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

BOOK 2
Resource Adequacy
Summary

Resource Adequacy requires enough capacity be available to meet the needs of all consumers in the MISO footprint to meet peak load serving needs. To achieve this, MISO supports its states and load-serving entities by providing projected risks and continuously works to improve transparency into near and long-term resource requirements.

A convergence of trends, including an aging generation fleet and growth of variable energy resources, has required MISO to look at existing processes to support states' and load-serving entities' efforts to satisfy their Resource Adequacy requirements. Improvements in MISO processes will benefit the system through ensuring sufficient energy is able to meet operational needs in all times of the year.

BOOK HIGHLIGHTS

- The footprint has sufficient resources to meet peak load for 2019. Risks exist in subsequent years as generation retires and is replaced by often lower-capacity resources like wind and solar, as well as Load Modifying Resources currently accessible only through the declaration of emergency operations.
- MISO is currently investigating how to ensure the efficient conversion of capacity cleared in the Planning Resource Auction into energy needed by real-time operations through its Resource Availability and Need (RAN) effort.
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Section 6: Resource Adequacy

6.0 Resource Adequacy Introduction and Enhancements
6.1 Planning Reserve Margin
6.2 Long Term Resource Assessment
6.3 Seasonal Resource Assessment
6.0 Resource Adequacy
Introduction and Enhancements

MISO’s ongoing goal is to support the achievement of Resource Adequacy — to ensure enough capacity is available to meet the needs of all consumers in the MISO footprint during all time frames and at just, reasonable rates. The responsibility for Resource Adequacy does not lie with MISO, but rather rests with load-serving entities and the states oversee them (as applicable by jurisdiction). MISO’s role in resource adequacy is to support these entities and provide transparency into near- and long-term resource requirements. Additional Resource Adequacy goals include maintaining confidence in the attainability of Resource Adequacy in all time horizons, building confidence in MISO’s Resource Adequacy assessments and providing sufficient transparency and market mechanisms to mitigate potential shortfalls.

Five guiding principles provide the framework necessary to achieve these goals:

1. Resource Adequacy processes must ensure confidence in Resource Adequacy outcomes in all time horizons
2. MISO will work with stakeholders to ensure an effective and efficient Resource Adequacy construct with appropriate consideration of all eligible internal and external resources and resource types and recognition of legal/regulatory authorities and responsibilities
3. MISO will determine adequacy at the regional and zonal level and provide appropriate regional and zonal Resource Adequacy transparency and awareness for multiple forward time horizons
4. MISO will administer and evolve processes in a manner that provides transparency and reasonable certainty, and that appropriately protects individual market participant proprietary information in order to support efficient stakeholder resource and transmission investment decisions
5. MISO’s resource planning auction and other processes will support multiple methods of achieving and demonstrating Resource Adequacy, including self-supply, bilateral contracting and market-based acquisition

To date, the Resource Adequacy process has been a successful tool for facilitating and demonstrating Resource Adequacy in the near term, through such tools as the Loss of Load Expectation (LOLE) analysis, the Planning Resource Auction, and the Organization of MISO States (OMS) MISO Survey.

However, evolving market conditions at MISO have resulted in a resource portfolio with changed operational characteristics and less-certain available capacity. In the past, a Maximum Generation (MaxGen) Emergency occurred infrequently, with resource adequacy risk being focused on summer peak needs. In comparison, there have been more than 12 emergency events since the start of the 2016/17 Planning Year, occurring in all four seasons.

As a result, MISO began an effort to focus on the conversion of capacity to available energy, called Resource Availability and Need (RAN). The RAN effort will focus on:

1. Ensuring expected resource outages are matched with commitments
2. Examining, in close cooperation with state regulators, the characteristics of emergency only resources and their requirements in MISO processes
3. Committing capacity to meet resource needs throughout the year (Seasonal Resource Adequacy)
4. Ensuring resource attributes are sufficient to support reliability in light of the changing fleet characteristics (Essential Reliability Services)
6.1 Planning Reserve Margin

The MISO Installed Capacity Planning Reserve Margin (PRM ICAP) for the 2018-2019 planning year, spanning from June 1, 2018, through May 31, 2019, is 17.1 percent, an increase of 1.3 percentage points from the 15.8 percent PRM set in the 2017-2018 planning year (Figure 6.1-1).

The PRM ICAP is established with resources at their installed capacity rating at the time of the system-wide MISO coincident peak load. The 1.3 percentage point PRM ICAP increase was the net effect of an increase in forced outage rates and reduction in load forecasts.

As directed under Module E-1 of the MISO Tariff, MISO coordinates with stakeholders to determine the appropriate Planning Reserve Margin (PRM) for the applicable planning year based upon the probabilistic analysis of the ability to reliably serve MISO Coincident Peak Demand for that planning year. The probabilistic analysis uses a Loss of Load Expectation (LOLE) study that assumes no internal transmission limitations within the MISO region. MISO calculates the PRM such that the LOLE for the next planning year is one day in 10 years, or 0.1 days per year. The minimum amount of capacity above Coincident Peak Demand in the MISO region required to meet the reliability criteria is used to establish the PRM. The PRM is established as an unforced capacity (PRM UCAP) requirement based upon the weighted average forced outage rate of all Planning Resources in the MISO region.
The LOLE study and the deliverables from the LOLE Working Group are based on the Resource Adequacy construct per Module E-1. MISO performs an annual LOLE study to determine the congestion-free PRM on an installed and unforced capacity basis for the MISO system. In addition, a per-unit zonal Local Reliability Requirement (LRR) for the planning year is determined for each Local Resource Zone (LRZ) (Figure 6.1-2), which is defined as the amount of resources a particular area needs to meet the LOLE criteria of one day in 10 years without the benefit of importing capacity. These results are merged with the Capacity Import Limit (CIL), Capacity Export Limit (CEL) and Wind Capacity Credit results to form the deliverables to the annual Planning Resource Auction.

