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STATE OF MINNESOTA
BEFORE THE
MINNESOTA PUBLIC UTILITIES COMMISSION

In the Matter of Petition of Northern States Power Company to Initiate a Competitive Resources Acquisition Process

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MPUC Docket No.: E-002/CN-12-1240
OAH Docket No.: 8-2500-30760

Exhibit No.: ____ (PJH-7)

REBUTTAL TESTIMONY OF PAUL HIBBARD

ON BEHALF OF CALPINE CORPORATION

October 18, 2013

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I. INTRODUCTION

Q. Would you please state your name?

A. My name is Paul Hibbard.

Q. Are you the same Paul Hibbard who previously submitted Direct Testimony in this proceeding?

A. Yes, I am.

II. PURPOSE AND SUMMARY OF TESTIMONY

Q. What is the purpose of your Rebuttal Testimony?

A. The purpose of my Rebuttal Testimony is to respond to portions of the Direct Testimonies of Xcel Energy, Inc. ("Xcel") witness Steven W. Wishart, Invenergy Witnesses James Shield and Daniel Ewan, and Minnesota Department of Commerce ("DOC") Witness Dr. Steve Rakow. In particular, I respond to Mr. Wishart's and Dr. Rakow's discussions with respect to their Strategist modeling results, and I respond to the discussion of relative value of combined cycle ("CC") and combustion turbine ("CT") technologies presented by Mr. Shield and Mr. Ewan.

Q. Could you please summarize your Rebuttal Testimony?

A. Yes. Based on my review of the direct testimony submitted in this proceeding, I find that the conclusions I drew in my direct testimony – namely that Calpine's Mankato bid should be among the bids selected as a result of this procurement – is robust across all of the analyses and perspectives offered by other parties. Specifically, despite using a number of inappropriate assumptions (discussed below) that are adverse to the Mankato facility relative to competing proposals in this procurement, the base case Strategist analyses conducted by DOC and Xcel are consistent with the conclusions I drew from my

levelized cost of electricity ("LCOE") analysis, and strongly confirm that Mankato and Black Dog are the highest-value resources among the bids. Second, a close review of the Xcel and DOC Strategist analyses reveals that not only is the Mankato facility among the highest-value resources in the procurement under base case conditions, but its value is by far the most robust to changes in key assumptions and sensitivities. Finally, while Invenergy attempts to suggest that CT technology is more appropriate than CC technology under existing Xcel system circumstances, the correct conclusion to draw is exactly the opposite. In fact, several parties have raised a number of key non-price considerations that are consistent with the conclusions I drew in my direct testimony, and that highlight the importance of adding combined cycle capacity through this procurement. Selecting *only* CT capacity in this proceeding – compared to CC capacity or a mix of CT and CC capacity – would diminish the resilience of Xcel's resource mix to higher-than-expected load growth and baseload resource retirements, and would constrain the flexibility the system has to integrate variable renewable resources in an economically- and environmentally-responsible manner.

III. STRATEGIST MODELING RESULTS

Q. Have you reviewed the Strategist modeling results presented in the testimonies of Mr. Wishart and Dr. Rakow?

A. Yes I have.

Q. Would you please summarize your conclusions based on your review of the Strategist modeling results, and the LCOE analysis you presented in your Direct Testimony?

A. Yes. The Direct Testimony in this case contains three analyses comparing the value of the bids submitted in this procurement – a transparent, robust LCOE analysis that I included in my Direct Testimony, and comprehensive Strategist analyses submitted by Xcel and the DOC. Each of these analyses presents results under "base case" conditions as well as under alternative assumptions and sensitivities representative of different potential economic and energy/environmental policy scenarios. The single most important factor for the Minnesota Public Utilities Commission (Commission) to recognize in its review is that one resource stands out as a clear winner across the full range of models and scenarios reviewed in this case – Calpine's Mankato expansion. This result holds despite the fact that (1) I explicitly used conservative assumptions in my analysis (that is, assumptions that tend to disfavor the Mankato proposal relative to the other thermal energy generating resources in the procurement), and (2) in my view the assumptions used in some of the Strategist modeling scenarios carried out by Xcel and DOC similarly disfavor the Mankato bid.

