SW Minnesota-->Twin Cities EHV Development
Comparison of "Base Plan" and "System Alternative"
(Costs & logistics)

Background

This analysis provides a comparison of the costs associated with the "Base Plan" and "System Alternative" transmission options, and provides some discussion of the logistical differences with respect to implementation and long-term operation.

Conclusions

The "Base Plan" configuration is the superior option, considering the amount of outlet capacity achievable, installed cost, and logistical concerns.

The Base Plan configuration provides approximately 100 MW more generation outlet, at a lower cost than the "System Alternative" configuration. The System Alternative, which achieves a total of approximately 1800 MW Buffalo Ridge generation outlet, is expected to cost 10 - 36% more than the Base Plan, which achieves approximately 1900 MW. Consequently, the Base Plan provides better performance at lower cost.

Installed Costs (indicative estimates)

The following tabulations are for the purpose of comparing the installed cost (capital investment) required for each transmission option, to achieve a total of 1800 - 1900 MW of SW Minnesota Buffalo Ridge area transmission outlet capability. Derivation of the cost components for each option is described in the following sections.

	$ M
Base Plan (single ckt 345 kV)	305
Fixes to get to 1900 MW	27
Total installed Cost for 1900 MW	**332**

System Alternative (single ckt 345 kV separate structures from 230 kV)	216
Fixes to get to 1800 MW (not including Blue Lk outlet)	31
	247
Blue Lake outlet improvements	26
Twin Cities Outer Loop (1/2 of Helena-Lk Marion-Hampton Corner 345)	25
Total installed cost	298
WAPA xmsn service	61
WAPA losses	5
Total equivalent installed cost for 1800 MW	**364**

System Alternative (double ckt 345/230 kV)	258
Removal cost of existing 230 kV	4
Fixes to get to 1800 MW (not including Blue Lk outlet)	31
	293
Blue Lake outlet improvements	26
Twin Cities Outer Loop (1/2 of Helena-Lk Marion-Hampton Corner 345)	25
Additional fixes due to double circuit outages	14
Additional fixes to avoid production penalties during const	29
Total installed cost	387
WAPA xmsn service	61
WAPA losses	5
Total equivalent installed cost for 180 MW	**453**

Logistics

The System Alternative is based on the concept of constructing a new 345 kV line paralleling the existing 230 kV Minn Valley-Panther-McLeod-Blue Lk line. The cost estimate and TLTG analysis for this “System Alternative” are based on the two lines being physically separate.

If it were instead required to establish the new 345 kV circuit by rebuilding the existing 230 kV line to be a double circuit 345/230 kV facility, both cost and power system performance would be affected. These effects are described in the following sections.

Cost would increase due to the higher cost of double-circuit construction compared to single-circuit construction, plus the removal cost of the existing 230 kV line. The incremental cost of the second circuit is assumed to be 50% of the base cost of a single-circuit line; this adder is $400,000 per mile; for 105 miles of line this yields an incremental cost of $42 million.

Power system performance would be affected during two periods: during construction, and following completion.

During construction, the sections of the existing 230 kV line would each be out of service for several months. During this time, the Buffalo Ridge outlet capability will be severely reduced. A TLTG simulation was performed to represent this "prior outage of 230 kV" condition. The table below indicates that during the rebuilding of the Minn Valley-Panther segment of 230 kV, the Buffalo Ridge outlet capability would be limited to less than 1200 MW by the following conditions:

Total Buffalo Ridge Outlet, MW				
Existing System	230 kV Prior outage	Limiting Facility	Outage	"fix" $M
N/A	**0**	***Sacred Heart-Renville 69**	**(no outage)**	**2.3**
N/A	**0**	***Sacred Heart-Renville 69**	**Wilmarth-Lakefield Jct 345**	**--**
N/A	**0**	***Hoot Lk-Fergus Fls 115**	**Fergus Falls-Wahpeton 230**	**.3**
194	0	Grant Co-Morris 115	Wahpeton-Fergus Fls 230	
813	0	Wilmarth-Eastwood 115	(no outage)	
0	0	Wilmarth-Eastwood 115	Wilmarth-Dome 115	
N/A	**116**	***Minn Valley-Sacred Heart 69**	**(no outage)**	**2.3**
N/A	**497**	***Emmet-Renville 69**	**(no outage)**	**0.2**
655	266	Willmar 230/69 tx	Willmar-Kandiyohi Co 230	
719	363	Grant Co-Elbow Lk 115	Henning-Fergus Fls 230	
926	392	Granite Falls-Willmar 230	Wilmarth-Lakefield Jct 345	
1128	521	Morris 230/115 tx #1 or 2	Morris 230/115 tx #2 or 1	
884	577	Henning-Fergus Fls 230	Audubon-Hubbard 230 & Hubbard tx	
N/A	**633**	***Green Lk-Grove Cy 69**	**Paynesville-Kandiyohi Co 230**	**0.5**
N/A	**697**	***Emmet-Crooks 69**	**(no outage)**	**0.5**
N/A	**819**	***Litchfield M Tp-Grove Cy 69**	**Paynesville-Kandiyohi Co 230**	**1.1**
1012	856	Loon Lk Tp-Eastwood 115	(no outage)	
N/A	**858**	***Crooks-Danube 69**	**(no outage)**	**1.2**
1307	**940**	***Heron Lk-Brewster 161**	**Nobles Co-Lakefield Jct 345**	**4.9**
1337	**1034**	***Wahpeton-Fergus Fls 230**	**Sheyenne-Audubon 230**	**0.2**
1234	**1073**	**Loon Lk Tp-Eastwood 115**	**Byron 345/161 tx**	**11.0**
1282	**1125**	***Wilmarth-Lakefield 345**	**Sherco #3 gen**	**9.8**
1561	**1135**	***Brandon-Alex SS 115**	**Henning-Fergus Fls 230**	**1.3**
1871	**1135**	***Blue Heron-Richmond 69**	**Paynesville-Wakefield 115**	**0.5**
1310	**1155**	***St Cloud Tp-Wakefield 115**	**Wilmarth-Lakefield Jct 345**	**1.5**
N/A	**1185**	***Fergus Fls 230/115 tx**	**Wahpeton-Fergus Fls 230**	**2.0**
	1200	(None)		

