

Review of Xcel's Reply Comments

Sections 2J, 3

2020-2034 Upper Midwest Integrated
Resource Plan,

Docket No. E002/RP-19-368



TELOS ENERGY

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1 Executive Summary

This report captures the review and commentary from a power systems engineering perspective of Section 2J (Maintaining Stability Along the Sherco Gen-Tie Line in the Alternate Plan) and Section 3 (System Restoration and Blackstart) from Xcel Energy's (Xcel) 2020-2034 Upper Midwest Resource Plan Reply Comments. This report is prepared for Clean Grid Alliance, Fresh Energy, Minnesota Center for Environmental Advocacy, and Union of Concerned Scientists (Intervening as "Clean Energy Organizations")

Xcel's justification for the need for a new gas-fired combustion turbine (CT) to support stability of the proposed Sherco gen-tie line is based on an incomplete analysis. The information provided by Xcel regarding the stability on the Sherco gen-tie line does not demonstrate that the proposed Lyon County CT is the only or best option for providing stability for the interconnection of 2,400 MW of renewable inverter-based resources (IBR) to the Sherco gen-tie line. There are multiple other technologies and design options to determine the most cost-effective approach to stable operation of the Sherco gen-tie line with 2,400 MW of IBRs. For example, spreading the IBR generation out along the tie-line and using grid-forming (GFM) inverter technology is likely to reduce or eliminate the need for series compensation and synchronous condensers, and thus for the proposed Lyon County CT. It would also very likely ease project siting and land-use rights acquisition and reduce the complexity and cost of the project significantly.

Similarly, Xcel has not justified **[TRADE SECRET BEGINS...**

TRADE SECRET ENDS] For reimagining Xcel's blackstart process, a holistic perspective is needed -- one that does not stop at ownership boundaries. It starts with identifying the needs of the system for restoration services, where the needs of critical loads are prioritized. Next, a complete set of candidate resources should be identified -- including not only conventional technologies but also battery technologies, and including existing resources owned by Xcel and by nearby utilities. Then the relative merits of each resource candidate can be evaluated and quantified. Finally, a comprehensive plan can be developed that meets the needs of Xcel's customers and is substantiated by a quantitative analysis. Xcel's analysis does not meet this standard of rigor.

2 Review of Xcel Reply Comments Section 2J: Maintaining Stability Along the Sherco Gen-Tie Line in the Alternate Plan

2.1 Introduction

Xcel's Alternate Plan as provided in its reply comments, includes a "Sherco gen-tie line," described as a 140-mile double-circuit 345 kV line with series compensation,¹ intended to interconnect 2,400² MW of inverter-based resources³ (IBR) to the grid at the Sherco site. Xcel does not specify where along the 140-mile line the IBR will be connected. Xcel also proposes to include a 400 MW combustion turbine (CT) that can also run as a synchronous condenser to provide stability to the IBR sited at the end of the gen-tie line. The information provided in Xcel's Reply Comments and subsequent information requests does not establish that the proposed CT is required for adequate stability and leaves many major questions unaddressed. Further analysis should be done to determine the best approach for reliably interconnecting 2,400 MW of IBR via the proposed Sherco gen-tie line.

2.2 Open Questions on the Need for CTs to Stabilize the Sherco Gen-Tie Line

More detail is needed to evaluate the stability of the proposed project, and then to assess the equipment needs and estimate the costs vs. benefits before assuming a new 400 MW CT is the optimal design choice. Three major open questions include:

- Where along the 140-mile line is the new IBR generation intended to be connected?
- Could grid-forming inverters provide significant stability on the line?
- How does the timing of implementing the whole project potentially address stability issues?

First, the location and distribution of generation resources along the gen-tie transmission line has a major impact on the scale of stability challenges of the gen-tie. From a stability standpoint, sending all 2,400 MW of generation from the end of the line would be the most challenging configuration because the maximum power must be transmitted the greatest distance. However, siting generation closer to the Sherco interconnection and/or spreading out the generation to different points along the line would significantly reduce stability concerns. Until we have a better idea of just where the resources will be located, we cannot know the line's overall need for stability reinforcement and the best mix of technologies and solutions to meet that need.