Q. Please summarize why you believe the LCOE and PVSC analyses strongly support the selection of the Mankato facility.

A. To understand how robust Mankato's value is in the context of this procurement, one needs to review the base case conclusions drawn by Xcel and DOC, the assumptions that underlie these analyses, and how the results vary under different yet plausible scenarios related to future power system and policy circumstances.

The Xcel and DOC Strategist modeling results differ somewhat in scope and approach from the LCOE analysis I presented in my Direct Testimony. Specifically, the Strategist results compare the present value of societal costs ("PVSC") of different combinations of bids that would, at a minimum, meet the identified resource needs. While there are many similarities in the bid cost information presented in the analyses, the key difference is that the Strategist model also includes a representation of the impact that incorporating the proposed units in system dispatch has on overall system costs. Nevertheless, the fundamental conclusions are consistent. My LCOE analysis identifies the Mankato expansion as the clear winner, with the Black Dog unit next. Similarly, based on its Strategist analysis, DOC unequivocally recommends that "…the Commission approve Calpine's proposal and Xcel's proposal for a unit at the Black Dog site with a 2019 in-service date."[1] Xcel in turn recommends that the "…Commission identify Black Dog 6 in combination with either Invenergy's Cannon Falls proposal or Calpine's Mankato Energy Center expansion as the least cost projects in this process."[2]

In short, based on its analysis, and using only base case assumptions, Xcel concludes that in resource combinations including its Black Dog facility, the Mankato and Cannon Falls facilities are in a virtual tie. Consequently, taken together, the Commission has before it three separate modeling exercises – conducted using similar inputs but slightly varying methods and assumptions – that in the base case analyses conclude that the Mankato facility should be viewed as the best – or in Xcel's analysis among the best – options available to the commission from LCOE and PVSC perspectives.

[1] Direct Testimony of Dr. Steve Rakow, on behalf of the Division of Energy Resources of the Minnesota Department of Commerce, Docket No. E002/CN12-1240, at 43.
[2] Direct Testimony and Schedules of Steven W. Wishart, Docket No. E002/CN-12-1240, at 43.

Q. In what ways do you believe Xcel's *Base Case* Strategist analysis disfavors Mankato relative to other bids?

A. While Mankato fares well in Xcel's analysis, it does so despite certain assumptions that I believe tend to favor Invenergy's and Xcel's CT proposals relative to Calpine's CC proposal. The most important may be factors that influence asset utilization. As I noted in my direct testimony, the Commission's expectation about the likely utilization of the resource(s) selected in this procurement will be critically important to its decision in this case, and that the Commission should carefully consider in this context the efficiency of the Mankato expansion relative to Xcel's existing resource mix, potential future retirements, the evolution of system load and operations, and Minnesota's energy policy goals.[3]

There are a number of ways in which the Strategist analysis may tend to underestimate the capacity factor for Mankato, which would have the effect of underestimating its system benefits from efficiency, cost and emission perspectives. For example, the analysis uses a forecast of load and energy significantly lower than that approved by the Commission (and supported by DOC). Lower load and energy forecasts are likely to disproportionately affect the total energy output of a combined cycle facility, relative to peaking facilities. Further, it appears Xcel and DOC may have understated Mankato's summer output, which is actually 315 MW (rather than the **[TRADE SECRET INFORMATION BEGINS TRADE SECRET INFORMATION ENDS]** used in the Strategist modeling. To the extent that the Strategist analysis understates unit capability in summer months, it could reduce total

[3] Direct Testimony of Paul J. Hibbard, on behalf of Calpine Corporation, Docket No. E002/CN-12-1240, at 21.

annual output from the Mankato facility in the Strategist modeling, decreasing the value of its efficiency benefits. Finally, the evaluation of PPAs in the Strategist model extends only to twenty years, reducing the potential value of Mankato from an efficiency perspective (relative to competing CT proposals) beyond year twenty.

