Book 4 / Regional Energy Information

Section 9: Regional Energy Information

9.1 MISO Overview

MISO is a not-for-profit, member-based organization that administers wholesale electricity and ancillary services markets. MISO provides customers a wide array of services including reliable system operations; transparent energy and ancillary service prices; open access to markets; and system planning for long-term reliability, efficiency and to meet public policy needs.

MISO has 48 Transmission Owner members with more than $34.5 billion in transmission assets under MISO's functional control. MISO has 128 non-transmission owner members that contribute to the stability of the MISO markets.

By improving grid reliability and increasing the efficient use of generation, MISO saves the average residential customer $46 to $57 a year, at an annual expense of $5 per customer.

The services MISO provides translate into material benefits for members and end users. By improving grid reliability and increasing the efficient use of generation, MISO saves the average residential customer $46 to $57 a year at an annual expense of $5 per customer. The MISO 2016 Value Proposition[1] explains the various components of this benefits calculation.

The value drivers are:

1. **Improved Reliability** - MISO's broad regional view and state-of-the-art reliability tool set enables improved reliability for the region as measured by transmission system availability.
2. **Dispatch of Energy** - MISO's real-time and day-ahead energy markets use security constrained unit commitment and centralized economic dispatch to optimize the use of all resources within the region based on bids and offers by market participants.
3. **Regulation** - With MISO's Regulation Market, the amount of regulation required within the MISO footprint dropped significantly. This is the outcome of the region moving to a centralized common footprint regulation target rather than several non-coordinated regulation targets.
4. **Spinning Reserves** - Starting with the formation of the Contingency Reserve Sharing Group and continuing with the implementation of the Spinning Reserves Market, the total spinning reserve requirement declined, freeing low-cost capacity to meet energy requirements.
5. **Wind Integration** - MISO's regional planning enables more economic placement of wind resources in the region. Economic placement of wind resources reduces the overall capacity needed to meet required wind energy output.
6. **Compliance** - Before MISO, utilities in the MISO footprint managed their own FERC and NERC compliance. With MISO, many of these compliance responsibilities have been consolidated. As a result, member responsibilities decreased, saving them time and money.
7. **Footprint Diversity** - MISO's large footprint increases the load diversity allowing for a decrease in regional planning reserve margins from 20.98 percent to 15.20 percent. This decrease delays the need to construct new capacity.
8. **Generator Availability Improvement** - MISO's wholesale power market improved power plant availability by 1.18 percent, delaying the need to construct new capacity.
9. **Demand Response** - MISO enables demand response through transparent market prices and market platforms. MISO-enabled demand response delays the need to construct new capacity.
10. **MISO Cost Structure** - MISO expects administrative costs to remain relatively flat and to represent a small percentage of the benefits.

[1] https://www.misoenergy.org/WhatWeDo/ValueProposition/Pages/ValueProposition.aspx

MISO provides these services for the largest regional transmission operator geographic footprint in the U.S. MISO undertakes this mission from control centers in Carmel, Ind.; Eagan, Minn.; and Little Rock, Ark., with regional offices in Metairie, La., and Little Rock, Ark. (Figure 9.1-1).

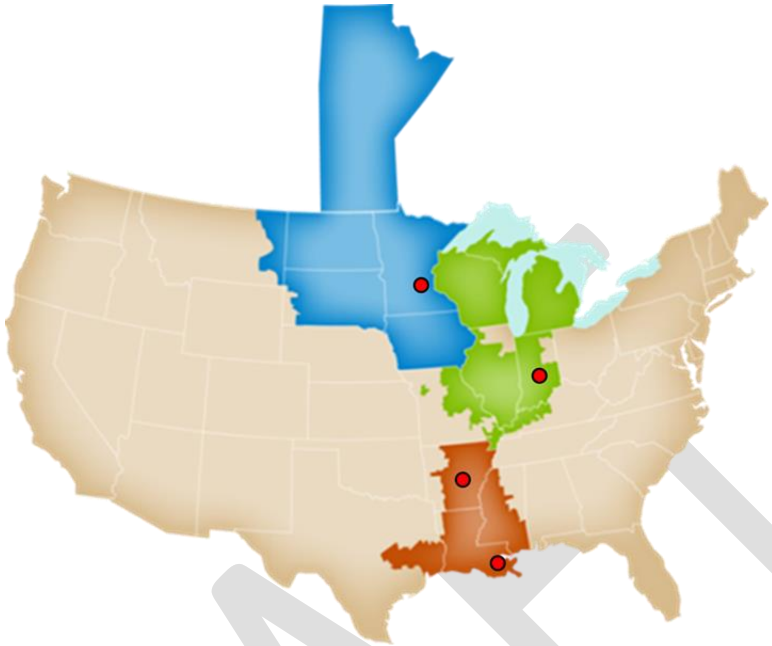

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Figure 9.1-1: The MISO geographic footprint and office locations

MISO By The Numbers

Generation Capacity (as of March 2017)

- 174,724 MW (market)
- 191,062 MW (reliability)[2]

Historic Summer Peak Load (set July 20, 2011)

- 127,125 MW (market)
- 133,917 MW (reliability)[3]

Historic Winter Peak Load (set Jan. 6, 2014)

- 109,307 MW (market)
- 117,903 MW (reliability)[4]

Miles of transmission

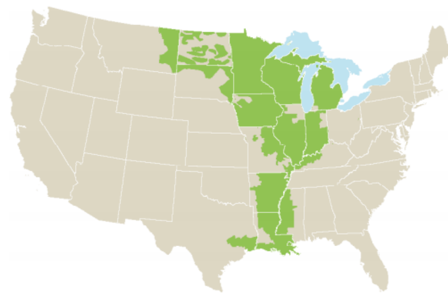
- 65,800 miles of transmission
- 383 approved new projects in MTEP16, representing $2.7 billion investment and 7,100 miles of new transmission