¹ Series compensation is a form of transmission line reinforcement that has been used for decades to improve the power transfer capability of long transmission lines.

² 2,400 MW is the value provided in Xcel's proposal in the Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 52. This is interpreted as the maximum instantaneous power transfer on the gen-tie line, regardless of ownership of the generating resources. It is acknowledged that the collective MW of renewables by nameplate may exceed 2,400 MW, but the total power transfer on the line will not exceed 2,400 MW. The maximum instantaneous power transfer is the critical value for grid stability assessment.

³ Inverter-based resources (IBRs) is the broad industry term for all resources that interface to the grid through power electronics rather than a convention rotating generator. IBRs include wind, solar PV, battery energy storage, fuel cell, etc.

Additionally, connecting generation at several points along the length of the line is better for several reasons:

- for stability, because less power must be transmitted the full distance, and because the voltage support provided by IBR (or synchronous machines) is even more effective when it is provided at multiple points along the line and not just at the end;
- for land-use, where it can be easier to site generation over a larger area rather than trying to find a single site for all generation; and
- for spatial diversity of generation, where variations in the wind or solar resource do not cause all generation to increase or decrease simultaneously but having physical distance among generation sites provides a natural generation-leveling effect.

The second major unanswered question is the potential role for Grid-Forming (GFM) inverters. The industry today is on the cusp of an inverter technology revolution, where the rapidly emerging GFM inverter technology stands to enhance the stability of inverter-based resources and therefore to enable interconnection of higher levels of renewables with less transmission reinforcements. GFM technology is rapidly advancing, and it is now commercially available for battery energy storage systems (BESSs).⁴ The pace of GFM development is expected to continue quickly because the primary effort is one of improving the software controls programmed into the inverters.

While GFM technology is not widely applied today, it is expected to dramatically increase in the coming years as it offers a powerful new tool to the industry for integrating high levels of IBR into the grid in a stable manner.⁵ Early investigations show that GFM performance is superior to that of conventional synchronous machine technology from a stability standpoint. Synchronous condensers can improve some aspects of grid stability, but also introduce electromechanical modes that challenge the stable operation of the grid.⁶ Given the long lead time until the proposed tie line CT would be in service, rapidly emerging GFM inverter technology should be examined.

The third open question is how project timing impacts the need and/or solutions for stability on the line. It appears that Xcel intends to distribute resources to the line over a period of many years, which

⁴ Major inverter manufacturers are offering grid-forming technologies, including: SMA <https://www.sma-america.com/industrial-systems/large-scale-storage-solutions.html>, Tesla <https://www.tesla.com/support/energy/tesla-software>, and ABB <https://search.abb.com/library/Download.aspx?DocumentID=4CAE000822&LanguageCode=en&DocumentPartId=US-web&Action=Launch>.

⁵ A recent white paper released by the Australian Energy Market Operator summarizes five different studies and operating projects utilizing grid-forming inverter technology to improve the stability of high-renewable grids: Application of Advanced Grid-scale Inverters in the NEM, Australian Energy Market Operator, August 2021: <https://aemo.com.au/-/media/files/initiatives/engineering-framework/2021/application-of-advanced-grid-scale-inverters-in-the-nem.pdf>.

⁶ “Going the Distance: Moving AC Power from Large Inverter-Based Generation Pockets to Load Centers,” Nick Miller and Matthew Richwine. Energy Systems Integration Group. March 11, 2021. <https://www.esig.energy/download/going-the-distance-moving-ac-power-from-large-inverter-based-generation-pockets-to-load-centers-nick-miller-matthew-richwine/>.

mitigates the stability challenge. For example, Xcel states in response to SC IR 207⁷ that solar resources will be added in the 2024-2026 time frame and would be located closer to the Sherco site. The response also states that “the best wind resources available are located further outstate,” implying that these would be connected farther from Sherco and after the solar installations. Based on Xcel’s proposed schedule for its Alternate Plan, no wind resources would be added before 2028.⁸ Spreading resource additions out over time defers the stability challenges, which are most acute once the project size surpasses 2 GW, to a future date. In the meantime, more details about the total project will be certain and the stability needs can be studied to determine exactly which mitigations are most cost effective, whether it is inverter controls tuning, series compensation, synchronous condensers, or emerging technology like GFMs.

