Alternative Evaluation Study

Center to Grand Forks 345 kV Line

Minnkota Power Cooperative, Inc.

Prepared for

Rural Utilities Service

Prepared by

Minnkota Power Cooperative, Inc.

&

HDR Engineering, Inc.

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Executive Summary

Minnkota Power Cooperative, Inc. (Minnkota) proposes to construct a 345 kV high voltage transmission line from the Milton R Young Station near Center, North Dakota, to the Prairie Substation near Grand Forks, North Dakota (Center to Grand Forks Line or Project). The length of this line would be approximately 260 miles. It would be constructed using single pole steel structures. Various modifications to associated substations in the area would also be required. The current cost estimate for the line construction is about $286 million with an additional estimated $37 million required for substation modifications. Financing support will be requested from the Rural Utilities Services (RUS) in the form of a loan or loan guarantee.

The need for this transmission project is driven by the transaction to reallocate existing transmission and generation assets. In response to its members' growing load requirements Minnkota has evaluated various options. The most economical and effective option is a mutually beneficial transaction with Square Butte Electric Cooperative (Square Butte) and Minnesota Power. With this transaction, Minnesota Power will release to Minnkota the rights to its share of generation from the Square Butte-owned Milton R Young Station Unit 2 (Young 2) power plant. This will allow Minnkota to increase its allocation of power from the Young 2 power plant from 50 percent to 100 percent over the next several years. In return, Minnkota will agree to release its rights for transmitting power from Young 2 on the Square Butte high-voltage direct-current (HVDC) transmission line that terminates near Duluth, Minnesota. This arrangement will allow Minnesota Power to acquire the DC line from Square Butte in 2010, and use it to develop and transmit wind power generated in North Dakota to its loads in Minnesota.

As presented in Section 2.3 of this Alternative Evaluation Study (AES), regional transmission-system studies since 2005 have shown that even without additional load growth, there are system voltage stability and load serving issues in eastern North Dakota and northwestern Minnesota. The existing AC transmission system is already operating at capacity. With future load growth, these issues are of even greater concern. The system studies show that additional transmission into the eastern part of North Dakota from the area of concentrated generation in central North Dakota is the preferred alternative to alleviate this condition. These same studies have shown that additional transmission lines, such as the Bemidji to Grand Rapids 230 kV Line, are independently needed in Minnesota.

Therefore, when the HVDC line is no longer continuously available to transmit Young 2 output in 2013, a new transmission line will be required. As reviewed in Section 3 of this AES, additional system studies have been completed which show that a 230 kV line would not be adequate. These studies also assessed the relative merits of a new 345 kV line from Center, North Dakota, to Fargo, North Dakota, or Grand Forks, North Dakota. Either alternative would improve voltage stability and load-serving capabilities in the area. However, the studies demonstrate greater benefits to the northern Red River Valley load-serving area when terminating the line at Grand Forks.

The proposed transmission line project would provide a direct link into Minnkota's service territory while providing a major improvement to the regional transmission grid. It would also provide a sound technical solution to the well-identified northern Red River Valley voltage stability issue.

As a transmission provider in an attractive wind resource area, the Minnkota interconnection request queue has received requests for several hundred megawatts of new wind generation. These requests are currently being studied to determine the system impact and the technical solutions (and associated costs) to implement the solutions. The impact of the proposed new transmission facilities is presented in Section 3.1.3 of this AES. Possibilities include tapping the proposed line and adding a second circuit to the Fargo area.

Input is being solicited from the public and from federal, state, and local agencies and governing bodies. This input will be used to shape the final scope and configuration of the Project.

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Table of Abbreviations

Abbreviation	Definition
ACSR	Aluminum conductor steel reinforced
ACSS	Aluminum conductor steel supported
ACSS/TW	Aluminum conductor steel supported/trapezoidal wire
AES	Alternatives Evaluation Study
Arrowhead	HVDC converter station near Duluth, Minnesota
CapX 2020	Capacity Expansion 2020 initiative
Center	Center 345 kV Substation located at the Milton R Young generating station located near Center, North Dakota
CIP	Conservation Improvement Program
DSM	Demand side management
HVDC	High voltage direct current
kcmil	thousand circular mils (conductor diameter)
kV	Kilovolt
kW	Kilowatt
Maple River	Maple River Substation located near Fargo, North Dakota
MAPP	Mid-Continent Area Power Pool
MHEX	Manitoba Hydro Export Interface
MISO	Midwest Independent Transmission System Operator
MPUC	Minnesota Public Utilities Commission
MVA	Megavolt-ampere
MVAR	Megavolt-ampere reactive
MW	Megawatt
MWh	Megawatt hour
N-1	Single contingency
N-2	Double contingency
NDEX	North Dakota Export interface
NEPA	National Environmental Protection Act
NERC	North America Electric Reliability Council
NMORWG	The Northern MAPP Operating Review Working Group
NMPA	Northern Municipal Power Agency
NORDAGS	North Dakota Group Study
OPGW	Optical Ground Wire
Prairie	Prairie Substation located near Grand Forks, North Dakota
PPA	power purchase agreements
P-V	Power-voltage
PVRR	Present value revenue requirements
RUS	Rural Utilities Service
SIL	Surge impedance load

Abbreviation	Definition
SVC	Static VAR compensator
TIPS	Transmission Improvement Planning Study
VAR	Volt-ampere reactive
WAPA	Western Area Power Administration
Young 2	Milton R Young Station Unit 2
Young 3	Milton R Young Station Unit 3

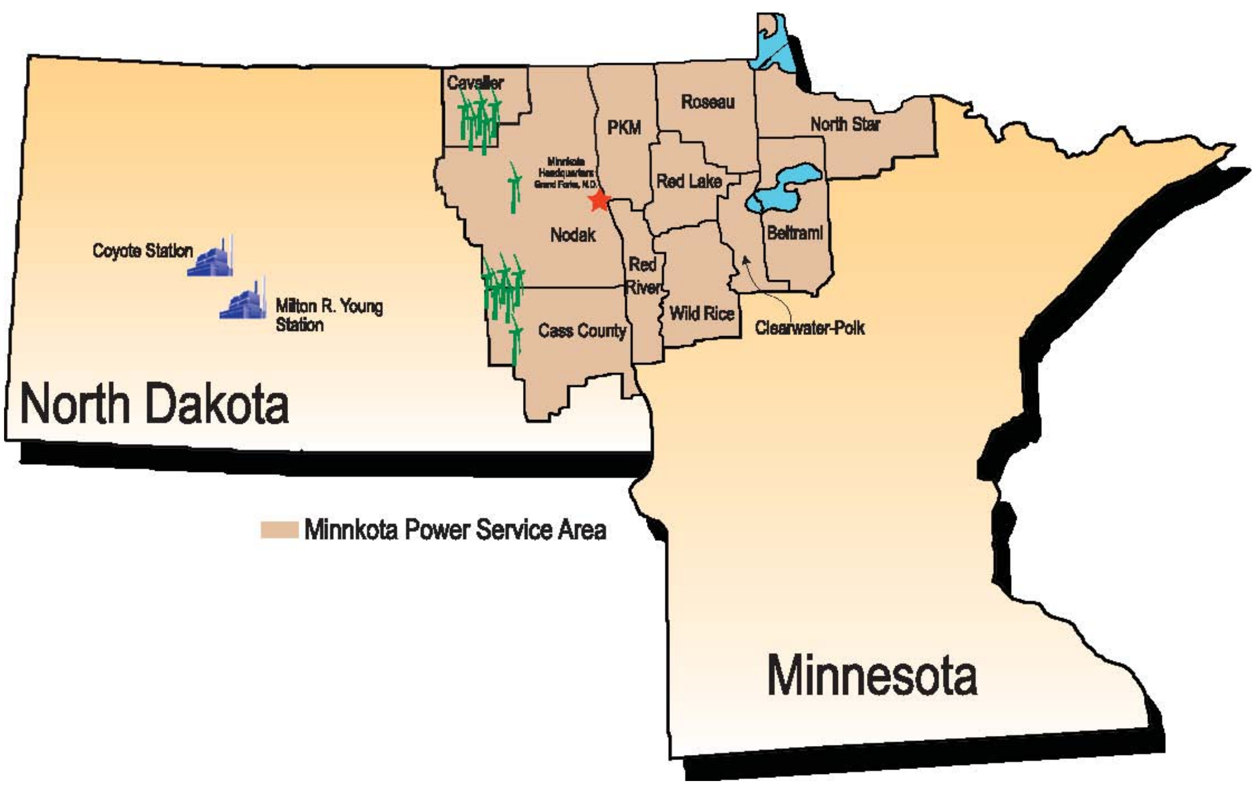
Section 1 Introduction

1.1 Background

This Alternative Evaluation Study (AES) was prepared by Minnkota Power Cooperative, Inc. (the Applicant or Minnkota) and HDR Engineering, Inc. to support the proposed action to construct an approximately 260-mile long, 345 kV transmission line between Center and Grand Forks, North Dakota (Project).

Minnkota is a wholesale electric generation and transmission cooperative headquartered in Grand Forks, North Dakota. Incorporated in 1940, Minnkota provides, on a nonprofit basis, wholesale electric service to 11 retail distribution cooperatives which are the members and owners of Minnkota. These co-ops, in turn, serve approximately 125,000 of the 300,000 retail customers in the area, including many of the region's schools, farms, homes and businesses such as LM Glasfiber (a wind turbine blade manufacturer) and Polaris Industries. The member systems' service areas encompass 34,500 square miles in northwestern Minnesota and the eastern third of North Dakota (see Figure 1-1 below).

Figure 1-1. Map of Minnkota Service Areas



Minnkota also serves as operating agent for the Northern Municipal Power Agency (NMPA), headquartered in Thief River Falls, Minnesota. NMPA is the energy supplier for 12 municipal utilities located within the Minnkota service area.