Markets

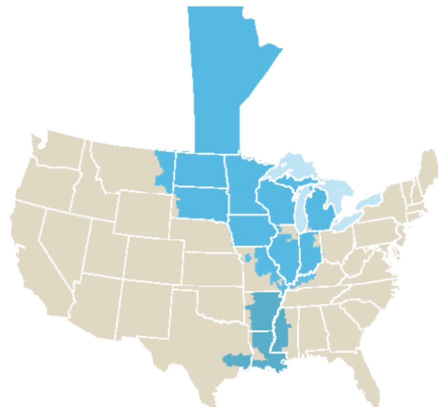
- $25.3 billion in annual gross market charges (2017)
- 2,434 pricing nodes
- 437 Market Participants serving approximately 42 million people

Renewable Integration

- 16,173 MW Registered In-Service Wind Generation Capacity
- 16,326 MW Registered Wind Generation Capacity



MARKET AREA



RELIABILITY COORDINATION AREA

[2,3,4] MISO Fact Sheet

9.2 Electricity Prices

Wholesale Electric Rates

MISO operates a market for the buying and selling of wholesale electricity. The price of energy for a given hour is referred to as the Locational Marginal Price (LMP). The LMP represents the cost incurred, expressed in dollars per megawatt hour, to supply the last incremental amount of energy at a specific point on the transmission grid.

The MISO LMP is made up of three components: the Marginal Energy Component (MEC), the Marginal Congestion Component (MCC) and the Marginal Loss Component (MLC). MISO uses these three components when calculating the LMP to capture not only the marginal cost of energy but also the limitations of the transmission system.

In a transmission system without congestion or losses, the LMP across the MISO footprint would be the same. In reality, the existence of transmission losses and transmission line limits result in adjustments to the cost of supplying the last incremental amount of energy. For any given hour, the MEC of the LMP is the same across the MISO footprint. However, the MLC and MCC create the difference in the hourly LMPs.

The 24-hour average day-ahead LMP at the Indiana hub over a two-week period highlights the variation in the components that make up the LMP for the first two weeks in 2017 (Figure 9.2-1). A real-time look at the MISO prices can be found on the LMP Contour Map[5] (Figure 9.2-2).

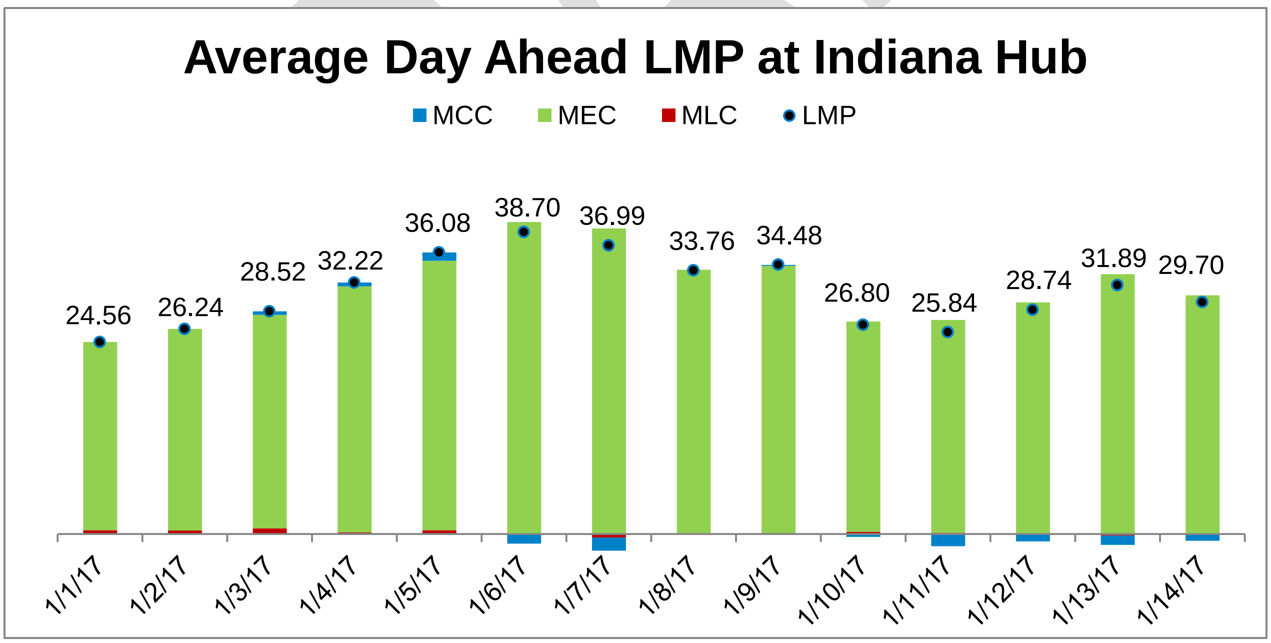


Figure 9.2-1: Average day-ahead LMP at the Indiana hub

[5] Market Analysis Monthly Operations Report: https://www.misoenergy.org/LMPContourMap/MISO_All.html

