

Market Monitor Report

Members Committee

May 18, 2017

Joe Bowring



Monitoring Analytics

Energy Market results were competitive

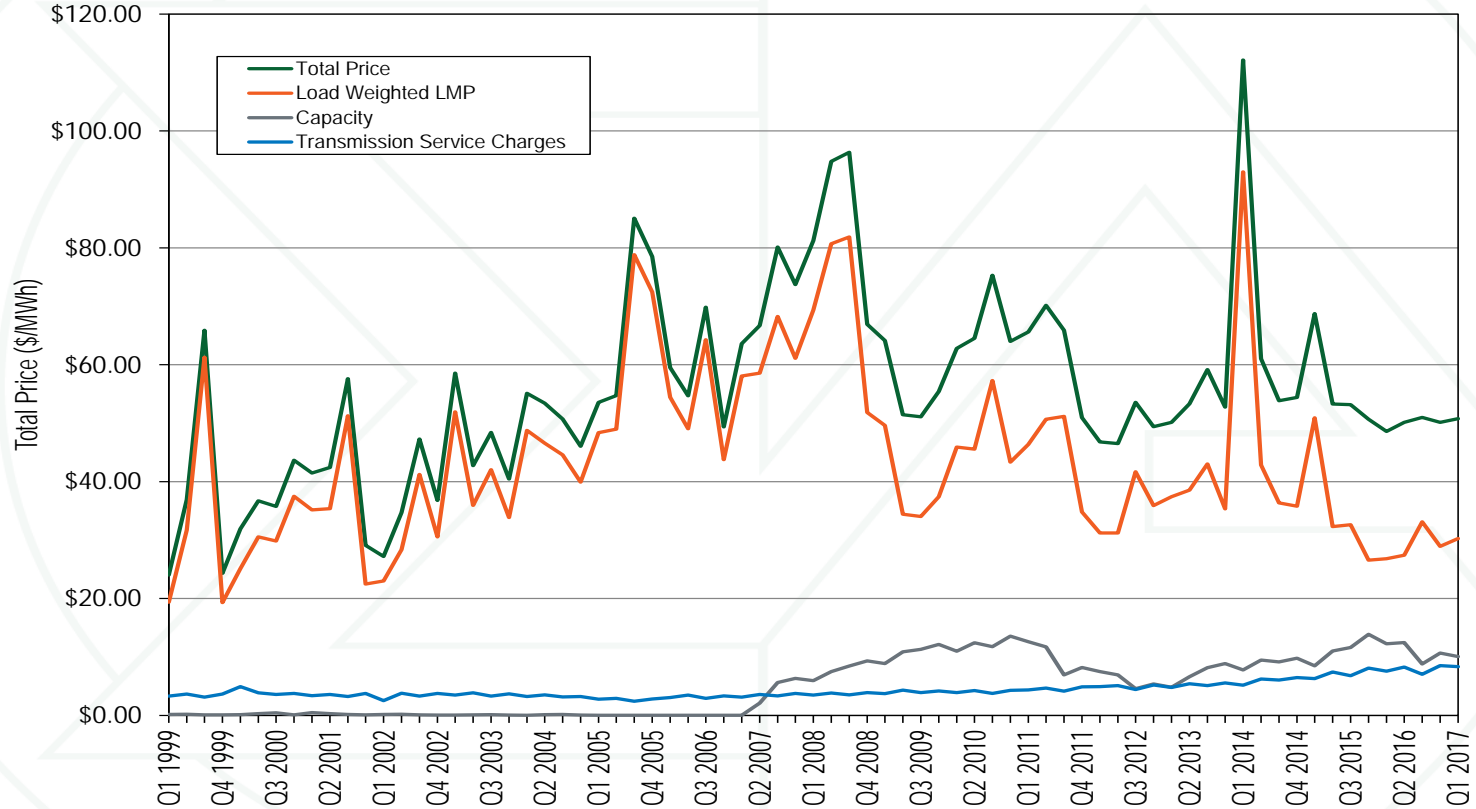
Market Element	Evaluation	Market Design
Market Structure: Aggregate Market	Competitive	
Market Structure: Local Market	Not Competitive	
Participant Behavior	Competitive	
Market Performance	Competitive	Effective



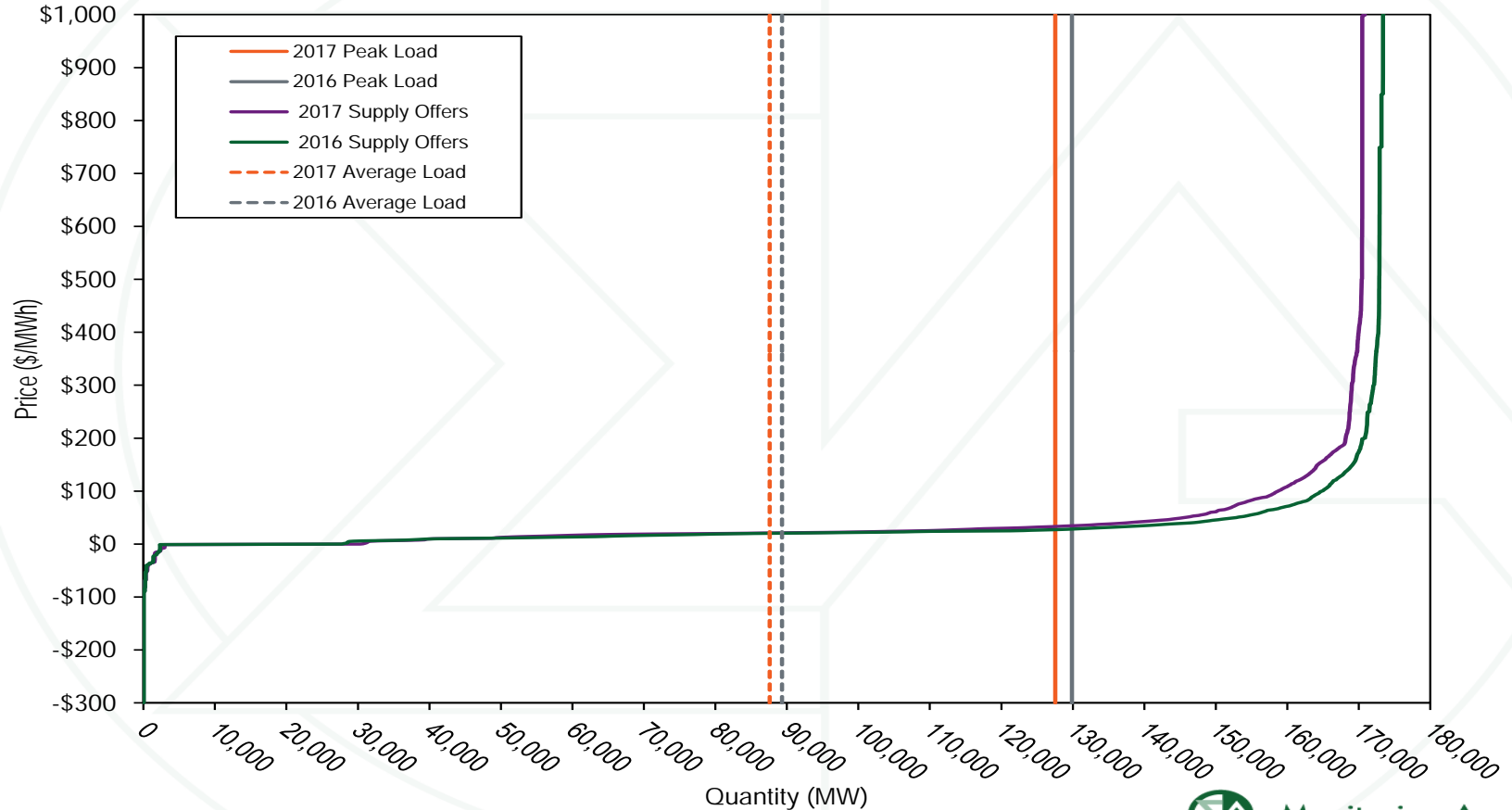
Total price per MWh by category

Category	Jan-Mar 2016 \$/MWh	Jan-Mar 2016 Percent of Total	Jan-Mar 2017 \$/MWh	Jan-Mar 2017 Percent of Total	Percent Change Totals
Load Weighted Energy	\$26.80	55.2%	\$30.28	59.6%	13.0%
Capacity	\$12.27	25.3%	\$10.08	19.9%	(17.9%)
Transmission Service Charges	\$7.57	15.6%	\$8.33	16.4%	10.0%
Transmission Enhancement Cost Recovery	\$0.54	1.1%	\$0.61	1.2%	14.2%
PJM Administrative Fees	\$0.45	0.9%	\$0.50	1.0%	11.6%
Reactive	\$0.38	0.8%	\$0.46	0.9%	21.2%
Regulation	\$0.11	0.2%	\$0.11	0.2%	(0.1%)
Energy Uplift (Operating Reserves)	\$0.20	0.4%	\$0.10	0.2%	(48.4%)
Transmission Owner (Schedule 1A)	\$0.09	0.2%	\$0.10	0.2%	7.1%
Black Start	\$0.08	0.2%	\$0.09	0.2%	14.2%
Synchronized Reserves	\$0.04	0.1%	\$0.06	0.1%	37.7%
NERC/RFC	\$0.03	0.1%	\$0.03	0.1%	1.8%
Load Response	\$0.01	0.0%	\$0.01	0.0%	(33.3%)
Non-Synchronized Reserves	\$0.01	0.0%	\$0.01	0.0%	(58.9%)
RTO Startup and Expansion	\$0.00	0.0%	\$0.00	0.0%	3.3%
Day Ahead Scheduling Reserve (DASR)	\$0.00	0.0%	\$0.00	0.0%	(84.1%)
Transmission Facility Charges	\$0.00	0.0%	\$0.00	0.0%	(100.0%)
Capacity (FRR)	\$0.00	0.0%	\$0.00	0.0%	0.0%
Emergency Load Response	\$0.00	0.0%	\$0.00	0.0%	0.0%
Emergency Energy	\$0.00	0.0%	\$0.00	0.0%	0.0%
Total Price	\$48.59	100.0%	\$50.76	100.0%	4.5%

