Table of Contents		Overview: Section 12, Planning	62
Table of Contents		Overview: Section 13, FTRs and ARRs	67
Preface	i		
STOTION A LANGE		SECTION 2 Recommendations	<b>7</b> 5
SECTION 1 Introduction	1	New Recommendations	75
2017 Q3 in Review	1	New Recommendations from Section 5, Capacity Market	76
PJM Market Summary Statistics	6	New Recommendation from Section 10, Ancillary Services	76
PJM Market Background	6	Complete List of Current MMU Recommendations	76
Conclusions	7	Section 3, Energy Market	76
Energy Market Conclusion	8	Section 4, Energy Uplift	79
Capacity Market Conclusion	10	Section 5, Capacity	81
Tier 2 Synchronized Reserve Market Conclusion	10	Section 6, Demand Response	83
Day-Ahead Scheduling Reserve Market Conclusion	10	Section 7, Net Revenue	85
Regulation Market Conclusion	11	Section 8, Environmental	85
FTR Auction Market Conclusion	11	Section 9, Interchange Transactions	85
Role of MMU	12	Section 10, Ancillary Services	86
Reporting	12	Section 11, Congestion and Marginal Losses	88
Monitoring	12	Section 12, Planning	88
Market Design	13	Section 13, FTRs and ARRs	89
New Recommendations	13		
New Recommendations from Section 5, Capacity Market	14		
New Recommendation from Section 10, Ancillary Services	14	SECTION 3 Energy Market	91
Total Price of Wholesale Power	14	Overview	92
Components of Total Price	14	Market Structure	92
Section Overviews	22	Market Behavior	93
Overview: Section 3, Energy Market	22	Market Performance	95
Overview: Section 4, Energy Uplift	30	Scarcity	96
Overview: Section 5, Capacity Market	34	Recommendations	96
Overview: Section 6, Demand Response	41	Conclusion	98
Overview: Section 7, Net Revenue	45	Market Structure	100
Overview: Section 8, Environmental and Renewables	46	Market Concentration	100
Overview: Section 9, Interchange Transactions	49	Ownership of Marginal Resources	104
Overview: Section 10, Ancillary Services	52	Type of Marginal Resources	105
Overview: Section 11, Congestion and Marginal Losses	61		

Supply	108	Balancing Operating Reserve Determinants	210
Generator Offers	111	Energy Uplift Credits	218
Demand	120	Characteristics of Credits	218
Supply and Demand: Load and Spot Market	128	Types of Units	218
Market Behavior	130	Concentration of Energy Uplift Credits	219
Offer Capping for Local Market Power	130	Pool Scheduled and Self Scheduled Generation	22
TPS Test Statistics	136	<b>Economic and Noneconomic Generation</b>	22
Parameter Limited Schedules	138	Geography of Charges and Credits	224
Markup Index	141		
Energy Market Cost-Based Offers	145		
Frequently Mitigated Units (FMU) and Associated Units (AU)	147	SECTION 5 Capacity Market	227
Virtual Offers and Bids	149	Overview	227
Market Performance	160	RPM Capacity Market	227
Markup	160	Generator Performance	229
Prices	168	Recommendations	230
Scarcity	190	Conclusion	233
Emergency Procedures	191	Installed Capacity	230
Scarcity and Scarcity Pricing	194	Fuel Diversity	237
PJM Cold Weather Operations 2017	202	RPM Capacity Market	238
		Market Structure	238
	202	Market Conduct	250
SECTION 4 Energy Uplift (Operating Reserves)	203	Market Performance	253
Overview	203	Generator Performance	260
Energy Uplift Results	203	Capacity Factor	260
Characteristics of Credits	203	Generator Performance Factors	26
Geography of Charges and Credits	204	Generator Forced Outage Rates	262
Recommendations	204		
Conclusion	206	anaman - n	
Energy Uplift	207	SECTION 6 Demand Response	269
Credits and Charges Categories	207	Overview	269
Energy Uplift Results	209	Recommendations	270
Energy Uplift Charges	209	Conclusion	27
Operating Reserve Rates	212	PJM Demand Response Programs	273
Reactive Services Rates	215	Non-PJM Demand Response Programs	274
		, -	

iv Table of Contents © 2017 Monitoring Analytics, LLC

274	Federal Environmental Regulation	310
275	Control of Mercury and Other Hazardous Air Pollutants	310
283	Air Quality Standards: Control of NO <sub>X</sub> , SO <sub>2</sub> and O <sub>3</sub> Emissions Allowances	311
		3
293	Engines	313
293	Regulation of Greenhouse Gas Emissions	314
293	Federal Regulation of Environmental Impacts on Water	315
293	Federal Regulation of Coal Ash	316
293	State Environmental Regulation	317
294	New Jersey High Electric Demand Day (HEDD) Rules	317
294	Illinois Air Quality Standards (NO <sub>x</sub> , SO <sub>2</sub> and Hg)	318
297	State Regulation of Greenhouse Gas Emissions	318
299	State Renewable Portfolio Standards	320
300	Emissions Controlled Capacity and Renewables in PJM Markets	330
301	Emission Controlled Capacity in the PJM Region	330
302	Wind and Solar Peak Hour Output	334
303	Wind Units	335
304	Solar Units	337
304		
304		
306	SECTION 9 Interchange Transactions	341
	Overview	341
	Interchange Transaction Activity	341
	Interactions with Bordering Areas	341
307	Recommendations	342
307	Conclusion	343
	Interchange Transaction Activity	344
	Charges and Credits Applied to Interchange Transactions	344
	Aggregate Imports and Exports	345
	Real-Time Interface Imports and Exports	348
309	Real-Time Interface Pricing Point Imports and Exports	349
	Day-Ahead Interface Imports and Exports	353
309	Day-Ahead Interface Pricing Point Imports and Exports	356
	275 283 293 293 293 293 294 294 297 299 300 301 302 303 304 304 304 306 307 307 307 307 307 308 309 309 309 309	Control of Mercury and Other Hazardous Air Pollutants Air Quality Standards: Control of NO <sub>x</sub> , SO <sub>2</sub> and O <sub>3</sub> Emissions Allowances Emission Standards for Reciprocating Internal Combustion Engines Regulation of Greenhouse Gas Emissions Federal Regulation of Coal Ash State Environmental Regulation New Jersey High Electric Demand Day (HEDD) Rules Illinois Air Quality Standards (NO <sub>x</sub> , SO <sub>2</sub> and Hg) State Regulation of Greenhouse Gas Emissions State Regulation of Greenhouse Gas Emissions State Renewable Portfolio Standards Emissions Controlled Capacity and Renewables in PJM Markets Emission Controlled Capacity in the PJM Region Wind and Solar Peak Hour Output Wind Units Solar Units  SECTION 9 Interchange Transactions  Overview Interchange Transaction Activity Interactions with Bordering Areas Recommendations Conclusion Interchange Transaction Activity Charges and Credits Applied to Interchange Transactions Aggregate Imports and Exports Real-Time Interface Imports and Exports Real-Time Interface Pricing Point Imports and Exports Day-Ahead Interface Inports and Exports Day-Ahead Interface Pricing Point Imports and Exports

Loop Flows	365	Spot Imports	409
PJM and MISO Interface Prices	372	Interchange Optimization	411
PJM and NYISO Interface Prices	374	Interchange Cap During Emergency Conditions	411
Summary of Interface Prices between PJM and Organized Market	ts 377	45 Minute Schedule Duration Rule	412
Neptune Underwater Transmission Line to Long Island, New York	377	MISO Multi-Value Project Usage Rate (MUR)	412
Linden Variable Frequency Transformer (VFT) facility	379		
Hudson Direct Current (DC) Merchant Transmission Line	380		
Interchange Activity During High Load Hours	382	SECTION 10 Ancillary Service Markets	415
Operating Agreements with Bordering Areas	382	Overview	416
PJM and MISO Joint Operating Agreement	383	Primary Reserve	416
PJM and New York Independent System Operator Joint		Tier 1 Synchronized Reserve	416
Operating Agreement (JOA)	384	Tier 2 Synchronized Reserve Market	417
PJM and TVA Joint Reliability Coordination Agreement (JRCA)	386	Nonsynchronized Reserve Market	418
PJM and Duke Energy Progress, Inc. Joint Operating Agreement	386	Secondary Reserve	418
PJM and VACAR South Reliability Coordination Agreement	388	Regulation Market	419
Balancing Authority Operations Coordination Agreement		Black Start Service	421
between Wisconsin Electric Power Company (WEC) and PJM		Reactive	421
Interconnection, LLC	388	Ancillary Services Costs per MWh of Load: January through	
Northeastern ISO-Regional Transmission Organization Planning		September, 1999 through 2017	422
Coordination Protocol	388	Recommendations	422
Interface Pricing Agreements with Individual Balancing		Conclusion	424
Authorities	388	Primary Reserve	425
Other Agreements with Bordering Areas	390	Market Structure	425
nterchange Transaction Issues	391	Price and Cost	429
Hudson Transmission Partners (HTP) and Linden VFT Requests		Tier 1 Synchronized Reserve	430
to Convert Firm Transmission Withdrawal Rights (FTWR) to		Market Structure	430
Non Firm Transmission Withdrawal Rights (NFTWR)	391	Tier 1 Synchronized Reserve Event Response	432
PJM Transmission Loading Relief Procedures (TLRs)	393	Tier 2 Synchronized Reserve Market	436
Up to Congestion	394	Market Structure	436
Sham Scheduling	399	Market Behavior	440
Elimination of Ontario Interface Pricing Point	399	Market Performance	442
PJM and NYISO Coordinated Interchange Transactions	400	Nonsynchronized Reserve Market	448
Reserving Ramp on the PJM/NYISO Interface	404	Market Structure	448
PJM and MISO Coordinated Interchange Transaction Proposal	405	Secondary Reserve	451
Willing to Pay Congestion and Not Willing to Pay Congestion	409		

vi Table of Contents © 2017 Monitoring Analytics, LLC

Market Structure	452	Congestion-Event Summary for MISO Flowgates	510
Market Conduct	453	Congestion-Event Summary for NYISO Flowgates	512
Market Performance	453	Congestion-Event Summary for the 500 kV System	514
Regulation Market	456	Congestion Costs by Physical and Financial Participants	515
Market Design	456	Congestion-Event Summary: Impact of Changes in UTC Volumes	516
Market Structure	468	Marginal Losses	517
Market Conduct	472	Marginal Loss Accounting	517
Market Performance	475	Total Marginal Loss Cost	519
Black Start Service	479	Energy Costs	524
NERC – CIP	482	Energy Accounting	524
Minimum Tank Suction Level (MTSL)	483	Total Energy Costs	524
Reactive Service	483		
Recommended Market Approach to Reactive Costs	484	CROTTON 45 O 41 IT I I I	
Improvements to Current Approach	486	SECTION 12 Generation and Transmission Planning	529
Reactive Costs	488	Overview	529
		Planned Generation and Retirements	529
CDOTION 44 C	400	Generation and Transmission Interconnection Planning Process	529
SECTION 11 Congestion and Marginal Losses	489	Regional Transmission Expansion Plan (RTEP)	530
Overview	489	Backbone Facilities	530
Congestion Cost	489	Transmission Facility Outages	53
Marginal Loss Cost	490	Recommendations	53
Energy Cost	491	Conclusion	532
Conclusion	491	Planned Generation and Retirements	533
Locational Marginal Price (LMP)	491	Planned Generation Additions	533
Components	491	Planned Retirements	536
Hub Components	495	Existing Generation Mix	54
Component Costs	496	Generation and Transmission Interconnection Planning Process	542
Congestion	496	The Earlier Queue Submittal Task Force	542
Congestion Accounting	496	Interconnection Queue Analysis	543
Total Congestion	497	Relationship Between Project Developer and Transmission Owner	
Congested Facilities	502	Transmission Facility Outages	558
Congestion by Facility Type and Voltage	502	Scheduling Transmission Facility Outage Requests	558
Constraint Duration	506	Rescheduling Transmission Facility Outage Requests	56
Constraint Costs	508	Long Duration Transmission Facility Outage Requests	562

