Planning Year 2022-2023
Wind and Solar Capacity Credit

January 2022

Highlights

- MISO class average wind capacity credit for the 2022-2023 Planning Year is 15.5%, a 0.8 percentage point decrease from the prior Planning Year driven primarily by less wind generation output on peak hours during Summer 2021 in conjunction with an increase in fleetwide installed wind capacity.

- New solar resources will continue to receive the class average capacity credit of 50% for their first year in operation while existing solar resources will continue to be accredited based on historical summer performance.

- MISO is planning on discussing and re-evaluating the Effective Load Carrying Capability (ELCC) accreditation process for intermittent resources with stakeholders at the Resource Adequacy Subcommittee (RASC) in 2022.

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Executive Summary

The MISO system-wide wind capacity credit for the 2022-2023 Planning Year (PY) is 15.5 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 during summer peak demand periods to allocate the MISO system-wide ELCC value across all operational wind Commercial Pricing Nodes (CPNodes) in the MISO system to determine a unique wind capacity credit for each wind CPNode.

As of June 30, 2021, the MISO system had 26,735 MW (253 CPNodes) of in-service nameplate wind capacity. This means 4,139 MW (26,735 MW x 15.5%) of wind unforced capacity (UCAP) potentially qualifies under Module E-1 of MISO's tariff. As a result of FERC accepting the Intermittent Deliverable ICAP tariff changes in October 2020, a slightly higher fleetwide wind UCAP of 4,223 MW is allocatable for the 2022-2023 PY. To the extent that the 4,223 MW of unforced wind capacity has demonstrated deliverability 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 253 individual wind CPNodes is proprietary information—however, the percent credit across all wind CPNodes ranged from 0.3 to 31.1 percent. Section 3 describes the details of allocating the total fleetwide wind UCAP to the 253 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. The values for LRZs 4 & 5 shown in Figure 1-1 have been combined so that proprietary information would not be revealed. MISO South does not currently have any wind CPNodes in operation.

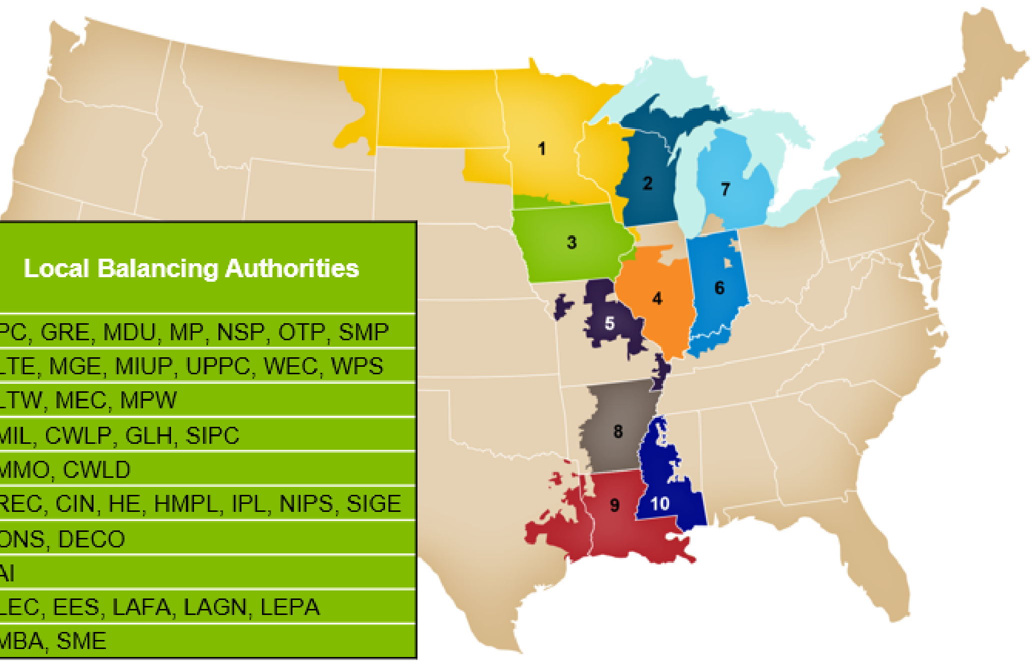
The MISO 2022-2023 Wind Capacity Credit has decreased from the 2021-2022 Wind Capacity Credit of 16.3 percent. The decreased amount of load served by wind during MISO's peak load hours relative to the increased fleetwide installed capacity resulted in the 15.5 percent capacity credit.

Solar

Existing solar resources are accredited based on their performance during summer peak hours as outlined in the MISO Resource Adequacy BPM-011 (section 4.2.3.3.2). New solar resources with less than 30 consecutive days of metered summer output will continue to receive the default solar capacity credit of 50%.

As of December 2021, there are 2,338 MW nameplate of solar resources registered in the MISO system. MISO observes an increasing number of solar projects entering the Generation Interconnection Queue. MISO will continue to use the current accreditation methodology for new solar resources until sufficient front-of-meter solar resources are in operation to perform a solar capacity credit study.

