PUBLIC VOLUME

ATTACHMENT E

CAPX2020 VISION STUDY

CapX 2020 Technical Update:
Identifying Minnesota's
Electric Transmission Infrastructure Needs

October 2005

EXECUTIVE SUMMARY

Background

Minnesota's electric transmission infrastructure, a network of transmission lines of 230 kilovolts and higher, primarily was designed and built during the 1960s and 1970s. As explained in CapX 2020's December 2004 interim report, the system is adequate to meet today's needs. But to support customers' growing demand for electricity, this high-voltage transmission system in Minnesota and neighboring states requires major upgrades and expansion during the next 15 years.

To ensure that this backbone transmission system is developed and available to serve growing demand for electricity and to plan for major capital expenditures, Minnesota's largest transmission-owning utilities—Great River Energy, Minnesota Power, Missouri River Energy Services, Otter Tail Power Company, Southern Minnesota Municipal Power Agency, and Xcel Energy—initiated the CapX 2020 project.

CapX 2020's mission is to:

- Create a joint vision of required transmission infrastructure investments needed to meet growing demand for electricity in Minnesota and the region.
- Work to create an environment that allows these projects to be developed in a timely, efficient manner, consistent with the public interest.

The utilities have completed a draft study that defines a vision for transmission infrastructure investments needed in Minnesota through 2020. That technical study, which meets the first part of CapX 2020's mission, is described in this report. Studies will continue to determine which facilities will need to be built first. As other regional transmission studies are completed, they will be integrated into the CapX 2020 study. A report that describes progress on the second part of CapX 2020's mission, including pending legislation, is planned for this summer

Study overview

In developing this long-range plan for major new construction, the CapX 2020 technical team considered two potential scenarios for growth in electricity demand:

1. Anticipated load growth of 2.49 percent annually from 2009 through 2020, for an increase of 6,300 megawatts. This is based on load projections for utilities with customers in Minnesota, published by the Mid-Continent Area Power Pool (MAPP) in the *2004 MAPP Load and Capability Report* and in recent utility resource plan filings. Load growth of 6,300 MW would require over 8000 MW of new generation, given losses that occur when transmitting.
2. Slower load growth—about two-thirds of the published load projections—of 4,500 MW.

Based on information from independent power producers, wind developers, utility resource planning staff, and the Midwest Independent Transmission System Operator's generation interconnection queue, the team also worked out three generation scenarios, each including 2,400 MW of renewable energy, to illustrate potential locations of new electric generating plants or wind farms.

The goals were to identify new transmission *independent* of where plants are located *and* to identify new transmission *specific* to particular electric generation scenarios. The team considered planning requirements for meeting the Minnesota Renewable Energy Objective, addressed issues related to relieving transmission congestion, and focused on high-voltage solutions that best addressed the three different generation scenarios.

Results: The CapX 2020 Vision Plan

Facilities common to two of the three generation scenarios were identified as the cornerstone of the CapX 2020 Vision Plan—1,620 miles of 345 kV transmission lines that total $1.215 billion, about 80 percent of the cost of each scenario individually. The following table identifies these facilities. Any long-range vision plan also will have to include additional unique facilities for each scenario.

Facility Name				
From	**To**	**Volt (kV)**	**Miles**	**Cost ($M)**
Alexandria, MN	Benton County (St. Cloud, MN)	345	80	60
Alexandria, MN	Maple River (Fargo, ND)	345	126	94.5
Antelope Valley (Beulah, ND)	Jamestown, ND	345	185	138.75
Arrowhead (Duluth, MN)	Chisago County (Chisago City, MN)	345	120	90
Arrowhead (Duluth, MN)	Forbes (northwest Duluth, MN)	345	60	45
Benton County (St. Cloud, MN)	Chisago County (Chisago City, MN)	345	59	44.25
Benton County (St. Cloud, MN)	Granite Falls, MN	345	110	82.5
Benton County (St. Cloud, MN)	St. Bonifacius, MN	345	62	46.5
Blue Lake (southwest Twin Cities, MN)	Ellendale, MN	345	200	150
Chisago County (Chisago City, MN)	Prairie Island (Red Wing, MN)	345	82	61.5
Columbia	North LaCrosse	345	80	60

Ellendale, ND	Hettinger, ND	345	231	173.25
Rochester, MN	North LaCrosse	345	60	45
Jamestown, ND	Maple River (Fargo, ND)	345	107	80.25
Prairie Island (Red Wing, MN)	Rochester, MN	345	58	43.5
	Total miles 1620		**Total cost $1,215 ($M)**	

Conclusion

The CapX 2020 technical team believes the results documented here to be the basis for additional studies to better identify the transmission needs of the study region. The following report details the technical study behind this update. Section headings are:

- Base model assumptions
  (about loads and generation and how scenarios were determined, biases).
- Analysis
  (of study assumptions such as system conditions, contingencies, Big Stone II, and other sensitivities).
- Scenario analysis
  (of existing system performance, transmission alternatives, and line flows on interface and tie lines).
- Slow growth analysis.
- Common facilities.
- Conclusion and next steps.
- CapX 2020 Technical Team members.
- Appendices.

Although the existing transmission system is adequate to meet the reliability needs of customers today, the CapX 2020 study shows that the study region will experience specific and numerous transmission overloads, outages, and voltage problems if we make no transmission additions between now and 2020. Collaborative efforts and plans, such as those identified in this report, are necessary to reduce the risk of investing in new transmission infrastructure and to preserve electric reliability for customers.

1. Base Model Assumptions

The CapX study region encompasses the service territories of electric utilities that have load-serving responsibilities for Minnesota consumers. This region is represented in Diagram 1 below.

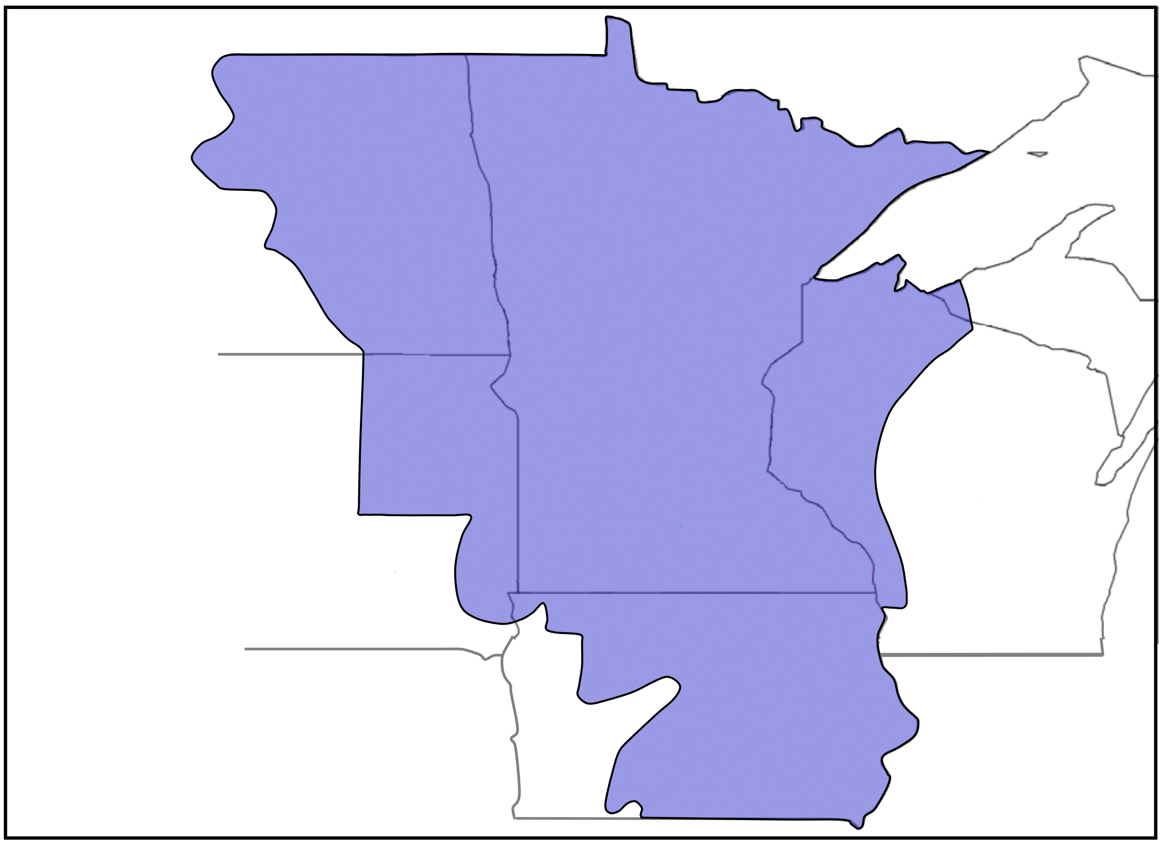

Diagram 1 – CapX 2020 Region

1.1 Loads

The CapX 2020 technical team chose the MAPP 2004 Series, 2009 summer peak model, as the base model to begin scaling loads to the anticipated 2020 load level. To accurately model 2020 loads, the technical team used individual company load growth from the *2004 MAPP Load and Capability Report* for the following control areas: Alliant Energy (west), Xcel Energy (north), Southern Minnesota Municipal Power Agency, Otter Tail Power Company, and Dairyland Power Cooperative.

Note that each control area contains not only load belonging to the control area operator, but also that of other companies. For example, Missouri River Energy Services has load in the Alliant Energy (west), Minnesota Power, Otter Tail Power Company, Western Area Power Administration, and Xcel Energy (north) control areas).

Minnesota Power and Great River Energy's loads were scaled based on their most recent resource plan filings. The growth results are in Table 1

Control area	2009 load level (2004 MAPP Series) (MW)	Yearly growth rate (%)	Calculated 2020 load level (MW)
ALT (West)	3265.3	1.60	3888.2
Xcel Energy (North)	9632.6	2.68	12885.1
MP	1507.3	1.70	1814.4
SMMPA/RPU	330.0	2.70	442.4
GRE	2833.5	3.27	3943.2
OTP/MPC	1677.2	2.70	2248.3
DPC	954.7	2.60	1266.2
Total	20200.6	Ave. = 2.49%	26487.8

Table 1 – CapX 2020 Anticipated Area Growth

Table 1 shows an anticipated load growth of approximately 6300 megawatts (MW) in the CapX 2020 region for the period from 2009 to 2020. The technical team also studied historical loads for Great River Energy, Minnesota Power, Missouri River Energy Services, Otter Tail Power Company, and Xcel Energy to determine whether anticipated load growth was consistent with historical load growth in the region. Load growth for these companies averaged 2.64 percent during the period 1980 to 2004. Diagram 2 shows the variability of load growth as well as the continuing upward growth in load for the region. The technical team's forecast from 2009 through 2020 is a slower growth curve than the actual growth in the early 2000's (2.49 percent vs. 2.64 percent).

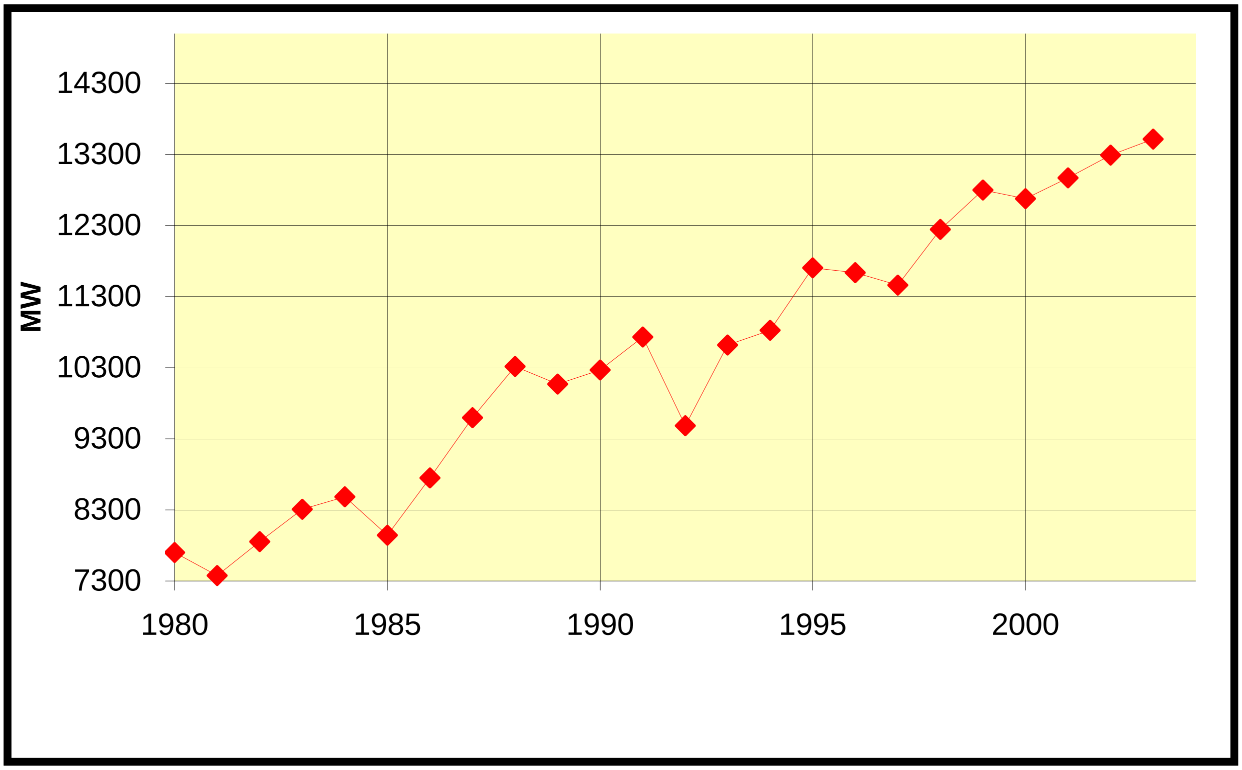

Diagram 2 – Historical Growth

1.2 Generation

The CapX 2020 technical team assumed that the generation modeled in the 2009 summer model would still exist in 2020 and would continue to serve the load modeled in 2009. To address anticipated load growth of 6,300 MW, the technical team solicited information from independent power producers (including wind developers), resource planning entities within various organizations, and the Midwest Independent System Operator's (MISO) generation interconnection queue.

Diagrams 3 and 4 are maps of potential generation addition locations that have been identified either from the MISO queue (Diagram 3) or from Wind on the Wires (which is a wind advocate organization) potential wind sites (Diagram 4).

The technical team combined this information to form potential generation development nodes, independent of fuel type, which they used in the modeling process to supply load increases.

