

# Table of Contents

Preface	i	Overview: Section 10, Ancillary Services	55
SECTION 1 Introduction	1	Overview: Section 11, Congestion and Marginal Losses	64
2019 Q2 in Review	1	Overview: Section 12, Planning	66
PJM Market Summary Statistics	4	Overview: Section 13, FTRs and ARRs	73
PJM Market Background	4	SECTION 2 Recommendations	79
Conclusions	6	New Recommendations	79
Energy Market Conclusion	6	New Recommendation from Section 6, Demand Response	80
Capacity Market Conclusion	8	New Recommendation from Section 8, Environmental and Renewable Energy Regulations	80
Tier 2 Synchronized Reserve Market Conclusion	9	New Recommendation from Section 9, Interchange Transactions	80
Day-Ahead Scheduling Reserve Market Conclusion	9	Complete List of Current MMU Recommendations	80
Regulation Market Conclusion	10	Section 3, Energy Market	80
FTR Auction Market Conclusion	10	Section 4, Energy Uplift	83
Role of MMU	11	Section 5, Capacity Market	85
Reporting	11	Section 6, Demand Response	87
Monitoring	11	Section 7, Net Revenue	89
Market Design	12	Section 8, Environmental	89
New Recommendations	12	Section 9, Interchange Transactions	90
New Recommendation from Section 6, Demand Response	13	Section 10, Ancillary Services	91
New Recommendation from Section 8, Environmental and Renewable Energy Regulations	13	Section 11, Congestion and Marginal Losses	93
New Recommendation from Section 9, Interchange Transactions	13	Section 12, Planning	93
Total Price of Wholesale Power	13	Section 13, FTRs and ARRs	95
Components of Total Price	13	SECTION 3 Energy Market	97
Section Overviews	21	Overview	98
Overview: Section 3, Energy Market	21	Supply and Demand	98
Overview: Section 4, Energy Uplift	30	Competitive Assessment	100
Overview: Section 5, Capacity Market	35	Recommendations	102
Overview: Section 6, Demand Response	42	Conclusion	105
Overview: Section 7, Net Revenue	48	Supply and Demand	108
Overview: Section 8, Environmental and Renewables	49	Market Structure	108
Overview: Section 9, Interchange Transactions	52		

Market Behavior	124	Uplift Eligibility	232
Supply and Demand: Load and Spot Market	124	Economic and Noneconomic Generation	233
Hourly Offers and Intraday Offer Updates	125	Concentration of Energy Uplift Credits	234
Parameter Limited Schedules	126	Credits and Charges Categories	236
Virtual Offers and Bids	131	Energy Uplift Results	237
Market Performance	144	Energy Uplift Charges	237
LMP	144	Operating Reserve Rates	240
Zonal LMP and Dispatch	163	Reactive Services Rates	243
Fuel Prices, LMP, and Dispatch	166	Balancing Operating Reserve Determinants	244
Components of LMP	173	Geography of Charges and Credits	245
Scarcity	177	Energy Uplift Issues	246
Emergency Procedures	178	Intraday Segments Uplift Settlement	246
PAIs and Capacity Performance	179		
Scarcity and Scarcity Pricing	180		
PJM Cold Weather Operations 2019	184		
Competitive Assessment	184	<b>SECTION 5 Capacity Market</b>	<b>249</b>
Market Structure	184	Overview	250
Market Behavior	190	RPM Capacity Market	250
Market Performance	208	Reliability Must Run Service	252
		Generator Performance	252
		Recommendations	252
		Conclusion	254
<b>SECTION 4 Energy Uplift (Operating Reserves)</b>	<b>221</b>	Installed Capacity	259
Overview	221	Fuel Diversity	260
Energy Uplift Credits	221	RPM Capacity Market	261
Energy Uplift Charges	222	Market Structure	261
Geography of Charges and Credits	222	Market Conduct	270
Recommendations	222	Market Performance	272
Conclusion	224	Reliability Must Run (RMR) Service	281
Energy Uplift Results	226	Generator Performance	282
Characteristics of Credits	227	Capacity Factor	282
Types of Units	227	Generator Performance Factors	283
Day-Ahead Unit Commitment for Reliability	228	Generator Forced Outage Rates	284
Balancing Operating Reserve Credits	229		
Lost Opportunity Cost Credits	231		

