

MINNESOTA POWER HVDC Terminal Expansion Capability (HTEC) Project
(Concept Paper title was HVDC Modernization Project)
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Minnesota Power, a division of ALLETE, Inc., provides electricity in a 26,000-square-mile region of northern Minnesota.

Technical Points of Contact:

Daniel W. Gunderson, Vice President –
Transmission and Distribution
218-348-3133 (mobile)
218-355-2014 (office)
dwgunderson@mnpower.com

Christian Winter, Supervising Engineer
507-530-0472 (mobile)
218-355-2908 (office)
cwinter@mnpower.com

Peter Schommer, Manager-Power Delivery
and Asset Management
651-253-0661 (mobile)
218-355-2639 (office)
pschommer@mnpower.com

Project Management:

Kent Ogston, Director-Engineering Services
218-391-1362 (mobile)
218-355-3002 (office)
kogston@mnpower.com

Key Personnel:

David R. Moeller, Senior Regulatory Counsel
218-591-1076 (mobile)
218-723-3963 (office)
dmoeller@allete.com

Jennifer Cady, Director-Regulatory Affairs
218-349-2924 (mobile)
218-355-3202 (office)
jjcady@mnpower.com

Business Point of Contact

David Chura, Manager – Emerging
Initiatives
218-348-0787 (mobile)
218-355-3280 (office)
dchura@mnpower.com

Project Locations:

Center, North Dakota and Solway Township, Minnesota

PROJECT OVERVIEW

Background

Minnesota Power, a division of ALLETE, Inc., is an investor-owned public utility headquartered in Duluth, Minnesota. Minnesota Power (MP) supplies retail electric service to 150,000 retail customers and wholesale electric service to 14 municipalities in a 26,000-square-mile electric service territory located in northeastern Minnesota. MP's transmission network is interconnected with the regional transmission grid to promote reliability and is a member of the Midcontinent Independent System Operator (MISO) and the Midwest Reliability Organization (MRO).

MP owns approximately 1,730 megawatt (MW) of electric power generation comprised of wind, solar, hydropower, coal, biomass and natural gas-fired power plants in Minnesota and North Dakota. As a leader in the renewable transition for the Upper Midwest, since 2005 the share of MP's electricity generated from renewables has increased from 10% to 50%, will increase to over 70% by 2030, and align to meet the requirements in the State of Minnesota to be 100% carbon-free by 2040.

MP owns and operates an existing 465-mile long high voltage direct current (HVDC) transmission line (HVDC Line) and two HVDC terminals located in Center, North Dakota and Hermantown, Minnesota (together the HVDC System). Much of the renewable electricity consumed by MP's retail and municipal customers is delivered to its service area by this HVDC Line. The HVDC System was originally commissioned in 1977 and operated to deliver 500 MW of coal-fired power from Unit 2 of the Milton R. Young Station (Young 2), located adjacent to the HVDC Line in Center, to northeastern Minnesota. MP's purchase of the HVDC Line in 2010 and subsequent upgrade to 550 MW in 2013 cleared the way for the line to be repurposed to deliver wind power generated in the plains of North Dakota to northeastern Minnesota.

MP has a project that is not part of this application to modernize and upgrade both HVDC terminals and interconnect the upgraded terminals to the existing alternating-current (AC) transmission system. There is an urgent need to replace the existing line commutated converter (LCC) HVDC converter stations at the terminals because they are at the end of their design life and experiencing increasing failure rates. The existing 550 MW LCC converter stations will be replaced with higher-capacity (900 MW) voltage source converter (VSC) HVDC converter stations. This will bring multiple new grid-supporting attributes that will deliver substantial new value to the regional transmission system.

This **HVDC Terminal Expansion Capability (HTEC) Project** involves designing the new VSC HVDC converter stations and connecting substations to also meet MP's long-term needs for the regional transmission system. In the existing, non-federally funded project, the HVDC System will be limited to 900 MW. The installation of the new HVDC converter stations represents a once-in-40-years opportunity to lay a foundation for significantly increased future renewable energy transfer capability and grid resiliency. Federal funding for the HTEC Project will add

expandability features into the new HVDC converter stations to procure the best-available capacity rating for VSC HVDC converters (3000 Amps or 1500 MW for MP's application).

Project Goal

Federal funding would be used to increase the design capacity of the HVDC terminals. The additional capacity at the terminals will make the HVDC System future-ready for greater expansion to support the increased transfer of clean energy from one of the highest efficiency renewable energy areas in North America, provide greater grid support and operating flexibility, and enhance reliability of the system as intermittent generation continues to be added to the grid. This substantial increase in the capability of the terminals will ensure that the HVDC System is ready when the line is upgraded to a minimum of 1500 MW or optimally upgraded to a 3000 MW bi-pole HVDC system by mirroring the existing 1500 MW system, a groundbreaking way to leverage existing assets to achieve CO₂ reduction goals through modular upgrades. The value of increased transmission capacity will only grow as MP and other energy companies across the nation add more renewable energy sources to our energy mix to achieve de-carbonization goals.

DOE Impact

A \$50 million grant from the DOE would provide critical funding for a portion of the estimated \$104 million incremental investment needed to allow MP to invest in a larger, expandable terminal design that is capable of transferring up to 1500 MW of energy, bi-directionally across the 465-mile line spanning from renewable-rich central North Dakota to the energy intensive industries of Northeast Minnesota and beyond to other load centers in the Upper Midwest. DOE funding will ensure future expandability features are incorporated into the original design of the converter stations to support the long-term needs of the grid. Otherwise, they would need to be replaced well before the end of their useful life in the event of an upgrade to meet future system needs. Given the existing planned replacement of the 45-year-old existing HVDC terminals, the timing is ideal to invest in a larger, expandable terminal design and make the first incremental investment to facilitate a broader regional expansion of the HVDC System in the future. This investment will catalyze future renewable and low-carbon clean electricity, enable connections to other high voltage transmission projects being considered in the region, allow new renewable power transfers, and prepare the regional grid for a decarbonized future.

MP firmly believes that high-capacity VSC HVDC technology is the right choice for the region and will provide a foundation for a modular and flexible system that can advance clean energy deployment. This was validated by MISO in their February 2021 Renewable Integration Impact Assessment ("RIIA") Report.¹ The purpose of RIIA was to "better understand the impacts of renewable energy growth in MISO over the long term." Through a technically rigorous analysis

¹ <https://www.misoenergy.org/planning/policy-studies/Renewable-integration-impact-assessment/#nt=%2Fria%3AReport&t=10&p=0&s=Updated&sd=desc>.

process, MISO found that “[t]o import power from wind-rich zones located in weak areas, building a VSC HVDC line into those weak areas may be more economical than incrementally installing a combination of AC transmission lines with many synchronous condensers.”

Community Benefits Plan MP has a long history of engagement with the communities in Minnesota and North Dakota, as well as organizations that serve the impacted communities, disadvantaged communities (DACs) served by the HVDC Line, and area workforce. A high level of stakeholder engagement has already begun and will continue prior to project initiation. This will allow community and tribal members to offer input for project planning and minimize negative impacts to community members when construction begins. Energy democracy will be at the forefront of the community engagement plan, with milestones including public listening sessions, regular meetings with Tribal Nations and labor organizations, and community education opportunities about the role of transmission in the clean energy transition.

Benefits from this Project will flow to the host communities and DACs served by the HVDC Line in the following ways:

- Provide high quality jobs and apprenticeship programs including clean energy jobs.
- Increase community tax revenue.
- Increased access to clean power, especially in DACs where home-sited renewables may not be attainable.
- Reduced environmental exposure and burdens for DACs, especially projected flood risk, expected agricultural loss, and projected wildfire risk associated with climate change.
- More reliable and resilient grid infrastructure to serve all of MP’s customers, including DACs, as beneficial electrification increases electric grid reliance.

