Exhibit F

South Minneapolis Electric Reliability Study

Xcel Energy Services; Transmission System Planning and Reliability Assessment.

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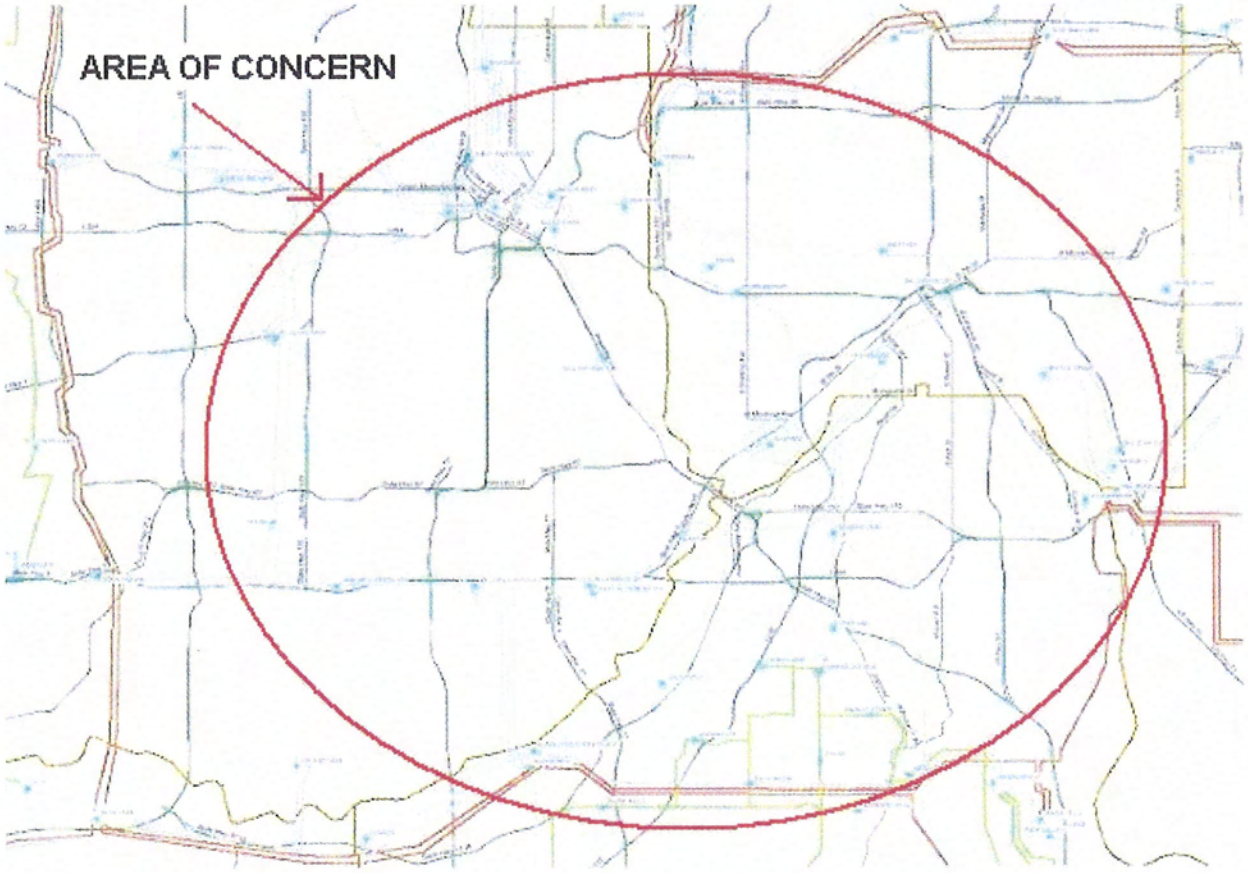
1.0: Overview

This report represents the results of a long-range study for the electrical transmission network in the greater Minneapolis Metro area with a focus on the south Minneapolis area. This study reviewed the capability of the existing transmission system to serve the proposed new distribution substations to accommodate the projected Minneapolis metro load growth. The result of this analysis is a recommendation to build a new 345 kV line to serve the new distribution substations along with several new 115 kV lines to serve the projected load growth in the Minneapolis Metro area to the year 2028. This plan is expected to have an installed cost of $115,722,800.

1.1: Map



2.0: Conclusions & Recommended Plan

The Preferred Plan is the Hiawatha 345 Option, which adds the following facilities:

- In 2010 add a new Hiawatha 115 kV distribution substation on the Elliot Park-Southtown 115 kV line. A new Midtown 115 kV substation with a new double-circuit 115 kV line to the Hiawatha substation.