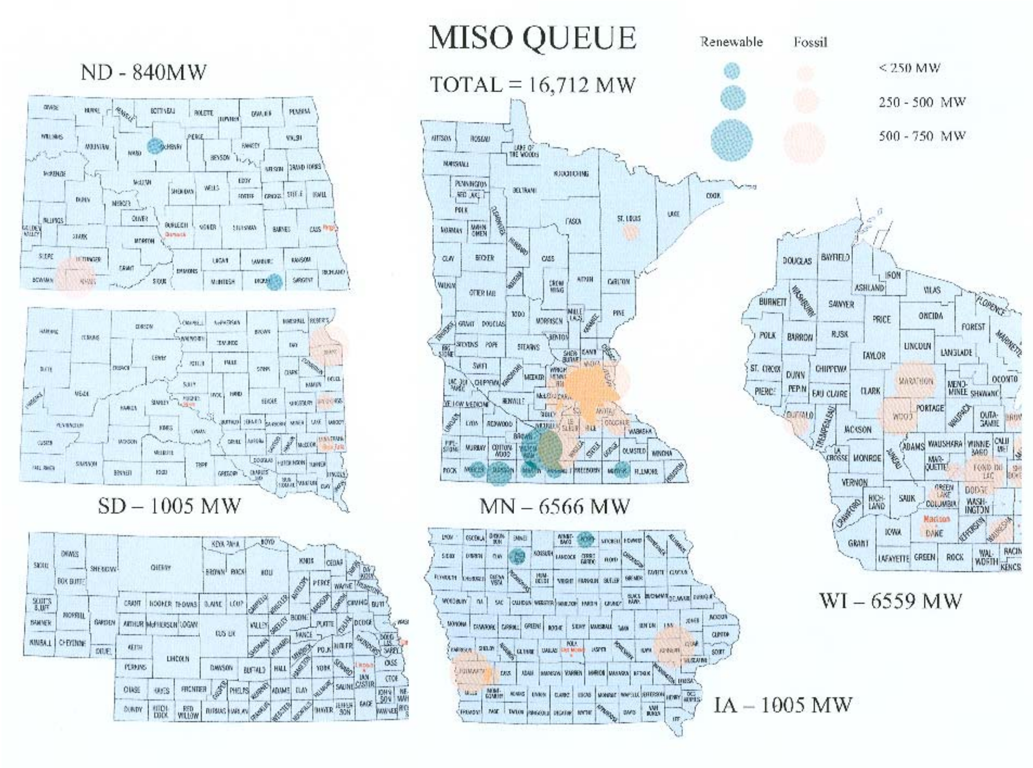

Diagram 3 – Potential Generation Areas

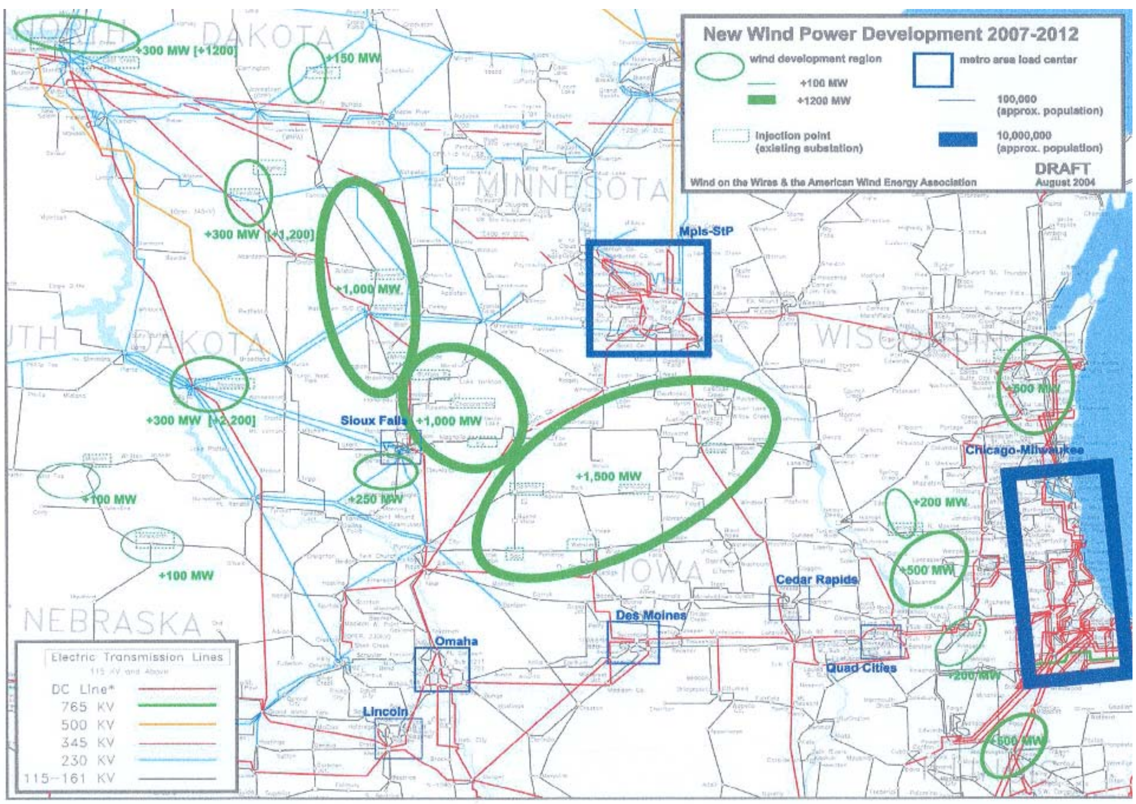

Diagram 4 – Potential Wind Generation Areas

The CapX 2020 technical team mapped the locations of these resources and identified five generation regions: Northern Minnesota, Dakotas (North Dakota and South Dakota), Southern Minnesota/Northern Iowa, Wisconsin and the Metro (Twin Cities Metropolitan) area. These regions are shown in Diagram 5.

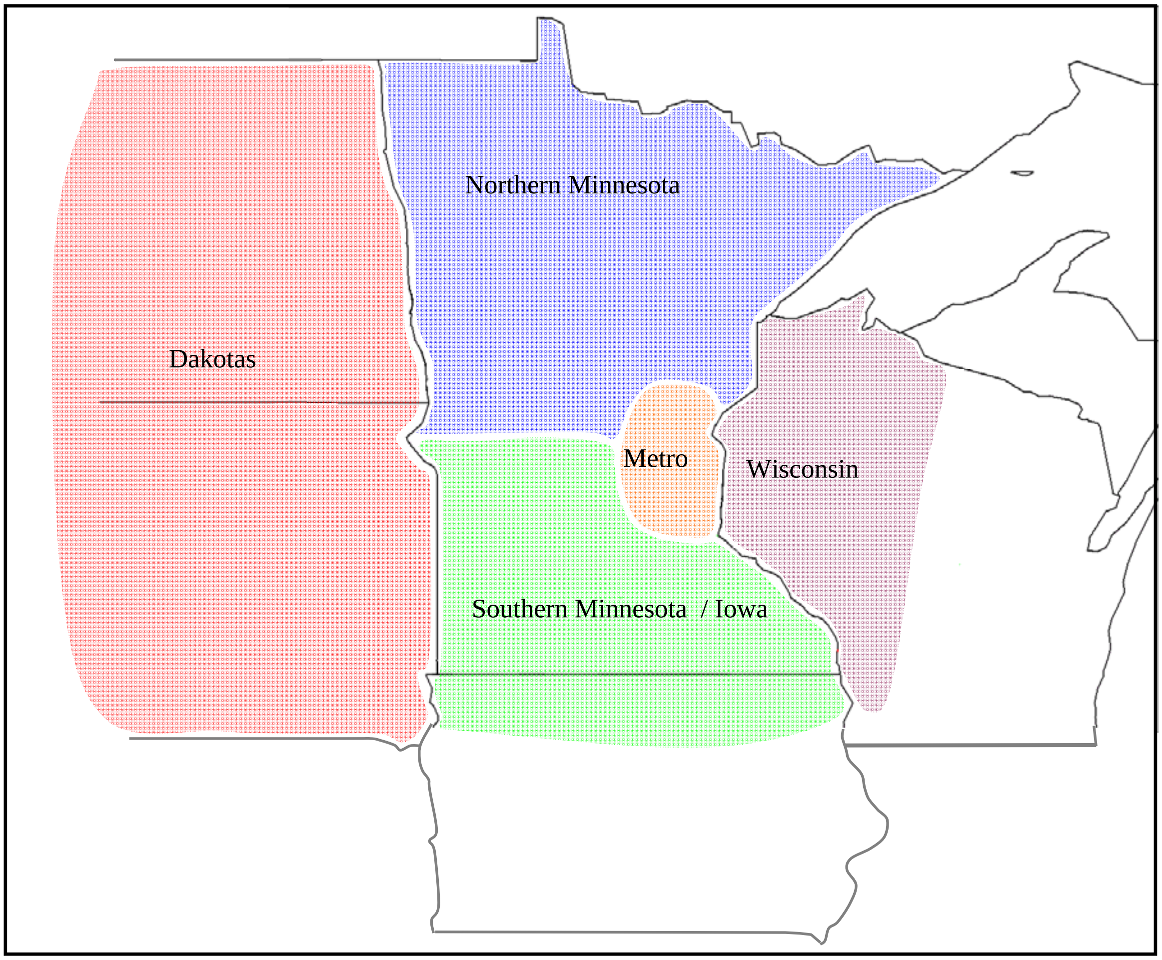

Diagram 5 – CapX 2020 Generation Regions

2.3 Scenario determination

The team modeled three generation scenarios to address the anticipated load growth of 6,300 MW from 2009 to 2020. Each of the scenarios includes sufficient renewable resources to address the Minnesota Renewable Energy Objective of the CapX 2020 participants.

The three generation scenarios consist of a North/West bias, a Minnesota bias, and an Eastern bias. These three generation biases reflect potential generation development that might influence electric power flows on the regional grid and thus indicate the size and location of new transmission infrastructure needed to deliver the generation to customers.

Each of the scenarios includes generation resources from several of the regions. See Table 2.

Generation areas	North /West Bias	Scenario Minnesota Bias	Eastern Bias
Northern MN	1700[1]	1250	550
Dakotas	2100	1000	1600
Southern MN/ Iowa	1875	1875	2175
Metro	650	2200	1000
Wisconsin	0	0	1000
Total	6325	6325	6325

Table 2 – Generation Scenarios

Diagrams 6, 7, and 8 provide geographical representation of the regions for which generation will be modeled in each scenario.

2.3.1 North/West Bias Generation

In the north/west bias generation case the new generation modeled is more heavily based on importing generation into Minnesota from Manitoba, North Dakota, South Dakota, and Iowa.

The generation mix includes 2275 MW to meet Minnesota's Renewable Energy Objective: 975 MW from Minnesota and 1300 MW from outside of Minnesota. It also includes 1950 MW of other Minnesota generation and 2100 MW of other generation from outside of Minnesota.

Chart 1 below illustrates the north/west generation mix.

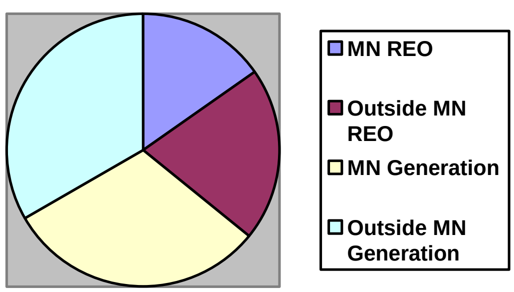

Chart 1 - North/West Bias Generation Mix

[1] This 1700-MW total includes a 1000-MW import from Manitoba.

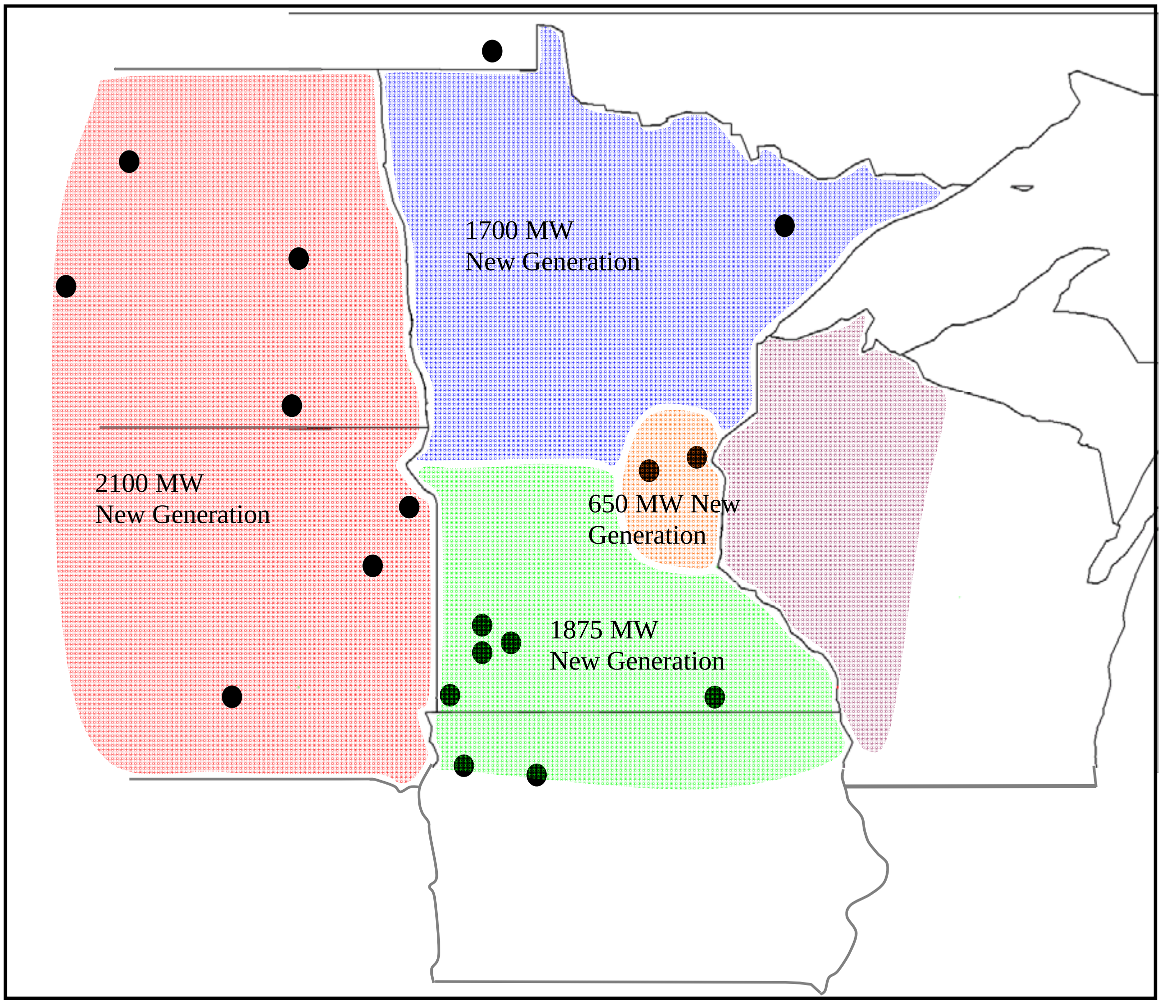

Diagram 6 - North/West Bias Generation Locations

2.3.2 Minnesota Bias Generation

In the Minnesota Bias Generation case all new generation outside of Minnesota (North Dakota, South Dakota, and Iowa) is modeled as 1300 MW of wind generation (REO). The generation modeled inside of Minnesota is a mixture of REO, peaking, and base load generation.

