APPENDIX J2 – RELIABILITY REQUIREMENT

As the Company increases the amount of renewable generation on our system, it is important to recognize that these resources cannot alone reliably provide customers the energy they demand every hour of every day, or maintain the stability of the grid. Until such time as new technologies develop to fully transition the grid to carbon-free resources, some level of load-supporting, firm dispatchable resources is necessary for grid resilience and customer reliability.

As penetration of variable and intermittent resources like wind and solar increase on the grid, it requires a new planning paradigm. The traditional method of planning on a capacity-basis for a single system peak will no longer ensure we meet our customers' needs in every hour. Our planning needs to become energy-oriented and be able to match available generation and customer load as available resources and customer load go up and down every day. A winter peak, while much lower than summer, can be just as challenging to meet if we do not have sufficient resources at the time of the peak. The January 2019 polar vortex is an example of this – but severe winter weather is not the only time this issue can occur. As we discuss below, it can also occur on an otherwise normal winter or summer day.

This planning concern is not limited to the NSP System, but rather across all of MISO's footprint – and in other regions with increasing levels of renewables. Although MISO recognizes these challenges, its current planning constructs do not fully incorporate measures to address them. We have therefore developed a Reliability Requirement to inform this Resource Plan and mitigate risks to customer reliability and system resilience as MISO determines how to incorporate these issues into its planning process. The Reliability Requirement will ensure we have a sufficient level of dispatchable load supporting resources that can quickly respond to fill gaps between customer demand and energy supply at times of low or non-existent renewable generation. In short, it ensures that we can serve customers with reliable energy every hour of every day.

Below, we discuss the specific system conditions and events we believe call for the addition of the Reliability Requirement. We also discuss how we derived this requirement, and how we applied it in the modeling underlying this Resource Plan. Because the Reliability Requirement involves consideration of the level of market reliance we can reasonably depend on, we start with an overview of MISO and its resource zones.

I. MIDCONTINENT INDEPENDENT SYSTEM OPERATOR OVERVIEW

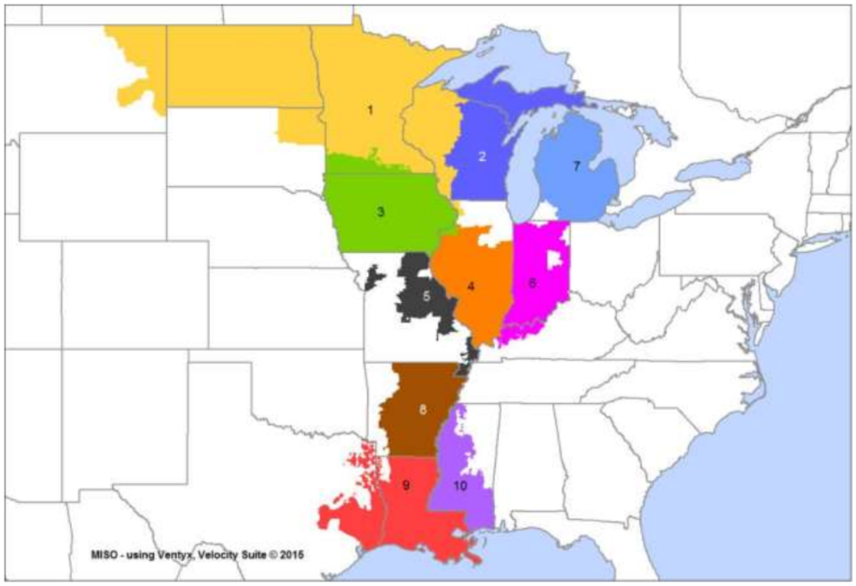
The current wholesale energy market in MISO is a subsection of the Eastern Interconnection, which is the electric transmission grid that spans from the east coast of the United States to the central plains and from the Hudson Bay in Canada to the Gulf of Mexico. Wholesale energy markets, including MISO, rely on a large pool of resources with geographically diverse needs and resources that aim to allow excess resources in one part of the footprint to meet customer demand in another through use of the transmission grid. This diversity helps to mitigate the need to locate generation in close proximity to areas of demand, and can level variability in renewable resources by taking advantage of weather differences across the entire market's footprint.

While today's interconnected grid of transmission facilities reliably transfers large amounts of energy over long distances to meet customer demand, the grid was not originally developed to serve regular (*i.e.,* "base system") customer demand across distant geographies for significant durations throughout the year; nor was it designed to serve customers from densely-sited renewable generation, like it does now. And while these individual systems are interconnected, the there is not sufficient transmission infrastructure to be able to operate the MISO footprint like one of the original utility footprints. Therefore, one of the reliability measures that MISO instituted was to develop Local Resource Zones (LRZ) and inter-LRZ transfer limits to ensure ongoing reliable system operation.

The Figure below portrays the geographic diversity of the current MISO footprint and shows the different LRZs by number and color.

Figure 1: MISO Local Resource Zones

Map of MEP Local Resource Zone Boundaries



Source: Attachment WW of the MISO Tariff.

The NSP System is in LRZ1 along with Dairyland Power Cooperative, Great River Energy, Montana-Dakota Utilities, Minnesota Power, Ottertail Power Company, and Southern Minnesota Municipal Power Association.

This has worked well, however, the fundamental nature of the resource side of the equation is changing, which drastically changes the dynamics on the grid. There are more distributed, intermittent generating sources – and large synchronous generating units are retiring from the system. Inverter-connected resources at high levels of penetration generally do not provide the system services necessary for utilities to operate reliably. Without the inertia from the large generating units, system stability could be compromised – and the system is much more susceptible to the effects from what traditionally would have been inconsequential disturbances. As the level reliance on these interver-based resources continues to increase, new approaches to system planning are needed, as the current state of those processes cannot sufficiently address the differences in these resource types.

