

Table of Contents

Preface	i		
SECTION 1 Introduction	1		
2015 Q2 in Review	1		
PJM Market Summary Statistics	3		
PJM Market Background	3		
Conclusions	5		
Role of MMU	8		
Reporting	8		
Monitoring	9		
Market Design	10		
Recommendations	10		
New Recommendation from Section 3, Energy Market	10		
New Recommendation from Section 6, Demand Response	10		
New Recommendation from Section 10, Ancillary Services	10		
New Recommendation from Section 12, Planning	11		
Total Price of Wholesale Power	11		
Components of Total Price	11		
Section Overviews	12		
Overview: Section 3, “Energy Market”	12		
Overview: Section 4, “Energy Uplift”	18		
Overview: Section 5, “Capacity Market”	22		
Overview: Section 6, “Demand Response”	26		
Overview: Section 7, “Net Revenue”	30		
Overview: Section 8, “Environmental and Renewables”	30		
Overview: Section 9, “Interchange Transactions”	33		
Overview: Section 10, “Ancillary Services”	36		
Overview: Section 11, “Congestion and Marginal Losses”	41		
Overview: Section 12, “Planning”	43		
Overview: Section 13, “FTR and ARRs”	46		
SECTION 2 Recommendations			53
New Recommendations for Q2, 2015			53
New Recommendation from Section 3, Energy Market			53
New Recommendation from Section 6, Demand Response			54
New Recommendation from Section 10, Ancillary Services			54
New Recommendation from Section 12, Planning			54
Complete List of MMU Recommendations			54
Section 3, Energy Market			54
Section 4, Energy Uplift			55
Section 5, Capacity			57
Section 6, Demand Response			59
Section 7, Net Revenue			60
Section 8, Environmental			60
Section 9, Interchange Transactions			60
Section 10, Ancillary Services			61
Section 11, Congestion and Marginal Losses			62
Section 12, Planning			62
Section 13, FTRs and ARRs			63
SECTION 3 Energy Market			65
Overview			66
Market Structure			66
Market Behavior			67
Market Performance			68
Scarcity			69
Recommendations			69
Conclusion			70
Market Structure			71
Market Concentration			71
Ownership of Marginal Resources			73
Type of Marginal Resources			74
Supply			75
Demand			84

Supply and Demand: Load and Spot Market	92	Balancing Operating Reserve Determinants	154
Market Behavior	94	Energy Uplift Credits	156
Offer Capping for Local Market Power	94	Characteristics of Credits	156
Offer Capping for Local Market Power	95	Types of Units	156
Markup	97	Concentration of Energy Uplift Credits	157
Frequently Mitigated Units and Associated Units	98	Economic and Noneconomic Generation	159
Virtual Offers and Bids	101	Geography of Charges and Credits	161
Generator Offers	111	Energy Uplift Issues	163
Market Performance	112	Lost Opportunity Cost Credits	163
Markup	112	Black Start Service Units	166
Prices	120	Reactive / Voltage Support Units	166
Scarcity	135	Confidentiality of Energy Uplift Information	168
Emergency procedures	135	Energy Uplift Recommendations	168
Scarcity and Scarcity Pricing	139	Credits Recommendations	168
PJM Cold Weather Operations 2015 Natural gas supply and prices	139	Allocation Recommendations	171
Parameter Limited Schedules	140	Quantifiable Recommendations Impact	176
		April through June Energy Uplift Charges Analysis	177
SECTION 4 Energy Uplift (Operating Reserves)	141	SECTION 5 Capacity Market	181
Overview	141	Overview	181
Energy Uplift Results	141	RPM Capacity Market	181
Characteristics of Credits	141	Generator Performance	183
Geography of Charges and Credits	142	Recommendations	183
Energy Uplift Issues	142	Conclusion	185
Energy Uplift Recommendations	142	Installed Capacity	187
Recommendations	142	RPM Capacity Market	188
Conclusion	144	Market Structure	188
Energy Uplift	145	Generator Performance	192
Credits and Charges Categories	145	Capacity Factor	192
Energy Uplift Results	147	Generator Performance Factors	193
Energy Uplift Charges	147	Generator Forced Outage Rates	195
Operating Reserve Rates	150		
Reactive Services Rates	153		

SECTION 6 Demand Response	205	Federal Environmental Regulation	240
Overview	205	Control of Mercury and Other Hazardous Air Pollutants	240
Recommendations	206	Air Quality Standards: Control of NO _x , SO ₂ and O ₃ Emissions Allowances	240
Conclusion	207	Emission Standards for Reciprocating Internal Combustion Engines	242
PJM Demand Response Programs	209	Regulation of Greenhouse Gas Emissions	243
Participation in Demand Response Programs	210	State Environmental Regulation	245
Economic Program	211	New Jersey High Electric Demand Day (HEDD) Rules	245
Emergency Program	218	Illinois Air Quality Standards (NO _x , SO ₂ and Hg)	245
		State Regulation of Greenhouse Gas Emissions	245
SECTION 7 Net Revenue	229	Renewable Portfolio Standards	247
Overview	229	Emissions Controlled Capacity and Renewables in PJM Markets	253
Net Revenue	229	Emission Controlled Capacity in the PJM Region	253
Conclusion	229	Wind Units	255
Net Revenue	229	Solar Units	258
Theoretical Energy Market Net Revenue	230		
New Entrant Combustion Turbine	232	SECTION 9 Interchange Transactions	259
New Entrant Combined Cycle	233	Overview	259
New Entrant Coal Plant	233	Interchange Transaction Activity	259
New Entrant Diesel	234	Interactions with Bordering Areas	259
New Entrant Nuclear Plant	234	Recommendations	260
New Entrant Wind Installation	234	Conclusion	261
New Entrant Solar Installation	235	Interchange Transaction Activity	262
Spark Spreads	235	Aggregate Imports and Exports	262
		Real-Time Interface Imports and Exports	263
SECTION 8 Environmental and Renewable Energy Regulations	237	Real-Time Interface Pricing Point Imports and Exports	265
Overview	237	Day-Ahead Interface Imports and Exports	268
Federal Environmental Regulation	237	Day-Ahead Interface Pricing Point Imports and Exports	270
State Environmental Regulation	238	Loop Flows	275
Emissions Controls in PJM Markets	239	PJM and MISO Interface Prices	280
State Renewable Portfolio Standards	239	PJM and NYISO Interface Prices	283
Conclusion	239	Summary of Interface Prices between PJM and Organized Markets	285

Neptune Underwater Transmission Line to Long Island, New York	285	Primary Reserve	314
Linden Variable Frequency Transformer (VFT) facility	287	Tier 1 Synchronized Reserve	314
Hudson Direct Current (DC) Merchant Transmission Line	288	Tier 2 Synchronized Reserve Market	315
Operating Agreements with Bordering Areas	290	Non-Synchronized Reserve Market	316
PJM and MISO Joint Operating Agreement	291	Regulation Market	317
PJM and New York Independent System Operator Joint Operating Agreement (JOA)	292	Black Start Service	318
PJM and TVA Joint Reliability Coordination Agreement (JRCA)	294	Reactive	318
PJM and Duke Energy Progress, Inc. Joint Operating Agreement	294	Ancillary Services Costs per MWh of Load: 2004 through 2015	318
PJM and VACAR South Reliability Coordination Agreement	296	Recommendations	319
Balancing Authority Operations Coordination Agreement between Wisconsin Electric Power Company (WEC) and PJM Interconnection, LLC	296	Conclusion	319
Interface Pricing Agreements with Individual Balancing Authorities	296	Primary Reserve	320
Other Agreements with Bordering Areas	297	Market Structure	320
Interchange Transaction Issues	297	Price and Cost	323
PJM Transmission Loading Relief Procedures (TLRs)	297	Tier 1 Synchronized Reserve	325
Up-To Congestion	299	Market Structure	325
Sham Scheduling	301	Tier 1 Synchronized Reserve Event Response	327
Elimination of Ontario Interface Pricing Point	302	Tier 2 Synchronized Reserve Market	330
PJM and NYISO Coordinated Interchange Transactions	303	Market Structure	330
Reserving Ramp on the PJM/NYISO Interface	305	Market Behavior	334
PJM and MISO Coordinated Interchange Transaction Proposal	305	Market Performance	335
Willing to Pay Congestion and Not Willing to Pay Congestion	307	Non-Synchronized Reserve Market	340
Spot Imports	307	Market Structure	340
Interchange Optimization	308	Secondary Reserve (DASR)	343
45 Minute Schedule Duration Rule	309	Market Structure	343
Interchange Transaction Credit Screening Process	310	Market Conduct	344
Marginal Loss Surplus Allocation	310	Market Performance	344
		Regulation Market	347
SECTION 10 Ancillary Service Markets	313	Market Design	347
Overview	314	Market Structure	354
		Market Conduct	358
		Market Performance	361
		Black Start Service	362
		Reactive Service	365

