# Table of Contents

## Preface

SECTION 1 Introduction	1
2020 Q2 in Review	1
PJM Market Summary Statistics	3
PJM Market Background	3
Conclusions	5
Energy Market Conclusion	5
Capacity Market Conclusion	7
Tier 2 Synchronized Reserve Market Conclusion	8
Day-Ahead Scheduling Reserve Market Conclusion	8
Regulation Market Conclusion	9
FTR Auction Market Conclusion	9
Role of MMU	10
Reporting	10
Monitoring	10
Market Design	12
New Recommendations	12
New Recommendation from Section 9, Interchange Transactions	12
New Recommendation from Section 10, Ancillary Services	12
New Recommendation from Section 13, Financial Transmission	
Rights and Auction Revenue Rights	12
Total Price of Wholesale Power	12
Components of Total Price	13
Section Overviews	18
Overview: Section 3, Energy Market	18
Overview: Section 4, Energy Uplift	28
Overview: Section 5, Capacity Market	33
Overview: Section 6, Demand Response	41
Overview: Section 7, Net Revenue	46
Overview: Section 8, Environmental and Renewables	48
Overview: Section 9, Interchange Transactions	52

i

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	73
SECTION 2 Recommendations	81
New Recommendations	82
New Recommendation from Section 9, Interchange Transactions	82
New Recommendation from Section 10, Ancillary Services	82
New Recommendation from Section 13, Financial Transmission Rig	ghts
and Auction Revenue Rights	82
Complete List of Current MMU Recommendations	82
Section 3, Energy Market	82
Section 4, Energy Uplift	86
Section 5, Capacity Market	88
Section 6, Demand Response	90
Section 7, Net Revenue	92
Section 8, Environmental and Renewables	92
Section 9, Interchange Transactions	93
Section 10, Ancillary Services	94
Section 11, Congestion and Marginal Losses	96
Section 12, Planning	96
Section 13, FTRs and ARRs	98

SECTION 3 Energy Market	101
Overview	102
Supply and Demand	102
Competitive Assessment	104
Recommendations	106
Conclusion	109
Supply and Demand	112
Market Structure	112

Market Behavior	130
Supply and Demand: Load and Spot Market	130
Generator Offers	131
Parameter Limited Schedules	133
Virtual Offers and Bids	138
Market Performance	152
LMP	152
Zonal LMP and Dispatch	170
Fuel Prices, LMP, and Dispatch	173
Components of LMP	179
Scarcity	183
Emergency Procedures	184
Scarcity and Scarcity Pricing	186
Competitive Assessment	191
Market Structure	191
Market Behavior	196
Market Performance	216
Market Structure, Participant Behavior, and Market Performance	227

Overview	229
Energy Uplift Credits	229
Energy Uplift Charges	230
Geography of Charges and Credits	230
Recommendations	230
Conclusion	232
Energy Uplift Credits Results	234
Characteristics of Credits	235
Types of Units	235
Day-Ahead Unit Commitment for Reliability	236
Balancing Operating Reserve Credits	237
Lost Opportunity Cost Credits	239
Uplift Eligibility	240

Economic and Noneconomic Generation	241
Concentration of Energy Uplift Credits	242
Credits and Charges Categories	245
Energy Uplift Charges Results	246
Energy Uplift Charges	246
Operating Reserve Rates	249
Reactive Services Rates	252
Balancing Operating Reserve Determinants	253
Geography of Charges and Credits	254
Energy Uplift Issues	255
Intraday Segments Uplift Settlement	255
SECTION 5 Capacity Market	257
Overview	258
RPM Capacity Market	258
Reliability Must Run Service	259
Generator Performance	259
Recommendations	259
Conclusion	262
Installed Capacity	268
Fuel Diversity	269
RPM Capacity Market	270
Market Structure	270
Market Conduct	282
Market Performance	286
Timing of Unit Retirements	294
Reliability Must Run (RMR) Service	294
Generator Performance	297
Capacity Factor	297
Generator Performance Factors	298
Generator Forced Outage Rates	300