2.3 Sherco Gen-Tie Line Stability Issues Conclusion

The information provided by Xcel regarding the stability on the Sherco gen-tie line does not demonstrate that the proposed Lyon County CT is the only or best option for providing stability for the power transfer of 2,400 MW of IBR on the Sherco gen-tie line. There are multiple other technologies and design options that can be explored to determine the most cost-effective approach to stable operation of the Sherco gen-tie line with 2,400 MW of IBR power transfer. For example, spreading the IBR generation out along the tie-line and using GFM inverter technology is likely to reduce or eliminate the need for series compensation and synchronous condensers. It would also very likely ease project siting and land-use rights acquisition and reduce the complexity and cost of the project significantly.

3 Review of Xcel Reply Comments Section 3: System Restoration and Blackstart

3.1 Introduction

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...TRADE SECRET ENDS] System restoration,

also referred to as blackstart, is the process of re-starting the grid and restoring power to all customers following a complete and widespread outage. In the exceedingly rare event where there is a very widespread loss of the grid, such that power from the grid is not available and cannot be made available in a reasonable period of time from another part of the grid that is still operating, then the grid must be restarted from scratch. The system restoration process has several steps. First, specially designed power plants called “initial units” that have on-site power available to restart without the grid are needed to begin energizing small parts of the transmission grid that connect to “target units.” Target units are power plants that can be started from initial units and are also controllable and capable of energizing larger parts of the grid. This “bootstrapping” process is repeated until the grid and customers are fully restored. This process is necessary because most fossil-fueled power plants require a significant amount

⁷ Sierra Club Information Request 207, Docket No.: E002/RP-19-368.

⁸ Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Table 4-10, Page 113.

of power in order to start up after being shut down (most shut-downs are intentional – for maintenance or economic reasons).

Today, Xcel’s blackstart process **[TRADE SECRET BEGINS...**

...TRADE SECRET ENDS] Xcel proposes to shift from what it deems as a “centralized” approach to a “zonal” approach for blackstart. Xcel’s plan involves having Xcel-operated plants in smaller subsections of Xcel’s territory to restart these subsections in a blackstart scenario. Currently, these “zonal” subsections have access to available blackstart resources – **[TRADE SECRET BEGINS...**

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Xcel’s analysis leaves many technical questions unanswered and many economic comparisons unquantified. These include:

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- Why does the gap analysis identifying the needs for blackstart resources over-estimate the scale of blackstart needs by not accounting for the transition from cold load to warm load during energization?
- Why is battery energy storage technology not evaluated for a role in blackstart when its capability has been demonstrated in the field?
- How will the zonal approach impact system planning and operations and how much will this cost?

3.2 Coordination of Blackstart Resources with other Minnesota and Regional Utilities Should be Explored for Future Needs

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especially prudent given the geographic distribution of Xcel's service territory in western Minnesota and the Dakotas and its overlap and proximity to multiple other utilities with generation in the area. As stated in Xcel's reply comments, "At a high level, our existing System Restoration Plan currently uses a state-by-state approach, with our restoration focused primarily on restoring load in the large population/load centers in Minnesota, Wisconsin, and the Dakotas. Although our plan primarily relies on our own thermal resources, in some cases we rely on other utilities to help get portions of our system started and in other cases, other utilities rely on the NSP System to get their systems started."⁹ Xcel continues that [TRADE SECRET BEGINS...

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The cross-utility coordination is especially sensible in this region of MISO because the geographic footprint and location of gas-fired and hydro generation resources of the utilities including Xcel, GRE, OTP, MMPA, MP, DPC, as well as plants owned by independent power producers (IPPs), is highly overlapping, as shown in Figure 1. The map in Figure 1 shows that there are over 16 gas-fired or hydro power plants in the region that have not been considered for a role in support system restoration of Xcel's territory. Note that the map does not show:

- nuclear plants, which are not considered a qualifying technology for blackstart,
- coal-fired plants, which – though they are a qualifying technology – are planned for retirement in the IRP time horizon, or
- renewables, which are not currently considered qualifying technologies for participation in blackstart, though Xcel has alluded to their potential future inclusion in system restoration planning.¹¹

⁹ Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 57.

