

Table of Contents

Preface	i		
SECTION 1 Introduction	1		
2015 Q1 in Review	1		
PJM Market Summary Statistics	3		
PJM Market Background	4		
Conclusions	5		
Role of MMU	9		
Reporting	9		
Monitoring	9		
Market Design	10		
Recommendations	11		
Total Price of Wholesale Power	15		
Components of Total Price	15		
Section Overviews	17		
Overview: Section 3, “Energy Market”	17		
Overview: Section 4, “Energy Uplift”	22		
Overview: Section 5, “Capacity Market”	26		
Overview: Section 6, “Demand Response”	30		
Overview: Section 7, “Net Revenue”	34		
Overview: Section 8, “Environmental and Renewables”	35		
Overview: Section 9, “Interchange Transactions”	37		
Overview: Section 10, “Ancillary Services”	40		
Overview: Section 11, “Congestion and Marginal Losses”	46		
Overview: Section 12, “Planning”	48		
Overview: Section 13, “FTR and ARRs”	51		
SECTION 2 Recommendations			57
New Recommendations for Q1, 2015			58
Complete List of MMU Recommendations			58
Section 3, Energy Market			58
Section 4, Energy Uplift			59
Section 5, Capacity			61
Section 6, Demand Response			63
Section 7, Net Revenue			64
Section 8, Environmental			64
Section 9, Interchange Transactions			64
Section 10, Ancillary Services			65
Section 11, Congestion and Marginal Losses			65
Section 12, Planning			66
Section 13, FTRs and ARRs			66
SECTION 3 Energy Market			69
Overview			70
Market Structure			70
Market Behavior			71
Market Performance			72
Scarcity			73
Recommendations			73
Conclusion			74
Market Structure			75
Market Concentration			75
Ownership of Marginal Resources			77
Type of Marginal Resources			78
Supply			79
Demand			88
Supply and Demand: Load and Spot Market			96
Market Behavior			98
Offer Capping for Local Market Power			98
Offer Capping for Local Market Power			99

Markup	101	Concentration of Energy Uplift Credits	160
Frequently Mitigated Units and Associated Units	102	Economic and Noneconomic Generation	162
Virtual Offers and Bids	105	Geography of Charges and Credits	164
Generator Offers	115	Energy Uplift Issues	166
Market Performance	116	Lost Opportunity Cost Credits	166
Markup	116	Black Start Service Units	169
Prices	123	Reactive / Voltage Support Units	169
Scarcity	138	Confidentiality of Energy Uplift Information	171
Emergency procedures	138	Energy Uplift Recommendations	171
Scarcity and Scarcity Pricing	142	Credits Recommendations	171
PJM Cold Weather Operations 2015	142	Allocation Recommendations	174
Natural gas supply and prices	142	Quantifiable Recommendations Impact	179
Parameter Limited Schedules	143	January through March Energy Uplift Charges Analysis	180
		Energy Uplift and Conservative Operations	182
		Lost Opportunity Cost Credits	183
SECTION 4 Energy Uplift (Operating Reserves)	145		
Overview	145	SECTION 5 Capacity Market	185
Energy Uplift Results	145	Overview	185
Characteristics of Credits	145	RPM Capacity Market	185
Geography of Charges and Credits	146	Generator Performance	187
Energy Uplift Issues	146	Recommendations	187
Energy Uplift Recommendations	146	Conclusion	189
Recommendations	146	Installed Capacity	191
Conclusion	148	RPM Capacity Market	192
Energy Uplift	149	Market Structure	192
Credits and Charges Categories	149	Market Conduct	198
Energy Uplift Results	150	Generator Performance	203
Energy Uplift Charges	150	Capacity Factor	203
Operating Reserve Rates	153	Generator Performance Factors	204
Reactive Services Rates	156	Generator Forced Outage Rates	205
Balancing Operating Reserve Determinants	157		
Energy Uplift Credits	159		
Characteristics of Credits	159		
Types of Units	159		

SECTION 6 Demand Response	213	Control of Mercury and Other Hazardous Air Pollutants	240
Overview	213	Air Quality Standards: Control of NO _x , SO ₂ and O ₃ Emissions Allowances	240
Recommendations	214	Emission Standards for Reciprocating Internal Combustion Engines	241
Conclusion	215	Regulation of Greenhouse Gas Emissions	242
PJM Demand Response Programs	216	State Environmental Regulation	244
Participation in Demand Response Programs	218	New Jersey High Electric Demand Day (HEDD) Rules	244
Economic Program	219	Illinois Air Quality Standards (NO _x , SO ₂ and Hg)	245
Emergency Program	224	State Regulation of Greenhouse Gas Emissions	245
		Renewable Portfolio Standards	247
SECTION 7 Net Revenue	229	Emissions Controlled Capacity and Renewables in PJM Markets	252
Overview	229	Emission Controlled Capacity in the PJM Region	252
Net Revenue	229	Wind Units	254
Conclusion	229	Solar Units	256
Net Revenue	229		
Theoretical Energy Market Net Revenue	230	SECTION 9 Interchange Transactions	257
New Entrant Combustion Turbine	232	Overview	257
New Entrant Combined Cycle	233	Interchange Transaction Activity	257
New Entrant Coal Plant	233	Interactions with Bordering Areas	258
New Entrant Diesel	234	Recommendations	258
New Entrant Nuclear Plant	234	Conclusion	259
New Entrant Wind Installation	235	Interchange Transaction Activity	260
New Entrant Solar Installation	235	Aggregate Imports and Exports	260
		Real-Time Interface Imports and Exports	261
SECTION 8 Environmental and Renewable Energy Regulations	237	Real-Time Interface Pricing Point Imports and Exports	263
Overview	237	Day-Ahead Interface Imports and Exports	266
Federal Environmental Regulation	237	Day-Ahead Interface Pricing Point Imports and Exports	268
State Environmental Regulation	238	Loop Flows	273
Emissions Controls in PJM Markets	238	PJM and MISO Interface Prices	279
State Renewable Portfolio Standards	239	PJM and NYISO Interface Prices	281
Conclusion	239	Summary of Interface Prices between PJM and Organized Markets	283
Federal Environmental Regulation	240	Neptune Underwater Transmission Line to Long Island, New York	283

Linden Variable Frequency Transformer (VFT) facility	284
Hudson Direct Current (DC) Merchant Transmission Line	286
Operating Agreements with Bordering Areas	287
PJM and MISO Joint Operating Agreement	288
PJM and New York Independent System Operator Joint Operating Agreement (JOA)	289
PJM and TVA Joint Reliability Coordination Agreement (JRCA)	291
PJM and Duke Energy Progress, Inc. Joint Operating Agreement	291
PJM and VACAR South Reliability Coordination Agreement	293
Balancing Authority Operations Coordination Agreement between Wisconsin Electric Power Company (WEC) and PJM Interconnection, LLC	293
Northeastern ISO-Regional Transmission Organization Planning Coordination Protocol	293
Interface Pricing Agreements with Individual Balancing Authorities	293
Other Agreements with Bordering Areas	294
Interchange Transaction Issues	294
PJM Transmission Loading Relief Procedures (TLRs)	294
Up-To Congestion	296
Sham Scheduling	298
Elimination of Ontario Interface Pricing Point	298
PJM and NYISO Coordinated Interchange Transactions	299
Reserving Ramp on the PJM/NYISO Interface	301
PJM and MISO Coordinated Interchange Transaction Proposal	302
Willing to Pay Congestion and Not Willing to Pay Congestion	303
Spot Imports	304
Interchange Optimization	304
45 Minute Schedule Duration Rule	305
Interchange Transaction Credit Screening Process	305
Marginal Loss Surplus Allocation	306

