# Planning Year 2019-2020

## Wind & Solar Capacity Credit

## December 2018

# Contents

| Reason for Revision | Revised by: | Date: |
|---|---|---|
| Draft Posted | MISO | 12/10/2018 |
| Final Posted | MISO | 12/19/2018 |
| Correction to Fig. 2-4 | MISO | 1/18/2019 |
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# 1 Executive Summary

The MISO system-wide wind capacity credit for the 2019-2020 planning year is 15.7 percent. Since 2009, MISO has embarked on a process to determine the capacity value for the increasing fleet of wind generation in the MISO system. The MISO process, as developed and vetted through the MISO stakeholder community, consists of a two-step method. The first step utilizes a probabilistic approach to calculate the MISO system-wide Effective Load Carrying Capability (ELCC) value for all wind resources in the MISO footprint. The second step employs a deterministic approach using the historical output of each wind resource, which considers each wind resource's location. The MISO system-wide ELCC value is then allocated across all wind Commercial Pricing Nodes (CPNodes) in the MISO system to determine a wind capacity credit for each wind CPNode.

As of June 30th, 2018, the MISO system had 18,210 MW (215 CPNodes) of registered wind capacity. This means 2,855 MW (18,210 MW x 15.7%) of unforced wind capacity potentially qualifies under Module E-1 of MISO's tariff. To the extent that the 2,855 MW of unforced wind capacity is deliverable at the individual wind CPNodes, the unforced capacity megawatts may be converted to Zonal Resource Credits (ZRCs) to meet Resource Adequacy obligations.

The capacity credit at the 215 individual wind CPNodes is proprietary information—however, the percent credit across all wind CPNodes ranged from 0.5 to 27.2 percent. Section 3 describes the details of allocating the total 2,855 MW to the 215 wind CPNodes. Upon request to MISO, the capacity credit details for individual wind CPNodes are available to the associated Market Participants. Figure 1-1 geographically illustrates the ten MISO Local Resource Zones (LRZs). The table in Figure 1-1 shows the most detailed results that MISO can share. MISO North & Central LRZs have multiple market participants with wind CPNodes with the exception of LRZ 5. Therefore, the values for LRZ 5 shown in Figure 1-1 have been combined with LRZ 4 so that proprietary information would not be revealed. MISO South does not currently have any wind CPNodes.

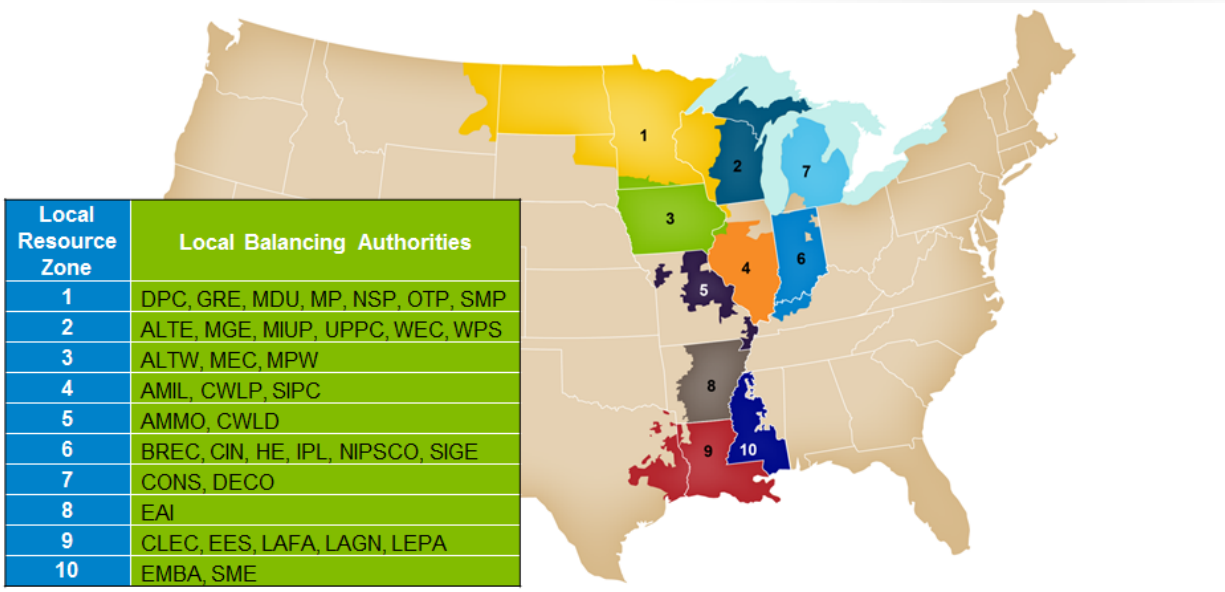
The MISO 2019-2020 Wind Capacity Credit has increased from the 2018-2019 Wind Capacity Credit of 15.2 percent. The increased amount of load served by wind during MISO's peak load hours resulted in the 15.7 percent capacity credit.

**Solar**

Existing solar units use operational credit outlined in BPM-011 (section 4.2.3.4.1). New solar units without operational data will continue to receive 50% capacity credit.

MISO observes an increasing number of solar projects entering the Generation Interconnection Queue. MISO will continue to use the current credit methodology for new solar units until more operational data is available to perform a solar capacity credit study.