An additional assumption in Strategist base case modeling heavily disfavors Mankato relative to Invenergy's CT facilities. Specifically, Xcel assumes that Invenergy's pricing for natural gas will be based on interruptible transportation service, with no cost adjustment for sufficient alternative fuel storage capability needed to ensure reliable, year-round operations. As discussed in my Direct Testimony, this is a fundamental inconsistency in the comparison of resources proposed in this procurement, and inappropriately favors the Invenergy proposals relative to the Mankato facility.[4] As noted below, assuming a comparable firm-fuel transportation requirement for the Invenergy CTs in order for that resource to meet the same capacity needs on a year-round basis would cause the Strategist results to assign even greater value to the Mankato-Black Dog combination as the highest-ranked resource plan. It is simply not clear why Black Dog was modeled based on firm fuel while Invenergy was modeled based on non-firm fuel.

[4] I recognize that Invenergy mentions in its proposal that the Cannon Falls unit could run on oil, but Xcel notes that "…the fuel tanks at the site are barely sufficient to support the operation of a single turbine. For reliable winter operation the amount of on-site fuel storage would need to be expanded. Invenergy has not included these costs in their bid and has not provided supplemental information on the issue." Direct Testimony of Steven Wishart at pp. 49-50. This means that the Strategist analysis of the Invenergy proposal contains costs for *neither* sufficient oil-burning capability *nor* firm fuel service to ensure reliable year-round operations.

Q. Should the Commission base its decision only on the base case results considered in the modeling analyses?

A. No, in my view that would be a significant mistake. All of the modeling analyses in this docket view results under varying assumptions and scenarios, and the implications of changing assumptions (from base case assumptions) should be an important consideration in the review of modeling results. As DOC witness Mr. Shah suggested, "…the fundamental goal in certificate of need and resource planning proceedings is not to establish a plan that is least cost under a single forecast but for the plan to be least cost across a wide range of forecasts."[5] In my direct testimony I highlight a number of significant comparability, economic and policy factors that need to be considered carefully by the Commission when reviewing the evaluation of proposals in this procurement. These factors include (a) the need for each proposal to represent an equivalent capacity product, available year round (related to fuel supply and transportation assumptions); (b) the real possibility of controls on carbon emissions at existing power plants, which heightens the need to pay attention to the possibility of retirements and the relative efficiency and emission rates of new resources that would (in part) replace the output of retired intermediate or baseload assets; and (c) the impact of renewable standards on the operational requirements of the power grid, increasing the need for resources that can continuously and economically offer operational flexibility across *all hours of the year*, and do so without diluting – from an emissions perspective – the environmental objectives of Minnesota's Renewable Energy Standard ("RES").

[5] Direct Testimony of Sachin Shah, on behalf of the Division of Energy Resources of the Minnesota Department of Commerce, Docket No. E002/CN12-1240, at 14.

Q. Do the modeling results presented in direct testimony shed light on how the Commission should think about these issues?

A. Yes. The LCOE and Strategist modeling scenarios contain a number of variations on base case assumptions, many of which are directly relevant to the issues discussed above. The overwhelming conclusion from considering these various modeling outcomes is that the Mankato facility is not only in the best portfolios in the base case, but also represents by far *the most robust* resource to a wide range of assumptions and scenarios. This means that selection of Mankato in this procurement is not only the best option from the perspective of ratepayer costs, but it also represents a critically important asset and hedge against possible future resource and policy circumstances that could significantly affect Xcel system costs, efficiency and operations in the coming decades.

For example, in my LCOE analysis, I included a number of different scenarios to explicitly and transparently test the sensitivity of modeling results to factors directly relevant in the current procurement, such as capacity factors, pollution control technology investments, power purchase agreement ("PPA") terms (extending the PPAs to 35 years), CO_2 cost variations, and the pricing of natural gas transportation service (i.e., firm versus non-firm). In virtually every case, the Mankato facility consistently represents the lowest-cost resource from the ratepayer's perspective, often by a wide margin.