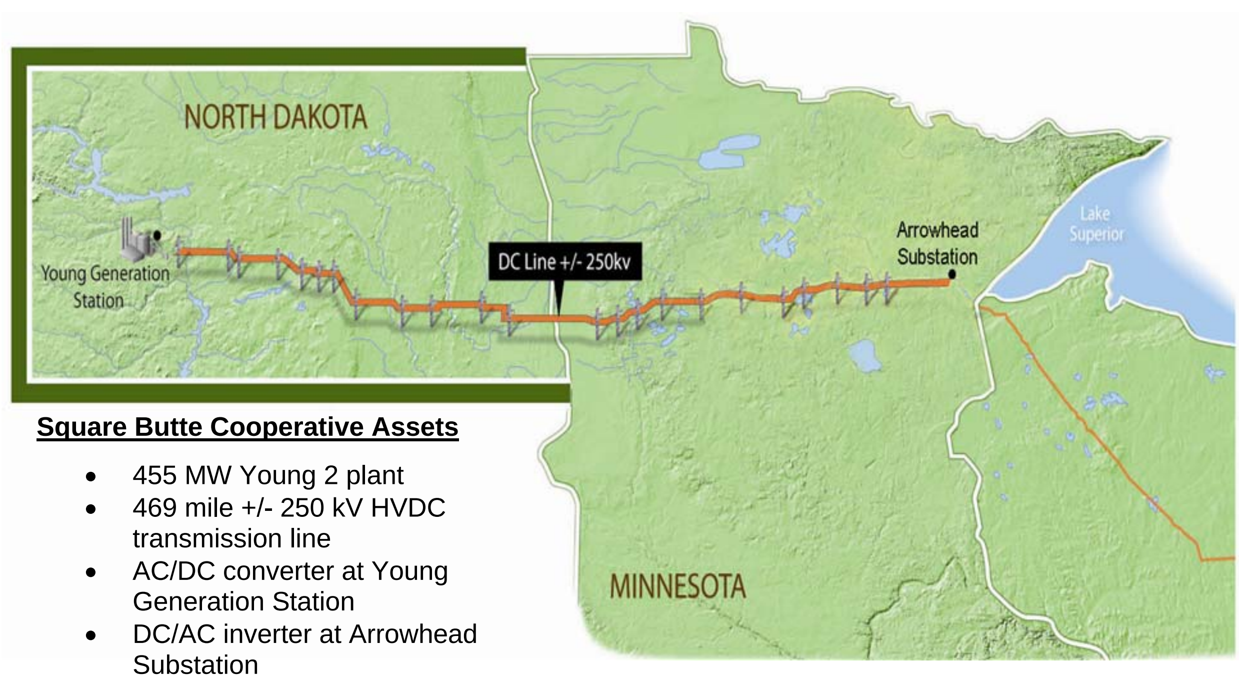
The primary source of base-load generation for the rural cooperatives is the Milton R Young Station located approximately 40 miles northwest of Bismarck, North Dakota, near the community of Center, North Dakota. As operating agent for the NMPA members, Minnkota oversees NMPA's 30 percent share of the output from the Coyote Station near Beulah, North Dakota. In addition, Minnkota has acquired, through recent power purchase agreements (PPAs) with large wind developers, significant North Dakota-based wind energy resources that will total 357 MW nameplate capacity by 2010.

Minnkota intends to obtain financing for ownership of the Project from the Rural Utilities Service (RUS). Minnkota would also operate and maintain this facility. RUS financing of the Project constitutes a "federal action," which requires RUS to conduct an environmental review under the National Environmental Protection Act (NEPA). This AES is one of the preliminary documents RUS requires in conducting an environmental review, and it was developed in accordance with the requirements of RUS Bulletin 1794A-603, *Scoping Guide for RUS Funded Projects Requiring Environmental Assessments with Scoping and Environmental Impact Statements* (Feb. 2002). It is designed to provide information about the proposed action to federal, state, and local agencies, and to the public to facilitate its participation in the NEPA process.

The AES describes the need for a new transmission line to deliver power from the existing Milton R Young Station Unit 2 (Young 2) power plant located near Center, North Dakota, to a delivery point in Minnkota's service area near Grand Forks, North Dakota.

Young 2 (455 MW) is owned by Square Butte Electric Cooperative (Square Butte) and is operated by Minnkota. Square Butte was formed in 1972 by the same 11 distribution cooperatives that are member/owners of Minnkota. Square Butte financed and constructed Young 2 and the 469 mile +/-250 kV HVDC transmission line with its associated AC/DC converter and DC/AC inverter stations that carries power generated by Young 2 to the Arrowhead terminal near Duluth, Minnesota. See Figure 1-2 below.

Figure 1-2. Square Butte Cooperative Assets



Minnkota and neighboring Minnesota Power Company (Allete) have had a long-standing business relationship associated with the Square Butte project. Minnesota Power currently has operating responsibility for the HVDC transmission system. Minnkota and Minnesota Power share maintenance responsibilities for the Square Butte HVDC transmission facilities.

Minnkota and Minnesota Power have established long-term power-purchase agreements (PPAs) with Square Butte for the energy output from Young 2. Transmission service agreements for transmission capacity on the Square Butte HVDC transmission system are also in place. The percentage of Young 2 output allocated to Minnkota and Minnesota Power has varied over time and is currently at 50 percent to each company.

In 2006, Minnkota and Minnesota Power began a joint effort to study options for meeting their respective future energy supply needs.

Historically, Minnkota's load has grown at a rate of 2.93 percent annually over the past 10 years. Furthermore, Minnkota's 2007 Load Forecast study shows that load will continue to grow at a rate of approximately 2.5 percent annually over the next 20 years. It is expected that much of this load growth will have a high load factor. Thus, Minnkota must increase its base-load generation resources to accommodate this future load growth. Adding a third unit at the Milton R Young Generation Station (Young 3) was identified as a prime candidate for meeting future load growth requirements. A system impact study was undertaken to determine the transmission requirements and impacts of a Young 3 generation addition to the AC transmission system. Although the Young 3 project is no longer being pursued, many of the results of this study are valid for the transition of Young 2 power onto the North Dakota AC system.

While exploring the potential for partnership in Young 3, Minnesota Power also identified a need to increase its renewable resource portfolio. Having previously selected the area near the Milton R Young plant as a viable and productive wind generation resource, Minnesota Power expressed interest in expanding this resource.

In 2008, Minnkota was approached by Minnesota Power with a proposal to restructure the agreements with Square Butte. By January 1, 2010, action will have been taken to amend Minnkota's and Minnesota Power's PPAs with Square Butte to increase the amount of energy Minnkota receives from Square Butte's Young 2 station from 50 percent to 100 percent between the years 2013 to 2026. In exchange, Minnkota will also amend its agreement with Square Butte to release its share of capacity in the Square Butte HVDC transmission system. This will facilitate Square Butte selling the HVDC system to Minnesota Power.

This transaction and modified PPAs will fulfill objectives of both companies. Minnkota will have access to additional base-load generation from a resource with a well established record of low cost, reliable power generation with a dedicated and dependable fuel source. Minnesota Power will be able to utilize the HVDC transmission system to transmit power from future wind power resources in central North Dakota to the Duluth, Minnesota, area. The higher capacity factor wind farms in North Dakota will provide a more cost-effective means for Minnesota Power to meet future renewable energy portfolio standards established by the state of Minnesota.

As the Square Butte HVDC transmission system currently provides the primary transmission path for generation from the Young 2 plant to serve Minnkota's loads in northeastern North

Dakota and northwestern Minnesota, a new AC transmission line would be required. This line will provide a more direct path from Young 2 generation to Minnkota's loads and will facilitate the development of additional wind generation in North Dakota by Minnesota Power for delivery to eastern Minnesota on the existing HVDC transmission system.

To facilitate this transaction and modified PPAs, Minnkota must establish this new transmission path from Young 2 and transition off of the HVDC line by 2013. This transmission path would consist of a new 345 kV AC transmission line from the Center 345 kV Substation near Center, North Dakota, to a centrally located substation (Prairie) near Grand Forks, North Dakota.

After 2026, the Square Butte to Arrowhead HVDC line may be used exclusively for transmitting power from proposed wind farms in North Dakota. Several hundred megawatts of wind generation are being considered for interconnection at the Square Butte 230 kV Substation by other parties. As a result of the HVDC line being reallocated for the transmission of wind energy, the only available transmission outlet for Young 2 will be the North Dakota AC transmission system, which drives the need for the proposed Center to Grand Forks 345 kV transmission line project.

1.2 Project Description

The Applicant proposes to construct a 345 kV transmission line from Center, North Dakota, to Grand Forks, North Dakota. Proposed corridors for this Project are shown in Figure 1-3 and Figure 1-4 below.

The proposed Center to Grand Forks Project would consist of the following six major components.

- 345 kV High Voltage Transmission Line – Consisting of about 260 miles (based on the average length of typical routes within the study corridor) of new high voltage transmission line from the Center 345 kV Substation at the Milton R Young generating station near Center, North Dakota, to the Prairie Substation near Grand Forks, North Dakota. A crossing of the Missouri River in central North Dakota would be required. The Center to Grand Forks Project would serve to deliver existing baseload generation to Minnkota's members.

  While final engineering and design has not been completed, the line would likely be constructed with single-pole steel structures. These structures may be designed with double circuit capability, which will allow significant upgrades. Typical structures would be approximately 150 feet high and be placed approximately 1,000 ft apart. The typical right-of-way (ROW) for a single pole 345 kV line is approximately 150 ft wide. It is anticipated that the Project would use 795 kcmil (thousand circular mils (conductor diameter)) or 954 kcmil ACSR (aluminum conductor steel reinforced) or ACSS (aluminum conductor steel supported) conductors (bundled) with a minimum thermal capacity of approximately 960 MVA (mega volt-ampere). The conductor size or type may need to be modified once the ultimate route is selected and additional electrical optimization studies are completed.
- Center 345 kV Substation Upgrades – All upgrades would occur within the existing substation's (owned by Otter Tail Power Company) fenced boundary. This would involve installing new 345 kV circuit breakers and 345 kV dead-end structures, a new

345/230 kV transformer and associated bus work, new 345 kV switches, and associated foundations, steel structures, and control panels. The existing 345/230 kV transformer may be replaced with a larger transformer for reliability improvement. A line reactor for open line voltage control may also be required.

- Second 230 kV tie line –This 1,500 ft 230 kV tie line between the Center 345 kV Substation and the Square Butte 230 kV Substation would parallel the existing tie line on Minnkota-owned property. It would be needed to complete this transmission to transmission interconnect with the Square Butte 230 kV substation.
- Square Butte 230 kV Substation – Existing 230 kV circuit breakers and line terminal equipment would be reallocated from the existing HVDC tie line to the new 345 kV interconnect as part of the agreement with Minnesota Power.
- Prairie Substation Upgrades – All upgrades would occur within the existing Minnkota-owned substation's fenced boundary. This would involve installing new 345 kV circuit breakers and 345 kV dead-end structures, two new 345/230 kV transformers and associated bus work, new 345 kV switches, and associated foundations, steel structures, and control panels. New 230 kV circuit breakers would be added to accommodate interconnecting with the existing 230 kV ring bus. Existing transmission line termination would be required to be moved to convert the ring bus into a breaker-and-a-half bus arrangement.
- Fiber Optic Regeneration Stations – Two or more fiber optic regeneration stations would be required along the transmission line route to re-amplify the protection and control signals carried in the optical ground wire (OPGW). Each station would require a 50 ft by 50 ft fenced area and small control building to house the electronic equipment.

The cost of constructing the proposed 345 kV line is estimated to be in the range of $1.1 to $1.8 million per mile in 2009 dollars (including ROW, permitting, and other ancillary costs) with a total estimated cost for line construction of approximately $286 million. An additional estimated $37 million will be required to modify the terminus substations near Center and Grand Forks for a total estimated construction cost for the Project of $323 million for a 260 mile line length. The Applicant has a target completion date for the Project of January 1, 2013.

Studies are underway to address third party impacts to neighboring transmission systems as well as to address the needs of potential interconnection customers who have requests listed on Minnkota's interconnection queue[1]. The results of these studies may indicate a need to increase the overall scope of this Project. Such scope changes could include the addition of one or more project components as described in Section 3.1.3 part B sub. b. The cost of these project additions would be borne by the beneficiaries of the additions.

[1] Current requests are for wind energy development projects.