II. CURRENT MISO RENEWABLE CAPACITY VALUE DETERMINATIONS

On today's system, MISO has an annual processes to assign capacity values to generating resources that vary by resource type, and that establish resource adequacy requirements for load serving entities such as the Company. These values come from the availability of the resource type as evaluated over a long base of operating experience at a specific hour of the year. The set of resources with specific performance attributes are put into a Loss of Load Expectation (LOLE) study and mixed with simultaneous probabilities (i.e. Monte Carlo type analyses) of when those outages may occur across the grid. This analysis also considers transmission performance capabilities and thus probabilities of loss of a transmission element. These analyses combine to ensure that the chosen resource mix and the specific grid will allow for load to be served to a load loss standard usually of no more than one day loss in 10 years. These capacity valuation mechanisms include the MISO Effective Load Carrying Capability (ELCC) analysis[1] and Wind and Solar Capacity report. The resource capacity values are commonly known as "accredited" amounts of capacity that can be relied upon to meet customer demand for planning purposes. MISO's resource adequacy process also establishes the margin by which the Company's resources are required to exceed demand in order to cover potential uncertainty in the availability of resources or level of demand.

If there are larger amounts of resources with the same performance attributes included in this analysis, the probability of loss of all those resources at the same time increases – and thus, the probability of impact on the load loss standard increases. For transmission for example, a consideration is the proportion of longer lines, which are more susceptible to weather or other types of disruptions, compared to shorter lines. As we discuss in more detail below, this is the reason that higher proportions of intermittent or variable resources erodes the capacity value for *more* of that resource – because the probabiblity of loss increases. Diversity in the type and location of a resource mix has always been important, and that will only become more important as the grid continues to evolve.

MISO's current resource adequacy requirements do not consider this expected marginal decline in load carrying capability from renewables as penetration increases, which we believe could ultimately result in a resource deficiency. The capacity accreditation also does not take into account the seasonal and weather-related variability that we have observed in both winter and summer instances, where renewables have vastly underperformed their expected contribution to load. In these circumstances, firm dispatchable, load supporting resources have been needed to fill the gap. Our Reliability Requirement is intended to recognize this new normal that is emerging. We outline the current MISO processes that determine resource adequacy requirements and capacity accreditation for wind and solar resources below.

[1] ELCC is a measure for estimating a resource's capacity value to meet customer needs with no net change in reliability.

A. Loss of Load Expectation Study

A Loss of Load Expectation (LOLE) study is intended to assess the overall probability that there will be a shortage of power, and is defined as the expected number of days per year for which the available generation capacity is insufficient to serve the demand at least once per day. The MISO LOLE is performed annually, analyzing a two-year horizon. From this study, several threshold requirements used in resource planning efforts are established for the following year – including a margin of resources the Company is required to maintain over and above its expected customer demand. This resource adequacy margin is the amount of generating capacity, over-and-above expected customer load that needs to be present on the system to ensure reliability in all but the most extreme circumstances; this margin does not however, currently account for the intermittent nature of renewable resources. As we describe below, renewable resources are assigned an accredited capacity value based on their annual average contribution to the system peak, rather than their ability to contribute to customer needs every hour of every day.

After these general obligations have been determined, we consider the type of resources suitable to meet that requirement. MISO's tariff and business practices set forth procedures to enable various types of resources to be used to achieve our requirement. These resources are referred to as "Planning Resources," which include the following sub-types:

- *Capacity Resources*: Physical Generation Resources (i.e. physical assets and purchase agreements), External Resources if located outside of MISO's footprint, and Demand Response (DR)resources participating in MISO's energy and operating reserves market, available during emergencies.
- *Load Modifying Resources*: Behind-the-Meter Generation and Demand Resources available during emergencies, which reduces the demand for energy supplies coming from the load-serving entity (LSE).
- *Energy Efficiency Resources*: Installed measures on retail customer facilities designed and tested to achieve a permanent reduction in electric energy usage while maintaining a comparable quality of service.

The Planning Reserve Margin (PRM) process establishes PRM values on both an installed capacity (ICAP) basis, which reflects the nameplate capacity of a resource, and on an unforced capacity (UCAP) basis, which incorporates the resource's operation, maintenance and utilization characteristics. Utility planning for system needs, including the planning we do as part of Minnesota Integrated Resource

Planning process, focuses on UCAP values, so we can plan to the measure of a resource's reliable contribution to system needs.

Physical generating resources and registered DR are assigned a UCAP value by applying a discount to their installed capacity. For a generator, the discount represents its forced outage rate. For DR, MISO uses a documented process of assessing the resource's observed responsiveness and effectiveness at reducing load. Intermittent Resources—including large-scale Solar, Wind, and Hydro–are assigned UCAP values that are determined by the individual unit's historical performance during the peak hours of the planning period.[2] As we discuss above, we are entering a new planning paradigm, and planning for a single system peak will no longer ensure customer reliability.

B. Wind and Solar Capacity Credit Report

Using the data from the LOLE study, MISO creates an annual Wind and Solar Capacity Credit Report that establishes MISO-wide capacity values for all wind and solar resources for the next planning year. MISO currently uses a probabilistic analysis as the first step in determining the ELCC for wind and solar resources. The second portion of the analysis utilizes a deterministic approach using historical wind resource output data, which incorporates the resource location. Combining these two sets of analyses, MISO then aggregates the characteristics to the nearest Commercial Pricing Node (CPNode) to determine a localized Wind Capacity Credit for each CPNode.