DOC's results are just as absolute with respect to the value of the Mankato expansion. In his Strategist modeling, Dr. Rakow tested 27 different scenarios for his eight preferred resource plans[6] varying items such as load forecast, fuel prices, CO_2 prices and externality values, market prices, and capital costs. He found that the Calpine

[6] Dr. Rakow's eight best resource plans were selected based upon his initial screening of resource plans in Strategist. Rakow Direct Testimony at 4 and 35.

Mankato/Black Dog combination was the lowest-cost option across all 27 scenarios.[7] This result also holds under all variations when he sets CO_2 costs to zero with one exception.[8] The only exception is the low-forecast scenario, with CO_2 costs set to zero.[9] This modeling scenario happens to be the *only* one of more than 50 scenarios considered by DOC in which Calpine is not included in the lowest-cost option. Even then, in DOC's analysis the Calpine/Black Dog option (ranked number 2) remains a lower-cost option than the Invenergy/Black Dog option (ranked number 5).[10]

Finally, Xcel's own analysis paints a similar picture when variations are made in key assumptions related to cost, emissions, and contract-term values. For example, see Table 9 of SWW-1. Removing 750 MW wind (which is the scenario that may be considered more analogous to the higher energy and capacity need set by the Commission, and used in DOC's base case analysis), Xcel found that the Calpine Mankato/Black Dog combination was $13 million less than the Invenergy Cannon Falls/Black Dog plan. Likewise, when Xcel compared the packages extending the Calpine and Invenergy PPAs to 35 years, they found that the Calpine Mankato Expansion/Black Dog combination was $7 million less than the Invenergy Cannon Falls/Black Dog proposal. Perhaps most important, however, is how comprehensive the results are with respect to the value of the Mankato expansion. Referring again to Table 9, it is striking to realize that (1) virtually every plan involving Mankato is the most robust across different sensitivity tests, and (2) every plan involving Invenergy's units

[7] Rakow Direct, Ex. SR-5A, page 3 of 8. In this exhibit, Dr. Rakow refers to the scenarios as "contingencies."
[8] Rakow Direct, Ex. SR-5A, page 7 of 8.
[9] Incidentally, the DOC low-forecast scenario uses a load forecast closest to that used in all of the Xcel Strategist analysis. With respect to the capacity forecast, Mr. Shah noted that Dr. Rakow's 'low forecast' was consistent with Xcel's updated spring forecast of 93 MW in 2017 and 300 MW in 2019. Shah Direct at 7, 14.
[10] Rakow Direct, Ex. SR-5A, page 7 of 8.

fails relative to Mankato in particular – as well as all other plans – when all bids are compared consistently on the basis of firm natural gas transportation costs.[11]

IV. THE RELATIVE VALUE OF CC VERSUS CT CAPACITY

Q. Have you reviewed the discussion of CC and CT capacity contained in the Direct Testimony of Invenergy Witnesses Ewan and Shield?

A. Yes I have.

Q. Do you believe these witnesses appropriately capture the purpose of this procurement and the relative value of CC versus CT capacity?

A. No, I do not. The Direct Testimonies of Invenergy's witnesses contain numerous flaws and mischaracterizations relative to the purpose of this procurement, the proper perspective for evaluating competing resources, and the operational flexibility and environmental impacts of CT versus CC resources in Xcel's current context.

Q. Please discuss how Invenergy's witnesses mischaracterize the purpose of this procurement, and how to evaluate competing resources given procurement objectives.

A. Invenergy's witnesses confuse or mischaracterize the fundamental purpose of the procurement, and the ability of various resource proposals to meet the stated need. In its Order on Xcel's Integrated Resource Plan, the Commission made a very straightforward determination of need – namely that Xcel needs to build or obtain 150 MW of capacity by 2017, increasing to up to 500 MW by 2019, and that the need should be met by "…peaking resources, intermediate resources, or a combination of the two."[12]

[11] Wishart Direct, Table 9 at page 39.
[12] Minnesota Public Utilities Commission, "Order Approving Plan, Finding Need, Establishing Filing Requirements, and Closing Docket," Docket No. E-002/RP-10-825, at 7.