Components of quarterly total price (\$/MWh)



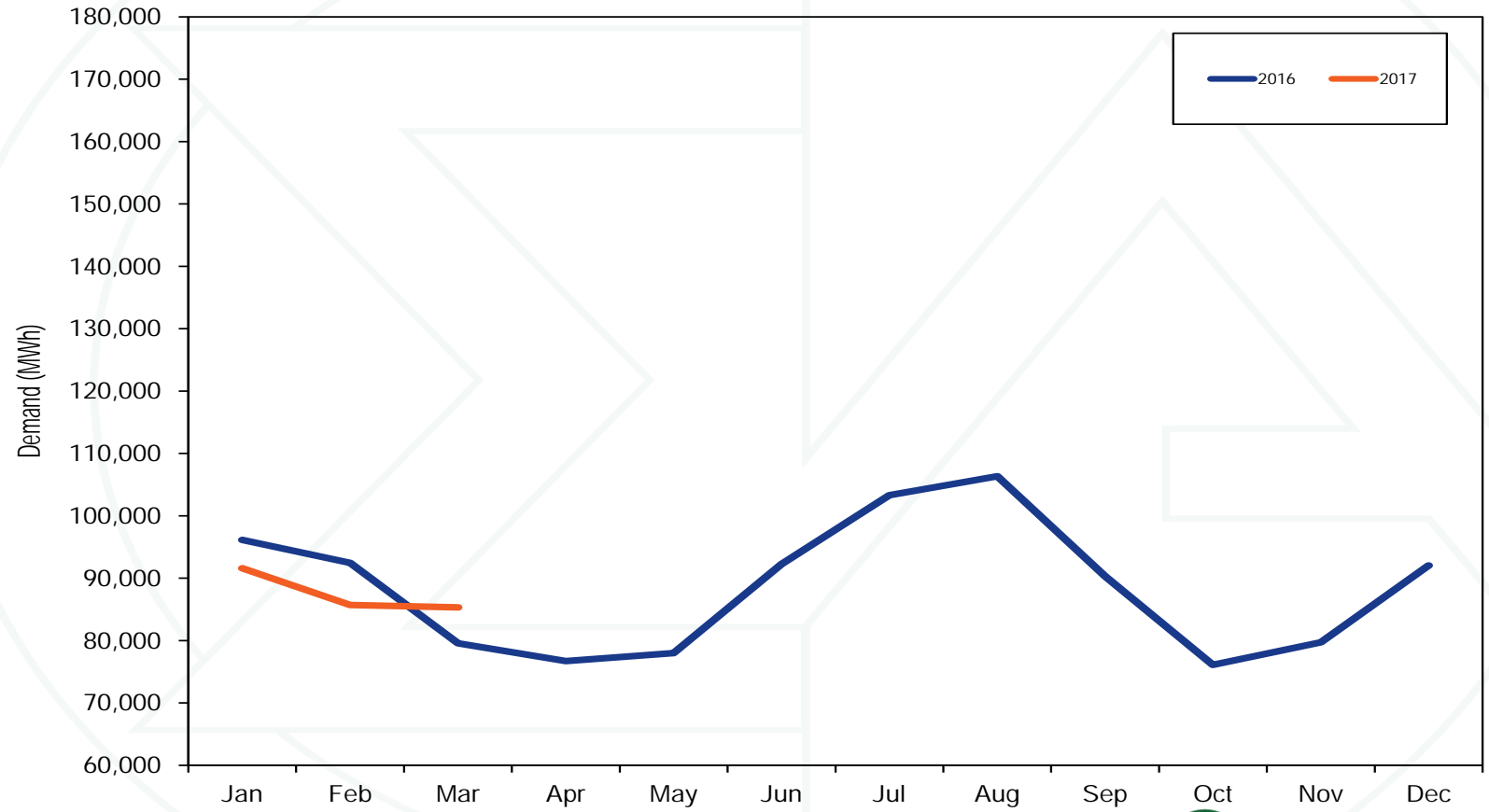
Average RT supply curves



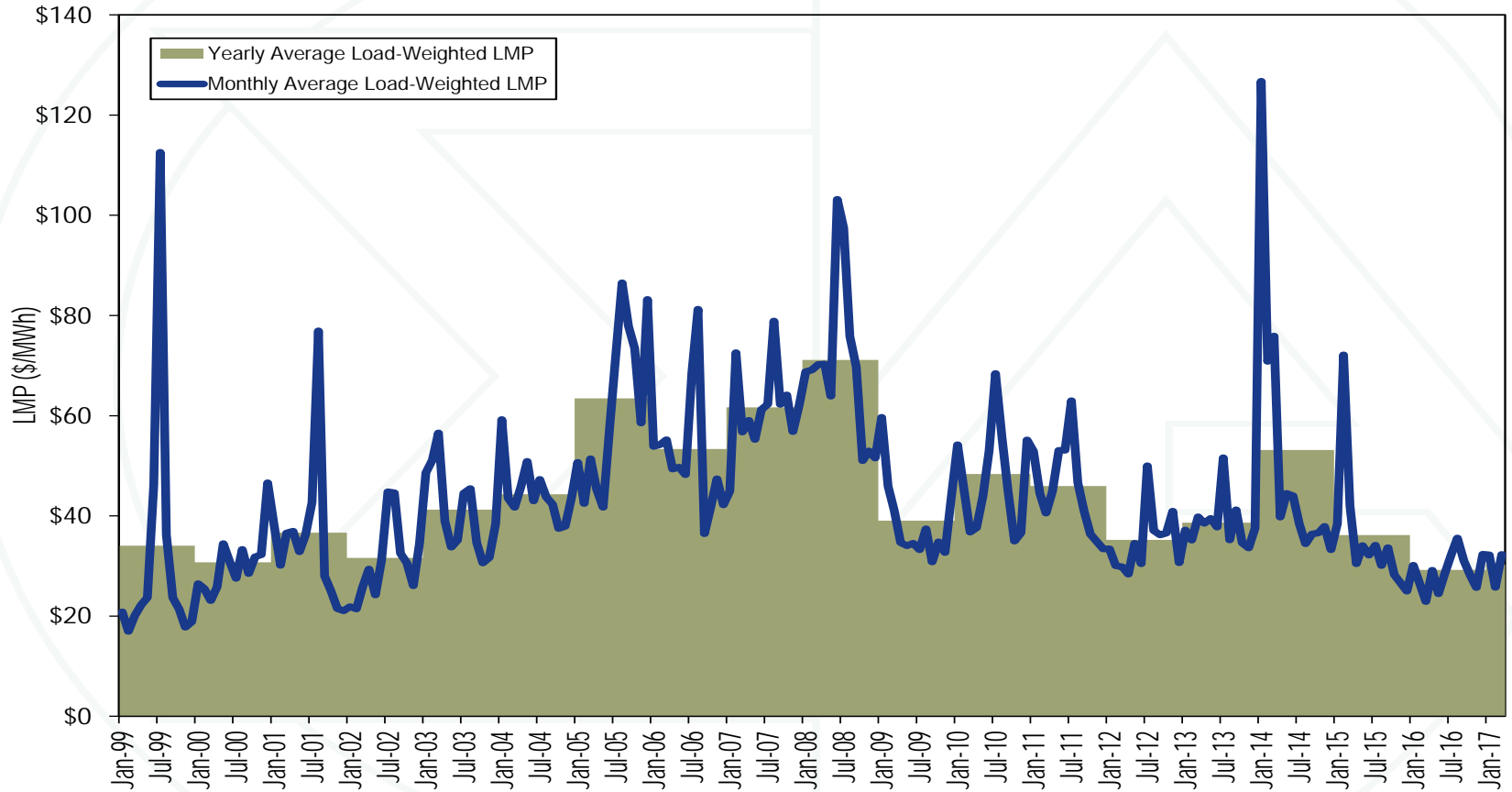
RT average hourly load

Jan-Mar	PJM Real-Time Demand (MWh)				Year-to-Year Change			
	Load		Load Plus Exports		Load		Load Plus Exports	
	Load	Standard Deviation	Demand	Standard Deviation	Load	Standard Deviation	Demand	Standard Deviation
1998	28,019	3,762	28,019	3,762	NA	NA	NA	NA
1999	29,784	4,027	29,784	4,027	6.3%	7.0%	6.3%	7.0%
2000	30,367	4,624	30,367	4,624	2.0%	14.8%	2.0%	14.8%
2001	31,254	3,846	33,452	3,704	2.9%	(16.8%)	10.2%	(19.9%)
2002	29,968	4,083	30,988	3,932	(4.1%)	6.1%	(7.4%)	6.1%
2003	39,249	5,546	41,600	5,701	31.0%	35.8%	34.2%	45.0%
2004	39,549	5,761	41,198	5,394	0.8%	3.9%	(1.0%)	(5.4%)
2005	71,388	8,966	79,319	9,587	80.5%	55.6%	92.5%	77.8%
2006	80,179	8,977	86,567	9,378	12.3%	0.1%	9.1%	(2.2%)
2007	84,586	12,040	90,304	12,012	5.5%	34.1%	4.3%	28.1%
2008	82,235	10,184	89,092	10,621	(2.8%)	(15.4%)	(1.3%)	(11.6%)
2009	81,170	11,718	86,110	11,948	(1.3%)	15.1%	(3.3%)	12.5%
2010	81,121	10,694	86,843	11,262	(0.1%)	(8.7%)	0.9%	(5.7%)
2011	81,018	10,273	86,635	10,613	(0.1%)	(3.9%)	(0.2%)	(5.8%)
2012	86,329	10,951	91,090	11,293	6.6%	6.6%	5.1%	6.4%
2013	91,337	10,610	95,835	10,452	5.8%	(3.1%)	5.2%	(7.4%)
2014	98,317	13,484	104,454	12,843	7.6%	27.1%	9.0%	22.9%
2015	97,936	13,445	102,821	13,855	(0.4%)	(0.3%)	(1.6%)	7.9%
2016	89,322	13,262	92,777	13,409	(8.8%)	(1.4%)	(9.8%)	(3.2%)
2017	87,598	11,208	92,791	11,295	(1.9%)	(15.5%)	0.0%	(15.8%)