SECTION 10 Ancillary Service Markets	309
Overview	310
Primary Reserve	310
Tier 1 Synchronized Reserve	310
Tier 2 Synchronized Reserve Market	311
Non-Synchronized Reserve Market	312
Regulation Market	313
Black Start Service	314
Reactive	314
Ancillary Services Costs per MWh of Load: 2004 through 2015	314
Recommendations	315
Conclusion	316
Primary Reserve	316
Market Structure	316
Price and Cost	320
Tier 1 Synchronized Reserve	321
Market Structure	321
Tier 1 Issues	323
Tier 1 Synchronized Reserve Event Response	326
Tier 2 Synchronized Reserve Market	327
Market Structure	328
Market Behavior	331
Market Performance	333
Non-Synchronized Reserve Market	337
Market Structure	337
Secondary Reserve (DASR)	339
Market Structure	340
Market Conduct	340
Market Performance	340
Regulation Market	342
Market Design	342
Market Structure	348
Market Conduct	353
Market Performance	356

Black Start Service	360		
Reactive Service	362		
SECTION 11 Congestion and Marginal Losses	365		
Overview	365		
Congestion Cost	365		
Marginal Loss Cost	366		
Energy Cost	367		
Conclusion	367		
Locational Marginal Price (LMP)	367		
Components	367		
Zonal Components	369		
Hub Components	370		
Component Costs	371		
Congestion	371		
Congestion Accounting	371		
Total Congestion	371		
Congested Facilities	375		
Congestion by Facility Type and Voltage	376		
Constraint Duration	379		
Constraint Costs	381		
Congestion-Event Summary for MISO Flowgates	383		
Congestion-Event Summary for NYISO Flowgates	385		
Congestion-Event Summary for the 500 kV System	386		
Congestion Costs by Physical and Financial Participants	387		
Congestion-Event Summary before and after September 8, 2014	388		
Marginal Losses	388		
Marginal Loss Accounting	388		
Marginal Loss Accounting	389		
Total Marginal Loss Costs	389		
Energy Costs	391		
Energy Accounting	391		
Total Energy Costs	392		
		SECTION 12 Generation and Transmission Planning	395
		Overview	395
		Planned Generation and Retirements	395
		Generation and Transmission Interconnection Planning Process	395
		Regional Transmission Expansion Plan (RTEP)	395
		Backbone Facilities	396
		Transmission Facility Outages	396
		Recommendations	396
		Conclusion	397
		Planned Generation and Retirements	397
		Planned Generation Additions	397
		Planned Retirements	401
		Generation Mix	403
		Generation and Transmission Interconnection Planning Process	406
		Interconnection Study Phase	406
		Regional Transmission Expansion Plan (RTEP)	409
		Backbone Facilities	409
		Transmission Facility Outages	410
		Scheduling Transmission Facility Outage Requests	410
		Rescheduling Transmission Facility Outage Requests	412
		SECTION 13 Financial Transmission and Auction	
		Revenue Rights	413
		Overview	413
		Financial Transmission Rights	413
		Auction Revenue Rights	414
		Recommendations	415
		Conclusion	416
		Financial Transmission Rights	418
		Market Structure	420
		Market Behavior	421
		Market Performance	424
		Revenue Adequacy Issues and Solutions	436

Auction Revenue Rights	441
Market Structure	442
Market Performance	446

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 March, 2015 5

SECTION 3 Energy Market 69

- Figure 3-1 Fuel source distribution in unit segments: January through March 2015 76
- Figure 3-2 PJM hourly Energy Market HHI: January through March 2015 77
- Figure 3-3 Day-ahead marginal up-to congestion transaction and generation units: 2014 through March of 2015 79
- Figure 3-4 Average PJM aggregate real-time generation supply curves by offer price: January through March of 2014 and 2015 79
- Figure 3-5 Distribution of PJM real-time generation plus imports: January through March of 2014 and 2015 82
- Figure 3-6 PJM real-time average monthly hourly generation: January through March of 2014 and 2015 83
- Figure 3-7 Distribution of PJM day-ahead supply plus imports: January through March of 2014 and 2015 84
- Figure 3-8 PJM day-ahead monthly average hourly supply: January through March 2014 and 2015 85
- Figure 3-9 Day-ahead and real-time supply (Average hourly volumes): January through March 2015 87
- Figure 3-10 Difference between day-ahead and real-time supply (Average daily volumes): January through March 2014 and 2015 87
- Figure 3-11 Map of PJM real-time generation less real-time load by zone: January through March 2015 88
- Figure 3-12 PJM footprint peak loads: January through March 1999 to 2015 89
- Figure 3-13 PJM peak-load comparison: Friday, February 20, 2015, and Tuesday, January 7, 2014 90
- Figure 3-14 Distribution of PJM real-time accounting load plus exports: January through March 2014 and 2015 90
- Figure 3-15 PJM real-time monthly average hourly load: 2014 and January through March 2015 91
- Figure 3-16 PJM heating and cooling degree days: January 2014 through March 2015 92
- Figure 3-17 Distribution of PJM day-ahead demand plus exports: January through March of 2014 and 2015 93
- Figure 3-18 PJM day-ahead monthly average hourly demand: January through March 2014 and 2015 94
- Figure 3-19 Day-ahead and real-time demand (Average hourly volumes): January through March 2015 96
- Figure 3-20 Difference between day-ahead and real-time demand (Average daily volumes): January through March 2014 and 2015 96
- Figure 3-21 Frequently mitigated units and associated units total months eligible: February, 2006 through March, 2015 104
- Figure 3-22 Frequently mitigated units and associated units (By month): February, 2006 through March, 2015 105
- Figure 3-23 PJM day-ahead aggregate supply curves: 2015 example day 106
- Figure 3-24 Monthly bid and cleared INCs, DECs, and UTCs (MW): January 2005 through March 2015 108
- Figure 3-25 Daily bid and cleared INCs, DECs, and UTCs (MW): January 2014 through March 2015 108
- Figure 3-26 PJM monthly cleared up-to congestion transactions by type (MW): January 2005 through March 2015 114
- Figure 3-27 PJM daily cleared up-to congestion transaction by type (MW): January 2014 through March 2015 115
- Figure 3-28 Markup Contribution to real-time hourly load-weighted LMP (Unadjusted): January through March 2014 and 2015 119
- Figure 3-29 Markup Contribution to real-time hourly load-weighted LMP (Adjusted): January through March 2014 and 2015 119

Figure 3-30 Average LMP for the PJM Real-Time Energy Market: January through March 2014 and 2015	124	Figure 4-6 Cumulative share of energy uplift credits in the first three months of 2014 and 2015 by unit	161
Figure 3-31 PJM real-time, load-weighted, average LMP: January through March 2015	126	Figure 4-7 PJM Closed Loop Interfaces Map	170
Figure 3-32 PJM real-time, monthly and annual, load-weighted, average LMP: January 1999 through March 2015	127	Figure 4-8 Energy uplift charges change from January through March of 2015 to January through March of 2015 by category	181
Figure 3-33 Spot average fuel price comparison with fuel delivery charges: 2012 through 2014 (\$/MMBtu)	127	Figure 4-9 Day-ahead operating reserve charges change from January through March 2014 to January through March 2015	181
Figure 3-34 Average LMP for the PJM Day-Ahead Energy Market: January through March 2014 and 2015	130	Figure 4-10 Balancing operating reserve charges change from January through March 2014 to January through March 2015	182
Figure 3-35 Day-ahead, monthly and annual, load-weighted, average LMP: June 2000 through March 2014	132	Figure 4-11 Balancing operating reserve credits to generators committed before the operating day and outside the Day-Ahead Energy Market by category: January through March 2014 and 2015	183
Figure 3-36 Real-time hourly LMP minus day-ahead hourly LMP: January through March 2015	137	Figure 4-12 Average output from generators committed before the operating day and outside the Day-Ahead Energy Market by category: January through March 2014 and 2015	183
Figure 3-37 Monthly average of real-time minus day-ahead LMP: January through March 2015	137	Figure 4-13 BOR and LOC Generation: January through March 2014 and 2015	184
Figure 3-38 PJM system hourly average LMP: January through March 2015	138		
Figure 3-39 Average daily delivered price for natural gas: January through March, 2014 and 2015 (\$/MMBtu)	143		
SECTION 4 Energy Uplift (Operating Reserves)	145	SECTION 5 Capacity Market	185
Figure 4-1 Daily day-ahead operating reserve rate (\$/MWh): 2014 and 2015	154	Figure 5-1 Percentage of PJM installed capacity (By fuel source): June 1, 2007 through June 1, 2014	192
Figure 4-2 Daily balancing operating reserve reliability rates (\$/MWh): 2014 and 2015	154	Figure 5-2 Map of PJM Locational Deliverability Areas	195
Figure 4-3 Daily balancing operating reserve deviation rates (\$/MWh): 2014 and 2015	155	Figure 5-3 Map of PJM RPM EMAAC subzonal LDAs	195
Figure 4-4 Daily lost opportunity cost and canceled resources rates (\$/MWh): 2014 and 2015	155	Figure 5-4 Map of PJM RPM ATSI subzonal LDA	195
Figure 4-5 Daily reactive transfer interface support rates (\$/MWh): 2014 and 2015	157	Figure 5-5 History of PJM capacity prices: 1999/2000 through 2017/2018	201
		Figure 5-6 Map of RPM capacity prices: 2014/2015 through 2017/2018	202
		Figure 5-7 PJM outages (MW): 2012 through March 2015	204
		Figure 5-8 PJM equivalent outage and availability factors: 2007 to 2015	204