As of December 2018, MISO has 313 MW (ICAP) of in front of the meter solar and 297 MW (ICAP) of registered behind the meter solar in commercial operation.




| Local Resource Zone | Local Balancing Authorities |
|---|---|
| 1 | DPC, GRE, MDU, MP, NSP, OTP, SMP |
| 2 | ALTE, MGE, MIUP, UPPC, WEC, WPS |
| 3 | ALTW, MEC, MPW |
| 4 | AMIL, CWLP, SIPC |
| 5 | AMMO, CWLD |
| 6 | BREC, CIN, HE, IPL, NIPSCO, SIGE |
| 7 | CONS, DECO |
| 8 | EAI |
| 9 | CLEC, EES, LAFA, LAGN, LEPA |
| 10 | EMBA, SME |

| 2019 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Metric | MISO | Zone 1 | Zone 2 | Zone 3 | Zone 4 and Zone 5 | Zone 6 | Zone 7 | Zone 8 | Zone 9 | Zone 10 |
| Registered Max (MW) | 18,210 | 5,080 | 734 | 9,488 | 763 | 282 | 1,863 | 0 | 0 | 0 |
| UCAP (MW) | 2,855 | 891 | 114 | 1,438 | 92 | 22 | 298 | 0 | 0 | 0 |
| ELCC % | 15.7% | 17.5% | 15.6% | 15.2% | 12.1% | 7.8% | 16.0% | 0.0% | 0.0% | 0.0% |
| Wind CPNode Count | 215 | 74 | 11 | 91 | 9 | 4 | 26 | 0 | 0 | 0 |

**Figure 1-1: MISO Local Resource Zones (LRZs) and Distribution of Wind Capacity**

# 2 MISO System-Wide Wind ELCC Study

## 2.1 Probabilistic Analytical Approach

The probabilistic measure of load not being served is known as Loss of Load Probability (LOLP) and when this probability is summed over a period of time, e.g. one year, it is known as Loss of Load Expectation (LOLE). The accepted industry standard for what has been considered a reliable system has been the “less than 1 day in 10 years” criteria for LOLE. This measure is more often expressed as 0.1 day/year, as one year is the period of time for which the LOLE index is calculated.

Effective Load Carrying Capability (ELCC) is defined as the amount of incremental load a resource, such as wind, can dependably and reliably serve, while also considering the probabilistic nature of generation shortfalls and random forced outages as driving factors to load not being served. ELCC has been used in the determination of capacity value for generation resources as far back as 1966 when L.L. Garver demonstrated the use of loss of load probability mathematics in the calculation of ELCC[1].

[1] Garver, L.L.; , "Effective Load Carrying Capability of Generating Units," Power Apparatus and Systems, IEEE Transactions on, vol.PAS-85, no.8, pp.910-919, Aug. 1966

To measure the ELCC of a particular resource, the reliability effects need to be isolated for the resource in question from those of all the other sources. This is accomplished by calculating the LOLE of two different cases: one “with” and one “without” the resource. Inherently, the case “with” the resource should be more reliable and consequently have fewer days per year of expected loss of load (smaller LOLE).

The new resource in the example shown in Figure 2-1 made the system 0.07 days/year more reliable, but there is another way to express the reliability contribution of the new resource besides the change in LOLE. This way requires establishing a common baseline reliability level and then adjusting the load in the two cases (“with” and “without” the new resource) to this common LOLE level. A common baseline that is chosen is the industry-accepted reliability standard of 1 day in 10 years (or 0.1 day/year) LOLE criteria.

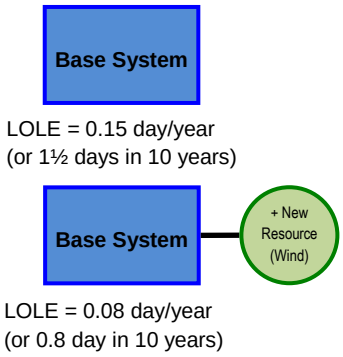



**Figure 2-1: Example System “with” & “without” New Resource**

With each case being at the same reliability level, as shown in Figure 2-2, the only difference between the two cases is the load adjustment values that were used to reach reliability. The difference between the adjustments for both cases is the amount of ELCC expressed in load or megawatts, which is 300 MW (100 minus -200) for the new resource in this example. This number may be divided by the Registerd Maximum Capacity (RMax) of the new resource and then expressed in percentage form. The new resource in the ELCC Example Figure 2-2 has an ELCC of 30 percent of the resource’s nameplate capacity.

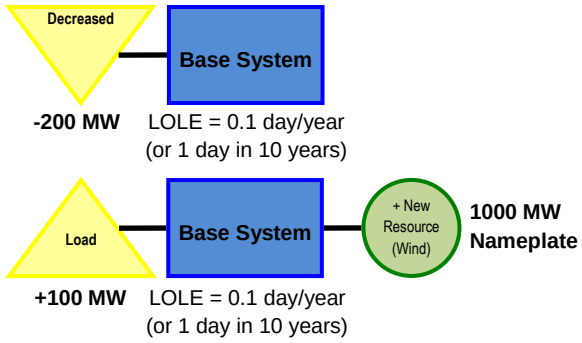



**Figure 2-2: ELCC Example System at the same LOLE**

The methodology illustrated in the simple example of Figure 2-2 was utilized as the analytical approach for the determination of the 2018 MISO system-wide ELCC of the wind resources in the much more complex MISO system. ELCC is the preferred methodology for determining the capacity value of wind[2].

## 2.2 LOLE Model Inputs & Assumptions

MISO applies the ELCC calculation methodology by utilizing the Strategic Energy & Risk Valuation Model (SERVM) program by Astrapé Consulting to calculate LOLE values with and without wind resources modeled. This model consists of three major inputs:

1. Generator Forced Outage Rates (EFORd)
2. Actual Historic Hourly Load Values
3. Actual Historic Hourly Wind Output Values

Forced outage rates are used for the conventional type of units in the LOLE model. These EFORd are calculated from the Generator Availability Data System (GADS) that MISO uses to collect historic operation performance data for all conventional unit types in the MISO system.

For the 2019-20 ELCC study, the historical 2018 hourly concurrent load and wind output at the wind CPNodes is used to calculate the ELCC values for the wind generation in MISO on a system-wide basis. The second-to-last column of Table 2-1 illustrates the ELCC results for the past 14 years.