Wind Capacity by Local Resource Zone (LRZ)



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, GLH, SIPC
5	AMMO, CWLD
6	BREC, CIN, HE, HMPL, IPL, NIPS, SIGE
7	CONS, DECO
8	EAI
9	CLEC, EES, LAFA, LAGN, LEPA
10	EMBA, SME

2022-2023 PY										
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)	26,735	7,938	802	12,426	1,684	782	3,104	0	0	0
UCAP (MW)	4,223	1,472	99	2,064	170	87	333	0	0	0
Average Credit %	15.5%	16.9%	11.7%	15.5%	9.8%	8.9%	11.2%	0.0%	0.0%	0.0%
Wind CPNode Count	253	91	11	99	12	6	34	0	0	0

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

MISO System-Wide Wind ELCC Study

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 time-varying electric demand 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].

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).

[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

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.

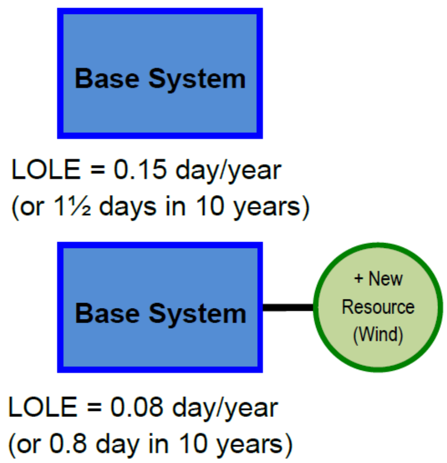


Figure 2-1: Example System *with* & *without* New Resource

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 Registered 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.

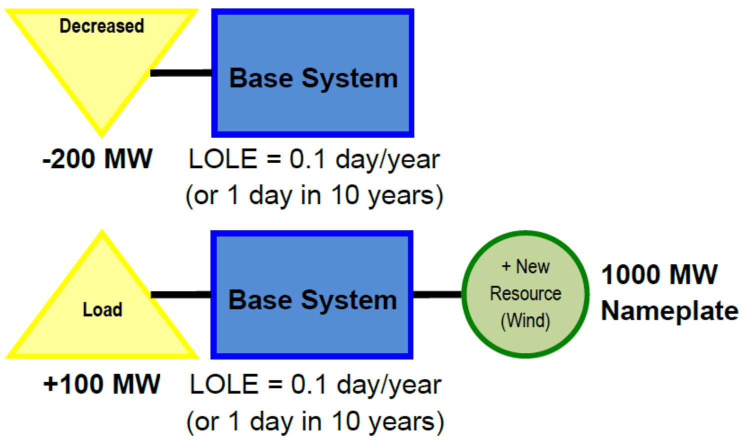


Figure 2-2: ELCC Example System at the same LOLE

The methodology illustrated in the simple example of Figure 2-2 was utilized as the analytical approach for the determination of the 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] 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

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 resources 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 resource types in the MISO system.

For the 2022-23 ELCC study, the historical 2021 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 17 years.

MISO System-Wide ELCC Results

MISO calculated ELCC percentage results for historical years 2005 through 2021 and at multiple scenarios of increased penetration levels, corresponding to 30 GW, 40 GW, and 50 GW of installed wind capacity. This creates an ELCC penetration characteristic for each year, as illustrated by the various trend lines 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. The initial leftmost data point for each curve is at the lowest penetration point and represents the actual annual ELCC for that year. Annual historical ELCC values can be found in Table 2-1. The values along each year's characteristic curve at the higher penetration levels reflect what that year's wind ELCC would have been with similar wind generation and load profiles if more capacity had been installed over the same year and footprint. The high-end 50 GW level of penetration (approximately 42 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 seventeen years, and how those characteristics from multiple years were merged to establish the current wind capacity credit of 15.5 percent.

