Book 4
Regional
Energy
Information
2016

Chapter 9

Regional Energy Information

2016

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.

By improving grid reliability and increasing the efficient use of generation, MISO saves the average residential customer $39 to $57 a year, at an annual expense of $5 per customer

MISO has 52 Transmission Owner members with more than $31.4 billion in transmission assets under MISO's functional control. MISO has 123 non-transmission owner members that contribute to the stability of the MISO markets.

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 $39 to $57 a year at an annual expense of $5 per customer. The MISO 2015 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 18.8 percent to 15.2 percent. This decrease delays the need to construct new capacity.
8. **Generator Availability Improvement** - MISO's wholesale power market improved power plant availability by 1.5 percent, delaying the need to construct new capacity.

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

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.

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).

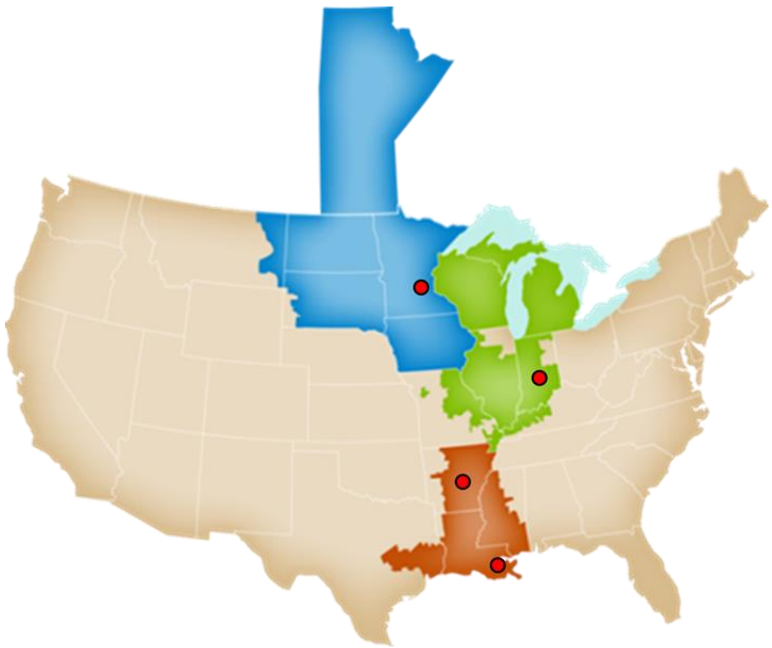


Figure 9.1-1: The MISO geographic footprint and office locations

MISO By The Numbers

Generation Capacity (as of September 2016)

- 176,559 MW (market)
- 191,985 MW (reliability)[2]

Historic Summer Peak Load (set July 20, 2011)

- 127,125 MW (market)
- 130,917 MW (reliability)[3]

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

- 109,307 MW (market)
- 117,629 MW (reliability)[4]

Miles of transmission

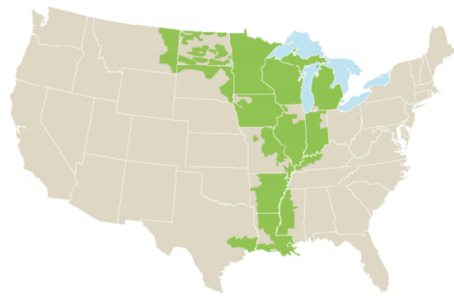
- 65,800 miles of transmission
- 8,400 miles of new/upgraded lines planned through 2023

Markets

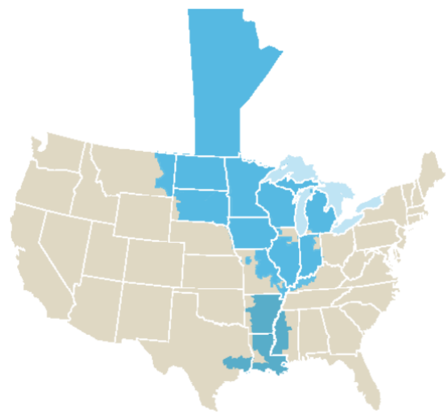
- $24.7 billion in annual gross market charges (2015)
- 2,545 pricing nodes
- 426 Market Participants serving more than 42 million people

Renewable Integration

- 15,215 MW active projects in the interconnection queue
- 14,995 MW wind in service
- 16,268 MW registered wind capacity
- 13,088 MW Historic Wind Peak (set Feb. 19, 2016)



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 2016 (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).

