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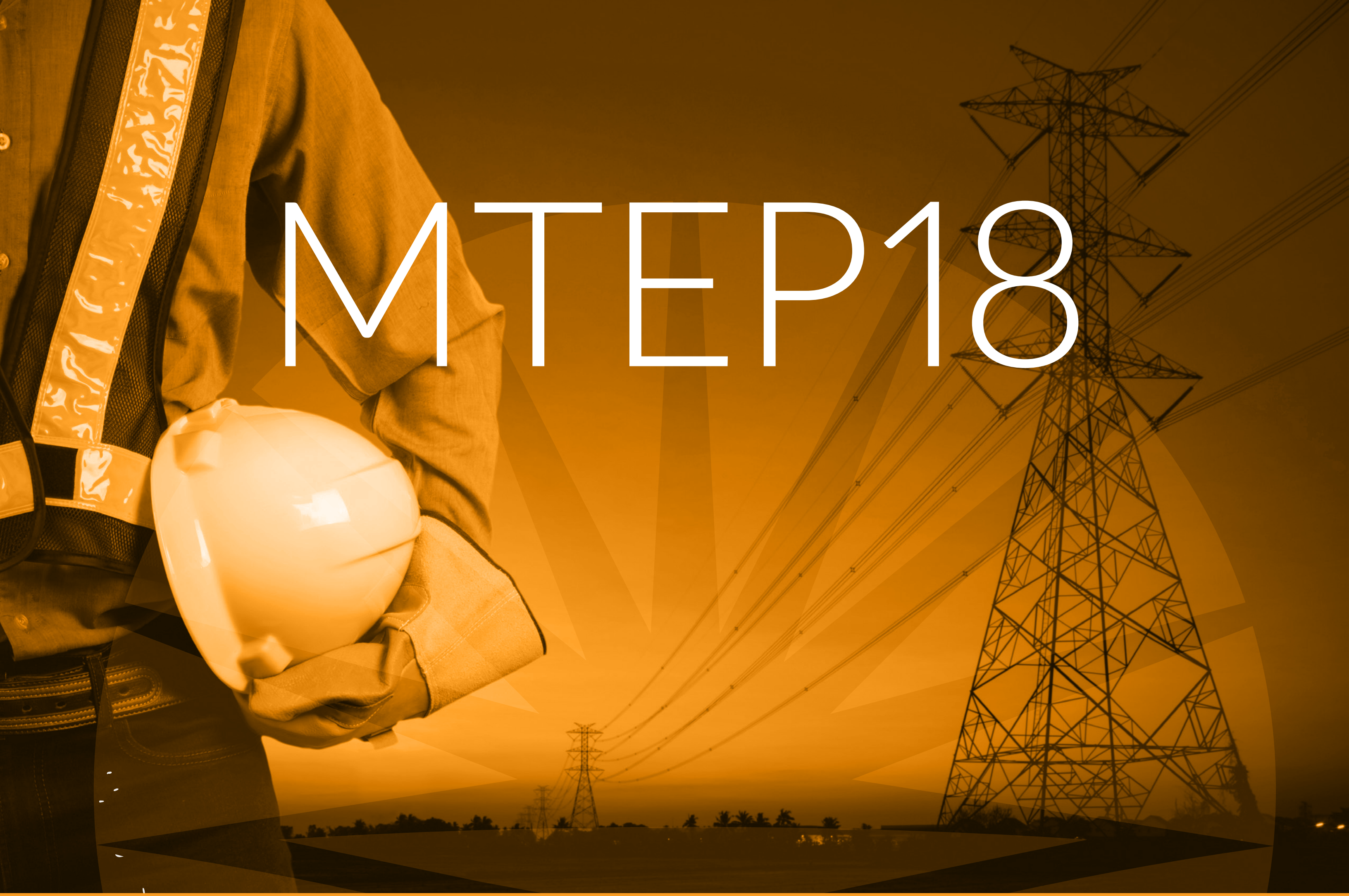

In this MISO Transmission Expansion Plan, MISO staff recommends $3.3 billion of new transmission enhancement projects for Board of Directors' approval.

BOOK 4

Regional Energy Information

MISO

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MTEP18

Regional Energy Information

Summary

The MISO footprint is not a monolithic area, but a dynamic region made up of different geographies, different generation mixes, varied pricing and conditions that affect load. Book 4 presents additional regional energy information to show a more complete picture of the regional energy system.

BOOK HIGHLIGHTS

- With its 50 Transmission Owner members, MISO has more than $37.9 billion in transmission assets under its functional control
- Planned generation additions and retirements in the U.S. from 2017 to 2021, separated by fuel type, shows the increased role natural gas and renewable energy sources will play in the future
- Load varies per time of year and geographic location. For calendar year 2017, the highest instantaneous peak load occurred on July 20 at 120,644 MW; the lowest load happened April 9 at 51,898 MW.

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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 51 Transmission Owner members with more than $37.9 billion in transmission assets under its functional control. MISO has 131 non-transmission owner members that contribute to the stability of the MISO markets.

MISO has 51 Transmission Owner members with more than $37.9 billion in transmission assets under MISO's functional control. MISO has 131 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. The MISO's 2017 Value Proposition[1] affirms the company's core belief that a collective, region-wide approach to grid planning and management delivers the greatest benefits. MISO's landmark analysis serves as a model for other grid operators and transparently communicates the benefits in everything it does.

