Rebuttal Testimony and Schedules
Christian Winter

Before the Minnesota Public Utilities Commission

State of Minnesota

In the Matter of the Application of Minnesota Power
for a Certificate of Need and Route Permit for the HVDC Modernization Project
in Hermantown, Saint Louis County

OAH Docket No. 5-2500-39600
MPUC Docket Nos. E015/CN-22-607
and E015/TL-22-611

TRANSMISSION PLANNING, COST ESTIMATES, SCHEDULE IMPACTS, AND TECHNICAL CONSIDERATIONS

March 11, 2024

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I. INTRODUCTION

Q. Please state your name and business address.

A. My name is Christian Winter, and my business address is 30 West Superior Street, Duluth, Minnesota 55802.

Q. By whom are you employed and in what position?

A. I am employed by ALLETE, Inc., doing business as Minnesota Power ("Minnesota Power" or the "Company") as Manager – Regional Transmission Planning.

Q. Did you previously provide testimony in this proceeding?

A. Yes. On February 14, 2024, I provided Direct Testimony supporting Minnesota Power's proposed configuration of its high-voltage direct-current ("HVDC") Modernization Project ("HVDC Modernization Project").

Q. What is the purpose of your Rebuttal Testimony?

A. I am providing responses to certain Direct Testimony filed by the Department of Commerce, Division of Energy Resources ("DOC-DER"), the Large Power Intervenors ("LPI"), and American Transmission Company LLC, by and through its corporate manager ATC Management Inc. ("ATC"). More specifically, I provide the following responses in my Rebuttal Testimony:

- In response to testimony from LPI's witness Kavita Maini, I provide additional context and explanation related to the evaluation by the Midcontinent Independent System Operator, Inc. ("MISO") of potential future expansion and cost allocation opportunities beyond the 900 megawatts ("MW") of capacity which Minnesota Power holds for its customers. I also provide a response to Ms. Maini's request that the Company provide cost sharing proposals and HVDC Modernization Project alternatives.
- In response to testimony from DOC-DER's witness, I provide background and information on the operating lives of the 465-mile HVDC ±250 kV transmission line ("HVDC Line") and converter stations ("HVDC System") and Minnesota

Power's North Dakota wind generation facilities. I also discuss information related to certain alternatives identified by DOC-DER that should be evaluated to ensure a complete record. Additionally, I discuss some of the concerns DOC-DER identified with the alternative configuration proposed by ATC in this proceeding ("ATC Arrowhead Alternative").

- In response to testimony from ATC's witnesses Robert McKee, Tobin Larsen, Dustin Johanek, and Thomas Dagenais I provide responses to various topics. These include conversations between ATC and Minnesota Power before Minnesota Power filed the combined Certificate of Need and Route Permit Application ("Application") in this proceeding; ATC's proposed equipment for the ATC Arrowhead Alternative; cost estimates provided by ATC; the overall ATC Arrowhead Alternative in-service date; and the power flow and stability studies performed by ATC.

Q. Are you sponsoring any exhibits in this proceeding?

A. Yes. I am sponsoring the following schedules to my Direct Testimony:

- MP Exhibit ___ (Winter), Rebuttal Schedule 1 – Minnesota Power Response to LPI Information Request ("LPI IR") 003;
- MP Exhibit ___ (Winter), Rebuttal Schedule 2 – Minnesota Power Response to DOC-DER Information Request ("DOC IR") 018;
- MP Exhibit ___ (Winter), Rebuttal Schedule 3 – Minnesota Power Response to LPI IR 034;
- MP Exhibit ___ (Winter), Rebuttal Schedule 4 – Minnesota Power Response to LPI IR 023;
- MP Exhibit ___ (Winter), Rebuttal Schedule 5 – ATC Response to LPI IR 004;
- MP Exhibit ___ (Winter), Rebuttal Schedule 6 – ATC Response to DOC IR 019;
- MP Exhibit ___ (Winter), Rebuttal Schedule 7 – Minnesota Power Response to ATC Information Request ("ATC IR") 039;
- MP Exhibit ___ (Winter), Rebuttal Schedule 8 – Minnesota Power Response to LPI IR 009;

- MP Exhibit ___ (Winter), Rebuttal Schedule 9 – Minnesota Power Response to DOC IR 012;
- MP Exhibit ___ (Winter), Rebuttal Schedule 10 – Minnesota Power Response to LPI IR 027;
- MP Exhibit ___ (Winter), Rebuttal Schedule 11 – Minnesota Power Response to DOC IR 013;
- MP Exhibit ___ (Winter), Rebuttal Schedule 12 – Minnesota Power Response to DOC IR 014;
- MP Exhibit ___ (Winter), Rebuttal Schedule 13 – September 19, 2022 Email Between Minnesota Power and ATC;
- MP Exhibit ___ (Winter), Rebuttal Schedule 14 – September 23, 2022 Email Between Minnesota Power and ATC;
- MP Exhibit ___ (Winter), Rebuttal Schedule 15 – September 27, 2022 Email Between Minnesota Power and ATC;
- MP Exhibit ___ (Winter), Rebuttal Schedule 16 – Minnesota Power Response to ATC IR 010;
- MP Exhibit ___ (Winter), Rebuttal Schedule 17 – ATC Response to LPI IR 02;
- MP Exhibit ___ (Winter), Rebuttal Schedule 18 – 2024 MWEX Stability Study;
- MP Exhibit ___ (Winter), Rebuttal Schedule 19 – ATC Arrowhead Alternative Updated Cost Estimate;
- MP Exhibit ___ (Winter), Rebuttal Schedule 20 – Minnesota Power Response to ATC IR 012;
- MP Exhibit ___ (Winter), Rebuttal Schedule 21 – Summary of Original Minnesota Interconnection Facilities Cost Estimates;
- MP Exhibit ___ (Winter), Rebuttal Schedule 22 – Minnesota Power St. Louis County 345 kV/230kV Updated Cost Estimate;
- MP Exhibit ___ (Winter), Rebuttal Schedule 23 – ATC Arrowhead Alternative-PST Updated Cost Estimate;
- MP Exhibit ___ (Winter), Rebuttal Schedule 24 – Summary of Updated Cost Estimates;

- MP Exhibit ___ (Winter), Rebuttal Schedule 25 – Minnesota Power Response to ATC IR 043;
- MP Exhibit ___ (Winter), Rebuttal Schedule 26 – HVDC Modernization Project Schedule;
- MP Exhibit ___ (Winter), Rebuttal Schedule 27 – HVDC Modernization Project Schedule – ATC Arrowhead Alternative;
- MP Exhibit ___ (Winter), Rebuttal Schedule 28 – ATC Response to Minnesota Power Information Request (“MP IR”) 025;
- MP Exhibit ___ (Winter), Rebuttal Schedule 29 – Minnesota Power Response to ATC IR 034;
- MP Exhibit ___ (Winter), Rebuttal Schedule 30 – Minnesota Power Response to ATC IR 026;
- MP Exhibit ___ (Winter), Rebuttal Schedule 31 – ATC Response to MP IR 026;
- MP Exhibit ___ (Winter), Rebuttal Schedule 32 – ATC Response to LPI IR 005;
- MP Exhibit ___ (Winter), Rebuttal Schedule 33 – ATC Response to LPI IR 003;
- MP Exhibit ___ (Winter), Rebuttal Schedule 34 – ATC Response to MP IR 024; and
- MP Exhibit ___ (Winter), Rebuttal Schedule 35 – ATC Response to MP IR 023.

II. RESPONSE TO LPI DIRECT TESTIMONY

Q. Please summarize Ms. Maini’s concerns related to the future expandability of the HVDC Modernization Project.

A. In Direct Testimony, Ms. Maini cites information provided by the Company about design provisions for future expandability of the new HVDC converter stations proposed for the HVDC Modernization Project, as well as the Company’s statements about the potential future role of the HVDC System in regional transmission development, particularly as MISO considers solutions for LRTP Tranche 2 or future Tranches. Ms. Maini also expresses concern that the Company’s customers are paying the cost for future expandability that will ultimately provide regional benefits. Ms. Maini concludes: “Minnesota Power’s ratepayers should not be solely responsible for the high upfront costs of the Project if it is designed and scoped with the expectation of providing regional benefits."[1]

Q. What future expandability is proposed by Minnesota Power for the HVDC Modernization Project?

A. As stated in Minnesota Power's response to LPI IR 003, a copy of which is attached to my Rebuttal Testimony as Rebuttal Schedule 1, when the Project is complete, the new HVDC converter stations (one in Minnesota and one in North Dakota) will be capable of transferring up to 1,500 megawatts ("MWs"). As also explained, the HVDC Line will not be capable of this 1,500 MW transfer without modifications to the transmission line itself. In its response to DOC IR 018, the Company explains that it currently holds transmission service requests ("TSRs") granting it rights for an additional 350 MW of capacity on the HVDC Line above its present 550 MW capability. A copy of this response is included with my Rebuttal Testimony as Rebuttal Schedule 2. This capacity will become usable for Minnesota Power's customers upon completion of the Project and a separate HVDC 900 MW Transmission Line Upgrade project.[2] As discussed in Minnesota Power's response to LPI IR 034, attached to my Rebuttal Testimony as Rebuttal Schedule 3, the HVDC 900 MW Transmission Line Upgrade Project, which is not part of this proceeding, does not require a Certificate of Need because it involves upgrading an existing transmission line on existing right-of-way without changing the voltage (Minn. R. 7850.1500, subp. 1(B)(2)). Once Minnesota Power has completed the Project and this additional transmission line upgrade project, the HVDC System will be capable of delivering 900 MW of renewable energy, either for the exclusive use of Minnesota Power's customers or optionally to be assigned by Minnesota Power to others, offsetting costs for Minnesota Power's customers. Therefore, the capacity presently available on the HVDC Line with existing assets and planned upgrades is 900

[1] Maini Direct at 20:17-19.
[2] A potential need for increased capacity on the HVDC transmission line has been reported in the Minnesota Biennial Transmission Projects Report since 2013 under MPUC Tracking Number 2013-NE-N17. The Minnesota Biennial Transmission Projects Report is available at www.minnelectrans.com.

MW, which is fully subscribed by Minnesota Power. Any upgrade beyond 900 MW would require the HVDC transmission line to be rebuilt to a larger capacity. Furthermore, the layout of the HVDC converter stations will be designed such that if future conditions warrant, it will be straightforward to add another 1,500 MW converter which would allow for a total HVDC System capacity up to 3,000 MW after a concurrent rebuild of the transmission line for the higher capacity.

Q. What features in the design of the HVDC converter stations provide for this potential future expandability?

A. As discussed in response to LPI IR 023, attached to my Rebuttal Testimony as Rebuttal Schedule 4, HVDC suppliers will design and deliver HVDC converter stations to the specific capacity and configuration requested by the customer. If future expandability provisions are not incorporated into the design of the HVDC converters when they are initially designed and deployed, it will not be possible to increase their capacity without an extensive overhaul, up to and likely including removal of the existing equipment and replacement with new higher-capacity HVDC converter stations. All of this would be at a substantially higher cost than just incorporating the flexibility at this time. This is because the greatest portion of the cost of these components is driven by the basic component, itself – the cost of expandability is incremental and often not a directly proportional cost-to-capacity increase.

When the components are designed with future expandability incorporated, Minnesota Power would be able to efficiently leverage readily-available additional capacity and incremental design changes to achieve higher capacity for the basic building blocks of the HVDC converter stations. Some of the largest HVDC converter station components, such as the converter transformers, converter valves (power electronics), and converter hall (building) may readily provide for incremental capacity through relatively modest incremental design changes, typically impacting their ampacity rating.

Q. How might MISO consider the potential future expandability of the HVDC Modernization Project as it considers LRTP Tranche 2 and future LRTP Tranches?

A. MISO has not historically included HVDC in regional planning solutions. However, MISO has repeatedly reinforced the importance of VSC HVDC for achieving long-term regional decarbonization goals and signaled its intention to incorporate VSC HVDC technology into its consideration of future LRTP solutions.[3] While the initial LRTP Tranche 2 concepts released by MISO on March 4, 2024, do not incorporate HVDC solutions or any significant new 345 kV projects in Minnesota beyond southern Minnesota, MISO has acknowledged to the Company and other transmission owners, including ATC, that its proposed approach to LRTP Tranche 2 leaves many identified Future 2A[4] issues unresolved. To continue the development of its proposed Tranche 2 portfolio, MISO has announced it is seeking additional project submissions through April 5, 2024.[5] Minnesota Power and its neighboring utilities in Minnesota are actively planning to participate in the project submittal process to advocate for MISO to consider projects that support long-term Minnesota state energy policy and reliability needs while also providing broad regional benefits. After the April 5 deadline, MISO will evaluate if any revisions or additions to its Tranche 2 concepts will be incorporated as it continues its analysis and justification of the Tranche 2 portfolio before presenting it to the MISO Board of Directors for approval in the second half of 2024. Further, in its presentation

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[3] See Section 3.3.3 of the Application for discussion of MISO's consideration of VSC HVDC solutions in the LRTP and prior to that in its Renewable Energy Integration Impact Assessment ("RIIA"). The February 2021 RIIA Summary Report is available at https://cdn.misoenergy.org/RIIA%20Summary%20Report520051.pdf.

[4] Future 2A refers to one of MISO's three forward-looking scenarios, which forecast multiple paths and timelines for states and utilities to meet their energy goals. The Futures are designed to "bookend" the potential range of future economic and policy outcomes, ensuring that the actual future is within the range of the Futures. These Futures are then used by MISO to assess and identify the transmission needed to deliver the necessary energy reliably and efficiently from generation resources to customers. The MISO Futures are developed through an iterative and robust stakeholder process which includes representatives from MISO utilities, state regulatory authorities, public consumer advocates, environmental representatives, and independent power producers. More information on the MISO Futures is available at https://www.misoenergy.org/planning/futures-development/.

[5] Tranche 2: Initial Draft Portfolio, March 4, 2024 LRTP Workshop at 9, *available at* https://cdn.misoenergy.org/20240315%20LRTP%20Workshop%20Tranche%202%20Anticipated%20Portfolio632013.pdf.

on March 4, 2024, MISO acknowledged that "Tranche 2 does not eliminate the consideration of HVDC . . . for future needs."[6]

MISO has also suggested that unresolved Future 2A issues may be the subject of subsequent LRTP investigation after the approval of the initial Tranche 2 portfolio, with some addressed through the continued MISO iterative analysis it is currently undertaking. The unresolved Future 2A issues largely involve the long-distance transmission and bulk delivery of high-capacity renewable energy resources to load centers across multiple states in the MISO region. These are needs that VSC HVDC is uniquely suited to address. Once the HVDC Modernization Project is complete, including the St. Louis County 345 kV/230 kV Substation, the new HVDC and 345 kV infrastructure will serve the immediate needs of Minnesota Power and its customers, while also providing powerful and cost-effective building blocks to support future transmission development linking together multiple Minnesota utilities to support local and regional reliability within the state of Minnesota and MISO more broadly.

The Company will continue to engage with MISO and other stakeholders as practicable to urge further consideration of VSC HVDC and complementary regional 345 kV solutions with the initial Tranche 2 package and future MISO LRTP analysis. Should such expandability be identified by MISO as necessary to provide regional benefits, the Company would advocate for appropriate cost allocation considerations by MISO.

Q. Does the fact that the recently-released MISO LRTP Tranche 2 initial concept map lacks any projects connecting to the St. Louis County Substation mean MISO's perspective with respect to the St. Louis County Substation has changed?

A. No. ATC may be quick to dismiss the role of the St. Louis County Substation in the MISO LRTP as a result of the recently-released MISO LRTP Tranche 2 initial concepts, as evidenced by its recent responses to LPI IR 004, attached as Rebuttal Schedule 5 to my Rebuttal Testimony, and DOC IR 019, attached as Rebuttal Schedule 6 to my

[6] *Id.* at 7.

Rebuttal Testimony, but the thorough review of the history of MISO's development of the St. Louis County Substation concept and the overall LRTP roadmap for addressing the long-term needs of the regional transmission system presented in my Direct Testimony[7] continues to be valid. MISO has consistently stated that the LRTP study is a multi-phase effort taking place over many years and that the LRTP Tranche 2 portfolio is in early development and subject to change.

To insinuate, as ATC does, that MISO has somehow abandoned the St. Louis County Substation concept by virtue of releasing one map that does not include projects connecting to it, is not only short-sighted, it is wrong. MISO has incorporated Minnesota Power's proposed configuration for the HVDC Modernization Project, including the St. Louis County 345 kV/230 kV Substation, into its planning models for LRTP Tranche 2, as stated in my Direct Testimony and confirmed in Minnesota Power's response to ATC IR 039, which is attached to my Rebuttal Testimony as Rebuttal Schedule 7. The same cannot be said for the ATC Arrowhead Alternative.

Q. Please respond to Ms. Maini's concerns related to cost allocation in light of the expandability of the HVDC Modernization Project.

A. Minnesota Power has developed the HVDC Modernization Project to meet its customers' near-term needs for continued reliable delivery of renewable energy resources while efficiently preserving optionality for future expandability to benefit both Minnesota Power's customers and the region if future conditions support expansion. To be clear, the HVDC Modernization Project is intended to provide benefits to Minnesota Power customers to the greatest extent practicable. The future expandability capabilities of the proposed configuration of the HVDC Modernization Project are intended to preserve the ability to efficiently and effectively increase capacity of the HVDC System in the future, but not at this time. The designed optionality for future expandability is a prudent and appropriate step that aligns with typical transmission planning practice for a large-scale transmission infrastructure

[7] Winter Direct, pages 46-49

project with a multi-decade operating life.[8] The overall reasonableness of this configuration is further supported when combined with Minnesota Power's efforts to obtain grant funding to mitigate near-term rate impacts of these incremental costs to retain the optionality.

To that end, Minnesota Power has leveraged federal and state grant funding opportunities to protect its customers from much of the incremental cost associated with the future expandability options incorporated into the design of the HVDC Modernization Project. Minnesota Power also continues to work with MISO to assess opportunities for recognition of the regionally-beneficial attributes of its VSC HVDC converters, either through LRTP cost allocation or through new tariff development. In that respect, the Company has taken reasonable steps to ensure that its customers are responsible for the cost associated with customer needs of the HVDC Modernization Project but not paying for potential future regional benefits that may be leveraged in the future for future expandability.

Q. What response do you have to Ms. Maini's proposal that Minnesota Power scale back the HVDC Modernization Project?

A. As discussed in Minnesota Power's response to LPI IR 036, attached to the Rebuttal Testimony of Mr. Gunderson as Rebuttal Schedule 10, if the optionality for future expandability is removed from the HVDC Modernization Project, the cost of the overall project would decrease by approximately $100 million. However, with this $100 million reduction, Minnesota Power would also lose grant funding of up to $75 million, along with the potential additional federal grant funding opportunity in DOE GRIP Round 2 for the HVDC Interconnections concept paper. Therefore, the scaling back that

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[8] *In the Matter of the Application of Great River Energy, Northern States Power Company (d/b/a Xcel Energy) and Others for Certificates of Need for the CapX 345-kV Transmission Projects*; Docket No. ET2/E002, *et al.*/CN-06-1115, ORDER GRANTING CERTIFICATES OF NEED WITH CONDITIONS at Order Point 3 (May 22, 2009) (Commission ordered construction of the Upsized Alternative, which leveraged the needed 345 kV transmission structures by ordering that they be constructed to 345 kV/345 kV double circuit compatible, with the second circuit positions available for future needs. Fifteen years later, projects are currently being planned or evaluated to install the second circuit on the majority of these lines, including some which are part of the MISO LRTP).

Ms. Maini proposes would not have a material cost savings for Minnesota Power customers and, if future expandability were necessary, the system would need to be removed and replaced at an even greater cost to Minnesota Power customers.

Q. How do you respond to Ms. Maini's proposal to retire the HVDC system and leverage MISO's LRTP process?

A. As discussed in Section 4.8.2 of the Application, in my Direct Testimony, and in response to LPI IR 009, attached to my Rebuttal Testimony as Rebuttal Schedule 8, this proposal would require significant investment in AC transmission lines and other network upgrades. Because it would be Minnesota Power's decision to retire the HVDC System that would necessitate that AC transmission investment, MISO would likely require Minnesota Power to cover those transmission upgrade costs – which would be directly assigned to Minnesota Power customers.[9] Finally, relying on the MISO LRTP process, over which Minnesota Power would have very little meaningful control over the size, type, or timing of MISO's recommendations and the subsequent implementation of transmission projects, is not in the interest of Minnesota Power customers and the significant investments these customers have made in low-cost North Dakota wind energy resources to support the clean energy transition. Company witness Mr. Gunderson provides more information on the MISO cost allocation process in his Rebuttal Testimony in response to Ms. Maini's Direct Testimony.

III. RESPONSE TO DOC-DER DIRECT TESTIMONY

Q. Did DOC-DER raise any concerns in its Direct Testimony regarding Minnesota Power's statement of need for the HVDC Modernization Project?

A. No. In his Direct Testimony, Mr. Zajicek concurs with Minnesota Power's assessment of the need for the Project, stating: "Based on my review of the data provided by [Minnesota Power], I conclude that the HVDC line is experiencing increasing outages

[9] There is no legitimate pathway for Minnesota Power to make a deliberate decision to retire the HVDC System and then expect MISO to spread the costs of mitigating the resulting transmission system issues across its footprint through the LRTP or any other planning process resulting in regional cost allocation. MISO strives to align costs with causation, and in this case, the cause would clearly be the retirement of the HVDC System.

which are likely to continue in the future, eventually leading to the failure of the HVDC line altogether."[10] While Mr. Zajicek goes on to raise some questions about alternatives he believes should have been considered by the Company and should be evaluated as part of this proceeding, he repeatedly concludes that the Company has provided adequate evidence in his review of the Certificate of Need criteria.

Q. What questions did Mr. Zajicek raise in his Direct Testimony regarding Minnesota Power's evaluation of alternatives for the HVDC Modernization Project?

A. While Mr. Zajicek states that the Company "provided a thorough discussion of alternatives to the Project" he raises three additional questions regarding alternatives.[11] First, Mr. Zajicek states that "the Company has provided no analysis that discusses the feasibility of replacing [North Dakota] generation assets with generation located in Minnesota nearer to [Minnesota Power]'s customers."[12] Second, Mr. Zajicek states that certain aspects of a no build alternative have "not been discussed in detail in the Company's [Certificate of Need] filing."[13] Third, Mr. Zajicek states that the Company's alternatives analysis does not specifically address distributed generation as an alternative to the Project.[14]

A. <u>Operating Lives and Repowering of North Dakota Wind Resources</u>

Q. What is the primary purpose of the HVDC System?

A. As stated in my Direct Testimony, the HVDC System creates a direct path from Minnesota Power's existing high-capacity renewable energy resources in central North Dakota to its customers in northeastern Minnesota, bridging a large and often-congested area of the regional AC transmission system that would otherwise separate these valuable generation resources from Minnesota Power's customers. The purpose of the HVDC Modernization Project is to replace existing end-of-life HVDC transmission

[10] Zajicek Direct at 13:6-8.
[11] Zajicek Direct at 16:14.
[12] Zajicek Direct at 19:8-10.
[13] Zajicek Direct at 22:10.
[14] Zajicek Direct at 23:10-11.

infrastructure that supports the continued reliable operation of the HVDC System to serve Minnesota Power's customers and support Minnesota Power's plans for the decarbonization of its energy resources.

Q. How does Mr. Zajicek connect the operating lives of Minnesota Power's wind generation facilities to the proposed HVDC Modernization Project?

A. Noting that the purpose of the HVDC System is to bring energy produced in North Dakota to eastern Minnesota, Mr. Zajicek discusses the operating lives of the existing North Dakota generation assets that utilize the HVDC System. Based on a 25 year general service life for wind energy facilities, Mr. Zajicek suggests that Minnesota Power ought to have considered the feasibility of replacing its existing North Dakota wind energy resources at the end of their initial service lives with new wind energy resources closer to Minnesota Power's customers which presumably would not require the use of the HVDC System.[15] Mr. Zajicek's apparent proposition is that the cost of the HVDC Modernization Project may be avoided by ceasing to utilize the existing North Dakota wind energy resources associated with the HVDC System at the end of their service lives.

Q. Is it reasonable to assume that the HVDC Modernization Project could be avoided if Minnesota Power ceased to utilize its existing North Dakota wind generation facilities at the end of their service lives?

A. No. Minnesota Power began to discuss these reasons in response to DOC IR 012, attached to my Rebuttal Testimony as Rebuttal Schedule 9. There are at least three reasons why Mr. Zajicek's proposition is unreasonable, but is an appropriate avenue of analysis for completeness of the record: (1) Any new wind generation resources are very unlikely to be more cost-effective than continuing to utilize wind generation resources that are already constructed and operational; (2) The proposition does not account for the urgent need to replace the existing, failing HVDC converter stations, which does not align with the timing of the end of service life for the existing wind generation facilities;

[15] Zajicek Direct at 19:11.

and (3) The proposition is essentially the same as the delay and no-build alternatives discussed in the Application.

Q. Would wind generation resources in northeastern Minnesota be more cost-effective than continued use of the North Dakota wind generation resources?

A. No. First and foremost, Minnesota Power's latest Integrated Resource Plan ("IRP") continues to utilize its existing wind energy resources in North Dakota, including the Bison Wind Energy Center and the purchase agreements for the recently-repowered Oliver County I and II facilities. Minnesota Power's long-range planning has assumed the HVDC Modernization Project would be implemented to ensure the continued reliable and efficient delivery of these resources to Minnesota Power's customers and support local transmission system reliability in northern Minnesota Power. To meet the State of Minnesota's aggressive decarbonization by 2040 goals, Minnesota Power needs to be adding to its renewable energy fleet and implementing projects that support long-term reliability of the transmission system. Avoiding the HVDC Modernization Project by retiring existing renewable energy resources would be a step backwards on both of those fronts..

As Mr. Zajicek acknowledges, it is hard to envision a more reasonable or cost-effective option for expanding upon Minnesota Power's renewable energy portfolio than continuing to utilize existing renewable energy resources with established infrastructure and transmission interconnection rights.[16] Minnesota Power's existing North Dakota wind resources are situated within some of the best wind resource zones in the country, while wind capacity factors closer to Minnesota Power's customers in northeastern Minnesota are among the lowest in the region. Wind energy resources in northeastern Minnesota simply cannot compete with the efficiency and value of wind energy resources in central North Dakota, which is a big part of the reason Minnesota Power chose to develop its renewable energy resource plan around North Dakota and the HVDC System when it first acquired full ownership of the HVDC System. Even if the

[16] Zajicek Direct at 20:1-25.

wind resource in northeastern Minnesota was competitive with central North Dakota, the potential costs associated with obtaining new transmission interconnection rights through the MISO generator interconnection process exceed the transmission network upgrade costs associated with simply continuing to utilize the existing HVDC System to deliver the existing North Dakota wind energy resources, as demonstrated in Minnesota Power's response to LPI IR 027, attached as Rebuttal Schedule 10 to my Rebuttal Testimony.

Q. How do the age of the HVDC System and wind generation resources compare?

A. There is an urgent need to modernize the HVDC converter stations due to increasing failure rates. The existing HVDC converter stations are already more than 15 years beyond their original 30-year design life. While Minnesota Power has obtained a guaranteed in-service date for the new converter stations in April 2030, it is continuing to work with the HVDC Supplier to identify if there is an opportunity for an earlier in-service date, possibly as early as 2028. Given the continually-increasing failure rates and the well-established economic and reliability impacts of these failures, which are acknowledged by Mr. Zajicek, Minnesota Power needs to continue to work to deliver the HVDC Modernization Project as soon as possible.[17] As Mr. Zajicek notes in his Direct Testimony, the Bison Wind Energy Center would not be due for repowering until 2035-2040.[18] The Oliver County I and II facilities, for which Minnesota Power has a power purchase agreement through 2040, were recently repowered. With a latest in-service date for the Project by 2030[19] and potentially earlier than that, the timing simply does not align to retire the HVDC System and the North Dakota wind energy resources at the same time. Failing to undertake the HVDC Modernization Project would leave Minnesota Power customers with significant stranded generation assets that the existing AC transmission system could not support without major upgrades.

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[17] Zajicek Direct at 16:1-14.
[18] Zajicek Direct at 19:11-13.
[19] As noted earlier, this is the guaranteed in-service date for Minnesota Power's proposed configuration of the HVDC Modernization Project.

Q. Please explain how ceasing to utilize the North Dakota wind generation facilities is equivalent to the no-build alternative discussed in the Application.

A. In the end, Mr. Zajicek's inquiry into whether the HVDC Modernization Project may be avoided by ceasing to utilize the existing North Dakota wind energy resources is essentially the same as the delay and no-build alternatives discussed in the Application. This alternative does not address the urgent asset renewal needs of the existing HVDC System, does not continue or expand reliable and efficient delivery of high-capacity renewable energy resources to Minnesota Power's customers, and does not provide the same local reliability benefits to Minnesota Power's local 230 kV transmission system.

Even if it were possible to obtain replacement renewable energy resources closer to Minnesota Power's service territory and that obtaining these replacement resources could potentially eliminate the need for the HVDC Modernization Project and the HVDC System itself (which Minnesota Power does not agree with), the alternative is not to "do nothing" with the HVDC System and the surrounding AC System. As discussed in Section 4.8.2 of the Application, the retirement of the HVDC System would likely lead to many AC transmission upgrades, with anticipated costs and environmental impacts significantly exceeding those of the Project. While these AC transmission network upgrades are somewhat related to the wind energy resources located on the North Dakota end of the HVDC System, they are also reflective of the embedded role of the HVDC System in the AC transmission network. Over the course of the last approximately 50 years, the AC network in North Dakota and Minnesota has been planned and built up around the presence of the HVDC System. Its removal is not a trivial matter – especially at a time when bulk long-distance transfer capability for renewable energy resources is at a premium. The removal of the HVDC System and would be certain to result in costly network upgrades regardless of assumptions about Minnesota Power's North Dakota wind energy resources.

Q. Did Minnesota Power provide the DOC-DER with the information necessary to address its questions related to overall costs of a no-build alternative?

A. Yes. This information was provided in response to DOC IR 013. A copy of this response is attached to my Rebuttal Testimony as Rebuttal Schedule 11. In his Direct Testimony, Mr. Zajicek puts forward a rough cost of $492,750,000 for a no-build alternative based on the average hourly cost of outages provided by Minnesota Power in response to DOC IR 008, a copy of which is attached to the Direct Testimony of Mr. Zajicek at Attachment 3.[20] While Mr. Zajicek's approach rightly includes long-term outage costs for congestion and replacement power, it inadvertently omits the cost of AC network upgrades that would be required for a true "no-build" alternative.

As stated by Minnesota Power in the Application and in response to DOC IR 013, and as Mr. Zajicek acknowledges in his Direct Testimony, it is important to recognize that there is not a true "no-build" alternative to the Project.[21] With no viable plan to modernize the existing HVDC converters, Minnesota Power would immediately need to begin developing alternative AC transmission solutions. These alternative AC transmission solutions would be required to facilitate continued delivery of Minnesota Power's existing North Dakota wind energy, mitigate system impacts caused by the retirement of the HVDC System as identified in coordination with MISO and neighboring utilities to comply with NERC transmission planning standards, and replace the grid support that will be provided by the VSC HVDC converters. Based on Minnesota Power's analysis of retiring the HVDC Line and mitigating the associated network upgrades with AC transmission solutions, discussed in Section 4.8.2 of the Application, Minnesota Power concluded that the cost of the AC network upgrades could be nearly double the estimated mid-range cost of the Project, approximately $1.4 billion. This amount does not include analysis of additional outage and congestion impacts, such as the $492,750,000 calculated by Mr. Zajicek. Some amount of that cost would still be realized in addition to the $1.4 billion due to the loss of the congestion

[20] Zajicek Direct at 11:13 and 21:16-19.
[21] Zajicek 18:13-19:6.

management capabilities of the HVDC Line. Therefore, the Company has demonstrated that the true cost of a "no-build" alternative would be far greater than the cost of the HVDC Modernization Project.

Q. Did Minnesota Power provide the DOC-DER with the information Mr. Zajicek requested regarding a distributed generation alternative to the HVDC Modernization Project?

A. Yes. This information was provided in response to DOC IR 014. A copy of this response is attached to my Rebuttal Testimony as Rebuttal Schedule 12. Mr. Zajicek's initial understanding, as stated in his Direct Testimony, is correct in that it is "unlikely that distributed generation alone could be an alternative for the" HVDC Modernization Project.[22]

B. DOC-DER's Concerns with the ATC Arrowhead Alternative

Q. Please summarize Mr. Zajicek's concerns or open questions related to the ATC Arrowhead Alternative.

A. Mr. Zajicek discusses unresolved questions about the ATC Arrowhead Alternative regarding its scope and cost (particularly with respect to the need for the Arrowhead phase shifting transformer ("PST")), potential impacts on project schedule, potential impacts on Minnesota Power's state and federal grant opportunities, and impacts on the Arrowhead-Weston 345 kV Project 800 MVA limitation. Mr. Zajicek also rightly notes that prior to filing Direct Testimony, ATC had not provided any modeling to support its proposed configuration changes for the ATC Arrowhead Alternative. Further, with respect to the Arrowhead PST, Mr. Zajicek again rightly notes that ATC had provided nothing more than a general statement that ATC believes it is no longer necessary.[23]

[22] Zajicek Direct at 23.
[23] Zajicek Direct at 37:1-2.

Q. Has the Company already responded to any of these concerns in its Direct Testimony?

A. Yes. I have addressed questions relating to the scope and cost of the ATC Arrowhead Alternative, project schedule impacts, and the Arrowhead PST in my Direct Testimony and further expand upon those items in Section IV of my Rebuttal Testimony. I also provided an overview of the history and significance of the 800 MVA limit in my Direct Testimony. Questions regarding the impact of the ATC Arrowhead Alternative on Minnesota Power's state and federal grant applications are addressed in the direct and rebuttal testimonies of Company witness Mr. Gunderson.

Q. What is your response to Mr. Zajicek's concerns regarding the 800 MVA Limit?

A. Mr. Zajicek correctly identified that no request to remove the 800 MVA limitation on the ATC Arrowhead 345 kV/230 kV Substation had been submitted to the Commission. Unfortunately, and based on erroneous information provided by ATC, Mr. Zajicek may incorrectly understand the 800 MVA limitation to be an audible noise limitation and not a power flow limitation.

Q. What information can you provide regarding Mr. Zajicek's questions regarding the 800 MVA limitation?

A. I provide information on the origination and purpose of the 800 MVA limitation in my Direct Testimony at Section IV.B. The limitation was put in place to ensure power flows into Wisconsin were limited at 800 MVA. The record information from the Minnesota Environmental Quality Board proceeding for the Arrowhead – Weston 345 kV Transmission Line Project, attached to my Direct Testimony at Schedules 31-34, explain the origination of this limitation and that it was a power flow, not a noise, limitation placed on that transmission project.

Minnesota Power's proposed configuration of the HVDC Modernization Project would not result in exceedances of this 800 MVA limitation placed on the ATC Arrowhead 345 kV/230 kV Substation. Minnesota Power's analysis of the ATC Arrowhead

Alternative and ATC's own limited study of the ATC Arrowhead Alternative both demonstrate that the ATC Arrowhead Alternative as proposed by ATC would result in exceedances of the 800 MVA limitation at the ATC Arrowhead 345 kV/230 kV Substation. In fact, in the Direct Testimony of ATC witness Mr. Dagenais, ATC confirms that "[Minnesota Power] is correct that implementation of the [ATC Arrowhead Alternative] could cause flows through the Arrowhead 345/230 kV transformer to exceed 800 MVA" if the Commission ordered construction of the ATC Arrowhead Alternative.[24]

Q. Can the 800 MVA limitation be maintained with the ATC Arrowhead Alternative?

A. Yes, but not with the configuration proposed by ATC. Instead, not only would the existing PST need to remain in place, but another PST would need to be added at the ATC Arrowhead 345 kV/230 kV Substation to provide the control capability to schedule power flow into the Minnesota Power 230 kV/115 kV Substation to maintain the flow into the ATC Wisconsin transmission system below the 800 MVA limit. Adding this PST would increase the cost of the ATC Arrowhead Alternative by nearly $30 million above the estimate for ATC's preferred ATC Arrowhead Alternative configuration. I provide updated cost estimate information for both the ATC Arrowhead Alternative and Minnesota Power's proposed Project configuration in Section IV.C. of my Rebuttal Testimony. The Minnesota Power customer impact of this cost increase is discussed in the Direct Testimony of Company witness Mr. Gunderson at Section IV.C. and an update is provided in Mr. Gunderson's Rebuttal Testimony at Section III. To maintain the 800 MVA limitation, the ATC Arrowhead Alternative would cost considerably more than Minnesota Power's proposed configuration of the HVDC Modernization Project.

[24] In making this statement, Mr. Dagenais erroneously confines the applicability of the 800 MVA limitation to the ATC Arrowhead 345 kV/230 kV transformer only. In reality, the 800 MVA limitation is meant to regulate the flow of power into Wisconsin through the transformer and onto the Arrowhead-Weston 345 kV transmission line. As such, both the power flow through the transformer and the power leaving the ATC Arrowhead 345/230 kV Substation and flowing into Wisconsin need to be considered when evaluating this limit

IV. RESPONSE TO ATC DIRECT TESTIMONY

Q. Please summarize the portions of ATC's Direct Testimony that you will be discussing in your Rebuttal Testimony.

A. I will be responding to Mr. McKee's mischaracterization of Minnesota Power's pre-Application information gathering meetings and correspondence with ATC; Mr. Larsen's testimony on proposed equipment and sequencing of the ATC Arrowhead Alternative; Mr. Johanek's cost estimate information that was not developed using the same basic assumptions used for Minnesota Power's proposed HVDC Modernization Project configurations, as well as Mr. Johanek's schedule information, including how ATC's proposal would negatively impact the overall in-service schedule of the Project; and Mr. Dagenais' system performance conclusions that are based on studies that are limited in scope and, in some cases, inconsistent with typical transmission planning practice and which, even if taken at face value, support the concerns raised in Minnesota Power's Direct Testimony that ATC is seeking to implement an alternative that would be entirely paid for by Minnesota Power customers but will transfer benefits away from Minnesota Power customers and to the Wisconsin transmission system.

A. Early Conversations with ATC Regarding Configuration and Project Need

Q. Please explain ATC's perspective on meetings with Minnesota Power in late 2022 regarding the HVDC Modernization Project.

A. In Direct Testimony, ATC's witness, Mr. McKee, states that during a meeting on September 23, 2022, Minnesota Power "notified ATC of its intent" to interconnect the HVDC Line to the ATC Arrowhead 345 kV/230 kV Substation but then "that changed" in an October 10, 2022 meeting and an October 14, 2022 email, "when [Minnesota Power] informed ATC of its intention to build a new St. Louis County Substation . . . rather than to interconnect the [HVDC Modernization Project] to the [ATC] Arrowhead [345 kV/230 kV] Substation, contrary to its statement in September 2022." Mr. McKee characterizes Minnesota Power's decision regarding the configuration for the HVDC Modernization Project as an "abrupt turn" and a "sudden change of course."[25]

[25] McKee Direct at 7:1-2.

Q. Do you agree with Mr. McKee's characterization of these discussions between Minnesota Power and ATC?

A. No. While I can understand that this is Mr. McKee's perspective, this series of conversations requires a significant amount of context. Minnesota Power originally requested to initiate these discussions with ATC transmission planning personnel via email on September 19, 2022, as shown in Rebuttal Schedule 13 to my Rebuttal Testimony. Contrary to Mr. McKee's summary provided in response to MP IR 008 (McKee Direct Schedule 1), this email on September 19, 2022, was the first time Minnesota Power notified ATC of the Company's intent to upgrade the converter stations associated with its HVDC Line. Minnesota Power's September 19, 2022, communication to ATC provides some of this context that is important to understanding the series of discussions that followed. At that time, and as stated in the email, Minnesota Power was "considering" moving the point of interconnection for the HVDC System from the Minnesota Power Arrowhead 230 kV/115 kV Substation to the ATC Arrowhead 345 kV/230 kV Substation. Minnesota Power was in an exploratory phase of project development at the time and was seeking collaboration with ATC to gain a better understanding of the potential configuration involving the ATC Arrowhead 345 kV/230 kV Substation.

As illustrated in Schedule 24 to my Direct Testimony, Minnesota Power began to explore configuration opportunities together with ATC during the September 23, 2022, meeting. While slide 5 of that presentation states that Minnesota Power, at that time, had a "preference" to move from the 230 kV bus to a 345 kV bus, slide 6 identifies both a 230 kV option and a 345 kV option on the map. Further, the presentation notes that the potential relocation of the point of interconnection to the ATC Arrowhead 345 kV/230 kV Substation is "so the converter transformers do not have to be replaced at a later date." Thus, leaving the door open for consideration of other configurations that accomplish the same purpose.[26] After the September 23 discussion, Minnesota Power sent a follow-up email to the meeting participants outlining next steps, which is attached as Rebuttal Schedule 14 to my Rebuttal Testimony. In that email Minnesota Power stated the purpose of the next meeting would be to "define [a] path forward," acknowledging that there was not, at the time, a defined or committed path forward for the HVDC Modernization Project with respect to its configuration and the discussions between Minnesota Power and ATC.

Minnesota Power coordinated schedules with ATC and then provided a meeting request for the planned follow-up discussion on October 10, 2022. In this meeting request, which is attached to my Rebuttal Testimony as Rebuttal Schedule 15, Minnesota Power restated its exploratory process, as the meeting was requested to continue "discussion of MP's request to *look at* moving from 230 kV bus to 345 kV bus . . ." (emphasis added). While it is reasonable Mr. McKee may have developed the impression during these discussions that Minnesota Power, at the time, favored moving the point of interconnection for the HVDC System to the ATC Arrowhead 345 kV/230 kV Substation, the Company had been clear in its communications since introducing the topic on September 19 that no such decision or commitment had yet been made.

Q. Is Mr. McKee's assessment that Minnesota Power's plan for the HVDC Modernization Project apparently changed between the September and October 2022 meetings with ATC accurate?

A. Not exactly. Minnesota Power was still developing its plan and gathering information from ATC and internal resources at this time and did not have a set plan for the AC interconnection components of the HVDC Modernization Project at the time of the discussions with ATC. The Company was in the midst of a planning process where it

[26] See my Direct Testimony, Section III, for an extensive discussion of how Minnesota Power considered the need for 345 kV converter transformers in balance with the need to maintain the existing HVDC System point of interconnection at the Minnesota Power Arrowhead 230 kV/115 kV bus in making the determination that construction of the new St. Louis County 345 kV/230 kV Substation was the best solution for the HVDC Modernization Project.

was considering options to define the overall configuration of the Project and had invited ATC into that process to gain a better understanding of the option to interconnect to the ATC Arrowhead 345 kV/230 kV Substation. Similar to Mr. McKee's statements in his Direct Testimony about ATC's normal planning coordination discussions with its neighbors,[27] Minnesota Power interacts with ATC and other neighboring utilities as a normal course of business when considering options and planning new transmission facilities. Minnesota Power would not unilaterally decide that it should interconnect its facilities with those of another utility but would instead collaborate with that utility to understand the feasibility, scope, and process for establishing such an interconnection. During these conversations with ATC, and in its subsequent internal deliberations, Minnesota Power gained critical insight into the complexities and risks of moving the HVDC System point of interconnection from the Minnesota Power Arrowhead 230 kV/115 kV Substation to the ATC Arrowhead 345 kV/230 kV Substation.

Q. What key considerations regarding an interconnection to ATC's substation arose during and after that September 2022 meeting with ATC?

A. During the September 23, 2022, meeting, as alluded to on slide 7 of Schedule 24 to my Direct Testimony, Minnesota Power and ATC began to discuss what modifications would be required at the ATC Arrowhead 345 kV/230kV Substation and what study work would be necessary to facilitate moving the point of interconnection for the HVDC System. As a result of the discussion, two critical assumptions arose regarding an interconnection at the ATC Arrowhead 345 kV/230 kV Substation: (1) a second 345 kV/230 kV transformer would need to be installed at the ATC Arrowhead 345 kV/230 kV Substation; and (2) the existing ATC Arrowhead PST would either need to be bypassed and removed or a second PST would need to be installed. These material modifications to the existing ATC Arrowhead 345 kV/230 kV Substation increased the complexity and, potentially, the cost of this configuration while providing no apparent benefit to Minnesota Power's customers over a configuration option that maintained the existing HVDC System point of interconnection at the Minnesota Power Arrowhead

[27] McKee Direct at 4:1-2

230 kV/115 kV Substation. I discuss these issues at length in Section IV.A. of my Direct Testimony.

As I explained in my Direct Testimony at Section IV, Minnesota Power took this information and other feedback received from ATC during the September 23, 2022, meeting into its internal and iterative planning process and continued its evaluation of the overall HVDC Modernization Project configuration. In light of HVDC Modernization Project need and schedule considerations, the additional complexities associated with interconnecting at the ATC Arrowhead 345 kV/230 kV Substation and the perceived risk of delegating critical path components of the HVDC Modernization Project to a third party outside of Minnesota Power's direct control both raised significant concerns within Minnesota Power regarding the concept of moving the HVDC System point of interconnection to the ATC Arrowhead 345 kV/230 kV Substation. Minnesota Power's internal discussions focused on the need to develop the greatest amount of certainty and control over the development and implementation schedule for the HVDC Modernization Project, as well as the need to maximize the beneficial attributes of the Project for Minnesota Power's customers. Additionally, Minnesota Power identified concerns with the 800 MVA power flow limitation that was ordered by the Minnesota Environmental Quality Board for the ATC Arrowhead 345 kV/230 kV Substation (including unknown regulatory response to any modification of that limitation) and cost considerations for the PSTs potentially necessary to maintain this limit. At the same time, the potential long-term need for a stand-alone St. Louis County Substation, as MISO had been proposing since the initiation of the LRTP study, also remained part of Minnesota Power's internal discussions.

As a result, Minnesota Power began to more seriously consider the option of installing the new 345 kV/230 kV transformer required for the Project in the new St. Louis County 345 kV/230 kV Substation rather than the ATC Arrowhead 345 kV/230 kV Substation. With a new 230 kV connection from the St. Louis County 345 kV/230 kV Substation to the existing HVDC System 230 kV point of interconnection at the Minnesota Power

Arrowhead 230 kV/115 kV Substation, this potential configuration not only would mitigate Minnesota Power's concerns with the alternative ATC substation configuration but would do so with a similar overall cost and greater benefits to Minnesota Power's customers.

Q. How and when did Minnesota Power communicate its consideration of these two configuration options to ATC?

A. Minnesota Power met with ATC again on October 10, 2022. During that meeting, Minnesota Power was able to share more information about the configurations under consideration and benefits associated with those options described in Schedule 25 to my Direct Testimony. At that time, Minnesota Power also shared detailed electrical configuration information about both options with ATC, re-affirming its plan[28] to construct a standalone St. Louis County Substation regardless of which option moved forward, as shown in Schedule 26 to my Direct Testimony.[29] As explained in Schedule 27 to my Direct Testimony, on October 14, 2022, Minnesota Power confirmed with ATC that the HVDC Modernization Project configuration including a new St. Louis County 345 kV/230 kV Substation with a 230 kV AC point of interconnection at the Minnesota Power Arrowhead 230 kV/115 kV Substation "is the right fit . . . as opposed to the complexities introduced by moving to the [ATC] Arrowhead 345 kV bus." Because Minnesota Power's plans no longer involved or directly impacted ATC's Arrowhead 345 kV/230 kV Substation, Minnesota Power considered the collaborative process of discussing this potential configuration with ATC to have successfully come to an end at this point and began to make plans to move forward as expeditiously as possible with its proposed HVDC Modernization Project configuration. To the extent

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[28] Minnesota power had originally informed ATC of its intention to build a standalone St. Louis County Substation in the initial September 19, 2022, email to Mr. McKee and others, stating "The plan would also involve establishing a new 345 kV yard ("St Louis County") at the VSC-HVDC converter station with expandability to accommodate future 345 kV development in Northern Minnesota."