### Figure 6.1-2: Local Resource Zones (LRZ)

#### 2018-2019 Deliverables to the Planning Resource Auction

The PRM deliverables are needed for the Planning Resource Auction (PRA). These deliverables include the PRM UCAP, a per-unit zonal LRR, and CIL and CEL values (Table 6.1-1).

The PRM UCAP\(^1\) increased from 7.8 percent in the 2017-2018 LOLE report to 8.4 percent in the 2018-2019 LOLE report due to the modeling parameter changes. More information on the increase is available in the 2018 LOLE report\(^2\). Under the existing construct, the PRM UCAP is applied to the peak of each load-serving entity coincident with the MISO peak. A zonal CIL and CEL for each LRZ was calculated with the monitored and contingent elements reported (Tables 6.1-2 and 6.1-3; Figures 6.1-3 and 6.1-4). Adjustments were made to CIL based on a December 31, 2015, FERC order to reflect resources committed to non-MISO load. The ultimate PRM, CIL and CEL values for a zone could be adjusted within the PRA depending on the demand forecasts received and offers into the auction to assure that the

---

\(^1\) PRM UCAP is the value accounting for the forced outage rate of capacity. More information on this calculation may be found in the LOLE report.

resources cleared in the auction can be reliably delivered. Most CIL values for the 2018-2019 Planning Resource Auction\(^3\) were revised from the initial values calculated in the 2018 LOLE report to reflect changes in imports and exports submitted to the PRA (Table 6.1-1, Tables 6.1-2 and 6.1-3).

<table>
<thead>
<tr>
<th>PRA and LOLE Metrics</th>
<th>LRZ 1</th>
<th>LRZ 2</th>
<th>LRZ 3</th>
<th>LRZ 4</th>
<th>LRZ 5</th>
<th>LRZ 6</th>
<th>LRZ 7</th>
<th>LRZ 8</th>
<th>LRZ 9</th>
<th>LRZ 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default Congestion Free PRM UCAP</td>
<td>8.4%</td>
<td>8.4%</td>
<td>8.4%</td>
<td>8.4%</td>
<td>8.4%</td>
<td>8.4%</td>
<td>8.4%</td>
<td>8.4%</td>
<td>8.4%</td>
<td>8.4%</td>
</tr>
<tr>
<td>LRR UCAP per-unit of LRZ Peak Demand</td>
<td>1.148</td>
<td>1.186</td>
<td>1.152</td>
<td>1.216</td>
<td>1.239</td>
<td>1.144</td>
<td>1.153</td>
<td>1.267</td>
<td>1.127</td>
<td>1.489</td>
</tr>
<tr>
<td>Capacity Import Limit (CIL) (MW)</td>
<td>4,415</td>
<td>2,595</td>
<td>3,369</td>
<td>6,411</td>
<td>4,332</td>
<td>7,941</td>
<td>3,785</td>
<td>4,834</td>
<td>3,622</td>
<td>2,688</td>
</tr>
<tr>
<td>Capacity Export Limit (CEL) (MW)</td>
<td>516</td>
<td>2,017</td>
<td>5,430</td>
<td>4,280</td>
<td>2,122</td>
<td>3,249</td>
<td>2,578</td>
<td>2,424</td>
<td>2,149</td>
<td>1,824</td>
</tr>
</tbody>
</table>

Table 6.1-1: Deliverables to the 2018-2019 Planning Resource Auction (PRA)

<table>
<thead>
<tr>
<th>LRZ</th>
<th>Tier</th>
<th>18-19 Limit (MW)(^4)</th>
<th>Monitored Element</th>
<th>Contingent Element</th>
<th>Figure 6.1-3 Map ID</th>
<th>GLT Applied</th>
<th>Generation Redispacth (MW)</th>
<th>17-18 Limit (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1&amp;2</td>
<td>4,415</td>
<td>Sherman Street to Sunnyvale 115 kV</td>
<td>Arpin to Rocky Run 115 kV</td>
<td>1</td>
<td>No</td>
<td>0</td>
<td>3,531</td>
</tr>
<tr>
<td>2</td>
<td>1&amp;2</td>
<td>2,595</td>
<td>Plano B to Electric Junction B 345 kV</td>
<td>Plano R to Electric Junction 345 kV</td>
<td>2</td>
<td>No</td>
<td>2,000</td>
<td>2,227</td>
</tr>
<tr>
<td>3</td>
<td>1&amp;2</td>
<td>3,369</td>
<td>Sub 3458 to Sub 3456 345 kV</td>
<td>Sub 3455 to Sub 3740 345 kV</td>
<td>3</td>
<td>No</td>
<td>2,000</td>
<td>2,408</td>
</tr>
<tr>
<td>4</td>
<td>N/A</td>
<td>6,411</td>
<td>North Decatur West Bus 138 kV voltage</td>
<td>Clinton Generation</td>
<td>4</td>
<td>No</td>
<td>N/A</td>
<td>5,815</td>
</tr>
<tr>
<td>5</td>
<td>1&amp;2</td>
<td>4,332</td>
<td>Joppa 345/161 kV</td>
<td>Shawnee 500/345 kV</td>
<td>5</td>
<td>No</td>
<td>2,000</td>
<td>4,096</td>
</tr>
<tr>
<td>6</td>
<td>1&amp;2</td>
<td>7,941</td>
<td>Paradise to BRTAP 161 kV</td>
<td>Phillips Bend to Volunteer 500 kV</td>
<td>6</td>
<td>Yes</td>
<td>2,000</td>
<td>6,248</td>
</tr>
<tr>
<td>7</td>
<td>N/A</td>
<td>3,785</td>
<td>Hager 120 kV bus voltage</td>
<td>Wyane to Monroe 345 kV</td>
<td>7</td>
<td>No</td>
<td>N/A</td>
<td>3,320</td>
</tr>
<tr>
<td>8</td>
<td>1&amp;2</td>
<td>4,834</td>
<td>Sterlington 500/115 kV #2</td>
<td>Sterlington to El Dorado 500 kV</td>
<td>8</td>
<td>No</td>
<td>2,000</td>
<td>3,275</td>
</tr>
<tr>
<td>9</td>
<td>1&amp;2</td>
<td>3,622</td>
<td>Sterlington to Downsville 115 kV</td>
<td>Mt. Olive to El Dorado 500 kV</td>
<td>9</td>
<td>Yes</td>
<td>2,000</td>
<td>3,371</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>2,688</td>
<td>Henando to Coldwater 115 kV</td>
<td>Moon Lake to Batesville 230 kV</td>
<td>10</td>
<td>No</td>
<td>1,670</td>
<td>1,910</td>
</tr>
</tbody>
</table>

