

Planning Year 2013-2014 Wind Capacity Credit

December 2012

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1 Executive Summary

The system-wide wind resource capacity credit for Planning Year 2013 is 13.3 percent. This was the fourth year of applying a process based on determining the Effective Load Carrying Capability (ELCC) from analyzing wind performance over historical years since 2005.

As of June 30, 2012 there was 11,774 MW of registered wind capacity on the MISO system. After analyzing 2005 through August 2012 wind performance, this means that 11,774 x 13.3 percent = 1,567 MW potentially qualify as unforced capacity megawatts under Module E-1 of MISO’s tariff. To the extent that the 1,567 MW of unforced wind capacity is deliverable at the individual wind Commercial Pricing Nodes (CPnodes), the unforced capacity megawatts may be converted to Zonal Resource Credits (ZRC) to meet Resource Adequacy obligations.

The capacity credit at the 169 individual wind Commercial Pricing Nodes (CPnodes) is proprietary information, however the percent credit ranged from zero to 30.4 percent. Section 3 describes the details of allocating the total 1,567 MW to the 169 wind CPnodes. Upon request to MISO, the capacity credit details for individual wind CPnodes are available to the associated Market Participant. Appendix A of the Resource Adequacy Business Practices Manual (BPM)¹ documents the methods for both the system-wide and CPnode aspects of wind capacity credit. Figure 1-1 geographically illustrates the seven Local Resource Zones (LRZ). The table in Figure 1-1 shows the most detailed results that MISO can share. Except for Zone 5, there are more than two market participants in each zone so that the information can be made public. Therefore in the table Zones 5 was combining with Zone 4. Otherwise without combining Zones 4 and 5, the zone parameters would have revealed the information of a single market participant in Zone 5.