Consequently, this is a procurement to meet Xcel's *capacity needs*, and the Commission specifically provided that the need may be met effectively with CT and/or CC capacity. That is, the Commission determined that Xcel's *capacity* needs can be met by either type of resource, or a combination of the two.

This is, of course, correct. Both CT and CC resources can qualify – and have qualified – to be available to meet the capacity needs of many companies and regions, as defined in the capacity markets or the capacity obligations of balancing authority areas. Moreover – and contrary to the implications of the Direct Testimonies of the Invenergy witnesses[13] – either resource type can fully and effectively meet such capacity needs under a wide range of conditions related to the Company's resource mix. For example, this is true (a) whether a company's load factor is increasing or decreasing; (b) whether a company's existing assets are dominated by new, efficient intermediate resources, old inefficient, peaking resources, or anything in-between; (c) whether a company's existing assets are heavily or lightly utilized; and (d) whether or not the company plans to add a little or a lot of variable renewable resources.

Invenergy's witnesses would have the Commission believe that this is wrong, and ultimately mischaracterize the purpose of the procurement and the potential role of CC versus CT capacity to meet identified needs. For example, Mr. Ewan constructs new definitions for resources – noting that (for the purpose of his testimony) "'Capacity Resources' refers to dispatchable (i.e., controllable) quick-start thermal peaking resources (e.g., natural gas-fired General Electric 7FA or equivalent technology) and 'Energy Resources' refers to baseload…and intermediate (e.g., natural gas-fired combined cycle)

[13] See, for example, the discussion of load factor, CC operations, and renewables integration in the Direct Testimony of Daniel Ewan at 23-27.

resources."[14] Mr. Ewan then goes on to conclude that "…the Xcel service area … has a need for Capacity Resources, not Energy Resources."[15] In short, Invenergy would have the Commission believe or conclude that CC resources are not capacity resources, or somehow can not be used to meet the identified capacity need in the current procurement.

This is obviously not the case. Of course, *either* Invenergy's CT resources *or* Calpine's proposed CC resource – or both – can be used effectively to meet the *capacity* need that is the focus and purpose of the current procurement. What matters is not whether CT or CC resources can meet the stated need – either or both can – but rather what resource (or set of resources) meets the need in an optimal fashion (1) from the perspective of ratepayers, and (2) from the perspective of the energy and environmental policy interests of the State of Minnesota, considering the role of CT and CC resource flexibility in this context.

Moreover, Invenergy's argument is particularly suspect in the context of its bids being modeled based on an interruptible fuel supply compared with the firm fuel supply that is included in the analysis of the Calpine bid. It is difficult to see how Invenergy's proposal would be more reliable (i.e., have a greater capacity value) than Mankato if the Invenergy plants cannot be relied upon throughout the year, as is the case with Mankato.[16] Invenergy's units will simply have little "flexibility" value for managing variable resource output when, as noted by Xcel, the units "…will not be available on many winter days."[17]

[14] Direct Testimony of Daniel Ewan at 23.
[15] Direct Testimony of Daniel Ewan at 23.
[16] As noted above, in footnote 4, Invenergy has been modeled without costs associated with either firm fuel supply or sufficient dual-fuel capability to ensure reliable year-round operation.
[17] Xcel Energy response to the Department of Commerce, Supplement to Information Request No. 042, Docket E002/CN-12-1240, June 28, 2013, at p. 5.

Q. Do the Direct Testimonies of the Invenergy witnesses appropriately frame the issue of ratepayer costs?

A. No. The most important consideration before the Commission is which resource set will minimize ratepayer cost and risks in meeting the identified capacity need under the widest set of plausible future conditions, considering LCOE and PVSC analyses presented in this docket. As discussed above, this question is answered solidly in Mankato's favor in the LCOE and Strategist analysis of competing proposals under various assumptions and scenarios.

In his Direct Testimony, Mr. Ewan attempts to confuse this issue by implying that if CC capacity is selected in this procurement, ratepayers will be forced to pay for an underutilized asset, will fail to pay for existing CC capacity, and will be "doubling down" on underutilized CC capacity.[18] Such claims both mischaracterize current and future Xcel system conditions and ignore the fact that asset utilization is specifically and explicitly incorporated in the modeling of ratepayer impacts.

