4.0 Conceptual Plans

4.1 Introduction

The Legislature directed the utilities to prepare a conceptual plan to guide ongoing planning efforts to develop the transmission necessary to support the Renewable Energy Standards and milestones. Conceptual plans are attempts to describe transmission infrastructure that might be constructed to meet a particular objective. Conceptual plans are developed from a macroscopic perspective, relying on currently available information to make assumptions on such matters as loads, availability and location of (in this case renewable) energy resources, and power system performance characteristics. Conceptual plans are only that – concepts. At a later time specific studies will have to be performed, relying on facts and updated assumptions, to identify individual transmission projects and their technical characteristics.

Even prior to the passage of the Renewable Energy Act, the utilities had engaged in the development of conceptual plans. The CapX 2020 Vision Plan, while not focusing on renewable energy only, is a conceptual study, and work continues by the CapX utilities to examine future options. Xcel Energy began a study to develop a conceptual plan to meet renewable energy goals in 2007 before the Legislature even established the new standards. Since the adoption of the new standards, the utilities commissioned the development of a conceptual plan to identify one set of transmission lines that might be required to meet the standards and milestones. Finally, MISO has been engaged in the development of concepts for transporting large amounts of energy from wind-rich areas in the west to markets in the east.

In all, the utilities can report on four different conceptual plans. Other than the Phase I Projects selected by the CapX utilities, none of the plans has identified specific lines for construction, and none is preferable to the others. They are concepts only, and a great deal of work remains before any specific plan can be pursued or any particular project can be chosen.

4.2 CapX 2020 Vision Plan

The CapX 2020 Vision Plan was completed in May 2005. This study focused on identifying the type of transmission necessary in the year 2020 for the Minnesota utilities serving load within Minnesota and the surrounding area. Part of the effort was to examine the impact of the location of future generation sources to serve the future load growth. Based on load forecast at the time, the estimated new generation required was 8000 MW. This generation level corresponded to a 6300 MW increase in the load in the footprint noted in the map that follows this subsection. This study also investigated the transmission needed given only a 4500 MW increase in load.

