

APPENDIX L – XCEL ENERGY RESOURCES: SHERCO CC**I. INTRODUCTION**

We are moving forward with project development for a Combined Cycle (CC) gas plant at the Sherco site that will replace part of the capacity retiring at current Sherco Units 1 and 2, as discussed in our previous resource plan. The Sherco CC will give us an important firm dispatchable resource necessary to successfully reduce our Upper Midwest NSP System carbon emissions by 80 percent from 2005 levels by 2030 and transition to 100 percent carbon-free in 2050 – while ensuring reliable and affordable electric service to support our economy and communities. This transition will put us in many untested circumstances, where it will be critical to have viable system options to provide flexibility to respond. No one yet knows what that future looks like – and we are confident that it relies on technologies that are not yet developed. It is prudent and responsible, and our obligation as a public utility, to ensure we are planning and implementing viable infrastructure options that will help to drive a successful and economic transition to a stable future state.

Our previous Resource Plan stated that, in order to retire the coal-fired units, there were certain grid reliability issues that would need to be resolved, as well as community support objectives to meet. Those issues remain true today. There have also been several developments since our last Resource Plan that reinforce and highlight the system benefits the Sherco CC will provide.

Overall, building a new CC at the Sherco site is the most appropriate holistic solution to serve grid needs when the Sherco coal units retire, for the following reasons:

- It will provide system needs including voltage support, power deliverability, and system regulation in the absence of Sherco Units 1 and 2.
- It will provide replacement capacity for our black start restoration path.
- It will facilitate our carbon reduction plan in three ways. First, in providing the grid support the Monticello nuclear plant needs (and which will be absent if the Sherco Units are not replaced). Second, by facilitating the integration of large renewable additions contemplated by our Preferred Plan. Third, by avoiding the costly and lengthy transmission upgrades that would be required if we built new units on a greenfield site.
- It will satisfy, in part, the system's need for sufficient firm and dispatchable capacity as our coal units retire and do so in a way that is superior to CT's

because of the lower heat rate and emission profile.

- It will help us fulfill our commitments to the Becker community as we transition away from legacy coal-fired baseload assets.

We discuss each of these factors in more detail below, and we also provide an update as to the status of the Sherco CC project.

II. THE NEED FOR THE SHERCO CC AS DISCUSSED IN OUR LAST RESOURCE PLAN

In our last Resource Plan, we proposed to retire Sherco Units 1 and 2, which provide approximately 1,400 MW of stable, baseload generating capacity to our system. Given the amount of energy and firm capacity these two baseload units provide, we undertook an in-depth analysis to determine the grid needs that would arise upon their retirement.

The specific studies the Company undertook included an Attachment Y2 study, performed by MISO, and a separate study by Siemens Power Technologies International. The Y2 is a non-binding, informational study that identifies any reliability impacts of a potential future status change of a generating unit(s) – in this case, Sherco Units 1 and 2. The MISO Tariff requires that any generation retirement be studied and approved by MISO to ensure that it results in no adverse effects to the reliability of the system, and we commenced the Y2 study when we first contemplated retiring Sherco Units 1 and 2. The focus of this study was on the impacts to the broader MISO grid if one or both of Sherco Units 1 and 2 ceased operation.

We retained Siemens to study the effects of potential phased retirement of one or both Sherco Units on the transmission system, technical implications (including voltage analyses and transient stability analyses) and upgrade costs associated with replacement of one or both Units at alternate locations on the NSP System, and the potential impacts of the cumulative effect of additional larger generation unit retirements on the NSP System, in particular the Monticello Nuclear Plant due to its proximate location in Sherburne County and one Prairie Island Unit in combination with Sherco Units 1 and 2.

Below we briefly discuss the studies' findings and note that each of the issues identified by the retirement of the Sherco Units below is solved by the Sherco CC – holistically and at a prudent cost to our customers. For a more in-depth discussion of these reports, please see Attachment D to the Company's January 29, 2016

Supplement to its 2015 Integrated Resource Plan in Docket No. E002/RP-15-21.