The 2018 report utilized installed wind capacity as of June 30, 2018, which included 18,210 MW of nameplate generating capacity assigned to 215 individual CPNodes. The values from this report are intended for incorporation into the following planning year – in this case, 2019. These values are as follows:

- Wind Capacity Credit (MISO system-wide):[3] 15.7%
- Solar Capacity Credit:[4] 50%

[2] Currently, these units are measured on historical performance during the operating hours of 1500 to 1700 in the months of June-August over the three most recent summers. Each site must have one complete historic period of data prior to unit accreditation.

[3] The calculation of the Wind Capacity Credit is the Individual CPNode Capacity Credit % = Peak Metric * K, where K is the coefficient representing the ratio between the calculated ELCC and the sum of the individual CPNode peak metrics.

[4] As of December 2018, MISO had a registered total of 313 MW of installed solar capacity. Because of the relatively low volume, MISO assigns each new solar unit a 50 percent capacity credit until additional operational data is available.

MISO also conducts studies on an LRZ-level to ensure regional reliability.

C. Relevant Regional Planning Considerations

MISO has the largest geographical footprint of any regional transmission organization. This provides valuable geographic diversity and access to additional resources when needed for back-up purposes. However, there are limitations on the amount of energy that can be shared between LRZs, and the amount of energy that can be imported or exported between MISO and other regional transmission organizations. As a result, MISO has developed localized studies that address the resources needed within each LRZ, as well as the limitations on transferring energy between LRZs, as follows:

- *Local Reliability Requirement.* This value is calculated to determine the amount of resource capacity needed on a LRZ level to ensure reliable service of customer demand during peak usage.
- *Capacity Transfer Limitations.* Capacity Import Limitation (CIL) and Capacity Export Limitation (CEL) values are determined through a capacity transfer study that signals the levels of capacity that can be both imported into a LRZ and exported to a LRZ while maintaining reliability.

Despite its broad geographic diversity, MISO remains susceptible to variations in resource availability based on, among other things, weather. As we have explained, today's interconnected grid is not the same as the traditional utility-specific grids that were built to serve local customer loads. There is not sufficient transmission infrastructure within MISO to transfer any resource type any distance – nor can it import limitless resources from other regional grids. Weather has taken out all of a certain type of resource – specifically wind, in the case of the 2019 polar vortex. Similarly, a day in July 2018 was an especially windless day and in one hour, the wind turbines that were online were taking more power than they were producing. This hour was also part of an approximately *110 hour* sustained stretch in which the combined output of all wind resources in the MISO footprint fell well below the accredited values used in present planning processes.

Individual utilities therefore must consider what level of reliance on the MISO market is reasonable to fulfill their system needs without exposing their customers to potential shortfalls or high prices, particularly in the event of high system stress conditions. We take our responsibility to ensure we have access to a sufficient level of resources in all grid conditions to meet our customers' needs seriously. The future

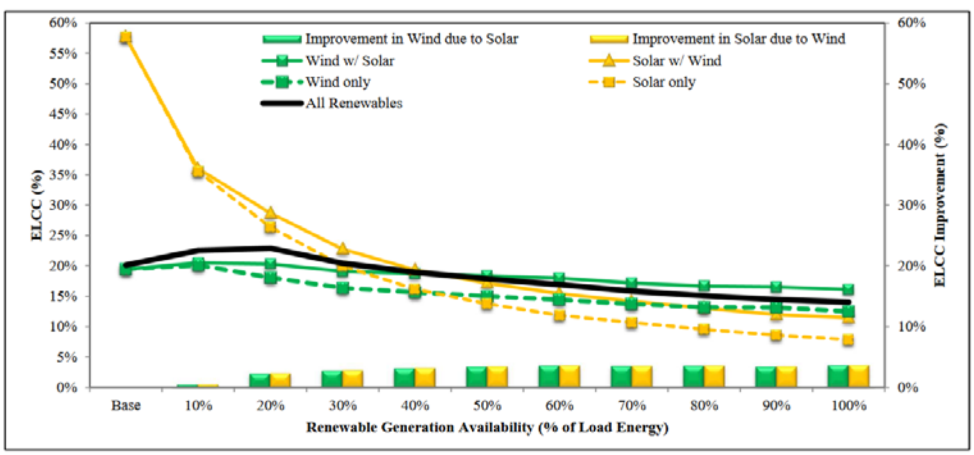
MISO grid will rebalance the new resource mix and the new transmission configuration needed to support it. We expect there will be many transitional stages between now and then to achieve this resource shift reliably. Determining our level of market reliance as part of our Reliability Requirement is a necessary part of this transition.

III. HIGH LEVELS OF RENEWABLES RESULT IN DECLINING CAPACITY VALUE

The industry is beginning to recognize and adapt planning processes to incorporate declining capacity values for wind and solar resources as penetration levels increase. However, MISO has not yet changed its planning processes to account for these limitations.

In 2017, MISO initiated its *Renewable Integration Impact Assessment* (RIIA) to examine issues surrounding effective integration of high levels of renewable resources. The figure shown below is an excerpt from an April 18, 2018 MISO presentation showing that, as wind and solar approach 100 percent penetration, their ELCC values decline significantly and approach 10 percent. When the generation fleet is diversified by including both wind and solar, the relative ELCC value for each is higher, but there is still a significant decrease in value as combined penetration approaches 100 percent.