[29] Also at this time, as shown in Schedule 26, Minnesota Power disclosed to ATC its plan to bring an additional 230 kV line into the Minnesota Power Arrowhead 230 kV/115 kV Substation from the Hilltop Substation as part of the Minnesota Power Duluth Loop transmission project (MPUC Docket No. E015/CN-21-140 and E015/TL-21-141). Unfortunately, this planned development does not appear to have been communicated to Mr. Larsen (see response to Mr. Larsen's Direct Testimony in Section IV.B. of my Rebuttal Testimony).

ATC had concerns about Minnesota Power's plans for the HVDC Modernization Project, it did not make any meaningful effort to further engage with Minnesota Power after sending the October 2022 response from Mr. Dagenais that ATC continued to support "leveraging Arrowhead."[30] I did not personally hear from anyone at ATC about the HVDC Modernization Project again until the second half of 2023, after Minnesota Power had received a Commission determination of completeness on its Application for the HVDC Modernization Project.

Q. Do you agree with Mr. McKee's characterization of Minnesota Power's communications during the October 10, 2022, meeting and subsequent communications in October 2022?

A. No. In his Direct Testimony and in his response to MP IR 008 (McKee Direct Schedule 1), Mr. McKee emphasizes Minnesota Power's disclosures to ATC about long-term planning considerations for the HVDC Line and the St. Louis County 345 kV/230 kV Substation. As demonstrated in my Direct Testimony, the preceding discussion in this Rebuttal Testimony, and supporting Schedules which I have attached to my direct and rebuttal testimonies, the Company's first priority and primary focus in all of its collaboration with ATC was to identify the best solution to meet Minnesota Power customers' needs for the HVDC Modernization Project. I also disagree with Mr. McKee's characterization of Minnesota Power's decision regarding the best configuration for the HVDC Modernization Project as an "abrupt turn" and a "sudden change of course."[31] My Direct Testimony includes extensive information on the iterative project development process Minnesota Power undertook over many years. Much of the information regarding Minesota Power's internal planning consideration of the best interconnection configuration for the HVDC Modernization Project was made available to Mr. McKee prior to the development of his Direct Testimony through Minnesota Power's responses to ATC's information requests, such as ATC IR 010, attached to my Rebuttal Testimony as Rebuttal Schedule 16, and ATC IR 021,

[30] See Winter Direct Section IV (page 56:11-17).
[31] McKee Direct at 7:1-2.

significant attachments to which were attached to my Direct Testimony as Schedules 22, 23, 24, 25, and 26. Further, the communications with ATC in 2022 emphasize the ongoing process of consideration and development of a plan for the HVDC Modernization Project. Having participated in Minnesota Power's extensive internal conversations and many years of internal analysis, I can assure you that Minnesota Power has not made abrupt or sudden decisions in the planning of the HVDC Modernization Project.

Q. Do you have any other comments on ATC's recollection of these interactions?

A. Yes. Mr. McKee states that it was Minnesota Power's filing of the Application that "moved this discussion to the current docket."[32] Minnesota Power, when it met with Mr. McKee and others from ATC in September 2022 stated its intention to file the Application as early as "January 2023."[33] From the time Minnesota Power informed ATC of its plan to proceed with the interconnection at the Minnesota Power Arrowhead 230 kV/115 kV Substation in October 2022 until August 2023, ATC remained silent as to its intent to formally object to Minnesota Power's proposed HVDC Modernization Project configuration and propose its own system alternative. In the midst of attempting to meet with ATC to discuss its concerns, Minnesota Power only found out that ATC was filing its request for the Commission to consider the ATC Arrowhead Alternative when Mr. McKee spoke with a Company executive on the day of ATC's filing, September 15, 2023. Minnesota Power had informed ATC in October 2022 that Minnesota Power could file its Application for the HVDC Modernization Project as early as January 2023, and that Minnesota Power intended to move forward with a Project configuration that involved constructing the St. Louis County 345 kV/230 kV Substation to maintain the HVDC System point of interconnection at the Minnesota Power Arrowhead 230 kV/115 kV Substation. Unfortunately, ATC chose to wait more than nine months before engaging with Minnesota Power again on this issue, at which

[32] McKee Direct at 8:18-21.
[33] Winter Direct Schedule 24 at 7.

point there was very little time for Minnesota Power and ATC to have meaningful and collaborative discussions about ATC's concerns.

Q. Is it reasonable for ATC to expect Minnesota Power to plan for both its proposed HVDC Modernization Project configuration and the ATC Arrowhead Alternative?

A. No. In its response to LPI IR 002, attached as Rebuttal Schedule 17, ATC states that "At this time, [Minnesota Power] should be conducting detailed studies of both its preferred point-of-interconnection for the Project . . . and the [ATC Arrowhead Alternative] to prepare for the possibility the Commission could order implementation of either alternative." Setting aside open questions about the scope, configuration, and system impacts of the ATC Arrowhead Alternative, which are addressed in my Direct Testimony and subsequent sections of my Rebuttal Testimony, and which make it impractical for the Company to proceed with detailed design studies for the ATC Arrowhead Alternative without first studying and developing it more thoroughly, this proposition fundamentally undermines ATC's arguments with respect to the benefits of the ATC Arrowhead Alternative. When faced with legitimate concerns about the impact of the ATC Arrowhead Alternative on the benefits, costs, and schedule of the HVDC Modernization Project, it appears that ATC's solution is for Minnesota Power to spend twice the amount of time and money with its own internal resources, consultants, and HVDC Supplier to simultaneously develop the ATC Arrowhead Alternative in parallel with Minnesota Power's own thoroughly-developed and carefully-crafted HVDC Modernization Project configuration.

Under this scenario proposed by ATC, Minnesota Power would need to double the employee hours that are already being dedicated to the HVDC Modernization Project and likely double the contract work for the HVDC Supplier and other key consultants, such as Minnesota Power's HVDC Owner's Engineer – all at a real and material cost to Minnesota Power's customers. Minnesota Power is not as large of a utility as ATC and does not have unlimited resources to expend on completing double the work: (1) for a well-considered and studied HVDC Modernization Project configuration and (2) in parallel for a configuration in the ATC Arrowhead Alternative that Minnesota Power considers to be inferior from a cost, schedule, and customer benefit standpoint. In this instance, unfortunately, ATC's responses and expectations are not indicative of an overarching concern for Minnesota Power's customer's needs or a spirit of "continued collaboration" as Mr. McKee states in his Direct Testimony.[34]

B. <u>ATC Arrowhead Alternative Equipment and Sequencing</u>

Q. Do you have any comments on the expansion of the ATC Arrowhead 345 kV/230 kV Substation for the ATC Arrowhead Alternative as described in Mr. Larsen's Direct Testimony?

A. Yes. Mr. Larsen notes that two existing 345 kV capacitor banks located in the southeast corner of the ATC Arrowhead 345 kV/230 kV Substation must be removed for ATC to relocate the terminus of the existing ATC Arrowhead-Weston 345 kV transmission line and ultimately create an open bay for interconnection of the second proposed 345 kV/230 kV transformer necessary for the ATC Arrowhead Alternative.[35] As I discuss later in my Rebuttal Testimony at Section IV.E., transmission system impacts from the removal of these 345 kV capacitor banks have not been thoroughly vetted and Minnesota Power's studies[36] cast doubt on the reasonableness of ATC's assumption that this equipment is no longer needed.[37] To the extent ATC's plan for reconfiguring the ATC Arrowhead 345 kV/230 kV Substation to accommodate the ATC Arrowhead Alternative relies on the removal of these capacitor banks, ATC's current proposed plan may require revisions, such as retaining, relocating, or replacing the existing capacitor banks, that would impact both the schedule and cost of the ATC Arrowhead Alternative.

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[34] McKee Direct at 8:18-19.
[35] Larsen Direct at 6-7 and Exhibit 3.
[36] Winter Direct Schedule 14 (2024 ATC Arrowhead Alternative Concept Power Flow Analysis); Winter Rebuttal Schedule 18 (2024 MWEX Stability Study).
[37] While these Minnesota Power studies are not definitive, they do raise questions that require further study before implementation of the proposed configuration, which will require time, money, and resources not needed to be expended for the Minnesota Power configuration of the HVDC Modernization Project.

Q. Is there any equipment Minnesota Power believes is absent from this discussion?

A. Yes. In addition to the likely need to retain the existing 345 kV capacitor banks at the ATC Arrowhead 345 kV/230 kV Substation, the ATC Arrowhead Alternative should consider the potential need to retain the existing 230 kV PST and install a second 230 kV PST, along with its associated bypass circuit breaker and other equipment. As discussed extensively in Section IV of my Direct Testimony, and as I will discuss later in my Rebuttal Testimony in response to the Direct Testimony of ATC witness Mr. Dagenais, the transmission system impacts and performance that would occur as a result of the removal of the existing PST and absence of a new PST for the ATC Arrowhead Alternative have not been thoroughly vetted. Further, Minnesota Power's studies cast doubt on the reasonableness of ATC's assumptions that this equipment is not necessary for the effective implementation of the ATC Arrowhead Alternative. To the extent ATC's proposed reconfiguration of the ATC Arrowhead 345 kV/230 kV Substation to accommodate the ATC Arrowhead Alternative does not include the installation of a second 230 kV PST, this plan may require revisions that could lead to space constraints in the substation and would certainly impact both the cost and schedule of the ATC Arrowhead Alternative.

Q. Do you agree with the scope of work Mr. Larsen describes in his Direct Testimony for the ATC Arrowhead Alternative?

A. No. In addition to my concerns about the 345 kV capacitor bank and the 230 kV PSTs, I will also note that Mr. Larsen's assumption about the configuration of the interconnections between the 345 kV/230 kV transformers and the Minnesota Power 230 kV/115 kV Substation are not valid. To connect the new 345 kV/230 kV transformer for the ATC Arrowhead Alternative to the Minnesota Power 230 kV/115 kV Substation, Mr. Larsen states that the connection for the existing 345 kV/230 kV transformer lead line would be relocated from its current point of connection to the Minnesota Power 230 kV/115 kV Substation to "an existing open rung just to the west of its current location in [Minnesota Power]'s 230/115 kV substation yard."[38] In reality,

[38] Larsen Direct at 7:10-13.

by the end of 2025, this existing rung that Mr. Larsen assumes is open and available for ATC's 345 kV/230 kV transformer will actually be occupied by a new 230 kV line connection to the Minnesota Power Hilltop 230 kV/115 kV Substation. This new 230 kV line connection is being established as part of Minnesota Power's Duluth Loop Reliability Project.[39]

This oversight regarding the existing rung by ATC could have been readily identified if ATC had coordinated its plans for the ATC Arrowhead Alternative with Minnesota Power. Based on the actual equipment configurations and documented project plans, in order to accommodate the re-connection of the existing Arrowhead 345 kV/230 kV transformer as proposed by Mr. Larsen, Minnesota Power would have to reconstruct the newly-constructed Hilltop 230 kV transmission line so it aligns with the adjacent breaker position currently occupied by the existing ATC 345 kV/230 kV transformer, with removals and additions as shown on pages 11 and 12, respectively, of Rebuttal Schedule 19 to my Rebuttal Testimony.

I agree with Mr. Larsen that it is necessary to relocate the termination point of the existing 345 kV/230 kV transformer for the ATC Arrowhead Alternative to ensure that the new and existing 345 kV/230 kV transformers are not located on adjacent bus positions and subject to potential simultaneous outages. This situation is, however, another example of the very limited development and vetting that has been applied by ATC to the ATC Arrowhead Alternative and illustrative of the associated risks for cost and schedule if the Commission orders the construction of the ATC Arrowhead Alternative. Mr. Larsen himself acknowledges this uncertainty in his Direct Testimony, stating "the exact location for the termination of each transformer lead line could change depending on several factors that will need to be discussed and agreed upon with [Minnesota Power] during detailed design, including project construction sequence,

[39] *In the Matter of the Application of Minnesota Power for a Certificate of Need and a Route Permit for the Duluth Loop Reliability Project in St. Louis County, Minnesota*, Docket Nos. E015/CN-21-140 and E015/TL-21-141, ORDER GRANTING CERTIFICATE OF NEED AND ISSUING AND ROUTE PERMIT (Apr. 3, 2023).

outage schedule, asset ownership agreements, and reliability considerations."[40] All of these are items that Minnesota Power already has well underway or are not applicable for Minnesota Power's configuration of the HVDC Modernization Project. The fact that these items, necessary for the ATC Arrowhead Alternative as Mr. Larsen discusses, are not already well under way demonstrates the conceptual nature of the ATC Arrowhead Alternative and the continuing risk of the ability to meet a 2030 in-service date, let alone an accelerated Project delivery schedule, if the Commission orders the construction of the ATC Arrowhead Alternative.

C. ATC Arrowhead Alternative Cost Estimates

Q. Did ATC provide cost estimate information for the ATC Arrowhead Alternative with its Direct Testimony?

A. Yes. ATC witness Mr. Johanek provided information on ATC's estimated cost for the ATC Arrowhead Alternative.

Q. What is ATC's cost estimate for the Arrowhead Alternative and how is it characterized by Mr. Johanek?

A. According to Mr. Johanek, ATC's current estimate for the cost of the Arrowhead Substation Alternative is approximately $39.5 million, with a range of $34.9 million to $47.5 million (in 2022 dollars). In his Direct Testimony and in response to DOC IR 009, Mr. Johanek states that the cost was developed "based on consultations with suppliers and contractors" and includes a lower, middle, and upper range.[41] The mid-range reflects ATC's primary estimate in 2022 dollars, while the lower range reflects a -10% contingency and the upper range reflects a +20% contingency.[42]

[40] Larsen Direct at 7:14-16.
[41] Zajicek Direct at Attachment 4 (DOC IR 009); Winter Direct at Schedule 4 (DOC IR 009); Johanek Direct at 4:8-16.
[42] Johanek Direct at 4:3-7, 5:8-16.

Q. How does ATC's cost estimate for the ATC Arrowhead Alternative compare to Minnesota Power's cost estimate for the corresponding components of the HVDC Modernization Project, according to Mr. Johanek?

A. Mr. Johanek compares ATC's $39.5 million cost estimate to the $55 million cost estimate provided by Minnesota Power in the Application for the "Minnesota Interconnection Facilities" component of the HVDC Modernization Project.[43] Mr. Johanek concludes that the cost of the ATC Arrowhead Alternative is "significantly lower" than Minnesota Power's proposal.[44] Mr. Johanek further states that he believes ATC's cost estimate provides a more representative and accurate picture of the likely costs due to its having been developed "in consultation with . . . suppliers and contractors" as compared to Minnesota Power's original estimate based on "a general cost estimating guide."[45]

Q. Does Mr. Johanek provide any further context on the assumptions or component-level breakdown of ATC's cost estimate?

A. Mr. Johanek does not provide any insight into the underlying assumptions for ATC's cost estimate or provide documentation to support its reasonableness or accuracy, so it is not possible to evaluate ATC's assumptions or directly compare them with the MISO transmission cost estimating guide assumptions employed by Minnesota Power for the estimate provided in the Application for the HVDC Modernization Project or in other cost comparisons prepared by Minnesota Power for the ATC Arrowhead Alternative.

However, Mr. Johanek does provide a rough component-level breakdown of the costs of the ATC Arrowhead Alternative, as presented in his Direct Testimony and in ATC's response to DOC IR 009. A copy of this response is available at Schedule 4 to my Direct Testimony.

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[43] Johanek Direct at 5:17-6:9.
[44] Johanek Direct at 6:21.
[45] Johanek Direct at 6:14-17.

Q. Do you have any concerns with Mr. Johanek's comparison of ATC's cost estimate and Minnesota Power's cost estimate?

A. Yes. In his presentation of ATC's cost estimate, Mr. Johanek leaves out critical components of the "Minnesota Interconnection Facilities" that are common to both the ATC Arrowhead Alternative and Minnesota Power's proposed configuration. In omitting these components, Mr. Johanek's Direct Testimony gives the inaccurate impression that the cost of Minnesota Power's proposed configuration is "nearly 40 percent higher" than the cost of the ATC Arrowhead Alternative. Further, by using two different sets of cost estimating assumptions – one for the ATC Arrowhead Alternative and one for the HVDC Modernization Project Minnesota Interconnection Facilities – it is impossible to compare the two resulting costs and draw any reasonable conclusions from these estimates.[46]

Q. What common project costs were left out of ATC's cost estimate by Mr. Johanek, and why was it inaccurate to exclude those costs?

A. Mr. Johanek's estimate for the ATC Arrowhead Alternative leaves out the "Minnesota Land Acquisition" ($10 million mid-range) and "HVDC Line Entrance" ($2 million mid-range) components of the ATC Arrowhead Alternative cost estimate.[47] These two components represent Minnesota Power's estimated cost of Minnesota land acquisition for all Project needs and Minnesota Power's estimated cost of rerouting the existing HVDC Line to interconnect to the proposed new HVDC converter station in Minnesota, respectively. Both of these components are necessary in their entirety regardless of whether the Commission approves the Project configuration proposed by Minnesota Power or the ATC Arrowhead Alternative. With respect to the HVDC Line Entrance, Mr. Johanek acknowledges that this is a common Project component in his response to DOC IR 009, attached to my Direct Testimony as Schedule 4, where he states "Minnesota Power will be required to undertake this work regardless of whether the

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[46] Johanek Direct at 7:1.
[47] Gunderson Rebuttal Schedule 5.

Arrowhead Substation Alternative is implemented." After making this statement, he then erroneously omits the cost of this work from ATC's estimate while keeping it in Minnesota Power's estimate for his comparison. Regarding land acquisition, Minnesota Power made ATC aware that it had acquired all parcels necessary for the scope of the HVDC Modernization Project in its response to ATC IR 012, a copy of which is attached to my Rebuttal Testimony as Rebuttal Schedule 20. Therefore, ATC was already aware that the costs for land acquisition had been incurred for the Project by Minnesota Power regardless of whether the ATC Arrowhead Alternative or Minnesota Power's configuration of the HVDC Modernization Project is constructed. These costs were also omitted from ATC's estimate but retained in Minnesota Power's estimate for Mr. Johanek's comparison.

Q. What is the impact of restoring these common project costs into ATC's cost estimate for the ATC Arrowhead Alternative?

A. I have provided an updated comparison of Minnesota Power's original estimate for Minnesota Interconnection Facilities and ATC's cost estimate for the ATC Arrowhead Alternative with these common project costs restored, which is attached to my Rebuttal Testimony as Rebuttal Schedule 21. When these costs are restored to the ATC Arrowhead Alternative estimate provided by Mr. Johanek, ATC's mid-range cost estimate increases to $51.5 million, which is $3.5 million less that Minnesota Power's mid-range cost estimate of $55 million for the corresponding facilities of Minnesota Power's proposed configuration. To put this in context for the overall HVDC Modernization Project, this $3.5 million difference is less than one-half of one percent of the $800 million mid-range Project cost estimate provided by Minnesota Power in the Application. This difference does not rise to the level of being "significantly lower" when compared to Minnesota Power's proposed configuration of the HVDC Modernization Project. Finally, as discussed in more detail by Mr. Gunderson, the cost estimate provided by ATC for the ATC Arrowhead Alternative does not include the tax gross-up that it has proposed for the lump-sum payment it has stated would be required to be made by Minnesota Power and its customers if the Commission orders the construction of the ATC Arrowhead Alternative, which is substantive for determining the actual rate impact of the alternative.[48]

Q. Does Mr. Johanek omit any other potential costs for the ATC Arrowhead Alternative?

A. Yes. Mr. Johanek's cost estimate does not include the potential cost of an additional PST at the ATC Arrowhead 345 kV/230 kV Substation, which could add approximately $30 million to the cost of the ATC Arrowhead Alternative and introduce additional schedule impacts. Minnesota Power's estimate of the cost of the ATC Arrowhead Alternative, including an additional ATC Arrowhead PST, is also shown alongside Mr. Johanek's cost estimate (with common project costs restored as previously discussed) in Rebuttal Schedule 21. As discussed extensively in my Direct Testimony, and discussed later in my Rebuttal Testimony in response to the Direct Testimony of ATC's witness Mr. Dagenais, the transmission system impacts that could result from the removal of the existing PST at the ATC Arrowhead 345 kV/230 kV Substation have not been thoroughly vetted and Minnesota Power's studies cast doubt on the reasonableness of ATC's assumption that a new PST is not needed for the ATC Arrowhead Alternative.

Q. Has Minnesota Power taken any further steps to develop verifiable and comparable cost estimates for the ATC Arrowhead Alternative and Minnesota Power's proposed configuration of the HVDC Modernization Project?

A. Yes. As a result of the opaque cost estimate information provided by ATC in discovery responses and Direct Testimony for the ATC Arrowhead Alternative that were not developed in a manner consistent with cost estimates for the Minnesota Power configuration of the HVDC Modernization Project Minnesota AC Interconnection Facilities, Minnesota Power employed Burns and McDonnell, a well-known and reputable utility consulting firm whose engineering consultant resources Minnesota Power regularly employs, to develop detailed cost estimates for the major Minnesota

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[48] Gunderson Rebuttal Schedule 6 (ATC Response to MP IR 004).

Interconnection Facility substation components[49] of both Minnesota Power's proposed HVDC Modernization Project configuration and the ATC Arrowhead Alternative. These estimates were based on preliminary engineering analysis. The complete background assumptions, detailed cost estimate, and associated substation general arrangement drawings for Minnesota Power's proposed St. Louis County 345 kV/230 kV Substation are provided with my Rebuttal Testimony as Rebuttal Schedule 22. The complete background assumptions, detailed cost estimates, and associated substation general arrangement drawings (including demolition and new construction prints) for the ATC Arrowhead Alternative, with and without a new PST, are provided with my Rebuttal Testimony as Rebuttal Schedule 19 and Rebuttal Schedule 23, respectively.

Q. How are Minnesota Power's updated cost estimates for the proposed Project configuration and the ATC Arrowhead Alternative superior to prior estimates provided by Minnesota Power and ATC?

A. The updated estimates provided in Rebuttal Schedules 19, 22, and 23 to my Rebuttal Testimony are based on preliminary engineering analysis by a reputable and independent third-party consultant. The preliminary engineering analysis on which these estimates are based is approaching a 20-25 percent overall progression of design for both alternatives. These updated cost estimates for both the ATC Arrowhead Alternative and the Minnesota Power configuration of the HVDC Modernization Project are based on clearly-articulated, transparent, and uniformly-applied assumptions for both configurations. The estimate for the ATC Arrowhead Alternative also accurately reflects necessary modifications needed in the Minnesota Power Arrowhead 230 kV/115 kV Substation, which were not accurately represented in ATC's assumptions, as I discussed in Section IV.B of my Rebuttal Testimony.

[49] These estimates were developed so that a true equivalent comparison of the two alternatives could be established on the record in this proceeding.

Q. Based on the current cost estimates, how does the estimated cost of the ATC Arrowhead Alternative compare to the estimated cost of Minnesota Power's proposed HVDC Modernization Project configuration?

A. The comparison tables for Minnesota Power's proposed HVDC Modernization Project configuration and the ATC Arrowhead Alternative, including the updated substation cost estimates and retaining original assumptions for all other Minnesota Interconnection Facilities components, are provided in Rebuttal Schedule 24 to my Rebuttal Testimony. Without a PST, the ATC Arrowhead Alternative is estimated to cost $4 million less than Minnesota Power's proposed Project configuration. With a PST, the ATC Arrowhead Alternative is estimated to cost $27 million more than Minnesota Power's proposed Project configuration. These estimates do not include the financial impacts related to ATC's proposed reimbursement mechanism (lump sum plus tax gross up), which must be taken into account when preparing the individual customer rate impact analysis discussed in the Rebuttal Testimony of Company witness Mr. Gunderson. It is my understanding that when this reimbursement mechanism is applied to the cost of the ATC Arrowhead Alternative without a PST, the individual customer rate impact is higher for the ATC Arrowhead Alternative than for the Minnesota Power configuration of the HVDC Modernization Project.[50]

[50] The rate impact analysis provided in Mr. Gunderson's Rebuttal Testimony uses the original Minnesota Power-provided cost estimates based on MISO Cost Estimating Guide and the ATC-provided costs estimates for the ATC Arrowhead Alternative with common project costs restored to ensure an equivalent basis comparison. The revised estimates attached to my Rebuttal Testimony were not available at the time the analysis was complete. Despite this, the incremental cost difference ($4 million) is the same in both cost estimates, so the conclusions will be the same with respect to the comparison regardless of which estimate assumptions are used for the rate calculation

D. ATC Arrowhead Alternative In-Service Date

Q. Does Mr. Johanek's discussion about the proposed schedule for implementation of the ATC Arrowhead Alternative substantiate any of your concerns from your Direct Testimony?

A. Yes. Mr. Johanek only discusses a 2030 in-service date,[51] which would not allow Minnesota Power to achieve the accelerated in-service date as early as 2028 that it has been working so diligently to prepare for. As stated in response to ATC IR 030, attached to my Direct Testimony as Direct Schedule 35, Minnesota Power has been planning for completion of the AC interconnection facilities for the Project by the fourth quarter of 2027 to support a potential 2028 in-service date for the HVDC converter station.

Q. Do you have reason to believe that the HVDC Supplier could deliver the Project earlier than April 2030?

A. Yes. As Minnesota Power shared in response to ATC IR 043, attached to my Rebuttal Testimony as Rebuttal Schedule 25, since kicking off technical discussions with the HVDC Supplier in March 2023, Minnesota Power has had regular discussions with the HVDC Supplier regarding the status and timing of the Project. In recent discussions, the HVDC Supplier has indicated there is increasing potential for an earlier in-service date and that it is willing to begin discussing the opportunity more seriously with Minnesota Power. Confirming those recent discussions, the HVDC Supplier sent Minnesota Power a formal request on March 1, 2024, to begin discussing an early completion date for the HVDC Modernization Components during the planned Front End Studies and Engineering Design ("FEED") kickoff meeting in late March.

Q. Would the ATC Arrowhead Alternative impact the possibility of obtaining an earlier in-service date for the HVDC converter stations?

A. Yes. As stated in the formal request from the HVDC Supplier, the Company and the Supplier still need to "discuss certain conditions precedent thereto (**technical**,

[51] Johanek Direct at 9. Mr. Johanek also discusses ATC's response to MP IR 012, but no copy of this response is provided with Mr. Johanek's Direct Testimony nor is there a cross-reference to where this response may be found attached to another ATC witness' Direct Testimony.

regulatory, etc.). Further, the Parties should discuss how such conditions precedent would be **timely satisfied** to support any such Early Completion Date." (emphasis added). Given the front-end work that must be undertaken if the Commission orders construction of the ATC Arrowhead Alternative, including changes to technical assumptions of the Project, MISO coordination, studies, design, engineering, and negotiation of transmission-transmission project agreements, Minnesota Power may not be able to make the commitment for an earlier in-service date in a timely manner (with such commitment potentially necessary in mid- to late- 2024). In this situation, it is the Company's expectation that the opportunity for an earlier in-service date would no longer be available if the ATC Arrowhead Alternative is selected by the Commission.

Q. Do you have any other concerns with Mr. Johanek's discussion of the proposed schedule for implementation of ATC's Arrowhead Alternative?

A. Yes. The construction schedule provided by Mr. Johanek also does not address impacts from the ATC Arrowhead Alternative on the development and delivery of the HVDC converter station itself by Minnesota Power's HVDC Supplier.[52] As discussed in my Direct Testimony, delays introduced by additional MISO and Minnesota Power studies required for the ATC Arrowhead Alternative could put the HVDC Supplier's April 2030 delivery date in jeopardy.[53]

Q. Has Minnesota Power taken any further steps to determine if the ATC Arrowhead Alternative could cause a delay of the HVDC Supplier's guaranteed April 2030 delivery date.

A. Yes. Working with our HVDC Owner's Engineer ("HVDC OE"), Minnesota Power has developed a detailed comparison of the schedule for completing FEED leading up to the execution of definitive agreements and a final notice to proceed ("FNTP") with the HVDC Supplier. Minnesota Power's current plan for completing the FEED Phase of the HVDC Modernization Project development for the HVDC converter stations in

[52] *See* Johanek Direct Schedule 2.
[53] Winter Direct at 28:22-30:9 and 33:9-34:23.

coordination with the HVDC Supplier is illustrated in Rebuttal Schedule 26 to my Rebuttal Testimony. The anticipated impact of the ATC Arrowhead Alternative on the FEED Phase is illustrated in Rebuttal Schedule 27 to my Rebuttal Testimony.

Q. Please describe Minnesota Power's current plan for completing the FEED phase of project development for the HVDC converter stations.

A. The FEED process takes place in three stages. First Minnesota Power, working with its HVDC OE, completes various Pre-FEED activities such as gathering input data and completing studies in coordination with the HVDC Supplier. In this stage, most of the work is completed by Minnesota Power and the HVDC OE. The deliverables from this stage provide necessary inputs to the HVDC Supplier's work in the next stage. As described in my Direct Testimony, Minnesota Power has been working on completing its Pre-FEED activities since early 2023.

In the next stage, the HVDC Supplier takes Minnesota Power's input data and begins to complete the actual FEED activities that are necessary to define the technical specification and performance requirements for the HVDC converter stations. In this stage, most of the work is completed by the HVDC Supplier, with review and approval by Minnesota Power and its HVDC OE. The HVDC Supplier's activities, as Minnesota Power anticipates they will take place during FEED, as shown in Rebuttal Schedule 26.[54] This stage is scheduled to kick off on March 20, 2024. In parallel with the technical studies completed during this stage, Minnesota Power and the HVDC Supplier will also negotiate the terms and conditions of the final engineering, procurement, and construction ("EPC") contract.

In the final stage, the HVDC Supplier takes the completed technical specification for the HVDC converter stations based on the FEED studies and prepares a final offer, including firm pricing, for delivery of the HVDC converter stations by the guaranteed

[54] At this time, Minnesota Power has not received a detailed workback schedule from the HVDC Supplier for the completion of its FEED Phase activities. This is not expected until after the FEED kickoff.

April 2030 in-service date. This stage is scheduled to kick off in early 2026. The culmination of the FEED phase is the execution by Minnesota Power of the definitive EPC contract for the HVDC converter stations. At that point, Minnesota Power will give a FNTP directing the HVDC Supplier to move forward with delivering the HVDC converter stations. In order for the HVDC Supplier to meet the guaranteed April 2030 in-service date, Minnesota Power must give the FNTP no later than October 1, 2026. The above final state dates would move up if the guaranteed in-service date can be accelerated.

Q. What will happen to the guaranteed April 2030 in-service date if Minnesota Power does not give the FNTP to the HVDC Supplier on or before October 1, 2026?

A. The HVDC Supplier's guarantee of an April 2030 in-service date in the Preferred Supplier Agreement ("PSA") is contingent on certain schedule milestones being met by both parties. If Minnesota Power does not give the FNTP for the HVDC Supplier to move ahead with delivery of the HVDC converter stations by October 1, 2026, then the HVDC Supplier's guarantee of an April 2030 in-service date will no longer be valid under the PSA. At that point, Minnesota Power and the HVDC Supplier will need to determine how the delay impacts the manufacturing slot commitments made by the HVDC Supplier. If the major project components and resource commitments from the HVDC Supplier cannot move forward within the manufacturing slots already committed by the HVDC Supplier, those slot reservations would be lost. In that case, as discussed in my Direct Testimony, the next-available slots likely would not be able to support a 2030 in-service date. The global HVDC market continues to be very competitive and Minnesota Power's understanding from conversations with the HVDC Supplier is that slot reservations are currently being reserved into 2032. Therefore, if Minnesota Power misses the current contractual FNTP date because of the ATC Arrowhead Alternative, the overall in-service date for the HVDC Modernization Project could be delayed into 2032 or later.

Q. How would the ATC Arrowhead Alternative impact the completion of FEED and, ultimately, the guaranteed April 2030 in-service date?

A. As described in Section III.C.1 of my Direct Testimony and shown in my Rebuttal Schedule 27 the additional studies required for a full review of the system impacts of the ATC Arrowhead Alternative in coordination with MISO, along with the subsequent rework of Minnesota Power's pre-FEED studies, would delay the schedule for the completion of FEED with the HVDC Supplier by about 12 months overall. Even with relatively optimistic assumptions for the completion of specific studies and FEED activities compared to the current FEED schedule, the result would delay the FNTP date for the project from the contractual October 1, 2026, date to approximately September 2027. With typical HVDC converter station delivery times in the range of 40-42 months from FNTP, the delay from the ATC Arrowhead Alternative would render the guaranteed April 2030 in-service date unachievable.

E. <u>ATC Arrowhead Alternative Transmission System Performance</u>

Q. Did ATC provide system performance study information with its Direct Testimony?

A. Yes. ATC witness Mr. Dagenais provided information on three different planning analyses that ATC performed in recent months, which he claims demonstrate that the ATC Arrowhead Alternative "provides an as reliable or more reliable solution for interconnecting the Project . . .relative to [Minnesota Power]'s proposal."[55] In my Direct Testimony I expressed concern that no study had been conducted by ATC.

Q. Do ATC's studies address your concerns?

A. No. If anything, the approach taken by ATC for its studies, and the findings of those studies, confirm my concerns that further analysis of the ATC Arrowhead Alternative is necessary before concluding, as Mr. Dagenais does, that it is a reliable alternative for the configuration of Minnesota Power's HVDC Modernization Project. ATC's studies are relatively limited in scope, and the study files from ATC raise more questions than

[55] Dagenais Direct at 6:1-3.

answers about the methodology and assumptions employed by ATC. While it is not my intent to elaborate upon every question or criticism[56] of ATC's studies, there are several areas where ATC's studies fall short of the level of comprehensive analysis that should be expected to effectively analyze the ATC Arrowhead Alternative. Additionally, it is worth noting that the limited insights that may be gleaned from ATC's studies actually support the findings of Minnesota Power's studies, specifically regarding the transferal of benefits away from Minnesota Power's customers to the ATC Wisconsin transmission system that would result from the implementation of the ATC Arrowhead Alternative.[57]

Q. Why is it necessary for the ATC Arrowhead Alternative to be subjected to such a high level of comprehensive analysis?

A. As discussed in Section IV.A of my Direct Testimony, the ATC Arrowhead Alternative includes changes to the configuration of the transmission system that are neither trivial nor "simple," as claimed in several places in Mr. Dagenais' Direct Testimony.[58] In contrast to Minnesota Power's proposed Project configuration, which maintains the existing transmission system unchanged in terms of the HVDC System point of interconnection (at the Minnesota Power Arrowhead 230 kV/115 kV Substation), the ATC Arrowhead PST (in service), the ATC Arrowhead 345 kV/230 kV transformer (one transformer, not two), the ATC Arrowhead 345 kV capacitor banks (in service), and the Arrowhead-Weston Project 800 MVA limit (not exceeded), the ATC Arrowhead Alternative materially modifies each of these aspects.

[56] For example, Mr. Dagenais devotes a notable portion of his Direct Testimony to discussing the modeling of the Stinson PST, which is a matter only tangentially related to ATC's analysis of the Project and the ATC Arrowhead Alternative. ATC's apparent confusion about the modeling of this particular element of the existing transmission system could have easily been cleared up by simply discussing it with Minnesota Power. Regardless of its apparent significance to ATC, this issue does not have a meaningful impact on the comparison between the ATC Arrowhead Alternative and Minnesota Power's proposed HVDC Modernization Project configuration.

[57] Dagenais Direct at 33:4-13 (regional transfer of benefits if the ATC Arrowhead Alternative is implemented); Dagenais Direct at 38:15-16 (exceed the 800 MVA limitation on the ATC Arrowhead 345 kV/230 kV Substation).

[58] Dagenais Direct at 15:1 and 42:3.

The configurations of the HVDC System, the ATC Arrowhead 345 kV/230 kV Substation (including the ATC Arrowhead PST and 345 kV capacitor banks), and the Arrowhead – Weston 345 kV transmission line, as they exist today, were studied extensively and developed over many years in coordination with and with cooperation from several regional utilities before finally being implemented. These features have continued to be studied in their current configurations over many years of planning and operations since their original implementation. It should not be controversial to claim that a plan consisting of several substantive material modifications to important regional transmission system facilities (as would be necessary with the ATC Arrowhead Alternative) requires more scrutiny than has thus far been applied to the ATC Arrowhead Alternative. In fact, the studies thus far presented by ATC and Minnesota Power only emphasize this point.

Q. What new studies does Mr. Dagenais discuss in his direct testimony?

A. Mr. Dagenais discusses the results of three studies: (1) steady state reliability analysis: (2) dynamic stability reliability analysis; and (3) steady state voltage stability analysis. According to Mr. Dagenais, these specific studies were performed to "assess the relative performance of MP's proposal and the Arrowhead Substation Alternative under relevant planning criteria."[59]

Q. Please summarize Mr. Dagenais' discussion of the methodology and assumptions for ATC's steady state reliability analysis.

A. Mr. Dagenais first discusses the power flow models that ATC used for steady state analysis, which consisted of four models representing different seasonal and system conditions provided by Minnesota Power in response to ATC IR 005[60] and four additional models which ATC developed based on the latest MISO MTEP23 power flow models. In all eight power flow models, ATC generally mirrors the assumptions utilized by Minnesota Power for its studies. Mr. Dagenais provides his assessment of

[59] Dagenais Direct at 18:8-10.
[60] The applicable studies were attached to my Direct Testimony as Schedules 5, 6, 7, 8, 9, 10, 12, and 13.

these assumptions, stating they are, in some cases, "more aggressive than or inconsistent with" typical MISO MTEP modeling assumptions and reflect situations that he believes "have a low probability of occurring but would highly stress the system if they did occur."[61]

One assumption that Mr. Dagenais categorizes as a low probability, high-stress assumption, pertains to the scheduling of wind generation across the HVDC System up to its maximum rated capacity while simultaneously dispatching the Nemadji Trail Energy Center ("NTEC") at its full output near the ATC Arrowhead 345 kV/230 kV Substation.[62] Mr. Dagenais concludes that these assumptions are "not necessarily flawed" because it can be "reasonable to 'stress test' a project."[63]

Mr. Dagenais also discusses the importance of evaluating "multiple different scenarios" to provide a "more comprehensive picture" of system performance, noting specifically that findings of transmission planning studies "depend heavily on the inputs (or assumptions) that are utilized."[64]

Q. Do you agree with the methodology and assumptions employed by ATC for its steady state reliability analysis?

A. To the extent that ATC attempted to conduct a study mirroring the methodology and assumptions utilized by Minnesota Power, I agree with the study methodology. I do have several questions and concerns at a detail level about ATC's methodology that I believe would substantively improve its study results, but most of these would not be productive to discuss in Rebuttal Testimony. It is unclear to me why Mr. Dagenais specifically calls out what he calls the "low probability high-stress assumptions" about the HVDC Line and the NTEC facility, especially in view of the fact, as I discuss later, that this specific assumption is employed exclusively by ATC for its transient stability

[61] Dagenais Direct at 24:3-4 and 24:9-10.
[62] Dagenais Direct at 24:11-15.
[63] Dagenais Direct at 24:22-33.
[64] Dagenais Direct at 20:12-17.

and voltage stability studies. Nevertheless, I agree with Mr. Dagenais that it is important to develop aggressive assumptions to "stress test" the transmission system, that it is also important to study a variety of assumptions to provide a "comprehensive picture" of system performance, and that the findings of a study are fundamentally only as good as than the assumptions behind it.

Q. Please summarize Mr. Dagenais' discussion of the results of ATC's steady state reliability analysis.

A. Based on ATC's steady state reliability analysis, Mr. Dagenais concludes that the ATC Arrowhead Alternative and Minnesota Power's proposed HVDC Modernization Project configuration "result in similar performance" across all models evaluated by ATC, noting that potential overloads occur on many of the same monitored transmission facilities in each scenario.[65]

Q. Do you agree with Mr. Dagenais' conclusion?

A. No. The results from ATC's steady state reliability analysis show similar performance, but digging a little deeper into the study results, as Minnesota Power did in its 2024 Arrowhead Alternative Concept Power Flow Analysis (attached to my Direct Testimony as Schedule 14), would reveal that there are substantive differences. For example, as I discussed in my Direct Testimony, the ATC Arrowhead Alternative moves an additional seven to ten MW per 100 MW delivered over the HVDC System away from Minnesota Power customers and into the Wisconsin transmission system.

Q. How does ATC's steady state reliability analysis compare to Minnesota Power's power flow studies?

A. When compared to Minnesota Power's August 2023 HVDC Modernization Project Power Flow Analysis (attached to my Direct Testimony as Schedule 12) and 2024 ATC Arrowhead Alternative Concept Power Flow Analysis (attached to my Direct Testimony as Schedule 14), Mr. Dagenais' analysis provides a relatively limited view

[65] Dagenais Direct at 30:4.

into a comparison of the ATC Arrowhead Alternative with Minnesota Power's proposed HVDC Modernization Project configuration. ATC's steady state analysis is not particularly helpful for determining the actual system impacts of either configuration because the methodology and assumptions could be refined to improve the results of the study.

Q. What are the deficiencies of the steady state reliability analysis presented by Mr. Dagenais?

A. I have concerns with ATC's approach to modeling the Stinson PST, its decision not to include certain MISO LRTP Tranche 1 projects in Minnesota with the additional models it developed for these studies (as confirmed in ATC's response to MP IR 025, attached to my Rebuttal Testimony as Rebuttal Schedule 28), and its approach to modeling special protection systems like the Manitoba Hydro Remedial Action Scheme ("RAS") in its steady state analysis, all of which I can confirm were modeled accurately in all of Minnesota Power's analysis. Further, while Minnesota Power, in its 2024 ATC Arrowhead Alternative Concept Power Flow Study (Schedule 14 to my Direct Testimony), provides in-depth analysis to highlight some material disparities between the ATC Arrowhead Alternative and Minnesota Power's proposed configuration of the HVDC Modernization Project, ATC's steady state reliability analysis did not pursue the same level of in-depth analysis. Therefore, ATC's steady state analysis is not sufficient to fully and comprehensively demonstrate the reliability performance of either the ATC Arrowhead Alternative or Minnesota Power's proposed configuration of the HVDC Modernization Project.

Q. How do you respond to Mr. Dagenais' statement that the Stinson PST "was assumed to operate in a manner that was inconsistent with how MISO models that equipment" in Minnesota Power's models?[66]

A. Minnesota Power informed ATC of the proper approach to modeling the Stinson PST in response to ATC IR 034, subpart (e), attached to my Rebuttal Testimony as Rebuttal

[66] Dagenais Direct at 23:16-21.

Schedule 29. Upon reviewing the models provided by Minnesota Power and employed by ATC for its studies, along with the other MTEP models that ATC developed for its steady state reliability analysis, I was not able to identify any errors in the Minnesota Power models that would have impacted ATC's results if it was modeling the Stinson PST according to the typical methodology employed by Minnesota Power and MISO. The "inconsistent operating parameters" Mr. Dagenais appears to refer to in his testimony seem to be the maximum and minimum phase angle adjustment parameters available to the Stinson PST for automatic operations, for which I did see that there was a data entry error in Minnesota Power's original models that led to a more restrictive range of operation than would normally be expected. However, upon reviewing the models carefully I was able to determine that the Stinson PST was operating at the appropriate power flow schedule (0 MW) while the phase angle was still within the more restrictive range in all of the Minnesota Power-provided models. When evaluating post-contingent performance in steady state reliability analysis as ATC did, the maximum and minimum phase angle range parameters do not impact results because the normal methodology is to solve the post-contingent case with automatic PST adjustment disabled and then evaluate the impact of its post-contingent operations by manually adjusting the PST where study results indicate it would respond according to its control settings.[67]

This means that the Stinson PST should have been locked at its initial phase angle setting for all of ATC's contingency analysis. The initial pre-contingent phase angle already being within the more restrictive range would then result in modeling of the Stinson PST in a manner consistent with its normal operations, and there is, therefore, nothing about this minor data-entry error that would have impacted ATC's results if it was modeling the Stinson PST according to typical practices employed by Minnesota Power and MISO. While it is not clear why ATC was not able to come to this conclusion on its own, Minnesota Power appreciates ATC identifying this minor data-entry error so that the Company could take the proper steps to verify the results and update internal

[67] It is my understanding that the same modeling approach is typically applied to the ATC Arrowhead PST

models to reflect the correct minimum and maximum phase angle parameters for the Stinson PST going forward.

Q. Please summarize Mr. Dagenais' discussion of the methodology and assumptions for ATC's dynamic stability reliability analysis.

A. Mr. Dagenais states that ATC performed a dynamic (or "transient") stability study utilizing three dynamic stability models developed for the MISO MTEP23 study.[68] The models were modified by ATC so certain assumptions affecting the HVDC System were consistent with the power flow models used for steady state reliability analysis discussed above. Mr. Dagenais also states that ATC's modeling for Minnesota Power's HVDC converter stations was updated to "the VSC technology that MP is proposing for the project."[69] Significantly, Mr. Dagenais' Table 4 also shows that the NTEC generator (described in the table as "J732 Injection Level") is dispatched at its full capacity in all three of ATC's dynamic stability models.[70]

Q. Did Minnesota Power provide ATC with a dynamic model of the VSC HVDC technology that it is proposing for the HVDC Modernization Project?

A. No. In fact, in response to ATC IR 026, attached as Rebuttal Schedule 30 to my Rebuttal Testimony,[71] Minnesota Power stated that a final dynamic stability model for the HVDC Supplier's proposed VSC HVDC converter stations was not yet available. When asked to clarify the meaning of this statement in response to MP IR 026, ATC responded it had used a generic VSC HVDC model which it "understands . . .does not reflect the specific VSC configuration for the Project." This is important because generic stability models are inherently more limited in their ability to represent the actual expected response of the VSC HVDC converter than more customized user-written models or alternative approaches, to the point where HVDC Suppliers generally discourage the

[68] Dagenais Direct at 25:7-9.
[69] Dagenais Direct at 25:12-14.
[70] Dagenais Direct at 27.
[71] To my Rebuttal Testimony, I am only attaching the response and not the response attachments. ATC IR 026.01 was attached to my Direct Testimony as Schedule 11. ATC IR 026.02 Attach contains modeling files that include critical energy infrastructure information and are not filed.

use generic models for anything more than high-level screening analysis. While I agree with ATC's statement in response to MP IR 026 that the generic model was probably the best available option for its transient stability studies, the way that that this model is represented by Mr. Dagenais in his Direct Testimony gives a false impression of the accuracy and applicability of ATC's modeling of the VSC HVDC converters. A copy of ATC's response to MP IR 026 is included with my Rebuttal Testimony as Rebuttal Schedule 31.

Q. What is the significance of ATC's assumption regarding the NTEC generator?

A. As Mr. Dagenais states in his Direct Testimony, the findings of transmission planning studies "depend heavily on the inputs (or assumptions) that are utilized" and it is important to evaluate "multiple different scenarios" to provide a "more comprehensive picture" of system performance.[72] In this case, ATC has chosen to dispatch the NTEC generator for all study scenarios. This assumption will have a material impact on the results of its analysis and limit the comprehensiveness of the conclusions which may be drawn from the analysis. The impact of this assumption can be viewed both positively and negatively.