Table 6.1-2: 2018-2019 Planning Year Capacity Import Limits

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\(^3\) Or: https://cdn.misoenergy.org/2018-19%20PRA%20Results173180.pdf

\(^4\) The 18-19 Limit represents the limit after redispatch has been considered.
Figure 6.1-3: 2018-2019 Capacity Import Limit Map
<table>
<thead>
<tr>
<th>LRZ</th>
<th>18-19 Limit (MW)</th>
<th>Monitored Element</th>
<th>Contingent Element</th>
<th>Figure 6.1-4 Map ID</th>
<th>GLT Applied</th>
<th>Generation Redispatch (MW)</th>
<th>17-18 Limit (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>516</td>
<td>Lakefield to Dickson 161 kV</td>
<td>Webster to Kossuth 345 kV</td>
<td>1</td>
<td>Yes</td>
<td>1,685</td>
<td>686</td>
</tr>
<tr>
<td>2</td>
<td>2,017</td>
<td>Zion EC to Zion Station 345 kV</td>
<td>Zion to Pleasant Prairie 345 kV</td>
<td>2</td>
<td>Yes</td>
<td>950</td>
<td>2,290</td>
</tr>
<tr>
<td>3</td>
<td>5,430</td>
<td>Council Bluffs to Sub 3456 345 kV</td>
<td>Nebraska City Unit 2</td>
<td>3</td>
<td>Yes</td>
<td>1,111</td>
<td>1,772</td>
</tr>
<tr>
<td>4</td>
<td>4,280</td>
<td>Marion CT to Renshaw 161 kV</td>
<td>Marion Ct to Marion S 161 kV</td>
<td>4</td>
<td>Yes</td>
<td>0</td>
<td>11,756</td>
</tr>
<tr>
<td>5</td>
<td>2,122</td>
<td>Maywood to Spencer Creek 161 kV</td>
<td>System Intact</td>
<td>5</td>
<td>Yes</td>
<td>353</td>
<td>2,379</td>
</tr>
<tr>
<td>6</td>
<td>3,249</td>
<td>Wilson to Matanzas 161 kV</td>
<td>Green River to Wilson 161 kV</td>
<td>6</td>
<td>Yes</td>
<td>1,058</td>
<td>3,191</td>
</tr>
<tr>
<td>7</td>
<td>2,578</td>
<td>Monroe to Allendorf 345 kV</td>
<td>Lulu to Morocco to Milan 345 kV</td>
<td>7</td>
<td>Yes</td>
<td>0</td>
<td>2,519</td>
</tr>
<tr>
<td>8</td>
<td>2,424</td>
<td>Russelville South to Dardanelle 161 kV</td>
<td>Arkansas Nuclear to Fort Smith 500 kV</td>
<td>8</td>
<td>No</td>
<td>0</td>
<td>2,493</td>
</tr>
<tr>
<td>9</td>
<td>2,149</td>
<td>Clay to Aberdeen 161 kV</td>
<td>West Point to Clay 500 kV</td>
<td>9</td>
<td>No</td>
<td>2,000</td>
<td>2,373</td>
</tr>
<tr>
<td>10</td>
<td>1,824</td>
<td>Batesville to Tallahachie 161 kV</td>
<td>Choctaw to Clay 500 kV</td>
<td>10</td>
<td>No</td>
<td>1,534</td>
<td>1,747</td>
</tr>
</tbody>
</table>

Table 6.1-3: 2018-2019 Planning Year Capacity Export Limits
Figure 6.1-4: 2018-2019 Capacity Export Limit Map
MTEP Projects and Capacity Import and Export Limits

The Capacity Import and Export Limits are deliverables to the PRA and, in combination with the Local Clearing Requirement (LCR), determine the maximum amount of imports or exports allowed for a zone. Constraints may occur in the PRA when the imports or exports are limited by the CIL, CEL and LCR. These constraints are considered in the development of the MTEP. Table 6.1-4 outlines projects impacting LCR, CIL or CEL that impact limits that have bound in the previous two Planning Resource Auctions.

<table>
<thead>
<tr>
<th>LRZ</th>
<th>CEL or CEL</th>
<th>Monitored Element</th>
<th>MTEP Project ID</th>
<th>Target Appendix</th>
<th>Project Name</th>
<th>Min Expected ISD</th>
</tr>
</thead>
</table>

Table 6.1-4: MTEP project impacting CEL, which has bound in the PRA

For full details of the LOLE study, refer to the Planning Year 2018 LOLE study report.

Wind Capacity Credit

A class-average wind capacity credit of 15.2 percent was established for the 2018-2019 planning year by determining the Effective Load Carrying Capability (ELCC) of wind resources. The wind capacity credit decreased from the wind capacity credit of 15.6 percent established in the 2017-2018 Planning Year (Figure 6.1-5). For more information, refer to the complete 2018-2019 Wind Capacity Credit Report.