The generation mix includes 2275 MW of Renewable Energy Objective and 4050 MW of Minnesota generation.

Chart 2 below illustrates the Minnesota bias generation mix.

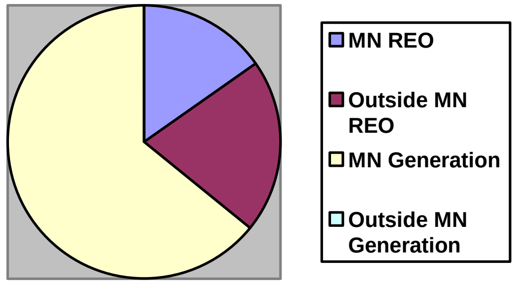

Chart 2 - Minnesota Bias Generation Mix Chart

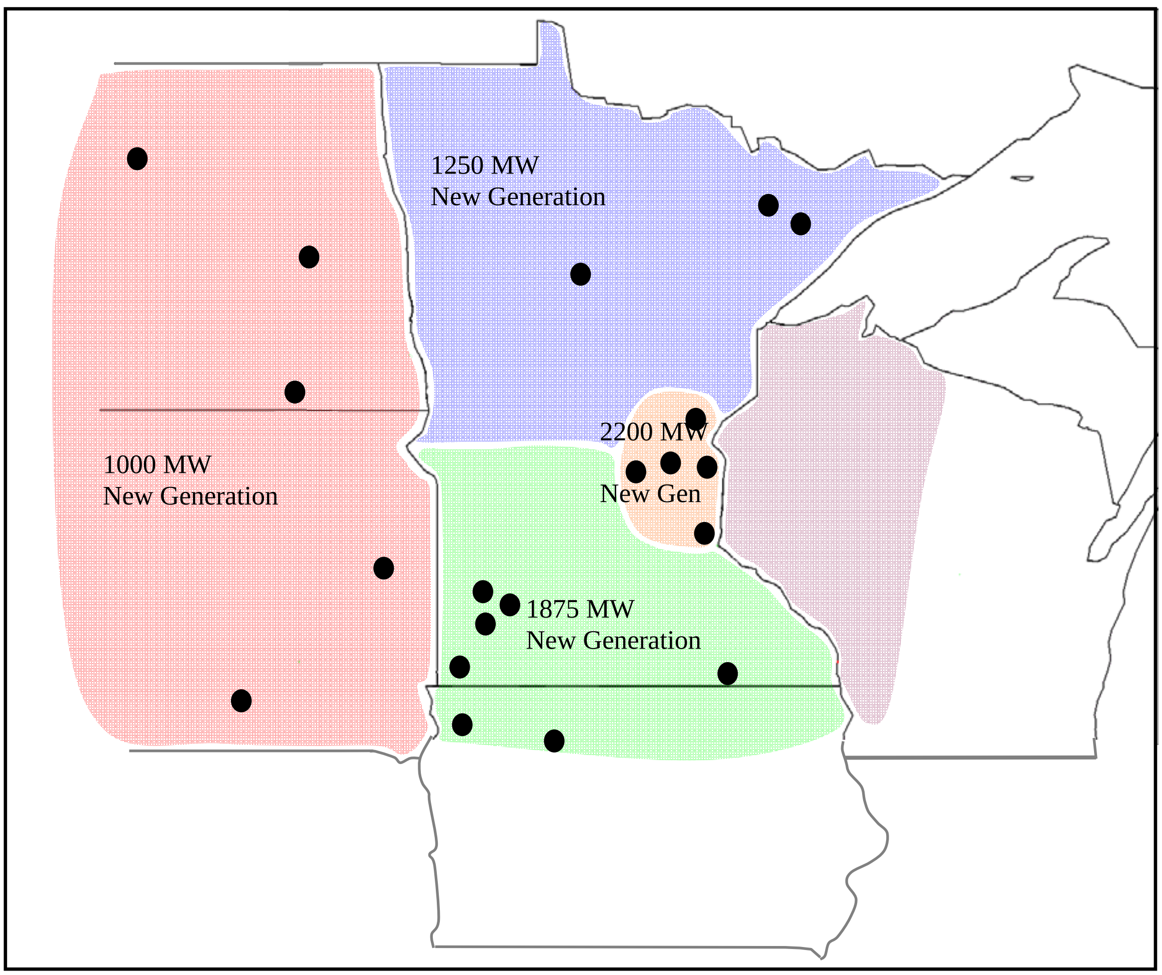

Diagram 7 - Minnesota Bias Generation Locations

2.3.3 Eastern Bias Generation

In the Eastern Bias generation case the new generation modeled is more heavily based on importing generation into Minnesota from Wisconsin and Iowa with

1000 MW new generation modeled in Wisconsin and 1050 MW of new generation modeled in Iowa.

The generation mix includes 2275 MW of Renewable Energy Objective (975 MW of Minnesota REO and 1300 MW from outside of Minnesota REO), 1700 MW of generation from inside of Minnesota, and 2350 MW of generation from outside of Minnesota.

Chart 3 below illustrates the Eastern bias generation mix.

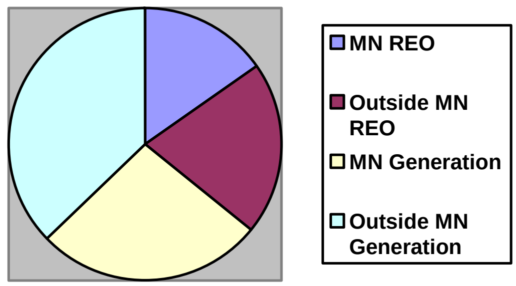

Chart 3 - Eastern Bias Generation Mix

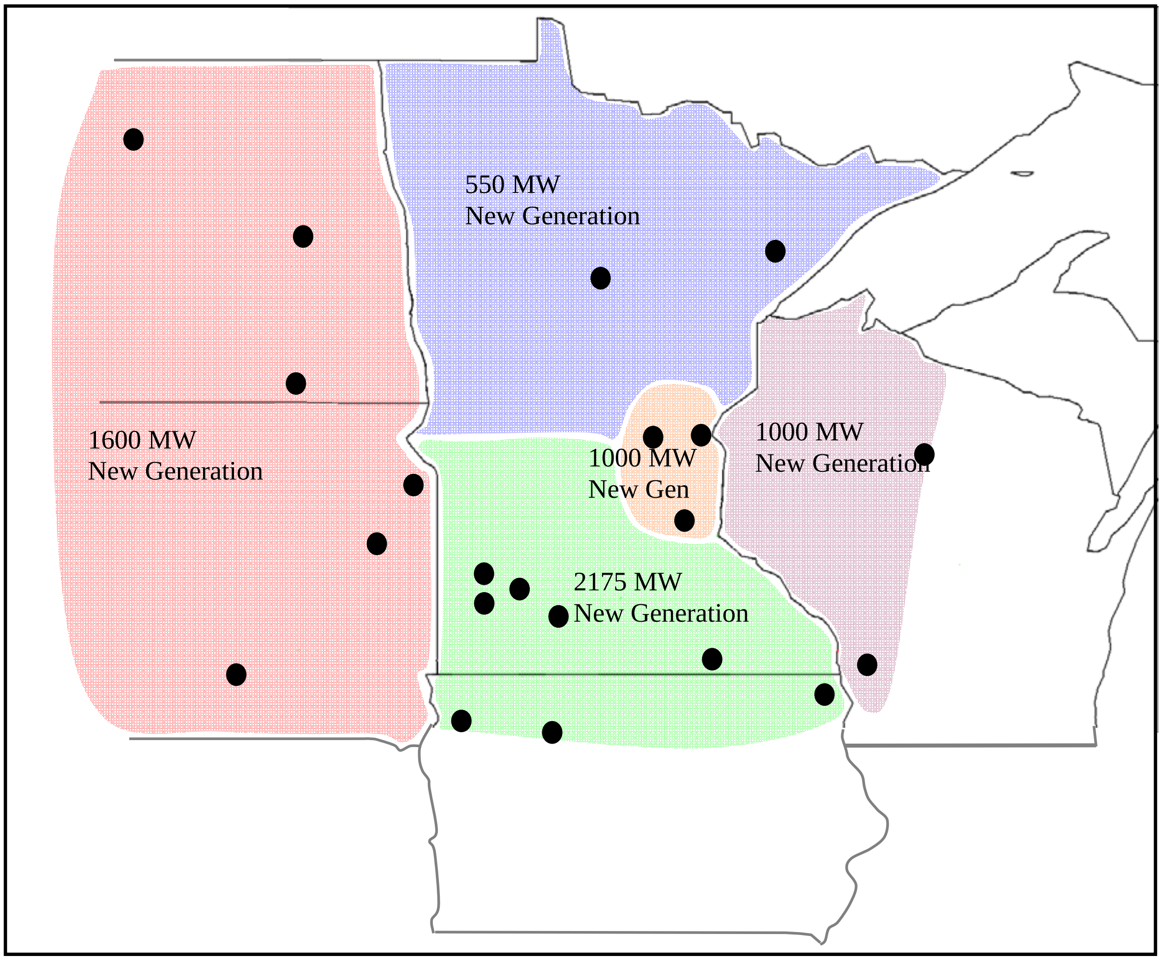

Diagram 8 - Eastern Bias Generation Locations

3 Analysis

The CapX 2020 technical team's primary goal was to create a common transmission backbone that could sustain system growth based on the three generation scenarios. In the future as specific generation is built, other transmission facilities will be required to tie the generation to the transmission backbone system and tie the load-serving centers to the local-serving distribution substations.

With this goal in mind, the team developed an initial list of possible transmission facilities. These facilities are shown in Diagram 9. Diagram 9 was created using inputs from various regional Midwest Independent System Operator (MISO) exploratory studies, the 2004 MISO Transmission Expansion Plan (MTEP '04), as well as input from utility transmission planners in the study area. The team purposely kept lines vague, leaving the routes and endpoints to be determined as study work progressed. Transmission alternatives were limited to facilities 345 kilovolts and larger for the purpose of this vision study of the high voltage bulk transmission study.

The technical team incorporated transmission alternatives identified in on-going studies in conjunction with transmission plans identified by various transmission stakeholders. The goals were to identify transmission improvements that connect remote generation to the load-serving centers in the region and to develop a transmission backbone that supports continued load growth in the various load centers. The transmission improvements focused on high voltage solutions (345 kV lines and 500 kV lines) that best addressed the load areas and the various generation scenarios.

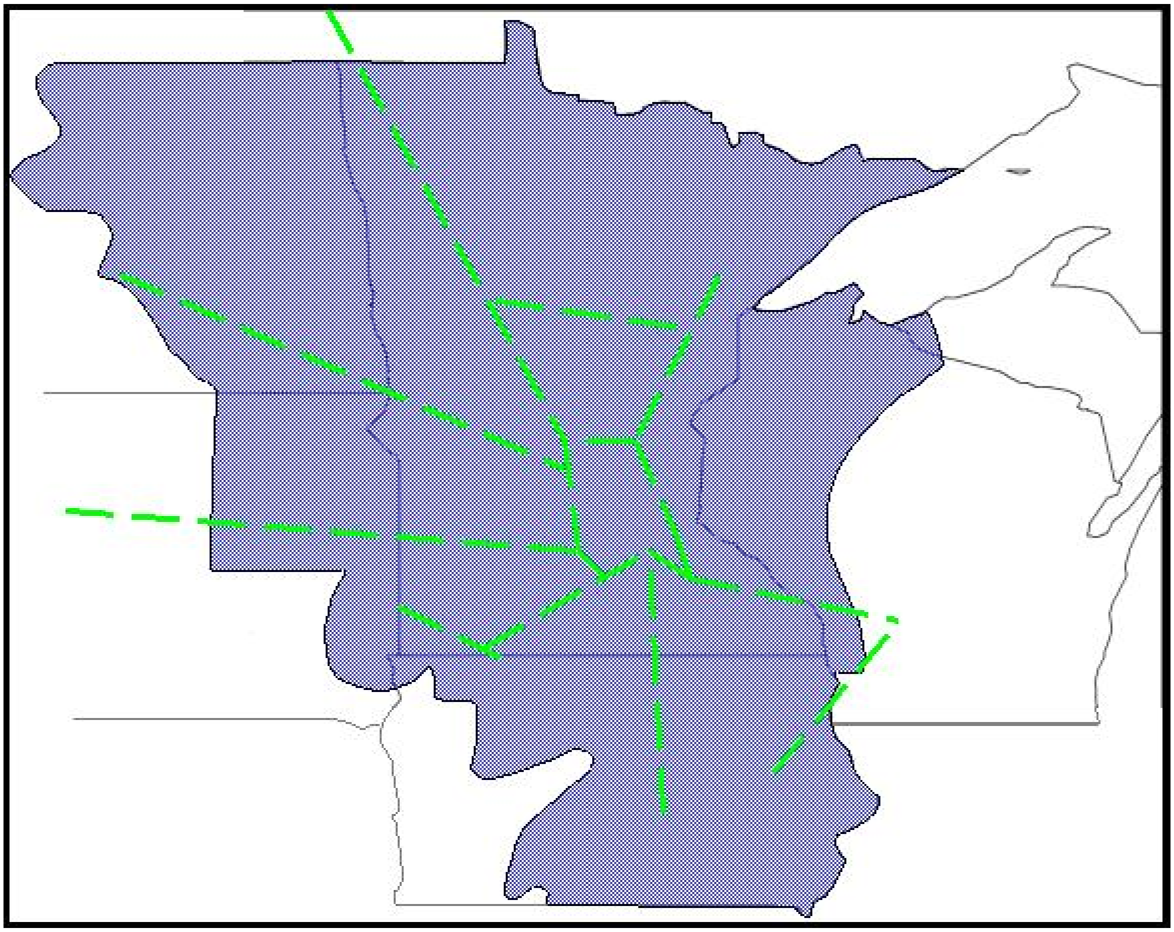

Diagram 9 – Possible Transmission Facilities

As a starting point, the technical team utilized the most probable transmission options from the exploratory studies already underway in the MISO/MAPP footprint, most notably the Southwest Minnesota/ Northern Iowa study and the Northwest Exploratory study. These transmission options are shown below:

- A 345 kV line from the North Dakota coal fields to Fargo and continuing to near St. Cloud, Minnesota
- A 345 kV line from Prairie Island, near Red Wing, Minnesota, to Rochester, Minnesota, and continuing to southwest Wisconsin
- Two 345 kV lines into central Iowa
- A 345 kV or 500 kV line from Manitoba into near St. Cloud, Minnesota.
- Generation outlet transmission facilities presently under study through MISO.

