

# Impact on Energy Market if Transmission Penalty Factors set prices

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# Transmission Penalty Factor Overrides

- **PJM currently uses a default penalty factor of \$30,000 per MWh of violation degree in the day ahead market.**
- **PJM currently uses a default penalty factor of \$2,000 per MWh of violation degree in the real time market.**
- **Prior to June 2, 2014, PJM used a default penalty factor of \$1,000 per MWh of violation degree in the real time market.**
- **PJM dispatchers have the discretion to increase or decrease transmission penalty factors in both day ahead and real time markets.**

# Historical Frequency of Transmission Penalty Factor Overrides

Real Time Market		Constraint Intervals		
Year	Type	Default	Higher	Lower
2013	Internal Constraint	60,189	6,843	917
2013	M2M Constraint	4,402	7,510	32,652
2013	Reactive Interface	7,872	2,084	190
2013	Surrogate	1,037		
2014	Internal Constraint	86,692	14,058	2,545
2014	M2M Constraint	4,833	9,432	32,863
2014	Reactive Interface	5,664	4,832	363
2014	Surrogate	12,728	80	38,074
2015	Internal Constraint	118,618	4,694	15,477
2015	M2M Constraint	8,513	4,196	37,585
2015	Reactive Interface	4,326	100	264
2015	Surrogate	1,284		17,423
2016	Internal Constraint	117,124	1,211	23,770
2016	M2M Constraint	9,407	6,912	37,925
2016	Reactive Interface	218		4
2016	Surrogate	91		8,577
2017	Internal Constraint	89,531	1,301	17,589
2017	M2M Constraint	3,309	12,652	31,447
2017	Reactive Interface	1,249		3
2017	Surrogate			5,446

Day Ahead Market		Constraint Hours		
Year	Type	Default (\$30,000 per MWh)	Higher	Lower
2013	Internal Constraint	416,303	71,632	10,915
2013	Reactive Interface	15,625		
2013	Surrogate	99		
2014	Internal Constraint	396,482	3,648	140
2014	Reactive Interface	15,514		
2014	Surrogate	5,251		
2015	Internal Constraint	174,060	1,058	125
2015	Reactive Interface	8,270		
2015	Surrogate	1,555		
2016	Internal Constraint	268,480	1,900	67
2016	Reactive Interface	4,924		
2016	Surrogate	51		
2017	Internal Constraint	295,343	945	
2017	Reactive Interface	4,521		
2017	Surrogate	114		

# Transmission Penalty Factor Overrides

- **If there were two binding or violated constraints in a single five minute interval, they were counted as two instances.**
- **Reactive interfaces are special constraints modeled to protect PJM from voltage collapse. Examples include AP-SOUTH and Bedington-Black Oak.**
- **Thermal surrogate constraints are special constraints modeled to enable resources called on to control a constraint to set price.**
- **Unlike other classes of transmission constraints, the penalty factor for market to market constraints are dynamically adjusted to equal the shadow price calculated by the other RTO.**

# Changes to Transmission Facility Ratings

- **PJM dispatchers have the discretion to lower the transmission facility ratings.**
- **The transmission facility ratings are provided to PJM by the transmission owners.**
- **Currently, no set of uniform standards are followed by transmission facility owners for setting normal, emergency and load dump ratings for transmission facilities within the PJM operational footprint.**

# Historical Frequency Distribution of Changes to Transmission Facility Limits

Year	Type	Flow Limit as a Percent of Transmission Facility's Rated Limit							
		< 50%	50%-60%	60%-70%	70%-80%	80%-90%	90%-95%	95%-99.99%	100%
2013	Internal Constraint	1.3%	0.5%	1.4%	0.1%	4.6%	37.9%	48.1%	6.1%
2013	M2M Constraint	0.0%	0.0%	0.0%	0.0%	0.8%	12.4%	7.1%	79.6%
2013	Reactive Interface	0.8%	0.0%	0.0%	0.3%	1.5%	42.9%	52.0%	2.6%
2013	Surrogate	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	82.5%	17.5%
2014	Internal Constraint	3.9%	1.1%	1.0%	0.2%	14.0%	38.4%	28.4%	13.1%
2014	M2M Constraint	0.1%	0.0%	0.1%	0.1%	4.4%	10.8%	3.1%	81.3%
2014	Reactive Interface	0.2%	0.0%	0.0%	0.0%	2.0%	43.4%	47.2%	7.2%
2014	Surrogate	0.0%	0.0%	0.0%	0.1%	1.4%	14.0%	3.5%	80.9%
2015	Internal Constraint	0.2%	0.0%	0.0%	0.1%	18.4%	47.9%	16.6%	16.7%
2015	M2M Constraint	0.1%	0.0%	0.0%	0.2%	2.4%	20.6%	4.0%	72.7%
2015	Reactive Interface	0.0%	0.0%	0.1%	0.6%	7.2%	66.1%	22.2%	3.8%
2015	Surrogate	0.0%	0.0%	0.0%	0.0%	0.0%	9.2%	0.0%	90.7%
2016	Internal Constraint	1.0%	7.8%	0.5%	0.2%	23.8%	43.5%	10.5%	12.6%
2016	M2M Constraint	0.0%	0.0%	0.1%	0.0%	3.6%	15.1%	2.2%	79.0%
2016	Reactive Interface	1.4%	0.0%	0.0%	0.0%	4.5%	18.9%	53.6%	21.6%
2016	Surrogate	0.0%	0.3%	0.0%	0.0%	0.0%	0.1%	0.0%	99.4%
2017	Internal Constraint	3.0%	2.4%	0.1%	0.2%	19.8%	51.1%	11.4%	11.9%
2017	M2M Constraint	0.0%	0.0%	0.0%	0.0%	4.3%	13.6%	2.5%	79.5%
2017	Reactive Interface	0.0%	0.0%	0.0%	0.2%	3.2%	62.8%	33.0%	0.8%
2017	Surrogate	8.8%	0.0%	4.0%	8.4%	0.0%	35.2%	10.8%	32.9%

