

# Table of Contents

<b>Preface</b>	<b>i</b>		
<b>SECTION 1 Introduction</b>	<b>1</b>		
2019 Q3 in Review	1		
PJM Market Summary Statistics	4		
PJM Market Background	4		
Conclusions	6		
Energy Market Conclusion	6		
Capacity Market Conclusion	8		
Tier 2 Synchronized Reserve Market Conclusion	9		
Day-Ahead Scheduling Reserve Market Conclusion	9		
Regulation Market Conclusion	10		
FTR Auction Market Conclusion	10		
Role of MMU	11		
Reporting	11		
Monitoring	11		
Market Design	12		
New Recommendations	12		
New Recommendations from Section 3, Energy Market	13		
New Recommendation from Section 10, Ancillary Services	13		
New Recommendation from Section 11, Congestion and Marginal Losses	13		
New Recommendation from Section 12, Generation and Transmission Planning	13		
Total Price of Wholesale Power	13		
Components of Total Price	14		
Section Overviews	21		
Overview: Section 3, Energy Market	21		
Overview: Section 4, Energy Uplift	31		
Overview: Section 5, Capacity Market	35		
Overview: Section 6, Demand Response	43		
Overview: Section 7, Net Revenue	49		
		Overview: Section 8, Environmental and Renewables	50
		Overview: Section 9, Interchange Transactions	53
		Overview: Section 10, Ancillary Services	56
		Overview: Section 11, Congestion and Marginal Losses	65
		Overview: Section 12, Planning	67
		Overview: Section 13, FTRs and ARRs	74
		<b>SECTION 2 Recommendations</b>	<b>81</b>
		New Recommendations	81
		New Recommendations from Section 3, Energy Market	82
		New Recommendation from Section 10, Ancillary Services	82
		New Recommendation from Section 11, Congestion and Marginal Losses	82
		New Recommendation from Section 12, Generation and Transmission Planning	82
		Complete List of Current MMU Recommendations	82
		Section 3, Energy Market	82
		Section 4, Energy Uplift	85
		Section 5, Capacity Market	87
		Section 6, Demand Response	90
		Section 7, Net Revenue	92
		Section 8, Environmental	92
		Section 9, Interchange Transactions	92
		Section 10, Ancillary Services	94
		Section 11, Congestion and Marginal Losses	95
		Section 12, Planning	96
		Section 13, FTRs and ARRs	98
		<b>SECTION 3 Energy Market</b>	<b>101</b>
		Overview	102
		Supply and Demand	102
		Competitive Assessment	104

Recommendations	106	Types of Units	237
Conclusion	109	Day-Ahead Unit Commitment for Reliability	238
Supply and Demand	112	Balancing Operating Reserve Credits	239
Market Structure	112	Lost Opportunity Cost Credits	241
Market Behavior	128	Uplift Eligibility	242
Generator Offers	128	Economic and Noneconomic Generation	243
Hourly Offers and Intraday Offer Updates	130	Concentration of Energy Uplift Credits	244
Parameter Limited Schedules	131	Credits and Charges Categories	246
Virtual Offers and Bids	135	Energy Uplift Results	248
Market Performance	149	Energy Uplift Charges	248
LMP	149	Operating Reserve Rates	251
Zonal LMP and Dispatch	167	Reactive Services Rates	253
Fuel Prices, LMP, and Dispatch	169	Balancing Operating Reserve Determinants	254
Components of LMP	178	Geography of Charges and Credits	255
Scarcity	182	Energy Uplift Issues	256
Emergency Procedures	184	Intraday Segments Uplift Settlement	256
PAIs and Capacity Performance	186		
Scarcity and Scarcity Pricing	186		
PJM Cold Weather Operations 2019	193		
Competitive Assessment	194	<b>SECTION 5 Capacity Market</b>	<b>259</b>
Market Structure	194	Overview	260
Market Behavior	200	RPM Capacity Market	260
Market Performance	219	Reliability Must Run Service	262
		Generator Performance	262
		Recommendations	262
		Conclusion	265
<b>SECTION 4 Energy Uplift (Operating Reserves)</b>	<b>231</b>	Installed Capacity	269
Overview	231	Fuel Diversity	270
Energy Uplift Credits	231	RPM Capacity Market	271
Energy Uplift Charges	232	Market Structure	271
Geography of Charges and Credits	232	Market Conduct	283
Recommendations	232	Market Performance	285
Conclusion	234	Reliability Must Run (RMR) Service	293
Energy Uplift Results	236	Generator Performance	294
Characteristics of Credits	237	Capacity Factor	294