Once these lines were placed on the map, the technical team analyzed the system for the best regional method to tie all these study results together, while maximizing load-serving potential for the entire region well into the future. The team also created a second 345 kV transmission ring around the wider Twin Cities metro area, with "spokes" leading out to the smaller load and/or generation pockets in the region.

A complete list of the potential transmission facilities is included in Appendix A.

3.1 Study Assumptions

3.1.1 System Condition Assumptions

The CapX 2020 study was based on a system snapshot with the best-known 2020 state of the transmission system as of August 2004 for the MAPP region. Since August 2004, very few changes have been made to the base case model. In the last ten months, load, generation and transmission modeling may have been modified in other studies, which the CapX 2020 study does not reflect.

3.1.2 Contingency Analysis Assumptions

The technical team tested several transmission solutions for each generation scenario and performed steady-state powerflow analysis (first contingency simulations) to determine which transmission solution eliminates thermal overloads on transmission lines 161 kV and higher in the region. Because the intent of this study was bulk level load serving, the technical team decided to model all generation on the highest voltage bus available local to the generation, and to run the contingency simulations on a limited list of facilities, namely 161 kV and above.

When reviewing the results of this study, note that only the bulk system overloads and solution are represented. None of the associated substation, generation interconnection facilities, or underlying lower-voltage (below 161 kV) transmission system infrastructure was studied.

3.1.3 Big Stone II Inclusion in the CapX 2020 Vision Study

Interconnection steady-state results from the Big Stone II generation study were completed in the late fall 2004 and, therefore, were included in the CapX 2020 Vision Study. Big Stone II was modeled in the north/west and eastern biases. In the north/west bias, the generator was modeled along with the outlet options that included:

- Big Stone – Canby new 230 kV line
- Canby – Granite Falls 115 kV line converted to 230 kV
- Big Stone – Willmar new 230 kV line

The eastern bias included the generator along with outlet options that included:

- Big Stone – Canby, Minnesota, new 230 kV line
- Canby – Granite Falls, Minnesota, 115 kV line converted to 230 kV
- Big Stone – Ortonville, Minnesota, new 230 kV-line
- Ortonville – Johnson Jct. - Morris, Minnesota, 115 kV line converted to 230 kV

Because the Minnesota bias focused on generation located within state boundaries with the exception of wind resources, Big Stone II, which is a potential coal-fired plant in South Dakota, was not included in this generation bias.

Based on the results from this vision study, the Minnesota and north/west generation biases include a new 345 kV line from Granite Falls, Minnesota, to Benton County (St. Cloud), Minnesota, and all three generation scenarios include a new 345 kV line from Ellendale, North Dakota, to Blue Lake (Mpls/St. Paul), Minnesota, regardless of whether Big Stone II was included. These lines could be instrumental to wind outlet in the North Dakota and South Dakota.

3.1.4 Sensitivities to Current Area Study Work

- Big Stone II was partially included in this vision study as described in section 3.1.3 above. Because the Big Stone II interconnection study was completed during the CapX 2020 technical study timeframe, variations of the interconnection study results were included in the CapX 2020 study. When a certificate of need (CON) is filed for Big Stone II, a vision study sensitivity will be completed to determine how the Big Stone II project proposed facilities fit into the timeline for the CapX 2020 vision study facility additions.
- Buffalo Ridge Incremental Study conducted by Xcel Energy in the winter of 2004 through spring 2005 had no public results available to include during the CapX 2020 case development time. In addition, the Buffalo Ridge study is a lower voltage study than the CapX 2020 focus.

4 Scenario Analysis

The preliminary base case model for the year 2020 includes the 6300 MW of anticipated load growth and the new generation to meet and serve the growth, however the base case doesn't contain any new necessary transmission facilities.[2] The CapX 2020 technical team's preliminary base case analysis of the three generation scenarios identified a significant number of transmission overloads that could occur if no additional transmission is built to serve the projected load growth and the new generation needed by 2020 to meet this growth. The team simulated the loss (outage) of single transmission elements (n-1 analysis) to help determine transmission alternatives to address potential violations of North American Electric Reliability Council criteria, such as low voltages and thermally overloaded facilities.

Power Technology's PSS/E program, Version 29, was used to perform this analysis. Within PSS/E, the activity called ACCC, or AC Contingency Checking, was used as a first check of the entire study area to find problems. ACCC sequentially examines all relevant single contingencies in the region of interest for a given load and transfer base case. Facilities identified in the ACCC outputs were considered limiters if they had line outage distribution factors of 2 percent or greater. Bus voltages lower than 0.9 per unit were also flagged.

For the more detailed analysis of each scenario, the team used a contingency program developed by Great River Energy. The contingency program uses the IPLAN programming language within PSS/E. It performs many functions on the user-defined model, including developing user-defined contingencies with appropriate line-switching procedures,

[2] Exception: The north/west bias base 2020 case includes a 345 kV facility from Manitoba to near St Cloud, MN

monitoring files for bus voltage and line loading violations, and the output files are then easily imported into Microsoft Excel. Transmission facilities identified in the Excel outputs were considered limiters if they had power transfer distribution factors and/or line outage distribution factors of 2 percent or greater. Bus voltages lower than 0.9 per unit were also flagged

For the n-1 analysis, the team ran transmission contingencies and monitored the transmission system in the following control areas:

Control area	**PSS/E area #**
Alliant Energy West	331
Xcel Energy	600
Minnesota Power	608
Southern Minnesota Municipal Power Agency	613
Great River Energy	618
Otter Tail Power Company	626
Dairyland Power Company	680

4.1 Existing System Performance / Base Case Analysis

The ACCC activity performs all contingencies in the area and, therefore, provides an excellent screening tool for determining as to when and where violations of the planning criteria occur.

Initially, the team ran ACCC on the existing system for the three generation scenario bias cases: Peak load with all the Minnesota bias generation on-line at the 2020 load levels, peak load with all the north/west bias generation on-line at the with 2020 load levels, and peak load with all the eastern bias generation on-line at the 2020 load levels. The team temporarily put aside base case results but eventually will compare them with the post-new facility results for each bias to find the most effective set of 345 kV and higher transmission infrastructure additions to meet the 6,300 MW of new load. The base case system n-1 results are included in Appendix B of this report for each bias case.

Table 3 shows the number of overloaded transmission facilities and voltage violations in the base case 2020 models. Sections 4.2 through 4.5 of this report will discuss the results for each scenario in further detail. Again, n-1 contingency output results are tabulated in Appendix B.

Scenario	System Intact Overloads	n-1 Overload Violations[3]	Voltage Violations
North/West Bias[4]	42	142	45
Minnesota Bias	42	187	14
Eastern Bias	42	197	33

[3] Outages of individual facilities 161 kV and higher were simulated.

[4] Includes the addition of a 345 kV facility from Manitoba to near St. Cloud, Minnesota

Table 3 – Base Case 2020 Transmission System Violations

4.2 Transmission Alternatives

As mentioned previously in this report, Appendix A of this report includes a complete list of all transmission facilities 345 kV and higher that the CapX 2020 technical team considered. The team analyzed each generation scenario separately to determine which of these facilities would most effectively solve thermal and voltage violations on the bulk (161 kV and higher) transmission system in the study area. To do this, the team inserted specific facilities or facility groups from Appendix A one at a time into the model to assess each facility's benefits.

The team selected facilities to insert into the model by determining the location of the need for system improvement. The team recommended as facility additions those facilities that had the greatest benefit to the system by reducing the thermal overload and/or solving voltage violations during n-1 contingency.

The results of the facility addition benefits are shown in Appendix B in the n-1 contingency output result tables for each generation scenario.

4.3 Minnesota Bias Scenario Results

4.3.1 Recommended Transmission Vision Facilities

Diagram 10 shows the final compilation of recommended transmission facilities for the Minnesota bias based on the n-1 contingency analysis completed using the facilities in Appendix A and Table 4. All contingency analysis results and PSS/E automaps are included in Appendix B-1.

Ref. Ref.#	Data Source	Facility name				
		From	To	Volt (kV)	Miles	Cost ($M)
F-02	TIPS	Alexandria	Benton County	345	80	60
F-03	TIPS	Alexandria	Maple River	345	126	94.5
F-06	NW	Antelope Valley	Maple River	345	292	219
F-07	CAPX	Arrowhead	Chisago	345	120	90
F-08	CAPX	Arrowhead	Forbes	345	60	45
F-09	CAPX	Benton County	Chisago County	345	59	44.25
F-10	CAPX	Benton County	Granite Falls	345	110	82.5
F-11	MH	Benton County	Riverton	345	78	58.5
F-12	CAPX	Benton County	St. Boni	345	62	46.5

F-13	CAPX	Blue Lake	Ellendale	345	200	150
F-17	CAPX	Boswell	Forbes	345	64	48
F-26	CAPX	Chisago County	Prairie Island	345	82	61.5
F-28	CAPX	Columbia	North LaCrosse	345	80	60
F-30	NW	Ellendale	Hettinger	345	231	173.25
F-32	CAPX	Forbes	Riverton	345	114	85.5
F-36	SMNI	Rochester	North LaCrosse	345	60	45
F-56	SMNI	Prairie Island	Rochester	345	58	43.5
F-63	CAPX	Lakefield Jct	Adams	345	92	69
				Total	**1968**	**1,476**

CAPX – CapX Technical Team
NW – MISO Northwest Exploratory Study
SMNI – MISO Southern Minnesota/Northern Iowa Exploratory Study
TIPS – Transmission Improvement Plans Study
MH – Manitoba Hydro Studies

Table 4 – Minnesota Bias Recommended Facilities

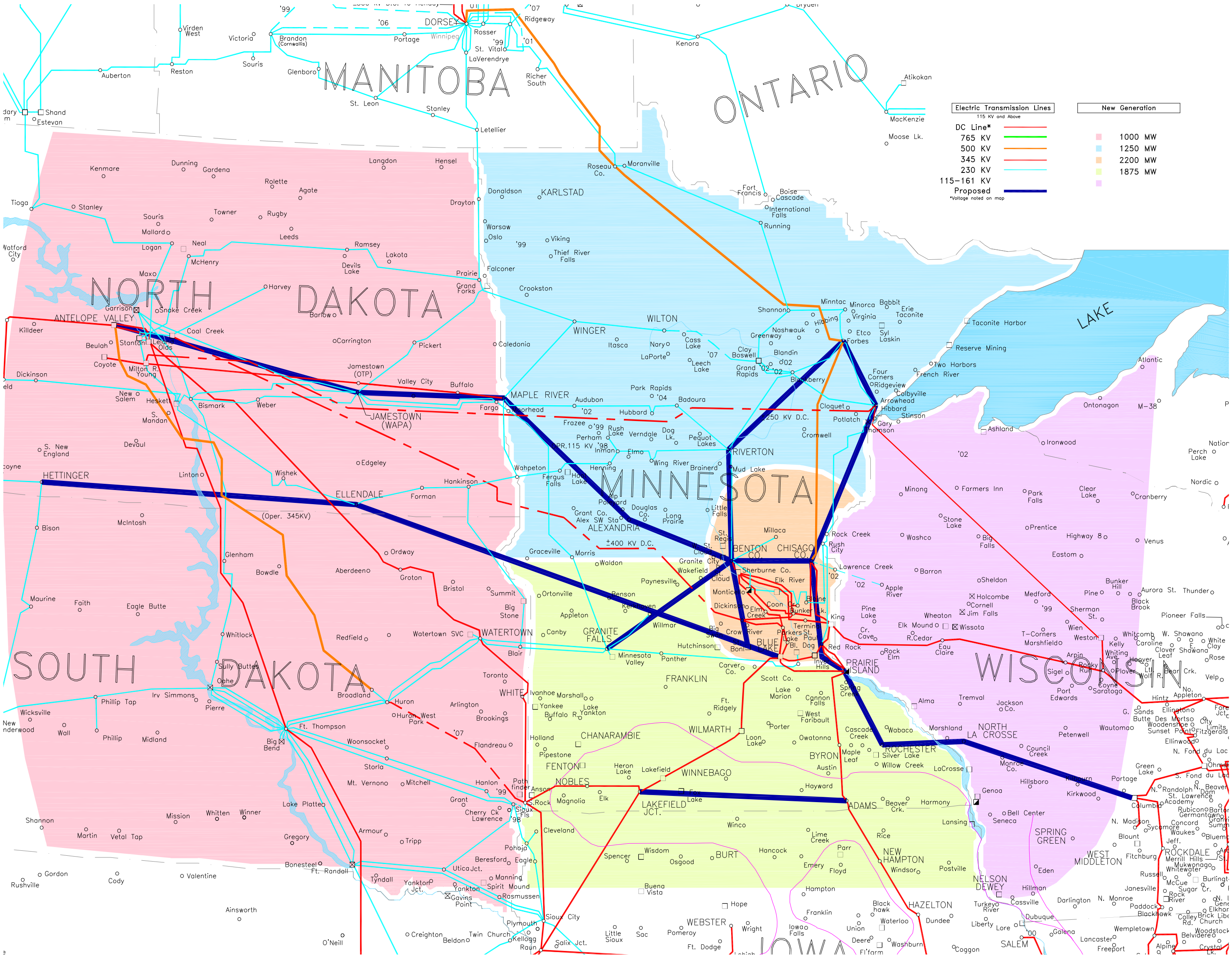

Diagram 10 – Minnesota Bias Recommended Facilities

4.3.2 Line Flows on Interface and Tie Lines

The CapX 2020 technical team collected system intact line flows on a select set of tie lines and interfaces in and around the Minnesota system. Table 5 predominantly focuses on lines coming into and going out of Minnesota, including some lines internal to Minnesota connecting pockets of transmission. Table 5 shows that adding the facilities recommended for the Minnesota bias scenario mostly causes reductions in MW flow over these 230 kV and higher interfaces.