Figure 1-3. Proposed Project Corridors

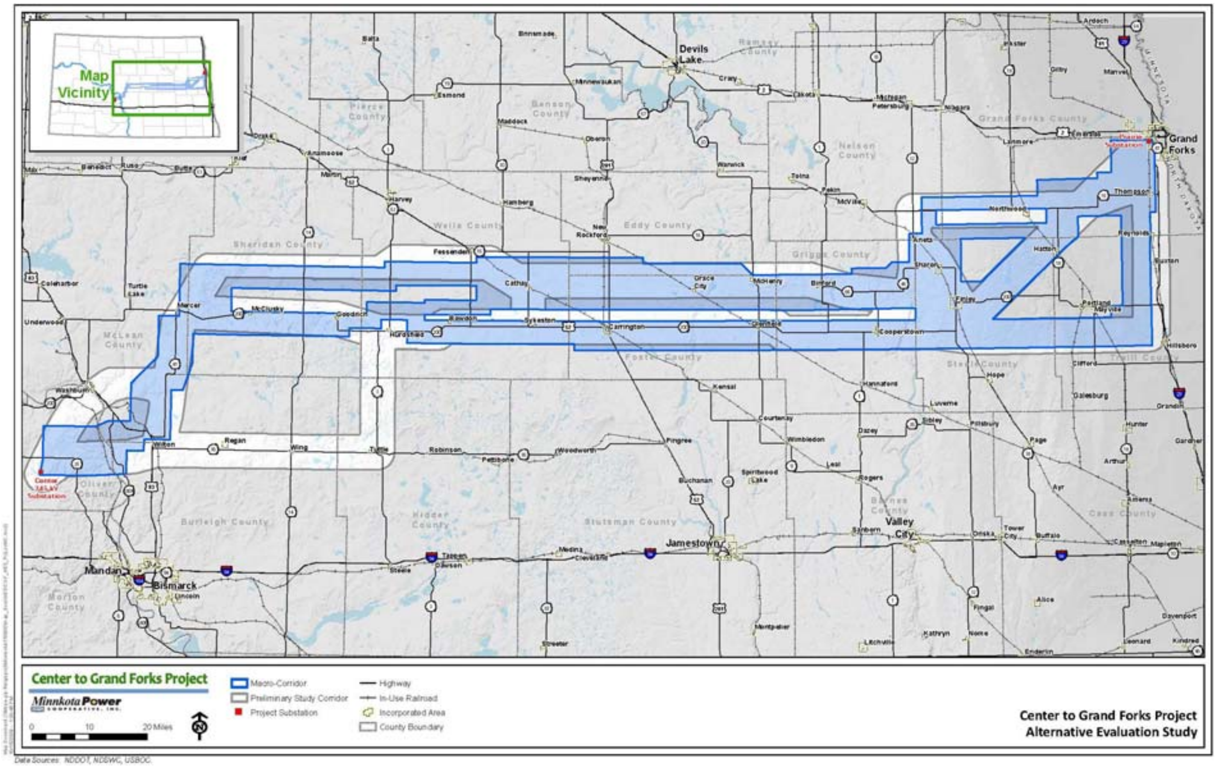
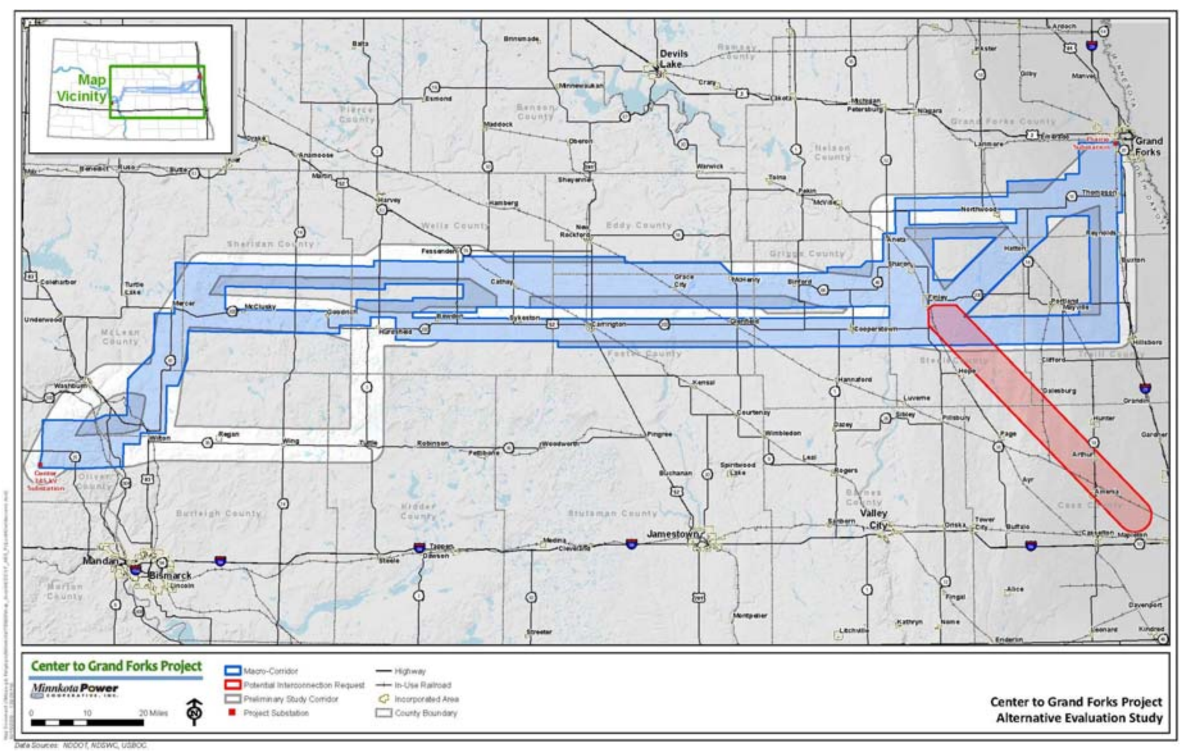


Figure 1-4. Proposed Project Corridors (blue) with Optional Corridor Concept (red) for Interconnection Requests



Section 2 Purpose and Need

By the year 2013, an alternative to using the existing HVDC system as a means of delivering energy from Young 2 to Minnkota's service area must be in place. Additionally, various regional transmission studies have been performed that demonstrate the need for additional transmission to enhance voltage stability and load serving capability to the Red River Valley region. Minnkota has completed various transmission system scoping and feasibility studies and has determined that a single 345 kV transmission line from Center to Grand Forks greatly enhances both Red River Valley voltage stability and Minnkota's ability to serve its load. This Section discusses the basis for that conclusion.

2.1 Overview of Minnkota's System

Minnkota's current transmission/distribution system consists of approximately 3,000 miles of high voltage AC lines (69 kV to 345 kV), 33,000 miles of distribution lines, and more than 200 transmission and distribution substations. Most of this infrastructure is located in the Red River Valley region of eastern North Dakota and northwestern Minnesota as shown in Figure 2-2 (Page 9).

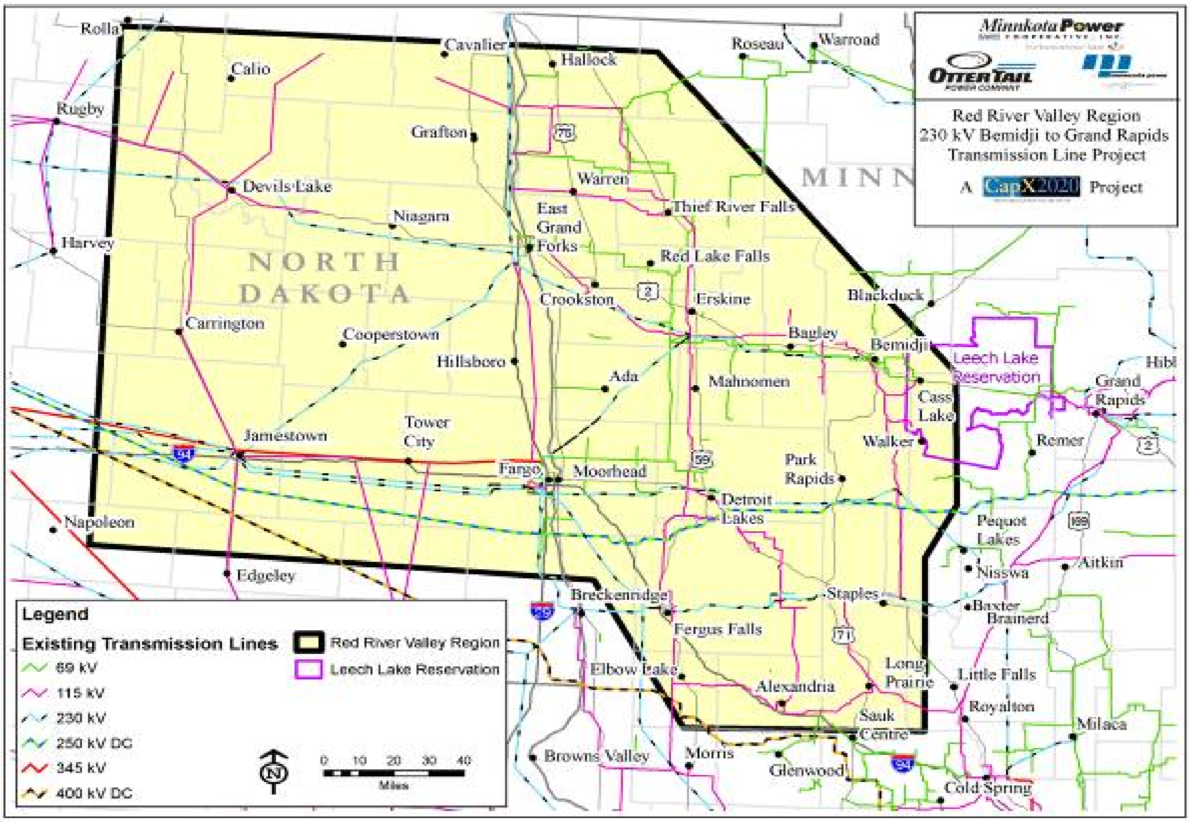
2.2 Overview of Eastern North Dakota and Red River Valley Regional Transmission System

The bulk electric transmission system in the Red River Valley primarily consists of a 230 kV network. There is a single 210-mile 345 kV connection from the Milton R Young generating station near Center, North Dakota, to the Maple River substation near Fargo, North Dakota. With the exception of recent and rapidly developing wind farms, nearly all of the power supply to the Red River Valley is from remote generation sources. The nearest base-load generation resources are to the west in central North Dakota and to the north in Manitoba Province, Canada. As a result, prevailing power flow through the Red River Valley region is typically west-to-east and north-to-south.

South-to-north power flows can occur during adverse hydrological conditions in Manitoba, which is served primarily by hydroelectric generation. The great majority of Manitoba's hydroelectric generation is in the northern part of the province. Two long HVDC lines provide the transmission connection between the northern generation and the load center in southern Manitoba. Manitoba Hydro (MH) has established long-term power purchase and capacity exchange agreements with United States power suppliers to sustain adequate service to their loads in the event of a problem with the MH HVDC system. These agreements require that adequate transmission capability be maintained to enable both northward and southward power transfers at all times of the year and all load levels.

During the mid-1990s, large capacitor installations were made at the Prairie 115 kV Substation (12 x 40 MVAR (Megavolt-ampere reactive)) near Grand Forks, North Dakota, the Sheyenne Substation in Fargo, North Dakota (5 x 40 MVAR), and the Ramsey substation near Devils Lake, North Dakota (2 x 30 MVAR). These capacitors were installed to maintain acceptable voltages in the Red River Valley during various regional flow patterns and transmission contingencies. See Figure 2-1 below, which was developed for the Bemidji to Grand Rapids Project Alternatives Evaluation Study previously submitted to RUS by the Bemidji to Grand Rapids project participants.