SECTION 11 Congestion and Marginal Losses	367		
Overview	367		
Congestion Cost	367		
Marginal Loss Cost	368		
Energy Cost	369		
Conclusion	369		
Locational Marginal Price (LMP)	369		
Components	369		
Hub Components	372		
Component Costs	373		
Congestion	374		
Congestion Accounting	374		
Total Congestion	374		
Congested Facilities	378		
Congestion by Facility Type and Voltage	378		
Constraint Duration	382		
Constraint Costs	384		
Congestion-Event Summary for MISO Flowgates	386		
Congestion-Event Summary for NYISO Flowgates	388		
Congestion-Event Summary for the 500 kV System	389		
Congestion Costs by Physical and Financial Participants	390		
Congestion-Event Summary before and after September 8, 2014	391		
Marginal Losses	391		
Marginal Loss Accounting	391		
Marginal Loss Accounting	392		
Total Marginal Loss Costs	392		
Energy Costs	394		
Energy Accounting	394		
Total Energy Costs	395		
SECTION 12 Generation and Transmission Planning	397		
Overview	397		
Planned Generation and Retirements	397		
Generation and Transmission Interconnection Planning Process	397		
Regional Transmission Expansion Plan (RTEP)	397		
Backbone Facilities	398		
Transmission Facility Outages	398		
Recommendations	398		
Conclusion	399		
Planned Generation and Retirements	400		
Planned Generation Additions	400		
Planned Retirements	402		
Generation Mix	406		
Generation and Transmission Interconnection Planning Process	408		
Interconnection Study Phase	408		
Regional Transmission Expansion Plan (RTEP)	411		
Artificial Island Update	412		
Cost Estimates and Allocations	412		
Backbone Facilities	414		
Transmission Facility Outages	415		
Scheduling Transmission Facility Outage Requests	415		
Rescheduling Transmission Facility Outage Requests	417		
Transmission Facility Outage Analysis for the FTR Market	418		
Transmission Facility Outage Analysis in the Day-Ahead Market	421		
SECTION 13 Financial Transmission and Auction Revenue Rights	423		
Overview	424		
Financial Transmission Rights	424		
Auction Revenue Rights	425		
Recommendations	426		
Conclusion	426		
Financial Transmission Rights	429		
Market Structure	430		
Market Behavior	433		

Market Performance	437
Revenue Adequacy Issues and Solutions	455
Auction Revenue Rights	460
Market Structure	461
Market Performance	466

Figures

SECTION 1 Introduction 1

Figure 1-1 PJM's footprint and its 20 control zones	4
Figure 1-2 PJM reported monthly billings (\$ Billions): 2008 through June, 2015	4

SECTION 3 Energy Market 65

Figure 3-1 Fuel source distribution in unit segments: January through June 2015	73
Figure 3-2 PJM hourly Energy Market HHI: January through June 2015	73
Figure 3-3 Day-ahead marginal up-to congestion transaction and generation units: 2014 through June of 2015	75
Figure 3-4 Average PJM aggregate real-time generation supply curves by offer price: January through June of 2014 and 2015	76
Figure 3-5 Distribution of PJM real-time generation plus imports: January through June of 2014 and 2015	78
Figure 3-6 PJM real-time average monthly hourly generation: January 2014 through June 2015	79
Figure 3-7 Distribution of PJM day-ahead supply plus imports: January through June of 2014 and 2015	80
Figure 3-8 PJM day-ahead monthly average hourly supply: January 2014 through June 2015	81
Figure 3-9 Day-ahead and real-time supply (Average hourly volumes): January through June 2015	83
Figure 3-10 Difference between day-ahead and real-time supply (Average daily volumes): January 2014 through June 2015	83
Figure 3-11 Map of PJM real-time generation less real-time load by zone: January through June 2015	84
Figure 3-12 PJM footprint calendar year peak loads: January through June 1999 to 2015	85

Figure 3-13 PJM peak-load comparison: Friday, February 20, 2015, and Tuesday, June 17, 2014	86
Figure 3-14 Distribution of PJM real-time accounting load plus exports: January through June 2014 and 2015	86
Figure 3-15 PJM real-time monthly average hourly load: January 2014 through June 2015	87
Figure 3-16 PJM heating and cooling degree days: January 2014 through June 2015	88
Figure 3-17 Distribution of PJM day-ahead demand plus exports: January through June of 2014 and 2015	89
Figure 3-18 PJM day-ahead monthly average hourly demand: January 2014 through June 2015	90
Figure 3-19 Day-ahead and real-time demand (Average hourly volumes): January through June 2015	92
Figure 3-20 Difference between day-ahead and real-time demand (Average daily volumes): January 2014 through June 2015	92
Figure 3-21 Frequently mitigated units and associated units total months eligible: February, 2006 through June, 2015	100
Figure 3-22 Frequently mitigated units and associated units (By month): February 2006 through June 2015	101
Figure 3-23 PJM day-ahead aggregate supply curves: 2015 example day	102
Figure 3-24 Monthly bid and cleared INCs, DECs, and UTCs (MW): January 2005 through June 2015	104
Figure 3-25 Daily bid and cleared INCs, DECs, and UTCs (MW): January 2014 through June 2015	104
Figure 3-26 PJM monthly cleared up-to congestion transactions by type (MW): January 2005 through June 2015	110
Figure 3-27 PJM daily cleared up-to congestion transaction by type (MW): January 2014 through June 2015	111
Figure 3-28 Markup Contribution to real-time hourly load-weighted LMP (Unadjusted): January through June 2014 and 2015	115
Figure 3-29 Markup Contribution to real-time hourly load-weighted LMP (Adjusted): January through June 2014 and 2015	115

Figure 3-30 Average LMP for the PJM Real-Time Energy Market: January through June 2014 and 2015	121	Figure 4-6 Cumulative share of energy uplift credits in the first six months of 2014 and 2015 by unit	158
Figure 3-31 PJM real-time, load-weighted, average LMP: January through June 2015	123	Figure 4-7 PJM Closed Loop Interfaces Map	167
Figure 3-32 PJM real-time, monthly and annual, load-weighted, average LMP: January 1999 through June 2015	123	Figure 4-8 Energy uplift charges change from April through June of 2014 to April through June of 2015 by category	178
Figure 3-33 Spot average fuel price comparison with fuel delivery charges: 2012 through June, 2015 (\$/MMBtu)	124	Figure 4-9 Balancing operating reserve charges change from April through June 2014 to April through June 2015	178
Figure 3-34 Average LMP for the PJM Day-Ahead Energy Market: January through June 2014 and 2015	127	Figure 4-10 Reactive services charges change from April through June 2014 to April through June 2015	179
Figure 3-35 Day-ahead, monthly and annual, load-weighted, average LMP: June 2000 through June 2015	128	SECTION 5 Capacity Market	181
Figure 3-36 Real-time hourly LMP minus day-ahead hourly LMP: January through June 2015	134	Figure 5-1 Percentage of PJM installed capacity (By fuel source): June 1, 2007 through June 1, 2017	188
Figure 3-37 Monthly average of real-time minus day-ahead LMP: January through June 2015	134	Figure 5-2 PJM outages (MW): 2012 through June 2015	193
Figure 3-38 PJM system hourly average LMP: January through June 2015	135	Figure 5-3 PJM equivalent outage and availability factors: 2007 to 2015	194
Figure 3-39 Average daily delivered price for natural gas: January through June, 2014 and 2015 (\$/MMBtu)	140	Figure 5-4 Trends in the PJM equivalent demand forced outage rate (EFORd): 2007 through 2015	196
SECTION 4 Energy Uplift (Operating Reserves)	141	Figure 5-5 PJM distribution of EFORd data by unit type	197
Figure 4-1 Daily day-ahead operating reserve rate (\$/MWh): 2014 and 2015	151	SECTION 6 Demand Response	205
Figure 4-2 Daily balancing operating reserve reliability rates (\$/MWh): 2014 and 2015	151	Figure 6-1 Demand response revenue by market: January through June 2008 through 2015	211
Figure 4-3 Daily balancing operating reserve deviation rates (\$/MWh): 2014 and 2015	152	Figure 6-2 Economic program credits and MWh by month: January 2010 through June 2015	213
Figure 4-4 Daily lost opportunity cost and canceled resources rates (\$/MWh): 2014 and 2015	152	SECTION 7 Net Revenue	229
Figure 4-5 Daily reactive transfer interface support rates (\$/MWh): 2014 and 2015	154	Figure 7-1 Energy Market net revenue factor trends: 2009 through 2015	230
		Figure 7-2 Average operating costs: 2009 through 2015	232
		Figure 7-3 Spark spread for selected zones: 2013 through 2015	235