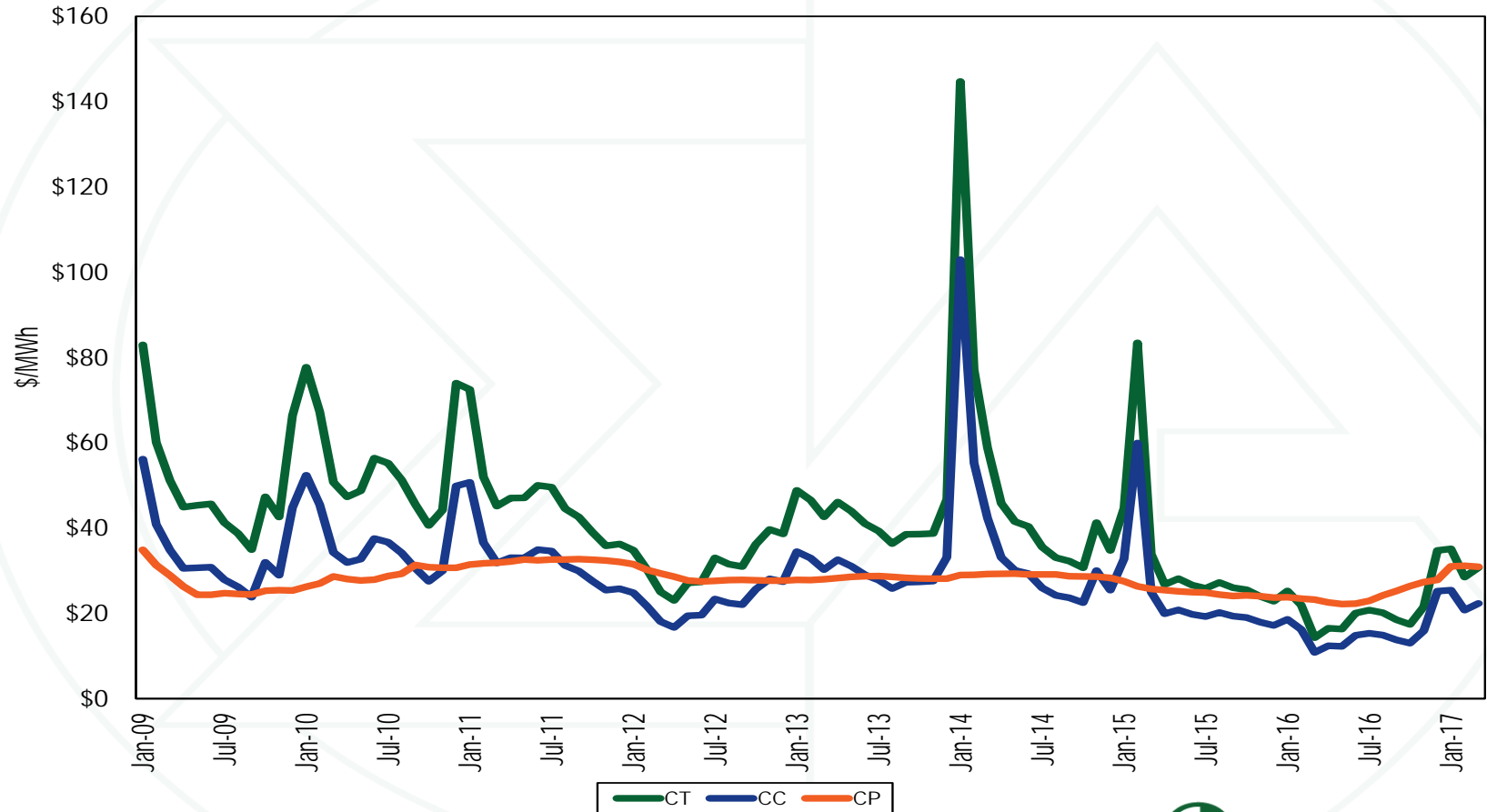
RT monthly average hourly load



RT LMP



Short run marginal costs



RT annual, fuel-cost adjusted, load-weighted average LMP

	2017 Load-Weighted LMP	2017 Fuel-Cost Adjusted, Load-Weighted LMP	Change
Average	\$30.28	\$23.35	(22.9%)
	2016 Load-Weighted LMP	2017 Fuel-Cost Adjusted, Load-Weighted LMP	Change
Average	\$26.80	\$23.35	(12.9%)
	2016 Load-Weighted LMP	2017 Load-Weighted LMP	Change
Average	\$26.80	\$30.28	13.0%

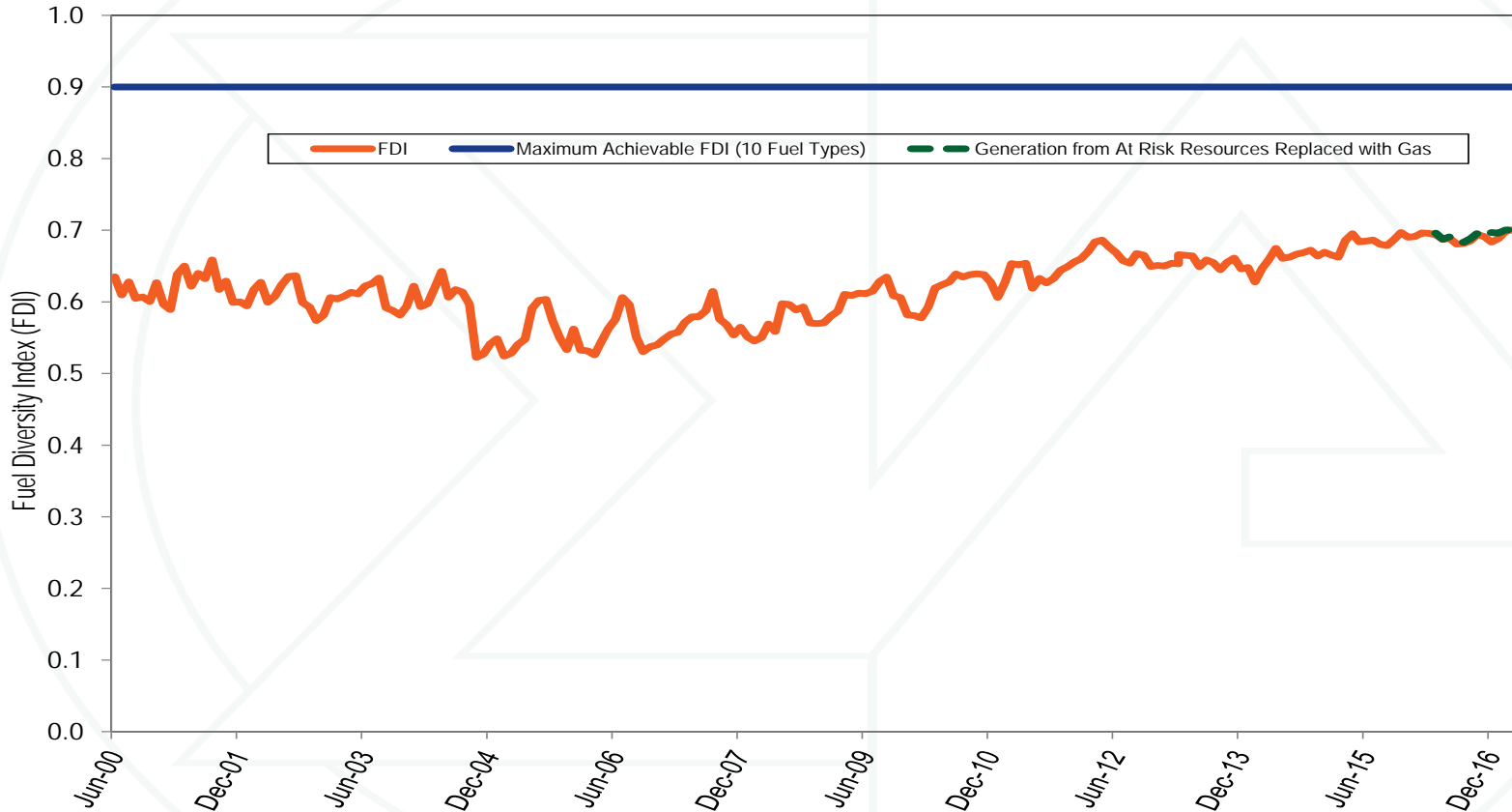
RT LMP and inflation adjusted LMP

Year	Load-Weighted, Average LMP	Inflation Adjusted Load-Weighted, Average LMP
1998	\$18.13	\$18.10
1999	\$19.38	\$19.03
2000	\$25.10	\$23.89
2001	\$35.16	\$32.35
2002	\$23.01	\$20.90
2003	\$51.93	\$45.86
2004	\$48.77	\$42.36
2005	\$48.37	\$40.73
2006	\$54.43	\$44.21
2007	\$58.07	\$46.05
2008	\$69.35	\$52.85
2009	\$49.60	\$37.83
2010	\$45.92	\$34.21
2011	\$46.35	\$33.83
2012	\$31.21	\$22.14
2013	\$37.41	\$26.09
2014	\$92.98	\$64.01
2015	\$50.91	\$35.04
2016	\$26.80	\$18.25
2017	\$30.28	\$20.11