## 2.3 MISO System-Wide ELCC Results

MISO calculated ELCC percentage results for historical years 2005 through 2018 and at multiple scenarios of penetration levels, corresponding to 20 GW, 30 GW and 40 GW of installed wind capacity. This creates an ELCC penetration characteristic for each year, as illustrated by the different curves in Figure 2-3. The ELCC characteristic of each year can be represented by a 2$^{nd}$-order polynomial trend line equation that has an R-squared coefficient of no less than 0.99. This is the basis for achieving accuracy with sparse or few years of data. The initial left most data point for each curve, except years 2012 and 2013, is at the lowest penetration point and represents the actual annual ELCC for that year. The second data point for the curves associated with years 2012 and 2013 represents the actual annual ELCC for those years. These values are shown in the second to last column of Table 2-1. The values along each year's characteristic curve at the higher penetration levels reflect what that year's wind resources would have as an ELCC if more capacity had been installed over the same year and footprint. The high-end 40 GW level of penetration (approximately 32 percent on x-axis of Figure 2-3) is an estimate of the amount of wind generation that could result in MISO, as the Load Serving Entities (LSEs) collectively increase renewable resource portfolios. Figure 2-3 illustrates the ELCC versus penetration characteristic of each of the fourteen years, and how those characteristics from multiple years were merged to establish the current 15.7 percent wind capacity credit.

[2] Keane, A.; Milligan, M.; Dent, C.J.; Hasche, B.; D'Annunzio, C.; Dragoon, K.; Holttinen, H.; Samaan, N.; Soder, L.; O'Malley, M.; , "Capacity Value of Wind Power," Power Systems, IEEE Transactions on , vol.26, no.2, pp.564-572, May 2011

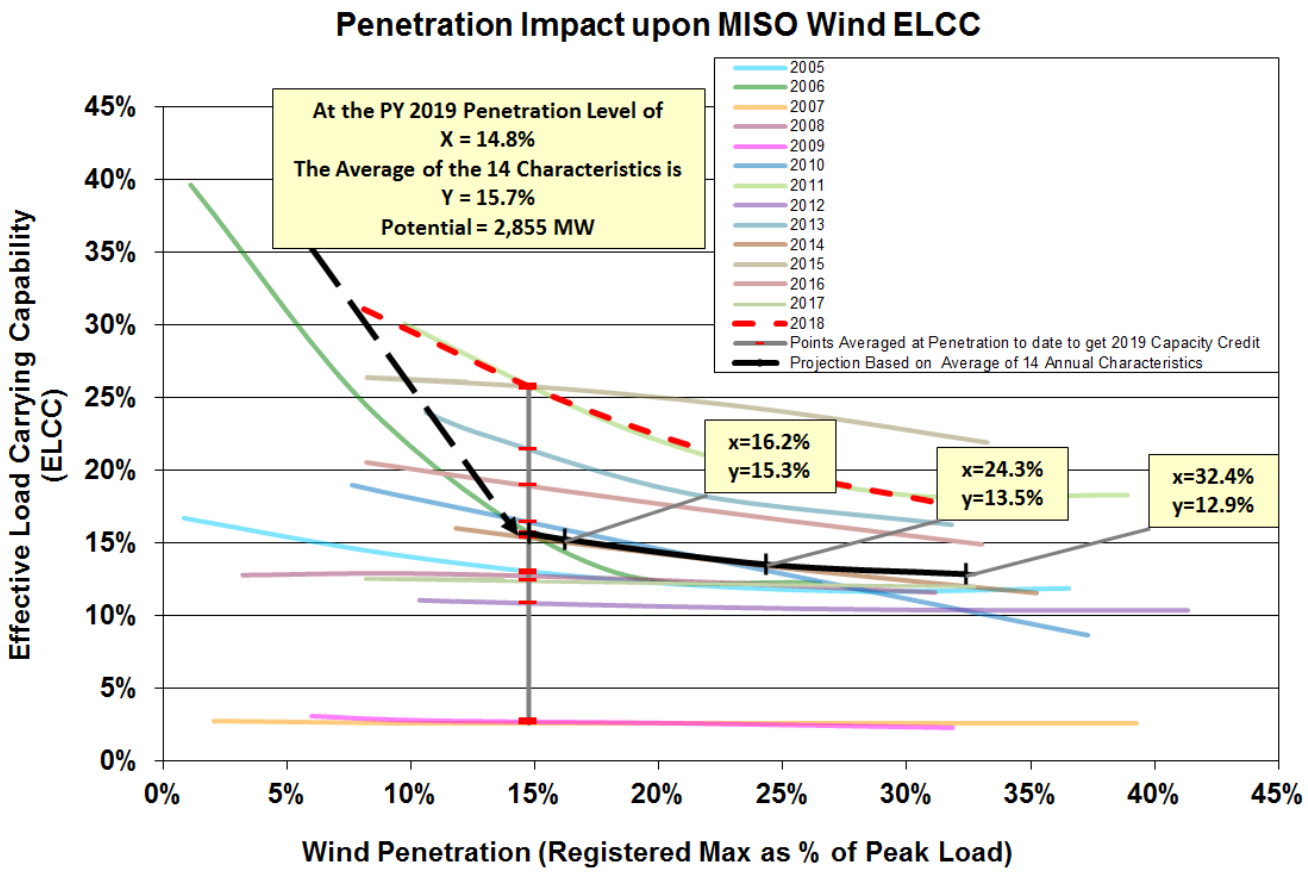



**Figure 2-3: Fourteen Years of Historical Wind ELCC Penetration Characteristics**

The 2019-20 Planning Year (PY) wind capacity credit is determined by averaging the fourteen ELCC values found along each year's ELCC/penetration characteristic curve. The averaging is done at the penetration level that corresponds to the penetration level at the end of the 2nd quarter of 2018. The registered amount of capacity at the end of the 2nd quarter is the convention used to set the capacity going into the summer season. The penetration level at the end of the 2nd quarter of 2018 was 14.8 percent. The historical 2018 penetration level is calculated by dividing the 2nd quarter 18,210 MW wind capacity (from column 4 of Table 2-1) by the 123,454 MW peak load (column 1 of Table 2-1). The peak load is defined as the highest average integrated hourly load for the year. The vertical line called out in the legend of Figure 2-3 as "Points Averaged at Penetration to date to get 2019 Capacity Credit" illustrates where each of the fourteen ELCC values from each year's characteristic curve intersect with the most recent 14.8 percent historical penetration level. The legend of Figure 2-3 also indicates that the average of the intersected values is the 15.7 percent system-wide ELCC for the 2019-20 PY. The black projection line in Figure 2-3 starts with the 2019-20 PY 15.7 percent, and is more clearly observed as the current 15.7 percent point and forward projection in Figure 2-4.