Figure 2-1. Red River Valley Transmission System

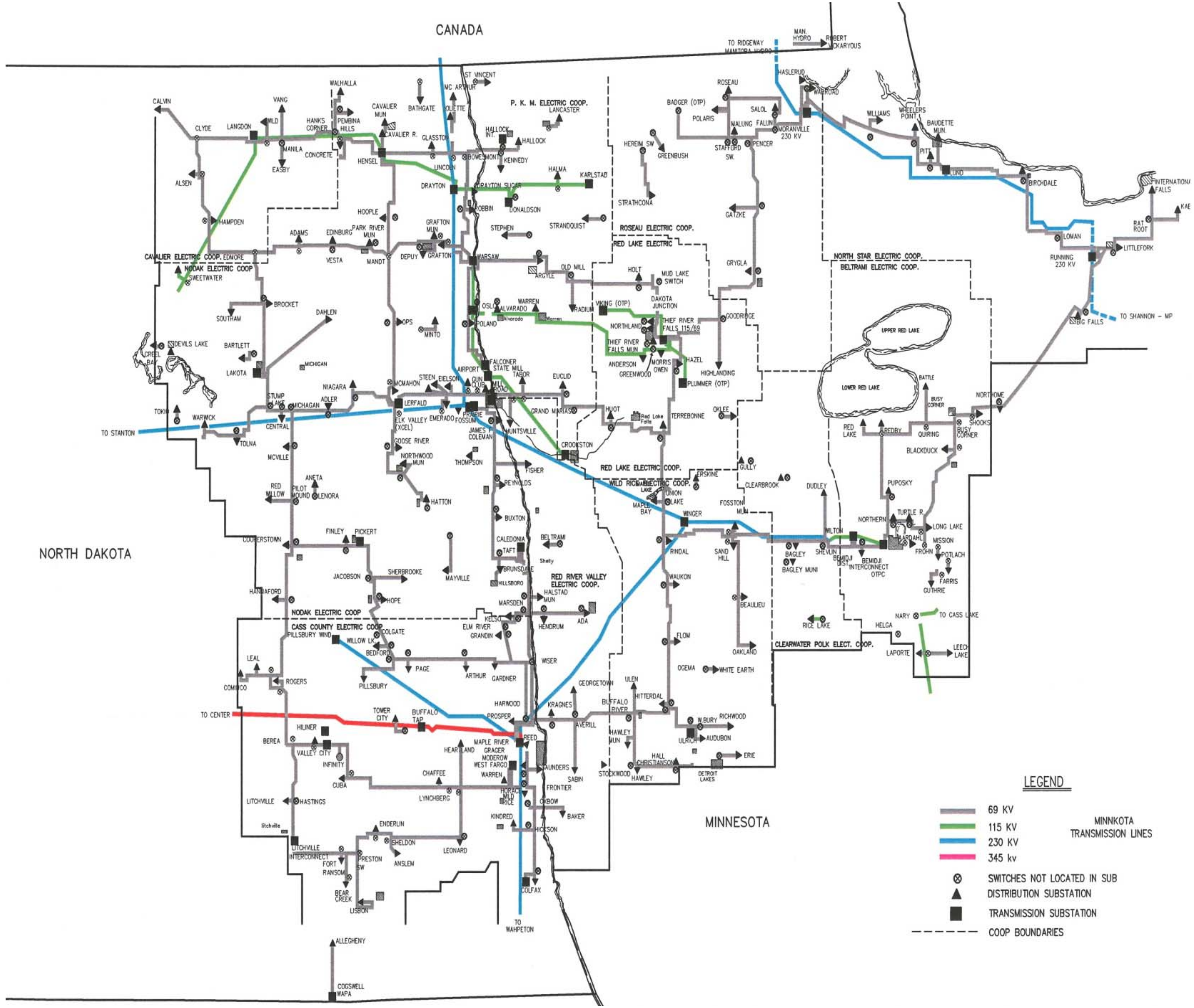


Load-serving capability in the Red River Valley is constrained by post-contingent voltage and loading concerns.

Peak load conditions result in high reactive power losses on the transmission grid, contributing to the risk of regional voltage collapse. The performance is of greatest concern during times when Manitoba is importing power from the United States. During these stressed system conditions, a prolonged outage of a high voltage transmission line in the area is difficult to sustain.

In the summer of 2000, the McHenry–Ramsey 230 kV line, which establishes a 230 kV tie from western North Dakota to Grand Forks, had about 10 miles of structures knocked down by severe storms. A coordinated emergency mobilization of the regional utilities' construction crews enabled the line to be temporarily restored to service in early December of that year to prepare for peak winter loads throughout the region. The resulting sustained outage raised operating concerns. The Northern MAPP (Mid-Continent Area Power Pool) Operating Review Working Group (NMORWG) alerted regional utilities of the potential risk of voltage collapse in the Red River Valley for various critical contingencies and system operating parameters.

Figure 2-2. Minnkota Transmission System



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2.3 Regional Transmission System Studies and Analyses

The need for the Center to Grand Forks line is supported by various transmission system studies. These studies analyzed transmission issues in west-central Minnesota and eastern North Dakota (Red River Valley). Minnkota's service area is in the center of this geographic area. A brief history of the studies is provided below. Additional system studies have been completed to identify the best alternative for meeting this need. These studies are discussed in Section 3.

2.3.1 2005 CapX 2020 Technical Update

Minnesota's largest transmission-owning utilities launched the Capacity Expansion 2020 (CapX 2020) initiative in 2004. This initiative focused on prioritizing the transmission infrastructure investments needed in Minnesota to meet the growing demand for electricity in the region and to ensure timely and efficient regulatory review and approval of those investments. The result was the CapX 2020 Vision Plan. This plan and other information about this initiative can be found at <www.capx2020.com>.

CapX 2020 released its written report in May 2005 describing its planning effort. The report is entitled *CapX 2020 Technical Update: Identifying Minnesota's Electric Transmission Infrastructure Needs*. The Technical Update is on the CapX webpage at: <http://www.capx2020.com/Images/5-11-05%20CapX2020%20Tech%20Update.pdf >. This study concluded that a number of new high-voltage transmission lines will be required to accommodate the Red River Valley and surrounding region's increasing demand for electricity, and the additional generation capacity required to meet that demand. The Bemidji, Minnesota, to Grand Rapids, Minnesota, 230 kV Line[2], and the Fargo, North Dakota, to Monticello, Minnesota, 345 kV line[3] were preferred transmission alternatives for this region. They were shown to be effective in: 1) addressing the voltage stability and load serving needs of Bemidji and other principal load centers within the Red River Valley, and 2) improving the load-serving capability of the transmission system in Minnesota and the surrounding region to meet the load growth anticipated by 2020.

2.3.2 2005 Minnesota Biennial Transmission Projects Report

In 2005, sixteen utilities that own or operate high voltage transmission lines in Minnesota prepared the third Minnesota Biennial Transmission Projects Report (2005 Biennial Report) for the Minnesota Public Utilities Commission (MPUC or Commission). The Biennial Report was prepared pursuant to Minnesota Statutes, Section 216B.2425, which requires utilities owning or operating electric transmission facilities in the state to report on the status of the transmission system, including present and foreseeable inadequacies and proposed solutions.

Referencing the 2005 CapX 2020 Technical Update, the 2005 Biennial Report indicated that upgrades of the Red River Valley's transmission system were necessary to handle the increasing loads in the region and maintain reliable voltage stability margins. The 2005 Biennial Report included preliminary study results of four new transmission options, which indicated that the combination of the Bemidji to Grand Rapids 230 kV line and the Fargo to

[2] This line is described as the Boswell-Wilton 230 kV line in the Technical Update

[3] This line is described as the Fargo-Alexandria-Benton County 345 kV line in the Technical Update

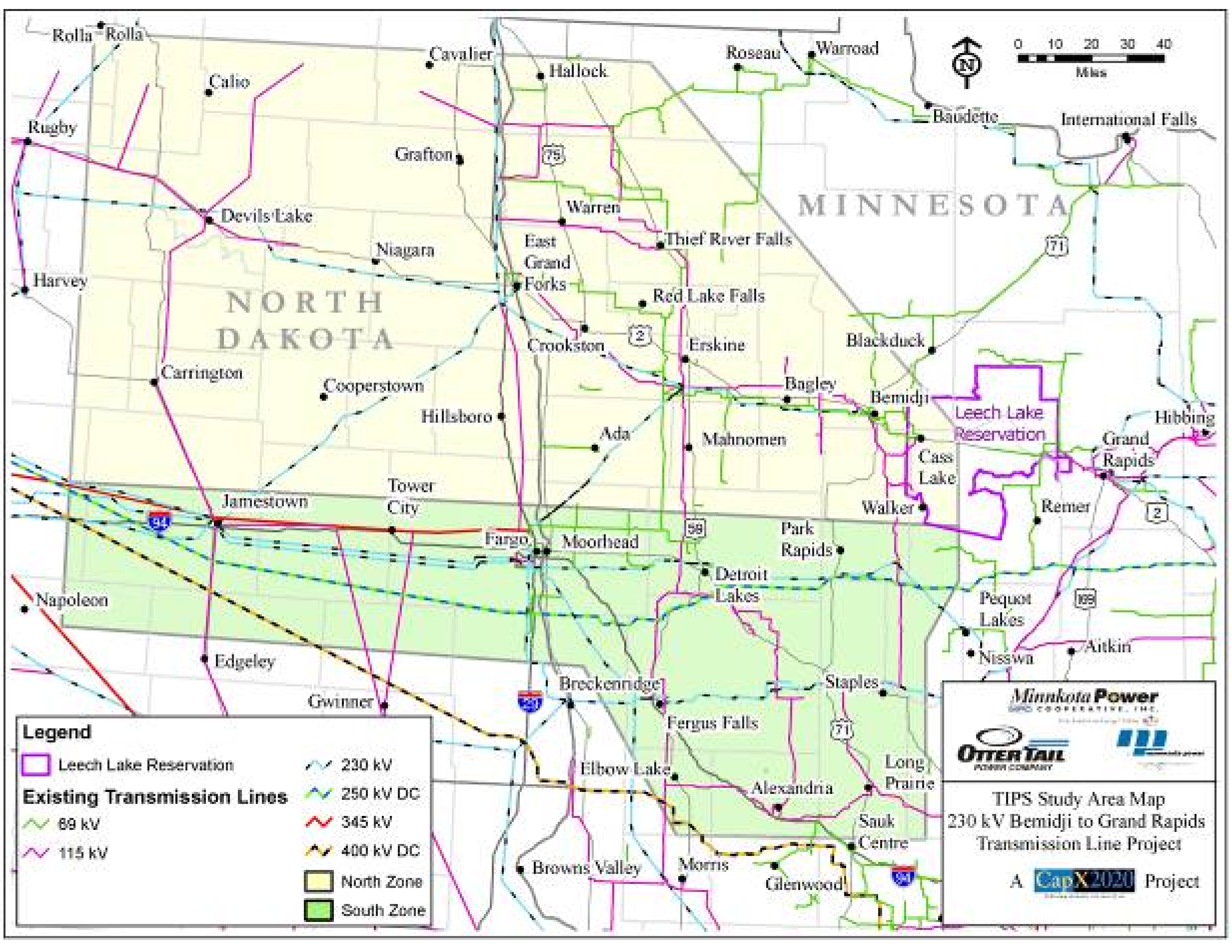
Monticello 345 kV line would provide the most robust, economic, and efficient transmission solution to address the concerns regarding the Bemidji and Red River Valley areas' voltage stability and load-serving capability.