Figure 2: MISO RIIA Study Finding –
Declining ELCC Value for Wind and Solar Resources



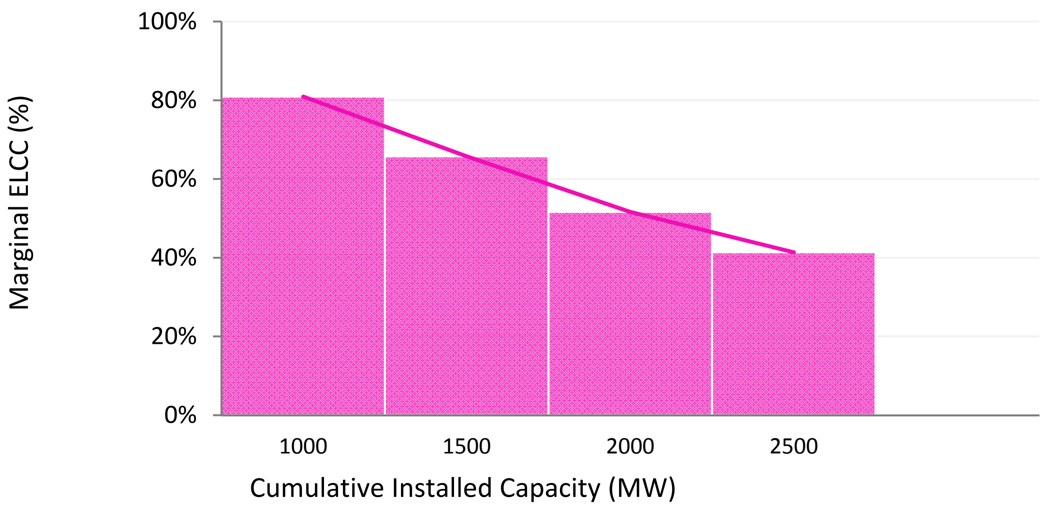
Source: MISO April 18, 2018 RIIA presentation at page 8.[5]

Notably, solar and wind are not the only resources whose capacity values decrease as

[5] https://cdn.misoenergy.org/20180418%20PAC%20Item%2003d%20RIIA174068.pdf

penetration increases. As shown in the analysis performed by E3 in connection with this Resource Plan, demand management programs also have decreasing relative effectiveness as participation increases.

Figure 3: E3 Marginal ELCC (%) – Four-Hour Demand Response



Source: E3 RECAP Analysis

Although early in the process and mainly focusing on their Resource Availability and Need (RAN) initiative,[6] MISO also recognizes that its current approach of using historical load shapes to predict the long-term future is no longer sufficient as Distributed Energy Resources (DER), Demand Response (DR), and energy efficiency become more prevalent. MISO likewise acknowledges that impact of these resources on demand, energy, and corresponding load shapes needs to be better understood and accounted for in its planning construct.

IV. RECENT ACTUAL LOW RENEWABLES PERFORMANCE EVENTS

In addition to these future planning – or accreditation – limitations, the actual performance of renewable resources reveals certain limitations with their ability to ensure reliability under all conditions and at all times without the support of some amount of dispatchable generation. To show this, we consider a number of actual case studies from the last 12 months below.

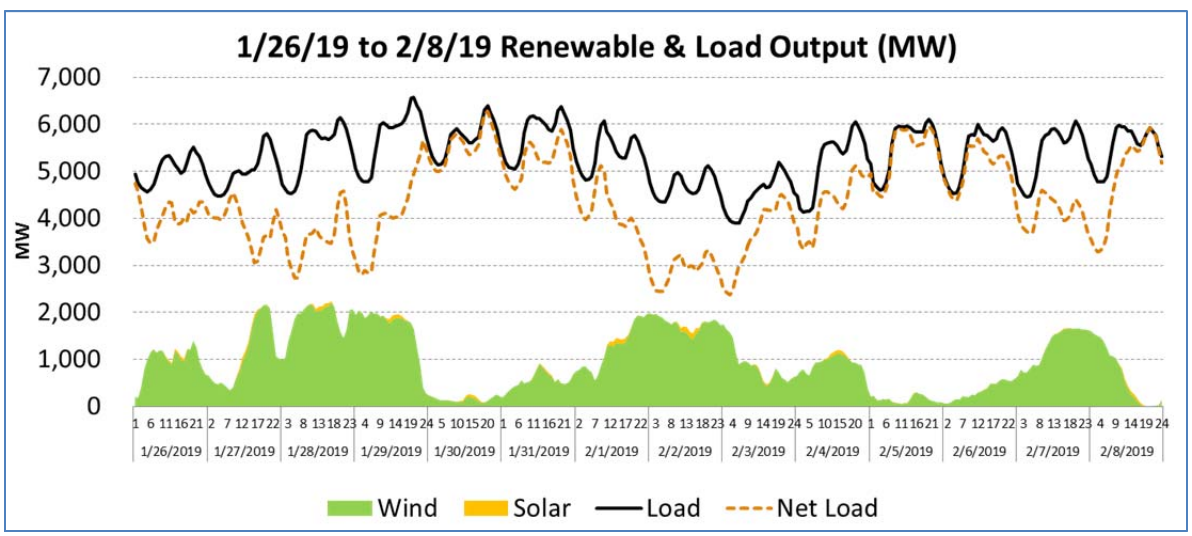
[6] The purpose of the MISO RAN initiative is to assure the conversion of committed capacity resources into sufficient energy every hour of the Planning Year.

A. Winter Case Study Events

In the past, winter months traditionally matched well with renewable resource production. In winter, we typically experience lower system demand and increased transfer capabilities, (meaning the ability to effectively transfer large amounts of renewable energy from where it is produced to load centers such as the Twin Cities Metro area). Additionally, wind resources generally achieve their highest efficiencies of the year over the winter months. However, as the penetration of renewable resources in the Company's fleet has increased and taken on a growing role in base energy production, winter has become an increasing concern. As we discuss below, during the 2019 polar vortex and an otherwise "normal" winter (and summer) day, firm dispatchable resources were needed to fill sustained periods of time where renewable resources were not producing at their accredited levels.

