Clair J. Moeller
Executive Vice President, Transmission and Technology
651.632.8441
cmoeller@misoenergy.org

Wednesday, April 17, 2013

Chairman Ed Whitfield
Subcommittee on Energy and Power
Committee on Energy and Commerce
United States House of Representatives
2125 Rayburn House Office Building
Washington, DC 20515-6115

Dear Chairman Whitfield:

Thank you for the opportunity to testify before the Subcommittee on Energy and Power on March 19, 2013, at the hearing entitled: "American Energy Security and Innovation: The Role of Regulators and Grid Operators in Meeting Natural Gas and Electric Coordination Challenges."

Enclosed are my responses to the follow-up questions from you and Mr. Dingell. Please let me know if you have any further questions. MISO looks forward to continuing to work with the Committee.

Respectfully,

Clair J. Moeller
Executive Vice President, Transmission and Technology

1. As environmental modifications and outages related to Utility MACT compliance occur over the next few years, combined with the build-out of new gas generation, what concerns do you have about the sufficiency of labor, technology supply, materials, etc.?

In May of 2012, The Brattle Group completed a study for MISO titled Supply Chain and Outage Analysis of MISO Coal Retrofits for MATS[1]. The study evaluated the feasibility of the large number of simultaneous environmental retrofits and new generation construction expected as asset owners work to comply with the Mercury and Air Toxics Standards (MATS).

Two of the key findings of this study include:

1) MATS will require retrofit and new build activities that exceed the historical industry maximum in the Midwest by 51%-162% based on MISO's projected retrofit requirements and individual plant owner announcements.

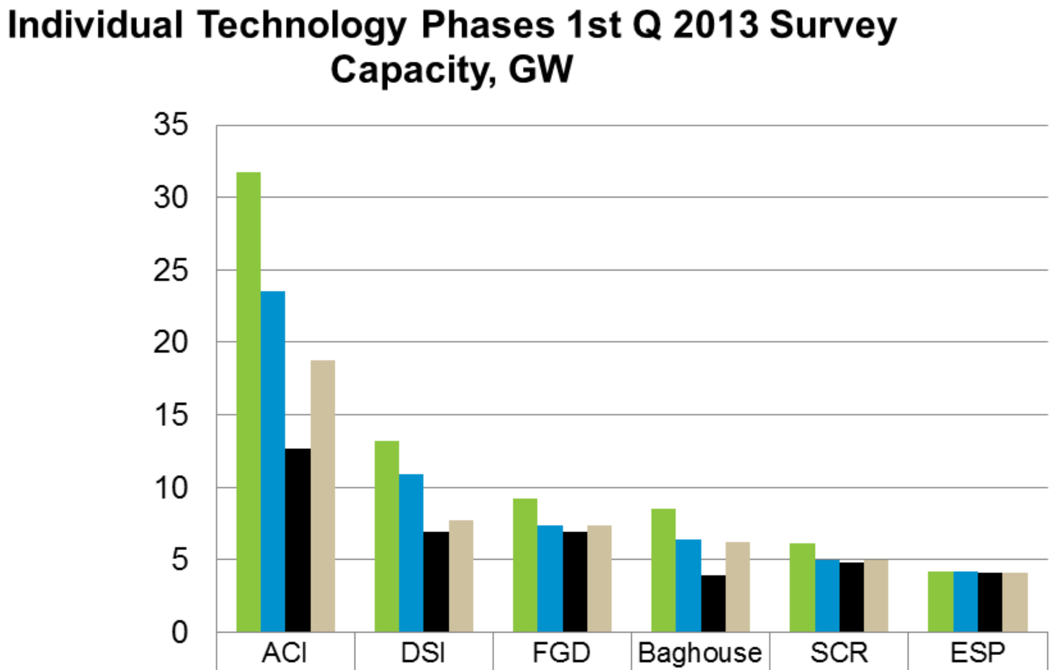
2) MATS will require a ramp up in labor, engineering, equipment, and construction that is likely to introduce substantial bottlenecks locally or nationally. The potential demand for skilled labor is a specific concern.

The study also noted that certain emissions control technologies, such as activated carbon injection (ACI) and dry sorbent injection (DSI) require less time for implementation, whereas retrofit projects using other technologies, including wet and dry flue gas desulfurization (FGD), baghouse/fabric filter, electrostatic precipitator (ESP), and selective catalytic reduction (SCR) require 3-4 year lead times.

The most recent MISO Quarterly Survey of asset owners' compliance strategies with MATS found that ACI and DSI account for over 60% (as a % of total capacity) of the retrofits needed in the MISO footprint. Of the total work required for installation of emissions control technology, almost 80% had been scheduled as of March 2013. The complete breakdown of work required, scheduled and contracted, as well as outages scheduled, can be found in Figure 1.

[1] The study can be found at the following link: https://www.misoenergy.org/Library/Repository/Communication%20Material/Key%20Presentations%20and%20Whitepapers/Supply%20Chain%20and%20Outage%20Analysis%20of%20MISO%20Coal%20Retrofits%20for%20MATS.pdf.

Figure 1. Individual Technology Phases from the 1st Quarter 2013 Survey (Capacity, GW)



	ACI	DSI	FGD	Baghouse	SCR	ESP
Work Required (GW)	31.7	13.2	9.2	8.5	6.1	4.2
Work Scheduled (GW)	23.5	10.9	7.4	6.4	5.0	4.2
Work Contracted (GW)	12.7	6.9	6.9	3.9	4.8	4.1
Outage Scheduled (GW)	18.8	7.7	7.4	6.2	5.0	4.1

While MISO does have concerns about the sufficiency of skilled labor and other supply chain impacts, based on the findings from Brattle, we are focused on maintaining system reliability during this transitional period. This means working closely with our Stakeholders to accommodate outages required for retrofits and ensuring that we have adequate resources to meet demand during outage periods.

a. Isn't there an overlap of what is needed to accomplish adding the necessary environmental controls to coal plants and the building of new natural gas plants – especially labor?

It is foreseeable that the labor pool for power plant construction and for retrofit and retirement of coal generation facilities will have some overlap. The Brattle study compared projected labor needs against the current labor supply for each craft, and found that boilermakers are the most likely bottleneck:

> "As many as 7,590 boilermakers (or 40% of boilermakers currently employed nationally) could be needed to complete the projected retrofits and new generation construction by 2015. This potential demand is more than four times the number of boilermakers (1,850) currently employed in the Utility System Construction Industry. Therefore, meeting the projected demand for boilermakers will likely require a combination of adjustments on the supply side, including training new labor, relocation, extending work hours, and attracting craft labor from other industries," p43, see footnote 1.

b. From your studies, is it possible to get this work done in time to maintain the reliability of the electric grid?