MP has a strong working relationship with the trades and union labor is part of all of our projects. MP will continue to work with organizations representing labor, including International Union of Operating Engineers Local 49, the Laborers' International Union of North America (LIUNA), and the International Brotherhood of Electrical Workers (IBEW), to provide quality union jobs are created by the Project. In support of the full application, MP includes letters of support from a variety of stakeholders representing unions, residents, government, tribal communities and DACs whom MP has well established working relationships and partnerships with.

Sharing and maximizing benefits across disadvantaged communities

MP has an established, long-standing commitment to its communities and workforce. Working with local colleges and apprenticeship programs, a workforce readiness plan related to this effort will be developed as has been done with other large project implementations. The plan will describe the skillset and availability of the workforce needed for the successful implementation of this project. MP is also advancing diversity in hiring and collaborating with local leaders and colleges to identify partnerships and share internships, as well as with

workforce development and diversity groups to expand hiring reach. Out of MP's approximately 1,000 full-time employees, over 400 are represented by unions. MP has collective bargaining agreements with the IBEW Local 31 and Local 1593. Additionally, MP has a strong working relationship with the trades and union labor is a part of all of our projects. The company offers many apprenticeship training programs to upskill employees. These apprenticeships are indentured with the State of Minnesota, and are guided by a joint labor-management apprenticeship committee. MP currently has 63 apprentices indentured with the State.

MP advances DEIA through five main focus areas: workforce, supply chain, customer, corporate citizenship and communication. DEIA will be incorporated via participation from underserved groups, seeking diverse suppliers, developing Justice40 (J40) and stakeholder engagement plans, tracking impacts to DACs, and increasing stakeholder participation to improve project outcomes. MP continues to work to expand and partner with diverse suppliers including minority-owned, women-owned, veteran-owned, LGBT-owned, disability-owned, small economically disadvantaged businesses, and HUBZone businesses so that our suppliers reflect the diversity of the communities we serve. MP's commitment to DEIA also extends to attracting and retaining employees who value diverse backgrounds, ideas, and perspectives.

MP makes DEIA part of everything we do – from how we deliver energy and build our workforce to creating opportunities for communities to thrive. MP's DEIA initiatives are led by a DEI Steering Committee. In 2022, MP created an employee-led DEIA Engagement Subcommittee to raise awareness and identify, organize, and communicate educational and engagement opportunities related to DEIA. MP is committed and taking action for a more equitable society, expanding hiring and supplier diversity and engaging stakeholders in advisory panels, Tribal liaisons, and government and community contacts to build relationships, solicit feedback, and collaborate.

Because the Project is such a critical piece of electrical infrastructure, MP has performed a rigorous evaluation of both terminal locations to minimize its exposure to climate-related emergencies. Both terminals have been located outside of Federal Emergency Management Agency flood zones and away from locations susceptible to wildfires. Additionally, MP has performed soil analysis to ensure site stability. MP engaged early in project development with local regulators and the community to ensure the proposed locations aligned with local development and climate resiliency goals.

TECHNICAL DESCRIPTION, INNOVATION, AND IMPACT

Relevance and Outcomes, Feasibility, Innovation and Impacts

HVDC Transmission Expansion Capability (HTEC) Project Description

Federal funding will enable MP to implement the HVDC Transmission Expansion Capability Project (HTEC Project) by building on the foundation of an existing modernization effort to increase the design capacity of the HVDC converter terminals. Enabling a low-carbon future

requires transmission capacity and operational transfer capacity through grid enhancing technologies such as voltage source converter (VSC) HVDC. In support of this objective MP has initiated a modernization project that will replace the 45-year old existing HVDC terminals with modern technology to ensure safe, reliable operations well into the future and increase the operating capacity of the HVDC Line from 550 MW to 900 MW. With a target in-service date of December 31, 2028, that modernization project is a critical element in MP's **EnergyForward** journey where we've committed to be more than 70% renewable by 2030, cease all coal operations by 2035, and align ourselves with the requirements in the State of Minnesota to be 100% carbon free by 2040. The modernization project is the foundation that will facilitate the HTEC Project to enable a larger upgrade of the HVDC System in the future.

The existing HVDC terminals are currently interconnected to the 230-kV transmission system on both ends of the HVDC Line because that is the interconnection voltage for MP's wind generation and the local backbone network voltage in northeastern Minnesota. As a result of HTEC Project, the use and significance of the HVDC Line will increase over the life of the proposed converter stations and it will become increasingly important for the HVDC Line to be directly interconnected to the regional 345-kV network, rather than the local 230-kV network. As the regional transmission system continues to develop to support the clean energy transition, the near-term focus is to develop a strong 345-kV network. This is clearly demonstrated by Tranche 1 of the MISO Long Range Transmission Plan (LRTP), which was approved by the MISO Board of Directors on July 25, 2022, and consisted of 18 individual 345-kV projects totaling over \$10 billion. Therefore, to ensure the long-term viability of the interconnection voltage of the new HVDC converters, Minnesota Power is incurring additional cost to interconnect the new HVDC converters at 345-kV. The additional costs consist of installing new 345-kV/230-kV transformers, 345-kV substations, and 345-kV transmission lines on each end of the HVDC Line and are coordinating with MISO for regionally cost shared 345-kV lines that support this effort as part of MISO LRTP Tranche 2.

The total estimated cost of the upgrade is approximately \$155 million. This cost can be broken down into two components: the incremental cost of purchasing HVDC converter stations with expandability features (HTEC Project), as described throughout this Application, and the incremental cost of interconnecting to the existing AC transmission system at 345-kV rather than 230-kV. The HTEC Project will exclusively fund the incremental cost of the HVDC converter stations and does not include any of the incremental cost associated with 345-kV AC interconnections. The incremental cost of the HVDC converter station component is \$104 million, as illustrated in the budget workbook. The incremental cost of developing AC interconnections for the new HVDC converter stations at 345-kV rather than 230-kV is approximately \$51 million. MP's current cost estimate for the AC interconnection facilities on both ends of the HVDC Line are based on planning-level assumptions and are not developed with sufficient detail to be included in this Application. Therefore, as stated above, the \$51 million incremental cost of 345-kV interconnection is over and above the HTEC Project costs included in the budget workbook.

Technology Description

For nearly a decade MP has been engaged in the evaluation of options and alternatives to justify the non-federal modernization project. A robust analysis of the technology and system capabilities has been completed to determine the optimal path forward. The analysis has determined that the time is now for this innovative project and its many unique characteristics, including:

- 1) Low impact, cost effective transfer capability compared to new build options.
- 2) Use and optimization of the existing transmission line and right-of-way, minimizing land use, environmental and owner impact.
- 3) Proximity and alignment to other potential regional HVDC transmission projects that would create potential HVDC corridors across the country.
- 4) Extensive existing internal expertise and experience owning and operating an HVDC System in a regional market as one of only a few HVDC operators in the United States and the only one of its kind in the MISO footprint.

