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Xcel Energy
Docket No.: E002, ET2/CN-06-1115
Response To: Elizabeth Goodpaster and Mary Marrow WOW, et al — Information Request No. 19
Date Received: April 7, 2008

Question:

In addition to the description of the power flow software as requested in our IR No. 15:

a) Please describe the dynamic stability model and software used to test the dynamic stability of the regional system both with and without the CAPX2020 facility additions.

b) Please list the critical disturbances such as line faults and the system responses to the critical disturbances.

c) Where did both the power flow and dynamic stability models originate with respect to the parties entering all the line characteristics and other configuration data?

d) How was the accuracy of the entered data confirmed and what other quality controls were used to ensure data accuracy?

Response:

Stability studies were undertaken as part of the TIPS Update and Southwestern Minnesota Study. A stability study was not done as part of the Rochester/La Crosse Study. Reponses for the TIPS Update (Appendix A-3) and Southwestern Minnesota Study (Appendix A-4) are shown below.

TIPS Update

a)

For the TIPS Update, the study used to identify much of the benefit associated with the Twin Cities - Fargo 345 kV line, the dynamic stability models used were part of the 2003 Northern Mid-Continent Area Power Pool ("MAPP") Operating Review Working Group ("NMORWG") stability study package. The NMORWG package is a series of files that are put together by the Northern MAPP Operating Review Working Group. Each of the utilities with major regional transmission infrastructure participates in NMORWG and contributes to the model development process. The models that were used in the stability review were 2003 Summer Off-Peak and 2003 Winter Peak cases. The basic assumptions in the cases were as follows:

2003 Summer Off-Peak Case
-Manitoba Hydro Export ("MHEX"): 2,176 megawatts ("MW") (north to south flow)
-North Dakota Export ("NDEX"): 1,951 MW
-Minnesota – Wisconsin Stability Interface ("MWSI"): 1,480 MW
-North Dakota generation modeled at typical "Cruise" output (not maximum "Urge" output)

2003 Winter Peak Case
-MHEX: 700 MW (south to north flow)
-NDEX: -69 MW (negative flow represents flow into North Dakota)
-MWSI: -63 MW (negative flow represents flow into Minnesota)
-North Dakota generation modeled at typical "Cruise" output (not maximum "Urge" output)

An additional 2003 summer off-peak case was studied with NDEX at 2,301 MW.

The stability study package mentioned above was used in conjunction with PSS/E to model 18 regional contingencies that are known to have impacts on stability in the upper Midwest. More information on the procedure followed to complete the dynamic stability can be found in Section 4.3 of the TIPS Update (Appendix A-3).

b)

The list of faults that were applied during these dynamic stability studies is detailed in Section 4.3 of the TIPS Update (Appendix A-3, Page 18). A detailed description of each of these faults is included on that page.

c)

All of the utilities in the region participate in the model development process. At the time of the TIPS Update, the model building working group began the model building process with the previous year's models. Each utility submitted its changes to the models, the changes were compiled into the model, and the models were sent back to the utilities for review. The utilities reviewed the topology, load levels, and generation dispatch for their service territories and suggested changes. Those changes were made and the models were sent back to the utilities once again. This process was repeated until each of the utilities was satisfied with how its system was represented.

Southwestern Minnesota Study

a) and c)

The steady-state (power flow) model used for the Southwestern Minnesota Study was developed from the model used for the Big Stone II Transmission Service Request ("TSR") study performed by Otter Tail Power Company on behalf of the Midwest Independent Transmission System Operator ("MISO"). This model was chosen because it was extensively reviewed by all the interested regional utilities, all Big Stone II project participants and MISO staff. Considering this extensive scrutiny to which the model had been subject, it was recognized as being the best available model, and therefore the most appropriate for use as the starting model for the Southwestern Minnesota Study.

The Buffalo Ridge Incremental Generation Outlet transmission facilities and respective generation representing 1,200 MW of southwest Minnesota wind generation were added to the Big Stone II model. Generation was added as stated in the Southwestern Minnesota Study's Appendix H-11 and dispatched to sinks listed in the same section. Transmission lines, transformers and reactive devices were added to represent the transmission options being studied.

The dynamic stability model used for the Southwestern Minnesota Study was developed as stated in Section 4.5.2 of the study. The dynamic stability model was derived from the "Big Stone II Outlet Interconnection Study" dynamic stability model. This dynamic stability model was chosen for the same reasons the steady state model was chosen; because it went through the same review process. The model was adjusted as needed to represent the "1200 MW and "2000 MW" Southwest Minnesota generation levels and the circuit configurations corresponding to the transmission options under evaluation.