The resulting wind capacity credit is expressed in Unforced Capacity (UCAP) megawatts. If the individual CPNodes were to have full deliverability via the Generator Interconnection process, the system-wide capacity rating could represent as much as 2,855 MW of UCAP in 2019. MISO calculates the associated

UCAP at each wind CPNode and provides it to the appropriate Market Participant on a requested confidential basis. The capacity credit values can also be viewed in the Module E Capacity Tracking (MECT) tool. For the 2019-20 PY, a total UCAP of 2,855 MW is allocated among 215 wind CPNodes, up from 207 CPNodes of the previous planning year. Section 3 describes the details of the allocation method. The amount at each node that can qualify under Module E-1 is subject to the specific deliverability limit for each location.

| Market-wide Operational Tracking | | | | | | | |
|---|---|---|---|---|---|---|---|
| Peak Load (MW) | Planning Year (PY) | Metered Wind at Peak Load[1] (MW) | Registered Maximum Capacity[2] (MW) | Peak Day RMax[2] (%) | Historical Penetration (%) | Annual Historical ELCC (%) | MISO Capacity Credit (%) |
| 109,473 | 2005 | 104 | 908 | 11.5% | 0.8% | 16.7% | N/A |
| 113,095 | 2006 | 700 | 1,251 | 56.0% | 1.1% | 39.6% | N/A |
| 101,800 | 2007 | 44 | 2,065 | 2.1% | 2.0% | 2.8% | N/A |
| 96,321 | 2008 | 384 | 3,086 | 12.4% | 3.2% | 12.8% | N/A |
| 94,185 | 2009 | 86 | 5,636 | 1.5% | 6.0% | 3.1% | 20.0% |
| 107,171 | 2010 | 1,770 | 8,179 | 21.6% | 7.6% | 18.9% | 8.0% |
| 102,804 | 2011 | 4,421 | 9,996 | 44.2% | 9.7% | 30.1% | 12.9% |
| 96,764 | 2012 | 1,152 | 11,774 | 9.8% | 12.2% | 11.0% | 14.7% |
| 94,298 | 2013 | 6,439 | 12,239 | 52.6% | 13.0% | 22.4% | 13.3% |
| 113,507 | 2014 | 3,213 | 13,403 | 24.0% | 11.8% | 16.0% | 14.1% |
| 120,292 | 2015 | 3,723 | 14,732 | 25.3% | 12.2% | 26.1% | 14.7% |
| 121,092 | 2016 | 3,569 | 15,910 | 22.4% | 13.1% | 19.3% | 15.6% |
| 122,170 | 2017 | 1,977 | 16,761 | 11.8% | 13.7% | 12.5% | 15.6% |
| 123,454 | 2018 | 9,054 | 18,210 | 49.7% | 14.8% | 25.8% | 15.2% |
| Pending | 2019 | Pending | Pending | Pending | Pending | Pending | 15.7% |

**Notes:** 1 Curtailed and Dispatchable Intermittent Resources (DIRs) MW have been added to settlement MW

2 Registered Maximum Capacity (RMax)

**Table 2-1: Historical Tracking of Wind Related Metrics**

The current method to set the capacity credit was developed at the LOLE Working Group, and was first applied to planning year 2011. Table 2-2 shows the consistency of that method's results over nine planning years. The black curve in Figure 2-4 is the projection going forward, where the influence of future annual ELCC characteristics are still pending. The left portion of Figure 2-4 demonstrates the increasing volatility that would have resulted if the current calculating process had been applied to successively fewer sets of historical annual ELCC penetration characteristics. Figure 2-4 also repeats the 2019-20 PY point and the extension to future higher penetration levels from Figure 2-3.

| Planning Year | Wind Penetration | Capacity Credit (%) |
|---|---|---|
| PY 2011 | 7.6% | 12.9% |
| PY 2012 | 9.7% | 14.7% |
| PY 2013 | 12.2% | 13.3% |
| PY 2014 | 13.0% | 14.1% |
| PY 2015 | 11.8% | 14.7% |
| PY 2016 | 12.2% | 15.6% |
| PY 2017 | 13.1% | 15.6% |
| PY 2018 | 13.7% | 15.2% |
| PY 2019 | 14.8% | 15.7% |