LINE	**kV Voltage Level**	**Base 6300 MW flow (MW)**	**6300 mw UPGRADE scenario (MW)**	**Description**
Forbes – Chisago	500 kV	870	687	Northern Minnesota to Twin Cities loop
Riel – Roseau	500 kV	1418	1308	Manitoba Hydro to northern Minnesota
Richer – Roseau	230 kV	170	183	Manitoba Hydro to northern Minnesota
Letellier – Drayton	230 kV	325	300	Manitoba Hydro to MN-ND border
Glenboro – Rugby	230 kV	18	2	Manitoba Hydro – North Dakota (this and the 3 lines above are all that ties Manitoba and U.S. as planned of 2009)
Arrowhead – Stone Lake	345 kV	116	97	Duluth area to northwestern Wisconsin (then to Weston)
Eau Claire – Arpin	345 kV	111	87	West to central Wisconsin
Prairie Island – Byron	345 kV	116	320	South of Twin Cities metro to west of Rochester
Adams – Hazelton	345 kV	127	50	Southeastern Minnesota – eastern Iowa
Lakefield Jct. – Wilmarth	345 kV	768	594	Southwestern Minnesota to Mankato area
Split Rock – Nobles County	345 kV	175	159	North of Sioux Falls, SD, to northwest of Worthington, MN
Nobles County – Lakefield Jct.	345 kV	300	285	Northwest of Worthington to Lakefield Jct. sub. (Minnesota)
Watertown – Granite Falls	230 kV	315	292	Eastern South Dakota to western Minnesota
Blair – Granite Falls	230 kV	329	317	Runs parallel with Watertown – Granite Falls
Granite Falls – Minnesota Valley	230 kV	263	220	Western Minnesota
Fargo – Moorhead	230 kV	53	62	Fargo, North Dakota, to Moorhead, Minnesota
Fargo – Sheyenne	230 kV	260	162	North Dakota, Minnesota border
Maple River – Winger	230 kV	76	69	Fargo area to northwestern Minnesota
Prairie – Winger	230 kV	138	84	Grand Forks area to Winger
Wahpeton – Fergus Falls	230 kV	234	153	ND-MN border east to Fergus Falls
Bear Creek – Rock Creek	230 kV	53	51	South of Duluth toward the Twin Cities loop
Blackberry – Riverton	230 kV	220	114	Northern Minnesota towards south
Mud Lake – Benton County	230 kV	10	26	Coming from the north into St. Cloud
Sheyenne – Audubon	230 kV	214	178	Fargo area west into Minnesota
Genoa – Coulee	161 kV	263	204	Western Wisconsin
Boswell – Blackberry Ckt 1	230 kV	291	192	Northern Minnesota
Boswell – Blackberry Ckt 2	230 kV	283	187	Northern Minnesota

Table 5 – Minnesota Bias Tie Line / Interface Flows

4.4 North / West Scenario Results

4.4.1 Recommended Transmission Vision Facilities

Diagram 11 shows the final compilation of recommended facilities for the North/West Bias based on the n-1 contingency analysis using the facilities in Appendix A and Table 6. All contingency analysis results and PSS/E automaps are included in Appendix B-2.

Ref. Ref.#	**Data Source**	**Facility Name**				
		From	**To**	**Volt (kV)**	**Miles**	**Cost ($M)**
F-02	TIPS	Alexandria	Benton County	345	80	60
F-03	TIPS	Alexandria	Maple River	345	126	94.5
F-06	NW	Antelope Valley	Maple River	345	292	219
F-07	CAPX	Arrowhead	Chisago	345	120	90
F-08	CAPX	Arrowhead	Forbes	345	60	45
F-09	CAPX	Benton County	Chisago County	345	59	44.25
F-10	CAPX	Benton County	Granite Falls	345	110	82.5
F-12	CAPX	Benton County	St. Boni	345	62	46.5
F-13	CAPX	Blue Lake	Ellendale	345	200	150
F-26	CAPX	Chisago County	Prairie Island	345	82	61.5
F-28	CAPX	Columbia	North LaCrosse	345	80	60
F-29	MH	Dorsey	Karlstad	345	134	100.5
F-30	NW	Ellendale	Hettinger	345	231	173.25
F-36	SMNI	Rochester	North LaCrosse	345	60	45
F-45	MH	Karlstad	Winger	345	91	68
F-40	MH	Winger	Benton Co.	345	162	121.5
F-56	SMNI	Prairie Island	Rochester	345	58	43.5
	Total				**2007**	**1,505**

Table 6 – North/West Bias Recommended Facilities

Key for Table 6:
CAPX – CapX Technical Team
NW – MISO Northwest Exploratory Study
SMNI – MISO Southern Minnesota/Northern Iowa Exploratory Study
TIPS – Transmission Improvement Plans Study
MH – Manitoba Hydro Studies

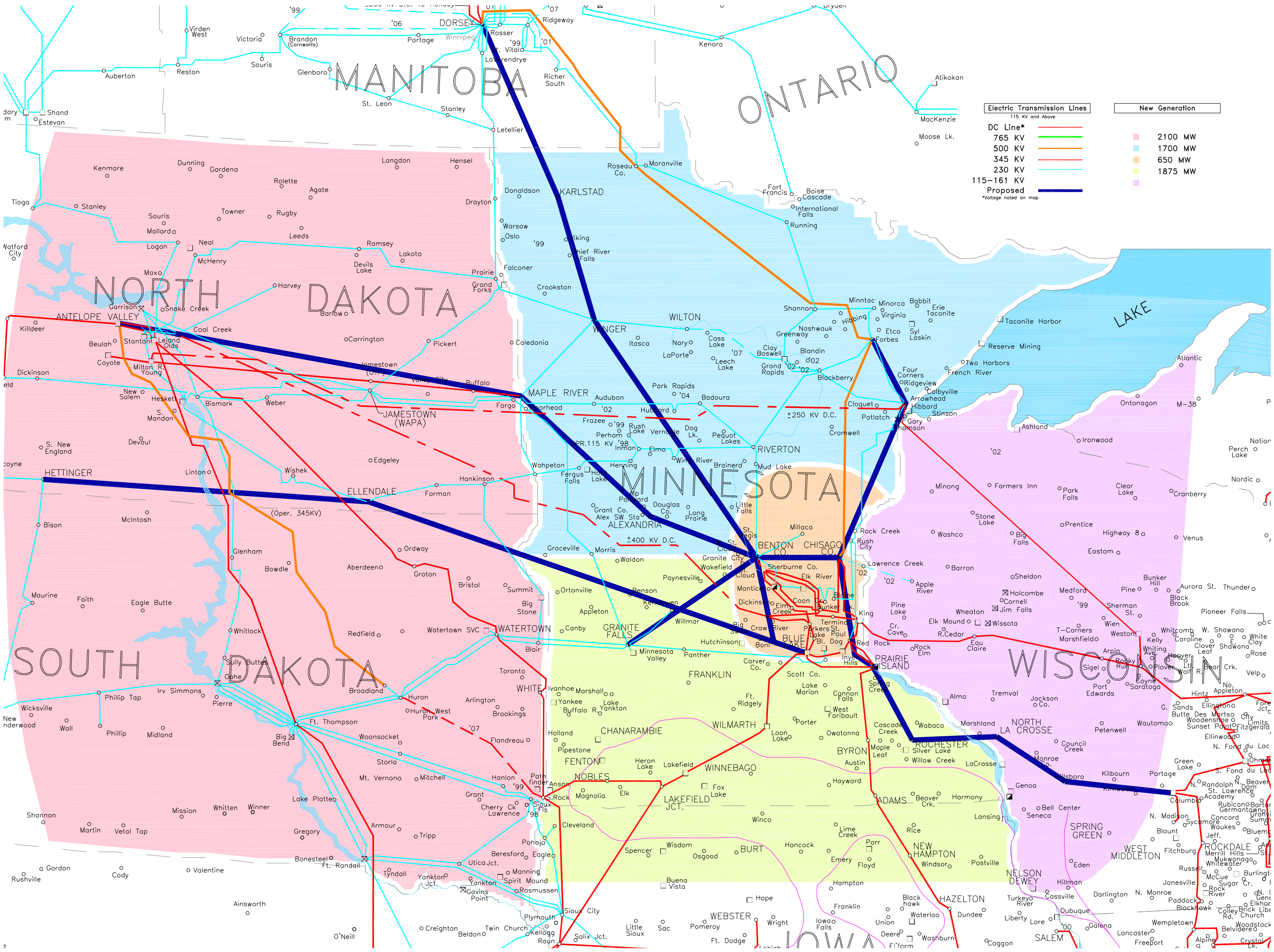

Diagram 11 – North/West Bias Recommended Facilities

4.4.2 Line Flows on Interface and Tie Lines

The Technical Team collected system intact line flows on a select set of tie lines and interfaces in and around the Minnesota system. Table 7 predominantly focuses on lines coming into and going out of Minnesota, including some lines internal to Minnesota connecting pockets of transmission.

The table shows that adding the facilities recommended for the north /west bias scenario causes about equal amounts of reductions and additions in MW flow over these 230 kV-and-higher interfaces. Note that in this north/west scenario the Manitoba Hydro flows are lower than in the slow growth scenario Manitoba Hydro export. The reason for this difference is that the CapX technical team has added the 345 kV line in the 6,300 MW load base case, which has 816 megavolt amperes flowing on it.

LINE	kV Voltage Level	Base 6300 MW flow (MW)	6300 MW UPGRADE scenario (MW)	Description
Forbes – Chisago	500 kV	1507.7	1343.3	Northern Minnesota to Twin Cities loop
Riel – Roseau	500 kV	1591.8	1507.5	Manitoba Hydro to northern Minnesota
Richer – Roseau	230 kV	219.2	212.8	Manitoba Hydro to northern Minnesota
Letellier – Drayton	230 kV	286.5	303.7	Manitoba Hydro to MN-ND border
Glenboro – Rugby	230 kV	64.4	10.6	Manitoba Hydro – North Dakota (This and the 3 lines above are all that ties Manitoba and U.S. as planned through 2009.)
Arrowhead – Stone Lake	345 kV	271.0	295.4	Duluth area to northwestern Wisconsin (then to Weston)
Eau Claire – Arpin	345 kV	148.4	71.0	West to central Wisconsin
Prairie Island – Byron	345 kV	284.4	277.3	South of Twin Cities metro to west of Rochester
Adams – Hazelton	345 kV	274.1	156.6	Southeastern Minnesota – eastern Iowa
Lakefield Jct. – Wilmarth	345 kV	978.5	819.3	Southwestern Minnesota to Mankato area
Split Rock – Nobles County	345 kV	350.7	261.6	North of Sioux Falls, SD, to northwest of Worthington, MN
Nobles County – Lakefield Jct.	345 kV	500.7	409.9	Northwest of Worthington to Lakefield Jct. sub. (Minnesota)
Watertown – Granite Falls	230 kV	293.0	245.0	Eastern South Dakota to western Minnesota
Blair – Granite Falls	230 kV	334.5	292.4	Runs parallel with Watertown – Granite Falls
Granite Falls – Minnesota Valley	230 kV	455.5	404.4	Western Minnesota
Fargo – Moorhead	230 kV	50.8	39.1	Fargo, North Dakota to Moorhead, Minnesota
Fargo – Sheyenne	230 kV	286.6	230.0	North Dakota, Minnesota border
Maple River – Winger	230 kV	64.3	20.9	Fargo area to northwestern Minnesota
Prairie – Winger	230 kV	110.0	70.8	Grand Forks area to Winger
Wahpeton – Fergus Falls	230 kV	277.8	213.4	ND-MN border east to Fergus Falls
Bear Creek – Rock Creek	230 kV	89.6	90.0	South of Duluth toward the Twin Cities loop
Blackberry – Riverton	230 kV	203.5	175.0	Northern Minnesota towards south
Mud Lake – Benton County	230 kV	47.6	36.6	Coming from the north into St.Cloud area
Sheyenne – Audubon	230 kV	265.4	233.0	Fargo area west into Minnesota
Genoa – Coulee	161 kV	278.0	212.0	Western Wisconsin

Boswell – Blackberry Ckt 1	230 kV	284.4	276.2	Northern Minnesota
Boswell – Blackberry Ckt 2	230 kV	277.6	269.7	Northern Minnesota

Table 7 – North/West Bias Tie Line/Interface Flows

4.5 Eastern Bias

In the eastern bias scenario, the CapX 2020 technical team added part of the additional generation to the east of Minnesota (part on the border of northeastern Iowa and southwestern Wisconsin, part central Wisconsin), in addition to having generation throughout Minnesota, northern Iowa, North Dakota, and South Dakota as in the other two scenarios.

4.5.1 Recommended Transmission Vision Facilities

		Facility Name				
Ref. #	**Data Source**	**From**	**To**	**Volt (kV)**	**Miles**	**Cost ($M)**
F-56	SMNI	Prairie Island	Rochester	345	58	43.7
F-64	CAPX	Eau Claire	King	345	84	63.1
F-65	CAPX	N. LaCrosse	Eau Claire	345	73	55.1
F-66	CAPX	Genoa	N LaCrosse	345	42	31.7
F-67	CAPX	Genoa	Columbia	345	113	84.8
F-68	CAPX	Genoa	Nelson Dewey	345	70	52.4
F-69	SMNI	Nelson Dewey	Salem	345	34	25.6
F-70	CAPX	Genoa	Lansing	345	21	15.8
F-71	CAPX	Lansing	Rochester	345	89	66.8
F-72	CAPX	Ellendale	Big Stone	345	194	145.8
F-73	CAPX	Big Stone	Blue Lake	345	71	53.4
F-02	TIPS	Maple River	Benton Co	345	206	154.5
F-03	NW	Antelope Va.	Maple River	345	292	218.8
F-07	CapX	Arrowhead	Chisago	345	120	90
F-08	CapX	Arrowhead	Forbes	345	60	45
F-09	CapX	Benton Co	Chisago	345	59	44.2
F-10	CapX	Benton Co	Granite Falls	345	110	82.5
F-12	CapX	Benton Co	St Boni	345	62	46.5
F-26	CapX	Chisago Co	Prairie Island	345	82	61.5
F-30	NW	Ellendale	Hettinger	345	231	218.8
			Total		**2071**	**1,600**

Table 8 – Eastern Bias Recommended Facilities

Key for Table 8:
CAPX – CapX Technical Team
NW – MISO Northwest Exploratory Study

SMNI – MISO Southern Minnesota/Northern Iowa Exploratory Study
TIPS – Transmission Improvement Plans Study
MH – Manitoba Hydro Studies