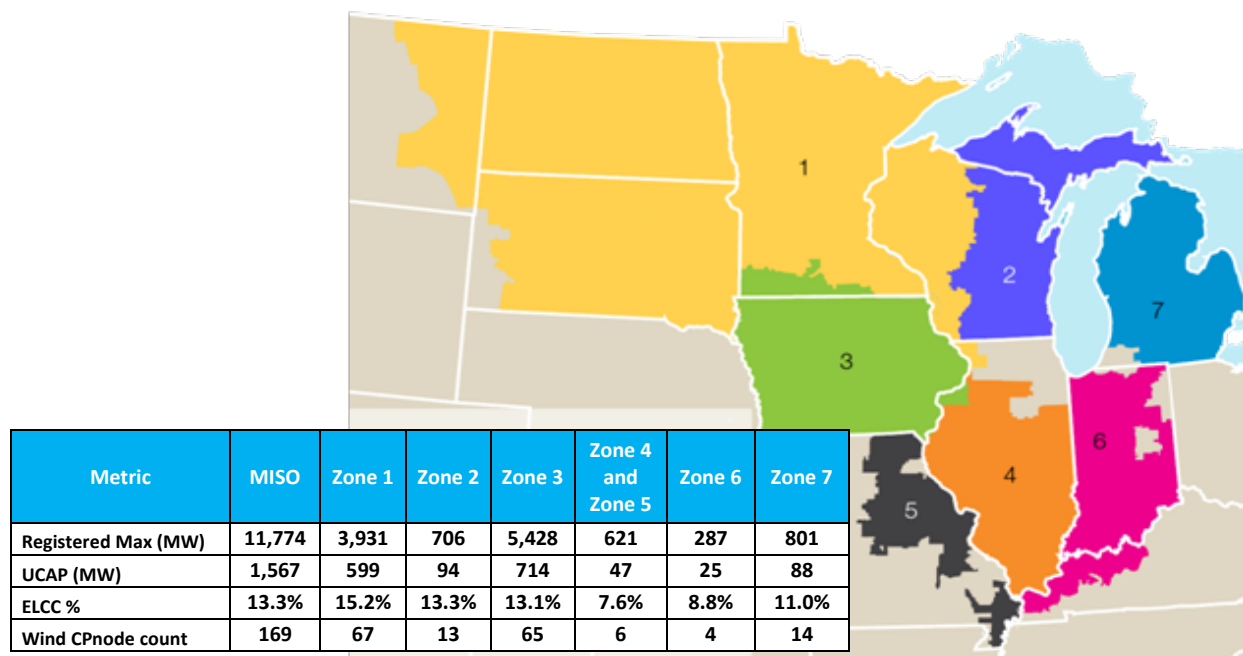


Figure 1-1: MISO Local Resource Zones (LRZ) And Distribution of Wind Capacity

¹ Resource Adequacy BPM: https://www.misoenergy.org/_layouts/MISO/ECM/Redirect.aspx?ID=19206

2 Details of MISO System Wind Capacity

The 13.3 percent system-wide MISO wind capacity credit is based on determining the Effective Load Carrying Capability (ELCC) of the intermittent wind resources. A first LOLE simulation is done with the historical-hourly load and same corresponding historical-hour wind resource outputs, and this sets an LOLE benchmark. In a second LOLE simulation the wind resources are removed, and replaced with a trial amount of load reduction that is varied until the same benchmark LOLE result is achieved. The amount of load reduction that achieves the same LOLE result is then the ELCC. As a percentage the ELCC is the resulting load reduction MW divided-by registered wind capacity MW).

MISO calculates ELCC percentage results for historic years 2005 through 2012, and at multiple penetration levels, corresponding to 10 GW, 20 GW, and 30 GW of installed wind capacity². This creates an ELCC-versus-wind penetration characteristic for each historic year, and those are the various annual curves shown in Figure 2-1. Details of how MISO selects an equation to represent each ELCC-versus-wind penetration characteristic are in the BPM¹. Compared to a perfect R squared coefficient of “1” a second order polynomial has provided the best fit each year, and the R squared coefficients have been greater than 0.999. The initial left most point and therefore the lowest penetration point on each characteristic curve represents the actual annual ELCC for that year, and the values to their right at higher penetration levels, reflect what that year’s wind resource would have as an ELCC if more capacity had been installed over the same footprint. The high end 30 GW level of penetration is an estimate of the amount of wind generation that could result in MISO, as the Load Serving Entity’s (LSE) collectively meet renewable resource mandates of the various MISO States. For example, a survey of LSE’s summarized in a 2009 Regional Generation Outlet Study (RGOS) indicated that about 18 GW of cumulative capacity (existing plus additions going forward) would be needed by the year 2027 if wind delivered energy at a 30 percent capacity factor. Also, Section 2.6 of MTEP 11, studied alternative policy futures that included up to 28,800 MW of new wind generation to meet the 20 percent Federal RPS. Therefore, the 30 GW range was selected to illustrate a reasonable upper end for depicting the wind penetration effect. Figure 2-1 illustrates the ELCC versus penetration characteristic of each year, and how those characteristics from multiple years were merged to establish the current 13.3 percent wind capacity credit.

The Planning Year (PY) 2013 wind capacity credit is determined by averaging the eight ELCC values found along each year’s ELCC-and-penetration characteristic curve. The averaging is done at the penetration level that corresponds to the penetration level at the end of the 2nd Quarter 2012. 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. For comparison, over the course of 2012, the January registered capacity was 10,718 MW, by the 2nd Quarter it was 11,774 MW, and the following January 2013 value is expected to be greater than 12,444 MW. The penetration level at the end of the 2nd Quarter 2012 was 12.2 percent. The historical 2012 penetration level is calculated by dividing the 2nd Quarter 11,774 MW (from column 4 of Table 2-1) by the 96,015 MW peak load (column 1). The vertical line called out in the legend of Figure 2-1 as “Points Averaged at penetration to date to get 2013 Capacity Credit” illustrates where each of the eight ELCC values from each year’s characteristic curve intersect with the most recent 12.2 percent historical penetration level, and the notes box reflect that the average of intersected values is the 13.3 percent system-wide ELCC for PY 2013. The black projection line in Figure 2-1 starts with the PY 2013 13.3 percent, and is more clearly observed as the current 13.3 percent point and forward projection in Figure 2-2.