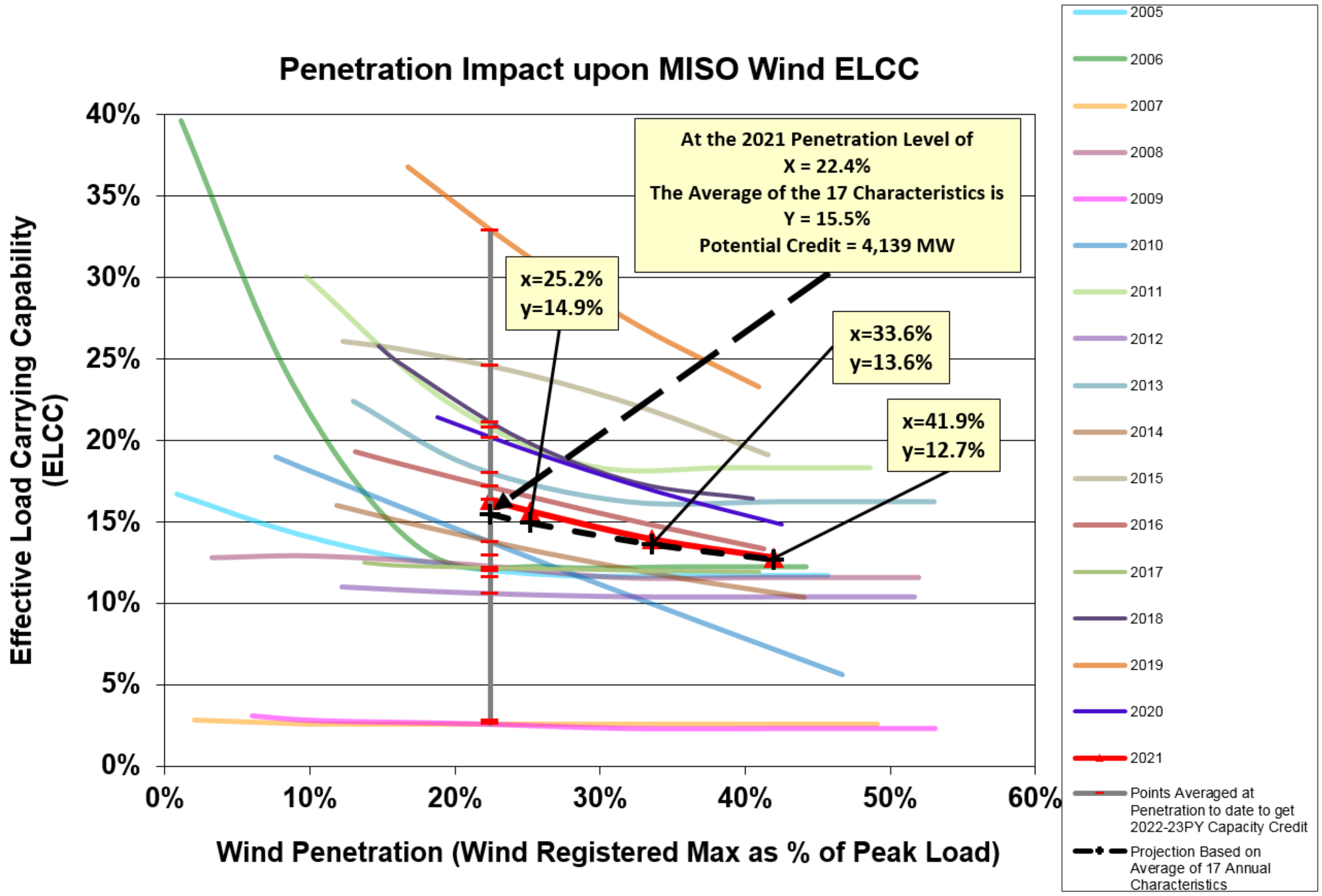


Figure 2-3: Seventeen Years of Historical Wind ELCC Penetration Characteristics

The 2022-23 PY wind capacity credit is determined by averaging the seventeen 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 2021. The in-service amount of wind capacity at the end of the 2nd quarter is the convention used to set the capacity going into the summer season. The penetration level of peak load at the end of the 2nd quarter of 2021 was 22.4 percent. The historical 2021 penetration level is calculated by dividing the 2nd quarter 26,735 MW fleetwide wind capacity (from column 4 of Table 2-1) by the 119,215 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 that is expressed in the legend of Figure 2-3 as "Points Averaged at Penetration to date to get 2022-2023PY Capacity Credit" illustrates where each of the seventeen ELCC values from each year's characteristic curve intersect with the most recent 22.4 percent historical penetration level. The legend of Figure 2-3 also indicates that the average of the intersected values is the 15.5 percent system-wide ELCC for the 2022-23 PY. The black projection line in Figure 2-3 starts with the 2022-23 PY 15.5 percent and is more clearly observed as the 15.5 percent studied wind capacity credit point and forward capacity credit 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 4,223 MW of UCAP in the 2022-2023 PY. 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.

As a result of FERC accepting the Intermittent Deliverable ICAP tariff changes (FERC Docket #ER20-2005), for the 2022-23 PY, a slightly higher fleetwide wind UCAP of 4,223 MW is allocatable, determined as the resulting UCAP total from the summation (at the resource level) of the larger of two fleetwide allocation methodologies, with and without curtailments added to settled output during the top 8 annual peaks. This fleetwide wind UCAP value of 4,223 MW is allocated among 253 wind CPNodes, up from 228 CPNodes of the previous planning year. Section 3 describes the details of the new allocation methodology. The amount of UCAP at each node that can qualify for the annual Planning Resource Auction under Module E-1 is subject to the deliverability procured for each resource.

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

Market-wide Operational Tracking							
Peak Load (MW)	Planning Year (PY)	Metered Wind at Peak Load (MW)	Registered Maximum Capacity (MW)	Peak Day RMax[1] (%)	Historical Penetration of Peak Load[2] (%)	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%
122,210	2019	9,210	20,452	45.0%	16.7%	36.8%	15.7%
117,540	2020	6,482	22,040	29.4%	18.8%	21.4%	16.6%
119,215	2021	2,787	26,735	10.4%	22.4%	16.3%	16.3%
Pending	2022	Pending	Pending	Pending	Pending	Pending	15.5%

Notes: 1 Registered Maximum Capacity (RMax)
2 Wind's historical penetration is the fleetwide studied in-service RMax divided by the year's peak load

The method to set the capacity credit was developed at the LOLE Working Group, and was first applied to the 2011-12 PY. Table 2-2 shows the consistency of that method's results over twelve 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 2022-2023 PY point and the extension to future higher penetration levels from Figure 2-3.