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, significantly less regulation is required within the MISO footprint. This is due to one centralized footprint regulation target rather than multiple non-coordinated targets across the footprint.
4. **Spinning Reserves** - Starting with the formation of the CRSG and continuing with the Spinning Reserve Market, the total spinning reserve requirement has been significantly reduced. Reduced requirement frees up low-cost capacity to meet energy market needs.
5. **Wind Integration** - MISO's regional planning enables more economic placement of wind resources in the North/Central 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 22.15 percent to 15.80 percent. This decrease delays the need to construct new capacity.

[1] https://www.misoenergy.org/about/miso-value-proposition/

8. **Generator Availability Improvement** - MISO's wholesale power market improved power plant availability in the North/Central region by 0.84 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.

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., Little Rock, Ark., and Eagan, Minn. (Figure 9.1-1).

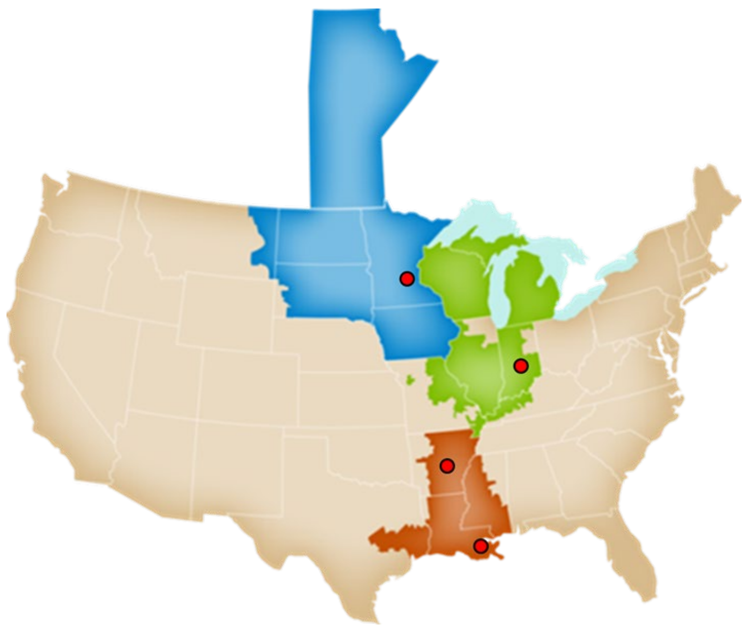


Figure 9.1-1: The MISO geographic footprint and office locations

MISO by the Numbers

Generation Capacity (as of June 2018)

- 172,196 MW (market)
- 188,584 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)

- 109,336 MW (market)
- 117,903 MW (reliability)[4]

Miles of transmission

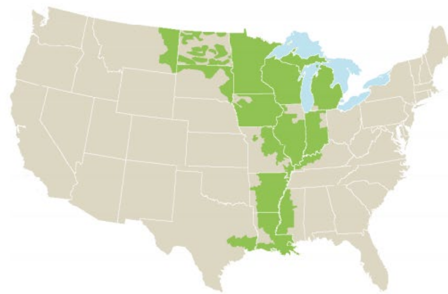
- 65,800 miles of transmission
- 383 approved new projects in MTEP17, representing $2.7 billion investment and 7,100 miles of new transmission

Markets

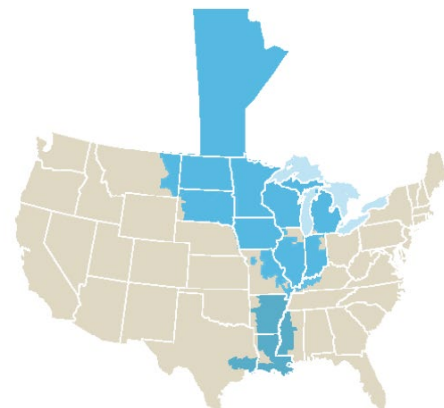
- $25.3 billion in annual gross market charges (2017)
- 453 Market Participants serving approximately 42 million people

Renewable Integration (June 2018)

- 17,117 MW Registered In-Service Wind Generation Capacity
- 18,204 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 2018 (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).