Generator Performance Factors	295		
Generator Forced Outage Rates	297		
<b>SECTION 6 Demand Response</b>	<b>301</b>	<b>SECTION 8 Environmental and Renewable Energy Regulations</b>	<b>351</b>
Overview	301	Overview	351
Recommendations	302	Federal Environmental Regulation	351
Conclusion	04	State Environmental Regulation	352
PJM Demand Response Programs	306	State Renewable Portfolio Standards	352
Non-PJM Demand Response Programs	307	Emissions Controls in PJM Markets	352
Participation in Demand Response Programs	307	Renewable Generation	352
Economic Program	308	Recommendations	353
Emergency and Pre-Emergency Programs	318	Conclusion	353
Distributed Energy Resources	331	Federal Environmental Regulation	355
<b>SECTION 7 Net Revenue</b>	<b>333</b>	CAA: NESHAP/MATS	355
Overview	333	CAA: NAAQS/CSAPR	355
Net Revenue	333	CAA: NSR	356
Historical New Entrant CT and CC Revenue Adequacy	333	CAA: RICE	357
Conclusion	333	CAA: Greenhouse Gas Emissions	357
Net Revenue	334	CWA: WOTUS Definition and Effluents	358
Spark Spreads, Dark Spreads, and Quark Spreads	335	RCRA: Coal Ash	360
Theoretical Energy Market Net Revenue	337	State Environmental Regulation	361
New Entrant Combustion Turbine	339	State Regulation of Greenhouse Gas Emissions	361
New Entrant Combined Cycle	340	State Renewable Portfolio Standards	366
New Entrant Coal Plant	340	Carbon Pricing	382
New Entrant Nuclear Plant	341	Alternative Compliance Payments	383
New Entrant Diesel	341	Emission Controlled Capacity and Emissions	387
New Entrant On Shore Wind Installation	342	Emission Controlled Capacity	387
New Entrant Off Shore Wind Installation	342	Emissions	388
New Entrant Solar Installation	342	Renewable Energy Output	391
Historical New Entrant CT and CC Revenue Adequacy	342	Wind and Solar Peak Hour Output	391
Nuclear Net Revenue Analysis	344	Wind Units	391
		Solar Units	394

<b>SECTION 9 Interchange Transactions</b>	<b>397</b>	<b>Interchange Transaction Issues</b>	<b>444</b>
Overview	397	Requests to Convert Firm to NonFirm Transmission Withdrawal Rights	444
Interchange Transaction Activity	397	PJM Transmission Loading Relief Procedures (TLRs) Up To Congestion	445
Interactions with Bordering Areas	398	Sham Scheduling	447
Recommendations	398	Elimination of Ontario Interface Pricing Point	450
Conclusion	400	PJM and NYISO Coordinated Interchange Transactions	451
Interchange Transaction Activity	400	Reserving Ramp on the PJM/NYISO Interface	456
Charges and Credits Applied to Interchange Transactions	400	PJM and MISO Coordinated Interchange Transaction Proposal	456
Aggregate Imports and Exports	401	Willing to Pay Congestion and Not Willing to Pay Congestion	460
Real-Time Interface Imports and Exports	403	Spot Imports	461
Real-Time Interface Pricing Point Imports and Exports	405	Interchange Optimization	462
Day-Ahead Interface Imports and Exports	408	Interchange Cap During Emergency Conditions	462
Day-Ahead Interface Pricing Point Imports and Exports	412	45 Minute Schedule Duration Rule	463
Loop Flows	420	MISO Multi-Value Project Usage Rate (MUR)	464
PJM and MISO Interface Prices	428		
PJM and NYISO Interface Prices	430		
Summary of Interface Prices between PJM and Organized Markets	432		
Neptune Underwater Transmission Line to Long Island, New York	432		
Linden Variable Frequency Transformer (VFT) facility	434		
Hudson Direct Current (DC) Merchant Transmission Line	436		
Interchange Activity During High Load Hours	437		
Operating Agreements with Bordering Areas	437		
PJM and MISO Joint Operating Agreement	438		
PJM and New York Independent System Operator Joint Operating Agreement (JOA)	440		
PJM and TVA Joint Reliability Coordination Agreement (JRCA)	441		
PJM and Duke Energy Progress, Inc. Joint Operating Agreement	442		
PJM and VACAR South Reliability Coordination Agreement	442		
Balancing Authority Operations Coordination Agreement between Wisconsin Electric Power Company (WEC) and PJM Interconnection, LLC	442		
Northeastern ISO-Regional Transmission Organization Planning Coordination Protocol	442		
Interface Pricing Agreements with Individual Balancing Authorities	442		
		<b>SECTION 10 Ancillary Service Markets</b>	<b>467</b>
		Overview	468
		Primary Reserve	468
		Tier 1 Synchronized Reserve	468
		Tier 2 Synchronized Reserve Market	469
		Nonsynchronized Reserve Market	470
		Secondary Reserve	470
		Regulation Market	471
		Black Start Service	473
		Reactive	473
		Frequency Response	473
		Ancillary Services Costs per MWh of Load: January through September, 1999 through 2019	474
		Recommendations	474
		Conclusion	476
		Primary Reserve	477