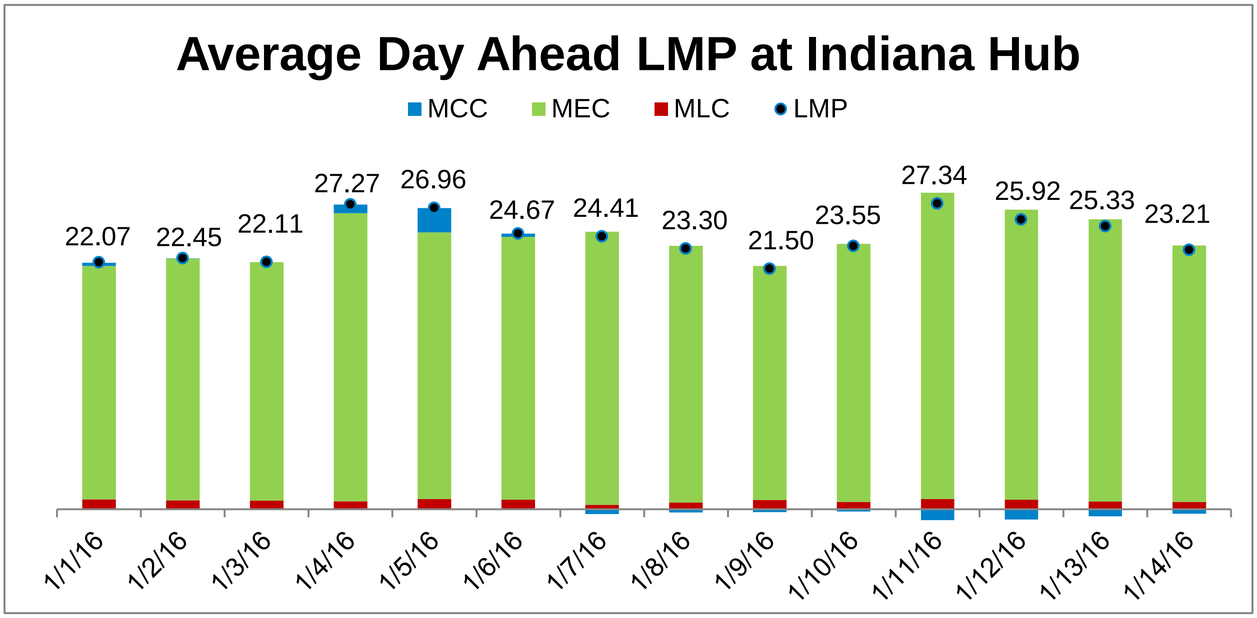


Figure 9.2-1: Average day-ahead LMP at the Indiana hub

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

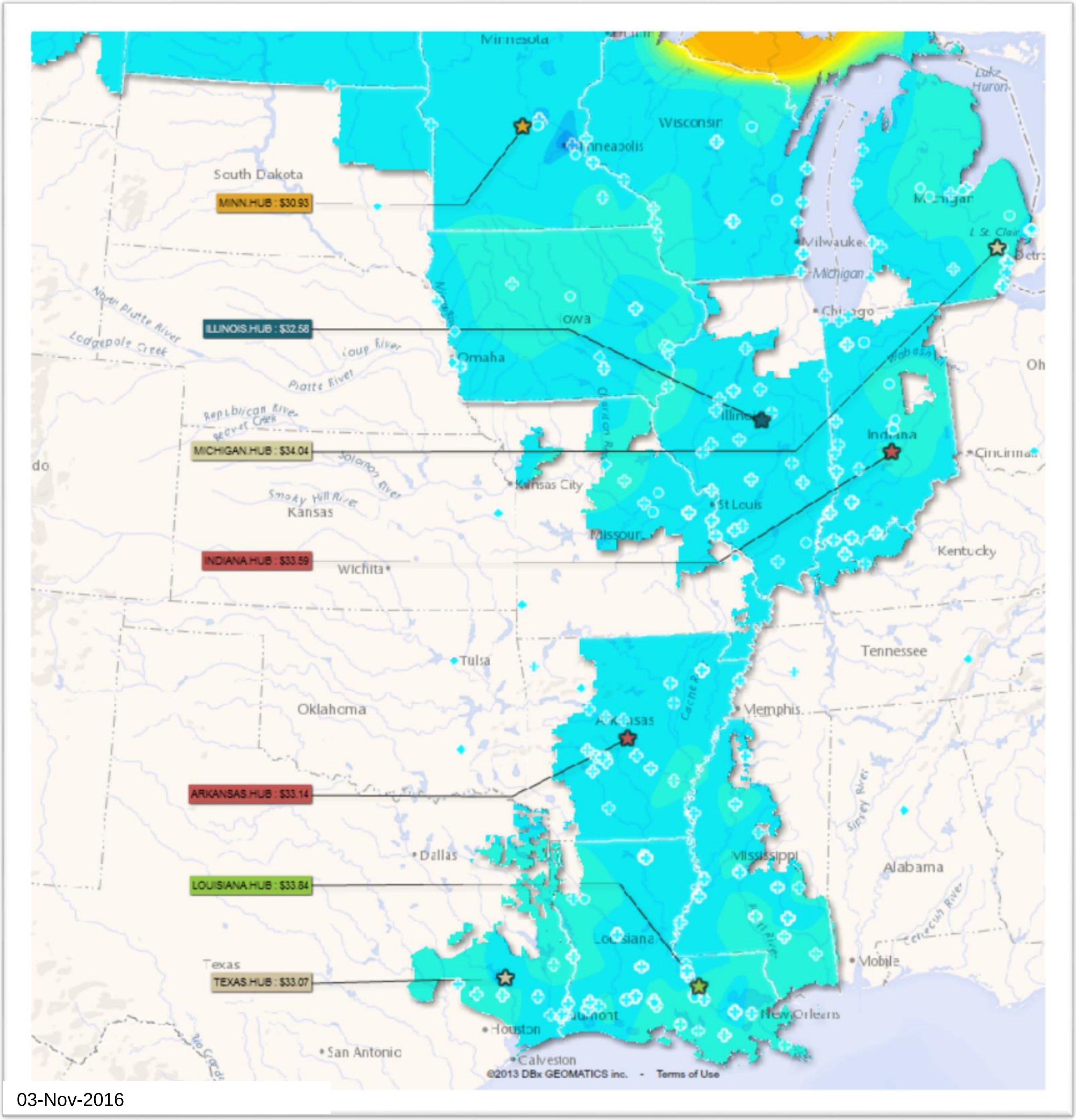


Figure 9.2-2: LMP contour map

Retail Electric Rates

The MISO-wide average retail rate, weighted by load in each state, for the residential, commercial