In evaluating the HVDC technology options, MP considered two fundamentally different types of HVDC converter technology: line commutated converters (LCC), the legacy technology which relies on the AC system voltage for commutating current from the outgoing valves to the incoming valves, and VSC which are force-commutated using electronic gating signals. The existing non-federal project would replace the two existing 1970s-era LCC HVDC converter stations, which are limited to 550 MW of capacity, with two new VSC HVDC terminals with the capability to transfer of up to 900 MW. The HTEC Project would increase the capacity of the new terminals to facilitate 1500 MW after a future transmission line upgrade. The 1500 MW rating is the highest capacity currently available for VSC HVDC converters consistent with the operating voltage requirements of MP's system. Benefits of VSC HVDC technology include:

- Allows for bi-directional flows, facilitating large amounts of energy transfer by bringing the power to where it's needed most based on market and reliability signals, thereby optimizing the system. In addition, it can be scheduled to flow in a specific direction if needed to support system reliability, regardless of market signals, in the event of a resiliency need. The new, expandable HVDC System is one that can be maximized to support reliability, resilience, and the market for the delivery of affordable clean energy to customers.
- Supports the AC system with frequency regulation, voltage and reactive power support, and other ancillary services (such as black start), and is practically immune to weak system conditions and AC system faults, unlike LCC converter technology. After in-service, the grid operator will have a resource that acts as a stable source to restart all grid assets from an unaffected part of the grid that is far away. This will create new opportunities for system restoration stabilization following extreme events on the grid. Because of this, the HVDC System will have the capability to support system restoration needs in the upper

Midwest. The long distance of the line (465 miles) also links two distinct regions of the grid to provide interregional support in the case of extreme events in either area.

- HVDC controls improve the visibility of the electrical system to grid operators to help quickly rebalance the electrical system with autonomous controls combined with a large reactive resource. In addition, the HVDC System will automatically provide voltage support to the grid as it monitors and reacts to conditions in the surrounding system.
- Flows can be increased/decreased quickly (5 minutes or less) based on MISO market and regional needs. This is a vast improvement from the hourly scheduling of today and can allow for far more flexibility in market operations.

Feasibility

Given the age of the HVDC System, there is a sense of urgency regarding the replacement as it is beyond its useful life and component failure rates are increasing. MP has completed the RFP process and received bids from the top HVDC vendors in the worldwide market to ensure a competitive procurement process. With supply chain issues, labor shortages and increased demand for HVDC, particularly in the European markets, MP has positioned itself to secure the earliest production slot that's available.

MP is poised and ready to invest in its existing system to prepare it for the near-term needs. With DOE's support we can ensure that the system is flexible and ready to meet the needs of the future regional grid.

VSC HVDC is a mature technology but still making many advances. Since the first commercial system was commissioned in 1999, vendors have been increasing voltage and power ratings. That first system was an 80kV, 50MW design and today system designs up to 600kV and 4000MW are being discussed. Commercial systems today are being built to deliver up to 2000MW. The HTEC project is feasible given the RFP strategy, existing body of work, and because the converter stations will be connected to existing infrastructure.

Support of energy goals, strategies and plans

The HTEC Project will position MP for a future where the line can be further upgraded without having to replace the new terminals before the end of their useful life. This cost savings is important to keep electricity rates affordable for customers. MP forecasts the need for additional bulk regional transfers of renewable energy within the next decade to support energy policy in Minnesota and throughout the Upper Midwest. The HVDC converters that will be enabled with federal funding will be capable of the best-available current ratings and will allow the converters to be operated at 1500 MW in the future. This additional capability comes at an estimated incremental cost of \$155 million (\$104 million for increased converter terminal design capacity plus the non-federal \$51 million transmission line upgrades) beyond what is necessary to meet MP's near-term needs. In planning for this HTEC Project cost, MP is seeking a

\$50 million grant from the DOE. MP is also seeking to obtain funding from the States of North Dakota and Minnesota (\$25 million from each state) and will seek customer cost recovery for the remaining \$55 million. The \$25 million in state funding in Minnesota will be dependent on receiving federal funding for this project. If funding from Minnesota and North Dakota does not occur, MP remains committed to the HTEC Project.

This funding strategy and the future cost savings from the HTEC Project is very important to MP's customer base. The communities served by MP rely on the HVDC Line to transfer increasing amounts of wind power located in central North Dakota to Minnesota, which helps ensure reliable, affordable, and low-carbon energy for all of the customers and communities we serve.

In addition to the direct customer benefits, MP also sees significant strategic benefit of an expanded system to the entire upper Midwest region of the U.S. As a transmission owning member of MISO, MP's network is interconnected with the regional transmission grid and provides resources that are integral to both reliability and affordability for other transmission owners beyond our service territory. One of the most critical regional resources is MP's HVDC Line as it plays an important part of the clean energy transformation for the entire region. However, the current system does not have the resiliency characteristics that are needed by a modern grid to manage disruptive events and respond to external grid disruptions. The modernization project that MP is not seeking federal funding for and the HTEC Project are needed to ensure the line is able to transfer increasing maximum amounts of clean energy while expanding critical grid support functions.

In addition to the regional benefits, the HTEC Project aligns with state energy policy. In the current legislative session, Minnesota enacted legislation that requires all utilities in the state to provide 100% carbon free energy by 2040. This landmark energy bill will require massive amounts of renewable energy to be constructed and transported from areas where that energy can be most effectively produced to the load centers within the state. Industry experts have recognized that modernization and expansion of existing HVDC infrastructure is one of the fastest and lowest-cost ways to add substantial capacity to the grid as it concentrates energy flows into high-capacity corridors. This dynamic becomes even more critical as additional renewable capacity is built out, as HVDC allows a greater amount of energy to be transferred when it is available and stabilizes the grid when it is not. Technology upgrades like those planned for the HTEC Project therefore present a cost-effective opportunity to substantially increase the design capacity of the HVDC terminals to allow for efficient transfer of additional renewable and low-carbon energy in the future. The increased HVDC capacity will be critical to fill the energy void as fossil fuel facilities transition to less carbon intensive operations or retirement, making investments in the future expandability of the terminals of even greater importance.

In addition to achieving Minnesota's CO₂ reduction goals, increased renewable power transfer is particularly important to the communities served by MP because the region experiences very

high energy demand during winter months due to extreme cold temperatures. The regional energy grid can become highly congested during disruptive weather events and the HVDC Line helps to ensure resiliency and reliability during times of high congestion. An upgraded DC line is likely to decrease the market volatility related to unplanned outages, which impacts all customers, but is particularly hard on the low-income customer base due to the cost of replacement power being spread across all energy sales, a dynamic that creates difficulty despite MP's industry-leading low-income rate program. Expanded capacity capability within this funding opportunity will allow for less volatility in the future through reliable operations and lower capital costs in the future this will help the company provide more predictability for customer bills, including low-income customers. MP's service territory consists of many rural communities with median household incomes far below the state average. Future upgrading of the HVDC Line at a significantly lower cost will continue to allow MP to offer reliable, low-carbon electricity at affordable rates to these communities as we maximize renewable energy transfers, balancing the needs of our most vulnerable economic challenges with the decarbonization that is the cornerstone of MP's goals and energy policy in both the state of Minnesota and our country.

MP sees the HTEC Project as one of the most strategic projects for the Upper Midwestern grid that supports federal and state energy policy goals and can be designed to provide customer relief from future costs by thoughtful planning today.

How will the project have a significant effect in encouraging and facilitating the development of smart grid functions identified as priority focus areas in 1.B.Topic Area 2.

The existing grid was developed around centralized central station generation sources where grid variability was minor and relatively predictable, even with unplanned outages. HVDC is an ideal technology as the grid incorporates more intermittent resources because of the scheduling and reliability benefits it provides. This is why the demand for HVDC is high in Europe as well as the five new long-distance transmission HVDC projects in the U.S. that are currently under development. The HTEC Project will demonstrate the ability to upgrade HVDC assets in a modular fashion, unlocking benefits for both local customers and the broader grid.