Generation by fuel source

	Jan - Mar	2016		2017		Change in Output
		GWh	Percent	GWh	Percent	
Coal		62,503.2	32.0%	66,884.2	33.3%	7.0%
	Bituminous	56,062.4	28.7%	57,284.4	28.5%	2.2%
	Sub Bituminous	5,089.0	2.6%	7,383.5	3.7%	45.1%
	Other Coal	1,351.8	0.7%	2,216.3	1.1%	64.0%
Nuclear		71,578.3	36.6%	71,964.8	35.8%	0.5%
Gas		48,989.1	25.1%	49,673.5	24.7%	1.4%
	Natural Gas	48,453.7	24.8%	49,074.8	24.4%	1.3%
	Landfill Gas	535.3	0.3%	598.1	0.3%	11.7%
	Other Gas	0.1	0.0%	0.6	0.0%	950.0%
Hydroelectric		4,156.8	2.1%	3,618.7	1.8%	(12.9%)
	Pumped Storage	975.6	0.5%	905.9	0.5%	(7.2%)
	Run of River	2,825.7	1.4%	2,372.6	1.2%	(16.0%)
	Other Hydro	355.5	0.2%	340.2	0.2%	(4.3%)
Wind		5,802.7	3.0%	6,573.7	3.3%	13.3%
Waste		979.4	0.5%	957.1	0.5%	(2.3%)
	Solid Waste	979.4	0.5%	957.1	0.5%	(2.3%)
	Miscellaneous	0.0	0.0%	0.0	0.0%	NA
Oil		617.2	0.3%	481.3	0.2%	(22.0%)
	Heavy Oil	137.7	0.1%	3.6	0.0%	(97.4%)
	Light Oil	142.0	0.1%	87.3	0.0%	(38.5%)
	Diesel	26.4	0.0%	7.1	0.0%	(73.0%)
	Gasoline	0.0	0.0%	0.0	0.0%	NA
	Kerosene	65.5	0.0%	0.8	0.0%	(98.7%)
	Jet Oil	0.0	0.0%	0.0	0.0%	NA
	Other Oil	245.5	0.1%	382.4	0.2%	55.8%
Solar, Net Energy Metering		181.3	0.1%	267.8	0.1%	47.8%
Energy Storage		4.2	0.0%	9.2	0.0%	118.5%
	Battery	4.2	0.0%	9.2	0.0%	118.5%
	Compressed Air	0.0	0.0%	0.0	0.0%	NA
Biofuel		516.9	0.3%	493.0	0.2%	(4.6%)
Geothermal		0.0	0.0%	0.0	0.0%	NA
Other Fuel Type		0.0	0.0%	48.2	0.0%	NA
Total		195,329.0	100.0%	200,971.5	100.0%	2.9%

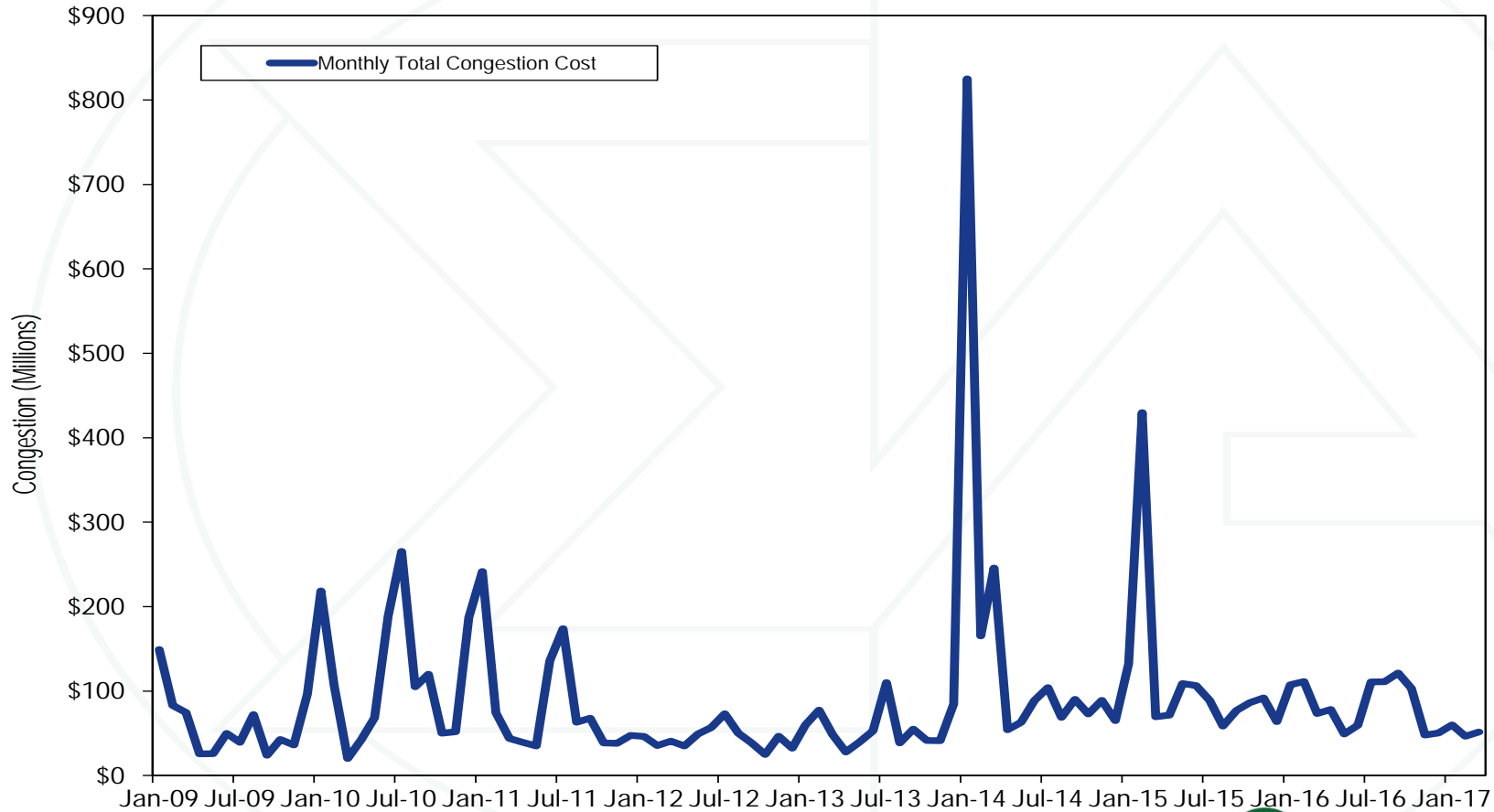
Generation fuel diversity index



Monthly markup components of real-time load-weighted LMP

	2016			2017		
	Markup Component (All Hours)	Off Peak Markup Component	Peak Markup Component	Markup Component (All Hours)	Off Peak Markup Component	Peak Markup Component
Jan	(\$1.89)	(\$1.95)	(\$1.82)	\$1.75	\$0.47	\$3.11
Feb	(\$0.43)	(\$0.59)	(\$0.28)	\$1.13	\$0.53	\$1.70
Mar	(\$1.24)	(\$1.22)	(\$1.25)	\$1.12	\$1.70	\$0.60
Total	(\$1.21)	(\$1.30)	(\$1.12)	\$1.35	\$0.89	\$1.80

Monthly total congestion costs



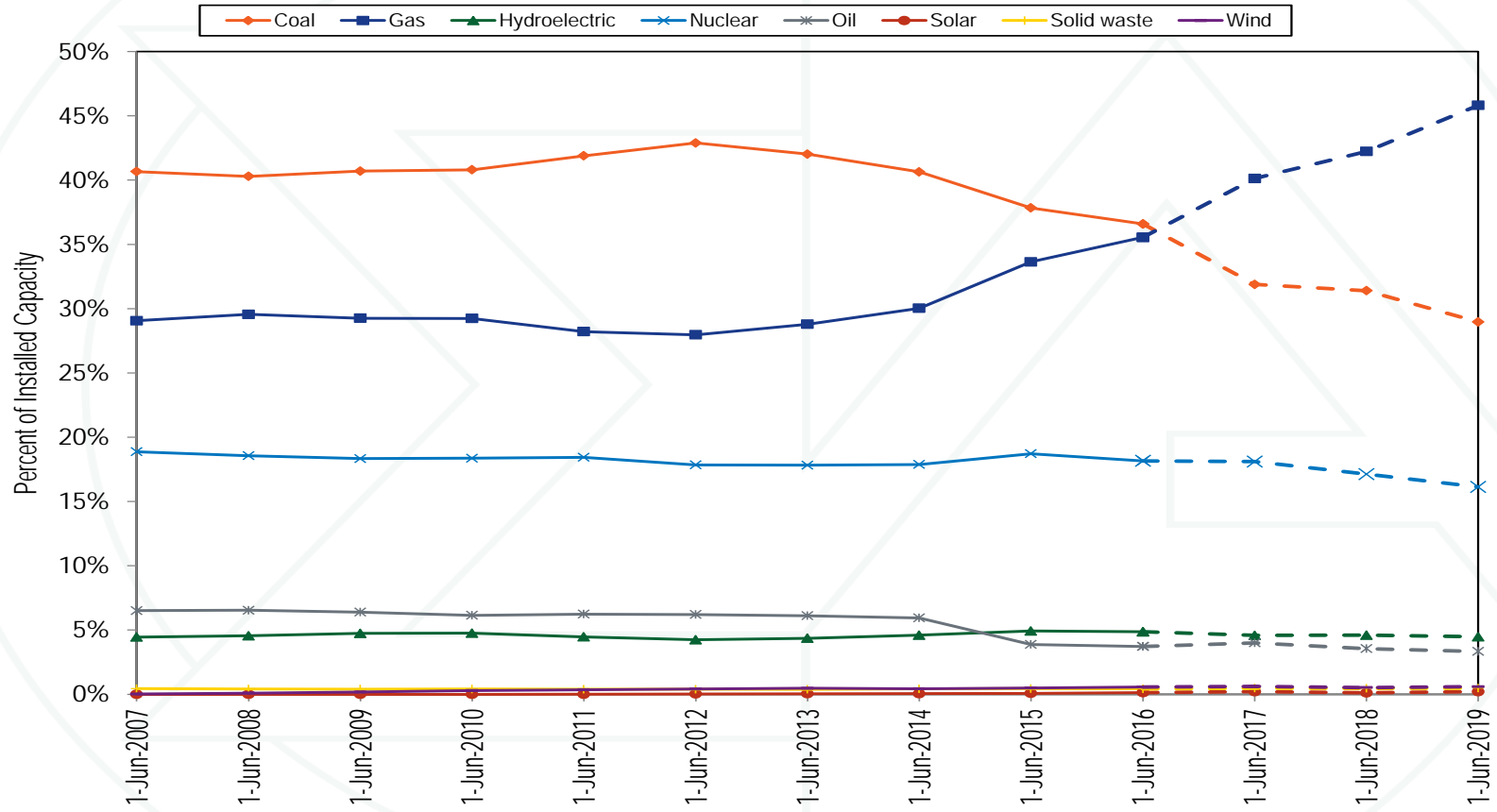
Capacity Market results were competitive