Given the variability of renewable generation, we have encountered times when the net customer load (which is the amount of customer demand not being met by renewable generation and for which firm dispatchable resources are needed) is near, or even equal to, the gross demand on the system. As shown below, this was the case during both the January 29-31, 2019 polar vortex, which was an extreme weather event marked by historically-severe and sustained cold temperatures combined with high winds, as well as February 5, 2019, a normal winter peak period.

Figure 4: Renewable Output and Load
January 26 – February 8, 2019



This illustrates why planning for a single system peak no longer works. We have to also plan to meet our customers' energy requirements on a net load basis – or the gap between customer needs and variable resource availability every hour of every day.

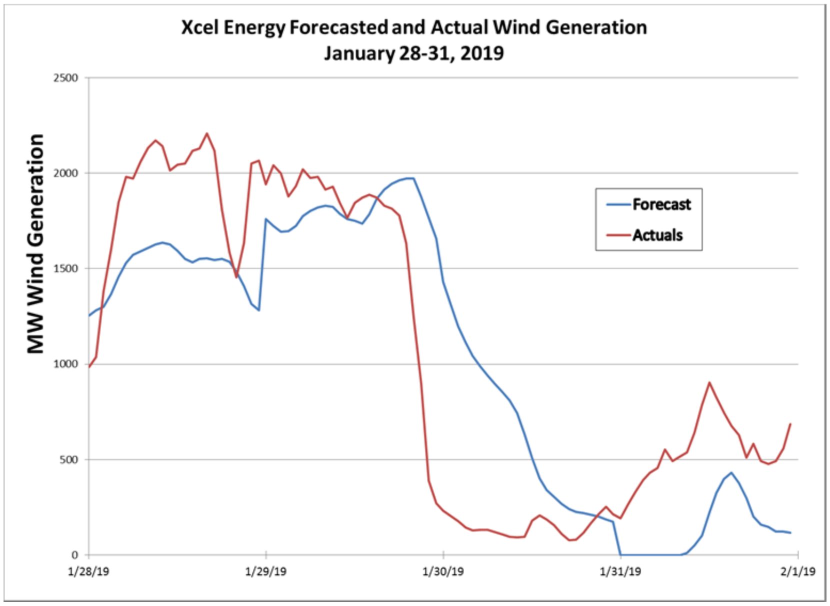
1. Extreme/Polar Vortex Event

The January 28 to February 1, 2019 timeframe, referred-to as the 2019 Polar Vortex, was marked by extreme cold temperatures over a sustained period of time across the northern United States, and specifically within the MISO footprint. The MISO region experienced ambient temperatures well below zero degrees Fahrenheit (F) for several consecutive days, with temperatures falling well below -20 degrees F in some areas. During this period, MISO experienced a resource deficiency and relied upon external resources and load control measures to reliably operate the system and balance generation resources with customer demand. Due to the duration and magnitude of the resource shortfall, neither DR nor energy storage could substantially contribute to reducing the Net Load.

The overwhelming majority of wind turbines now have operating temperature cutoffs at approximately -22 degrees F. MISO, however, did not have established measures to account for these limitations. As a result, and because of the high wind speeds during the polar vortex event, the MISO wind forecast projected upwards of 14 GW of wind generation to be online. However, the vast majority of wind turbines shut down in the early morning hours of January 30^{th}, and output dropped to approximately 3 GW sooner than the forecast had predicted. As a result, firm dispatchable resources were needed to fill the gap left by the lack of wind.

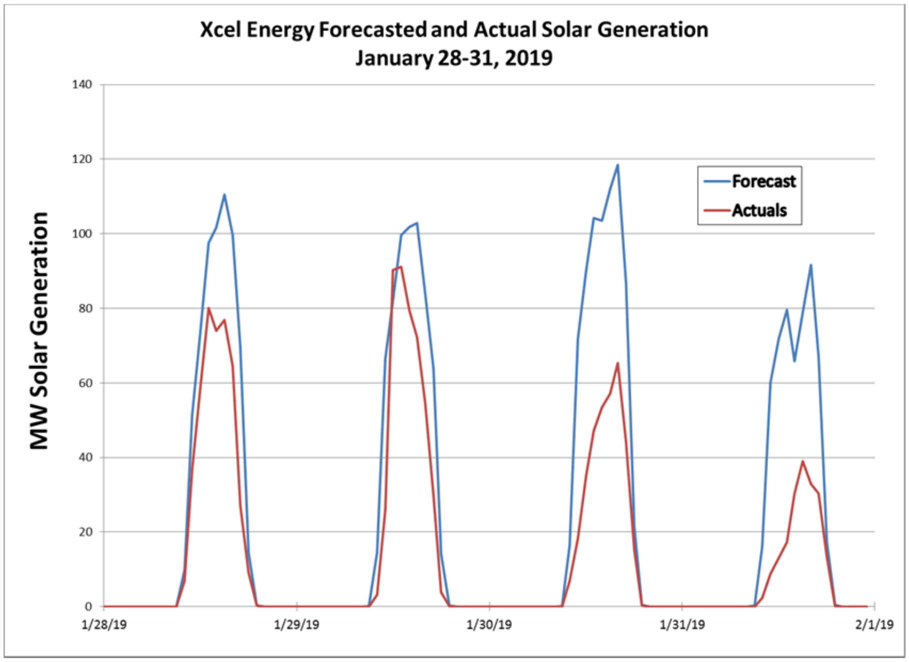
Figure 5 below shows the Xcel Energy wind actuals compared to the forecast during this period, which we note closely mirrored the MISO forecast and actuals.