<b>SECTION 6 Demand Response</b>	<b>287</b>	<b>SECTION 8 Environmental and Renewable Energy Regulations</b>	<b>337</b>
Overview	287	Overview	337
Recommendations	288	Federal Environmental Regulation	337
Conclusion	290	State Environmental Regulation	337
PJM Demand Response Programs	292	State Renewable Portfolio Standards	338
Non-PJM Demand Response Programs	293	Emissions Controls in PJM Markets	338
Participation in Demand Response Programs	294	Renewable Generation	338
Economic Program	295	Recommendations	338
Emergency and Pre-Emergency Programs	302	Conclusion	339
Distributed Energy Resources	316	Federal Environmental Regulation	340
<b>SECTION 7 Net Revenue</b>	<b>319</b>	MATS	341
Overview	319	CSAPR	341
Net Revenue	319	Federal Regulation of Greenhouse Gas Emissions	342
Historical New Entrant CT and CC Revenue Adequacy	319	Federal Regulation of Environmental Impacts on Water	344
Conclusion	319	Federal Regulation of Coal Ash	345
Net Revenue	320	State Environmental Regulation	346
Spark Spreads, Dark Spreads, and Quark Spreads	321	State Regulation of Greenhouse Gas Emissions	346
Theoretical Energy Market Net Revenue	323	State Renewable Portfolio Standards	351
New Entrant Combustion Turbine	325	Alternative Compliance Payments	366
New Entrant Combined Cycle	326	Emission Controlled Capacity and Emissions	369
New Entrant Coal Plant	326	Emission Controlled Capacity	369
New Entrant Nuclear Plant	327	Emissions	370
New Entrant Diesel	327	Renewable Energy Output	373
New Entrant On Shore Wind Installation	328	Wind and Solar Peak Hour Output	373
New Entrant Off Shore Wind Installation	328	Wind Units	373
New Entrant Solar Installation	328	Solar Units	376
Historical New Entrant CT and CC Revenue Adequacy	328	<b>SECTION 9 Interchange Transactions</b>	<b>379</b>
Nuclear Net Revenue Analysis	330	Overview	379
		Interchange Transaction Activity	379
		Interactions with Bordering Areas	379
		Recommendations	380

Conclusion	381	Sham Scheduling	427
<b>Interchange Transaction Activity</b>	<b>382</b>	Elimination of Ontario Interface Pricing Point	428
Charges and Credits Applied to Interchange Transactions	382	PJM and NYISO Coordinated Interchange Transactions	429
Aggregate Imports and Exports	383	Reserving Ramp on the PJM/NYISO Interface	433
Real-Time Interface Imports and Exports	385	PJM and MISO Coordinated Interchange Transaction Proposal	433
Real-Time Interface Pricing Point Imports and Exports	386	Willing to Pay Congestion and Not Willing to Pay Congestion	436
Day-Ahead Interface Imports and Exports	389	Spot Imports	437
Day-Ahead Interface Pricing Point Imports and Exports	392	Interchange Optimization	439
Loop Flows	398	Interchange Cap During Emergency Conditions	439
PJM and MISO Interface Prices	405	45 Minute Schedule Duration Rule	440
PJM and NYISO Interface Prices	407	MISO Multi-Value Project Usage Rate (MUR)	440
Summary of Interface Prices between PJM and Organized Markets	409		
Neptune Underwater Transmission Line to Long Island, New York	409		
Linden Variable Frequency Transformer (VFT) facility	411		
Hudson Direct Current (DC) Merchant Transmission Line	413		
Interchange Activity During High Load Hours	414		
<b>Operating Agreements with Bordering Areas</b>	<b>415</b>	<b>SECTION 10 Ancillary Service Markets</b>	<b>443</b>
PJM and MISO Joint Operating Agreement	415	Overview	444
PJM and New York Independent System Operator Joint Operating Agreement (JOA)	417	Primary Reserve	444
PJM and TVA Joint Reliability Coordination Agreement (JRCA)	418	Tier 1 Synchronized Reserve	444
PJM and Duke Energy Progress, Inc. Joint Operating Agreement	419	Tier 2 Synchronized Reserve Market	445
PJM and VACAR South Reliability Coordination Agreement	421	Nonsynchronized Reserve Market	446
Balancing Authority Operations Coordination Agreement between Wisconsin Electric Power Company (WEC) and PJM Interconnection, LLC	421	Secondary Reserve	446
Northeastern ISO-Regional Transmission Organization Planning Coordination Protocol	421	Regulation Market	447
Interface Pricing Agreements with Individual Balancing Authorities	421	Black Start Service	449
<b>Interchange Transaction Issues</b>	<b>422</b>	Reactive	449
Hudson Transmission Partners (HTP) and Linden VFT Requests to Convert Firm Transmission Withdrawal Rights (FTWR) to NonFirm Transmission Withdrawal Rights (NFTWR)	422	Frequency Response	449
PJM Transmission Loading Relief Procedures (TLRs)	424	Ancillary Services Costs per MWh of Load: January through June, 1999 through 2019	450
Up To Congestion	425	Recommendations	450
		Conclusion	452
		<b>Primary Reserve</b>	<b>453</b>
		Market Structure	453
		Price and Cost	458
		<b>Tier 1 Synchronized Reserve</b>	<b>459</b>
		Market Structure	459
		Tier 1 Synchronized Reserve Event Response	461