A. Voltage Support

The Y2 study found that retiring the existing units (with no replacement solution) would result in significant violations of the prevailing voltage and thermal ranges. Analysis of bulk electric system (BES) impacts from new or changing generation and transmission facilities are measured against standards and requirements established and enforced by the North American Reliability Corporation (NERC), per authority from FERC.¹

The real-time conditions on the transmission system are constantly changing and require ongoing adjustments to maintain voltages at required levels. As large synchronous power sources, Sherco Units 1 and 2 also provide system voltage support and reactive power. The system must be able to facilitate both “active” and “reactive” power. Active power, measured in watts, is the form of electricity that powers equipment. Reactive power, measured in volt-amperes reactive (VARs), is the energy supplied to create or be stored in electric or magnetic fields in and around electrical equipment. Reactive power is particularly important for equipment that relies on magnetic fields for the production of induced electric currents (e.g., motors, transformers, pumps and air conditioning). Due to physics, reactive power can be transmitted only over relatively short distances, and thus must be supplied as needed from nearby generators. If the correct level of reactive power cannot be supplied promptly and in sufficient quantity, voltages deteriorate and, in extreme cases, can result in a voltage collapse.

The issues identified by the Y2 study were significant enough that MISO would likely designate the units as System Support Resources (SSR) and not allow them to retire as planned, if an alternate mitigation was not in place. These violations would also be in conflict with the Monticello nuclear plant’s operating license. To move forward with the Sherco retirements, MISO and/or the Nuclear Regulatory Commission (NRC) would require that the Company mitigate the identified voltage and thermal violations in another manner, generally requiring either new firm generation on site or significant transmission system upgrades.

B. Power Deliverability

The Siemens’ analysis confirmed that the system operates well with significant

¹ We discuss NERC’s role in more detail in Appendix J1: Baseload Study.

injection at the Sherco site and that replacing the retiring units at a different location would require transmission system upgrades and come with other tradeoffs (i.e. increased energy losses from a new unit placed further away from the Twin Cities' load center). Transmission systems are typically developed to receive significant amounts of power from specific injection sites and then move the power over long distances to meet areas of demand. This amount of power than can be moved is often referred to as "transfer capability," and changing generator characteristics or locations impacts the performance of the surrounding grid by impacting Transfer Capability.

Our system was designed to receive significant injections of power from the Sherco site and then deliver energy out from it to areas of customer demand, including the Twin Cities metro area. The Siemens study confirmed that replacement of Sherco Units 1 and 2 with a large generating unit that provides similar benefits to the NSP System as the existing Sherco Units (like a combined cycle) will cost-effectively meet the physical system requirement to ensure voltage, frequency, and reliable service for our customers.

C. System Regulation

The Siemen's analysis also addresses the heavy reliance of the system on Sherco Units 1 and 2 for system regulation. System regulation essentially refers to the ability of the system to maintain reliable operation through changes in usage and production. In other words, equipment that provides system regulation ensures that the grid is keeping generation and load in balance at all times.

To maintain this balance, there is a need for system resources that are flexible and responsive to dispatch signals. Currently, the system relies heavily upon units like Sherco Units 1 and 2 to provide this type of regulation. The overall system frequency, required to be maintained at 60 Hz in the U.S., is an active measure of this balance. When there are sudden large changes to the generation and load balance, such as a generating unit dropping offline or an event that disrupts operation of a transmission facility, the frequency of the grid can fluctuate up and down depending on the size of the disturbance. The grid requires sufficient system regulation, which means its ability to respond instantly to changes in usage – i.e., keeping the generator and loads matched at all times. Insufficient system regulation can cause disturbances like these to make the system unstable. However, the Sherco CC addresses these system regulation issues because of its electrical characteristics that provide this fast response balancing in real time, similar to Sherco Units 1 and 2 today.