**Figure 5: Xcel Energy Wind Generation Actuals vs. Forecast
January 28-31, 2019**



Solar generation performance is also affected by temperature, but does not involve cold weather cut-offs. Rather, solar panel efficiency drops off steadily once *panel* temperatures exceed approximately 42 degrees Celsius (107 Farenheit). Panel temperatures are typically approximately 20 degrees Celsius higher than the ambient air temperatures, thus solar production efficiency starts to decline when the ambient air temperature is in the range of 87-91 degrees Farenheit. PV Solar panel production works most efficiently during cold temperatures, with the obvious caveat that cloud cover and/or snow on the panels will reduce solar generation. We provide as Figure 6 below, a comparison of the Xcel Energy solar actuals compared to the forecast during the polar vortex period.

Figure 6: Xcel Energy Solar Generation Actuals vs. Forecast January 28-31, 2019



This solar forecast compared to actuals chart indicates a forecast error, especially for the last two days of the period. Our meteorologists attribute the error to a snow event at one of our larger solar facilities, where the conditions at the time were like those shown in Figure 7 below.

Figure 7: Snow Impacting a Large Solar Installation

Essentially, the solar panels that can "track" the sun are are built to maximize solar generation by continuously finding the optimal sun angle. Due to heavy snow in this situation, the panels were unable to move and the angle was insufficient to shed the snow cover, thus affecting actual production and not matching our forecast. In fixed-axis solar resources, there are options: (1) optimize to shed snow cover, which reduces the ability of that resource to produce energy; and, (2) optimize to output the most energy, which reduces its ability to shed snow cover. As we discuss below, winter solar performance is also affected by fewer light hours/shorter days and less optimal sun angles.

According to a report compiled by the MISO Independent Market Monitor (IMM), during this timeframe the MISO footprint used resource "reserves," which consisted of non-firm resources offered by neighboring regional transmission organizations into the MISO market. The level of these resources that MISO had to use to remain operational and avoid further emergency actions ranged from 5,000 MW to 11,500 MW – with an average of 6,500 MW on January 30th. The maximum offered reserve resources was 13,500 MW, which MISO nearly exhausted at one point in order to avoid a critical deficiency in available energy.

Although extreme, this weather event may reasonably be expected to occur again, and a disruption in electric service during a similar event in the future would have detrimental and serious impacts on our customers and public safety in general. We therefore believe this case study provides an important, recent example to consider as we manage the transformation of our generation portfolio while prioritizing the reliability and stability of our system.

2. Normal Winter Day

In addition to cold temperatures affecting wind production, snow cover and icing also decrease wind and solar output in winter months; non-ideal sun angles and shorter days, and thus limited light hours, additionally impact solar production. While the polar vortex involved extreme weather conditions that affected wind production especially, February 5, 2019 was a normal winter day that offers another example where Gross Load was at, or near, Net Load (Gross Load minus contributing renewable resources) for a significant number of hours.

Between 7:00 a.m. and 11:00 p.m., there were 16 consecutive hours where Net Load was over 5,400 MW. Due to the duration and magnitude of this shortfall, neither DR nor energy storage could substantially contribute to reducing the Net Load, at least for the entire period. During this period, all wind and solar resources on the system combined to have an average hourly capacity factor of *six* percent, and there were particular hours when neither wind nor solar resources had a capacity factor greater than *three* percent. We provide the hourly capacity factors for wind and solar resources below.

Table 1: Hourly Wind and Solar Capacity Factors
February 5, 2019

Hour Ending	Wind Capacity Factor	Solar Capacity Factor
1	9%	0%
2	9%	0%
3	6%	0%
4	5%	0%
5	7%	0%
6	6%	0%
7	7%	0%
8	4%	0%
9	3%	0%
10	3%	3%
11	2%	6%
12	3%	6%
13	3%	5%
14	7%	5%
15	12%	4%
16	13%	2%
17	11%	1%
18	11%	0%
19	9%	0%
20	6%	0%
21	5%	0%
22	4%	0%
23	3%	0%
24	4%	0%

Because we currently have access to sufficient baseload and firm dispatchable resources on our system, we were able to serve customers reliably and affordably throughout the duration of this period.

3. Other Winter Conditions

In considering the resources available during periods of low wind generation, the Company also needs to assess availability of resources across MISO. The MISO footprint encompasses large areas that experience snow cover and extreme low temperatures in the winter months. This impacts the output of renewable resources throughout MISO in several ways.

Wind turbines are designed to cut-out at extreme cold temperatures to protect their operational mechanisms. During the 2019 Polar Vortex, temperatures dropped below the -22 degree F cutoff, causing wide-spread reduction of wind resources despite relatively high wind speeds.

Snow cover and icing negatively impact solar and wind generation resources. As discussed above, during the winter months in the Upper Midwest, snow and ice cover on solar panels significantly decreases the energy capabilities of those resources. Wind turbines are susceptible to blade icing, which causes decreased output or complete cessation. While these issues are limited to certain geographical areas, those same areas highly correlate with the most dense and highest average capacity-factor renewable resources in the MISO footprint.

Limited light hours combined with non-ideal sun angles reduce the output of solar resources in winter months. These conditions are prevalent throughout the MISO footprint, which combine to reduce the output of solar resources to fewer hours of the day, and lower levels of energy output when the sun is available.