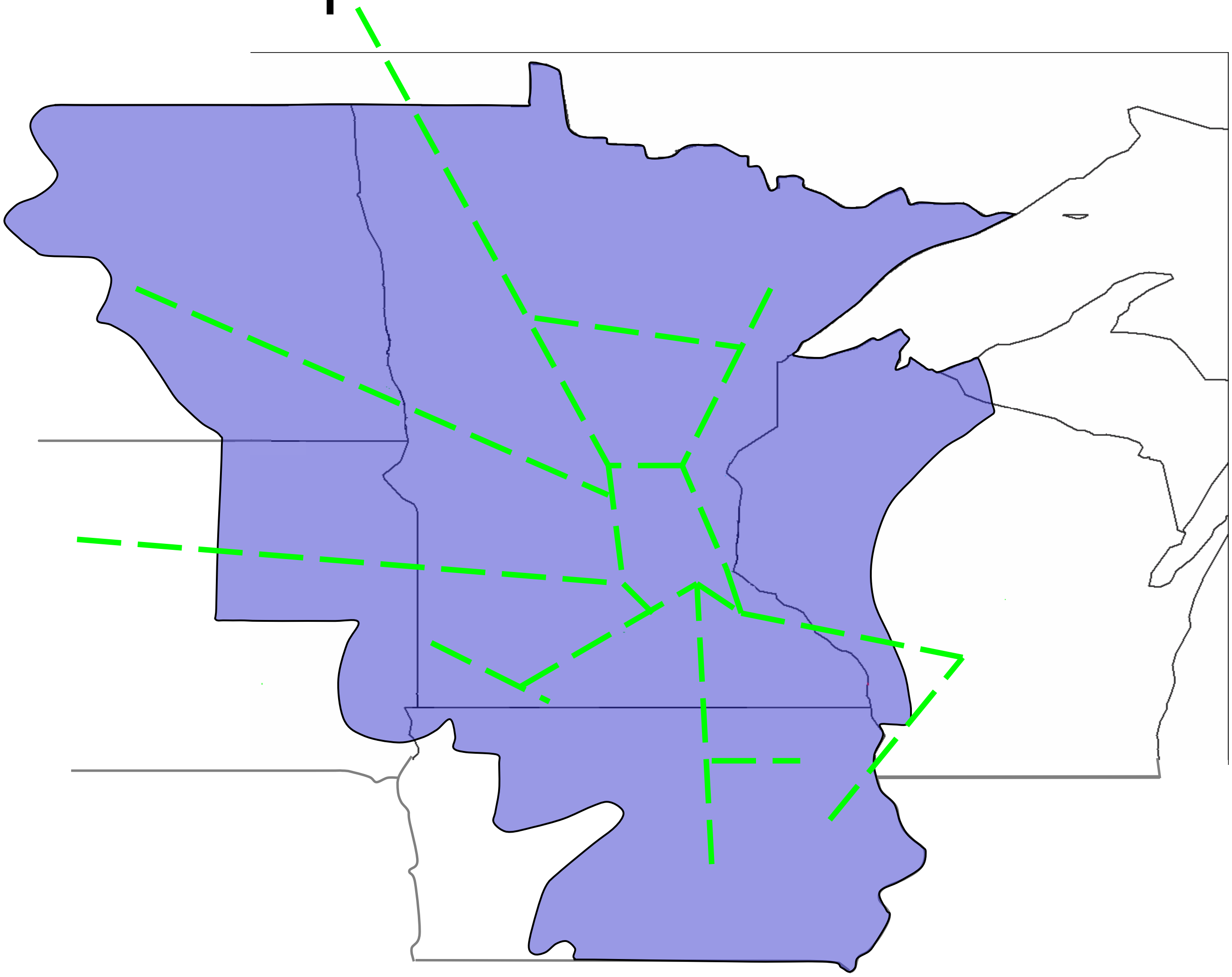
At the time of the study, Minnesota had a Renewable Energy Objective of ten percent of Minnesota energy sales from renewable generation resources in effect. Based on estimated energy sales, each scenario sited 2400 MW of generation in areas where renewable resources were likely to be developed. These sites were selected based on information from the MISO generation queue, sites identified in previous studies, and from wind advocacy groups.

At each of the load levels, three generation biases (northwest, Minnesota, and eastern) were studied to determine what transmission network would be needed to address connecting new generation to serve the load growth. A common set of 345 kV transmission elements were identified that focused on the development of a 345 kV ring around the Twin Cities metropolitan area (similar to the existing double-circuit network) that would encompass a much larger area and the creation of transmission spokes that connect remote generation to load centers in Minnesota.

A whole section in the 2005 Biennial Report was devoted to the CapX 2020 effort and the 2007 Biennial Report also devotes an entire section to the CapX 2020 Projects. The CapX utilities are continuing to develop their vision for future transmission infrastructure and are in the process of developing new iterations of the initial Vision Plan.

A schematic of various conceptual transmission lines being looked at as part of the CapX Vision Plan is shown on the following page.