When MP's existing HVDC Line, known as the Square Butte HVDC Line was constructed in the 1970s, VSC technology was not available, but the project was one of the first in the world to adopt LCC thyristor technology. When installation was complete, reactive support needed by the LCC system was provided by local fossil fuel generation in North Dakota and external grid supporting assets in Minnesota. This type of support will be less available as more baseload fossil fuel units retire. With an award from the DOE, the HTEC Project will provide incremental benefits as the terminals will be sized to the maximum capacity now and allow for the capacity of the HVDC line to be expanded in the future at far lower cost (saving at least \$700 million for MP ratepayers) than replacing the terminals.

The VSC technology is quickly becoming the globally-favored HVDC installation due to its inherent ability to provide voltage and reactive power (“VAR”) support to the grid as well as transfer of real power. VSC is viewed by many as the DC technology of the future because of the dual benefits of mass transfer and reactive power support required with increased penetration of intermittent resources. Simply stated, VSC today is a modern solution to a modern problem. It is ideally suited for and is being used for offshore wind farms and in areas with weak grids. The same benefits for those applications also make VSC extremely attractive for land-based systems that must accommodate large additions of intermittent resources, such as this project.

Contrasted with the original LCC system, which is a VAR consumer and does not respond to the dynamics of the grid with support, VSC generates its own dynamic reactive support and can operate as a voltage-regulating device to support the surrounding system even if the HVDC line isn’t transmitting any power. VAR support is necessary for the grid to operate and move power reliably, especially as the traditional baseload fossil fuel units historically providing VAR support to the system are retired. While variable renewable energy resources do provide some VAR support when they are operating, they cannot by themselves provide a one-for-one replacement for traditional baseload units either in terms of the magnitude or the location of support because of their intermittent operation. This is the underlying reason that renewable integration studies like MISO’s RIIA continue to find that other devices on the system, such as VSC HVDC, are necessary to achieve higher levels of renewable penetration in the future grid.

Besides voltage support, VSC HVDC can provide dynamic reactive response that supports transient stability. Transient stability is the ability for the system to stabilize after significant events such as load loss, generator loss, faults, or sudden line outages. For example, if a heavily loaded AC line trips out of service, it has potential to cause wild power and frequency swings that can create an unstable grid for an undesirable period of time. The HVDC control system can be programmed to recognize these conditions and modulate real and reactive power output to compensate, helping to alleviate a number of conditions such as low voltages, tripping of large electric motors or generators, widespread outages, islanding, and generator damage from sub-synchronous torsional interaction. It is MP’s desire to demonstrate this feature set at 900 MW and ensure that the same asset can provide this critical resiliency function at the 1500 MW level when the line is upgraded to that capacity.

The new HVDC System will also demonstrate the flexibility to operate with dynamic scheduling at both the 900 MW and 1500 MW level when the Project is completed. This will allow for the HVDC System to respond to market and reliability signals more frequently in real-time that will be far more representative of the value to the market of HVDC. Unfortunately, the existing system is limited to changing real power dispatch once per hour due to the age and condition of the equipment. The new system will be able to follow current market dispatch schedules for MISO and will be prepared for even more frequent dispatch adjustments. This will benefit the system by creating efficiency, being able to more closely match wind output with power flow in

near-real time, and following market signals more closely to facilitate optimal power dispatch. If awarded, MP's goal is to work with MISO on the upgrade path from 900 MW to 1500 MW from the initial stages of the HTEC Project. The upgrade in the transfer capability of the HVDC terminals means the system will be able to provide these grid benefits well into the future as significantly larger amounts of renewable and low-carbon electricity come on the grid, allowing for an additional future 600 MW of renewables to fill the line when they are available.

The biggest value of the Project as a contributor to the broader grid is encouraging and facilitating the advancement of smart grid functions will be the demonstration of modular scalability that will first ensure scalable hardware design features (from 900 MW to 1500 MW) followed by applicable future software and control modifications upon future line capacity upgrades. This approach will demonstrate a cost-conscious approach to design whereby large cost savings can be leveraged when the broader grid is ready for further expansion.

How will the project enhance the system flexibility to meet program objectives?

Success with federal and state energy policy, specifically related to de-carbonization initiatives, will rely on deploying high efficiency renewable resources and creating high reliability paths to load centers where energy is being used. This project fits perfectly into the program initiatives due to the existing assets located in North Dakota in one of the highest efficiency wind areas in the country transferring energy in proximity to some of the largest industrial load centers in the country in northeastern Minnesota. One key and exciting element of the Project is that HVDC VSC Technology has not yet been used for bulk transfer of energy in the United States over long distances, as will be demonstrated with the project. The Project also meets the program objectives with a unique, scalable project that has the opportunity to transform reliability and grid stability with dynamic reactive response and black start within two critical regions of the country. This technology has been similarly utilized for several decades on a smaller scale and has most recently been the transformative technology throughout the European grid to manage the increased amount of energy from renewable resources. It is the intent of MP to demonstrate this value at the initial scale and leverage the new terminal assets within the scope of this project with a future upgrade of the line.

This project also aligns with program objectives by providing optimally flexible, asset-utilizing, bi-directional scheduling of energy transfer, providing maximum value for the grid with increasing intermittent energy. This particular modular project design will also enable further private sector capacity and clean energy additions to grow as the project is upgraded. The connection to other transmission corridors under development will promote and be a catalyst for broader interregional transfer options establishing expandable energy hubs that will optimize land use in both North Dakota and Minnesota, creating future project options for the modern grid including renewable energy additions and storage.

WORKPLAN

Project Objectives

MP will implement the HVDC Transmission Expansion Capability Project (HTEC Project) by building on the foundation of an existing effort and increasing the design capacity of the terminals from 900 MW to 1500 MW. MP has initiated a modernization project that will replace the 45-year old existing HVDC terminals with modern technology to ensure safe, reliable operations well into the future and increase the operating capacity of the HVDC Line from 550 MW to 900 MW. With a target in-service date of December 31, 2028, that modernization project is a critical element in MP's Energy**Forward** journey where we've committed to be more than 70% renewable by 2030, cease all coal operations by 2035 and align ourselves with the requirements in the State of Minnesota to be 100% carbon free by 2040. The modernization project is the foundation which will facilitate a larger upgrade of the HVDC System in the future. The additional capacity from the HTEC project will make the HVDC System future-ready for further expansion to support the increased transfer of clean energy from one of the highest efficiency renewable energy areas in North America, provide greater grid support and operating flexibility, and enhance resiliency of the system as intermittent generation continues to be added to the grid.

Technical Scope Summary

The HTEC Project will work with an HVDC supplier to design and build two VSC HVDC terminal stations capable of delivering 1500 MW, ensuring that they are sized and configured appropriately to deliver the expected energy. Once the equipment design is finalized, manufacturing, acceptance testing, installation, and operation can proceed. The supplier will use a prescriptive process to commission all of the equipment until the HVDC transmission line is connected and the system begins to transmit power. The HTEC Project will use the same planned physical footprint for each terminal station.

The Project is presently anticipated to be in-service December 31, 2028. MP will own and operate all of the facilities proposed.

HVDC terminal stations are designed and equipment is manufactured by a limited number of suppliers globally. Due to their specialized nature, MP plans to enter an engineer, procure, construct (EPC) contract with a selected supplier for this project. The supplier will help define the project by performing front-end engineering and design (FEED) studies. The supplier will then develop a firm price bid, complete detailed engineering, manufacture the equipment, conduct acceptance testing, and will work with a contractor to develop site specifications, install, test, and commission the converters.