2.3.3 2006 Red River Valley/Northwest Minnesota Load-Serving Transmission Study (2006 TIPS Update)

In 2006, the CapX 2020 group collaborated on a study to verify that the proposed transmission solutions were valid and optimal in addressing specific voltage stability issues and load serving deficiencies within the Red River Valley. The study report was called the TIPS Update because it followed several previous efforts, which had become known as the TIPS (Transmission Improvement Planning Study) studies. Two transmission projects in particular were investigated, the Bemidji to Grand Rapids 230 kV line, and the Fargo to Monticello 345 kV line.

For the study, the Red River Valley was divided into zones, as shown in Figure 2-3, below, which was developed for the Bemidji to Grand Rapids Alternatives Evaluation Study. These zones were: the northern portion of the Red River Valley region (North Zone), the southern portion of the Red River Valley region (South Zone), and the entire Red River Valley region (Combined Zone).

Figure 2-3. TIPS Update Study Area



Consistent with previous studies, the 2006 TIPS Update confirmed that transmission improvements are needed to maintain post-contingent voltages above established criteria. Whereas the Fargo to Monticello 345 kV line showed promise in supporting the Combined Zone, the Bemidji to Grand Rapids 230 kV line provide the greatest benefit to the Northern Zone of the Red River Valley.

A review of the power system topology and loading levels lends insight into the TIPS results. The transmission interface into the North Zone consists of four 230 kV lines. The South Zone has one 345 kV line and nine 230 kV lines. The Bemidji to Grand Rapids line will add one 230 kV circuit to the North Zone, and the Fargo to Monticello line will add one 345 kV circuit to the South Zone.

The historic peak loads, as presented in the TIPS report, summed to 1,880 MW of non-coincident peak load in the North and South Zones. Given that nearly half of this load (45 percent) was in the North Zone, it is clear that the North Zone transmission system is in the greatest need of development.

2.3.4 North Dakota Group Study (NORDAGS) – December 14, 2007

In 2007, Minnkota and three other utilities in the region assessed the possibility of jointly building a third generating unit (Young 3 – 600 MW) at the Milton R Young power station. As part of that assessment and as part of the MISO (Midwest Independent Transmission System Operator) interconnection study process, Minnkota commissioned a system impact study. Two other generation projects were included in the study, because they were located in the same general area in North Dakota. The MISO queue information for this group study was:

- G531: 68 MW facility upgrade at the Stanton generation plant in Mercer County, North Dakota – MISO Queue # 38534-01
- G581: 600 MW (Young 3) steam generation facility in Oliver County, North Dakota, with connection to the Minnkota transmission system at the Center 345 kV bus – MISO Queue # 3871301
- G607: 25 MW facility upgrade at the Coyote generation plant in Mercer County, North Dakota – MISO Queue # 38777-01

This study evaluated the collective impact of the proposed projects on the transmission system and is referred to as the North Dakota Group Study (NORDAGS). The study comprised stability, steady-state, constrained interface, and short-circuit analyses. MISO performed a separate Deliverability Study to identify any additional upgrades that may be required for Network Resource status.

The proposed projects were all expected to be in service by 2015. Some prior-queued generation projects were excluded from the study models due to lack of sufficient information on those studies at the time the NORDAGS study started.

The primary findings of this study were that a significant transmission system improvement would be needed to achieve acceptable performance under system intact and contingency conditions. Options included a new 345 kV transmission line from Center to either Fargo or Grand Forks, and adding switched shunts and static VAR (volt-ampere reactive) compensation at strategic locations within the region.

Although the Young 3 project is no longer being pursued, many of the results of the NORDAGS study are valid for the transition of Young 2 power onto the North Dakota AC system.

2.4 Conclusion of Purpose and Need

The aforementioned studies point to the need for additional transmission infrastructure to meet the need for delivering Young 2 power to the Minnkota load through the AC transmission system. This will be necessary as a result of the amendments of the PPAs between Square Butte, Minnkota, and Minnesota Power. Minnkota's share of the Young 2 output will increase from 50 percent to 100 percent, and the capacity of the existing Square Butte HVDC transmission line will be allocated to Minnesota Power for wind generation development in central North Dakota.

The NORDAGS study, discussed in Section 2.3.4 above, identified several viable transmission projects that could support acceptable dynamic and steady state performance for the added loading that a 600 MW power plant at Center, North Dakota would place on the AC system. It provides helpful insight into an appropriate AC transmission improvement after Young 2's 455 MW of power is transitioned off of the Square Butte HVDC line.

The TIPS Update study discussed in Section 2.3.3 provided definition of the steady state and voltage stability limitations for serving the loads in eastern North Dakota and west-central Minnesota. It outlined a constrained region, and further divided it into northern and southern zones. This information helps to ensure that transmission outages of critical tie lines into the constrained region are analyzed when considering suitable transmission improvements to the area.

The study results demonstrate the need to establish a transmission project. This project meets the requirements of providing a plant outlet and improved voltage stability in Minnkota's load serving region.

Alternatives for this line are discussed in the next section.

Section 3 Alternatives Evaluated

3.1 Transmission Alternatives

According to RUS Bulletin 1794A-603, § 3.1.1, when there is a need for additional capacity in an area, the Applicant responsible for serving the area may address the need with upgrades of the existing power system, new transmission, new generation, power purchases, load management, or energy conservation. A proposed action to meet the capacity need must be analyzed along with the other relevant alternatives. Since the transaction and modified PPAs with Minnesota Power and Square Butte, and the sale of the existing HVDC line to Minnesota Power, as described in Section 1.1, eliminates the need for new generation and any additional power purchases, load management, or energy conservation, the only relevant alternatives are those associated with transmission capacity to move the generation to load.

This section discusses the following alternatives to the proposed Center to Grand Forks 345 kV Line: 1) a no-action alternative that focuses on using the existing AC system for the output of Young 2, 2) a 230 kV line from Center to Grand Forks, and 3) various configurations of a 345 kV line from Center to the Red River Valley, including an eastern terminus of Fargo instead of Grand Forks. This section also explains why these alternatives are unacceptable or less than optimal in comparison with the proposed transmission line.

3.1.1 No Transmission Addition

The substantial wind generation development at the Square Butte bus, and subsequent reallocation of Young 2 outlet, results in significant steady state and dynamic stability impacts on the AC transmission system in the North Dakota coal field region. Study efforts have been completed to evaluate these impacts. The studies have revealed significant problems in system performance for the "no transmission addition" alternative. The study results are summarized below.

A. Young 2 AC Transmission Outlet Study – Preliminary Near-Term Analysis Results – June 15, 2009

Minnkota commissioned ABB to perform a technical study to evaluate near term issues of exporting power from the Young 2 generating unit to the North Dakota AC transmission system.

A typical study goal for out-year studies is to demonstrate that the project under study does not degrade the dynamic response to regionally limiting faults. This approach is used, instead of simply watching for criteria violations, because of other unanticipated transmission and generation system developments that may take place before the project is in service. Minimum dynamic swing voltages at critical buses are compared in the pre- and post-project models to document impact. In the "no transmission addition" case, the Young 2 AC transition caused an 8 percent reduction in the minimum dynamic voltage for the most limiting fault. Demonstration of "no degradation" would require that the change be zero or positive at the critical bus. Therefore, affected neighboring transmission owners would normally not accept this impact.

In addition to regional fault review, faults near the Young 2 location were also studied. For the "no transmission addition alternative," several local faults produced dynamic under-voltage violations on the existing 345 kV outlet from Center, North Dakota.

B. Young 2 AC Transmission Outlet Study – 2015 Summer Off-Peak Powerflow Analysis Results – June 23, 2009

Steady state flow impacts were analyzed on the Center, North Dakota, area AC transmission system for the "no transmission addition" case. This evaluation was done for the summer off-peak condition, with generation assumptions consistent with a 2015 time frame. The summer off-peak condition is generally considered to be the most limiting because it results in the maximum amount of power being exported from the region.

One outlet line, the Center to Heskett 230 kV line, was consistently loaded above its limit as a result of the increased flows. System Intact pre-contingent flow was increased from 70 percent to 110 percent of the 428 MVA continuous rating by the reallocated 455 MW of Young 2 generation. The reallocated generation increased post-contingent flow from approximately 70 percent to 105 percent of the 471 MVA short-term emergency rating for numerous local contingencies. For the contingency that has the most impact on Center to Heskett, post-contingent flow was increased from 100 percent to 143 percent of the emergency rating.

Post-contingent overloads were observed on numerous other circuits. Table 3-1 below, summarizes the impacts.

Table 3-1. Peak Powerflow Results

Monitored Facility	Emergency Rating (MVA)	Post-contingent flow (Percent of Emergency Rating)		Critical Contingency
		Pre-project	Post-project	
Square Butte 345/230 kV transformer	352 MVA	89%	112%	*(This content has been removed because it may be classified as Critical Energy Infrastructure Information.)*
Maple River 345/230 kV transformer #1	420 MVA	93%	105%	
Center-Heskett 230 kV line	471 MVA	100%	143%	
Beulah-Coyote 115 kV line	101 MVA	89%	126%	
Coyote 345/115 kV transformer	172 MVA	90%	122%	
Bismarck-Ward 230 kV line	352 MVA	72%	105%	
Ward-Heskett 230 kV line	352 MVA	74%	108%	
Bismarck-Weber 230 kV line	350 MVA	93%	106%	
Weber-Jamestown 230 kV line	350 MVA	93%	106%	
G132 Point of Interconnect-Ellendale 230 kV line	319 MVA	92%	101%	

The Western Area Power Administration (WAPA) is the neighboring transmission owner with the largest presence near the Young 2 generator. Several of the monitored circuits in the table above belong to WAPA. Overall, the Young 2 transition to the AC system increased WAPA's system losses in the 2015 summer off-peak case by more than

7 percent. It is generally understood that this would present an undue burden on the WAPA system.

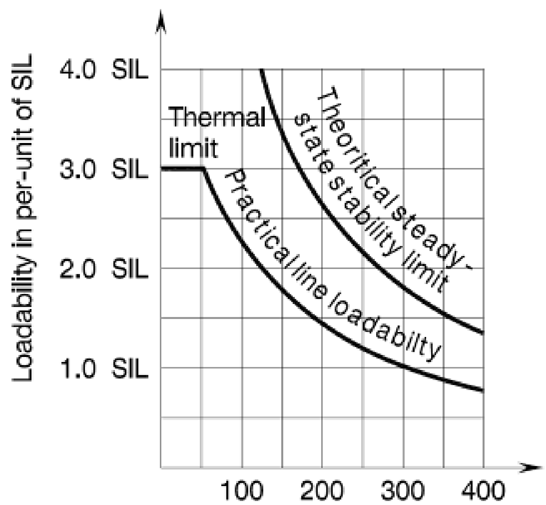
Based on results of the above studies, the "no transmission addition" option is not feasible due to the dynamic stability and steady state impacts on the North Dakota AC transmission system. Study results show that a new transmission line is required to transition the output of Young 2 off of the Square Butte DC line and onto the AC system.

3.1.2 New Transmission – 230 kV Center to Grand Forks

Minnkota conducted a study in 2005[4] to assess the options for providing a transmission outlet for a possible third unit addition at the Milton R Young Station. At that time, the assumed generator size was 250 MW and the output was assumed to be delivered to Grand Forks. Even at 250 MW, a 230 kV line resulted in a significant increase in power flowing through WAPA's transmission system. A new 230 kV line for the full output of Young 2 (455 MW) would cause far more serious impacts to the existing AC system.