Planning Year	Wind Nameplate Penetration of Annual Peak Load	Capacity Credit (%)
2011-12 PY	7.6%	12.9%
2012-13 PY	9.7%	14.7%
2013-14 PY	12.2%	13.3%
2014-15 PY	13.0%	14.1%
2015-16 PY	11.8%	14.7%
2016-17 PY	12.2%	15.6%
2017-18 PY	13.1%	15.6%
2018-19 PY	13.7%	15.2%
2019-20 PY	14.8%	15.7%
2020-21 PY	16.7%	16.6%
2021-22 PY	18.8%	16.3%
2022-23 PY	22.4%	15.5%

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

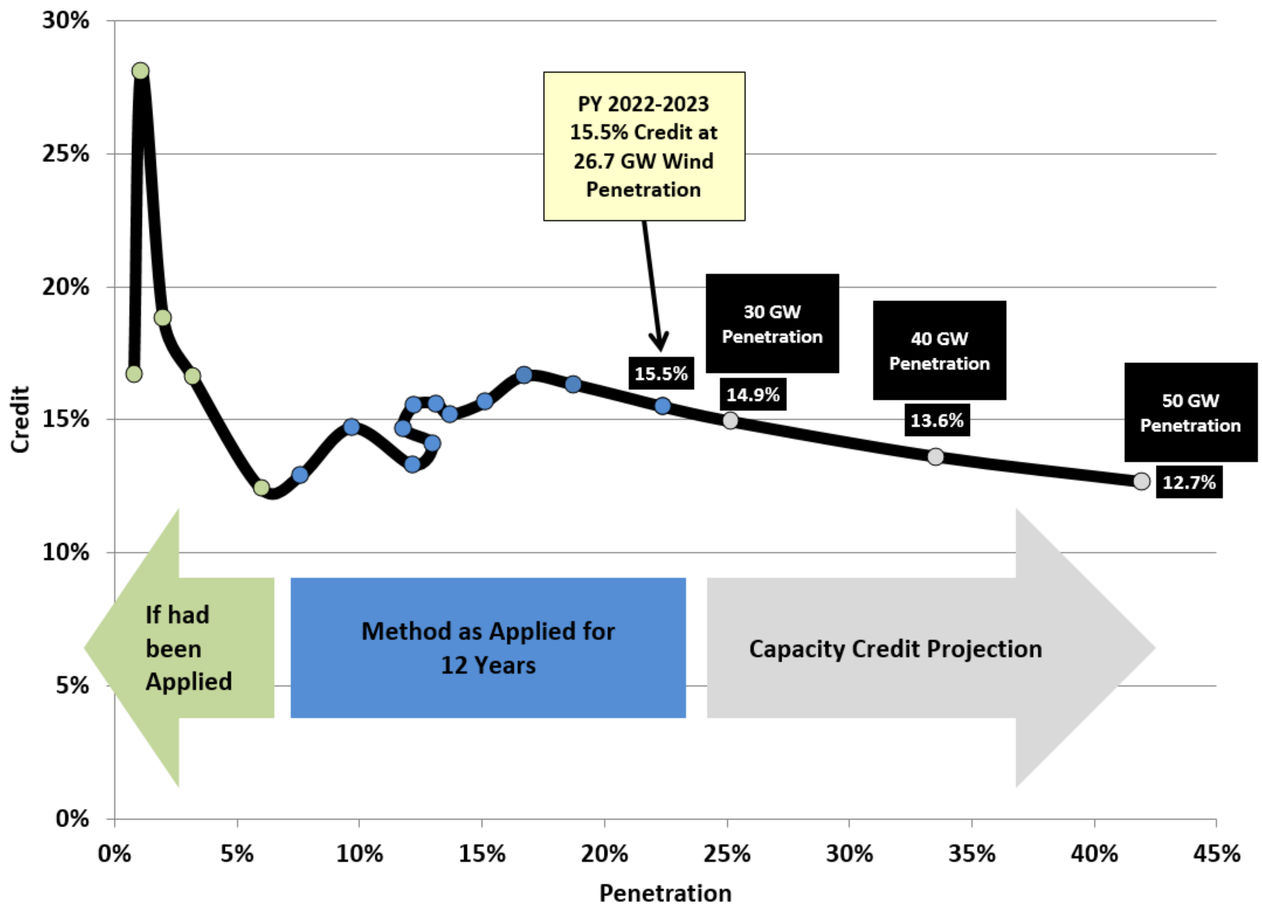


Figure 2-4: Demonstration of Applying Capacity Credit Method Starting with 2006-07 PY

For the 2015-2016 PY 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 2014-15 PY.

Details of Wind Capacity by CPNode

Correlated Peak Load and Wind Output

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 a wind resource's capacity factor over multiple years. Using the top 8 daily peak days will be evaluated each year as more data is received. Table 3-1 is a listing of the total system wind output at the time of each of the 136 daily peak loads.