and industrial sector, is 8.74 cents/kWh, about 14 percent lower than the national average of 9.99 cents/kWh. The average retail rate in cents per kWh varies by 3.9 cents/kWh per state in the MISO footprint (Figure 9.2-3).

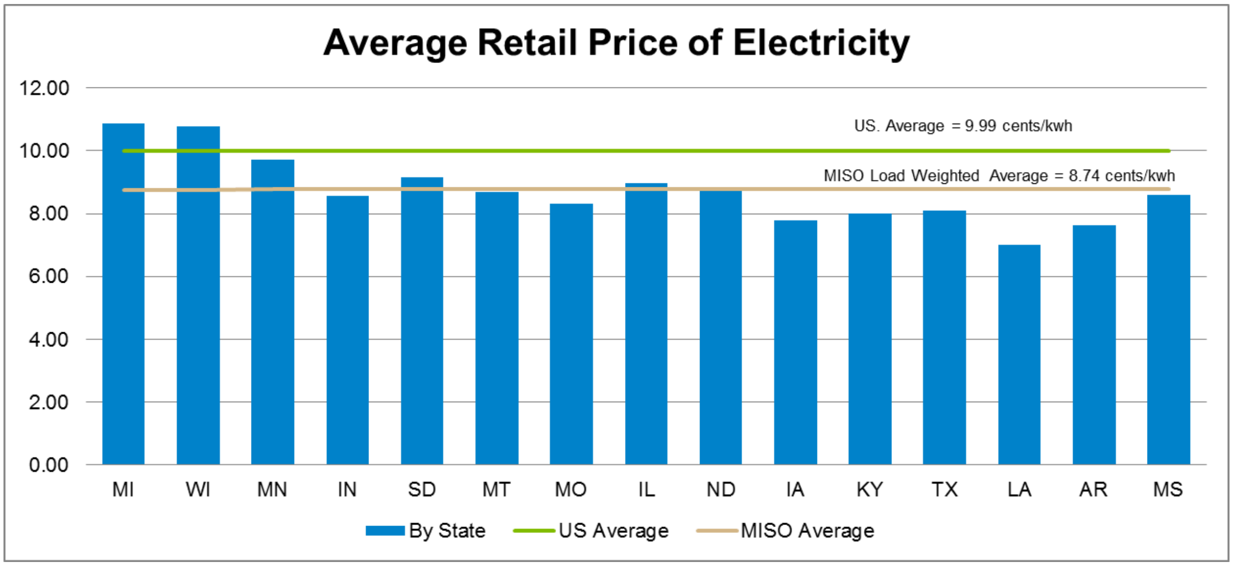


Figure 9.2-3: Average retail price of electricity per state[6]