Transmission Facility Outage Analysis for the FTR Market	563
Annual FTR Market	563
Monthly FTR Market	566
Transmission Facility Outage Analysis in the Day-Ahead	
Energy Market	569
ECTION 13 Financial Transmission and Auction	
evenue Rights	573
Overview	574
Auction Revenue Rights	574
Financial Transmission Rights	575
Markets Timeline	576
Recommendations	576
Conclusion	577
Auction Revenue Rights	581
Market Structure	582
Market Performance	587
Financial Transmission Rights	590
Market Structure	591
Market Performance	593
Revenue Adequacy Issues and Solutions	607
ARRs as an Offset to Congestion for Load	614
FERC Order on FTRs: Balancing Congestion and M2M	
Payment Allocation	614
Credit Issues	615
FTR Forfeitures	615
FERC Order on FTR Forfeitures	615

viii Table of Contents © 2017 Monitoring Analytics, LLC

Figures		Figure 3-11 Distribution of PJM day-ahead supply plus imports:	
		January 1 through September 30, 2016 and 2017	116
SECTION 1 Introduction	1	Figure 3-12 PJM day-ahead monthly average hourly supply:  January 1, 2016 through September 30, 2017	117
Figure 1-1 PJM's footprint and its 20 control zones	7	Figure 3-13 Day-ahead and real-time supply (Average hourly	117
Figure 1-2 Top three components of quarterly total price (\$/MWh):	-	volumes): January 1 through September 30, 2017	119
January 1, 1999 through September 30, 2017	21	Figure 3-14 Difference between day-ahead and real-time supply	113
Figure 1-3 Inflation adjusted top three components of quarterly total		(Average daily volumes): January 1, 2016 through	
price (\$/MWh): January 1, 1999 through September 30, 2017	21	September 30, 2017	119
Figure 1-4 Quarterly total price and quarterly inflation adjusted total		Figure 3-15 Map of PJM real-time generation, less real-time load,	
price (\$/MWh): January 1, 1999 through September 30, 2017	22	by zone: January 1 through September 30, 2017	120
		Figure 3-16 PJM footprint calendar year peak loads: January 1	
		through September 30, 1999 to 2017	121
SECTION 3 Energy Market	91	Figure 3-17 PJM peak-load comparison Thursday, August 11, 2016	
Figure 3-1 Fuel source distribution in unit segments: January 1		and Wednesday, July 19, 201	122
through September 30, 2017	102	Figure 3-18 Distribution of PJM real-time accounting load plus	
Figure 3-2 PJM hourly energy market HHI: January 1 through		exports: January 1 through September 30, 2016 and 2017	122
September 30, 2017	102	Figure 3-19 PJM real-time monthly average hourly load:	
Figure 3-3 Days with pivotal suppliers and numbers of pivotal		January 1, 2016 through September 30, 2017	123
suppliers in the PJM Day-Ahead Energy Market: January		Figure 3-20 PJM heating and cooling degree days: January 1, 2016	
through September, 2017	103	through September 30, 2017	124
Figure 3-4 Type of fuel used (By real-time marginal units): January 1		Figure 3-21 Distribution of PJM day-ahead demand plus exports:	
through September 30, 2004 through 2017	106	January 1 through September 30, 2016 and 2017	125
Figure 3-5 Day-ahead marginal up to congestion transaction and		Figure 3-22 PJM day-ahead monthly average hourly demand:	
generation units: January 1, 2014 through September 30, 2017	107	January 1, 2016 through September 30, 2017	126
Figure 3–6 Average PJM aggregate real–time generation supply curves		Figure 3-23 Day-ahead and real-time demand (Average hourly	
by offer price: summer of 2016 and 2017	108	volumes): January 1 through September 30, 2017	128
Figure 3-7 Average PJM aggregate real-time generation supply curves		Figure 3-24 Difference between day-ahead and real-time demand	
by offer price: summer of 2014 through 2017	108	(Average daily volumes): January 1, 2016 through	
Figure 3-8 Fuel diversity index for PJM monthly generation: June 1,		September 30, 2017	128
2000 through September 30, 2017	113	Figure 3-25 Offers with varying markups at different MW output	
Figure 3-9 Distribution of PJM real-time generation plus imports:		levels	131
January 1 through September 30, 2016 and 2017	114	Figure 3-26 Offers with a positive markup but different economic	
Figure 3-10 PJM real-time average monthly hourly generation:	115	minimum MW	132
January 1, 2016 through September 30, 2017	115	Figure 3-27 Dual fuel unit offers	134

Figure	3-28 Real-time offer capped unit statistics: January 1 through		Figure 3-43 PJM real-time, monthly and annual, load-weighted,	
Sej	ptember 30, 2016 and 2017	136	average LMP: January 1, 1999 through September 30, 2017	172
Figure	3-29 Frequency distribution of highest markup of gas units		Figure 3-44 PJM real-time, monthly, load-weighted, average LMP	
off	fered using unadjusted cost offers: January 1 through		and real-time, monthly inflation adjusted load-weighted,	
Sej	ptember 30, 2016 and 2017	143	average LMP: January 1, 1998 through September 30, 2017	172
Figure	3-30 Frequency distribution of highest markup of coal units		Figure 3-45 Spot average fuel price comparison with fuel delivery	
off	fered using unadjusted cost offers: January 1 through		charges: January 1, 2012 through September 30, 2017	
Sej	ptember 30, 2016 and 2017	143	(\$/MMBtu)	173
Figure	3-31 Frequency distribution of highest markup of oil units		Figure 3-46 Average LMP for the PJM Day-Ahead Energy Market:	
off	fered using unadjusted cost offers: January 1 through		January 1 through September 30, 2016 and 2017	177
Sej	ptember 30, 2016 and 2017	144	Figure 3-47 Day-ahead, monthly and annual, load-weighted,	
Figure	3-32 Cumulative number of unit intervals with markups		average LMP: June 1, 2000 through September 30, 2017	179
abo	ove \$150 per MWh: January 1 through September 30, 2016		Figure 3-48 PJM day-ahead, monthly, load-weighted, average LMP	
and	d 2017	144	and day-ahead, monthly inflation adjusted load-weighted, average	e
Figure	3-33 Frequently mitigated units and associated units (By		LMP: June 1, 2000 through September 30, 2017	179
mo	onth): February 1, 2006 through September 30, 2017	149	Figure 3-49 UTC daily gross profits and losses and net profits:	
Figure	3-34 PJM day-ahead aggregate supply curves: 2017 example		January 1 through September 30, 2017	182
day	y	149	Figure 3-50 Cumulative daily UTC profits: January 1, 2013 through	
Figure	3-35 Monthly bid and cleared INCs, DECs and UTCs (MW):		September 30, 2017	183
Jar	nuary 1, 2005 through September 30, 2017	152	Figure 3-51 Real-time hourly LMP minus day-ahead hourly LMP:	
Figure	3-36 Daily bid and cleared INCs, DECs, and UTCs (MW):		January 1 through September 30, 2017	188
Jar	nuary 1, 2016 through September 30, 2017	153	Figure 3-52 Monthly average of real-time minus day-ahead LMP:	
Figure	3-37 PJM monthly cleared up to congestion transactions by		January 1, 2013 through September 30, 2017	188
typ	pe (MW): January 1, 2005, through September 30, 2017	160	Figure 3-53 Monthly average of the absolute value of real-time	
-	3-38 PJM daily cleared up to congestion transaction by type		minus day-ahead LMP by pnode: January 1, 2013 through	
	W): January 1, 2016, through September 30, 2017	160	September 30, 2017	189
-	3-39 Markup contribution to real-time hourly load-weighted		Figure 3-54 PJM system hourly average LMP: January 1 through	
	MP (Unadjusted): January 1 through September 30, 2016 and		September 30, 2017	189
20		163	Figure 3-55 PJM declared emergency alerts: January 1 through	
_	3-40 Markup contribution to real-time hourly load-weighted		September 30, 2013 to 2017	190
	MP (Adjusted): January 1 through September 30, 2016 and 2017	163	Figure 3-56 PJM declared emergency warnings and actions:	
•	3-41 Average LMP for the PJM Real-Time Energy Market:		January 1 through September 30, 2013 to 2017	191
	nuary 1 through September 30, 2016 and 2017	169	Figure 3-57 Updated synchronized reserve demand curve showing	
-	3-42 PJM real-time, load-weighted, average LMP: January 1		the permanent second step	197
thr	rough September 30, 2017	171		

x Table of Contents © 2017 Monitoring Analytics, LLC

Figure 3-58 Net RTO scheduled and actual interchange on	100	Figure 5-8 Map of RPM capacity prices: 2017/2018 through	250
September 21, 2017	199	2020/2021 Firmum F. O. D.I.M. outbornes (MAN): 2012 through Contombor 2017	259
Figure 3-59 Average daily delivered price for natural gas: January 1,		Figure 5-9 PJM outages (MW): 2012 through September 2017	261
2016 through September 30, 2017 (\$/MMBtu)	202	Figure 5-10 PJM equivalent outage and availability factors:	262
		January 1 through September 30, 2007 to 2017 Figure 5-11 Trends in the PJM equivalent demand forced outage	262
SECTION 4 Energy Uplift (Operating Reserves)	203	rate (EFORd): January 1 through September 30, 1999 through	
Figure 4-1 Daily day-ahead operating reserve rate (\$/MWh):		2017	263
January 1, 2016 through September 30, 2017	213	Figure 5-12 PJM EFORd, XEFORd and EFORp: January 1 through	203
Figure 4-2 Daily balancing operating reserve reliability rates	213	September 30, 2017	267
(\$/MWh): January 1, 2016 through June 30, 2017	213	Figure 5-13 PJM monthly generator performance factors: January 1	
Figure 4-3 Daily balancing operating reserve deviation rates	213	through September 30, 2017	267
(\$/MWh): January 1, 2016 through September 30, 2017	214		
Figure 4-4 Daily lost opportunity cost and canceled resources rates			
(\$/MWh): January 1, 2016 through September 30, 2017	214	SECTION 6 Demand Response	269
Figure 4-5 Daily reactive transfer interface support rates (\$/MWh):		Figure 6-1 Demand response revenue by market: January 1 through	
January 1, 2016 through September 30, 2017	216	September 30, 2008 through 2017	275
Figure 4-6 Cumulative share of energy uplift credits: January 1		Figure 6-2 Economic program credits and MWh by month:	
through September 30, 2016 and 2017 by unit	220	January 1, 2010 through September 30, 2017	277
		Figure 6-3 Installed energy efficiency MW by type: 2017/2018	
CECTION E Compait Mondret	227	Delivery Year	285
SECTION 5 Capacity Market	227		
Figure 5-1 Percent of PJM installed capacity (By fuel source):		SECTION 7 Net Revenue	293
June 1, 2007 through June 1, 2020	237		293
Figure 5-2 Fuel Diversity Index for PJM installed capacity:		Figure 7-1 Energy market net revenue factor trends: January 1,	
January 1, 2002 through June 1, 2020	238	2009 through September 30, 2017	294
Figure 5-3 Capacity market load obligation served: June 1, 2007		Figure 7-2 Hourly spark spread (gas) for peak hours (\$/MWh):	
through June 1, 2017	240	January 1 through September 30, 2017	296
Figure 5-4 Map of PJM locational deliverability areas	243	Figure 7-3 Hourly dark spread (coal) for peak hours (\$/MWh):	200
Figure 5-5 Map of PJM RPM EMAAC subzonal LDAs	243	January 1 through September 30, 2017	296
Figure 5-6 Map of PJM RPM ATSI subzonal LDA	243	Figure 7-4 Hourly quark spread (uranium) for selected zones	207
Figure 5-7 History of PJM capacity prices: 1999/2000 through	250	(\$/MWh): January 1 through September 30, 2017	297
2020/2021	258	Figure 7-5 Average short run marginal costs: January 1, 2009	200
		through September 30, 2017	298