First and foremost, the LCOE and PVSC analyses presented in this proceeding represent the costs to Xcel's ratepayers under a wide range of potential capacity factors for competing resources, and a wide range of potential future conditions, fully addressing in a modeling sense the impact of asset utilization on ratepayer costs. Regardless of assumed or expected capacity factors, if modeling results show Mankato to be better from a ratepayer perspective, then ratepayers are <u>not</u> paying for underutilized capacity – they are paying the least amount of money to meet the system's combined energy and capacity needs. Past utilization of existing resources, and comparisons to national CC utilization –

[18] Direct Testimony of Daniel Ewan at 28-29.

as raised in the Direct Testimony of Invenergy Witness Ewan[19] – are a distraction; they are simply not relevant to the analytic task of estimating the impact on ratepayers of various resource combinations competing in the current procurement at different rates of utilization. The potential utilization of the resources bid is fully accounted for or explicitly demonstrated in the Strategist and LCOE analysis presented in Direct Testimony in this proceeding, which demonstrates that the Mankato expansion is in the best resource plans from ratepayer perspectives across a wide range of potential rates of utilization.

Further, the suggestions by Invenergy witness Ewan that Xcel is overstocked on CC capacity, understocked on CT capacity, and will rely far more heavily in the future on CT capacity is simply wrong. Xcel's Sherco Study presents the current and modeled future resource mix on its system, including a breakdown of natural gas-fired resources between CT and CC capacity.[20] As figures 6.1 and 6.2, and Appendix D-6 in the Sherco Study demonstrate, (1) there are currently roughly equal quantities of CT and CC capacity on the Xcel system (approximately 1,500 MW of CT capacity and 1,400 MW of CC capacity); (2) each resource type currently represents twenty percent or less of Xcel's resource mix (approximately 20 percent for CC, and 19 percent for CT)[21]; and (2) the Company's projected capacity mix shows an increasing and significant contribution from CC capacity, far outstripping the projected growth of CT capacity. Importantly, this level of projected growth in CC capacity in the Sherco study occurs at the Strategist-modeled

[19] Direct Testimony of Daniel Ewan at 25-27.
[20] Xcel Energy, "Life Cycle Management Study for Sherburne County (Sherco) Generating Station Units 1 and 2," Minnesota Public Utilities Commission Docket Number E002/RP-13-368, July 1, 2013 (hereafter "Sherco Study), at 32, Figures 6.1 and 6.2, and Appendix D-6.
[21] This includes Xcel-owned and contract purchases of capacity.

costs for a generic CC unit, a cost that is likely significantly higher than the cost of the proposed Mankato expansion.

Second, while either resource could meet the capacity need, it is important to consider how CT and CC resources compare from the standpoint of non-price factors relevant to the policy interests and expectations of the Commission. It is in this latter consideration that Invenergy's discussion of the relative value of CC and CT resources is relevant, but erroneous.

Q. Do the Direct Testimonies of Invenergy's witnesses appropriately frame the flexibility of CC versus CT technologies, and the energy and environmental policy interests of the State of Minnesota?

A. No. Invenergy does not address the potential retirement of baseload resources, and the associated need for intermediate and/or baseload replacement capacity. As noted in my Direct Testimony, I believe this is an important consideration for the Commission in the current procurement with respect to the relative importance of CC and CT capacity. Second, in the context of providing operational flexibility for the integration of variable renewable resources, Invenergy confuses the issue of relative value of CC and CT resources by overstating the value of CT capacity and understating the value of CC capacity. Finally, the Commission should consider the relative environmental impact of CC versus CT capacity in meeting Minnesota's renewable and environmental policy goals.