Hour Ending EST of Daily Peak	Wind Registered Max (MW)	Estimated Curtailment (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	58	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	31	3,979	27.0%	114,150	2015	6
7/17/15 16:00	14,732	106	2,061	14.0%	114,408	2015	5
7/24/15 17:00	14,732	4	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	4	3,723	25.3%	120,292	2015	1
7/29/15 15:00	14,732	335	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	6	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	3,580	22.5%	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	191	3,962	24.9%	118,731	2016	6
8/4/16 16:00	15,910	50	2,780	17.5%	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	0	4,955	31.1%	119,451	2016	3
8/11/16 16:00	15,910	24	2,202	13.8%	117,886	2016	7
6/12/17 16:00	16,761	301	6,012	35.9%	112,273	2017	7
7/6/17 17:00	16,761	10	4,058	24.2%	112,940	2017	6
7/12/17 16:00	16,761	4	3,003	17.9%	112,102	2017	8
7/18/17 17:00	16,761	52	1,610	9.6%	114,664	2017	4
7/19/17 16:00	16,761	2	4,097	24.4%	118,833	2017	2
7/20/17 17:00	16,761	15	2,013	12.0%	122,170	2017	1
7/21/17 16:00	16,761	12	3,900	23.3%	117,563	2017	3
9/22/17 16:00	16,761	733	9,918	59.2%	114,635	2017	5
6/28/18 17:00	18,210	21	4,774	26.2%	114,279	2018	6
6/29/18 17:00	18,210	420	9,768	53.6%	120,125	2018	1
6/30/18 17:00	18,210	1	3,709	20.4%	115,432	2018	2
7/9/18 17:00	18,210	24	2,310	12.7%	113,879	2018	8
7/10/18 16:00	18,210	7	1,966	10.8%	114,947	2018	4
7/12/18 17:00	18,210	27	4,788	26.3%	113,911	2018	7
7/13/18 17:00	18,210	35	1,966	10.8%	115,012	2018	3
7/16/18 17:00	18,210	85	1,050	5.8%	114,840	2018	5
7/2/19 16:00	20,452	3	1,573	7.7%	110,830	2019	7
7/9/19 17:00	20,452	500	8,041	39.3%	111,240	2019	6
7/10/19 16:00	20,452	1,035	12,212	59.7%	114,078	2019	4
7/17/19 16:00	20,452	98	6,040	29.5%	116,307	2019	2
7/18/19 18:00	20,452	1,242	5,478	26.8%	115,576	2019	3
7/19/19 16:00	20,452	1,830	10,760	52.6%	120,016	2019	1
8/5/19 16:00	20,452	127	5,266	25.7%	113,282	2019	5
8/13/19 16:00	20,452	358	6,039	29.5%	109,594	2019	8
7/2/20 15:00	22,040	111	2,862	13.0%	111,654	2020	8
7/6/20 15:00	22,040	5	1,614	7.3%	112,068	2020	6
7/7/20 15:00	22,040	117	2,922	13.3%	112,641	2020	5
7/8/20 14:00	22,040	35	8,005	36.3%	114,027	2020	2
7/9/20 15:00	22,040	152	5,900	26.8%	114,002	2020	3

7/17/20 16:00	22,040	230	11,607	52.7%	113,079	2020	4
8/24/20 16:00	22,040	16	6,721	30.5%	116,795	2020	1
8/25/20 15:00	22,040	241	6,893	31.3%	111,690	2020	7
7/26/21 16:00	26,735	900	7,431	27.8%	116,637	2021	5
7/27/21 16:00	26,735	4	5,000	18.7%	115,624	2021	7
7/28/21 16:00	26,735	265	9,329	34.9%	117,686	2021	2
7/29/21 15:00	26,735	0	5,587	20.9%	115,540	2021	8
8/10/21 15:00	26,735	78	6,462	24.2%	116,933	2021	3
8/23/21 16:00	26,735	0	3,046	11.4%	116,195	2021	6
8/24/21 15:00	26,735	1,400	8,106	30.3%	117,979	2021	1
8/25/21 16:00	26,735	1,762	2,231	8.3%	116,919	2021	4
System-Wide Average Peak Metric				**20.73%**			
Note 1 **Curtailed MW have been added to settlement MW**							

Table 3-1: Wind Output for 17 Years at Time of 8 Top Daily Load Peaks Each Year

Deterministic Analytical Technique

To account for the diverse generation profile of numerous wind CPNodes throughout the MISO system (253 front-of-meter wind resources as of June 2021), a deterministic approach that accounts for historical performance during peak system demand is used to equitably allocate the system-wide capacity value of wind to all of the registered and in-service 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 to recognize the capacity contributions of each individual wind resource. In a market, it is important to convey where wind resources tend to provide more capacity value, and how the location and corresponding relative performance of each wind CPNode relates to the contribution of wind ELCC to system-wide reliability.

For the 2022-2023 planning year, the system-wide wind ELCC value of 15.5 percent multiplied by the 2021 registered and in-service maximum wind capacity (RMax) of 26,735 MW (2nd Quarter of 2021) results in 4,139 MW of system-wide wind capacity. New wind CPNodes that do not have historical output data would receive the system-wide wind capacity credit of 15.5 percent.

This 4,139 MW of system-wide wind capacity is distributed across the 253 individual wind CPNodes under two allocation techniques: with and without curtailments added to each individual wind resource's output during system peak. These two techniques yield two slightly different capacity values for each wind resource with each resource being allocated the larger of the two capacity values. The result of the fleetwide allocation using the greater-of determination of an individual resource's capacity value from the two allocation techniques results in a total of 4,223 MW system-wide wind capacity that is ultimately deemed allocatable. A wind resource's allocatable portion of the 4,223 MW is referred to as its Total UCAP.