	Figure 8-11 $SO_2$ and $NO_X$ emissions during on and off peak hours by year (thousands of short tons), by PJM units: January	
305	through September, 1999 through 2017	334
	Figure 8-12 Wind and solar output during the top 100 peak load	
	hours in PJM: January 1 through September 30, 2017	334
305	Figure 8-13 Average hourly real-time generation of wind units in	
	PJM: January 1 through September 30, 2017	335
	Figure 8-14 Average hourly day-ahead generation of wind units in	
	PJM: January 1 through September 30, 2017	336
307	Figure 8-15 Marginal fuel at time of wind generation in PJM:	
	January 1 through September 30, 2017	337
313	Figure 8-16 Average hourly real-time generation of solar units in	
	PJM: January 1 through September 30, 2017	338
323	Figure 8-17 Average hourly day-ahead generation of solar units in	
	PJM: January 1 through September 30, 2017	339
323		
	CECTION O.1 ( 1 T	0.41
325	SECTION 9 Interchange Transactions	341
	Figure 9-1 PJM real-time and day-ahead scheduled imports and	
328	exports: January 1 through September 30, 2017	347
	Figure 9-2 PJM real-time and day-ahead scheduled import and	
328	export transaction volume history: January 1, 1999 through	
	September 30, 2017	347
329	Figure 9-3 PJM's footprint and its external day-ahead and real-time	
	•	364
332	· · · · · · · · · · · · · · · · · · ·	
		373
332		
	•	376
333		
	September 30, 2017	379
	307 313 323 323 325 328 328 329 332	Tigure 8-12 Wind and solar output during the top 100 peak load hours in PJM: January 1 through September 30, 2017  Figure 8-13 Average hourly real-time generation of wind units in PJM: January 1 through September 30, 2017  Figure 8-14 Average hourly day-ahead generation of wind units in PJM: January 1 through September 30, 2017  Figure 8-15 Marginal fuel at time of wind generation in PJM: January 1 through September 30, 2017  Figure 8-16 Average hourly real-time generation of solar units in PJM: January 1 through September 30, 2017  Figure 8-16 Average hourly real-time generation of solar units in PJM: January 1 through September 30, 2017  Figure 8-17 Average hourly day-ahead generation of solar units in PJM: January 1 through September 30, 2017  SECTION 9 Interchange Transactions  Figure 9-1 PJM real-time and day-ahead scheduled imports and exports: January 1 through September 30, 2017  Figure 9-2 PJM real-time and day-ahead scheduled import and export transaction volume history: January 1, 1999 through September 30, 2017  Figure 9-3 PJM's footprint and its external day-ahead and real-time scheduling interfaces  Figure 9-4 Real-time and day-ahead daily hourly average price difference (MISO/PJM Interface minus PJM/MISO Interface): January 1 through September 30, 2017  Figure 9-5 Real-time and day-ahead daily hourly average price difference (NY/PJM proxy - PJM/NYIS Interface): January 1 through September 30, 2017

xii Table of Contents © 2017 Monitoring Analytics, LLC

Figure 9-7 Linden hourly average flow: January 1 through		Figure 10-7 Average hourly tier 2 MW by unit type by SRMCP	
September 30, 2017	380	range: January through September, 2017	437
Figure 9-8 Hudson hourly average flow: January 1 through		Figure 10-8 Monthly average actual vs default synchronized reserve	
September 30, 2017	382	requirements, RTO Zone and MAD Subzone: January 2016	
Figure 9-9 Credits for coordinated congestion management:		through September 2017	438
January 1, 2016 through September 30, 2017	384	Figure 10-9 MAD monthly average tier 2 synchronized reserve	
Figure 9-10 Credits for coordinated congestion management		scheduled MW: January 1, 2016 through September 30, 2017	439
(flowgates): January 1, 2016 through September 30, 2017	385	Figure 10-10 RTO monthly average tier 2 synchronized reserve	
Figure 9-11 Credits for coordinated congestion management		scheduled MW: January 1, 2016 through September 30, 2017	439
(PARs): January 1, 2016 through September 30, 2017	385	Figure 10-11 Tier 2 synchronized reserve hourly offer and eligible	
Figure 9-12 Con Edison Protocol	391	volume (MW), averaged daily: January through September, 2017	441
Figure 9-13 Monthly up to congestion cleared bids in MWh:		Figure 10-12 MAD average daily tier 2 synchronized reserve offer	
January 1, 2005 through September 30, 2017	395	by unit type (MW): January through September, 2014	
Figure 9-14 Monthly cleared PJM/NYIS CTS bid volume:		through 2017	442
November 1, 2014 through September 30, 2017	404	Figure 10-13 RTO Zone average daily tier 2 synchronized reserve	
Figure 9-15 Spot import service use: January 1, 2013 through		offer by unit type (MW): January through September, 2014	
September 30, 2017	410	through 2017	442
		Figure 10-14 Synchronized reserve events duration distribution	
		curve: January, 2012 through September, 2017	448
SECTION 10 Ancillary Service Markets	415	Figure 10-15 Daily average RTO Zone nonsynchronized reserve	
Figure 10-1 PJM RTO Zone and MAD Subzone geography: 2017	425	market clearing price and MW purchased: January 1 through	
Figure 10-2 Mid-Atlantic Dominion Subzone primary reserve MW		September 30, 2017	450
by source (Daily Averages): January through September, 2017	428	Figure 10-16 Daily average components of DASR clearing price	
Figure 10-3 RTO Reserve Zone primary reserve MW by source		(\$/MW), marginal unit offer and LOC: January through	
(Daily Averages): January through September, 2017	429	September, 2017	455
Figure 10-4 Daily weighted average market clearing prices (\$/MW)		Figure 10-17 Hourly average performance score by unit type:	
for synchronized reserve and nonsynchronized reserve: January		January 1 through September 30, 2017	457
through September, 2017	429	Figure 10-18 Hourly average performance score by regulation	
Figure 10-5 Daily average tier 1 synchronized reserve supply (MW)		signal type: January 1 through September 30, 2017	458
in the MAD Subzone: January through September, 2017	432	Figure 10-19 Daily average MBF and mileage ratio during excursion	
Figure 10-6 Cleared tier 2 synchronized reserve average hourly		and nonexcursion hours: January 1, 2016 through	
MW per hour by unit type, RTO Zone: January 1, 2016 through		September 30, 2017	462
September 30, 2017	437	Figure 10-20 Maximum, minimum, and average PJM calculated MBF	
		by month for excursion and nonexcursion hours: January 1	
		through September 30, 2017	464

Figure 10-21 MBF curve before and after December 14, 2015, revisions by PJM  Figure 10-22 Example MBF functions with percent RegD and RegD MW  Figure 10-23 Illustration of correct method for calculating effective MW  Figure 10-24 Average monthly total effective MW and RegA and RegD performance adjusted MW: PJM market calculated versus benefit factor based: January 1, 2016 through September 30, 2017	464 466 466	Figure 11-4 Location of the top 10 constraints by PJM day-ahead congestion costs: January 1 through September 30, 2017  Figure 11-5 Daily congestion event hours: January 1, 2014 through September 30, 2017  Figure 11-6 Monthly balancing congestion cost incurred by up to congestion: January 1, 2014 through September 30, 2017  Figure 11-7 PJM monthly marginal loss costs (Dollars (Millions)): January 1, 2008 through September 30, 2017  Figure 11-8 PJM monthly energy costs (Millions): January 1, 2008 through September 30, 2017	510 517 517 522 527
Figure 10-25 Average cleared RegD MW and average cleared RegD with an effective price of \$0.00 by month: January 1, 2016 through September 30, 2017	467	SECTION 12 Generation and Transmission Planning	529
Figure 10-26 Cost of excess effective MW cleared by month, peak and off peak: January 1, 2016 through September 30, 2017	468	Figure 12-1 Map of PJM unit retirements: 2011 through 2020 Figure 12-2 PJM capacity (MW) by age (years): September 30, 2017	537 542
Figure 10-27 Off peak, on peak, nonramp, and ramp regulation levels: January 1, 2016 through September 30, 2017	473	Figure 12-3 Queue project MW by fuel type and queue entry year:	E 4 0
Figure 10-28 PJM regulation market daily weighted average market-clearing price, marginal unit opportunity cost and offer	473	January 1, 1997 through September 30, 2017 Figure 12-4 Illustration of day-ahead market analysis on November 22, 2016	548 569
price (Dollars per MW): January 1 through September 30, 2017 Figure 10-29 PJM monthly CPS1 and BAAL performance: January 1, 2011 through September 30, 2017	476 479	Figure 12-5 Approved or active outage requests: January 1, 2015 through September 30, 2017	570
Figure 10-30 Oil tank MTSL not changed from addition of black start generator		Figure 12-6 Day-ahead market model outages: January 1, 2015 through September 30, 2017 Figure 12-7 Approved or active outage requests: January 1, 2015	570
Figure 10-31 Oil tank black start MTSL portion	482	through September 30, 2017	571
SECTION 11 Congestion and Marginal Losses	489	SECTION 13 Financial Transmission and Auction	
Figure 11-1 PJM monthly total congestion cost (Dollars (Millions)):		Revenue Rights	<b>57</b> 3
January 1, 2009 through September 30, 2017 Figure 11-2 Location of the top 10 constraints by PJM total	501	Figure 13-1 Historic Stage 1B and Stage 2 ARR Allocations from the	
congestion costs: January 1 through September 30, 2017	510	2011/2012 through 2017/2018 planning periods Figure 13-2 Dollars per ARR MW paid to ARR holders compared to	585
Figure 11-3 Location of the top 10 constraints by PJM balancing congestion costs: January 1 through September 30, 20 17	510	congestion and FTR target allocations: 2010/2011 through 2017/2018	589