Conceptual Transmission



4.3 Xcel Energy 4300 MW Study

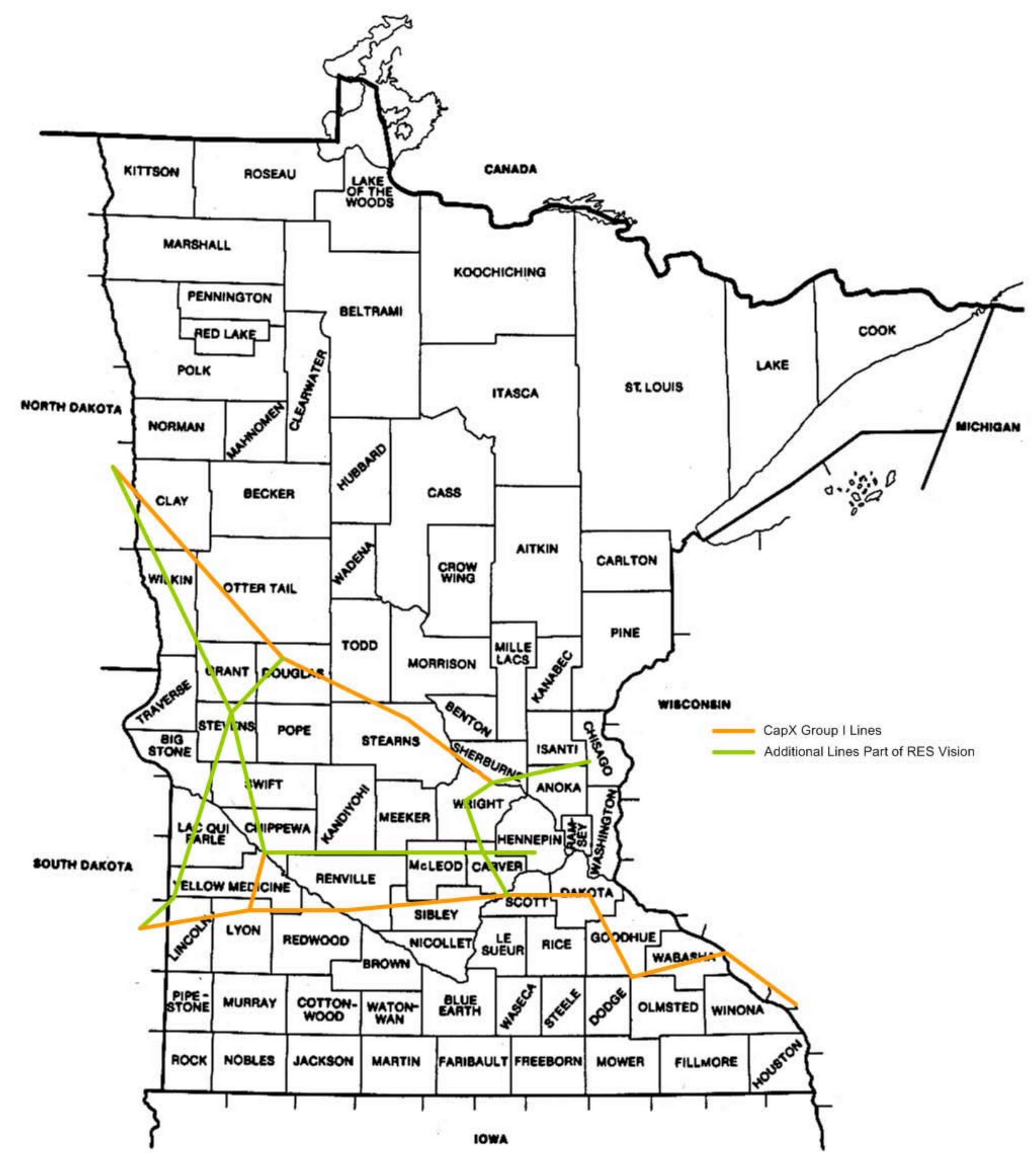
In anticipation of the renewable energy standard legislation, a study was performed by Xcel Energy’s Transmission Planning department in early 2007 to determine the amount of transmission necessary to move roughly 4300 MW of wind-generated energy from western Minnesota and the Dakotas to the Twin Cities.

The model used for the study already had 1900 MW of generation in place and included the four CapX 2020 Group I projects. The MISO generation queue was used as a rough guideline for this development, but some discretion was also exercised in examining the impact of locations for generation projects.