As stated in section 4.5.1 of the report, the Siemens Power Technologies, Inc. PSS/E (Version 29) digital computer power flow and dynamic stability simulation program was used for the power system modeling and evaluation.

b)

The list of faults that were applied during these dynamic stability studies is detailed in Appendix J of the Southwestern Minnesota Study (Volume II, Pages 273 - 274). A detailed description of each of these faults is included on that page. This list is reproduced below:

Disturbance Index

Mnemonic	Disturbance Description
ag1	4 cycle slgf @ Leland Olds 345 on Ft. Thompson line, Leland Olds breaker 2692 stuck. Clear @ 11 cycles by tripping faulted line.
ei2	Permanent bipole fault on the CUDC line. Both Coal Creek units tripped at 0.30 sec.
mqs	Single line to ground fault with breaker fail at Sherco with 8N28 stuck. Trip Sherco generator 3.
mss	Single line to ground fault with breaker fail at Sherco with 8N32. Trip Sherco to Coon Creek 345 kV line.
mts	Single line to ground fault with breaker fail at Monticello with 8N6 stuck. Trip Monticello to Elm Creek 345 kV.
nbz	Three-phase fault at Chisago on Chisago County-Forbes 500 kV line.
mad	4 cycle 3 phase fault at Dorsey 500 kV. Clear the Dorsey - Forbes 500 kV line.
nad	4 cycle 3 phase fault at Forbes 500 kV. Clear the Forbes - Dorsey 500 kV line.
mat	Dorsey - Forbes line trip without a fault.
oas	single line to ground fault with breaker fail at Dorsey with 602L stuck. Trip D602F.
pcs	Single line to ground fault with breaker fail at King with 8P6 stuck. Trip King - Eau Claire - Arpin 345 kV line and King to Chisago County 345 kV line.
pct	Trip King - Eau Claire - Arpin 345 kV line and King to Chisago County 345 kV line without fault
pyt	Trip of Prairie Island - Byron 345 kV without a fault
pys	14 cycle SLG fault at Prairie Island 345 kV, trip Prairie Island-Byron 345 kV line.
nbs	SLGBF fault at Big Stone with 2665 stuck; Trip Big Stone -

	Ortonville 230 kV Line in 17 cycles
nsc	SLGBF fault at Big Stone with 2665 stuck; Trip Big Stone - Ortonville 230 kV Line in 14 cycles
nmz	4 cycle, 3 phase fault at Chisago trip f601c, transformer trip D602F; use new 100% reduction init from Chisago, leave SVS on mp sys
lb3	4 cycle 3 phase fault at Brookings County 345 kV. Clear the Brookings County-Lyon County 345 kV line.
lf3	4 cycle 3-phase fault at Lyon County 345 kV. Clear the Lyon County-Franklin 345 kV line.
fh3	4 cycle 3-phase fault at Helena 345 kV. Clear the Franklin-Helena 345 kV line.
lh3	4 cycle 3-phase fault at Lake Marion. Clear the Helena-Lake Marion 345 kV line.
lc3	4 cycle 3-phase fault at Lyon County 345 kV. Clear the Lyon County-Hazel 345 kV line.
wh3	4 cycle 3-phase fault at Hazel 345 kV. Clear the West Waconia-Hazel 345 kV line.

For all system configurations and disturbances studied, dynamic stability performance was found to be satisfactory with regard to angular stability, relay margins, and damping. The only performance deficiencies found were related to dynamic undervoltage (one disturbance; nbz) and transient overvoltage (one disturbance; mat).

At 2,000 MW of southwest Minnesota wind generation "nbz" causes low voltage at Arrowhead and Riverton 230 kV substations. The identified "nbz" issues have been addressed by the recently completed Forbes Substation 500 kV bus re-configuration.

For the disturbance "mat" a transient overvoltage was experienced for which the report identified three fixes that the utilities can choose from to address the issue. The fixes are identified in Section 5.2 of the Southwestern Minnesota Study.

<u>Joint Response (TIPS Update and Southwestern Minnesota Study):</u>

d)

The accuracy of the data placed into the models was confirmed by having numerous engineers from various utilities throughout the region review the models for accuracy. Until each of the utilities indicates they are comfortable with the model, the models are not released for use in power flow studies.

Engineers throughout the region verify the accuracy of their models in various ways. Among them are the following:

- Checking of the base cases for system intact overloads or low voltages;
- Plotting of flow diagrams ("automaps") and review of the indicated flows and voltages to identify possible configuration or impedance errors (these automaps are contained in the study appendices);
- Comparison of Transfer Limit Table Generator ("TLTG") results to those of previous studies with regard to which limiting facilities are identified, and the relative megawatt levels at which they are encountered;
- Checking of impedance magnitudes (flagging of very small and very large values);
- Checking of transmission line X/R ratios;
- Careful review of results from initial "test" TLTG runs, to identify incorrect ratings and circuit configurations;
- Review of substation loads and power factors;
- Checking of constrained interface loadings (NDEX, MHEX, etc.);
- Comparison of dynamic stability results to those of previous studies with similar initial power system configuration and power transfer levels;
- Checking of generator reactive power outputs;
- Review of PSS/E dialogue output files generated during execution of automated activities such as TLTG, AC Contingency Checking ("ACCC"), and solution routines; and
- Review of switched shunt (capacitor and reactor) data and resultant "solved case" device statuses.

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