SECTION 8 Environmental and Renewable Energy Regulations

Figure 8-1 Spot monthly average emission price comparison: January 2014 through June 2015	237
Figure 8-2 Average solar REC price by jurisdiction: 2009 through 2015	247
Figure 8-3 Average Tier I REC price by jurisdiction: 2009 through 2015	250
Figure 8-4 Average Tier II REC price by jurisdiction: 2009 through 2015	250
Figure 8-5 Average hourly real-time generation of wind units in PJM: January through June 2015	251
Figure 8-6 Average hourly day-ahead generation of wind units in PJM: January through June 2015	256
Figure 8-7 Marginal fuel at time of wind generation in PJM: January through June 2015	257
Figure 8-8 Average hourly real-time generation of solar units in PJM: January through June 2015	257

SECTION 9 Interchange Transactions

Figure 9-1 PJM real-time and day-ahead scheduled imports and exports: January through June 2015	259
Figure 9-2 PJM real-time and day-ahead scheduled import and export transaction volume history: January 1999 through June 2015	263
Figure 9-3 PJM's footprint and its external interfaces	263
Figure 9-4 Real-time and day-ahead daily hourly average price difference (MISO/PJM Interface minus PJM/MISO Interface): January through June 2015	274
Figure 9-5 Real-time and day-ahead daily hourly average price difference (NY/PJM proxy - PJM/NYIS Interface): January through June 2015	282
	284

Figure 9-6 PJM, NYISO and MISO real-time and day-ahead border price averages: January through June 2015	285
Figure 9-7 Neptune hourly average flow: January through June 2015	287
Figure 9-8 Linden hourly average flow: January through June 2015	288
Figure 9-9 Hudson hourly average flow: January through June 2015	290
Figure 9-10 Credits for coordinated congestion management: January 2013 through June 2015	292
Figure 9-11 Credits for coordinated congestion management (flowgates): January 2013 through June 2015	293
Figure 9-12 Credits for coordinated congestion management (Ramapo PARs): January 2013 through June 2015	294
Figure 9-13 Monthly up-to congestion cleared bids in MWh: January 2005 through June 2015	299
Figure 9-14 Spot import service utilization: January 2013 through June, 2015	308

SECTION 10 Ancillary Service Markets

Figure 10-1 PJM RTO geography and primary reserve requirement: 2015	313
Figure 10-2 Mid-Atlantic Dominion subzone primary reserve MW by source (Daily Averages): January through June 2015	321
Figure 10-3 RTO subzone primary reserve MW by source (Daily Averages): January through June 2015	323
Figure 10-4 Daily average market clearing prices (\$/MW) for synchronized reserve and non-synchronized reserve: January through June 2015	323
Figure 10-5 Daily average tier 1 synchronized reserve supply (MW) in the MAD subzone: January through June 2015	324
Figure 10-6 Cleared Tier 2 Synchronized Reserve Average Hourly MW per Hour by unit type, full RTO Zone: January through June 2015	326
	331

Figure 10-7 Monthly average actual vs default synchronized reserve requirements, RTO and MAD: January 2014 through June 2015	332	Figure 10-21 Example marginal benefit line in percent RegD and RegD MW terms	351
Figure 10-8 Mid-Atlantic Dominion Reserve subzone monthly average synchronized reserve required vs. tier 2 synchronized reserve scheduled MW: January 2014 through June 2015	332	Figure 10-22 Illustration of correct method for calculating effective MW	351
Figure 10-9 RTO Reserve zone monthly average synchronized reserve required vs. tier 2 synchronized reserve scheduled MW: January 2014 through June 2015	333	Figure 10-23 Daily average percent of RegD effective MW by peak: January through June 2015	352
Figure 10-10 Tier 2 synchronized reserve daily average offer and eligible volume (MW): January through June 2015	334	Figure 10-24 Average cleared RegD MW and average cleared RegD with an effective price of \$0.00 by month: January 2014 through June 2015	353
Figure 10-11 Mid-Atlantic Dominion subzone average daily tier 2 synchronized reserve offer by unit type (MW): January through June, 2012 through 2015	335	Figure 10-25 Average monthly peak effective MW: PJM market calculated versus benefit factor based	353
Figure 10-12 RTO Zone average daily tier 2 synchronized reserve offer by unit type (MW): January through June 2012 through 2015	335	Figure 10-26 Cost of excess effective MW cleared by month, peak and off peak: January 1, 2014 through June 30, 2015	354
Figure 10-13 Synchronized reserve events duration distribution curve: 2011 through 2015	338	Figure 10-27 PJM monthly CPS1 and BAAL performance: January 2011 through June 2015	357
Figure 10-14 Daily average MAD subzone Non-synchronized Reserve Market clearing price and MW purchased: January through June 2015	342	Figure 10-28 PJM Regulation Market HHI distribution: 2014 and 2015	357
Figure 10-15 Daily average RTO Zone Non-synchronized Reserve Market clearing price and MW purchased: January through June 2015	342	Figure 10-29 Off peak and on peak regulation levels: 2015	359
Figure 10-16 Daily average components of DASR clearing price (\$/MW), marginal unit offer and LOC: January through June 2015	346	Figure 10-30 PJM regulation market daily weighted average market-clearing price, marginal unit opportunity cost and offer price (Dollars per MW): 2015	361
Figure 10-17 Daily average DASR prices and MW by classification: January through June 2015	346	SECTION 11 Congestion and Marginal Losses	367
Figure 10-18 Hourly average performance score by unit type and regulation signal type: January through June 2015	348	Figure 11-1 PJM monthly total congestion cost (Dollars (Millions)): 2009 through June of 2015	377
Figure 10-19 Daily average marginal benefit factor and mileage ratio: 2015	349	Figure 11-2 Location of the top 10 constraints by PJM total congestion costs: January through June of 2015	386
Figure 10-20 Maximum, minimum, and average PJM calculated marginal benefit factor by month: January through June of 2015	350	Figure 11-3 Location of the top 10 constraints by PJM day-ahead congestion costs: January through June of 2015	386
		Figure 11-4 Location of the top 10 constraints by PJM balancing congestion costs: January through June of 2015	386
		Figure 11-5 Daily congestion event hours: 2014 through June of 2015	391

Figure 11-6 PJM monthly marginal loss costs (Dollars (Millions)): 2009 through June of 2015	394	Figure 13-11 Ten largest positive and negative FTR target allocations summed by sink: 2014 to 2015 planning period	448
Figure 11-7 PJM monthly energy costs (Dollars (Millions)): January 2009 through June 2015	396	Figure 13-12 Ten largest positive and negative FTR target allocations summed by source: 2014 to 2015 planning period	448
SECTION 12 Generation and Transmission Planning	397	Figure 13-13 FTR payout ratio by month, excluding and including excess revenue distribution: January 2004 through June 2015	453
Figure 12-1 Map of PJM unit retirements: 2011 through 2019	403	Figure 13-14 FTR surplus and the collected Day-Ahead, Balancing and Total congestion: January 2005 through June 2015	459
Figure 12-2 PJM capacity (MW) by age (years): At June 30, 2015	407	Figure 13-15 FTR target allocation compared to sources of positive and negative congestion revenue	460
Figure 12-3 PJM Backbone Projects	414	Figure 13-16 Historic Stage 1B and Stage 2 ARR Allocations from the 2011 to 2012 through 2014 to 2015 planning periods	463
SECTION 13 Financial Transmission and Auction Revenue Rights	423	Figure 13-17 Stage 1A Infeasibility Funding Impact	467
Figure 13-1 Illustration of INC/DEC FTR forfeiture rule	434	Figure 13-18 Dollars per ARR MW paid to ARR holders: Planning periods 2010 to 2011 through 2014 to 2015	468
Figure 13-2 Monthly FTR forfeitures for physical and financial participants: June 2010 through May 2015	434	Figure 13-19 Excess ARR revenue: Planning periods 2011 to 2012 through 2014 to 2015	469
Figure 13-3 FTR forfeitures for INCs/DECs and INCs/DECs/UTCs for both the PJM and MMU methods: January 2013 through June 2015	435		
Figure 13-4 Illustration of UTC FTR forfeiture rule	436		
Figure 13-5 Illustration of UTC FTR Forfeiture rule with one point far from constraint	436		
Figure 13-6 Annual Bid FTR Auction volume: Planning period 2009 to 2010 through 2015 to 2016	439		
Figure 13-7 Annual Cleared FTR Auction volume: Planning period 2009 to 2010 through 2015 to 2016	439		
Figure 13-8 Cleared auction volume (MW) as a percent of total FTR cleared volume by calendar month: June 2004 through June 2015	442		
Figure 13-9 Long Term, Annual and Monthly FTR Auction bid and cleared volume: June 2003 through June 2015	443		
Figure 13-10 Annual FTR Auction volume-weighted average buy bid price: Planning period 2009 to 2010 through 2015 to 2016	444		