- In 2013 add a new Cleveland 345/115 kV substation that taps the 345 kV line from Terminal to Kohlman Lake. A new 115 kV line from the Cleveland to the Lexington substation. Upgrade the two 448 MVA transformers at Red Rock to two 672 MVA transformers.
- In 2014 add a new 115 kV Crosstown distribution substation and add a double-circuit 115 kV line to the Wilson substation. Upgrade the two 448 MVA transformers at Parkers Lake to two 672 MVA transformers. Upgrade the two 448 MVA transformers at Eden Prairie to two 672 MVA transformers.
- In 2016 add the second distribution transformers at Crosstown and Midtown.
- In 2017 add the second distribution transformer at Hiawatha.
- In 2018 reconductor the 115 kV line from Afton-Red Rock.
- In 2020, add a new 345 kV line from the Cleveland substation to the Hiawatha substation. Add a new 345/115 kV, 448 MVA transformer at Hiawatha.

This option appears to offer the best overall results with respect to:

- Power system performance (system intact & contingent loadings & voltages)
- Practicality (logistics of construction and operation)
- Price (cumulative present worth cost)
- Fit overall vision for the metro area
- System Losses
- Best option for serving the distribution load

It is noted that the distribution transformers are not considered a transmission cost, but the costs were applied equally to every option studied. So the net effect of removing them would be the same for all the options.

3.0: Study History & Participants

Xcel Energy technical staff and consultants performed the powerflow simulations, economic analyses, and tabulation of results. These results were presented and reviewed at the study group's meetings, at which comments, conclusions, and recommendations were developed to guide each successive stage of analysis.

This study was presented at the July 24th, 2008 SPG meeting held at Great River Energy's Offices.

4.0: Introduction

4.1: System Description

The Twin Cities metropolitan area is served by a 115 kV transmission system within a 345 kV double circuit loop. Most of the Twin Cities generation is connected to this 345 kV loop except the High Bridge and Riverside combustion turbines. For this analysis, before the year 2018 all Twin Cities generation was assumed on during system peak. The post 2018 cases were

developed to accommodate a 30% wind penetration on the system. In order to accommodate this local Twin Cities generation was turned down. This will put extra strain on the existing 345/115 kV transformers along the 345 kV loop as internal generation is turned down.

Load projections from distribution planning has determined a need for addition load serving support in the south Minneapolis Metro area to meet the expected load growth. This new load growth along with the continued load growth for the entire metro area will increase the burden on the existing transmission system, causing several transmission overloads under contingency.

4.2: Scope of Study

The purpose of this study is to examine a 10-year planning horizon to identify transmission system deficiencies and propose solutions to alleviate these issues. Steady-state powerflow cases are run to determine if the transmission system is capable of handling the subsequent load associated with the new interconnection request during normal and contingent system operation. Dynamic simulations are run to determine how the interconnections and upgrades impact the transmission systems dynamic performance under contingencies.

5.0: Planning Criteria

Steady-State Criteria

A summary of Xcel Energy's steady state planning criteria is shown in Table 1.

Table 1 – Steady-State Planning Criteria

Limits	System Intact Condition	Post-Contingency Condition
Transmission Line Loading	100% of Rating	110% of rating for single contingency. Sag limit of line for double contingency.
Transformer Loading	100% of Rating	115% post-contingency if pre-contingency loading is below 90%
Generator Bus Voltage	0.95 to 1.10 per unit	0.95 to 1.10 per unit
Load Bus Voltage	Twin Cities metro 0.92 to 1.10 per unit. Outside TC Metro 0.90 to 1.10 per unit.	Twin Cities Metro 0.92 to 1.10 per unit. Outside TC Metro 0.90 to 1.10 per unit.

In addition to adhering to these planning criteria, we meet all the guidelines outlined for the TPL planning standards as defined by NERC.

Dynamic Criteria

A summary of Xcel Energy's dynamic planning criteria is shown in Table 2.

Table 2 – Dynamic Stability Criteria

NERC Categories	Transient Voltage Deviation Limits	Rotor Angle Oscillation Damping Ratio Limits
A	Nothing in addition to NERC Requirements	
B	Minimum 0.70 p.u. at any bus	Not to be less than 0.0081633 for disturbances with faults or less than 0.0167660 for line trips.
C	Minimum 0.70 p.u. at any bus	Not to be less than 0.0081633 for disturbances with faults or less than 0.0167660 for line trips.
D	Nothing in addition to NERC Requirements	

5.1: Models Employed

5.1.1: Steady State Models

The powerflow models employed were developed by the MRO model building group. The models are based on the 2007 Series MRO models, Year 2012 summer peak and a modified 2018 summer peak model as updated:

- to reflect system changes by appropriate study year.
- to reflect the Post CAPX2020 Group 1 facilities by appropriate study year (2018).
- to reflect 30% wind penetration for a specific 2018 case.

5.1.2: Dynamics models

There were no dynamic stability runs done with this study.