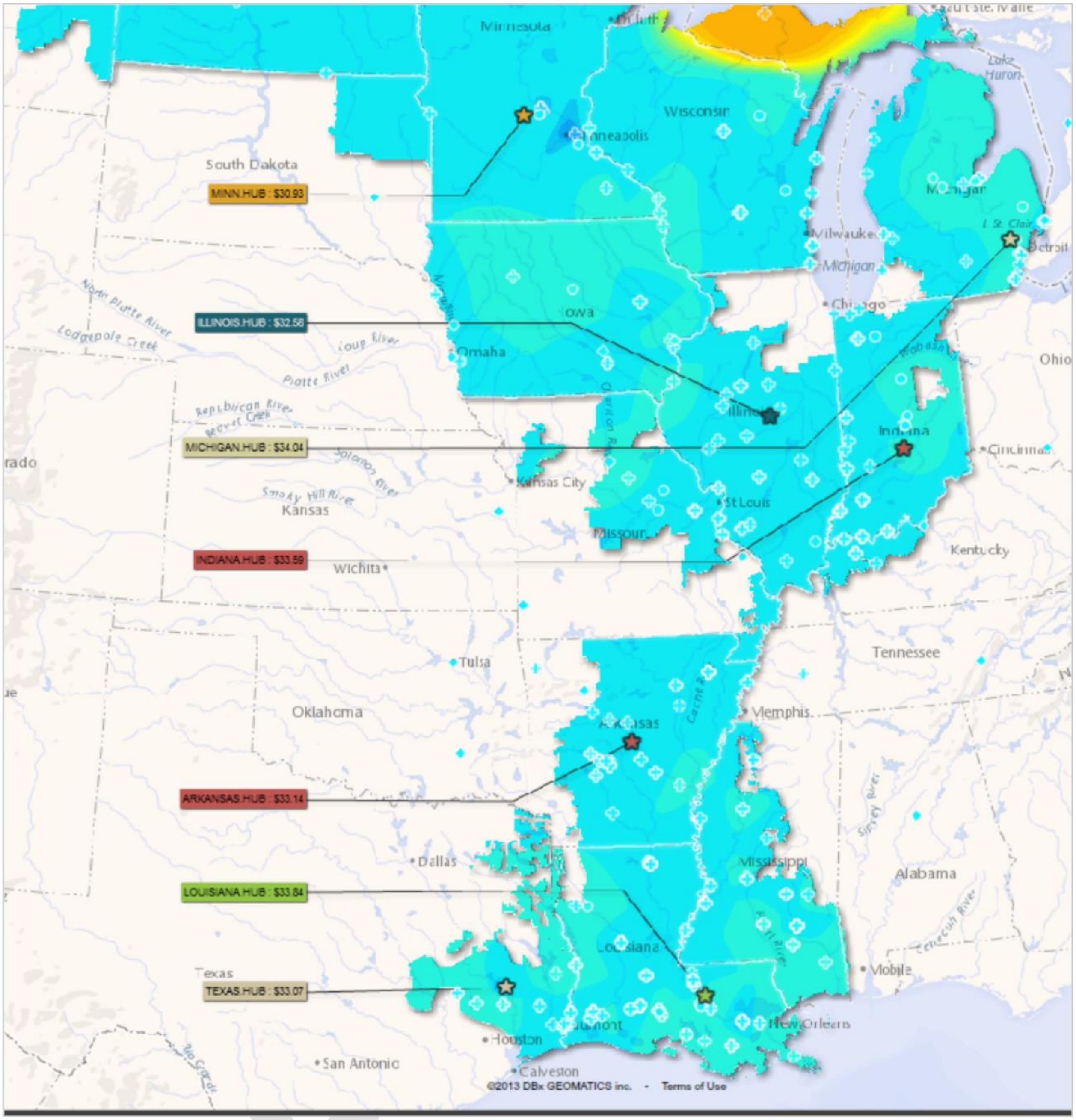


Figure 9.2-2: LMP Contour Map

Retail Electric Rates

The MISO-wide average retail rate, weighted by load in each state, for the residential, commercial and industrial sector, is 9.15 cents/kWh, about 10 percent lower than the national average of 10.10 cents/kWh. The average retail rate in cents per kWh varies by 3.7 cents/kWh per state in the MISO footprint (Figure 9.2-3).

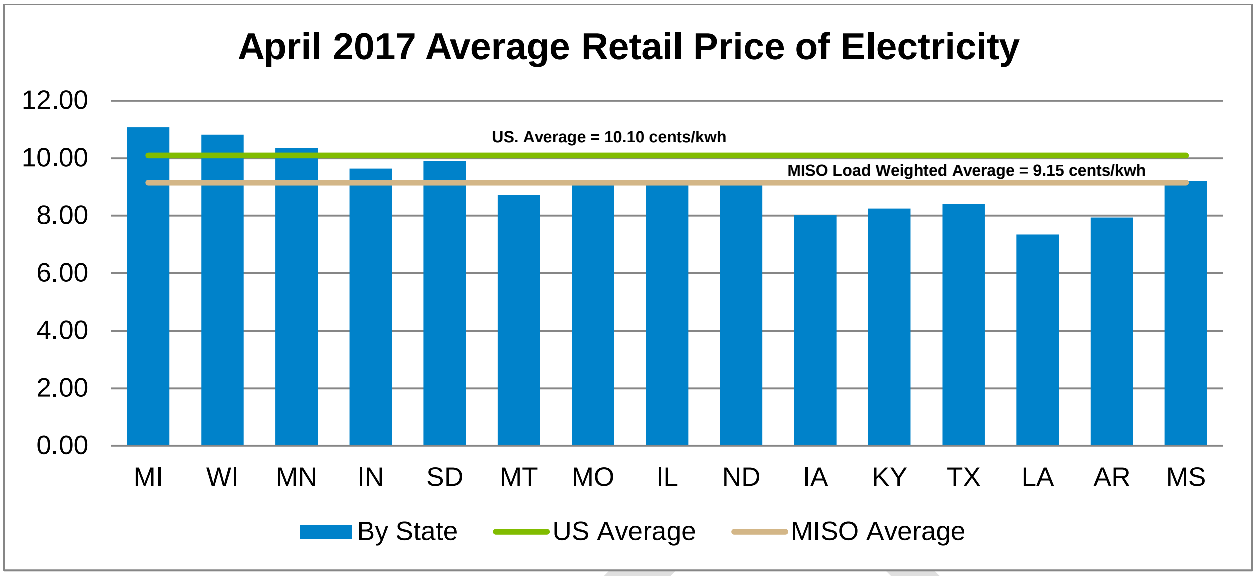


Figure 9.2-3: Average retail price of electricity per state[6]

[6] April 2017 EIA, Average Price of Electricity to Ultimate Customers by End-Use Sector, by State

9.3 Generation Statistics

The energy resources in the MISO footprint continue to evolve. Environmental regulations, improved technologies and ageing infrastructure have spurred changes in the way electricity is generated.

Fuel availability and fuel prices introduce a regional aspect into the selection of generation, not only in the past but also going forward. Planned generation additions and retirements in the U.S. from 2016 to 2020, separated by fuel type, shows the increased role natural gas and renewable energy sources will play in the future (Table 9.3-1).