Over the past year, MP has engaged multiple suppliers to gain insight on different HVDC technologies and compared the advantages and disadvantages of both. The outcome of that process was the decision to proceed with VSC technology. After that decision was made, MP

began a Request for Proposal (RFP) process with the main suppliers. The RFP was evaluated on four criteria:

- a) Proposal for Exclusivity Agreement, including FEED
- b) Base Proposal including Project Cost Estimate, Technical Description and Contracting Strategy, with particular focus on engineering and procurement (EP) components.
- c) Project Schedule, including FEED.
- d) Suppliers proposed terms and conditions for Project Execution Contract (EPC Agreement).

The global market demand for HVDC is very high; therefore, the RFP approach used was not traditional. It is important to start working early with a single vendor and secure their resources to support the Project. MP has executed an agreement with a preferred supplier to secure manufacturing capacity and begin progressing through the stages previously mentioned – front end studies through commissioning.

HVDC converters are specialized equipment with limited global supply and no domestic suppliers. Siemens Energy will design and manufacture all converter equipment in Germany and Brazil. However, the installation contractors will be regional and local. They will also source building materials from domestic sources as much as possible for items such as structural steel, conduit, wire trays, brackets, supports, etc. MP's largest customers are producers of U.S. iron and steel and we recognize the importance of this key industry and its role in a strong domestic economy. MP will explore the purchase of domestically produced iron and steel that meets technology specifications for these balance-of-plant components. MP intends to include a Buy America provision for materials procurement and labor to the extent possible.

Work Breakdown Structure (WBS)/Task Description Summary

The HTEC Project is very ambitious and requires thoughtful execution. MP's experience in project management, planning and execution of large utility projects will help ensure its success. In addition, as described below, MP has carefully laid out an implementation plan with specific milestones.

Community Benefits Plan: This plan outlines MP's framework to ensure that federal investments in the power sector advance the following four priorities: (1) community and labor engagement; (2) investing in the American workforce; (3) advancing DEIA; and (4) the Justice40 Initiative. The plan sets forth MP's intention to engage meaningfully with labor and community stakeholders on these priorities through the following: holding community listening sessions; regular meetings with Tribal Nations served by the HVDC Line, including meetings with the MN Tribal Contractors Council to ensure inclusion of tribal contractors in construction; partnering with Clean Energy Organizations to offer community education sessions; holding biannual meetings with labor organizations and union representatives; attending job fairs near the host communities and DACs within MP's service territory; holding stakeholder events in DACs served by the HVDC Line during each project phase; increasing the percentage of diverse suppliers in project bids; identifying diverse Tier 1 suppliers and non-diverse businesses with a diverse

supplier program that can connect and contribute to MP's Tier 2 program; and establishing a Community Benefits Committee to negotiate and develop a Community Benefits Agreement.

Technical Specification Development: Several key deliverables occur during this task to prepare the project for success and cost certainty. A series of studies are completed to ensure that the system being proposed will operate properly within the electrical system where it is being constructed. During this task the models are developed, performance criteria are determined, operating conditions are evaluated, etc. to plan for a future 1500 MW operation. The main deliverable of the FEED is a technical specification agreed upon by MP and the supplier, which will be used to generate a firm bid. This is a joint effort between MP, the supplier, and any additional consultants MP may use. After completion of the studies, the supplier will compile a firm bid proposal. In parallel with bid development, all parties will work on contract language in order to execute the Engineering, Procurement, Construction (EPC) contract as expeditiously as practical. At this point MP will make a Go/No-Go decision based on the firm price. Once the proposal is reviewed and an EPC contract is executed, MP will give Final Notice to Proceed (FNTP, also a Go/No-GO decision), which initiates an invoice that secures equipment.

The EPC contract will detail several tasks listed below:

System Studies: The supplier will complete the final design after the EPC contract is executed. During this phase, the supplier will complete several more detailed groups of studies. Design studies determine the equipment that will be used for the project and the main circuit parameters. Performance studies are completed to ensure reliability, radio interference, and electromagnetic coupling meet the specified requirements. Network studies use power system simulation to model the HVDC system into the grid where it will be placed to ensure controls will behave correctly for hundreds of operational scenarios. This task will also include performance verification with simulation reports including radio interference, electrical interference, and performance verification results. Finally, this task includes engineering of the converter modules. By completion of this task all equipment and control parameters are known and the factories can begin final design of the equipment.

Main Component Design and Manufacture: An HVDC system is comprised of many different components of varying complexity, size, and lead times. Suppliers complete studies in a specific order to get the longest equipment designed first. The primary piece of AC equipment in a system is the converter transformer. During this task the primary design parameters will be sent to the transformer factory where they will complete the detailed design. Upon completion each unit will be manufactured, tested and subsequently shipped to the site. It is common for company representatives to witness factory acceptance testing. Besides transformers, all remaining AC equipment is designed, manufactured and transported. In addition to AC equipment, there is also DC equipment and measuring devices to design, manufacture and transport. Factory acceptance testing of transformers and converter modules are both Go/No-Go decisions.

Control and Protection: Next, the control and protection system is designed to enable all the features included in the final approved models. The control and protection equipment is a series of electrical cubicles with servers, network equipment, signal processing cards, Input/Output (I/O) cards and various other devices to coordinate communication between all the other major equipment. It is what makes the system work and detects and alarms when there are problems. Once the control and protection is designed, it is connected to a simulator that mimics the electrical grid. Then many simulations are completed to verify the system behaves as expected in hundreds of scenarios. Acceptance of factory testing is a Go/No-Go decision.

Installation: Upon delivery of vendor equipment, it will be installed. The vendor will oversee installation of their equipment by the contractor. After installation is complete the contractor will start the demobilization process.

Testing and commissioning: As equipment is installed, the vendor will provide a plan to function test every piece. When all equipment is tested, it will then be energized and commissioned. The deliverables for this task include completion of all tests, documentation delivered and accepted by MP. When the Project is considered substantially complete, the vendor will turn over operation to MP and complete any remaining items that do not impact or limit operation of the system.

Milestone Summary

Milestone	Verification	Yr/Qtr ²	SMART
Community Listening Sessions	Meeting summaries and attendance list	2024 Q1	X
Establish Community Benefits Committee	Kickoff meeting minutes	2024 Q1	X
Begin Technical Spec Development	Kick-off meeting agenda and minutes.	2024 Q1	
Main Circuit Parameter Study Complete	Main circuit parameter study dated report.	2024 Q2	X
Tribal Scholarship Award	Award letter and financial documentation	2024 Q2	X
Certificate of Need Decision, State of MN	Written order from MN Public Utilities Commission.	2024 Q3	
Anti-bias Training	Completion certificate	2024 Q4	X
Supplier Diversity	2024 annual supplier diversity report	2025 Q1	X
Technical Specification complete	Technical Specification final document.	2025 Q1	X
Invoice for Firm Proposal Fee	Invoice has arrived in MP accounts payable system.	2025 Q1	
Job Fair	News release about event	2025 Q2	X
Tribal Scholarship Award	Award letter and financial documentation	2025 Q2	X

² Milestones assume a January 1, 2024 project start date.