¹⁰ Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 65.

¹¹ [Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 71.

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Figure 1: Gas-Fired and Hydro Generation Resources in the Region, Color-Coded by Ownership

Consider two specific cases:

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¹³ [TRADE SECRET BEGINS...

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...TRADE SECRET ENDS] The sharing and coordination of resources among highly interconnected utilities like Xcel for its system restoration functions is commendable and is a practice that should be expanded. However, it does not appear that building on the existing coordination with regional utilities was analyzed as an option.

Considering Xcel’s future blackstart needs beyond Western Minnesota and the Dakotas, further coordination with regional utilities **[TRADE SECRET BEGINS...**

...TRADE SECRET ENDS] This option should be explored through a robust cost/benefit analysis.

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¹⁵ Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 74.

¹⁶ Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 74.

¹⁷ Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 65.

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3.5 Unanswered Questions Regarding Consideration of [TRADE SECRET BEGINS... ...TRADE SECRET ENDS]

In the Twin Cities region, Xcel has historically [TRADE SECRET BEGINS...

¹⁸ Clean Energy Organizations (CEO) Information Request No. 131, Docket No. E002/RP-19-368.

¹⁹ Clean Energy Organizations (CEO) Information Request No. 131, Docket No. E002/RP-19-368.

²⁰ Sierra Club Information Request No. 228, Docket No. E002/RP-19-368.

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3.6 Flaws in Xcel's Assumptions Regarding the Scale of Blackstart Needs

To estimate the scale of future blackstart needs, Xcel presents a "Gap Analysis." This analysis is supported by the data in Table 3-4²⁵ in which demand for power during a blackstart event is assumed to be the summer peak load, and this value is broken down for different zones of the grid. The rationale for using summer peak load, which is the highest load for Xcel's planning cases, is that it approximates the elevated load associated with cold-load-pickup, even if the blackstart event does not occur during summer or a peak-load hour. It is understood that picking up "cold loads" or loads that have been off for some time is significantly higher than normal operating load because thermostatically-controlled devices like air-conditions, refrigerators, water heaters, etc. are all turning on at the same time. But the elevated load during a cold-load-pickup event is also understood to be temporary and will start to approach normal load in a certain period of time after reenergization. Xcel's gap analysis does not discuss the elapsed time in restoration of the load, during which the load being reenergized will be transitioning from elevated cold-load pickup levels back to normal levels. This is because the first blocks of load picked up in a restoration process would be returning to normal levels while the restoration process is still ongoing, and therefore, the total load being restored would be less than the assumed summer peak level, which is the absolute highest load level considered. The result of the gap analysis assumption that cold-load does not return to normal load values in the timeframe of a restoration is that the gap analysis is biased towards showing a larger gap. Xcel basing its blackstart needs on this larger gap in turn drives the need for more blackstart resources, which may not actually be needed.

The gap analysis in Table 3-4 shows about 9 GWs of load being restored, including a blackstart gap of 2.4 to 3.3 GW in zone MN-1 alone, which may be substantially impacted by the pessimistic assumption

²³ Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 79.

²⁴ [TRADE SECRET BEGINS...

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²⁵ Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 73.

made in the existing gap analysis that load remains at the elevated cold-load levels throughout the restoration process. This temporal aspect of estimated cold-load-pickup load levels and restoration time deserves more consideration in the gap analysis and the resources required to perform the system restoration, specifically:

- How are the initial cold-load values determined and supported?
- What is the rate at which cold-load pickup will return to normal load levels?
- What are the major milestones in restoration and their associated times after the initial event (i.e., a graph showing the load restored as a function of time)?
- During restoration, how is load pickup prioritized among customers (i.e., emergency services, consumer & industrial, residential, etc.)? What is the load breakdown for each?

Determining the need for blackstart services should consider not only the total cold load to be restored, as Xcel has done in their gap analysis, but also consider the priority of loads restored and the transition of “cold” load to “warm” load as the restoration progresses so as not to overstate the need for blackstart services in creating a robust and economic blackstart plan.