Q. How does Invenergy mischaracterize the flexibility value of CT versus CC resources?

A. There are two major considerations for the Commission related to the relative value of CC versus CT resources in the current procurement – the need for sufficient intermediate and baseload capacity in the face of potential retirements, and the need for flexible resources to integrate variable renewable generation. The first – not addressed in the Direct Testimony of Invenergy's witnesses – relates to the very real potential that a significant quantity of baseload coal-fired resources may become uneconomic as a result of changes in the dispatch of resources due to low natural gas costs and/or existing and future environmental requirements that will be relevant within the timeframe of interest in the current proceeding. I discuss this in my Direct Testimony; in the current context, the Commission should consider this risk in its evaluation of the resources competing in this procurement, since new regulations – possibly including requirements on CO_2 emissions at existing power plants – will influence asset decisions by the time this procurement's resources come on line. The potential loss of baseload resources in Xcel's service territory heightens the need for replacement with intermediate or baseload capacity, such as can be provided by CC units.

Importantly, retirement risk and its impact on company reserve margins is absolutely not only an Xcel risk and concern – Xcel's neighbors are heavily dependent on coal-fired generation at risk of retirement, and this has implications for the future development of sufficient baseload and intermediate resources throughout all of MISO. As noted by the Independent Market Monitor for the MISO region, "…the increased penetration of wind resources and new EPA regulations will put substantial economic

pressure on baseload coal resources that should accelerate retirements and reduce planning reserve margins."[22] Consequently, the Commission should not assume that there will be sufficient excess reserve capacity throughout MISO to fill in any gaps in Xcel's needs.

The second major consideration related to the relative value of CC and CT resources is the potential growth in variable resource generation, the resulting increase in net load variability, and the need for flexible resources to manage such variability. Invenergy does provide testimony on this issue, but mischaracterizes the relative value of CC versus CT resources in this respect. Specifically, Mr. Ewan suggests that the potential increased variable generation output on Xcel's system means that "…Xcel's need is best filled by dispatchable peaking resources…"[23] No credit is given to the ability of dispatchable CC resources to help manage an increase in net load variability

Q. Can CT resources provide valuable flexibility for the integration of variable renewable resources?

A. Absolutely. CTs – provided they are fully available to operate with firm fuel on a year-round basis – can help manage the increase in net load variability associated with increased penetration of renewable resources. The fast-start and fast-ramp capability of CTs mean that they are effective in addressing system contingencies that need to be met through resource activation within a half-hour to several hours.[24] On the other hand, CT resources can not help manage variability on the order of seconds to tens of minutes (unless they happen to be on line, which is unlikely given expected low capacity factors),

[22] Potomac Economics, "2012 State of the Market Report for the MISO Electricity Markets," June 2013 at v.
[23] Direct Testimony of Daniel Ewan at 28.
[24] As noted in my Direct Testimony at 28, the CTs proposed in this procurement may require at least **[TRADE SECRET INFORMATION BEGINS [TRADE SECRET INFORMATION ENDS]**.

and they are simply inferior as a balancing resource over any time frame when the need to balance net load variability can be met at higher efficiency, lower cost, and lower emission rates by CC capacity.

Q. Can CC resources provide valuable flexibility for the integration of variable renewable resources?

A. Absolutely. When off line, CC units can help manage unexpected swings in net load that can be reasonably forecast several hours in advance, and when on line CC units can *continuously* help manage variations in net load over all time frames, from second-to-second variations to hourly and daily swings.

Perhaps the most important concept to recognize is that the *value* of a resource from a flexibility perspective is determined by three things: (1) the operational characteristics of the resource, such as the ability to ramp up and down on a second-by-second, minute-by-minute basis, start quickly, etcetera; (2) the amount of time that the resource can contribute to managing net load variability (a function of how often it is on line); and (3) the efficiency, cost, and emission characteristics of the resource when it is being used to manage net load variability. The management of variations in net load due to contingencies or unexpected changes that need to be responded to between thirty minutes to several hours can be better met by CTs, if CC capacity is either not on-line, or all operating CC capacity is already at maximum load. However, the overall value of CC capacity to help integrate variable resources is likely higher, because it can manage net load variability more efficiently, and at lower cost and lower emissions than CT capacity: (a) when variation needs to be managed on timescales of several hours or more, when the capacity is off line, and (b) when variations of *any* timescale (i.e., on the order of seconds

to minutes to hours to days) need to be managed, and there is CC capacity already on line. Put another way, compared to CC capacity, CT capacity is an expensive and higher-emitting way to meet any net load variability that otherwise could be met by on-line or off-line CC capacity.