To make up the difference between the 1900 MW modeled and the 4300 MW desired, 400 MW generation installations were modeled at the following locations: Fargo, North Dakota (Maple River Substation), Lincoln County, Minnesota, Stevens County, Minnesota, Morris Substation, Lyon County Substation, and Minnesota Valley Substation. These installations would likely take place at other locations on the lower-voltage systems, and these stations were selected as approximate models of their injection points into the high voltage grid. When it actually comes time to study the locations of generation projects, it may be determined that upgrades to the lower-voltage system are necessary in order to move the generation to the high-voltage grid where it was modeled for this study.

After analyzing the overloads that occurred, a series of projects were inserted into the model to transfer the wind-generated power to the Twin Cities.

A map of how the new major transmission facilities might look under this conceptual plan is shown on the following page.


CANADA
NORTH DAKOTA
SOUTH DAKOTA
WISCONSIN
MICHIGAN
IOWA
KITTSON
ROSEAU
LAKE OF THE WOODS
MARSHALL
KOOCHICHING
PENNINGTON
BELTRAMI
RED LAKE
COOK
POLK
CLEARWATER
LAKE
ST. LOUIS
ITASCA
NORMAN
MAHNOMEN
HUBBARD
CLAY
BECKER
CASS
AITKIN
CARLTON
CROW WING
WADENA
OTTER TAIL
PINE
MILLE LACS
TODD
MORRISON
KANABEC
GRANT
DOUGLAS
TRAVERSE
BENTON
STEVENS
POPE
STEARNS
ISANTI
CHISAGO
BIG STONE
SHERBURNE
ANOKA
SWIFT
KANDIYOHI
WRIGHT
MEEKER
WASHINGTON
LAC QUI PARLE
CHIPPEWA
HENNEPIN
RAMSEY
McLEOD
CARVER
RENVILLE
YELLOW MEDICINE
DAKOTA
SCOTT
SIBLEY
LINCOLN
LYON
REDWOOD
NICOLLET
LE SUEUR
RICE
GOODHUE
WABASHA
BROWN
PIPESTONE
MURRAY
COTTONWOOD
WATONWAN
BLUE EARTH
WASECA
STEELE
DODGE
OLMSTED
WINONA
ROCK
NOBLES
JACKSON
MARTIN
FARIBAULT
FREEBORN
MOWER
FILLMORE
HOUSTON
CapX Group I Lines
Additional Lines Part of RES Vision

4.4 RES Conceptual Plan

Beginning in late summer 2007, the utilities undertook an effort to identify a conceptual set of high voltage transmission lines that could transport the amount of renewable energy to Minnesota retail customers that would likely be required to meet the Renewable Energy Standard in 2020 and 2025. That undertaking was just completed in October 2007.

Assumptions. A number of assumptions went into this study. First, based on the Gap Analysis that was performed to estimate the amount of renewable energy generation that might be required to meet Minnesota renewable milestones, (*See* Section 2.0 of this Report), it was assumed that Minnesota utilities will require approximately 5,000 to 6,000 MW of new renewable energy to meet the RES.

Second, for purposes of this effort, it was assumed that all of the new renewable generation resources will be wind energy developments. The wind energy resource characteristics in Minnesota are such that the most economical locations for wind-energy developments are in southwestern Minnesota (Buffalo Ridge) and southeastern Minnesota (primarily Mower/Fillmore/Dodge Counties). The Buffalo Ridge extends northwesterly into South Dakota, and there are also excellent wind resources further west in South Dakota, throughout much of North Dakota, and also in much of northern Iowa. In addition, it was assumed that 1200 MW of dispersed renewable generation would be developed on the lower voltage transmission system.

