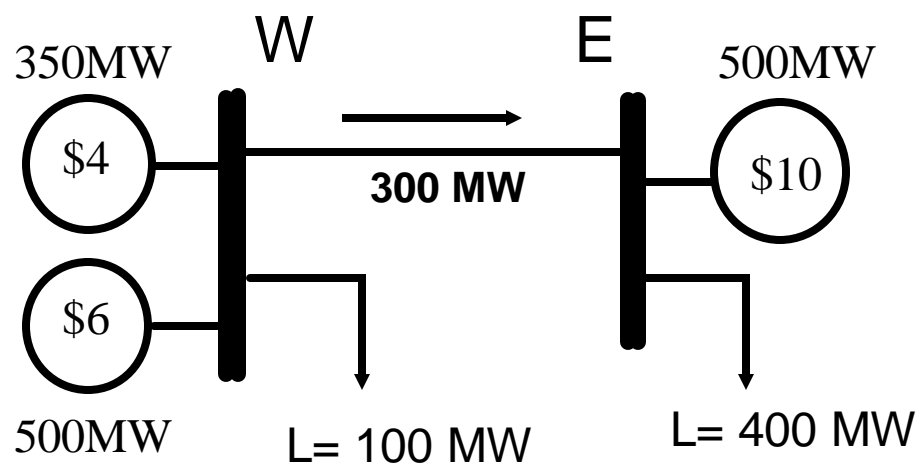
Transmission line limited at 300 MW

Assumption: Load holds a 300 MW TCC

Total congestion payment = $400\text{MW} * \$4 = \1600

Hedged congestion payment = $300\text{MW} * \$4 = \1200

Unhedged congestion payment = total - hedged = $\$400$



Production cost	\$2700
Load payment	\$4600
Generation payment	\$3400
Congestion payment	\$1600
Interface flow	300 MW



Congestion impact

Impact On	Constrained	Unconstrained	Difference
Bid Production Costs	\$2700	\$2300	\$400
Load Payments	\$4600	\$3000	\$1600
Generation Payments	\$3400	\$3000	\$400
Congestion Payments	\$1600	\$0	\$1600
Physical Flows	300 MW	400 MW	100 MW

Impact On	Constrained	Unconstrained	Difference
Energy + losses (load - congestion payments)	\$3000	\$3000	\$0



Congestion impact on load payments

Impact on	Calculation	Result
Total load payment	from previous table	\$1600
- hedged congestion	\$1200	\$400
+ TCC costs	+ TCC costs	\$400 + TCC costs
Net unhedged congestion		\$400 + TCC costs



Congestion impact on load payments

Assumption: $TSC = TCC + \text{Net TSC}$

Assumption: $TSC = \text{fixed } \$3000$

Total load payment	Constrained	Unconstrained
Total (from previous calculation)	\$4600	\$3000
+ net TSC	\$1800	\$3000
Net payment (accounting for system charges)	\$6400	\$6000



Example 2



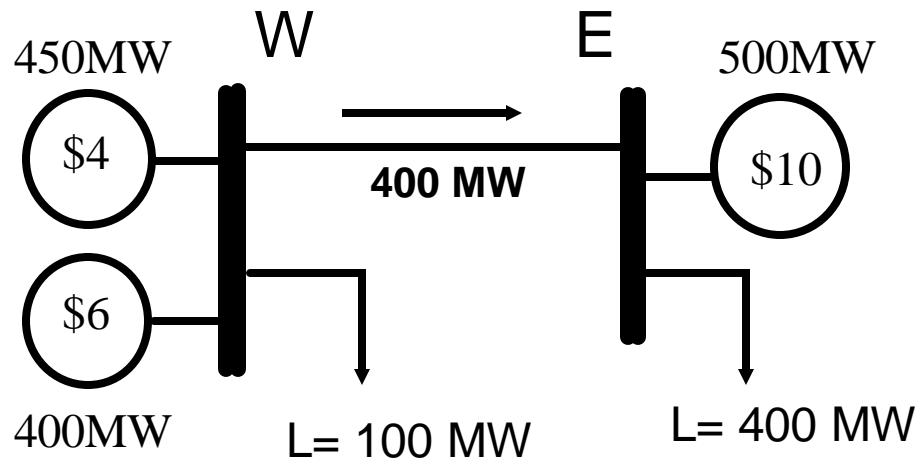
Unconstrained 2-bus system

Bid production cost = $(450\text{MW} \times \$4) + (50\text{MW} \times \$6) = \$2100$

Load payment = $500\text{MW} \times \$6 = \3000

Generation payment = $500\text{MW} \times \$6 = \3000

Flow = 400 MW



Production cost	\$2100
Load payment	\$3000
Generation payment	\$3000
Congestion payment	\$0
Interface flow	400 MW