Figure 5-9 Trends in the PJM equivalent demand forced outage rate (EFORd): 2007 through 2015	206		
Figure 5-10 PJM distribution of EFORd data by unit type	207		
SECTION 6 Demand Response	213		
Figure 6-1 Demand response revenue by market: January through March 2008 through 2015	218		
Figure 6-2 Economic program credits and MWh by month: January 2010 through March 2015	221		
SECTION 7 Net Revenue	229		
Figure 7-1 Energy Market net revenue factor trends: 2009 through 2015	230		
Figure 7-2 Average operating costs: 2009 through 2015	231		
SECTION 8 Environmental and Renewable Energy Regulations	237		
Figure 8-1 Spot monthly average emission price comparison: January 2014 through March 2015	247		
Figure 8-2 Average hourly real-time generation of wind units in PJM: January through March 2015	254		
Figure 8-3 Average hourly day-ahead generation of wind units in PJM: January through March 2015	255		
Figure 8-4 Marginal fuel at time of wind generation in PJM: January through March 2015	256		
Figure 8-5 Average hourly real-time generation of solar units in PJM: January through March 2015	256		
SECTION 9 Interchange Transactions	257		
Figure 9-1 PJM real-time and day-ahead scheduled imports and exports: January through March, 2015	261		
Figure 9-2 PJM real-time and day-ahead scheduled import and export transaction volume history: January, 1999, through March, 2015	261		
Figure 9-3 PJM's footprint and its external interfaces	272		
Figure 9-4 Real-time and day-ahead daily hourly average price difference (MISO Interface minus PJM/MISO): January through March, 2015	280		
Figure 9-5 Real-time and day-ahead daily hourly average price difference (NY proxy - PJM/NYIS): January through March, 2015	282		
Figure 9-6 PJM, NYISO and MISO real-time and day-ahead border price averages: January through March, 2015	283		
Figure 9-7 Neptune hourly average flow: January through March, 2015	284		
Figure 9-8 Linden hourly average flow: January through March, 2015	286		
Figure 9-9 Hudson hourly average flow: January through March, 2015	287		
Figure 9-10 Credits for coordinated congestion management: January, 2013 through March, 2015	289		
Figure 9-11 Credits for coordinated congestion management (flowgates): January, 2013 through March, 2015	290		
Figure 9-12 Credits for coordinated congestion management (Ramapo PARs): January, 2013 through March, 2015	291		
Figure 9-13 Monthly up-to congestion cleared bids in MWh: January 2005, through March 2015	296		

SECTION 10 Ancillary Service Markets	309	
Figure 10-1 PJM RTO geography and primary reserve requirement: 2015	318	
Figure 10-2 Mid-Atlantic Dominion subzone primary reserve MW by source (Daily Averages): January through March 2015	319	
Figure 10-3 RTO subzone primary reserve MW by source (Daily Averages): January through March 2015	320	
Figure 10-4 Daily average market clearing prices (\$/MW) for synchronized reserve and non-synchronized reserve: January through March 2015	321	
Figure 10-5 Daily average tier 1 synchronized reserve supply (MW) in the MAD subzone: January through March 2015	322	
Figure 10-6 Daily average tier 1 actual MW (credited) vs daily average estimated tier 1 MW, January 2014 through March 2015	326	
Figure 10-7 Cleared Tier 2 Synchronized Reserve by unit type, full RTO Zone: January through March 2015	328	
Figure 10-8 Monthly average actual vs default synchronized reserve requirements, RTO and MAD: January 2014 through March 2015	329	
Figure 10-9 Mid-Atlantic Dominion Reserve subzone monthly average synchronized reserve required vs. tier 2 synchronized reserve scheduled MW: January 2015 through March 2015	330	
Figure 10-10 RTO Reserve zone monthly average synchronized reserve required vs. tier 2 synchronized reserve scheduled MW: January 2015 through March 2015	330	
Figure 10-11 Tier 2 synchronized reserve daily average offer and eligible volume (MW): January through March 2015	332	
Figure 10-12 Mid-Atlantic Dominion subzone average daily tier 2 synchronized reserve offer by unit type (MW): January through March, 2013 through 2015	332	
Figure 10-13 RTO Zone average daily tier 2 synchronized reserve offer by unit type (MW): January through March 2013 through 2015	333	
Figure 10-14 Synchronized reserve events duration distribution curve: 2011 through 2015	337	
		Figure 10-15 Daily average MAD subzone Non-synchronized Reserve Market clearing price and MW purchased: January through March 2015 338
		Figure 10-16 Daily average RTO Zone Non-synchronized Reserve Market clearing price and MW purchased: January through March 2015 339
		Figure 10-17 Daily average components of DASR clearing price (\$/MW), marginal unit offer and LOC: January through March 2015 341
		Figure 10-18 Daily average DASR prices and MW by classification: January through March 2015 342
		Figure 10-19 Average cleared RegD MW and average cleared RegD with an effective price of \$0.00 by month: January 2014 through March 2015 345
		Figure 10-20 Average monthly peak effective MW: PJM market calculated versus benefit factor based 345
		Figure 10-21 Off peak regulation summary statistics 346
		Figure 10-22 Hourly average performance score by unit type and regulation signal type: January through March 2015 347
		Figure 10-23 Daily average marginal benefit factor and mileage ratio: 2015 347
		Figure 10-24 Daily average percent of RegD effective MW by peak: 2015 348
		Figure 10-25 Monthly cleared effective MW and performance score by signal: 2015 349
		Figure 10-26 Monthly cleared actual MW and performance score by signal: 2015 350
		Figure 10-27 PJM monthly CPS1 and BAAL performance: January 2011 through March 2015 351
		Figure 10-28 PJM Regulation Market HHI distribution: 2014 and 2015 352
		Figure 10-29 Off peak and on peak regulation levels: 2015 354
		Figure 10-30 PJM Regulation Market daily weighted average market-clearing price, marginal unit opportunity cost and offer price (Dollars per MW): 2015 356