While the NTEC generator will generally contribute to improved transient stability performance for events outside of the immediate area of the NTEC generator and the Arrowhead Substations, dispatching it to full output at the same time the HVDC System is injecting its full capacity at the ATC Arrowhead 345 kV/230 kV Substation results in transient stability violations for the ATC Arrowhead Alternative.[73]

While ATC's assumption about the NTEC generator is significant for its transient stability analysis results, this assumption is even more significant when evaluating the

[72] Dagenais Direct at 20:12-17.
[73] The term "transient stability violations" refers to violations of established transmission planning criteria for acceptable system response in terms of, among other things, transient voltage recovery, angular stability, relay operations and frequency deviations. In the case of ATC's dynamic stability studies, as well as in the case of Minnesota Power's transient stability studies discussed later on, the primary transient stability violations of interest impact transient voltage recovery

results of ATC's voltage stability analysis, as discussed later in my Rebuttal Testimony. At the very minimum, ATC's assumptions about the NTEC generator for its stability studies preclude ATC, Minnesota Power, or any other fact finder from making comprehensive or determinative conclusions about the ATC Arrowhead Alternative based solely on ATC's analyses, given the relatively narrow set of assumptions and system conditions evaluated.

Q. Please summarize Mr. Dagenais' discussion of the results of ATC's dynamic stability reliability analysis.

A. Based on ATC's dynamic stability reliability analysis, Mr. Dagenais concludes that the ATC Arrowhead Alternative and Minnesota Power's proposed HVDC Modernization Project configuration "perform similarly."[74] Mr. Dagenais then highlights "certain contingencies" for which the ATC Arrowhead Alternative purportedly performs better than Minnesota Power's proposed Project configuration, as well as other contingencies for which both alternatives are "insecure."[75] Mr. Dagenais' proposed solution for these scenarios is to redispatch the NTEC generator.[76] Finally, Mr. Dagenais describes one additional scenario unique to the ATC Arrowhead Alternative for which the system is not transiently stable and also prescribes redispatching[77] the NTEC generator as ATC's preferred approach for mitigating this issue.[78]

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[74] Dagenais Direct at 30:16-17.
[75] Dagenais Direct at 30:17-19.
[76] Dagenais Direct at 30:20-31:1.
[77] The term "redispatch" here refers to real-time adjustment of the scheduled power output of a generator to prevent negative reliability impacts. Because generators are typically dispatched for optimal economic operation, redispatching generators to prevent negative reliability impacts often has significant cost associated with it, especially for the owner of the generator whose output is curtailed. In many cases, the generator owner must procure replacement energy at a higher cost. While redispatching is an important tool for maintaining reliable transmission system operations, reliance on this approach is typically minimized where reasonable in transmission planning studies due to its potential economic impacts.
[78] Dagenais Direct at 31:1-5.

Q. Do you agree with Mr. Dagenais' assessment of the results of ATC's dynamic stability reliability analysis.

A. No. After reviewing Mr. Dagenais' Direct Testimony and the working files associated with ATC's dynamic stability reliability analysis, I find Mr. Dagenais' assessment of the results of this study to be lacking in context and ATC's presentation of the results to be lacking sufficient detail to adequately analyze the concerns highlighted by Mr. Dagenais. With respect to context, ATC does not make any attempt to quantify the results of its transient stability analysis and its study results do not include sufficiently detailed information to assess its findings. For example, Mr. Dagenais highlights the purportedly better performance of the ATC Arrowhead Alternative for "certain contingencies" where it had fewer violations than Minnesota Power's proposed HVDC Modernization Project configuration in some of the models employed by ATC. However, Mr. Dagenais fails to address the fact that both configurations are insecure for these "certain contingencies" according to ATC's own results when considering all three models evaluated by ATC. Going back to Mr. Dagenais' own statements, it is important to consider a variety of scenarios in transmission planning studies in order to present a comprehensive picture of system performance. A problem in one model is still a problem, regardless of whether or not that problem exists when considering other assumptions in a different model. Because ATC's study results provide only a "pass" or "fail" for several transient stability criteria, it is not possible to assess the nature and significance of these issues.

Q. Do the findings of ATC's dynamic stability reliability analysis raise any concerns about the ATC Arrowhead Alternative configuration?

A. Yes. Mr. Dagenais appears to downplay the significance of the transient stability issues associated with the loss of both ATC Arrowhead 345 kV/230 kV transformers, but this is an issue that is entirely unique to the configuration of the ATC Arrowhead Alternative. While this is, in fact, a material difference between the ATC Arrowhead Alternative and Minnesota Power's proposed configuration of the HVDC Modernization Project that is the direct result of ATC's proposal to move the HVDC

System point of interconnection to the ATC Arrowhead 345 kV/230 kV Substation, Mr. Dagenais' solution is to curtail the output of the NTEC generator any time one of ATC's 345 kV/230 kV transformers is out of service.

Q. Is there any other solution to the loss of both ATC Arrowhead 345 kV/230 kV transformers that might be considered by transmission system operators?

A. Yes, although it is not mentioned by Mr. Dagenais. One other operational solution that would be considered in real-time operations is to curtail the transfer capability of Minnesota Power's HVDC System. In this case, the findings of ATC's analysis highlight and expand upon the concerns expressed in my Direct Testimony about the risks to HVDC System operations from integrating the HVDC System more closely with the Wisconsin 345 kV transmission system.[79] Helpfully, Mr. Dagenais' discussion of ATC's analysis also highlights similar risks that could exist for the NTEC generator. These impacts and risks are created by the ATC Arrowhead Alternative and are not observed in studies performed for the Minnesota Power proposed configuration of the HVDC Modernization Project. These types of findings from ATC's analysis are the reason Minnesota Power continues to emphasize that the ATC Arrowhead Alternative introduces complexities that have not been comprehensively and sufficiently studied to date. As discussed in my Direct Testimony and previously in my Rebuttal Testimony, the additional time needed to complete those studies and identify what additional modifications to the ATC Arrowhead Alternative are necessary for it to be implemented reliably places the HVDC Modernization Project in-service date and awarded grant funding at significant risk.

Q. Please summarize Mr. Dagenais' discussion of the methodology and assumptions for ATC's voltage stability analysis.

A. Mr. Dagenais states that ATC performed a voltage stability study utilizing one model developed for the MISO Definitive Planning Phase ("DPP") 2021 cycle.[80] This means

[79] Winter Direct at 84:1-18.
[80] Dagenais Direct at 29:2-4.

that ATC used a model originally developed for the 2021 cycle of the MISO generator interconnection process. The model was modified in several ways to remove outdated assumptions from the DPP cycle and update assumptions about the HVDC System to match other studies conducted by ATC and Minnesota Power. Significantly, Mr. Dagenais specifically states that "ATC maximized generation from NTEC" for its voltage stability study.[81] Finally, Mr. Dagenais states that ATC selected the Stone Lake 345 kV Substation for voltage measurement and the Superior – Stone Lake 345 kV Line as the flowgate for real power measurements.[82] These are important assumptions for voltage stability because a voltage stability study is typically performed by increasing the real power flow on an interface (or flowgate) until the voltage at one or more substations becomes unstable.

Q. What is the significance of ATC's selection of the Superior – Stone Lake 345 kV Line as the monitored flowgate for its voltage stability analysis?

A. For the system conditions selected by ATC for its voltage stability study, the Superior – Stone Lake 345 kV Line is likely to be heavily loaded due to the confluence of output from the NTEC generator, injection from the HVDC System, and high regional Minnesota-Wisconsin power flows. However, it would have been more insightful, as well as more consistent with typical regional transmission planning and operating studies (including the MISO DPP), for ATC to perform its voltage stability analysis on the thoroughly-documented and well-understood regional Minnesota-Wisconsin Export ("MWEX") interface rather than the Superior – Stone Lake 345 kV Line.[83]

Quantitatively, this is illustrated by the fact that ATC's overall transfer adjustments in its voltage stability model only result in about a three percent change in power flow on the Superior – Stone Lake 345 kV Line. Therefore, to increase the power flow on the Superior – Stone Lake 345 kV Line by 100 MW, ATC would need to adjust regional

[81] Dagenais Direct at 28:13-16.
[82] Dagenais Direct at 28:20-29:6.
[83] A copy of the most recent operating guide for the MWEX Interface is included as Schedule 28 to my Direct Testimony.

transfers by over 3,000 MW. That is a tremendous amount of change that will impact a broad area of the regional transmission system. This is why a more comprehensive regional interface evaluation would have been more insightful and appropriate. ATC's evaluation of voltage stability at the Stone Lake 345 kV Substation for increasing power flow on the Superior – Stone Lake 345 kV Line is significantly more limited in scope compared to a typical regional MWEX voltage stability study and, therefore, leaves a lot of potential issues and impacts unassessed. This is particularly the case when considering the significance of ATC's assumptions regarding the NTEC generator. As a result, it's not clear that ATC's voltage stability analysis actually assesses system conditions and events that provide a meaningful understanding of the anticipated impacts of either the ATC Arrowhead Alternative or Minnesota Power's proposed configuration for the HVDC Modernization Project.

Q. What is the significance of ATC's assumption regarding the NTEC generator for its voltage stability analysis?

A. Once again, as Mr. Dagenais states in his Direct Testimony, and I have repeated in my Rebuttal Testimony, the findings of transmission planning studies "depend heavily on the inputs (or assumptions) that are utilized" and it is important to evaluate "multiple different scenarios" to provide a "more comprehensive picture" of system performance.[84] As with its transient stability analysis, ATC's decision to maximize the dispatch of the NTEC generator for its voltage stability analysis will materially impact the results and limit the comprehensiveness of the conclusions which may be drawn from its voltage stability analysis.

In this case, the NTEC generator will increase power flow, and therefore stress, on ATC's selected Superior – Stone Lake 345 kV flowgate, but the generator will also contribute positively to voltage support in northwestern Wisconsin, likely improving voltage stability for most contingencies. Furthermore, dispatching the NTEC generator will reduce the power flow through the Arrowhead 345 kV/230 kV Substation, masking

[84] Dagenais Direct at 20:12-17.

the response of the Arrowhead PST as it would operate in a typical MWEX voltage stability study for the Minnesota Power proposed Project configuration and diminishing its perceived importance. As I stated previously, at the very minimum, ATC's assumptions about the NTEC generator for its stability studies preclude ATC, Minnesota Power, or any other fact finder from making comprehensive or determinative conclusions about the ATC Arrowhead Alternative based solely on ATC's analyses, given the relatively narrow set of assumptions and system conditions evaluated.

Q. While you have said you are not able to make comprehensive or determinative conclusions about the ATC Arrowhead Alternative based on ATC's voltage stability analysis, what are you able to summarize with respect to the results?

A. Much of the "benefit" that ATC highlights in its studies relates to transmission facilities in Wisconsin. This emphasizes concerns raised in the Direct Testimony of myself and Company witness Mr. Gunderson: ATC is seeking to have Minnesota Power's customers pay for the ATC Arrowhead Alternative, rather than Minnesota Power's proposed Project configuration, even though the ATC Arrowhead Alternative increases benefits to the Wisconsin transmission system and removes them from Minnesota Power customers. This is fundamentally inconsistent with the purpose and need of the HVDC Modernization Project.

Q. What conclusions drawn by Mr. Dagenais support your understanding?

A. Mr. Dagenais states that the ATC Arrowhead Alternative results in a 100 MW higher voltage stability system operating limit for power flows on the Superior – Stone Lake 345 kV Line and allows for greater west-to-east transfers compared to Minnesota Power's proposed HVDC Modernization Project configuration.[85] He concludes that, because of this, the ATC Arrowhead Alternative "outperforms" the Minnesota Power configuration of the HVDC Modernization Project.[86] Mr. Dagenais further concludes from ATC's voltage stability analysis that the ATC Arrowhead 345 kV capacitor banks

[85] Dagenais Direct at 31:6-7.
[86] Dagenais Direct at 31:9-11.

are no longer necessary for the ATC Arrowhead Alternative, having stated previously that these capacitor banks were originally installed to maintain voltage stability but that the ATC Arrowhead Alternative would rely on Minnesota Power's VSC HVDC converter station for that.[87] Finally, Mr. Dagenais concludes from ATC's voltage stability and its other two studies that the ATC Arrowhead PST may be bypassed for the ATC Arrowhead Alternative without negatively impacting regional reliability.[88]

Q. Do you agree with Mr. Dagenais' conclusions?

A. I do not. While I agree with Mr. Dagenais' conclusion that the ATC Arrowhead Alternative facilitates greater regional transfers between Minnesota and Wisconsin, I do not agree with his assessment that this means the ATC Arrowhead Alternative "outperforms" Minnesota Power's proposed Project configuration. Such an assessment presumes that greater regional transfers between Minnesota and Wisconsin are a desired outcome of the Project. The purpose of the HVDC Modernization Project is to replace the aging infrastructure and to maintain and improve upon the same benefits for Minnesota Power's customers that they receive today.

As thoroughly discussed in my Direct Testimony, Minnesota Power's analysis also found that the ATC Arrowhead Alternative would increase Minnesota-Wisconsin transfer capability. This is a feature of the ATC Arrowhead Alternative that is altogether inconsistent with the purpose and need for Minnesota Power's HVDC Modernization Project, providing benefits to ATC's Wisconsin transmission system at the expense of Minnesota Power's customers. Furthermore, I do not agree with Mr. Dagenais' conclusions regarding the ATC Arrowhead 345 kV capacitor banks or the ATC Arrowhead PST. I have already discussed the many limitations and questionable

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[87] Dagenais Direct at 10 and 33:10-13. Note that Mr. Dagenais has misinterpreted Minnesota Power's statement about this in the Application. The quoted text from page 27 of the Application is referring to additional reactive support being eliminated for the operation of the HVDC System itself, as would otherwise be required for a line commutated converter ("LCC") HVDC system. Minnesota Power was not offering or proposing to provide reactive support to enable ATC to increase Minnesota-Wisconsin transfer capability or remove its own existing capacitor banks from the transmission system.

[88] Dagenais Direct at 33:14-19.

assumptions of ATC's studies, but one additional point to consider is that ATC is relying on certain attributes of the HVDC System to justify these changes for the ATC Arrowhead Alternative. ATC, however, has yet to present any consideration of the impact from a prior outage of the HVDC converter station, which would essentially put the system back to the same configuration as it is today – but without the ATC Arrowhead capacitor banks or the ATC Arrowhead PST if they are removed for the ATC Arrowhead Alternative. To make such definitive conclusions based on such a limited amount of analysis is inconsistent with good transmission planning practices.

Q. Please summarize your concerns with the three ATC studies discussed in the Direct Testimony of Mr. Dagenais.

A. While I can appreciate that ATC has provided steady state, transient stability, and voltage stability studies showing some diligence undertaken by ATC on the system impacts of the ATC Arrowhead Alternative, the methodology and assumptions employed by ATC in the completion of these studies necessarily limits the conclusions that may be drawn from them. Furthermore, the study files I reviewed are not comprehensive enough to thoroughly vet all of the assumptions ATC has made in its development of the ATC Arrowhead Alternative, such as the removals of the ATC Arrowhead PST and capacitor banks. I certainly do not find ATC's studies sufficient for making the determination that the material modifications to the configuration of the existing transmission system proposed by ATC for the ATC Arrowhead Alternative may be implemented reliably without any remaining risk of changes to ATC's proposed configuration or additional network upgrades to mitigate negative impacts from it.

What can be discerned from ATC's studies thus far also further confirms Minnesota Power's assessment that the ATC Arrowhead Alternative would result in a transfer of benefits from Minnesota Power customers to the Wisconsin transmission system that is not observed with Minnesota Power's configuration of the HVDC Modernization Project. As discussed in my Direct Testimony, these benefits would be transferred to the Wisconsin transmission system but paid for by Minnesota Power customers.

Q. Has Minnesota Power recently completed any additional analysis that would help to illustrate your concerns?

A. Yes. As a result of the aforementioned concerns about the ATC Arrowhead Alternative, Minnesota Power directed the development of a technical comparison of certain transmission system impact and performance aspects of Minnesota Power's proposed HVDC Modernization Project configuration and the ATC Arrowhead Alternative. The study consists of voltage stability and transient stability analyses of the impacts from the two alternative configurations on the regional MWEX interface, closely paralleling the typical MWEX transmission planning and operating study methodology normally employed by ATC and MISO, but focusing only on the anticipated most limiting contingencies for the Arrowhead Substation area and northwest Wisconsin.

This study was only recently completed and was not available for discussion with my Direct Testimony. Minnesota Power's "2024 MWEX Stability Study" is attached as Rebuttal Schedule 18 to my Rebuttal Testimony. In addition to clarifying Minnesota Power's concerns with the configuration and performance of the ATC Arrowhead Alternative, the 2024 MWEX Stability Study helps illustrate the limitations of the transient and voltage stability studies presented by ATC.

Q. How is Minnesota Power's 2024 MWEX Stability Study different from ATC's transient and voltage stability analyses?

A. Minnesota Power's 2024 MWEX Stability Study is different from ATC's stability analyses in several ways, but I will highlight three. First, unlike ATC's studies, the 2024 MWEX Stability Study focuses specifically on the regional MWEX interface, which has a well-established study methodology and operating guide, which is attached to my Direct Testimony as Schedule 28. As discussed in my Direct Testimony and illustrated in Schedule 28 to my Direct Testimony, the ATC Arrowhead PST and the ATC Arrowhead 345 kV capacitor banks are critical reliability components for the MWEX interface. Their removal and the other changes proposed by ATC for the ATC

Arrowhead Alternative will have a substantive impact the planning and operating of the MWEX interface. Second, unlike ATC's studies, the 2024 MWEX Stability Study focuses only on the one or two most limiting contingency events for the Arrowhead Substation area and northwest Wisconsin. While this is a much narrower focus than in ATC's studies in terms of the contingency events studied, the overall focus of Minnesota Power's study is on the broader regional impacts and this narrowed focus on the most challenging events identified in previous planning studies enabled Minnesota Power to provide a deeper and more thorough analysis of the results. This thorough analysis of Minnesota Power's proposed HVDC Modernization Project configuration and the ATC Arrowhead Alternative provides a useful comparison of the nuances of the different impacts from each configuration. These nuances are not evident in ATC's studies. Third, unlike ATC's studies, Minnesota Power assumed that the NTEC unit was offline in all cases. From a regional MWEX interface perspective, performing the studies with NTEC offline is expected to produce the more limiting results for the Arrowhead Substation area and northwest Wisconsin, because the local power injection and dynamic voltage support from the NTEC generator will not be present to support the transmission system. At the very least, by employing this assumption (NTEC generator offline), Minnesota Power's 2024 MWEX Stability Study expands upon certain gaps in ATC's stability studies, which assumed the NTEC generator was online in all cases. However, in my view, the methodology and assumptions used for the 2024 MWEX Stability Study provide a more useful and insightful understanding of the relative system impacts corresponding to each configuration.

Q. Please summarize the methodology and assumptions for the voltage stability part of Minnesota Power's 2024 MWEX Stability Study.

A. The voltage stability models are based on power flow models originally developed for Minnesota Power's 2023 HVDC Modernization Project Power Flow Analysis, which is attached to my Direct Testimony as Schedule 12.[89] The focus of the 2024 MWEX

[89] These are the same power flow models Minnesota Power provided to ATC, which ATC used as the basis for its steady state reliability analysis and for setting up some (but not all) of the assumptions for its transient and voltage stability analyses

Stability Study was on the system conditions that have historically been identified as the most stressed for the MWEX interface, meaning that Minnesota Power used the "Shoulder High Wind (SSH)" case representing off-peak load levels with high renewable energy output, little or no synchronous generation, and high regional transfers. As a result, the HVDC System is dispatched at its maximum capacity and the NTEC generator is offline.[90] Two scenarios were evaluated representing the configuration of the regional transmission system before and after the completion of the MISO LRTP Tranche 1 portfolio of transmission projects. Voltage stability analysis focused on one fault event that has historically been the most challenging for the Arrowhead Substation area and northwest Wisconsin. Generally speaking, this event involves tripping of the closest large regional tie line that also crosses the Minnesota-Wisconsin border.

Loss of this tie line causes power to be rerouted very rapidly onto adjacent regional tie lines, including the Arrowhead-Weston 345 kV Line[91], resulting in a large increase in power flow through the ATC Arrowhead 345 kV/230 kV Substation into northwest Wisconsin. Voltages before and after the limiting fault event were monitored and applicable control and protection systems, such as those associated with the Arrowhead PST, were allowed to operate after the contingency according to ATC's typical MWEX voltage stability study methodology. The voltage stability system operating limit ("SOL") was then defined according to ATC's planning criteria. To further assess the voltage stability margins, both configurations were also evaluated at the initial conditions, which are the conditions in the model prior to increasing the MWEX transfer level. Due to the configuration changes resulting from the ATC Arrowhead Alternative,

[90] As noted in the study report (p. 4-2), these assumptions are consistent with the MWEX Voltage Stability Study performed by ATC for the 2021 Phase 1 West Area MISO DPP study cycle. That study was completed by ATC on April 11, 2023.

[91] While the term Arrowhead-Weston 345 kV Line is used here and in the following discussion for clarity and consistency with previous discussion in my Direct and Rebuttal testimonies, this facility is typically referred to in the 2024 MWEX Voltage Stability Study report as the "Arrowhead – Superior 345 kV Line" or the "Arrowhead – Superior – Stone Lake 345 kV Line." All of these names refer to the same basic transmission line facility connecting the ATC Arrowhead 345 kV/230 kV Substation to the rest of the Wisconsin transmission system.

the MWEX interface definition was modified slightly[92] for the 2024 MWEX Stability Study to facilitate a more direct comparison between Minnesota Power's proposed HVDC Modernization Project configuration and the ATC Arrowhead Alternative configuration.

Q. Please summarize the findings and conclusions of the voltage stability portion of the 2024 MWEX Stability Study.

A. The proposed HVDC Modernization Project configuration and the ATC Arrowhead Alternative result in similar MWEX voltage stability SOLs, with the ATC Arrowhead Alternative providing a slightly higher SOL in the post-LRTP case. Due to the designed automatic operation of the ATC Arrowhead PST, the proposed Project configuration results in notably higher voltage stability margins (11-16%) compared with the ATC Arrowhead Alternative configuration (5%). The voltage stability margin is a measure of the difference between the operating point (the SOL) and the point where the voltage actually becomes unstable. ATC's planning criteria requires a minimum voltage stability margin of five percent; however, more margin is generally considered to be better where it is achievable.

Due to the removal of the ATC Arrowhead capacitor banks (as proposed by ATC according to ATC's Direct Testimony) and the increased dependency it establishes between MWEX and Minnesota Power's HVDC converter station, the ATC Arrowhead Alternative draws significantly more reactive power from Minnesota Power's HVDC converter station. In fact, when the HVDC converter station reached its reactive power limit for the ATC Arrowhead Alternative, the MWEX interface immediately became unstable. This means that the stability of the regional MWEX interface at that point was entirely dependent on the reactive power contributed by Minnesota Power's HVDC

[92] Specifically, the measurement point for the flow into Wisconsin on the Arrowhead-Weston 345 kV Line was moved from the ATC Arrowhead PST to the ATC Arrowhead – Superior 345 kV Line. This modification was necessary primarily due to the relocation of the HVDC System point of interconnection from the Minnesota Power Arrowhead 230 kV/115 kV Substation to the ATC Arrowhead 345 kV/230 kV Substation in the ATC Arrowhead Alternative configuration. In the present configuration of the ATC Arrowhead 345 kV/230 kV Substation, the power flow on the ATC Arrowhead PST and the ATC Arrowhead – Superior 345 kV Line is roughly equal.

converter station. With Minnesota Power's proposed Project configuration, HVDC reactive power output was well within limits at all times and significantly less than the ATC Arrowhead Alternative at the SOL. These voltage stability results begin to illustrate the value and purpose of the existing ATC Arrowhead PST and ATC Arrowhead capacitor banks in the existing transmission system and some of the consequences of their prospective removal as a part of the ATC Arrowhead Alternative.

Q. Please summarize the methodology and assumptions for the transient stability part of the 2024 MWEX Stability Study.

A. The transient stability models, like the voltage stability models, are based on power flow models originally developed for Minnesota Power's 2023 HVDC Modernization Project Power Flow Analysis (Schedule 12 to my Direct Testimony). System condition and scenario modeling assumptions are identical to the voltage stability models discussed above. The dynamic behavior of the VSC HVDC converter stations was modeled using a preliminary and proprietary user-written model provided by the HVDC Supplier, which was still in development by the Supplier and not considered final at the time of this study.[93]

Transient stability analysis focused on two fault events that have historically been the most challenging for the Arrowhead Substation area and northwest Wisconsin. Similar to the fault event studied for voltage stability analysis, these two events involve tripping of the closest large regional tie line that also crosses the Minnesota-Wisconsin border. Starting with the voltage stability SOL, the MWEX transfer level was increased to find the point of transient instability. This information was used to define a common transient

[93] Even though the model was (and still is) preliminary, it provides the best approximation for the actual dynamic behavior of the VSC HVDC converters be implemented by Minnesota Power. What remains for Minnesota Power and the HVDC Supplier to do is to vet the model by using it and then fine tune it based on the results. In fact, the study report discusses how the implementation of this model for the MWEX Stability Study enabled Minnesota Power to identify certain necessary refinements to the Supplier's user-written model, which were subsequently communicated to the Supplier. Meanwhile, an alternative modeling approach was developed to simulate the expected operation of the VSC HVDC converters for the simulations where the Supplier's model did not respond as expected. Minnesota Power continues to work with the HVDC Supplier to test and refine its preliminary model representation of the VSC HVDC converters, which will be finalized during the FEED studies.

stability test level for comparison of the ATC Arrowhead Alternative and Minnesota Power's proposed HVDC Modernization Project configuration. Transient stability performance was evaluated against applicable criteria at the test level, and voltage sag severity indices[94] were calculated to compare transient stability criteria margins for each configuration. Both configurations were also evaluated at the initial conditions, which are the conditions in the model prior to increasing the MWEX transfer level.

Q. Please summarize the findings and conclusions of the transient stability portion of Minnesota Power's 2024 MWEX Stability Study.

A. The ATC Arrowhead Alternative generally results in higher MWEX transient stability limits than the Minnesota Power configuration of the HVDC Modernization Project. The study results indicate that the reason the ATC Arrowhead Alternative results in higher transient stability limits is that it induces more power transfer through the ATC Arrowhead 345 kV/230 kV Substation into northwest Wisconsin, unloading stressed regional 345 kV transmission paths that parallel the MWEX interface lines in southwest Wisconsin and eastern Iowa, where instability occurs at higher west-to-east transfer levels. The potential negative impact of the increased transfers through northwest Wisconsin is offset by the dynamic reactive support provided to northwest Wisconsin by the VSC HVDC converter when it is interconnected to the ATC Arrowhead 345 kV/230 kV Substation in the ATC Arrowhead Alternative configuration. These transient stability results further demonstrate the regional nature of the support provided by the ATC Arrowhead Alternative, particularly for Minnesota-Wisconsin transfer capability, and reinforce the dependency the ATC Arrowhead Alternative establishes between the MWEX interface and Minnesota Power's new VSC HVDC converters.

[94] The voltage sag severity index or "VSSI" is a measure of transient voltage performance relative to applicable transient voltage criteria over the duration of the transient period which was developed based on IEEE Standard 1159 and IEEE Standard 1564. Minnesota Power has utilized this metric to assist with understanding transient voltage performance degradation and the amount of transient voltage margin in the system. See Appendix C.2 of the 2024 MWEX Stability Study report.

Q. Were any sensitivities considered in the 2024 MWEX Stability Study?

A. Yes. For both voltage stability and transient stability analysis, the same methodology was applied to assess the impact of a prior outage of the HVDC System for both the ATC Arrowhead Alternative and Minnesota Power's proposed HVDC Modernization Project configuration, considering both the pre-LRTP and post-LRTP system configuration. The prior outage of the HVDC System sensitivity is important for two reasons. First and foremost, it is important to consider this sensitivity because the HVDC System will be offline from time to time and the local and regional transmission system must continue to remain reliable during those times. Second, and importantly for this proceeding, the ATC Arrowhead Alternative involves changes to the configuration of the existing transmission system, such as the removal of the ATC Arrowhead PST and Arrowhead 345 kV capacitor banks, that rely heavily on the HVDC System to offset the otherwise potentially negative reliability impacts from these changes. Examination of the prior outage of the HVDC System sensitivity will help to further understand if it is reasonable to assume, as ATC does, that these configuration changes can be made without impacting the reliability of the transmission system.

Q. Please summarize the findings and conclusions of the voltage stability portion of the HVDC prior outage sensitivities in the 2024 MWEX Stability Study.

A. To understand the voltage stability results for the HVDC prior outage sensitivity, it is important to note that ATC's planning criteria does not require a voltage stability margin for prior outage conditions. Following ATC's planning criteria, Minnesota Power's proposed configuration of the HVDC Modernization Project and the ATC Arrowhead Alternative have similar MWEX voltage stability SOLs during a prior outage of the HVDC System. However, the relative security of the transmission system at that SOL is much greater with the proposed Project configuration, which has a 10 percent stability margin at the SOL due to the operation of the ATC Arrowhead PST. For the ATC Arrowhead Alternative, consistent with ATC's planning criteria for prior outage conditions, there is no stability margin at the SOL – meaning the system is operating right up to the last stable operating condition. For the ATC Arrowhead Alternative, which does not have the Arrowhead PST available to adjust, to achieve a margin on the system similar to what ATC requires for normal system conditions would require that nearby generation in the regional system be redispatched. The resulting voltage stability SOL would be reduced by approximately 155 MW and, in that case, would be notably less compared to Minnesota Power's proposed HVDC Modernization Project configuration. This finding reinforces the value of the ATC Arrowhead PST for preserving voltage stability margin on the MWEX interface under a variety of credible system operating conditions. To implement the ATC Arrowhead Alternative without degrading the MWEX voltage stability margin during a prior outage of the HVDC System, it would seemingly be necessary to retain the existing ATC Arrowhead PST.

Q. Did the HVDC prior outage sensitivities in the 2024 MWEX Stability Study identify any system operation concerns with ATC's proposed removal of the Arrowhead 345 kV capacitors when the HVDC System is out of service?

A. Yes. With the ATC Arrowhead Alternative at the voltage stability SOL and the HVDC System out of service, the final post-contingent voltage at the ATC Arrowhead 345 kV Substation and the ATC Stone Lake 345 kV Substation was significantly lower because the ATC Arrowhead 345 kV capacitors were removed. This is consistent with the system intact voltage stability results, where it was observed that reactive power output of the VSC HVDC converter was heavily utilized to support the stability of the MWEX interface with the ATC Arrowhead Alternative. These findings continue to reinforce the new dependency between the regional MWEX interface and Minnesota Power's new VSC HVDC converters that is established by the ATC Arrowhead Alternative, and the low voltages observed in the prior outage case call into question the reasonableness of ATC's proposal to remove the ATC Arrowhead 345 kV capacitors.

Q. Please summarize the findings and conclusions of the transient stability portion of the HVDC prior outage sensitivities in the 2024 MWEX Stability Study.

A. Without the VSC HVDC converter station online, transient stability is more limiting than voltage stability for both Minnesota Power's proposed Project configuration and the ATC Arrowhead Alternative. The MWEX transient stability limit is still higher with the ATC Arrowhead Alternative than with Minnesota Power's proposed Project configuration, though the difference between the configurations is notably less with the VSC HVDC converter offline for the prior outage sensitivity. As with the system intact cases, transient stability limits with the ATC Arrowhead Alternative are higher because the alternative configuration induces more power transfer through the Arrowhead 345 kV/230 kV Substation into northwest Wisconsin, unloading stressed regional transmission paths parallel to the MWEX interface lines in southwest Wisconsin and eastern Iowa where instability occurs at higher transfer levels.

Unlike the system intact cases, the increased transfers through northwest Wisconsin are not offset by additional reactive support from the VSC HVDC converters in the HVDC prior outage cases, since the VSC HVDC is offline and the ATC Arrowhead 345 kV capacitor banks have been removed. The result is that transient voltages at the Minnesota Power and ATC Arrowhead substations and in northwest Wisconsin are noticeably worse with the ATC Arrowhead Alternative compared to Minnesota Power's proposed Project configuration.

These findings from transient stability analysis are among the clearest indicators of a common thread underlying all study results comparing the two configurations: that the ATC Arrowhead Alternative configuration generally provides more regional benefits for the MWEX interface and Minnesota-Wisconsin transfer capability compared to Minnesota Power's proposed HVDC Modernization Project configuration and that those regional benefits often come as a result of less benefit being provided for the local area around the Minnesota Power Arrowhead 230 kV/115 kV Substation.

Q. How do the findings and conclusions of the 2024 MWEX Stability Study illustrate your concerns with the ATC Arrowhead Alternative?

A. The findings from the 2024 MWEX Stability Study demonstrate that Minnesota Power's proposed HVDC Modernization Project configuration and the ATC Arrowhead

Alternative present two fundamentally different systematic alternatives with different impacts and requirements for maintaining the reliability of the MWEX interface. For Minnesota Power's proposed Project configuration, the MWEX interface is operated in much the same way as it is today. Intentionally-designed automatic operation of the ATC Arrowhead PST contributes to robust stability margins and the ATC Arrowhead 345 kV capacitor banks provide sufficient voltage support to maintain current levels of MWEX transfer capability. For the ATC Arrowhead Alternative, the removal of the ATC Arrowhead PST means that the stability margin must be maintained exclusively by redispatching generation, and the resulting margins are generally less compared to the proposed Project configuration.

Increased power transfer into Wisconsin through the Arrowhead 345 kV/230 kV Substation resulting from the ATC Arrowhead Alternative generally increases MWEX transient stability limits, while most negative impacts from these increased transfers and the removal of the ATC Arrowhead 345 kV capacitor banks is offset by increased reactive power contributions from Minesota Power's VSC HVDC converter station. However, when the VSC HVDC converter station reaches its reactive power limit or is offline during a prior outage, the loss of this critical voltage support from the VSC HVDC converter has a significant impact on the reliability of the northwest Wisconsin transmission system and the MWEX interface. These findings merit further investigation to determine what, if any, mitigation may be necessary to ensure that the configuration changes proposed for the ATC Arrowhead Alternative do not degrade the reliability of the transmission system or result in unintended consequences for system operations and performance.

Q. Based on this overview of Minnesota Power's 2024 MWEX Stability Study, what are your final thoughts on Mr. Dagenais' assertions about ATC's proposed removal of the ATC Arrowhead PST and Arrowhead 345 kV capacitor banks for the ATC Arrowhead Alternative?

A. Unlike Mr. Dagenais, I cannot conclude, based on this study or any of the Minnesota Power or ATC studies that I have seen so far, that ATC's proposed ATC Arrowhead Alternative configuration, including removal of the ATC Arrowhead PST and Arrowhead 345 kV capacitors banks, can be implemented reliably. In fact, the results of Minnesota Power's 2024 MWEX Stability Study cast significant doubt on the possibility that they can. Mr. Dagenais' claims in his Direct Testimony and ATC's response to DOC IR 009 (attached to my Direct Testimony as Schedule 4), and reiterated ATC's response to LPI IR 005 (attached to my Rebuttal Testimony as Rebuttal Schedule 32), that the ATC Arrowhead PST has been "rendered obsolete for its original intended purpose" due to changes in the "function and operation of the electric grid since the commissioning of the Arrowhead PST" are clearly refuted by Minnesota Power's 2024 MWEX Stability Study – which was based on ATC's own study methodology.[95] Based on these study results and a review of the current MWEX operating guide,[96] there can be no doubt that the removal of the Arrowhead PST would have a substantive impact on the planning an operation of the MWEX interface.

Mr. Dagenais' further attempt to justify his untenable position by noting that the ATC Arrowhead PST has "never operated automatically out of a need to prevent voltage instability" also rings hollow.[97] While in practice the ATC Arrowhead PST will only operate automatically in the relatively unlikely event that certain high-impact faults on the transmission systems occur during certain high-stress system conditions,[98] this functionality was an intentional design decision (made after many iterations of study

[95] Dagenais Direct at 37:15-17.
[96] Winter Direct, Schedule 28
[97] Dagenais Direct at 37:19-20.
[98] While Minnesota Power is thankful these conditions have not come to fruition, good utility practice requires that the system be designed and capable of responding safely and reliably under even unlikely scenarios.

were undertaken) from the initial establishment of the Arrowhead-Weston 345 kV Project. Minnesota Power's 2024 MWEX Stability Study results, like the many MWEX stability study results prepared by ATC prior to this proceeding, demonstrate that the ATC Arrowhead PST is important and valuable for the reliable planning and secure operation of the MWEX interface. Mr. Dagenais unfortunately appears to be currently supporting a position that is not consistent with typical or good transmission planning practice.

Q. What was Mr. Dagenais' response to your concerns about the impact of the ATC Arrowhead Alternative increasing power flows from the HVDC System into Wisconsin and away from Minnesota Power's customers?

A. In his Direct Testimony, Mr. Dagenais stated his position that this concern is "overstated and out-of-touch with the reality of how the modern power grid functions."[99] Then again in ATC's response to LPI IR 003, which is attached as Rebuttal Schedule 33, Mr. Dagenais stated "this is not how the interconnected alternating current (AC) transmission system operates." To substantiate his position, Mr. Dagenais briefly discussed the physics of the flow of electricity on the AC transmission system, stating in response to LPI IR 003 that the power delivered to the Arrowhead Substation by the HVDC System "instantaneously becomes intermingled with power flows from other sources, including outside of MP's transmission system." Mr. Dagenais then goes on to acknowledge that the ATC Arrowhead Alternative "results in marginal additional electric flow on certain transmission lines in Wisconsin" but states that "increased flows into Wisconsin on certain facilities will be offset by lower flows on other transmission lines into Wisconsin" and that Minnesota Power "cannot claim that implementation of the [ATC Arrowhead Alternative] would somehow jeopardize its ability to reliably serve customer load." Finally with respect to this issue, Mr. Dagenais asserts that Minnesota Power's analysis is "based on a single set of modeling runs" that are "not necessarily representative of how the system would operate at all points in time during

[99] Dagenais Direct at 39:10-11

a given year" and claims that the ATC Arrowhead Alternative "will also likely allow more power to flow from Wisconsin into Minnesota."

Q. What is your response to Mr. Dagenais' dismissal of Minnesota Power's concerns about increased power flows into Wisconsin resulting from the ATC Arrowhead Alternative?

A. I am pleased to see that Mr. Dagenais acknowledges that the ATC Arrowhead Alternative will result in increased power flows between Minnesota and Wisconsin. On that point, Minnesota Power and ATC appear to be in agreement. Mr. Dagenais also rightly states that the increased flow into Wisconsin from Minnesota Power's HVDC System will offset power flow into Wisconsin on other regional tie lines. This is also clearly demonstrated from the results of Minnesota Power's 2024 MWEX Stability Study, as discussed previously in my Rebuttal Testimony. What is not clear to me, is why Mr. Dagenais thinks that it is appropriate for the power flows on other tie lines into Wisconsin to be offset by siphoning off power delivered over the HVDC System, which is being paid for and is intended to benefit Minnesota Power's customers. From Minnesota Power's perceptive, it would be better if power flows into Wisconsin continued to flow on the regional tie lines specifically constructed to facilitate them, rather than being offset by additional flows from Minnesota Power's HVDC System obtained at the expense of Minnesota Power's customers through implementation of the ATC Arrowhead Alternative. Rightly understood, Minnesota Power's concerns are not about energy adequacy, as Mr. Dagenais insinuates in his response to LPI IR 003 (Rebuttal Schedule 33 to my Rebuttal Testimony), but about energy *equity*. In all of its decisions with respect to the HVDC Modernization Project, including the decision to maintain the existing point of interconnection for the HVDC System at the Arrowhead 230 kV/115 kV Substation by proposing to construct the St. Louis County 345 kV/230 kV Substation, Minnesota a Power has sought to maximize the benefits its customers will receive from the HVDC System that they are paying for. To outsource any part of those benefits to electric customers in Wisconsin who will not be paying for the Project, as would be the result of the ATC Arrowhead Alternative, when it is possible to retain those benefits by constructing a superior alternative in the form of Minnesota Power's proposed HVDC Modernization Project configuration would be inconsistent with Minnesota Power's obligation and duty to serve its customers.

Q. What is your response to Mr. Dagenais' statement that these concerns are "out-of-touch with the reality of how the modern power grid functions"?

A. While I readily acknowledge that the physics of the power grid are complex, and that the nuances of how it functions are not easily reduced to simple explanations when it comes to trying to understand the impacts of particular changes, I respectfully disagree with Mr. Dagenais' statement that Minnesota Power's concerns are "out of touch" or somehow invalid by virtue of attempting to provide a simplified understanding of the disparate impacts of the ATC Arrowhead Alternative and Minnesota Power's proposed HVDC Modernization Project configuration. The distribution factor analysis used by Minnesota Power in its 2024 ATC Arrowhead Alternative Concept Power Flow Analysis[100] is a common analysis tool utilized by transmission planners to understand, quantify, and assign responsibility for the impacts of specific changes on the operation and performance of the transmission system. For example, the term "distribution factor" and different variations of its shorthand term "DF" are used more than 30 times in the MISO Generator Interconnection Business Practice Manual.[101] In fact, MISO uses distribution factor calculations to identify and assign network upgrade costs to individual generators as a normal part of its generator interconnection process.[102] When confronted with the need to identify, understand, and compare the transmission system impacts and benefits resulting from a particular project, it is not only common but necessary to utilize tools, such as distribution factor calculations, that help delineate amongst the many "intermingled . . . power flows"[103] on the AC transmission system and enable a simplified understanding of a particular concept among the many nuances

[100] Winter Direct Schedule 14.
[101] The latest version of the MISO Generator Interconnection Business Practice Manual, or BPM-015, is available at https://www.misoenergy.org/legal/rules-manuals-and-agreements/business-practice-manuals/.
[102] See MISO BPM-015, Sections 6.1.1.1.8 and 6.1.1.1.10
[103] ATC response to LPI IR 003, Winter Rebuttal Schedule 33.

of the power system. Contrary to Mr. Dagenais' assertions, there is nothing "out of touch" about this approach.

Q. What is your response to Mr. Dagenais' statement that Minnesota Power's assertions are "based on a single set of modeling runs" that are "not necessarily representative of how the system would operate at all points in time during a given year"?

A. This statement from Mr. Dagenais in ATC's response to LPI IR 003 is incorrect. It may be easily demonstrated by a cursory inspection of Minnesota Power's 2024 Arrowhead Alternative Concept Power Flow Analysis study report[104] that Minnesota Power's conclusion that the ATC Arrowhead Alternative will result in an additional seven to ten percent increase in power flow from the HVDC System into Wisconsin was developed based on three out the same four power flow models previously developed and used by Minnesota Power for its 2023 MP HVDC Modernization Project Power Flow Analysis[105] and subsequently used by ATC for its steady state reliability analysis. Since distribution factor calculations are most fundamentally related to the impedance of the power system, they are generally similar across all power flow models where the configuration of the transmission system is similar, regardless of assumptions about generation dispatch, load levels, and regional transfer conditions.[106] The seven to ten percent range provided by Minnesota Power accounted for results from the Summer Peak, Shoulder, and Winter North Flow power flow cases utilized in both Minnesota Power and ATC's power flow studies. These three power flow cases incorporate widely-varying assumptions about generation dispatch (including the power output of the nearby NTEC generator), load levels, and regional transfer conditions, demonstrating that the distribution factors presented by Minnesota Power hold true over a broad range of system conditions. In fact, it is entirely reasonable to conclude based on Minnesota

[104] For example, see Table 8 on Page 15 of Winter Direct Schedule 14.
[105] Winter Direct Schedule 12.
[106] The power output of nearby generators, such as the NTEC generator in this case, may have a more significant influence on the distribution factor, but that influence does not typically outweigh the more fundamental influence of the impedance resulting from the configuration of the transmission system

Power's analysis that the ATC Arrowhead Alternative would draw more power from the HVDC System into the Wisconsin transmission system any time the HVDC System is online and transferring power, even in conditions such as those referenced by ATC where the scheduled power flow on the HVDC System is low or the prevailing direction of regional power flow is from Wisconsin to Minnesota. Mr. Dagenais' attempts to cast doubt on the meaningfulness of Minnesota Power's distribution factor analysis are unfounded, and inconsistent with typical transmission planning practices.

Q. Is there anything else from the Direct Testimony of Mr. Dagenais that you would like to respond to?

A. Yes. Mr. Dagenais claims, several times, that the ATC Arrowhead Alternative presents a more reliable configuration compared to Minnesota Power's proposed HVDC Modernization Project configuration by virtue of the fact that a second 345 kV/230 kV transformer would be installed within the ATC Arrowhead 345 kV/230 kV Substation.[107] To quote Mr. Dagenais, "[t]his is a notable advantage compared to [Minnesota Power]'s proposal" because "if one transformer were forced out-of-service, the other can continue to provide reliable service to the Project."[108]

Q. Do you agree with Mr. Dagenais that the addition of this second 345 kV/230 kV transformer is "a notable advantage" for the ATC Arrowhead Alternative configuration compared to Minnesota Power's proposed configuration of the HVDC Modernization Project?

A. No. Mr. Dagenais' conclusion is misplaced. There are four primary reasons why this is not a "notable advantage."

First, immediately before introducing this "notable advantage" for the ATC Arrowhead Alternative configuration, Mr. Dagenais states that the ATC Arrowhead 345 kV/230 kV Substation is already available to serve the Project "well more than 99 percent of any

[107] Dagenais Direct at 13:21-14:07; 15:10-14; 32:2-15; and 41:19-20.
[108] Dagenais Direct at 13.

given year."[109] When asked by Minnesota Power in MP IR 024 to quantify the percentage increase in the reliability of the ATC Arrowhead 345 kV/230 kV Substation that ATC anticipates achieving from the addition of a second 345 kV/230 kV transformer, Mr. Dagenais responded that "ATC cannot quantify" such increase. A copy of ATC's response to MP IR 024 is attached to my Rebuttal Testimony as Rebuttal Schedule 34. From a survey of recent 345 kV/230 kV transformer outages and ATC's spare strategy for the Arrowhead 345 kV/230 kV transformer (see ATC's response to MP IR 023 attached to my Rebuttal Testimony as Rebuttal Schedule 35), there is little, if any, room for improvement from 99 to 100 percent availability.

Second, Minnesota Power's St. Louis County 345 kV/230 kV Substation is being designed with the same configuration for the 345 kV/230 kV transformer and spare that has resulted in 99 percent availability at the ATC Arrowhead 345 kV/230 kV Substation. Here again, there is little room for "notable" improvement, as the St. Louis County 345 kV/230 kV Substation should reasonably be expected to achieve similar availability ATC Arrowhead 345 kV/230 kV Substation (99 percent).

Third, the HVDC System consists of a single 465-mile transmission line with highly-complex HVDC converter stations on each end, which are then each connected to the AC transmission system through a single bank of HVDC/345 kV converter transformers. The impact of these HVDC System elements on the overall availability and reliability of the HVDC System will far outweigh any impacts from a 345 kV/230 kV transformer in a substation that is already 99 percent available.

Fourth, as all of Minnesota Power's studies have demonstrated, and as is discussed in detail Section IV.A. of my Direct Testimony, ATC would benefit far more than Minnesota Power from the addition of the second Arrowhead 345 kV/230 kV transformer due to the additional Minnesota-Wisconsin transfer benefits realized by the reduced impedance between the Minnesota 230 kV transmission system and Wisconsin

[109] Dagenais Direct at 13:16.

345 kV transmission system if the Commission were to order the construction of the ATC Arrowhead Alternative.

For these reasons, I do not agree Mr. Dagenais' repeated assertion that the second Arrowhead 345 kV/230 kV transformer is a "notable advantage" for the ATC Arrowhead Alternative. Any potential advantage related to the addition of a second transformer at the ATC Arrowhead 345 kV/230 kV Substation is certainly not outweighed by the many system performance, cost, and schedule concerns associated with implementation of the ATC Arrowhead Alternative outlined in my direct and rebuttal testimonies and the direct and rebuttal testimony of Company witness Mr. Gunderson.