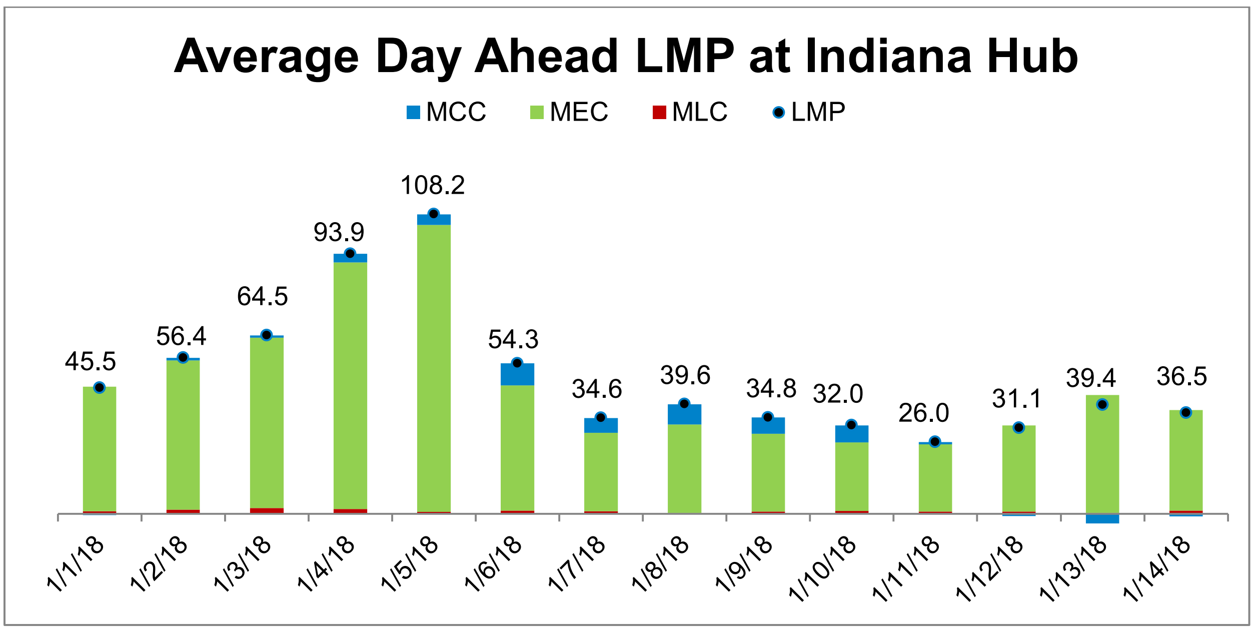


Figure 9.2-1: Average day-ahead LMP at the Indiana hub

[5] Markets and Operations Real-Time Displays: https://www.misoenergy.org/markets-and-operations/real-time-displays/

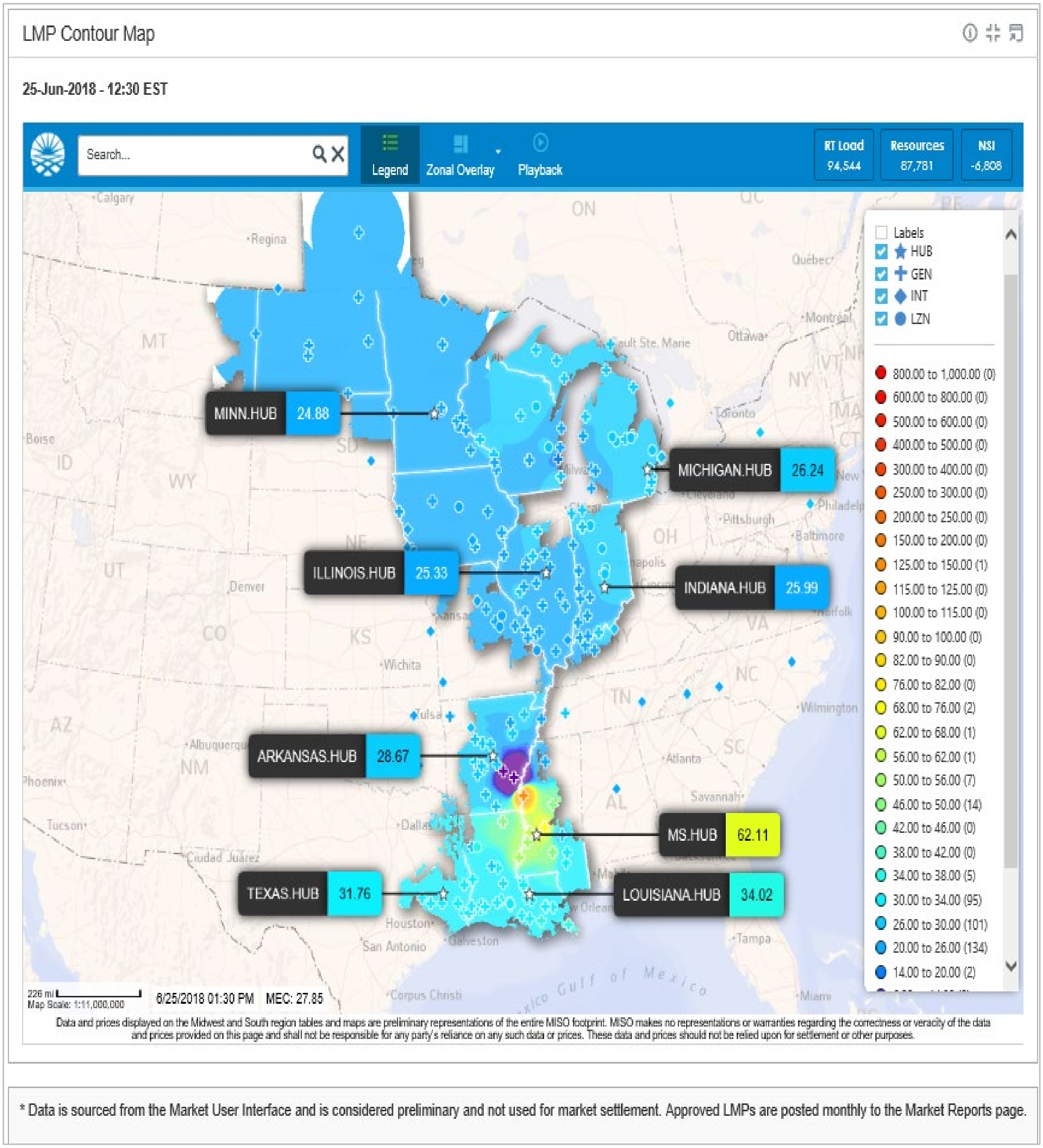


Figure 9.2-2: LMP contour map

Retail Electric Rates

The MISO-wide average retail rate, weighted by load in each state, for the residential, commercial and industrial sector, is 9.12 cents/kWh, about 11 percent lower than the national average of 10.23 cents/kWh. The average retail rate in cents per kWh varies by 4.2 cents/kWh per state in the MISO footprint (Figure 9.2-3).