xiv Table of Contents © 2017 Monitoring Analytics, LLC

Figure 13-3 Monthly excess ARR revenue: Planning periods	
2011/2012 through 2017/2018	589
Figure 13-4 Cleared auction volume (MW) as a percent of total FTR	
cleared volume by calendar month: June 1, 2004 through	
September 30, 2017	596
Figure 13-5 Long Term, Annual and Monthly FTR Auction bid and	
cleared volume: June 1, 2003 through September 30, 2017	597
Figure 13-6 Ten largest positive and negative FTR target allocations	
summed by sink: 2017/2018 planning period	602
Figure 13-7 Ten largest positive and negative FTR target allocations	
summed by source: 2017/2018 planning period	602
Figure 13-8 FTR payout ratio by month, excluding and including	
excess revenue distribution: January 1, 2004 through	
September 30, 2017	606
Figure 13-9 FTR surplus and the collected day-ahead, balancing and	
total congestion: January 1, 2005 through September 30, 2017	613
Figure 13-10 FTR target allocation compared to sources of positive	
and negative congestion revenue	613

xvi Table of Contents © 2017 Monitoring Analytics, LLC

## **Tables** Table 3-5 Marginal unit contribution to PJM real-time, load-weighted LMP (By parent company): January 1 through September 30, 2016 and 2017 105 **SECTION 1 Introduction** 1 Table 3-6 Marginal resource contribution to PJM day-ahead, Table 1-1 PJM Market Summary Statistics: January 1 through load-weighted LMP (By parent company): January 1 through September 30, 2016 and 2017 6 September 30, 2016 and 2017 105 Table 1-2 The Energy Market results were competitive 8 Table 3-7 Type of fuel used (By real-time marginal units): January 1 Table 1-3 The Capacity Market results were competitive 10 through September 30, 2013 through 2017 106 Table 1-4 The Tier 2 Synchronized Reserve Market results were Table 3-8 Day-ahead marginal resources by type/fuel: January 1 competitive 10 through September 30, 2011 through 2017 107 Table 1-5 The Day-Ahead Scheduling Reserve Market results were Table 3-9 PJM generation (By fuel source (GWh)): January 1 through competitive 10 September 30, 2016 and 2017 109 Table 1-6 The Regulation Market results were competitive 11 Table 3-10 Monthly PJM generation (By fuel source (GWh)): Table 1-7 The FTR Auction Markets results were competitive 11 January 1 through September 30, 2017 110 Table 1-8 Total price per MWh by category: January 1 through Table 3-11 Distribution of MW for dispatchable unit offer prices: September 30, 2016 and 2017 16 January 1 through September 30, 2017 111 Table 1-9 Inflation adjusted total price per MWh by category: Table 3-12 Distribution of MW for self scheduled and dispatchable January 1 through September 30, 2016 and 2017 17 unit offer prices: January 1 through September 30, 2017 112 Table 1-10 Total price per MWh by category: Calendar Years 1999 Table 3-13 PJM real-time average hourly generation and real-time through 2016 18 average hourly generation plus average hourly imports: January 1 Table 1–11 Inflation adjusted total price per MWh by category: through September 30, 2000 through 2017 114 Calendar Years 1999 through 2016 19 Table 3-14 PJM day-ahead average hourly supply and day-ahead Table 1–12 Percent of total price per MWh by category: Calendar average hourly supply plus average hourly imports: January 1 Years 1999 through 2016 20 through September 30, 2000 through 2017 116 Table 3-15 Day-ahead and real-time supply (MW): January 1 through September 30, 2016 and 2017 118 **SECTION 3 Energy Market** 91 Table 3-16 PJM real-time generation less real-time load by zone Table 3-1 The energy market results were competitive 91 (GWh): January 1 through September 30, 2016 and 2017 120 Table 3-2 PJM hourly energy market HHI: January 1 through Table 3-17 Actual PJM footprint peak loads: January through September 30, 2016 and 2017 September, 1999 to 2017 121 101 Table 3-3 PJM hourly energy market HHI (By supply segment): Table 3-18 PJM real-time average hourly load and real-time average January 1 through September 30, 2016 and 2017 101 hourly load plus average hourly exports: January 1 through Table 3-4 Frequency of days as a pivotal supplier for the 10 largest September 30, 1998 through 2017 123 suppliers: January 1 through September 30, 2017 104 Table 3-19 PJM heating and cooling degree days: January 2016 through September, 2017 124

Table 3-20 PJM day-ahead average demand and day-ahead average		Table 3-31 Offer capping statistics for reliability: January 1 through	
hourly demand plus average hourly exports: January 1 through		September 30, 2013 to 2017	135
September 30, 2000 through 2017	126	Table 3-32 Real-time offer capped unit statistics: January 1 through	
Table 3-21 Cleared day-ahead and real-time demand (MWh):		September 30, 2016 and 2017	136
January 1 through September 30, 2016 and 2017	127	Table 3-33 Numbers of hours when control zones experienced	
Table 3-22 Monthly average percent of real-time self-supply load,		congestion resulting from one or more constraints binding for	
bilateral-supply load and spot-supply load based on parent		75 or more hours or from an interface constraint: January 1	
companies: January 1 through September 30, 2016 and 2017	129	through September 30, 2009 through 2017	137
Table 3-23 Monthly average share of day-ahead self-supply demand,		Table 3-34 Three pivotal supplier test details for interface constraints:	
bilateral supply demand, and spot-supply demand based on		January 1 through September 30, 2017	137
parent companies: January 1 through September 30, 2016 and		Table 3-35 Summary of three pivotal supplier tests applied for	
2017	130	interface constraints: January 1 through September 30, 2017	138
Table 3-24 Units offered with crossing curves in the Day-Ahead and		Table 3-36 Average, real-time marginal unit markup index (By offer	
Real-Time Energy Markets: January 1 through		price category unadjusted): January 1 through September 30,	
September 30, 2017	131	2016 and 2017	142
Table 3-25 Units offered with lower minimum run time on price		Table 3-37 Average, real-time marginal unit markup index (By offer	
compared to cost but with positive markup in the Day-Ahead and		price category adjusted): January 1 through September 30,	
Real-Time Energy Markets: January 1 through		2016 and 2017	142
September 30, 2017	132	Table 3-38 Percent of marginal units with markup below, above and	
Table 3-26 Units offered with lower economic minimum MW on		equal to zero (By fuel type unadjusted): January 1 through	
price compared to cost but with positive markup in the		September 30, 2016 and 2017	142
Day-Ahead and Real-Time Energy Markets: January 1 through		Table 3-39 Percent of marginal units with markup below, above and	
September 30, 2017	133	equal to zero (By fuel type adjusted): January 1 through	
Table 3-27 Units with lower dispatch cost on price based offer		September 30, 2016 and 2017	142
compared to cost based offer, having positive markup in the		Table 3-40 Average day-ahead marginal unit markup index (By offer	
Day-Ahead and Real-Time Energy Markets: January 1 through		price category, unadjusted): January 1 through September 30,	
•	133	2016 and 2017	145
Table 3-28 Units with potential evasion that failed the TPS test and		Table 3-41 Average day-ahead marginal unit markup index (By offer	
were marginal in the Real-Time Energy Market: January 1		price category, adjusted): January 1 through September 30, 2016	
through September 30, 2017	134	and 2017	145
Table 3-29 Offer capping statistics – energy only: January 1 through		Table 3-42 Hourly average number of cleared and submitted INCs,	
September 30, 2013 to 2017	135	DECs by month: January 1, 2016 through September 30, 2017	150
Table 3-30 Offer capping statistics for energy and reliability: January	1	Table 3-43 Hourly average of cleared and submitted up to congestion	
through September 30, 2013 to 2017	135	bids by month: January 1, 2016 through September 30, 2017	150

xviii Table of Contents © 2017 Monitoring Analytics, LLC

Table 3-44 Hourly average day-ahead number of cleared and		Table 3-57 Monthly markup components of real-time load-weighted	
submitted import and export transactions by month:		LMP (Unadjusted): January 1 through September 30,	
January 1, 2016 through September 30, 2017	151	2016 and 2017	162
Table 3-45 Type of day-ahead marginal units: January 1, 2016		Table 3-58 Monthly markup components of real-time load-weighted	
through September 30, 2017	152	LMP (Adjusted): January 1 through September 30,	
Table 3-46 PJM INC and DEC bids and cleared MW by type of		2016 and 2017	162
parent organization (MW): January 1 through		Table 3-59 Average real-time zonal markup component (Unadjusted):	
September 30, 2016 and 2017	153	January 1 through September 30, 2016 and 2017	164
Table 3-47 PJM up to congestion transactions by type of parent		Table 3-60 Average real-time zonal markup component (Adjusted):	
organization (MW): January 1 through September 30, 2016		January 1 through September 30, 2016 and 2017	164
and 2017	153	Table 3-61 Average real-time markup component (By price category,	
Table 3-48 PJM import and export transactions by type of parent		unadjusted): January 1 through September 30, 2016 and 2017	165
organization (MW): January 1 through September 30, 2016		Table 3-62 Average real-time markup component (By price category,	
and 2017	154	adjusted): January 1 through September 30, 2016 and 2017	165
Table 3-49 PJM virtual offers and bids by top 10 locations (MW):		Table 3-63 Markup component of the annual PJM day-ahead, load-	
January 1 through September 30, 2016 and 2017	154	weighted, average LMP by primary fuel type and unit type:	
Table 3-50 PJM cleared up to congestion import bids by top 10		January 1 through September 30, 2016 and 2017	165
source and sink pairs (MW): January 1 through		Table 3-64 Monthly markup components of day-ahead (Unadjusted),	
September 30, 2016 and 2017	155	load-weighted LMP: January 1 through September 30, 2016	
Table 3-51 PJM cleared up to congestion export bids by top 10		and 2017	166
source and sink pairs (MW): January 1 through		Table 3-65 Monthly markup components of day-ahead (Adjusted),	
September 30, 2016 and 2017	156	load-weighted LMP: January 1, 2016 through September 30,	
Table 3-52 PJM cleared up to congestion wheel bids by top 10		2017	166
source and sink pairs (MW): January 1 through		Table 3-66 Day-ahead, average, zonal markup component	
September 30, 2016 and 2017	157	(Unadjusted): January 1 through September 30, 2016 and 2017	167
Table 3-53 PJM cleared up to congestion internal bids by top 10		Table 3-67 Day-ahead, average, zonal markup component	
source and sink pairs (MW): January 1 through		(Adjusted): January 1 through September 30, 2016 and 2017	167
September 30, 2016 and 2017	158	Table 3-68 Average, day-ahead markup (By LMP category,	
Table 3-54 Number of PJM offered and cleared source and sink		unadjusted): January 1 through September 30, 2016 and 2017	168
pairs: January 1, 2016 through September 30, 2017	159	Table 3-69 Average, day-ahead markup (By LMP category, adjusted):	
Table 3-55 PJM cleared up to congestion transactions by type		January 1 through September 30, 2016 and 2017	168
(MW): January 1 through September 30, 2016 and 2017	159	Table 3-70 PJM real-time, average LMP (Dollars per MWh):	
Table 3-56 Markup component of the overall PJM real-time,		January 1 through September 30, 1998 through 2017	170
load-weighted, average LMP by primary fuel type and unit type:		Table 3-71 PJM real-time, load-weighted, average LMP (Dollars per	
January 1 through September 30, 2016 and 2017	162	MWh): January 1 through September 30, 1998 through 2017	170