Market Structure	477	<b>SECTION 11 Congestion and Marginal Losses</b>	<b>541</b>
Price and Cost	482	Overview	542
<b>Tier 1 Synchronized Reserve</b>	<b>483</b>	Congestion Cost	542
Market Structure	483	Marginal Loss Cost	543
Tier 1 Synchronized Reserve Event Response	486	Energy Cost	543
<b>Tier 2 Synchronized Reserve Market</b>	<b>488</b>	Recommendations	543
Market Structure	489	Conclusion	543
Market Behavior	492	Issues	544
Market Performance	494	Closed Loop Interfaces and CT Pricing Logic	544
<b>Nonsynchronized Reserve Market</b>	<b>500</b>	Balancing Congestion Cost Calculation Logic Change	545
Market Structure	500	<b>Locational Marginal Price (LMP)</b>	<b>546</b>
<b>Secondary Reserve</b>	<b>503</b>	Components	546
Market Structure	503	Hub Components	550
Market Conduct	504	<b>Congestion</b>	<b>551</b>
Market Performance	505	Congestion Accounting	551
<b>Regulation Market</b>	<b>507</b>	Total Congestion	553
Market Design	508	<b>Congested Facilities</b>	<b>563</b>
Market Structure	518	Congestion by Facility Type and Voltage	563
Market Conduct	522	Constraint Duration	567
Market Performance	526	Constraint Costs	569
<b>Black Start Service</b>	<b>529</b>	Congestion Event Summary: Impact of Changes in UTC Volumes	572
NERC – CIP	532	<b>Marginal Losses</b>	<b>575</b>
Minimum Tank Suction Level (MTSL)	532	Marginal Loss Accounting	575
<b>Reactive Service</b>	<b>533</b>	Total Marginal Loss Cost	576
Recommended Market Approach to Reactive Costs	534	<b>Energy Costs</b>	<b>582</b>
Improvements to Current Approach	534	Energy Accounting	582
Reactive Costs	537	Total Energy Costs	582
<b>Frequency Response</b>	<b>538</b>		
Frequency Control Definition	538		

<b>SECTION 12 Generation and Transmission Planning</b>	<b>587</b>		
Overview	587		
Generation Interconnection Planning	587		
Regional Transmission Expansion Plan (RTEP)	588		
Transmission Facility Outages	589		
Recommendations	589		
Conclusion	591		
Generation Interconnection Planning	593		
Existing Generation Mix	593		
Generation Retirements	596		
Generation Queue	602		
Regional Transmission Expansion Plan (RTEP)	624		
RTEP Process	624		
Market Efficiency Process	624		
PJM MISO Targeted Market Efficiency Process (TMEP) and Interregional Market Efficiency Process (IMEP)	627		
Supplemental Transmission Projects	627		
Board Authorized Transmission Upgrades	632		
Qualifying Transmission Upgrades (QTU)	632		
Cost Allocation	633		
Transmission Facility Outages	633		
Scheduling Transmission Facility Outage Requests	633		
Rescheduling Transmission Facility Outage Requests	636		
Long Duration Transmission Facility Outage Requests	637		
Transmission Facility Outage Analysis for the FTR Market	638		
Transmission Facility Outage Analysis in the Day-Ahead Energy Market	644		
<b>SECTION 13 Financial Transmission and Auction Revenue Rights</b>	<b>647</b>		
Overview	649		
Auction Revenue Rights	649		
Financial Transmission Rights	650		
		Recommendations	651
		Conclusion	652
		<b>Auction Revenue Rights</b>	<b>655</b>
		Market Structure	657
		Market Performance	659
		<b>Financial Transmission Rights</b>	<b>660</b>
		Market Structure	661
		Market Performance	665
		<b>Revenue Adequacy</b>	<b>673</b>
		FTR Revenue Adequacy and Stage 1B/Stage 2 ARR Allocations	674
		Surplus Congestion Revenue	674
		ARR and FTR Revenue Adequacy	676
		FTR Uplift Charge	678
		Revenue Adequacy Issues and Solutions	678
		<b>ARRs as an Offset to Congestion for Load</b>	<b>679</b>
		FERC Order on FTRs: Balancing Congestion and M2M Payment Allocation	679
		Zonal ARR Congestion Offset	681
		<b>Credit</b>	<b>682</b>
		<b>FTR Forfeitures</b>	<b>682</b>
		Hourly FTR Cost	682
		FERC Order on FTR Forfeitures	683