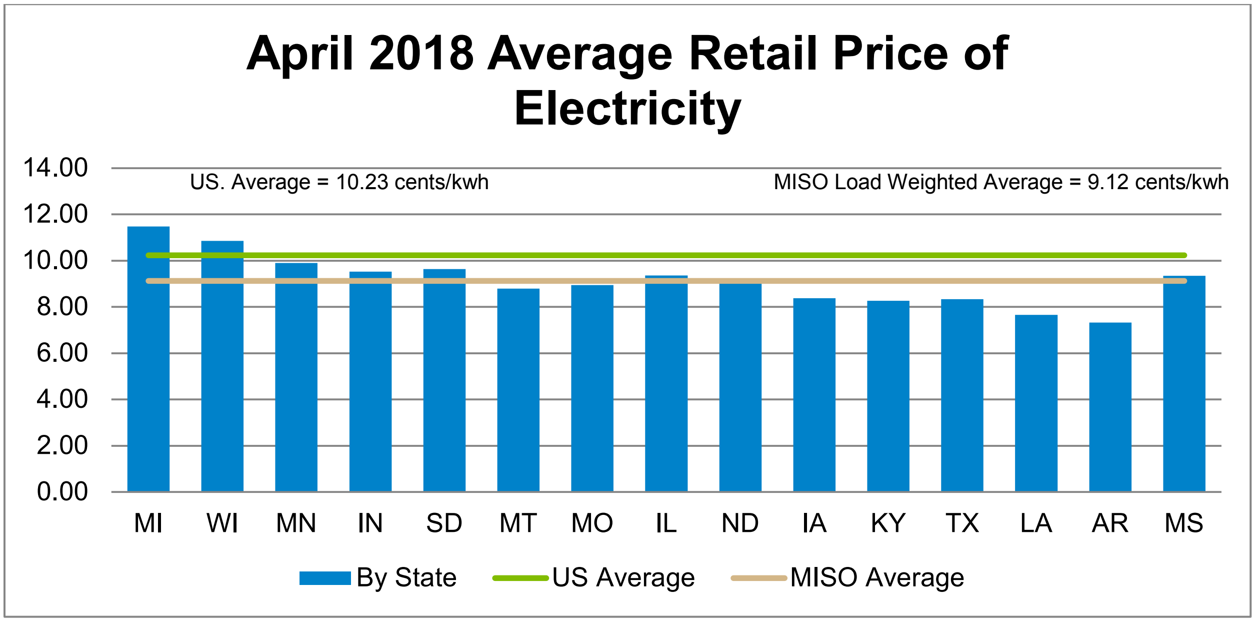


Figure 9.2-3: Average retail price of electricity per state[6]

[6] April 2018 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 aging 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 2017 to 2021, 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, 2017-2021					
Energy Source	Generator Additions		Generator Retirements		Net Capacity Additions	
	Number of Generators	Net Summer Capacity (MW)	Number of Generators	Net Summer Capacity (MW)	Number of Generators	Net Summer Capacity (MW)
Coal	2	292	76	19,049	-74	-18,757
Petroleum	22	33	52	948	-30	-915
Natural Gas	421	69,374	131	12,121	290	57,253
Other Gases	4	513	--	--	4	513
Nuclear	4	4,400	3	2,088	1	2,312
Hydroelectric Conventional	35	600	18	221	17	379
Wind	190	25,421	7	59	183	25,362
Solar Thermal and Photovoltaic	740	14,261	5	2	735	14,259
Wood and Wood-Derived Fuels	5	313	5	73	--	239
Geothermal	5	187	2	60	3	127
Other Biomass	47	202	23	14	24	188
Hydroelectric Pumped Storage	--	--	--	--	--	--
Other Energy Sources	45	567	--	--	45	567
U.S. Total	1,520	116,161	322	34,635	1,198	81,527

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

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

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 began to decrease as the amount of generation from gas units increased, as shown by trend lines (Figure 9.3-1).