Q. Please discuss the importance of the relative environmental impact of CT versus CC capacity?

A. It may seem at first glance that the environmental impacts of CT technology are better than CC technology, since total annual emissions are likely to be lower for CTs.[25] However, this position ignores the metric of relevance – namely the emission rates of each technology on a pound per megawatt-hour (lb/MWh) generated basis. A true apples-to-apples comparison of the environmental impacts of the projects in this procurement requires a comparison not of total annual tonnage, but based on emissions per unit of energy produced. From this perspective, the emissions from the proposed Mankato expansion are far lower than from the CTs proposed in this procurement, per unit of energy generated. This means that for every MWh generated by either the Mankato facility or one of the CTs proposed in this procurement to meet *incremental* demand, emissions from the Mankato expansion would be significantly lower.

Total annual emissions, in turn, are a product of emission rates in pounds per MWh produced, and the total MWh produced. Consequently, for equal quantities of MWh produced, the Mankato expansion would have lower total emissions than the CTs proposed. But to the extent that the Mankato expansion operates more hours than the CTs (because, for example, the CC capacity is more valuable to the system because of its

[25] See, e.g., Minnesota Department of Commerce, "Environmental Report," Minnesota Public Utilities Commission Docket Number E002/CN-12-1240, October 2013, at 35-38.

energy benefits), then on a unit-to-unit comparison basis, the Mankato expansion could have higher total annual emissions. However, this also would be an incomplete comparison, as it would ignore emission displacement. As noted in footnote 1 of my Direct Testimony, I would expect that Mankato would fare well in a comparison of system emissions that includes such impacts, since "…the more efficient and more highly-utilized CC capacity would likely generate greater … emission displacement than CT capacity." That is, for every hour of operation of a CC resource when the CT would not operate, you are not adding incremental emissions – you are likely *displacing* generation from resources that also have a higher emission rate in lb/MWh than the new CC facility, and thus emissions are reduced.

V. CONCLUSION

Q. Would you please summarize your testimony?

A. Yes. I have reviewed the Direct Testimony of the witnesses for Xcel, DOC, and Invenergy. In my view a fair reading of these filings supports the conclusions I drew in my Direct Testimony – namely, that consideration of ratepayer costs, Xcel's changing resource mix needs, and Minnesota's energy and environmental policy goals supports the selection of the Mankato expansion in this procurement.

The ratepayer benefits of the Mankato facility are strongly supported by the base case modeling analyses provided in Direct Testimony – including my LCOE analysis as well as the Strategist analyses carried out by Xcel and DOC – despite the application in each case of assumptions likely to disadvantage Mankato relative to competing proposals. Moreover, the results of the various scenarios and sensitivities conducted in all three analyses consistently demonstrate how robust Mankato's advantage is across most or all

plausible future outcomes that vary from base case conditions in terms of items such as demand growth, fuel procurement options, environmental costs and emission control technology investment. In short, the Mankato facility should be selected in this procurement because it represents the best value for ratepayers, either by itself or in combination with Black Dog, and is the best tool for hedging the risks of economic, industry, and policy outcomes that differ from current expectations.

Finally, the Mankato expansion represents the best option from the perspective of Minnesota's energy and environmental policy goals. Selecting *only* CT capacity as a result of this procurement would diminish the resilience of Xcel's resource mix to increasingly stringent environmental requirements, would constrain the flexibility that the system has to react to the potential retirement of baseload generation assets, and would limit the ability of the system to effectively and efficiently integrate an expanding set of variable renewable resources over time. Finally, efficient CC generation represents the most environmentally appropriate thermal energy resource in this procurement, because it has the lowest emission rate on the basis of emissions per unit of energy generated, and would likely lead to greater displacement than CT capacity of higher-emitting resources on the system.

Q. Does this conclude your testimony?

A. Yes.