In addition, a transmission line's ability to transport increasing amounts of electric power is referred to as the line's loading limit. It is generally constrained by the line's thermal limit. When a transmission line is short, the impedance of the conductor is smaller and therefore the line can be loaded up to its capacity, or thermal limit, and still maintain stable voltage (steady state stability). The longer the transmission line becomes, however, the higher the impedance of its conductor and the lower its ability to maintain acceptable steady state voltage. In short, as a line's length increases its practical loading limit becomes less than its thermal limit, resulting in a longer line providing less load-serving capacity than a shorter line of the same voltage. Figure 3-1 below illustrates the relationship between line length and practical loadability.

Figure 3-1. Transmission Line Loadability Limits



Note: The above transmission line loadability curve is for 60 Hz uncompensated overhead lines, and based on Figure 6.1.2 from Power System Analysis and Design, Glover/Sarma, at 217 (PWS Publishers 1987). "SIL" refers to "surge impedance load," which is the power delivered to an electric load that is equal to a transmission line's characteristic impedance. For a 230 kV line, the SIL is approximately 145 MW.

[4] Young 3 Transmission Study Report with Generator Cruise Rating of 250 MW; Tim Bartel, Senior Systems Engineer, Minnkota Power Cooperative, Inc., January 11, 2005

Due to the length of the proposed line and the amount of output from Young 2, it has been concluded that 230 kV is not an acceptable voltage.

3.1.3 New Transmission – 345 kV Center to Red River Valley

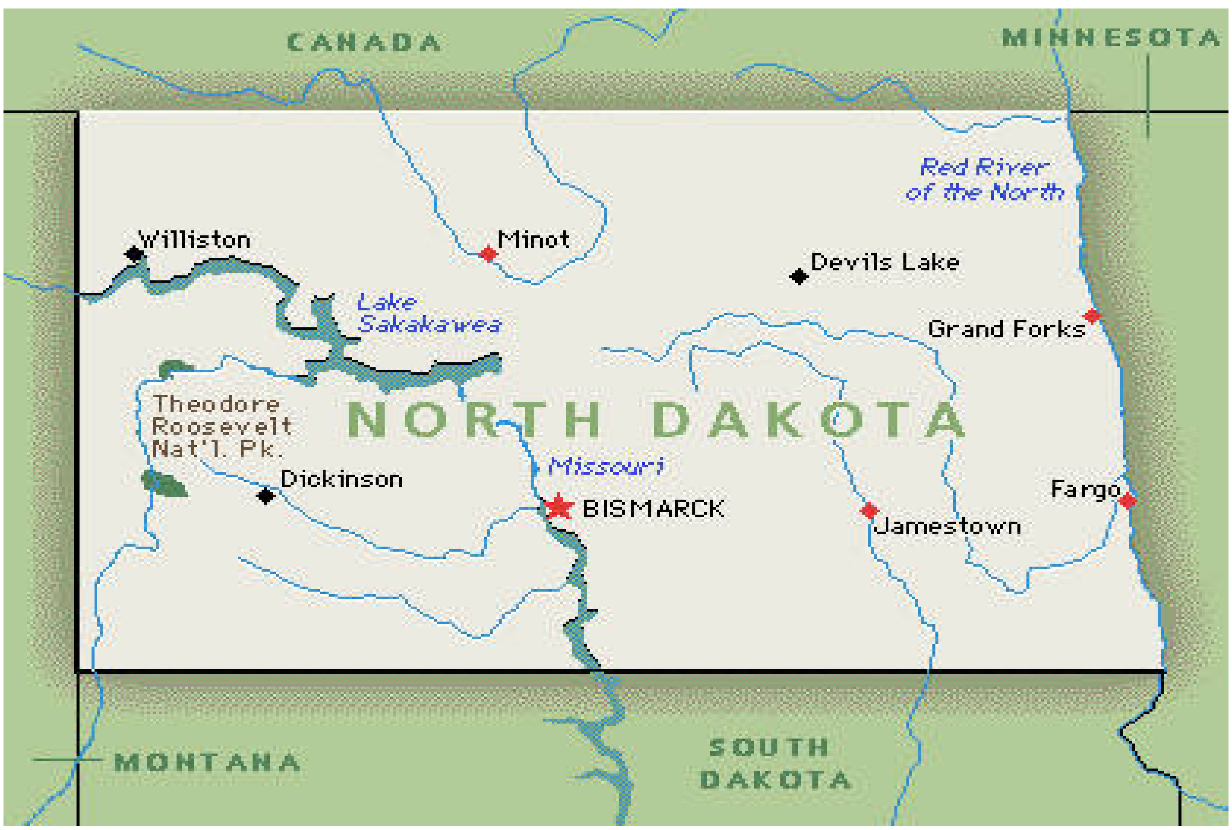
Minnkota then evaluated various 345 kV transmission line options/configurations to determine the optimal transmission solution to meet its load serving needs and the needs of the northern Red River Valley region as a whole. Options/configurations evaluated were: A.) eastern terminus options and B.) line capacity and configuration options

A. Eastern Terminus Alternatives

The Applicant evaluated two new general transmission line options; see Figure 3-2 below:

- A new Center to Grand Forks 345 kV line (from the existing substation near Center, to the existing Prairie Substation near Grand Forks)
- A new Center to Fargo 345 kV line (from the existing substation near Center, to the existing Maple River Substation near Fargo)

Figure 3-2. Eastern Terminus Options



Variations of these two options were studied to determine which other system modifications and/or configurations would result in the best overall performance. Two studies were performed by ABB to analyze and compare the performance of each option:

a. Young 2 AC Transmission Outlet Study – Preliminary Near-Term Analysis Results - June 15, 2009

As discussed in Section 3.1.1, Minnkota commissioned ABB to perform a technical study to evaluate near term issues of exporting power from the Young 2 generating unit to the North Dakota AC transmission system.

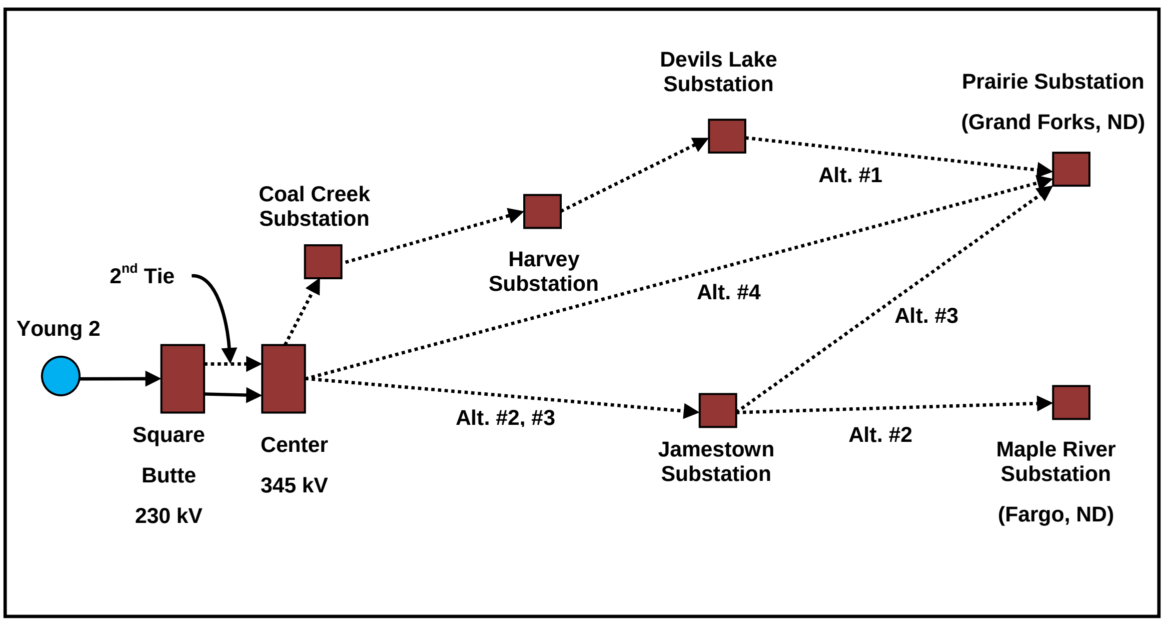
Five cases were developed. The base case had no additional transmission for Young 2. Four alternative cases (Figure 3-3 below) looked at various combinations of 345 kV line paths from the Center 345 kV Substation to the Prairie Substation and Maple River Substation. Each alternative included a second transformer connecting the Center 230 kV Substation to the Center 345 kV Substation.

The results of the study indicated that stability performance is acceptable for all four alternatives; however, there are some performance differences between the proposed 345 kV transmission alternatives.

Transmission Alternative #1 resulted in the worst transient voltage impacts and was eliminated from further study.

Transient voltage impacts in transmission Alternatives #2, #3, and #4 may require capacitor additions at the Groton 345 kV Substation located near Groton, South Dakota (not shown on the diagram below), an SVC at the Jamestown or Maple River Substations, and a capacitor bank at the Jamestown or Maple River Substations.

Figure 3-3. New 345 kV Center to Red River Valley Line Alternatives for Preliminary Near-Term Analysis



b. Young 2 AC Transmission Outlet Study – Voltage Stability Analysis Memo – July 27, 2009

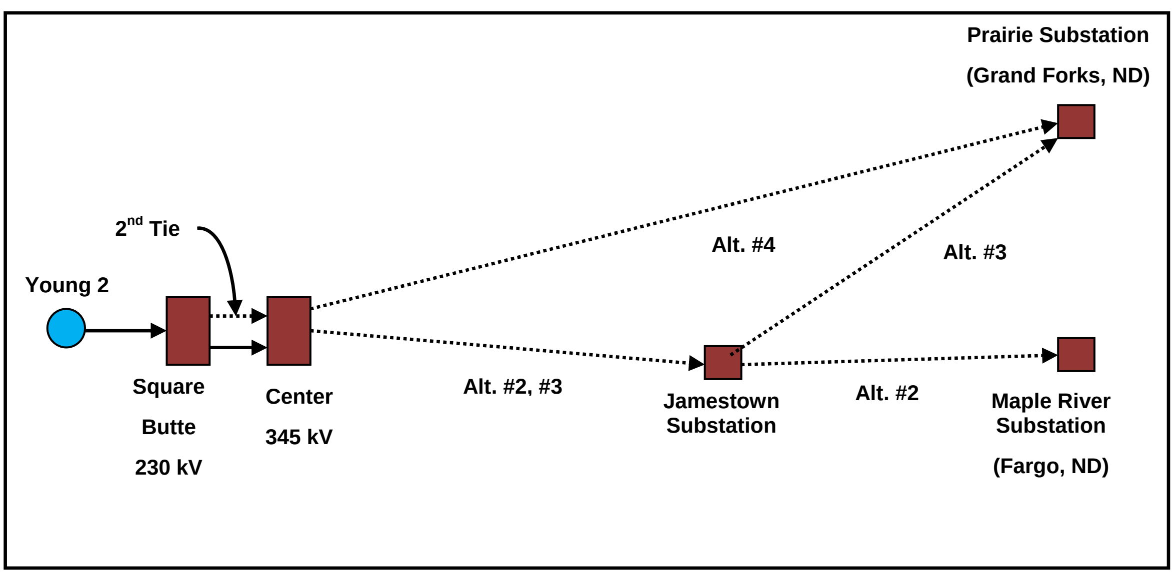
The June 15, 2009 Near Term Analysis (previous Section 3.1.3 Part A, sub. a) identified four 345 kV AC transmission alternatives for which acceptable dynamic stability performance could be achieved with the proposed transfer of power from Young 2 onto the North Dakota AC transmission system. Three of the four alternatives examined in that study were found to exhibit the best performance. Those alternatives were #2, #3, and #4.