D. Black Start

In addition to the needs identified by the studies discussed above, Sherco Units 1 and 2 also play a critical role in our system when it comes to black start planning. In the event of a major outage, the existing Sherco Units 1 and 2 units are an integral “Target Unit” in our grid restoration plan. Once an “Initial Unit” (i.e. the unit that jumpstarts the grid) is re-started, Sherco Units 1 and 2 can be started and run at low loads and provide the necessary capabilities to restart other key generators, such as Sherco Unit 3, in the restoration path.

Only dispatchable units of a certain size that are capable of creating and absorbing reactive power are eligible to provide this function, and there are few viable alternatives in our current system. Nuclear units, for example, can only come online after the system is fully stable, and thus are not used as Target Units. Renewable generation, such as solar and wind, are generally not able to provide these services effectively, nor for the duration needed to serve as the Target Unit, due to their inability to create and absorb sufficient levels of reactive power – and because they are weather-dependent and not firm and dispatchable. A large battery energy storage system can technically be configured to be capable of providing black start service, likely as part of a relatively small initial black start unit. However, current battery technologies may not yet be economically viable for this purpose. There are also technical concerns with regard to how batteries can absorb reactive power, which would be needed if the battery was not paired with another type of generation asset.

While the Blackstart Plan can be re-routed if needed, constructing the proposed CC at Sherco provides the most efficient restoration path, and avoids other upgrades that would be required to re-route the path. As we noted in our January 29, 2016 Resource Plan Supplement in Docket No. E002/RP-15-21, altering the path away from the Sherco site would require various equipment upgrades on our transmission system and potentially the addition of new generation elsewhere if transmission upgrades could not fully mitigate this need. Selecting a less efficient path would also lengthen the overall restoration period, which may result in other restoration challenges during cold weather events.

III. EMERGENT ISSUES IN THIS RESOURCE PLAN

Since the last Resource Plan, the system conditions discussed above and underlying our need for a new CC at Sherco have not changed in any material way. In fact, we see many of the reliability issues identified becoming more relevant and pronounced in light of our aggressive carbon goals and the transmission interconnection

constraints that have emerged in recent years. Below, we discuss the issues new to this Resource Plan, which we believe further confirm the need for the Sherco CC.

A. Monticello Extension

Extending the Monticello nuclear plant's operational life for 10 years past its current retirement date helps us retain zero emissions baseload power on the system while we integrate additional intermittent renewables (in particular, solar PV) in 2025 and beyond. However, as discussed in our last Resource Plan, we need a large grid-stabilizing resource to ensure we can operate Monticello within the requirements of our NRC operating license. And the transmission issues outlined in our previous Resource Plan filing have also not improved. In fact, the MISO generator interconnection queue is more congested now than it was in 2016, with substantial new renewable generation proposed but very little additional transmission capacity dedicated to integrating those resources. This would very likely impact our ability to site necessary stabilizing resources in a greenfield location near Monticello, and any new unit would likely be responsible for substantial transmission upgrade costs to interconnect to the broader grid—assuming it could even make it through the MISO queue in time to facilitate a 2026 retirement of Sherco Unit 1.