[6] May 2014 EIA Electric Power Monthly with Load Ratio Share data calculated from December 2013 MISO Attachment O data

9.3 Generation

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 2015 to 2019, 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, 2015-2019					
	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	6	694	178	28,892	-173	-28,198
Petroleum	31	59	72	1,622	-41	-1,563
Natural Gas	389	54,893	131	7,887	258	47,006
Other Gases	3	403	--	--	3	403
Nuclear	3	3,322	1	610	2	2,712
Hydroelectric Conventional	66	1,088	22	433	44	655
Wind	198	21,624	6	60	192	21,564
Solar Thermal and Photovoltaic	627	13,220	1	1	626	13,219
Wood and Wood-Derived Fuels	5	199	6	37	-1	162.7
Geothermal	8	192	--	--	8	191.8
Other Biomass	57	263	32	52	25	211
Hydroelectric Pumped Storage	--	--	--	--	--	--
Other Energy Sources	20	579	2	1	18	578
U.S. Total	**1,412**	**96,536**	**451**	**39,594**	**961**	**56,942**

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, 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

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

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

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.

After the December 2013 integration of the South region, the percentage of generation from coal units decreases as the amount of generation from gas units increases as shown by trend lines (Figure 9.3-1).

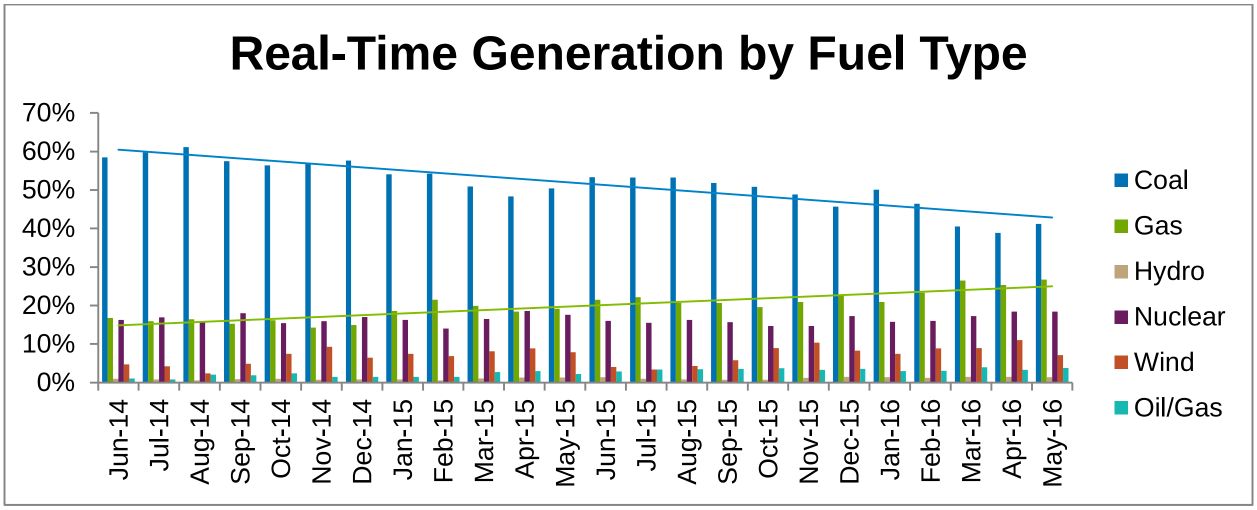
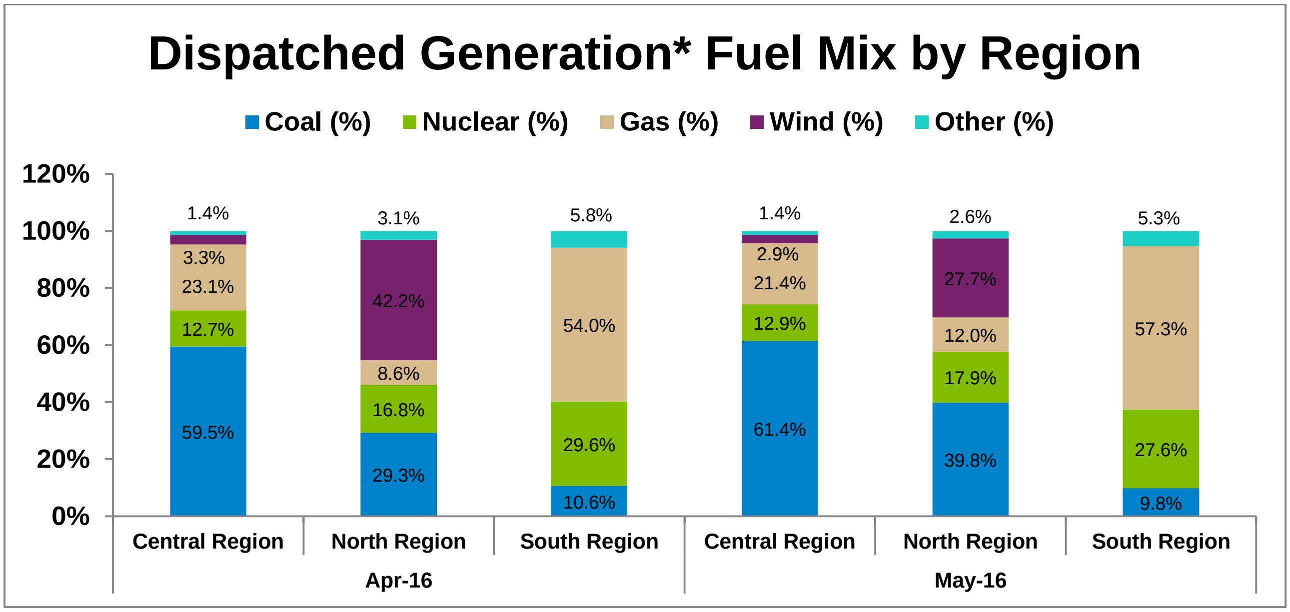