Constrained 2-bus system

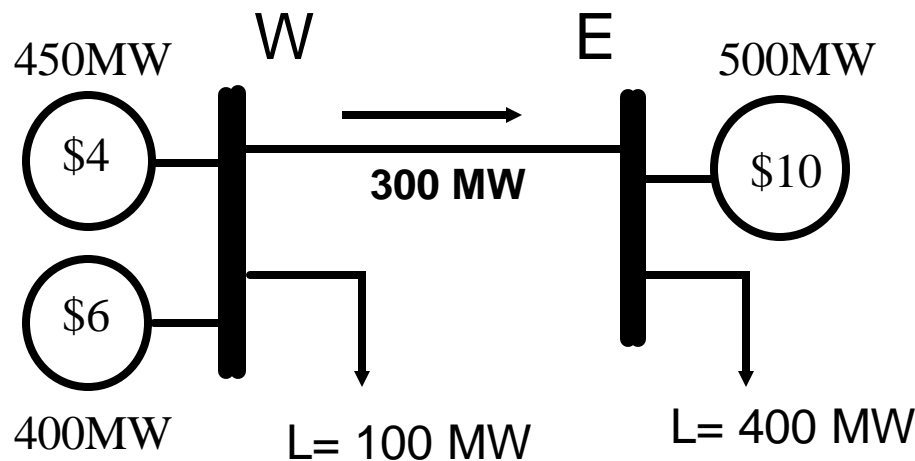
Transmission line limited at 300 MW

Bid production cost = $(400\text{MW} \times \$4) + (100\text{MW} \times \$10) = \$2600$

Load payment = $400\text{MW} \times \$10 + 100\text{MW} \times \$4 = \$4400$

Generation payment = $400\text{MW} \times \$4 + 100\text{MW} \times \$10 = \$2600$

Flow = 300 MW



Production cost	\$2600
Load payment	\$4400
Generation payment	\$2600
Congestion payment	
Interface flow	300 MW



Constrained 2-bus system (cont'd)

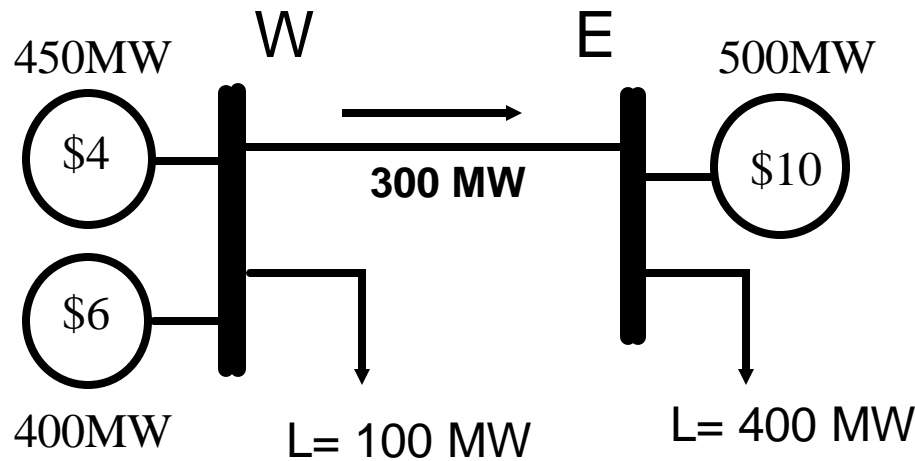
Transmission line limited at 300 MW

Assumption: Load holds a 300 MW TCC

Total congestion payment = $400\text{MW} * \$6 = \2400

Hedged congestion payment = $300\text{MW} * \$6 = \1800

Unhedged congestion payment = total - hedged = $\$600$



Production cost	\$2600
Load payment	\$4400
Generation payment	\$2600
Congestion payment	\$2400
Interface flow	300 MW



Congestion impact

Impact On	Constrained	Unconstrained	Difference
Bid Production Costs	\$2600	\$2100	\$500
Load Payments	\$4400	\$3000	\$1400
Generation Payments	\$2600	\$3000	-\$400
Congestion Payments	\$2400	\$0	\$2400
Physical Flows	300 MW	400 MW	100 MW

Impact On	Constrained	Unconstrained	Difference
Energy + losses (load - congestion payments)	\$3000	\$3000	\$0



Congestion impact on load payments

Impact on	Calculation	Result
Total load payment	from previous table	\$1400
- hedged congestion	\$1800	-\$400
+ TCC costs	+ TCC costs	-\$400 + TCC costs
Net unhedged congestion		-\$400 + TCC costs



Congestion impact on load payments

Assumption: $TSC = TCC + \text{Net TSC}$

Assumption: $TSC = \text{fixed } \$3000$

Total load payment	Constrained	Unconstrained
Total (from previous calculation)	\$4400	\$3000
+ net TSC	\$1200	\$3000
Net payment (accounting for system charges)	\$5600	\$6000



In summary



Who wins and who loses from congestion

	example 1	example 2
G1 (W @ \$4)	neutral	loser
G2 (W @ \$6)	loser	loser
G3 (E @ \$10)	winner	winner
L1 (W)	possibly neutral (depends on TSC determination)	winner
L2 (E)	loser	winner



Conclusions

- Even for the simple 2-bus example
 - money flows vary
 - losers & winners varydepending on system configuration
- Results may be counter-intuitive and may not be easily generalized
- Transmission constraint may increase or decrease generation/load payments
- Current market design does minimize production cost but does not minimize load payments