Based on the results of our most recent Quarterly Survey, it is evident that most of the planned retrofit work and associated outages are being scheduled and contracted on a timely basis. While there is still some uncertainty about retrofit and retirement timelines, we continue to work closely with our Stakeholders during this transitional period to ensure reliable system operation.

c. Across the MISO footprint, how much will the installation of environmental controls for coal plants and the construction of new natural gas-fired plants and pipeline infrastructure cost?

Costs for compliance with the Mercury and Air Toxics Standards (MATS) in the MISO footprint are estimated at $8.9B (overnight construction cost). This number is based on results of MISO's most recent Quarterly Survey and only covers the cost of retrofits, not the costs of construction of replacement capacity.

Costs for construction of new natural gas-fired plants assuming a one-to-one replacement of projected coal capacity retirements with gas-fired generation is estimated as follows:

From (10.4 GW of coal retirements) x ($676M/GW) = $7.03B (assuming all coal replaced with Combustion Turbines, or CTs)

To (10.4 GW of coal retirements) x ($1023M/GW) = $10.6B (assuming all coal replaced with combined cycle units, or CCs)

The 10.4 GW figure is based on the most recent MISO Quarterly Survey results, including all capacity that has reported it will retire along with those that have replied as "TBD (To Be Determined)", and excluding the capacity that did not respond. The $676M/GW figure is the overnight construction cost for a new combustion turbine, and the $1023M/GW figure, likewise, for combined cycle units, both based on modeling assumptions for MISO's 2013 MISO Transmission Expansion Plan (MTEP13), which have been approved MISO Stakeholders. As the actual generation built in coming years will likely be a combination of CTs and CCs, this range provides a rough estimation of costs for the construction of new natural gas-fired plants. The figure will vary based on individual plant costs, the level of retirements, and the performance of existing and projected generation, as well as other factors.

Costs for natural gas infrastructure expansion to accommodate a projected increase in gas-fired generation in the Midwest, as calculated in the Phase I[2] gas study commissioned by MISO and completed in 2012, are estimated at $3B:

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[2] MISO's Phase I Gas Study, found at https://www.misoenergy.org/Library/Repository/Communication%20Material/Key%20Presentations%20and%20Whitepapers/Natural%20Gas-Electric%20Infrastructure%20Interdependency%20Analysis_022212_Final%20Public.pdf. The modeling assumptions for this study included a $4.50/MMBtu gas price and 12.6 GW of coal capacity retirements in 2015 in the MISO footprint.

> "It is conceivable, based on recent pipeline expansion projects, that the cost to accommodate the needed lateral and mainline expansion projects in the MISO region and the need for additional gas storage and LNG could easily exceed $3.0 Billion," p12.

The Phase I study recognizes, and subsequent conversations with the natural gas industry further confirm, the dynamic nature of gas pipeline flow patterns regionally and nationally—and the impact of these flows on future expansion. Additionally, MISO acknowledges that various operational and contractual characteristics of natural gas transportation and delivery infrastructure may allow for additional flexibility not accounted for in the estimations of costs as identified in the Phase I Study.

2. MISO's analysis shows a shortfall in generation in the MISO footprint in the 2013-2016 timeframe (3.5 GW summer and 11.7 GW winter).

a. What is the primary reason for this?

MISO models the adequacy of projected generation resources to meet projected demand in order to better plan for future system operation. To capture a range of likely future system conditions, we use a range of model inputs, including moderate ("50/50"[3]) and high ("90/10"[4]) forecasts of load. These load forecasts are one of many factors considered in the modeling process. Others include expected retirements and expected new generation resources, as well as maintenance periods and potential unit de-rates. Increased certainty of the model inputs translates to increased certainty of the results--and to an improved ability to plan for future system conditions. MISO's most recent forecasts of resource adequacy[5] highlight the uncertainty in near-term resource adequacy projections. For example, in Figure 2, under a 50/50 load forecast, MISO will potentially see a summer surplus in 2016 of 2 GW of capacity, and a winter surplus of 1 GW. Compare this to a 90/10 load forecast in Figure 3, and 12 GW and 9 GW shortfalls, in 2016 summer and winter, respectively. In both load forecast scenarios, the assumption is made that as much as 16 GW of gas-fired generation will experience de-rates (will have reduced ability to generate), in addition to 9 GW of typical winter maintenance and de-rates. This assumption takes into account the uncertainty of fuel supply for those gas-fired generators without backup fuel on-site or firm gas transportation contracts.

These numbers differ from previous resource adequacy modeling results due to updated data and additional considerations of uncertainty – and are subject to change as more information becomes available. The takeaway from these numbers is that uncertainty in the forward look *could* result in a shortfall. We're working to address that uncertainty and ensure that we have adequate resources going forward.

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[3] A 50/50 forecast is the mean value in a normal probability distribution, meaning there is a 50 percent chance the load will be higher or lower than the forecast.

[4] A 90/10 forecast is an industry standard for forecasting high load conditions. It means that there is a 10 percent chance that the actual load will exceed the forecast load.

[5] MISO's March 27th, 2013, presentation on Resource Adequacy Impact of EPA Implementation, https://www.misoenergy.org/Library/Repository/Communication%20Material/Power%20Up/EPA%20Compliance%20Update.pdf.