5.2: Conditions Studied

5.2.1: Steady State Modeling Assumptions

The technical analysis was performed based upon year 2012 and 2018 summer peak cases from the 2007 MRO series powerflow models. The base models were adjusted to represent the latest available forecast data for summer season peak (100%) load conditions. The 2018 30% wind penetration case simulates 30% renewable generation transferred to the Twin Cities.

Table 3

					Net generation, MW				
	load					Blue	Black	High	River
Condition	level	NDEX[1]	MHEX[2]	MWEX[3]	Wind	Lake	Dog	Bridge	Side
Peak	100 %	497.0	555.7	399.0	1014	497	588	610	563
30% Case	100 %	1044.6	472.8	535.2	3600	0	352	610	314
NMORWG Limit:		2080	2175	1480					

Notes

1) NDEX= sum of flows on the 18 lines comprising the "North Dakota Export" Boundary;
2) MHEX = sum of flows on the 4 Manitoba Hydro-U.S. 230 & 500 kV tie lines;
3) MWEX = sum of flows on Minnesota-Wisconsin Export (King- Eau Claire 345 kV, phase shifter on Arrowhead-Weston 345 kV) This interface was in the process of being reevaluated to include the Arrowhead-Weston 345 kV line during this study.

5.2.2: Performance Evaluation Methods

Power system performance simulation was performed with the aid of the MUST (Managing and Utilizing System Transmission) digital computer powerflow program (Version 8.3) as supplied by Power Technologies, Inc. System intact and first-contingency analysis was performed primarily using PSS-MUST (Version 8.3) activities ACCC and TLTG ("Transfer Limit Table Generator"). TLTG performs automated contingency analysis while progressively incrementing power transfer between a defined "source" and "sink" location.

For both the ACCC and the TLTG analysis, the following apply:

Monitored facilities:

All transmission lines and transformers 69 kV and above in the model areas:

NSP (Xcel) GRE

Study area (facilities subject to outage):

All transmission lines and transformers 69 kV and above in the model zones:

NSP (Xcel) GRE

Activity TLTG achieves computational efficiency by extensive use of Power Transfer Distribution Factors (PTDFs) and Line Outage Distribution Factors (LODFs), concepts applicable to linear, time-invariant systems. These methods are appropriate for power system analysis, provided it is recognized their accuracy is constrained by their inherent limitations arising from non-linear effects such as exhaustion of reactive power supply and LTC transformer range limits. Consequently, the resultant reported transfer limits from TLTG are thus approximate.

Facilities identified in the TLTG outputs are considered valid limiters if they…

have a PTDF of 5.0% or greater (system intact) or
have an OTDF of 3.0% or greater (outage condition).

This 5.0% criterion was selected in accordance with the MISO's cutoff level for system impact analyses. Very large reductions in generation (over 50:1) are required in order to achieve a perceptible amount of loading relief. Consequently, PTDFs/OTDFs lower than 5% strongly indicate that other power system adjustments are likely to be much more effective in producing the desired ameliorative effect than would generation adjustments in the study area. Refer to Section 5.2 for further discussion on evaluation of incremental loadings on constrained interfaces ("flowgates") and non-flowgate facilities.

5.2.3: Steady State Contingencies modeled

For this study we included all N-1 and tie line contingencies for the Xcel and GRE areas. In addition, we ran all the Category C contingencies listed in the UPDATE-2-7 w stk bkrs.con file.

Key area system deficiencies and contingencies:

Base Case Issue	Contingency	Year
Goose Lake-Vadnais Hgts 115 kV	Apache Tp-Arden Hills 115 kV	2012-2014
Lexington-Vadnais Hgts 115 kV	Apache Tp-Arden Hills 115 kV	2012-2014
Apache Tp-Arden Hills 115 kV	Goose Lake Dbl Ckt	2012-2014
Coon Creek 345/115 xfmrs	Eden Prairie STK breaker	2018
Cedervale-Southtown 115 kV	Coon Creek STK breaker	2020
High Bridge-Sheppard 115 kV	Elliot Park STK breaker	2021
Terminal 345/115 xfmrs	Elliot Park STK breaker	2021
Eliot Park-Mainstreet 115 kV	Shepard-Southtown DBL Ckt	2022
Elliot Park-Hiawatha 115 kV	Shepard-Southtown DBL Ckt	2020
Parkers Lk-Basset Creek 115 kV	Terminal STK breaker	2022

Relevant contingencies are provided in Appendix C.

5.3: Options (Plans) Evaluated

Several distribution options we evaluated to see if they provided any advantage over the transmission options. Loss analysis and present worth analysis were used to determine the best location of the Midtown substation. The following distribution improvement options were evaluated:

DO1 "East Distribution Site"

This option has the Hiawatha substation tapping the existing 115 kV line from Elliot Park-Southtown. Adding 2-115 kV lines from Hiawatha to the new Midtown substation located east of the Sears Building.

DO2 "West Distribution Site"

This option has the Hiawatha substation tapping the existing 115 kV line from Elliot Park-Southtown. Adding 2-115 kV lines from Hiawatha to the new Midtown substation located west of I-35W.