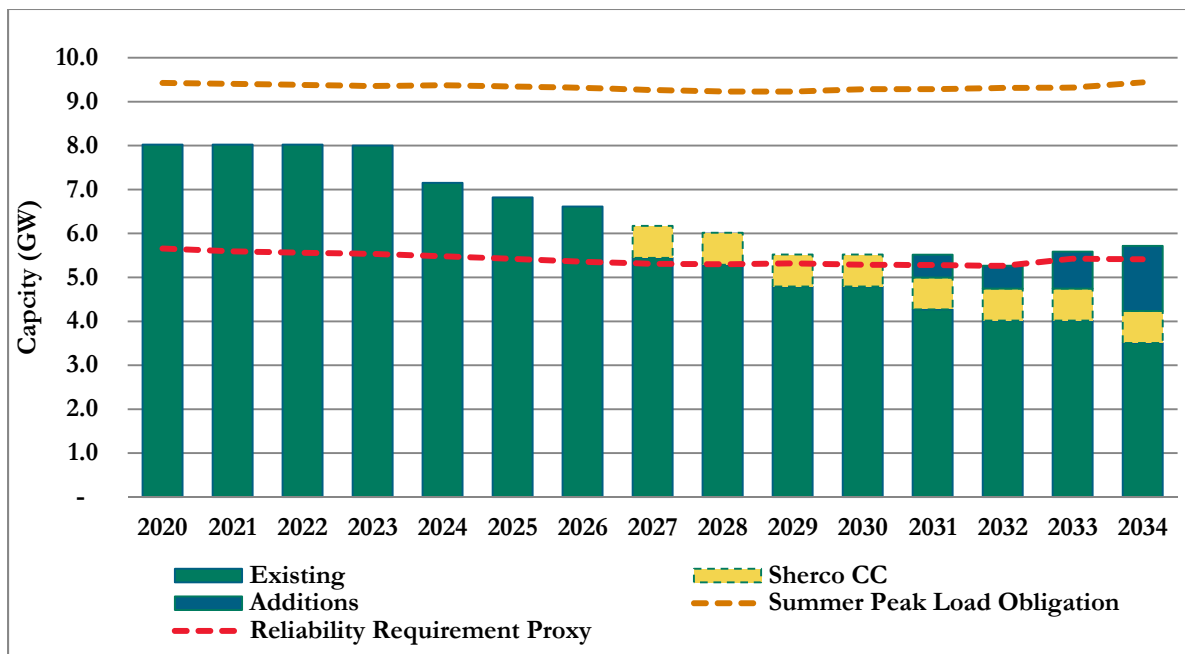
B. Reliability Requirement

Not only is the Sherco CC beneficial in supporting the proposed Monticello extension, it also helps ensure that we have sufficient load supporting, firm dispatchable resources on our system for grid resilience and reliability purposes. As we increase the amount of renewable generation on our system, these resources alone cannot reliably provide customers the energy they demand every hour of every day – or maintain the stability of the grid. Until MISO planning constructs fully incorporate measures to address the emerging challenges associated with increasing levels of renewables, we have incorporated a Reliability Requirement into our planning for this Resource Plan (See Appendix J2). Our Preferred Plan does not show a need for additional load supporting resources until 2031, which is partially so because the Sherco CC is already modeled as a part of our future resource portfolio.

As seen in Figure 1 below, if we were to forego building the Sherco CC, we would begin to see a firm capacity deficit relative to the Reliability Requirement by 2029, with the gap widening post-2030 when Sherco Unit 3 retires. Given technologies available today, this need would be most cost-effectively be filled by gas combustion turbines (CT). However, CTs also typically run at higher heat rates, with higher levels of emissions than CCs. While we have said we can wait until future cycles to

reevaluate and determine which technologies may be able to meet these needs in the post-2030 timeframe, we have a responsibility to ensure we meet our customers’ needs now. The confluence of Monticello and grid stability needs, and proposed coal retirements further support that the Sherco CC is an appropriate choice to provide that system reliability service in the near term.

Figure 1: Projected Firm Capacity as Compared To Summer Peak and Reliability Requirement²



We are facing a long transition from today to 2030 – and even longer to 2050 – with significant changes at multiple stages. We must have operation options that give us flexibility to respond to many unknowns that are sure to come. The Sherco CC will help us make this transition responsibly, while we monitor developments and take advantage of technologies, such as hydrogen and other carbon-free fuels when they become commercially-viable. We discuss some of these resources in Appendix F6: Resource Options.