Market Element	Evaluation	Market Design
Market Structure: Aggregate Market	Not Competitive	
Market Structure: Local Market	Not Competitive	
Participant Behavior	Competitive	
Market Performance	Competitive	Mixed

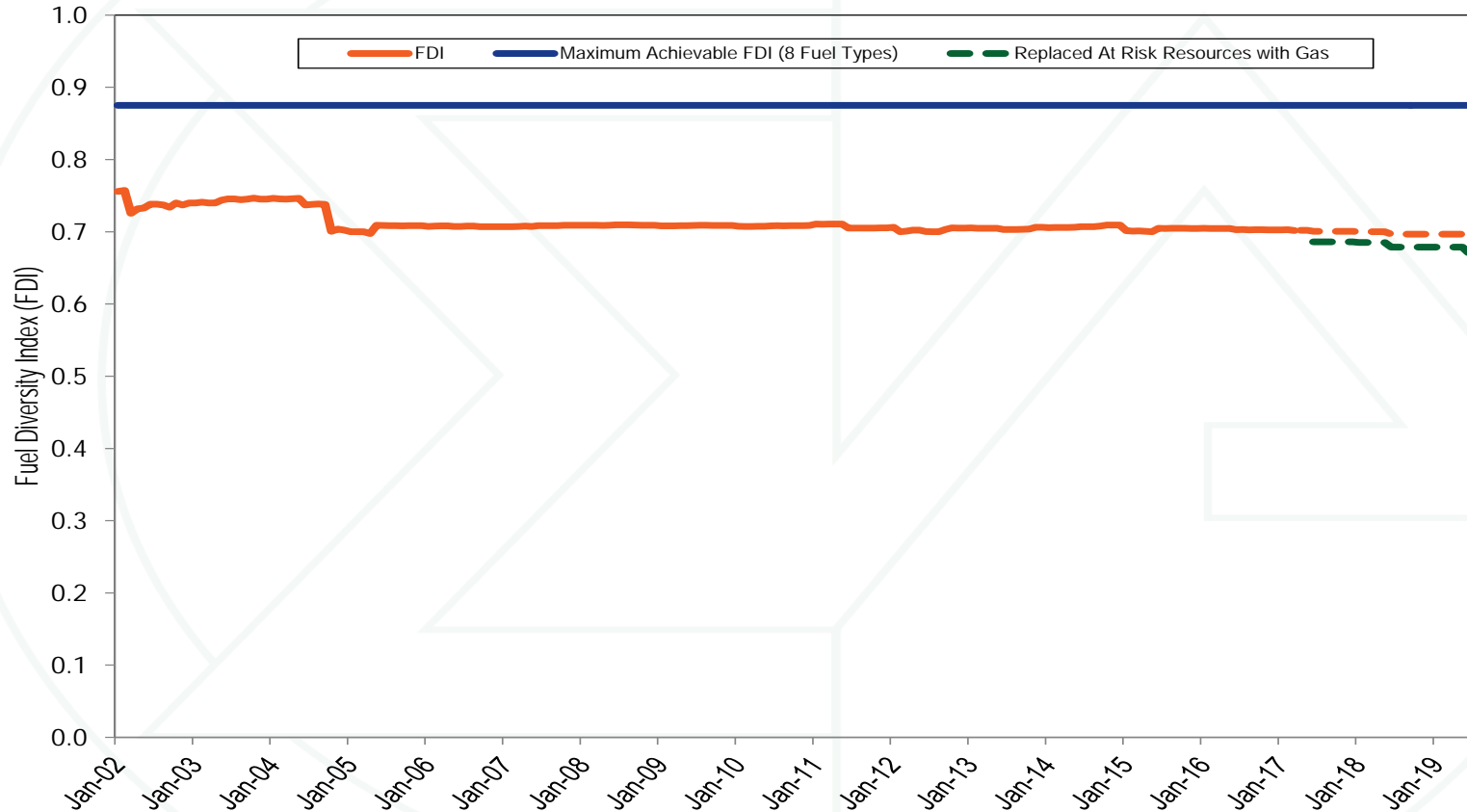
Installed capacity (By fuel source)

	1-Jan-17		31-Jan-17		28-Feb-17		31-Mar-17	
	MW	Percent	MW	Percent	MW	Percent	MW	Percent
Coal	66,622.2	36.5%	66,622.2	36.5%	67,149.5	36.5%	66,940.5	36.5%
Gas	65,110.3	35.7%	65,084.5	35.7%	65,895.5	35.9%	65,895.5	35.9%
Hydroelectric	8,850.4	4.9%	8,850.4	4.9%	8,850.4	4.8%	8,850.4	4.8%
Nuclear	33,043.4	18.1%	33,043.4	18.1%	33,021.7	18.0%	33,103.7	18.0%
Oil	6,733.6	3.7%	6,733.6	3.7%	6,687.0	3.6%	6,687.0	3.6%
Solar	262.3	0.1%	268.0	0.1%	268.0	0.1%	268.0	0.1%
Solid waste	769.4	0.4%	769.4	0.4%	769.4	0.4%	769.4	0.4%
Wind	1,019.1	0.6%	1,074.2	0.6%	1,079.1	0.6%	1,079.1	0.6%
Total	182,410.7	100.0%	182,445.7	100.0%	183,720.6	100.0%	183,593.6	100.0%

Percent of installed capacity (by fuel source)



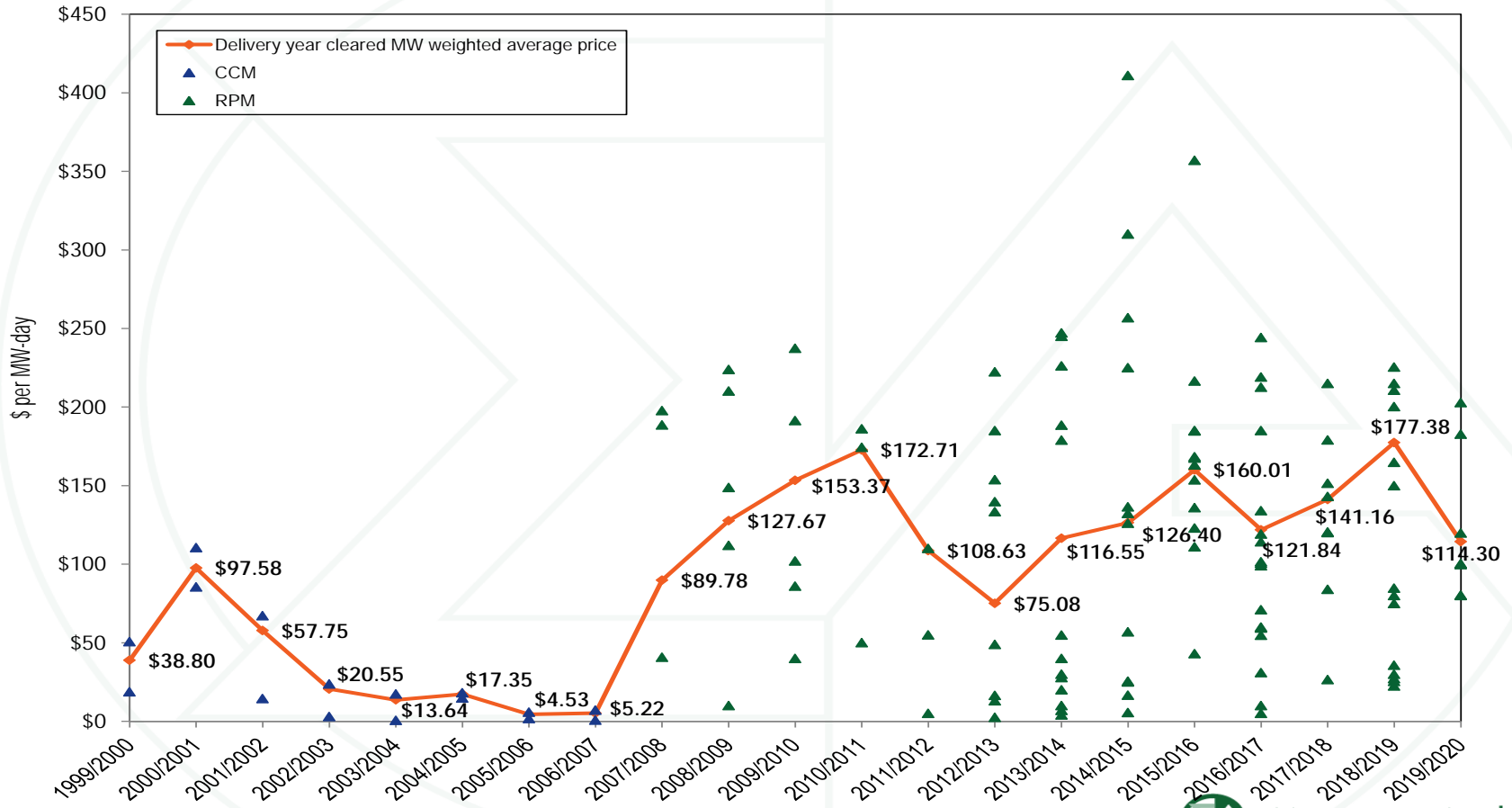
Installed capacity fuel diversity index



EFORd demand forced outage trends



History of capacity prices



Summary of unit retirements by fuel (MW)