3.7 Batteries Are a Viable Blackstart Technology

Xcel’s blackstart analysis does not compare or quantify battery storage blackstart options. Xcel dismisses battery storage in part because “There are ... technical concerns with regard to how batteries can absorb reactive power (discussed more below), which would be needed if the battery was not paired with another type of generation asset.”²⁶ Later in the section, Xcel correctly describes the need for sufficient reactive power capability from its blackstart resources when lines or transformers are first energized. However, Xcel fails to connect or describe why batteries cannot supply and/or absorb the reactive power required during inrush transients associated with cold energization.

The fact is that battery technology, when equipped with grid-forming (GFM) controls, can absorb reactive power and can also supply the reactive power needed to energize lines and transformers, and start motors and other power plants.²⁷ Like all resources tasked with performing a specific function, they must be designed and sized appropriately to provide the reactive capability demanded by the application. But there is no question that battery technology – if designed appropriately and operated with a sufficient state of charge – can perform blackstart functions. For example, this has been demonstrated at a battery storage installation in South Australia.²⁸ The technical capability of battery technology for blackstart has also been demonstrated in California by an Imperial Irrigation District

²⁶ Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 61.

²⁷ Even wind installations, despite their intermittency, may be able to provide blackstart services, as recently demonstrated when wind power energized a part of the transmission network of Scotland. Scottish Power shows black start capability of wind power in world-first demonstration, Institute for Energy Economics and Financial Analysis. November 6, 2020. <https://ieefa.org/scottish-power-shows-black-start-capability-of-wind-power-in-world-first-demonstration/>.

²⁸ S. Cherevatskiy, et al., Grid Forming Energy Storage System addresses challenges of grids with high penetration of renewables (A case study). CIGRE Session 48, C2-C6-322, Paris 2020. <https://www.electra.net.com.au/wp-content/uploads/2021/02/CIGRE48-Grid-Forming-BESS-Case-Study-August-2020.pdf>.

battery project, which demonstrates the technology's potential even though, as Xcel has mentioned,²⁹ that battery storage project is not designated as a blackstart unit. Battery storage is a known and demonstrated blackstart technology, and therefore, any analysis that includes new blackstart resources should consider battery storage as an option.

3.8 Unanswered Questions Regarding Xcel's Proposed "Zonal" System Restoration Approach

It is important to note that what Xcel has termed the "zonal" approach to blackstart is not an industry-standard term but is a descriptor of Xcel's change in approach. Xcel's proposed zonal approach may offer some benefits, but the impacts on grid planning, operations, and costs have not been sufficiently discussed or quantified to know if those benefits outweigh costs and whether other options may be superior, specifically:

- How will system planning be impacted with a zonal approach?
 - Will the criteria for resource participation be changed to allow more resource technologies?
 - What are the criteria for defining a "zone"? What factors influence the size and geographical boundaries of a "zone"?
- How will operations be impacted by the shift to a zonal approach? Does a zonal approach increase the complexity of the restoration process by attempting to restore multiple zones simultaneously rather than a more sequential approach historically taken?
- What is the transition plan for moving to a zonal approach? How does the transition timeline fit with the planned retirements and resource additions?
- What are the costs of the zonal approach relative to the costs of the existing approach with increased coordination and augmentation of existing resources where needed?

The zonal approach may have some merits in that it may expand the number of resources that play a role in system restoration such that each individual resource is less critical to the overall objective of restarting the system. Or said another way, each resource is backed-up by a larger number of other resources. Xcel acknowledged this in stating that, "Because the zonal approach will build small, geographically-dispersed islands, we are in a better position to incorporate our renewable resources to restore customers."³⁰

Xcel states that "Renewable generation, such as solar and wind are not currently considered eligible Initial or Target Units due to their inherent intermittent nature, and their general inability to provide or absorb reactive power."³¹ However, the statement that renewables have a general inability to provide or absorb reactive power is simply incorrect. FERC Order 827³² requires all transmission-connected

²⁹ Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 61.

³⁰ Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 71.

³¹ Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 59.