	Planned Generating Capacity Changes, by Energy Source, 2016-2020					
	Generator Additions		Generator Retirements		Net Capacity Additions	
Energy Source	Number of Generators	Net Summer Capacity (MW)	Number of Generators	Net Summer Capacity (MW)	Number of Generators	Net Summer Capacity (MW)
Coal	5	752.0	93	16,943.9	-88	-16,191.9
Petroleum	22	50.3	52	1,101.2	-30	-1,050.9
Natural Gas	395	65,095.4	114	10,223.0	281	54,872.4
Other Gases	3	403.0	--	--	3	403.0
Nuclear	5	5,522.0	7	5,488.9	-2	33.1
Hydroelectric Conventional	63	950.2	24	435.1	39	515.1
Wind	184	22,603.0	6	59.2	178	22,543.8
Solar Thermal and Photovoltaic	565	14,494.5	2	1.5	563	14,493.0
Wood and Wood-Derived Fuels	4	204.5	4	45.1	--	159.4
Geothermal	7	311.9	4	90.0	3	221.9
Other Biomass	66	187.5	30	19.0	36	168.5
Hydroelectric Pumped Storage	--	--	--	--	--	--
Other Energy Sources	22	285.5	--	--	22	285.5
U.S. Total	1,341	110,832.8	336	34,406.9	1,005	76,425.9

Table 9.3-1: Forecasted generation capacity changes by energy source[7]

The majority of MISO North and Central regions' dispatched generation comes, historically, from coal. With the introduction of the South region in December 2013, MISO added an area where a majority of the dispatched generation comes from natural gas. The increased fuel-mix diversity from the addition of the South region helps to limit the exposure to the variability of fuel prices. This adjustment to the composition of resources contributes to MISO's goal of an economically efficient wholesale market that minimizes the cost to deliver electricity.

The increased fuel-mix diversity from the addition of the South region helps limit the exposure to the variability of fuel prices.

After the integration of the South region, the percentage of generation from coal units decreases as the amount of

[7] EIA, http://www.eia.gov/electricity/annual/html/epa_04_05.html

generation from gas units increases as shown by trend lines (Figure 9.3-1).

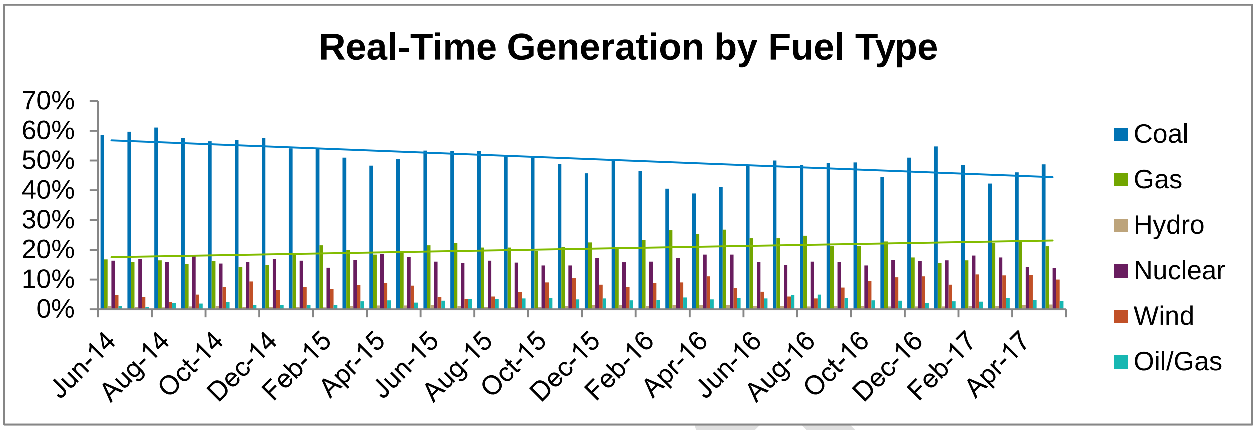
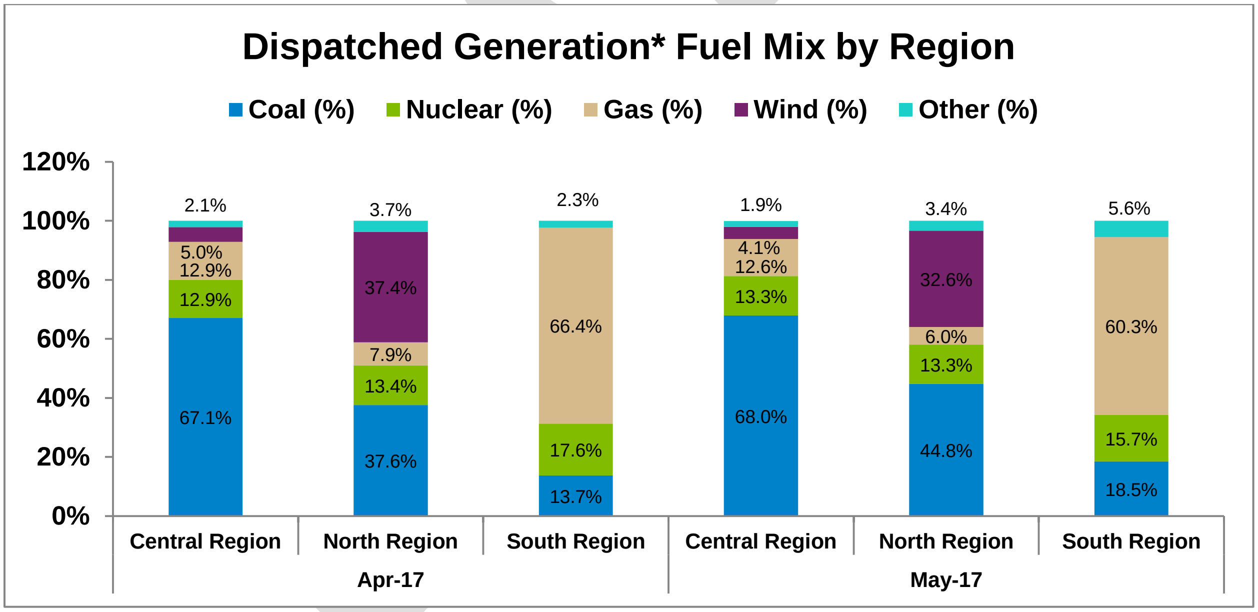


Figure 9.3-1: Real-time generation by fuel type

Different regions have different makeups in terms of generation (Figure 9.3-2). A real-time look at MISO fuel mix can be found on the [MISO Fuel Mix Chart.][8]



* Based on 5-minute unit level dispatch target

Figure 9.3-2: Dispatched generation fuel mix by region

[8] https://www.misoenergy.org/MarketsOperations/RealTimeMarketData/Pages/FuelMix.aspx

Renewable Portfolio Standards

Renewable portfolio standards (RPS) require utilities to use or procure renewable energy to account for a defined percentage of their retail electricity sales. Renewable portfolio goals are similar to renewable portfolio standards but are not a legally binding commitment.