DO3 "6-Bank Hiawatha (Super Hiawatha)"

This option has the Hiawatha substation tapping the existing 115 kV line from Elliot Park-Southtown. There is no Midtown substation assumed for this option. Instead 6 conductor lines will be served from 3 115/13.8 kV transformers located at Hiawatha.

DO4 "Hiawatha-Midtown 34.5 kV underground"

This option has the Hiawatha substation tapping the existing 115 kV line from Elliot Park-Southtown. Adding 2-34.5 kV underground lines from Hiawatha to the Midtown substation located east of the Sears Building.

The following transmission improvement options were evaluated:

Option 1 "115 kV dbl ckt, dbl bundled Hiawatha Plan"

This option establishes a new 345/115 kV Cleveland substation that taps the existing 345 kV line from Coon Creek-Kohlman Lake. Build a new double circuited, double bundled 115 kV line from Cleveland to the new Hiawatha substation. Build a new double circuited 115 kV line from the Hiawatha substation to a new Midtown substation.

Option 2 "345 kV Hiawatha Plan"
This option establishes a new 345/115 kV Cleveland substation that taps the existing 345 kV line from Coon Creek-Kohlman Lake. Build a new 345 kV line from the Cleveland substation to a new Hiawatha substation. Build a new double circuited 115 kV line from the Hiawatha substation to a new Midtown substation.

Option 3 "Parkers Lake-Aldrich 345 kV Plan"
This option establishes a new 345 kV line from Parkers Lake to Aldrich. Build a new 115 kV line from Aldrich to a new Midtown substation. Build a double circuited 115 kV line from Midtown to Hiawatha.

Option 4 "Quad 345 kV Plan"
This option establishes a new 345/115 kV Cleveland substation that taps the existing 345 kV line from Coon Creek-Kohlman Lake. Build a new 345 kV line from the Cleveland substation to a new Hiawatha substation. Build a new double circuited 115 kV line from the Hiawatha substation to a new Midtown substation. Build a new 345 kV line from Parkers Lake to Aldrich. Build a new 345 kV line from Red Rock-Rodgers Lake. Add a new 345 kV bus section and transformer at the existing Black Dog substation.

These options all address the immediate load serving needs of the South Minneapolis area and take into consideration future load serving needs of the whole area.

6.0: Results of Detailed Analysis

6.1: Losses: Technical and Economic Evaluation

Losses are power that dissipates in electric conductors due to a materials resistance. The amount of loss is greatly reduced by lowering the current flowing through a line. For the Xcel Energy 10 Year plan losses were evaluated during projects to show system benefits. The cost of purchasing generation at marginal prices for capacity and energy were evaluated. This savings was factored into the economic analysis.

To develop the savings associated with reducing losses an evaluation technique was developed. Ten transformers were studied throughout the Twin Cities. Transformer load was taken at peak conditions and then an average loading was gathered. This information was used to develop a load duration curve. The MRO models use a 10% coincidence factor, which means loads appear 10% less than their transformer peak. This coincidence factor is shown in the calculations. Table 6.1 shows the calculations used to create a loading factor. Equation 6.1 details how the Load Factor (LF_1) was calculated.

$$\text{Equation 6.1: } LF = \frac{TRavg}{0.9 * TR\max}$$

Transformer	TR avg	TR Max	Load factor
TR#1	22	44	0.56
TR#2	30.56	51.73	0.66
TR#3	8.44	20.08	0.47
TR#4	11.33	21.04	0.6
TR#5	33.65	63.39	0.59
TR#6	8.85	20.24	0.49
TR#7	21.35	41.83	0.57
TR#8	6.33	19.77	0.36
TR#9	21.4	45.39	0.52
TR#10	30.22	56.11	0.6
		Average Load Factor	0.54

Table 6.1 Load Factor Development

To calculate the Loss Factor (LF_2) the following equations detail the methodology. Equation 6.3 details the correlation between load and current. As the load increases the loading on the

transmission lines will increase in equal proportions. Due to this relationship equation 6.4 can be applied to get the loss factor. This development comes from the standard loss formula 6.2.

Equation 6.2 Power Loss Formula: $Losses = I^2 R$

Equation 6.3 Correlation between load and current: $Load \propto I$

Equation 6.4 Loss Factor (LF_2) development: $LF_2 = \sqrt{LF_1}$

The loss factor was calculated to 0.298. This relates the amount of losses in the peak case to the expect amount of losses at an average level throughout the year. These values were used to calculate energy use. Marginal energy cost was supplied by Xcel Energy's resource planning department. Capacity cost was also supplied at $20,000 per MW.