Figure 10-31 Comparison of monthly average RegA and RegD RMCP Credits per Effective MW: October 2012 through March 2015	357	Figure 13-3 FTR forfeitures for INCs/DECs and INCs/DECs/UTCs for both the PJM and MMU methods: January 2013 through March 2015	423
SECTION 11 Congestion and Marginal Losses	365	Figure 13-4 Illustration of UTC FTR forfeiture rule	424
Figure 11-1 PJM monthly total congestion cost (Dollars (Millions)): 2009 through March of 2015	374	Figure 13-5 Illustration of UTC FTR Forfeiture rule with one point far from constraint	424
Figure 11-2 Location of the top 10 constraints by PJM total congestion costs: January through March of 2015	383	Figure 13-6 Annual FTR Auction volume: Planning period 2009 to 2010 through 2014 to 2015	425
Figure 11-3 Location of the top 10 constraints by PJM day-ahead congestion costs: January through March of 2015	383	Figure 13-7 Cleared auction volume (MW) as a percent of total FTR cleared volume by calendar month: June 2004 through March 2015	427
Figure 11-4 Location of the top 10 constraints by PJM balancing congestion costs: January through March of 2015	383	Figure 13-8 Long Term, Annual and Monthly FTR Auction bid and cleared volume: June 2003 through March 2015	428
Figure 11-5 Daily congestion event hours: 2014 through march of 2015	388	Figure 13-9 Annual FTR Auction volume-weighted average buy bid price: Planning period 2009 to 2010 through 2014 to 2015	428
Figure 11-6 PJM monthly marginal loss costs (Dollars (Millions)): 2009 through March of 2015	391	Figure 13-10 Ten largest positive and negative FTR target allocations summed by sink: 2014 to 2015 planning period through March	430
Figure 11-7 PJM monthly energy costs (Dollars (Millions)): January 2009 through March 2015	393	Figure 13-11 Ten largest positive and negative FTR target allocations summed by source: 2014 to 2015 planning period through March	431
SECTION 12 Generation and Transmission Planning	395	Figure 13-12 FTR payout ratio by month, excluding and including excess revenue distribution: January 2004 through March 2014	434
Figure 12-1 Map of PJM unit retirements: 2011 through 2019	402	Figure 13-13 FTR surplus and the collected Day-Ahead, Balancing and Total congestion: January 2005 through March 2015	440
Figure 12-2 PJM capacity (MW) by age (years): at March 31, 2015	405	Figure 13-14 FTR target allocation compared to sources of positive and negative congestion revenue	441
Figure 12-3 PJM Backbone Projects	410	Figure 13-15 Historic Stage 1B and Stage 2 ARR Allocations from the 2011 to 2012 through 2014 to 2015 planning periods	444
SECTION 13 Financial Transmission and Auction Revenue Rights	413	Figure 13-16 Dollars per ARR MW paid to ARR holders: Planning periods 2010 to 2011 through 2014 to 2015	449
Figure 13-1 Illustration of INC/DEC FTR forfeiture rule	422	Figure 13-17 Excess ARR revenue: Planning periods 2011 to 2012 through 2014 to 2015	449
Figure 13-2 Monthly FTR forfeitures for physical and financial participants: June 2010 through March 2015	422		

Tables

SECTION 1 Introduction 1

Table 1-1 PJM Market Summary Statistics, January through March, 2014 and 2015 3

Table 1-2 The Energy Market results were competitive 6

Table 1-3 The Capacity Market results were competitive 7

Table 1-4 The Regulation Market results were competitive 7

Table 1-5 The Tier 2 Synchronized Reserve Markets results were competitive 8

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 Summarized list of MMU recommendations 11

Table 1-9 Total price per MWh by category: January through March, 2014 and 2015 16

SECTION 2 Recommendations 57

Table 2-1 PJM progress in responding to MMU recommendations 58

SECTION 3 Energy Market 69

Table 3-1 The Energy Market results were competitive 69

Table 3-2 PJM hourly Energy Market HHI: January through March 2014 and 2015 76

Table 3-3 PJM hourly Energy Market HHI (By supply segment): January through March 2014 and 2015 76

Table 3-4 Marginal unit contribution to PJM real-time, load-weighted LMP (By parent company): January through March 2014 and 2015 77

Table 3-5 Marginal resource contribution to PJM day-ahead, load-weighted LMP (By parent company): January through March of 2014 and 2015 77

Table 3-6 Type of fuel used (By real-time marginal units): January through March 2014 and 2015 78

Table 3-7 Day-ahead marginal resources by type/fuel: January through March of 2014 and 2015 78

Table 3-8 PJM generation (By fuel source (GWh)): January through March of 2014 and 2015 80

Table 3-9 Monthly PJM generation (By fuel source (GWh)): January through March 2015 80

Table 3-10 PJM real-time average hourly generation and real-time average hourly generation plus average hourly imports: January through March of 2000 through 2015 82

Table 3-11 PJM day-ahead average hourly supply and day-ahead average hourly supply plus average hourly imports: January through March 2000 through 2015 84

Table 3-12 Day-ahead and real-time supply (MWh): January through March 2014 and 2015 86

Table 3-13 PJM real-time generation less real-time load by zone (GWh): January through March 2014 and 2015 88

Table 3-14 Actual PJM footprint peak loads: January through March 1999 to 2014 89

Table 3-15 PJM real-time average hourly load and real-time average hourly load plus average hourly exports: January through March of 1998 through 2015 91

Table 3-16 PJM heating and cooling degree days: January 2014 through March 2015 92

Table 3-17 PJM day-ahead average demand and day-ahead average hourly demand plus average hourly exports: January through March 2000 through 2015 93

Table 3-18 Cleared day-ahead and real-time demand (MWh): January through March 2014 and 2015 95

Table 3-19 Monthly average percentage of real-time self-supply load, bilateral-supply load and spot-supply load based on parent companies: 2014 and January through March 2015	97	Table 3-34 Type of day-ahead marginal units: January through March of 2015	108
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 March 2015	98	Table 3-35 PJM INC and DEC bids by type of parent organization (MW): January through March 2014 and 2015	109
Table 3-21 Offer-capping statistics – energy only: January through March, 2011 to 2015	98	Table 3-36 PJM up-to congestion transactions by type of parent organization (MW): January through March 2014 and 2015	109
Table 3-22 Offer-capping statistics for energy and reliability: January through March, 2011 to 2015	99	Table 3-37 PJM import and export transactions by type of parent organization (MW): January through March 2014 and 2015	109
Table 3-23 Real-time offer-capped unit statistics: January through March, 2014 and 2015	99	Table 3-38 PJM virtual offers and bids by top ten locations (MW): January through March 2014 and 2015	110
Table 3-24 Numbers of hours when control zones experienced congestion resulting from one or more constraints binding for 25 or more hours or from an interface constraint: January through March, 2009 to 2015	99	Table 3-39 PJM cleared up-to congestion import bids by top ten source and sink pairs (MW): January through March 2014 and 2015	111
Table 3-25 Three pivotal supplier test details for interface constraints: January through March, 2015	100	Table 3-40 PJM cleared up-to congestion export bids by top ten source and sink pairs (MW): January through March 2014 and 2015	111
Table 3-26 Summary of three pivotal supplier tests applied for interface constraints: January through March, 2015	101	Table 3-41 PJM cleared up-to congestion wheel bids by top ten source and sink pairs (MW): January through March 2014 and 2015	112
Table 3-27 Average, real-time marginal unit markup index (By offer price category): January through March 2014 and 2015	102	Table 3-42 PJM cleared up-to congestion internal bids by top ten source and sink pairs (MW): January through March 2014 and 2015	112
Table 3-28 Average day-ahead marginal unit markup index (By offer price category): January through March of 2014 and 2015	102	Table 3-43 Number of PJM offered and cleared source and sink pairs: January 2013 through March 2015	113
Table 3-29 Frequently mitigated units and associated units by total months eligible: 2014 and January through March, 2015	104	Table 3-44 PJM cleared up-to congestion transactions by type (MW): January through March 2014 and 2015	114
Table 3-30 Number of frequently mitigated units and associated units (By month): 2014 and January through March, 2015	105	Table 3-45 Distribution of MW for dispatchable unit offer prices: January through March 2015	115
Table 3-31 Hourly average number of cleared and submitted INCs, DECs by month: January 2014 through March 2015	106	Table 3-46 Distribution of MW for self scheduled offer prices: January through March 2015	116
Table 3-32 Hourly average of cleared and submitted up-to congestion bids by month: January 2014 through March 2015	107	Table 3-47 Markup component of the overall PJM real-time, load-weighted, average LMP by primary fuel type and unit type: January through March 2014 and 2015	118
Table 3-33 Hourly average number of cleared and submitted import and export transactions by month: January 2014 through March 2015	107	Table 3-48 Monthly markup components of real-time load-weighted LMP (Unadjusted): January through March 2014 and 2015	118
		Table 3-49 Monthly markup components of real-time load-weighted LMP (Adjusted): 2013 and 2014	118