Solar Capacity Credit

A class-average solar capacity credit of 50 percent was established for the 2018-2019 planning year by estimating the peak period contribution from historical solar irradiance simulation data. New resources without summer operating history will receive this class average capacity credit until at least 30 consecutive days of summer performance data are available, at which time the resource’s individual capacity credit will be based on its own operating history. More details can be found in the MISO BPM-011 in section 4.
6.2 Long-Term Resource Assessment

The Long-Term Resource Assessment (LTRA) examines the balance between projected resources and the projected load. These resources are compared with Planning Reserve Margin Requirements (PRMR) to calculate a projected surplus or shortfall.

MISO forecasts sufficient capacity resources to meet expected demand and reserves for Planning Year 2019 above the Planning Reserve Margin Requirement (PRMR) of 17.1 percent. Beginning in 2020, MISO capacity is projected to fall below the PRMR and remain there for the rest of the assessment period (Table 6.2-1). MISO anticipates the projected margins will change significantly as load-serving entities and state commissions solidify future capacity plans.

<table>
<thead>
<tr>
<th>In GW (ICAP)</th>
<th>PY 2019/20</th>
<th>PY 2020/21</th>
<th>PY 2021/22</th>
<th>PY 2022/23</th>
<th>PY 2023/24</th>
<th>PY 2024/25</th>
<th>PY 2025/26</th>
<th>PY 2026/27</th>
<th>PY 2027/28</th>
<th>PY 2028/29</th>
</tr>
</thead>
<tbody>
<tr>
<td>(+) Existing Resources</td>
<td>140.2</td>
<td>139.7</td>
<td>138.5</td>
<td>136.9</td>
<td>134.7</td>
<td>133.6</td>
<td>133.1</td>
<td>132.7</td>
<td>132.7</td>
<td>132.7</td>
</tr>
<tr>
<td>(+) New Resources</td>
<td>2.7</td>
<td>2.9</td>
<td>3.5</td>
<td>3.6</td>
<td>3.6</td>
<td>3.6</td>
<td>3.6</td>
<td>3.6</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>(+) DRR</td>
<td>7.5</td>
<td>7.5</td>
<td>7.5</td>
<td>7.6</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>(+) BTMG</td>
<td>4.3</td>
<td>4.4</td>
<td>4.7</td>
<td>4.8</td>
<td>4.8</td>
<td>4.8</td>
<td>4.8</td>
<td>4.8</td>
<td>4.8</td>
<td>4.8</td>
</tr>
<tr>
<td>(+) Imports</td>
<td>4.1</td>
<td>4.1</td>
<td>4.3</td>
<td>4.3</td>
<td>4.3</td>
<td>4.3</td>
<td>4.3</td>
<td>4.3</td>
<td>4.3</td>
<td>4.3</td>
</tr>
<tr>
<td>(-) Exports</td>
<td>3.4</td>
<td>3.1</td>
<td>3.1</td>
<td>3.1</td>
<td>3.1</td>
<td>3.1</td>
<td>3.1</td>
<td>3.1</td>
<td>3.1</td>
<td>3.1</td>
</tr>
<tr>
<td>(-) Low Certainty Resources</td>
<td>5.2</td>
<td>6.1</td>
<td>6.0</td>
<td>5.6</td>
<td>5.8</td>
<td>6.2</td>
<td>6.9</td>
<td>7.8</td>
<td>8.1</td>
<td>8.1</td>
</tr>
<tr>
<td>(-) Transfer Limited</td>
<td>3.1</td>
<td>2.7</td>
<td>3.1</td>
<td>3.0</td>
<td>2.8</td>
<td>2.6</td>
<td>2.4</td>
<td>2.2</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Available Resources</td>
<td>147.0</td>
<td>146.7</td>
<td>146.3</td>
<td>145.4</td>
<td>143.6</td>
<td>142.4</td>
<td>140.5</td>
<td>139.3</td>
<td>139.2</td>
<td>139.4</td>
</tr>
<tr>
<td>DPP Potential Resources</td>
<td>0.8</td>
<td>1.3</td>
<td>2.4</td>
<td>4.2</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
</tr>
<tr>
<td>Demand</td>
<td>125.0</td>
<td>125.3</td>
<td>125.6</td>
<td>126.0</td>
<td>126.4</td>
<td>126.7</td>
<td>129.4</td>
<td>129.1</td>
<td>128.9</td>
<td>128.9</td>
</tr>
<tr>
<td>PRMR</td>
<td>146.4</td>
<td>146.7</td>
<td>147.1</td>
<td>147.5</td>
<td>148.0</td>
<td>148.4</td>
<td>151.5</td>
<td>151.2</td>
<td>151.0</td>
<td>151.0</td>
</tr>
<tr>
<td>PRMR Shortfall</td>
<td>0.6</td>
<td>0.0</td>
<td>-0.8</td>
<td>-2.1</td>
<td>-4.3</td>
<td>-6.0</td>
<td>-11.1</td>
<td>-11.8</td>
<td>-11.7</td>
<td>-11.5</td>
</tr>
<tr>
<td>Reserve Margin Percent (%)</td>
<td>17.6%</td>
<td>17.1%</td>
<td>16.5%</td>
<td>15.4%</td>
<td>13.7%</td>
<td>12.3%</td>
<td>8.6%</td>
<td>7.9%</td>
<td>8.0%</td>
<td>8.2%</td>
</tr>
</tbody>
</table>

Table 6.2-1: MISO projected PRMR details (cumulative)
MISO projects a regional surplus for the summer of 2019, and then a continual decrease through the assessment period.

Operating at the reserve margin creates a new operating reality for MISO members where the use of all resources available on the system and emergency operating procedures are more likely. This reality will lead to a projected dependency in the use of Load Modifying Resources (LMR), such as Behind-the-Meter Generation (BTMG) and Demand Response (DR).