Tables

SECTION 1 Introduction 1

Table 1-1 PJM Market Summary Statistics, January through June, 2014 and 2015	3
Table 1-2 The Energy Market results were competitive	5
Table 1-3 The Capacity Market results were competitive	6
Table 1-4 The Regulation Market results were competitive	7
Table 1-5 The Tier 2 Synchronized Reserve Markets results were competitive	7
Table 1-6 The Day-Ahead Scheduling Reserve Market results were competitive	8
Table 1-7 The FTR Auction Markets results were competitive	8
Table 1-8 Total price per MWh by category: January through June, 2014 and 2015	12

SECTION 3 Energy Market 65

Table 3-1 The Energy Market results were competitive	65
Table 3-2 PJM hourly Energy Market HHI: January through June 2014 and 2015	72
Table 3-3 PJM hourly Energy Market HHI (By supply segment): January through June 2014 and 2015	72
Table 3-4 Marginal unit contribution to PJM real-time, load-weighted LMP (By parent company): January through June 2014 and 2015	74
Table 3-5 Marginal resource contribution to PJM day-ahead, load-weighted LMP (By parent company): January through June of 2014 and 2015	74
Table 3-6 Type of fuel used (By real-time marginal units): January through June 2014 and 2015	75
Table 3-7 Day-ahead marginal resources by type/fuel: January through June of 2014 and 2015	75

Table 3-8 PJM generation (By fuel source (GWh)): January through June of 2014 and 2015	76
Table 3-9 Monthly PJM generation (By fuel source (GWh)): January through June 2015	77
Table 3-10 PJM real-time average hourly generation and real-time average hourly generation plus average hourly imports: January through June of 2000 through 2015	78
Table 3-11 PJM day-ahead average hourly supply and day-ahead average hourly supply plus average hourly imports: January through June 2000 through 2015	80
Table 3-12 Day-ahead and real-time supply (MWh): January through June 2014 and 2015	82
Table 3-13 PJM real-time generation less real-time load by zone (GWh): January through June 2014 and 2015	84
Table 3-14 Actual PJM footprint peak loads: January through June 1999 to 2015	85
Table 3-15 PJM real-time average hourly load and real-time average hourly load plus average hourly exports: January through June of 1998 through 2015	87
Table 3-16 PJM heating and cooling degree days: January 2014 through June 2015	88
Table 3-17 PJM day-ahead average demand and day-ahead average hourly demand plus average hourly exports: January through June 2000 through 2015	90
Table 3-18 Cleared day-ahead and real-time demand (MWh): January through June 2014 and 2015	91
Table 3-19 Monthly average percentage of real-time self-supply load, bilateral-supply load and spot-supply load based on parent companies: January 2014 through June 2015	93
Table 3-20 Monthly average percentage of day-ahead self-supply demand, bilateral supply demand, and spot-supply demand based on parent companies: January 2014 through June 2015	94
Table 3-21 Offer-capping statistics – energy only: January through June, 2011 to 2015	94

Table 3-22 Offer-capping statistics for energy and reliability: January through June, 2011 to 2015	95	Table 3-38 PJM import and export transactions by type of parent organization (MW): January through June 2014 and 2015	105
Table 3-23 Offer-capping statistics for reliability: January through June, 2011 to 2015	95	Table 3-39 PJM virtual offers and bids by top ten locations (MW): January through June 2014 and 2015	106
Table 3-24 Real-time offer-capped unit statistics: January through June, 2014 and 2015	95	Table 3-40 PJM cleared up-to congestion import bids by top ten source and sink pairs (MW): January through June 2014 and 2015	107
Table 3-25 Numbers of hours when control zones experienced congestion resulting from one or more constraints binding for 50 or more hours or from an interface constraint: January through June, 2009 through 2015	96	Table 3-41 PJM cleared up-to congestion export bids by top ten source and sink pairs (MW): January through June 2014 and 2015	107
Table 3-26 Three pivotal supplier test details for interface constraints: January through June, 2015	96	Table 3-42 PJM cleared up-to congestion wheel bids by top ten source and sink pairs (MW): January through June 2014 and 2015	108
Table 3-27 Summary of three pivotal supplier tests applied for interface constraints: January through June, 2015	97	Table 3-43 PJM cleared up-to congestion internal bids by top ten source and sink pairs (MW): January through June 2014 and 2015	108
Table 3-28 Average, real-time marginal unit markup index (By offer price category): January through June 2014 and 2015	98	Table 3-44 Number of PJM offered and cleared source and sink pairs: January 2013 through June 2015	109
Table 3-29 Average day-ahead marginal unit markup index (By offer price category): January through June of 2014 and 2015	98	Table 3-45 PJM cleared up-to congestion transactions by type (MW): January through June 2014 and 2015	110
Table 3-30 Frequently mitigated units and associated units by total months eligible: 2014 and January through June, 2015	99	Table 3-46 Distribution of MW for dispatchable unit offer prices: January through June 2015	111
Table 3-31 Number of frequently mitigated units and associated units (By month): January 2014 through June 2015	100	Table 3-47 Distribution of MW for self scheduled offer prices: January through June 2015	112
Table 3-32 Hourly average number of cleared and submitted INCs, DECs by month: January 2014 through June 2015	102	Table 3-48 Markup component of the overall PJM real-time, load-weighted, average LMP by primary fuel type and unit type: January through June 2014 and 2015	114
Table 3-33 Hourly average of cleared and submitted up-to congestion bids by month: January 2014 through June 2015	103	Table 3-49 Monthly markup components of real-time load-weighted LMP (Unadjusted): January through June 2014 and 2015	114
Table 3-34 Hourly average number of cleared and submitted import and export transactions by month: January 2014 through June 2015	103	Table 3-50 Monthly markup components of real-time load-weighted LMP (Adjusted): January through June 2014 and 2015	114
Table 3-35 Type of day-ahead marginal units: January through June of 2015	103	Table 3-51 Average real-time zonal markup component (Unadjusted): January through June 2014 and 2015	116
Table 3-36 PJM INC and DEC bids by type of parent organization (MW): January through June 2014 and 2015	105	Table 3-52 Average real-time zonal markup component (Adjusted): January through June 2014 and 2015	116
Table 3-37 PJM up-to congestion transactions by type of parent organization (MW): January through June 2014 and 2015	105	Table 3-53 Average real-time markup component (By price category, unadjusted): January through June 2014 and 2015	117