	Coal	Diesel	Heavy Oil	Hydro	Kerosene	Landfill Gas	Light Oil	Natural Gas	Nuclear	Wind	Wood Waste	Total
Retirements 2011	543.0	0.0	0.0	0.0	0.0	0.0	63.7	522.5	0.0	0.0	0.0	1,129.2
Retirements 2012	5,907.9	0.0	0.0	0.0	0.0	0.0	788.0	250.0	0.0	0.0	16.0	6,961.9
Retirements 2013	2,589.9	2.9	166.0	0.0	0.0	3.8	85.0	0.0	0.0	0.0	8.0	2,855.6
Retirements 2014	2,427.0	50.0	0.0	0.0	184.0	15.3	0.0	294.0	0.0	0.0	0.0	2,970.3
Retirements 2015	7,661.8	10.3	0.0	0.0	644.2	2.0	212.0	1,239.0	0.0	10.4	0.0	9,779.7
Retirements 2016	243.0	59.0	74.0	0.5	0.0	11.0	14.0	0.0	0.0	0.0	0.0	401.5
Retirements 2017 (Jan-Mar)	209.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	209.0
Planned Retirements for April 2017 and Later	6,516.0	2.4	182.0	0.0	0.0	0.0	30.6	661.8	614.5	0.0	0.0	8,007.3
Total	26,097.6	124.6	422.0	0.5	828.2	32.1	1,193.3	2,967.3	614.5	10.4	24.0	32,314.5

Total energy uplift charges

	(Jan - Mar) 2016 Charges (Millions)	(Jan - Mar) 2017 Charges (Millions)	Change	Percent Change
Total Energy Uplift	\$39.5	\$25.6	(\$13.9)	(35.2%)
Energy Uplift as a Percent of Total PJM Billing	0.4%	0.3%	(0.2%)	(36.6%)

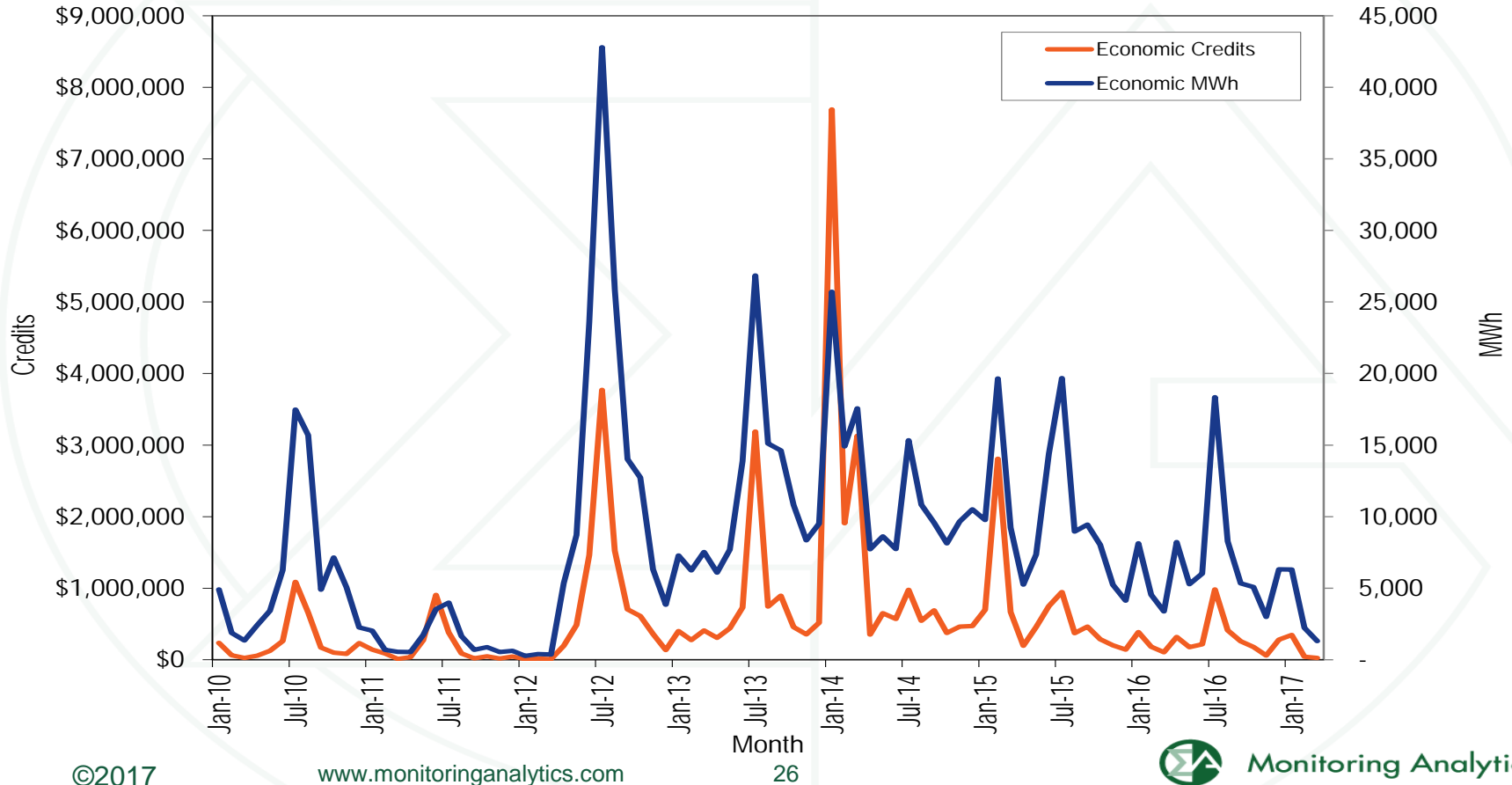
Top 10 units and organizations energy uplift credits

Category	Type	Top 10 Units		Top 10 Organizations	
		Credits (Millions)	Credits Share	Credits (Millions)	Credits Share
Day-Ahead	Generators	\$4.6	86.9%	\$5.2	98.5%
	Canceled Resources	\$0.0	100.0%	\$0.0	100.0%
Balancing	Generators	\$2.4	18.7%	\$9.8	76.4%
	Local Constraints Control	\$0.0	100.0%	\$0.0	100.0%
	Lost Opportunity Cost	\$0.4	28.2%	\$1.1	69.4%
Reactive Services		\$5.9	96.5%	\$6.1	100.0%
Synchronous Condensing		\$0.0	0.0%	\$0.0	0.0%
Black Start Services		\$0.1	93.4%	\$0.1	100.0%
Total		\$11.5	44.7%	\$21.5	83.3%

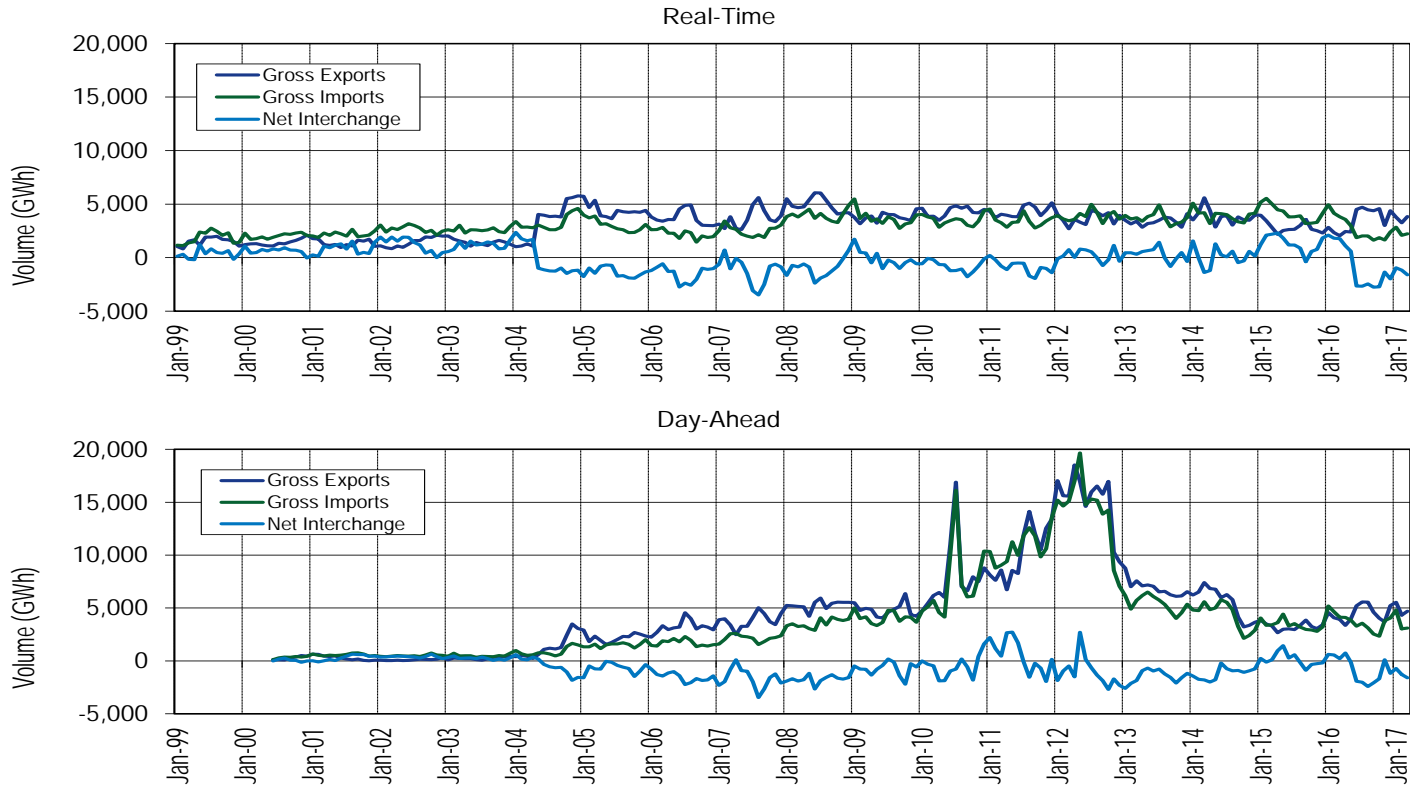
Operating reserve rates statistics

Region	Transaction	Rates Charged (\$/MWh)			Standard Deviation
		Maximum	Average	Minimum	
East	INC	2.606	0.202	0.000	0.355
	DEC	2.663	0.227	0.002	0.356
	DA Load	0.172	0.025	0.000	0.038
	RT Load	0.471	0.028	0.000	0.067
	Deviation	2.606	0.202	0.000	0.355
West	INC	2.443	0.193	0.000	0.336
	DEC	2.500	0.218	0.002	0.338
	DA Load	0.172	0.025	0.000	0.038
	RT Load	0.390	0.024	0.000	0.059
	Deviation	2.443	0.193	0.000	0.336