Renewable portfolio standards are determined at the state level and differ based upon state-specific policy objectives (Table 9.3-2). Differences may include eligible technologies, penalties and the mechanism by which the amount of renewable energy is being tallied.

State	RPS Type	Target RPS (%)	Target Mandate (MW)	Target Year
Arkansas	None			
Illinois	Standard	25%		2025
Indiana	Goal	10%		2025
Iowa	Standard		105	2018
Kentucky	None			
Louisiana	None			
Michigan	Standard	15%		2021
Minnesota	Standard: all utilities	25%		2025
	Xcel Energy	30%		2020
	Solar standard – investor-owned utilities	1.5%		2020
Mississippi	None			
Missouri	Standard	15%		2021
Montana	Standard	15%		2015
North Dakota	Goal	15%		2015
South Dakota	Goal	10%		2015
Texas	Standard		10,000	2025
Wisconsin	Standard	10%		2015

Table 9.3-2: Renewable portfolio policy summary for states in the MISO footprint

Wind

Wind energy is the most prevalent renewable energy resource in the MISO footprint. Wind capacity in the MISO footprint has increased exponentially since the start of the energy market in 2005. Beginning with nearly 1,000 MW of installed wind, the MISO footprint now contains 16,323MW of total registered wind capacity as of May 2017.

Wind energy offers lower environmental impacts than conventional generation, contributes to renewable portfolio standards and reduces dependence on fossil fuels. Wind energy also presents a unique set of challenges. Wind energy is intermittent by nature and driven by weather conditions. Wind energy also may face unique siting challenges.

A real-time look at the average wind generation in the MISO footprint can be seen on the MISO real time wind generation graph[9].

[9] https://www.misoenergy.org/MarketsOperations/RealTimeMarketData/Pages/RealTimeWindGeneration.aspx

Data collected from the MISO Monthly Market Assessment Reports[10] determines the energy contribution from wind and the percentage of total energy supplied by wind (Figure 9.3-3).

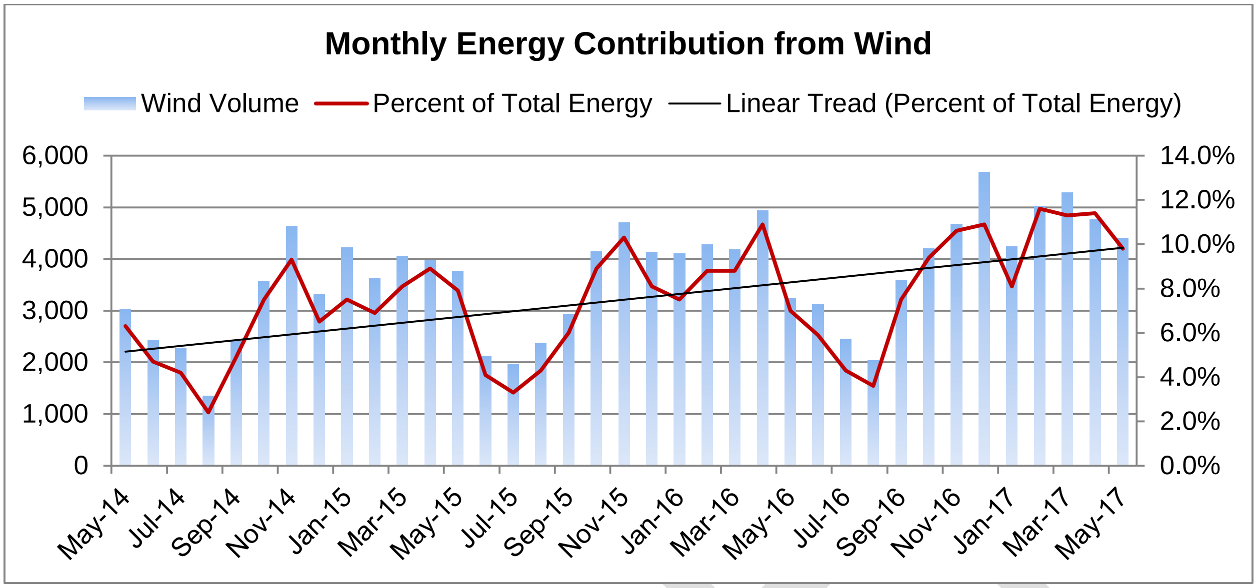
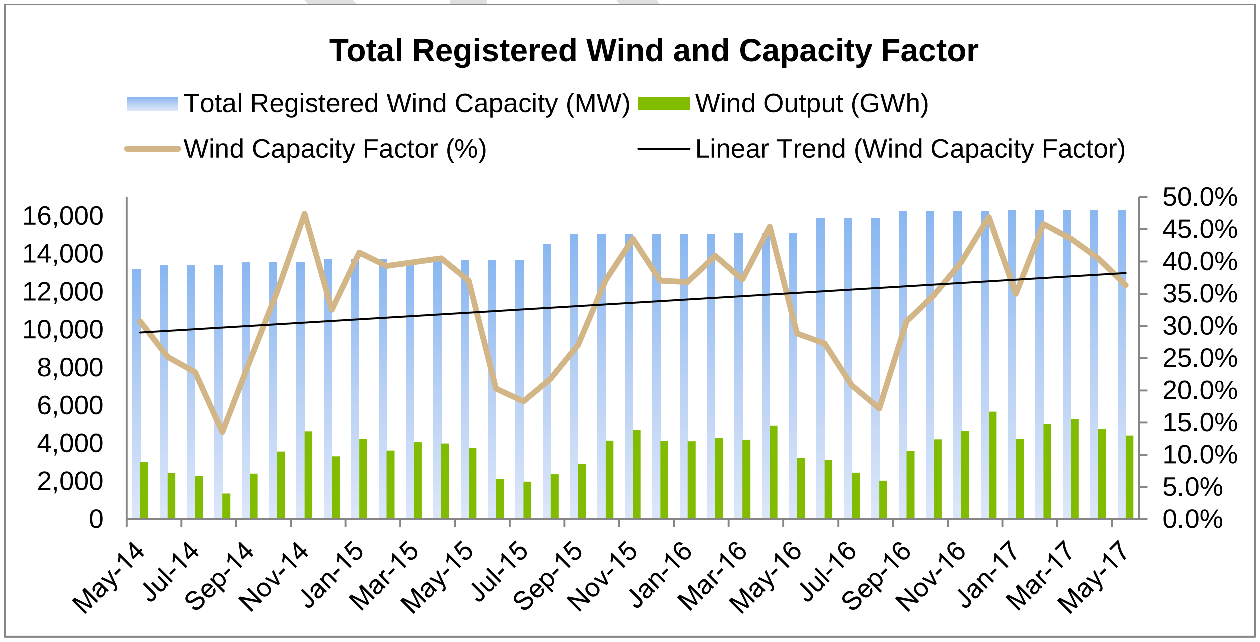