The next step is to determine how much of the Total UCAP is eligible to be converted into ZRCs, but before that can be calculated, the demonstrated deliverability of the wind resource must be known. Deliverability is determined in accordance with Module E-1 (section 69A.3.1.g) of the MISO Tariff. At a high level, deliverability of a wind resource is quantified as the combination of existing Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service with a valid Transmission Service Request (ERIS w/ TSR).

Historic output has been tracked for each wind CPNode over the top 8 daily peak hours for each year 2005 through 2021. The average capacity factor for each CPNode during all 136 (*8 hours x 17 years*) historical daily peak hours is called the *Peak Performance Capacity Factor* (also referred to as the $PKmetric_{CPNode)}$ for that CPNode. The capacity factor over those 136 hours and the RMax of each CPNode are the basis for allocating the 4,223 MW of capacity to the 253 CPNodes. If the market start date of the CPNode was after 2005, the average capacity factor over fewer years is used.

The Total UCAP for a wind resource is distributed into two categories for the purpose of determining the amount of capacity eligible for conversion into Zonal Resource Credits (ZRCs), either convertible UCAP or undeliverable ERIS UCAP. To calculate convertible UCAP, which is eligible to be converted into ZRCs, a *Deliverability Adjusted Capacity Factor* is first applied. The *Deliverability Adjusted Capacity Factor* uses historical peak observances of an intermittent resource and is calculated by 'capping' historical intermittent output during peak load observances to the resource's demonstrated deliverability and then dividing by the resource's RMax. The *Peak Performance Capacity Factor* utilizes identical historical peak observances divided by the resource's RMax, but does not cap those observances by the resource's demonstrated deliverability.

$$\text{Convertible UCAP} = \text{Total Interconnection UCAP} * \frac{\text{Deliverability Adjusted Capacity Factor}}{\text{Peak Performance Capacity Factor}}$$

The remaining Total UCAP that is left after calculating Convertible UCAP is considered the undeliverable ERIS UCAP.

Optionally, the classified undeliverable ERIS UCAP can become eligible to be converted into ZRCs by procuring firm Transmission Service. Figure 3-1 represents the conversion of UCAP to ZRCs at the resource level as a block diagram.

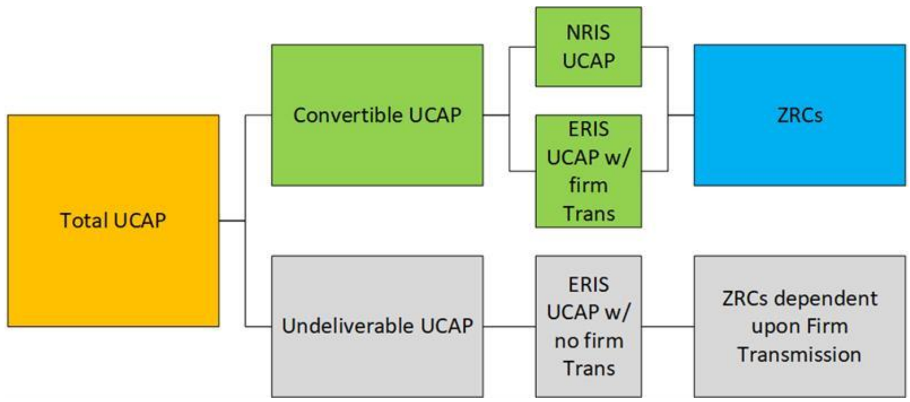


Figure 3-1: Block Diagram of Conversion of Total Unforced Capacity to Zonal Resource Credits

ERIS UCAP is not generally convertible to ZRCs at a one-to-one MW ratio. Each resource will have unique conversion data generated based on its past performance and deliverability which indicates the level of firm Transmission Service necessary to be obtained to gain a given level of ZRCs.

An example and further explanation are shown in Figure 3-2 below:

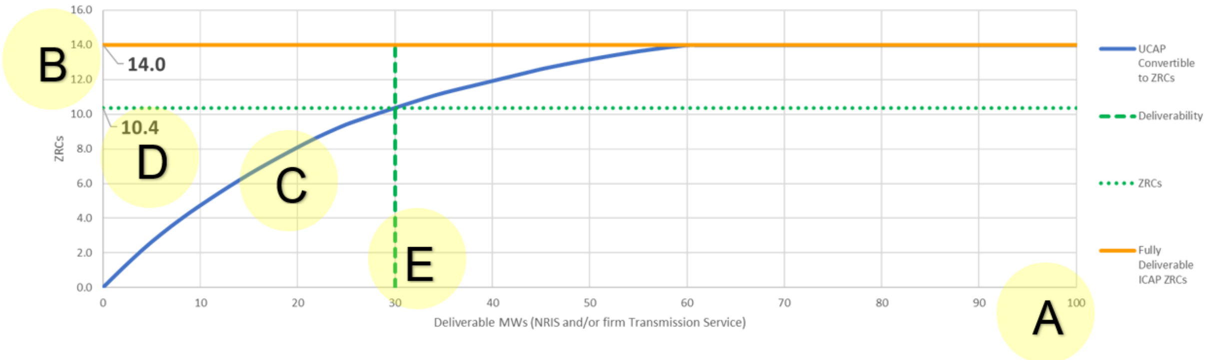


Figure 3-2: ZRC Deliverability Curve Chart

Where:

A: Equals the registered maximum output of the resource (RMax). In this example, this resource is 100 MW.