Firm Proposal Due	Firm proposal delivered via purchasing system to Minnesota Power	2025 Q3	
Native American Contractors Inclusion Plan	Plan acceptance by MP and MN Tribal Contractors Council	2025 Q3	X
Community Education Sessions	Presentation slides and attendance list	2025 Q4	X
DAC Stakeholder Events	Event summaries and attendance lists	2025 Q4	X
Final Notice to Proceed	Document signed by MP and delivered to supplier.	2025 Q4	
Anti-bias Training	Completion certificate	2025 Q4	X
Supplier Diversity	2025 annual supplier diversity report	2026 Q1	X
Begin Transformer Design/Manufacturing	Kick-off meeting agenda and minutes.	2026 Q1	
Begin Converter module Design/Manufacturing	Kick-off meeting agenda and minutes.	2026 Q1	
Issue Supplier Diversity Questionnaire	Completed questionnaire	2026 Q1	X
Job Fair	News release about event	2026 Q2	
Community Listening Sessions	Meeting summaries and attendance list	2026 Q2	X
Tribal Scholarship Award	Award letter and financial documentation	2026 Q2	X
Meet with labor organizations	Meeting minutes	2026 Q2 & Q4	X
Anti-bias Training	Completion certificate	2026 Q4	X
Supplier Diversity	2026 annual supplier diversity report	2027 Q1	X
Tribal Scholarship Award	Award letter and financial documentation	2027 Q2	X
Converter Module Factory Acceptance Testing Complete	Factory report of test results delivered to MP showing 1500MW passed.	2027 Q3	X
Control and Protection System Factory Acceptance Testing Complete	Factory report of test results delivered to MP showing tests passed.	2027 Q3	
Converter Transformer Factory Acceptance Testing Complete	Factory report of test results delivered to MP showing tests passed.	2027 Q4	
Meet with labor organizations	Meeting minutes	2027 Q2 & Q4	X
Anti-bias Training	Completion certificate	2027 Q4	X
Supplier Diversity	2027 annual supplier diversity report	2028 Q1	X
Job Fair	News release about event	2028 Q2	
Tribal Scholarship Award	Award letter and financial documentation	2028 Q2	X
Meet with labor organizations	Meeting minutes	2028 Q2	X
Equipment Installation Complete	Email or daily report from CM to PM stating installation is complete.	2028 Q3	
DAC Stakeholder Events	Event summaries and attendance lists	2028 Q4	X
Commissioning Complete	Email/document from supplier indicating substantial completion reached.	2028 Q4	X
Ribbon Cutting Ceremony	News release recapping event	2028 Q4	X
Anti-bias Training	Completion certificate	2028 Q4	X

Supplier Diversity	2028 annual supplier diversity report	2029 Q1	X
Community Update Meeting	Meeting summary and attendance list	2029 Q2	X
DAC Stakeholder Events	Event summaries and attendance lists	2029 Q4	X

Go/No-Go Decision Points

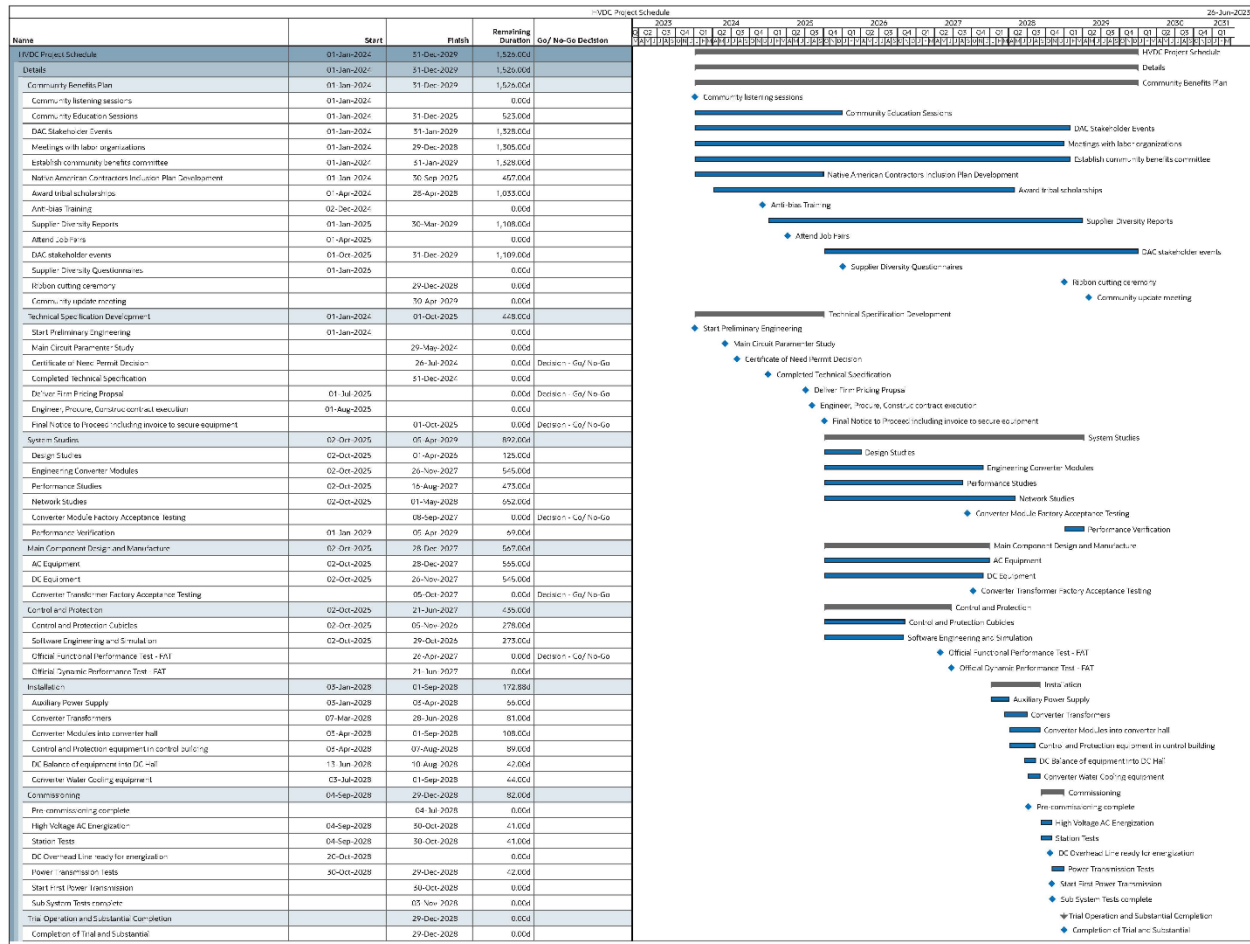
Given the size and scope of the HTEC Project there will be several Go/No-Go decision points throughout the project. They are:

1. **Certificate of Need Decision, State of MN:** To comply with MN regulatory requirements MP is required to submit applications for a Certificate of Need and Route Permit for the project. This filing is anticipated in Spring 2023 with a final decision expected in Q3 2024. This milestone will be verified with the written Order from the MN Public Utilities Commission.
2. **Firm Proposal:** Following the completion of the initial studies, the HVDC vendor will prepare and present a firm project proposal to MP for consideration. This is anticipated to take place in Q3 2025 as evidenced by formal proposal submission into MP's purchasing system.
3. **Final Notice to Proceed:** Following review and negotiation of the firm proposal by MP and the HVDC vendor MP will issue a Final Notice to Proceed (FNTTP). This is expected in Q4 2025 and will be documented through a formal contract signed by MP and the HVDC vendor.
4. **Factory Acceptance Testing:** In Q3 and Q4 of 2027 MP expects to complete Factory Acceptance Testing of the converter transformers, control and protection system, and converter modules. These will be the final Go/No-Go decision points and will be documented through Factory Acceptance Testing reports.