**Table 2-2: Consistent and Responsive System-Wide ELCC Method Demonstrated by Applying It Over Nine Planning Years**

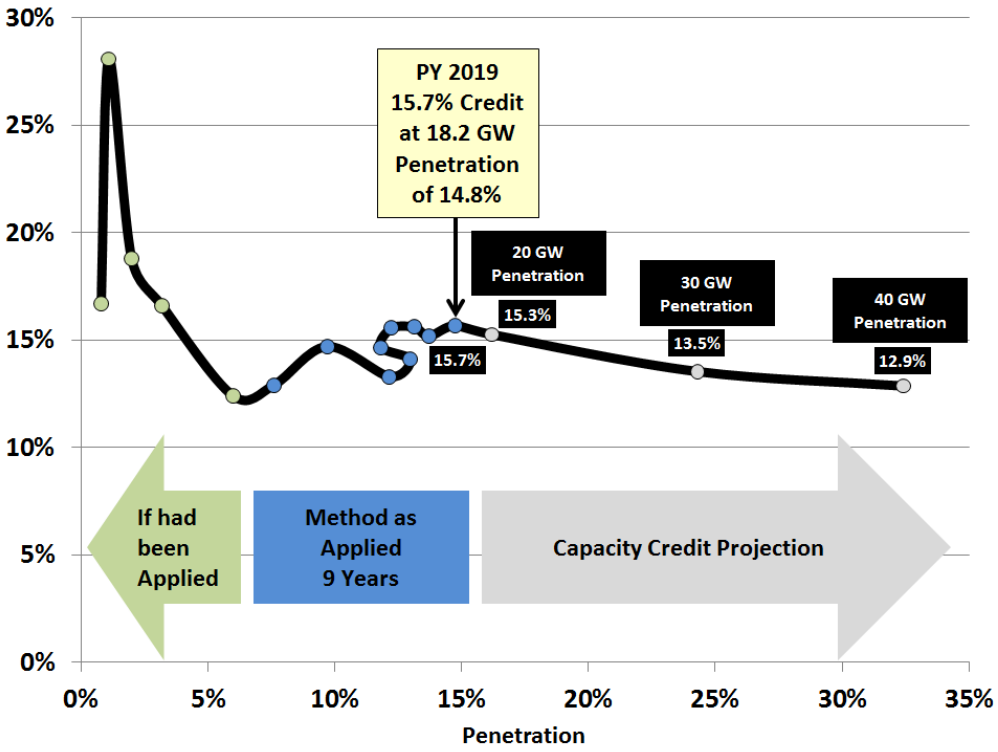



**Figure 2-4: Demonstration of Applying Capacity Credit Method Starting with PY 2006**

For the 2015-2016 Wind Capacity Credit analysis, MISO saw a lower penetration level of wind. This was due to the addition of MISO South in December 2013 to the MISO system. MISO South brought a substantial amount of load to the MISO footprint with no wind capacity. This decreased the wind penetration in MISO as compared to the 2014-2015 planning year.

# 3 Details of Wind Capacity by CPNode

## 3.1 Deterministic Analytical Technique

Since there are many wind CPNodes throughout the MISO system (215 in June 2018), a deterministic approach involving a historic-period metric is used to allocate the single system-wide ELCC value of wind to all the registered wind CPNodes. While evaluation of all CPNodes captures the benefit of the geographic diversity, it is also important to assign the capacity credit of wind at the individual CPNode locations, because in the MISO market the location relates to deliverability due to possible congestion on the transmission system. Also, in a market it is important to convey the correct incentive signal regarding where wind resources are relatively more effective. The location and corresponding relative performance is a valuable input in determining the tradeoffs between constructing wind facilities in high-capacity value locations that typically require more transmission investment versus locating wind generating facilities at less effective wind resource locations that may require less transmission build-out.

For the 2019-2020 planning year, the system-wide wind ELCC value of 15.7 percent times the 2018 registered maximum wind capacity (RMax) of 18,210 MW (2$^{nd}$ Quarter of 2018) results in 2,855 MW of system-wide wind capacity. The 2,855 MW is then allocated to the 215 different CPNodes in the MISO system. The historic output has been tracked for each wind CPNode over the top 8 daily peak hours for each year 2005 through 2018. The average capacity factor for each CPNode during all 112 (8 hours * 14 years) historical daily peak hours is called the "$PKmetric_{CPNode}$" for that CPNode. The capacity factor over those 112 hours and the RMax at each CPNode are the basis for allocating the 2,855 MW of capacity to the 215 CPNodes. If the market start date of the CPNode was after 2005, the average capacity factor over fewer years is used. MISO has developed business practice rules for the handling of new wind CPNodes that do not have historical output data. Table 3-1 is a listing of the total system wind output at the time of the 112 daily peak loads. These 112 peaks are the top eight daily peaks over each of the past fourteen summers.

Tracking the top 8 daily peak hours in a year is sufficient to capture the peak load times that contribute to the annual LOLE of 0.1 days/year. The selection of 8 days was found sufficient to capture the correlation between wind output and peak load times in all cases. If many more years of historical data were available, one could simply utilize the single peak hour from each year as the basis for determining the $PKmetric_{CPNode}$ over multiple years. Using the top 8 daily peak days will be evaluated each year as more data is received.