Tier 2 Synchronized Reserve Market	464	Balancing Congestion Cost Calculation Logic Change	517
Market Structure	464	Locational Marginal Price (LMP)	518
Market Behavior	468	Components	518
Market Performance	469	Hub Components	522
Nonsynchronized Reserve Market	476	Congestion	523
Market Structure	476	Congestion Accounting	523
Secondary Reserve	479	Total Congestion	525
Market Structure	479	Congested Facilities	534
Market Conduct	481	Congestion by Facility Type and Voltage	534
Market Performance	481	Constraint Duration	538
Regulation Market	483	Constraint Costs	540
Market Design	483	Congestion Event Summary: Impact of Changes in UTC Volumes	543
Market Structure	494	Marginal Losses	546
Market Conduct	496	Marginal Loss Accounting	546
Market Performance	499	Total Marginal Loss Cost	548
Black Start Service	502	Energy Costs	553
NERC – CIP	506	Energy Accounting	553
Minimum Tank Suction Level (MTSL)	506	Total Energy Costs	553
Reactive Service	507	<b>SECTION 12 Generation and Transmission Planning</b>	<b>559</b>
Recommended Market Approach to Reactive Costs	508	Overview	559
Improvements to Current Approach	508	Generation Interconnection Planning	559
Reactive Costs	511	Regional Transmission Expansion Plan (RTEP)	560
Frequency Response	512	Transmission Facility Outages	562
Frequency Control Definition	512	Recommendations	562
<b>SECTION 11 Congestion and Marginal Losses</b>	<b>513</b>	Conclusion	564
Overview	514	Generation Interconnection Planning	566
Congestion Cost	514	Existing Generation Mix	566
Marginal Loss Cost	515	Generation Retirements	568
Energy Cost	515	Generation Queue	575
Conclusion	515	Regional Transmission Expansion Plan (RTEP)	595
Issues	516	RTEP Process	595
Closed Loop Interfaces and CT Pricing Logic	516	Backbone Facilities	595

Market Efficiency Process	595	Revenue Adequacy Issues and Solutions	661
PJM MISO Interregional Targeted Market Efficiency Process (TMEP)	597	ARRs as an Offset to Congestion for Load	663
Supplemental Transmission Projects	598	FERC Order on FTRs: Balancing Congestion and M2M Payment Allocation	663
Board Authorized Transmission Upgrades	602	Zonal ARR Congestion Offset	664
Qualifying Transmission Upgrades (QTU)	602	Credit	665
Cost Allocation	602	Modified Credit Requirements	665
Transmission Facility Outages	603	GreenHat Energy, LLC Default	666
Scheduling Transmission Facility Outage Requests	603	GreenHat Energy Default Lessons Learned	667
Rescheduling Transmission Facility Outage Requests	606	Bilateral Indemnification Provisions	667
Long Duration Transmission Facility Outage Requests	607	Report of the Independent Consultants on the GreenHat Default	668
Transmission Facility Outage Analysis for the FTR Market	608	FTR Forfeitures	669
Transmission Facility Outage Analysis in the Day-Ahead Energy Market	615	Hourly FTR Cost	669
		FERC Order on FTR Forfeitures	669
<b>SECTION 13 Financial Transmission and Auction Revenue Rights</b>	<b>619</b>		
Overview	621		
Auction Revenue Rights	621		
Financial Transmission Rights	622		
Recommendations	623		
Conclusion	624		
Auction Revenue Rights	627		
Market Structure	628		
Market Performance	630		
Financial Transmission Rights	634		
Market Structure	635		
Market Performance	641		
Revenue Adequacy	655		
FTR Revenue Adequacy and Stage 1B/Stage 2 ARR Allocations	656		
Surplus Congestion Revenue	656		
ARR and FTR Revenue Adequacy	658		
FTR Uplift Charge	661		