The Conceptual Plan also assumes that the following CapX 2020 Phase I facilities have been installed:

- Fargo-Monticello 345 kV
- Brookings Co-Twin Cities 345 kV (including Lyon Co-Hazel Creek 345 kV)
- Twin Cities-Rochester-LaCrosse 345 kV
- Bemidji-Grand Rapids 230 kV

It is also assumed that the proposed Big Stone II outlet facilities have been installed:

- Big Stone-Morris 230 kV
- Big Stone-Canby-Hazel Creek 345 kV

Other Factors. It was also recognized that although this particular needs analysis was spurred by the Minnesota RES, in planning the region's electric transmission system, it is necessary to consider the neighboring states' resource needs and policies. In particular, it is known that the Wisconsin electric utilities are in need of considerable amounts of renewable generation, and are actively pursuing utilization of Minnesota and Iowa wind generation resources. This will create additional demand for wind-related transmission improvements, beyond those which would be needed simply for accommodating the Minnesota REO. This factor was accommodated by assuming the higher number of additional generation that may be required.

Adding large amounts of wind generation to the electric power system requires three types of transmission additions. These additions are required in order to

- connect the new generation to the local power system;
- allow for delivery of the power to the remote loads to be served;
- facilitate absorbing the minute-by-minute and hour-by-hour fluctuations of the wind output into the larger regional power system. This is referred to as “blending” the wind generation into the regional transmission footprint.

With regard to the first bullet above – connecting to the local power system – transmission must be developed (typically at 115 or 161 kV) to connect the individual generation projects to the bulk transmission system. The details of these transmission facilities will be driven in large part by the individual interconnection requests considered collectively and the characteristics of the existing network facilities. These lines will be high capacity (nominally 300 – 600 MW) and relatively short, typically less than 30 miles.

Allowing for delivery to remote loads with reasonable efficiency requires higher voltage transmission (345 kV or higher). In addition to the benefit of lower losses, use of voltages of 345 kV or higher minimizes the number of circuits required to achieve satisfactory performance with respect to applicable steady-state, dynamic stability, and voltage stability criteria. These lines will be typically 80 – 150 miles in length, with connections to the lower-voltage systems at several locations along their path. Most of these lines are expected to be 345 kV, as the higher voltages (500 or 765 kV) are better for longer distances, and where few taps or interconnections are required.

From Minnesota to the east and south, additional high-capacity interconnections are required. The 2006 Minnesota Wind Integration Study concluded that wind generation penetrations of up to 25% are feasible, with only relatively modest “integration costs.” This conclusion was reached based on an analysis in which the wind generation output fluctuations were absorbed by the entire MISO system. Since most of MISO is located east or south of Minnesota, the addition of 5,000 to 6,000 MW of wind generation in Minnesota and the Dakotas for satisfying the Minnesota REO will require establishing several thousand MW of additional transfer capability to the east and south.

Further amounts of transmission to the east will also be required for delivery of any Minnesota or Dakotas generation that is intended to be exported to those markets. Considering the magnitude of the total inter-regional interconnection capacity required, and the distances involved, these “lines to the east” will primarily be either double-circuit 345 kV or single-circuit 765 kV.

It is also known that transmission in certain areas is already constrained and must be taken into account.

1. The western, southwestern, southern, and southeastern Minnesota regions are already generation-rich relative to local load, and are already export-constrained. Consequently, any new generation installed anywhere in those regions will need new transmission outlet capacity.

2. Northeastern Minnesota, although not as "generation rich," is constrained with respect to transmission capacity to the south. Generation additions in this region will need new transmission capacity increments.

3. Northwestern Minnesota is "upstream" of the North Dakota Export (NDEX) boundary. Power deliveries across this constrained interface (to Minnesota load centers) will require increases in the NDEX capability; this requires new transmission.

Given the magnitude of the generation needs identified, the practical transmission voltages to consider are 345, 500, and 765 kV. Developments at 500 and 765 kV are well-suited for situations where relatively large amounts of power (roughly 1000 - 1500 MW or more) must be transmitted over hundreds of miles, with few taps required, while 345 kV is better suited for situations involving shorter distances, and where multiple connections to the local lower-voltage transmission system are required. High-voltage DC (HVDC) is not generally applicable here because the distances involved are not sufficient for HVDC to be more economical than a comparable AC development.