End of Project Goal

The end goal of the HTEC Project is to have two VSC HVDC terminals installed and operating with the ability to operate at 1500MW when the line is upgraded. The HTEC Project will establish the HVDC transmission corridor as an essential building block for reliably moving renewable energy across the Upper Midwest. It will: 1) utilize the latest HVDC technology to increase the reliability and system stability of the grid in both Minnesota and North Dakota, 2) increase access to additional clean energy transfer with limited land impact, 3) optimize energy resources in North Dakota and Minnesota with bidirectional power flow across the line, and 4) be expandable, for efficiently developing a larger corridor to further optimize regional energy flows in the future.

Project Schedule



Project Management

Project management plays an important role in delivering the HTEC Project successfully. The HVDC terminals are a major component within the HVDC system and given the magnitude of the project it will require a combination of internal and external resources to adequately staff all facets of project delivery. Existing company processes, policies, procedures, and best practices will be utilized to execute the project. Examples of these include, but are not limited to: the project manual and guidance document, gated process, safety, environmental, and purchasing policies as well as input from the Executive Sponsors and Management Committee.

A Project Organization Chart provides the structure for key roles related to the Project and is depicted in Fig. 1. Key internal roles include the following:

Overall Project Manager: Organizes and directs project activities by coordinating the efforts of the project team to complete the Project within the limitations of the project scope, budget and schedule. Responsible for providing direction, oversight and reporting to the Executive Sponsors and Management Committee.

Transmission Planning and Studies Project Engineer: Responsible for development and scoping of the Project during the planning and detailed design phase, including determining the performance requirements for the HVDC system and providing boundaries as to how the HVDC System needs to interact with the existing system.

Regulatory DOE Lead: Responsible for ensuring all permitting and environmental regulations and procedures are followed from project initiation through construction and close-out. Main point of contact for DOE and Federal Project Officer.

Land and Right-of-Way Lead: Responsible for land and land rights acquisition. Ensures commitments to any affected land owners are met. Serves as the liaison with impacted property owners during construction activities.

Procurement Lead: Responsible for procurement strategy, contracts, and ensuring purchasing policies are followed. Assists in prequalification of vendors, solicits proposals from qualified vendors and contractors, assists in evaluation of proposals, and provides administration of contracts including bonding and insurance requirements, review of commercial terms and conditions, and expediting services as requested from the project team.

Engineering Project Manager: Responsible for overall management and coordination of the technical portion of the project with the HVDC supplier. Involved with project research, development, design review, testing, and Project Quality Assurance and Project Quality Control ("QA/QC"). Collaborate and work closely with other teams to ensure that technical solutions are aligned with the overall goals of the project and able to be successfully implemented.

Compliance and Security Lead: Responsible for ensuring NERC standards and security requirements are incorporated into the design and implementation of the project. This includes incorporating the new HVDC terminals into the MP Cyber security plan. Best practices, architectures, and technology can rapidly change. MP will build into our plan opportunities that will further strengthen the workforce, cyber security controls, protection, and detection technologies to help protect, and respond to cyber threats in the Bulk Electric System ("BES").

Project Controls Lead: Responsible for overseeing financial analysis and modeling activities to ensure favorable project economics and provide data used to inform decision-making within the project team.

Overall Construction Manager Lead: Responsible for oversight and coordination of the field construction managers, ensuring contractual adherence, construction documentation, inspections, and reports are completed. Additionally responsible for construction scheduling, input on sequencing in support of the project scope, schedule, and budget.

Community Benefits Lead: Responsible for developing and implementing project programs and initiatives that support the well-being of the community. Key advisor to the project team.

Safety Lead: Ensures that the project complies with all relevant safety regulations, standards, and guidelines to ensure a safe and healthy working environment for all employees. Establishes policies and training programs to reduce the risk of accidents, injuries, illnesses, and promote a positive safety culture throughout the organization.

Legal Lead: Responsible for ensuring that all legal aspects of the Project are addressed and managed effectively. Provides legal support and guidance to the project team. Ensures the project is legally sound, complies with all relevant regulations, and minimizes legal risks.

Each of these areas may require additional support from other internal subject matter experts or consulting expertise from outside of the company. Multiple key supporting roles report up through the lead positions. Utilization of consultants is planned for specialties that fall outside of internal expertise or are not able to be adequately staffed with internal resources. Additionally, aspects of construction management and inspection services may utilize consultants.

Other related projects will be completed in conjunction with the HTEC Project, including projects related to the minor upgrades of the transmission line and construction of the associated substations. This includes establishing key communication links between the converter stations, transmission line, and the substations as these are critical to the day-to-day operation of the HVDC System.

A variety of existing systems are in place to provide risk mitigation, as well as to aid in managing the technical aspects of the project. Internal discipline engineers are assigned to interface with the HVDC EPC supplier working on the technical design to ensure company standards are met and technical scopes of work are completed on time. In addition to the technical aspects, a project cost estimate and schedule is maintained and updated as needed throughout the project. Frequent and reoccurring check in meetings will be utilized with the project team to provide up to date information.

Contracting approaches may vary depending on the scope of various parts of the work. An EPC contract will cover the design, construction and commissioning of the converter stations. Additional risk mitigation measures include prequalification of major contractors utilizing ISNetworld. A project risk register will also be developed to identify, prioritize, and mitigate risk. The register is also a tool to establish appropriate levels of contingency through the life of the project. Union labor is planned for the construction of the project. A major project labor agreement is planned to provide consistency across the labor unions for the project. In the event local union labor is not available, prevailing wage will be utilized.

In the event of a significant change in project scope, the responsible project engineer will prepare a project change order request. Included will be the change, its impact on schedule, maintenance and operation, and an estimate of additional costs or savings resulting from the change. The change will be communicated to the Engineering Project Manager and Overall Project Manager. The Overall Project Manager will communicate the change to the Executive

Sponsor and members of the project team. Project Manager will also inform and seek approval from DOE for any significant scope changes.

QA/QC will be maintained through a gated process. Deliverables for each gate will be established. A construction management plan will be written by the Overall Construction Manager and will include a QA/QC plan for construction.

Project communications will be maintained through regularly documented meetings. The frequency and attendees will change over the life of the project. At a minimum, quarterly meetings to update the Management Committee are planned. More frequent and reoccurring project team meetings will be conducted. Bi-weekly or weekly meetings are anticipated for the design and construction phases of the Project for the relevant parties.

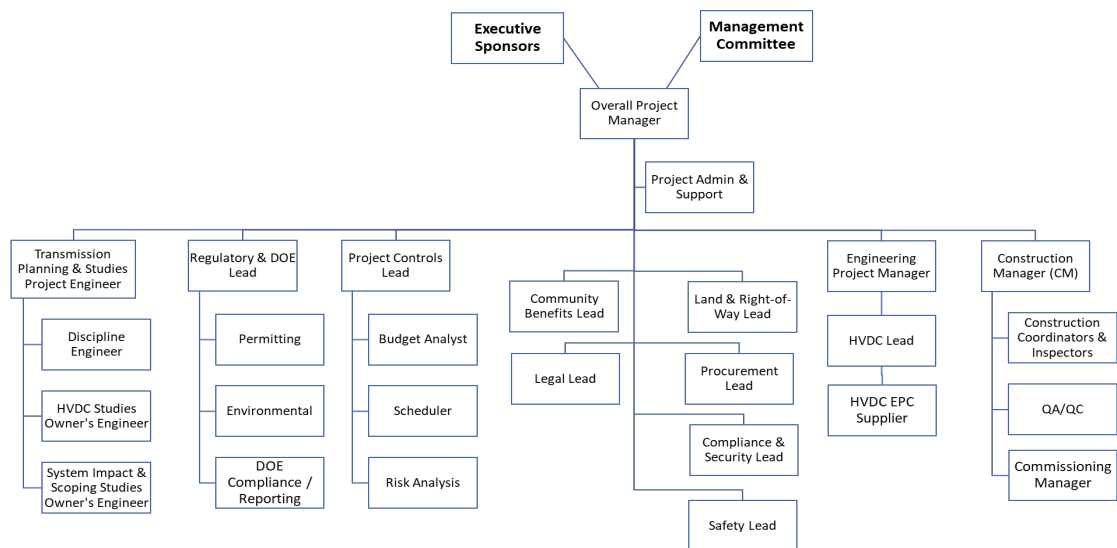


Figure 1: Project Organization Chart

TECHNICAL QUALIFICATIONS AND RESOURCES

MP has a long history of large capital project implementation and management as it has been responsible for regional transmission, distribution and generation assets to deliver reliable electric service to customers for over 116 years. MP takes an active role in the design, engineering, procurement and construction of its large capital projects. Furthermore, operation and maintenance of these facilities demands many small and large projects to replace and upgrade equipment during the lifetimes of these assets. Between the large initial build, upgrades, and retrofits, MP continuously exercises project management discipline.