Table 3-50 Average real-time zonal markup component (Unadjusted): January through March 2014 and 2015	120	Table 3-66 Components of PJM real-time (Unadjusted), annual, load- weighted, average LMP: January through March 2014 and 2015	129
Table 3-51 Average real-time zonal markup component (Adjusted): January through March 2014 and 2015	120	Table 3-67 Components of PJM real-time (Adjusted), annual, load- weighted, average LMP: January through March 2014 and 2015	130
Table 3-52 Average real-time markup component (By price category, unadjusted): January through March 2014 and 2015	121	Table 3-68 PJM day-ahead, average LMP (Dollars per MWh): January through March of 2001 through 2015	131
Table 3-53 Average real-time markup component (By price category, adjusted): January through March 2014 and 2015	121	Table 3-69 PJM day-ahead, load-weighted, average LMP (Dollars per MWh): January through March 2001 through 2015	131
Table 3-54 Markup component of the annual PJM day-ahead, load- weighted, average LMP by primary fuel type and unit type: January through March of 2014 and 2015	121	Table 3-70 Components of PJM day-ahead, (unadjusted) annual, load-weighted, average LMP (Dollars per MWh): January through March of 2014 and 2015	133
Table 3-55 Monthly markup components of day-ahead (Unadjusted), load-weighted LMP: January through March of 2014 and 2015	122	Table 3-71 Components of PJM day-ahead, (adjusted) annual, load- weighted, average LMP (Dollars per MWh): January through March of 2014 and 2015	133
Table 3-56 Monthly markup components of day-ahead (Adjusted), load-weighted LMP: January through March of 2014 and 2015	122	Table 3-72 Cleared UTC profitability by source and sink point: January through March 2014 and 2015	134
Table 3-57 Day-ahead, average, zonal markup component (Unadjusted): January through March of 2014 and 2015	122	Table 3-73 Day-ahead and real-time average LMP (Dollars per MWh): 2013 and 2014	135
Table 3-58 Day-ahead, average, zonal markup component (Adjusted): January through March of 2014 and 2015	123	Table 3-74 Day-ahead and real-time average LMP (Dollars per MWh): January through March 2001 through 2015	135
Table 3-59 Average, day-ahead markup (By LMP category, unadjusted): January through March of 2014 and 2015	123	Table 3-75 Frequency distribution by hours of PJM real-time LMP minus day-ahead LMP (Dollars per MWh): January through March of 2007 through 2015	136
Table 3-60 Average, day-ahead markup (By LMP category, adjusted): January through March 2014 and 2015	123	Table 3-76 Summary of emergency events declared: January through March, 2014 and 2015	138
Table 3-61 PJM real-time, average LMP (Dollars per MWh): January through March of 1998 through 2015	125	Table 3-77 Description of Emergency Procedures	140
Table 3-62 PJM real-time, load-weighted, average LMP (Dollars per MWh): January through March of 1998 through 2015	125	Table 3-78 PJM declared emergency alerts, warnings and actions: January through March, 2015	141
Table 3-63 Zone real-time and real-time, load-weighted, average LMP (Dollars per MWh): January through March of 2014 and 2015	126		
Table 3-64 PJM real-time annual, fuel-cost adjusted, load-weighted average LMP (Dollars per MWh): year over year	128		
Table 3-65 Change in PJM real-time annual, fuel-cost adjusted, load- weighted average LMP (Dollars per MWh) by Fuel-type: year over year	128		

SECTION 4 Energy Uplift (Operating Reserves)	145	
Table 4-1 Day-ahead and balancing operating reserve credits and charges	149	Table 4-17 Energy uplift credits by category: January through March 2014 and 2015
Table 4-2 Reactive services, synchronous condensing and black start services credits and charges	150	Table 4-18 Energy uplift credits by unit type: January through March 2014 and 2015
Table 4-3 Total energy uplift charges: January through March 2014 and 2015	150	Table 4-19 Energy uplift credits by unit type: January through March 2015
Table 4-4 Energy uplift charges by category: January through March 2014 and 2015	151	Table 4-20 Top 10 units and organizations energy uplift credits: January through March 2015
Table 4-5 Monthly energy uplift charges: 2014 and January through March 2015	151	Table 4-21 Identification of balancing operating reserve credits received by the top 10 units by category and region: January through March 2015
Table 4-6 Day-ahead operating reserve charges: January through March 2014 and 2015	152	Table 4-22 Daily energy uplift credits HHI: January through March 2015
Table 4-7 Balancing operating reserve charges: January through March 2014 and 2015	152	Table 4-23 Day-ahead and real-time generation (GWh): January through March 2015
Table 4-8 Balancing operating reserve deviation charges: January through March 2014 and 2015	152	Table 4-24 Day-ahead and real-time economic and noneconomic generation from units eligible for operating reserve credits (GWh): January through March 2015
Table 4-9 Additional energy uplift charges: January through March 2014 and 2015	153	Table 4-25 Day-ahead and real-time generation receiving operating reserve credits (GWh): January through March 2015
Table 4-10 Regional balancing charges allocation (Millions): January through March 2014	153	Table 4-26 Day-ahead generation scheduled as must run by PJM (GWh): 2014 and January through March 2015
Table 4-11 Regional balancing charges allocation (Millions): January through March 2015	153	Table 4-27 Day-ahead generation scheduled as must run by PJM by category (GWh): January through March 2015
Table 4-12 Operating reserve rates (\$/MWh): January through March 2014 and 2015	156	Table 4-28 Geography of regional charges and credits: January through March 2015
Table 4-13 Operating reserve rates statistics (\$/MWh): January through March 2015	156	Table 4-29 Geography of reactive services charges: January through March 2015
Table 4-14 Local voltage support rates: January through March 2014 and 2015	157	Table 4-30 Monthly lost opportunity cost credits (Millions): 2014 and January through March 2015
Table 4-15 Balancing operating reserve determinants (MWh): January through March 2014 and 2015	158	Table 4-31 Day-ahead generation from combustion turbines and diesels (GWh): 2014 and January through March 2015
Table 4-16 Deviations by transaction type: January through March 2015	158	Table 4-32 Lost opportunity cost credits paid to combustion turbines and diesels by scenario (Millions): 2014 and January through March 2015