Figure 2. Projected Resource Adequacy under 50/50 Load Forecast

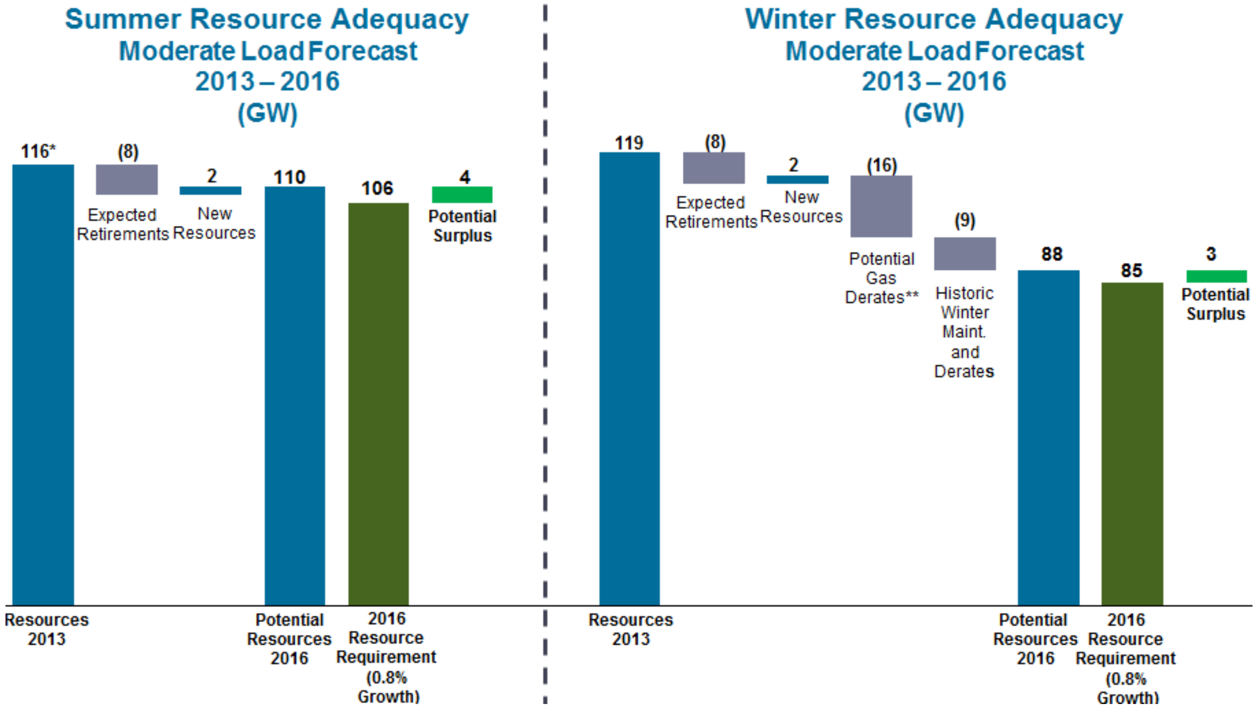
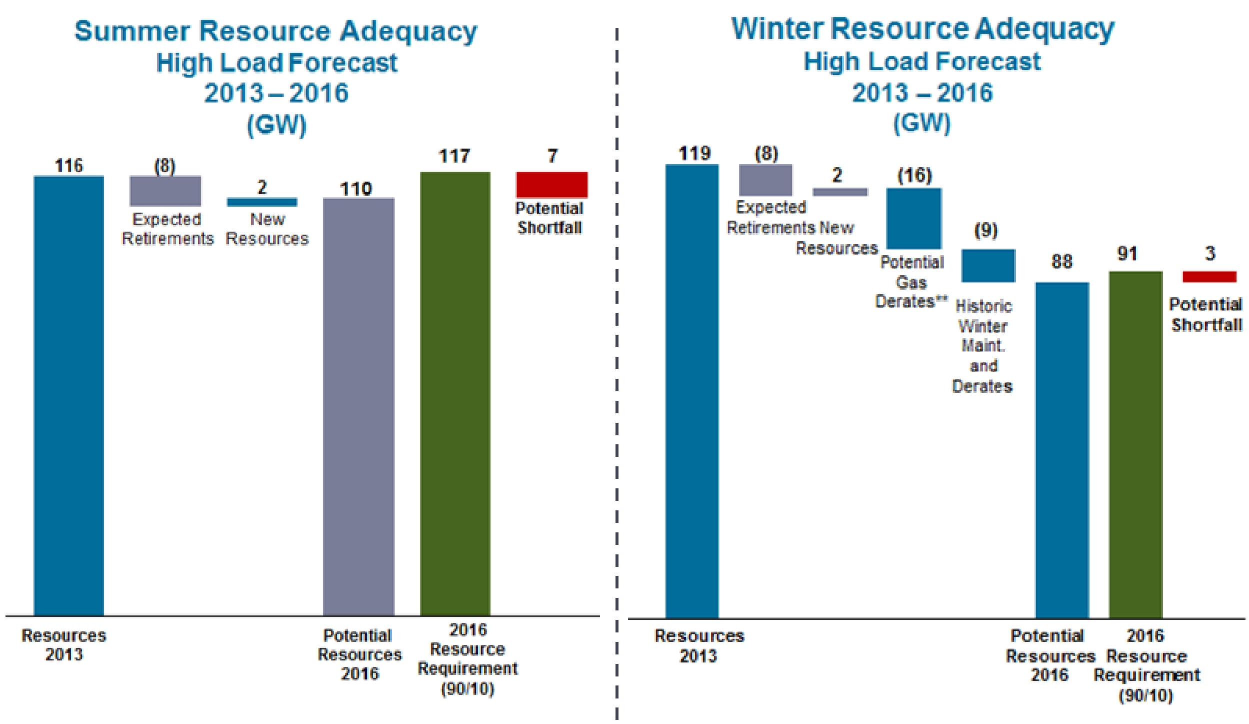