B: Total UCAP, or max UCAP, that can potentially be converted into ZRCs. This also represents the share of the fleetwide ELCC capacity. This value is based on the size and performance of the resource.

C: This is the Convertible UCAP function which is the resource's Total UCAP multiplied by the ratio of its Deliverability Adjusted Capacity Factor divided by its Peak Performance Capacity Factor. Convertible UCAP varies depending on the amount of demonstrated deliverability of the resource.

D: This is the resulting Convertible UCAP value for a corresponding demonstrated deliverability amount in MW.

E: This is the example Deliverable value. The point at which E intersects C provides the amount of ZRCs the Market Participant would obtain based on the size, performance, and demonstrated deliverability of the resource.

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:

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

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):

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

Where K for 2021 was found by obtaining the PKmetric at each CPNode over the 17-year period, and solving expression (3):

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

This results in the sum of the MW ratings calculated for the CPNodes equal to the system-wide ELCC 4,139 MW. The values in (3) are:

ELCC = 4,139 MW

$\sum \text{RMax}_{\text{CPNode n}} \times \text{PKmetric}_{\text{CPNode n}}$ = 7,083 MW

Therefore: K = 0.5843 = 4,139 / 7,083

Wind CPNode Capacity Credit Results & Example

The individual $PKmetric_{CPNode}$ of the CPNodes ranged from 0.6% to 53.2%. The individual Capacity Credit percent for CPNodes therefore ranged from 0.3% to 31.1%, by applying expression (2). Under the adjusted intermittent deliverable ICAP, Capacity Credit (MW) would be equivalent to Total UCAP under one of the two allocation techniques described earlier in this section.

Example: RMax = 100 MW
PKmetric = 25%
K = 0.5843

$$(\text{Capacity Credit }\%)_{CPNode\ n} = PKmetric * K = 0.25 * 0.5843 = 15.5\%$$

$$\text{Capacity Credit (MW)} = RMax * \text{Capacity Credit }\% = 100\ MW * 15.5\% = 15.5\ MW$$

Figure 3-3 shows how the system-wide 15.5 percent wind capacity credit percent compares with the individual capacity credit percent for the 253 active wind CPNodes as of the 2nd quarter of 2021. This reflects implementing the formulas referred to earlier in this section to allocate the total fleetwide 4,223 MW to the 253 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 for the market participant the CPNode's capacity credit (or Total UCAP) in megawatts that is potentially convertible to ZRCs in the Planning Resource Auction. The wind resource's demonstrated deliverability is considered when determining the amount of Total UCAP that qualifies for Zonal Resource Credits.