Figure 9.3-3: Monthly energy contribution from wind

Capacity factor measures how often a generator runs over a period of time. Knowing the capacity factor of a resource gives a greater sense of how much electricity is actually produced relative to the maximum the resource could produce. The graphic compares the total registered wind capacity with the actual wind output for the month. The percentage trend line helps to emphasize the variance in the capacity factor of wind resources (Figure 9.3-4).



[10] https://www.misoenergy.org/MarketsOperations/MarketInformation/Pages/MonthlyMarketAnalysisReports.aspx

Figure 9.3-4: Total registered wind and capacity factor

9.4 Load Statistics

The withdrawal of energy from the transmission system can vary significantly based on the surrounding conditions. The amount of load on the system varies by time of day, current weather and the season. Typically, weekdays experience higher load then weekends. Summer and winter seasons have a greater demand for energy than do spring or fall.

End-Use Load

It is a challenge to develop accurate information on the composition of load data. Differences in end-use load can be seen at a footprint-wide, regional and Load-Serving Entity levels.

To keep up with changing end-use consumption, MISO relies on the data submitted to the Module E Capacity Tracking (MECT) tool. MECT data is used for all of the long-term forecasting including Long Term Reliability Assessment and Seasonal Assessment as well as to determine Planning Reserve Margins.

The Energy Information Agency (EIA) Electric Power Monthly provides information on the retail sales of electricity to the end-use customers by sector for each state in the MISO footprint (Table 9.4-1).

April 2017 - Retail Sales of Electricity to Ultimate Customers by End-Use Customer							
State	Residential		Commercial		Industrial		All Sectors
	(Million kWh)	% of total	(Million kWh)	% of total	(Million kWh)	% of total	
Arkansas	1,072	32.4%	879	26.5%	1,361	41.1%	3,313
Iowa	927	25.8%	889	24.8%	1,773	49.4%	3,589
Illinois	2,662	27.7%	3,585	37.3%	3,334	34.6%	9,622
Indiana	1,938	28.0%	1,749	25.3%	3,227	46.7%	6,916
Kentucky	1,577	30.2%	1,409	27.0%	2,241	42.9%	5,228
Louisiana	1,948	28.7%	1,868	27.5%	2,963	43.7%	6,781
Michigan	2,214	29.4%	2,995	39.7%	2,329	30.9%	7,539
Minnesota	1,528	31.1%	1,707	34.7%	1,679	34.2%	4,916
Missouri	2,009	38.3%	2,293	43.7%	939	17.9%	5,242
Mississippi	1,168	32.9%	1,050	29.5%	1,336	37.6%	3,554
Montana	374	33.5%	393	35.2%	348	31.2%	1,116
North Dakota	341	23.4%	479	32.8%	639	43.8%	1,459
South Dakota	334	37.0%	350	38.8%	218	24.1%	903
Texas	8,861	32.5%	9,862	36.2%	8,503	31.2%	27,240
Wisconsin	1,522	29.2%	1,768	33.9%	1,930	37.0%	5,220
Total	**28,475**	**30.7%**	**31,276**	**33.8%**	**32,820**	**35.4%**	**92,638**

Table 9.4-1: Retail sales of electricity to ultimate customers by end-use sector, April 2016[11]

[11] http://www.eia.gov/electricity/annual

Load

Peak load drives the amount of capacity required to maintain a reliable system. Load level variation can be attributed to various factors, including weather, economic conditions, energy efficiency, demand response and membership changes. The annual peaks, summer and winter, from 2007 through 2016, show the fluctuation (Figure 9.4-2).

Within a single year, load varies on a weekly cycle. Weekdays experience higher load. On a seasonal cycle, it also peaks during the summer with a lower peak in the winter, and with low-load periods during the spring and fall seasons (Figure 9.4-3). The Load Curve shows load characteristics over time (Figure 9.4-4). Looking at all 366days in 2016, these curves show the highest instantaneous peak load of 121,092 MW on July 22, 2016; the minimum load of 50,659 MW on April 17, 2016; and every day in order of load size. This data is reflective of the market footprint at the time of occurrence.