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 1,567 MW of UCAP in 2013. MISO calculates the associated

² MISO first examined the relationship of the declining capacity effectiveness of wind resources as penetration increases, in the 2010 LOLE report’s Appendix E and demonstrated the decline utilizing the ELCC method.

UCAP capacity at each wind CPnode and provides it to the appropriate Market Participant on a requested confidential basis. The PY 2013 1,567 MW of UCAP are allocated among 169 wind CPnodes, up from 143 CPnodes in PY 2012. Section 3 shows 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.

The eight percent capacity credit for PY 2010, shown in Table 2-1 utilized ELCC, however the current process to merge multiple years results had not been developed. In contrast Table 2-2 shows a 12.4 percent capacity credit value for PY 2010, which reflects applying the current method that was not fully developed until 2011. PY 2011 was the first year where the fully developed quantitative method for merging multiple historical ELCC characteristics was applied, as illustrated in Figure 2-1.

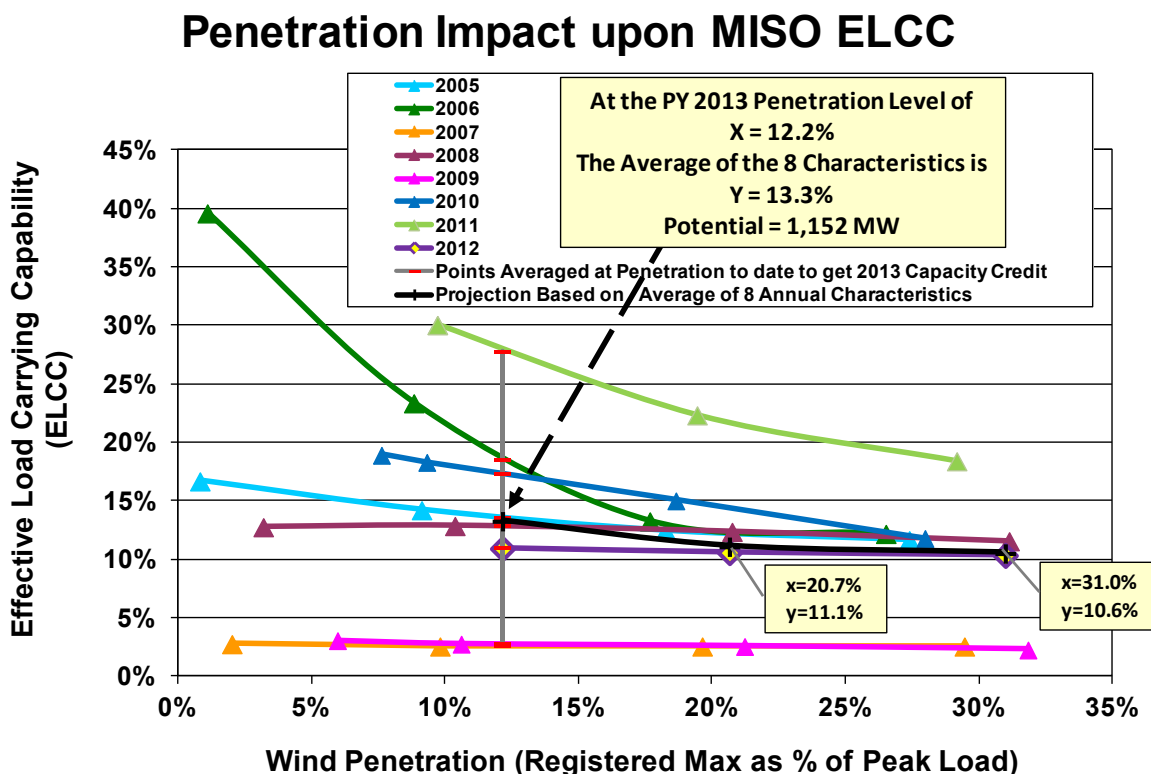


Figure 2-1: Eight Years of Historical ELCC Penetration Characteristics

Table 2-1: Historical Tracking of Wind Related Metrics

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	1.4%	6.0%	3.1%	20.0%
107,171	2010	1,770	8,179	21.3%	7.6%	18.9%	8.0%
102,804	2011	4,421	9,996	42.8%	9.7%	30.1%	12.9%
96,794	2012	1,152	11,774	9.8%	12.2%	11.1%	14.7%
Pending	2013	Pending	Pending	Pending	Pending	Pending	13.3%