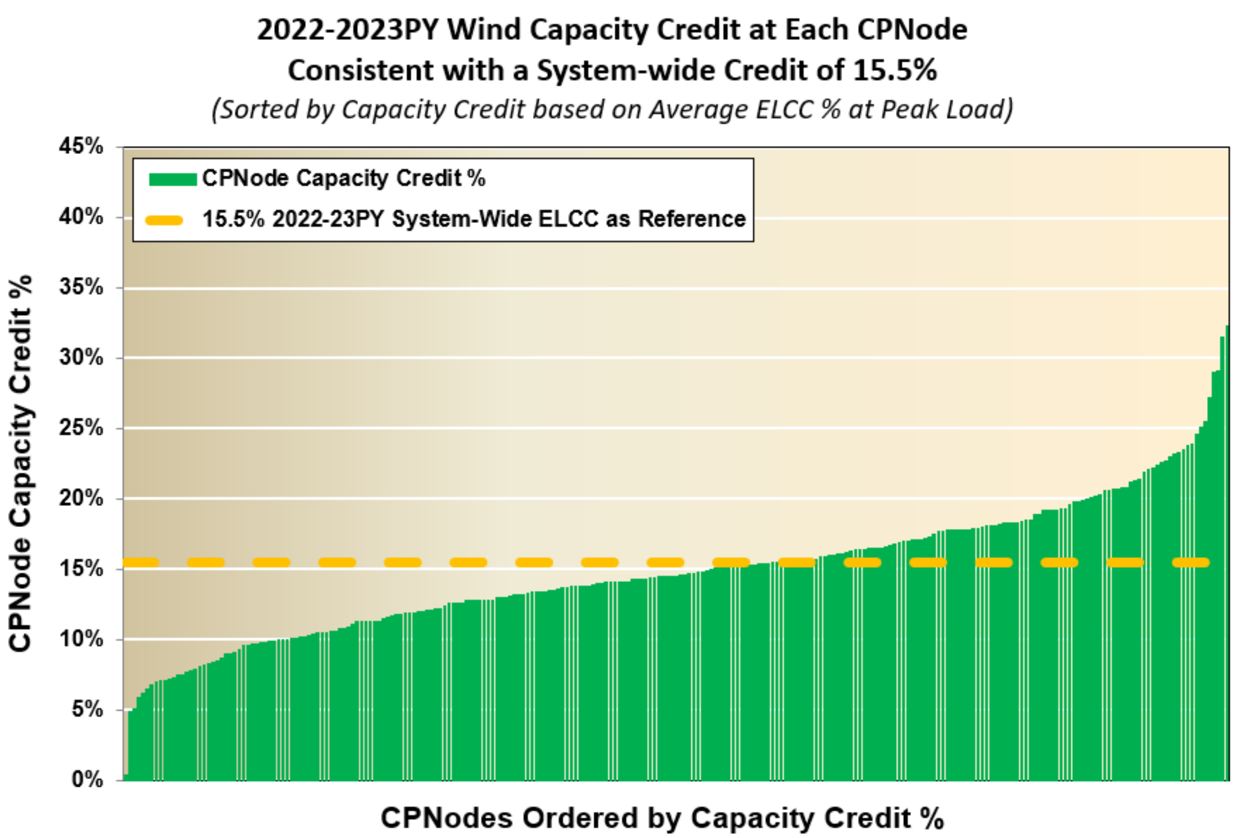


Figure 3-3: Allocation of Capacity Credit % over 253 CPNodes Consistent with a System-Wide Credit of 15.5%

Appendix

Deliverability Curve for New Wind Resources

This curve applies for new CPNode wind resources that are registering with MISO, that do not have an entire summer of metered production data, and that wish to participate in the annual capacity auction held at the beginning of April, known as the Planning Resource Auction (PRA). This curve is included in the Module E Capacity Tracking (MECT) tool for Market Participants to utilize for determining the conversion of Unforced Capacity (UCAP) to Zonal Resource Credits (ZRCs) based on the wind resource's deliverability.

Market Participants can use this to curve to calculate how much of a new wind resource's registered maximum capacity (RMax) will be convertible to Zonal Resource Credits (ZRCs) for utilization in the PRA. A new wind resource will first have the class average wind capacity credit of 15.5% applied to its RMax to get to a Total UCAP value. This represents the full amount of MW that are potentially convertible to ZRCs, dependent on the amount of Total Deliverability the resource has been studied for and/or requested. Along with the new wind resource's RMax, Market Participants will also need to supply the resource's total demonstrated deliverability, the combination of the resource's Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service in conjunction with a valid Transmission Service Request (ERIS w/ TSR).

The new wind deliverability curve represents the normalized capacity factors of every CPNode wind resource that has come online in the most recent 5 years during the top 8 annual system peak demand hours, identical to those that sampled for the deterministic allocation process of the annual wind capacity credit study. This results in a total of 40 sampled hours of wind output correlated with system peak demand at the resource level. This resource-level production data has been normalized as percentages of nameplate capacity (or RMax) to establish capacity factors on peak for each resource, and then those observances are sorted from lowest to highest to establish a capacity factor duration curve using a 2nd-order polynomial trend fit.

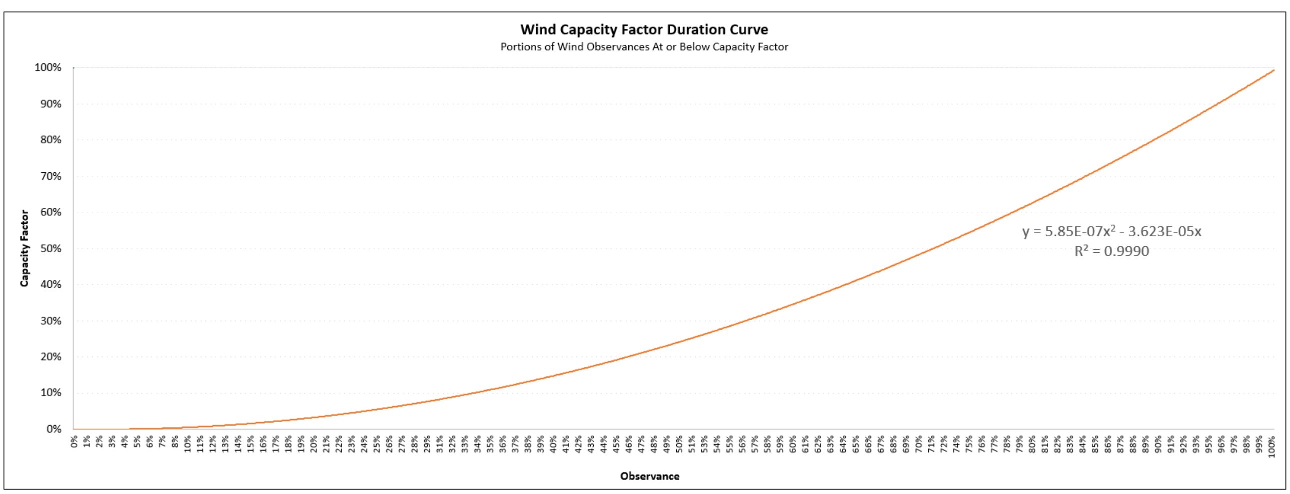


Figure 4-1: Fleetwide UCAP-to-ZRC Deliverability Curve for New Wind Resources

References

- MISO Tariff
  - Module E-1 - Resource Adequacy
- MISO Business Practices Manual
  - BPM 011 - Resource Adequacy
- FERC Filing & Order Acceptance — Intermittent Deliverable ICAP
  - Docket Nos. ER20-2005-000, ER20-2005-001