Table 3-72 Zone real-time and real-time, load-weighted, average LMP (Dollars per MWh): January 1 through September 30,		Table 3-84 Components of PJM day-ahead, (adjusted), load-weighted, average LMP (Dollars per MWh): January 1	
2016 and 2017	171	through September 30, 2016 and 2017	181
Table 3-73 PJM real-time, yearly, load-weighted, average LMP and		Table 3-85 Cleared UTC profitability by source and sink point:	
real-time, yearly inflation adjusted load-weighted, average LMP:		January 1 through September 30, 2016 and 2017	182
January 1 through September 30, 1998 through 2017	173	Table 3-86 UTC profits by month: January 1, 2013 through	
Table 3-74 PJM real-time annual, fuel-cost adjusted, load-weighted		September 30, 2017	183
average LMP (Dollars per MWh): January 1 through		Table 3-87 Day-ahead and real-time average LMP (Dollars per	
September 30, 2016 and 2017	174	MWh): January 1 through September 30, 2016 and 2017	184
Table 3-75 Change in PJM real-time annual, fuel-cost adjusted,		Table 3-88 Day-ahead and real-time average LMP (Dollars per	
load-weighted average LMP (Dollars per MWh) by fuel type:		MWh): January 1 through September 30, 2001 through 2017	185
January 1 through September 30, 2016 and 2017	174	Table 3-89 Frequency distribution by hours of PJM real-time LMP	
Table 3-76 Components of PJM real-time (Unadjusted),		minus day-ahead LMP (Dollars per MWh): January 1 through	
load-weighted, average LMP: January 1 through		September 30, 2007 through 2017	186
September 30, 2016 and 2017	176	Table 3-90 Summary of emergency events declared: January 1	
Table 3-77 Components of PJM real-time (Adjusted), load-weighted,		through September 30, 2016 and 2017	190
average LMP: January 1 through September 30, 2016 and 2017	176	Table 3-91 Description of emergency procedures	193
Table 3-78 Frequency and average shadow price of transmission		Table 3-92 PJM declared emergency alerts, warnings and actions:	
constraints in PJM: January 1 through September 30, 2016		January 1 through September 30, 2017	194
and 2017	176	Table 3-93 RTO synchronized reserve MW and extended	
Table 3-79 PJM day-ahead, average LMP (Dollars per MWh):		synchronized reserve requirement during synchronized reserve	
January 1 through September 30, 2001 through 2017	177	shortage	197
Table 3-80 PJM day-ahead, load-weighted, average LMP (Dollars		Table 3-94 RTO primary reserve MW and extended primary reserve	
per MWh): January 1 through September 30, 2001 through 2017	178	requirement during primary reserve shortage	198
Table 3-81 Zone day-ahead and day-ahead, load-weighted, average		Table 3-95 MAD primary reserve MW and extended primary reserve	
LMP (Dollars per MWh): January 1 through September 30, 2016		requirement during primary reserve shortage	198
and 2017	178	Table 3-96 Performance of synchronized reserves during spinning	
Table 3-82 PJM day-ahead, yearly, load-weighted, average LMP and		events: January 1, 2015 through September 30, 2017	201
day-ahead, yearly inflation adjusted load-weighted, average			
LMP: January 1 through September 30, 2000 through 2017	180		
Table 3-83 Components of PJM day-ahead, (unadjusted),			
load-weighted, average LMP (Dollars per MWh): January 1	100		
through September 30, 2016 and 2017	180		

xx Table of Contents © 2017 Monitoring Analytics, LLC

SECTION 4 Energy Uplift (Operating Reserves)	203	Table 4-17 Energy uplift credits by category: January 1 through	
Table 4-1 Day-ahead and balancing operating reserve credits and		September 30, 2016 and 2017	218
charges	208	Table 4-18 Energy uplift credits by unit type: January 1 through September 30, 2016 and 2017	219
Table 4-2 Reactive services, synchronous condensing and black start		Table 4-19 Energy uplift credits by unit type: January 1 through	219
services credits and charges	209	September 30, 2017	219
Table 4-3 Total energy uplift charges: January 1 through		Table 4-20 Top 10 units and organizations energy uplift credits:	2.5
September 30, 2016 and 2017	209	January 1 through September 30, 2017	220
Table 4-4 Energy uplift charges by category: January 1 through		Table 4-21 Identification of balancing operating reserve credits	
September 30, 2016 and 2017	210	received by the top 10 units by category and region: January 1	
Table 4-5 Monthly energy uplift charges: January 1, 2016 through	210	through September 30, 2017	220
September 30, 2017	210	Table 4-22 Daily energy uplift credits HHI: January 1 through	
Table 4-6 Day-ahead operating reserve charges: January 1 through	211	September 30, 2017	221
September 30, 2016 and 2017 Table 4-7 Balancing operating reserve charges: January 1 through	211	Table 4-23 Day-ahead and real-time generation commitment status	
September 30, 2016 and 2017	211	percent: January through September 2017	221
Table 4-8 Balancing operating reserve deviation charges: January 1	211	Table 4-24 Day-ahead and real-time generation (GWh): January 1	
through September 30, 2016 and 2017	211	through September 30, 2017	222
Table 4-9 Additional energy uplift charges: January 1 through		Table 4-25 Day-ahead and real-time economic and noneconomic	
September 30, 2016 and 2017	212	generation from units eligible for operating reserve credits	
Table 4-10 Regional balancing charges allocation (Millions):		(GWh): January 1 through September 30, 2017	222
January 1 through September 30, 2016	212	Table 4-26 Day-ahead and real-time generation receiving operating	222
Table 4-11 Regional balancing charges allocation (Millions):		reserve credits (GWh): January 1 through September 30, 2017	222
January 1 through September 30, 2017	212	Table 4-27 Day-ahead generation scheduled as must run by PJM (GWh): January 1, 2016 through September 30, 2017	223
Table 4-12 Operating reserve rates (\$/MWh): January 1 through		Table 4-28 Day-ahead generation scheduled as must run by PJM by	223
September 30, 2016 and 2017	215	category (GWh): January 1 through September 30, 2017	223
Table 4-13 Operating reserve rates statistics (\$/MWh): January 1		Table 4-29 Geography of regional charges and credits: January 1	223
through September 30, 2017	215	through September 30, 2017	225
Table 4-14 Local voltage support rates: January 1 through		amough september 50, 2017	
September 30, 2016 and 2017	216		
Table 4-15 Balancing operating reserve determinants (MWh):	245		
January 1 through September 30, 2016 and 2017	217		
Table 4-16 Deviations by transaction type: January 1 through	217		
September 30, 2017	217		

SECTION 5 Capacity Market	227	Table 5-20 EFOF, EPOF, EMOF and EAF by unit type: January 1	
Table 5-1 The capacity market results were competitive Table 5-2 RPM related MMU reports, January 2016 through	227	through September 30, 2007 through 2017 Table 5-21 PJM EFORd data for different unit types: January 1 through September 30, 2007 through 2017	262 263
September 2017 Table 5-3 PJM installed capacity (By fuel source): January 1,	235	Table 5-22 OMC outages: January 1 through September 30, 2017 Table 5-23 Contribution to EFOF by unit type by cause: January 1	264
May 31, June 1, and September 30, 2017 Table 5-4 Generation capacity changes: 2007/2008 to 2017/2018	237 239	through September 30, 2017	265
Table 5-5 Capacity market load obligation served: June 1, 2017 Table 5-6 RSI results: 2017/2018 through 2020/2021 RPM Auctions	240 242	Table 5-24 Contributions to Economic Outages: January 1 through September 30, 2017	266
Table 5-7 RPM imports: 2007/2008 through 2020/2021 RPM Base Residual Auctions	245	Table 5-25 PJM EFORd, XEFORd and EFORp data by unit type: January 1 through September 30, 2017	266
Table 5-8 RPM load management statistics by LDA: June 1, 2016 to June 1, 2020	248	SECTION 6 Demand Response	269
Table 5-9 RPM commitments, replacement, and registrations for Demand Resources: June 1, 2007 to June 1, 2020	249	Table 6-1 Overview of demand response programs	274
Table 5-10 RPM commitments and replacements for Energy Efficiency Resources: June 1, 2007 to June 1, 2020	249	Table 6-2 Economic program registrations on the last day of the month: January 1, 2010 through September 30, 2017	276
Table 5-11 ACR statistics: RPM Auctions conducted in third quarter, 2017	252	Table 6-3 Sum of peak MW reductions for all registrations per month: January 1, 2010 through September 30, 2017	276
Table 5-12 MOPR Statistics: 2017/2018 through 2020/2021 RPM Base Residual Auctions	253	Table 6-4 Credits paid to the PJM economic program participants: January 1 through September 30, 2010 through 2017	277
Table 5-13 RPM commitments and replacements for all Capacity Resources: June 1, 2007 to June 1, 2020	253	Table 6-5 PJM economic program participation by zone: January 1 through September 30, 2016 and 2017	278
Table 5-14 Capacity prices: 2007/2008 through 2020/2021 RPM Auctions	254	Table 6-6 Settlements submitted in the economic program: January 1 through September 30, 2010 through 2017	278
Table 5-15 Weighted average clearing prices by zone: 2017/2018 through 2020/2021	256	Table 6-7 Participants and CSPs submitting settlements in the economic program by year: January 1 through September 30,	
Table 5-16 RPM revenue by type: 2007/2008 through 2020/2021	257	2010 through 2017  Table 6-8 HHl and market concentration in the economic program:	278
Table 5-17 RPM revenue by calendar year: 2007 through 2021 Table 5-18 RPM cost to load: 2016/2017 through 2020/2021 RPM Auctions	258	January 1, 2016 through September 30, 2017  Table 6-9 Hourly frequency distribution of economic program MWh	279
Table 5-19 PJM capacity factor (By unit type (GWh)): January 1 through September 30, 2016 and 2017	260 261	reductions and credits: January 1 through September 30, 2016 and 2017	279
anoagh september 30, 2010 and 2017	201		