Figure 9.3-1: Real-time generation by fuel type

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			
Iowa	Standard		105	1999
Illinois	Standard	25%		2025
Indiana	Goal	10%		2025
Kentucky	None			
Louisiana	None			
Michigan	Standard	10%	1,100	2015
Minnesota	Standard: all utilities	25%		2025
	Xcel Energy	30%		2020
	Solar standard – investor-owned utilities	1.5%		2020
Missouri	Standard	15%		2021
Mississippi	None			
Montana	Standard	15%		2015
North Dakota	Goal	10%		2015
South Dakota	Goal	10%		2015
Texas	Standard		5,880	2015
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 15,106 MW of total registered wind capacity as of May 2016.

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].

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).

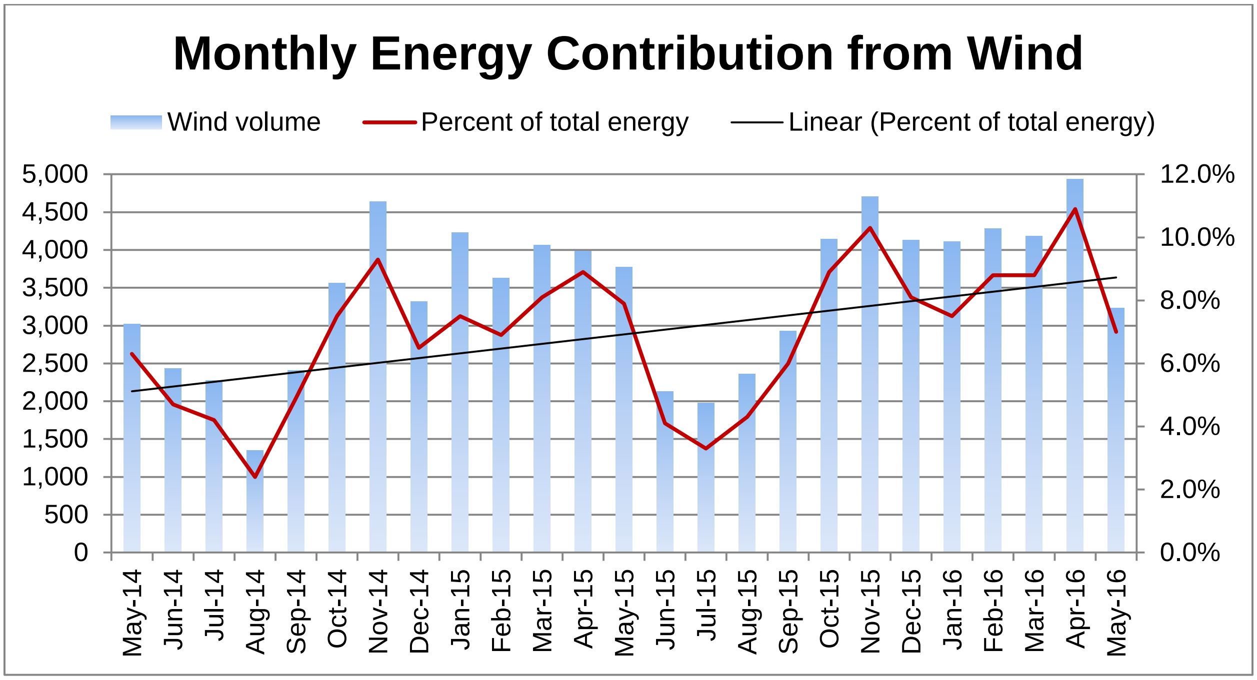


Figure 9.3-3: Monthly energy contribution from wind

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).