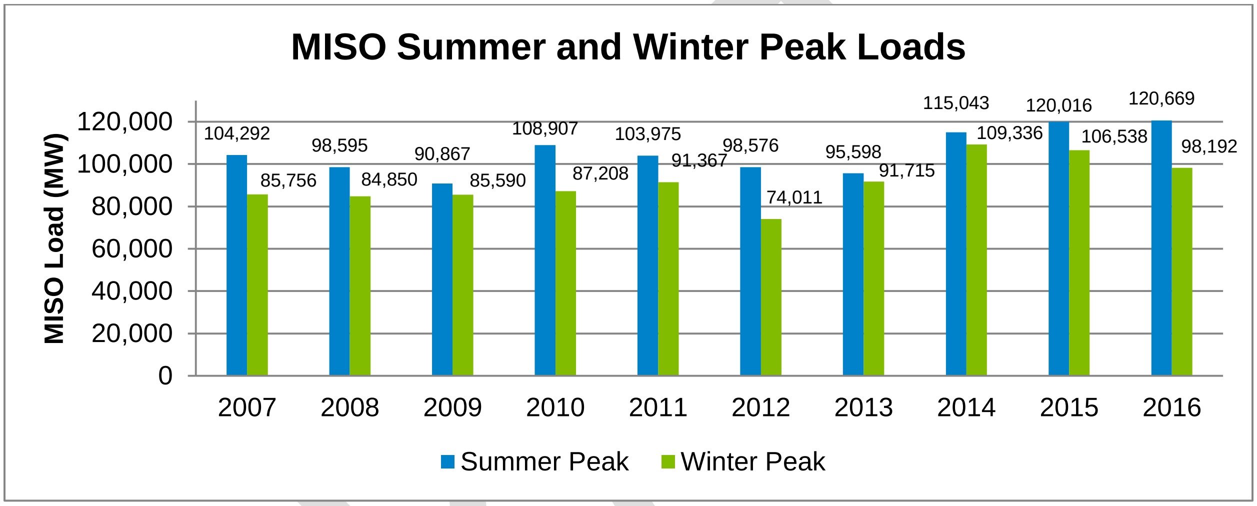
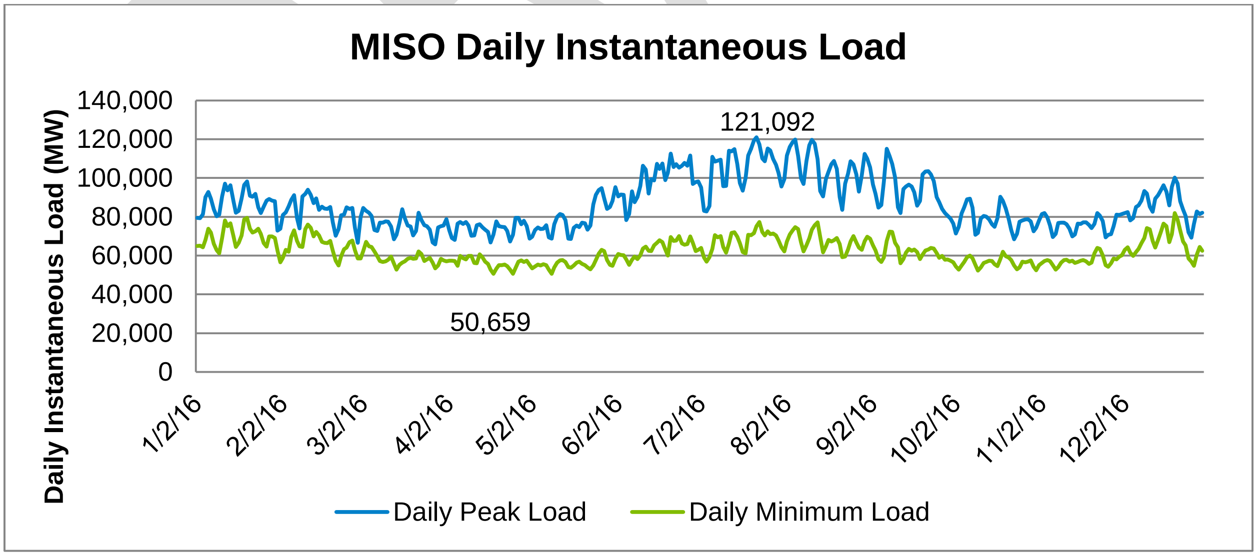


Figure 9.4-2: MISO Summer and Winter Peak Loads – 2007 through 2016[12]



[12] Source: MISO Market Data (2007-2014)

Figure 9.4-3: 2016 MISO - Daily Load[13]

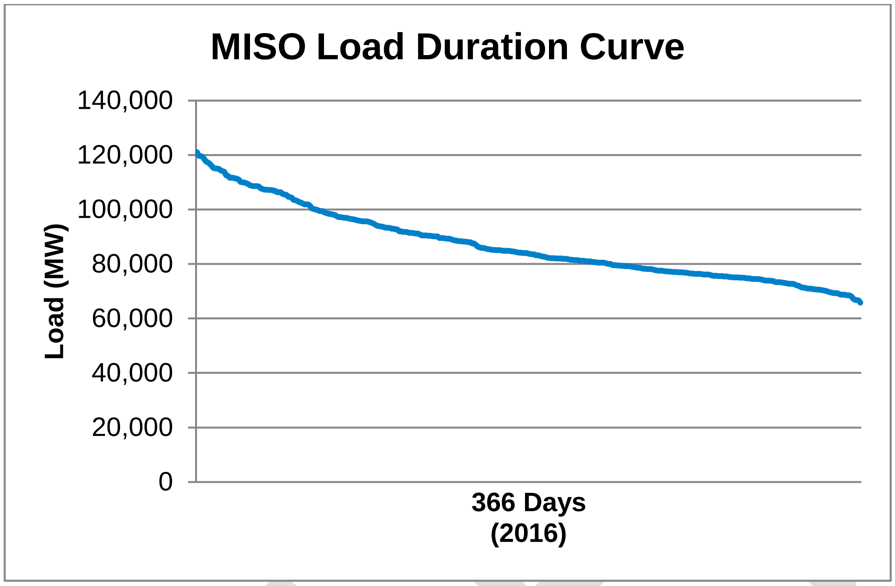


Figure 9.4-4: MISO Load Duration Curve – 2016[14]

[13] Source: MISO Market Data (2016)
[14] Source: MISO Market Data (2016)

Appendices

Most MTEP17 appendices[15] are available and accessible on the MISO public webpage. Confidential appendices, such as D2 through D8, will be available by the 2nd draft report in September on the MISO MTEP17 Planning Portal[16]. Access to the Planning Portal site requires an ID and password.