xxii Table of Contents © 2017 Monitoring Analytics, LLC

Table 6-10 Frequency distribution of economic program zonal,		Table 6-27 Distribution of registrations and associated MW in the	
load-weighted, average LMP (By hours): January 1 through		full option across ranges of minimum dispatch: 2017/2018	
September 30, 2016 and 2017	280	Delivery Year	292
Table 6-11 Net benefits test threshold prices: April 1, 2012 through			
September 30, 2017	280		
Table 6-12 Hours with price higher than NBT and DR occurrences in		SECTION 7 Net Revenue	293
those hours: January 1, 2016 through September 30, 2017	281	Table 7-1 Peak hour spreads (\$/MWh): January 1, 2011, through	
Table 6-13 Zonal DR charge: January 1 through September 30, 2017	281	September 30, 2017	295
Table 6-14 Zonal DR charge per MWh of load and exports: January 1		Table 7-2 Peak hour spread standard deviation (\$/MWh): January 1,	
through September 30, 2017	282	2011, through September 30, 2017	295
Table 6-15 Monthly day-ahead and real-time DR charge: January 1,		Table 7-3 Average short run marginal costs: January 1 through	
2016 through September 30, 2017	282	September 30, 2017	298
Table 6-16 HHI value for LDAs by delivery year: 2016/2017 and		Table 7-4 Average run hours: January 1 through September 30,	
2017/2018 Delivery Years	283	2009 through 2017	299
Table 6-17 Zonal monthly capacity revenue: January 1 through		Table 7-5 Energy net revenue for a new entrant gas fired CT under	
September 30, 2017	284	economic dispatch: January 1 through September 30, 2009	
Table 6-18 Energy efficiency resources (MW): 2012/2013 through		through 2017 (Dollars per installed MW-year)	299
2017/2018 Delivery Year	284	Table 7-6 Energy net revenue for a new entrant CC under economic	
Table 6-19 Nominated MW and locations by product type and lead		dispatch: January 1 through September 30, 2009 through 2017	
time: 2016/2017 Delivery Year	286	(Dollars per installed	
Table 6-20 Nominated MW and locations by product type and lead		MW-year)	300
time: 2017/2018 Delivery Year	286	Table 7-7 Energy net revenue for a new entrant CP: January 1	
Table 6-21 Reduction MW by each demand response method:		through September 30, 2009 through 2017 (Dollars per installed	
2016/2017 Delivery Year	287	MW-year)	301
Table 6-22 Reduction MW by each demand response method:		Table 7-8 Energy market net revenue for a new entrant DS:	
2017/2018 Delivery Year	287	January 1 through September 30, 2009 through 2017 (Dollars	
Table 6-23 Onsite generation fuel type (MW): 2016/2017		per installed MW-year)	302
Delivery Year	288	Table 7-9 Energy net revenue for a new entrant nuclear plant:	
Table 6-24 Onsite generation fuel type (MW): 2017/2018		January 1 through September 30, 2009 through 2017 (Dollars	
Delivery Year	288	per installed MW-year)	303
Table 6-25 Demand response cleared MW UCAP for PJM: 2011/2012		Table 7-10 Energy net revenue for a wind installation: January 1	
through 2016/2017 Delivery Year	288	through September 30, 2012 through 2017 (Dollars per installed	
Table 6-26 Distribution of registrations and associated MW in the		MW-year)	304
full option across ranges of minimum dispatch prices:			
2016/2017 Delivery Year	292		

Table 7-11 PSEG energy net revenue for a solar installation:		Table 8-13 Carbon price per MWh by unit type	329
January 1 through September 30, 2012 through 2017 (Dollars	204	Table 8-14 Renewable alternative compliance payments in PJM	220
per installed MW-year)	304	jurisdictions: September 30, 2017	330
Table 7-12 Assumptions for analysis of new entry Table 7-13 Avoidable cost recovery by quartile	306 306	Table 8-15 SO <sub>2</sub> emission controls by fuel type (MW): September 30, 2017	331
Table 7-13 Avoidable cost recovery by quartile	300	Table 8-16 NO <sub>v</sub> emission controls by fuel type (MW): September 30,	221
		2017	331
SECTION 8 Environmental and Renewable Energy		Table 8-17 Particulate emission controls by fuel type (MW):	331
Regulations	307	September 30, 2017	331
Table 8-1 Current and proposed CSAPR ozone season NO <sub>v</sub> budgets		Table 8-18 Capacity factor of wind units in PJM: January 1 through	
for electric generating units (before accounting for variability)	312	September 30, 2017	335
Table 8-2 Minimum criteria for existing CCR ponds (surface	3.2	Table 8-19 Capacity factor of wind units in PJM by month:	
impoundments) and landfills and date by which implementation		January 1, 2016 through September 30, 2017	336
is expected	317	Table 8-20 Capacity factor of solar units in PJM: January 1	
Table 8-3 HEDD maximum NO <sub>x</sub> emission rates	318	through September 30, 2017	337
Table 8-4 RGGI CO <sub>2</sub> allowance auction prices and quantities in short		Table 8-21 Capacity factor of solar units in PJM by month:	
tons and metric tonnes: 2009-2011, 2012-2014 and 2015-2017		January 1, 2016 through September 30, 2017	338
Compliance Periods	319		
Table 8-5 Renewable standards of PJM jurisdictions: 2017 to 2028	321	SECTION 9 Interchange Transactions	341
Table 8-6 Additional renewable standards of PJM jurisdictions:		9	
2017 to 2028	322	Table 9-1 Charges and credits applied to interchange transactions	345
Table 8-7 Solar renewable standards by percent of electric load for		Table 9-2 Real-time scheduled net interchange volume by	2.40
PJM jurisdictions: 2017 to 2028	322	interface (GWh): January 1 through September 30, 2017	348
Table 8-8 Renewable resource generation by jurisdiction and		Table 9-3 Real-time scheduled gross import volume by interface	2.40
renewable resource type (GWh): January 1 through		(GWh): January 1 through September 30, 2017	349
September 30, 2017	324	Table 9-4 Real-time scheduled gross export volume by interface (GWh): January 1 through September 30, 2017	349
Table 8-9 PJM renewable capacity by jurisdiction (MW):	225	Table 9-5 Real-time scheduled net interchange volume by interface	343
September 30, 2017 Table 8-10 Renewable capacity by jurisdiction, non-PJM units	325	pricing point (GWh): January 1 through September 30, 2017	351
registered in GATS (MW), on September 30, 2017	326	Table 9-6 Real-time scheduled gross import volume by interface	331
Table 8-11 REC Tracking systems in PJM states with renewable	320	pricing point (GWh): January 1 through September 30, 2017	352
portfolio standards	327	Table 9-7 Real-time scheduled gross export volume by interface	
Table 8-12 Geographic restrictions on REC purchases for renewable	J-1	pricing point (GWh): January 1 through September 30, 2017	353
portfolio standard compliance in PJM states	327		

xxiv Table of Contents © 2017 Monitoring Analytics, LLC

Table 9-8 Day-ahead scheduled net interchange volume by interface		Table 9-23 Net scheduled and actual PJM flows by interface pricing	
(GWh): January 1 through September 30, 2017	354	point and interface (GWh): January 1 through	
Table 9-9 Day-ahead scheduled gross import volume by interface		September 30, 2017	370
(GWh): January 1 through September 30, 2017	355	Table 9-24 PJM and MISO flow based hours and average hourly	
Table 9-10 Day-ahead scheduled gross export volume by interface		price differences: January 1 through September 30, 2017	373
(GWh): January 1 through September 30, 2017	356	Table 9-25 Distribution of hourly flows that are consistent and	
Table 9-11 Day-ahead scheduled net interchange volume by interface		inconsistent with price differences between PJM and MISO:	
pricing point (GWh): January 1 through September 30, 2017	358	January 1 through September 30, 2017	374
Table 9-12 Up to congestion scheduled net interchange volume by		Table 9-26 Distribution of hourly flows that are consistent and	
interface pricing point (GWh): January 1 through September 30,		inconsistent with price differences between PJM and MISO:	
2017	359	June 1 through September 30, 2017	374
Table 9-13 Day-ahead scheduled gross import volume by interface		Table 9-27 PJM and NYISO flow based hours and average hourly	
pricing point (GWh): January 1 through September 30, 2017	360	price differences: January 1 through September 30, 2017	375
Table 9-14 Up to congestion scheduled gross import volume by		Table 9-28 Distribution of hourly flows that are consistent and	
interface pricing point (GWh): January 1 through		inconsistent with price differences between PJM and NYISO:	
September 30, 2017	361	January 1 through September 30, 2017	376
Table 9-15 Day-ahead scheduled gross export volume by interface		Table 9-29 Distribution of hourly flows that are consistent and	
pricing point (GWh): January 1 through September 30, 2017	362	inconsistent with price differences between PJM and NYIS:	
Table 9-16 Up to congestion scheduled gross export volume by		May 1 through September 30, 2017	377
interface pricing point (GWh): January 1 through		Table 9-30 PJM, NYISO and MISO real-time and day-ahead border	
September 30, 2017	363	price averages: January 1 through September 30, 2017	377
Table 9-17 Active real-time and day-ahead scheduling interfaces:		Table 9-31 PJM and NYISO flow based hours and average hourly	
January 1 through September 30, 2017	364	price differences (Neptune): January 1 through	
Table 9-18 Active day-ahead and real-time scheduled interface		September 30, 2017	378
pricing points: January 1 through September 30, 2017	364	Table 9-32 Percent of scheduled interchange across the Neptune	
Table 9-19 Net scheduled and actual PJM flows by interface (GWh):		line by primary rights holder: July 1, 2007 through	
January 1 through September 30, 2017	366	September 30, 2017	378
Table 9-20 Net scheduled and actual PJM flows by interface pricing		Table 9-33 PJM and NYISO flow based hours and average hourly	
point (GWh): January 1 through September 30, 2017	367	price differences (Linden): January 1 through	
Table 9-21 Net scheduled and actual PJM flows by interface pricing		September 30, 2017	379
point (GWh) (Adjusted for IMO Scheduled Interfaces): January 1		Table 9-34 Percent of scheduled interchange across the Linden VFT	
through September 30, 2017	368	Line by primary rights holder: November 1, 2009 through	
Table 9-22 Net scheduled and actual PJM flows by interface and		September 30, 2017	380
interface pricing point (GWh): January 1 through		Table 9-35 PJM and NYISO flow based hours and average hourly price	
September 30, 2017	369	differences (Hudson): January 1 through September 30, 2017	381

Table 9-36 Percent of scheduled interchange across the Hudson		Table 9-51 Monthly differences between forecast and actual	
Line by primary rights holder: May 1, 2013 through		PJM/MISO interface prices (average price difference):	
September 30, 2017	381	January 1 through September 30, 2017	408
Table 9-37 Summary of elements included in operating agreements		Table 9-52 Monthly uncollected congestion charges: January 1,	
with bordering areas	383	2010 through September 30, 2017	409
Table 9-38 Real-time average hourly LMP comparison for Duke,		Table 9-53 MISO Projected Multi Value Project Usage Rate: 2017	
PEC and NCMPA: January 1 through September 30, 2017	389	through 2036	413
Table 9-39 Day-ahead average hourly LMP comparison for Duke,			
PEC and NCMPA: January 1 through September 30, 2017	389		
Table 9-40 PJM MISO, and NYISO TLR procedures: January 1, 2014		SECTION 10 Ancillary Service Markets	415
through September 30, 2017	393	Table 10-1 The Tier 2 Synchronized Reserve Market results were	
Table 9-41 Number of TLRs by TLR level by reliability coordinator:		competitive	415
January 1 through September 30, 2017	394	Table 10-2 The Day-Ahead Scheduling Reserve Market results were	
Table 9-42 Monthly volume of cleared and submitted up to		competitive	415
congestion bids: January 1, 2016 through September 30, 2017	396	Table 10-3 The Regulation Market results were competitive	415
Table 9-43 Credit risk associated with varying levels of potential		Table 10-4 History of ancillary services costs per MWh of Load:	
uplift: September 8, 2014 through December 7, 2015	398	January through September, 1999 through 2017	422
Table 9-44 Differences between forecast and actual PJM/NYIS		Table 10-5 Average monthly reserves used to satisfy the primary	
interface prices: January 1 through September 30, 2017	401	reserve requirement, MAD Subzone: January 1, 2016 through	
Table 9-45 Differences between forecast and actual PJM/NYIS		September 30, 2017	427
interface prices: January 1 through September 30, 2017	401	Table 10-6 Average monthly reserves used to satisfy the primary	
Table 9-46 Monthly Differences between forecast and actual		reserve requirement, RTO Zone: January 1, 2016 through	
PJM/NYIS interface prices (percent of intervals): January 1		September 30, 2017	427
through September 30, 2017	402	Table 10-7 MW credited, price, cost, and all-in price for primary	
Table 9-47 Monthly differences between forecast and actual PJM/NY	S	reserve and its component products, RTO Reserve Zone: January	
interface prices (average price difference): January 1		through September, 2017	430
through September 30, 2017	403	Table 10-8 Monthly average market solution tier 1 synchronized	
Table 9-48 Differences between forecast and actual PJM/MISO		reserve (MW) identified hourly: January 1, 2016 through	
interface prices: January 1 through September 30, 2017	406	September 30, 2017	431
Table 9-49 Differences between forecast and actual PJM/MISO		Table 10-9 Tier 1 synchronized reserve event response costs:	
interface prices: January 1 through September 30, 2017	406	January 1, 2016 through September 30, 2017	433
Table 9-50 Monthly Differences between forecast and actual		Table 10-10 Weighted price of tier 1 synchronized reserve	
PJM/MISO interface prices (percent of intervals): January 1	407	attributable to a nonsynchronized reserve price above zero:	
through September 30, 2017	407	January 1, 2016 through September 30, 2017	433