# Historical Frequency Distribution of Changes to Transmission Facility Limits

- **If there were two binding or violated constraints in a single five minute interval, they were counted as two instances.**
- **In 2014, for 51.1 percent of binding or violated internal transmission constraints in PJM, the flow limit was lowered to be between 90 and 95 percent of the rated line limit. The rated facility limits are provided to the PJM by the transmission facility's owner.**
- **On average, the flow limits were lowered for nearly two thirds of all binding or violated transmission constraints.**
- **On average, the flow limits were lowered for half of all binding or violated transmission constraints to be within 10 percent of the rated facility limit**

# Impact of Removing Constraint Relaxation Logic

- **PJM currently relaxes transmission constraint and recalculates shadow price and LMPs whenever a transmission constraint is violated**
- **The relaxation results in shadow prices of violated transmission constraints that are lower than the transmission penalty factors**
- **IMM simulated the clearing of the real time market, setting the shadow prices of violated transmission constraints to the transmission penalty factors**
- **The simulation is a good basis for estimating the impact of not relaxing violated transmission constraints**

# Impact on PJM Average RT LMP

## January through December, 2017

	Load Weighted Average LMP	
	Actual	Transmission Penalty Factors Set Prices
January	\$32.25	\$32.25
February	\$25.73	\$25.73
March	\$32.30	\$32.32
April	\$28.39	\$28.40
May	\$31.29	\$31.31
June	\$28.30	\$28.32
July	\$32.88	\$32.90
August	\$27.72	\$27.73
September	\$33.55	\$33.58
October	\$28.67	\$28.69
November	\$28.59	\$28.60
December	\$40.08	\$40.09

# Impact on RT Load Weighted Average LMP

- **The real time LMPs for every node and for every five minute interval were recalculated by setting the shadow price of a violated transmission constraint equal to its penalty factor.**
- **LMPs were changed but the dispatch was assumed to remain the same.**
- **The impact on the system wide load weighted average LMP was very small.**

# Impact on Energy Market Payments and Credits

## January through December, 2017

### Energy Market Payments and Credits (\$ Millions)

	Actual			Transmission Penalty Factors Set Prices		
	Day Ahead	Balancing	Total	Day Ahead	Balancing	Total
Load Payments	\$23,463.71	\$102.57	\$23,566.28	\$23,463.71	\$107.46	\$23,571.17
Generation Credits	\$23,146.83	\$1.72	\$23,148.56	\$23,146.83	\$11.77	\$23,158.60
Virtual Credits	\$44.77	\$43.51	\$88.28	\$44.77	\$49.12	\$93.89
Other Payments	\$589.42	-\$5.64	\$583.78	\$589.42	-\$3.47	\$585.95
Net Payments	\$861.53	\$51.69	\$913.22	\$861.53	\$43.10	\$904.64

# Impact on Load Payments

## January through December, 2017

### Load Payments (\$ Millions)

	Transmission Penalty			Percent Change
	Actual	Factors Set Prices	Change	
Day Ahead	\$23,463.71	\$23,463.71	\$0.00	0.00%
Balancing Market	\$102.57	\$107.46	\$4.89	4.77%
Balancing Market Surplus Allocation	\$51.69	\$43.10	-\$8.58	-16.61%
Net Payments	\$23,514.59	\$23,528.07	\$13.48	0.06%

# Impact on Generation Credits

## January through December, 2017

### Generation Credits (\$ Millions)

	Transmision Penalty			Percent Change
	Actual	Factors Set Prices	Change	
Day Ahead	\$23,146.83	\$23,146.83	\$0.00	0.00%
Balancing Market	\$1.72	\$11.77	\$10.05	583.12%
Net Credits	\$23,148.56	\$23,158.60	\$10.05	0.04%

# Impact on Energy Market Payments and Credits

- **If the transmission penalty factors set prices in the real time market, the net load payments in 2017 increase by \$13.5 Million or 0.06 percent of the total net load payments in the energy market.**
- **If the transmission penalty factors set prices in the real time market, the net generation credits increase by \$10.1 Million or 0.04 percent of the total net generation credits in the energy market.**

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