| End Time of Daily Peak | Wind Registered Max (MW) | Estimated Curtailment and DIR (MW) | Wind Output at Daily Peak Load [1] (MW) | Wind Output % of Registered Max at Daily Peak Load [1] | Daily Peak Load (MW) | Year | Planning Year Daily Peak Rank |
|---|---|---|---|---|---|---|---|
| 6/27/05 15:00 | 908 | 0 | 291 | 32.1% | 105,353 | 2005 | 6 |
| 7/21/05 16:00 | 908 | 0 | 92 | 10.2% | 104,998 | 2005 | 7 |
| 7/25/05 15:00 | 908 | 0 | 89 | 9.8% | 108,558 | 2005 | 3 |
| 8/1/05 17:00 | 908 | 0 | 58 | 6.4% | 106,949 | 2005 | 5 |
| 8/2/05 16:00 | 908 | 0 | 211 | 23.2% | 109,099 | 2005 | 2 |
| 8/3/05 16:00 | 908 | 0 | 104 | 11.5% | 109,473 | 2005 | 1 |
| 8/8/05 17:00 | 908 | 0 | 396 | 43.6% | 104,011 | 2005 | 8 |
| 8/9/05 16:00 | 908 | 0 | 282 | 31.1% | 107,615 | 2005 | 4 |
| 7/17/06 16:00 | 1,251 | 0 | 430 | 34.4% | 110,011 | 2006 | 4 |
| 7/18/06 16:00 | 1,251 | 0 | 63 | 5.1% | 102,742 | 2006 | 5 |
| 7/19/06 16:00 | 1,251 | 0 | 378 | 30.2% | 101,744 | 2006 | 7 |
| 7/25/06 17:00 | 1,251 | 0 | 53 | 4.3% | 100,948 | 2006 | 8 |
| 7/28/06 16:00 | 1,251 | 0 | 471 | 37.6% | 102,161 | 2006 | 6 |
| 7/31/06 16:00 | 1,251 | 0 | 700 | 56.0% | 113,095 | 2006 | 1 |
| 8/1/06 16:00 | 1,251 | 0 | 139 | 11.1% | 110,947 | 2006 | 2 |
| 8/2/06 16:00 | 1,251 | 0 | 36 | 2.9% | 110,499 | 2006 | 3 |
| 6/26/07 15:00 | 2,065 | 0 | 363 | 17.6% | 97,413 | 2007 | 8 |
| 7/9/07 15:00 | 2,065 | 0 | 45 | 2.2% | 98,049 | 2007 | 6 |
| 7/31/07 17:00 | 2,065 | 0 | 352 | 17.0% | 98,955 | 2007 | 5 |
| 8/1/07 16:00 | 2,065 | 0 | 64 | 3.1% | 101,496 | 2007 | 2 |
| 8/2/07 16:00 | 2,065 | 0 | 45 | 2.2% | 101,268 | 2007 | 4 |
| 8/6/07 17:00 | 2,065 | 0 | 76 | 3.7% | 97,435 | 2007 | 7 |
| 8/7/07 17:00 | 2,065 | 0 | 59 | 2.9% | 101,306 | 2007 | 3 |
| 8/8/07 16:00 | 2,065 | 0 | 44 | 2.1% | 101,800 | 2007 | 1 |
| 7/16/08 16:00 | 3,086 | 0 | 455 | 14.8% | 95,982 | 2008 | 2 |
| 7/17/08 16:00 | 3,086 | 0 | 423 | 13.7% | 95,592 | 2008 | 3 |
| 7/18/08 16:00 | 3,086 | 0 | 97 | 3.1% | 93,144 | 2008 | 5 |
| 7/29/08 16:00 | 3,086 | 0 | 384 | 12.5% | 96,321 | 2008 | 1 |
| 7/31/08 17:00 | 3,086 | 0 | 402 | 13.0% | 92,544 | 2008 | 7 |
| 8/1/08 16:00 | 3,086 | 0 | 405 | 13.1% | 93,422 | 2008 | 4 |
| 8/4/08 17:00 | 3,086 | 0 | 178 | 5.8% | 92,245 | 2008 | 8 |
| 8/5/08 16:00 | 3,086 | 0 | 212 | 6.9% | 93,089 | 2008 | 6 |
| 6/22/09 16:00 | 5,636 | 0 | 527 | 9.4% | 87,846 | 2009 | 5 |
| 6/23/09 15:00 | 5,636 | 0 | 720 | 12.8% | 91,671 | 2009 | 3 |
| 6/24/09 17:00 | 5,636 | 0 | 300 | 5.3% | 92,402 | 2009 | 2 |
| 6/25/09 14:00 | 5,636 | 0 | 86 | 1.5% | 94,185 | 2009 | 1 |
| 6/26/09 16:00 | 5,636 | 0 | 1,082 | 19.2% | 87,355 | 2009 | 6 |
| 8/10/09 14:00 | 5,636 | 0 | 167 | 3.0% | 89,039 | 2009 | 4 |
| 8/14/09 16:00 | 5,636 | 0 | 2,126 | 37.7% | 87,023 | 2009 | 7 |
| 8/17/09 15:00 | 5,636 | 0 | 1,132 | 20.1% | 85,593 | 2009 | 8 |
| 7/23/10 16:00 | 8,179 | 0 | 692 | 8.5% | 102,995 | 2010 | 8 |
| 8/3/10 16:00 | 8,179 | 0 | 365 | 4.5% | 103,646 | 2010 | 4 |
| 8/4/10 16:00 | 8,179 | 0 | 948 | 11.6% | 103,527 | 2010 | 6 |
| 8/9/10 16:00 | 8,179 | 0 | 383 | 4.7% | 103,571 | 2010 | 5 |
| 8/10/10 16:00 | 8,179 | 30 | 1,770 | 21.6% | 107,171 | 2010 | 1 |
| 8/11/10 16:00 | 8,179 | 0 | 129 | 1.6% | 104,075 | 2010 | 3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8/12/10 16:00 | 8,179 | 25 | 1,788 | 21.9% | 106,653 | 2010 | 2 |
| 8/13/10 16:00 | 8,179 | 0 | 2,072 | 25.3% | 102,996 | 2010 | 7 |
| 6/7/11 17:00 | 9,996 | 57 | 5,624 | 56.3% | 94,933 | 2011 | 7 |
| 7/18/11 15:00 | 9,996 | 0 | 991 | 9.9% | 98,177 | 2011 | 4 |
| 7/19/11 16:00 | 9,996 | 0 | 1,880 | 18.8% | 101,076 | 2011 | 2 |
| 7/20/11 17:00 | 9,996 | 197 | 4,421 | 44.2% | 102,804 | 2011 | 1 |
| 7/21/11 16:00 | 9,996 | 158 | 961 | 9.6% | 99,601 | 2011 | 3 |
| 7/22/11 16:00 | 9,996 | 71 | 1,192 | 11.9% | 93,759 | 2011 | 8 |
| 8/1/11 15:00 | 9,996 | 0 | 2,427 | 24.3% | 95,703 | 2011 | 5 |
| 8/2/11 16:00 | 9,996 | 64 | 2,613 | 26.1% | 95,169 | 2011 | 6 |
| 6/28/12 17:00 | 11,774 | 8 | 1,387 | 11.8% | 93,031 | 2012 | 6 |