³² FERC Order 827, Reactive Power Requirements for Non-Synchronous Generation, Issued June 16, 2016.

resources to supply and absorb reactive power, regardless of technology, and the majority of inverter-based resources have been offering such capability for over a decade. While Xcel has acknowledged that the addition of renewable resources has the potential to improve the system restoration process if there is greater diversity in location and technology of blackstart resources, Xcel has not proposed changes to its own criteria for Initial or Target Units that would allow the participation of renewable resources in system restoration.

The proposed zonal approach to blackstart, in which multiple parts of Xcel's service territory are restarted simultaneously³³ and later synchronized, implies an added complexity and burden on grid operations. Xcel did not discuss the impact of the zonal approach on the grid operations or the potential increased complexity of a zonal approach, which will require system operators to simultaneously re-start multiple power islands and synchronize them, rather than restarting one or two primary power islands and then expanding them.

Xcel alludes to some of the costs implied by the transition to a zonal approach in a qualitative and spotty manner. For instance, identified upgrades including "special controls that allow the plant to run at a stable frequency without an established and energized electrical grid" are described as "specifications that are determined when building a new plant, and an existing unit is not easily (or inexpensively) retrofitted to serve this purpose."³⁴ Not only is there no attempt to quantify the costs of upgrades, but it is missing critical context. The extent of such upgrades can vary significantly from plant to plant, depending on the technology and vintage of the excitation and governor systems. This context is important for making a true assessment – and furthermore, the cost of controls system upgrades pales in comparison to the cost of an entirely new plant.

3.9 Blackstart Conclusion

Xcel's justification for its new "zonal" blackstart approach [TRADE SECRET BEGINS...

...TRADE SECRET ENDS] is based on an incomplete analysis. Xcel has not quantified the costs for [TRADE SECRET BEGINS...

...TRADE SECRET ENDS] Xcel has not considered the dynamics of system restoration in evaluating the needs for blackstart resources and has likely overestimated the scale of its blackstart need. Xcel has not adequately considered the use of new and proven technologies for blackstart like battery storage. And while mentioning that the proposed new approach could include more participation from renewable resources, Xcel has not provided a description of how renewables could be included nor described changes to the blackstart planning

³³ Xcel has estimated restoration times in response to OAG IR 11, in which Xcel acknowledges that the estimates are based on judgment and MISO-led drills, as Xcel has never had to blackstart its grid in its history. Moreover, the response times should include an overall customer-hours metric (analogous to SAIDI metrics commonly used by utilities for reporting outage impacts) to fully understand benefits vs. cost of changing response times.

³⁴ Upper Midwest Integrated Resource Plan 2020-2034 Reply Comments, Xcel Energy, Page 58.

process and resource qualification criteria. These critical aspects of the analysis are missing; and therefore, the proposed changes are insufficiently substantiated.

4 Overall Conclusion

Xcel's justification for the need for a new CT to support stability of the Sherco gen-tie line is based on an incomplete analysis. The information provided by Xcel regarding the stability on the Sherco tie line does not demonstrate that the proposed Lyon County CT is the only or best option for providing stability for the power transfer from 2,400 MW of IBR on the Sherco gen-tie line. There are multiple other technologies and design options to determine the most cost-effective approach to stable operation of the Sherco gen-tie line with 2,400 MW of IBR power transfer. For example, spreading the IBR generation out along the tie-line and using GFM inverter technology is likely to reduce or eliminate the need for series compensation and synchronous condensers, and thus for the proposed CT capacity. It will also very likely ease project siting and land-use rights acquisition and reduce the complexity and cost of the project significantly.

Similarly, Xcel has not justified **[TRADE SECRET BEGINS...**

...TRADE SECRET ENDS] For reimagining the blackstart process, a holistic perspective and analysis is needed -- one that does not stop at ownership boundaries. It starts with identifying the needs of the system for restoration services, where the needs of critical loads are prioritized. Next, a complete set of candidate resources should be identified – including not only conventional technologies but also battery technologies, and including existing resources owned by Xcel and nearby utilities. Then the relative merits of each resource candidate can be evaluated and quantified. Finally, a comprehensive plan can be developed that meets the needs of Xcel's customers and is substantiated by a quantitative analysis. Xcel's analysis does not meet this standard of rigor.