Table 3-54 Average real-time markup component (By price category, adjusted): January through June 2014 and 2015	117	Table 3-69 PJM day-ahead, average LMP (Dollars per MWh): January through June of 2001 through 2015	127
Table 3-55 Markup component of the annual PJM day-ahead, load-weighted, average LMP by primary fuel type and unit type: January through June of 2014 and 2015	117	Table 3-70 PJM day-ahead, load-weighted, average LMP (Dollars per MWh): January through June 2001 through 2015	128
Table 3-56 Monthly markup components of day-ahead (Unadjusted), load-weighted LMP: January through June of 2014 and 2015	118	Table 3-71 Components of PJM day-ahead, (unadjusted) six month, load-weighted, average LMP (Dollars per MWh): January through June of 2014 and 2015	129
Table 3-57 Monthly markup components of day-ahead (Adjusted), load-weighted LMP: January through June of 2014 and 2015	118	Table 3-72 Components of PJM day-ahead, (adjusted) six month, load-weighted, average LMP (Dollars per MWh): January through June of 2014 and 2015	130
Table 3-58 Day-ahead, average, zonal markup component (Unadjusted): January through June of 2014 and 2015	119	Table 3-73 Cleared UTC profitability by source and sink point: January through June 2014 and 2015	131
Table 3-59 Day-ahead, average, zonal markup component (Adjusted): January through June of 2014 and 2015	119	Table 3-74 Day-ahead and real-time average LMP (Dollars per MWh): January through June, 2014 and 2015	132
Table 3-60 Average, day-ahead markup (By LMP category, unadjusted): January through June of 2014 and 2015	120	Table 3-75 Day-ahead and real-time average LMP (Dollars per MWh): January through June 2001 through 2015	132
Table 3-61 Average, day-ahead markup (By LMP category, adjusted): January through June 2014 and 2015	120	Table 3-76 Frequency distribution by hours of PJM real-time LMP minus day-ahead LMP (Dollars per MWh): January through June of 2007 through 2015	133
Table 3-62 PJM real-time, average LMP (Dollars per MWh): January through June of 1998 through 2015	121	Table 3-77 Summary of emergency events declared: January through June, 2014 and 2015	135
Table 3-63 PJM real-time, load-weighted, average LMP (Dollars per MWh): January through June of 1998 through 2015	122	Table 3-78 Description of Emergency Procedures	137
Table 3-64 Zone real-time and real-time, load-weighted, average LMP (Dollars per MWh): January through June of 2014 and 2015	122	Table 3-79 PJM declared emergency alerts, warnings and actions: January through June, 2015	138
Table 3-65 PJM real-time annual, fuel-cost adjusted, load-weighted average LMP (Dollars per MWh): six months over six months	124		
Table 3-66 Change in PJM real-time annual, fuel-cost adjusted, load-weighted average LMP (Dollars per MWh) by Fuel-type: six months over six months	125	SECTION 4 Energy Uplift (Operating Reserves)	141
Table 3-67 Components of PJM real-time (Unadjusted), six month, load-weighted, average LMP: January through June 2014 and 2015	126	Table 4-1 Day-ahead and balancing operating reserve credits and charges	146
Table 3-68 Components of PJM real-time (Adjusted), six month, load-weighted, average LMP: January through June 2014 and 2015	126	Table 4-2 Reactive services, synchronous condensing and black start services credits and charges	146
		Table 4-3 Total energy uplift charges: January through June 2014 and 2015	147

Table 4-4 Energy uplift charges by category: January through June 2014 and 2015	147	Table 4-21 Identification of balancing operating reserve credits received by the top 10 units by category and region: January through June 2015	158
Table 4-5 Monthly energy uplift charges: 2014 and January through June 2015	148	Table 4-22 Daily energy uplift credits HHI: January through June 2015	158
Table 4-6 Day-ahead operating reserve charges: January through June 2014 and 2015	148	Table 4-23 Day-ahead and real-time generation (GWh): January through June 2015	159
Table 4-7 Balancing operating reserve charges: January through June 2014 and 2015	149	Table 4-24 Day-ahead and real-time economic and noneconomic generation from units eligible for operating reserve credits (GWh): January through June 2015	159
Table 4-8 Balancing operating reserve deviation charges: January through June 2014 and 2015	149	Table 4-25 Day-ahead and real-time generation receiving operating reserve credits (GWh): January through June 2015	160
Table 4-9 Additional energy uplift charges: January through June 2014 and 2015	149	Table 4-26 Day-ahead generation scheduled as must run by PJM (GWh): 2014 and January through June 2015	160
Table 4-10 Regional balancing charges allocation (Millions): January through June 2014	150	Table 4-27 Day-ahead generation scheduled as must run by PJM by category (GWh): January through June 2015	161
Table 4-11 Regional balancing charges allocation (Millions): January through June 2015	150	Table 4-28 Geography of regional charges and credits: January through June 2015	162
Table 4-12 Operating reserve rates (\$/MWh): January through June 2014 and 2015	152	Table 4-29 Geography of reactive services charges: January through June 2015	162
Table 4-13 Operating reserve rates statistics (\$/MWh): January through June 2015	153	Table 4-30 Monthly lost opportunity cost credits (Millions): 2014 and January through June 2015	163
Table 4-14 Local voltage support rates: January through June 2014 and 2015	153	Table 4-31 Day-ahead generation from combustion turbines and diesels (GWh): 2014 and January through June 2015	164
Table 4-15 Balancing operating reserve determinants (MWh): January through June 2014 and 2015	155	Table 4-32 Lost opportunity cost credits paid to combustion turbines and diesels by scenario (Millions): 2014 and January through June 2015	165
Table 4-16 Deviations by transaction type: January through June 2015	155	Table 4-33 Day-ahead generation (GWh) from combustion turbines and diesels receiving lost opportunity cost credits by value: 2014 and January through June 2015	165
Table 4-17 Energy uplift credits by category: January through June 2014 and 2015	156	Table 4-34 PJM Closed Loop Interfaces	167
Table 4-18 Energy uplift credits by unit type: January through June 2014 and 2015	157	Table 4-35 Impact on energy market lost opportunity cost credits of rule changes (Millions): January through June 2015	171
Table 4-19 Energy uplift credits by unit type: January through June 2015	157	Table 4-36 Current energy uplift allocation	175
Table 4-20 Top 10 units and organizations energy uplift credits: January through June 2015	158	Table 4-37 MMU energy uplift allocation proposal	175

Table 4-38 Current and proposed energy uplift charges by allocation (Millions): 2014 and January through June 2015	176		
Table 4-39 Current and proposed average energy uplift rate by transaction: 2014 and January through June 2015	177		
SECTION 5 Capacity Market	181		
Table 5-1 The Capacity Market results were competitive	181		
Table 5-2 RPM related MMU reports, 2014 through 2015	186		
Table 5-3 PJM installed capacity (By fuel source): January 1, May 31, June 1, and June 30, 2015	187		
Table 5-4 Generation capacity changes: 2007/2008 through 2015/2016	189		
Table 5-5 Capacity Market load obligations served: June 1, 2015	189		
Table 5-6 RPM load management statistics by LDA: June 1, 2014 to June 1, 2017	191		
Table 5-7 RPM load management cleared capacity and ILR: 2007/2008 through 2017/2018	192		
Table 5-8 RPM load management statistics: June 1, 2007 to June 1, 2017	192		
Table 5-9 PJM capacity factor (By unit type (GWh)): January through June of 2014 and 2015	193		
Table 5-10 EAF by unit type: 2007 through 2015	195		
Table 5-11 EMOF by unit type: 2007 through 2015	195		
Table 5-12 EPOF by unit type: 2007 through 2015	195		
Table 5-13 EFOF by unit type: 2007 through 2015	195		
Table 5-14 PJM EFORD data for different unit types: 2007 through 2015	196		
Table 5-15 OMC Outages	199		
Table 5-16 Contribution to EFOF by unit type by cause: 2015	202		
Table 5-17 Contributions to Economic Outages: 2015	203		
Table 5-18 PJM EFORD, XEFORD and EFORp data by unit type	203		
SECTION 6 Demand Response	205		
Table 6-1 Overview of demand response programs	209		
Table 6-2 Economic program registrations on the last day of the month: January 2010 through June 2015	212		
Table 6-3 Sum of peak MW reductions for all registrations per month: January through June, 2010 through 2015	212		
Table 6-4 Credits paid to the PJM economic program participants: January through June 2010 through 2015	213		
Table 6-5 PJM economic program participation by zone: January through June of 2014 and 2015	214		
Table 6-6 Settlements submitted by year in the economic program: January through June of 2009 through 2015	214		
Table 6-7 Participants and CSPs submitting settlements in the economic program by year: January through June of 2009 through 2015	214		
Table 6-8 HHI and market concentration in the economic program: January through June of 2014 and 2015	214		
Table 6-9 Hourly frequency distribution of economic program MWh reductions and credits: January through June 2014 and 2015	215		
Table 6-10 Frequency distribution of economic program zonal, load-weighted, average LMP (By hours): January through June 2014 and 2015	215		
Table 6-11 Result from net benefits tests: April 2012 through June 2015	216		
Table 6-12 Hours with price higher than NBT and DR occurrences in those hours: January through June 2014 and 2015	216		
Table 6-13 Zonal DR charge: January through June 2015	217		
Table 6-14 Zonal DR charge per MWh of Load and Exports: January through June 2015	217		
Table 6-15 Monthly day-ahead and real-time DR charge: January through June 2014 and 2015	218		
Table 6-16 Zonal monthly capacity revenue: January through June 2015	218		