| 7/2/12 16:00 | 11,774 | 80 | 3,668 | 31.1% | 92,605 | 2012 | 7 |
| 7/5/12 16:00 | 11,774 | 0 | 659 | 5.6% | 92,473 | 2012 | 8 |
| 7/6/12 16:00 | 11,774 | 75 | 2,397 | 20.4% | 95,262 | 2012 | 3 |
| 7/16/12 17:00 | 11,774 | 2 | 4,336 | 36.8% | 94,727 | 2012 | 4 |
| 7/17/12 15:00 | 11,774 | 8 | 1,159 | 9.8% | 96,102 | 2012 | 2 |
| 7/23/12 16:00 | 11,774 | 0 | 1,152 | 9.8% | 96,794 | 2012 | 1 |
| 7/25/12 17:00 | 11,774 | 63 | 4,276 | 36.3% | 93,408 | 2012 | 5 |
| 7/15/13 16:00 | 12,239 | 14 | 1,734 | 14.2% | 88,517 | 2013 | 8 |
| 7/16/13 17:00 | 12,239 | 23 | 1,798 | 14.7% | 90,807 | 2013 | 4 |
| 7/17/13 17:00 | 12,239 | 17 | 1,478 | 12.1% | 93,190 | 2013 | 2 |
| 7/18/13 16:00 | 12,239 | 212 | 6,439 | 52.6% | 94,298 | 2013 | 1 |
| 7/19/13 16:00 | 12,239 | 51 | 3,606 | 29.5% | 91,097 | 2013 | 3 |
| 8/26/13 17:00 | 12,239 | 124 | 4,515 | 36.9% | 89,196 | 2013 | 7 |
| 8/27/13 17:00 | 12,239 | 93 | 2,776 | 22.7% | 89,456 | 2013 | 6 |
| 8/29/13 16:00 | 12,239 | 16 | 1,849 | 15.1% | 89,642 | 2013 | 5 |
| 6/17/14 16:00 | 13,403 | 81 | 4,647 | 34.7% | 109,460 | 2014 | 6 |
| 6/30/14 17:00 | 13,403 | 170 | 4,094 | 30.5% | 108,465 | 2014 | 7 |
| 7/21/14 17:00 | 13,403 | 1 | 4,690 | 35.0% | 111,157 | 2014 | 3 |
| 7/22/14 17:00 | 13,403 | 1 | 3,213 | 24.0% | 113,507 | 2014 | 1 |
| 8/22/14 17:00 | 13,403 | 1 | 484 | 3.6% | 110,604 | 2014 | 4 |
| 8/25/14 15:00 | 13,403 | 6 | 1,683 | 12.6% | 113,429 | 2014 | 2 |
| 8/26/14 16:00 | 13,403 | 0 | 327 | 2.4% | 108,136 | 2014 | 8 |
| 9/4/14 16:00 | 13,403 | 164 | 5,231 | 39.0% | 109,527 | 2014 | 5 |
| 7/13/15 17:00 | 14,732 | 35 | 3,979 | 27.0% | 114,150 | 2015 | 6 |
| 7/17/15 16:00 | 14,732 | 2 | 2,061 | 14.0% | 114,408 | 2015 | 5 |
| 7/24/15 17:00 | 14,732 | 3 | 2,127 | 14.4% | 113,049 | 2015 | 8 |
| 7/27/15 16:00 | 14,732 | 0 | 4,285 | 29.1% | 119,290 | 2015 | 2 |
| 7/28/15 16:00 | 14,732 | 0 | 3,723 | 25.3% | 120,292 | 2015 | 1 |
| 7/29/15 15:00 | 14,732 | 347 | 7,922 | 53.8% | 116,898 | 2015 | 3 |
| 8/14/15 16:00 | 14,732 | 2 | 1,157 | 7.9% | 114,657 | 2015 | 4 |
| 9/1/15 17:00 | 14,732 | 0 | 2,418 | 16.4% | 113,157 | 2015 | 7 |
| 7/20/16 17:00 | 15,910 | 0 | 6,133 | 38.5% | 118,857 | 2016 | 4 |
| 7/21/16 16:00 | 15,910 | 10 | 3,569 | 22.4% | 121,092 | 2016 | 1 |
| 7/22/16 17:00 | 15,910 | 0 | 1,796 | 11.3% | 118,786 | 2016 | 5 |
| 8/3/16 17:00 | 15,910 | 202 | 3,821 | 24.0% | 118,731 | 2016 | 6 |
| 8/4/16 16:00 | 15,910 | 50 | 2,730 | 17.2% | 119,552 | 2016 | 2 |
| 8/9/16 16:00 | 15,910 | 0 | 895 | 5.6% | 116,441 | 2016 | 8 |
| 8/10/16 16:00 | 15,910 | 9 | 4,946 | 31.1% | 119,451 | 2016 | 3 |
| 8/11/16 16:00 | 15,910 | 28 | 2,173 | 13.7% | 117,886 | 2016 | 7 |
| 6/12/17 16:00 | 16,761 | 320 | 5,692 | 34.0% | 112,273 | 2017 | 7 |
| 7/6/17 17:00 | 16,761 | 10 | 4,048 | 24.2% | 112,940 | 2017 | 6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7/12/17 16:00 | 16,761 | 4 | 2,999 | 17.9% | 112,102 | 2017 | 8 |
| 7/18/17 17:00 | 16,761 | 10 | 1,600 | 9.5% | 114,664 | 2017 | 4 |
| 7/19/17 16:00 | 16,761 | 3 | 4,094 | 24.4% | 118,833 | 2017 | 2 |
| 7/20/17 17:00 | 16,761 | 37 | 1,977 | 11.8% | 122,170 | 2017 | 1 |
| 7/21/17 16:00 | 16,761 | 12 | 3,888 | 23.2% | 117,563 | 2017 | 3 |
| 9/22/17 16:00 | 16,761 | 778 | 9,212 | 55.0% | 114,635 | 2017 | 5 |
| 6/28/18 17:00 | 18,210 | 51 | 4,706 | 25.8% | 114,279 | 2018 | 6 |
| 6/29/18 17:00 | 18,210 | 620 | 9,311 | 51.1% | 120,125 | 2018 | 1 |
| 6/30/18 17:00 | 18,210 | 26 | 3,712 | 20.4% | 115,432 | 2018 | 2 |
| 7/9/18 17:00 | 18,210 | 69 | 2,225 | 12.2% | 113,879 | 2018 | 8 |
| 7/10/18 16:00 | 18,210 | 129 | 1,819 | 10.0% | 114,947 | 2018 | 4 |
| 7/12/18 17:00 | 18,210 | 82 | 4,710 | 25.9% | 113,911 | 2018 | 7 |
| 7/13/18 17:00 | 18,210 | 67 | 1,816 | 10.0% | 115,012 | 2018 | 3 |
| 7/16/18 17:00 | 18,210 | 153 | 867 | 4.8% | 114,840 | 2018 | 5 |
| **System Wide Average Peak Metric** | | | | **19.16%** | | | |
| Note 1 **Curtailed and DIR MW have been added to settlement MW** | | | | | | | |