xxvi Table of Contents © 2017 Monitoring Analytics, LLC

Table 10-11 Excess payments for tier 1 synchronized reserve:		Table 10-27 DASR Market, regular hours vs. adjusted fixed demand	
January 1, 2016 through September 30, 2017	434	hours: January 1, 2016 through September 30, 2017.	454
Table 10-12 Tier 1 compensation as currently implemented by PJM	435	Table 10-28 DASR Market all hours of DASR market clearing price	
Table 10-13 Tier 1 compensation as recommended by MMU	435	greater than \$0: January 1, 2016 through September 30, 2017	455
Table 10-14 RTO Zone ASO tier 1 estimate biasing: January 2016		Table 10-29 Seasonal regulation requirement definitions	459
through September 2017	435	Table 10-30 Average monthly price paid per performance adjusted	
Table 10-15 Default Tier 2 Synchronized Reserve Markets required		MW of RegD and RegA: January 1 through September 30, 2016	
MW, RTO Zone and Mid-Atlantic Dominion Subzone	438	through 2017	462
Table 10-16 Three pivotal supplier test results for the RTO Zone and		Table 10-31 Average monthly price paid per effective MW of RegD	
MAD Subzone: January 1, 2016 through September 30, 2017	440	and RegA under mileage and MBF based settlement: January 1	
Table 10-17 Mid-Atlantic Dominion subzone, weighted average		through September 30, 2016 through 2017	463
SRMCP and average scheduled, tier 1 estimated and demand		Table 10-32 Performance adjusted and effective RegD MW eligible	
response MW: January 1, 2016 through September 30, 2017	443	and cleared: January through September: 2016 and 2017	464
Table 10-18 RTO zone weighted average SRMCP and average		Table 10-33 MBF assumed RegD proportions versus market solution	
scheduled, tier 1 estimated and demand response MW:		realized RegD proportions	465
January 1, 2016 through September 30, 2017	444	Table 10-34 PJM regulation capability, daily offer and hourly	
Table 10-19 RTO Zone, Mid-Atlantic Subzone tier 2 synchronized		eligible: January through September, 2017	469
reserve MW, credits, weighted price, and cost (including self		Table 10-35 PJM regulation by source: January through	
scheduled): January 1 through September 30, 2017	444	September, 2016 and 2017	470
Table 10-20 Synchronized reserve events 10 minutes or longer,		Table 10-36 Active battery storage projects in the PJM queue system	
tier 2 response compliance, RTO Reserve Zone: January 1		by submitted year: 2012 to 2017	470
through September 30, 2017	445	Table 10-37 PJM Regulation Market required MW and ratio of	
Table 10-21 Synchronized reserve events: January 1, 2010 through		eligible supply to requirement for ramp and nonramp hours:	
September 30, 2017	446	January through September, 2016 and 2017	471
Table 10-22 Nonsynchronized reserve market HHls: January 1		Table 10-38 Regulation market monthly three pivotal supplier	
through September 30, 2017	449	results: January 1, 2015 through September 30, 2017	472
Table 10-23 Nonsynchronized reserve market pivotal supply test:		Table 10-39 RegD self scheduled regulation by month: October 31,	
January 1 through September 30, 2017	450	2012 through September 30, 2017	474
Table 10-24 RTO zone, MAD subzone nonsynchronized reserve MW,		Table 10-40 Regulation sources: spot market, self scheduled, bilateral	
charges, price, and cost: January 1 through September 30, 2017	451	purchases: January 1, 2016 through September 30, 2017	475
Table 10-25 DASR market three pivotal supplier test results and		Table 10-41 Regulation sources: January through September, 2012	
number of hours with DASRMCP above \$0: January 1, 2016		through 2017	475
through September 30, 2017	453	Table 10-42 PJM regulation market monthly component of price	
Table 10-26 Impact of Adjusted Fixed Demand on DASR prices and		(Dollars per MW): January 1 through September 30, 2017	477
demand: January 1, 2017 through September 30, 2017	454		

Table 10-43 Total regulation charges: January 1, 2016 through		Table 11-6 Hub real-time, load-weighted average LMP components	
September 30, 2017	478	(Dollars per MWh): January 1 through September 30, 2016 and	
Table 10-44 Components of regulation cost, January 1, 2016,		2017	495
through September 30, 2017	478	Table 11-7 Hub day-ahead, load-weighted average LMP components	
Table 10-45 Comparison of average price and cost for PJM		(Dollars per MWh): January 1 through September 30, 2016 and	
regulation: January through September, 2009 through 2017	479	2017	495
Table 10-46 Black start revenue requirement charges: January 1		Table 11-8 Total PJM costs by component (Dollars (Millions)):	
through September 30, 2010 through 2017	481	January 1 through September 30, 2008 through 2017	496
Table 10-47 Black start zonal charges for network transmission use:		Table 11-9 Total PJM congestion (Dollars (Millions)): January 1	
January 1 through September 30, 2016 and 2017	481	through September 30, 2008 through 2017	498
Table 10-48 Black start zonal revenue requirement estimate:		Table 11-10 Total PJM congestion costs by accounting category by	
2017/2018 through 2019/2020 delivery years	483	market (Dollars (Millions)): January 1 through September 30,	
Table 10-49 Reactive zonal charges for network transmission use:		2008 through 2017	498
January 1 through September 30, 2016 and 2017	488	Table 11-11 Total PJM congestion costs by transaction type by	
		market (Dollars (Millions)): January 1 through September 30,	
		2017	499
SECTION 11 Congestion and Marginal Losses	489	Table 11-12 Total PJM congestion costs by transaction type by market	t
Table 11-1 PJM real-time, load-weighted average LMP components		(Dollars (Millions)): January 1 through September 30, 2016	499
(Dollars per MWh): January 1 through September 30, 2008		Table 11-13 Change in total PJM congestion costs by transaction type	e
through 2017	492	by market: January 1 through September 30, 2016 and 2017	
Table 11-2 PJM day-ahead, load-weighted average LMP components		(Dollars (Millions))	500
(Dollars per MWh): January 1 through September 30, 2008		Table 11-14 Monthly PJM congestion costs by market (Dollars	
through 2017	493	(Millions)): January 1, 2016 through September 30, 2017	500
Table 11-3 PJM real-time, load-weighted average LMP by constrained	d	Table 11-15 Monthly PJM congestion costs by virtual transaction	
and unconstrained hours (Dollars per MWh): January 1, 2016		type and by market (Dollars (Millions)): January 1 through	
through September 30, 2017	493	September 30, 2017	501
Table 11-4 Zonal and PJM real-time, load-weighted average LMP		Table 11-16 Monthly PJM congestion costs by virtual transaction	
components (Dollars per MWh): January 1 through September		type and by market (Dollars (Millions)): 2016	501
30, 2016 and 2017	493	Table 11-17 Congestion summary (By facility type): January 1	
Table 11-5 Zonal and PJM day-ahead, load-weighted average LMP		through September 30, 2017	503
components (Dollars per MWh): January 1 through September		Table 11-18 Congestion summary (By facility type): January 1	
30, 2016 and 2017	494	through September 30, 2016	503
		Table 11-19 Congestion event hours (day-ahead against real-time):	
		January 1 through September 30, 2016 and 2017	504

xxviii Table of Contents © 2017 Monitoring Analytics, LLC

Table 11-20 Congestion event hours (real-time against day-ahead):		Table 11-35 Total component costs (Dollars (Millions)): January 1	
January 1 through September 30, 2016 and 2017	504	through September 30, 2008 through 2017	519
Table 11-21 Congestion summary (By facility voltage): January 1		Table 11-36 Total PJM marginal loss costs by accounting category	
through September 30, 2017	505	(Dollars (Millions)): January 1 through September 30, 2008	
Table 11-22 Congestion summary (By facility voltage): January 1		through 2017	519
through September 30, 2016	505	Table 11-37 Total PJM marginal loss costs by accounting category	
Table 11-23 Top 25 constraints with frequent occurrence: January 1		by market (Dollars (Millions)): January 1 through	
through September 30, 2016 and 2017	506	September 30, 2008 through 2017	520
Table 11-24 Top 25 constraints with largest year-to-year change in		Table 11-38 Total PJM loss costs by transaction type by market	
occurrence: January 1 through September 30, 2016 and 2017	507	(Dollars (Millions)): January 1 through September 30, 2017	521
Table 11-25 Top 25 constraints affecting PJM congestion costs (By		Table 11-39 Total PJM loss costs by transaction type by market	
facility): January 1 through September 30, 2017	508	(Dollars (Millions)): January 1 through September 30, 2016	521
Table 11-26 Top 25 constraints affecting PJM congestion costs (By		Table 11-40 Monthly marginal loss costs by market (Millions):	
facility): January 1 through September 30, 2016	509	January 1, 2016 through September 30, 2017	522
Table 11-27 Top 20 congestion cost impacts from MISO flowgates		Table 11-41 Monthly PJM loss costs by virtual transaction type and	
affecting PJM dispatch (By facility): January 1 through		by market (Dollars (Millions)): January 1 through	
September 30, 2017	511	September 30, 2017	523
Table 11-28 Top 20 congestion cost impacts from MISO flowgates		Table 11-42 Monthly PJM loss costs by virtual transaction type and	
affecting PJM dispatch (By facility): January 1 through		by market (Dollars (Millions)): 2016	523
September 30, 2016	512	Table 11-43 Marginal loss credits (Dollars (Millions)): January 1	
Table 11-29 Top congestion cost impacts from NYISO flowgates		through September 30, 2008 through 2017	524
affecting PJM dispatch (By facility): January 1 through		Table 11-44 Total PJM costs by energy component (Dollars	
September 30, 2017	513	(Millions)): January 1 through September 30, 2008 through 2017	524
Table 11-30 Top three congestion cost impacts from NYISO		Table 11-45 Total PJM energy costs by accounting category (Dollars	
flowgates affecting PJM dispatch (By facility): January 1		(Millions)): January 1 through September 30, 2008 through 2017	525
through September 30, 2016	513	Table 11-46 Total PJM energy costs by market category (Dollars	
Table 11-31 Regional constraints summary (By facility): January 1		(Millions)): January 1 through September 30, 2008 through 2017	525
through September 30, 2017	514	Table 11-47 Total PJM energy costs by transaction type by market	
Table 11-32 Regional constraints summary (By facility): January 1		(Dollars (Millions)): January 1 through September 30, 2017	526
through September 30, 2016	515	Table 11-48 Total PJM energy costs by transaction type by market	
Table 11-33 Congestion cost by type of participant: January 1		(Dollars (Millions)): January 1 through September 30, 2016	526
through September 30, 2017	516	Table 11-49 Monthly energy costs by market type (Dollars	
Table 11-34 Congestion cost by type of participant: January 1		(Millions)): January 1, 2016 through September 30, 2017	527
through September 30, 2016	516		