### **SECTION 6 Demand Response**

Overview	305
Recommendations	306
Conclusion	308
PJM Demand Response Programs	310
Non-PJM Demand Response Programs	312
Participation in Demand Response Programs	312
Economic Program	313
Emergency and Pre-Emergency Programs	321
Distributed Energy Resources	333

#### SECTION 7 Net Revenue

Overview
Net Revenue
Recommendations
Historical New Entrant CC Revenue Adequacy
Conclusion
Net Revenue
Spark Spreads, Dark Spreads, and Quark Spreads
Theoretical Energy Market Net Revenue
New Entrant Combustion Turbine
New Entrant Combined Cycle
New Entrant Coal Plant
New Entrant Nuclear Plant
New Entrant Diesel
New Entrant Onshore Wind Installation
New Entrant Offshore Wind Installation
New Entrant Solar Installation
Historical New Entrant CC Revenue Adequacy
Nuclear Net Revenue Analysis

Regulations	355
Overview	355
Federal Environmental Regulation	355
State Environmental Regulation	356
State Renewable Portfolio Standards	356
Emissions Controls in PJM Markets	357
Renewable Generation	357
Recommendations	357
Conclusion	357
Federal Environmental Regulation	359
CAA: NESHAP/MATS	360
CAA: NAAQS/CSAPR	360
CAA: NSR	361
CAA: RICE	362
CAA: Greenhouse Gas Emissions	362
CWA: WOTUS Definition and Effluents	363
RCRA: Coal Ash	364
State Environmental Regulation	366
State Emissions Regulations	366
State Regulation of Greenhouse Gas Emissions	366
State Renewable Portfolio Standards	371
Alternative Compliance Payments	386
Emission Controlled Capacity and Emissions	389
Emission Controlled Capacity	389
Emissions	390
Renewable Energy Output	393
Wind and Solar Peak Hour Output	393
Wind Units	394
Solar Units	396

## SECTION 9 Interchange Transactions

Overview	399
Interchange Transaction Activity	399
Interactions with Bordering Areas	400
Recommendations	400
Conclusion	401
Interchange Transaction Activity	402
Charges and Credits Applied to Interchange Transactions	402
Aggregate Imports and Exports	404
Real-Time Interface Imports and Exports	406
Real-Time Interface Pricing Point Imports and Exports	408
Day-Ahead Interface Imports and Exports	410
Day-Ahead Interface Pricing Point Imports and Exports	413
Loop Flows	419
PJM and MISO Interface Prices	427
PJM and NYISO Interface Prices	429
Summary of Interface Prices between PJM and Organized Markets	431
Neptune Underwater Transmission Line to Long Island, New York	431
Linden Variable Frequency Transformer (VFT) facility	433
Hudson Direct Current (DC) Merchant Transmission Line	434
Interchange Activity During High Load Hours	436
Operating Agreements with Bordering Areas	436
PJM and MISO Joint Operating Agreement	437
PJM and New York Independent System Operator Joint Operating	
Agreement (JOA)	438
PJM and TVA Joint Reliability Coordination Agreement (JRCA)	440
PJM and Duke Energy Progress, Inc. Joint Operating Agreement	440
PJM and VACAR South Reliability Coordination Agreement	440
Balancing Authority Operations Coordination Agreement between	
Wisconsin Electric Power Company (WEC) and PJM	
Interconnection, LLC	441
Northeastern ISO-Regional Transmission Organization Planning	
Coordination Protocol	441

Interface Pricing Agreements with Individual Balancing	
Authorities	441
Interchange Transaction Issues	442
PJM Transmission Loading Relief Procedures (TLRs)	442
Up To Congestion	443
Sham Scheduling	445
Elimination of Ontario Interface Pricing Point	446
PJM and NYISO Coordinated Interchange Transactions	447
Reserving Ramp on the PJM/NYISO Interface	450
PJM and MISO Coordinated Interchange Transaction Proposal	451
Willing to Pay Congestion and Not Willing to Pay Congestion	454
Spot Imports	455
Interchange Optimization	456
Interchange Cap During Emergency Conditions	456
45 Minute Schedule Duration Rule	457
MISO Multi-Value Project Usage Rate (MUR)	458