The total yearly savings was calculated by equation 6.5. This equation includes the cost of energy and capacity. For the economic analysis, this formula was applied each year.

$$\$Savings = MWreduction_{peak} * 8760 * (\$ / MWH) + MWreduction_{peak} * \$20{,}000$$

Equation 6.5 Savings calculation

Option 2 (Hiawatha @ 345 kV) in this study shows significant amounts of loss savings. In 2012 there were 1.7 MW of savings and 3 MW of savings in 2018. For economic analysis the MW savings were scaled at this rate of increase from 2011 through 2023. For a pessimistic view 2024-2030 was held fixed at 5 MW.

7.0: Economic Analysis

7.1: Total Installed Cost

The total installed costs were based off of indicative estimates and may change with estimate refinement. The estimated years are estimates based on a 1.5% load growth for the study area. These are subject to change based on the actual load growth experienced in the area. This will not change the need only the in-service date.

Option 1: 115 kV dbl ckt, dbl bundled Hiawatha Plan –

- 115/13.8 kV stations at Midtown and Hiawatha. Midtown is located at Oakland site
- Staging for costs
    - 2010
        - HIA & MID @ 115 kV - $18,311,000
    - 2013
        - Cleveland substation - $15,187,000
        - Cleveland-Lexington 115 kV (4 mi) - $3,016,000

        - 2 – 672 MVA xfmrs at Red Rock - $13,394,000
    - 2014
        - Crosstown substation - $6,143,000
        - Crosstown-WIL 115 kV dbl ckt (3 mi) - $3,381,000
        - 2 – 672 MVA xfmrs at Parkers Lake - $12,080,000
        - 2 – 672 MVA xfmrs at Eden Prairie - $15,000,000
    - 2016
        - Crosstown 2nd dist xfmr - $3,774,000
        - MID 2nd dist xfmr - $3,774,000
    - 2017
        - HIA 2nd dist xfmr - $4,610,000
    - 2018
        - Reconductor Afton-Red Rock 115 kV ckt (12.8mi) - $3,404,800
    - 2020
        - Cleveland-HIA 115 kV dbl ckt Dbl Bundle (7mi) - $7,889,000

Total Cost - $109,963,000

Option 2: 345 kV Hiawatha Plan -

- 115/13.8 kV stations at Midtown and Hiawatha. Midtown is located at Oakland site
- Staging for costs
    - 2010
        - HIA & MID @ 115 kV - $18,311,000
    - 2013
        - Cleveland substation - $15,187,000
        - Cleveland-Lexington 115 kV (4 mi) - $3,016,000
        - 2 – 672 MVA xfmrs at Red Rock - $13,394,000
    - 2014
        - Crosstown substation - $6,143,000
        - Crosstown-WIL 115 kV dbl ckt (3 mi) - $3,381,000
        - 2 – 672 MVA xfmrs at Parkers Lake - $12,080,000
        - 2 – 672 MVA xfmrs at Eden Prairie - $15,000,000
    - 2016
        - Crosstown 2nd dist xfmr - $3,774,000
        - MID 2nd dist xfmr - $3,774,000
    - 2017
        - HIA 2nd dist xfmr - $4,566,000
    - 2018
        - Reconductor Afton-Red Rock 115 kV ckt (12.8mi) - $3,404,800
    - 2018
        - Cleveland-HIA 345 kV (7mi) - $6,552,000
        - HIA 345 kV sub work - $7,140,000

Total Cost - $115,722,800

Option 3: Parkers Lake-Aldrich 345 kV Plan -

- 115/13.8 kV stations at Midtown and Hiawatha. Midtown is located at Oakland site
- Staging for costs
  - 2010
    - HIA & MID @ 115 kV - $18,311,000
  - 2013
    - Cleveland substation - $15,187,000
    - Cleveland-Lexington 115 kV (4 mi) - $3,016,000
    - 2 – 672 MVA xfmrs at Red Rock - $13,394,000
  - 2014
    - ALD sub work - $13,540,000
    - ALD-PKL 345 kV (7 mi) - $6,552,000
    - Crosstown addition - $6,143,000
    - Crosstown-WIL 115 kV dbl ckt (3 mi) - $3,381,000
    - 2 – 672 MVA xfmrs at Eden Prairie - $15,000,000
  - 2016
    - Crosstown 2nd dist xfmr - $3,774,000
    - MID 2nd dist xfmr - $3,774,000
  - 2017
    - HIA 2nd dist xfmr - $4,610,000
  - 2018
    - Reconductor Afton-Red Rock 115 kV ckt (12.8mi) - $3,404,800
  - 2019
    - ALD-MID 115 kV (2 mi) - $1,576,000