Notes: **1** Curtailed and Dispatchable Intermittent Resources (DIR) MW have been added to settlement MW
2 Registered Maximum (RMax)

The current method to set the capacity credit was developed at the LOLE Working Group, and was first applied to PY 2011. Table 2-2 shows the consistency of that method's results over four Planning Years, including if the current method had also been applied in PY 2010. Again, the black curve in Figure 2-2 is the projection going forward, where the influence of future annual ELCC characteristics are still pending. For related study work that require hourly wind and load patterns, such as required in PROMOD® simulations, MISO has indicated that the historical 2005 wind and load shapes are typical patterns to use at MISO. The appropriateness of continuing to use 2005 as a typical year is confirmed in Figure 2-1, since the black trend line that reflects all history lies nearly on top of the blue line representing the single year 2005. The left portion of Figure 2-2 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. The Figure 2-2 also repeats the 2013 point and the extension to future higher penetration levels from Figure 2-1.

Table 2-2: Consistent and Responsive System-wide ELCC Method
 Demonstrated by applying it Over Four Planning Years

Planning Year	Wind Penetration	ELCC
PY 2010	6.0%	12.4%
PY 2011	7.6%	12.9%
PY 2012	9.7%	14.7%
PY 2013	12.2%	13.3%

MISO Wind Capacity Credit

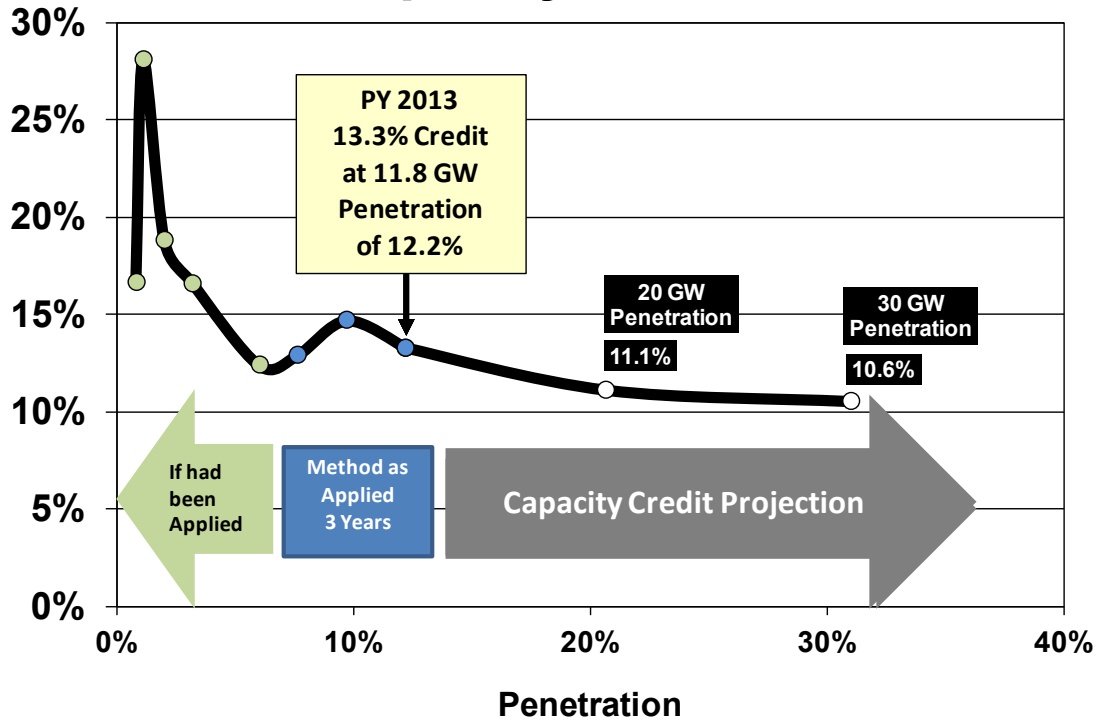


Figure 2-2: Demonstration of Applying Capacity Credit Method Starting with PY 2006