**Table 3-1 - Wind Output for 14 Years**
**At Time of 8 Top Daily Load Peaks each Year**

## 3.2 Wind CPNode Equations

Registered Maximum (RMax) is the MISO market term for the installed capacity of a resource. The relationship of the wind capacity rating to a CPNode's installed capacity value and Capacity Credit percent is expressed as:

$$(\text{Wind Capacity Rating})_{\text{CPNoden}} = \text{RMax}_{\text{CPNoden}} \times (\text{Capacity Credit \%})_{\text{CPNoden}} \quad (1)$$

Where $\text{RMax}_{\text{CPNode n}}$ = Registered Maximum installed capacity of the wind facility at the CPNode n. The right most term in expression (1), the $(\text{Capacity Credit \%})_{\text{CPNode n}}$, can be replaced by the expression (2):

$$(\text{Capacity Credit \%})_{\text{CPNoden}} = \text{K} \times (\text{PKmetric}_{\text{CPNoden}}\%) \quad (2)$$

Where K for Year 2018 was found by obtaining the PKmetric at each CPNode over the 14 year period, and solving expression (3):

$$\text{K} = \frac{\text{ELCC}}{\sum_{1}^{215} (\text{RMax}_{\text{CPNode n}} \times \text{PKmetric}_{\text{CPNode n}})} \quad (3)$$

This results in the sum of the MW ratings calculated for the CPNodes equal to the system-wide ELCC 2,855 MW. The values in (3) are:

ELCC = 2,855 MW

$\sum \text{RMax}_{\text{CPNode n}} \times \text{PKmetric}_{\text{CPNode n}} = 4{,}116$ MW

Therefore: K = 0.6937 = 2,855 / 4,116

## 3.3 Wind CPNode Capacity Credit Results & Example

The individual $PKmetric_{CPNode}$ of the CPNodes ranged from 0.8% to 39.3%. The individual Capacity Credit percent for CPNodes therefore ranged from 0.5% to 27.2%, by applying expression (2).

Example: RMax = 100 MW

PKmetric = 25%

K = 0.6937

$$(\text{Capacity Credit }\%)_{\text{CPNoden}} = \text{PKmetric} * K$$

$$= 0.25 * 0.6937$$

$$= 17.3\%$$

Capacity Credit (MW) = RMax * Capacity Credit %

= 100 MW * 17.3%

= 17.3 MW

Figure 3-1 shows how the system-wide 15.7 percent capacity credit percent compares with the individual capacity credit percent for the 215 active CPNodes as of the 2nd quarter of 2018. This reflects implementing the formulas referred to earlier in this section to allocate the total system 2,855 MW to the 215 CPNodes. The CPNodes have been sorted by their capacity credit percentages. Along with the specific identity of CPNodes, a given market participant is provided only the results, or selected bars on the chart that correspond to their CPNodes. The percentage is applied to the node's RMax and provides the CPNodes capacity credit in megawatts for the market participant. The CPNode's deliverability status determines the amount of the capacity credit MW that qualifies for LRZ credits in Module E-1.

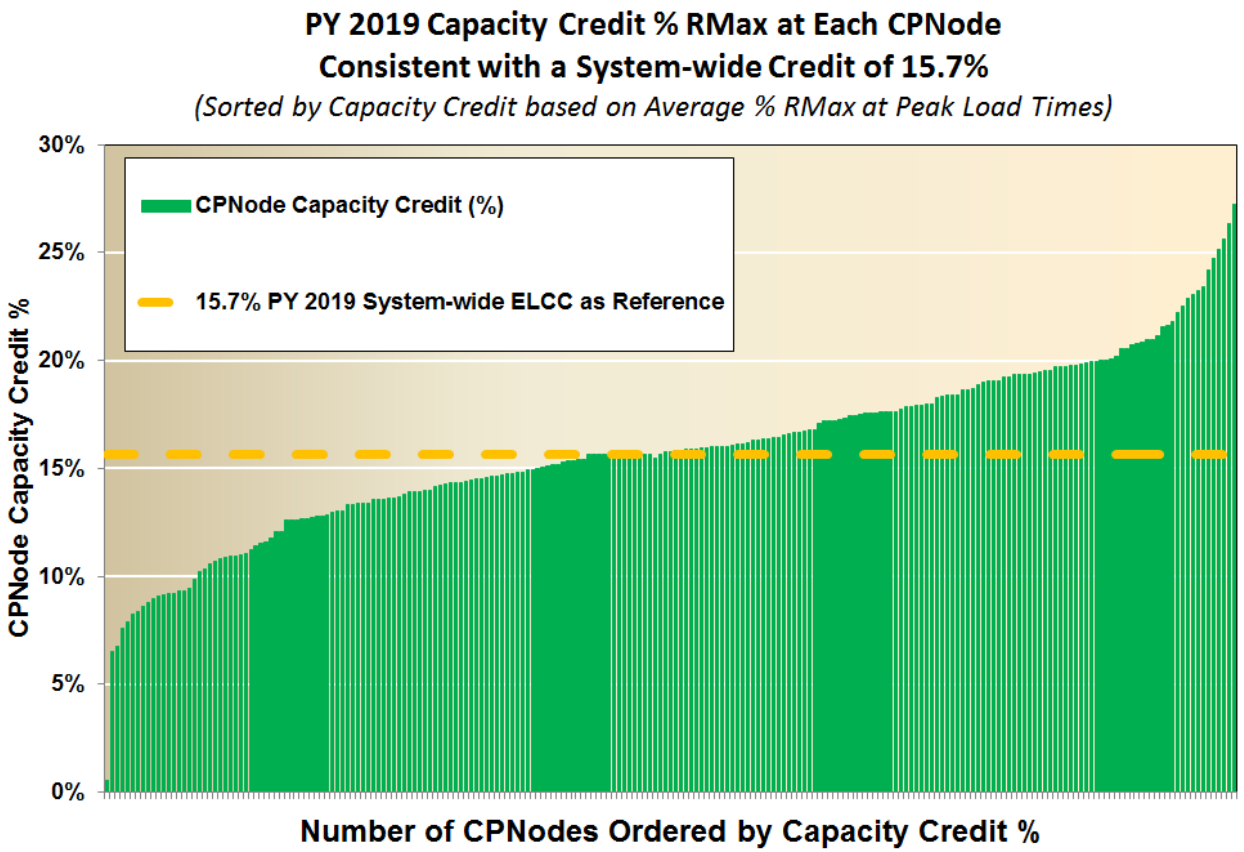



**Figure 3-1 – Allocation of Capacity Credit % over 215 CPNodes Consistent with a System-Wide Credit of 15.7%**