Figure 3. Projected Resource Adequacy under 90/10 Load Forecast

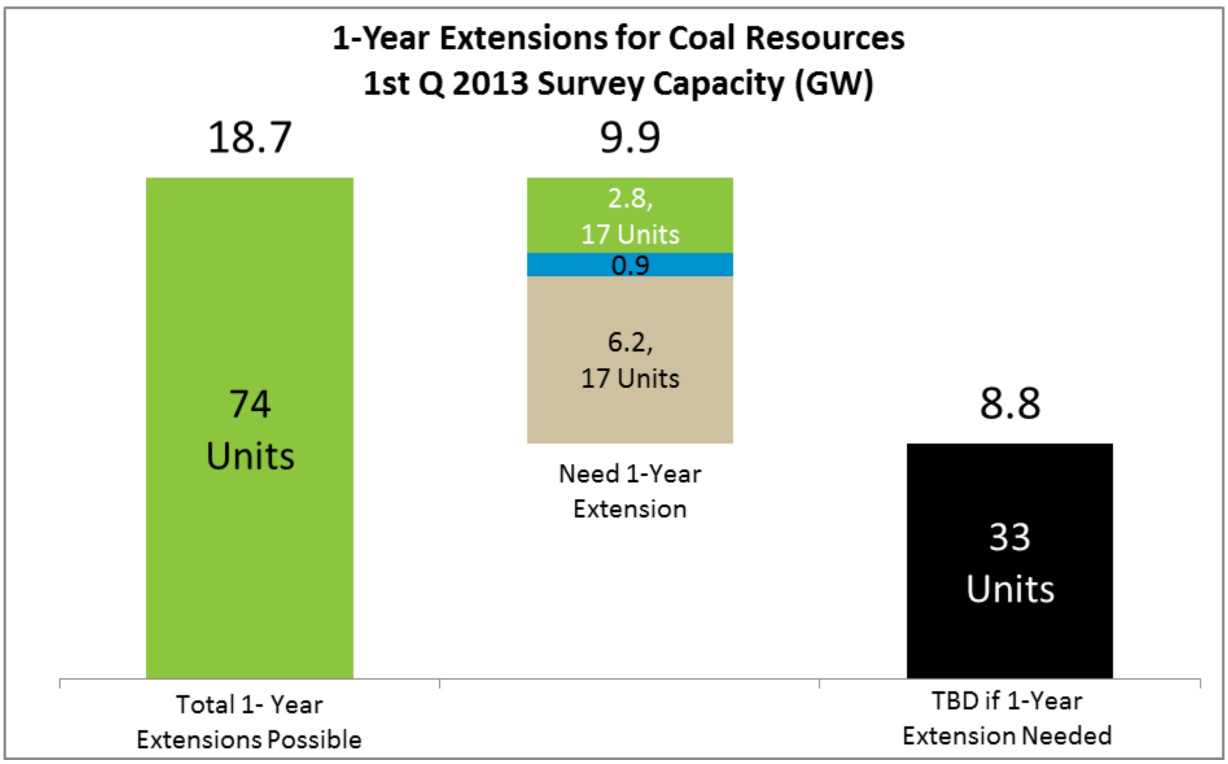


b. Would more time for Utility MACT compliance help?

More time may be needed. The timeline for approval and construction of new mainline gas pipelines is on the order of 3 to 5 years, and for new laterals[6], 1 to 2 years. However, construction of new gas infrastructure will only occur with long-term, firm commitments from customers and there is currently little to incent generation owners to invest in firm fuel contracts. While added time for compliance with the Environmental Protection Agency's Mercury and Air Toxics Standards (i.e. 1-year extensions) will be helpful in accommodating and planning for retrofits of coal facilities, the issue of increasing demands upon the gas infrastructure in the Midwest remains.

Through MISO's 1st Quarter Survey of 2013, we've learned that almost 10 GW (41 units) of coal capacity in MISO needs a 1-year extension for compliance with MATS. Of this figure, over 7 GW (24 units) have pending or approved extension applications. Another 33 units have yet to determine whether they will require an extension. The figure below shows the breakdown of 1-year extensions as reported in the 1st Q 2013 Survey.

Figure 4. Findings from MISO's 1st Q 2013 Survey



In total, almost 50 GW of coal capacity in the MISO footprint are impacted by MATS—or about 38% of total MISO Market Footprint capacity. We are currently working to ensure adequate maintenance

[6] Generally, laterals are pipelines providing service to a specific end-use customer (e.g. to serve a gas-fired power plant) and are smaller in diameter than mainline pipelines.

margins during this transitional period and beyond, by coordinating outages and communicating with Stakeholders. Even though the 1-year extensions will provide some cushion for dealing with these changes, we are still facing a significant amount of uncertainty. Many asset owners have yet to report their compliance strategies or to schedule outages for retrofits. Also, as gas-fired generation begins to serve more of the demand previously met by coal-fueled power plants, questions about fuel supply add uncertainty.

c. What about those units that have announced retirement or will be mothballed? Is more flexibility needed for those units?

We recently revised our generator retirement processes to better accommodate retirement and mothball decisions driven by MATS. These processes should provide adequate flexibility for generators to comply.

3. What will happen after 2015-2016 if there is a reliability problem? Can you order generators to run even though they may be seeking to retire an uncontrolled unit? If you ask generators to run for reliability purposes, and they say "no", how might any resulting impacts be addressed?

A brief description of MISO's generator retirement process is helpful here. If an asset owner has made a definitive decision to retire or suspend operation of a particular unit, that asset owner must submit a form called Attachment Y (found in Section 38.2.7 of the MISO Tariff) at least six months prior to the planned date of retirement or suspension. Next, the host transmission owner is notified, a study is scoped, and MISO performs a reliability assessment. If the results of the reliability assessment indicate that the retirement of this generator will result in reliability criteria violations, the unit is designated as a System Support Resource (SSR). MISO then meets with Stakeholders to review the violations, and solicits alternatives including, but not limited to: system re-dispatch, system switching or reconfiguration, demand-side management, new or re-powered generation, and transmission projects. If mitigation cannot occur prior to the unit change of status, a System Support Resource (SSR) contract may be used. This contract provides a financial mechanism to make a generation resource "whole", i.e. to cover the costs of keeping a unit available for reliability purposes, until the time when an alternative solution is implemented.

If there are potential reliability issues in 2015-16 due to uncontrolled[7] unit retirements, the uncontrolled unit could choose to install necessary controls under an SSR agreement to maintain system reliability. However, the SSR process cannot require an uncontrolled unit to install controls or to run if they don't add required controls. The MISO Tariff requires the uncontrolled unit to make good faith efforts to seek any available waivers or exemptions from environmental regulatory requirements in order to permit the uncontrolled unit to continue to qualify for SSR status. If uncontrolled unit retirements and mitigation plans cannot be implemented and available waivers or exemptions cannot be obtained in time, there is the potential for reliability issues. If an event which may cause a reliability issue had the potential to occur, it would be necessary to curtail customer demand or firm system use to maintain overall reliability of transmission system.

[7] "Uncontrolled" units do not have pollution controls installed to satisfy MATS requirements; "controlled" units do.

4. Can the State regulators in the MISO footprint order their utilities to build new generators to meet any potential shortfall? Please explain.

Of the 11 states in the MISO Midwest footprint, 10 have the authority to regulate resource procurement, whether new generation or power purchase agreements, for example, over their investor owned utilities (IOUs) to meet ratepayer demand. In general, IOUs are only obligated to procure capacity on behalf of their ratepayers.

Panel II

Questions for Mr. Clair Moeller, Executive Vice President, Midwest Independent Transmission System Operator (MISO)