Economic program credits and MWh



RT and DA scheduled import and export transaction volume history



Regulation Market results were competitive

Market Element	Evaluation	Market Design
Market Structure	Not Competitive	
Participant Behavior	Competitive	
Market Performance	Competitive	Flawed



Tier 2 Synchronized Reserve Market results were competitive

Market Element	Evaluation	Market Design
Market Structure: Regional Markets	Not Competitive	
Participant Behavior	Competitive	
Market Performance	Competitive	Mixed

History of ancillary services costs /MW load

Year (Jan-Mar)	Regulation	Scheduling, Dispatch and System Control	Reactive	Synchronized Reserve	Total
1999	\$0.04	\$0.23	\$0.25	\$0.00	\$0.52
2000	\$0.21	\$0.38	\$0.37	\$0.00	\$0.96
2001	\$0.49	\$0.64	\$0.22	\$0.00	\$1.35
2002	\$0.24	\$0.67	\$0.16	\$0.00	\$1.07
2003	\$0.65	\$1.01	\$0.22	\$0.11	\$1.99
2004	\$0.54	\$1.06	\$0.26	\$0.17	\$2.03
2005	\$0.47	\$0.80	\$0.25	\$0.07	\$1.59
2006	\$0.48	\$0.70	\$0.28	\$0.09	\$1.55
2007	\$0.58	\$0.72	\$0.25	\$0.11	\$1.66
2008	\$0.59	\$0.73	\$0.30	\$0.07	\$1.69
2009	\$0.38	\$0.35	\$0.34	\$0.03	\$1.10
2010	\$0.34	\$0.36	\$0.35	\$0.05	\$1.10
2011	\$0.27	\$0.30	\$0.38	\$0.12	\$1.07
2012	\$0.18	\$0.41	\$0.48	\$0.03	\$1.10
2013	\$0.28	\$0.41	\$0.63	\$0.04	\$1.36
2014	\$0.63	\$0.38	\$0.37	\$0.29	\$1.67
2015	\$0.32	\$0.41	\$0.36	\$0.18	\$1.26
2016	\$0.11	\$0.42	\$0.38	\$0.04	\$0.95
2017	\$0.11	\$0.46	\$0.46	\$0.06	\$1.09

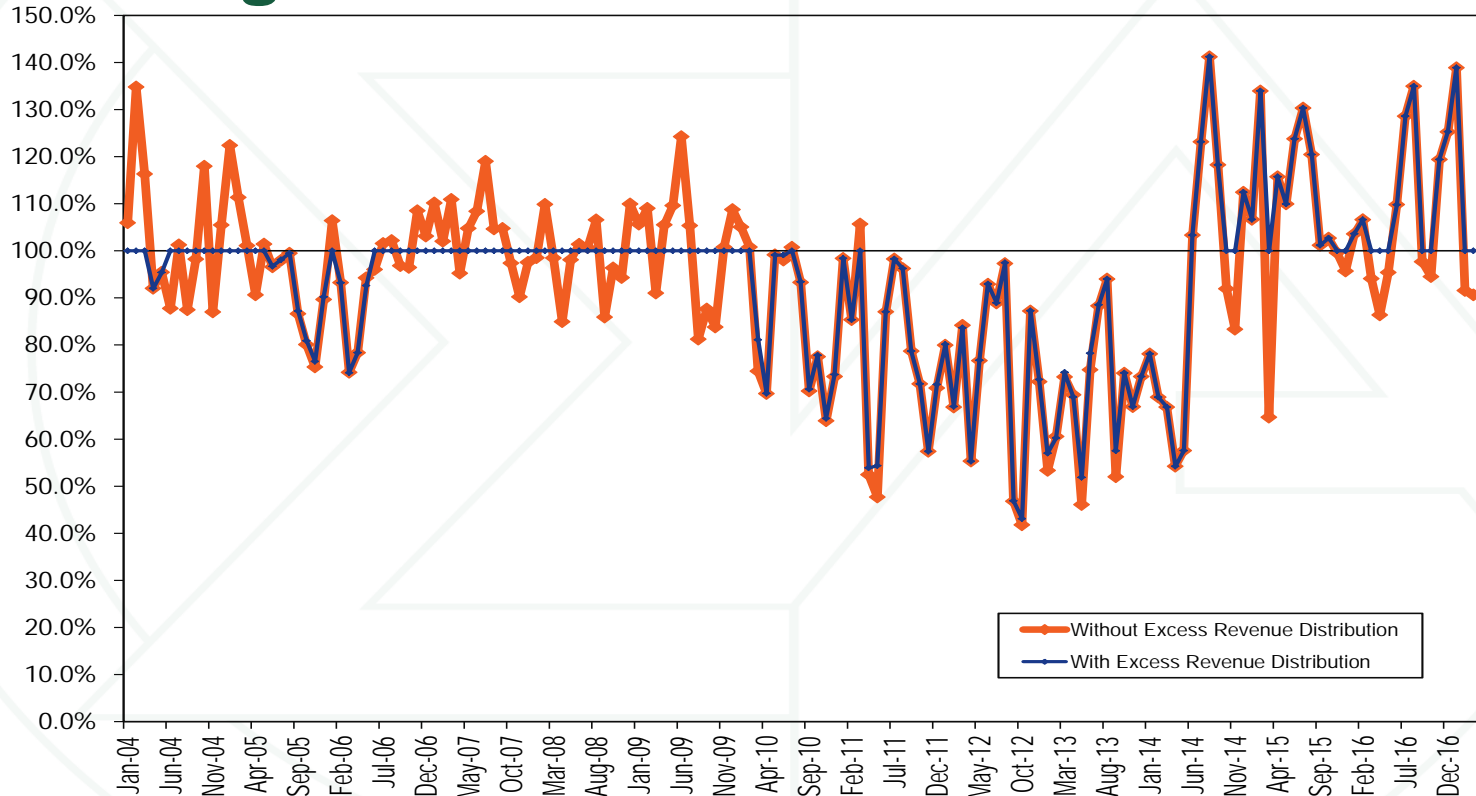
Comparison of average price and cost for regulation

Year (Jan-Mar)	Weighted Regulation Market Price	Weighted Regulation Market Cost	Regulation Price as Percent Cost
2009	\$22.25	\$34.06	65.3%
2010	\$17.97	\$31.24	57.5%
2011	\$11.52	\$25.03	46.0%
2012	\$12.62	\$16.75	75.3%
2013	\$33.91	\$39.36	86.2%
2014	\$92.97	\$112.30	82.8%
2015	\$47.91	\$58.23	82.3%
2016	\$15.55	\$17.92	86.8%
2017	\$13.87	\$18.40	75.4%

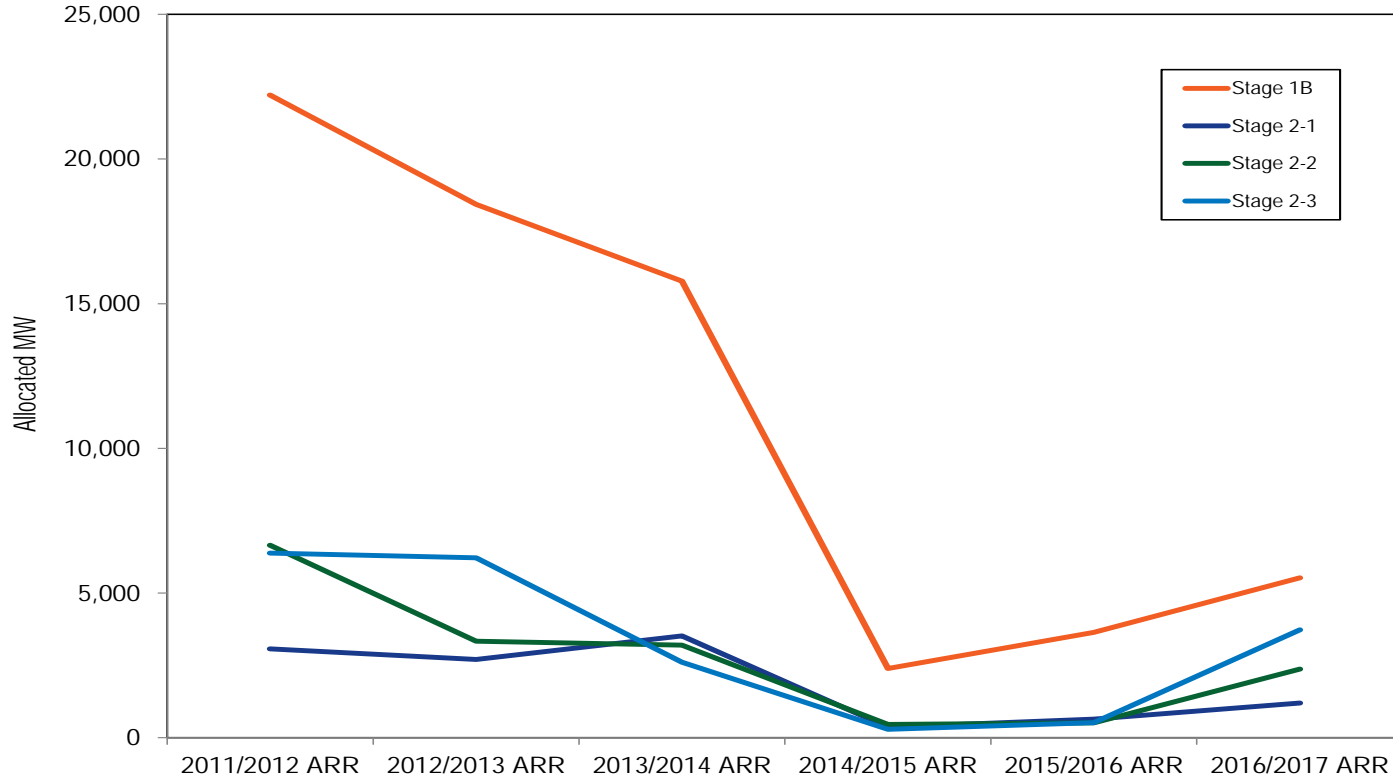
FTR Auction Markets results were competitive