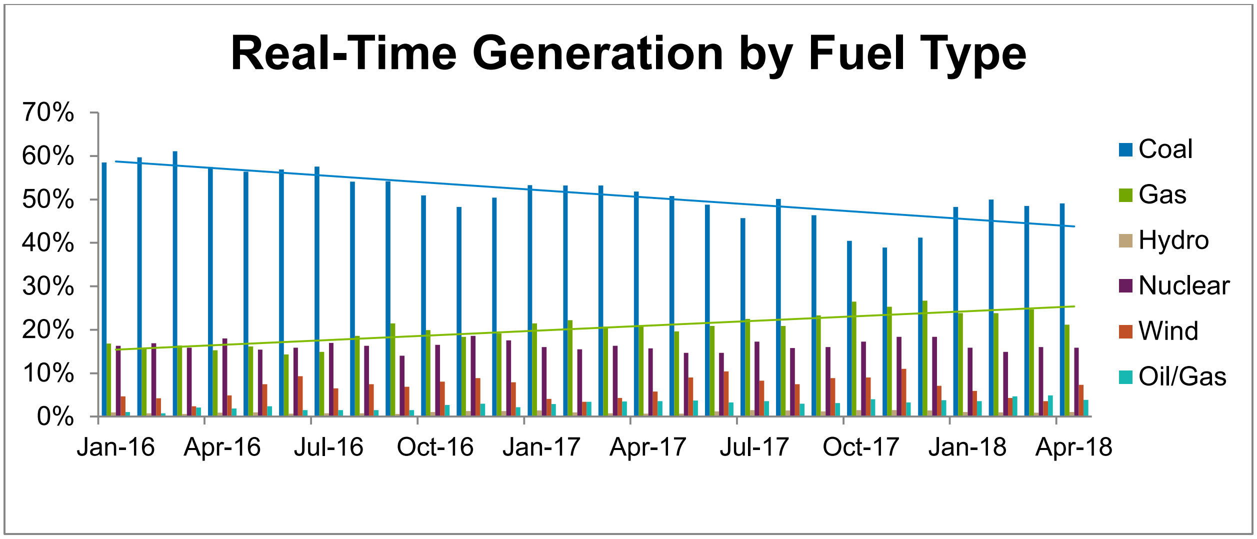
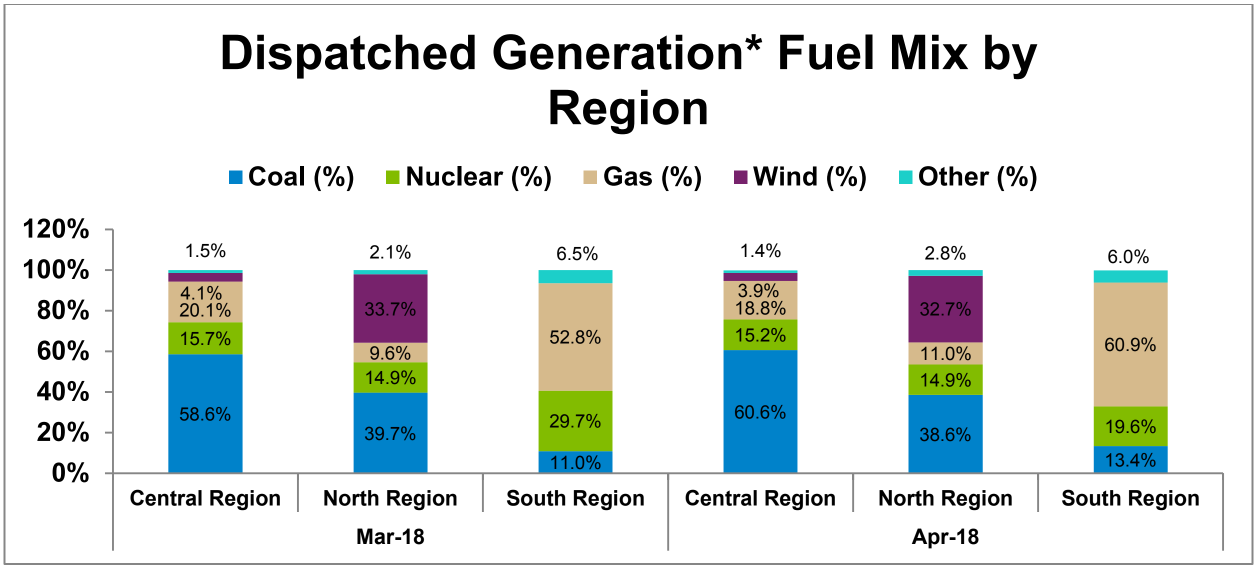


Figure 9.3-1: Real-time generation by fuel type

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.](https://www.misoenergy.org/markets-and-operations/real-time-displays/)[8]

[8] https://www.misoenergy.org/markets-and-operations/real-time-displays/



* Based on 5-minute unit level dispatch target

Figure 9.3-2: Dispatched generation fuel mix by region

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	10%		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 17,071 MW of total registered wind capacity as of April 2018.

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/markets-and-operations/real-time-displays/

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).