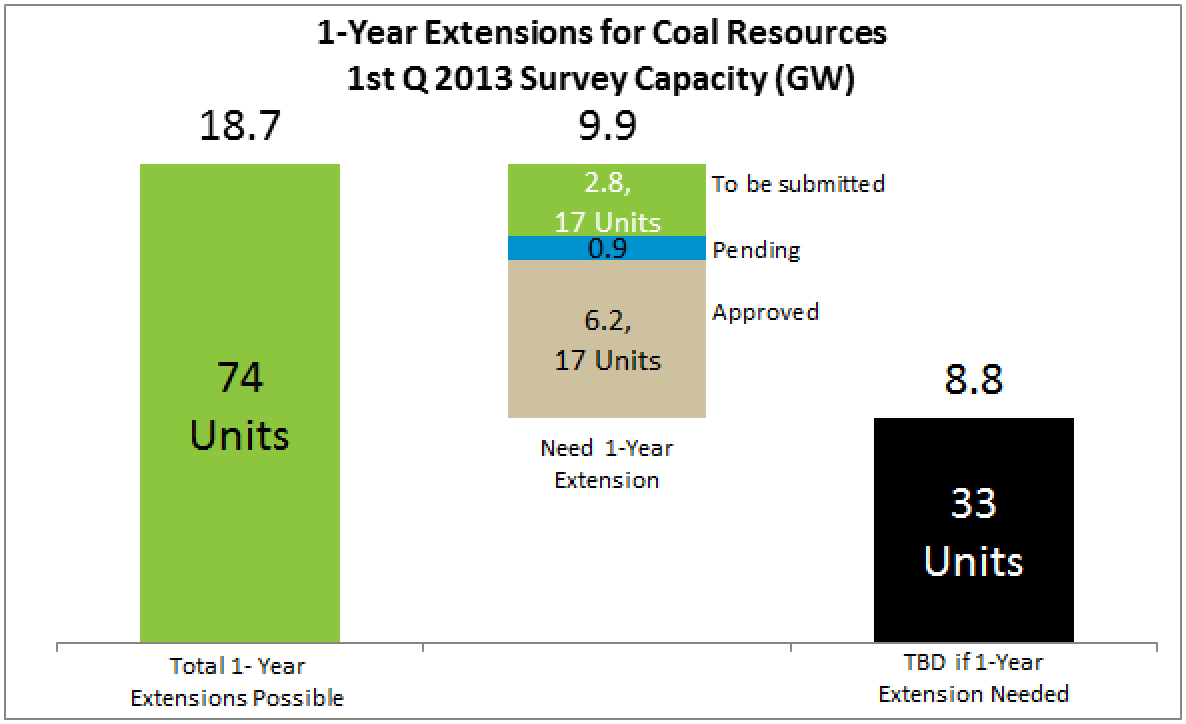
1. Is more time needed for compliance under the mercury rule to give time for new gas infrastructure and generation to be built?

More time may be needed. The timeline for approval and construction of new mainline gas pipelines is on the order of 3 to 5 years, and for new laterals[8], 1 to 2 years. However, construction of new gas infrastructure will only occur with long-term, firm commitments from customers and there is currently little to incent generation owners to invest in firm fuel contracts. While added time for compliance with the Environmental Protection Agency's Mercury and Air Toxics Standards (i.e. 1-year extensions) will be helpful in accommodating and planning for retrofits of coal facilities, the issue of increasing demands upon the gas infrastructure in the Midwest remains.

Through MISO's 1st Quarter Survey of 2013, we've learned that almost 10 GW (41 units) of coal capacity in MISO needs a 1-year extension for compliance with MATS. Of this figure, over 7 GW (24 units) have pending or approved extension applications. Another 33 units have yet to determine whether they will require an extension. Figure 1 shows the breakdown of 1-year extensions as reported in the 1st Q 2013 Survey.

[8] Generally, laterals are pipelines providing service to a specific end-use customer (e.g., to serve a gas-fired power plant) and are smaller in diameter than mainline pipelines.

Figure 1. Findings from MISO's 1st Q 2013 Survey



In total, almost 50 GW of coal capacity in the MISO footprint are impacted by MATS—or about 38% of total MISO Market Footprint capacity. We are currently working to ensure adequate maintenance margins during this transitional period and beyond, by coordinating outages and communicating with Stakeholders. Even though the 1-year extensions will provide some cushion for dealing with these changes, we are still facing a significant amount of uncertainty. Many asset owners have yet to report their compliance strategies or to schedule outages for retrofits. Also, as gas-fired generation begins to serve more of the demand previously met by coal-fueled power plants, questions about fuel supply add uncertainty.

2. In your testimony you note that given the nature of pipeline contracts with utilities, some natural gas fired plants cannot run to provide additional generation during certain peak events. Do you believe there are changes to be made to ensure utilities have contracts in place that provide the supply they need to run longer?

Yes, there are changes that need to be made to ensure a reliable fuel supply for generators operating in the MISO footprint.

MISO is currently discussing the issue of fuel supply and its relation to reliability with its Stakeholders and members of the natural gas industry via MISO's Electric and Natural Gas Coordination Task Force. Additionally, we're working through the Task Force to better characterize the issues surrounding 1) the misalignment of the Gas Day and the Electric Day, 2) coordinated operations and communications between the Gas Industry and the Electric Industry, and 3) market signals that help ensure reliability.

Discussions around all of these issues feed into the overall conversation on ensuring availability of generation resources. Finally, we are examining 1) our planning models to determine how to incorporate the risk associated with fuel supply, and 2) our market constructs to determine ways to incentivize reliable fuel supply across the generation fleet.

MISO strives for reliable, safe and cost-effective operation. Efficiently reducing uncertainty and risk associated with fuel supply is in line with this goal.

3. With improved weather forecasting and the increased use of wind to generate electricity, do you believe this and other forms of renewable electricity should be included in resource adequacy predictions?

Yes. MISO currently takes into account characteristics of all generation resources it models in its resource adequacy forecasts, including renewable resources. The intermittency of wind resources is captured in MISO's resource adequacy planning process through the use of historical performance of the fleet of wind farms in the MISO footprint. The methodology used by MISO to calculate the capacity accreditation for wind resources is described in the attached article, "Determining Capacity Credit for Wind Used in MISO Resource Adequacy". This document explains how we account for the variability of wind resources, while recognizing their value as part of the generation resource mix in the MISO footprint. Specifically, we employ a two-step methodology that consists of 1) a probabilistic approach to calculate the MISO system-wide Effective Load Carrying Capability[9] (ELCC) value for all wind resources in the MISO footprint and 2) a deterministic approach using specific information about the location of each wind resource to allocate the single system-wide ELCC value across all wind in the MISO footprint, in order to determine a wind capacity credit for each wind node. The method accounts for variation in wind resources both geographically and temporally, and uses actual historical power output as a basis for setting the capacity rating of wind resources—which is currently 13.3% of rated capacity.

Finally, MISO recently incorporated the concept of Dispatchable Intermittent Resources (DIRs) into its Market construct. Wind resources registered as DIRs can be dispatched up and down as needed, providing another tool for MISO Operators to meet load and respond to changes in system operating conditions. Improved weather forecasting translates to improved wind resource forecasts—which helps MISO more accurately anticipate the amount of wind that will be online and available to meet demand**.**

[9] Effective Load Carrying Capability (ELCC) is defined as the amount of incremental load a resource, such as wind, can dependably and reliably serve, while considering the probabilistic nature of generation shortfalls and random forced outages as driving factors to load not being served.