Specific to the HTEC Project, MP has supported the operation of the Square Butte HVDC project for over 45 years and has experienced staff for daily operations. Between 1977 and 2009, MP operated the HVDC line jointly with Minnkota Power Cooperative (MPC) under the Square Butte Electric Cooperative. Each company supported the project with engineering and technical staff. When MP purchased the HVDC line in 2010, additional engineers and technicians were hired to replace the positions staffed by MPC. The HVDC system is unique to the transmission system in the way it requires periodic maintenance. The major outages are scheduled every third year with a large amount of work needing coordination. These major outages are treated as projects and are run as such. In that respect the staff is prepared for intense project work which keeps skills sharp for large capital projects. In addition to the three-year major outages, there are also two to four shorter outages each year based on need.

Throughout the life of the system there have been major upgrades including control replacement (2004), bushing replacement (2007-2013), valve cooling upgrades (2010), a 50 MW upgrade (2013) and AC protection replacements (2016 and 2018). Each of these projects spanned multiple years in order to complete engineering, procurement, and construction activities. The experience gained through these projects has given the project team the skill to successfully execute this project plan. Each of these projects was run by a team of individuals who have developed their skillset with the HVDC technology specifically and will contribute to the success of this the project.

MP has a long history of executing large projects with similar risk and complexity compared to the HTEC Project as the utility's infrastructure has been built up over the past 116 years. The most recently completed project is the Great Northern Transmission Line (GNTL), a 225 mile 500kV AC transmission line between Manitoba, Canada and near Grand Rapids, Minnesota. The GNTL took ten years from planning to completion and had a project cost of approximately \$700 million. It included several years of public outreach, permitting, and engineering followed by four years of construction. A key highlight of this critical infrastructure project was MP's commitment to stakeholder participation and outreach, creating an environment where there was very little stakeholder intervention on the project route. This commitment to stakeholder involvement was recognized by the White House and the DOE as how to permit and develop new transmission lines and ultimately resulted in the DOE's issuance of a Presidential Permit for the international border crossing. MP also received the strong support of the Red Lake Nation for this project based on this early stakeholder work. Along with the GNTL line, the Iron Range 500/230kV substation was built, one of the largest in MP's territory. GNTL went into service in June 2020.

Along with GNTL, MP also constructed the Warroad River Series Compensation station (WRSC). Series compensation is used on very long AC transmission lines to increase capacity and is typically located at the midpoint or ends of the line. In this case MP chose a location near Warroad, MN, at the midpoint of the line. The WRSC is a set of capacitor banks and ancillary equipment operated by a dedicated control system. It is also considered a type of Flexible AC

Transmission Systems (FACTS) device that has a lot of similarities to HVDC. The typical delivery mechanism for this type of device is an EPC contract with one of the limited number of global suppliers. Throughout the stages of that process the MP team remained engaged to review, comment, learn, and prepare to operate the system independently upon completion. The WRSC was placed in service in late 2020.

In 2019 MP added another FACTS device, a STATCOM, after several years of development, engineering, and construction. A STATCOM provides dynamic reactive support to the system which was needed due to the retirement of coal fired generating units. Similar to HVDC and series compensation, a STATCOM is a set of power electronics with a dedicated control system. This project used an EPC structure like the WRSC and was successfully completed on schedule.

Directly related to the existing HVDC system were several projects including a 50 MW upgrade that enabled MP to increase investment in renewable generation opportunities in North Dakota. The project consisted of raising approximately 120 transmission line spans along the line for additional ground clearance and replacing 48 transformer cooling units. The work required outages on the operating system and was managed over a three year period so the completion would coincide with wind generation coming online and AC system upgrades that were identified at the time the HVDC line was purchased by MP. This work was completed in 2013.

The successful execution of these projects demonstrates the dedication and skill of MP's teams and that MP can complete this type of project.

Internal Resources

Several key employees will be dedicated to the Project to help ensure its successful implementation. Transmission Planning team plays a large role, particularly in the development and scoping of the Project. They determine the performance needs of the electrical system and give boundaries to how the HVDC system needs to interact with other components of the grid. They will be a core player during the FEED and help to detail the technical specification, particularly the performance requirements. When the control and protection has been built, they will also attend factory acceptance testing to verify that the system meets specifications in a lab environment. It is expected that one to two members from the Transmission Planning team will spend one-third to one-half of their time on the Project from the beginning until EPC begins, then their commitment will reduce to one-quarter through the remainder of the project.

Power Delivery Engineering includes the designated HVDC engineers on staff at MP. They will play a key role throughout the project, spending half and at some points 100% of their time on the Project and will engage during the FEED so they understand the performance needs being designed into the system. They will also use their knowledge of the existing HVDC system to help shape the technical specifications, weighing in on aspects such as serviceability, safety, security, cyber security, environmental considerations, etc. Once the EPC begins they will be

actively participating in the detailed design in order to understand the need for each part in the system and why it was designed as such. During manufacturing they will be at the factory a substantial amount of time for witness testing and are also on site for a majority of the equipment installation and commissioning. The end goal for the HVDC engineers is to understand the system to successfully operate it for the next 30-40 years.

Project Management will also play a key role. There will be a Project Manager (PM) dedicated for at least 50% of their time for the duration of the Project and at points up to 100% as needed. The PM will also have supporting staff such as construction managers, schedulers, budget analysts, etc. that would spend 25-50% of their time on the project depending on the stage.

Aside from those key roles there are many others at MP who will participate. Other engineering disciplines will provide input including physical electrical, control, SCADA, civil, communications, etc. Beyond engineering there will be participation from system operations, security, purchasing, finance, and risk management; essentially all the supporting roles that make our business run on a daily basis.

External Resources

In addition to internal expertise, MP has long-standing relationships with partners who will support the HTEC Project. RBJ Engineering has worked with MP for over 20 years in a variety of capacities. They have performed system studies for new lines, helped with evaluation of HVDC technologies and the STATCOM project, and provided guidance on many other HVDC operational questions. MP has hired RBJ Engineering as the engineering consultant for the project.

MP has entered into a development agreement with Siemens Energy to execute this project. Siemens is a major supplier and has successfully completed many projects globally, including in North America. In fact, Siemens installed the world's first VSC modular multilevel-converter (MMC) project in 2010. The MMC architecture was a major advancement in VSC technology and has been the basis for VSC HVDC systems since. MP has past experience with Siemens on transmission and generation projects.

MP has worked with all currently anticipated partners for the HTEC Project during previous projects to successfully deliver them.