The conclusions from the long-term resource assessments are:

- Lower demand-growth forecasts across most zones in MISO
- The increase in committed resources from BTMG and Demand Response
- MISO projects that each zone within the MISO footprint will have sufficient resources within their boundaries to meet their Local Clearing Requirements or the amount of resource, which must be contained within their boundaries
- All zones within MISO are sufficient from a resource adequacy point of view in the near term, when available capacity and transfer limitations are considered. Regional shortages in later years may be rectified by the utilities; also MISO is engaged with stakeholders in a number of Resource Adequacy reforms to help rectify these out-year shortages.

Policy and changing generation trends continue to drive new potential risks to resource adequacy, requiring continued transparency and vigilance to ensure long-term needs.

MISO projects that reserve margins will continue to tighten over the next five years, approaching the reserve margin requirement.

**Assumptions**

At the end of 2013 MISO and Organization of MISO States (OMS) first conducted a Resource Adequacy survey of load-serving entities to help bridge the gap of limited visibility that exists between the annual Module E Tariff process and Forward Resource Assessment. MISO finished the fifth iteration of the OMS-MISO survey in June 2018, and it was instrumental in the development of the Long-Term Resource Assessment and the Resource Adequacy outlook for the MISO region.

**Demand Growth**

In 2019, MISO anticipates that the MISO Region’s coincident demand will be 124,983 MW, which is a 50/50 weather-normalized load forecast.

Load-serving entities submit demand forecasts for the upcoming 10 years. MISO utilizes these forecasts to calculate a MISO business-as-usual load growth. Based on these forecasts, MISO anticipates a system-wide average growth rate of 0.3 percent for the period from 2019 to 2028.
Resources

In 2019, MISO expects a total of 148,600 MW of Anticipated Capacity Resources to be available on peak.

MISO’s current generation capacity (nameplate) of 170,500 MW steps down to Existing-Certain Capacity Resources of 140,200 MW by accounting for summer on-peak generator performance (including wind capacity at 15.2 percent of nameplate and solar at 50 percent of nameplate), transmission limitations and energy-only capacity (Existing-Other Capacity Resources). MISO only relies on 140,200 MW towards its PRMR to meet a loss-of-load expectation of one day in 10 years.

BTMG, Interruptible Load (IL), Direct Control Load Management (DCLM) and Energy Efficiency Resources (EER) are eligible to participate as registered LMRs. All of these are emergency resources available to MISO only during a Maximum Generation Emergency Event Step 2b per MISO’s Emergency Operating Procedures. MISO assumes the 4,280 MW of BTMG increasing to 4,782 in 2023 and 5,990 MW of LMR DR that was qualified in the 2018 Planning Resource Auction to be available throughout the assessment period.

In the 2018 OMS-MISO Survey, resources that were identified to have a low certainty of serving load were not included (Figure 6.2-1).

Through the Generator Interconnection Queue (GIQ) process, MISO anticipates 3,646 MW of future firm capacity additions and uprates to be in-service and expected on-peak during the assessment period. This is based on a snapshot of the GIQ as of June 2018 and is the aggregation of active projects with a signed Interconnection Agreement.

![Anticipated Firm Resource Additions](image)

**Figure 6.2-1: Anticipated Resource Additions and Uprates (Cumulative) of active projects with a signed Interconnection Agreement in the MISO Region**
Imports and Exports
MISO assumes a forecast of 4,064 MW of capacity from outside of the MISO footprint to be designated firm for use during the assessment period and cannot be recalled by the source transmission provider. This capacity was designated to serve load within MISO through the Module E process for summer 2018. It’s assumed that the firm imports continue at this level for the assessment period. MISO assumes a forecast of 3,398 MW of firm capacity exports in year 2019. Exports are projected to decrease to 3,100 MW in 2020 and remain at that level for the rest of the assessment period.

When comparing reserve margin percent numbers between Figure 6.2-1 and the NERC LTRA, the percent for each planning year will be slightly lower in the NERC LTRA because of differences in the reserve margin percent calculation. MISO’s resource adequacy construct counts DR as a resource while the NERC calculates DR on the demand side. While the percent will be slightly different, the absolute GW shortfall/surplus is comparable between the two.
6.3 Seasonal Resource Assessment

MISO has historically conducted seasonal resource assessments for the winter months of December, January and February, and the summer months of June, July and August. In 2018, MISO also conducted a spring assessment to capture risks during March, April and May. Seasonal assessments primarily evaluate the expected near-term system performance and prepare operators for the upcoming season. The MISO resource assessments coincide with NERC seasonal reliability assessments and MISO operational readiness workshops held prior to the assessment’s season.

The 2017-2018 winter, 2018 spring and 2018 summer season findings show that the projected capacity levels exceed the Planning Reserve Margin Requirement, with adequate resources to serve load.

Seasonal Assessment Methods

MISO studies multiple scenarios at varying capacity resource levels, expected demand levels and forced outage rates. In order to align with the Sub-regional Export Constraint (SREC) from the Planning Resource Auction (PRA), only 1,500 MW above the MISO South load and reserve margin were counted toward aggregate margins at coincident peak demand in all of the projected scenarios for the 2018 Summer Assessment.

MISO coordinates extensively with neighboring Reliability Coordinators as part of the seasonal assessment and outage coordination processes, via scheduled daily conference calls and ad-hoc communications as need arises in real-time operations. There is always the potential for a combination of higher loads, higher forced outage rates and fuel limitations. In the summer, unusually hot and dry weather can lead to low water levels and/or high water temperatures. This can impact the maximum operating capacity of thermal generators that rely on water resources for cooling, leading to added deratings in real time and lowering functional capacity. MISO resolves these situations through existing procedures depending on the circumstances, and several scenarios are studied for each season to project the possible reserve margins expected.