V. CONCLUSION

Q. Based on your analysis of the need for the Project and the pre-filed Direct Testimony, what are your final recommendations?

A. The HVDC Modernization Project, as proposed by Minnesota Power, is the culmination of a decade of broad evaluation of the opportunities to modernize the HVDC System equipment for the continued use and benefit of Minnesota Power's customers. Minnesota Power has actively undertaken studies of the HVDC System over many years to carefully and methodically develop the HVDC Modernization Project, including working closely with MISO to understand the transmission system performance under the proposed HVDC Modernization Project Configuration. Further, in light of the significant opportunities to position the HVDC Modernization Project for future expandability, while offsetting most of that incremental cost by leveraging state and federal grant funds, Minnesota Power thoughtfully incorporated those innovative plans into the HVDC Modernization Project. Minnesota Power's configuration of the HVDC Modernization Project will ensure the upgraded HVDC System is available no later than April 2030, and likely earlier, to meet the current needs of Minnesota Power and its customers and provide future optionality to be leveraged when conditions warrant that expansion. Given Minnesota Power's thorough and diligent planning for the HVDC

Modernization Project, I recommend that the Commission reject the ATC Arrowhead Alternative and issue a Certificate of Need and Route Permit for Minnesota Power's proposed configuration of the HVDC Modernization Project.

ATC's position with respect to the ATC Arrowhead Alternative is summarized neatly by Mr. Dagenais: "Simply put, the [ATC Arrowhead Alternative] provides a more reliable solution for interconnecting the Project to the AC high-voltage transmission system, at a lower overall cost and with fewer environmental and human impacts."[110] The ATC Arrowhead Alternative and arguments in support of the ATC Arrowhead Alternative that have been made by ATC have been thoroughly assessed by Minnesota Power and determined to be inconsistent with the stated purpose and need of the HVDC Modernization Project. My testimony demonstrates that there are additional considerations not mentioned by ATC – such as project schedule impacts – which must also be factored into the Commission's consideration of the ATC Arrowhead Alternative. For all the technical nuances of the arguments put forth by Minnesota Power and ATC, this decision really boils down to a handful of propositions:

1) The ATC Arrowhead Alternative is not a more reliable solution for interconnecting Minnesota Power's HVDC System to the AC transmission system. None of the studies provided by ATC or Minnesota Power has raised any concern with the reliability or the system impacts of Minnesota Power's proposed HVDC Modernization Project configuration, while a high-level review of both Minnesota Power's and ATC's studies demonstrates that there are many outstanding questions arising from the unnecessary changes to the configuration of the existing transmission system[111] introduced by the ATC Arrowhead Alternative.
2) The ATC Arrowhead Alternative is not a lower cost solution when accurately compared with Minnesota Power's proposed HVDC Modernization Project

[110] Dagenais Direct at 15:1-3

[111] Moving the HVDC System point of interconnection to the ATC Arrowhead 345 kV Substation, bypassing and removing the ATC Arrowhead PST, removing the ATC Arrowhead 345 kV capacitor banks, adding a second ATC Arrowhead 345 kV/230 kV transformer, and exceeding the Arrowhead-Weston 800 MVA limitation – none of which are required for Minnesota Power's proposed HVDC Modernization Project configuration

configuration. Even assuming, as ATC does, that a second Arrowhead PST is not needed, the direct capital cost difference between the ATC Arrowhead Alternative and the proposed Project configuration is less than one half of one percent of the overall Project mid-range cost. As discussed in the Direct Testimony of Mr. Gunderson, when this is translated into rate impacts, the cost of the ATC Arrowhead Alternative is actually higher than the proposed Project due to ATC's proposed method of recovering its costs from Minnesota Power's customers. Factoring in the risk of additional costs due to the many open questions about the technical configuration of the ATC Arrowhead Alternative and the federal grant opportunities Minnesota Power is working to obtain for the Project, the already-higher cost of the ATC Arrowhead Alternative will only increase.

3) The ATC Arrowhead Alternative will unnecessarily delay Minnesota Power's implementation of the HVDC Modernization Project, in direct conflict with the primary purpose and need of the Project. Minnesota Power has an urgent need to replace its existing nearly 50-year-old HVDC converter station infrastructure before there is a catastrophic failure. With its proposed Project configuration, Minnesota Power has obtained a guarantee that the HVDC Modernization Project will be implemented no later than April 2030, with a very real opportunity to deliver the Project much earlier as a result of Minnesota Power's diligent efforts working with its HVDC Supplier. With the ATC Arrowhead Alternative, any opportunity to deliver the Project early will be forfeited and the currently-guaranteed April 2030 in-service date will likely also become unachievable. Delaying the Project by another two years or more is not in the best interest of Minnesota Power's customers.
4) The ATC Arrowhead Alternative is not a more reasonable or prudent solution when considering potential socioeconomic and environmental impacts, as discussed by Company witness, Mr. McCourtney.

While the record on the ATC Arrowhead Alternative has been developed with a tremendous volume of additional information since the ATC Arrowhead Alternative was formally introduced by ATC in September 2023, the additional information on the record validates the concerns originally expressed by Minnesota Power in its response to ATC's initial filing of the ATC Arrowhead Alternative and further illustrates why the ATC Arrowhead Alternative is not a more reasonable and prudent alternative than Minnesota Power's proposed HVDC Modernization Project configuration and why Minnesota Power moved forward with its configuration of the HVDC Modernization Project after meetings with ATC in late 2022. If it is a matter of selecting the solution that best meets the needs of Minnesota Power's customers, the record demonstrates that the Commission should reject the ATC Arrowhead Alternative and issue a Certificate of Need and Route Permit for Minnesota Power's proposed configuration of the HVDC Modernization Project.

Q. Does this complete your testimony?

A. Yes.

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: November 7, 2023

Requested From: Minnesota Power Response Due: December 1, 2023

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

Information Request No. 3

Refer to page 11 of the Certificate of Need Application where the following is stated: "Given the long-term significance of the HVDC Line for Minnesota Power and the region, design options to accommodate future expansion are a major consideration for the Project. The new voltage source converter ("VSC") HVDC Converter Stations will be designed with a flexible, scalable approach that will enable their future expansion to accommodate bulk regional transfers of renewable energy. Minnesota Power is working with the HVDC supplier to procure the most current capacity and technology for the new VSC Converter Stations, as well as additional expandability features to enable staged development of additional HVDC capacity to meet future regional needs."

a. Please explain in detail the long-term significance associated with the HVDC Line for Minnesota Power. In your response, please expound upon the "additional expandability features," and the "staged development" referenced and include a timeline of the expansion.

b. Please explain in detail the long-term significance associated with the HVDC Line for the region. In your response, please expound upon the "additional expandability features," and the "staged development" referenced and include a timeline of the proposed expansion.

c. Please describe in detail how Minnesota Power's proposed Project will benefit bulk regional transfers of renewable energy and to meet future regional needs.

Response:

a. The Square Butte HVDC Line has served Minnesota Power customers with reliable, economic energy for over 45 years. While developing the Project, as described in Chapter

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Response by: Peter Schommer

Title: Manager – Power Delivery & Asset Management

Department: Transmission

Telephone: 218-355-2639

2.0 of the CON/RP Application and taking into consideration the reasons described in Chapter 3.0, the HVDC Line plays a major role in continuing to deliver reliable, economic and clean energy from Minnesota Power's zero fuel cost North Dakota wind energy. With this Project, Minnesota Power has an opportunity to build for a future that consists of more clean energy as we execute the State of Minnesota's 100% carbon free by 2040 standard. This Project includes the replacement of the HVDC terminals and, due to the nature of the HVDC equipment, the Project will provide additional capacity for the converters. When the Project is complete, the new HVDC converter terminals will be capable of transferring up to 1500MW (although the HVDC Line will not be capable of this transfer without modifications to the HVDC Line). Furthermore, the layout of the HVDC converter stations will be designed such that it will be straightforward to add another converter to operate a second 1500MW HVDC pole, similar to the way the current bipole system operates, creating the potential to increase the total capacity up to 3000MW. Even after the initial converter station replacement, the existing HVDC Line itself will limit the capacity of the system to its present capacity or, with targeted transmission line upgrades, up to 900MW to serve Minnesota Power's needs. Over the next several years Minnesota Power will continue to evaluate the needs of its system and resources and be engaged with the MISO Long Range Transmission Planning effort to determine when and if the HVDC Line will be upgraded to 1500MW or more. There is no defined timeline for these decisions currently.

b. The Square Butte HVDC Line has also served the region with benefits such as dynamic response for specific fault conditions, congestion management, and frequency stabilization. The VSC technology offers several more system support benefits described in Section 3.3.2 of the CON/RP Application. Just as Minnesota Power continually evaluates the needs of our customers, the regional planning entities such as MISO continually evaluate the needs

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of the region in a changing resource environment. In its Renewable Integration Impact Assessment ("RIIA") study, MISO found that there was a long-term need for VSC HVDC projects to achieve renewable penetration levels consistent with clean energy goals. In its recent Long Range Transmission Plan ("LRTP") study, MISO has begun to identify and develop a justification for the specific projects necessary for the clean energy transition. From the beginning of the LRTP process, MISO has shown several high-capacity HVDC connections on its long-term indicative roadmap, including one that overlaps the Square Butte HVDC corridor. Since the beginning of 2023, MISO has been working with stakeholders to identify the assumptions, technologies, issues, and potential projects for its second tranche of LRTP projects. The stakeholder process has included significant discussions about HVDC technology and MISO appears to have recognized the likely need for HVDC projects to be considered in LRTP Tranche 2. Minnesota Power has made MISO aware of the expandability considerations for its planned VSC HVDC converters as detailed in the response to subpart (a) for MISO's consideration as they evaluate needs and alternatives for the LRTP Tranche 2 portfolio. At this time, MISO is still in the process of developing models for the LRTP Tranche 2 study and it is too early to say whether specific projects will be a part of the LRTP Tranche 2 portfolio or not. The LRTP Tranche 2 portfolio is expected to be approved by the MISO Board in mid to late 2024. For projects included in LRTP Tranche 2, it is expected that the in-service dates of the projects will be targeted for approximately 2035-2040.

c. The HVDC Modernization Project as proposed by Minnesota Power serves the renewable energy transfer needs of Minnesota Power's customers. The additional expandability features discussed in the response to subpart (a) have been included by Minnesota Power to position the HVDC facility to also meet future regional needs for bulk renewable energy transfers, in much the same way as an AC transmission line may be intentionally designed

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: November 7, 2023

Requested From: Minnesota Power Response Due: December 1, 2023

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

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with the capability to add a second circuit for future use. The MISO Generation Interconnection Queue as of 11/07/2023 shows 28 projects consisting of 6,723MW of wind when filtering for North Dakota active projects. Furthermore, the MISO West region has 200 active projects adding up to 35.27GW. If those projects are to come to fruition to support clean energy and carbon reduction goals, more transmission must be built to get the energy delivered to the loads across the system. Increasing the capacity of the existing HVDC Line is one potential solution to do just that but is one part of the larger picture, as the MISO LRTP indicative roadmap illustrates. With future upgrades, the HVDC Line could help transport up to 3000MW of renewable energy from Central and Western North Dakota to Minnesota, Wisconsin, and beyond. Several of the states in the region have renewable or carbon free goals and the HVDC Line can help reach those goals.

Response by: Peter Schommer

Title: Manager – Power Delivery & Asset Management

Department: Transmission

Telephone: 218-355-2639

Minnesota Department of Commerce
85 7th Place East | Suite 280 | St. Paul, MN 55101
Information Request

Docket Number: E015/CN-22-607
Requested From: Minnesota Power
Type of Inquiry: General

☐Nonpublic ☒Public
Date of Request: 2/22/2024
Response Due: 3/4/2024

SEND RESPONSE VIA EMAIL TO: Utility.Discovery@state.mn.us as well as the assigned analyst(s).
Assigned Analyst(s): Michael N. Zajicek
Email Address(es): michael.zajicek@state.mn.us
Phone Number(s): 651-539-1830

ADDITIONAL INSTRUCTIONS:
Each response must be submitted as a text searchable PDF, unless otherwise directed. Please include the docket number, request number, and respondent name and title on the answers. If your response contains Trade Secret data, please include a public copy.

Request Number:	**18**
Topic:	Future Expansion
Reference(s):	Click or tap here to enter text.

Request:

To the extent that future expansion of the HVDC line or interconnections to Minnesota Powers proposed St. Louise County Substation allow for other parties to use the HVDC line or power transported by the HVDC line, what options for cost sharing will be available for Minnesota Power?

Response:

If the HVDC Line were expanded beyond the capacity proposed in the Certificate of Need filing (beyond the 900 MW held by Minnesota Power, up to 1500 MW), cost allocation and access to the additional capacity would be governed by the MISO Tariff. Presently, the available 900 MW of capacity of the HVDC Line with the proposed project is fully subscribed by Minnesota Power. This includes the 550 MW currently used by Minnesota Power and the additional 350 MW of transmission service requests held by Minnesota Power that may be used by Minnesota Power as necessary or assigned by Minnesota Power to another party. If Minnesota Power were to assign any of the 350 MW in transmission service requests to another party, Minnesota Power customers would receive the financial benefit of any such transaction.

Any other party seeking to use the capacity of the HVDC Line under the current framework would need to procure capacity rights from Minnesota Power through its tariff and would be charged Minnesota Power's HVDC tariff rates. Any party seeking to expand the capacity of the HVDC Line above 900 MW would need to fund the additional system upgrades that are incremental and necessary to increase the capacity of the HVDC Line . The

To be completed by responder

Response Date: March 4, 2024
Response by: Randi Nyholm
Email Address: rnyholm@mnpower.com
Phone Number: 218-723-7466

Minnesota Department of Commerce
85 7th Place East | Suite 280 | St. Paul, MN 55101
Information Request

Docket Number: E015/CN-22-607 ☐Nonpublic ☒Public
Requested From: Minnesota Power Date of Request: 2/22/2024
Type of Inquiry: General Response Due: 3/4/2024

SEND RESPONSE VIA EMAIL TO: Utility.Discovery@state.mn.us as well as the assigned analyst(s).
Assigned Analyst(s): Michael N. Zajicek
Email Address(es): michael.zajicek@state.mn.us
Phone Number(s): 651-539-1830

ADDITIONAL INSTRUCTIONS:
Each response must be submitted as a text searchable PDF, unless otherwise directed. Please include the docket number, request number, and respondent name and title on the answers. If your response contains Trade Secret data, please include a public copy.

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entity would then also pay Minnesota Power's annual operating HVDC tariff rates based on the applicable pro-rata share.

If a future expansion of the HVDC Line was determined by MISO to meet the definition of a multi-value project ("MVP") or market efficiency project ("MEP") under the MISO tariff, then the incremental cost of increasing the HVDC capacity would be allocated by MISO according to the applicable tariff provisions for regional cost allocation. The actual application of cost sharing with other parties is highly dependent on facts and circumstances pertaining to future expansion.

This discussion is limited to an overview of two potential approaches to cost sharing and is not intended be a comprehensive assessment of all possible avenues for cost sharing of potential future expansion or related projects impacting the HVDC line.

Interconnection at the St. Louis County substation is governed by Minnesota Power's Transmission Interconnection Requirements which are published at www.mnpower.com.

To be completed by responder

Response Date: March 4, 2024
Response by: Randi Nyholm
Email Address: rnyholm@mnpower.com
Phone Number: 218-723-7466

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: February 28, 2024

Requested From: Minnesota Power Response Due: March 11, 2024

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

Information Request No. 34

Refer to the Presentation entitled "Minnesota Power and IRP 101" that was discussed at a webinar on February 21, 2024 (attached). Slide 22 entitled "Transmission to Support the Transition" indicates that "When complete, the 465-mile HVDC Line will be capable of transferring 900 MW (from 550 MW)." Please respond to the following:

1. Please explain if the Company has already initiated a process to seek approval of upgrading the HVDC Line to 900 MW and if not, when the Company intends to initiate this process.

2. Please explain the process Minnesota Power intends to use to seek approval of upgrading the HVDC Line to 900 MW

3. Please explain if the upgrade will require a certificate of need process and if not, why not.

4. Please provide cost estimates for upgrading the HVDC Line to increase the capability to 900 MW.

Response:

1. With respect to MISO approvals, upgrading the capacity of the HVDC transmission line from 550 MW to 900 MW (HVDC 900 MW Transmission Line Upgrade) was studied by MISO in the System Impact Study for the Transmission Service Requests ("TSRs") discussed in Minnesota Power's response to ATC IR 038. With respect to Minnesota Public Utilities Commission ("Commission") approvals, Minnesota Power has not initiated a process to seek approval or notification under Minn. R. 7850.1500, subp. 1(B)(2)) of the HVDC 900 MW Transmission Line Upgrade, but a potential need for increased capacity on the HVDC transmission line has been reported in the Minnesota Biennial Transmission Projects Report since 2013 under MPUC Tracking Number 2013-NE-N17. The Minnesota Biennial Transmission Projects Report is available at www.minnelectrans.com.

Response by: Randi Nyholm
Title: RTO Coordination Manager
Department: Strategy & Planning
Telephone: 218-723-7466

LARGE POWER INTERVENORS

Utility Information Request

Docket Number: E015/CN-22-607; E015/TL-22-611 Date of Request: February 28, 2024

Requested From: Minnesota Power Response Due: March 11, 2024

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

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2. The execution by MISO and Minnesota Power of the Facilities Construction Agreement referenced in response to ATC IR 038, triggers MISO to move the status of the HVDC 900 MW Transmission Line Upgrade to “Recommended” - granting it presumptive approval in the current MTEP cycle (MTEP24). The project will be formally approved by the MISO Board of Directors when the full MTEP24 report is approved in December 2024. Commission review of cost recovery for the HVDC 900 MW Transmission Line Upgrade will occur in a subsequent proceeding and has not been requested at this time.

3. The HVDC 900 MW Transmission Line Upgrade does not require a Certificate of Need because it involves upgrading an existing transmission line on existing right-of-way without changing the voltage (Minn. R. 7850.1500, subp. 1(B)(2)).

4. The cost estimate for the HVDC 900 MW Transmission Line Upgrade is documented in the MISO Facilities Study, which was provided previously as LPI IR 005.05 Attach. The estimated cost is $58 million.

Response by: Randi Nyholm
Title: RTO Coordination Manager
Department: Strategy & Planning
Telephone: 218-723-7466

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: December 27, 2023

Requested From: Minnesota Power Response Due: January 6, 2024
Extension Granted to: January 12, 2024

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

Information Request No. 23

Refer to response to LPI's IR 3 which states in part "This Project includes the replacement of the HVDC terminals and, due to the nature of the HVDC equipment, the Project will provide additional capacity for the converters. When the Project is complete, the new HVDC converter terminals will be capable of transferring up to 1500MW (although the HVDC Line will not be capable of this transfer without modifications to the HVDC Line). Furthermore, the layout of the HVDC converter stations will be designed such that it will be straightforward to add another converter to operate a second 1500MW HVDC pole, similar to the way the current bipole system operates, creating the potential to increase the total capacity up to 3000MW." Please respond to the following:

a. Please provide more specifics regarding the "nature of the HVDC equipment" and how it impacts or results in providing additional capacity for the converters.

b. Please explain if HVDC equipment is available to be sized such that the HVDC converter terminals are capable of transferring up to 600 MW or the same amount of MWs as the present time (i.e., "a like-for-like" change with no alteration in capacity). If so, please provide the associated cost differentials between sizing for 600 MW compared to Minnesota Power's proposal in the Application.

Response:

a. There are several basic building blocks of an HVDC converter station, including outdoor equipment like reactors, converter transformers, filters (if needed), circuit breakers, and cooling towers as well as indoor equipment such as converter valves (power electronics), cooling equipment, and control and protection equipment. Significant site infrastructure, including buildings, foundations, and support structures are also required to support or

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Response by: Peter Schommer

Title: Manager – Power Delivery & Asset Management
Department: Transmission

Telephone: 218-355-2639

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: December 27, 2023

Requested From: Minnesota Power Response Due: January 6, 2024
Extension Granted to: January 12, 2024

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

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house this equipment. The nature of an HVDC converter station project is such that all of these basic building blocks are necessary. For many of the components, a certain amount of additional capacity may be readily-available due to standardization of component ratings. Most individual parts that make up the components will not be rated for exactly what is needed, so the supplier will use the next highest-rated standard part in the design, resulting in the overall component having additional capacity. In many cases, incremental capacity may also be achievable with relatively modest incremental changes in component design and cost because most of the cost originates with needing the component in the first place. Some of the largest HVDC converter station components, such as the converter transformers, converter valves, and converter hall (building), may readily provide for incremental capacity in these ways.

b. HVDC suppliers will provide the capacity requested by the customer. If a supplier received a request for proposals for a 600 MW HVDC converter station, then they would provide a bid for a solution at that capacity by scaling the few pieces of equipment that are custom designed. However, as noted above, many of the components in the HVDC supplier's solution, including potentially some of the highest-cost components, may be suitable for higher capacity with little or no modification. For example the converter valve electronics may be rated standard for 3000A with sufficient cooling, but the supplier could intentionally limit the size of the cooling system which would in turn limit the valve electronics to something less than 3000A based on what the customer requests. Minnesota Power provided an estimated $/kW rate for increasing capacity of the HVDC converters in response to LPI IR 027.

Response by: Peter Schommer

Title: Manager – Power Delivery & Asset Management
Department: Transmission

Telephone: 218-355-2639

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: March 1, 2024

Requested From: American Transmission Company LLC Response Due: March 11, 2024

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

Information Request No. 4

On page 49, Winters testimony indicates that the construction of the St. Louis County Substation would be necessary in the future even if ATC's Arrowhead Alternative were implemented at this time. Does ATC agree with this assessment? Please explain why or why not.

Response: No. Minnesota Power (MP) claims that it anticipates that the new 345 kV St. Louis County Substation will be needed in the future "[b]ased on the Company's review of the development of the MISO LRTP roadmap and anticipation of needs identified by MISO in the LRTP Tranche 2 process." However, as discussed in ATC witness Thomas Dagenais rebuttal testimony, the conceptual 345 kV St. Louis County Substation that MISO has been evaluating as part of the Long Range Transmission Plan (LRTP) Tranche 2 process is a preliminary conceptual transmission asset and is not the same as the 345 kV St. Louis County Substation that MP is proposing to construct as part of the Project. To ATC's knowledge, MISO has never endorsed the specific iteration of the St. Louis County Substation that MP has proposed in this proceeding.

Additionally, on March 4, 2023, MISO published its initial draft portfolio for LRTP Tranche 2, a copy of which is available at the hyperlink provided below. While this plan is subject to change between now and when it is submitted to the MISO Board of Directors for formal approval (likely later this year), it currently includes no new 345 kV transmission assets in Minnesota Power's service territory and no new 345 kV substation in St. Louis County. Therefore, construction of the new 345 kV St. Louis County Substation as part of LRTP Tranche 2 is by no means a foregone conclusion, as MP appears to presume.

https://cdn.misoenergy.org/20240315%20LRTP%20Workshop%20Tranche%202%20Anticipated%20Portfolio632013.pdf

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Response by: Thomas Dagenais

Title: Director, System Planning

Telephone: (608) 877-7161

Minnesota Department of Commerce
85 7th Place East │ Suite 280 │ St. Paul, MN 55101
Information Request

Docket Number: E015/CN-22-607 ☐Nonpublic ☒Public

Requested From: American Transmission Company LLC Date of Request: 2/22/2024
Type of Inquiry: General Response Due: 3/4/2024

SEND RESPONSE VIA EMAIL TO: Utility.Discovery@state.mn.us as well as the assigned analyst(s).
Assigned Analyst(s): Michael N. Zajicek
Email Address(es): michael.zajicek@state.mn.us
Phone Number(s): 651-539-1830

ADDITIONAL INSTRUCTIONS:
Each response must be submitted as a text searchable PDF, unless otherwise directed. Please include the docket number, request number, and respondent name and title on the answers. If your response contains Trade Secret data, please include a public copy.

Request Number:	**19**
Topic:	ATC's Arrowhead Substation Alternative Timeline
Reference(s):	Dustin Johanek Schedule 2

Request: Does ATC's Arrowhead Substation Alternative Timeline as submitted by ATC witness Dustin Johanek as Schedule 2 to his direct testimony include any time for MISO studies or include flexibility to make changes to the project based on the results of MISO studies?

RESPONSE: Schedule 2 presents a high-level schedule for construction of the Arrowhead Substation Alternative. While the schedule does not specifically account for the time that might be required for MISO to study this alternative, there is sufficient time within the schedule to accommodate those studies. Based on the planning analysis it has conducted to date, ATC believes that the Arrowhead Substation Alternative provides an adequate and reliable means of interconnecting the Project to the high-voltage alternating current transmission system; as such, ATC does not believe that the results of the foregoing studies will require any material modifications to the scope of work that ATC has presented for the Arrowhead Substation Alternative in this proceeding.

At pages 30-31 of Minnesota Power ("MP") witness Christian Winter's direct testimony, MP stated that upon execution of a Facilities Construction Agreement with MISO, the HVDC Modernization Project ("Project") "is ready to be recommended to the MISO Board for approval in the current MTEP cycle." MP reiterated this point in response to ATC Information Request No. 38, stating that "it is Minnesota Power's expectation that [the Project] will be considered for approval by the MISO Board of Directors in the current MTEP cycle (MTEP24) anticipated in December 2024." (*See* Attachment 1)

Assuming MP does seek to have the Project approved as part of the current MISO Transmission Expansion Plan ("MTEP") during this planning cycle, it will be subject to further review and input from MISO and other stakeholders—including ATC—as part of MISO's open, transparent, and collaborative MTEP planning process. Specifically, the Project is currently listed in the active MTEP database as an "Other" type transmission project. Per Sections 2.3.2.1 of MISO's Transmission Planning Business Practice Manual (No. 020) ("BPM"), "Other" transmission

To be completed by responder

Response Date: March 8, 2024
Response by: Dustin Johanek, Consultant Project Manager; Thomas Dagenais, Director – System Planning
Email Address: djohanek@atcllc.com; tdagenais@atcllc.com
Phone Number: (920) 338-6516; (608) 877-7161

Minnesota Department of Commerce
85 7th Place East | Suite 280 | St. Paul, MN 55101
Information Request

Docket Number: E015/CN-22-607 ☐Nonpublic ☒Public

Requested From: American Transmission Company LLC Date of Request: 2/22/2024
Type of Inquiry: General Response Due: 3/4/2024

SEND RESPONSE VIA EMAIL TO: Utility.Discovery@state.mn.us as well as the assigned analyst(s).
Assigned Analyst(s): Michael N. Zajicek
Email Address(es): michael.zajicek@state.mn.us
Phone Number(s): 651-539-1830

ADDITIONAL INSTRUCTIONS:
Each response must be submitted as a text searchable PDF, unless otherwise directed. Please include the docket number, request number, and respondent name and title on the answers. If your response contains Trade Secret data, please include a public copy.

Request Number:	**19**
Topic:	ATC's Arrowhead Substation Alternative Timeline
Reference(s):	Dustin Johanek Schedule 2

projects are considered "bottom-up" transmission projects that may be needed to address (among other things) aging transmission infrastructure or to improve operational performance or address other operational issues. As discussed in Section 4.1 and 4.3 of the MISO Transmission Planning BPM, these projects are subject to stakeholder review and feedback—including concerning potential alternatives—as part of the MTEP process before the MISO Board of Directors can approve such projects at the end of the current MTEP cycle. Assuming the Project is reviewed as part of the current MTEP cycle, ATC would have until May 31 to submit the Arrowhead Substation Alternative to MISO for consideration, which MISO and other stakeholders will review and evaluate, including at upcoming subregional planning meetings between May and August.

MISO will then evaluate the feedback it has received, analyze the alternatives that have been submitted (including thorough detailed planning analysis), and recommend the best solution for inclusion in the current MTEP and approval by the MISO Board. Therefore, by the end of this planning year, MISO can review and approve for inclusion in the MTEP the Project as proposed by MP, or the Project as modified by the Arrowhead Substation Alternative.

In sum, there is sufficient time for MISO to review and study both the Project and the Arrowhead Substation Alternative within the framework of the existing schedule for construction of the Arrowhead Substation Alternative, given the expected timeline for MISO's review of the Project and that alternative as part of the MTEP process.

To be completed by responder

Response Date: March 8, 2024
Response by: Dustin Johanek, Consultant Project Manager; Thomas Dagenais, Director – System Planning
Email Address: djohanek@atcllc.com; tdagenais@atcllc.com
Phone Number: (920) 338-6516; (608) 877-7161

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	February 21, 2024
Requested From:	Minnesota Power	Response Due:	March 4, 2024

By: American Transmission Company LLC

Information Request No. 38.

Reference pages 30-31 of the direct testimony of MP witness Christian Winter

a. Please provide the System Impact Study that MISO has completed in connection with the Transmission Service Requests that You submitted to increase the capacity of the HVDC Line from 550 MW to 900 MW.

b. Please provide the execution copy of Your Facilities Construction Agreement (FCA) with MISO "outlining the terms and obligations associated with constructing the upgrades necessary to accommodate the TSRs." If the FCA has not yet been executed, provide the most recent draft of the agreement.

c. If You have not yet executed the FCA with MISO, please identify the approximate date at which You expect to execute that agreement.

d. Please identify those provisions of the MISO tariff and/or MISO business practice manuals that You contend authorize the MISO Board of Directors to approve the HVDC Modernization Project "for approval in the current MTEP cycle."

Response:

a. The System Impact Studies are posted on MISO's OASIS page and can be accessed via the following links, which ATC has full access to:
   - System Impact Study for 150 MW of transmission service, issued July 23, 2020: http://www.oasis.oati.com/woa/docs/MISO/MISOdocs/A746_Final_Report.pdf
   - System Impact Study for 200 MW of transmission service, issued December 13, 2019:

Response by: Randi Nyholm
Title: RTO Coordination Manager
Department: Strategy & Planning
Telephone: 218-723-7466

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	February 21, 2024
Requested From:	Minnesota Power	Response Due:	March 4, 2024

By: American Transmission Company LLC

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http://www.oasis.oati.com/woa/docs/MISO/MISOdocs/A727_Revised_Final_Report_V2.pdf

- It should be noted that MISO did update its analysis to evaluate the Project in its currently-proposed configuration including the St. Louis County 345/230 kV Substation in 2023, but because the results summarized in the System Impact Study reports did not materially change from the topology originally considered in 2019, MISO has not issued updated reports

b. See ATC IR 038.01 Attach and ATC IR 038.02 Attach.

c. Minnesota Power signed the FCAs on February 23, 2024. MISO executed the FCAs on February 28, 2024 and the FERC filing is scheduled for March 5, 2024.

d. The provisions are described in MISO BPM-020-r30, of which ATC has full access to, as follows:
   - BPM-020-r30, Section 2.3.2.6 (Page 28) defines *Transmission Delivery Service Projects* as: "Network Upgrades required to facilitate long-term firm point-to-point transmission service requests." The HVDC Modernization Project ("Project") was identified as a Network Upgrade required to facilitate long-term firm point-to-point transmission service requests ("TSRs") and therefore it meets the definition of a Transmission Delivery Service Project.
   - BPM-020-r30, Section 2.3.1.3 (Page 25) defines *Externally Driven Projects* as "projects driven by needs identified outside of the MISO Transmission Expansion Plan ("MTEP") planning process." This section further states: "Externally driven projects include . . . Transmission Delivery Service Projects . . . ." The Project, as a Transmission Delivery Service Project, also falls under the more general category of an Externally Driven Project

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Response by: Randi Nyholm
Title: RTO Coordination Manager
Department: Strategy & Planning
Telephone: 218-723-7466

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	February 21, 2024
Requested From:	Minnesota Power	Response Due:	March 4, 2024

By: American Transmission Company LLC

- BPM-020-r30, Section 2.4.7 (Page 39) describes the process for Externally Driven Projects to be submitted into the MTEP project database. This section states "MISO staff or Transmission Owner(s) will submit externally driven projects into the MTEP project database at such time when all conditions, including but not limited to *execution of applicable agreements*, have been satisfied for formal recommendation of the project for approval by the MISO board of directors. All externally driven projects will be submitted to the MTEP project database with a Planning Review Status of *Recommended*." (emphasis added) Upon execution of the FCA, it is Minnesota Power's understanding that the Project, as an Externally Driven Project, will have met all such conditions for submission into the MTEP project database with Planning Review Status of Recommended. In this case, because there is already an existing database entry representing the Project in MTEP Appendix B, it is Minnesota Power's expectation that MISO will move that existing project to "Recommended" status rather than creating a new project database entry.
- BPM-020-r30, Section 2.4.3 (Page 36) describes the process for a project to be moved into Appendix A, which is MISO's list of all approved projects. This section states, "the draft MTEP Appendix A prior to MTEP report approval contains all projects within the transmission project database that have a Planning Review Status of either *Recommended* or *Approved*. . . . Upon approval of a specific MTEP report and associated recommendations, all projects in MTEP Appendix A of that MTEP report are considered approved and the Planning Review Status will be set to Approved." Since the HVDC Modernization Project will be moved to "Recommended" status upon execution of the FCA, it is Minnesota Power's expectation that it will be considered for approval by the MISO Board of Directors in the current MTEP cycle (MTEP24) anticipated December 2024.

Response by: Randi Nyholm
Title: RTO Coordination Manager
Department: Strategy & Planning
Telephone: 218-723-7466

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	February 21, 2024
Requested From:	Minnesota Power	Response Due:	March 4, 2024

By: American Transmission Company LLC

Attachments to this information request contain confidential security data that the Company considers to be trade secret data as defined by Minn. Stat. § 13.37(1)(a). Due to security information policies and concerns, the information provided in this response has been marked **HIGHLY CONFIDENTIAL TRADE SECRET INFORMATION**. The public disclosure or use of this information creates an unacceptable risk because those who want to disrupt the electric system for political or other reasons may learn which facilities to target to create the greatest disruption. Thus, Minnesota Power maintains this information as trade secret pursuant to Minn. Rule 7829.0500, subp. 3.

Supplemental Response (March 6, 2024):

b. For executed copies of FCAs as filed with FERC on March 5, 2024, please see ATC IR 038.03 Attach.

c. See response to subpart b.

Attachments to this information request contain confidential security data that the Company considers to be trade secret data as defined by Minn. Stat. § 13.37(1)(a). Due to security information policies and concerns, the information provided in this response has been marked **HIGHLY CONFIDENTIAL TRADE SECRET INFORMATION**. The public disclosure or use of this information creates an unacceptable risk because those who want to disrupt the electric system for political or other reasons may learn which facilities to target to create the greatest disruption. Thus, Minnesota Power maintains this information as trade secret pursuant to Minn. Rule 7829.0500, subp. 3.

Response by: Randi Nyholm
Title: RTO Coordination Manager
Department: Strategy & Planning
Telephone: 218-723-7466

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	February 21, 2024
Requested From:	Minnesota Power	Response Due:	March 4, 2024

By: American Transmission Company LLC

Information Request No. 39.

Reference pages 30-31 of the direct testimony of MP witness Christian Winter. Please identify the specific "power flow base models for LRTP Tranche 2" that MISO released in January 2024 and that "incorporate the HVDC Modernization Project configuration proposed by Minnesota Power as a base (pre-LRTP Tranche 2) assumption."

Response:

As a MISO transmission owner, ATC has access to these models. The most recent LRTP Tranche 2 power flow models were released by MISO on January 24, 2024, as shown in ATC IR 039.01 Attach. In its email announcing the release of these models, MISO provides the following background:

> ***Background****: On October 25, 2023, MISO posted Version 1 of all eight (8) core reliability models to Sharefile for the LRTP Tranche 2 Study. The models are based on previously posted and reviewed LRTP Tranche 2 Reliability Topology models (MTEP22 series models – including approved transmission projects as of December 2022) and dispatch adjusted as per dispatch methodology shared in LRTP Tranche 2 Reliability Study Whitepaper, which includes dispatching new Future 2A generation, turning off future retirements and adjusting dispatch level of existing units. Version 2 models were posted in December 2023 with stakeholder feedback provided by December 8. Version 2.1 addresses additional items identified through January 4, 2024.*

Modeling topology specific to Minnesota Power's proposed configuration of the HVDC Modernization Project has been included in every release of the MISO LRTP power flow models since October 25, 2023. The models are available on MISO's sharefile at the link provided in the

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Response by: Christian Winter
Title: Manager-Regional Transmission Planning
Department: Delivery Support Operations
Telephone: 218-355-2908

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	February 21, 2024
Requested From:	Minnesota Power	Response Due:	March 4, 2024

By: American Transmission Company LLC

MISO email attached as ATC IR 039.01 Attach, of which ATC also received a copy as a MISO transmission owner.

Response by: Christian Winter
Title: Manager-Regional Transmission Planning
Department: Delivery Support Operations
Telephone: 218-355-2908

From: Planning SuperList on behalf of Dana Cochran
To: MISOPLANSL@LISTS.MISOENERGY.ORG
Subject: [EXTERNAL MAIL] [MISO] LRTP Tranche 2 MISO Reliability Models (Version 2.1), Additional Scenario Models and N-1 Results Posting
Date: Wednesday, January 24, 2024 8:06:18 AM

Dear Stakeholders,

MISO received stakeholder feedback on reliability models after MISO's Version 2 posting on December 21, 2023. These updates included topology fixes, line ratings, and line impedance updates. This feedback has been incorporated into all eight (8) core reliability models (Version 2.1).

This posting also includes additional scenario models (described in slide 4 of the August 2023 LRTP workshop presentation) in the folder labeled "Additional Scenario Models." These models have been dispatched per methodology shared in the LRTP Tranche 2 Reliability Study Whitepaper.

Lastly, contingency analysis results (thermal and voltage screening using TARA) for both the core reliability models (Version 2.1) and the additional scenario models are posted, along with the latest input files used to run the analysis.

To request access to Sharefile, follow the instructions within MISO's Help Center. Restrictions may apply based on the account's association with MISO and/or the Appendix A employee function of the requestor. Please see posting information below.

Background: On October 25, 2023, MISO posted Version 1 of all eight (8) core reliability models to Sharefile for the LRTP Tranche 2 Study. The models are based on previously posted and reviewed LRTP Tranche 2 Reliability Topology models (MTEP22 series models – including approved transmission projects as of December 2022) and dispatch adjusted as per dispatch methodology shared in LRTP Tranche 2 Reliability Study Whitepaper, which includes dispatching new Future 2A generation, turning off future retirements and adjusting dispatch level of existing units. Version 2 models were posted in December 2023 with stakeholder feedback provided by December 8. Version 2.1 addresses additional items identified through January 4, 2024.

Find the reliability models and results on Sharefile via direct link or path here: *MTEP > LRTP Tranche 2 > Powerflow Models > Reliability Models (Updated_01_23_2024)*

Thank you.

Find directions and contact information on our website.

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: November 7, 2023

Requested From: Minnesota Power Response Due: November 17, 2023

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

Information Request No. 9

Refer to page 42 where the following is stated: "The total estimated direct cost for the AC Alternative is nearly $1.4 billion, a 70 percent increase over the estimated mid-range cost of the HVDC Modernization Project. Because the need for these network upgrades would be triggered by retirement of the HVDC Line, the entirety of this cost would most likely be assigned to Minnesota Power."

a. Minnesota Power identified transmission line upgrades in multiple states including Iowa, North Dakota, South Dakota, and Minnesota associated with the AC alternative. Please explain why other states would not benefit from these lines and therefore be allocated costs.

b. As currently proposed in the Application, does Minnesota Power anticipate that its preferred and proposed Project will include cost sharing with others? Please explain.

Response:

a. The transmission line upgrades in question were associated with the retirement of the HVDC line and identified in the study according to typical threshold criteria for assigning system impacts. The upgrades are not needed if the HVDC line remains in service. Because the need for the upgrades in the study is caused by the retirement of the HVDC line, Minnesota Power assumed that the costs would be assigned based on this direct causation regardless of ancillary benefits to neighboring entities. The only clear way for costs to be assigned to others would be if the projects meet cost allocation criteria outlined in the MISO Tariff, for example as a Multi-Value Project ("MVP") or Market Efficiency Project

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Response by: Christian Winter

Title: Manager-Regional Transmission Planning

Department: Delivery Support Operations

Telephone: 218-355-2908

LARGE POWER INTERVENORS

Utility Information Request

Docket Number: E015/CN-22-607; E015/TL-22-611 Date of Request: November 7, 2023

Requested From: Minnesota Power Response Due: November 17, 2023

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

("MEP"). Minnesota Power does not anticipate that upgrades associated with the retirement of the HVDC line would meet these criteria.

b. No, at this time Minnesota Power does not anticipate its proposed Project will include cost sharing with others. Currently, the only clear way for costs to be assigned to others would be if the project meets cost allocation criteria outlined in the MISO Tariff, for example as an MVP or MEP.

Response by: Christian Winter

Title: Manager-Regional Transmission Planning

Department: Delivery Support Operations

Telephone: 218-355-2908

Minnesota Department of Commerce
85 7th Place East | Suite 280 | St. Paul, MN 55101
Information Request

Docket Number: E015/CN-22-607
Requested From: Minnesota Power
Type of Inquiry: General

☐Nonpublic ☒Public
Date of Request: 2/7/2024
Response Due: 2/20/2024

SEND RESPONSE VIA EMAIL TO: Utility.Discovery@state.mn.us as well as the assigned analyst(s).
Assigned Analyst(s): Michael N. Zajicek
Email Address(es): michael.zajicek@state.mn.us
Phone Number(s): 651-539-1830

ADDITIONAL INSTRUCTIONS:
Each response must be submitted as a text searchable PDF, unless otherwise directed. Please include the docket number, request number, and respondent name and title on the answers. If your response contains Trade Secret data, please include a public copy.

Request Number:	**12**
Topic:	Alternatives Considered
Reference(s):	Certificate of Need

Request:

Did Minnesota Power consider any alternatives to the Project of obtaining alternative generation resources nearer to Minnesota Power's service territory? Please provide a discussion of this analysis and why the Company did not believe this was a reasonable alternative.

If not, please provide a discussion on whether or not such an alternative would be reasonable, and how its costs might compare to the proposed Project.

Response:
The HVDC Line is closely tied with the delivery of existing renewable energy resources, the decision to move forward with the HVDC Modernization Project ("Project") is in line with the resource planning decisions to procure economic and high-capacity factor wind in North Dakota. The purpose of the Project is to replace existing end-of-life HVDC transmission infrastructure that supports Minnesota Power's plan to decarbonize the energy portfolio by maintaining the delivery path for high-capacity factor renewable wind energy resources from North Dakota and the reliability of Minnesota Power's local 230 kV transmission system in northeastern Minnesota. In other words, the purpose of the Project is for asset preservation and renewal needed for Minnesota Power to meet State and Company renewable and carbon goals.

To be completed by responder

Response Date: February 20, 2024
Response by: Christian Winter
Email Address: cwinter@mnpower.com
Phone Number: (218) 355-2908

Minnesota Department of Commerce
85 7th Place East | Suite 280 | St. Paul, MN 55101
Information Request

Docket Number: E015/CN-22-607 ☐Nonpublic ☒Public
Requested From: Minnesota Power Date of Request: 2/7/2024
Type of Inquiry: General Response Due: 2/20/2024

SEND RESPONSE VIA EMAIL TO: Utility.Discovery@state.mn.us as well as the assigned analyst(s).
Assigned Analyst(s): Michael N. Zajicek
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Minnesota Power's latest Integrated Resource Plan ("IRP") continues to utilize its existing wind energy resources in North Dakota, including the Bison Wind Energy Center and the purchase agreements for the recently repowered Oliver County I and II facilities. The IRP assumed the HVDC line would be modernized and available to deliver North Dakota wind energy to customers. Procuring alternative generation closer to Minnesota Power's service territory is not reasonable given the commitments Minnesota Power already has in North Dakota and the significant impact it would have on the Company achieving renewable goals and carbon free goals.

An AC alternative does not address the urgent asset renewal needs of the existing HVDC converter stations and their continually increasing failure rates, would not provide any benefit for maintaining reliable delivery of Minnesota Power's existing renewable energy resources from North Dakota to its customers in northeastern Minnesota, and would not provide the same local reliability benefits to Minnesota Power's 230 kV transmission system. As Minnesota Power stated in Section 4.2 of the Application, "[t]here is no alternative generation or non-wire solution that can replace the function of the HVDC Converter Stations in facilitating the bulk long distance transfer of renewable energy across the grid." Minnesota Power will continue to maintain wind generating resources in North Dakota that will require delivery to Minnesota Power customers and Minnesota Power must continue to maintain the reliability of its 230 kV transmission system in northeastern Minnesota. Even if it is assumed that obtaining renewable energy resources closer to Minnesota Power's service territory would potentially eliminate the need for the Project and the HVDC Line (which Minnesota Power does not agree with), the alternative is not to "do nothing" with the HVDC Line and the surrounding AC System. As discussed in Section 4.8.2 of the Application, the retirement of the HVDC Line would likely lead to many AC Network Upgrades, with anticipated costs and environmental impacts significantly exceeding those of the Project.

To be completed by responder

Response Date: February 20, 2024
Response by: Christian Winter
Email Address: cwinter@mnpower.com
Phone Number: (218) 355-2908

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: December 27, 2023

Requested From: Minnesota Power Response Due: January 6, 2024
Extension Granted to: January 12, 2024

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

Information Request No. 27

Please provide the following assumptions related to generic wind included in Minnesota Power's most recent IRP:

a. Interconnection Costs on a $/KW basis and justification for using this assumption;

b. $/KW investment cost for generic wind and justification for using this assumption; and

c. Assumed capacity factor and justification for using this assumption.

Response:

a. The interconnection cost assumed for generic new wind in the more recent Integrated Resource Plan ("IRP") was a range of $343–$491/kilowatt ("kW") (2020 dollars). From the most recent IRP (Docket No. E015/RP-21-33), please refer to "Part 4: Generator Interconnection Network Upgrade Assumptions" of "Appendix F: Transmission Planning Activities" for the support and justification for this assumption.

   One important aspect of the HVDC Modernization Project is its ability to accommodate future expansion. Such expansion above 550 MW to the capabilities of the proposed converter station equipment (without needs to upgrade the HVDC Line, itself) is very economic and competitive when compared to the cost estimate for interconnecting new generic wind. The incremental cost to increase the HVDC line transfer capacity is approximately $260/kW, which is significantly lower than the interconnection cost range of $343–$491/kW estimated in the most recent IRP. This demonstrates that the HVDC Modernization Project is a cost-effective strategy for interconnecting new wind. The

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Response by: Eric Palmer

Title: Manager Utility Planning

Department: Strategy & Planning

Telephone: 218-355-3839

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: December 27, 2023

Requested From: Minnesota Power Response Due: January 6, 2024
Extension Granted to: January 12, 2024

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

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increase in capability aligns well with the last IRP, through which the Commission approved procuring up to 400 MW of additional wind.

b. The investment cost (i.e. capital cost) for generic wind in the more recent IRP was **[TRADE SECRET DATA BEGINS** [redacted] **TRADE SECRET DATA ENDS]**. Note that to capture the potential for future price reductions the capital build costs beyond 2021 are adjusted utilizing a technology curve. Minnesota Power's approach to developing capital cost for wind was discussed at the Modeling Subcommittee Meetings. Support and justification can be found in the notes and meeting materials from these discussions in "Appendix R Attachment 4 – Modeling Subcommittee Meeting Materials" (Docket No. E015/RP-21-33).

   The information assigned a trade secret designation herein includes project-specific information and has been marked as trade secret as defined by Minn. Stat. § 13.37, subd. 1(b). The information derives an independent economic value from not being generally known or readily ascertainable by others who could obtain a financial advantage from their use.

c. The assumed capacity factor for generic new wind was 46 percent. The capacity factor for wind was based on Minnesota Power's existing wind projects.