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

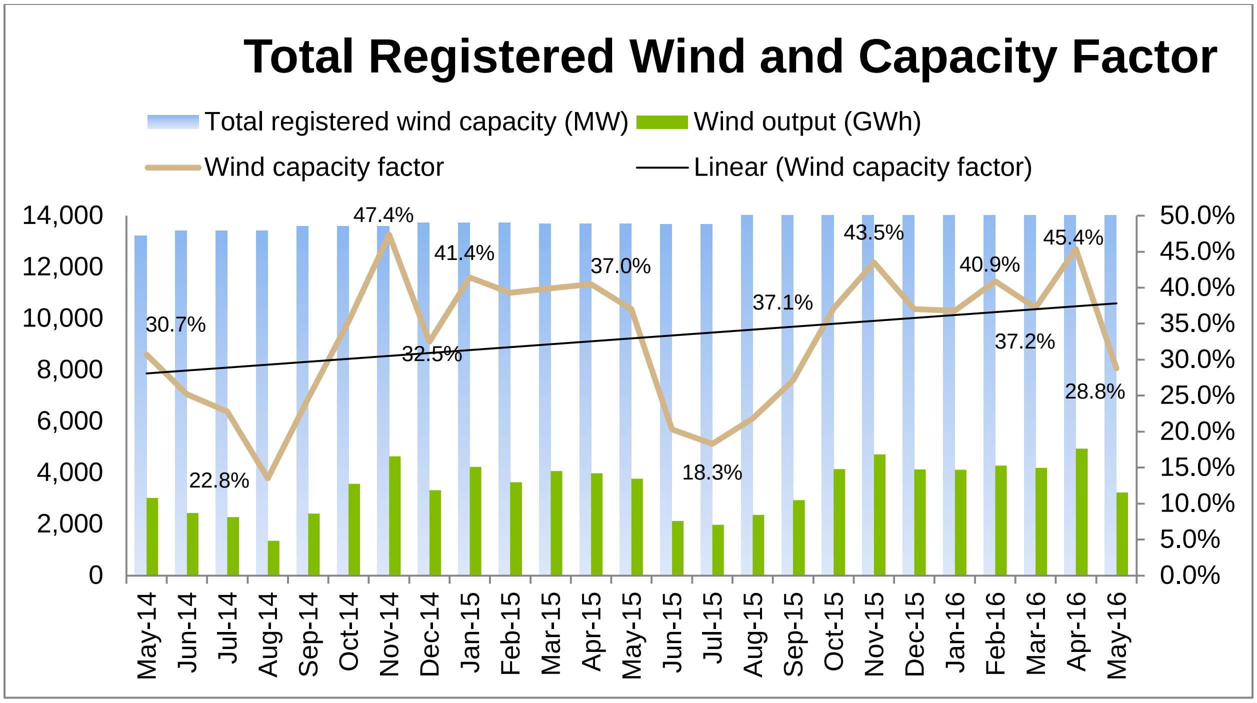


Figure 9.3-4: Total registered wind and capacity factor

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.

In 2014, with the addition of the South region, MISO set a new all-time winter instantaneous peak load of 109.3 GW on January 6. The new peak surpassed the previous all-time winter peak of 99.6 GW set in 2010.

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 2016 - 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	1,041	32.6%	877	27.4%	1,278	40.0%	3,195
Iowa	920	26.0%	895	25.3%	1,728	48.8%	3,543
Illinois	2,812	28.1%	3,828	38.3%	3,327	33.3%	10,004
Indiana	1,999	28.3%	1,764	25.0%	3,298	46.7%	7,063
Kentucky	1,610	30.5%	1,416	26.8%	2,250	42.6%	5,276
Louisiana	1,762	27.4%	1,823	28.4%	2,840	44.2%	6,426
Michigan	2,305	29.7%	2,969	38.2%	2,499	32.1%	7,774
Minnesota	1,485	31.2%	1,750	36.8%	1,525	32.0%	4,761
Missouri	1,960	38.3%	2,240	43.8%	914	17.9%	5,116
Mississippi	1,050	30.7%	999	29.2%	1,371	40.1%	3,419
Montana	369	33.5%	382	34.7%	349	31.7%	1,100
North Dakota	348	24.9%	463	33.1%	586	41.9%	1,398
South Dakota	329	36.6%	365	40.6%	206	22.9%	900
Texas	8,354	30.1%	10,575	38.1%	8,847	31.8%	27,790
Wisconsin	1,527	29.4%	1,789	34.5%	1,878	36.2%	5,193
	27,871	30.0%	32,135	34.6%	32,896	35.4%	92,958

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 2015, 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 365 days in 2015, these curves show the highest instantaneous peak load of 120,016 MW on July 29, 2015; the minimum load of 51,459 MW on May 3, 2015; and every day in order of load size. This data is reflective of the market footprint at the time of occurrence.