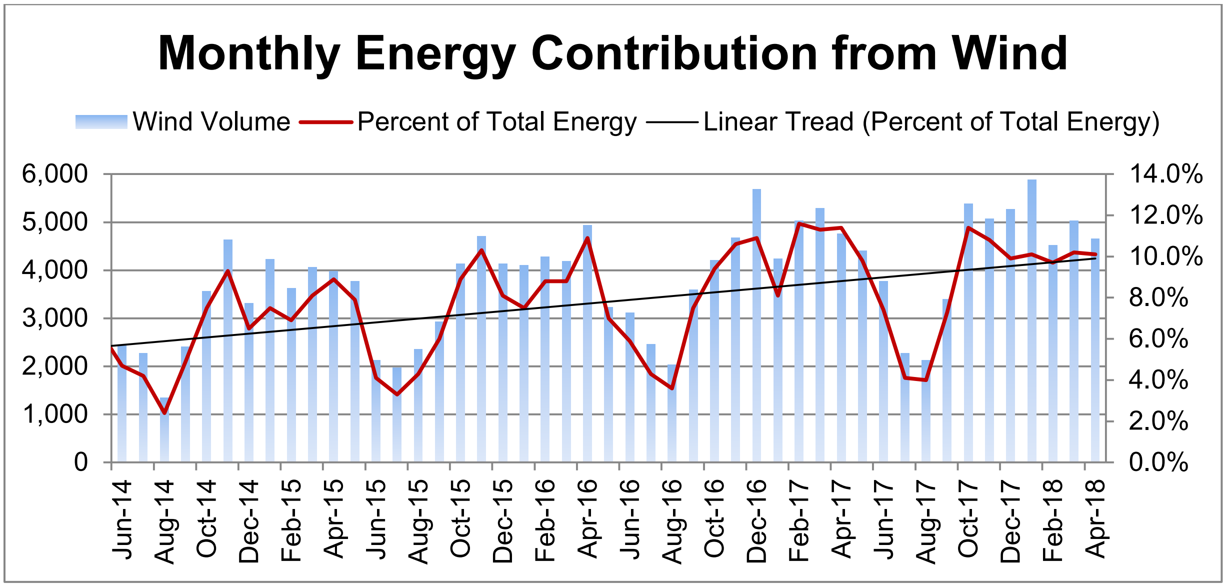


Figure 9.3-3: Monthly energy contribution from wind

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).

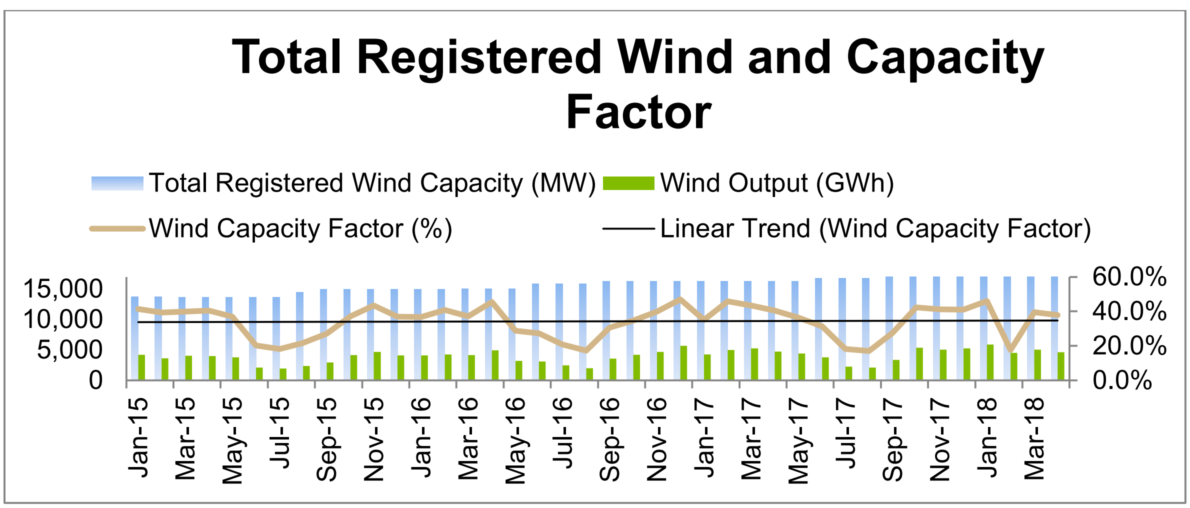


Figure 9.3-4: Total registered wind and capacity factor

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

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 than 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 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	1,128	33.0%	870	25.5%	1,417	41.5%	3,415
Iowa	1,050	26.9%	953	24.4%	1,901	48.7%	3,905
Illinois	3,046	30.0%	3,762	37.0%	3,305	32.5%	10,156
Indiana	2,262	30.7%	1,776	24.1%	3,336	45.2%	7,376
Kentucky	1,787	33.0%	1,392	25.7%	2,229	41.2%	5,408
Louisiana	1,810	27.8%	1,799	27.6%	2,904	44.6%	6,514
Michigan	2,467	31.6%	3,029	38.8%	2,317	29.7%	7,813
Minnesota	1,636	32.2%	1,768	34.8%	1,669	32.9%	5,075
Missouri	2,368	42.3%	2,323	41.5%	901	16.1%	5,594
Mississippi	1,126	32.2%	999	28.6%	1,368	39.2%	3,492
Montana	421	35.5%	401	33.8%	363	30.6%	1,185
North Dakota	407	25.6%	525	33.0%	658	41.4%	1,590
South Dakota	393	39.3%	389	38.9%	217	21.7%	1,000
Texas	8,745	31.5%	10,318	37.2%	8,665	31.2%	27,743
Wisconsin	1,633	30.3%	1,840	34.1%	1,916	35.6%	5,389
Total	30,279	31.7%	32,144	33.6%	33,166	34.7%	95,655

Table 9.4-1: Retail sales of electricity to ultimate customers by end-use sector, April 2017[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 2017, 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 Duration Curve shows load characteristics over time (Figure 9.4-4). Looking at all 365 days in 2017, these curves show the highest instantaneous peak load of 120,644 MW on July 20, 2017; the minimum load of 51,898 MW on April 9, 2017; and every day in order of load size. This data is reflective of the market footprint at the time of occurrence.