   When evaluating the cost of wind and associated capacity factors, these values are highly dependent on the location, technology, and economic factors (i.e. inflation, interest rate, exchange rates, commodity pricing, etc.). The capital cost and capacity factor will vary across projects depending on the specific local geography, wind regime, wind technology chosen, and economic factors at the time of the build.

Response by: Eric Palmer

Title: Manager Utility Planning

Department: Strategy & Planning

Telephone: 218-355-3839

Minnesota Department of Commerce
85 7th Place East | Suite 280 | St. Paul, MN 55101
Information Request

Docket Number: E015/CN-22-607 ☐Nonpublic ☒Public
Requested From: Minnesota Power Date of Request: 2/7/2024
Type of Inquiry: General Response Due: 2/20/2024

SEND RESPONSE VIA EMAIL TO: Utility.Discovery@state.mn.us as well as the assigned analyst(s).
Assigned Analyst(s): Michael N. Zajicek
Email Address(es): michael.zajicek@state.mn.us
Phone Number(s): 651-539-1830

ADDITIONAL INSTRUCTIONS:
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Request Number:	**13**
Topic:	Alternatives Considered
Reference(s):	Certificate of Need

Request:

The Company provided an estimated outage cost for the Project $1,825 per hour in response to the Departments information request #8. Extrapolating that cost to the likely 30 year expected life of the Project, that amounts to $492,750,000 ignoring inflation and other changes in outage costs, which the Department assumes will likely cause an increase the outage cost per hour over time.

Please provide a discussion on the Company's projections on the cost of outages over the expected lifespan of the Project under that assumption that the Project is not built, i.e. a no-build alternative that has the Company paying outage, congestion, and replacement power costs (and any other related costs). Please discuss what the Company's projected costs of such an alternative would be and if the Company believes this to be a viable option or if other factors would necessitate the Company take some other action.

Response:
It is important to recognize that there is not a true "no-build" alternative to the Project. The anticipated consequences for costs and reliability if the Project does not move forward are discussed in Section 4.11 of the Application. With no viable plan to modernize the existing HVDC converters, Minnesota Power would immediately need to begin developing alternative AC transmission solutions. These alternative AC transmission solutions would be required to facilitate continued delivery of Minnesota Power's existing North Dakota wind energy, mitigate system impacts caused by the retirement of the HVDC Line as identified in coordination with MISO and

To be completed by responder

Response Date: February 20, 2024
Response by: Christian Winter
Email Address: cwinter@mnpower.com
Phone Number: (218) 355-2908

Docket Number: E015/CN-22-607 ☐Nonpublic ☒Public
Requested From: Minnesota Power Date of Request: 2/7/2024
Type of Inquiry: General Response Due: 2/20/2024

SEND RESPONSE VIA EMAIL TO: Utility.Discovery@state.mn.us as well as the assigned analyst(s).
Assigned Analyst(s): Michael N. Zajicek
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neighboring utilities to comply with NERC transmission planning standards, and replace the grid support that will be provided by the VSC HVDC converters. The potential scope and cost of these alternative AC transmission solutions is discussed in Section 4.8.2 of the Application.

As the owner of the HVDC Line being retired (in the scenario where the Project does not move forward), Minnesota Power would be obligated to work with MISO and other neighboring utilities to identify and implement the necessary upgrades to bring the system back to a state that is at least as reliable as when the HVDC Line was operating. Therefore, the cost of these upgrades must be considered in addition to the costs of outages, congestion, and replacement power when evaluating a "no-build" alternative to the Project. Based on Minnesota Power's analysis of retiring the HVDC Line and mitigating the associated network upgrades with AC transmission solutions, discussed in Section 4.8.2 of the Application, Minnesota Power concluded that the cost of the AC network upgrades could be nearly double the estimated mid-range cost of the Project, approximately $1.4 billion. This amount does not include analysis of additional outage and congestion impacts, such as the $492 million calculated by the Department for this information request. Some amount of that cost would still be realized in addition to the $1.4 billion due to the loss of the congestion management capabilities of the HVDC Line. Minnesota Power believes this $1.4 billion would be the responsibility of Minnesota Power's customers (and not cost allocated across MISO) as explained in more detail in response to LPI IR 009, included with this response as DOC IR 013.01 Attach.

The estimated $1.4 billion cost also does not account for additional human and environmental impacts from the development of many miles of new AC transmission line projects to replace the HVDC Line or the schedule impacts for implementing the alternative transmission solutions. Working with MISO and neighboring utilities to assess retirement of the HVDC Line and develop alternative AC transmission solutions is estimated to take 12-24 months,

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To be completed by responder

Response Date: February 20, 2024
Response by: Christian Winter
Email Address: cwinter@mnpower.com
Phone Number: (218) 355-2908

Minnesota Department of Commerce
85 7th Place East | Suite 280 | St. Paul, MN 55101
Information Request

Docket Number: E015/CN-22-607 ☐Nonpublic ☒Public
Requested From: Minnesota Power Date of Request: 2/7/2024
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depending on the findings of the studies and how many iterations would be required to develop comprehensive solution recommendations. After that, the alternative transmission solutions, including many miles of new AC transmission lines, would have to be developed, permitted, and constructed over a period likely ranging from 10-15 years before the HVDC Line could be retired. Thus, one would have to assume that the existing HVDC converter stations are capable of running for approximately 60 years – or double their useful life – in order to reliably implement an HVDC Line retirement ("no-build") alternative to the Project.

Based on this assessment of the costs, impacts, and timeline for this alternative, Minnesota Power concluded it is not a viable alternative to the Project. Therefore, the scenario presented in this Information Request, in which the HVDC Line is retired and Minnesota Power incurs only the estimated hourly outage cost, is not a prudent scenario for at least three reasons. First, Minnesota Power would not be able to retire the HVDC Line without first implementing alternative AC transmission solutions to mitigate the reliability impacts of its retirement. Second, Minnesota Power would incur the cost of these alternative AC transmission solutions – estimated to be around $1.4 billion – in addition to some portion of the estimated hourly outage cost. Third, the existing HVDC converter stations cannot reasonably be expected to continue operating for the amount of time it would take to implement the alternative AC transmission solutions necessary for the "no-build" alternative to the Project.

To be completed by responder

Response Date: February 20, 2024
Response by: Christian Winter
Email Address: cwinter@mnpower.com
Phone Number: (218) 355-2908

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: November 7, 2023

Requested From: Minnesota Power Response Due: November 17, 2023

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

Information Request No. 9

Refer to page 42 where the following is stated: "The total estimated direct cost for the AC Alternative is nearly $1.4 billion, a 70 percent increase over the estimated mid-range cost of the HVDC Modernization Project. Because the need for these network upgrades would be triggered by retirement of the HVDC Line, the entirety of this cost would most likely be assigned to Minnesota Power."

a. Minnesota Power identified transmission line upgrades in multiple states including Iowa, North Dakota, South Dakota, and Minnesota associated with the AC alternative. Please explain why other states would not benefit from these lines and therefore be allocated costs.

b. As currently proposed in the Application, does Minnesota Power anticipate that its preferred and proposed Project will include cost sharing with others? Please explain.

Response:

a. The transmission line upgrades in question were associated with the retirement of the HVDC line and identified in the study according to typical threshold criteria for assigning system impacts. The upgrades are not needed if the HVDC line remains in service. Because the need for the upgrades in the study is caused by the retirement of the HVDC line, Minnesota Power assumed that the costs would be assigned based on this direct causation regardless of ancillary benefits to neighboring entities. The only clear way for costs to be assigned to others would be if the projects meet cost allocation criteria outlined in the MISO Tariff, for example as a Multi-Value Project ("MVP") or Market Efficiency Project

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Response by: Christian Winter

Title: Manager-Regional Transmission Planning

Department: Delivery Support Operations

Telephone: 218-355-2908

LARGE POWER INTERVENORS

Utility Information Request

Docket Number: E015/CN-22-607; E015/TL-22-611 Date of Request: November 7, 2023

Requested From: Minnesota Power Response Due: November 17, 2023

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

("MEP"). Minnesota Power does not anticipate that upgrades associated with the retirement of the HVDC line would meet these criteria.

b. No, at this time Minnesota Power does not anticipate its proposed Project will include cost sharing with others. Currently, the only clear way for costs to be assigned to others would be if the project meets cost allocation criteria outlined in the MISO Tariff, for example as an MVP or MEP.

Response by: Christian Winter

Title: Manager-Regional Transmission Planning

Department: Delivery Support Operations

Telephone: 218-355-2908

Minnesota Department of Commerce
85 7th Place East | Suite 280 | St. Paul, MN 55101
Information Request

Docket Number: E015/CN-22-607
Requested From: Minnesota Power
Type of Inquiry: General

☐Nonpublic ☒Public
Date of Request: 2/7/2024
Response Due: 2/20/2024

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Assigned Analyst(s): Michael N. Zajicek
Email Address(es): michael.zajicek@state.mn.us
Phone Number(s): 651-539-1830

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Request Number:	**14**
Topic:	Alternatives Considered
Reference(s):	Certificate of Need

Request:

Please provide a discussion on the feasibility of Distributed Generation as an alternative to the Project.

Response:

The Company discusses the feasibility of generation and non-wire alternatives, which would include distribution generation, in Section 4.2 of the Application.

The HVDC Modernization Project involves replacing the existing HVDC converter stations on either end of the existing HVDC Line and reconnecting the new HVDC converter stations to the existing Minnesota Power 230 kV AC transmission system. By maintaining the HVDC Line in good working order, the Project is simultaneously supporting the continued bulk long-distance transfer of existing renewable energy resources from North Dakota to Minnesota Power's customers and ensuring continued (and enhanced) reliability support for Minnesota Power's local 230 kV transmission system. Because the purpose of the Project is to ensure the continued use of this existing critical transmission infrastructure to meet Minnesota Power's customers' needs by delivering 550 MW of renewable wind energy from North Dakota,

To be completed by responder

Response Date: February 20, 2024
Response by: Christian Winter
Email Address: cwinter@mnpower.com
Phone Number: (218) 355-2908

Minnesota Department of Commerce
85 7th Place East | Suite 280 | St. Paul, MN 55101
Information Request

Docket Number: E015/CN-22-607
Requested From: Minnesota Power
Type of Inquiry: General

☐Nonpublic ☒Public
Date of Request: 2/7/2024
Response Due: 2/20/2024

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there is no alternative generation, non-wire, or distributed generation solution that can replace the function of the HVDC Converter Stations.

To be completed by responder

Response Date: February 20, 2024
Response by: Christian Winter
Email Address: cwinter@mnpower.com
Phone Number: (218) 355-2908

From: Christian Winter (MP-Transmission) (MP)
Sent: Monday, September 19, 2022 10:31 AM
To: Dagenais, Thomas (tdagenais@atcllc.com); 'ewinsand@atcllc.com'; 'Berry, Joel' (jberry@atcllc.com); 'rmckee@atcllc.com'
Subject: MP HVDC Project - 345 kV POI Discussion

Good morning Tom, Erik, Joel, and Bob,

I hope you are doing well. It was great to hear ATC's perspective during the MISO Tranche 2 meeting on Friday. I'm glad they are pulling all of us together early in the process this time to have some collaborative discussion. It will be very interesting to see how they narrow down the scope of Tranche 2 to a more manageable amount of investment.

I have been meaning to reach out to ATC regarding MP's HVDC Upgrade Project and the project scoping that we have been working on in recent months. As I mentioned during the MISO meeting, we are looking at implementing VSC technology for the modernization/upgrade of our existing LCC converters at Center and Arrowhead. Our intent is to commission the replacement project by 2027. As we develop the scope, we are also considering how our near-term investments in the MP HVDC system fit into the broader regional picture and what we can do to incorporate expansion potential into the converters we will be implementing. Relating to that, we are considering moving the HVDC POI from the 230 kV bus to the 345 kV bus at Arrowhead as part of the initial near-term upgrade project. Obviously that's change that we will need to work on together closely with ATC. The plan would also involve establishing a new 345 kV yard ("St Louis County") at the VSC-HVDC converter station with expandability to accommodate future 345 kV development in Northern Minnesota.

Would you all be available for a 1-hr discussion sometime this week, so I can give you an overview of our plans for the HVDC modernization/upgrade project and what the 345 kV interconnection would look like? We're on a fairly rapid schedule due to HVDC market conditions, material leadtimes, and the condition of our existing HVDC system, so the sooner we start the conversation the better. Here are some times that would work on our end:

- Any time between 10:30-1pm this Wednesday (9/21)
- Any time between 11-12:30 this Thursday (9/22)
- Any time between 9-10am this Friday (9/23)

Also, if there are other folks from ATC that should be involved in the discussion please let me know. I can set up a webex meeting once we find a time that works. If the times this week don't work at all, I will look into early next week. Just let me know. Thanks!

Christian Winter
Supervising Engineer - T&D Planning
Minnesota Power
Duluth, MN USA
Office: 218.355.2908
Cell: 507.530.0472
Email: cwinter@mnpower.com

From:	Christian Winter (MP-Transmission) (MP)
To:	Dagenais, Thomas (tdagenais@atcllc.com); Winsand, Erik; McKee, Robert; "Berry, Joel" (jberry@atcllc.com); amanty@atcllc.com; Burmester, Dale; Scott Hoberg (MP-Transmission) (MP); Andrew Kienitz (MP-Transmission) (MP)
Subject:	MP HVDC Project - 345 kV POI Discussion
Date:	Friday, September 23, 2022 4:31:21 PM
Attachments:	UMEX Project Overview.pdf

Thanks everyone for the great discussion this morning. Attached is a one-pager overview of Minnesota Power's HVDC Upgrade project plans – the project is being branded the "Upper Midwest Express" or UMEX. I am hoping to provide you with the slides that I shared today soon, but want to make sure it's all good with my management before I send them out. Please let us know what questions you have in the meantime.

Here are the next steps I wrote down:

- MP to review ATC's T-T Interconnection Guide and let ATC know if we have questions
- ATC to discuss internally to ensure a holistic response/approach
- MP & ATC to review if there is an existing NDA between the parties. If not, we will work on executing a new one.
- Next MP-ATC discussion in two weeks, goal to define path forward. Below are some times that work for MP, let me know what works on your end:
    - Monday 10/3 @ 2PM or 4PM
    - Tuesday 10/4 @ 10AM
    - Wednesday 10/5 @ 3PM or 4PM

Have a good weekend!

Christian Winter

Supervising Engineer - T&D Planning

Minnesota Power

Duluth, MN USA

Office: 218.355.2908

Cell: 507.530.0472

Email: cwinter@mnpower.com

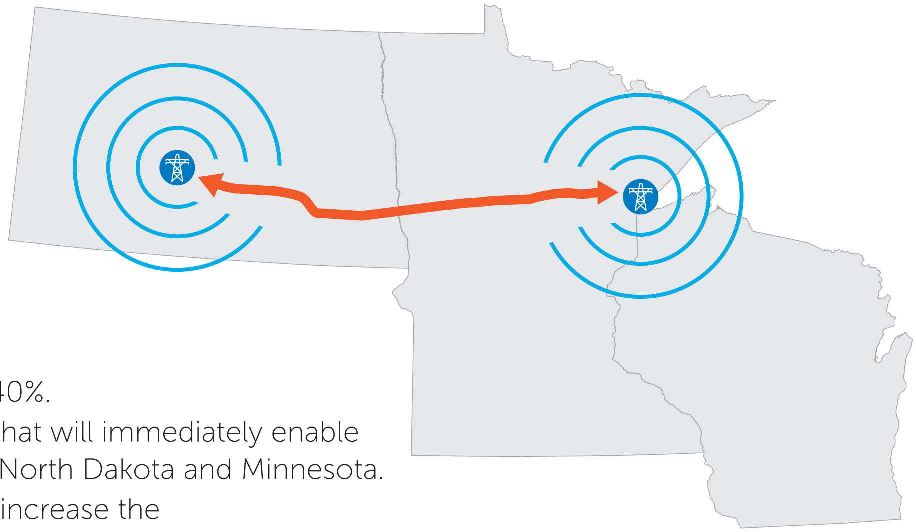
Upper Midwest Express

Reimagining an Existing Inter-state High Voltage Transmission Corridor

minnesota power
AN ALLETE COMPANY

EnergyForward

About the Project



Minnesota Power is modernizing its 465-mile HVDC transmission line that connects the plains of North Dakota to Northeastern Minnesota. This existing transmission corridor has been serving the Upper Midwest for over 40 years and **Minnesota Power is using this unique opportunity to:**

- Upgrade the existing line capacity by 40%.
- Create a larger transmission highway that will immediately enable the transfer of more energy between North Dakota and Minnesota.
- Utilize the latest HVDC technology to increase the reliability of the grid in both Minnesota and North Dakota.

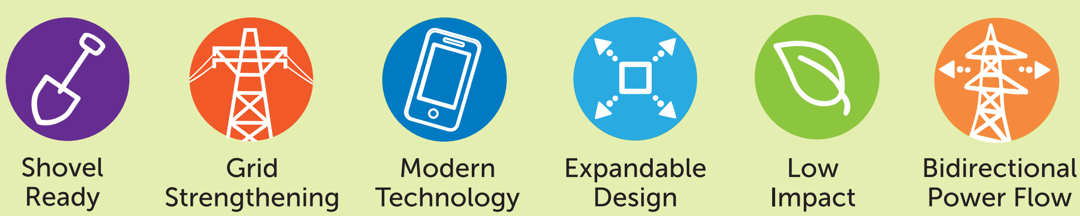
With an anticipated 2027 in-service, Phase 1 of this visionary $700 million dollar project will:

- Position it for further expansion with expandable, modular technology.
- Establish the transmission corridor as an essential building block for reliably moving energy across the Upper Midwest.
- Create new construction jobs and additional long-term tax base in North Dakota and Minnesota.

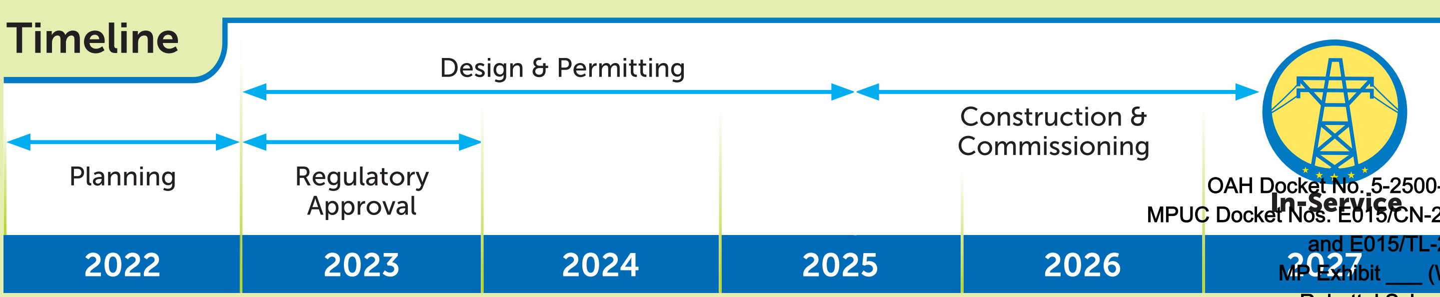
Project Benefits | Once complete, this modern transmission highway will:

- **Augment reliability** and system stability in North Dakota and Minnesota
- **Increase access** to additional energy transfer with limited land impact
- **Optimize energy resources** in North Dakota and Minnesota with bidirectional power flow across the line
- **Be expandable,** for efficiently developing up to a **3,000 megawatt** corridor to further optimize regional energy flows
- **Align with MISO, FERC and Department of Energy** goals for regional transmission expansion

Project Attributes



Timeline



OAH Docket No. 5-2500-39600
MPUC Docket Nos. E015/CN-22-607
and E015/TL-22-611
MP Exhibit ___ (Winter)
Rebuttal Schedule 14
Page 2 of 2

22107

Subject: MP-ATC Follow Up on HVDC Project
Location: WEBEX

Start: Mon 10/10/2022 10:00 AM
End: Mon 10/10/2022 11:00 AM
Show Time As: Tentative

Recurrence: (none)

Meeting Status: Not yet responded

Organizer: Christian Winter (MP-Transmission) (MP)
Required Attendees Scott Hoberg (MP-Transmission) (MP); Andrew Kienitz (MP-Transmission) (MP); McKee, Robert; Winsand, Erik; amanty@atcllc.com; Burmester, Dale; Dagenais, Thomas (tdagenais@atcllc.com)

Follow up from our discussion of MP's request to look at moving from 230 kV bus to 345 kV bus as part of HVDC Upgrade project

-- Do not delete or change any of the following text. --

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Join by meeting number
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Meeting password: wcMk5dfe*26

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AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	November 30, 2023
Requested From:	Minnesota Power	Response Due: Extension Granted to:	December 11, 2023 December 13, 2023

By: American Transmission Company LLC

Information Request No. 10.

Reference page 10 of the Reply Comments.

a. Please Identify each and every Person employed by, retained by, or affiliated with Minnesota Power who played a role in "considering and rejecting the Arrowhead Alternative," either before or after "discussions with ATC in Fall 2022."

b. Did You consider the Arrowhead Alternative as an alternative to the new proposed St. Louis County Substation prior to "discussions with ATC in Fall 2022."?

c. Approximately how much time did you take to "consider[]" the Arrowhead Alternative as an alternative to the new proposed St. Louis County Substation before "rejecting" it?

Objection:

Minnesota Power objects to the request in subpart a. to the extent the request is overly broad and it would be unduly burdensome to identify "each and every Person employed by, retained by, or

---

Response by: Christian Winter	As to Objection: David Moeller
Title: Manager-Regional Transmission Planning	Title: Senior Regulatory Counsel
Department: Delivery Support Operations	Department: Legal
Telephone: 218-355-2908	Telephone: (218) 723-3963

affiliated with Minnesota Power who played a role in 'considering and rejecting the Arrowhead Alternative,' either before or after 'discussions with ATC in Fall 2022'" as requested.

Minnesota Power also objects to subpart a. to the extent it mischaracterizes Minnesota Power's Reply Comments at p. 10, which state "which is why Minnesota Power proposed the Project as it is configured after considering and rejecting the Arrowhead Alternative ***following*** discussions with ATC in Fall 2022." (emphasis added).

Subject to and without waiving the foregoing objections, Minnesota Power provides the following response.

Response:

a. Minnesota Power has considered all aspects of its HVDC Modernization Project in coordination with a core strategy team including representatives from Strategy & Planning, Transmission Planning, System Performance, Power Delivery Engineering, Engineering Services, Permitting & Environmental, Real Estate, Legal, Regulatory, and Finance, along with key strategy and technical consultants. Individuals involved directly with the two ATC-Minnesota Power discussions in September and October 2022 included Christian Winter, Scott Hoberg, and Andy Kienitz, working in coordination with Dan Gunderson.

Response by: Christian Winter	As to Objection: David Moeller
Title: Manager-Regional Transmission Planning	Title: Senior Regulatory Counsel
Department: Delivery Support Operations	Department: Legal
Telephone: 218-355-2908	Telephone: (218) 723-3963

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	November 30, 2023
Requested From:	Minnesota Power	Response Due: Extension Granted to:	December 11, 2023 December 13, 2023

By: American Transmission Company LLC

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b. Minnesota Power considered many options for the HVDC Modernization Project prior to the two ATC-Minnesota Power discussions in September and October 2022, including interconnecting the new HVDC converters at both 230 kV and 345 kV as well as interconnecting at either the Arrowhead 230 kV bus or the Arrowhead 345 kV bus. One of the Minnesota Power presentations to MISO provided in response to LPI IR 005 demonstrates that Minnesota Power was considering an interconnection configuration similar to the ATC Arrowhead Alternative as early as June 2022.[1] Internal planning documentation provided in response to ATC IR 021 also demonstrates that Minnesota Power was seriously considering interconnecting the new HVDC converters to the Arrowhead 345 kV bus in an interconnection configuration similar to the ATC Arrowhead alternative as early as March 2022, well in advance of the discussions with ATC in the fall of 2022.

c. Minnesota Power considered and evaluated many options for the HVDC Modernization Project, including interconnecting the new HVDC converters at both 230 kV and 345 kV as well as interconnecting at either the Arrowhead 230 kV bus or the Arrowhead 345 kV bus, over a period of many months in 2022 and 2023, starting with the kickoff of its HVDC Technology Assessment in February 2022 and culminating with the filing of the combined Certificate of Need and Route Permit Application for the HVDC Modernization Project on

[1] See LPI IR 005.01 Attach_2022.06.09 MP-MISO HVDC Discussion, Page 8.

Response by: Christian Winter	As to Objection: David Moeller
Title: Manager-Regional Transmission Planning	Title: Senior Regulatory Counsel
Department: Delivery Support Operations	Department: Legal
Telephone: 218-355-2908	Telephone: (218) 723-3963

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

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By: American Transmission Company LLC

June 1, 2023. Internal planning documentation provided in response to ATC IR 021 demonstrates that Minnesota Power was seriously considering interconnecting the new HVDC converters to the Arrowhead 345 kV bus in an interconnection configuration similar to the ATC Arrowhead Alternative as early as March 2022. Minnesota Power elected to move forward with developing its plans for the proposed Project configuration rather than an interconnection to the ATC Arrowhead 345 kV bus shortly after the October 10, 2022, discussion between ATC and Minnesota Power, for the reasons discussed in the referenced Reply Comments.

Response by: Christian Winter	As to Objection: David Moeller
Title: Manager-Regional Transmission Planning	Title: Senior Regulatory Counsel
Department: Delivery Support Operations	Department: Legal
Telephone: 218-355-2908	Telephone: (218) 723-3963

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: March 1, 2024

Requested From: American Transmission Company LLC Response Due: March 11, 2024

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

Information Request No. 2

Refer to Winters testimony on page 28 where he states the following in part:

> "All of the detailed design and system integration studies completed or currently in progress to support detailed design of the HVDC converter stations would need to be updated or replaced if the ATC Arrowhead Alternative is ordered by the Commission to be constructed. Studies to be updated or replaced would include Power Flow Analysis, Stability Analysis, Transformer Energization Study, Short Circuit and SSTI Screening Analysis, Harmonic Impedance Study and updated AC Equivalents, at a minimum."

a. Please indicate if you agree or disagree with Mr. Winters' view and explain any associated impact to the Project schedule.

Response: ATC has not been involved in the studies that Minnesota Power (MP) or its HVDC supplier have conducted in connection with the HVDC Modernization Project (Project) and therefore cannot specifically speak to what measures would need to be taken to update those studies or how long that process would take, if the Arrowhead Substation Alternative were implemented. That said, as a general matter, ATC anticipates that the studies MP and its supplier have conducted in support of detailed design activities would only need to be updated for the eastern most end of the Project, since ATC's proposal would not change the Project's point-of-interconnection in North Dakota.

As for system integration studies that may need to be conducted in consultation with MISO, please reference pages 34-35 of Tom Dagenais' direct testimony and his rebuttal testimony. As described therein, there have been no system integration or planning studies conducted for the HVDC Modernization Project or the Arrowhead Substation Alternative as part of the Midcontinent Independent System Operator, Inc. (MISO) Transmission Expansion Plan (MTEP) process. These studies will need to be implemented regardless of which alternative the Minnesota Public Utilities Commission (Commission) selects, and ATC does not believe that the need to conduct these studies will have a material adverse impact on the overall Project schedule.

Response by: Thomas Dagenais

Title: Director, System Planning

Telephone: (608) 877-7161

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: March 1, 2024

Requested From: American Transmission Company LLC Response Due: March 11, 2024

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

Finally, it is important to note that Minnesota Power considered interconnecting the Project through ATC's 345/230 kV Arrowhead Substation as early as 2022 and has been aware of ATC's position that the Project should interconnect through this substation as early as September 2022. ATC formally presented the Arrowhead Substation Alternative to the Commission for consideration in this proceeding in September 2023. In light of this, MP has had ample opportunity to conduct detailed studies for the Arrowhead Substation Alternative before and during these proceedings. At this time, MP should be conducting detailed studies of both its preferred point-of-interconnection for the Project (the 345 kV St. Louis County Substation) and the Arrowhead Substation Alternative to prepare for the possibility the Commission could order implementation of either alternative.

Response by: Thomas Dagenais

Title: Director, System Planning

Telephone: (608) 877-7161

Siemens PTI Report R052-24

MWEX Stability Study

(Arrowhead Alternative Concept Study)

Prepared for

Minnesota Power

Submitted by:
Douglas Brown, Senior Manager
Radwa Abdalaal, Senior Consultant

March 1, 2024

Siemens PTI Project 62OT-002279

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Revision History

Date	Rev.	Description
March 1, 2024	A	Initial Release

Contents

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Section
1

Executive Summary

Minnesota Power's HVDC Modernization Project involves modernizing and upgrading both HVDC terminals of the existing 465-mile-long Square Butte HVDC Line. The new HVDC terminals will be constructed with state-of-the-art voltage source converter (VSC) HVDC equipment. To modernize the HVDC terminals and implement the latest technology, new buildings and electrical infrastructure need to be constructed on a new site near the existing HVDC terminals. In Minnesota, the Project would require the construction of a new St Louis County 345/230 kV Substation to connect the new HVDC converter station 345 kV bus to the existing Minnesota Power Arrowhead Substation 230 kV bus.

In the HVDC Modernization Project Certificate of Need and Route Permit dockets, American Transmission Company (ATC) has proposed an alternative concept to Minnesota Power's proposed St Louis County 345/230 kV Substation. The Arrowhead Concept proposed by ATC would involve connecting Minnesota Power's new St Louis County HVDC Converter Station 345 kV bus to the existing ATC Arrowhead 345 kV Substation via a new double-circuit 345 kV line rather than constructing the new St Louis County 345/230 kV Substation and connecting to the Minnesota Power Arrowhead 230 kV Substation. Several modifications would need to take place with the ATC Arrowhead 345 kV Substation and the Minnesota Power Arrowhead 230 kV Substation to accommodate the construction of the Arrowhead Concept.

This report documents voltage stability and transient stability analysis performed by Siemens PTI to provide a limited technical comparison of certain transmission system impact and performance aspects of Minnesota Power's proposed HVDC Modernization Project and ATC's proposed Arrowhead Concept. The Minnesota-Wisconsin Export (MWEX) Interface was evaluated, with a slight modification to facilitate comparison of the two alternatives, to identify the impact on the surrounding system and any notable differences in performance.

1.1 MWEX-345 Interface

The Minnesota Wisconsin Export Interface (MWEX) is defined as the summation of the flows into Wisconsin on the Arrowhead 230 kV phase shifting transformer (PST) measured at the Minnesota Power 230 kV side of the Arrowhead Substation, and on the King-Eau Claire 345 kV line measured at King. Due to the configuration changes at the Arrowhead 345/230 kV Substation resulting from the Arrowhead Concept, the MWEX interface definition had to be modified for this study to facilitate comparison of the proposed Project and Arrowhead Concept configurations. The modified interface is designated MWEX-345 and is the summation of the flows into Wisconsin on the Arrowhead-Superior 345 kV line measured at the ATC Arrowhead 345 kV bus, and on the King-Eau Claire 345 kV line measured at King.

Closely paralleling the typical MWEX study methodology, MWEX-345 voltage stability and transient stability were evaluated for "shoulder" conditions before construction of the MISO

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Long Range Transmission Plan (LRTP) Tranche 1 portfolio (Scenario 1) and after construction of the LRTP Tranche 1 portfolio (Scenario 2). The shoulder case represents high renewable energy transfers during off-peak load conditions. The HVDC Line was modeled with 900MW west to east transfers, and the NTEC natural gas unit was modeled offline. These critical assumptions were selected because they are expected to result in the greatest amount of stress on the MWEX-345 interface.

1.1.1 System Intact Conditions

Voltage stability and transient stability performance were analyzed for the MWEX-345 interface with the VSC HVDC converter and all other relevant transmission lines in service. For both types of stability analysis, only the most historically-challenging fault for the area was analyzed. In general, system intact voltage and transient stability analysis demonstrates that the changes implemented as part of the Arrowhead Concept configuration benefit Minnesota-Wisconsin transfer capability more than the proposed Project. The removal of the Arrowhead PST and Arrowhead 345 kV capacitor banks for the Arrowhead Concept was found to have notable impacts on system performance which may reduce the reliability of the system and merit further investigation, as discussed below.

1.1.1.1 Voltage Stability Summary

The proposed Project and Arrowhead Concept configurations have similar MWEX-345 voltage stability System Operating Limits (SOLs); the configurations have the same SOL in Scenario 1 and the Arrowhead concept SOL in Scenario 2 is 44 MW (2%) higher than the proposed project SOL. Due to automatic operation of the Arrowhead PST, the proposed Project has more margin (11-16%) than the Arrowhead Concept (5%) between the SOL and the point where the voltage actually becomes unstable.

Another interesting finding from the voltage stability analysis demonstrates the increased dependence established by the Arrowhead Concept between the MWEX-345 interface and the Minnesota Power VSC HVDC converters, as well as the impact of removing the Arrowhead 345 kV capacitor banks. With the Arrowhead Concept, the VSC HVDC converter hit its reactive power limit at the nose of the post-contingent voltage stability curve in Scenario 1 and Scenario 2. Once the VSC HVDC reached its reactive power limit with the Arrowhead Concept, MWEX-345 was immediately unstable, meaning that the stability of the regional MWEX-345 interface was entirely dependent on the reactive power contributed by the VSC-HVDC converter up to that point. With the proposed Project, VSC HVDC reactive power output was well within the limit at all times. Similarly, VSC HVDC reactive output at the voltage stability SOL was 116-180 MVAR higher with the Arrowhead Concept than the proposed Project configuration.

1.1.1.2 Transient Stability Summary

For the proposed Project configuration, transient stability is more limiting for the MWEX-345 interface than voltage stability in both scenarios. For the Arrowhead Concept configuration, the MWEX-345 transient stability limit is similar to the voltage stability SOL in both scenarios. The MWEX-345 transient stability limit was higher with the Arrowhead Concept than with the proposed Project because the Arrowhead Concept induces more power transfer through the Arrowhead 345/230 kV Substation into northwest Wisconsin, unloading stressed regional 345 kV transmission paths parallel to MWEX-345 in southwest Wisconsin and eastern Iowa where instability occurs at higher transfer levels. The potential negative impact of the increased transfers through northwest Wisconsin is offset by the dynamic reactive support provided to northwest Wisconsin by the VSC HVDC converter when it is interconnected to the Arrowhead 345 kV bus in the Arrowhead Concept configuration. This demonstrates the regional nature of the support provided by the Arrowhead Concept (particularly for Minnesota-Wisconsin transfer capability) and reinforces the dependency the alternative configuration establishes between MWEX-345 and the VSC HVDC converters.

1.1.2 HVDC Prior Outage

Voltage and transient stability performance were analyzed for the MWEX-345 interface with the VSC HVDC converter out of service and all other relevant transmission lines in service. When the St Louis County VSC HVDC converter is out of service with the Arrowhead Concept, there are no fast controls at the Arrowhead 345 kV bus because the Arrowhead PST is bypassed and removed and the 345 kV fast-switched capacitors were also removed. With the proposed Project configuration, both the Arrowhead PST and the 345 kV fast-switched capacitors remain in place as they are today. Analysis of the HVDC prior outage case is especially important for understanding the reliability impacts of the Arrowhead Concept due to the new relationship it creates between the HVDC Line and the MWEX-345 interface and the changes it makes to the configuration of the existing system, including removal of the Arrowhead PST and the Arrowhead 345 kV fast-switched capacitor banks.

1.1.2.1 Voltage Stability

To understand the voltage stability results, it is important to note that ATC's planning criteria does not require a voltage stability margin for prior outage conditions. Following ATC's planning criteria, the proposed Project and Arrowhead Concept configurations have similar MWEX-345 voltage stability SOLs during an HVDC prior outage. However, the relative security of the transmission system at that SOL is much greater with the proposed Project, which has a 10% margin at the SOL due to the operation of the Arrowhead PST. For the Arrowhead Concept, consisent with ATC's planning criteria for prior outage conditions, there is no stability margin at the SOL – meaning the system is operating right up to the stability limit. To achieve a 5% margin with the Arrowhead Concept, where there is no Arrowhead PST available to adjust, nearby generation in the regional system would need to be redispatched and the Arrowhead Concept SOL would be reduced by approximately 155 MW. This finding reinforces the value of the Arrowhead PST for preserving voltage stability margin on the MWEX-345 interface under a variety of credible system operating conditions.

Another interesting finding illustrates the impact of removing the Arrowhead 345 kV capacitor banks. With the Arrowhead Concept at the SOL, the final post-contingent voltage at the Arrowhead 345 kV bus and Stone Lake 345 kV bus was significantly lower because the Arrowhead 345 kV capacitors were removed. This is consistent with the system intact results, where it was observed that reactive power output of the VSC HVDC was heavily utilized to support the stability of the MWEX-345 interface. These findings continue to reinforce the new dependency between MWEX-345 and the VSC HVDC converters that is established by the Arrowhead Concept, and the low voltages observed in the prior outage case call into question the reasonableness of removing the Arrowhead 345 kV capacitors.

1.1.2.2 Transient Stability

Without the VSC HVDC converter station online, transient stability is more limiting than voltage stability for both the proposed Project and the Arrowhead Concept. The MWEX-345 transient stability limit is higher with the Arrowhead Concept than with the proposed Project in both Scenario 1 and Scenario 2, though the difference between the configurations is notably less with the VSC HVDC offline. As with the system intact cases, transient stability limits with the Arrowhead Concept are higher because the Arrowhead Concept induces more power transfer through the Arrowhead 345/230 kV Substation into northwest Wisconsin, unloading stressed regional transmission paths parallel to MWEX-345 in southwest Wisconsin and eastern Iowa where instability occurs at higher transfer levels. Unlike the system intact cases, the increased transfers through northwest Wisconsin are not offset by additional reactive support from the VSC HVDC converters in the prior outage cases, since the VSC HVDC is offline and the Arrowhead 345 kV fast-switched capacitor banks have been removed. The result is that transient voltages at the Arrowhead substations and in northwest Wisconsin are noticeably worse with the Arrowhead Concept compared to the proposed Project. This is clearly demonstrated by the fact that voltage sag severity indices ("VSSIs")[1] at the Arrowhead 230 kV bus and in northwest Wisconsin were generally more favorable with the proposed Project, meaning that transient voltage sags were less severe with the proposed Project than with the Arrowhead Concept. These findings from transient stability analysis are among the clearest indicators of a common thread underlying all of the MWEX-345 voltage and transient stability results: that the Arrowhead Concept configuration provides more regional benefits for MWEX-345 and Minnesota-Wisconsin transfer capability compared to the proposed Project configuration, but those regional benefits often come as a result of less benefit being provided for the local area around the Arrowhead Substation.

1.2 Additional Discussion

1.2.1 Arrowhead PST

One of the objectives of the MWEX stability analysis was to evaluate if the Arrowhead Phase Shifting Transformer (PST) can be bypassed and removed as part of the Arrowhead Concept without negatively impacting the reliability of the local or regional transmission system.

For system intact conditions, ATC requires a 5% MWEX voltage stability margin to reflect uncertainties in modeling, as well as to provide a reasonable reliability margin for secure system operations. With the proposed Project, the voltage stability margin is the result of automatic post-contingent operation of the Arrowhead PST. While in practice the Arrowhead PST will only operate automatically in the relatively unlikely event of certain high-impact faults on the transmission system, this functionality was an intential design decision from the initial establishment of the Arrowhead-Weston 345 kV Project and is valuable for reliable planning and secure operation of the MWEX interface. While the Arrowhead PST remains in place for the proposed Project configuration, it provides more than sufficient voltage stability margin for system intact conditions and during a prior outage of the HVDC Line. When the Arrowhead PST is removed for the Arrowhead Concept, any MWEX voltage stability margin must be created by redispatching and pre-positioning the surrounding transmission system. As a result, the voltage stability margin that is naturally preserved by the Arrowhead PST in the proposed Project configuration is reduced considerably, and in some cases eliminated altogether, at the same voltage stability SOL for the Arrowhead Concept. The results of this study clearly demonstrate the continued value of the Arrowhead PST for preserving greater

[1] The voltage sag severity index or VSSI is a measure of transient voltage performance relative to applicable transient voltage criteria over the duration of the transient period. It is a metric that helps understand the amount of transient voltage margin in the system.

MWEX voltage stability margins through its automatic operations, minimizing potentially costly redispatching of the system to maintain reliable operations.

1.2.2 Arrowhead 345 kV Capacitors

One of the objectives of the MWEX stability analysis was to evaluate if the Arrowhead 345 kV capacitors can be removed as part of the Arrowhead Concept without negatively impacting the reliability of the local or regional transmission system.

The Arrowhead Concept induces more power transfer through the Arrowhead 345/230 kV Substation into northwest Wisconsin by reducing the impedance of the connection between the Arrowhead 230 kV and 345 kV substations. The potential voltage impact of the increased transfers through northwest Wisconsin in the Arrowhead Concept configuration is generally offset by the voltage support provided to northwest Wisconsin by the VSC HVDC, which is interconnected at the Arrowhead 345 kV bus. For system intact cases, stability results demonstrate that providing this support to northwest Wisconsin in the Arrowhead Concept configuration results in significantly more reactive power output from the VSC HVDC converters compared to the proposed Project. This dependency is so significant that the voltage immediately goes unstable when the VSC HVDC converter reaches its reactive power limit. When the VSC HVDC converter is out of service, and therefore not contributing voltage support to northwest Wisconsin, post-contingent voltage at the Arrowhead 345 kV bus is significantly lower at the voltage stability SOL for the Arrowead Concept compared to the proposed Project configuration because the Arrowhead 345 kV capacitors were removed. These findings continue to reinforce the new dependency between MWEX-345 and the VSC HVDC converters that is established by the Arrowhead Concept, and the low voltages observed in the prior outage case call into question the reasonableness of removing the Arrowhead 345 kV capacitors.

1.3 Conclusions

The findings from this limited analysis of transient and voltage stability performance of the proposed HVDC Modernization Project compared to the ATC Arrowhead Concept demonstrate that the two configurations present two fundamentally different approaches to maintaining the reliability of the MWEX interface. For the proposed Project, the MWEX interface is operated in much the same way as it is today. Automatic operation of the Arrowhead PST contributes to robust stability margins and the Arrowhead 345 kV capacitor banks provide sufficient voltage support to maintain current levels of MWEX transfer capability. For the Arrowhead Concept, the removal of the Arrowhead PST means that the stability margin must be maintained exclusively by redispatching generation, and the resulting margins are generally less compared to the proposed Project configuration. Increased power transfer into Wisconsin through the Arrowhead 345/230 kV Substation generally improves MWEX stability limits, while any potentially negative voltage impacts from these increased transfers and the removal of the Arrowhead 345 kV capacitor banks is offset by increased reactive power contributions from the VSC HVDC converter. However, if the VSC HVDC converter reaches its reactive power limit or is offline, the loss of this critical voltage support has a significant impact on the reliability of northwest Wisconsin and the MWEX interface. These findings merit further investigation to determine what, if any, mitigation may be necessary to ensure that the configuration changes proposed for the Arrowhead Concept do not degrade the reliability of the transmission system or result in unintended consequences for system operations and performance.

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Section
2

Introduction

Siemens PTI worked with Minnesota Power on a technical comparison of the proposed HVDC project configuration, including the St Louis County 345/230kV Substation, to an alternative concept involving a direct 345kV connection to the Arrowhead 345kV Substation. Steady state model evaluation and contingency analysis were performed by Minnesota Power and are discussed in a separate report. Voltage and transient stability analysis on MWEX was performed by Siemens PTI as documented in this report. The goal of the Minnesota Power and Siemens PTI analysis was to address the following:

- Does the Arrowhead Concept cause the flow on the Arrowhead – Superior 345kV Line or through the Arrowhead 345/230kV Transformer(s) to exceed the 800MVA limit imposed on the Arrowhead-Weston Project by the State of Minnesota in its original permitting docket?
- Can the Arrowhead phase shifting transformer be bypassed and removed as part of the Arrowhead Concept? Or are phase shifters still required for the Arrowhead Concept?
- Can the Arrowhead 345kV capacitor banks be removed as part of the Arrowhead Concept? Or are there scenarios where capacitors banks are still necessary at the Arrowhead 345kV bus?
- Are there substantive differences in performance between the Proposed Project and the Arrowhead Concept, in terms of contingency analysis, voltage and transient stability?
- Does the Proposed Project provide more technical and reliability benefits to Minnesota Power's customers and Northern Minnesota in general in comparison with the Arrowhead Concept?

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Section
3

Model Development

The Arrowhead Alternative Concept configuration cases were built from the study cases originally developed for the HVDC Modernization Project Power Flow Analysis. The Arrowhead Alternative Concept Study considered the following cases:

- Seasonal Cases:

    1. Shoulder High Wind (SSH): off-peak load levels with high wind and HVDC dispatch, little or no synchronous generation online, and high regional transfers.

- Scenarios:

    1. Scenario 1 (S1): HVDC 900 MW, Pre-LRTP
    2. Scenario 2 (S2): HVDC 900 MW, Post-LRTP

The Shoulder High Wind (SSH) case was used because that case presents the most stress for MWEX. Cases including the Arrowhead Alternative Concept were created by taking the St Louis County 345/230kV Substation out of service and applying the following changes representing the Arrowhead Alternative Concept as proposed in the HVDC Modernization Project proceedings:

- Added St Louis County – Arrowhead 345kV double circuit line
- Added Arrowhead 345/230kV Transformer and Phase Shifting Transformer (PST) #2
- Removed Arrowhead 345kV Capacitor Banks (2x75 MVAr)
- Bypassed both Arrowhead 230kV PSTs (existing and new)

Adjustments were balanced by scaling generation in the MISO North and Central regions.

Diagrams are included in Appendix A.

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Appendix
A

Power Flow Cases

A.1 Scenario 1 Base Cases

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A.2 Scenario 1 SSH HVDC Prior Outage

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A.3 Scenario 2 Base Cases

[redacted]

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A.4 Scenario 2 SSH HVDC Prior Outage

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Appendix
B

MWEX Voltage Stability P-V Curves

B.1 Proposed Project MWEX P-V Curves

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B.2 Arrowhead Concept MWEX P-V Curves

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Appendix
C

MWEX Transient Stability Results

C.1 Transient Stability Results Summaries

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10900 Wayzata Boulevard
Minnetonka, Minnesota 55305 USA
Tel: +1 (952) 818-2227

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BURNS & McDONNELL

ESTIMATE BASIS

3Client:	**Minnesota Power**		
Project No.:	**144774**	**Estimate Date:**	**01/05/2023**
Project Name:	**Arrowhead**	**Estimate Class:**	**Class 3**
Project Location:	**Minnesota**		

DESCRIPTION OF SCOPE

Provide labor and materials for Arrowhead Substation at the Request of MP Counsel.

PURPOSE

The purpose of the "Basis of Estimate" is to describe the scope of work and how the estimate values were developed and compiled into the finished deliverable. Burns & McDonnell has developed a Class 3 estimate for the ATC Arrowhead Substation project, at the request of Minnesota Power. This work includes the engineering/design, procurement, and construction.