# SECTION 10 Ancillary Service Markets 461

Overview	462
Primary Reserve	462
Tier 1 Synchronized Reserve	462
Tier 2 Synchronized Reserve Market	463
Nonsynchronized Reserve Market	464
Secondary Reserve	464
Regulation Market	465
Black Start Service	467
Reactive	467
Frequency Response	468
Ancillary Services Costs per MWh of Load	468
Recommendations	469
Conclusion	471
Primary Reserve	472
Market Structure	472

Price and Cost	476
Tier 1 Synchronized Reserve	477
Market Structure	477
Tier 1 Synchronized Reserve Payments	479
Tier 2 Synchronized Reserve Market	482
Market Structure	482
Market Behavior	485
Market Performance	487
Nonsynchronized Reserve Market	493
Market Structure	493
Secondary Reserve	496
Market Structure	496
Market Conduct	498
Market Performance	498
Regulation Market	501
Market Design	501
Market Structure	513
Market Conduct	517
Market Performance	521
Black Start Service	523
CRF lssues	526
NERC – CIP	528
Minimum Tank Suction Level (MTSL)	528
Reactive Power Service and Capability	529
Recommended Market Approach to Reactive Costs	530
Improvements to Current Approach	530
Reactive Costs	533
Frequency Response	534
Frequency Control Definition	534

SECTION 11 Congestion and Marginal Losses	535
Overview	536
Congestion Cost	536
Marginal Loss Cost	537
System Energy Cost	537
Conclusion	537
lssues	538
Closed Loop Interfaces and CT Pricing Logic	538
Balancing Congestion Cost Calculation Logic Change	539
Locational Marginal Price (LMP)	541
Components	541
Hub Components	544
Congestion	545
Congestion Accounting	545
Total Congestion	549
Charges and Credits versus Congestion: Virtual Transactions,	
Load and Generation	550
Congested Facilities	560
Congestion by Facility Type and Voltage	561
Constraint Frequency	564
Constraint Costs	566
Congestion Event Summary: Impact of Changes in UTC Volumes	569
Marginal Losses	569
Marginal Loss Accounting	569
Total Marginal Loss Cost	571
System Energy Costs	576
Energy Accounting	576
Total System Energy Costs	576

## SECTION 12 Generation and Transmission Planning 581

Overview	581
Generation Interconnection Planning	581
Regional Transmission Expansion Plan (RTEP)	582
Transmission Facility Outages	583
Recommendations	583
Conclusion	585
Generation Interconnection Planning	587
Existing Generation Mix	587
Generation Retirements	590
Generation Queue	595
Regional Transmission Expansion Plan (RTEP)	618
RTEP Process	618
Market Efficiency Process	618
PJM MISO Interregional Market Efficiency Process (IMEP)	621
PJM MISO Targeted Market Efficiency Process (TMEP)	621
Supplemental Transmission Projects	622
Board Authorized Transmission Upgrades	627
Qualifying Transmission Upgrades (QTU)	627
Cost Allocation	628
Transmission Line Ratings	628
Transmission Facility Outages	630
Scheduling Transmission Facility Outage Requests	630
Rescheduling Transmission Facility Outage Requests	633
Long Duration Transmission Facility Outage Requests	634
Transmission Facility Outage Analysis for the FTR Market	635
Transmission Facility Outage Analysis in the Day-Ahead Energy	
Market	642

SECTION 13 Financial Transmission and Auction		
Revenue Rights	645	
Overview	647	
Auction Revenue Rights	647	
Financial Transmission Rights	648	
Recommendations	650	
Conclusion	651	
Auction Revenue Rights	654	
ARRs	654	
IARRs	654	
Market Structure	655	
Market Performance	658	
Financial Transmission Rights	662	
Market Structure	662	
Market Performance	668	
Surplus Congestion Revenue	684	
Revenue Adequacy	686	
ARRs as an Offset to Congestion for Load	690	
Zonal ARR Congestion Offset	692	
Credit	693	
GreenHat Settlement Proceedings	693	
Default Portfolio Considerations	694	
FTR Forfeitures	694	
Hourly FTR Cost	694	
FERC Order on FTR Forfeitures	694	