3 Details of Wind Capacity by CPnode

The Capacity Credit_{System-Wide} percent equals the Effective Load Carrying Capability (ELCC) megawatts divided by the megawatts of installed wind capacity. This section discusses how the wind capacity credit was determined for each recorded CPnode as of the 2nd Quarter in 2012. A Wind Capacity Credit of 13.3% of the Registered Maximum (RMax) capacity of wind resources is established for the Planning Year 2013. The 13.3% value was based on calculating the cumulative effect of ELCC over eight historical years and aligning each year to a trend curve, as described in Section 2. The 13.3% capacity credit corresponding to the actual 12.2% penetration in PY 2013 was computed by the averaging of the values from each of the eight yearly ELCC characteristic curves, as previously discussed and illustrated in Section 2 Figure 2-1. Table 3-1 is a listing of the total system wind output at time of 64 daily peak loads. These 64 peaks are the top eight daily peaks over the past eight summers.

The system-wide ELCC metric and the capacity factor of each CPnode during the historical daily peak hours are combine to calculate the individual capacity credit by CPnode. For each CPnode, the average capacity factor during the 64 historical daily peak hours is defined as the “PK metric_{CPnode}”.

The relationship of the UCAP rating to a CPnode’s RMax and Capacity Credit % is expressed as:

$$\text{Wind UCAP Rating}_{\text{CPnode } n} = \text{RMax}_n \times \text{Capacity Credit}_{\text{CPnode } n} \%$$

Where:

$$\text{RMax}_n = \text{Registered Maximum capacity of a wind facility at the CPnode } n.$$

The Capacity Credit % at a given CPnode “n” is:

$$\text{Capacity Credit}_{\text{CPnode } n} \% = \text{K3} \times \text{PKmetric}_{\text{CPnode } n} \%$$

Where “K3” for PY 2013 was found to be 0.6996 from solving the expression which equates system-wide UCAP MW to the sum of CPnodes UCAP MW:

$$\begin{aligned} & \text{(System RMax)} \times \text{(System-wide Capacity Credit \%)} \\ & = \text{K3} \times [\text{RMax}_{\text{CPnode } 1} \times \text{PKmetric}_{\text{CPnode } 1} + \text{RMax}_{\text{CPnode } 2} \times \text{PKmetric}_{\text{CPnode } 2} \dots \\ & \dots \dots \dots + \text{RMax}_{\text{CPnode } n} \times \text{PKmetric}_{\text{CPnode } n}] \end{aligned}$$

The values associated with the above equation are:

$$\begin{aligned} & \text{(11,774 MW)} \times \text{(13.3\%)} = \text{0.6996} \times \text{[2,240 MW]} \\ & \text{1,567 MW} = \text{1,567 MW} \end{aligned}$$

Each “PKmetric_{CPnode n}” is the average capacity factor in percent at each CPnode during the peak hours indicated in the first column of Table 3-1, 2005 through 2012. If the start date of the CPnode’s name was after 2005, then the average capacity factor over fewer years is used. The Capacity Credit_{System-Wide} % was 13.3%, and K3 was calculated to be 0.6996 over the eight years. Determined independently of the ELCC value, the 2,240 MW value in brackets is the sum of the RMax_{CPnode n} x PKmetric_{CPnode n} Of all 169 CPnodes. The individual PKmetric_{CPnode} of the CPnodes ranged from zero to 43.4%. The individual Capacity Credit percent for CPnode’s ranged from zero to 30.4%.