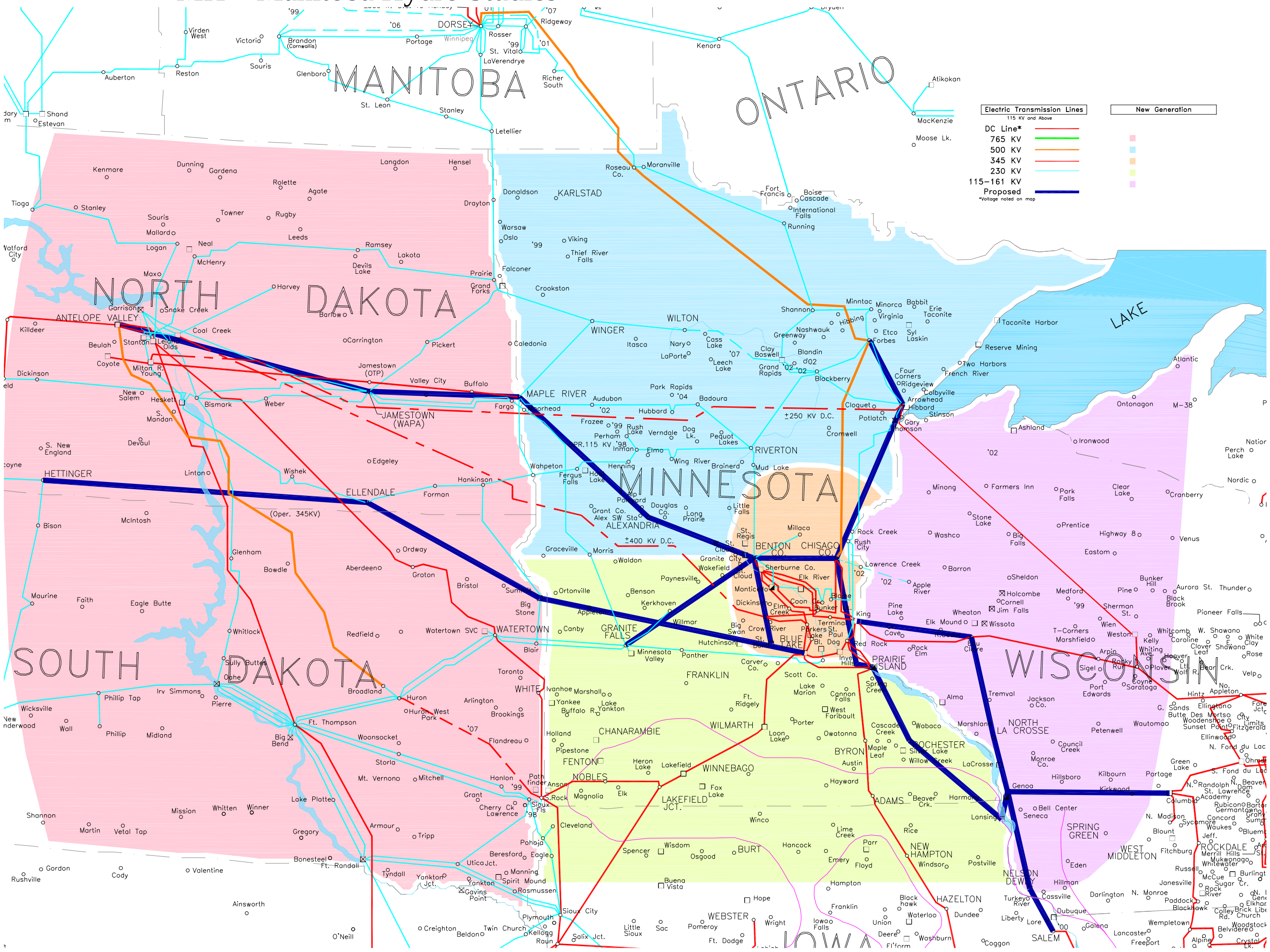

Diagram 12 – Eastern Bias Recommended Facilities

4.5.2 Line Flows on Interface and Tie Lines

The CapX 2020 technical team collected system intact line flows on a select set of tie lines and interfaces in and around the Minnesota system. Table 9 predominantly focuses on lines coming into and going out of Minnesota, including some lines inside Minnesota connecting pockets of transmission.

LINE	kV Voltage Level	Base 6300 MW flow (MW)	6300 MW UPGRADE scenario (MW)	Description
Forbes – Chisago	500 kV	1209.6	1191.7	Northern Minnesota to Twin Cities loop
Riel – Roseau	500 kV	1344.9	1329.6	Manitoba Hydro to northern Minnesota
Richer – Roseau	230 kV	178.8	177.7	Manitoba Hydro to northern Minnesota

Letellier – Drayton	230 kV	306.5	314.1	Manitoba Hydro to MN-ND border
Glenboro – Rugby	230 kV	-26.9	-18.6	Manitoba Hydro – North Dakota (This and the three lines above are all that ties Manitoba and U.S. as planned through 2009.)
Arrowhead – Stone Lake	345 kV	177.1	174.5	Duluth area to northwestern Wisconsin (then to Weston)
Eau Claire – Arpin	345 kV	-174.1	-41.8	West to central Wisconsin
Prairie Island – Byron	345 kV	-380.5	-263.7	South of Twin Cities metro to west of Rochester
Adams – Hazelton	345 kV	-138.5	-12.5	Southeastern Minnesota – eastern Iowa
Lakefield Jct. – Wilmarth	345 kV	724.4	660.1	Southwestern Minnesota to Mankato area
Split Rock – Nobles County	345 kV	97.9	81.1	North of Sioux Falls, SD, to northwest of Worthington, MN
Nobles County – Lakefield Jct.	345 kV	279.4	265.4	Northwest of Worthington to Lakefield Jct. sub. (Minnesota)
Watertown – Granite Falls	230 kV	234.2	224.2	Eastern South Dakota to western Minnesota
Blair – Granite Falls	230 kV	276.8	269.9	Runs parallel with Watertown – Granite Falls
Granite Falls – Minnesota Valley	230 kV	373.6	362.8	Western Minnesota
Fargo – Moorhead	230 kV	-23.1	-21.4	Fargo, North Dakota, to Moorhead, Minnesota
Fargo – Sheyenne	230 kV	305.9	297.2	North Dakota, Minnesota border
Maple River – Winger	230 kV	91.5	88.5	Fargo area to northwestern Minnesota
Prairie – Winger	230 kV	129.2	129.3	Grand Forks area to Winger
Wahpeton – Fergus Falls	230 kV	242.6	234.9	ND-MN border east to Fergus Falls
Bear Creek – Rock Creek	230 kV	93.1	92.5	South of Duluth toward the Twin Cities loop
Blackberry – Riverton	230 kV	227.0	233.4	Northern Minnesota towards south
Mud Lake – Benton County	230 kV	38.3	31.5	Coming from the north into St.Cloud area
Sheyenne – Audubon	230 kV	230.6	222.3	Fargo area west into Minnesota
Genoa – Coulee	161 kV	391.9	210.8	Western Wisconsin
Boswell – Blackberry Ckt 1	230 kV	279.9	280.3	Northern Minnesota
Boswell – Blackberry Ckt 2	230 kV	273.2	273.5	Northern Minnesota

Table 9 – Eastern Bias Tie Line/Interface Flows

4 Slow Growth Analysis

The CapX 2020 technical team performed a sensitivity analysis for a reduced load level of 4,500 MW to determine which facility additions are necessary at this slower growth load level. Assuming the 6,300 MW increased load level is reached in 2020 and using a linear load growth rate, the team determined that the 4,500 MW increased load level would be reached in the year 2016.

To model the 4,500 MW load level, the 6,300 MW load model was scaled down in each control area uniformly by scaling the load growth down by a factor of 2/3 (4500/6300). The scaled down load totals for each control area are shown in Table 10.

Control area	Calculated 2020 load level (6300 MW)	Scaled load level (4500 MW)
Alliant Energy (West) (331)	3888.2	3711.1
Xcel Energy (North) (600)	12885.1	11960.5
Minnesota Power Co. (608)	1814.4	1727.1
Southern MN Municipal Power Agency (613)	442.4	410.4
Great River Energy (618)	3943.2	3627.8
Otter Tail Power (626)	2248.3	2085.9
Dairyland Power Co. (680)	1266.2	1177.6
Total	26487.8	24700.6

Table 10 – CapX 2020 Slow Area Growth

The generation total also was reduced by scaling each generator down by a factor of 2/3 (4500/6300). Table 11 shows the reduced generation totals for each generation bias scenario.

Slow Growth Analysis						
	North/West		Minnesota		Eastern	
	6300 MW	4500 MW	6300 MW	4500 MW	6300 MW	4500 MW
Northern Minnesota	1700	1214	1250	893	550	393
Dakotas	2100	1500	1000	714	1600	1143
Southern MN/ Northern Iowa	1875	1340	1875	1340	2125	1554
Metro	650	464	2200	1571	1000	714
Wisconsin	0	0	0	0	1000	714
Total	**6325**	**4518**	**6325**	**4518**	**6325**	**4518**

Table 11 – Slow Growth Generation Scenario

The results for each generation scenario at the slow growth load level will be discussed in detail in sections 5.1 – 5.3 of this report. The n-1 contingency output results tabulated in Appendices B-1 through B-3. For the slow growth n-1 analysis, the same contingencies from the anticipated growth study were run again and the transmission system was monitored in the following control areas:

Control Area	**PSS/E Area #**
Alliant Energy West	331
Xcel Energy	600
Minnesota Power Co.	608
Southern Minnesota Municipal Power Agency	613
Great River Energy	618
Otter Tail Power Company	626
Dairyland Power Company	680

5.1 Transmission Alternatives Considered for Slow Growth

For the slow growth sensitivity the CapX 2020 technical team began the analysis of each generation scenario with the facilities recommended for the 6300-MW vision study. The recommended facilities were individually removed to determine which of the facilities were also necessary at the 4,500 MW load/generation level.

For the Minnesota and North/West biases, the team determined that the majority of the facilities still were necessary even with the load reduced by 33 percent. For the eastern bias case at the slow growth level, there was less justification for some of the various recommended transmission lines. Although, higher voltage lines from the Wisconsin – Iowa border area towards the Twin Cities were still appropriate. It was also still clear that relief of existing facilities is needed on the system between the Dakotas and Minnesota. As explained in section 4.5, additional sensitivity work is still pending for the eastern bias case, both at the 6300 MW level and the slow growth scenario.

5.2 Minnesota Bias Scenario Slow Growth Results

5.2.1 Recommended Facilities

Ref. #	**Data Source**	**Facility Name**				
		From	**To**	**Volt (kV)**	**Miles**	**Cost ($M)**
F-02	TIPS	Alexandria	Benton County	345	80	60
F-03	TIPS	Alexandria	Maple River	345	126	94.5
F-06	NW	Antelope Valley	Maple River	345	292	219
F-07	CAPX	Arrowhead	Chisago	345	120	90
F-08	CAPX	Arrowhead	Forbes	345	60	45
F-09	CAPX	Benton County	Chisago County	345	59	44.25
F-10	CAPX	Benton County	Granite Falls	345	110	82.5
F-11	MH	Benton County	Riverton	345	78	58.5
F-12	CAPX	Benton County	St. Boni	345	62	46.5

F-13	CAPX	Blue Lake	Ellendale	345	200	150
F-17	CAPX	Boswell	Forbes	345	64	48
F-26	CAPX	Chisago County	Prairie Island	345	82	61.5
F-28	CAPX	Columbia	North LaCrosse	345	80	60
F-30	NW	Ellendale	Hettinger	345	231	173.25
F-32	CAPX	Forbes	Riverton	345	114	85.5
F-36	SMNI	Rochester	North LaCrosse	345	60	45
F-56	SMNI	Prairie Island	Rochester	345	58	43.5
				Total	**1876**	**1407**

Table 12 – Slow Growth Load Level Minnesota Bias Recommended Facilities

Table 12 key:
CAPX – CapX Technical Team
NW – MISO Northwest Exploratory Study
SMNI – MISO Southern Minnesota/Northern Iowa Exploratory Study
TIPS – Transmission Improvement Plans Study
MH – Manitoba Hydro Studies

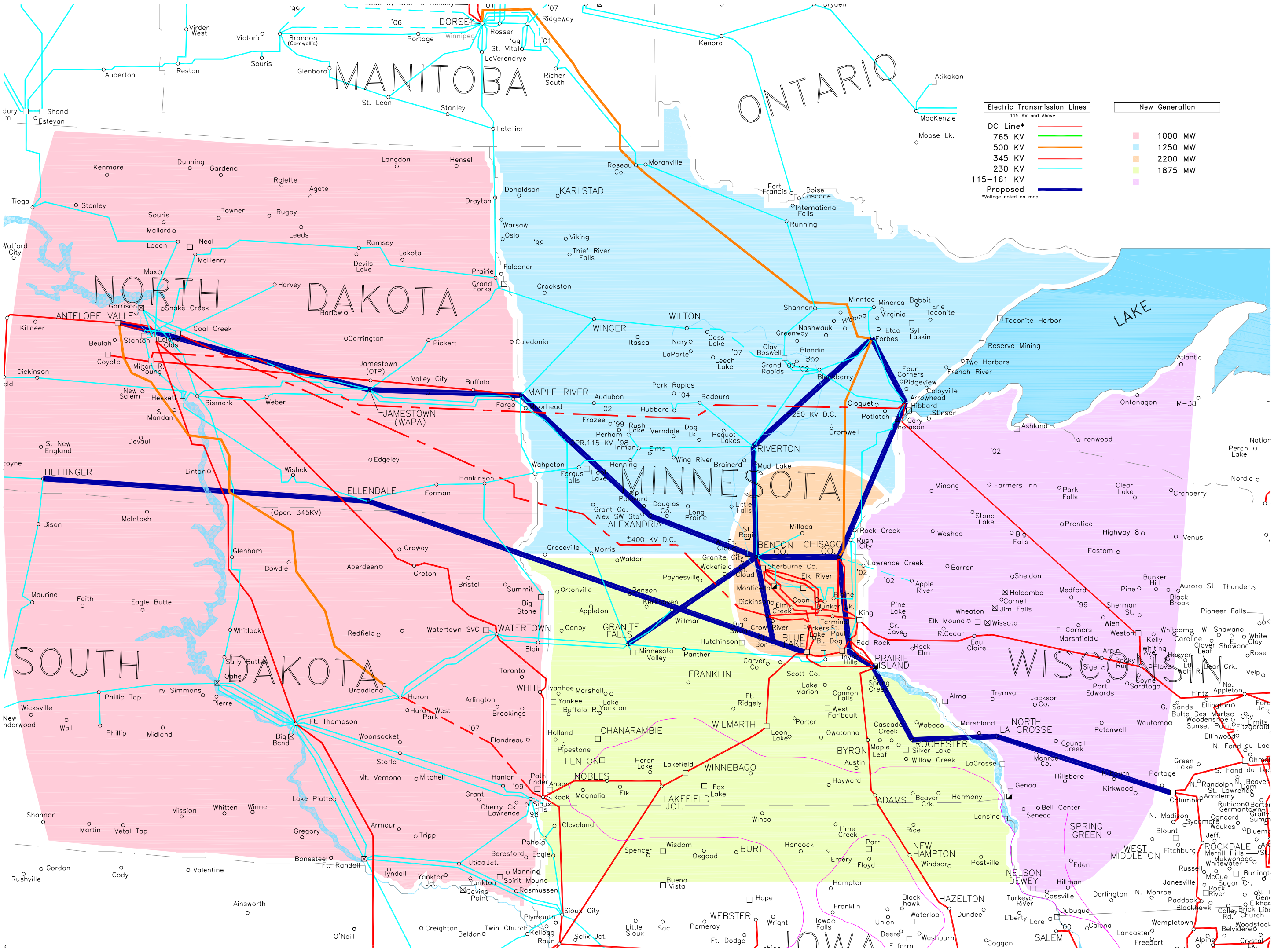

Diagram 13 – Slow Growth Load Level Minnesota Bias Recommended Facilities

5.2.2 Line Flows on Interface and Tie Lines

LINE	kV Voltage Level	Base 4500 MW FLOW (MW)	4500 MW UPGRADE scenario (MW)	Description
Forbes – Chisago	500 kV	1351	1187	Northern Minnesota to Twin Cities loop
Riel – Roseau	500 kV	1228	1224	Manitoba Hydro to northern Minnesota
Richer – Roseau	230 kV	180	184	Manitoba Hydro to northern Minnesota
Letellier – Drayton	230 kV	363	340	Manitoba Hydro to MN-ND border
Glenboro – Rugby	230 kV	17	38	Manitoba Hydro – North Dakota (This and the three lines above are all that ties Manitoba and U.S. as planned through 2009.)
Arrowhead – Stone Lake	345 kV	88	98	Duluth area to northwestern Wisconsin (then to Weston)