First-contingency (N-1) considerations dictate that the effective utilization of 500 or 765 kV transmission requires that either two or more circuits of that voltage be constructed, or that there be a relatively strong underlying network of 345 kV lines already present. This consideration, in combination with the moderate distances involved, indicates that transmission between the Minnesota/Dakotas best wind resource locations and the principal Minnesota load centers will be met primarily with 345 kV construction.

While connecting Minnesota's bulk transmission system to the eastern portion of the MISO region only needs to accommodate lower amounts of power, perhaps in the 4,000- 5,000 MW range, it is still a situation where voltages higher than 345 kV are likely to have proper application. The primary need here is to better integrate the Minnesota power system with the eastern MISO system, so that the burden of compensating for the fluctuations in the wind generation output may be shared among all the dispatchable generation resources throughout MISO, and also blended in with the naturally-occurring load fluctuations within this much larger power system. A secondary component of need derives from the need for delivery of some Minnesota wind generation output to Wisconsin utilities.

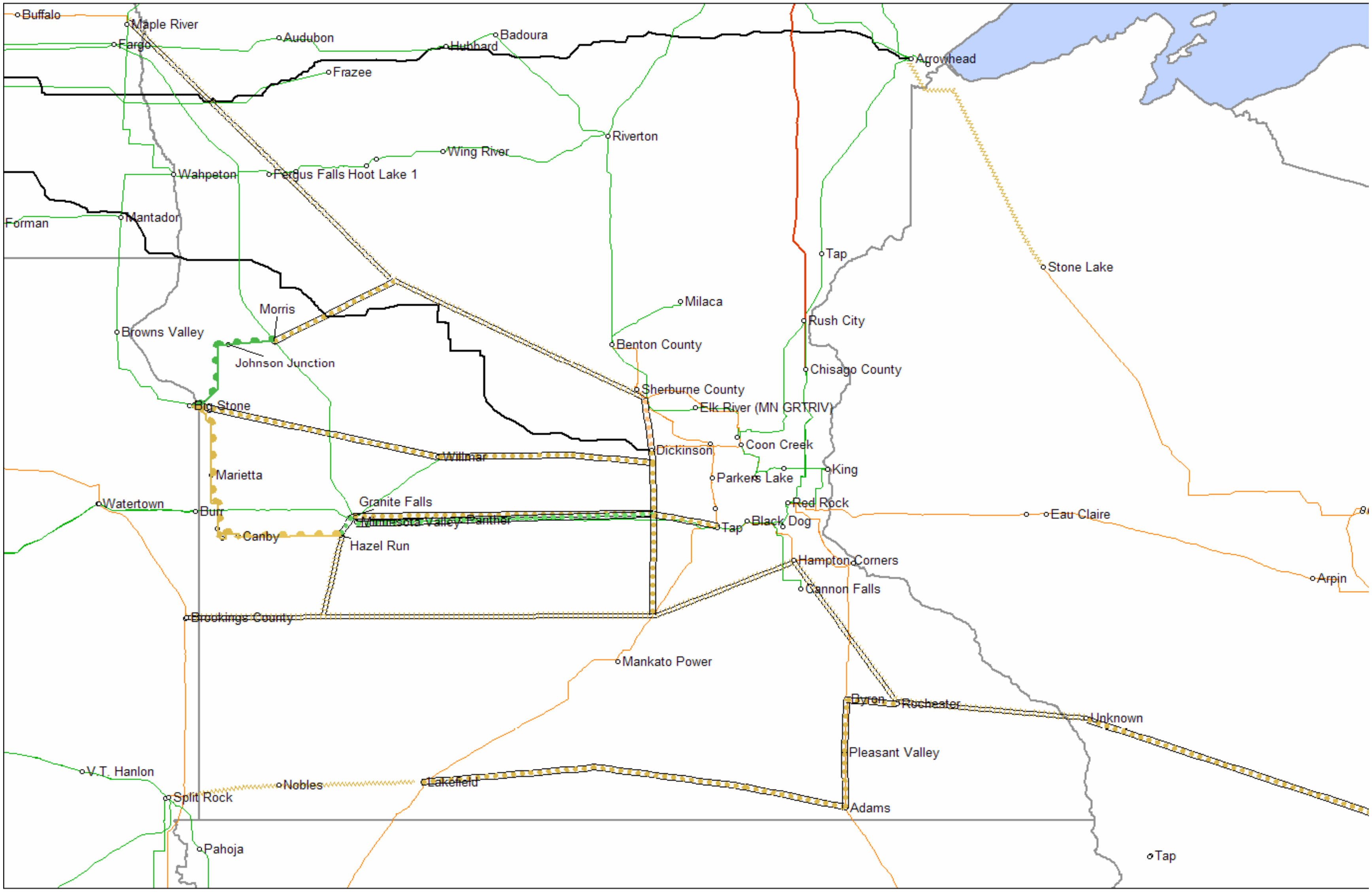
The Conceptual Plan. Taking into consideration these needs, the distances and power transfer levels involved, and the existing transmission voltages, this conceptual development to address the need to deliver power to the eastern MISO region will consist of :