Examples:

1) For the best performing CPnode through 2012 data, the 43.4% PKmetric drives the capacity credit equal to:

30.4% = 43.4% x 0.6996, and therefore 30.4% times that CPnode's RMax would equal the UCAP rating for that best performing CPnode.

2) For the CPnode nearest the nominal 13.3% capacity credit through 2012 data, the 19.0% PKmetric drives the capacity credit equal to:

13.3% = 19.0% x 0.6996, and therefore 13.3% times that CPnode's RMax would equal the UCAP rating for that CPnode.

**Table 3-1 - Wind Output for 7 years
At Time of 8 top Daily Load Peaks each Year**

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

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
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

System-wide Average Peak Metric

16.48%

Note 1 **Curtailed and DIR MW have been added to settlement MW**

Figure 3-1 shows how the system-wide 13.3% capacity credit percent compares with the individual capacity credit percents for the 169 active CPnodes as of 2nd quarter 2012. This reflects implementing the

formulas referred to earlier in this section to allocate the total system 1,567 MW to the 169 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.

PY 2013 Capacity Credit % RMax at Each CPnode

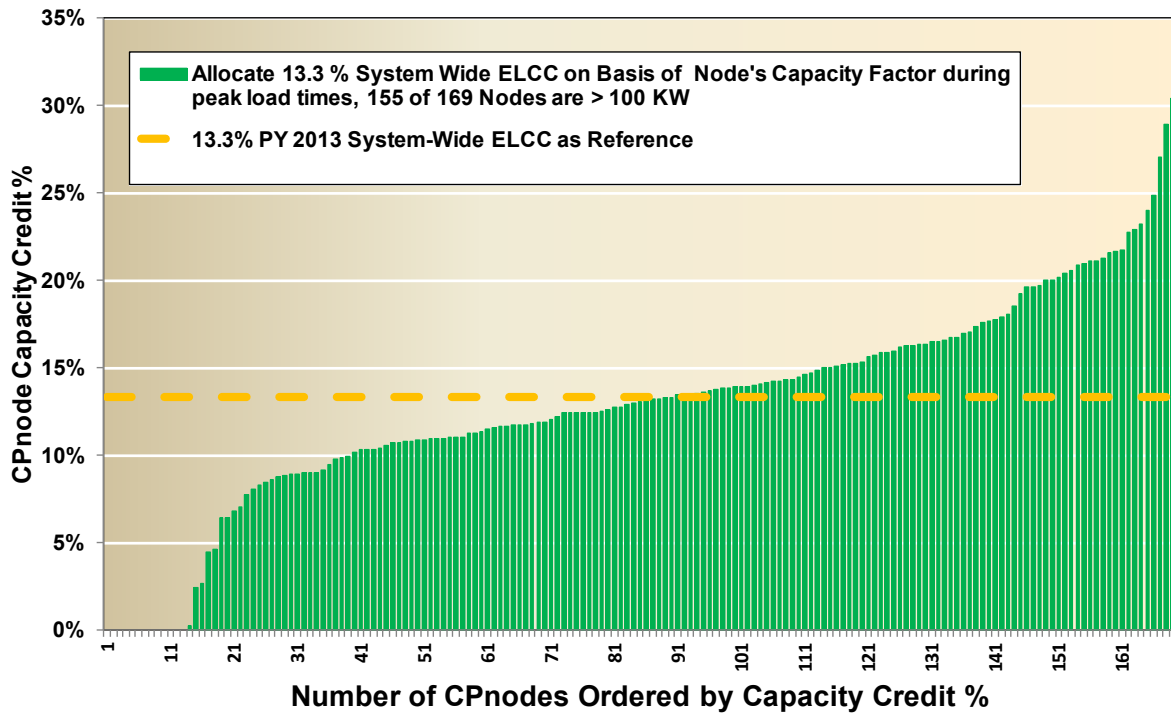


Figure 3-1 – Allocation of Capacity Credit % over 169 CPnodes Consistent with a System-wide Credit of 13.3%