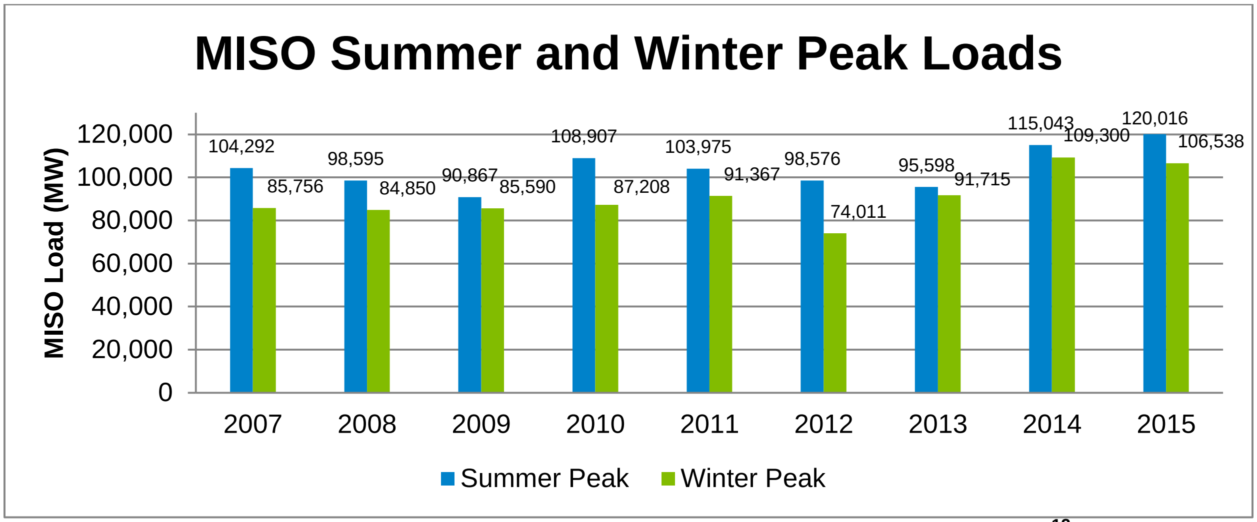


Figure 9.4-2: MISO Summer and Winter Peak Loads – 2007 through 2015[12]