Table 4-33 Day-ahead generation (GWh) from combustion turbines and diesels receiving lost opportunity cost credits by value: 2014 and January through March 2015	169	Table 5-13 RPM revenue by calendar year: 2007 through 2018	201
Table 4-34 PJM Closed Loop Interfaces	170	Table 5-14 RPM cost to load: 2014/2015 through 2017/2018 RPM Auctions	202
Table 4-35 Impact on energy market lost opportunity cost credits of rule changes (Millions): January through March 2015	174	Table 5-15 PJM capacity factor (By unit type (GWh)): January through March of 2014 and 2015	203
Table 4-36 Current energy uplift allocation	178	Table 5-16 EAF by unit type: 2007 through 2015	205
Table 4-37 MMU energy uplift allocation proposal	178	Table 5-17 EMOF by unit type: 2007 through 2015	205
Table 4-38 Current and proposed energy uplift charges by allocation (Millions): 2014 and January through March 2015	179	Table 5-18 EPOF by unit type: 2007 through 2015	205
Table 4-39 Current and proposed average energy uplift rate by transaction: 2014 and January through March 2015	180	Table 5-19 EFOF by unit type: 2007 through 2015	205
SECTION 5 Capacity Market	185	Table 5-20 PJM EFORd data for different unit types: 2007 through 2015	206
Table 5-1 The Capacity Market results were competitive	185	Table 5-21 OMC Outages	208
Table 5-2 RPM related MMU reports, 2014 through 2015	190	Table 5-22 Contribution to EFOF by unit type by cause: 2015	211
Table 5-3 PJM installed capacity (By fuel source): January 1, January 31, February 28, and March 31, 2015	191	Table 5-23 Contributions to Economic Outages: 2015	212
Table 5-4 Generation capacity changes: 2007/2008 through 2013/2014	193	Table 5-24 PJM EFORd, XEFORd and EFORp data by unit type	212
Table 5-5 RSI results: 2014/2015 through 2017/2018 RPM Auctions	194	SECTION 6 Demand Response	213
Table 5-6 RPM imports: 2007/2008 through 2017/2018 RPM Base Residual Auctions	196	Table 6-1 Overview of demand response programs	217
Table 5-7 RPM load management statistics by LDA: June 1, 2013 to June 1, 2017	197	Table 6-2 Economic program registrations on the last day of the month: January 2010 through March 2015	219
Table 5-8 RPM load management cleared capacity and ILR: 2007/2008 through 2017/2018	198	Table 6-3 Maximum economic MW dispatched by registration per month: 2010 through March 2015	220
Table 5-9 RPM load management statistics: June 1, 2007 to June 1, 2017	198	Table 6-4 Credits paid to the PJM economic program participants: January through March 2010 through 2015	220
Table 5-10 ACR statistics: 2015/2016 RPM Auctions	199	Table 6-5 PJM economic program participation by zone: January through March of 2014 and 2015	221
Table 5-11 Capacity prices: 2007/2008 through 2017/2018 RPM Auctions	200	Table 6-6 Settlements submitted by year in the economic program: January through March of 2009 through 2015	221
Table 5-12 RPM revenue by type: 2007/2008 through 2017/2018	201	Table 6-7 Participants and CSPs submitting settlements in the economic program by year: January through March of 2009 through 2015	222
		Table 6-8 HHI and market concentration in the economic program: January through March of 2014 and 2015	222

Table 6-9 Hourly frequency distribution of economic program MWh reductions and credits: January through March 2014 and 2015	222
Table 6-10 Frequency distribution of economic program zonal, load-weighted, average LMP (By hours): 2014 and 2015	223
Table 6-11 Result from net benefits tests: April 2012 through March 2015	223
Table 6-12 Hours with price higher than NBT and DR occurrences in those hours: January through March 2014 and 2015	223
Table 6-13 Zonal DR charge: January through March 2015	224
Table 6-14 Monthly day-ahead and real-time DR charge: January through March 2014 and 2015	224
Table 6-15 Zonal monthly capacity revenue: January through March 2015	225
Table 6-16 Energy efficiency resources by MW: 2012/2013 through 2014/2015 Delivery Year	225
Table 6-17 Lead time by product type: 2014/2015 Delivery Year	225
Table 6-18 Reduction MW by each demand response method: 2014/2015 Delivery Year	226
Table 6-19 On-site generation fuel type by MW: 2014/2015 Delivery Year	226
Table 6-20 Demand response cleared MW UCAP for PJM: 2011/2012 through 2014/2015 Delivery Year	226
Table 6-21 Distribution of registrations and associated MW in the emergency full option across ranges of minimum dispatch prices: 2014/2015 Delivery Year	228
SECTION 7 Net Revenue	229
Table 7-1 Average operating costs	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 (lbs/MWh)	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	248
Table 8-6 Additional renewable standards of PJM jurisdictions 2015 to 2028	249
Table 8-7 Pennsylvania weighted average AEC price per MWh and AEC price per MWh for 2010 to 2014 Delivery Years	249
Table 8-8 Renewable alternative compliance payments in PJM jurisdictions: As of March 31, 2015	250
Table 8-9 Renewable resource generation by jurisdiction and renewable resource type (GWh): January through March 2015	250
Table 8-10 PJM renewable capacity by jurisdiction (MW), on March 31, 2015	251

Table 8-11 Renewable capacity by jurisdiction, non-PJM units registered in GATS (MW), on March 31, 2015	251	Table 9-9 Day-Ahead scheduled gross export volume by interface (GWh): January through March, 2015	268
Table 8-12 SO ₂ emission controls (FGD) by fuel type (MW), as of March 31, 2015	252	Table 9-10 Day-ahead scheduled net interchange volume by interface pricing point (GWh): January through March, 2015	269
Table 8-13 NO _x emission controls by fuel type (MW), as of March 31, 2015	252	Table 9-11 Up-to congestion scheduled net interchange volume by interface pricing point (GWh): January through March, 2015	270
Table 8-14 Particulate emission controls by fuel type (MW), as of March 31, 2015	253	Table 9-12 Day-ahead scheduled gross import volume by interface pricing point (GWh): January through March, 2015	270
Table 8-15 CO ₂ , SO ₂ and NO _x emissions by month (short tons), by PJM units: January 2012 through March 2015	253	Table 9-13 Up-to congestion scheduled gross import volume by interface pricing point (GWh): January through March, 2015	271
Table 8-16 Capacity factor of wind units in PJM: January through March 2015	254	Table 9-14 Day-ahead scheduled gross export volume by interface pricing point (GWh): January through March, 2015	271
Table 8-17 Capacity factor of wind units in PJM by month, January 2014 through March 2015	255	Table 9-15 Up-to congestion scheduled gross export volume by interface pricing point (GWh): January through March, 2015	272
SECTION 9 Interchange Transactions	257	Table 9-16 Active interfaces: January through March, 2015	272
Table 9-1 Real-time scheduled net interchange volume by interface (GWh): January through March, 2015	262	Table 9-17 Active pricing points: January through March, 2015	273
Table 9-2 Real-time scheduled gross import volume by interface (GWh): January through March, 2015	263	Table 9-18 Net scheduled and actual PJM flows by interface (GWh): January through March, 2015	274
Table 9-3 Real-time scheduled gross export volume by interface (GWh): January through March, 2015	263	Table 9-19 Net scheduled and actual PJM flows by interface pricing point (GWh): January through March, 2015	275
Table 9-4 Real-time scheduled net interchange volume by interface pricing point (GWh): January through March, 2015	265	Table 9-20 Net scheduled and actual PJM flows by interface pricing point (GWh) (Adjusted for IMO Scheduled Interfaces): January through March, 2015	275
Table 9-5 Real-time scheduled gross import volume by interface pricing point (GWh): January through March, 2015	265	Table 9-21 Net scheduled and actual PJM flows by interface and interface pricing point (GWh): January through March, 2015	277
Table 9-6 Real-time scheduled gross export volume by interface pricing point (GWh): January through March, 2015	266	Table 9-22 Net scheduled and actual PJM flows by interface pricing point and interface (GWh): January through March, 2015	278
Table 9-7 Day-Ahead scheduled net interchange volume by interface (GWh): January through March, 2015	267	Table 9-23 PJM and MISO flow based hours and average hourly price differences: January through March, 2015	280
Table 9-8 Day-Ahead scheduled gross import volume by interface (GWh): January through March, 2015	267	Table 9-24 Distribution of hourly flows that are consistent and inconsistent with price differences between PJM and MISO: January through March, 2015	281
		Table 9-25 PJM and NYISO flow based hours and average hourly price differences: January through March, 2015	281