C. Renewable Integration Support

As we begin to integrate even higher levels of variable renewables on our grid, the

² Note that our Preferred Plan modeling also includes MEC’s full capacity throughout the planning period, which may result in an additional gap if the proposed acquisition is not approved. The firm supply depicted here also includes DR additions per the Preferred Plan.

value of a dispatchable intermediate resource like the Sherco CC increases. Our Preferred Plan includes 4,000 MW of new renewable development, some of which would be added as early as 2025. Adding substantial new variable renewable resources requires us to maintain a subset of resources that can provide both fast ramping capabilities and the longer duration energy needs, for times when these variable renewables are not available. Moreover, these renewable additions will occur during the same period in which we are retiring over 2,400 MWs of coal-fired generation (1,360 MW of previously planned coal retirements from Sherco Units 1 and 2, and another 1,045 MW of retirements by 2030 proposed at Sherco Unit 3 and King. As we replace increasing amounts of existing coal generation with cleaner fuels, the Sherco CC will support our transition by allowing us to reduce and ultimately eliminate dependence on coal units for these balancing and integration needs going forward.

Additionally, as the MISO region realizes substantially higher levels of renewables, planning constructs need to change from today's single system peak capacity construct – and adapt to the diminishing marginal returns these variable resources can provide. MISO has itself acknowledged in its *Renewable Integration Impact Assessment* (RIIA) study that, at higher levels of renewable adoption on the grid, the ELCC of wind and solar resources will decline.³ The firm capacity the Sherco CC will provide will become even more valuable in meeting our customers' needs every hour of every day as we navigate this transition while maintaining reliability.

D. Community Impact

Aside from significant grid support benefits discussed above, the Sherco CC also will partially offset the community tax and employment losses in Becker and Sherburne County that will result from the early retirement of the existing Sherco Units (including our proposal in this Resource Plan to retire Sherco Unit 3 in 2030). It also provides options for continued industrial steam supply to the Liberty Paper recycling facility located nearby. In addition, the Sherco CC could also provide options for our Sherco Unit 3 partner, Southern Minnesota Municipal Power Agency (SMMPA). These host communities and partners have been an integral part of our system for nearly 45 years, and we are committed to partnering with them as part of our upcoming baseload transition in hopes of mitigating the impacts of our Sherco retirements. Building a new CC unit at Sherco offers us the opportunity to meet our grid needs and serve the public interest, while also mitigating the impacts to these host communities and partners.

³ See Chapter 2: Planning Landscape and Appendix J1: Baseload Study for more detail.

IV. ALTERNATIVE OPTIONS

While it is possible to meet some of the identified grid needs with alternate investments, the Sherco CC provides a path to meet all of these needs holistically and at a prudent cost to our customers. Below we discuss the three alternatives we evaluated: (1) a Synchronous Condenser (SC), (2) renewables-plus-storage, and (3) alternative greenfield CC solutions. We discuss each of these alternative options briefly below and will expand this discussion in detail in our upcoming Sherco CC regulatory filing.

A. Synchronous Condenser

With respect to voltage support, one potential alternative solution would be the conversion of one existing generating unit into a Synchronous Condenser (SC). A SC is a motor, whose shaft is not connected to anything but spins freely. Its purpose is not to produce electric power, but to adjust conditions on the electric power transmission grid. Our initial analysis indicated that a SC may provide the required continuous voltage support the Monticello plant requires as well as the requisite inertia (due to its large rotating mass) to meet the grid's stability needs. However, a SC would not be able to address the thermal support Monticello requires or the black start capabilities the system requires.

In addition, our Preferred Plan proposes to retire Sherco Unit 3 in 2030. This has two key implications for the viability of a SC as an alternate investment to the planned Sherco CC. First, our Preferred Plan includes a proposal to pursue a Monticello nuclear operating license extension that would allow us to operate that plant through 2040. Both the Monticello license extension and our proposal to retire Sherco Unit 3 in 2030 are fundamental components of our carbon reduction goals. The SC design we studied, however, would not be able to provide the grid services we need to remain compliant with our nuclear operating license after Sherco Unit 3 retires. Indeed, it is not clear that the NRC would approve a relicense with only SC support, as opposed to a generating facility. And even if it were approved with only SC support, the SC would need to be much larger than previously anticipated in order to provide similar grid stability benefits after all the 2,400 MW of existing Sherco generation retire. Further, a SC provides reactive power by consuming power. Because of this, a SC does not address the need for firm dispatchable resources to meet our customer's capacity and energy needs. In this way, the Sherco CC provides a much greater value to the overall system.