Determining Capacity Credit for Wind Used in MISO Resource Adequacy

Brandon Heath, Charles Tyson, John Lawhorn
of Regulatory and Economic Studies Department
MISO
Saint Paul - Minnesota, USA
bheath@misoenergy.org, ctyson@misoenergy.org, jlawhorn@misoenergy.org

***Abstract*— With increasing wind penetration on the MISO system a process was developed to determine the capacity value of wind resources. This paper demonstrates the method developed at MISO to calculate the system-wide capacity value of wind resources and illustrates how the capacity credit is designated to the individual wind sites.**

Keywords - Effective Load Carrying Capability; Wind Capacity Credit; Resource Adequacy; MISO

I. Introduction & Background

The primary objective of resource adequacy is making sure there is enough generation capacity available when needed. The MISO is a Regional Transmission Organization and Independent System Operator in the United States that covers approximately 1.05 million square kilometers (406 thousand square miles), serves over 40 million people and comprises 135,000 MW of generation of which currently 11,000 MW is wind, Fig. 1. The MISO also operates a $27.5 billion annual energy market that incorporates 1,975 Commercial Pricing Nodes (CPnodes). MISO is currently adding 1,000 MW of wind on its system every year and it is expected to have 25,000 MW by 2025. As more and more new wind resources are being integrated into the MISO footprint and used in meeting the resource adequacy requirements the capacity value to assign this intermittent resource has taken on ever increasing importance. This paper discusses the techniques and processes used to accurately evaluate and assign the correct value of capacity for the wind resources.

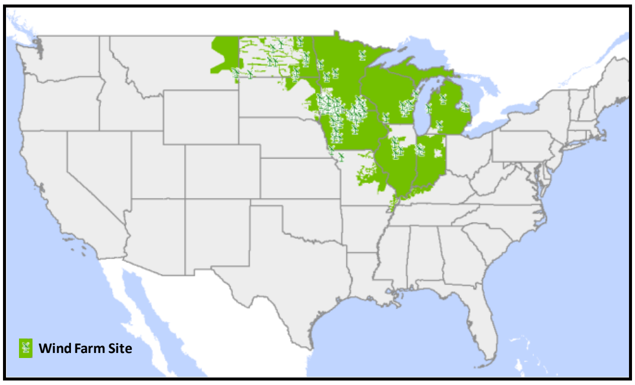


Figure 1. MISO Market Footprint

Since 2009 MISO has embarked on a process to determine the capacity value for the increasing fleet of wind generation in the 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 specific information about the location of each wind resource 'period metric' to allocate the single system-wide ELCC value across all wind CPnodes in the MISO system, to determine a wind capacity credit for each wind node.

As the geographical distance between wind generation increases, the correlation in the wind output decreases, as shown in Fig. 2. This leads to a higher average output from wind for a more geographically diverse set of wind plants, relative to a closely clustered group of wind plants. Due to the increasing diversity and the inter-annual variability of wind generation over time, the process needs to be repeated annually to incorporate the most recent historical performance of wind resources into the analysis. So for each upcoming planning year the wind capacity credit values in MISO are updated to account for both the stochastic nature of wind generation and the ever increasing integration of new resources into the system. The sections of this write-up and current results illustrated here are broken down to describe the details of the two-step method adopted by MISO for determining wind capacity credit for the 2012 planning year.

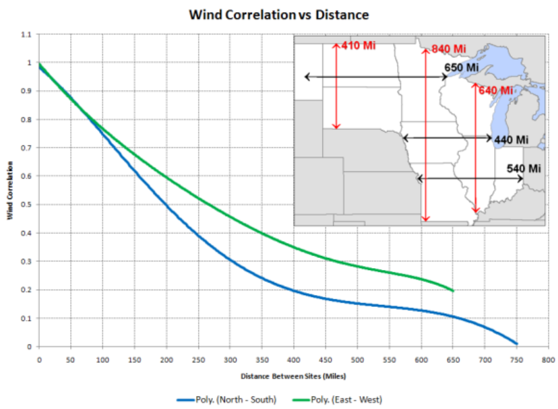


Figure 2: Wind Output Correlation to Distance Between Wind Sites

II. STEP-1: MISO SYSTEM-WIDE WIND ELCC STUDY

A. *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 time frame, 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 often expressed as 0.1 days/year, as that is often the time period (1 year) over 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 considering the probabilistic nature of generation shortfalls and random forced outages as driving factors to load not being served. Using ELCC in the determination of capacity value for generation resources has been around for nearly half a century. In 1966, Garver demonstrated the use of loss-of-load probability mathematics in the calculation of ELCC [1].

To measure 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 Fig. 3 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 each case "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 (0.1 days/year) LOLE criteria.

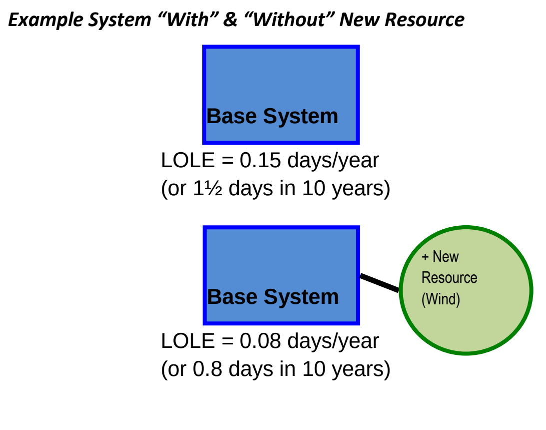


Figure 3. Example System "With" and "Without" New Resource

With each case being at the same reliability level, as shown in Fig. 4, the only difference between the two cases is that the load was adjusted. This difference is the amount of ELCC expressed in load or megawatts, which is 300 MW (100 – -200) for the new resource in this example. Sometimes this number is divided by the nameplate rating of the new resource and then expressed in percentage (%) form. The new resource in the ELCC example Fig. 4 has an ELCC of 30% of the resource nameplate.

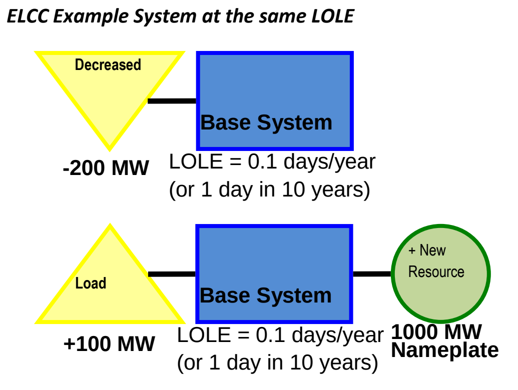


Figure 4. ELCC Example System at the same LOLE

The same methodology illustrated in the simple example of Fig. 4 was utilized as the analytical approach for the determination of the system-wide ELCC of the wind resource in the much more complex MISO system. For each historic year studied there were two types of cases analyzed, ones with and ones without the wind resources. Each case was adjusted to the same common baseline LOLE and the ELCC was measured off those load adjustments. Using ELCC is the preferred method of calculation for determining the capacity value of wind [2].

