

## Appendix M-1

### Sensitivity of TLTG results to NDEX and Big Stone Generation Levels

#### **Background**

The technical and economic evaluations of the transmission options presented in the body of this report are based upon results from an extensive set of powerflow simulations, focusing on the off-peak load condition. These simulations represent one set of possible flow patterns resulting from the selected combination of load level, power transfers, and generation pattern.

Following completion of most of the technical analysis, it was noted that the base case models employed inadvertently had the existing Big Stone Unit 1 at only 122 MW net output. Although this is a possible “minimum load” scenario, operation of Big Stone at or near full output is more common, and must be accommodated. Increased generation at Big Stone will tend to increase loading on the Granite Falls-Minn Valley-Panther-McLeod-Blue Lk 230 kV line. Since this line is also an important outlet path for Buffalo Ridge area generation, incremental loading on this path is of concern.

Another matter of interest is that in recent months the MAPP Design Review Subcommittee (DRS) has accepted technical studies supporting an increase in NDEX limit of 130 MW (from 1950 to 2080 MW). This increase has been shown to be achievable with the combination of a capacitor addition proposed for Watertown, SD (by WAPA) and a generator addition at Groton, SD (by Basin Electric). The powerflow models used in the Buffalo Ridge analysis to date have NDEX at 1850 MW. Similar to Big Stone, increased NDEX loading also contributes to increased power flow on the Granite Falls-Minn Valley-Panther-McLeod-Blue Lk 230 kV line.

The sensitivity analysis described in the following sections evaluates the incremental effect of Big Stone generation level and the planned increase in NDEX operating limit. The powerflow modeling also reflects an update to the 69 kV system configuration in the Troy, MN vicinity.

#### **Analysis**

##### Method & Results

This sensitivity analysis was performed to evaluate the effect of having Big Stone Unit #1 at full output, and the effect of the planned increase in NDEX dynamic limit. This was accomplished by increasing the Big Stone Unit #1 output to 415 MW and sending the 293 MW incremental output eastward (to Milwaukee [Oak Creek]). This action caused the NDEX loading to increase to 2135 MW, which is approximately 102% of the 2080 MW limit most recently recognized by the MAPP DRS. Consequently, this is a severe test of West-->East loading through western Minnesota.

Another model revision which was made for this sensitivity analysis relates to the Troy 69 kV switching station, which is being placed in service in late 2005. Troy is located on the 69 kV system between Minn Valley and Panther. The base case powerflow models were revised to correctly represent the 69 kV configuration in the Troy vicinity. This relatively minor model revision reduces pre- and post-contingent loadings on the Minn Valley-Panther 230 kV and the Panther 230/69 kV transformer.

Table 1 shows the incremental effect which the above-described Big Stone/NDEX changes to the base case powerflow models have on the limiting facilities encountered by four of the transmission options under study. These four options were chosen as representative of the full set of options, as they implement different transmission outlet upgrade strategies.

Table 1

SW Minnesota Buffalo Ridge Area  
Total Generation Outlet Capacity, MW

Limiting Facility	Rating MVA	NDEX:	Transmission Option							
			31A		31A6		5		9	
			low	high	low	high	low	high	low	high
Granite Falls-Minn Val 230	388		1457	<b>1148</b>	1398	<b>1139</b>	1487	<b>1195</b>	1463	<b>1143</b>
Minn Valley-Panther 230	388		1358	<b>1190</b>	1316	1185	1423	<b>1268</b>	1377	<b>1200</b>
Panther 230/69 tx	70		1302	1179*	1255	1165*	--	--	1301	1168*
Minn Valley 230/115 tx	187		1641	1473	1606	1473	--	1616	--	1464
Pipestone-Pathfinder 115	225		--	--	--	--	1577	1507	1134	1098
Canby-Granite Falls 115	96		--	--	1641	<b>1168</b>	--	--	--	--
Toronto-Burr 115	144		--	--	1490	1574	--	--	--	--
Johnson Jct-Ortonville 115	97		--	--	--	<b>641</b>	--	--	--	--

Notes:

1. The "low NDEX" values in Table 1 are from the corresponding tables in Appendix B. This represents the condition of NDEX = 1850 MW, Big Stone = 122 MW.

The "high NDEX" values are derived from new "TLTG" simulations performed for this sensitivity analysis. This corresponds to the condition of NDEX = 2135 MW, Big Stone = 415 MW.

The "raw" outputs for these new "high NDEX" TLTG simulations are provided in Appendix M-2. Since the base cases already have 918 MW of Buffalo Ridge generation represented, this amount is added to the MW limits indicated in the TLTG outputs to arrive at the "Buffalo Ridge Area Total Generation Outlet" MW limits displayed in Table 1.