GENERAL ASSUMPTIONS & QUALIFICATIONS

1. The estimate excludes costs to modify or replace any existing facilities, equipment, and materials.
2. Dewatering is assumed not required other than to remove normal surface water run-off due to rain.
3. The estimate excludes rework and redesign due to existing underground obstructions.
4. Subsurface conditions: We have assumed that no rock will be encountered.
5. Burns & McDonnell has not included any costs for identifying or addressing endangered species and historical items that could be encountered.
6. Detailed engineering drawings are not available at this time, so many assumptions have been made, which include, but are not limited to foundation sizes, steel weights, major equipment, miscellaneous material quantities, etc. These assumptions are based on historical data and recent project history.
7. No cost for a GPR (ground penetrating radar) scan to locate underground obstructions is included in this estimate.
8. The estimate is for the inside of the substations only. The estimate also includes costs for access roads from the gate to the existing road.
9. All major equipment (Transformers, Breakers, Switches, CCVTs, Arresters, etc.) and steel is assumed to be procured by Minnesota Power and no subcontractor in-directs have been added for any of that material.
10. In general, the estimate is based on the layout drawings submitted to Minnesota Power for Arrowhead Substation. The following is a more detailed description:
    a. CCVTs and Arresters were assumed to be needed only on each line terminal.
    b. A ground grid was assumed to be added with 25-foot spacing between 4/0 conductor runs.
    c. Quantity One (1) ground rod was assumed to be added for each arrester.
    d. The estimate does not include grounding stingers for each structure.
    e. High level takeoffs based on the current preliminary substation layout were taken for the conductor to each breaker.
    f. High level takeoffs based on the current preliminary substation layout were taken for the conductor for each line termination.
    g. High level takeoffs based on the current preliminary substation layout were taken for the conductor for each set of CCVTs and Arrestors.
    h. Bus support/insulator quantities were determined based on an assumed bus span.
    i. Security was not included in the estimate.
    j. Bus assumed to come in 40-foot increments.
    k. Substation scope:

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BURNS & McDONNELL

ESTIMATE BASIS

i. Provide cut and fill for new substation location. Quantities Provided
ii. Provide materials and labor for foundations as indicated in the estimate documents.
iii. Provide labor to install steel structures and equipment as indicated in the estimate documents (Steel Structure and Major Engineered Equipment will be procured by the owner)
iv. Provide materials and labor to install rigid busing and strain busing as indicated in the estimate documents
v. Provide materials and labor to install oil containment system for transformers.
vi. Provide fencing and insulating rock after all foundation, equipment, and busing is complete.
vii. Major equipment list included in the detailed estimate.

l. Site civil scope:
   i. One foot of topsoil stripping assumed across the site.
   ii. Three feet of granular engineered fill will be spread across the pad.
   iii. Class 5 aggregate base will be spread one foot across the pad and on the access road.
   iv. Pad is offset 5 feet from the fence line
   v. Existing contours based on MNTopo data

11. Pricing Basis
   a. No tax has been included per Minnesota Power request.
   b. Pricing for tubular steel pricing was estimated at $4.00/lb and will be procured by the owner.
   c. Pricing for structural steel was estimated at $3.40/lb and will be procured by the owner.
   d. Work will be executed on a single shift of 6-10 hour/day basis.
   e. Construction schedule and productivity assume normal weather conditions for the area site location.
   f. Cost for mobilization and de-mobilization is included.
   g. All major material, steel structures, control house and cable trench assumed provided by Minnesota Power. All other materials assumed to be supplied by subcontractors.
   h. Material costs are based on recent vendor quotes, if applicable, or other historical data for similar items. Quantities for the design are estimated based on the current preliminary substation layout.
   i. Permit cost is not included with this pricing.
   j. No escalation has been included.
   k. Detailed engineering, design, and procurement costs were calculated as 4% of direct project & purchased equipment costs (labor, construction equipment, and subcontractor materials).
   l. Burns & McDonnell Construction Management / General Conditions (CMCI) costs have been included at 7% of direct project costs (labor, construction equipment, and subcontractor materials).
   m. Wage rates are based on the IBEW local union rates. The rates include base wage, payroll insurance and taxes, overtime and benefits; we have also included subsistence.
   n. Costs are included for:
      i. Temporary facilities, onsite supplies, and expenses
      ii. Construction equipment, maintenance, and site vehicles
      iii. Small tools and consumables
      iv. Safety requirements
      v. Subcontractor field supervision
      vi. Subcontractor overhead and profit
      vii. All costs for labor, materials, and equipment are based on 2022 dollars.
   o. Indirect cost categories:
      i. Burns & McDonnell Construction Management / General Conditions costs have been included.
      ii. Burns & McDonnell Home Office Support (Procurement, Subcontract Management and Project Controls) costs have been included.
      iii. Permits – costs have not been included and are assumed as an owner's cost.

BURNS & McDONNELL

ESTIMATE BASIS

p. Project costs incurred by the Owner, including but not limited to start up and commissioning, owner's staff and overhead, hazardous, or contaminated materials handling, land and easement acquisition, and permitting are excluded from the estimate.

12. Foundation and concrete quantities are based on conceptual engineering and historical data. Cost is based on recent projects and in-house metrics. Piles are not included in the estimate and are not anticipated to be required.
13. Soil data was assumed based on the "Arrowhead sub geo report" provided to Burns & McDonnell from Minnesota Power by Braun Intertec from October 7th, 2022.
14. All conduit, duct bank and raceways were estimated based on the preliminary layout and historical projects.
15. Site work quantities are estimated based on the preliminary layout drawing and labor calculated using historical information.
16. Structural steel quantities are based on the preliminary layout. Labor is calculated using in-house metrics.
17. Bus work quantities were estimated based on the preliminary layout.
18. Quantities for cable are estimated using the preliminary layout.

CLIENT ESTIMATE SUMMARY

BURNS & McDONNELL

Client: MPL
Project No: 144774
Description: ARROWHEAD SUBSTATION REV3
Location: MINNESOTA

Estimator: R.SMITH
Date: 29-Jan-24
Estimate Type: FEL-2

NO.	ACCOUNT	Labor	Construction Equipment	Subcontractor Materials	Owner Purchased Materials (For reference Only)	Total
1	REMOVALS	241,918	164,578			$ 406,497
2	GROUNDING	85,809	35,604	64,230		$ 185,643
3	UNDERGROUND RACEWAY	142,335	92,090	50,029		$ 284,455
4	FOUNDATIONS	2,352,469	2,236,096	2,221,190		$ 6,809,755
5	STEEL STRUCTURES	702,041	407,422		3,084,500	$ 1,109,463
6	ELECTRICAL EQUIPMENT	1,037,861	632,954	27,154	49,377,985	$ 1,697,969
7	BUSWORK, CONDUCTOR, TERMINATIONS	447,856	215,017	389,883		$ 1,052,756
8	CONTROL CABLE & TERMINATIONS	615,942	251,866	360,559		$ 1,228,368
9	GENERAL			30,409		$ 30,409
10						$ -
11						$ -
12						$ -
13						$ -
14						$ -
15						$ -
16						$ -
17						$ -
18						$ -
19						$ -
	Total Direct Cost (TDC)	$ 5,626,232	$ 4,035,627	$ 3,143,455		12,805,314
		BMCD Procured Equipment				
		BMCD Engineering				$512,213
		BMCD CMCI				$896,372
		BMCD Estimate				$14,213,899
		Owner's Cost				
		Owner Purchased Materials & Equipment				$52,462,485
		O&M Cost				
		Land Acquisition / Real Estate				
		Permitting				
		Owner Contingency				
		Owner Escalation				
		Total Project Cost (TIC)				$66,676,384

Client: MPL

Project No: 144774

Description: ARROWHEAD SUBSTATION REV3

Location: MINNESOTA

Estimator: R.SMITH

Date: 29-Jan-24

Rev: FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
100000	**REMOVALS**							
101000	**RELAYS AND CONTROL EQUIPMENT**							
101010	RELAY RACKS	2	EA	$ 8,026	$ 5,825			$13,851
101500	**SUBSTATION MATERIALS**							
101510	5" ALUMINUM BUS	1,000	LF	$ 46,441	$ 23,350			$69,791
101520	5" BUS SUPPORT FITTINGS	20	EA	$ 3,981	$ 2,001			$5,982
101530	5" BUS TERMINAL FITTINGS	40	EA	$ 7,962	$ 4,003			$11,965
101540	1590 AAC FALCON CONDUCTOR	100	LF	$ 532	$ 466			$998
101550	345KV STATION POST INSULATORS (EXTRA HIGH STRENGTH	20	EA	$ 8,026	$ 5,825			$13,851
101560	345KV CCVT / PT JUNCTION BOX	1	EA	$ 1,728	$ 589			$2,318
102000	**SUBSTATION EQUIPMENT**							
102010	345KV 4000A, 63KAIC CIRCUIT BREAKER, THREE PHASE	2	EA	$ 16,052	$ 9,354			$25,406
102020	345KV, 3000A, DISCONNECT SWITCH	3	EA	$ 12,039	$ 8,737			$20,776
102030	345KV CCVT'S, 1PH 8100PF	3	EA	$ 2,408	$ 1,748			$4,155
102040	230KV SSVT'S, 100KVA	3	EA	$ 20,065	$ 14,562			$34,627
102050	345KV CAPACITOR BANKS	2	EA	$ 80,261	$ 58,245			$138,506
103000	**STEEL STRUCTURES**							
103010	345KV SINGLE PHASE BUS SUPPORTS	12	EA	$ 22,509	$ 20,500			$43,009
103020	345KK SWITCH STRUCTURES	3	EA	$ 10,009	$ 7,668			$17,676
103030	345KV THREE PHASE BUS SUPPORTS	1	EA	$ 1,878	$ 1,708			$3,586
150000	**GROUNDING**							
151000	GROUND GRID	1,000	LF	$ 9,011	$ 3,738	$ 10,915		$23,664

Client: MPL
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Estimator: R.SMITH
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NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
151500	GROUND CONNECTIONS	280	EA	$ 76,798	$ 31,866	$ 53,315		$161,979
200000	**UNDERGROUND RACEWAY**							
201000	BREAKERS 3-4"	8	EA	$ 52,032	$ 33,664	$ 21,740		$107,437
202000	TRANSFORMERS 4-4"	5	EA	$ 38,932	$ 25,200	$ 17,970		$82,102
203000	CCTV'S	18	EA	$ 38,114	$ 24,656	$ 6,961		$69,732
204000	SSVT'S	2	EA	$ 4,642	$ 3,002	$ 1,849		$9,493
205000	SUMP PUMP	4	EA	$ 8,615	$ 5,568	$ 1,508		$15,691
250000	**FOUNDATIONS**							
250300	345KV BREAKER	116	CY	$ 72,528	$ 45,989	$ 46,725		$165,242
250600	TRANSFORMER	128	CY	$ 108,053	$ 68,520	$ 61,397		$237,970
250900	FIREWALL FDN GRADE BEAM	66	CY	$ 14,401	$ 9,133	$ 19,493		$43,027
251200	230KV BREAKER	17	CY	$ 13,797	$ 8,750	$ 7,217		$29,764
251500	PHASE SHIFT TRANSFORMER	302	CY	$ 9,822	$ 6,230	$ 59,936		$75,989
251800	230KV PIR BREAKER	28	CY	$ 16,748	$ 10,619	$ 11,029		$38,395
252100	345KV LOW SWITCH	94	CY	$ 84,673	$ 97,746	$ 61,672		$244,092
252400	345KV 3PH HIGH BUS	71	CY	$ 63,504	$ 73,320	$ 46,254		$183,077
252700	345KV 3PH LOW BUS	31	CY	$ 28,222	$ 32,576	$ 20,557		$81,356
253000	345KV 1PH HIGH BUS	35	CY	$ 31,750	$ 36,654	$ 23,124		$91,528
253300	345KV 1PH LOW BUS	51	CY	$ 45,862	$ 52,953	$ 33,405		$132,220
253600	345KV 1PH CCVT	12	CY	$ 10,579	$ 12,220	$ 7,707		$30,506

Client: MPL
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Estimator: R.SMITH
Date: 29-Jan-24
Rev: FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
253900	230KV HIGH SWITCH	94	CY	$ 84,673	$ 97,746	$ 61,672		$244,092
254200	230KV 3PH HIGH BUS	31	CY	$ 28,874	$ 33,331	$ 20,950		$83,155
254500	230KV 3PH LOW BUS	55	CY	$ 49,392	$ 57,031	$ 35,974		$142,398
254800	230KV 1PH HIGH BUS	27	CY	$ 24,699	$ 28,509	$ 17,987		$71,195
255100	230KV 1PH LOW BUS	126	CY	$ 112,898	$ 130,344	$ 82,229		$325,472
255400	230KV 1PH CCVT	12	CY	$ 11,995	$ 13,861	$ 7,707		$33,563
255700	230KV STD SERVICE TRANSF	8	CY	$ 7,053	$ 8,146	$ 5,139		$20,338
256000	230KV TERTIARY BUS	24	CY	$ 21,662	$ 25,002	$ 15,713		$62,377
256300	230KV STANDBY TERTIARY BUS	31	CY	$ 28,874	$ 33,331	$ 20,950		$83,155
256600	230KV 1PH EXTRA HIGH BUS	16	CY	$ 14,443	$ 16,674	$ 10,474		$41,591
256900	230KV NEUTRAL BUS	31	CY	$ 28,874	$ 33,331	$ 20,950		$83,155
257200	230KV CT 3PH	8	CY	$ 9,109	$ 10,515	$ 5,139		$24,762
257800	345KV A-FRAME 1-BAY	502	CY	$ 187,749	$ 216,739	$ 269,458		$673,947
258100	345KV H-FRAME 3-BAY	171	CY	$ 55,994	$ 64,658	$ 79,078		$199,730
258400	230KV A-FRAME 1-BAY	377	CY	$ 140,809	$ 162,564	$ 202,094		$505,466
258700	230KV A-FRAME 2-BAY	256	CY	$ 280,623	$ 323,976	$ 346,215		$950,814
259000	LIGHTNING MAST - 100 FT W/WIRE	85	CY	$ 50,373	$ 58,137	$ 39,538		$148,048
259300	FIREWALL FDN GRADE BEAM	47	CY	$ 66,341	$ 76,583	$ 358,666		$501,590
259400	FIREWALL	3	EA	$ 333,561	$ 211,527	$ 92,298		$637,386
259600	**160MVA TRANSFORMER OIL CONTAINMENT**							
259605	OIL CONTAINMENT WALLS	36	CY	$ 185,525	$ 100,314	$ 27,811		$313,649
259610	OLI CONTAINMENT SLAB	141	CY	$ 68,255	$ 43,286	$ 55,651		$167,191
259900	**PHASE SHIFT OIL CONTAINMENT**							
259905	LINER - SEAMAN CORP XR-5 8138	6,000	SQFT	$ 17,867	$ 5,375	$ 10,947		$34,190
259910	ROCK FILL	500	CY	$ 12,813	$ 12,529	$ 26,830		$52,172
259915	PERFORATED PIPING 6" DIA.	400	LF	$ 26,004	$ 16,490	$ 5,289		$47,783

Client: MPL

Project No: 144774 | **Estimator:** R.SMITH

Description: ARROWHEAD SUBSTATION REV3 | **Date:** 29-Jan-24

Location: MINNESOTA | **Rev:** FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
259920	SOLID PIPING 8" DIA. GALVANIZED	50	LF	$ 4,068	$ 1,387	$ 3,913		$9,368
300000	**STEEL STRUCTURES**							
300200	345KV LOW SWITCH	6	EA	$ 42,994	$ 24,947		$ 108,000	$67,941
300300	345KV 3PH HIGH BUS	9	EA	$ 62,341	$ 36,173		$ 156,600	$98,514
300600	345KV 3PH LOW BUS	4	EA	$ 13,376	$ 7,762		$ 33,600	$21,137
300900	345KV 1PH HIGH BUS	9	EA	$ 11,823	$ 6,861		$ 29,700	$18,684
301200	345KV 1PH LOW BUS	13	EA	$ 13,282	$ 7,706		$ 27,300	$20,987
301500	345KV 1PH CCVT	3	EA	$ 3,941	$ 2,287		$ 8,100	$6,228
301800	230KV HIGH SWITCH	6	EA	$ 48,726	$ 28,273		$ 122,400	$76,999
302100	230KV 3PH HIGH BUS	4	EA	$ 21,019	$ 12,196		$ 52,800	$33,215
302400	230KV 3PH LOW BUS	7	EA	$ 23,408	$ 13,582		$ 58,800	$36,990
302700	230KV 1PH HIGH BUS	7	EA	$ 6,688	$ 3,880		$ 16,800	$10,568
303000	230KV 1PH LOW BUS	32	EA	$ 28,026	$ 16,262		$ 57,600	$44,287
303300	230KV 1PH CCVT	3	EA	$ 3,583	$ 2,079		$ 9,000	$5,662
303600	230KV STD SERVICE TRANSF	1	EA	$ 5,971	$ 3,465		$ 15,000	$9,437
303900	230KV TERTIARY BUS	6	EA	$ 12,182	$ 7,068		$ 30,600	$19,250
304200	230KV STANDBY TERTIARY BUS	8	EA	$ 16,242	$ 9,424		$ 40,800	$25,666
304500	230KV 1PH EXTRA HIGH BUS	4	EA	$ 4,777	$ 2,772		$ 12,000	$7,549
304800	230KV NEUTRAL BUS	8	EA	$ 16,242	$ 9,424		$ 40,800	$25,666
305100	CT 3PH	1	EA	$ 4,777	$ 2,772		$ 12,000	$7,549
305400	345KV A-FRAME 1-BAY	4	EA	$ 134,022	$ 77,766		$ 808,000	$211,788
305700	345KV H-FRAME 3-BAY	1	EA	$ 41,137	$ 23,870		$ 248,000	$65,008
306000	230KV A-FRAME 1-BAY	3	EA	$ 89,570	$ 51,974		$ 540,000	$141,544
306300	230KV A-FRAME 2-BAY	1	EA	$ 60,376	$ 35,032		$ 364,000	$95,408
306600	LIGHTNING MAST - 100 FT	2	EA	$ 19,268	$ 11,180		$ 193,600	$30,447
306900	OIL CONTAINMENT BEAM	4	EA	$ 2,389	$ 1,386		$ 7,800	$3,775
307200	OIL CONTAINMENT NON-METALLIC GRATING	6,648	SF	$ 15,883	$ 9,280		$ 91,200	$25,163
350000	**ELECTRICAL EQUIPMENT**							
351000	**MISC. MATERIALS**							
351010	230KV STATION POST INSULATORS (EXTRA HIGH STRENGTH	84	EA	$ 80,280	$ 48,743		$ 79,800	$129,023
351015	345KV STATION POST INSULATORS (EXTRA HIGH STRENGTH	63	EA	$ 90,273	$ 54,809		$ 85,050	$145,082
351020	230KV STRAIN BUS INSULATOR ASSEMBLY (STD. STRENGTH	5	EA	$ 4,779	$ 2,902		$ 3,750	$7,681
351025	345KV STRAIN BUS INSULATOR ASSEMBLY (STD. STRENGTH	4	EA	$ 5,730	$ 3,480		$ 4,500	$9,210
351030	230KV SURGE / LIGHTNING ARRESTORS	6	EA	$ 6,756	$ 4,101		$ 33,000	$10,857
351035	345KV SURGE / LIGHTNING ARRESTORS	12	EA	$ 13,512	$ 8,204		$ 105,600	$21,715
351040	HEAVY DUTY SAFETY FUSIBLE DISCONNECT SWITCH, NEMA	1	EA	$ 1,595	$ 544		$ 2,500	$2,139
351500	**TRANSFORMERS**							
351510	SINGLE PHASE 345KV/230KV 160MVA	4	EA	$ 235,916	$ 143,238		$ 14,964,000	$379,154
351520	PHASE SHIFTING TRANSFORMER 230KV 800MVA	1	EA	$ 107,014	$ 77,661		$ 30,000,000	$184,675
351530	24.5KV, SSVT'S, 167KVA	3	EA	$ 3,217	$ 1,954		$ 25,000	$5,171
351540	13.85KV, SSVT'S, 167KVA	3	EA	$ 9,651	$ 5,859		$ 60,000	$15,510

Client: MPL
Project No: 144774
Description: ARROWHEAD SUBSTATION REV3
Location: MINNESOTA

Estimator: R.SMITH
Date: 29-Jan-24
Rev: FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
352000	**BREAKERS / CIRCUIT SWITCHERS**							
352010	230KV 4000A, 63KAIC CIRCUIT BREAKER, THREE PHASE	2	EA	$ 24,128	$ 14,649		$ 514,710	$38,777
352020	345KV 4000A, 63KAIC CIRCUIT BREAKER, SINGLE PHASE	15	EA	$ 150,799	$ 91,558		$ 1,762,575	$242,357
352030	345KV 4000A, 63KAIC CIRCUIT BREAKER, THREE PHASE,P	1	EA	$ 13,404	$ 8,138		$ 500,000	$21,543
352500	**DISCONNECT SWITCHES**							
352520	230KV, 3000A, DISCONNECT SWITCH	8	EA	$ 64,341	$ 39,065		$ 218,400	$103,406
352530	345KV, 3000A, DISCONNECT SWITCH	10	EA	$ 134,043	$ 81,385		$ 336,000	$215,428
353000	**CCVT'S**							
353010	230KV CCVT'S, 1PH 11250PH	6	EA	$ 11,581	$ 7,032		$ 72,000	$18,613
353020	345KV CCVT'S, 1PH 8100PF	12	EA	$ 23,163	$ 14,063		$ 180,000	$37,226
353030	CCVT / PT JUNCTION BOX	18	EA	$ 11,965	$ 4,079	$ 27,154		$43,198
353500	**RELAY & CONTROL EQUIPMENT**							
353510	RELAY RACKS	9	EA	$ 14,447	$ 10,484		$ 360,000	$24,931
353520	TERMINAL CABINETS	1	EA	$ 803	$ 274		$ 1,100	$1,077
353530	AC PANEL 54 POLE	1	EA	$ 2,659	$ 906		$ 20,000	$3,565
353540	DC PANEL 40 POLE	2	EA	$ 5,318	$ 1,813		$ 30,000	$7,131
354000	**OIL CONTAINMENT SUMP PUMP**							
354010	SUMP PUMP	4	EA	$ 16,063	$ 5,723		$ 8,000	$21,786
354020	SUMP PUMP CONTROL CABINET	4	EA	$ 6,425	$ 2,290		$ 12,000	$8,715
450000	**BUSWORK, CONDUCTOR, TERMINATIONS**							
451000	5" ALUMINUM BUS	3,800	LF	$ 378,583	$ 190,335	$ 301,088		$870,006
451500	1590 ACSR FALCON CONDUCTOR (JUMPERS)	8,700	LF	$ 69,273	$ 24,682	$ 88,795		$182,750
500000	**CONTROL CABLE & TERMINATIONS**							
501000	**BREAKER CONTROL CABLES**							
501010	12/C #10	11,060	LF	$ 61,582	$ 25,182	$ 57,586		$144,351
501020	12/C #12	5,530	LF	$ 32,797	$ 13,411	$ 19,035		$65,243
501030	2/C#8	5,530	LF	$ 22,684	$ 9,275	$ 13,847		$45,806
501040	25/C #12 SHIELDED	5,530	LF	$ 65,592	$ 26,823	$ 38,069		$130,483
501050	3/C#10	5,530	LF	$ 20,597	$ 8,422	$ 7,109		$36,127
501060	4/C #10 SHIELDED	22,120	LF	$ 92,045	$ 37,640	$ 40,050		$169,735
501070	9/C#12	5,530	LF	$ 28,249	$ 11,550	$ 15,803		$55,601
501500	**TRANSFORMER CONTROL CABLES**							
501510	1/C #4	4,530	LF	$ 13,316	$ 5,447	$ 6,972		$25,735
501520	12/C #12	1,510	LF	$ 10,970	$ 4,483	$ 5,271		$20,723
501530	2/C #10	1,510	LF	$ 5,423	$ 2,218	$ 1,456		$9,096
501540	25/C #12 SHIELDED	1,510	LF	$ 21,937	$ 8,972	$ 10,541		$41,451
501550	3/C #8	1,510	LF	$ 6,862	$ 2,805	$ 3,803		$13,470
501560	4/C #10 SHIELDED	9,060	LF	$ 42,395	$ 17,338	$ 16,567		$76,300
501570	CAT5E	1,510	LF	$ 7,100	$ 2,905	$ 40		$10,045
502000	**SSVT POWER CABLES**							
502010	1/C #4-0	10,720	LF	$ 63,644	$ 26,025	$ 67,186		$156,854

Client: MPL
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Estimator: R.SMITH
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NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
502500	**CCVT CONTROL CABLES**							
502510	12/C #12	12,000	LF	$ 71,676	$ 29,307	$ 41,356		$142,339
502520	2/C #12	12,000	LF	$ 40,604	$ 16,603	$ 10,851		$68,058
503000	**SUMP PUMP**							
503010	3/C #8	2,000	LF	$ 8,469	$ 3,461	$ 5,018		$16,949
550000	**GENERAL**							
551000	STAKING	1	LS			$ 3,966		$3,966
552000	MOBILIZATION	1	LS			$ 6,611		$6,611
553000	MATERIAL TESTING	1	LS			$ 19,832		$19,832
				$ 5,626,232	$ 4,035,627	$ 3,143,455	$ 52,462,485	$ 12,805,314

[TRADE SECRET BEGINS . . .

PUBLIC DOCUMENT
TRADE SECRET DATA EXCISED

Removals

[redacted]

REFERENCE DRAWINGS:

- ME-31655-00 SHT.2 M&R DIAGRAM
- ME-31656-00 SHT.1 DRAWING INDEX - PHYSICAL SET
- ME-31656-05 SHT.1 FOUNDATION PLAN - 345kV
- ME-31656-05 SHT.2 FOUNDATION PLAN - 230kV
- ME-31656-07 SHT.1 GROUNDING PLAN - 345kV
- ME-31656-07 SHT.2 GROUNDING PLAN - 230kV
- ME-31656-08 SHT.1 CONDUIT PLAN - 345kV
- ME-31656-08 SHT.2 CONDUIT PLAN - 230kV
- ME-31656-09 SHT.1 CABLE TRENCH PLAN - 345kV
- ME-31656-09 SHT.2 CABLE TRENCH PLAN - 230kV
- ME-31656-10 SHT.4 OUTDOOR LIGHTING PLAN
- ME-31656-12 SHT.1 SPCC PLAN
- ME-31656-12 SHT.2 OIL CONTAINMENT PLAN & DETAILS
- ME-31656-12 SHT.3 OIL CONTAINMENT PLAN & DETAILS
- ME-31656-13 SHT.1 345kV STEEL STRUCTURE PLAN
- ME-31656-13 SHT.2 230kV STEEL STRUCTURE PLAN
- ME-31656-16 SHT.2 THREE LINE DIAGRAM - 345kV
- ME-31656-16 SHT.3 THREE LINE DIAGRAM - 230kV
- ME-31656-17 SHT.1 ELECTRICAL PLAN - 345kV
- ME-31656-17 SHT.9 ELECTRICAL PLAN - 230kV
- ME-31656-18 SHT.1 ELECTRICAL DETAILS
- ME-31656-18 SHT.2 ELECTRICAL DETAILS
- ME-31656-18 SHT.3 ELECTRICAL DETAILS
- ME-31656-18 SHT.4 ELECTRICAL DETAILS
- ME-31656-20 SHT.1 SHIELDING PLAN - 345kV
- ME-31656-20 SHT.2 SHIELDING PLAN - 230kV
- ME-31656-22 SHT.1 ELECTRICAL EQUIPMENT SHELTER LAYOUT
- ME-18463 SHT.2 3 LINE DIAGRAM - 230kV
- MF+22881 SHT.1 ELECT PLAN & ELEVATIONS - 230kV
- MF+22881 SHT.2 ELECT PLAN & ELEVATIONS - 230kV
- MF+22881 SHT.4 ELECT PLAN & ELEVATIONS - 230kV

[redacted]

AMERICAN TRANSMISSION COMPANY
THE ENERGY ACCESS COMPANY

minnesota power
AN ALLETE COMPANY

Commonwealth Associates Inc.
Jackson, Michigan
engineers consultants construction managers

NO.	DATE	REVISION DESCRIPTION	BY	APPROVED

NO.	DATE	REVISION DESCRIPTION	BY	APPROVED

DRAWN BY
APPROVED
DATE
SCALE 1"=100'

SITE PLAN

SHEET 1
REV.
ME-
CODE

CADD DRAWING - FOR REPRODUCTION ONLY

OAH Docket No. 5-2500-39600
MPUC Docket Nos. E015/CN-22-607
and E015/TL-22-611
MP Exhibit ___ (Winter)
Rebuttal Schedule 19
. . . TRADE SECRET ENDS]

[TRADE SECRET BEGINS . . .

PUBLIC DOCUMENT
TRADE SECRET DATA EXCISED

Additions

REFERENCE DRAWINGS:

[redacted]

[redacted]

AMERICAN TRANSMISSION COMPANY
THE ENERGY ACCESS COMPANY

ARROWHEAD 345KV SUBSTATION
SITE PLAN

SHEET 1 OF 1 REV. 8

ME-31656-04

CADD DRAWING - FOR REPRODUCTION ONLY

Commonwealth Associates Inc.
Jackson, Michigan
engineers consultants construction managers

DRAWN BY DMS
APPROVED
DATE 4/28/2005
SCALE 1"=100'

NO.	DATE	REVISION DESCRIPTION	BY	APPROVED
8	07-31-20	AS BUILT PER REV. 7 - ATC W.O. #601536	SAL	-
7	01-18-19	PHYSICAL SECURITY UPGRADES, ATC W.O. #601536	SAW	RJB/MLH
6	5/22/18	CONSTRUCTION REVISIONS EWO #100860	JCP	RJB
5	11/14/11	ADDED CAPACITOR BANK 24K	BL	ARS
4	12/21/09	XTR REPLACE, AS BUILT, REMOVED BACK CIRCLES UPDATED MAINT ACCESS RD	LAG	LAG
3	05/13/08	RECORD REVISION PER FIELD MARK UP & ISSUED FOR CONSTRUCTION (BX & CT WORK)	SMD	DA

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	November 30, 2023
Requested From:	Minnesota Power	Response Due: Extension Granted to:	December 11, 2023 December 13, 2023

By: American Transmission Company LLC

Information Request No. 12.

Reference Section 2.1.2.2 and Map 2 of the Application. Please describe the current status of negotiations between Minnesota Power and landowners for those “required Project parcels” for which “landowner negotiations are ongoing.”

Response:

All parcels required for the scope of Minnesota Power’s HVDC Modernization Project have been acquired by Minnesota Power.

Response by: Dan McCourtney

Title: Manager - Strategic Environmental Initiatives

Department: Environmental Land and Real Estate Services

Telephone: 218-355-3515

Line	Original CON Application: Minnesota Interconnection Facilities	Low	Med	High	Owner
1	Minnesota Land Acquisition	7	10	13	MP
2	HVDC Line Entrance	1.4	2	2.6	MP
3	HVDC - St Louis County 345kV Line	2.3	3.3	4.3	MP
4	St Louis County 345/230kV Substation	21.1	30.1	39.1	MP
5	St Louis County - Arrowhead 230kV Lines	2.3	3.3	4.3	MP
6	Arrowhead Line Entrances	4	5	7	MP
7	Rounding	1.9	1.3	-0.3	MP
8	**Total**	**40**	**55**	**70**	

Line	ATC Arrowhead Alternative (without PST) Based on ATC's Cost Estimate Minnesota Interconnection Facilities	Low	Med	High	Owner
1	Minnesota Land Acquisition	7	10	13	MP
2	HVDC Line Entrance	1.4	2	2.6	MP
3	HVDC 345kV Line Entrance for Ckt #2	2.2	3.1	4	MP
4	HVDC - Arrowhead 345kV Double Ckt	7.8	8.7	10.4	MP
5	Arrowhead 345kV Line Reconfiguration	Included in Line 4			ATC
6	Arrowhead 345/230kV Substation Expansion	25.2	27.7	33.2	ATC
7	Arrowhead 230 kV Phase Shifting Transformer	**0**	**0**	**0**	N/A
8	Arrowhead 230kV Bus Reconfigurations	Included in Line 6			MP
9	Rounding	0	0	0	N/A
10	**Total**	**43.6**	**51.5**	**63.2**	

Line	ATC Arrowhead Alternative Based on MP's Cost Estimate Minnesota Interconnection Facilities	Low	Med	High	Owner
1	Minnesota Land Acquisition	7	10	13	MP
2	HVDC Line Entrance	1.4	2	2.6	MP
3	HVDC 345kV Line Entrance for Ckt #2	2.2	3.1	4	MP
4	HVDC - Arrowhead 345kV Double Ckt	4.7	6.7	8.7	MP
5	Arrowhead 345kV Line Reconfiguration	1	1.4	1.8	ATC
6	Arrowhead 345/230kV Substation Expansion	15.4	22	28.6	ATC
7	Arrowhead 230 kV Phase Shifting Transformer	23.5	33.5	43.6	ATC
8	Arrowhead 230kV Bus Reconfigurations	3.4	4.9	6.4	MP
9	Rounding	1.4	1.4	1.3	N/A
10	**Total**	**60**	**85**	**110**	

BURNS & McDONNELL

ESTIMATE BASIS

3Client:	**Minnesota Power**		
Project No.:	**144774**	**Estimate Date:**	**08/07/2023**
Project Name:	**St. Louis County**	**Estimate Class:**	**Class 3**
Project Location:	**Minnesota**		

DESCRIPTION OF SCOPE

Provide labor and materials for St. Louis County Substation

PURPOSE

The purpose of the "Basis of Estimate" is to describe the scope of work and how the estimate values were developed and compiled into the finished deliverable. Burns & McDonnell has developed a Class 3 estimate for the Minnesota Power St. Louis County Substation project. This work includes the engineering/design, procurement, and construction.

GENERAL ASSUMPTIONS & QUALIFICATIONS

1. The estimate excludes costs to modify or replace any existing facilities, equipment, and materials.
2. Dewatering is assumed not required other than to remove normal surface water run-off due to rain.
3. The estimate excludes rework and redesign due to existing underground obstructions.
4. Subsurface conditions: We have assumed that no rock will be encountered.
5. Burns & McDonnell has not included any costs for identifying or addressing endangered species and historical items that could be encountered.
6. Detailed engineering drawings are not available at this time, so many assumptions have been made, which include, but are not limited to foundation sizes, steel weights, major equipment, miscellaneous material quantities, etc. These assumptions are based on historical data and recent project history.
7. No cost for a GPR (ground penetrating radar) scan to locate underground obstructions is included in this estimate.
8. The estimate is for the inside of the substations only. The estimate also includes costs for access roads from the gate to the existing road.
9. All major equipment (Transformers, Breakers, Switches, CCVTs, Arresters, etc.) and steel is assumed to be procured by Minnesota Power and no subcontractor in-directs have been added for any of that material.
10. In general, the estimate is based on the layout drawings submitted to Minnesota Power for St. Louis County substation. The following is a more detailed description:
    a. CCVTs and Arresters were assumed to be needed only on each line terminal.
    b. A ground grid was assumed to be added with 40-foot spacing between 4/0 conductor runs.
    c. Quantity One (1) ground rod was assumed to be added every 40' around the perimeter and for each arrester.
    d. The estimate does not include grounding stingers for each structure.
    e. A cable trench route was assumed to run from the control enclosure down the middle of the station and along each major equipment run.
    f. 250 feet of conductor was assumed as needed for each breaker.
    g. 600 feet of conductor was assumed as necessary for each line termination.
    h. 45 feet of conductor was assumed as necessary for each set of CCVTs and Arrestors
    i. Bus support/insulator quantities were determined based on an assumed bus span.
    j. Security was not included in the estimate.
    k. Bus assumed to come in 40-foot increments.
    l. Substation scope:

ESTIMATE BASIS

i. Provide cut and fill for new substation location. Quantities Provided
ii. Provide materials and labor for foundations as indicated in the estimate documents.
iii. Provide labor to install steel structures and equipment as indicated in the estimate documents (Steel Structure and Major Engineered Equipment will be procured by the owner)
iv. Provide materials and labor to install rigid busing and strain busing as indicated in the estimate documents
v. Provide materials and labor to install oil containment system for transformers.
vi. Provide fencing and insulating rock after all foundation, equipment, and busing is complete.
vii. Major equipment list included in the detailed estimate.

m. Site civil scope:
   i. There are buildings on site that will need to be demoed but were not included in our estimate.
   ii. The two pads will be separated by approximately 64 feet to avoid the need for a retaining wall and fit a ditch in-between the stations for drainage.
   iii. The slopes between the 2 pads are between 2:1 and 3:1 and this space will be topsoiled and seeded.
   iv. Typical three foot wide ditches and berms were used in the estimate to route stormwater.
   v. We estimated that one ponds will be needed to meet stormwater requirements.
   vi. One foot of topsoil stripping assumed across the site.
   vii. Three feet of granular engineered fill will be spread across the pad.
   viii. Class 5 aggregate base will be spread one foot across the pad and on the access road

11. Pricing Basis
   a. No tax has been included per Minnesota Power request.
   b. Pricing for tubular steel pricing was estimated at $4.00/lb and will be procured by the owner.
   c. Pricing for structural steel was estimated at $3.40/lb and will be procured by the owner.
   d. Work will be executed on a single shift of 6-10 hour/day basis.
   e. Construction schedule and productivity assume normal weather conditions for the area site location.
   f. Cost for mobilization and de-mobilization is included.
   g. All major material, steel structures, control house and cable trench assumed provided by Minnesota Power. All other materials assumed to be supplied by subcontractors.
   h. Material costs are based on recent vendor quotes for similar items. Quantities for the design are estimated based on the current preliminary substation layout.
   i. Permit cost is not included with this pricing.
   j. No escalation has been included.
   k. Detailed engineering, design, and procurement costs were calculated as 3% of direct project & purchased equipment costs (labor, construction equipment, purchased equipment, and subcontractor materials).
   l. Burns & McDonnell Construction Management / General Conditions (CMCI) costs have been included at 7% of direct project costs (labor, construction equipment, and subcontractor materials).
   m. Wage rates are based on the IBEW local union rates. The rates include base wage, payroll insurance and taxes, overtime and benefits; we have also included subsistence.
   n. Costs are included for:
      i. Temporary facilities, onsite supplies, and expenses
      ii. Construction equipment, maintenance, and site vehicles
      iii. Small tools and consumables
      iv. Safety requirements
      v. Subcontractor field supervision
      vi. Subcontractor overhead and profit
      vii. All costs for labor, materials, and equipment are based on 2022 dollars.
   o. Indirect cost categories:

ESTIMATE BASIS

i. Burns & McDonnell Construction Management / General Conditions costs have been included.
ii. Burns & McDonnell Home Office Support (Procurement, Subcontract Management and Project Controls) costs have been included..
iii. Permits – costs have not been included and are assumed as an owner's cost.

p. Project costs incurred by the Owner, including but not limited to start up and commissioning, owner's staff and overhead, hazardous or contaminated materials handling, land and easement acquisition, and permitting are excluded from the estimate.

12. Foundation and concrete quantities are based on conceptual engineering and historical data. Cost is based on recent projects and in-house metrics. Piles are not included in the estimate and are not anticipated to be required.
13. Soil data was assumed based on the "Arrowhead sub geo report" provided to Burns & McDonnell from Minnesota Power by Braun Intertec from October 7th, 2022.
14. All conduit, duct bank and raceways were estimated based on the preliminary layout and historical projects.
15. Site work quantities are estimated based on the preliminary layout drawing and labor calculated using historical information.
16. Structural steel quantities are based on the preliminary layout. Labor is calculated using in-house metrics.
17. Bus work quantities were estimated based on the preliminary layout.
18. Quantities for cable are estimated using the preliminary layout.

9400 Ward Parkway • Kansas City, Missouri 64114-3319
Tel: 816-333-9400 • Fax: 816-333-3690 • www.burnsmcd.com

CLIENT ESTIMATE SUMMARY

Client: MPL
Project No: 144774
Description: ST. LOUIS COUNTY SUBSTATION REV4
Location: ST LOUIS COUNTY, MINNESOTA

Estimator: R.SMITH
Date: 27-Feb-24
Estimate Type: FEL-2

NO.	ACCOUNT		Labor	Construction Equipment	Subcontractor Materials	Owner Purchased Materials (For reference Only)	Total
1	CIVIL		1,825,344	1,835,571	2,916,911		$ 6,577,826
2	GROUNDING		211,121	89,564	228,650		$ 529,335
3	UNDERGROUND RACEWAY		167,867	90,775	489,242		$ 747,883
4	FOUNDATIONS		1,755,214	1,518,884	1,314,753		$ 4,588,852
5	STEEL STRUCTURES		424,912	252,282		2,402,190	$ 677,194
6	ELECTRICAL EQUIPMENT		789,007	488,019	13,049	19,792,145	$ 1,290,075
7	BUSWORK, CONDUCTOR, TERMINATIONS		443,257	253,015	359,956		$ 1,056,229
8	CONTROL CABLE & TERMINATIONS		296,342	124,013	157,105		$ 577,459
9	GENERAL				44,117		$ 44,117
10							$ -
11							$ -
12							$ -
13							$ -
14							$ -
15							$ -
16							$ -
17							$ -
18							$ -
19							$ -
	Total Direct Cost (TDC)		$ 5,913,064	$ 4,652,124	$ 5,523,783		16,088,971
		BMCD Procured Equipment					
		BMCD Engineering					$643,559
		BMCD CMCI					$1,126,228
		BMCD Estimate					$17,858,758
		Owner's Cost					
		Owner Purchased Materials & Equipment					$22,194,335
		O&M Cost					
		Land Acquisition / Real Estate					
		Permitting					
		Owner Contingency					
		Owner Escalation					
		Total Project Cost (TIC)					$40,053,093

Client: MPL
Project No: 144774
Description: ST. LOUIS COUNTY SUBSTATION REV4
Location: ST LOUIS COUNTY, MINNESOTA
Estimator: R.SMITH
Date: 27-Feb-24
Rev: FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
1010000	**CIVIL**							
1010100	TOPSOIL STRIPPING	16000	CY	$ 155,113	$ 198,348			$353,461
1010300	EARTHWORK - FILL VOLUME	34000	CY	$ 285,700	$ 261,318	$ 22,507		$569,525
1010400	EARTHWORK - NET VOLUME	42000	CY	$ 605,011	$ 892,236			$1,497,247
1010500	GRANULAR ENGINEERED FILL	29000	CY	$ 148,162	$ 148,056	$ 1,776,417		$2,072,635
1010600	CLASS 5 AGGREGATE BASE	9900	CY	$ 50,579	$ 50,543	$ 606,249		$707,372
1010740	CRUSHED ROCK SURFACING	3200	CY	$ 78,662	$ 51,256	$ 227,566		$357,484
1010860	WOVEN GEOTEXTILE FABRIC	11100	SF	$ 96,438	$ 25,450	$ 1,950		$123,838
1010980	24" RCP CULVERT	40	LF	$ 972	$ 649	$ 2,845		$4,466
1011100	12" RCP CULVERT	20	LF	$ 395	$ 262	$ 645		$1,302
1011220	TOPSOIL REPLACEMENT	3100	CY	$ 66,122	$ 66,076	$ 132,676		$264,874
1011340	SEED & MULCH	4	AC	$ 24,921	$ 14,642	$ 7,563		$47,125
1011460	SILT FENCE	1100	LF	$ 11,083	$ 5,295	$ 1,205		$17,583
1011580	SEDIMENT CONTROL LOGS	85	EA	$ 5,411	$ 1,423	$ 5,857		$12,691
1011700	8' CHAINLINK FENCE AND POSTS W/1' BARB	1100	LF	$ 296,775	$ 120,017	$ 131,431		$548,224
1020000	**GROUNDING**							
1020100	**GROUND GRID**							
1020101	345KV YARD	11900	LF	$ 56,841	$ 24,113	$ 75,736		$156,689
1020102	230KV YARD	12400	LF	$ 59,380	$ 25,193	$ 78,736		$163,309
1020200	GROUND CONNECTIONS	261	EA	$ 71,253	$ 30,228	$ 53,837		$155,318
1020300	FENCE GOUNDING	104	EA	$ 23,648	$ 10,030	$ 20,341		$54,019

Client: MPL
Project No: 144774
Description: ST. LOUIS COUNTY SUBSTATION REV4
Location: ST LOUIS COUNTY, MINNESOTA
Estimator: R.SMITH
Date: 27-Feb-24
Rev: FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
1030000	**UNDERGROUND RACEWAY**							
1030100	CABLE TRENCH	725	LF	$ 88,927	$ 38,702	$ 463,233		$590,862
1030200	**DUCKBANK--POWER TRANSFORMERS 230/345KV - 300MVA**							
1030201	4-4"	3	EA	$ 14,646	$ 9,661	$ 7,209		$31,516
1030300	**DUCKBANK--SL&P, 230KV, 208Y/120, 167KVA**							
1030301	1-4"	1	EA	$ 1,523	$ 1,008	$ 617		$3,148
1030400	**DUCKBANK--SL&P, 345KV, 208Y/120, 167KVA**							
1030401	1-4"	1	EA	$ 1,523	$ 1,008	$ 617		$3,148
1030500	**DUCKBANK--230KV 4000A, 63KAIC CIRCUIT BREAKER**							
1030501	3-4"	2	EA	$ 8,137	$ 5,371	$ 3,632		$17,140
1030600	**DUCKBANK--345KV 4000A, 63KAIC CIRCUIT BREAKER, SIN**							
1030601	3-4"	3	EA	$ 12,205	$ 8,048	$ 5,448		$25,701
1030700	**DUCKBANK--345KV 4000A, 63KAIC CIRCUIT BREAKER, PIR**							
1030701	3-4"	1	EA	$ 4,064	$ 2,680	$ 1,816		$8,560
1030800	**DUCKBANK--230KV, 3000A, DISCONNECT SWITCH W MOTOR**							
1030801	1-2"	2	EA	$ 2,772	$ 1,829	$ 485		$5,086
1031000	**DUCKBANK--345KV, 3000A, DISCONNECT SWITCH W/ MOTOR**							
1031001	1-2"	2	EA	$ 2,772	$ 1,829	$ 485		$5,086
1031100	**DUCKBANK--230KV CCVT'S, 1PH**							
1031101	1-2"	6	EA	$ 2,672	$ 1,762	$ 524		$4,958

Client: MPL
Project No: 144774
Description: ST. LOUIS COUNTY SUBSTATION REV4
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Estimator: R.SMITH
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Rev: FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
1031102	2-2"	3	EA	$ 7,734	$ 5,104	$ 1,413		$14,250
1031200	**DUCKBANK--345KV CCVT'S, 1PH (1700PF)**							
1031201	1-2"	4	EA	$ 1,785	$ 1,180	$ 349		$3,315
1031202	2-2"	2	EA	$ 5,151	$ 3,398	$ 942		$9,491
1031300	**DUCKBANK--LIGHTING**							
1031303	1-1"	4	EA	$ 5,537	$ 3,650	$ 970		$10,157
1031400	**DUCTBANK-SUMP PUMP**							
1031403	1-2"	4	EA	$ 8,419	$ 5,546	$ 1,502		$15,467
1040000	**FOUNDATIONS**							
1040100	345KV BREAKER	1	EA	$ 14,379	$ 9,305	$ 9,507		$33,192
1040200	CONTROL HOUSE	2	EA	$ 80,881	$ 52,368	$ 72,695		$205,943
1040300	345KV 1PH CCVT	6	EA	$ 22,254	$ 26,245	$ 16,053		$64,552
1040400	345KV 1PH LOW BUS	4	EA	$ 14,840	$ 17,503	$ 10,701		$43,045
1040500	345KV 3PH LOW BUS	8	EA	$ 59,436	$ 52,655	$ 122,545		$234,636
1040600	345KV 3PH HIGH BUS	10	EA	$ 37,082	$ 43,736	$ 26,754		$107,573
1040700	345KV LOW SWITCH	8	EA	$ 29,664	$ 34,985	$ 21,405		$86,054
1040800	345KV 1PH HIGH BUS	6	EA	$ 22,254	$ 26,245	$ 16,053		$64,552
1040900	230KV 1PH CCVT	9	EA	$ 33,372	$ 39,364	$ 24,082		$96,818
1041000	230KV 1PH LOW BUS	14	EA	$ 51,923	$ 61,240	$ 37,458		$150,621
1041100	230KV 3PH LOW BUS	4	EA	$ 14,840	$ 17,503	$ 10,701		$43,045
1041200	230KV 3PH HIGH BUS	4	EA	$ 14,840	$ 17,503	$ 10,701		$43,045
1041300	230KV LOW SWITCH	8	EA	$ 76,183	$ 62,595	$ 179,436		$318,214
1041400	230KV 1PH HIGH BUS	16	EA	$ 59,331	$ 69,981	$ 42,808		$172,119
1041500	230KV HIGH SWITCH	16	EA	$ 59,331	$ 69,981	$ 42,808		$172,119
1041600	230KV TERTIARY BUS	13	EA	$ 48,206	$ 56,864	$ 34,781		$139,851