B. Normal Winter Day Case Study Extrapolated to Higher Levels of Renewables

Consistent with our vision for 100 percent carbon-free energy in 2050, we studied these scenarios with higher levels of renewable resources than exist today. To do so, we replicated the operational scenarios encountered on February 5, 2019, but modeled with 5,000 MW of nameplate capacity wind and 5,000 MW of nameplate capacity solar resources. The results were very similar. For 13 of the 16 hours, the Net Load remained above 5,300 MW and all hours exceeded 5,000 MW of Net Load.

C. Non-Winter Case Study Event

Because low temperatures and other conditions unique to winter are not the only cause of low renewable generation in MISO, we also looked to the summer months as potential case studies. July 29, 2018 was an especially windless day. During the 8:00 a.m. hour, the entire MISO wind portfolio (over 17,000 MW at that time) had a combined output of *minus* 11 MW – meaning the wind turbines that were online were taking more power than they were producing. This hour was part of an approximately *110 hour* sustained stretch in which the combined output of all wind resources in the MISO footprint fell well below the accredited values used in present planning processes. We again encountered sustained low wind conditions in early 2019, with 370 hours of wind production below accredited values before May 1.

These case studies are supported by a recent University of Minnesota Research Brief about an initiative that examined conversion of home heating from gas to electricity – and supplying that electricity with renewable energy, which had been identified as a critical national decarbonization pathway.[7] The May 8, 2019 *Research Brief: Planning for the future of energy demand with renewable energy* reported that researchers at the University of Minnesota and three other institutions sought to understand whether enough renewable energy can be generated locally to meet most, if not all, of that increased electricity demand.

Researchers mapped out three scenarios: one that included battery and thermal energy storage options; an option that assumes no storage; and an option that overbuilds renewable supply by 150 percent of demand. They then ran models using data from four cities in three different climate zones, including Minneapolis, Minnesota.[8] The study found that for scenarios without storage, wind-based supply dominates the optimal mix for Minneapolis. The study also found that when 12-hour storage is available, renewable penetration increases from 54 percent to 70 percent in Minneapolis. In light of these findings, the Brief stated:

> However, no matter the scenario, the study found that the use of fossil fuels would still be needed to meet peak demand in cold climates like Minneapolis and Fort Collins. This is because renewable energy cannot be produced at the rate needed to meet demand during the coldest months..

Finally, the Brief reported that researchers suggest policymakers and/or low carbon energy system planners do the following:

- Take into account the geographic and climatic differences when finding the optimal mix of wind and solar generation,
- Consider incentives to invest in battery storage systems, which will increase the overall amount of demand that can be met with renewables,
- Count on a smaller, but nonetheless important, role for fossil fuel plants to meet peak demand.

V. KEY TAKEAWAYS

As this data shows, today's intermittent generating resources cannot alone meet

[7] *See* https://twin-cities.umn.edu/news-events/research-brief-planning-future-energy-demand-renewable-energy

[8] Other cities were New York City, New York, Fort Collins, Colorado, and Tallahassee, Florida.

demand at all times of the year, at least without excessive costs.[9] Even during historically good times of the year for renewable generation on the Company's system, the availability of these resources is inexorably tied to the variability of weather patterns, and at times they are simply not available.

Additionally, current storage technologies and demand management programs are also insufficient to meet the duration of real events like those discussed above. Current battery storage systems are limited (typically to 4 hour discharge periods) with significant time needed to recharge. Unless overbuilt many times over, these resources would not be able to provide energy for the full duration of such events; they also may not be able to recharge fast enough to be a viable resource during the consecutive periods of low renewable output. Similarly, and as discussed above, some of the most significant current demand management programs are specifically designed to reduce capacity needs during the system's overall peak during summer hours, and they would not be as effective, or effective at all, during winter periods.

These case studies and industry insights have highlighted gaps in present MISO planning constructs that – until MISO adapts – we must take into account to ensure system resilience and customer reliability. Fundamentally, we have a responsibility to ensure we have access to a sufficient level of firm dispatchable resources in all grid conditions that can flexibly adapt to variable renewable resource performance to meet our customers' needs. We take this responsibility seriously. We view these case studies as highlighting gaps in the present MISO planning construct. Until MISO determines how best to address these gaps, we believe it is incumbent on us as the utility to take steps to ensure that our system is resilient, that our customers will be reliably served, and that our customers are reasonably protected from high financial exposure in the market when the system is under stress.

VI. DEVELOPING THE RELIABILITY REQUIREMENT

In an effort to mitigate resilience and reliability risks, we analyzed the data from these case studies and created a reliability requirement for our modeling that reflects a reasonable amount of reliance on MISO resources and demand response to meet our system needs. The intent of this requirement is to supplement our system planning process to ensure we have sufficient resources available to reliably serve our

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[9] Simply increasing the amount of solar and wind generation on the Company's system is an unrealistic approach to addressing capacity shortfalls. In order to have sufficient capacity to meet the customer demand discussed in the scenarios above, the Company would need in excess of 180,000 MW of nameplate capacity wind and solar generation. And, even this amount of renewable generation may be insufficient given the declining capacity value of renewable generation, as discussed above, and the probability there will be times with extremely low levels of wind and sunlight.

customers' energy needs every hour of every day – regardless of weather.

Establishing this reliability requirement involves a number of steps:

1. Establishing a level of peak demand to serve as a proxy for the most likely conditions where we would expect to have a gap between renewables performance and customer load.
2. Assessing the contribution we can reasonably expect from duration-limited resources like DR or energy storage to fill-in the gap.
3. Determining the extent to which it is reasonable, from a financial and operational risk perspective, to rely on the MISO market to make-up at least a portion of the gap.
4. Using these inputs to derive the level, of firm dispatchable resources that are needed to reasonably assure reliability. It is this level of firm dispatchable resources that ultimately forms the Reliability Requirement that we incorporated into our modeling for this Resource Plan.