Market Element	Evaluation	Market Design
Market Structure	Competitive	
Participant Behavior	Competitive	
Market Performance	Competitive	Flawed

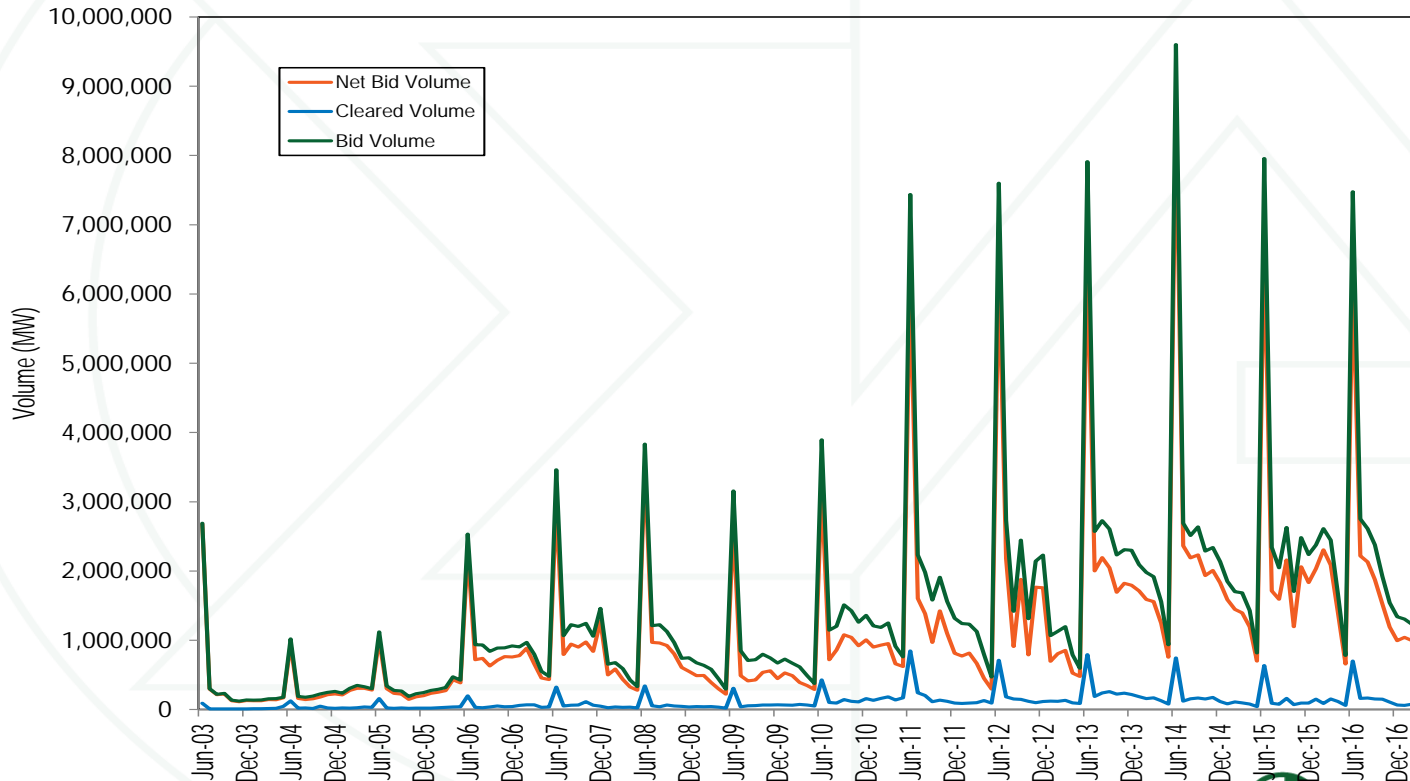
FTR payout ratio by month, excluding and including excess revenue distribution



Historic Stage 1B and Stage 2 ARR Allocations



Long Term, Annual and Monthly FTR Auction bid and cleared volume



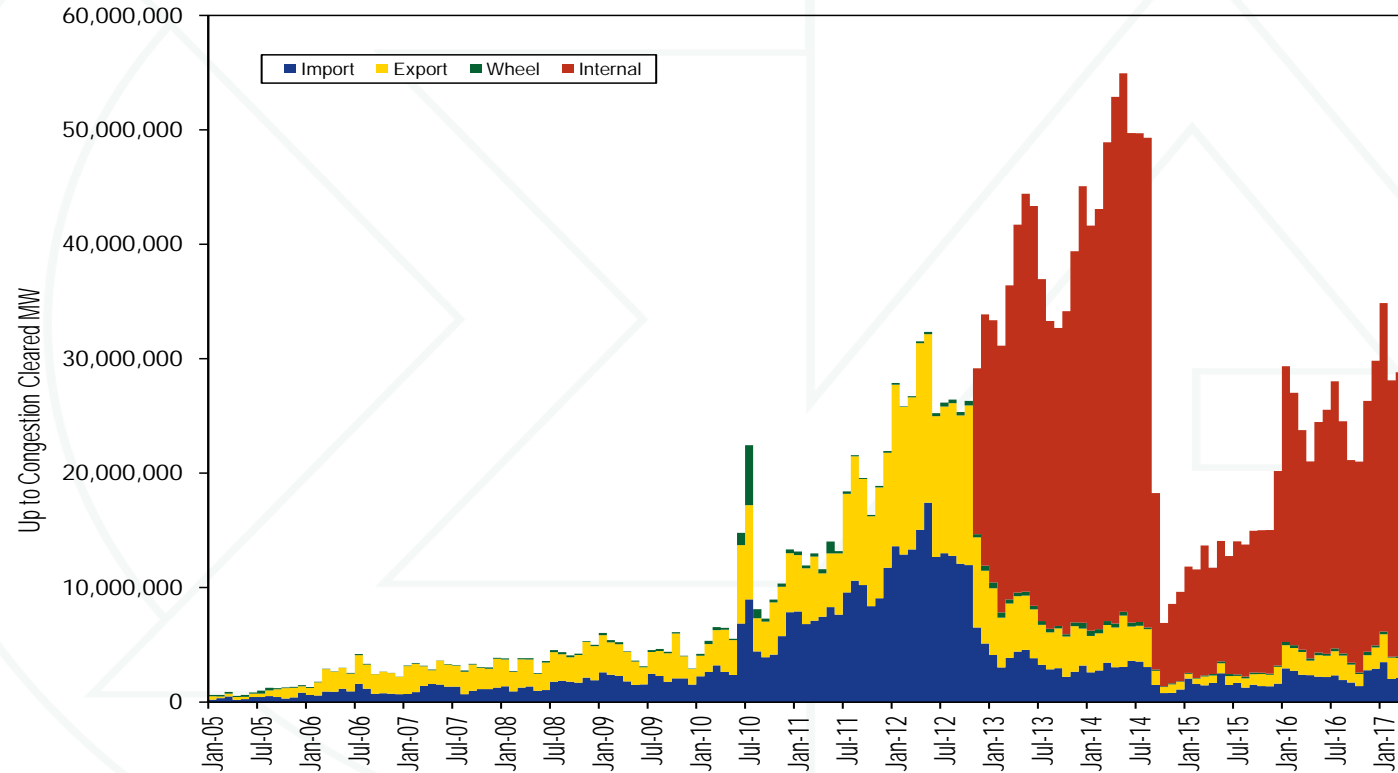
ARR and FTR total congestion offset (in millions) for ARR holders

Planning Period	ARR Credits	FTR Credits	Total Congestion	Total ARR/FTR Offset	Percent Offset	Unreturned Revenue
2011/2012	\$512.2	\$249.8	\$770.6	\$762.0	98.9%	\$8.5
2012/2013	\$349.5	\$181.9	\$575.8	\$531.4	92.3%	\$44.4
2013/2014	\$337.7	\$456.4	\$1,777.1	\$794.0	44.7%	\$983.1
2014/2015	\$482.4	\$404.4	\$1,390.9	\$886.8	63.8%	\$504.1
2015/2016	\$635.3	\$223.4	\$992.6	\$858.8	86.5%	\$133.8
2016/2017	\$533.8	\$169.6	\$761.2	\$703.4	92.4%	\$57.8
Total	\$2,850.9	\$1,685.5	\$6,268.1	\$4,536.4	72.4%	\$1,731.8

Monthly FTR profits by organization type

Month	Organization Type			Total
	Physical	Physical ARR Holders	Financial	
Jan	(\$1,519,199)	(\$10,870,707)	\$82,092	(\$12,307,814)
Feb	(\$2,227,836)	(\$1,645,130)	\$3,282,949	(\$590,017)
Mar	(\$2,878,185)	(\$2,232,065)	(\$673,693)	(\$5,783,943)
Total	(\$6,625,219)	(\$14,747,902)	\$2,691,348	(\$18,681,774)

Monthly cleared UTC transactions by type (MW)



Monitoring Analytics, LLC

2621 Van Buren Avenue

Suite 160

Eagleville, PA

19403

(610) 271-8050

MA@monitoringanalytics.com

www.MonitoringAnalytics.com