Appendix A: Projects recommended for approval
- A.1, A.2, A.3: Cost allocations
- A: MTEP17 Appendix A new projects and existing projects

Appendix B: Projects with documented need and effectiveness

Appendix D: Reliability studies analytical details with mitigation plan
- Section D.2: Modeling documentation

Appendix E: Additional MTEP17 Study support
- Section E.1: Reliability planning methodology
- Section E.2: Futures development

[15] https://www.misoenergy.org/Library/Pages/Results.aspx?q=MTEP16%20Appendix
[16] https://markets.midwestiso.org/MTEP/Studies/42/Study

Acronyms in MTEP17

TO BE UPDATED IN SEPTEMBER

AECI	Associated Electric Cooperative Inc.
AEG	Applied Energy Group
AFC	Available Flowgate Capacity
AMIL	Ameren Illinois
APC	Adjusted Production Cost
ARR	Auction Revenue Rights
BA	Balancing Authority
BAU	Business as Usual
BaseRel	Baseline Reliability Project
BPM	Business Practices Manual
BRP	Baseline Reliability Projects
BTMG	behind-the-meter generation
CC	Combined Cycle
CT	Combustion Turbine
CEII	Critical Energy Infrastructure Information
CEL	Capacity Export Limit
CIL	Capacity Import Limit
CO_2	Carbon Dioxide
CPCN	Certificate of Public Convenience and Necessity
CPP	Clean Power Plan
CROW	Control Room Operator's Window
CSP	Coordinated System Plan
CSAPR	Cross-State Air Pollution Rule
DCLM	Direct control load management
DG	Distributed Generation
DPP	Definitive Planning Phase
DR	Demand Response
DSG	Down Stream of Gypsy
DSIRE	Database of State Incentives for Renewables & Efficiency
DSM	Demand-Side Management
EE	Energy Efficiency
EER	Energy Efficiency Resource
EGEAS	Electric Generation Expansion Analysis System
EIA	Energy Information Agency
ELCC	Effective Load Carrying Capability
EPA	Environmental Protection Agency (U.S.)
ERAG	Eastern Reliability Assessment Group
ERC	Emission Rate Credits
ERCOT	Electric Reliability Council of Texas
ERIS	Energy Resource Interconnection Service
EER	Energy Efficiency Resources
EERS	Energy Efficiency Resource Standards
FCA	Facility Construction Agreement
FERC	Federal Energy Regulatory Commission
FTR	Financial Transmission Rights
GIA	Generator Interconnection Agreement
GIP	Generator Interconnection Projects
GIQ	Generator Interconnection Queue
GIS	Geographical Information System
GTC	Georgia Transmission Corp.
GVTC	Generator Verification Test Capacity
HD	High Demand
IL	Interruptible Load
IMEP	Interregional Market Efficiency Project
IPP	independent power producers
IPSAC	Interregional Planning Stakeholder Advisory Committee
IS	Integrated System
ITP	Integrated Transmission Plan
JOA	Joint Operating Agreement
JRPC	Joint RTO Planning Committee
LBA	Local Balancing Authority
LD	Low Demand
LFU	Load forecast uncertainty
LG&E/KU	Louisville Gas and Electric Co./Kentucky Utilities
LMP	Locational marginal price

LMR Load Modifying Resources

LOLE Loss of Load Expectation

LOLEWG Loss of Load Expectation Working Group

LRR Local Reliability Requirement

LRZ Local Resource Zones

LSE Load Serving Entity

LTRA Long-Term Resource Assessment

LTTR Long-Term Transmission Rights

M2M Market-to-Market

MATS Mercury and Air Toxics Standard

MCC Marginal Congestion Component

MCPS Market Congestion Planning Studies

MEAG Municipal Electric Authority of Georgia

MEC Marginal Energy Component (MEC)

MECT Module E Capacity Tracking

MEP Market Efficiency Projects

MISO Midcontinent Independent System Operator

MLC Marginal Loss Component

MMWG Multi-regional Modeling Working Group

MOD Model on Demand

MTEP MISO Transmission Expansion Plan

MVP Multi-Value Projects

MW Megawatt

NAAQS National Ambient Air Quality Standards

NERC North American Electric Reliability Corp.

NIPSCO Northern Indiana Public Service Co.

NO_x Nitrogen Oxide

NRIS Network Resource Interconnection Service

OASIS Open Access Same-Time Information System

OMS Organization of MISO States

OOS Out of Service

OVEC Ohio Valley Electric Corp.

PAC Planning Advisory Committee

PJM Pennsylvania-New Jersey-Maryland Interconnection

PRA Planning resource auction

PRM Planning Reserve Margin

PRM_{ICAP} PRM installed capacity

PRM_{UCAP} PRM uninstalled capacity

PRMR Planning Reserve Margin Requirement

PSC Planning Subcommittee

PV Photovoltaic

PV Present Value

RCPP Regional Clean Power Plan

RE Regional Entities

RECB Regional Expansion Criteria and Benefits

RFP Request for Proposal

RGOS Regional Generator Outlet Study

RPS Renewable Portfolio Standard

RRF Regional Resource Forecast

RTEP Regional Transmission Expansion Plan

RTO Regional transmission operator

SERTP Southeastern Regional Transmission Planning

SIS System Impact Study

SPC System Planning Committee

SPM Subregional Planning Meetings

SPP Southwest Power Pool

SRCPP Sub-Regional Clean Power Plan

SREC Sub-Regional Export Constraint

SUFG State Utility Forecasting Group

SSR System Support Resource

TDSP Transmission Delivery Service Project

TIS Total Interconnection Service

TMEP Targeted Market Efficiency Project

TO Transmission Owner

TPL Transmission Planning Standards

TSR Transmission Service Request

TSTF Technical Study Task Forces

TVA Tennessee Valley Authority

UNDA Universal Non-disclosure Agreement

VLR Voltage and Local Reliability Study

WOTAB West of the Atchafalaya Basin

Contributors to MTEP17

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MISO would like to thank the many stakeholders who provided MTEP17 report comments, feedback, and edits. The creation of this report is truly a collaborative effort of the entire MISO region.

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