Total Cost - $111,662,800

Option 4: Quad 345 kV Plan -

- 115/13.8 kV stations at Midtown and Hiawatha. Midtown is located at Oakland site
- Staging for costs
  - 2010
    - HIA & MID @ 115 kV - $18,311,000
  - 2013
    - Red Rock upgrade - $13,540,000
    - Rogers Lake upgrade - $13,540,000
    - RRK-RLK 345 kV (6 mi) - $5,616,000
    - Cleveland substation - $15,187,000
    - Cleveland-Lexington 115 kV (4 mi) - $3,016,000
  - 2014
    - Cleveland-HIA 345 kV (7mi) - $6,552,000
    - HIA 345 kV sub work - $7,140,000
    - BDS 345 kV sub addition - $15,187,000
    - Crosstown Substation - $6,143,000
    - Crosstown-WIL 115 kV dbl ckt (3 mi) - $3,381,000
  - 2015

- ALD sub work - $15,187,000
- ALD-PKL 345 kV (7 mi) - $6,552,000

o 2016

- Crosstown 2nd dist xfmr - $3,774,000
- MID 2nd dist xfmr - $3,774,000

o 2017

- HIA 2nd dist xfmr - $4,610,000

Total Cost - $141,510,000

7.2: Evaluated Costs (with losses)

Evaluated costs take into account present worth value and overall system loss savings. An economic analysis of the cost savings associated with transmission system loss reduction is discussed in section 6.1. The detailed Present Worth Analysis spreadsheets are listed in Appendix D.

115 kV dbl ckt, dbl bundled Hiawatha Plan –

Total Installed Cost - $109,963,000
Present Worth Cost - $94,797,345

345 kV Hiawatha Plan -

Total Installed Cost - $115,722,800
Present Worth Cost - $95,574,140

Parkers Lake-Aldrich 345 kV Plan -

Total Installed Cost - $111,662,800
Present Worth Cost - $93,785,538

Quad 345 kV Plan -

Total Installed Cost - $141,510,000
Present Worth Cost - $96,104,596

8.0: Relevant Concerns

8.1: Load Serving Issues

Several load-serving issues exist or are imminent in southern Minneapolis and in the greater Twin Cities metro areas. These are summarized below and described in the following paragraphs.

Load center	Critical Contingencies
Southtown Substation	Loss of any of the 115/13.8 kV distribution transformers
Distribution Feeders	System intact overloads, several N-1 overloads
Minneapolis Metro Transformers (Parkers Lake, Eden Prairie, Red Rock)	Loss of one of the 345/115 kV transformers currently feeding the inner 115 kV system

The Southtown substation located in south Minneapolis as is currently served at the 115 kV level. There are currently a total of 54 MW of load at risk for loss of one of the 3 existing 115/13.8 kV distribution transformers. Adding another distribution transformer to relieve this risk at the existing Southtown substation is not possible due to the site would have to be expanded to accommodate a new transformer. The current Southtown site is in a heavily populated and congested area making expansion difficult.

Currently, there are 16 distribution feeders within the south Minneapolis area that are experiencing normal (base case) overloads totaling about 24 MVA. There are an additional 39 feeders that have contingency overloads (N-1) totaling about 225 MVA. These feeders currently do not have adequate N-1 backup to serve the entire load. Load would have to be curtailed in some cases to prevent sever loading on the existing distribution system.

The Minneapolis/St. Paul metro 115 kV area is primarily fed through the double circuited 345 kV loop that feeds the 115 kV system through large 345/115 kV transformers. Continued load growth on the 115 kV system will push the bulk 345/115 kV transformers beyond their acceptable 115% emergency under certain contingencies. This will cause the need for replacing the existing transformers to larger transformers or to add additional transformer capacity on the 345 kV system. Several of these sites have site limitations on the substation making expansion unlikely. In the case of the Red Rock 345/115 kV transformers, even when the existing pair of 448 MVA transformers is replaced with a pair of 672 MVA transformers, load growth will outstrip capacity in 2016 forcing another solution.

8.2: Constructability & Schedule Considerations

The transmission Options under evaluation differ significantly with respect to the number and type of construction activities required. These differences have ramifications with respect to the lead times involved in implementing the series of improvements required. Simpler Options are easier to build.

Options that require large amounts of reconductoring and rebuilding require disproportionately more time. This arises because power system reliability considerations limit the number of circuits within a geographical sub-area that can be simultaneously out of service for upgrade or replacement, since many of the circuits involved are to some degree electrically in parallel. This dictates that construction cannot be undertaken simultaneously on more than a few existing

circuits per season; rather, sequential construction is required. In contrast, Options that rely less heavily on reconductors and rebuilds encounter fewer construction outage constraints.

Table 4 summarizes the types of transmission line work involved and gives an estimated duration of work; based on a January 2010 start date. For this study load growth was assumed at a conservative 1.5% based on the 7-year historical averages for the study area. This is considered low for a major metropolitan area.

Table 4
Constructability & Schedule Considerations
For the South Minneapolis Electric Reliability Project

		miles of transmission					
Option	Description	New	Recond	Rebuild	Total	Capacitors	Years
1	Hiawatha @ 115 kV	27	12.8	0	39.8	0	8
2	Hiawatha @ 345 kV	20	12.8	0	32.8	0	8
3	Aldrich @ 345 kV	22	12.8	0	34.8	0	9
4	Quad 345 kV	33	0	0	33	0	7

The timing of the transmission system improvements for each of these options is highly dependent on the system load growth. So this means that for each of these options some parts could happen sooner or later depending on how fast the load grows.