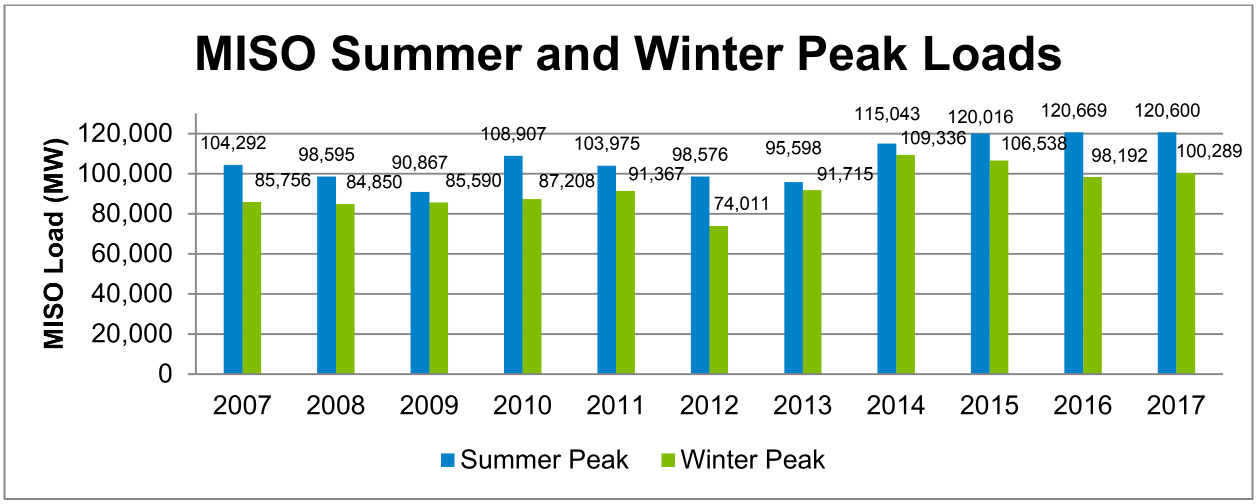


Figure 9.4-2: MISO Summer and Winter Peak Loads – 2007 through 2017[12]

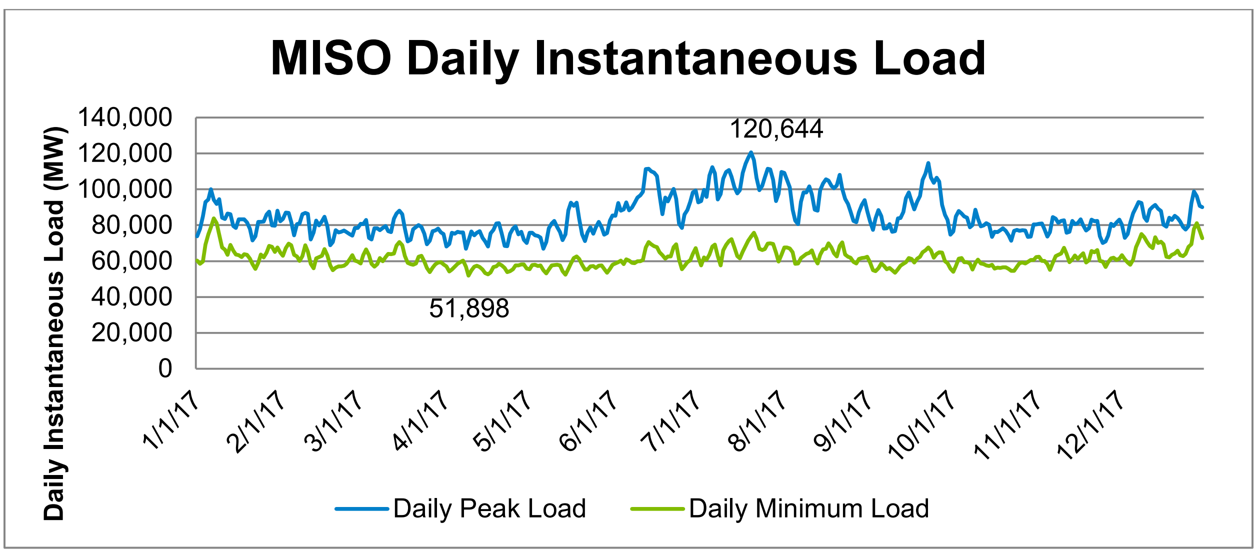


Figure 9.4-3: 2017 MISO - Daily Load[13]

[12] Source: MISO Market Data (MISO 2017 Summer and Winter Assessment Reports)

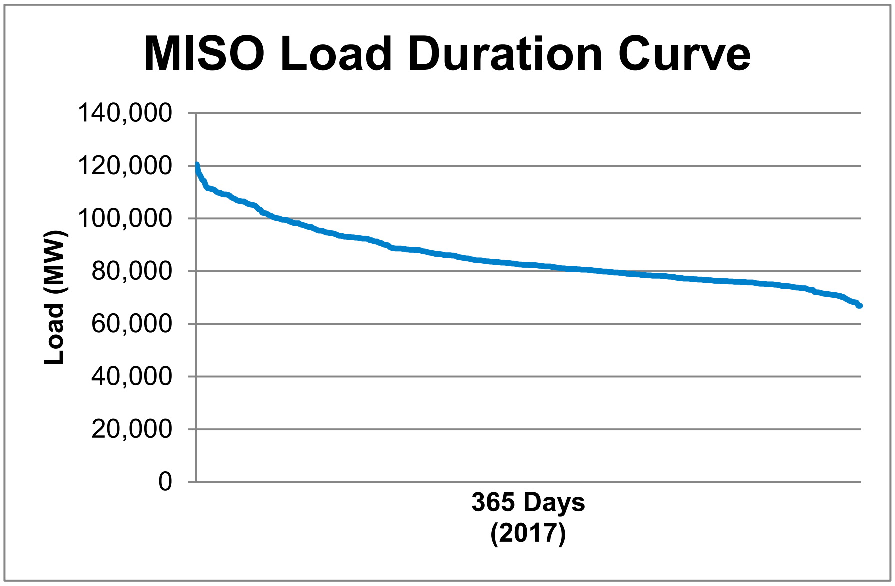


Figure 9.4-4: MISO Load Duration Curve – 2017[14]