Demand

Based on 22 years of historic actual load data, MISO calculates a Load Forecast Uncertainty (LFU) value from statistical analysis to determine the likelihood that actual load will deviate from forecasts. A normal distribution is created around the 50/50 forecast based on a standard deviation equal to the LFU of the 50/50 forecast. This curve represents all possible load levels with their associated probability of occurrence. At any point along the curve it is possible to derive the percent chance that load will be above or below a load value by finding the area under the curve to the right or left of that point. MISO chooses the 90th percentile for the High Load scenarios. For more information regarding this analysis, refer to the Planning Year 2018 LOLE Study.

Demand Reporting

MISO does not forecast load for the Seasonal Resource Assessments. Instead, Load-Serving Entities (LSEs) report load projections under the Resource Adequacy Requirements section (Module E-1) of the MISO Tariff. LSEs report their annual load projections on a MISO Coincident basis as well as their Non-Coincident load projections for the next 10 years, monthly for the first two years and seasonally for the remaining eight years. MISO LSEs have the best information of their load; therefore, MISO relies on them for load forecast information.
For these studies, MISO created a Non-Coincident and a Coincident peak demand on a regional basis by summing the annual peak forecasts for the individual LSEs in the larger regional area of interest.

**2017-2018 Winter Overview**

For planning year 2017-2018, MISO’s Planning Reserve Margin Requirement (PRMR) was 15.8 percent. For the 2017-2018 winter peak hour, MISO expected adequate resources to serve load, with a NERC-reported base projected reserve margin of 35.7 percent, which far exceeds the PRMR of 15.8 percent. The winter scenarios project the reserve margin to be in the range of 28.3 to 37.3 percent (Figure 6.3-1).

MISO’s 50/50 coincident peak demand for the 2017-2018 winter season was forecasted to be 103,407 MW including transmission losses, with 140,284 MW of capacity to serve MISO load during the 2017-2018 winter season. Excluded from the capacity are 3,906 MW of MISO South resources to align with the PRA SREC.

![Figure 6.3-1: Winter 2017-2018 Projected Reserve Margin Scenarios (GW)](image-url)
2017-2018 Winter Rated Capacity

For the 2017-2018 winter season, MISO projected 140,284 MW of existing certain capacity to serve MISO load during the winter. The capacity includes 2,459 MW of Behind-the-Meter Generation (BTMG) and 3,593 MW of Demand Resource programs, with 871 MW of Net Firm Exports. MISO expected 2,326 MW of wind capacity to be available to serve load for the winter.

MISO arrived at the Winter Rated Capacity value by reducing the Nameplate Capacity of its market footprint by multiple variables. The majority of the derates expected at-peak are due to resource interconnection limitations of 2,333 MW; thermal unit winter output reductions of 5,965 MW; and reductions due to the Effective Load Carrying Capability of wind resources of 13,905 MW based on available nameplate wind resources of 17,043 MW. Capacity from the South, equal to its load and reserve margin requirement, was included in the regional total. Additionally, it assumed that 1,500 MW of excess capacity transferred to the North/Central region of the footprint due to the estimated SREC for the PRA.

Winter Reserve Margin Scenarios

MISO’s projected 2017-2018 MISO Winter Rated Capacity varies by scenario (Figures 6.3-2 through 6.3-5). MISO chose the 90th percentile of the normal distribution around a 50/50 load forecast for the High Load scenarios, which was 110,666 MW for the 2017-2018 winter.

![Figure 6.3-2: 2017-2018 Winter Rated Capacity Projected Base Scenario (GW)](image)
The Probable scenario contains additional assumptions (Figure 6.3-3). MISO expects that any energy resource without firm Point-To-Point Transmission Service Rights will serve load locally, termed Energy Only. The portion of Energy Only from the MISO South region is excluded from the calculation to align with the 1,500 MW SREC limitation for the 2017-18 Planning Year Auction.

In real-time, during normal operating conditions, MISO must carry Operating Reserves above load to maintain system reliability. The amount of Operating Reserves required to clear on a daily basis for the 2017-2018 winter season was 2,400 MW, which is called on as a last resort before load shed (Figure 6.3-4). These reserves are made up of a combination of Regulating Reserves, Spinning Reserves and Supplemental Reserves.
The High Load, High Outage scenario has added assumptions (Figure 6.3-5). Beginning with the anticipated reserves from the Probable scenario (Figure 6.3-3), the load increases to show the higher load from a 90/10 forecast. Higher than normal outages are assumed reflecting the highest seasonal average outages reported in GADS from 2012-2016. The extreme outages reflect the highest number of GADS reported outages seen on winter peak from 2012-2016.

![Graph showing High Load High Outage Reserve Margin Scenario](image)

*Stranded South capacity is added to reserves to reflect outages seen by operations*

**Figure 6.3-5: Winter Rated Capacity Projected High Load, High Outage Scenario (GW)**

2018 Spring Overview

For planning year 2017-2018, MISO’s Planning Reserve Margin Requirement (PRMR) was 15.8 percent. For the 2018 spring peak hour, MISO expected adequate resources to serve load, with a NERC-reported base projected reserve margin of 34.8 percent, which far exceeds the PRMR of 15.8 percent. The spring scenarios project the reserve margin to be in the range of 27.5 to 36.5 percent (Figure 6.3-6).

MISO’s 50/50 coincident peak demand for the 2018 spring season was forecasted to be 103,407 MW including transmission losses, with 139,383 MW of capacity to serve MISO load during the 2018 spring season. Excluded from the capacity are 5,273 MW of MISO South resources to align with the PRA SREC.
2018 Spring Rated Capacity

For the 2018 spring season, MISO projected 139,383 MW of existing certain capacity to serve MISO load during the spring. The capacity includes 2,459 MW of Behind-the-Meter Generation (BTMG) and 3,593 MW of Demand Resource programs, with 871 MW of Net Firm Exports. MISO expected 2,345 MW of wind capacity to be available to serve load for the spring.