8.3: Double-Circuit Line Considerations

The 345 kV Hiawatha Plan, which has been identified as the "Preferred Plan", involves addition of a new Hiawatha 345/115 kV substation, a new Midtown 115 kV substation, a new Cleveland 345/115 kV substation, a new Crosstown 115 kV substation, a new double circuit 115 kV line from Hiawatha-Midtown, a new 345 kV line from Cleveland-Hiawatha, and a new double circuit 115 kV line from Wilson-Crosstown. Implementation of these circuits requires consideration of whether it is desirable or acceptable to construct these pairs of circuits on double-circuit structures.

The conclusion is that in the case of the Hiawatha-Midtown 115 kV lines and the Wilson-Crosstown 115 kV lines it is appropriate to put them on the same structures. Loss of these two lines will only affect the distribution load located at the new Midtown and Crosstown substations.

For the new 345 kV line between Hiawatha-Cleveland it is not appropriate to double circuit with existing lines. This new lines will be a major source to the area, double circuiting it with an existing line will mean we have to plan for loss of both lines under one contingency. The existing system can handle the loss of the new 345 kV line with out causing issues on the existing transmission system. Consequently, the 345 kV line from Cleveland-Hiawatha must be constructed in a manner that minimizes exposure to "common-mode" failures, which would simultaneously render both circuits unusable.

Common-mode failure mechanisms for double-circuit lines include

- electrical failure of line insulation due to lightning strike;
- mechanical failure of one or more structures;
- broken shield wire falling into power conductors;
- wind-blown debris causing conductor-conductor short circuits;
- insulator contamination due to road salt, soot, or agricultural chemicals;
- wind/sleet/ice conditions
- contact with aircraft or construction equipment (crane, dump truck)
- protective relaying malfunction ("sympathetic tripping" due to fault on adjacent circuit)

These common-mode failure mechanisms have all been experienced on the Xcel Energy/NSP transmission system, on double-circuit lines at all voltage levels from 69 kV to 345 kV.

In consideration of these common-mode outage mechanisms, the NERC Planning Standards recognize double-circuit line outages as a "single-contingency" type of event ("Category C-5"). Consequently, evaluation of electric transmission system capability is performed considering failure of both circuits of a double-circuit line as being a single-contingency event. Double-circuit lines therefore are not appropriate in situations where two independent circuits are required for reliability purposes.

Double-circuit construction is acceptable if the power system can reliably withstand simultaneous failure of both circuits. Double circuit construction therefore can be appropriate in situations where the two circuits serve different functions, connect different pairs of substations, split away and proceed in different directions, or where high capacity (but not redundancy) is required.

9.0: Detailed Listing of Recommended and System Alternative Plans' Facilities

The Recommended Plan is the "345 kV Hiawatha Plan" configuration.

Lines--new		miles	conductor kcm
Cleveland-Hiawatha 345 kV		7	2 x 795 ACSR
Cleveland-Lexington 115 kV		4	1 x 795 ACSS
Hiawatha-Midtown 115 kV dbl ckt		2 x 1.5	1 x 795 ACSS
Wilson-Crosstown 115 kV dbl ckt		2 x 3	1 x 795 ACSS
	Total	20	
Lines--reconductor or rebuild			
Afton-Red Rock 115 kV	reconductor	12.8	1 x 795 ACSS
	Total	12.8	

Transformers	MVA
Cleveland 345/115 kV	1 x 672
Hiawatha 345/115 kV	1 x 448

Red Rock #9 & #10 replacement	2 x 448 →	2 x 672
Parkers Lake #9 & #10 replacement	2 x 448 →	2 x 672
Eden Prairie #9 & #10 replacement	2 x 448 →	2 x 672
	Total Increase	2016

Reactive (voltage control) facilities

Shunt Capacitors		MVAR
None identified		
	Total Increase	0

Shunt Reactors		MVAR
None identified		
	Total Increase	0

Substations--new

Cleveland 345/115 kV Substation (by Cleveland Ave and Hwy 280)
Hiawatha 345/115 kV Substation (~1 mi North of Southtown substation)
Midtown 115 kV Substation (~2 mi South of downtown Minneapolis)
Crosstown 115 kV Substation (by 35 W and Hwy 62 interchange)

Substations--modified

Eden Prairie add 345 kV ring bus

Alternative 1 is the "115 kV Hiawatha Plan" configuration.