In this study, system performance was examined from a voltage stability perspective. The analysis focused on the effectiveness of improving voltage stability performance in the Red River Valley/Bemidji areas for each of the three alternatives.

As described in Section 2, load-serving capability in the Red River Valley and Bemidji areas is generally limited by voltage stability, especially during prior outage situations. Voltage stability performance was examined for the two transmission alternatives. Performance was observed following critical contingencies in the system intact and prior-outage conditions. Load-serving limits were determined for the different transmission alternatives and compared.

After an initial development and screening of alternatives, alternative #3 was dismissed due to the longer line distance and the understanding that its benefit to eastern North Dakota voltage stability would be generally the same as alternative #4. Alternatives #2 (new Center to Jamestown-Maple River 345 kV line) and #4 (new Center to Prairie 345 kV line) were studied in greater detail. These alternatives are shown in Figure 3-4.

Figure 3-4. New 345 kV Center to Red River Valley Line Alternatives for Voltage Stability Analysis



The voltage stability model was set up to simulate winter peak load conditions in 2010. For this analysis, out-year assumptions for queued wind generation projects was less critical, because all generation in or near the constrained region was turned off to demonstrate the most limiting case.

Post-project results were compared with pre-project results for assumed Manitoba Hydro Export Interface (MHEX) power flows of 700 MW north, and 1,000 MW south. The MHEX north-flow case demonstrated the limiting boundary condition, and the south-flow case represented normal winter operation.

The concept of a voltage-constrained north zone in eastern North Dakota/ west-central Minnesota, as presented in the 2006 TIPS Update, was explored and confirmed. The four 230 kV lines crossing the boundaries of this north zone proved to be critical to maximizing North Dakota load serving capability. These four lines are:

- Letellier to Drayton 230 kV line
- Balta to Ramsey 230 kV line
- Jamestown to Pickert to Grand Forks 230 kV line
- Maple River to Winger 230 kV line

Simulation of N-2 conditions in which two of the four lines were out of service proved to be limiting cases. N-2 conditions would occur when one of the lines is out of service for planned maintenance or emergency repairs, and the system must be prepared for the next critical contingency. For simulations involving the Letellier to Drayton 230 kV line, results were relatively independent of MHEX flow, implying that these load-serving limitations would apply any time that high winter load conditions occur, regardless of Manitoba operating conditions.

Based on the results obtained in this study, it was concluded that the termination of a new 345 kV line in the Prairie/Grand Forks area provides the most benefit to the Minnkota load region, and to the eastern North Dakota/west-central Minnesota regions as a whole.

The Minnkota load region is best served by alternative #4 because it provides significantly better load-serving performance over alternative #2 for contingencies and prior outages involving the critical north zone ties. This is because alternative #4 provides a new 345 kV connection across the north zone boundary, and alternative #2 does not.

On a broader scale, the studies demonstrate that system response for the MHEX north-flow condition is significantly improved by the alternative #4 transmission project. This is because the addition of a 345 kV line to the Prairie Substation strengthens the connection between the North Dakota generation and the MHEX interface. In the north-flow case, Alternative #4 supports a North Dakota load-serving limit that is 18 percent higher than that of alternative #2 for the regionally limiting contingency (see Figure 3-5 below).

The most definitive case for alternative #4 appears to be the prior-outage of the Jamestown to Pickert 230 kV line and the subsequent loss of the Maple River to

Winger 230 kV line during the MHEX north flow condition. Under this scenario, voltage stability limits for alternative #4 are approximately 28 percent higher than those exhibited by transmission alternative #2.

Several scenarios were investigated as part of this study. The conclusions from these scenarios are summarized below.

Series compensation of the Center to Prairie 345 kV line was tested in the model, and was found to have a modest impact on North Dakota voltage stability limits. Adding 40 percent series compensation increases voltage stability limits by 2 to 7 percent.

The voltage stability impact of eastern North Dakota and northwestern Minnesota generators was also modeled. The generators were found to benefit voltage stability performance. These generators, however, do not affect the relative performance of the two transmission alternatives proposed for Young 2.

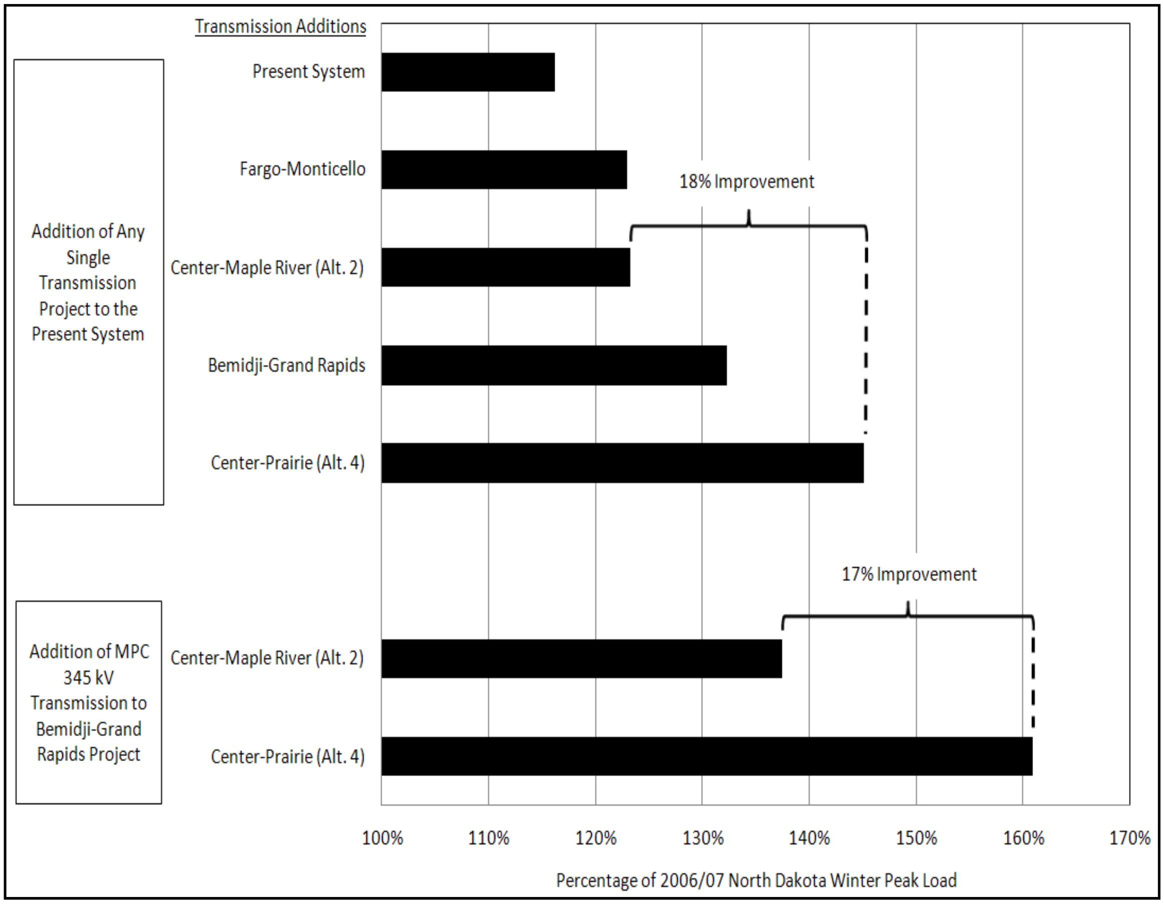
Sensitivity analyses were completed to evaluate voltage stability performance impacts of the two CAPX 2020 project lines closest to the study region; the Bemidji to Grand Rapids 230 kV line and the Fargo to Monticello 345 kV line. Both of these lines are expected to be in service by the end of 2015.

The CAPX 2020 Bemidji to Grand Rapids 230 kV line increases North Dakota voltage stability limits by 400 to 600 MW, but it does not affect the relative performance of the two transmission alternatives proposed for Young 2. During the MHEX north flow condition, alternative #4 continues to support a North Dakota load-serving limit that is 17 percent higher than that of alternative #2 for the regionally limiting contingency even with the Bemidji to Grand Rapids line in service (see Figure 3-5 below).

The addition of the CAPX 2020 Fargo to Monticello 345 kV line increases North Dakota voltage stability limits by 200 to 500 MW. In cases where transmission alternatives #2 and #4 had previously exhibited similar performance (without Fargo to St. Cloud), results show that the addition of Fargo to St. Cloud 345 kV tilts the balance more in favor of alternative #4.

When both CAPX lines were included, transmission alternative #4 continues to perform better than alternative #2 from the viewpoint of providing voltage support to the Bemidji and Red River Valley areas.

Figure 3-5. Benefit of Various Transmission Additions to ND Load-Serving Capability Following Worst-Case Regional Contingency (with U.S. to Manitoba Flow = 700 MW North)



B. Line Capacity and Configuration

a. Minnkota System Requirements

The Applicant developed a minimum line capacity criteria based on the full nameplate rating of Young 2, the expected cruise loading of the proposed 345 kV transmission line and the expected maximum emergency loading during N-1 and N-2 conditions. Preliminary load flow modeling indicates a maximum normal system cruise loading occurs during winter peak conditions with south flows. This loading level is approximately 404 MVA. The preliminary models also demonstrate that the expected maximum emergency loading on the proposed line will be 598 MVA during winter peak with north flow and prior outage of the Center to Jamestown 345 kV line and loss of the Center to Heskett 230 kV line.

To minimize corona, all design options reviewed for 345 kV constructions are based on a bundled conductor concept. According to RUS design recommendations the minimum recommended conductor size (to minimize corona) for a transmission line 230 kV and above is 795 kcmil. A two-conductor bundled 795 ACSR configuration per phase will provide a thermal limit with adequate margin above the expected maximum emergency loading.

For long transmission lines such as the Project's, the maximum power delivery capability and practical line loading limits are governed by the AC impedance of the circuit and will be less than the thermal limit. Preliminary study efforts demonstrate that the maximum expected emergency loading of 598 MVA is also below the calculated maximum power delivery capability level estimated for this 260-mile circuit with reasonable margin.

Representative routes within the study corridor identified for the Macro-Corridor Study (MCS) and shown in Figure 1-3 and Figure 1-4 on page 6 range from 248 miles to more than 280 miles, with 260 miles selected as the average potential route length for preliminary model development.

Single pole towers of steel construction with concrete foundations are proposed to minimize ROW width and eliminate guy wires. This construction type has been receiving favorable comments from the mostly rural landowners along the proposed corridor. Single pole, self supporting structures help minimize the obstacles in tillable soils helping to overcome objections to transmission line placement where GPS steering and extra large farm equipment are used.

The proposed base design configuration is then summarized as follows:

> A single circuit 260-mile long 345 kV transmission line with bundled, two-conductor 795 ACSR on steel self supporting structures with a thermal limit exceeding the maximum expected emergency loading.