B. *LOLE Model Inputs & Assumptions*

To apply the ELCC calculation methodology MISO uses the Multi-Area Reliability Simulation (MARS) program by GE Energy to calculate LOLE values with and without the wind resource modeled. This model consisted of three major inputs:

1. Generator Forced Outage Rates (FOR)
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 FOR 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 as well as the capacity throughout the country.

To incorporate historical information the actual 2005-2011 historical hourly concurrent load and wind output at the wind CPNodes is used to calculate the historic ELCC values for the wind generation in the MISO on a system-wide basis. The last two columns in Table I illustrate the ELCC results for the 7-years of MISO historic data.

C. *MISO System Wide ELCC Results*

MISO calculated ELCC percentage results for historic years 2005 through 2011 and at multiple scenarios of penetration levels, corresponding to 10 GW, 20 GW and 30 GW of installed wind capacity. This creates an ELCC penetration characteristic for each year, as illustrated by the different curves in Fig. 5. The initial left most data point for each curve is at the lowest penetration point on each characteristic curve and represents the actual annual ELCC for that year; and the values are shown in the right column in Table I. The values along each year's characteristic curve at the higher penetration levels reflect what that year's wind resource would have as an ELCC if more capacity had been installed in that year, over the same MISO footprint. The high end 30 GW level of penetration (approximately 30% on x-axis of Fig. 5) is an estimate of the amount of wind generation that could result in MISO, as the Load Serving Entities (LSE) collectively meet renewable resource mandates of the various MISO States. Fig. 5 illustrates the ELCC versus penetration characteristic of seven historical years, and how those characteristics, from multiple years, were merged to set an on-going wind capacity credit percent.

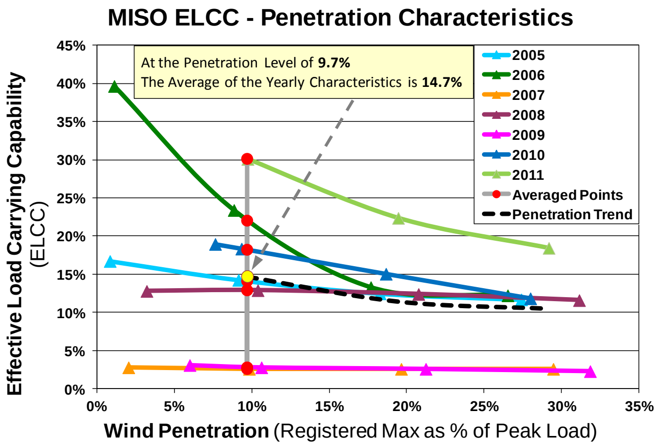


Figure 5: Seven Years of Historical ELCC Penetration Characteristics

The end of a 2nd Quarter is the convention used to set the capacity going into the next planning year. The penetration level at the end of the 2nd Quarter 2011 was 9.7%. Specifically as a percentage, the 2011 penetration level is the 2nd Quarter 9,996 MW in column-4 of Table I divided by the 102,804 MW peak load in column-1. The vertical line in Fig. 5 illustrates where the most recent historical 9.7% penetration level intersects each year's ELCC characteristic curve. The average of these seven intersect values is the 14.7% system wide ELCC assigned for the upcoming planning year 2012.

MISO HISTORICAL WIND ELCC VALUES

Year	MISO Peak Load (MW)	Registered Wind Max Capacity (MW)	Historical Wind Penetration (%)	System-Wide ELCC (MW)	System-Wide ELCC (%)
2005	109,473	908	0.8%	152	16.7%
2006	113,095	1,251	1.1%	495	39.6%
2007	101,800	2,065	2.0%	57	2.8%
2008	96,321	3,086	3.2%	395	12.8%
2009	94,185	5,636	6.0%	173	3.1%
2010	107,171	8,179	7.6%	1,548	18.9%
2011	102,804	9,996	9.7%	3,007	30.1%

The ELCC characteristic of each year can be represented by a trend line equation that has an R^2 coefficient of no less than 0.9996. This is the basis for achieving accuracy with sparse or few years of data. Alternative attempts to directly find a composite suitable single-trend-line curve to represent the aggregate 28 ELCC characteristic points of all seven years, met with poor R^2 coefficients in the range of 0.04 to 0.11. Fig. 6 shows the resulting trend line along with the associated equation and R^2 coefficient. While the trend line appears to represent a reasonable fit when compared to the dashed black line for the penetration trend in Fig. 5, the R^2 value of 0.1106 indicates that the process would be mathematically inferior.

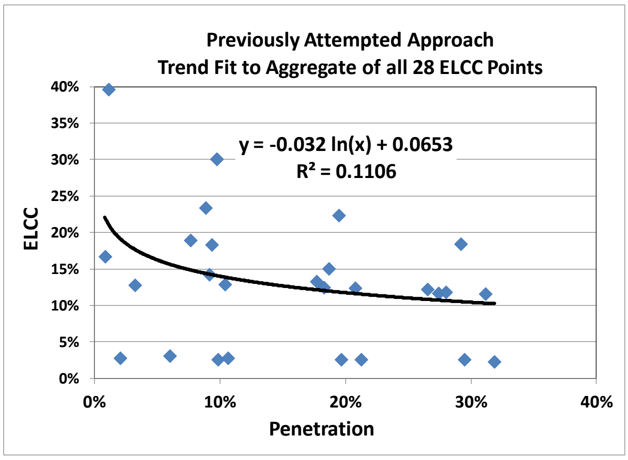


Figure 6. Penetration Trend by Fitting to all 28 ELCC Calculated Points

III. STEP-2: WIND CAPACITY CREDIT BY CPNODE CALCULATION

A. Deterministic Analytical Technique

Since there are many wind CPnodes throughout the MISO system (143 in 2011), a deterministic approach involving an 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 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 relative performance is a valuable input in determining the tradeoffs between constructing wind facilities in high capacity factor locations, that in the case of the MISO are located in more remote locations far from load centers, and requiring more transmission investment versus locating wind generating facilities at less effective wind resource locations that may require less transmission build-out. Fig. 7 illustrates that the most economical solution in the MISO is a combination of both remote and local wind resources.