2. "\*" indicates distribution factor is below 2.0%; due to Troy Switching Station-related model update.
3. Outlet limits are based on permissible post-contingent loading of 110% of continuous rating for lines & 130% for transformers.

Observations: (High increment; 500 - 575 MW)

From study of Table 1, it is observed that if a target Buffalo Ridge generation outlet level of approximately 1325 - 1400 MW were selected (825 plus 500 - 575 MW), the "new" limiters shown in **bold** would be encountered, due to the effects of the higher Big Stone/NDEX level.

The Granite Falls-Minn Valley 230 kV reconductor would therefore be added to each Option, and the Minn Valley-Panther 230 kV reconductor would be required for all the options studied, except for 31A6, which already includes it.

The Johnson Jct-Ortonville 115 kV overload appears as a new limiter, only for Option 31A6, because Buffalo Ridge generation increase has a distribution factor of over 2.0% on this facility for outage of the Granite Falls-Blair/Watertown 230 kV double circuit line. However, this overload would be addressed by the proposed Big Stone 2 interconnection improvements, and is actually also present for all other Options, but at levels slightly below the 2.0% reporting threshold.

The only other new limiter encountered in this 1325 - 1400 MW range is the Canby-Granite Falls 115 kV overload, in the case of Option 31A6. As with Johnson Jct-Ortonville 115 kV, the problematic contingency is loss of the Granite Falls-Blair/Watertown 230 kV double circuit line. The resultant overload is understandable, since both the NDEX/Big Stone increase and the added Buffalo Ridge generation cause incremental loading on this line.

Consequently, Option 31A6 has the relative advantage of not gaining the need for the 30-mile Minn Valley-Panther 230 kV reconductor but has the relative disadvantage of acquiring the need for the Canby-Granite Falls 115 kV rebuild (39 miles). The cost of the Canby-Granite Falls rebuild would be considerably higher than the avoided cost of the Minn Valley-Panther reconductor, so this represents a net penalty against the economics of Option 31A6, compared to what is encountered by the other Options.

#### Relationship to Big Stone 2 unit addition

Based on the results of the MISO interconnection study for this proposed generating unit, the Canby-Granite Falls 115 kV line is proposed to be rebuilt as a 230 kV line. Consequently, this "Canby-Granite Falls 115 kV rebuild" cost penalty against Option 31A6 would not be encountered if implementation of Option 31A6 were coordinated with the Big Stone 2 transmission improvements.

#### Observations: (Moderate increment; 375 MW)

If a lower Buffalo Ridge outlet capacity target level than 1325 - 1400 MW were chosen, the impacts would be slightly different. For example, at 1200 MW (825 + 375 MW) all Options would still need the addition of the Granite Falls-Minn Valley 230 kV reconductor, but Option 5 would not need the Minn Valley-Panther 230 kV reconductor, as it is not encountered until the 1268 MW Buffalo Ridge outlet level. Option 31A6 would suffer, as it gains (at 1185 MW) the need for the Minn Valley-Panther 230 kV reconductor, which previously was not needed until the 1316 MW Buffalo Ridge generation level. Consequently, Option 31A6 becomes less competitive at these lower Buffalo Ridge outlet levels.

## Conclusions

The effect of the Big Stone #1/NDEX increase is to accelerate the need for the Granite Falls-Minn Valley and Minn Valley-Panther 230 kV reconductors. Increased loadings on these 230 kV line segments leave less capacity for accommodating incremental loadings arising from Buffalo Ridge generation increases. Most transmission options studied suffer relatively similar impacts due to this change in base case conditions.

The exception to this general rule is Option 31A6. Presuming at least 1200 MW of total Buffalo Ridge outlet capability is desired (825 + 375 MW), Option 31A6 would incur the significant cost (approximately \$10 million) for the Canby-Granite Falls 115 kV rebuild if it (Option 31A6) were implemented prior to the Big Stone Unit 2 interconnection facility improvements. If this Option were implemented later, (such as by initially implementing Option 31A and later adding the White-Toronto 115 kV line segment) no such penalty is suffered.

Except for the Option 31A6 considerations discussed above, the differences in incremental impact observed among the Options are not significant, and therefore do not affect the conclusion that Option 31A is the Preferred Plan. Similarly, the conclusion that the addition of the White-Toronto 115 kV line also appears to be advantageous--particularly if a relatively large increment of Buffalo Ridge area generation outlet capacity is desired--remains correct, but tempered by the timing considerations described above.

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