- several new 345 kV circuits between Minnesota and Wisconsin
- and perhaps one new 765 kV line from southeastern Minnesota to northwestern Illinois

Additional 765 kV development between Minnesota and eastern MISO will likely be warranted if wind generation in Minnesota and the Dakotas significantly exceeds the 5,000 – 6,000 MW level required just for satisfying the Minnesota Year 2025 needs relating to the present Minnesota RES.

The Conceptual Plan presented here is one idea for possible transmission infrastructure to transport large amounts of wind from western and southern Minnesota and the Dakotas to customers east of the wind developments. The Plan is based primarily on high-capacity 345 kV development, mostly double-circuit construction, and in the longer term (2020-2025), perhaps a 765 kV interconnection to northwestern Illinois. There is also the recognition of a possible 500 or 765 kV overlay in portions of Minnesota and the Dakotas; this would also be in the latter years of the planning horizon, or even later.

A map generally showing this conceptual plan is shown on the following page.


Buffalo
Maple River
Fargo
Audubon
Hubbard
Badoura
Frazee
Arrowhead
Riverton
Wing River
Wahpeton
Fergus Falls Hoot Lake 1
Forman
Mantador
Tap
Stone Lake
Milaca
Morris
Rush City
Browns Valley
Benton County
Johnson Junction
Chisago County
Sherburne County
Big Stone
Elk River (MN GRTRIV)
Willmar
Dickinson
Coon Creek
Marietta
Parkers Lake
King
Watertown
Granite Falls
Red Rock
Burr
Minnesota Valley
Panther
Eau Claire
Canby
Tap
Black Dog
Hazel Run
Hampton Corners
Arpin
Cannon Falls
Brookings County
Mankato Power
Byron
Rochester
Unknown
Pleasant Valley
V.T. Hanlon
Nobles
Lakefield
Split Rock
Adams
Pahoja
Tap

4.5 MISO 765 kV Overlay Vision

MISO has begun a preliminary investigation into the feasibility of constructing a 765 kV overlay to allow delivery of large quantities of wind-generated energy from the resource-rich areas of western Minnesota, Iowa, and the Dakotas to points east, as far as the east coast. This effort is presently a vision plan only and much additional study is required before such a plan could be implemented. MISO is expected to conduct further analyses of this 765 kV option as part of the MTEP-08 work.

Initial study work has demonstrated that a 765 kV network assists in alleviating many regional transmission constraints and allows a substantial amount of west to east power transfer. Economic analysis of the 765 kV conceptual plan also indicates substantial savings could be achieved in generation production costs by adding the ability to rapidly interconnect wind, which has a production cost that is very low when compared to other fuel types. It should be emphasized that MISO's 765 kV vision plan assumed a strong 345 kV underlying system and included the CAPX group 1 projects.