Lines--new		miles	conductor kcm
Cleveland-Hiawatha 115 kV dbl ckt, dbl bundled		2 x 7	2 x 795 ACSS
Cleveland-Lexington 115 kV		4	1 x 795 ACSS
Hiawatha-Midtown 115 kV dbl ckt		2 x 1.5	1 x 795 ACSS
Wilson-Crosstown 115 kV dbl ckt		2 x 3	1 x 795 ACSS
	Total	27	

Lines--reconductor or rebuild			
Afton-Red Rock 115 kV	reconductor	12.8	1 x 795 ACSS
	Total	12.8	

Transformers		MVA
Cleveland 345/115 kV		1 x 672
Hiawatha 345/115 kV		1 x 448
Red Rock #9 & #10 replacement	2 x 448 →	2 x 672
Parkers Lake #9 & #10 replacement	2 x 448 →	2 x 672
Eden Prairie #9 & #10 replacement	2 x 448 →	2 x 672
	Total Increase	2016

Reactive (voltage control) facilities

Shunt Capacitors		MVAR
None identified		
	Total Increase	0

Shunt Reactors		MVAR
None identified		
	Total Increase	0

Substations--new

Cleveland 345/115 kV Substation (by Cleveland Ave and Hwy 280)
Hiawatha 115 kV Substation (~1 mi North of Southtown substation)
Midtown 115 kV Substation (~2 mi South of downtown Minneapolis)
Crosstown 115 kV Substation (by 35 W and Hwy 62 interchange)

Substations--modified

Eden Prairie add 345 kV ring bus

Alternative 2 is the " Parkers Lake-Aldrich 345 kV Plan " configuration.

Lines--new		miles	conductor kcm
Parkers Lake-Aldrich 345 kV		7	2 x 795 ACSR
Cleveland-Lexington 115 kV		4	1 x 795 ACSS
Aldirch-Midtown 115 kV		2	1 x 795 ACSS
Hiawatha-Midtown 115 kV dbl ckt		2 x 1.5	1 x 795 ACSS
Wilson-Crosstown 115 kV dbl ckt		2 x 3	1 x 795 ACSS
	Total	22	

Lines--reconductor or rebuild			
Afton-Red Rock 115 kV	reconductor	12.8	1 x 795 ACSS
	Total	12.8	

Transformers		MVA
Cleveland 345/115 kV		1 x 672
Hiawatha 345/115 kV		1 x 448
Red Rock #9 & #10 replacement	2 x 448 →	2 x 672
Eden Prairie #9 & #10 replacement	2 x 448 →	2 x 672
	Total Increase	1568

Reactive (voltage control) facilities

Shunt Capacitors		MVAR
None identified		
	Total Increase	0

Shunt Reactors		MVAR
None identified		
	Total Increase	0

Substations--new

Cleveland 345/115 kV Substation (by Cleveland Ave and Hwy 280)
Hiawatha 115 kV Substation (~1 mi North of Southtown substation)
Midtown 115 kV Substation (~2 mi South of downtown Minneapolis)
Crosstown 115 kV Substation (by 35 W and Hwy 62 interchange)

Substations--modified

Eden Prairie	add 345 kV ring bus
Aldrich	add 345 kV bus, open 115 kV tie breaker, 115 kV breaker addition

Alternative 3 is the "Quad Plan" configuration.

Lines--new		miles	conductor kcm
Cleveland-Hiawatha 345 kV		7	2 x 795 ACSR
Red Rock-Rodgers Lake 345 kV		6	2 x 795 ACSR
Aldrich-Parkers Lake 345 kV		7	2 x 795 ACSR
Cleveland-Lexington 115 kV		4	1 x 795 ACSS
Hiawatha-Midtown 115 kV dbl ckt		2 x 1.5	1 x 795 ACSS
Wilson-Crosstown 115 kV dbl ckt		2 x 3	1 x 795 ACSS
	Total	33	

Lines--reconductor or rebuild		
none	reconductor	0
	Total	0

Transformers		MVA
Cleveland 345/115 kV		1 x 672
Hiawatha 345/115 kV		1 x 448
Black Dog 345/115 kV		1 x 672
Rodgers Lake 345 /115 kV		1 x 448
	Total Increase	2240

Reactive (voltage control) facilities

Shunt Capacitors		MVAR
None identified		
	Total Increase	0

Shunt Reactors		MVAR
None identified		
	Total Increase	0

Substations--new

Cleveland 345/115 kV Substation (by Cleveland Ave and Hwy 280)
Hiawatha 115 kV Substation (~1 mi North of Southtown substation)
Midtown 115 kV Substation (~2 mi South of downtown Minneapolis)
Crosstown 115 kV Substation (by 35 W and Hwy 62 interchange)

Substations--modified

Eden Prairie	add 345 kV ring bus
Red Rock	add 345 kV breaker
Rodgers Lake	add 345 kV bus section and associated breakers
Aldrich	add 345 kV bus, open 115 kV tie breaker, 115 kV breaker addition
Black Dog	add 345 kV bus, 115 kV breaker additions.