Table 9-26 Distribution of hourly flows that are consistent and inconsistent with price differences between PJM and NYISO: January through March, 2015	282	Table 9-43 Monthly uncollected congestion charges: January 2010 through March 2015	304
Table 9-27 PJM and NYISO flow based hours and average hourly price differences (Neptune): January through March, 2015	283	SECTION 10 Ancillary Service Markets	309
Table 9-28 Percentage of Neptune transmission usage by primary rights holder: July, 2007, through March, 2015	284	Table 10-1 The Regulation Market results were competitive	309
Table 9-29 PJM and NYISO flow based hours and average hourly price differences (Linden): January through March, 2015	285	Table 10-2 The Tier 2 Synchronized Reserve Market results were competitive	309
Table 9-30 Percentage of Linden transmission usage by primary rights holder: November, 2009, through March, 2015	285	Table 10-3 The Day-Ahead Scheduling Reserve Market results were competitive	310
Table 9-31 PJM and NYISO flow based hours and average hourly price differences (Hudson): January through March, 2015	286	Table 10-4 History of ancillary services costs per MWh of Load: January through March, 2004 through 2015	315
Table 9-32 Percentage of Hudson transmission usage by primary rights holder: May 2013, through March 2015	287	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 March 2015	318
Table 9-33 Summary of elements included in operating agreements with bordering areas	288	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 March 2015	318
Table 9-34 Real-time average hourly LMP comparison for Duke, PEC and NCMPA: January through March, 2015	294	Table 10-7 MW credited, price, cost, and all-in price for primary reserve and its component products, full RTO Reserve Zone, 2015	321
Table 9-35 Day-ahead average hourly LMP comparison for Duke, PEC and NCMPA: January through March, 2015	294	Table 10-8 Monthly average market solution Tier 1 Synchronized Reserve (MW) identified hourly, January through March 2015	322
Table 9-36 PJM MISO, and NYISO TLR procedures: January 2012 through March 2015	295	Table 10-9 Weighted price of tier 1 synchronized reserve attributable to a non-synchronized reserve price above zero: January 2014 to March 2015	323
Table 9-37 Number of TLRs by TLR level by reliability coordinator: January through March, 2015	296	Table 10-10 Dollar impact of paying Tier 1 Synchronized Reserve the SRMCP when the NSRMCP goes above \$0: January 2014 through March 2015	324
Table 9-38 Monthly volume of cleared and submitted up-to congestion bids: January 2010, through March 2015	297	Table 10-11 Tier 1 compensation as currently implemented by PJM	324
Table 9-39 ITSCED/real-time LMP - PJM/NYIS interface price comparison (all intervals): January through March, 2015	300	Table 10-12 Tier 1 compensation as recommended by MMU	324
Table 9-40 ITSCED/real-time LMP - PJM/NYIS interface price comparison (by interval): January through March, 2015	300	Table 10-13 Actual payments made to tier 1 resources compared with correct tier 1 payments: October 2012 through December 2014	325
Table 9-41 ITSCED/real-time LMP - PJM/MISO interface price comparison (all intervals): January through March, 2015	302	Table 10-14 MAD subzone ASO tier 1 estimate biasing, January 2014 through March, 2015	326
Table 9-42 ITSCED/real-time LMP - PJM/MISO interface price comparison (by interval): January through March, 2015	303		

Table 10-15 Tier 1 synchronized reserve event response costs: January 2014 through March 2015	327	Table 10-32 Regulation market monthly three pivotal supplier results: 2013 through 2015	353
Table 10-16 Default Tier 2 Synchronized Reserve Markets required MW, RTO Zone and Mid-Atlantic Dominion Subzone	329	Table 10-33 RegD self scheduled regulation by month, October 2012 through March 2015	354
Table 10-17 Three Pivotal Supplier Test Results for the RTO Zone and MAD Subzone: January 2014 through March 2015	331	Table 10-34 Regulation sources: spot market, self-scheduled, bilateral purchases: 2014 and 2015	355
Table 10-18 Mid-Atlantic Dominion Subzone, weighted SRMCP and cleared MW (excludes self-scheduled): January through March 2015	333	Table 10-35 Regulation sources by year: 2011 through 2015	355
Table 10-19 RTO zone weighted SRMCP and cleared MW (excludes self-scheduled): January through March 2015	333	Table 10-36 PJM Regulation Market monthly weighted average market-clearing price, marginal unit opportunity cost and offer price (Dollars per MW): 2015	356
Table 10-20 Full RTO, RTO, Mid-Atlantic Subzone Tier 2 synchronized reserve MW, credits, price, and cost: January through March 2015	334	Table 10-37 Total regulation charges: 2014 and 2015	356
Table 10-21 Synchronized reserve events greater than 10 minutes, Tier 2 Response Compliance, RTO Reserve Zone: January through March 2015	335	Table 10-38 Components of regulation cost: 2015	357
Table 10-22 Synchronized reserve events, January 2010 through March 2015	336	Table 10-39 Comparison of monthly average RegA and RegD RMCP credits per effective MW: October 2012 through March 2015	358
Table 10-23 Non-synchronized reserve market HHIs: January through March 2015	338	Table 10-40 Comparison of monthly average RegA and RegD RMCP credits: October 2012 through March 2015	359
Table 10-24 Non-synchronized reserve market pivotal supply test: January through March 2015	338	Table 10-41 Comparison of average price and cost for PJM Regulation, January through March, 2009 through 2015	360
Table 10-25 Full RTO, RTO, Mid-Atlantic Subzone non-synchronized reserve MW, credits, price, and cost: January through March 2015	339	Table 10-42 Black start revenue requirement charges: 2010 through 2015	361
Table 10-26 PJM Day-Ahead Scheduling Reserve Market MW and clearing prices: 2012 through March 2015	341	Table 10-43 Black start zonal charges for network transmission use: 2014 and 2015	361
Table 10-27 PJM regulation capability, daily offer and hourly eligible: 2015	348	Table 10-44 Black start zonal revenue requirement estimate: 2015/2016 through 2017/2018 delivery years	362
Table 10-28 PJM regulation provided by coal units	349	Table 10-45 NERC CIP Costs: 2015	362
Table 10-29 Impact on PJM Regulation Market of currently regulating units scheduled to retire through 2015	349	Table 10-46 Reactive zonal charges for network transmission use: January through March, 2014 and 2015	363
Table 10-30 PJM Regulation Market required MW and ratio of eligible supply to requirement: January through March 2014 and 2015	351	SECTION 11 Congestion and Marginal Losses	365
Table 10-31 PJM cleared regulation HHI: 2014 and 2015	352	Table 11-1 PJM real-time, load-weighted average LMP components (Dollars per MWh): January through March of 2009 through 2015	368
		Table 11-2 PJM day-ahead, load-weighted average LMP components (Dollars per MWh): January through March of 2009 through 2015	369

Table 11-3 Zonal and PJM real-time, load-weighted average LMP components (Dollars per MWh): January through March of 2014 and 2015	369	Table 11-18 Congestion event hours (Real-Time against Day-Ahead): January through March of 2014 and 2015	377
Table 11-4 Zonal and PJM day-ahead, load-weighted average LMP components (Dollars per MWh): January through March of 2014 and 2015	370	Table 11-19 Congestion summary (By facility voltage): January through March of 2015	378
Table 11-5 Hub real-time, load-weighted average LMP components (Dollars per MWh): January through March of 2014 and 2015	370	Table 11-20 Congestion summary (By facility voltage): January through March of 2014	378
Table 11-6 Hub day-ahead, load-weighted average LMP components (Dollars per MWh): January through March of 2014 and 2015	371	Table 11-21 Top 25 constraints with frequent occurrence: January through March of 2014 and 2015	379
Table 11-7 Total PJM costs by component (Dollars (Millions)): January through March of 2009 through 2015	371	Table 11-22 Top 25 constraints with largest year-to-year change in occurrence: January through March of 2014 and 2015	380
Table 11-8 Total PJM congestion (Dollars (Millions)): January through March of 2008 through 2015	372	Table 11-23 Top 25 constraints affecting PJM congestion costs (By facility): January through March of 2015	381
Table 11-9 Total PJM congestion costs by accounting category by market (Dollars (Millions)): January through March of 2008 through 2015	372	Table 11-24 Top 25 constraints affecting PJM congestion costs (By facility): January through March of 2014	382
Table 11-10 Total PJM congestion costs by transaction type by market (Dollars (Millions)): January through March of 2015	373	Table 11-25 Top 20 congestion cost impacts from MISO flowgates affecting PJM dispatch (By facility): January through March of 2015	384
Table 11-11 Total PJM congestion costs by transaction type by market (Dollars (Millions)): January through March of 2014	373	Table 11-26 Top 20 congestion cost impacts from MISO flowgates affecting PJM dispatch (By facility): January through March of 2014	385
Table 11-12 Monthly PJM congestion costs by market (Dollars (Millions)): January through March of 2014 and 2015	374	Table 11-27 Top two congestion cost impacts from NYISO flowgates affecting PJM dispatch (By facility): January through March of 2015	386
Table 11-13 Monthly PJM congestion costs by virtual transaction type and by market (Dollars (Millions)): January through March of 2015	375	Table 11-28 Top two congestion cost impacts from NYISO flowgates affecting PJM dispatch (By facility): January through March of 2014	386
Table 11-14 Monthly PJM congestion costs by virtual transaction type and by market (Dollars (Millions)): January through March of 2014	375	Table 11-29 Regional constraints summary (By facility): January through March of 2015	386
Table 11-15 Congestion summary (By facility type): January through March of 2015	376	Table 11-30 Regional constraints summary (By facility): January through March of 2014	387
Table 11-16 Congestion summary (By facility type): January through March of 2014	376	Table 11-31 Congestion cost by type of participant: January through March of 2015	387
Table 11-17 Congestion event hours (Day-Ahead against Real-Time): January through March of 2014 and 2015	377	Table 11-32 Congestion cost by type of participant: January through March of 2014	388