Second, the three existing Sherco Units are key components of our current Black Start Plan, and a SC on its own cannot replace this functionality. We noted in our last Resource Plan that our Black Start Plan is substantially dependent on capacity at Sherco Units 1 and 2 being Target Units, and providing sufficient output to support restarting Sherco Unit 3 and then the remainder of the NSP system. Retiring Sherco Units 1 and 2 would require re-designing our restoration path and potentially substantial associated transmission upgrades, if not replaced with another type of firm and dispatchable generation. The Sherco CC helps us to bridge that gap after Sherco Unit 1 retires in 2026. Now that we are also planning to retire Sherco Unit 3, the Sherco CC becomes even more essential in maintaining our black start capabilities. Because the SC does not generate real power, it cannot provide the Black Start functionality that we need for our system.

B. Renewables Plus Storage

Given the Company's clean energy goals, we also considered whether or not a paired renewables-plus-storage facility could provide a viable alternative solution to the Sherco CC. While the renewable plus storage might provide adequate capacity and energy, a SC may also be needed to meet the grid reactive power voltage support needs discussed earlier. We anticipate storage being a key part of our system in the longer term, however, such a solution is not currently cost-effective at the scale required for this application – and would be much more complex to implement and operate. It is also not clear whether the NRC would allow a storage facility to serve as the external support required by our nuclear operating license for Monticello. Even assuming it was approved, though, the external support unit is required to be available for a duration exceeding the longest potential outage that Monticello could encounter. In normal operational conditions, outages for refueling at the plant could be expected to last approximately 30 days. This duration is far longer than currently available storage solutions could be reasonably expected to provide support, much less provide it at a reasonable cost. Even a solution that could, for example, provide continuous grid support of this magnitude for a single 24-hour period would be exorbitantly expensive.

In this example, such a plant would require a battery configuration that could provide hundreds of MW of full discharge capabilities for multiple cycles. And while we expect the cost and capabilities of battery technology to improve over the planning period, it is highly unlikely they would improve sufficiently to make this a more cost effective solution than the Sherco CC. The Sherco CC will be able to provide continuous support to the broader grid and Monticello across many consecutive days – indeed months - without needing to pull significant energy from another on-site

generator, or the broader grid. Today's short-term energy storage solutions simply cannot provide this level or kind of support. Future technologies may make this type of solution much more viable and economic. However, with grid stability and reliability at stake, we do not see a renewables-plus-storage solution as a viable alternative to the Sherco CC at this time.

C. Alternative Greenfield CC

As discussed in more detail in Appendix I: Supporting Infrastructure-Transmission and Distribution, the existing transmission system's capability to interconnect new projects without substantial infrastructure upgrades is very limited, and thus, the generation interconnection planning studies indicate there will likely be costly upgrades assigned to the prospective generators. The value of our Sherco interconnection is incredibly valuable due to the potential for upgrade costs assigned to greenfield projects as well as the time component associated with the interconnection process.

In 2018, we asked an independent engineering consultant to help us evaluate the cost and feasibility of building a greenfield CC plant. Six potential sites were examined. Overall, the study led us to the conclusion that building a greenfield CC would not be an economically favorable alternative, nor would a plant likely be able to be placed in-service in the timeframe we needed. As greenfield sites, we would have to gain new interconnection rights and conduct transmission system upgrades that would present significant challenges not only to building a cost competitive solution to the Sherco CC, but also to achieving the 2026 in-service date we need to transition Sherco Unit 1 off the system. The study determined that, across these six potential locations, the average required transmission system upgrade costs for a selected site would amount to more than \$500 million.

To put the plant in service by the time Sherco Unit 1 retires, the study determined we would need to see a 60 percent withdrawal rate from the MISO interconnection queue as it existed at the time of evaluation.⁴ In our experience, it would be unrealistic to expect transmission upgrades, and any necessary transmission and plant permitting and interconnection processes, to be completed in an appropriate timeframe for a greenfield site option to be viable. Thus, this was determined to not be a favorable alternative to the Sherco CC.

