Transmission Customer Q&A
Questions on Mesaba Transmisison Project

Question:

We continue to do powerflow analysis looking at network upgrades associated with the Mesaba Energy Project and its two generator interconnection requests. An issue that keeps showing up during critical contingencies is south 500kV loading above 1400MW operation guide which is associated with an outage of one of the Chisago 500/345kV autotransformers. Is Xcel Energy considering adding a third transformer because of the vintage/design of the existing ones or to eliminate this op guide and the associated SPS?

Are the series capacitors on the south line switchable such that they could be take out or put in service to adjust/control the line loading? We believe the capacitors were installed to try and keep MH deliveries on the 500kV rather than jumping off into the MP 230/115kV system. However, the addition of 1100MW of new Mesaba generation the flow through the Forbes 500/230kV transformers reverses and the south 500kV line loads heavier than the north line. We believe with Mesaba generation in-service operating without south 500kV series capacitors might be desirable. Is this correct? What about the stability aspects?

Our study results that indicate taking the south 500kV line series capacitors out does, in fact, help reduce the line flow by 200MW+. Our recent research appears that the 1400MW op guide is associated with arming the Chisago transformer SPS and is not necessarily a 'hard limit' that flows must remain below. Would you confirm and provide what is the current south 500kV line rating/limitation? Do we need to meet to discuss our preliminary study results and these issues?

Response:

The 1400 MW “operating guide” figure you refer to is not actually an operating guide value, but an arming level. A “20% (of Dorsey-Forbes 500 kV MW loading) MH HV dc runback” is initiated following loss of either of the Chisago Co 500/345 kV transformers, if the pre-contingent flow on the Forbes-Chisago 500 kV line is over 1400 MW.

This “loss of one Chisago Co 500/345 kV transformer” contingency is one of 13 which initiate a prescribed level (13, 20, 26, 40, 50, 65, or 100%) of MH HV dc runback. The other 12 contingencies relate to loss of a 500 kV line section, bypass of one or more series capacitors, tripout or overload of Forbes SVS, etc.

If not first limited by other power system loading considerations (overload of Chisago Co transformers, or other lines, or stability limitations), ultimately the South Line loading limit that will be encountered will be based on the Chisago Co series capacitor continuous rating of 1732 MVA (2000 amps). Short-term “emergency” rating is 125% of

this value, or 2165 MVA, again based on capacitor bank rating, as the line and all other associated series equipment are rated higher (e.g., wavetraps were upgraded from 2000 to 3000 amps as part of the Harvey-Glenboro 230 kV project).

The Chisago Co 500/345 kV transformer banks each have a continuous rating of 1204 MVA (3 x 401.333), based on nameplate data. The transformer overload rating is based on the high-side bushings, which have a rating of 1600 amps; this is 1385 MVA, or 115% of 1204. There is no proposal at present to add a third 500/345 kV transformer bank.

The Chisago Co series capacitor installation is arranged so that the series capacitor bank can be put into circuit (inserted) or taken out of circuit (bypassed) without need for a line outage. As you have noted, taking the capacitor out of service will of course reduce the 500 kV line loading, and the Chisago Co 500/345 kV transformer loading. The reduction in 500 kV loading of course also causes increased loading on other circuits, and an increase in total transmission system losses.

Based on the latest operating study for the MH-U.S. interface (*Central North Dakota-Manitoba 230 kV Interconnection Project Summer 2003 Operating Study; December 5, 2003*), with the Chisago Co series capacitor out of service, the MHEX transfer limit drops by approximately 75 - 275 MW, depending on NDEX level. The table below summarizes results from this Study's Tables 4.2-2 (system intact) and 28.2-1 (prior outage Chisago series capacitor).

NDEX	MHEX limit, MW			Limiter	
MW	with series cap	w/o series cap	reduction	with series cap	without series cap
0	1875	1690	185	L20D loading	L20D loading
500	2175	1900	275	L20D loading	L20D loading
1000	2425	2175	250	L20D loading	L20D loading
1500	2380	2230	150	Chisago SC	(not tested >2230MW)
1950	2175	2100	75	NBZ fault	Arrowhead-Rk Crk 230

Notes:

1. L20D is Letellier-Drayton 230 kV circuit (rating = 419 MVA).
2. Chisago SC is the Chisago 500 kV series capacitor (rating = 1732 MVA).
2. NBZ fault is "4-cycle 3-phase fault at Chisago on Chisago-Forbes 500 kV line; invoke 100% MH HV dc reduction; cross-trip Dorsey-Forbes 500 kV line at 4 cycles".
3. All limiters are steady-state (thermal), except for "NBZ fault".
4. NDEX is "North Dakota Export" limit as defined by the flow on a set of 18 tie lines.
5. MHEX is "Manitoba Hydro Export" limit as defined by the flow on a set of 4 Manitoba-U.S. tie lines.

Reviewing this table, it is evident that prior outage of the Chisago Co series capacitor causes a reduction in permissible MHEX, always due to thermal considerations. The amount of reduction is sensitive to NDEX level, and can be as high as 275 MW, or approximately 1/8 of the established 2175 MW interface TTC rating.

It is of course not known whether the thermal or the stability performance might be the more limiting consideration after a Mesaba generation addition, since--as you point out--stability for Mesaba has not been studied by anyone yet.

The 2003 Operating Study also indicates that due to stability considerations, prior outage of the Chisago Co series capacitor also requires reducing the “Coal Creek [two-unit tripping] Arming Level” from NDEX = 1500 MW to 1350 MW (Section 28.2.2). This is in consideration of the “block of CU dc line” disturbance (“EIS”).

Consequently, taking the Chisago Co series capacitor out of service today presents both steady-state and dynamic stability limitations with respect to transmission system loadability. Increased system losses would also be a concern.