Table 11-33 Total marginal loss component costs (Dollars (Millions)): January through March of 2009 through 2015	389	Table 12-8 Retirements by fuel type, 2011 through 2019	403
Table 11-34 Total PJM marginal loss costs by accounting category (Dollars (Millions)): January through March of 2009 through 2015	390	Table 12-9 Unit deactivations in 2015	403
Table 11-35 Total PJM marginal loss costs by accounting category by market (Dollars (Millions)): January through March of 2009 through 2015	390	Table 12-10 Existing PJM capacity: At March 31, 2015 (By zone and unit type (MW))	404
Table 11-36 Monthly marginal loss costs by market (Dollars (Millions)): January through March of 2014 and 2015	390	Table 12-11 PJM capacity (MW) by age (years): at March 31, 2015	404
Table 11-37 Marginal loss credits (Dollars (Millions)): January through March of 2009 through 2015	391	Table 12-12 Expected capacity in five years, as of March 31, 2015	405
Table 11-38 Total PJM costs by energy component (Dollars (Millions)): January through March of 2009 through 2015	392	Table 12-13 PJM generation planning process	406
Table 11-39 Total PJM energy costs by accounting category (Dollars (Millions)): January through March of 2009 through 2015	392	Table 12-14 Last milestone completed at time of withdrawal (January 1, 1997 through March 31, 2015)	407
Table 11-40 Total PJM energy costs by market category (Dollars (Millions)): January through March of 2009 through 2015	393	Table 12-15 Average project queue times (days) at March 31, 2015	407
Table 11-41 Monthly energy costs by market type (Dollars (Millions)): January through March of 2014 and 2015	393	Table 12-16 PJM generation planning summary: at March 31, 2015	407
SECTION 12 Generation and Transmission Planning	395	Table 12-17 Summary of project developer relationship to transmission owner	408
Table 12-1 Year-to-year capacity additions from PJM generation queue: Calendar years 2000 through 2015	398	Table 12-18 Developer-transmission owner relationship by fuel type	409
Table 12-2 Queue comparison by expected completion year (MW): December 31, 2014 vs. March 31, 2015	398	Table 12-19 Transmission facility outage request duration: January through March of 2014 and 2015	411
Table 12-3 Change in project status (MW): December 31, 2014 vs. March 31, 2015	399	Table 12-20 PJM transmission facility request status definition	411
Table 12-4 Capacity in PJM queues (MW): At March 31, 2015	399	Table 12-21 Transmission outage requests with on time status: January through March of 2014 and 2015	411
Table 12-5 Queue capacity by control zone and LDA (MW) at March 31, 2015	400	Table 12-22 Emergency transmission outage summary: January through March of 2014 and 2015	411
Table 12-6 Summary of PJM unit retirements by fuel (MW): 2011 through 2019	401	Table 12-23 Transmission facility outage ticket congestion status summary: January through March of 2014 and 2015	412
Table 12-7 Planned deactivations of PJM units, as of March 31, 2015	403	Table 12-24 Rescheduled transmission outage request summary: January through March of 2014 and 2015	412
		SECTION 13 Financial Transmission and Auction Revenue Rights	413
		Table 13-1 The FTR Auction Markets results were competitive	413
		Table 13-2 Monthly Balance of Planning Period FTR Auction patterns of ownership by FTR direction: 2015	421
		Table 13-3 Daily FTR net position ownership by FTR direction: 2015	421

Table 13-4 Comparison of self-scheduled FTRs: Planning periods 2009 to 2010 through 2014 to 2015	425	Table 13-22 Historic Stage 1B and Stage 2 ARR Allocations from the 2011 to 2012 through 2014 to 2015 planning periods	444
Table 13-5 Monthly Balance of Planning Period FTR Auction market volume: 2015	426	Table 13-23 Top 10 principal binding transmission constraints limiting the Annual ARR Allocation: Planning period 2014 to 2015	444
Table 13-6 Monthly Balance of Planning Period FTR Auction buy-bid, bid and cleared volume (MW per period): 2015	426	Table 13-24 ARRs and ARR revenue automatically reassigned for network load changes by control zone: June 1, 2013, through March 31, 2014	445
Table 13-7 Secondary bilateral FTR market volume: Planning periods 2013 to 2014 and 2014 to 2015	427	Table 13-25 Residual ARR allocation volume and target allocation: January through March 2015	446
Table 13-8 Monthly Balance of Planning Period FTR Auction cleared, weighted-average, buy-bid price per period (Dollars per MW): January through March 2015	429	Table 13-26 Annual ARR Allocation volume: planning periods 2013 to 2014 and 2014 to 2015	446
Table 13-9 FTR profits by organization type and FTR direction: 2015	429	Table 13-27 Constraints with capacity increases due to Stage 1A infeasibility for the 2014 to 2015 ARR Allocation	447
Table 13-10 Monthly FTR profits by organization type: 2015	429	Table 13-28 Projected ARR revenue adequacy (Dollars (Millions)): Planning periods 2013 to 2014 and 2014 to 2015	448
Table 13-11 Monthly Balance of Planning Period FTR Auction revenue: 2015	430	Table 13-29 ARR and self-scheduled FTR congestion offset (in millions): Planning periods 2013 to 2014 and 2014 to 2015	450
Table 13-12 Total annual PJM FTR revenue detail (Dollars (Millions)): Planning periods 2013 to 2014 and 2014 to 2015	433	Table 13-30 ARR and FTR congestion offset (in millions): Planning periods 2013 to 2014 and 2014 to 2015	451
Table 13-13 Unallocated congestion charges: Planning period 2012 to 2013 through 2014 to 2015	433		
Table 13-14 Monthly FTR accounting summary (Dollars (Millions)): Planning period 2013 to 2014 and 2014 to 2015	434		
Table 13-15 PJM reported FTR payout ratio by planning period	435		
Table 13-16 End of planning period FTR uplift charge example	436		
Table 13-17 PJM Reported and Actual Monthly Payout Ratios: Planning period 2014 to 2015	436		
Table 13-18 Example of FTR payouts from portfolio netting and without portfolio netting	438		
Table 13-19 Monthly positive and negative target allocations and payout ratios with and without hourly netting: Planning period 2013 to 2014 and 2014 to 2015	438		
Table 13-20 Example implementation of counter flow adjustment method	439		
Table 13-21 Counter flow FTR payout ratio adjustment impacts: Planning period 2013 to 2014 and 2014 to 2015	440		