Client: MPL
Project No: 144774
Description: ST. LOUIS COUNTY SUBSTATION REV4
Location: ST LOUIS COUNTY, MINNESOTA
Estimator: R.SMITH
Date: 27-Feb-24
Rev: FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
1041700	230KV STANDBY TERTIARY BUS	5	EA	$ 18,541	$ 21,872	$ 13,376		$53,789
1041800	230KV STD SERVICE TRANSF	2	EA	$ 7,418	$ 8,741	$ 5,352		$21,511
1041900	345KV A-FRAME (1-BAY)	8	EA	$ 95,544	$ 112,677	$ 111,286		$319,507
1042000	230KV A-FRAME (1-BAY)	8	EA	$ 95,544	$ 112,677	$ 111,286		$319,507
1042100	230KV H-FRAME (4-BAY)	5	EA	$ 74,780	$ 88,205	$ 88,660		$251,646
1042200	230KV BREAKER	2	EA	$ 13,177	$ 8,535	$ 7,001		$28,713
1042300	TRANSFORMERS	4	EA	$ 102,867	$ 66,606	$ 60,575		$230,048
1042400	FIREWALL FOUNDATION	4	EA	$ 25,017	$ 16,193	$ 22,515		$63,725
1042500	30' HIGH X30' LENGTH DURAWALL FIREWALLS (4-PH 1/ 2	4	EA	$ 408,497	$ 264,498	$ 114,257		$787,252
1042600	WAREHOUSE FDN	1	EA	$ 11,963	$ 7,747	$ 8,932		$28,643
1042700	230KV PIR BREAKER	1	EA	$ 15,480	$ 10,025	$ 9,891		$35,397
1042800	**OIL CONTAINMENT**							
1042801	OIL CONTAINMENT WALLS	4	EA	$ 180,987	$ 99,919	$ 27,701		$308,606
1042802	OIL CONTAINMENT SLAB	4	EA	$ 66,585	$ 43,115	$ 55,431		$165,132
1050000	**STEEL STRUCTURES**							
1050100	345KV 1PH CCVT	6	EA	$ 6,280	$ 3,727		$16,200	$10,007
1050200	345KV 1PH LOW BUS	4	EA	$ 3,256	$ 1,932		$8,400	$5,189
1050300	345KV 3PH LOW BUS	4	EA	$ 14,886	$ 8,835		$38,400	$23,721
1050400	345KV 3PH HIGH BUS	5	EA	$ 36,052	$ 21,398		$93,000	$57,450
1050500	345KV LOW SWITCH	2	EA	$ 13,956	$ 8,283		$36,000	$22,238
1050600	345KV 1PH HIGH BUS	6	EA	$ 7,676	$ 4,556		$19,800	$12,231
1050700	230KV 1PH CCVT	9	EA	$ 9,420	$ 5,591		$24,300	$15,011
1050800	230KV 1PH LOW BUS	14	EA	$ 9,769	$ 5,799		$25,200	$15,567
1050900	230KV 3PH LOW BUS	2	EA	$ 8,141	$ 4,832		$21,000	$12,973
1051000	230KV 3PH HIGH BUS	2	EA	$ 11,397	$ 6,765		$29,400	$18,162
1051100	230KV LOW SWITCH	6	EA	$ 34,889	$ 20,707		$90,000	$55,596
1051200	230KV 1PH HIGH BUS	16	EA	$ 14,886	$ 8,835		$38,400	$23,721
1051300	230KV HIGH SWITCH	4	EA	$ 35,819	$ 21,259		$92,400	$57,079
1051400	230KV TERTIARY BUS	13	EA	$ 25,701	$ 15,254		$86,190	$40,956
1051500	230KV STANDBY TERTIARY BUS	5	EA	$ 9,885	$ 5,867		$25,500	$15,753
1051600	230KV STD SERVICE TRANSF	1	EA	$ 5,815	$ 3,452		$15,000	$9,267
1051700	345KV A-FRAME (1-BAY)	2	EA	$ 39,153	$ 23,239		$404,000	$62,392
1051800	230KV A-FRAME (1-BAY)	2	EA	$ 34,889	$ 20,707		$360,000	$55,596
1051900	230KV A-FRAME (4-BAY)	1	EA	$ 85,284	$ 50,618		$880,000	$135,902
1052000	OIL CONTAINMENT SUPPORT BEAM	4	EA	$ 2,326	$ 1,381		$7,800	$3,706
1052100	OIL CONTAINMENT NON-METALLIC GRATING	3648	SF	$ 15,433	$ 9,244		$91,200	$24,677
1060000	**ELECTRICAL EQUIPMENT**							
1060100	**CONTROL HOUSE & COMPONENTS**							
1060101	RELAY RACKS	11	EA	$ 17,183	$ 12,764		$440,000	$29,946
1060102	BATTERIES / DC SYSTEM	4	EA	$ 26,083	$ 16,213		$200,000	$42,296

Client: MPL

Project No: 144774 **Estimator:** R.SMITH

Description: ST. LOUIS COUNTY SUBSTATION REV4 **Date:** 27-Feb-24

Location: ST LOUIS COUNTY, MINNESOTA **Rev:** FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
1060103	TERMINAL CABINETS	5	EA	$ 2,608	$ 1,621			$4,230
1060104	MISC CONTROL HOUSE CABINETS, DESK, CHAIR, ETC.	2	EA	$ 5,217	$ 3,243		$5,000	$8,459
1060105	FIBER DISTRIBUTION PANEL	4	EA	$ 2,087	$ 1,296			$3,383
1060106	CONTROL HOUSE (PREFABRICATED) - 24' X 50'	2	EA	$ 39,051	$ 29,008		$1,560,000	$68,059
1060200	345KV STATION POST INSULATORS (EXTRA HIGH STRENGTH	62	EA	$ 86,438	$ 53,728		$83,700	$140,166
1060300	230KV STATION POST INSULATORS (EXTRA HIGH STRENGTH	72	EA	$ 66,949	$ 41,614		$68,400	$108,563
1060400	230KV SURGE / LIGHTNING ARRESTORS	9	EA	$ 9,859	$ 6,128		$49,500	$15,988
1060500	345KV SURGE / LIGHTNING ARRESTORS	9	EA	$ 9,859	$ 6,128		$79,200	$15,988
1060600	HEAVY DUTY SAFETY FUSIBLE DISCONNECT SWITCH, NEMA	2	EA	$ 6,260	$ 3,891		$6,000	$10,151
1060700	230KV CCVT / PT JUNCTION BOX	3	EA	$ 6,990	$ 2,439	$ 4,658		$14,086
1060800	345KV CCVT / PT JUNCTION BOX	2	EA	$ 3,106	$ 1,084	$ 2,070		$6,261
1060900	POWER TRANSFORMERS 230/345KV - 200MVA	4	EA	$ 229,531	$ 142,673		$14,964,000	$372,204
1061000	SL&P, 230KV, 208Y/120, 167KVA	1	EA	$ 3,260	$ 2,027		$120,000	$5,287
1061100	SL&P, 345KV, 208Y/120, 167KVA	1	EA	$ 3,652	$ 2,270		$150,000	$5,922
1061200	230KV 4000A, 63KAIC CIRCUIT BREAKER 3 PHASE	2	EA	$ 31,300	$ 19,455		$514,710	$50,755
1061300	345KV 4000A, 63KAIC CIRCUIT BREAKER 1 PHASE	3	EA	$ 29,343	$ 18,240		$352,515	$47,583
1061400	345KV 4000A 63KAIC PIR CIRCUIT BREAKER 3 PHASE	1	EA	$ 15,650	$ 9,728		$500,000	$25,378
1061500	230KV, 3000A, DISCONNECT SWITCH	8	EA	$ 62,599	$ 38,911		$218,400	$101,510
1061600	230KV, 3000A, DISCONNECT SWITCH W MOTOR OP	2	EA	$ 21,127	$ 13,132		$89,520	$34,259
1061700	345KV, 3000A, DISCONNECT SWITCH	2	EA	$ 26,083	$ 16,213		$67,200	$42,296
1061800	345KV, 3000A, DISCONNECT SWITCH W/ MOTOR OP	2	EA	$ 31,561	$ 19,617		$106,000	$51,178
1061900	230KV CCVT'S, 1PH	9	EA	$ 16,902	$ 10,507		$108,000	$27,408
1062000	345KV CCVT'S, 1PH (1700PF)	6	EA	$ 11,268	$ 7,004		$90,000	$18,272
1062100	OIL CONTAINMENT SUMP PUMPS	4	EA	$ 15,630	$ 5,701		$8,000	$21,331
1062200	OIL CONTAINMENT SUMP PUMP CONTROL CABINETS	4	EA	$ 6,252	$ 2,280		$12,000	$8,533
1070000	**SUBSTATION LIGHTING**							
1070100	LIGHTING	4	EA	$ 3,158	$ 1,102	$ 6,321		$10,581
1080000	**BUSWORK, CONDUCTOR, TERMINATIONS**							
1080100	5" ALUMINUM BUS	3350	LF	$ 328,110	$ 168,731	$ 147,615		$644,457
1080200	STRAIN BUS FITTINGS (2-1590 ACSR)	136	EA	$ 35,428	$ 12,921	$ 44,776		$93,125
1080300	(2) 1590 ACSR FALCON CONDUCTOR	7947	LF	$ 79,719	$ 71,363	$ 167,566		$318,647
1090000	**CONTROL CABLE & TERMINATIONS**							
1090100	**WIRE & CABLE--POWER TRANSFORMERS 230/345KV - 300MV**							
1090101	3C8	750	LF	$ 3,436	$ 1,438	$ 1,886		$6,760
1090102	3C10	750	LF	$ 3,121	$ 1,307	$ 975		$5,402
1090103	4C10	2250	LF	$ 21,326	$ 8,926	$ 8,225		$38,478
1090104	1C4	750	LF	$ 6,610	$ 2,766	$ 3,456		$12,832
1090105	12C12	4500	LF	$ 5,659	$ 2,369	$ 2,621		$10,649
1090106	CAT5	750	LF	$ 3,523	$ 1,474	$ 1,011		$6,009
1090107	25C12	750	LF	$ 11,319	$ 4,737	$ 5,241		$21,297

Client: MPL

Project No: 144774 | **Estimator:** R.SMITH

Description: ST. LOUIS COUNTY SUBSTATION REV4 | **Date:** 27-Feb-24

Location: ST LOUIS COUNTY, MINNESOTA | **Rev:** FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
1090200	**WIRE & CABLE--SL&P, 230KV, 208Y/120, 167KVA**							
1090201	1C4/0	2400	LF	$ 14,735	$ 6,166	$ 15,026		$35,928
1090300	**WIRE & CABLE--SL&P, 345KV, 208Y/120, 167KVA**							
1090301	1C4/0	2240	LF	$ 13,856	$ 5,798	$ 14,030		$33,684
1090400	**WIRE & CABLE--230KV 4000A, 63KAIC CIRCUIT BREAKER**							
1090401	3C8	570	LF	$ 2,545	$ 1,066	$ 1,431		$5,042
1090402	3C10	570	LF	$ 2,312	$ 968	$ 739		$4,018
1090403	4C10	2280	LF	$ 10,505	$ 4,395	$ 4,157		$19,056
1090404	9C12	570	LF	$ 3,454	$ 1,446	$ 1,646		$6,546
1090405	12C12	570	LF	$ 4,106	$ 1,718	$ 1,985		$7,809
1090406	12C10	1140	LF	$ 7,936	$ 3,321	$ 5,974		$17,232
1090407	25C12	570	LF	$ 8,215	$ 3,436	$ 3,969		$15,620
1090500	**WIRE & CABLE--345KV 4000A, 63KAIC CIRCUIT BREAKER,**							
1090501	3C8	1370	LF	$ 5,709	$ 2,391	$ 3,428		$11,528
1090502	3C10	1370	LF	$ 5,181	$ 2,171	$ 1,763		$9,116
1090503	4C10	5480	LF	$ 23,309	$ 9,756	$ 9,931		$42,996
1090504	9C12	1370	LF	$ 7,354	$ 3,079	$ 3,923		$14,356
1090505	12C12	1370	LF	$ 8,620	$ 3,609	$ 4,728		$16,957
1090506	12C10	2740	LF	$ 16,379	$ 6,855	$ 14,277		$37,511
1090507	25C12	1370	LF	$ 17,239	$ 7,214	$ 9,456		$33,908
1090600	**WIRE & CABLE--345KV 4000A, 63KAIC CIR BREAKER PIR**							
1090601	3C8	250	LF	$ 1,145	$ 481	$ 629		$2,254
1090602	3C10	250	LF	$ 1,041	$ 436	$ 325		$1,802
1090603	4C10	1000	LF	$ 4,741	$ 1,982	$ 1,828		$8,551
1090604	9C12	250	LF	$ 1,581	$ 662	$ 724		$2,967
1090605	12C12	250	LF	$ 1,886	$ 789	$ 874		$3,548
1090606	12C10	500	LF	$ 3,665	$ 1,533	$ 2,626		$7,825
1090607	25C12	250	LF	$ 3,773	$ 1,578	$ 1,747		$7,099
1090700	**WIRE & CABLE--230KV, 3000A, DISCONNECT SWITCH W MO**							
1090701	3C10	700	LF	$ 3,165	$ 1,322	$ 918		$5,406
1090702	25C12	350	LF	$ 6,118	$ 2,559	$ 2,476		$11,153
1090900	**WIRE & CABLE--345KV, 3000A, DISCONNECT SWITCH W/ M**							
1090901	3C10	1920	LF	$ 7,216	$ 3,018	$ 2,468		$12,703
1090902	25C12	960	LF	$ 11,934	$ 4,992	$ 6,616		$23,542
1091000	**WIRE & CABLE--230KV CCVT'S, 1PH**							
1091001	3C12	850	LF	$ 4,333	$ 1,812	$ 826		$6,972
1091002	12C12	850	LF	$ 10,331	$ 4,323	$ 3,128		$17,783
1091100	**WIRE & CABLE--345KV CCVT'S, 1PH (1700PF)**							
1091101	3C12	960	LF	$ 4,055	$ 1,698	$ 898		$6,650
1091102	12C12	960	LF	$ 8,744	$ 3,660	$ 3,409		$15,812

Client: MPL

Project No: 144774 **Estimator:** R.SMITH

Description: ST. LOUIS COUNTY SUBSTATION REV4 **Date:** 27-Feb-24

Location: ST LOUIS COUNTY, MINNESOTA **Rev:** FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
1091200	**WIRE & CABLE--LIGHTING**							
1091201	3C10	4260	LF	$ 7,922	$ 3,313	$ 2,738		$13,972
1091300	**WIRE & CABLE--SUMP PUMPS**							
1091310	3/C #8	2000	LF	$ 8,241	$ 3,448	$ 4,998		$16,687
1100000	**GENERAL**							
1100100	TOPO SURVEY	1	LS			$ 6,585		$6,585
1100200	PROPERTY SURVEY	1	LS			$ 6,585		$6,585
1100300	STAKING	1	LS			$ 7,902		$7,902
1100400	MOBILIZATION	1	LS			$ 9,877		$9,877
1100500	MATERIAL TESTING	1	LS			$ 13,169		$13,169
				$ 5,913,064	**$ 4,652,124**	**$ 5,523,783**	**$ 22,194,335**	**$ 16,088,971**

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APPROVED	-
DATE	-
SCALE	1"=30'-0"

minnesota power

ST. LOUIS COUNTY 345kV SUBSTATION
345kV SWITCH YARD
GENERAL ARRANGEMENT

SHEET 1 OF 2 REV. 0

ME-XXXXX-17

MICROFILMED / /

AWHD CODE 3650

CADD DRAWING - FOR REPRODUCTION ONLY

ImageSite: TRANSMISSION SUBSTATION

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APPROVED	AL
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SCALE	1"=30'-0"

minnesota power

ST. LOUIS CTY
230kV SWITCHYARD
GENERAL ARRANGEMENT

SHEET 2 OF 2 REV. 0

ME-XXXXX-17

MICROFILMED / /

CODE

CADD DRAWING - FOR REPRODUCTION ONLY

ImageSite: TRANSMISSION SUBSTATION

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BURNS & McDONNELL

ESTIMATE BASIS

3Client:	**Minnesota Power**		
Project No.:	**144774**	**Estimate Date:**	**01/26/2023**
Project Name:	**Arrowhead**	**Estimate Class:**	**Class 3**
Project Location:	**Minnesota**		

DESCRIPTION OF SCOPE

Provide labor and materials estimate for Arrowhead Substation at the Request of MP Counsel.

PURPOSE

The purpose of the "Basis of Estimate" is to describe the scope of work and how the estimate values were developed and compiled into the finished deliverable. Burns & McDonnell has developed a Class 3 estimate for the ATC Arrowhead Substation Alternative Project, at the request of Minnesota Power. This work includes the engineering/design, procurement, and construction.

GENERAL ASSUMPTIONS & QUALIFICATIONS

1. The estimate excludes costs to modify or replace any existing facilities, equipment, and materials.
2. Dewatering is assumed not required other than to remove normal surface water run-off due to rain.
3. The estimate excludes rework and redesign due to existing underground obstructions.
4. Subsurface conditions: We have assumed that no rock will be encountered.
5. Burns & McDonnell has not included any costs for identifying or addressing endangered species and historical items that could be encountered.
6. Detailed engineering drawings are not available at this time, so many assumptions have been made, which include, but are not limited to foundation sizes, steel weights, major equipment, miscellaneous material quantities, etc. These assumptions are based on historical data and recent project history.
7. No cost for a GPR (ground penetrating radar) scan to locate underground obstructions is included in this estimate.
8. The estimate is for the inside of the substations only. The estimate also includes costs for access roads from the gate to the existing road.
9. All major equipment (Transformers, Breakers, Switches, CCVTs, Arresters, etc.) and steel is assumed to be procured by Minnesota Power and no subcontractor in-directs have been added for any of that material.
10. In general, the estimate is based on the layout drawings submitted to Minnesota Power for Arrowhead Substation. This alternate estimate assumes that no phase shifting transformer will be installed on the project, but space will be left for one in the future. In addition, one of the low side breakers and disconnect switches will not be installed, and bus work will be installed in its place. The following is a more detailed description:
    a. CCVTs and Arresters were assumed to be needed only on each line terminal.
    b. A ground grid was assumed to be added with 25-foot spacing between 4/0 conductor runs.
    c. Quantity One (1) ground rod was assumed to be added for each arrester.
    d. The estimate does not include grounding stingers for each structure.
    e. High level takeoffs based on the current preliminary substation layout were taken for the conductor to each breaker.
    f. High level takeoffs based on the current preliminary substation layout were taken for the conductor for each line termination.
    g. High level takeoffs based on the current preliminary substation layout were taken for the conductor for each set of CCVTs and Arrestors.
    h. Bus support/insulator quantities were determined based on an assumed bus span.

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   i. Security was not included in the estimate.
   j. Bus assumed to come in 40-foot increments.
   k. Substation scope:
      i. Provide cut and fill for new substation location. Quantities Provided
      ii. Provide materials and labor for foundations as indicated in the estimate documents.
      iii. Provide labor to install steel structures and equipment as indicated in the estimate documents (Steel Structure and Major Engineered Equipment will be procured by the owner)
      iv. Provide materials and labor to install rigid busing and strain busing as indicated in the estimate documents
      v. Provide materials and labor to install oil containment system for transformers.
         1. Oil containment was assumed to be a concrete basin for all Transformers
      vi. Provide fencing and insulating rock after all foundation, equipment, and busing is complete.
      vii. Major equipment list included in the detailed estimate.

11. Pricing Basis
   a. No tax has been included per Minnesota Power request.
   b. Pricing for tubular steel pricing was estimated at $4.00/lb and will be procured by the owner.
   c. Pricing for structural steel was estimated at $3.40/lb and will be procured by the owner.
   d. Work will be executed on a single shift of 6-10 hour/day basis.
   e. Construction schedule and productivity assume normal weather conditions for the area site location.
   f. Cost for mobilization and de-mobilization is included.
   g. All major material, steel structures, control house and cable trench assumed provided by Minnesota Power. All other materials assumed to be supplied by subcontractors.
   h. Material costs are based on recent vendor quotes, if applicable, or other historical data for similar items. Quantities for the design are estimated based on the current preliminary substation layout.
   i. Permit cost is not included with this pricing.
   j. No escalation has been included.
   k. Detailed engineering, design, and procurement costs were calculated as 4% of direct project & purchased equipment costs (labor, construction equipment, and subcontractor materials).
   l. Burns & McDonnell Construction Management / General Conditions (CMCI) costs have been included at 7% of direct project costs (labor, construction equipment, and subcontractor materials).
   m. Wage rates are based on the IBEW local union rates. The rates include base wage, payroll insurance and taxes, overtime and benefits; we have also included subsistence.
   n. Costs are included for:
      i. Temporary facilities, onsite supplies, and expenses
      ii. Construction equipment, maintenance, and site vehicles
      iii. Small tools and consumables
      iv. Safety requirements
      v. Subcontractor field supervision
      vi. Subcontractor overhead and profit
      vii. All costs for labor, materials, and equipment are based on 2022 dollars.
   o. Indirect cost categories:
      i. Burns & McDonnell Construction Management / General Conditions costs have been included.
      ii. Burns & McDonnell Home Office Support (Procurement, Subcontract Management and Project Controls) costs have been included.
      iii. Permits – costs have not been included and are assumed as an owner’s cost.
   p. Project costs incurred by the Owner, including but not limited to start up and commissioning, owner’s staff and overhead, hazardous, or contaminated materials handling, land and easement acquisition, and permitting are excluded from the estimate.

ESTIMATE BASIS

q. Transformer pricing has been updated based on values provided by Minnesota Power on 1/10/2024.

12. Foundation and concrete quantities are based on conceptual engineering and historical data. Cost is based on recent projects and in-house metrics. Piles are not included in the estimate and are not anticipated to be required.
13. Soil data was assumed based on the "Arrowhead sub geo report" provided to Burns & McDonnell from Minnesota Power by Braun Intertec from October 7th, 2022.
14. All conduit, duct bank and raceways were estimated based on the preliminary layout and historical projects.
15. Site work quantities are estimated based on the preliminary layout drawing and labor calculated using historical information.
16. Structural steel quantities are based on the preliminary layout. Labor is calculated using in-house metrics.
17. Bus work quantities were estimated based on the preliminary layout.
18. Quantities for cable are estimated using the preliminary layout.

CLIENT ESTIMATE SUMMARY

BURNS & McDONNELL

Client:	**MPL**	**Estimator:**	**R.SMITH**
Project No:	**144774**	**Date:**	**24-Jan-24**
Description:	**ARROWHEAD SUBSTATION ALT #1 REV2**	**Estimate Type:**	**FEL-2**
Location:	**MINNESOTA**		

NO.	ACCOUNT		Labor	Construction Equipment	Subcontractor Materials	Owner Purchased Materials (For reference Only)	Total
1	REMOVALS		241,866	164,542			$ 406,408
2	GROUNDING		85,790	35,597	64,215		$ 185,603
3	UNDERGROUND RACEWAY		128,054	82,840	43,708		$ 254,602
4	FOUNDATIONS		2,276,040	2,190,202	2,165,325		$ 6,631,568
5	STEEL STRUCTURES		701,887	407,335		3,084,500	$ 1,109,222
6	ELECTRICAL EQUIPMENT		913,407	544,709	27,148	19,096,180	$ 1,485,264
7	BUSWORK, CONDUCTOR, TERMINATIONS		455,543	219,466	394,200		$ 1,069,209
8	CONTROL CABLE & TERMINATIONS		552,468	225,901	328,840		$ 1,107,209
9	GENERAL				30,402		$ 30,402
10							$ -
11							$ -
12							$ -
13							$ -
14							$ -
15							$ -
16							$ -
17							$ -
18							$ -
19							$ -
	Total Direct Cost (TDC)		**$ 5,355,056**	**$ 3,870,593**	**$ 3,053,839**		**12,279,488**
			BMCD Procured Equipment				
			BMCD Engineering				$491,180
			BMCD CMCI				$859,564
			BMCD Estimate				**$13,630,232**
			Owner's Cost				
			Owner Purchased Materials & Equipment				$22,180,680
			O&M Cost				
			Land Acquisition / Real Estate				
			Permitting				
			Owner Contingency				
			Owner Escalation				
			Total Project Cost (TIC)				**$35,810,912**

Client: MPL

Project No: 144774 | **Estimator:** R.SMITH

Description: ARROWHEAD SUBSTATION ALT #1 REV2 | **Date:** 24-Jan-24

Location: MINNESOTA | **Rev:** FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
100000	**REMOVALS**							
101000	**RELAYS AND CONTROL EQUIPMENT**							
101010	RELAY RACKS	2	EA	$ 8,025	$ 5,823			$13,848
101500	**SUBSTATION MATERIALS**							
101510	5" ALUMINUM BUS	1000	LF	$ 46,431	$ 23,344			$69,775
101520	5" BUS SUPPORT FITTINGS	20	EA	$ 3,980	$ 2,001			$5,981
101530	5" BUS TERMINAL FITTINGS	40	EA	$ 7,960	$ 4,003			$11,963
101540	1590 AAC FALCON CONDUCTOR	100	LF	$ 533	$ 465			$998
101550	345KV STATION POST INSULATORS (EXTRA HIGH STRENGTH	20	EA	$ 8,025	$ 5,823			$13,848
101560	345KV CCVT / PT JUNCTION BOX	1	EA	$ 1,728	$ 590			$2,317
102000	**SUBSTATION EQUIPMENT**							
102010	345KV 4000A, 63KAIC CIRCUIT BREAKER, THREE PHASE	2	EA	$ 16,049	$ 9,352			$25,401
102020	345KV, 3000A, DISCONNECT SWITCH	3	EA	$ 12,037	$ 8,735			$20,771
102030	345KV CCVT'S, 1PH 8100PF	3	EA	$ 2,407	$ 1,747			$4,155
102040	230KV SSVT'S, 100KVA	3	EA	$ 20,060	$ 14,559			$34,619
102050	345KV CAPACITOR BANKS	2	EA	$ 80,243	$ 58,233			$138,475
103000	**STEEL STRUCTURES**							
103010	345KV SINGLE PHASE BUS SUPPORTS	12	EA	$ 22,504	$ 20,495			$43,000
103020	345KK SWITCH STRUCTURES	3	EA	$ 10,006	$ 7,665			$17,672
103030	345KV THREE PHASE BUS SUPPORTS	1	EA	$ 1,878	$ 1,708			$3,586
150000	**GROUNDING**							
151000	GROUND GRID	1000	LF	$ 9,008	$ 3,738	$ 10,912		$23,658

Client: MPL

Project No: 144774 **Estimator:** R.SMITH

Description: ARROWHEAD SUBSTATION ALT #1 REV2 **Date:** 24-Jan-24

Location: MINNESOTA **Rev:** FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
151500	GROUND CONNECTIONS	280	EA	$ 76,782	$ 31,859	$ 53,303		$161,945
200000	**UNDERGROUND RACEWAY**							
201000	BREAKERS 3-4"	7	EA	$ 45,568	$ 29,488	$ 19,019		$94,075
202000	TRANSFORMERS 4-4"	4	EA	$ 31,126	$ 20,133	$ 14,372		$65,631
203000	CCTV'S	18	EA	$ 38,106	$ 24,651	$ 6,960		$69,717
204000	SSVT'S	2	EA	$ 4,641	$ 3,002	$ 1,849		$9,492
205000	SUMP PUMP	4	EA	$ 8,613	$ 5,566	$ 1,508		$15,688
250000	**FOUNDATIONS**							
250300	345KV BREAKER	116	CY	$ 72,513	$ 45,979	$ 46,715		$165,207
250600	TRANSFORMER	128	CY	$ 92,864	$ 58,883	$ 52,937		$204,684
250900	FIREWALL FDN GRADE BEAM	66	CY	$ 14,398	$ 9,131	$ 19,489		$43,018
251200	230KV BREAKER	17	CY	$ 13,795	$ 8,748	$ 7,215		$29,757
251500	PHASE SHIFT TRANSFORMER	302	CY	$ 9,820	$ 6,229	$ 59,923		$75,972
251800	230KV PIR BREAKER	28	CY	$ 16,744	$ 10,616	$ 11,027		$38,386
252100	345KV LOW SWITCH	94	CY	$ 84,655	$ 97,725	$ 61,659		$244,039
252400	345KV 3PH HIGH BUS	71	CY	$ 63,490	$ 73,303	$ 46,243		$183,036
252700	345KV 3PH LOW BUS	31	CY	$ 28,216	$ 32,569	$ 20,553		$81,339
253000	345KV 1PH HIGH BUS	35	CY	$ 31,743	$ 36,646	$ 23,119		$91,507
253300	345KV 1PH LOW BUS	51	CY	$ 45,852	$ 52,941	$ 33,398		$132,191
253600	345KV 1PH CCVT	12	CY	$ 10,576	$ 12,218	$ 7,705		$30,499

Client: MPL

Project No: 144774 **Estimator:** R.SMITH

Description: ARROWHEAD SUBSTATION ALT #1 REV2 **Date:** 24-Jan-24

Location: MINNESOTA **Rev:** FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
253900	230KV HIGH SWITCH	94	CY	$ 84,655	$ 97,725	$ 61,659		$244,039
254200	230KV 3PH HIGH BUS	31	CY	$ 28,868	$ 33,324	$ 20,946		$83,138
254500	230KV 3PH LOW BUS	55	CY	$ 49,382	$ 57,019	$ 35,966		$142,367
254800	230KV 1PH HIGH BUS	27	CY	$ 24,693	$ 28,503	$ 17,982		$71,179
255100	230KV 1PH LOW BUS	126	CY	$ 112,874	$ 130,316	$ 82,211		$325,400
255400	230KV 1PH CCVT	12	CY	$ 11,992	$ 13,858	$ 7,705		$33,555
255700	230KV STD SERVICE TRANSF	8	CY	$ 7,052	$ 8,144	$ 5,138		$20,334
256000	230KV TERTIARY BUS	24	CY	$ 21,657	$ 24,996	$ 15,710		$62,363
256300	230KV STANDBY TERTIARY BUS	31	CY	$ 28,868	$ 33,324	$ 20,946		$83,138
256600	230KV 1PH EXTRA HIGH BUS	16	CY	$ 14,440	$ 16,671	$ 10,472		$41,583
256900	230KV NEUTRAL BUS	31	CY	$ 28,868	$ 33,324	$ 20,946		$83,138
257200	230KV CT 3PH	8	CY	$ 9,108	$ 10,513	$ 5,138		$24,758
257800	345KV A-FRAME 1-BAY	502	CY	$ 187,708	$ 216,692	$ 269,399		$673,798
258100	345KV H-FRAME 3-BAY	171	CY	$ 55,982	$ 64,644	$ 79,061		$199,686
258400	230KV A-FRAME 1-BAY	377	CY	$ 140,778	$ 162,528	$ 202,050		$505,355
258700	230KV A-FRAME 2-BAY	256	CY	$ 280,562	$ 323,904	$ 346,139		$950,605
259000	LIGHTNING MAST - 100 FT W/WIRE	85	CY	$ 50,361	$ 58,124	$ 39,530		$148,015
259300	FIREWALL FDN GRADE BEAM	47	CY	$ 66,326	$ 76,565	$ 358,587		$501,478
259400	FIREWALL	3	EA	$ 333,487	$ 211,481	$ 92,278		$637,246
259600	**OIL CONTAINMENT**							
259605	OIL CONTAINMENT WALL	36	CY	$ 185,484	$ 100,291	$ 27,802		$313,578
259610	OIL CONTAINMENT SLAB	141	CY	$ 68,232	$ 43,269	$ 55,676		$167,178
300000	**STEEL STRUCTURES**							
300200	345KV LOW SWITCH	6	EA	$ 42,984	$ 24,942		$108,000	$67,926

Client: MPL

Project No: 144774

Description: ARROWHEAD SUBSTATION ALT #1 REV2

Location: MINNESOTA

Estimator: R.SMITH

Date: 24-Jan-24

Rev: FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
300300	345KV 3PH HIGH BUS	9	EA	$ 62,328	$ 36,166		$156,600	$98,493
300600	345KV 3PH LOW BUS	4	EA	$ 13,373	$ 7,759		$33,600	$21,132
300900	345KV 1PH HIGH BUS	9	EA	$ 11,821	$ 6,859		$29,700	$18,680
301200	345KV 1PH LOW BUS	13	EA	$ 13,279	$ 7,704		$27,300	$20,983
301500	345KV 1PH CCVT	3	EA	$ 3,940	$ 2,287		$8,100	$6,227
301800	230KV HIGH SWITCH	6	EA	$ 48,715	$ 28,268		$122,400	$76,983
302100	230KV 3PH HIGH BUS	4	EA	$ 21,015	$ 12,193		$52,800	$33,207
302400	230KV 3PH LOW BUS	7	EA	$ 23,402	$ 13,579		$58,800	$36,981
302700	230KV 1PH HIGH BUS	7	EA	$ 6,686	$ 3,880		$16,800	$10,566
303000	230KV 1PH LOW BUS	32	EA	$ 28,019	$ 16,259		$57,600	$44,278
303300	230KV 1PH CCVT	3	EA	$ 3,582	$ 2,079		$9,000	$5,661
303600	230KV STD SERVICE TRANSF	1	EA	$ 5,969	$ 3,465		$15,000	$9,434
303900	230KV TERTIARY BUS	6	EA	$ 12,179	$ 7,067		$30,600	$19,246
304200	230KV STANDBY TERTIARY BUS	8	EA	$ 16,239	$ 9,422		$40,800	$25,661
304500	230KV 1PH EXTRA HIGH BUS	4	EA	$ 4,776	$ 2,772		$12,000	$7,548
304800	230KV NEUTRAL BUS	8	EA	$ 16,239	$ 9,422		$40,800	$25,661
305100	CT 3PH	1	EA	$ 4,776	$ 2,772		$12,000	$7,548
305400	345KV A-FRAME 1-BAY	4	EA	$ 133,993	$ 77,750		$808,000	$211,743
305700	345KV H-FRAME 3-BAY	1	EA	$ 41,128	$ 23,865		$248,000	$64,993
306000	230KV A-FRAME 1-BAY	3	EA	$ 89,550	$ 51,962		$540,000	$141,512
306300	230KV A-FRAME 2-BAY	1	EA	$ 60,362	$ 35,025		$364,000	$95,387
306600	LIGHTNING MAST - 100 FT	2	EA	$ 19,263	$ 11,178		$193,600	$30,441
306900	OIL CONTAINMENT BEAM	4	EA	$ 2,389	$ 1,385		$7,800	$3,774
307200	OIL CONTAINMENT NON-METALLIC GRATING	6648	SF	$ 15,879	$ 9,278		$91,200	$25,157
350000	**ELECTRICAL EQUIPMENT**							
351000	**MISC. MATERIALS**							
351010	230KV STATION POST INSULATORS (EXTRA HIGH STRENGTH	87	EA	$ 83,128	$ 50,472		$82,650	$133,600
351015	345KV STATION POST INSULATORS (EXTRA HIGH STRENGTH	63	EA	$ 90,253	$ 54,797		$85,050	$145,050
351020	230KV STRAIN BUS INSULATOR ASSEMBLY (STD. STRENGTH	5	EA	$ 4,777	$ 2,901		$3,750	$7,679
351025	345KV STRAIN BUS INSULATOR ASSEMBLY (STD. STRENGTH	4	EA	$ 5,729	$ 3,479		$4,500	$9,208
351030	230KV SURGE / LIGHTNING ARRESTORS	6	EA	$ 6,755	$ 4,100		$33,000	$10,855
351035	345KV SURGE / LIGHTNING ARRESTORS	12	EA	$ 13,508	$ 8,202		$105,600	$21,710
351040	HEAVY DUTY SAFETY FUSIBLE DISCONNECT SWITCH, NEMA	1	EA	$ 1,595	$ 543		$2,500	$2,139
351500	**TRANSFORMERS**							
351510	SINGLE PHASE 345KV/230KV 160MVA	4	EA	$ 235,864	$ 143,206		$14,964,000	$379,070
351530	24.5KV, SSVT'S, 167KVA	3	EA	$ 3,216	$ 1,954		$25,000	$5,170
351540	13.85KV, SSVT'S, 167KVA	3	EA	$ 9,649	$ 5,858		$60,000	$15,508
352000	**BREAKERS / CIRCUIT SWITCHERS**							
352010	230KV 4000A, 63KAIC CIRCUIT BREAKER, THREE PHASE	1	EA	$ 12,062	$ 7,323		[illegible]	[illegible]
352020	345KV 4000A, 63KAIC CIRCUIT BREAKER, SINGLE PHASE	15	EA	$ 150,766	$ 91,538		[illegible]	[illegible]
352030	345KV 4000A, 63KAIC CIRCUIT BREAKER, THREE PHASE,P	1	EA	$ 13,401	$ 8,137		[illegible]	[illegible]

Client: MPL

Project No: 144774 | **Estimator:** R.SMITH

Description: ARROWHEAD SUBSTATION ALT #1 REV2 | **Date:** 24-Jan-24

Location: MINNESOTA | **Rev:** FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
352500	**DISCONNECT SWITCHES**							
352520	230KV, 3000A, DISCONNECT SWITCH	7	EA	$ 56,286	$ 34,174		$191,100	$90,459
352530	345KV, 3000A, DISCONNECT SWITCH	10	EA	$ 134,014	$ 81,368		$336,000	$215,382
353000	**CCVT'S**							
353010	230KV CCVT'S, 1PH 11250PH	6	EA	$ 11,579	$ 7,031		$72,000	$18,610
353020	345KV CCVT'S, 1PH 8100PF	12	EA	$ 23,157	$ 14,060		$180,000	$37,218
353030	CCVT / PT JUNCTION BOX	18	EA	$ 11,963	$ 4,078	$ 27,148		$43,189
353500	**RELAY & CONTROL EQUIPMENT**							
353510	RELAY RACKS	9	EA	$ 14,444	$ 10,482		$360,000	$24,926
353520	TERMINAL CABINETS	1	EA	$ 802	$ 274		$1,100	$1,076
353530	AC PANEL 54 POLE	1	EA	$ 2,658	$ 907		$20,000	$3,565
353540	DC PANEL 40 POLE	2	EA	$ 5,316	$ 1,812		$30,000	$7,129
354000	**OIL CONTAINMENT SUMP PUMP**							
354010	SUMP PUMP	4	EA	$ 16,059	$ 5,722		$8,000	$21,781
354020	SUMP PUMP CONTROL CABINET	4	EA	$ 6,424	$ 2,289		$12,000	$8,714
450000	**BUSWORK, CONDUCTOR, TERMINATIONS**							
451000	5" ALUMINUM BUS	3920	LF	$ 390,265	$ 196,208	$ 310,527		$897,000
451500	1590 ACSR FALCON CONDUCTOR (JUMPERS)	8200	LF	$ 65,278	$ 23,258	$ 83,673		$172,209
500000	**CONTROL CABLE & TERMINATIONS**							
501000	**BREAKER CONTROL CABLES**							
501010	12/C #10	9940	LF	$ 55,058	$ 22,512	$ 51,753		$129,323
501020	12/C #12	4970	LF	$ 29,342	$ 11,998	$ 17,105		$58,445
501030	2/C#8	4970	LF	$ 20,342	$ 8,318	$ 12,445		$41,105
501040	25/C #12 SHIELDED	4970	LF	$ 71,258	$ 29,139	$ 41,539		$141,936
501050	3/C#10	4970	LF	$ 18,473	$ 7,554	$ 6,388		$32,416
501060	4/C #10 SHIELDED	19880	LF	$ 82,522	$ 33,744	$ 35,991		$152,257
501070	9/C#12	4970	LF	$ 25,288	$ 10,341	$ 14,201		$49,830
501500	**TRANSFORMER CONTROL CABLES**							
501510	1/C #4	2520	LF	$ 7,829	$ 3,203	$ 3,893		$14,925
501520	12/C #12	1510	LF	$ 6,973	$ 2,849	$ 2,962		$12,784
501530	2/C #10	1510	LF	$ 3,204	$ 1,310	$ 817		$5,331
501540	25/C #12 SHIELDED	1510	LF	$ 13,943	$ 5,700	$ 5,925		$25,567
501550	3/C #8	1510	LF	$ 4,104	$ 1,677	$ 2,124		$7,906
501560	4/C #10 SHIELDED	9060	LF	$ 25,607	$ 10,468	$ 9,282		$45,357
501570	CAT5E	1510	LF	$ 4,173	$ 1,708	$ 32		$5,913
502000	**SSVT POWER CABLES**							
502010	1/C #4-0	10720	LF	$ 63,630	$ 26,019	$ 67,171		$156,820
502500	**CCVT CONTROL CABLES**							
502510	12/C #12	12000	LF	$ 71,660	$ 29,300	$ 41,3[illegible]		$142,307
502520	2/C #12	12000	LF	$ 40,595	$ 16,600	$ 10,848		$68,043
503000	**SUMP PUMP**							

Client:	MPL
Project No:	144774
Description:	ARROWHEAD SUBSTATION ALT #1 REV2
Location:	MINNESOTA

Estimator: R.SMITH
Date: 24-Jan-24
Rev: FEL-2

NO.	DESCRIPTION	QTY	UNIT	LABOR	Construction Equipment	Subcontractor MAT'L	Owner Purchased Materials (For reference Only)	TOTAL
503010	3/C #8	2000	LF	$ 8,468	$ 3,461	$ 5,016		$16,945
550000	**GENERAL**							
551000	STAKING	1	LS			$ 3,966		$3,966
552000	MOBILIZATION	1	LS			$ 6,609		$6,609
553000	MATERIAL TESTING	1	LS			$ 19,828		$19,828
				$ 5,355,056	**$ 3,870,593**	**$ 3,053,839**	**$ 22,180,680**	**$ 12,279,488**

UPDATED COST ESTIMATES BASED ON PRELIMINARY ENGINEERING

Line	March 2024 Update: Comparison of Minnesota Interconnection Facilities	MP Proposed Project	ATC Arrowhead Alternative without PST	ATC Arrowhead Alternative with PST	Owner
1	Minnesota Land Acquisition	10	10	10	MP
2	HVDC Line Entrance	2	2	2	MP
3	HVDC - St Louis County 345kV Line	3.3	N/A	N/A	MP
4	St Louis County 345/230kV Substation[NOTE 1]	40.1	N/A	N/A	MP
5	St Louis County - Arrowhead 230kV Lines	3.3	N/A	N/A	MP
6	Arrowhead Line Entrances	5	N/A	N/A	MP
7	HVDC 345kV Line Entrance for Ckt #2	N/A	3.1	3.1	MP
8	HVDC - Arrowhead 345kV Double Ckt[NOTE 1]	N/A	8.7	8.7	MP
9	Arrowhead 345kV Line Reconfiguration	N/A	Included in Line 4	Included in Line 4	ATC
10	Arrowhead 345/230kV Substation Expansion[NOTE 1]	N/A	35.8	66.7	ATC
11	Arrowhead 230 kV Phase Shifting Transformer	N/A	Included in Line 6	Included in Line 6	ATC
12	Arrowhead 230kV Bus Reconfigurations	N/A	Included in Line 6	Included in Line 6	MP
13	Rounding	1.3	1.4	1.5	N/A
14	**Total**	**65**	**61**	**92**	

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	February 21, 2024
Requested From:	Minnesota Power	Response Due:	March 4, 2024

By: American Transmission Company LLC

Information Request No. 43.

Please reference page 22 of the direct testimony of MP witness Dan Gunderson.

a. Please state the factual basis for Your assertion that "there is a strong probability of accelerating the delivery schedule for the HVDC Modernization Project HVDC components."

b. Please produce copies of any Communications that You have had with Your HVDC Supplier concerning the in-service date for the Project since the filing of Your Application.

Objection:

Minnesota Power objects to this information request on the grounds that it seeks proprietary information of a third-party vendor that is subject to the confidentiality provisions in Minnesota Power's contract with this third-party vendor.

Notwithstanding and without waiving this objection, Minnesota Power responds as follows:

Response:

a. Since kicking off technical discussions with the HVDC Supplier in March 2023, Minnesota Power has had regular discussions with the HVDC Supplier regarding the status and timing of the Project. In recent discussions, the HVDC Supplier has indicated there is increasing potential for an earlier in-service date and that it is willing to begin discussing the opportunity more seriously with Minnesota Power. This is the factual basis for the identified Direct Testimony statements. Confirming those recent discussions, the HVDC

Response by: Christian Winter	As to Objection: David Moeller
Title: Manager-Regional Transmission Planning	Title: Senior Regulatory Counsel
Department: Delivery Support Operations	Department: Legal
Telephone: 218-355-2908	Telephone: (218) 723-3963

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	February 21, 2024
Requested From:	Minnesota Power	Response Due:	March 4, 2024

By: American Transmission Company LLC

Supplier sent Minnesota Power a formal request on March 1, 2024, to begin discussing an early completion date for the Project during the planned FEED kickoff meeting in late March.

b. Minnesota Power and its HVDC Supplier meet at least monthly to discuss Project updates and current action items. The in-service date of the Project is a regular topic of discussion in these meetings. Meeting minutes and communications with the HVDC Supplier are not retained at a level of detail documenting the specifics of these discussions. On March 1, 2024, the HVDC Supplier sent a formal request to begin discussing an early completion date for the Project during the planned FEED kickoff meeting in late March, as shown in ATC IR 043.01 Attach.