Table 11-50 Monthly PJM energy costs by virtual transaction type		Table 12-17 Number of projects entered in the queue:	
and by market (Dollars (Millions)): January 1 through		September 30, 2017	545
September 30, 2017	528	Table 12-18 Queue details by fuel group: September 30, 2017	545
Table 11-51 Monthly PJM energy costs by virtual transaction type		Table 12-19 Status of all generation queue projects: January 1, 1997	
and by market (Dollars (Millions)): 2016	528	through September 30, 2017	546
		Table 12-20 Status of all generation queue projects as a percent of	
CECTION 40.0 (* LE DI .	<b>-</b> 00	total projects by classification: January 1, 1997 through	
SECTION 12 Generation and Transmission Planning	529	September 30, 2017	546
Table 12-1 Queue comparison by expected completion year (MW):		Table 12-21 Status of all generation capacity (MW) in the PJM	
December 31, 2016 to September 30, 2017	534	generation queue: January 1, 1997 through September 30, 2017	547
Table 12-2 Change in project status (MW): December 31, 2016 to		Table 12-22 Status of all generation queue projects as percent of	
September 30, 2017	534	total MW in project classification: January 1, 1997 through	
Table 12-3 Capacity in PJM queues (MW): September 30, 2017	535	September 30, 2017	548
Table 12-4 Queue capacity by LDA, control zone and fuel (MW):		Table 12-23 Status of all natural gas generation queue projects:	
September 30, 2017	536	January 1, 1997 through September 30, 2017	549
Table 12-5 Summary of PJM unit retirements by fuel (MW): 2011		Table 12-24 Status of all natural gas generation capacity (MW) in the	
through 2020	537	PJM generation queue: January 1, 1997 through	
Table 12-6 Unit identification for map of PJM unit retirements:		September 30, 2017	549
2011 through 2020	538	Table 12-25 Status of all wind generation queue projects:	
Table 12-7 Planned retirement of PJM units: September 30, 2017	539	January 1, 1997 through September 30, 2017	550
Table 12-8 Retirements by fuel type: 2011 through 2020	539	Table 12-26 Status of all wind generation capacity (MW) in the	
Table 12-9 Retirements (MW) by fuel type and state: 2011 through		PJM generation queue: January 1, 1997 through	
2020	540	September 30, 2017	550
Table 12-10 Unit deactivations in January 1 through		Table 12-27 Status of all solar generation queue projects:	
September 30, 2017	540	January 1, 1997 through September 30, 2017	551
Table 12-11 Existing PJM capacity: September 30, 2017 (By zone		Table 12-28 Current status of all solar generation capacity (MW) in	
and unit type (MW))	541	the PJM generation queue: January 1, 1997 through	
Table 12-12 PJM capacity (MW) by age (years): September 30, 2017	541	September 30, 2017	552
Table 12-13 PJM generation planning process	543	Table 12-29 Relationship between project developer and	
Table 12-14 Last milestone at time of withdrawal: January 1, 1997		Transmission Owner for all interconnection queue projects MW	
through September 30, 2017	544	by fuel type: January 1, 1997 through September 30, 2017	553
Table 12-15 Average project queue times (days): September 30, 2017	544	Table 12-30 Relationship between project developer and Transmission	
Table 12-16 PJM generation planning summary: September 30, 2017	544	Owner for all solar projects MW in PJM interconnection queue:	
		January 1, 1997 through September 30, 2017	554

xxx Table of Contents © 2017 Monitoring Analytics, LLC

Table 12-31 Relationship between project developer and Transmission		Table 12-45 Annual FTR market modeled transmission facility outage	
Owner for all natural gas project MW in PJM interconnection		requests by congestion and received status: planning periods	
queue: January 1, 1997 through September 30, 2017	556	2016/2017 and 2017/2018	564
Table 12-32 Relationship between project developer and Transmission		Table 12-46 Annual FTR market modeled transmission facility outage	2
Owner for all wind project MW in PJM interconnection queue:		requests by processed status: planning periods 2016/2017 and	
January 1, 1997 through September 30, 2017	557	2017/2018	565
Table 12-33 Transmission facility outage request summary by		Table 12-47 Transmission facility outage requests not modeled in	
planned duration: planning periods 2016/2017 and 2017/2018	558	Annual FTR Auction: planning periods 2016/2017 and	
Table 12-34 PJM transmission facility outage request received status		2017/2018	565
definition	559	Table 12-48 Late transmission facility outage requests not modeled	
Table 12-35 Transmission facility outage request summary by		in Annual FTR Auction and submitted after annual bidding	
received status: planning periods 2016/2017 and 2017/2018	559	opening date: planning periods 2016/2017 and 2017/2018	566
Table 12-36 Transmission facility outage request summary by		Table 12-49 Monthly Balance of Planning Period FTR Auction	
emergency: planning periods 2016/2017 and 2017/2018	559	modeled transmission facility outage requests by received status:	
Table 12-37 Transmission facility outage request summary by		planning periods 2016/2017 and 2017/2018	567
congestion: planning periods 2016/2017 and 2017/2018	560	Table 12-50 Monthly Balance of Planning Period FTR Auction	
Table 12-38 Transmission facility outage request summary by		modeled transmission facility outage requests by processed	
received status, emergency and congestion: planning periods		status: planning periods 2016/2017 and 2017/2018	567
2016/2017 and 2017/2018	560	Table 12-51 Transmission facility outage requests that are not	
Table 12-39 Transmission facility outage requests that might cause		modeled in Monthly Balance of Planning Period FTR Auction:	
congestion status summary: planning periods 2016/2017 and		planning periods 2016/2017 and 2017/2018	568
2017/2018	561	Table 12-52 Late transmission facility outage requests that are not	
Table 12-40 Rescheduled and cancelled transmission outage request		modeled in Monthly Balance of Planning Period FTR Auction and	
summary: planning periods 2016/2017 and 2017/2018	561	submitted after monthly bidding opening date: planning periods	
Table 12-41 Transmission outage summary: planning periods		2016/2017 and 2017/2018	568
2016/2017 and 2017/2018	562		
Table 12-42 Summary of potentially long duration (> 30 days)		SECTION 12 Einancial Transmission and Austion	
outages: planning periods 2016/2017 and 2017/2018	562	SECTION 13 Financial Transmission and Auction	
Table 12-43 Annual FTR market modeled transmission facility outage		Revenue Rights	<b>57</b> 3
requests by received status: planning periods 2016/2017 and		Table 13-1 The FTR Auction Markets results were competitive	574
2017/2018	563	Table 13-2 Annual FTR product dates	576
Table 12-44 Annual FTR market modeled transmission facility outage		Table 13-3 Historic Stage 1B and Stage 2 ARR Allocations from the	
requests by emergency and received status: planning periods	F. C. A	2011/2012 through 2017/2018 planning periods	585
2016/2017 and 2017/2018	564		

Table 13-4 ARRs and ARR revenue automatically reassigned for		Table 13-21 FTR Auction net revenue: Long Term FTR Auction	
network load changes by control zone: June 1, 2016, through		compared to Annual FTR Auction	600
September 30, 2017	586	Table 13-22 Estimated additional Long Term FTR Auction revenue at	
Table 13-5 Residual ARR allocation volume and target allocation:		Annual FTR Auction prices	601
2017	587	Table 13-23 Monthly Balance of Planning Period FTR Auction	
Table 13-6 ARR Revenue at 2016/2017 and 2017/2018 planning		revenue: 2017	601
period FTR prices	587	Table 13-24 Total annual PJM FTR revenue detail (Dollars (Millions)):	
Table 13-7 Projected ARR revenue adequacy (Dollars (Millions)):		Planning periods 2016/2017 and 2017/2018	604
Planning periods 2016/2017 and 2017/2018	588	Table 13-25 Monthly FTR accounting summary (Dollars (Millions)):	
Table 13-8 Excess Auction Revenue: Planning periods 2010/2011		Planning period 2016/2017 and 2017/2018	605
through 2017/2018	590	Table 13-26 PJM reported FTR payout ratio by planning period	606
Table 13-9 Monthly Balance of Planning Period FTR Auction		Table 13-27 End of planning period FTR uplift charge example	607
patterns of ownership by FTR direction: 2017	593	Table 13-28 Example of FTR payouts from portfolio netting and	
Table 13-10 Daily FTR net position ownership by FTR direction:		without portfolio netting	609
2017	593	Table 13-29 Change in positive target allocation payout ratio given	
Table 13-11 Long Term FTR Auction quoted and cleared volume	594	portfolio construction	610
Table 13-12 Long Term and Annual Auction total cleared FTR MW	594	Table 13-30 Nodal day-ahead CLMPs	611
Table 13-13 Monthly Balance of Planning Period FTR Auction		Table 13-31 Mathematically equivalent FTR payments with and	
market volume: 2017	595	without portfolio netting	611
Table 13-14 Monthly Balance of Planning Period FTR Auction		Table 13-32 Example implementation of counter flow adjustment	
buy-bid, bid and cleared volume (MW per period): 2017	596	method	612
Table 13-15 Secondary bilateral FTR market volume: Planning		Table 13-33 Counter flow FTR payout ratio adjustment impacts:	
periods 2016/2017 and 2017/2018	597	Planning period 2016/2017 and 2017/2018	612
Table 13-16 Cleared Volume, Revenue and \$/MW for planning		Table 13-34 ARR and FTR total congestion offset (in millions) for	
periods 2012/2013 through 2017/2018 Annual FTR Auction	598	ARR holders under PJM's proposed FTR funding: Planning periods	5
Table 13-17 Monthly Balance of Planning Period FTR Auction cleared,		2011/2012 through 2017/2018	615
weighted-average, buy-bid price per period (Dollars per MW):			
January through September, 2017	598		
Table 13-18 FTR profits by organization type and FTR direction for			
the 2017/2018 planning period	599		
Table 13-19 Monthly FTR profits by organization type for the			
2016/2017 and 2017/2018 planning periods	599		
Table 13-20 Planning period FTR profits by organization type:			
2012/2013 through 2017/2018 planning periods	600		

xxxii Table of Contents © 2017 Monitoring Analytics, LLC