[13] Source: MISO Market Data (2017)
[14] Source: MISO Market Data (2017)

Appendices

Most MTEP18 appendices[15] are available and accessible on the MISO public webpage. Confidential appendices, such as D3 through D10, are available on the MISO MTEP18 Planning Portal. 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: MTEP18 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 MTEP18 Study support
Section E.1: Reliability planning methodology
Section E.2: Futures development

Appendix F: MTEP18 Stakeholders Feedback

[15] https://www.misoenergy.org/planning/transmission-studies-and-reports/#nt=%2Freport-study-analysistype%3AMTEP%2Fmtepdoctype%3AMTEP%20Report%2Fmtepreportyear%3AMTEP18&t=10&p=0&s=&sd=

Acronyms in MTEP18

ABB	ASEA Brown Boveri
AC	Alternating Current
AEG	Applied Energy Group
AFC	Accelerated Fleet Change
AMIL	Ameren Illinois
APC	Adjusted Production Cost
ARR	Auction Revenue Rights
BPM	Business Practices Manual
BRP	Baseline Reliability Projects
BTMG	Behind-the-meter Generation
CAGR	Compound Annual Growth Rate
CBBRP	Cross Border Baseline Reliability Projects
CFC	Continued Fleet Change
CT	Combustion Turbine
CEII	Critical Energy Infrastructure Information
CEL	Capacity Export Limit
CIL	Capacity Import Limit
CO_2	Carbon Dioxide
CP	Coincident Peak
CPCN	Certificate of Public Convenience and Necessity
CROW	Control Room Operator’s Window
DCLM	Direct control load management
DET	Distributed and Emerging Technologies
DG	Distributed Generation
DPP	Definitive Planning Phase
DPV	Distributed Solar Photovoltaic
DR	Demand Response
EE	Energy Efficiency
EER	Energy Efficiency Resource
EGEAS	Electric Generation Expansion Analysis System
EIA	Energy Information Agency
EIPC	Eastern Interconnection Planning Collaborative
ELCC	Effective Load Carrying Capability
EPA	Environmental Protection Agency (U.S.)
ERAG	Eastern Reliability Assessment Group
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
GVTC	Generator Verification Test Capacity
IESO	Independent Electricity System Operator of Ontario
IL	Interruptible Load
ILF	Independent Load Forecast
IMEP	Interregional Market Efficiency Project
IPSAC	Interregional Planning Stakeholder Advisory Committee
JOA	Joint Operating Agreement
LBA	Local Balancing Authority
LCR	Local Clearing Requirements
LFC	Limited Fleet Change
LFU	Load Forecast Uncertainty
LG&E	Louisville Gas and Electric Co.
LMP	Locational marginal price
LMR	Load Modifying Resources
LOLE	Loss of Load Expectation
LRR	Local Reliability Requirement
LRZ	Local Resource Zones
LSE	Load Serving Entity
LTRA	Long-Term Resource Assessment
LTTR	Long-Term Transmission Rights
MATS	Mercury and Air Toxics Standard
MCC	Marginal Congestion Component
MCPS	Market Congestion Planning Studies
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
NCP	Non-coincident Peak
NERC	North American Electric Reliability Corp.
NRIS	Network Resource Interconnection Service
OASIS	Open Access Same-Time Information System
OMS	Organization of MISO States
OOS	Out of Service
PAC	Planning Advisory Committee
PC	Project Candidate
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	Present Value
RAN	Resource Availability and Need
RE	Regional Entities
RECB	Regional Expansion Criteria and Benefits
RGOS	Regional Generator Outlet Study
RIIA	Renewable Integration Impact Assessment
ROW	Right of Way
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
SOCO	Southern Colorado Transmission Co.
SPC	System Planning Committee
SPM	Subregional Planning Meetings
SPP	Southwest Power Pool
SREC	Sub-Regional Export Constraint
SSR	System Support Resource
SUFG	State Utility Forecasting Group
TDSP	Transmission Delivery Service Project
TIS	Total Interconnection Service
TMEP	Targeted Market Efficiency Project
TO	Transmission Owner
TPL	Transmission Planning Standards
TPZ	Transmission Planning Zone
TSR	Transmission Service Request
TSTF	Technical Study Task Forces
TVA	Tennessee Valley Authority
UNDA	Universal Non-disclosure Agreement
UPV	Utility-scale photovoltaic
WOTAB	West of the Atchafalaya Basin

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MISO would like to thank the many stakeholders who provided MTEP18 report comments, feedback and edits. The creation of this report is truly a collaborative effort of the entire MISO region.

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