Table 6-17 Energy efficiency resources by MW: 2012/2013 through 2015/2016 Delivery Year	219
Table 6-18 Lead time by product type: 2014/2015 Delivery Year	219
Table 6-19 Lead time by product type: 2015/2016 Delivery Year	219
Table 6-20 Reduction MW by each demand response method: 2014/2015 Delivery Year	220
Table 6-21 Reduction MW by each demand response method: 2015/2016 Delivery Year	220
Table 6-22 On-site generation fuel type by MW: 2014/2015 Delivery Year	220
Table 6-23 On-site generation fuel type by MW: 2015/2016 Delivery Year	221
Table 6-24 Demand response cleared MW UCAP for PJM: 2011/2012 through 2015/2016 Delivery Year	221
Table 6-25 PJM declared load management events: 2015	221
Table 6-26 Demand response event performance: April 21, 2015 and April 22, 2015	223
Table 6-27 Distribution of participant event days and nominated MW across ranges of performance levels across the events: 2015	223
Table 6-28 Non-reporting locations and nominated ICAP: 2015 event days	224
Table 6-29 Distribution of registrations and associated MW in the emergency full option across ranges of minimum dispatch prices: 2014/2015 Delivery Year	225
Table 6-30 Distribution of registrations and associated MW in the emergency full option across ranges of minimum dispatch prices: 2015/2016 Delivery Year	226
Table 6-31 Energy reduction MWh and average real-time LMP during demand response event days: 2015	226
Table 6-32 Emergency Revenue by event: 2015	227

SECTION 7 Net Revenue 229

Table 7-1 Average operating costs: January through June, 2015	231
Table 7-2 Energy net revenue for a new entrant gas-fired CT under economic dispatch (Dollars per installed MW-year)	232
Table 7-3 Energy net revenue for a new entrant CC under economic dispatch (Dollars per installed MW-year)	233
Table 7-4 Energy net revenue for a new entrant CP (Dollars per installed MW-year)	233
Table 7-5 PJM energy market net revenue for a new entrant DS (Dollars per installed MW-year)	234
Table 7-6 Energy net revenue for a new entrant nuclear plant (Dollars per installed MW-year)	234
Table 7-7 Energy market net revenue for a wind installation (Dollars per installed MW-year)	235
Table 7-8 PSEG Energy Market net revenue for a solar installation (Dollars per installed MW-year)	235

SECTION 8 Environmental and Renewable Energy Regulations 237

Table 8-1 Interim and final targets for CO ₂ emissions goals for PJM states (Short Tons of CO ₂)	244
Table 8-2 HEDD maximum NO _x emission rates	245
Table 8-3 RGGI CO ₂ allowance auction prices and quantities in short tons and metric tonnes: 2009-2011, 2012-2014 and 2015-2017 Compliance Periods	246
Table 8-4 Renewable standards of PJM jurisdictions to 2028	248
Table 8-5 Solar renewable standards by percent of electric load for PJM jurisdictions: 2015 to 2028	249
Table 8-6 Additional renewable standards of PJM jurisdictions 2015 to 2028	249
Table 8-7 Renewable alternative compliance payments in PJM jurisdictions: As of June 30, 2015	251

Table 8-8 Renewable resource generation by jurisdiction and renewable resource type (GWh): January through June 2015	252	Table 9-7 Day-Ahead scheduled net interchange volume by interface (GWh): January through June 2015	269
Table 8-9 PJM renewable capacity by jurisdiction (MW) on June 30, 2015	252	Table 9-8 Day-Ahead scheduled gross import volume by interface (GWh): January through June 2015	269
Table 8-10 Renewable capacity by jurisdiction, non-PJM units registered in GATS (MW) on June 30, 2015	253	Table 9-9 Day-Ahead scheduled gross export volume by interface (GWh): January through June 2015	270
Table 8-11 SO ₂ emission controls (FGD) by fuel type (MW), as of June 30, 2015	253	Table 9-10 Day-ahead scheduled net interchange volume by interface pricing point (GWh): January through June 2015	271
Table 8-12 NO _x emission controls by fuel type (MW), as of June 30, 2015	254	Table 9-11 Up-to congestion scheduled net interchange volume by interface pricing point (GWh): January through June 2015	272
Table 8-13 Particulate emission controls by fuel type (MW) as of June 30, 2015	254	Table 9-12 Day-ahead scheduled gross import volume by interface pricing point (GWh): January through June 2015	272
Table 8-14 CO ₂ , SO ₂ and NO _x emissions by month (short tons), by PJM units: January 2012 through June 2015	255	Table 9-13 Up-to congestion scheduled gross import volume by interface pricing point (GWh): January through June 2015	273
Table 8-15 Capacity factor of wind units in PJM: January through June 2015	255	Table 9-14 Day-ahead scheduled gross export volume by interface pricing point (GWh): January through June 2015	273
Table 8-16 Capacity factor of wind units in PJM by month: January 2014 through June 2015	256	Table 9-15 Up-to congestion scheduled gross export volume by interface pricing point (GWh): January through June 2015	274
SECTION 9 Interchange Transactions	259	Table 9-16 Active interfaces: January through June 2015	274
Table 9-1 Real-time scheduled net interchange volume by interface (GWh): January through June 2015	264	Table 9-17 Active pricing points: January through June 2015	275
Table 9-2 Real-time scheduled gross import volume by interface (GWh): January through June 2015	265	Table 9-18 Net scheduled and actual PJM flows by interface (GWh): January through June 2015	276
Table 9-3 Real-time scheduled gross export volume by interface (GWh): January through June 2015	265	Table 9-19 Net scheduled and actual PJM flows by interface pricing point (GWh): January through June 2015	277
Table 9-4 Real-time scheduled net interchange volume by interface pricing point (GWh): January through June 2015	267	Table 9-20 Net scheduled and actual PJM flows by interface pricing point (GWh) (Adjusted for IMO Scheduled Interfaces): January through June 2015	278
Table 9-5 Real-time scheduled gross import volume by interface pricing point (GWh): January through June, 2015	267	Table 9-21 Net scheduled and actual PJM flows by interface and interface pricing point (GWh): January through June 2015	279
Table 9-6 Real-time scheduled gross export volume by interface pricing point (GWh): January through June 2015	268	Table 9-22 Net scheduled and actual PJM flows by interface pricing point and interface (GWh): January through June 2015	280
		Table 9-23 PJM and MISO flow based hours and average hourly price differences: January through June 2015	282

Table 9-24 Distribution of hourly flows that are consistent and inconsistent with price differences between PJM and MISO: January through June 2015	283	Table 9-40 ITSCED real-time LMP - PJM/NYIS interface price comparison (by interval): January through June 2015	304
Table 9-25 PJM and NYISO flow based hours and average hourly price differences: January through June 2015	284	Table 9-41 ITSCED real-time LMP - PJM/MISO interface price comparison (all intervals): January through June 2015	306
Table 9-26 Distribution of hourly flows that are consistent and inconsistent with price differences between PJM and NYISO: January through June 2015	285	Table 9-42 ITSCED real-time LMP - PJM/MISO interface price comparison (by interval): January through June 2015	306
Table 9-27 PJM and NYISO flow based hours and average hourly price differences (Neptune): January through June 2015	286	Table 9-43 Monthly uncollected congestion charges: January 2010 through June 2015	307
Table 9-28 Percentage of Neptune transmission usage by primary rights holder: July 2007 through June 2015	286	SECTION 10 Ancillary Service Markets	313
Table 9-29 PJM and NYISO flow based hours and average hourly price differences (Linden): January through June 2015	287	Table 10-1 The Regulation Market results were competitive	313
Table 9-30 Percentage of Linden transmission usage by primary rights holder: November 2009 through June 2015	288	Table 10-2 The Tier 2 Synchronized Reserve Market results were competitive	313
Table 9-31 PJM and NYISO flow based hours and average hourly price differences (Hudson): January through June 2015	289	Table 10-3 The Day-Ahead Scheduling Reserve Market results were competitive	313
Table 9-32 Percentage of Hudson transmission usage by primary rights holder: May 2013 through June 2015	289	Table 10-4 History of ancillary services costs per MWh of Load: January through June, 2004 through 2015	319
Table 9-33 Summary of elements included in operating agreements with bordering areas	291	Table 10-5 Average monthly tier 1 and tier 2 synchronized reserve, plus non-synchronized reserve used to satisfy the primary reserve requirement, MAD Subzone: January through June 2015	322
Table 9-34 Real-time average hourly LMP comparison for Duke, PEC and NCPMA: January through June 2015	296	Table 10-6 Average monthly tier 1 and tier 2 synchronized reserve, and non-synchronized reserve used to satisfy the primary reserve requirement, RTO Zone: January through June 2015	322
Table 9-35 Day-ahead average hourly LMP comparison for Duke, PEC and NCPMA: January through June 2015	297	Table 10-7 MW credited, price, cost, and all-in price for primary reserve and its component products, full RTO Reserve Zone, January through June 2015	325
Table 9-36 PJM MISO, and NYISO TLR procedures: January, 2012 through June 2015	298	Table 10-8 Monthly average market solution Tier 1 Synchronized Reserve (MW) identified hourly, January through June 2015	325
Table 9-37 Number of TLRs by TLR level by reliability coordinator: January through June, 2015	299	Table 10-9 Tier 1 synchronized reserve event response costs: January 2014 through June 2015	327
Table 9-38 Monthly volume of cleared and submitted up-to congestion bids: January 2010 through June 2015	300	Table 10-10 Weighted price of tier 1 synchronized reserve attributable to a non-synchronized reserve price above zero: January 2014 to June 2015	328
Table 9-39 ITSCED real-time LMP - PJM/NYIS interface price comparison (all intervals): January through June 2015	304		