⁴ The Interconnection Cost Estimate Study performed by Excel Engineering is provided in this filing as Appendix R.

V. CURRENT STATUS

The Company is currently in the project development stage with regard to moving forward on the Sherco CC. We expect this plant to utilize the best available technology for the design specifications at the time of construction, based on technology information from the major equipment suppliers in the market. When it is built and put into service, we also expect the plant to be the most efficient gas generator, with the lowest carbon emission rates, in our generation fleet and that it will be competitive in the MISO Upper Midwest market as well.

The project specifications are based on a 2x1, wet-cooled, unfired design condition. We have used internal estimates and currently available technology information to include the plant, and estimated associated new infrastructure required, in the Strategist-modeled portfolios presented in this Resource Plan. However, these cost estimates are preliminary and subject to updates as we progress through the project development process. In preparation to move forward with the project, we are currently working with consultant engineering firms to develop more targeted and up-to-date cost estimates for the new generation facility and required firm natural gas supply infrastructure, and to better define expected project schedules. We expect these inputs to inform our project development plans moving forward, as we thoroughly evaluate equipment and infrastructure supply options and make any relevant filings to the Commission.

We also note that there are several steps we are preparing to complete with regard to generator interconnection rights for the Sherco CC, and this process will also affect how the Sherco CC development process moves forward. We expect we will need to file a MISO Attachment X generator interconnection request in order for the CC to utilize the same interconnection rights currently assigned to the Sherco coal units. This must be filed at least one year prior to the existing unit ceasing operation, and the new unit must go into service not more than three years after the existing unit(s) cease to operate. We plan to meet these requirements so that we can avoid the lengthy interconnection queue process.

When we file these details with MISO, that initiates any reliability studies required under the MISO Tariff – the results of which MISO will share within 180 days of the request.⁵ The Tariff currently provides that these studies will evaluate whether the

⁵ The Attachment X Tariff provides that the Transmission Owner [MISO] shall use Reasonable Efforts to complete the Replacement Impact Study and Reliability Assessment Study and share results with the Interconnection Customer within one hundred eighty (180) Calendar Days of the request.

replacement generating facility has a material adverse impact on the transmission system when compared to the existing generating facility and the performance of the transmission system, and to determine if thermal and/or voltage violations of applicable NERC standards and MISO planning criteria are caused by removing the existing generating facility from service prior to the commercial operation date of the replacement generating facility. Upon completion of these studies, Xcel Energy Transmission will subsequently study any required facilities upgrades or changes – and MISO will incorporate these into the new Generator Interconnection Agreement we receive for the Sherco CC.⁶

VI. CONCLUSION

The need to build new firm capacity at the Sherco site has not abated since our last resource planning cycle. The Sherco CC is an important bridge to the future. No one yet knows what that future looks like – and we are confident that it relies on technologies that are not yet developed. The Sherco CC will give us the necessary flexibility that help us through all the different transitional stages to come, without risking grid resilience and customer reliability. Without the Sherco CC, we will be challenged to maintain the clean baseload power provided by our Monticello unit into the future, and challenged to integrate the thousands of megawatts of new solar power proposed in our Preferred Plan, while retiring the last of our coal units.

For these reasons, we included the Sherco CC as a baseline resource in our Preferred Plan and in the additional scenarios we analyzed. We are moving forward with project development internally, including working with engineering consultants to develop more detailed estimates for the cost to build the CC and secure the associated firm gas supply for the site. These estimates will be used to help ensure the project is completed at a reasonable cost to our customers. We plan to bring forward a detailed filing to the Commission in the coming years, which will present the most up-to-date information for this project.⁷

⁶ The evaluation currently consists of two studies: i) a Replacement Impact Study as set forth in Section 3.7.2.1 of the GIP, and ii) a Reliability Assessment Study as set forth in Section 3.7.2.2 of the GIP.

⁷ As authorized by HF 113, filed February 28, 2017.