MISO arrived at the Spring Rated Capacity value by reducing the Nameplate Capacity of its market footprint by multiple variables. The majority of the derates expected at-peak are due to resource interconnection limitations of 2,333 MW; thermal unit spring output reductions of 5,965 MW; and reductions due to the Effective Load Carrying Capability of wind resources of 13,905 MW based on available nameplate wind resources of 17,162 MW. Capacity from the South, equal to its load and reserve margin requirement, was included in the regional total. Additionally, it assumed that 1,500 MW of excess capacity transferred to the North/Central region of the footprint due to the estimated SREC for the PRA.
Spring Reserve Margin Scenarios

MISO’s projected 2018 MISO Spring Rated Capacity varies by scenario (Figures 6.3-7 through 6.3-10). MISO chose the 90\textsuperscript{th} percentile of the normal distribution around a 50/50 load forecast for the High Load scenarios, which was 110,666 MW for the 2018 spring.

The Probable scenario contains additional assumptions (Figure 6.3-8). MISO expects that any energy resource without firm Point-To-Point Transmission Service Rights will serve load locally, termed Energy Only. The portion of Energy Only from the MISO South region is excluded from the calculation to align with the 1,500 MW SREC limitation for the 2017-18 Planning Year.

Figure 6.3-7: 2018 Spring Rated Capacity Projected Base Scenario (GW)

Figure 6.3-8: 2018 Spring Rated Capacity Probable Scenario (GW)
In real-time, during normal operating conditions, MISO must carry Operating Reserves above load to maintain system reliability. The amount of Operating Reserves required to clear on a daily basis for the 2018 spring season was 2,400 MW, which is called on as a last resort before load shed (Figure 6.3-9). These reserves are made up of a combination of Regulating Reserves, Spinning Reserves and Supplemental Reserves.

The High Load, High Outage scenario has added assumptions (Figure 6.3-10). Beginning with the anticipated reserves from the Probable scenario (Figure 6.3-9), the load increases to show the higher load from a 90/10 forecast. Higher than normal outages are assumed reflecting the highest seasonal average outages reported in GADS from 2013-2017. The extreme outages reflect the highest number of GADS reported outages seen on spring peak from 2013-2017.
2018 Summer Overview

For planning year 2018-2019, MISO's summer PRM is 17.1 percent. During the 2018 summer peak hour, MISO expected adequate resources to serve load, with a NERC-reported base projected reserve margin of 19.1 percent, which exceeds the requirement of 17.1 percent by 2.0 percentage points. The summer scenarios project the reserve margin to be in the range of 14.5 to 20 percent (Figure 6.3-11).

MISO's 50/50 coincident peak demand for the 2018 summer season was forecasted to be 124,704 MW including transmission losses, with 148,553 MW of capacity to serve MISO load. Excluded from the capacity are 1,165 MW of MISO South resources to align with the 1,500 MW intra-RTO SREC.

![Base Reserve Margin Scenario](image1)

![Probable Reserve Margin Scenario](image2)

![High Load High Outage Reserve Margin Scenario](image3)

*Stranded South capacity is added to reserves to reflect outages seen by operations

**Figure 6.3-11: MISO Summer 2018 Projected Reserve Margin Scenarios**

2018 Summer Rated Capacity

For 2018, MISO projected 148,553 MW of capacity to serve MISO load during the 2018 summer season. The capacity includes 4,576 MW of BTMG and 7,137 MW of Demand Resource programs, while including 8 MW of Net Firm Exports. MISO expected 2,134 MW of wind capacity to be available to serve load this summer, after discounting wind capacity in the Commercial Model with pending interconnection agreements and capacity with Energy Resource Interconnection Service without a firm Point-To-Point Transmission Service Request. Capacity from the South, equal to its load and reserve margin requirement, was included in the regional total. Additionally, 1,500 MW of excess capacity was assumed as transferred to the North/Central region of the footprint.

MISO arrived at the Summer Rated Capacity value by reducing the Nameplate Capacity of its market footprint by multiple variables. The majority of the derates expected at-peak are due to resource interconnection limitations (1,704 MW); thermal unit summer output reductions (9,623 MW); and reductions due to the Effective Load Carrying Capability of wind resources (13,433 MW). Also, any MISO
South capacity over the total of South Load, South reserve margin requirement, and 1,500 MW of SREC was not included in the regional value. This means that 1,165 MW of MISO South excess capacity was excluded from the calculation to align with 1,500 MW SREC limitation.

**Reserve Margin Scenarios**

MISO’s projected 2018 MISO Summer Rated Capacity varies by scenario (Figures 6.3-12 through 6.3-16). MISO chose the 90th percentile of the normal distribution around a 50/50 load forecast for the High Load scenarios, which was 130,688 MW for the 2018 summer.

![Graph showing the reduction of reserves from installed nameplate capacity, including derates and transmission-limited resources.](image)

**Figure 6.3-12: 2018 Summer Rated Capacity Projected Base Scenario (GW)**
showing the reduction of reserves from installed nameplate capacity, including derates and transmission-limited resources.
The Probable scenario uses additional assumptions (Figure 6.3-13). MISO expects that any energy resource without firm Point-To-Point Transmission Service Rights will serve load locally, termed Energy Only. The portion of Energy Only from the MISO South region is excluded from the calculation to align with 1,500 MW SREC limitation. Additionally, any units designated as Under Study through the Attachment Y process are considered available.

![Figure 6.3-13: 2018 Summer Rated Capacity Projected Probable Scenario (GW)](image)

The High Load, High Outage scenario has added assumptions (Figure 6.3-14). Beginning with the Probable reserves from the Probable scenario (Figure 6.3-13), the load is increased to show the higher load from a 90/10 forecast. Also a higher forced outage rate is assumed, using the highest historical forced outage rate applied to the capacity resources available.