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

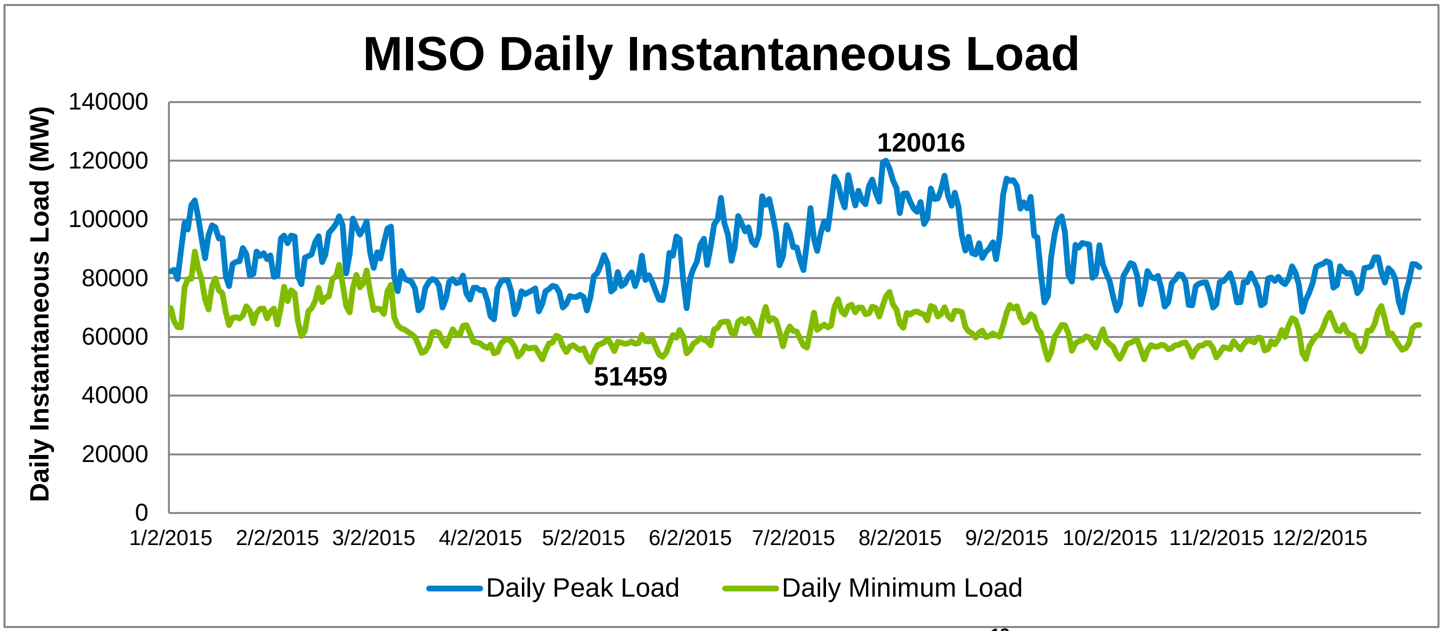


Figure 9.4-3: 2015 MISO - Daily Load[13]

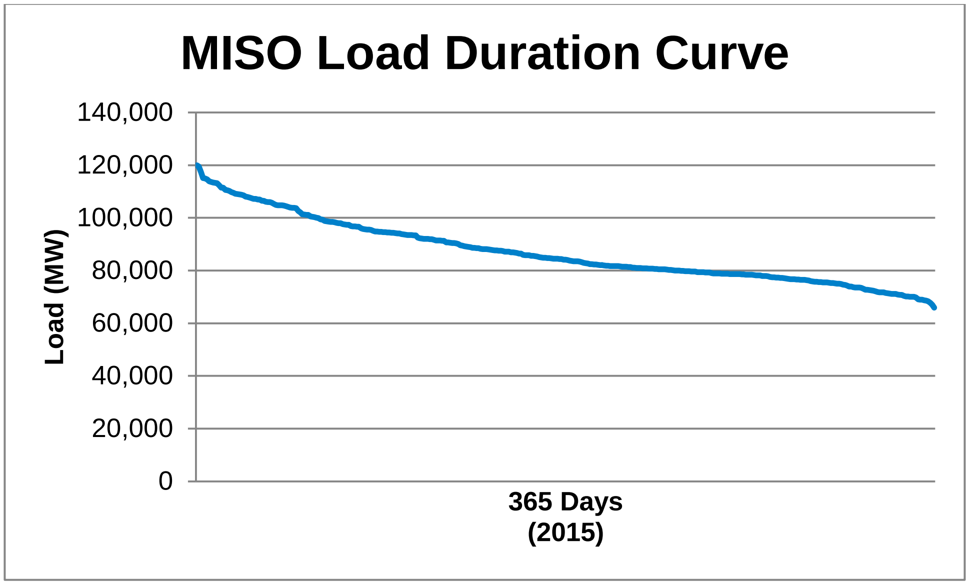


Figure 9.4-4: MISO Load Duration Curve – 2015[14]

[13] Source: MISO Market Data (2014)
[14] Source: MISO Market Data (2014)

Appendices

Most MTEP16 appendices[15] are available and accessible on the MISO public webpage. Confidential appendices, such as D2 - D8, are available on the MISO MTEP16 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: MTEP16 Appendix A new projects and existing projects

Appendix B: Projects with documented need and effectiveness

Appendix D: Reliability studies analytical details with mitigation plan[17]
- Section D.1: Project justification
- Section D.2: Modeling documentation
- Section D.3: Steady state
- Section D.4: Voltage stability
- Section D.5: Transient stability
- Section D.6: Generator deliverability
- Section D.7: Contingency coverage
- Section D.8: Nuclear plant assessment
- Section D.9: Planning Horizon Transfers
- Section D.10: Short Circuit Analysis

Appendix E: Additional MTEP16 Study support
- Section E.1: Reliability planning methodology
- Section E.2: Futures development

Appendix F: Stakeholder substantive comments

[15] https://www.misoenergy.org/Library/Pages/Results.aspx?q=MTEP16%20Appendix
[16] https://markets.midwestiso.org/MTEP/Studies/42/Study
[17] Appendix D is available on MISO's FTP site

Acronyms in MTEP16

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 MTEP16

MISO would like to thank the many stakeholders who provided MTEP16 report comments, feedback, and edits. The creation of this report is truly a collaborative effort of the entire MISO region.

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