The information assigned a trade secret designation herein includes project-specific information and has been marked as trade secret as defined by Minn. Stat. § 13.37, subd. 1(b). The information derives an independent economic value from not being generally known or readily ascertainable by others who could obtain a financial advantage from their use. Because the Company has classified this entire document as trade secret information, the Company provides the following description of the excised material as required by Minn. Rule 7829.0500, subp. 3:

Item/Location	Justification
ATC IR 043.01 Attach	Nature of the Material: Email communication from HVDC Supplier Author: HVDC Supplier

Response by: Christian Winter	As to Objection: David Moeller
Title: Manager-Regional Transmission Planning	Title: Senior Regulatory Counsel
Department: Delivery Support Operations	Department: Legal
Telephone: 218-355-2908	Telephone: (218) 723-3963

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	February 21, 2024
Requested From:	Minnesota Power	Response Due:	March 4, 2024

By: American Transmission Company LLC

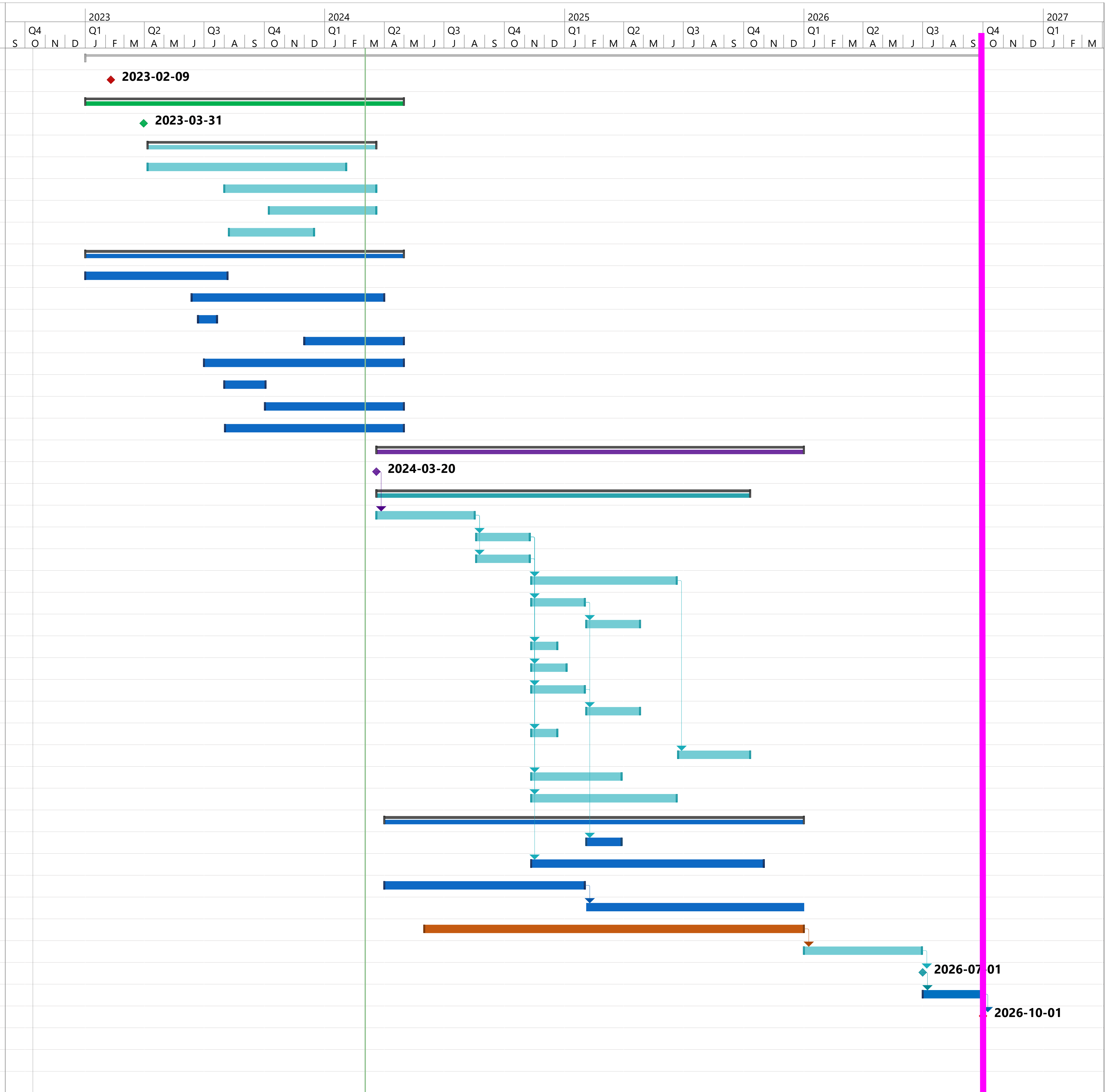
	General Import: This communication contains confidential project-specific information between the Company and the HVDC Supplier regarding formal request from HVDC Supplier to begin discussing Early Completion Date Date Prepared: March 1, 2024

Response by: Christian Winter	As to Objection: David Moeller
Title: Manager-Regional Transmission Planning	Title: Senior Regulatory Counsel
Department: Delivery Support Operations	Department: Legal
Telephone: 218-355-2908	Telephone: (218) 723-3963

PUBLIC DOCUMENT
TRADE SECRET DATA
EXCISED IN ITS ENTIRETY

ATC IR 043.01 Attach TS

ID	Task Name	Start	Finish
0	**Project schedule_FEED_Guaranteed_2024-03**	**2023-01-01**	**2026-10-01**
1	FE Studies and design engineering Awarded	2023-02-09	2023-02-09
2	**Pre-FEED & Technical Work Stream Phase**	**2023-01-01**	**2024-04-30**
3	Kick-off Technical Work Stream	2023-03-31	2023-03-31
4	**OEM's Pre-FEED Activities**	**2023-04-06**	**2024-03-19**
5	Preliminary LF/Stability model	2023-04-06	2024-02-02
6	Preliminary layout	2023-08-01	2024-03-19
7	Preliminary audible noise	2023-10-08	2024-03-19
8	Preliminary main circuit calculations	2023-08-08	2023-12-15
9	**MP Pre-FEED activities**	**2023-01-01**	**2024-04-30**
10	HVDC optimization power flow analysis	2023-01-01	2023-08-05
11	HVDC optimization stability analysis	2023-06-12	2024-03-31
12	Short circuit calculations at converter 345kV AC buses	2023-06-22	2023-07-20
13	Harmonic impedance calculations at converter 345kV AC buses	2023-12-01	2024-04-30
14	Develop AC system equivalent system for DPS	2023-07-01	2024-04-30
15	Background harmonic measurement (at nearest 230kV buses)	2023-08-01	2023-10-02
16	DC Line conductor study	2023-10-02	2024-04-30
17	Preliminary Detailed Technical Specification Development	2023-08-02	2024-04-30
18	**FEED Phase**	2024-03-20	**2025-12-31**
19	**Kick off of FEED**	2024-03-20	2024-03-20
20	**OEM's Activities (Anticipated)**	**2024-03-20**	**2025-10-10**
21	FEED Preparation	**2024-03-20**	2024-08-16
22	Main circuit parameters	**2024-08-19**	2024-11-08
23	Basic design and insulation coordination	**2024-08-19**	2024-11-08
24	Preliminary PSCAD model & Initial dynamic performance study	2024-11-11	2025-06-20
25	PSSE LF and Stability Model	2024-11-11	2025-01-31
26	SSO/SSTI studies	2025-02-03	2025-04-25
27	Reliability studies	2024-11-11	2024-12-20
28	Losses study	2024-11-11	2025-01-03
29	Valve configuration	2024-11-11	2025-01-31
30	Finalize HVDC One-line	2025-02-03	2025-04-25
31	Transformer transportation Study	2024-11-11	2024-12-20
32	AC and PLC filter design	2025-06-23	2025-10-10
33	Specifications for long lead time equipment	2024-11-11	2025-03-28
34	General arrangement, building and AC & DC yards	2024-11-11	2025-06-20
35	**MP's Activities**	**2024-04-01**	**2025-12-31**
36	Updated LF & Transient Stability Studies using updated OEM's model	2025-02-03	2025-03-28
37	Review OEM's FEED studies and design reports	2024-11-11	2025-10-31
38	MP Prepare Detailed Technical Specification	2024-04-01	2025-01-31
39	Update and Finalize Technical Specification with OEM	2025-02-03	2025-12-31
40	**MP Negotiate EPC Contract Conditions with OEM**	2024-06-01	2025-12-31
41	**OEM Prepare Final Offer**	2026-01-01	2026-06-29
42	**Final OEM Offer recived**	2026-07-01	2026-07-01
43	**Bid Review and Negotiaion**	2026-07-01	2026-09-30
44	**EPC Contract Execution/FNTP**	2026-10-01	2026-10-01
45			
46			
47			



Project: Project schedule_FEED_
Date: 2024-03-03

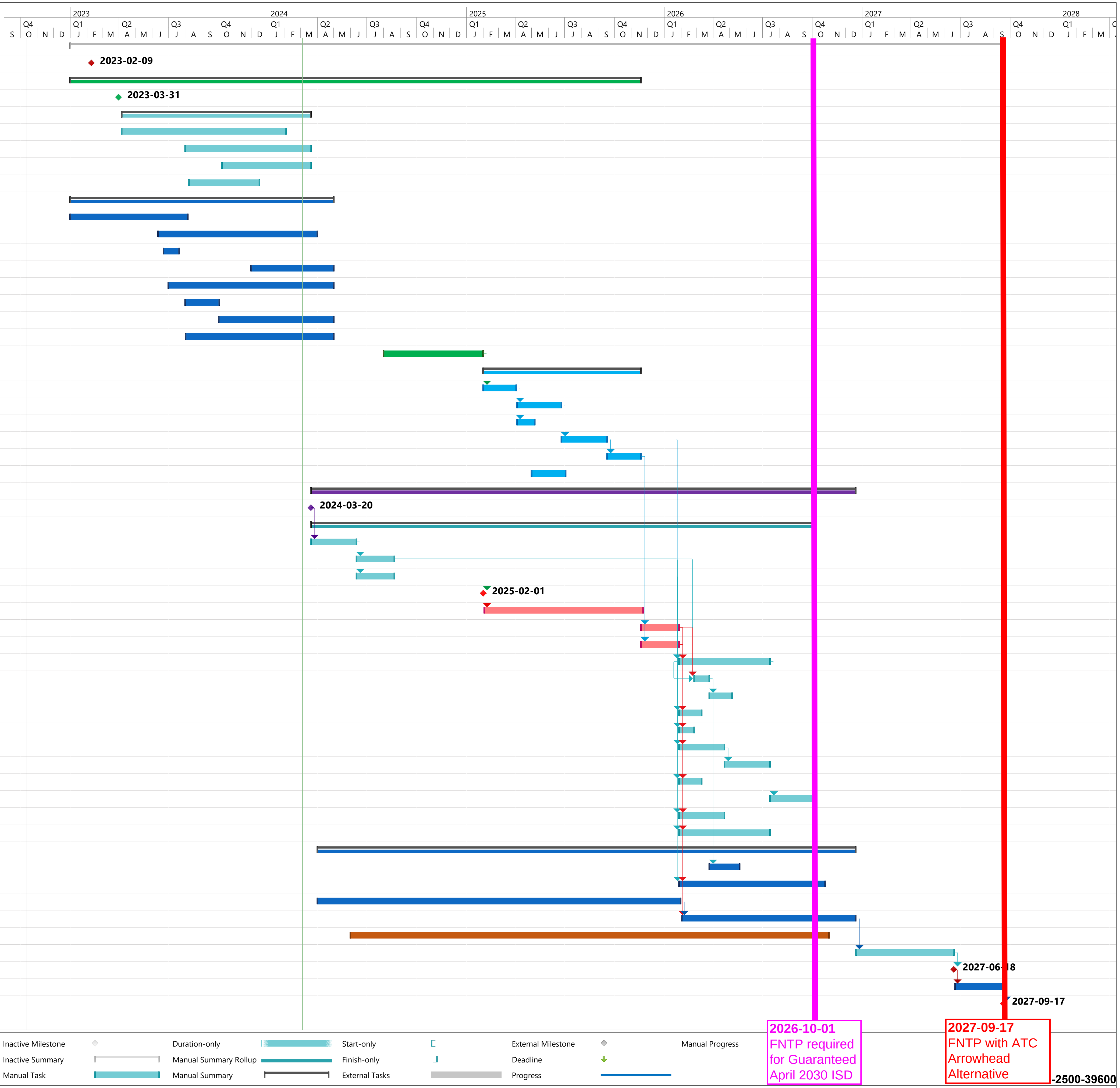
Task		Summary		Inactive Milestone		Duration-only		Start-only		External Milestone	
Split		Project Summary		Inactive Summary		Manual Summary Rollup		Finish-only		Deadline	
Milestone		Inactive Task		Manual Task		Manual Summary		External Tasks		Progress	

Manual Progres

2026-10-01
FNTP required
for Guaranteed
April 2030 ISD

O... 00-39600
MPUC Docket Nos. E015/CN-22-607
and E015/TL-22-611
MP Exhibit ___ (Winter)
Rebuttal Schedule 26
Page 1 of 1

ID	Task Name	Start	Finish
0	Project schedule_FEED_ATC Alternative_2024-03	2023-01-01	2027-09-17
1	FE Studies and Design Engineering Awarded	2023-02-09	2023-02-09
2	**Pre-FEED & Technical Work Stream Phase**	**2023-01-01**	**2025-11-18**
3	Kick-off Technical Work Stream	2023-03-31	2023-03-31
4	**OEM's Pre-FEED Activities**	**2023-04-06**	**2024-03-19**
5	Preliminary LF/Stability model	2023-04-06	2024-02-02
6	Preliminary layout	2023-08-01	2024-03-19
7	Preliminary audible noise	2023-10-08	2024-03-19
8	Preliminary main circuit calculations	2023-08-08	2023-12-15
9	**MP Pre-FEED Activities**	**2023-01-01**	**2024-04-30**
10	HVDC optimization power flow analysis	2023-01-01	2023-08-05
11	HVDC optimization stability analysis	2023-06-12	2024-03-31
12	Short circuit calculations at converter 345kV AC buses	2023-06-22	2023-07-20
13	Harmonic impedance calculations at converter 345kV AC buses	2023-12-01	2024-04-30
14	Develop AC system equivalent system for DPS	2023-07-01	2024-04-30
15	Background harmonic measurement (at nearest 230kV buses)	2023-08-01	2023-10-02
16	DC Line conductor study	2023-10-02	2024-04-30
17	Preliminary Detailed Technical Specification Development	2023-08-02	2024-04-30
18	**Update MISO Studies**	**2024-08-01**	**2025-01-31**
19	**Update MP Pre-FEED Activities**	**2025-02-01**	**2025-11-18**
20	HVDC optimization power flow analysis	2025-02-01	2025-04-02
21	HVDC optimization stability analysis	2025-04-04	2025-06-24
22	Short circuit calculations at converter AC buses	2025-04-04	2025-05-06
23	Develop AC system equivalent system for DPS	2025-06-25	2025-09-16
24	Harmonic impedance calculations at converter AC buses	2025-09-17	2025-11-18
25	Background harmonic measurement (at nearest 230kV buses)	2025-05-01	2025-07-02
26	**FEED Phase**	2024-03-20	**2026-12-20**
27	**Kick off of FEED**	**2024-03-20**	2024-03-20
28	**OEM's Activities (Anticipated)**	**2024-03-20**	**2026-10-06**
29	FEED Preparation	2024-03-20	2024-06-11
30	Main circuit parameters	2024-06-12	2024-08-20
31	Basic design and insulation coordination	2024-06-12	2024-08-20
32	**Restart FEED**	2025-02-01	2025-02-01
33	FEED Realignment	2025-02-03	2025-11-23
34	Update Main circuit parameters	2025-11-19	2026-01-27
35	Update Basic design and insulation coordination	2025-11-19	2026-01-27
36	Preliminary PSCAD model & Initial dynamic performance study	2026-01-28	2026-07-14
37	PSSE LF and Stability Model	2026-02-25	2026-03-24
38	SSO/SSTI studies	2026-03-25	2026-05-05
39	Reliability studies	2026-01-28	2026-03-10
40	Losses study	2026-01-28	2026-02-24
41	Valve configuration	2026-01-28	2026-04-21
42	Finalize HVDC One-line	2026-04-22	2026-07-14
43	Transformer transportation Study	2026-01-28	2026-03-10
44	AC and PLC filter design	2026-07-15	2026-10-06
45	Specifications for long lead time equipment	2026-01-28	2026-04-21
46	General arrangement, building and AC & DC yards	2026-01-28	2026-07-14
47	**MP's Activities**	**2024-04-01**	**2026-12-20**
48	Updated LF & Transient stability studies using updated OEM's model	2026-03-25	2026-05-19
49	Review OEM's FEED studies and design reports	2026-01-28	2026-10-25
50	MP Prepare detailed technical specification	2024-04-01	2026-01-30
51	Update and finalize technical specification with OEM	2026-02-02	2026-12-20
52	**MP Negotiate EPC Contract conditions with OEM**	2024-06-01	2026-11-01
53	**OEM Prepare final offer**	2026-12-21	2027-06-18
54	**Final OEM Offer recived**	2027-06-18	2027-06-18
55	**Bid review and negotiaion**	2027-06-21	2027-09-17
56	**EPC Contract execution/FNTP**	2027-09-17	2027-09-17
57			



Project: Project schedule_FEED_
Date: 2024-03-04

Task		Summary		Inactive Milestone		Duration-only		Start-only		External Milestone		Manual Progress	
Split		Project Summary		Inactive Summary		Manual Summary Rollup		Finish-only		Deadline			
Milestone		Inactive Task		Manual Task		Manual Summary		External Tasks		Progress			

-2500-39600
MPUC Docket Nos. E015/CN-22-607
and E015/TL-22-611
MP Exhibit ___ (Winter)
Rebuttal Schedule 27

MINNESOTA POWER

Utility Information Request

☐ Nonpublic ☒ Public

Docket No.:	**E015/CN-22-607** **E015/CN-22-611**	Date of Request:	February 26, 2024
Requested From:	American Transmission Company LLC	Response Due:	March 7, 2024

SEND RESPONSE VIA EMAIL TO: discoverymanager@mnpower.com

Request by:	David Moeller
Email Address(es):	dmoeller@allete.com
Phone Number(s):	(218)723-3963

Request Number:	025
Topic:	Information Requests
Reference:	

If your response includes any executable files or spreadsheets, please provide those attachments in both searchable PDF and original form with all formulas and links intact.

REFERENCE:

Page 20, lines 1-3 of the Direct Testimony of ATC witness Thomas Dagenais.

REQUEST:

a. Did ATC's system model for its steady state analysis include Long-Range Transmission Projects 1, 2, and 3 in Minnesota and the Dakotas?
b. If not, why not?

RESPONSE: ATC assumes that this request is referencing page 19, lines 1-3 of Mr. Dagenais' direct testimony. Subject to that clarification, ATC responds as follows:

a. Yes. As discussed at pages 18–19 of Mr. Dagenais' direct testimony, ATC used two different sets of power flow models for its steady state reliability analysis. The first set of models were sourced from the "2023 MP HVDC Modernization Project Power Flow Analysis" described at page 27 of Christian Winter's direct testimony. The "Post-LRTP" scenarios from these power flow models included all LRTP projects.

To be completed by responder

Response Date:	Mar. 8, 2024
Response by:	Thomas Dagenais, Director – System Planning
Email Address:	tdagenais@atcllc.com
Phone Number:	(608) 877-7161

The second set of models were sourced from the power flow models that MISO developed as part of MTEP 2023. Within each case, ATC modeled the system with and without the addition of LRTP Projects 4,5, and 6. ATC did not believe it was necessary to include LRTP Projects 1, 2, or 3 since they were already included in the previous MP-supplied power flow models, are electrically distant from the Project, and their presence or absence is unlikely to materially impact the comparison between MP's proposal and the Arrowhead Substation Alternative.

b. See ATC's response to subsection (a), above.

To be completed by responder

Response Date: Mar. 8, 2024
Response by: Thomas Dagenais, Director – System Planning
Email Address: tdagenais@atcllc.com
Phone Number: (608) 877-7161

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	January 25, 2024
Requested From:	Minnesota Power	Response Due:	February 5, 2024

By: American Transmission Company LLC

Information Request No. 34.

Reference MTEP Project ID 25311, "Stinson PST Retirement."[1]

a. Please provide a detailed justification concerning Your decision to retire and bypass the Stinson phase-shifting transformer ("PST").

b. Is the Stinson PST presently needed to maintain reliability on Your 115 kV transmission system or on other utilities' transmission systems? If not, please explain what conditions have changed to eliminate this historic need.

c. Have You conducted any system planning modeling or analysis (as that phrase is defined in ATC Information Request No. 19) to evaluate how retirement of the Stinson PST would impact the HVDC Modernization Project's ability to transfer 550 MW and 900 MW of power, or how implementation of the HVDC Modernization Project would impact Your ability to retire and bypass the Stinson PST? If so, please produce any and all inputs, outputs, models, study results, workpapers, and/or spreadsheets associated with such modeling or analysis.

d. Reference **[HIGHLY CONFIDENTIAL CRITICAL ENERGY INFRASTRUCTURE INFORMATION ("CEII") BEGINS]** [redacted] **[HIGHLY CONFIDENTIAL CEII ENDS]** If the Stinson PST is retired, how do You propose to maintain reliability during high west-to-east MISO system flows or scenarios in which there is high output from the Nemadji Trail Energy Center (J732) or other local generation following an outage of **[HIGHLY CONFIDENTIAL CEII BEGINS]** [redacted] **[HIGHLY**

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[1] *See* MISO, *MISO Transmission Expansion Plan* (last accessed Jan. 19, 2024), *available at* http://tinyurl.com/a57wws3p ("MTEP Projects Under Evaluation" under the "Project Tracking and Monitoring" tab).

Response by: Christian Winter
Title: Manager-Regional Transmission Planning
Department: Delivery Support Operations
Telephone: 218-355-2908

As to Objection: David Moeller
Title: Senior Regulatory Counsel
Department: Legal
Telephone: 218-723-3963

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	January 25, 2024
Requested From:	Minnesota Power	Response Due:	February 5, 2024

By: American Transmission Company LLC

CONFIDENTIAL CEII ENDS] Please provide a detailed explanation for Your response.

e. Please provide the existing capabilities and control settings for the Stinson PST.

   a. Flow control band settings (bandwidths);
   b. Flow target/regulation setpoints;
   c. Post-contingent automatic adjustment scheme information, including:
      i. Delta P controller setpoints and related information (positive & negative delta P, limits of PST taps used, control time delays, etc.);
      ii. Number of taps used when delta P or other controls are triggered;
   d. Any other applicable control system information for different control modes (e.g., fast vs. slow control); and
   e. Any other required information for modeling/simulating the functionality of the Stinson PST in power flow simulations, including:
      i. Normal regulator settings;
      ii. Post-contingent automatic action settings;
      iii. Min/max PST angles, number of taps; and
      iv. Any other information and/or requirements that limit the PST operation to less than its nameplate rated quantities

Objection:

Minnesota Power objects to this information request to the extent it mischaracterizes Minnesota Power's preferred option to retire the Stinson phase shifting transformer noted in the referenced MTEP Projects Under Evaluation. Minnesota Power has not "decided" to retire and bypass the Stinson phase shifting transformer as stated in the request.

Subject to and without waiving the foregoing objection, Minnesota Power provides the following response.

Response by: Christian Winter	As to Objection: David Moeller
Title: Manager-Regional Transmission Planning	Title: Senior Regulatory Counsel
Department: Delivery Support Operations	Department: Legal
Telephone: 218-355-2908	Telephone: 218-723-3963

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	January 25, 2024
Requested From:	Minnesota Power	Response Due:	February 5, 2024

By: American Transmission Company LLC

Response:

a) Minnesota Power, on behalf of its affiliate Superior Water Light and Power ("SWLP"), submitted MTEP Project ID 25311 for evaluation in the MTEP24 cycle to obtain a coordinated and transparent analysis of the potential retirement or long-term forced outage due to failure of the Stinson phase shifting transformer ("PST"). As the "System Need" for MTEP Project ID 25311 states, the Stinson PST is nearing the end of its useful life, exceeding 40 years in-service in 2028. The transformer is experiencing increasing failure rates and requiring increasingly costly maintenance, while like-for-like replacement with a new phase shifting transformer is a significant long-term investment for SWLP with a very long implementation lead time. Given all of these factors, the preference of Minnesota Power and SWLP is to retire and bypass the Stinson PST, if possible. However, Minnesota Power and SWLP are aware that such decisions cannot be made without coordinated and transparent regional planning studies. Therefore, Minnesota Power's intent is to work with MISO and any affected transmission owners through the MTEP process to identify reliability impacts from the retirement or long-term forced outage due to failure of the Stinson PST and then develop appropriate corrective action plans, if necessary. In other words, MTEP Project ID 25311 is part of a coordinated transmission planning and due diligence process that Minnesota Power and SWLP are undertaking to identify the best long-term solution for addressing end-of-life concerns for the current Stinson PST, which is nearly 40 years old, to either replace it or remove it and upgrade the surrounding transmission system as necessary. This is similar to the type of regional planning coordination that Minnesota Power has maintained is necessary before a determination can be made regarding ATC's proposal to bypass and remove the Arrowhead PST as part of its proposed Arrowhead Alternative.

b) Yes, the Stinson PST is presently needed to maintain reliability on the local transmission system in the Duluth-Superior area, as well as more broadly in northwest Wisconsin.

c) The Stinson PST has been included and modeled as it presently operates in Minnesota Power's studies of the HVDC Modernization Project (see response to part (e)). While

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Response by: Christian Winter
Title: Manager-Regional Transmission Planning
Department: Delivery Support Operations
Telephone: 218-355-2908

As to Objection: David Moeller
Title: Senior Regulatory Counsel
Department: Legal
Telephone: 218-723-3963

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	January 25, 2024
Requested From:	Minnesota Power	Response Due:	February 5, 2024

By: American Transmission Company LLC

Minnesota Power has evaluated the impact of bypassing or replacing the Stinson PST in separate and unrelated studies, Minnesota Power has not conducted any system planning modeling or analysis specifically to evaluate how retirement of the Stinson PST would impact the HVDC Modernization Project's ability to transfer 550 MW and 900 MW of power or how implementation of the HVDC Modernization Project would impact the ability to retire and bypass the Stinson PST.

d) In addition to the coordinated planning studies referenced above, Minnesota Power expects that any substantive changes to the configuration or operation of the Stinson PST will be thoroughly evaluated and incorporated into operating guides as appropriate once the optimal and preferred long-term solution for its retirement or replacement has been identified in planning studies.

e)

A. +/– 10 MW of target setpoint

B. Setpoint = 0 MW

C. Delta P of greater than 100 MW will cause PST to tap up to four taps and lock to manual operation mode, no programmed control time delay.

D. No other control modes

E. For a prolonged **[TRADE SECRET DATA BEGINS** [redacted] **TRADE SECRET DATA ENDS]** outage, the Stinson PST should be adjusted to maintain flows from Minnesota to Wisconsin at 55 MW unless flow on the out-of-service line had been from Wisconsin to Minnesota prior to the outage. In this case the Stinson PST should be scheduled at –55 MW resulting in flows from Wisconsin to Minnesota. PST has 32 taps total that result in approximately four degree change for each tap, total range is +/– 60 degrees.

The information designated as trade secret herein constitutes information related to the Company's transmission studies. To maintain the Company's competitiveness among other transmission owners, the Company maintains the confidentiality of the data that has been marked trade secret.

Response by: Christian Winter	As to Objection: David Moeller
Title: Manager-Regional Transmission Planning	Title: Senior Regulatory Counsel
Department: Delivery Support Operations	Department: Legal
Telephone: 218-355-2908	Telephone: 218-723-3963

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	January 25, 2024
Requested From:	Minnesota Power	Response Due:	February 5, 2024

By: American Transmission Company LLC

This data derives independent economic value from not being generally known to the public and the Company has taken reasonable precautions to maintain its confidentiality, thus the information is trade secret pursuant to Minn. Stat. § 13.37.

Response by: Christian Winter	As to Objection: David Moeller
Title: Manager-Regional Transmission Planning	Title: Senior Regulatory Counsel
Department: Delivery Support Operations	Department: Legal
Telephone: 218-355-2908	Telephone: 218-723-3963

AMERICAN TRANSMISSION COMPANY LLC AND ATC MANAGEMENT INC.

UTILITY INFORMATION REQUEST

Docket Numbers:	OAH 5-2500-39600; MPUC E-015/CN-22-607; MPUC E-015/TL-22-611	Date of Request:	December 20, 2023
Requested From:	Minnesota Power	Response Due:	December 30, 2023

By: American Transmission Company LLC

Information Request No. 26.

Please reference Your responses to ATC Information Request Nos. 5 and 19. Have You performed any "regional planning and integration studies" or "system planning modeling or analysis" of the Voltage Source Converter ("VSC") high-voltage direct current ("HVDC") technology using dynamic simulations using the Transient Security Assessment Tool ("TSAT") or Power System Simulator for Engineering ("PSS/E") software?

a. If yes, then please provide all of input and output files required to recreate such studies, modeling, or analysis, including but not limited to dynamic data (.dyr) files and switching (disturbance/fault) files.

b. If user-defined models ("UDM") were utilized in these analyses, please provide all associated files to setup and run the UDMs, including but not limited to dynamic link library (.dll) files.

Response:

With the assumption that this information request asks for studies or analyses related to the HVDC Modernization Project ("Project"), at the time of this response, Minnesota Power has not completed any transient stability analysis of the VSC HVDC technology and configuration planned for the Project. However, Minnesota Power has evaluated a generic VSC HVDC model in a previous transient stability study for a different project and provides the following information regarding this study in response to this request:

ATC IR 026.01 Attach – *2022 Iron Range – Benton County – Cassie's Crossing ("IRBC") Stability Study:* This study was performed for Minnesota Power and Great River Energy by Siemens Power Technologies International ("Siemens PTI") to evaluate transient stability impacts of the Northland

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Response by: Christian Winter
Title: Manager-Regional Transmission Planning
Department: Delivery Support Operations
Telephone: 218-355-2908

Reliability Project (formerly known as the Iron Range – Benton County – Cassie's Crossing Project) and other MISO LRTP Tranche 1 projects, with particular focus on transient voltage response and recovery. Where transient voltage recovery concerns were identified in certain IRBC Stability Study cases, sensitivity analysis was performed to evaluate potential solutions, including replacement of the existing Arrowhead LCC HVDC converter station with a proxy VSC HVDC converter. Since optimizing the interconnection configurations and specifications of the upgraded VSC HVDC system was beyond the scope of the study, a generic library model was used to represent the VSC HVDC converters. The generic model does not represent the VSC HVDC converters planned for the Project but was deemed sufficient for the limited purpose of screening for impacts and coordination with the Northland Reliability Project in the IRBC Stability Study. Solution sensitivities, including the VSC HVDC solution, are discussed in Section 5.0 of the report, which starts on page 5-1. Detailed modeling information for the generic VSC HVDC model is provided in Appendix E.2 of the report, which starts on page 308 of the pdf file. The study report is provided along with the transient stability package, attached as ATC IR 026.02 Attach, as delivered to Minnesota Power by Siemens PTI.

The information designated as **HIGHLY CONFIDENTIAL TRADE SECRET INFORMATION** herein constitutes information related to the Company’s transmission studies. To maintain the Company’s competitiveness among other transmission owners, the Company maintains the confidentiality of the data that has been marked trade secret. This data derives independent economic value from not being generally known to the public and the Company has taken reasonable precautions to maintain its confidentiality, thus the information is trade secret pursuant to Minn. Stat. § 13.37.

The attachments to this information request contain confidential security data that the Company considers to be trade secret data as defined by Minn. Stat. § 13.37(1)(a). Due to security information policies and concerns, the information provided in this response has been marked Non-Public. The public disclosure or use of this information creates an unacceptable risk because those who want to disrupt the electric system for political or other reasons may learn which facilities to target to create the greatest disruption. Thus, Minnesota Power maintains this information as trade secret pursuant to Minn. Rule 7829.0500, subp. 3.

Item	Justification
ATC IR 026.01 Attach	The information designated as trade secret herein constitutes information related to the Company’s transmission studies. To maintain the Company’s competitiveness among other transmission owners, the Company maintains the confidentiality of the data that has been marked trade secret. This data derives independent economic value from not being generally known to the public and the

Response by: Christian Winter
Title: Manager-Regional Transmission Planning
Department: Delivery Support Operations
Telephone: 218-355-2908

	Company has taken reasonable precautions to maintain its confidentiality, thus the information is trade secret pursuant to Minn. Stat. § 13.37. Nature of the Material: 2022 Iron Range – Benton County – Cassie's Crossing ("IRBC") Stability Study Author: Siemens Power Technologies International General Import: This study was performed for Minnesota Power and Great River Energy by Siemens Power Technologies International ("Siemens PTI") to evaluate transient stability impacts of the Northland Reliability Project (formerly known as the Iron Range – Benton County – Cassie's Crossing Project) and other MISO LRTP Tranche 1 projects, with particular focus on transient voltage response and recovery Date Prepared: January 24, 2023
ATC IR 026.02 Attach	The information designated as trade secret herein constitutes information related to the Company's transmission studies. To maintain the Company's competitiveness among other transmission owners, the Company maintains the confidentiality of the data that has been marked trade secret. This data derives independent economic value from not being generally known to the public and the Company has taken reasonable precautions to maintain its confidentiality, thus the information is trade secret pursuant to Minn. Stat. § 13.37. Nature of the Material: 2022 Iron Range – Benton County – Cassie's Crossing ("IRBC") Stability Package (contains modeling information)

Response by: Christian Winter
Title: Manager-Regional Transmission Planning
Department: Delivery Support Operations
Telephone: 218-355-2908

	Author: Siemens Power Technologies International General Import: This study was performed for Minnesota Power and Great River Energy by Siemens Power Technologies International ("Siemens PTI") to evaluate transient stability impacts of the Northland Reliability Project (formerly known as the Iron Range – Benton County – Cassie's Crossing Project) and other MISO LRTP Tranche 1 projects, with particular focus on transient voltage response and recovery Date Prepared: October 5, 2022

Response by: Christian Winter
Title: Manager-Regional Transmission Planning
Department: Delivery Support Operations
Telephone: 218-355-2908

Exhibit A: Definitions

The definitions used in ATC Information Request Nos. 1-25, served on November 30, 2023, apply to the foregoing information requests.

PUBLIC DOCUMENT
TRADE SECRET DATA
EXCISED IN ITS ENTIRETY

ATC IR 026.01 Attach HIGH TS - ADDITIONAL CONFIDENTIALITY

PUBLIC DOCUMENT
TRADE SECRET DATA
EXCISED IN ITS ENTIRETY

ATC IR 026.02 Attach HIGH TS - ADDITIONAL CONFIDENTIALITY

MINNESOTA POWER

Utility Information Request

☐ Nonpublic ☒ Public

Docket No.:	**E015/CN-22-607** **E015/CN-22-611**	Date of Request:	February 26, 2024
Requested From:	American Transmission Company LLC	Response Due:	March 8, 2024

SEND RESPONSE VIA EMAIL TO: discoverymanager@mnpower.com

Request by: David Moeller
Email Address(es): dmoeller@allete.com
Phone Number(s): (218)723-3963

Request Number: 026
Topic: Information Requests
Reference:

If your response includes any executable files or spreadsheets, please provide those attachments in both searchable PDF and original form with all formulas and links intact.

REFERENCE:

Page 25, lines 11-13 of the Direct Testimony of ATC witness Thomas Dagenais.

REQUEST:

a. Please clarify the meaning of the phrase "the VSC technology that MP is proposing for the Project" used in Mr. Dagenais' Direct Testimony when describing ATC's transient stability studies in light of MP's response to ATC IR 026, wherein MP stated "Minnesota Power has not completed any transient stability analysis of the VSC HVDC technology and configuration planned for the Project."
b. Please provide a description of the transient stability model ATC used to simulate the behavior of MP's proposed VSC HVDC converters, and why ATC chose to model the converters in that way.

RESPONSE: ATC objects to this request as vague. Subject to this objection, ATC responds as follows:

a. As stated in the referenced portions of Mr. Dagenais' testimony, ATC replaced the LCC HVDC converter technology that was present in the MTEP models with VSC technology, which MP has repeatedly stated it is utilizing for the HVDC Modernization Project.
b. For the transient stability analysis, ATC used dynamic model data for MP's HVDC system from

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To be completed by responder

Response Date: Mar. 8, 2024
Response by: Thomas Dagenais, Director – System Planning
Email Address: tdagenais@atcllc.com
Phone Number: (608) 877-7161

the “2022 Iron Range–Benton County–Cassie’s Crossing (“IRBC”) Stability Study” referenced in MP’s response to ATC IR 026. ATC understands that MP has characterized this as a “generic VSC HVDC model” that does not reflect the specific VSC configuration for the Project. However, ATC felt that this modeling approach was the best available option, given that MP has not completed any transient stability analysis of the VSC HVDC technology and configuration planned for the Project.

To be completed by responder

Response Date: Mar. 8, 2024
Response by: Thomas Dagenais, Director – System Planning
Email Address: tdagenais@atcllc.com
Phone Number: (608) 877-7161

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: March 1, 2024

Requested From: American Transmission Company LLC Response Due: March 11, 2024

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

Information Request No. 5

On pages 61-62 of his testimony, Winters indicates that not only will the ATC Arrowhead phase shifting transformer (PST) need to be retained but there could be a need for another PST. Please explain if ATC agrees or disagrees and explain why or why not. If ATC agrees, does it find the estimate of an additional $30 million for a second PST reasonable as indicated on page 78 of Winters testimony? Please explain.

Response: ATC does not agree. As explained at pages 31-33, 37-38, and Schedule 8 of ATC witness Thomas Dagenais' direct testimony and in his rebuttal testimony, the Arrowhead phase-shifting transformer (PST) does not operate automatically to control the flow of power between Wisconsin and Minnesota and is no longer used to serve its originally intended purpose. The planning analyses that ATC conducted demonstrate that the Arrowhead PST can be retired without adverse reliability impacts to the surrounding system. Accordingly, if the Arrowhead Substation Alternative is implemented, the existing Arrowhead PST can be retired and there will be no need for a new Arrowhead PST.

Response by: Thomas Dagenais

Title: Director, System Planning

Telephone: (608) 877-7161

LARGE POWER INTERVENORS

Utility Information Request

Docket Numbers: E015/CN-22-607; E015/TL-22-611 Date of Request: March 1, 2024

Requested From: American Transmission Company LLC Response Due: March 11, 2024

By: Large Power Intervenors (Andrew P. Moratzka, Amber S. Lee)

Information Request No. 3

On page 37 of Winters' testimony he describes three major benefits to ATC and concludes that "Each of these benefits to ATC is at the detriment to Minnesota Power's customers, even though Minnesota Power customers will pay the full cost of the Project." Please respond to the following:

a. Does ATC agree with Winters' assessment of the benefits? Please explain why or why not.

b. If there are benefits, please explain why there should not be cost assignments to ATC.

Response: ATC does not agree with Minnesota Power's (MP) assessment. The cited portion of Mr. Winter's direct testimony references three distinct "benefits" that the Arrowhead Substation Alternative would generate for ATC's customers, at the purported "detriment" of Minnesota Power's customers, which ATC addresses below.

First, MP claims that the Arrowhead Substation Alternative would create "additional power flow from the HVDC System into Wisconsin and away from Minnesota Power's customers." As explained in the rebuttal testimony of ATC witness Thomas Dagenais, this is not how the interconnected alternating current (AC) transmission system operates. Once power from MP's HVDC system is injected into the AC transmission system in Minnesota, it instantaneously becomes intermingled with power flows from other sources, including outside of MP's transmission system. Electric power from the HVDC System, and other sources on the transmission system, will still be used to serve MP's customers. MP has not and cannot claim that implementation of the Arrowhead Substation Alternative would somehow jeopardize its ability to reliably serve customer load. There will be an adequate supply of electric power to serve MP's customers under the Arrowhead Substation Alternative, even if that alternative results in marginal additional electric flow on certain transmission lines in Wisconsin, as MP claims. Ultimately, the available supply will adequately serve the demand, meaning that increased flows into Wisconsin on certain facilities will be offset by lower flows on other transmission lines into Wisconsin.

Response by: Thomas Dagenais, Robert McKee

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LARGE POWER INTERVENORS

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It is also worth noting that MP's assertion that the Arrowhead Substation Alternative will result in additional power flow into Wisconsin is based on a single set of modeling runs, which reflect conditions on the transmission system at a single point in time. The assumptions in these modeling runs are not necessarily representative of how the system would operate at all points in time during a given year. For example, in one of MP's power flow models, there are greater power flows from Wisconsin into Minnesota via ATC's 345/230 kV Arrowhead Substation. Further, there are likely to be times when (for example) MP's HVDC System is not dispatched at its full output because of a lack of wind production in North Dakota; during these times, or as system conditions may otherwise dictate, ATC's Arrowhead Substation Alternative will also likely allow more power to flow from Wisconsin into Minnesota.

Second, MP claims the Arrowhead Substation Alternative will result in "removal of the grid-support of the HVDC System from Minnesota Power's 230 kV local transmission system . . . where Minnesota Power has identified a need for system strength and voltage support to serve its customers." Again, this is not how the interconnected AC transmission system works. MP is proposing to connect the new HVDC converter station to a new 345 kV St. Louis County Substation, and then to MP's 230/115 kV Arrowhead Substation; ATC is proposing to interconnect the new HVDC converter station to its existing 345/230 kV Arrowhead Substation and then to MP's 230/115 kV Arrowhead Substation. In other words, both proposals are electrically similar in that they involve interconnecting the HVDC System to the AC transmission system in Minnesota at 345 kV; the only difference is that ATC's proposal would interconnect the system at an existing 345 kV substation, whereas MP's proposal calls for construction of an entirely new 345 kV substation. As explained in the rebuttal testimony of ATC witness Thomas Dagenais, in either case, the upgraded converter station will continue to provide voltage support to all area voltages, including ATC's 345 kV system and MP's 230 kV system; in fact, as discussed at pages 31-33 of Mr. Dagenais' direct testimony, the Arrowhead Substation Alternative provides a greater level of voltage support when compared to MP's proposal.

Third, MP claims that the Arrowhead Substation Alternative would "reduc[e] the impedance between Minnesota Power's 230 kV local transmission system and ATC's 345 kV regional transmission system, further increasing regional power flow into Wisconsin while at the same time

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removing the ability to control and limit such power flows." As explained in the rebuttal testimony of ATC witness Thomas Dagenais, the reduced impedance of the Arrowhead Substation Alternative is actually a benefit to MP because it results in reduced system-wide electrical losses, meaning there is more power available to serve MP's customers. Furthermore, the planning analysis that ATC has conducted and that is included in Mr. Dagenais' direct testimony demonstrates that there is no need to "control and limit" power flows from Minnesota into Wisconsin with the Arrowhead phase-shifting transformer. As explained in Mr. Dagenais' direct and rebuttal testimony, MISO does not operate the Arrowhead PST to limit or control power flows between the two states and this equipment is no longer needed. Maintaining the existing Arrowhead PST—or adding a second Arrowhead PST—would simply add cost and inefficiency to the system, with no corresponding benefit.

As discussed in Mr. Dagenais' rebuttal testimony, the Arrowhead Substation Alternative does create benefits for both Minnesota and Wisconsin by creating a stronger regional tie between the two transmission systems. With respect to cost-sharing, it is ATC's understanding that MISO has classified the Project as an "Other" type project in Appendix B of the MISO Transmission Expansion Plan (MTEP) process. Per Section 2.3.2.1 of MISO Business Practice Manual No. 020 (Transmission Planning), "Other" projects typically include projects to (among other things) address aging transmission infrastructure or improve operational performance or address other operational issues; these projects are not cost shared and are assigned to the applicable transmission owner. Moreover, as discussed in ATC's response to MP Information Request 004, the terms of MP and ATC's existing transmission-to-transmission interconnection agreement provide that MP will pay the costs associated with interconnection facilities and network upgrades to ATC's system that may be required as part of the Arrowhead Substation Alternative. ATC would recover the cost of these facilities via a lump sum payment with a tax gross-up and would not recover a return at its authorized return on equity on this amount over time.

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MINNESOTA POWER

Utility Information Request

☐ Nonpublic ☒ Public

Docket No.:	**E015/CN-22-607** **E015/CN-22-611**	Date of Request:	February 26, 2024
Requested From:	American Transmission Company LLC	Response Due:	March 7, 2024

SEND RESPONSE VIA EMAIL TO: discoverymanager@mnpower.com

Request by: David Moeller
Email Address(es): dmoeller@allete.com
Phone Number(s): (218)723-3963

Request Number:	024
Topic:	Information Requests
Reference:	

If your response includes any executable files or spreadsheets, please provide those attachments in both searchable PDF and original form with all formulas and links intact.

REFERENCE:

Page 13, line 11 through page 14, line 7 of the Direct Testimony of ATC witness Thomas Dagenais.

REQUEST:

a. Given that the ATC Arrowhead Substation is already 99 percent reliable, how much would the addition of the second transformer increase the reliability, in terms of percentage?
b. Does ATC have reliability concerns with the current configuration and assets invested in at the ATC Arrowhead Substation?

RESPONSE: ATC objects to this request as vague. Subject to this objection, ATC responds as follows:

a. ATC cannot quantify the additional reliability that would be provided by the second transformer "in terms of a percentage." That said, it is clear that having a second, parallel transformer on-site will improve the reliability of the substation in the event the first transformer is forced out-of-service.
b. No.

To be completed by responder

Response Date: Mar. 7, 2024
Response by: Thomas Dagenais, Director – System Planning
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Phone Number: (608) 877-7161

MINNESOTA POWER

Utility Information Request

☐ Nonpublic ☒ Public

Docket No.:	**E015/CN-22-607** **E015/CN-22-611**	Date of Request:	February 26, 2024
Requested From:	American Transmission Company LLC	Response Due:	March 7, 2024

SEND RESPONSE VIA EMAIL TO: discoverymanager@mnpower.com

Request by: David Moeller
Email Address(es): dmoeller@allete.com
Phone Number(s): (218)723-3963

Request Number: 023
Topic: Information Requests
Reference:

If your response includes any executable files or spreadsheets, please provide those attachments in both searchable PDF and original form with all formulas and links intact.

REFERENCE:

Page 13, lines 11-16 of the Direct Testimony of ATC witness Thomas Dagenais.

REQUEST:

a. Please provide the number of 345/230 kV transformer outages per year at the ATC Arrowhead Substation from 2014 to the present.
b. In the event of a 345/230 kV transformer failure at the ATC Arrowhead Substation, does ATC currently have a replacement transformer located in Minnesota?
c. Where is the replacement transformer located in relation to the ATC Arrowhead Substation?
d. What actions would be necessary to replace the failed transformer with the replacement transformer?
e. Does ATC have any employees located in Minnesota?
   i. If yes, where are those employees located in relation to the ATC Arrowhead Substation?
   ii. If not, where are ATC's employees located?
f. In the event of a transformer failure at the ATC Arrowhead Substation, how long does it take ATC crews to reach the ATC Arrowhead Substation?

To be completed by responder
Response Date: March 7, 2024
Response by: Thomas Dagenais, Director System Planning
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MINNESOTA POWER

Utility Information Request

Docket No.:	**E015/CN-22-607** **E015/CN-22-611**	☐ Nonpublic ☒ Public Date of Request:	 February 26, 2024
Requested From:	American Transmission Company LLC	Response Due:	March 8, 2024

SEND RESPONSE VIA EMAIL TO: discoverymanager@mnpower.com
Request by: David Moeller
Email Address(es): dmoeller@allete.com
Phone Number(s): (218)723-3963

Request Number: 023
Topic: Information Requests
Reference:

RESPONSE:

a. Between January 1, 2014 and December 31, 2023, there have been four outages to the existing 345/230 kV transformer in ATC's 345/230 kV Arrowhead Substation, as shown in the table below. Note that all three of the outages that occurred in 2021 were related to a common issue involving system protection equipment, which has since been resolved.

Date	Duration (mins)
Jun. 19, 2016 20:50	185
Jul. 3, 2021 19:43	1059
Jul. 5, 2021 21:23	988
Jul. 18, 2021 11:25	118

b. Yes, ATC has a spare transformer at its 345/230 kV Arrowhead Substation. To be clear, the existing Arrowhead 345/230 kV transformer consists of three single phase units; the spare transformer consists of one single-phase unit, which is a common practice in the industry.
c. See ATC's response to subsection (b), above.
d. The spare transformer is in place and ready to be connected if needed. No physical movement of equipment needs to occur. High and low side breakers and switches would need to be opened to create a safe work environment around the transformer. The spare transformer has a control cable that is already terminated in both the transformer and the modular transformer converter (MTC). Inter panel wiring between the MTC and the protection panels would need to be lifted off of the failed transformer termination points in the MTC and re-landed on the corresponding spare transformer termination points in the same MTC.
e. Yes. ATC has two employees in Minnesota—one in Plymouth and another in Duluth.
f. In the event of an incident at ATC's 345/230 kV Arrowhead Substation, Minnesota Power field crews serve as ATC's first responders. If needed, ATC could also contact one of ATC's alliance

To be completed by responder
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construction and commissioning partners for assistance. ATC has traditionally sent an ATC commissioning engineer (CE) or construction manager (CM) to work with the Minnesota Power field crews. It could take 4-6 hours for an ATC CE or CM to be on-site at the Arrowhead Substation.

To be completed by responder

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