![Figure 6.3-14: Summer Rated Capacity Projected High Load, High Outage Scenario (GW)](image)
2018 Summer Risk Assessment

MISO performs a probabilistic assessment on the region to determine the percent chance of utilizing Load Modifying Resources and Operating Reserves or having to curtail firm load. A risk profile is generated from this analysis (Figure 6.3-15).

It is always possible for a combination of higher loads, higher forced outage rates, fuel limitations, low water levels and other factors to lead to the curtailment of firm load. The Loss of Load Expectation (LOLE) model that MISO utilizes for PRMR takes into account the uncertainties associated with load forecasts (e.g., 50/50 versus 90/10) and generation outages (both forced and scheduled).

The chance of realizing an event is where the risk profile intersects the event range (Figure 6.3-10). As shown, the probabilistic analysis indicated a 79 percent chance of MISO calling a Maximum Generation Emergency Event Step 2b to access Load Modifying Resources; a 17 percent chance of initiating further steps to access Operating Reserves; and a 9 percent chance of curtailing firm load during the 2018 summer peak hour.

![Figure 6.3-15: MISO 2018 summer chance of initiating Maximum Generation Emergency Step 2b or higher at forecasted Probable Reserve Margin](image)

The reserves available in the Probable scenario are shown after forced, planned and maintenance outages are applied, showing the amount of Generation, BTMG, Demand Resource and Operating Reserves expected (Figure 6.3-16). In real-time, during normal operating conditions, MISO must carry Operating Reserves above load to maintain system reliability. The amount of Operating Reserves required to clear on a daily basis for the 2018 summer season was 2,400 MW, which is called on as a last resort before load shed. Operating reserves are made up of a combination of Regulating Reserves, Spinning Reserves and Supplemental Reserves.
MISO Summer Rated Capacity Methodology

Figure 6.3-16: Summer Rated Capacity Projected Probable Reserves (GW)

Figure 6.3-17: MISO 2018 Summer Rated Capacity Waterfall Chart — Base Scenario (GW)
The calculation of MISO Summer Rated Capacity resources separates into 13 parts (Figure 6.3-17). Separation of the Winter Rated Capacity is similar, with additional details found in the MISO 2017-2018 Winter Resource Assessment. The 13 parts include:

1. **Nameplate**: the summation of the maximum output from the latest commercial model. This reflects the amount of registered generation available internal to MISO.
2. **Inoperable**: the summation of approved mothballed or retired units determined through the Attachment Y process, which are still represented in the latest commercial model.
3. **Thermal Derates**: the summation of differences in unit nameplate capacities and the latest Generator Verification Test Capacity (GVTC) results, excluding inoperable resources.
4. **Other Derates**: the summation of differences in non-wind intermittent resource nameplate capacities and the resource averages of historical summer peak performance, excluding inoperable resources.
5. **Transmission-limited resources (GVTC-TIS)**: the summation of differences in GVTC and the unit’s Total Interconnection Service (TIS) rights based on latest unit deliverability test results. Transmission-limited resources for wind are the summation of differences in nameplate capacity and TIS.
6. **Not-in-Service and provisional wind**: units that are registered in the latest commercial model, but are not in service yet; the wind units that are connected to the system but their interconnection process is not completed yet.
7. **Wind Derates**: the summation of the differences in wind unit Nameplate Capacities and the unit wind capacity credit, which is determined based on the Effective Load Carrying Capability of wind. This excludes Inoperable Resources and Transmission-Limited MWs.
8. **ER without TSR Energy-only**: resources with Energy Resource Interconnection Service (ERIS) without a firm Point-To-Point Transmission Service Right.
9. **Scheduled Outages**: Scheduled generator outages from June 1, 2018, through August 31, 2018, were pulled from MISO’s Control Room Operator’s Window (CROW) outage scheduler in March 2018. The data pulled met the following criteria: 1. Mapped to the latest commercial model; 2. Outage Request Status is equal to Active, Approved, Pre-Approved, Proposed, Study or Submitted; 3. Request priority is equal to planned; 4. Equipment request type is equal to Out of Service (OOS) or “Derated To 0 MW.”
   
   In order to calculate the expected scheduled outages on peak, MISO calculates the amount of outages on a daily basis assuming that if a unit is out for as little as one hour, that unit will be out for that entire day. The highest amount of outages during the month of July is assumed to be equal to the amount of outage during summer peak conditions.
   
   This calculation amounts to an expected scheduled maintenance of 627 MW.
10. **Net Firm Exports**: MISO anticipated the net firm interchange to be exporting 8 MW for the 2018 summer.
11. **Non-Transferable to MISO North and Central**: 1,165 MW of MISO South resources were excluded from the available capacity to align with 1,500 MW SREC.
12. **Behind-the-Meter Generation (BTMG)**: the summation of approved and cleared load-modifying resources identified as Behind-the-Meter Generation through the Resource Adequacy (Module E) process. Based on the planning year 2018-2019 Planning Resource Auction, 4,576 MW of BTMG cleared to be available for the 2018 summer season.
13. **Demand Resource**: MISO currently separates contractual demand resource into two separate categories: Direct Control Load Management (DCLM) and Interruptible Load (IL).
   
   DCLM is the magnitude of customer service (usually residential) that can be interrupted at the time of peak by direct control of the applicable system operator. DCLM is typically used for “peak shaving.” In MISO, air conditioner interruption programs account for the vast majority of DCLM during the summer months.
   
   IL is the magnitude of customer demand (usually industrial) that, in accordance with contractual arrangements, can be interrupted at the time of peak by direct control of the system operator (remote tripping) or by action of the customer at the direct request of the system operator. The amount of registered and cleared load-modifying resources identified as demand resource through the Resource Adequacy (Module E) process is 7,137 MW for the 2018 summer season.