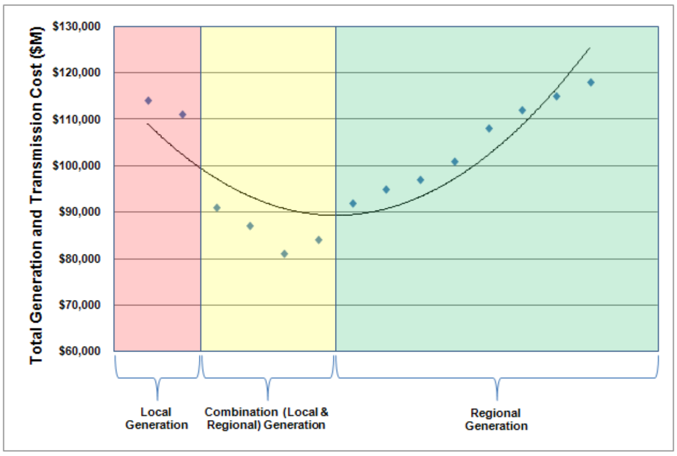


Figure 7. Conceptual Wind Generation Siting Cost Curve

The system-wide wind ELCC value of 14.7% times the 2011 installed registered wind capacity of 9,996 MW results in 1,469 MW of system-wide capacity. The 1,469 MW is then allocated to the 143 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 2011. The average capacity factor for each CPnode during all 56 (8-hours x 7-years) historical daily peak hours is called the "$\text{PKmetric}_{\text{CPnode}}$" for that CPnode. The capacity factor over those 56 hours and the installed capacity at each CPnode, are the basis for allocating the 1,469 MW of capacity to the 143 CPnodes. MISO has developed business practice rules for the handling of new wind CPnodes that do not have historic output data, and for CPnodes with less than 7-years of data.

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. For example, in the LOLE run for year 2011, all of the 0.1 days/year LOLE occurred in the month of July, but only 4 of the top 8 daily peaks occurred in the month of July. Therefore, no more than 4 of the top daily peaks contributed to the LOLE. Other years have LOLE contributions due to more than 4 days, however 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 $\text{PKmetric}_{\text{CPnode}}$ over multiple years.

B. *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 (1), the $(\text{Capacity Credit }\%)_{\text{CPnode n}}$ can be replaced by the expression (2) :

$$K \times (\text{PKmetric}_{\text{CPnode n}}\ \%) \quad (2)$$

Where "K" for Year 2011 was found by obtaining the PKmetric at each CPnode over the 7 year period, and solving expression (3):

$$K = \frac{\text{ELCC}}{\sum_{1}^{143} \text{RMax}_{\text{CPnode n}} \times \text{PKmetric}_{\text{CPnode n}}} \quad (3)$$

This results in the sum of the MW ratings calculated for the CPnodes equal to the system wide ELCC 1,479 MW. The values in (3) are:

ELCC = 1,469 MW

$\sum \text{RMax}_{\text{CPnode n}}$ x $\text{PKmetric}_{\text{CPnode n}}$ = 1,803 MW

Therefore: K = 0.8148 = 1,469 / 1,803

C. *Wind CPnode Capacity Credit Results & Examples*

The individual $\text{PKmetric's}_{\text{CPnode}}$ of the CPnodes ranged from zero to 39.9%. The individual Capacity Credit percent for CPnodes therefore ranged from zero to 32.5%, by applying expression (2)

Example 1) For the best performing CPnode through 2011 data, the 39.89% PKmetric drives the capacity credit equal to:

32.5% = 39.9% x 0.8148, and therefore 32.5% times that CPnode's RMax would equal the Unforced Capacity (UCAP) rating for the best performing CPnode.

Example 2) For the CPnode nearest the nominal 14.7% capacity credit through 2011 data, the 18.2% PKmetric drives the capacity credit equal to:

14.8% = 18.2% x 0.8148, and therefore 14.8% times that CPnode's RMax would equal the UCAP rating for that CPnode.

Fig. 8 shows how the system wide 14.7% ELCC value compares with the individual capacity credit percentages for the 143 CPnodes sorted in ascending order. The UCAP rating for each CPnode would equal the installed RMax capacity of the CPnode times the CPnode's capacity credit percent.

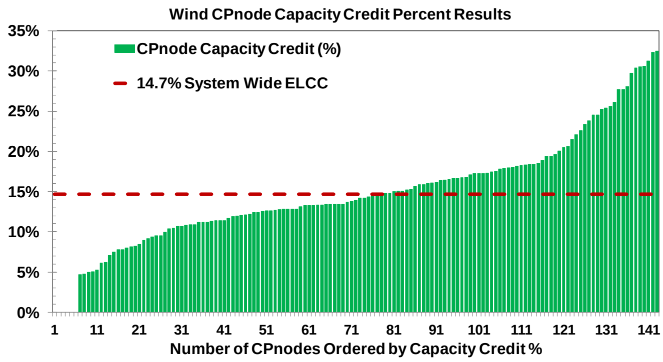


Figure 8. Allocation of 14.7% Capacity Credit over 143 CPnodes

IV. Conclusions

The MISO capacity credit method uses actual historical power output as a basis for setting the capacity rating of wind resources. While MISO is currently limited to applying seven years of historical power outputs from the wind resources; by applying the developed ELCC and merging techniques the results are converging and are reflective as if one had more years of historical data available for the process. Fig. 9 illustrates the method over a range of limited data results. The left most point on the x-axis is the system wide result while utilizing only one year of data, the second point represents having two years of historical data available for the process. Progressively, the seventh point illustrates where MISO is currently at with seven years of data, and a projection sensitive to penetration is shown. As data from each new successive year becomes available, the subsequent capacity credit for successive years is expected to stabilize, and be more exclusively driven by penetration.

While the process discussed here represents a consistent and repeatable way to calculate the MISO market needs, MISO will continue to track and consider adjustments that may be required to deal with further aspects of common mode failure of wind generation. The MISO believes that the capacity credit for wind will be near 10% as the system approaches 25,000 to 30,000 MW of installed wind generation.

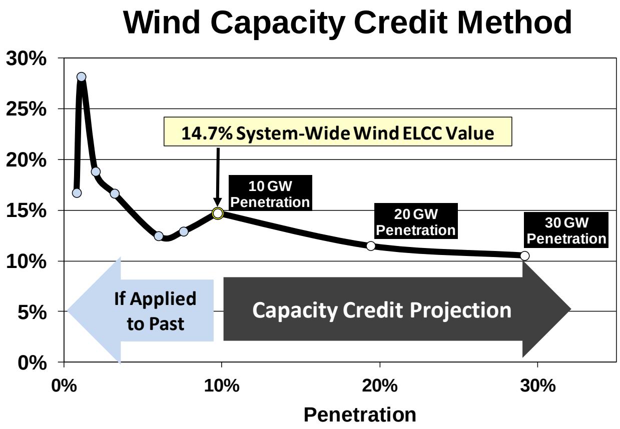


Figure 9. Applying Capacity Credit Method Starting with 2005 data

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