Table 10-11 Dollar impact of paying Tier 1 Synchronized Reserve the SRMCP when the NSRMCP goes above \$0: January 2014 through June 2015	328	Table 10-26 PJM regulation capability, daily offer and hourly eligible: January through June 2015	354
Table 10-12 Tier 1 compensation as currently implemented by PJM	329	Table 10-27 PJM regulation provided by coal units	355
Table 10-13 Tier 1 compensation as recommended by MMU	329	Table 10-28 Impact on PJM Regulation Market of currently regulating units scheduled to retire through 2015	355
Table 10-14 MAD subzone ASO tier 1 estimate biasing, January 2014 through June, 2015	329	Table 10-29 PJM Regulation Market required MW and ratio of eligible supply to requirement: January through June 2014 and 2015	356
Table 10-15 Default Tier 2 Synchronized Reserve Markets required MW, RTO Zone and Mid-Atlantic Dominion Subzone	331	Table 10-30 PJM cleared regulation HHI: 2014 and 2015	357
Table 10-16 Three Pivotal Supplier Test Results for the RTO Zone and MAD Subzone: January 2014 through June 2015	333	Table 10-31 Regulation market monthly three pivotal supplier results: 2013 through 2015	358
Table 10-17 Mid-Atlantic Dominion Subzone, weighted SRMCP and cleared MW (excludes self-scheduled): January through June 2015	336	Table 10-32 RegD self scheduled regulation by month, October 2012 through March 2015	359
Table 10-18 RTO zone weighted SRMCP and cleared MW (excludes self-scheduled): January through June 2015	336	Table 10-33 Regulation sources: spot market, self-scheduled, bilateral purchases: 2014 and 2015	360
Table 10-19 Full RTO, RTO, Mid-Atlantic Subzone Tier 2 synchronized reserve MW, credits, price, and cost: January through June 2015	337	Table 10-34 Regulation sources by year: 2011 through 2015	360
Table 10-20 Synchronized reserve events greater than 10 minutes, Tier 2 Response Compliance, RTO Reserve Zone: January through June 2015	337	Table 10-35 PJM regulation market monthly weighted average market-clearing price, marginal unit opportunity cost and offer price (Dollars per MW): 2015	361
Table 10-21 Synchronized reserve events, January 2010 through June 2015	339	Table 10-36 Total regulation charges: January 2014 through June 2015	362
Table 10-21 Synchronized reserve events, January 2010 through June 2015 (continued)	340	Table 10-37 Components of regulation cost: 2015	362
Table 10-22 Non-synchronized reserve market HHIs: January through June 2015	341	Table 10-38 Comparison of average price and cost for PJM Regulation, January through June, 2009 through 2015	362
Table 10-23 Non-synchronized reserve market pivotal supply test: January through June 2015	341	Table 10-39 Black start revenue requirement charges: January through June, 2010 through 2015	363
Table 10-24 Full RTO, RTO, Mid-Atlantic Subzone non-synchronized reserve MW, credits, price, and cost: January through June 2015	343	Table 10-40 Black start zonal charges for network transmission use: January through June, 2014 and 2015	364
Table 10-25 PJM Day-Ahead Scheduling Reserve Market MW and clearing prices: 2012 through June 2015	345	Table 10-41 Black start zonal revenue requirement estimate: 2015/2016 through 2017/2018 delivery years	365
		Table 10-42 NERC CIP Costs: 2015	365
		Table 10-43 Reactive zonal charges for network transmission use: January through Jun, 2014 and 2015	366

SECTION 11 Congestion and Marginal Losses	367		
Table 11-1 PJM real-time, load-weighted average LMP components (Dollars per MWh): January through June of 2009 through 2015	370	Table 11-15 Congestion summary (By facility type): January through June of 2015	379
Table 11-2 PJM day-ahead, load-weighted average LMP components (Dollars per MWh): January through June of 2009 through 2015	371	Table 11-16 Congestion summary (By facility type): January through June of 2014	379
Table 11-3 Zonal and PJM real-time, load-weighted average LMP components (Dollars per MWh): January through June of 2014 and 2015	371	Table 11-17 Congestion event hours (Day-Ahead against Real-Time): January through June of 2014 and 2015	380
Table 11-4 Zonal and PJM day-ahead, load-weighted average LMP components (Dollars per MWh): January through June of 2014 and 2015	372	Table 11-18 Congestion event hours (Real-Time against Day-Ahead): January through June of 2014 and 2015	380
Table 11-5 Hub real-time, load-weighted average LMP components (Dollars per MWh): January through June of 2014 and 2015	372	Table 11-19 Congestion summary (By facility voltage): January through June of 2015	381
Table 11-6 Hub day-ahead, load-weighted average LMP components (Dollars per MWh): January through June of 2014 and 2015	373	Table 11-20 Congestion summary (By facility voltage): January through June of 2014	381
Table 11-7 Total PJM costs by component (Dollars (Millions)): January through June of 2009 through 2015	373	Table 11-21 Top 25 constraints with frequent occurrence: January through June of 2014 and 2015	382
Table 11-8 Total PJM congestion (Dollars (Millions)): January through June of 2008 through 2015	374	Table 11-22 Top 25 constraints with largest year-to-year change in occurrence: January through June of 2014 and 2015	383
Table 11-9 Total PJM congestion costs by accounting category by market (Dollars (Millions)): January through June of 2008 through 2015	375	Table 11-23 Top 25 constraints affecting PJM congestion costs (By facility): January through June of 2015	384
Table 11-10 Total PJM congestion costs by transaction type by market (Dollars (Millions)): January through June of 2015	375	Table 11-24 Top 25 constraints affecting PJM congestion costs (By facility): January through June of 2014	385
Table 11-11 Total PJM congestion costs by transaction type by market (Dollars (Millions)): January through June of 2014	376	Table 11-25 Top 20 congestion cost impacts from MISO flowgates affecting PJM dispatch (By facility): January through June of 2015	387
Table 11-12 Monthly PJM congestion costs by market (Dollars (Millions)): January through June of 2014 and 2015	376	Table 11-26 Top 20 congestion cost impacts from MISO flowgates affecting PJM dispatch (By facility): January through June of 2014	388
Table 11-13 Monthly PJM congestion costs by virtual transaction type and by market (Dollars (Millions)): January through June of 2015	377	Table 11-27 Top two congestion cost impacts from NYISO flowgates affecting PJM dispatch (By facility): January through June of 2015	389
Table 11-14 Monthly PJM congestion costs by virtual transaction type and by market (Dollars (Millions)): January through June of 2014	378	Table 11-28 Top two congestion cost impacts from NYISO flowgates affecting PJM dispatch (By facility): January through June of 2014	389
		Table 11-29 Regional constraints summary (By facility): January through June of 2015	389