Eau Claire – Arpin	345 kV	206	146	West to central Wisconsin
Prairie Island – Byron	345 kV	169	227	South of Twin Cities metro to west of Rochester
Adams – Hazelton	345 kV	260	197	Southeastern Minnesota – Eastern Iowa
Lakefield Jct. – Wilmarth	345 kV	719	622	Southwestern Minnesota to Mankato area
Split Rock – Nobles County	345 kV	175	129	North of Sioux Falls, SD to northwest of Worthington, MN
Nobles County – Lakefield Jct.	345 kV	220	128	Northwest of Worthington to Lakefield Jct. sub. (Minnesota)
Watertown – Granite Falls	230 kV	302	272	Eastern South Dakota to western Minnesota
Blair – Granite Falls	230 kV	317	297	Runs parallel with Watertown – Granite Falls
Granite Falls – Minnesota Valley	230 kV	250	220	Western Minnesota
Fargo – Moorhead	230 kV	54	64	Fargo, North Dakota to Moorhead, Minnesota
Fargo – Sheyenne	230 kV	245	144	North Dakota, Minnesota border
Maple River – Winger	230 kV	75	55	Fargo area to northwestern Minnesota
Prairie – Winger	230 kV	137	78	Grand Forks area to Winger
Wahpeton – Fergus Falls	230 kV	209	136	ND-MN border east to Fergus Falls
Bear Creek – Rock Creek	230 kV	91	80	South of Duluth toward the Twin Cities loop
Blackberry – Riverton	230 kV	227	156	Northern Minnesota towards south
Mud Lake – Benton County	230 kV	1.2	34	Coming from the north into St.Cloud area
Sheyenne – Audubon	230 kV	194	165	Fargo area west into Minnesota
Genoa – Coulee	161 kV	268	206	Western Wisconsin
Boswell – Blackberry Ckt 1	230 kV	288	188	Northern Minnesota
Boswell – Blackberry Ckt 2	230 kV	281	183	Northern Minnesota

Table 13 – Slow Growth Minnesota Bias Tie Line/Interface Flows

5.3 North / West Scenario Slow Growth Results

5.3.1 Recommended Facilities

		Facility Name				
Ref. #	**Data Source**	**From**	**To**	**Volt (kV)**	**Miles**	**Cost ($M)**
F-02	TIPS	Alexandria	Benton County	345	80	60
F-03	TIPS	Alexandria	Maple River	345	126	94.5
F-06	NW	Antelope Valley	Maple River	345	292	219
F-07	CAPX	Arrowhead	Chisago	345	120	90
F-08	CAPX	Arrowhead	Forbes	345	60	45
F-09	CAPX	Benton County	Chisago County	345	59	44.25
F-10	CAPX	Benton	Granite Falls	345	110	82.5

		County				
F-12	CAPX	Benton County	St. Boni	345	62	46.5
F-13	CAPX	Blue Lake	Ellendale	345	200	150
F-26	CAPX	Chisago County	Prairie Island	345	82	61.5
F-28	CAPX	Columbia	North LaCrosse	345	80	60
F-30	NW	Ellendale	Hettinger	345	231	173.25
F-36	SMNI	Rochester	North LaCrosse	345	60	45
F-56	SMNI	Prairie Island	Rochester	345	58	43.5
			Total		**1620**	**1215**

Table 14 – Slow Growth Load Level North/West Bias Recommended Facilities

Table 14 key:
CAPX – CapX Technical Team
NW – MISO Northwest Exploratory Study
SMNI – MISO Southern Minnesota/Northern Iowa Exploratory Study
TIPS – Transmission Improvement Plans Study
MH – Manitoba Hydro Studies

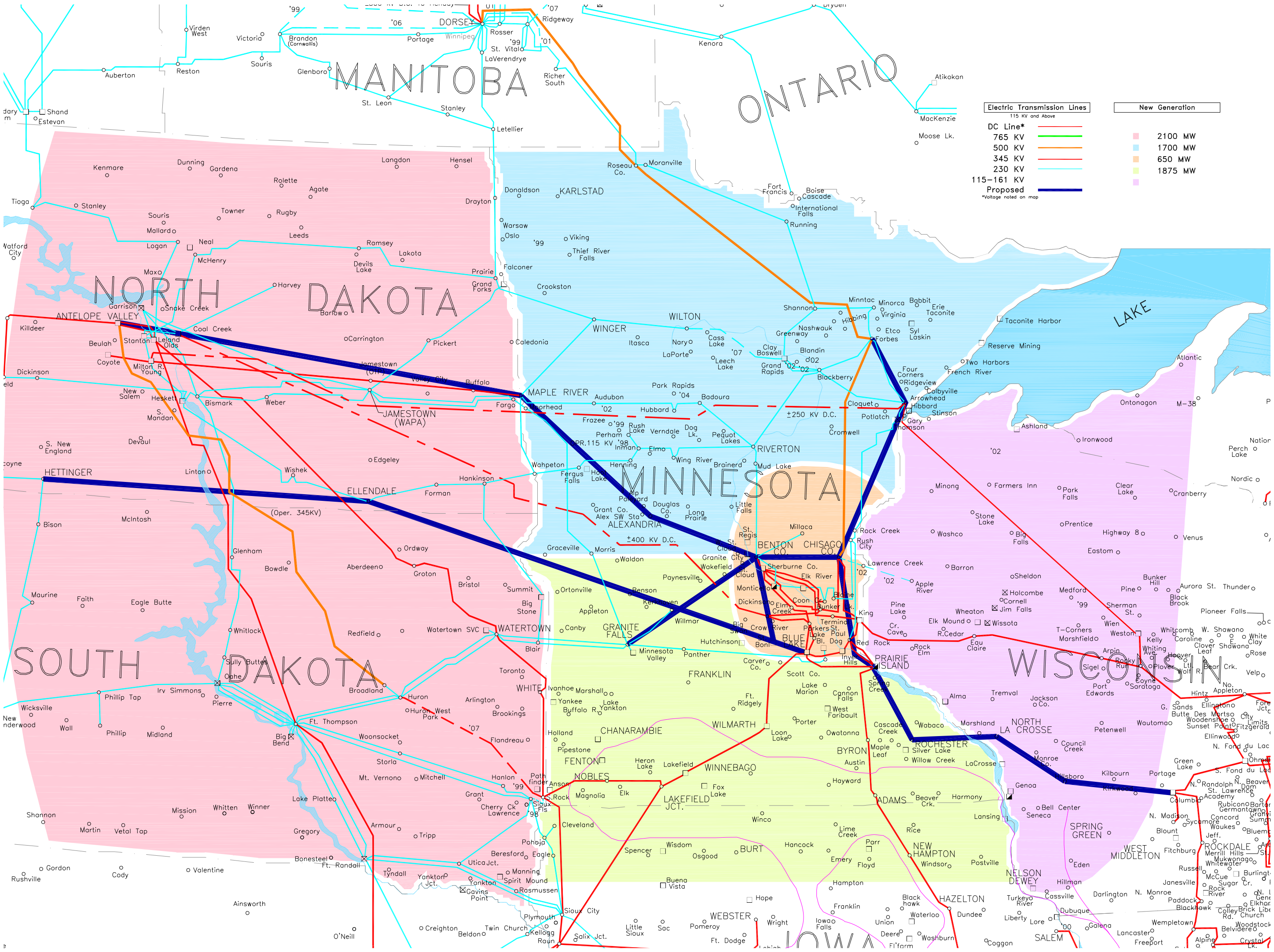

Diagram 14 – Slow Growth Load Level North/West Bias Recommended Facilities

5.3.2 Line Flows on Interface and Tie Lines

LINE	kV Voltage Level	Base 4500 MW FLOW	4500 MW UPGRADE scenario	Description
Forbes – Chisago	500 kV	1540.3	1398.6	Northern Minnesota to Twin Cities loop
Riel – Roseau	500 kV	1842.1	1782.9	Manitoba Hydro to Northern Minnesota
Richer – Roseau	230 kV	228.5	223.5	Manitoba Hydro to Northern Minnesota
Letellier – Drayton	230 kV	392.3	405.6	Manitoba Hydro to MN-ND border
Glenboro – Rugby	230 kV	34.1	81.1	Manitoba Hydro – North Dakota (This and the three lines above are all that ties Manitoba and U.S. as planned through 2009.)

Arrowhead – Stone Lake	345 kV	298.3	310.9	Duluth area to northwestern Wisconsin (then to Weston)
Eau Claire – Arpin	345 kV	72.3	57.8	West to central Wisconsin
Prairie Island – Byron	345 kV	165.4	185.3	South of Twin Cities metro to west of Rochester
Adams – Hazelton	345 kV	173.9	92.9	Southeastern Minnesota – eastern Iowa
Lakefield Jct. – Wilmarth	345 kV	746.1	602.3	Southwestern Minnesota to Mankato area
Split Rock – Nobles County	345 kV	263.9	184.4	North of Sioux Falls, SD, to northwest of Worthington, MN
Nobles County – Lakefield Jct.	345 kV	336.4	252.5	Northwest of Worthington to Lakefield Jct. sub. (Minnesota)
Watertown – Granite Falls	230 kV	248.5	232.0	Eastern South Dakota to western Minnesota
Blair – Granite Falls	230 kV	279.8	270.1	Runs parallel with Watertown – Granite Falls
Granite Falls – Minnesota Valley tap	230 kV	375.4	288.3	Western Minnesota
Fargo – Moorhead	230 kV	54.5	55.4	Fargo, North Dakota, to Moorhead, Minnesota
Fargo – Sheyenne	230 kV	271	200.7	North Dakota, Minnesota border
Maple River – Winger	230 kV	75.1	82.9	Fargo area to northwestern Minnesota
Prairie – Winger	230 kV	168.3	139.6	Grand Forks area to Winger
Wahpeton – Fergus Falls	230 kV	241.8	164.3	ND-MN border east to Fergus Falls
Bear Creek – Rock Creek	230 kV	96.1	95.5	South of Duluth toward the Twin Cities loop
Blackberry – Riverton	230 kV	232.8	216.5	Northern Minnesota towards south
Mud Lake – Benton County	230 kV	63.6	23.9	Coming from the north into St.Cloud area
Sheyenne – Audubon	230 kV	233.9	197.2	Fargo area west into Minnesota
Genoa – Coulee	161 kV	249.8	189.1	Western Wisconsin
Boswell – Blackberry Ckt 1	230 kV	293.9	287.2	Northern Minnesota
Boswell – Blackberry Ckt 2	230 kV	286.9	280.4	Northern Minnesota

Table 15 – Slow Growth North/West Bias Tie Line/Interface Flows

In the eastern bias scenario, the CapX 2020 technical team added part of the additional generation to the east of Minnesota (part on the border of northeastern Iowa and southwestern Wisconsin, part central Wisconsin), in addition to having generation throughout Minnesota, northern Iowa, North Dakota, and South Dakota as in the other two scenarios.