As Young 2 presently terminates in an existing 230 kV substation and the proposed 345 kV transmission line will also terminate at an existing 230 kV substation at the Prairie Substation, additional 345 to 230 kV transformations will be required. Preliminary studies also indicate the potential for overload on the existing Center 345/230 kV transformer for N-1 conditions. Three new, and one replacement, transformers rated 400/533/666 MVA @ 65°C are included in the base design to provide adequate and redundant capacity to avoid Young 2 reductions for transformer outages. The proposed substation modifications at Center and Prairie provide for the addition of the three new transformers and the connections to the existing 230 kV buses.

b. Wind Project Interconnection Request

As a transmission owner in a wind resource rich area, Minnkota has several interconnection requests in progress in the interconnection request queue. Three requests have listed the point of interconnection to be the proposed Center to Grand Forks 345 kV project. The three proposed wind projects are about 400 MW each, with two projects requesting a western end interconnection and one project requesting a mid-line interconnection. The Applicant has chosen to develop the base-case design based on the output capacity of Young 2 only, to help determine the incremental impact of each 400 MW wind project on the transmission system. This study approach will allow the Applicant to proceed with system impact studies for each interconnection request based on a system model with the Project in service, as it would for typical interconnection requests made to existing transmission facilities.

This study work is ongoing and will be presented to each interconnection requester to allow them to determine the economic feasibility of the wind project with transmission improvements and third party impacts considered.

As the impact to the Project base design is dependent on the number of wind projects that progress to construction stages, the transmission improvements are being developed as modifications to the base design. The interconnection requesting parties would be financially responsible for the modifications required to the base design which may include one or more of the following changes:

- Tap the proposed Center to Grand Forks 345 kV transmission line in the Finley, North Dakota, area and develop a 345 kV line section between Finley and Fargo, North Dakota. (See Figure 1-4 on page 6) Develop a new 345 kV substation near Finley.
- Increase conductor size or type on the base project between Center and Finley, North Dakota. The use of ACSS or ACSS/TW (Aluminum conductor steel supported/trapezoidal wire) can be used to raise the thermal capability without increasing conductor diameter.
- Insert a series compensation station at the Finley tap point to lower the effective impedance of the line and increase the transfer capability.
- Convert all structures between Center and Finley, North Dakota, to double-circuit-ready structures to accommodate a future second 345 kV circuit.
- Add a second 345 kV circuit between Center and Finley, North Dakota.
- Add phase shifting transformers to the Square Butte 230 kV substation to decrease flows into the 230 kV system at Center.
- Add shunt capacitors to the Jamestown 345 kV substation to increase transfer capability.
- Add an SVC (Static VAR compensator) to the Maple River substation to increase transfer capability.

The Applicant acknowledges that there is potential for some of the above listed project modifications to significantly alter the proposed overall Project scope and some may require additional environmental review and scoping as connected actions to the base Project. With the inherent uncertainty in the early stages of large wind projects and their associated interconnection requests, the Applicant must proceed with the review process for the base Project in order to meet its obligations for reliability and load serving capability.

c. Conservation Improvement Plan (CIP)

In 2008, the state of Minnesota passed Statute 216B.241 Energy Conservation Improvement, which states "Each individual utility and association shall have an annual energy-savings goal equivalent to 1.5 percent of gross annual retail energy sales." The Applicant has identified new transmission construction as one potential resource for reducing losses (thereby saving energy) by choosing a conductor type or size with a lower electrical resistance than one selected in standard design practice. Even though the thermal limit of the proposed 795 kcmil conductor is adequate for the base design, it can be demonstrated that choosing 954 or 1,272 kcmil conductor will save significant energy which can be used to meet the requirements of the Minnesota CIP. The use of trapezoidal wire is another option to reduce losses because of the larger aluminum surface area provided in the same size conductor.

The Minnesota statute allows for one third of the 1.5 percent goal to be met by supply-side projects. Preliminary studies indicate that increasing the conductor size to 954 ACSR would provide a 197 percent kWh loss savings over the CIP target KWh value. Using a shaped wire conductor of the same outside diameter as 795 ACSR, such as ACSS/TW, would provide a 170 percent KWh loss savings over the CIP target with a significant increase in the thermal limit over the 954 ACSR conductor.

d. Conductor Type and Sizing

The selection of bundled two-conductor 795 ACSR for the base design has been shown to be adequate from a thermal limit and a mechanical performance perspective. The final conductor type will take into consideration the economics of reduced losses offered by a larger conductor which may be offset by additional costs for heavier structures and increased construction costs. Newer technologies being analyzed for the proposed line include ACSS/TW, which is a shaped wire with concentric-lay compact aluminum conductors over a steel support, that provides lower losses than its equivalent outside-diameter sized ACSR wire. The additional advantage offered by the ACSS or ACSS/TW conductor is the ability to work at higher operating temperatures, which can provide a 100 percent or greater increase in the thermal limit of a similar sized ACSR wire. The use of ACSS or ACSS/TW conductor may provide a capacity upgrade option without the need for heavier poles and structures or increasing the number of conductors bundled per phase.

The final conductor chosen will take into consideration losses, thermal capacity, constructability, and strength. Until the final route is selected and maximum span lengths are determined for river crossings and other challenging areas, the conductor and pole designs are continuously being optimized with the overall goal of minimizing project lifetime cost.

3.1.4 Conclusions on Transmission Alternatives

The Center to Grand Forks 345 kV Line is the best performing transmission alternative to meet Minnkota's load serving needs as well as provide voltage support for the northern Red River Valley and Bemidji areas. This conclusion is based on the technical analyses previously performed by regional planners and by feasibility studies recently performed for Minnkota by its consultant.

Adding significant generation in central North Dakota will adversely impact the existing area transmission system performance, both under system intact and contingency conditions. For the Young 2 AC transition plan, various transmission improvements were identified to alleviate these impacts. Such improvements included a new 345 kV transmission line from Center to either Fargo or Grand Forks and possibly the addition of switched shunts and static VAR compensation at midpoints and/or endpoints of the new line.

Additional mitigation may be needed to address overloads on the Maple River 230/345 kV transformers, the Maple River to Sheyenne 230 kV line, and the Sheyenne to Audubon 230 kV line. Mitigation may also be needed for other criteria violations reported in the studies.

Feasibility studies show that moving the Young 2 connection to the Center 345 kV Substation generally performs better than leaving Young 2 connected to the Square Butte 230 kV Substation. However, either option will perform satisfactorily. Switching procedures have been identified that would isolate Young 2 from the 230 kV system with a direct connection to the Center 345 kV Substation to take advantage of these performance benefits if system conditions would warrant it.

Stability performance is acceptable with a new 345 kV line from Center, North Dakota, to either the Maple River Substation or the Prairie Substation. Although both of these alternatives meet MAPP criteria, there are some performance differences between them. Required mitigations may include capacitor additions at the Groton, South Dakota, 345 kV Substation, an SVC at Jamestown or Maple River, and a capacitor at Jamestown or Maple River.

Voltage stability performance was compared for the two 345 kV AC transmission alternatives. Based on study results, it can be concluded that the introduction of a 345 kV source into the Prairie/Grand Forks area significantly increases voltage stability performance in the Red River Valley and Bemidji areas. This alternative, in general, exhibits higher voltage stability limits compared to the Maple River/Fargo alternative.

The most definitive case for the Prairie/Grand Forks alternative appears to be the prior-outage of the Jamestown to Pickert 230 kV line, together with the subsequent loss of the Maple River to Winger 230 kV line for MHEX North Flow conditions. Under this contingency, voltage stability limits are approximately 28 percent higher for the Center to Prairie/Grand Forks alternative than those exhibited by the Center to Maple River/Fargo alternative.

In cases where these alternatives had previously exhibited similar performance (without the proposed Fargo to St. Cloud 345kV line), results show that the addition of the Fargo to St. Cloud line tilts the balance more in favor of the Center to Prairie/Grand Forks line.

Sensitivity analysis with both CAPX lines (Bemidji to Grand Rapids 230 kV and Fargo to St. Cloud 345 kV) included shows that the Center to Prairie/Grand Forks line would continue to perform better than the Center to Maple River/Fargo line from the viewpoint of providing voltage support to the Bemidji area and the Red River Valley.

Section 4 Total Project Cost Estimate

The Project has two major cost components. The transmission line portion of the Project is estimated on a cost per mile basis and the substation portion is estimated on a facilities improvement cost basis.

The current study corridor as identified in the Applicant's MCS provides for several line routing options. Route lengths through the study corridor are estimated to be between 248 and 284 miles. The average length of 10 possible routes reviewed that met the minimum avoidance area impact criteria is 260 miles. These preliminary routes are based on the Project's principle of following section lines and quarter section lines, as cross-country construction through tillable farmland is generally not accepted by landowners. The ultimate line length cannot be established until the route has been determined and the ROW acquisition process is substantially completed. The Project cost estimate has been developed using a shortest case, typical case, and longest case scenario that helps demonstrate the impact of the final route and ultimate line length impact to the overall Project cost. Table 4-1, below, provides the current total project cost estimate (2009 dollars) for three line length options.

Table 4-1. Center to Grand Forks Transmission Project Options Cost Estimates

Option	Line Length (miles)	Line Cost	Project Total
Center to Prairie Shortest Case	248	$272,800,000	$309,800,000
Center to Prairie Typical Case	260	$286,000,000	$323,000,000
Center to Prairie Longest Case	284	$312,400,000	$349,400,000

Note: All options are based on 795 ACSR conductor, mono-pole structures, an assumed line cost of $1,100,000 per mile, and an estimated cost of $37,000,000 for substations

The substation costs represent estimated expenditures at three existing facilities. The estimate for modifications to the Center 345 kV substation is $14 million, of which $3 million is for substation improvements and $11 million represents the cost of two new 345/230 kV 400 MVA power transformers.

The estimate for modifications to the Prairie 230 kV substation is $22 million of which $11 million is for improvements and additions and $11 million is for two new transformers equivalent to the Center units.

Cost estimates for third party impacts are not included in the project estimate at this time as the base project is anticipated to cause minimal impact to the existing transmission system.

Section 5 Conclusion

Minnkota has a need to transmit power from its base-load generating source at the Milton R Young plant near Center, North Dakota, to its load center in the Red River Valley and surrounding area. Previously, transmission service was provided by the Square Butte HVDC transmission facility. By 2013, this transmission service will no longer be available.

Minnkota has studied both no-action and new transmission alternatives to deal with the Young 2 AC transition. This AES demonstrates that the no-build and the 230 kV alternatives are neither responsible nor feasible options for Minnkota.

The best alternative to address Minnkota's transmission requirements and provide load serving benefit to the entire Red River Valley region is the addition of a 345 kV line from Center to the Red River Valley. A comparison of two new transmission options that could address the issue demonstrates that the Center to Grand Forks 345 kV line has better electrical performance and lower cost potential than the Center to Fargo 345 kV line.

The Project would provide a direct transmission link into Minnkota's service territory, a sound technical solution to the well-identified northern Red River Valley voltage stability issue, and a major improvement to the regional transmission grid.

Minnkota has also developed an MCS, which provides information on environmental, social, and cultural resources for each of the corridor alternatives. RUS makes both the AES and MCS publicly available during the public scoping process to facilitate the participation of interested parties in the environmental review of the proposed action. Input received from the public and interested parties will be used to determine the range of alternatives and impacts to be considered in the scope of the environmental assessment.