Table 11-30 Regional constraints summary (By facility): January through June of 2014	390	Table 12-4 Capacity in PJM queues (MW): At June 30, 2015	401
Table 11-31 Congestion cost by type of participant: January through June of 2015	390	Table 12-5 Queue capacity by control zone and fuel (MW) at June 30, 2015	402
Table 11-32 Congestion cost by type of participant: January through June of 2014	391	Table 12-6 Summary of PJM unit retirements by fuel (MW): 2011 through 2019	403
Table 11-33 Total marginal loss component costs (Dollars (Millions)): January through June of 2009 through 2015	392	Table 12-7 Planned deactivations of PJM units, as of June 30, 2015	404
Table 11-34 Total PJM marginal loss costs by accounting category (Dollars (Millions)): January through June of 2009 through 2015	393	Table 12-8 Retirements by fuel type, 2011 through 2019	404
Table 11-35 Total PJM marginal loss costs by accounting category by market (Dollars (Millions)): January through June of 2009 through 2015	393	Table 12-9 Retirements (MW) by fuel type and state, 2011 through 2019	404
Table 11-36 Monthly marginal loss costs by market (Dollars (Millions)): January through June of 2014 and 2015	393	Table 12-10 Unit deactivations in 2015	405
Table 11-37 Marginal loss credits (Dollars (Millions)): January through June of 2009 through 2015	394	Table 12-11 Existing PJM capacity: At June 30, 2015 (By zone and unit type (MW))	406
Table 11-38 Total PJM costs by energy component (Dollars (Millions)): January through June of 2009 through 2015	395	Table 12-12 PJM capacity (MW) by age (years): At June 30, 2015	406
Table 11-39 Total PJM energy costs by accounting category (Dollars (Millions)): January through June of 2009 through 2015	395	Table 12-13 Expected capacity (MW) in five years, as of June 30, 2015	407
Table 11-40 Total PJM energy costs by market category (Dollars (Millions)): January through June of 2009 through 2015	396	Table 12-14 PJM generation planning process	408
Table 11-41 Monthly energy costs by market type (Dollars (Millions)): January through June of 2014 and 2015	396	Table 12-15 Completed (withdrawn or in service) queue MW (January 1, 1997 through June 30, 2015)	408
SECTION 12 Generation and Transmission Planning	397	Table 12-16 Last milestone completed at time of withdrawal (January 1, 1997 through June 30, 2015)	409
Table 12-1 Year-to-year capacity additions from PJM generation queue: Calendar years 2000 through June 30, 2015	400	Table 12-17 Average project queue times (days): At June 30, 2015	409
Table 12-2 Queue comparison by expected completion year (MW): March 31, 2015 vs. June 30, 2015	401	Table 12-18 PJM generation planning summary: At June 30, 2015	409
Table 12-3 Change in project status (MW): March 31, 2015 vs. June 30, 2015	401	Table 12-19 Queue details by fuel group: At June 30, 2015	409
		Table 12-20 Summary of project developer relationship to transmission owner	410
		Table 12-21 Developer-transmission owner relationship by fuel type	411
		Table 12-22 2015 Board approved new baseline upgrades by transmission owner	412
		Table 12-23 Artificial Island recommended work and cost allocation	412
		Table 12-24 Transmission facility outage request summary by planned duration: January through June of 2014 and 2015	415
		Table 12-25 PJM transmission facility outage request received status definition	415
		Table 12-26 Transmission facility outage request summary by received status: January through June of 2014 and 2015	415

Table 12-27 Transmission facility outage request summary by emergency: January through June of 2014 and 2015	416
Table 12-28 Transmission facility outage request summary by congestion: June of 2014 and 2015	416
Table 12-29 Transmission facility outage requests that by received status, congestion and emergency: January through June of 2014 and 2015	416
Table 12-30 Transmission facility outage requests that might cause congestion status summary: January through June of 2014 and 2015	417
Table 12-31 Rescheduled transmission outage request summary: January through June of 2014 and 2015	417
Table 12-32 Transmission facility outage requests by received status: Planning period 2014 to 2015	418
Table 12-33 Transmission facility outage requests by received status and emergency: Planning period 2014 to 2015	418
Table 12-34 Transmission facility outage requests by received status and congestion: Planning period 2014 to 2015	419
Table 12-35 Transmission facility outage requests by received status and processed status: Planning period 2014 to 2015	419
Table 12-36 Transmission facility outage requests by received status, processed status, emergency and congestion: Planning period 2014 to 2015	420
Table 12-37 Transmission facility outage requests by submission status and bidding opening date: Planning period 2014 to 2015	420
Table 12-38 Late transmission facility outage requests that are submitted after annual bidding opening date: Planning period 2014 to 2015	420
Table 12-39 Transmission facility outage request instance summary by congestion and emergency: Planning period 2014 to 2015	421
Table 12-40 Transmission facility outage request instance status summary by congestion and emergency: Planning period 2014 to 2015	421

SECTION 13 Financial Transmission and Auction Revenue Rights	423
Table 13-1 The FTR Auction Markets results were competitive	423
Table 13-2 Annual FTR product dates	430
Table 13-3 Top 10 principal binding transmission constraints limiting the Annual FTR Auction: Planning period 2015 to 2016	432
Table 13-4 Annual FTR Auction patterns of ownership by FTR direction: Planning period 2015 to 2016	433
Table 13-5 Monthly Balance of Planning Period FTR Auction patterns of ownership by FTR direction: 2015	433
Table 13-6 Daily FTR net position ownership by FTR direction: 2015	433
Table 13-7 Annual FTR Auction market volume: Planning period 2015 to 2016	438
Table 13-8 Comparison of self-scheduled FTRs: Planning periods 2009 to 2010 through 2015 to 2016	440
Table 13-9 Monthly Balance of Planning Period FTR Auction market volume: 2015	441
Table 13-10 Monthly Balance of Planning Period FTR Auction buy-bid, bid and cleared volume (MW per period): 2015	442
Table 13-11 Secondary bilateral FTR market volume: Planning periods 2013 to 2014 and 2014 to 2015	443
Table 13-12 Annual FTR Auction weighted-average cleared prices (Dollars per MW): Planning period 2015 to 2016	444
Table 13-13 Monthly Balance of Planning Period FTR Auction cleared, weighted-average, buy-bid price per period (Dollars per MW): January through June 2015	445
Table 13-14 FTR profits by organization type and FTR direction: 2015	445
Table 13-15 Monthly FTR profits by organization type: 2015	445
Table 13-16 Annual FTR Auction revenue: Planning period 2015 to 2016	446
Table 13-17 Monthly Balance of Planning Period FTR Auction revenue: 2015	447

Table 13-18 Total annual PJM FTR revenue detail (Dollars (Millions)): Planning periods 2013 to 2014 and 2014 to 2015	450	Table 13-34 Annual ARR Allocation volume: planning periods 2014 to 2015 and 2015 to 2016	466
Table 13-19 Unallocated congestion charges: Planning period 2012 to 2013 through 2014 to 2015	451	Table 13-35 Projected ARR revenue adequacy (Dollars (Millions)): Planning periods 2013 to 2014 and 2014 to 2015	468
Table 13-20 Monthly FTR accounting summary (Dollars (Millions)): Planning period 2013 to 2014 and 2014 to 2015	452	Table 13-36 ARR and self-scheduled FTR congestion offset (in millions): Planning periods 2013 to 2014 and 2014 to 2015	470
Table 13-21 PJM reported FTR payout ratio by planning period	453	Table 13-37 ARR and FTR congestion offset (in millions): Planning periods 2013 to 2014 and 2014 to 2015	471
Table 13-22 End of planning period FTR uplift charge example	454		
Table 13-23 PJM Reported and Actual Monthly Payout Ratios: Planning period 2014 to 2015	455		
Table 13-24 Example of FTR payouts from portfolio netting and without portfolio netting	456		
Table 13-25 Monthly positive and negative target allocations and payout ratios with and without hourly netting: Planning period 2013 to 2014 and 2014 to 2015	457		
Table 13-26 Example implementation of counter flow adjustment method	458		
Table 13-27 Counter flow FTR payout ratio adjustment impacts: Planning period 2013 to 2014 and 2014 to 2015	459		
Table 13-28 Historic Stage 1B and Stage 2 ARR Allocations from the 2011 to 2012 through 2015 to 2016 planning periods	464		
Table 13-29 Top 10 principal binding transmission constraints limiting the Annual ARR Allocation: Planning period 2015 to 2016	464		
Table 13-30 ARRs and ARR revenue automatically reassigned for network load changes by control zone: June 1, 2013, through May 31, 2015	465		
Table 13-31 Incremental ARR allocation volume: Planning periods 2008 to 2009 through 2015 to 2016	465		
Table 13-32 IARRs allocated for the 2015 to 2016 Annual ARR Allocation for RTEP upgrades	465		
Table 13-33 Residual ARR allocation volume and target allocation: 2015	466		