5.4 East Scenario Slow Growth Results

5.4.1 Recommended Facilities

Ref. #	Data Source	Facility Name: From	To	Volt (kV)	Miles	Cost ($M)
F-56	SMNI	Prairie Island	Rochester	345	58	43.7
F-64	CAPX	Eau Claire	King	345	84	63.1
F-65	CAPX	N. LaCrosse	Eau Claire	345	73	55.1
F-66	CAPX	Genoa	N LaCrosse	345	42	31.7
F-67	CAPX	Genoa	Columbia	345	113	84.8
F-68	CAPX	Genoa	Nelson Dewey	345	70	52.4
F-69	SMNI	Nelson Dewey	Salem	345	34	25.6
F-70	CAPX	Genoa	Lansing	345	21	15.8
F-71	CAPX	Lansing	Rochester	345	89	66.8
F-72	CAPX	Ellendale	Big Stone	345	194	145.8
F-73	CAPX	Big Stone	Blue Lake	345	71	53.4
F-02	TIPS	Maple River	Benton Co	345	206	154.5
F-03	NW	Antelope Va.	Maple River	345	292	218.8
F-07	CapX	Arrowhead	Chisago	345	120	90
F-08	CapX	Arrowhead	Forbes	345	60	45
F-09	CapX	Benton Co	Chisago	345	59	44.2
F-10	CapX	Benton Co	Granite Falls	345	110	82.5
F-12	CapX	Benton Co	St Boni	345	62	46.5
F-26	CapX	Chisago Co	Prairie Island	345	82	61.5
F-30	NW	Ellendale	Hettinger	345	231	218.8
			Total		**2071**	**1,600**

Table 15– Eastern Bias Preliminary Recommended Facilities

Key for Table 15:
CAPX – CapX Technical Team
NW – MISO Northwest Exploratory Study
SMNI – MISO Southern Minnesota/Northern Iowa Exploratory Study
TIPS – Transmission Improvement Plans Study
MH – Manitoba Hydro Studies

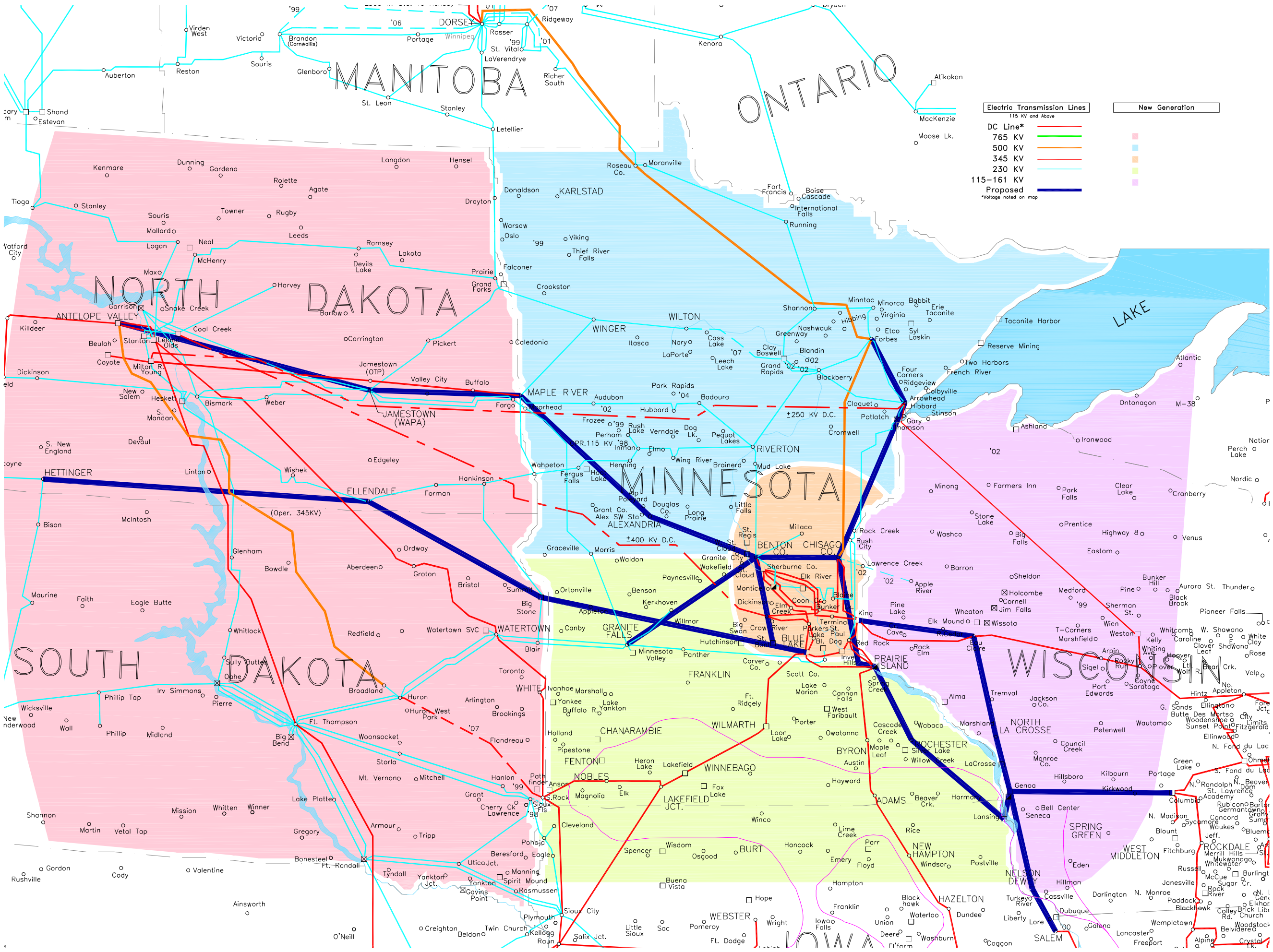

Diagram 15 – Eastern Bias Preliminary Recommended Facilities

6 Common Facilities

The CapX 2020 technical team's primary goal for this initial vision study was to identify a long-range transmission plan that would benefit Minnesota's electric reliability as load continues to grow over the next 15 years and beyond.

6.1 Common transmission alternatives between the Biases

The team found that the biases had 1620 miles of 345 kV transmission lines in common, for a total of $1.215 billion.[5] For comparison, that is a little more than 80 percent of the cost of each scenario individually. The common facilities are shown in Table 18.

[5] When reviewing the results of this study, note that only the cost of transmission line per mile is represented. None of the associated substation, generation interconnection facilities, or underlying lower-voltage (below 161 kV) transmission system infrastructure costs are determined or included in this vision study.

Facility Name				
From	**To**	**Volt (kV)**	**Miles**	**Cost ($M)**
Alexandria	Benton County	345	80	60
Alexandria	Maple River	345	126	94.5
Antelope Valley	Jamestown	345	185	138.75
Arrowhead	Chisago	345	120	90
Arrowhead	Forbes	345	60	45
Benton County	Chisago County	345	59	44.25
Benton County	Granite Falls	345	110	82.5
Benton County	St. Boni	345	62	46.5
Blue Lake	Ellendale	345	200	150
Chisago County	Prairie Island	345	82	61.5
Columbia	North LaCrosse	345	80	60
Ellendale	Hettinger	345	231	173.25
Rochester	North LaCrosse	345	60	45
Jamestown	Maple River	345	107	80.25
Prairie Island	Rochester	345	58	43.5
	Total miles 1620	**Total cost $1,215 ($M)**		

Table 16 – Common Recommended Facilities

6.2 Additional transmission facilities for each scenario

In addition to the common facilities in the above table, the Minnesota bias had three additional unique facilities for a total of 256 miles and $192 million. These facilities are a result of the high concentration of generation in the St Paul/Minneapolis metro area.

The north/west bias also had three unique facilities for a total of 387 miles and $290 million. These facilities are a direct result of the 1000-MW import from Manitoba Hydro, which is included in the north/west generation bias.

The East Bias has unique facilities due to the difficulties sending power from the East to West across minimal river crossings.

7 Conclusion and Next Steps

The CapX 2020 technical team believes these results to be the cornerstone of future studies to better identify the transmission needs of the study region. These results need to be integrated into the MISO Transmission Expansion Plan and ongoing utility load-serving studies.

The team envisions future study efforts to incorporate the results of adjoining regional study efforts, investigate how the bulk transmission solutions can support the load-serving transmission, and investigate how the impacts of new load forecasts and generation interconnections impact the transmission vision. Additional studies to consider include:

- Scaling the 2009 model's load to a point where transmission violations begin to occur and determining which transmission alternative best solves the problem. The study should continue this effort to determine sequence and/or combinations of transmission additions.
- Analyzing the lower voltage system (below 161 kV) for voltage violations and thermal overloads during n-1 contingency analysis.
- Conducting detail studies (including stability analysis) to support a certificate of need for facilities identified as being critical to meet the needs of the transmission customer.
- Identifying bulk substation locations that address overloads on the load-serving transmission system and preparing least-cost planning alternatives that meet the anticipated load growth in the area. Studies would involve detailed load scaling efforts to better model local load growth. The team would review short-term alternatives to address immediate concerns such as switched capacitors, reconductoring, and voltage upgrades on existing corridors.
- Investigating impacts of alternative transmission technology (DC, FACTS, phase shifting transformers, etc.)
- Reconsidering alternative generation locations in each of the biases to determine the sensitivity of generation location on the transmission vision.
- Updating study results based on new generation interconnect/delivery study results.
- Integrating results of adjoining regional and MISO study efforts to determine impacts on transmission vision.

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Appendices

A. Composite List of Transmission Data

B. Tabulated Contingency Results, Load Flow Data and Automaps

B-1. MN Bias
- N-1 Output 6300 MW
- Automaps for 6300 MW Case
- N-1 Output 4500 MW
- Automaps for 4500 MW case

B-2. NW Bias
- N-1 Output 6300 MW
- Automaps for 6300 MW Case
- N-1 Output 4500 MW
- Automaps for 4500 MW case

B-3. Eastern Bias
- N-1 Output 6300 MW
- Automaps for 6300 MW Case
- N-1 Output 4500 MW
- Automaps for 4500 MW case

C. Transmission Characteristics and Cost Estimate Data

Appendix A

Composite List of Transmission Data – Recommended Facilities Include Facility Characteristics

		Facility Name					**Facility Characteristics**						
Ref. #	**Data Source**	**From Name**	**To Name**	**Volt (kV)**	**Miles**	**Cost ($M)**	**From Bus #**	**To Bus #**	**R**	**X**	**Bch**	**Rating (MVA) Summer**	
F-01	SMNI	Adams	Hayward	345	34	25.3							
F-02	TIPS	Alexandria	Benton County	345	80	59.9	67010	60142	.00299	.03276	.559	1165	
F-03	TIPS	Alexandria	Maple River	345	126	94.2	67010	66792	.00506	.05544	.946	1165	
F-04	CAPX	Alma	Rock Elm	345	60	45							
F-05	CAPX	Alma	Tremval	345	40	30							
F-06	NW	Antelope Valley	Maple River	345	292	219	67101	66792	.01058	.11592	1.978	1165	
F-07	CAPX	Arrowhead	Chisago	345	120	90	61608	60199	.00438	.04718	.80974	1303	
F-08	CAPX	Arrowhead	Forbes	345	60	45	61608	61622	.00191	.02060	.35357	1303	
F-09	CAPX	Benton County	Chisago County	345	59	43.9	60142	60199	.00269	.02890	.49602	1303	
F-10	CAPX	Benton County	Granite Falls	345	110	82.7	60142	66797	.00506	.05449	.93523	1303	
F-11	MH	Benton County	Riverton	500	78	58.5	61620	60142	.00361	.000494	.665	1303	
F-12	CAPX	Benton County	St. Boni	345	62	46.6	60142	62655	.00285	.03068	.52655	1303	
F-13	CAPX	Blue Lake	Ellendale	345	200	150	60192	99990	.014398	.157752	2.6918	1166	
F-14	NW	Blue Lake	Franklin	345	87	65.0							
F-15	NW	Blue Lake	Granite Falls	345	127	95.4							
F-16	CAPX	Blue Lake	West Faribault	345	50	37.5							
F-17	CAPX	Boswell	Forbes	345	64	47.7	61628	61622	.00292	.03142	.53926	1303	
F-18	TIPS	Boswell	Wilton County	230	72	54.3							
F-19	SMNI	Burt	Webster	345	50	37.3							
F-20	SMNI	Burt	Winnebago	345	56	41.9							
F-21	SMNI	Byron	Rochester	345	31	23.6							
F-22	SMNI	Byron	Wilmarth	345	72	54.2							
F-23	SMNI	White	Franklin	345	76	57.2							
F-24	SMNI	Chanarambie	White	345	53	39.8							
F-25	CAPX	Chisago County	King	345	52	39							
F-26	CAPX	Chisago County	Prairie Island	345	82	61.2	60199	60105	.00375	.04031	.69189	1303	
F-27	CAPX	Columbia	Genoa	345	110	83							
F-28	CAPX	Columbia	North LaCrosse	345	80	60	39157	92605	.00316	.04954	.5371	1328	
F-29	MH	Dorsey	Karlstad	345	134	100.5	67625	66750	.00383	.05688	.89380	1295	
F-30	NW	Ellendale	Hettinger	345	231	173.3	99990	67175	.0092	.1008	1.72	1165	
F-31	NW	Ellendale	Watertown	345	131	98.2							

F-32	CAPX	Forbes	Riverton	345	114	85.4	61622	61620	.00522	.05622	.96491	1303	
F-33	CAPX	Franklin	Granite Falls	345	48	36							
F-34	CAPX	Franklin	Lyon County	345	70	52.5							
F-35	CAPX	Franklin	Wilmarth	345	60	45							
F-36	SMNI	Rochester	North LaCrosse	345	60	44.9	69999	92603	.00253	.02717	.46635	2110	
F-37	SMNI	Freemont	Rochester	345	0	0							
F-38	NW	Granite Falls	Watertown	345	93	69.9							
F-39	CAPX	Genoa	Lansing	345	0	0							
F-40	MH	Winger	Benton Co	345	162	121.5	66760	60142	.00735	.10920	1.7157	1295	
F-42	SMNI	Hayward	Winnebago	345	56	41.9							
F-43	SMNI	Hazelton	Salem	345	78	58.1							
F-44	NW	Jamestown	Maple River	345	107	80.4							
F-45	MH	Karlstad	Winger	345	91	114	66750	66803	.00311	.04623	.72631	1295	
F-46	CAPX	King	Rock Elm	345	50	37.5							
F-47	SMNI	Lakefield Junction	Winnebago	345	64	47.9							
F-48	CAPX	Lansing	Rochester	345	100	75							
F-49	CAPX	Lyon County	White	345	50	37.5							
F-50	SMNI	Nelson Dewey	Salem	345	35	25.9							
F-51	SMNI	Nelson Dewey	Spring Green	345	67	50.2							
F-52	SMNI	Nobles	Wilmarth	345	120	89.7							
F-54	SMNI	North LaCrosse	Spring Green	345	105	78.8							
F-55	CAPX	North Lacrosse	Tremval	345	55	41.3							
F-56	SMNI	Prairie Island	Rochester	345	58	43.7	60105	6999	.0046	.0494	.8479	2110	
F-57	MH	Riverton	Wilton County	500	96	72							
F-58	SMNI	Rockdale	West Middleton	345	36	26.7							
F-59	SMNI	Spring Green	West Middleton	345	31	23.2							
F-60	CAPX	West Faribault	Wilmarth	345	45	33.75							
F-61	MH	Wilton County	Winger	345	66	49.5							
F-62	CAPX	Wilmarth	Rochester	345	75	56.25							
F-63	CAPX	Lakefield Jct.	Adams	345	92	69	60331	60102	.00644	.06916	1.187	1303	
F-64	CAPX	Eau Claire	King	345	84	63.1							
F-65	CAPX	North LaCrosse	Eau Claire	345	73	55.1							
F-66	CAPX	Genoa	North LaCrosse	345	42	31.7							
F-67	CAPX	Genoa	Columbia	345	113	84.8							
F-68	CAPX	Genoa	Nelson Dewey	345	70	52.4							
F-69	SMNI	Nelson Dewey	Salem	345	34	25.6							

F-70	CAPX	Genoa	Lansing	345	21	15.8							
F-71	CAPX	Lansing	Rochester	345	89	66.8							
F-72	CAPX	Ellendale	Big Stone	345	194	145.8							
F-73	CAPX	Big Stone	Blue Lake	345	71	53.4							
				Total	**0**	**0**							

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For the rest of the Appendices please refer to www.capx2020.com for the electronic version of the Technical Update report.