We discuss the components of this calculation below.

A. Proxy Peak Demand

The first step in determining the Reliability Requirement was to approximate the customer peak demand we should expect during inevitable high stress MISO market scenarios. Although winter is not the only season in which we have experienced low renewable output relative to expected contributions, it is when we most expect weather conditions to impact wind turbine and solar panel performance (i.e. blade icing and snow cover). We therefore determined that the NSP System winter peak demand – or approximately 6,400 MW – would be an appropriate proxy and starting point to ultimately determine the resource types and amounts that we can reasonably rely on to fill the gap.

B. The Role of Duration-Limited Resources

Today, the Company is able to draw on DR and likely in the future, other time-limited resources such as storage to meet our customer needs. But, while these resources can help fill the gap to some extent, it would not be prudent or practical to fully rely on them to guarantee system reliability.

As discussed above, demand management programs have lower availability in winter months. As with all components of the Reliability Requirement, the DR proxy was designed to avoid unrealistic assumptions of demand response availability. This proxy, therefore, allows for the support of demand management programs up to the point where they can no longer be considered firm resources. We included a demand response proxy of approximately 200 MW in our modeling.

C. MISO Market Reliance

As noted above, resources from the MISO market may also be available to fill the gap between customer load and low renewables performance, although transfers within and between LRZs are constrained in accordance with MISO's identified system capabilities. This is a valuable benefit of being part of a regional market. However, we expect that that other resources and loads in MISO and LRZ1 will experience similar conditions – particularly if an event is weather-related. We do not believe it would be reasonable or in our customers' best interest to rely on the market to fulfill the resource gaps caused by the unavailability of intermittent resources – especially in high-stress scenarios. It is therefore important to determine an appropriate and reasonable level of reliance on market resources during a high-stress scenario. Notably, these high stress times frequently happen in periods of extreme cold when our system is even more critical than normal. This market reliance issue will only become more important as utilities retire firm dispatchable resources that today aid reliability during these times of system stress.

Using a combination of MISO planning data and the IMM analysis of excess resources during the 2019 Polar Vortex event, we derived a level of MISO market reliance for the NSP System to incorporate into our RRP calculation.

Table 2: Planning Parameters to Derive NSP System Level of Market Reliance – High Stress Scenarios

Relevant Planning Parameter	2019-2020 Planning Year Values
MISO Peak Demand	125,501 MW
LRZ1 Peak Demand	17,780 MW
NSP System Peak Demand	9,129 MW
NSP System Peak as Percent of MISO	*7.27%*
NSP System Peak as Percent of LRZ1	*51.3%*
Polar Vortex Event – Minimum Excess Resources	5,000 MW
Polar Vortex Event – Average Excess Resources	6,500 MW
NSP System Share of Excess Resources (7.27% of Min. and Avg. Excess Resources)	364-473 MW
NSP System Market Reliance Level	**500 MW**

From the IMM analysis of the 2019 Polar Vortex event, we know the minimum (5,000 MW) and the average (6,500 MW) MISO-wide excess resources that were used during this event. These are important values to understand, as they were the level of excess non-firm resources made available from outside of MISO and needed by MISO to avoid a critical energy deficiency.

If similar operational events and system demands were experienced across large areas of the full MISO footprint during a high-stress event, and assuming that reliance on external resources would be split based roughly on each utility's portion of total demand, the Company would be able to rely on only 7.27 percent of any excess generation in the MISO system. Therefore, to derive the NSP System share, we applied the NSP System load ratio share to the minimum and average levels of excess resources from this event, which equates to a minimum of 364 MW and an average of 473 MW. From here, we assumed some additional customer efficiency might lower our peak or operational efficiencies might increase external energy available to the NSP System, and thus determined that 500 MW would be a reasonable level of MISO market reliance during a high stress scenario.

After approximating the contribution from these sources, we are able to determine the quantity of firm, dispatchable resources we need to maintain on the NSP System to assure reliability.

D. Some Level of Load Supporting Resources are Needed

The calculation of the Reliability Requirement results in a minimum level of firm dispatchable resources necessary to adequately support customer loads. We discuss how we apply the Requirement to our modeling in Chapter 3: Minimum System Needs. We clarify here however, that while this concept is essential until MISO evolves its capacity construct, the Requirement has little effect in our modeling for this Resource Plan. The model does not select any firm dispatchable additions as a direct result of the Reliability Requirement until 2031, which is near the end of the planning period. This long runway leaves ample time for MISO and its stakeholders to address this aspect of its planning and provide additional direction.

That said, we demonstrate the calculation of the Requirement we applied in our modeling for this Plan in Figure 8 below.

Figure 8: NSP System Reliability Requirement Calculation – 2020 Example

Peak Demand Proxy – 6,400 MW
Minus Firm DR (Winter) Proxy – (200 MW)
Minus Firm Market Supply Proxy – (500 MW)

Reliability Requirement – 5,700MW
(Firm dispatchable resources)

We are confident that this is a reasonable and appropriate approach to determining a minimum level of firm dispatchable, load supporting resources necessary to maintain a reliable supply of power during high-impact low-frequency events like the 2019 Polar Vortex – as well as other typical summer or winter weather days that happen to have low renewable performance.

VII. SUMMARY

As the Company increases the amount of renewable generation in our system, it is important to recognize that these resources cannot alone reliably provide customers the energy they demand every hour of every day – or maintain the stability of the grid. MISO is beginning to recognize these challenges and that its current planning constructs do not yet address these issues. In the interim, our Reliability Requirement ensures we have the right mix of resources on our system every hour of every day to meet our customers' needs.