The entries in **BOLD** are new limitations (to below 1200 MW) not present if the 230 kV is kept in service during construction of the chosen transmission option. The BOLD entries with an asterisk are "new" limiters that are not encountered between 1200 MW and 1800 MW and therefore are not included in the cost of fixes required to achieve 1800 MW outlet capability.

The "not bold" entries represent limiters which will need to be addressed prior to construction (or their limits respected) regardless of which transmission option implementation method is selected. Note that the "prior outage of 230 kV" limiters are generally encountered at Buffalo Ridge generation levels approximately 300 - 500 MW lower than can be accommodated if the 230 kV is maintained in service.

The preceding table represents conditions present during a construction outage of the Minn Valley-Panther line segment. Comparable reductions in Buffalo Ridge area generation outlet capability would be suffered during rebuilding of the other sections of the 230 kV line.

These severe reductions in Buffalo Ridge generation outlet translate into large economic penalties for the Buffalo Ridge generation owners, or alternatively the purchasers of their output if "take or pay" power purchase contracts are in effect. The compensation under such arrangements is the value of the lost production, plus the forgone Production Tax Credit. Assuming that most of the wind power is being purchased at approximately $35/MWh (3.5 cents/kWh), and the federal Production Tax Credit is $18/MWh, a 100 MW curtailment during 1000 hours results in a penalty of

$53/MWh * 100 MW * 1000 hrs = $5,300,000.

Rebuilding the 105 miles of 230 kV line would likely take at least 12 months. Consequently, considering the amount of MWs of generation curtailment involved, and the probable durations, the magnitude of the curtailment penalty is likely to be several tens of millions of dollars.

An alternative to enduring generation curtailments and their associated cost is to upgrade all the limiting facilities. The total cost of addressing the asterisk-marked "BOLD" entries in the above table is approximately $28.6 million. For the purpose of this analysis. It was presumed it would be more economical to install the $28.6 million of improvements rather than incur the generation curtailment penalties.

<u>Following completion</u>, failure of both circuits of the double-circuit line must be considered as a single contingency, per NERC Planning Standards, category C-5. Consequently, outage of the new double circuit is similar to today's outage of the existing 230 kV line. Review of the "existing system" TLTG summary shows that outage of the Minn Valley-Panther or Panther-McLeod sections of the new double circuit causes several new limiters to be encountered:

Total Buffalo Ridge Outlet, MW	Limiting Facility	Outage	$M
1072	Granite Falls-Willmar 230	Minn Valley-Panther 230 & Hazel-Blue Lk 345	3.7
1569	Wilmarth-Lakefield 345	Minn Valley-Panther 230 & Hazel-Blue Lk 345	9.8
1882	HutchMN-Hutch 3M 115	McLeod-Blue Lk 230 & Hazel-Blue Lk 345	0.1
2000	--------------------------------	--	
2113	McLeod 230/115 tx	McLeod-Blue Lk 230 & Hazel-Blue Lk 345	
2169	Panther 230/69 tx	Minn Valley-Panther 230 & Hazel-Blue Lk 345	

There are three new limiting facilities encountered between the starting level of 1200 MW and the presumed target level of 1900 - 2000 MW. Remediation of these three limiters is anticipated to cost a total of approximately $13.6 million.

Blue Lake outlet improvements

The TLTG simulations which represent the new 345 kV line terminated at Blue Lake indicate that two new overloads (not present in the "Base Plan" scenario) arise due to the termination of the new line at Blue Lake. The principal post-contingent problems are overload of the Blue Lk-Black Dog 115 kV, and the Hyland Lk-Dean Lk 115 kV. The latter can be easily upgraded by reconductoring; however, the Blue Lk-Black Dog 115 kV line already has been upgraded to 330 MVA by use of high-temperature conductor. Relieving this circuit requires either a rebuild of the circuit, conversion to higher voltage, or establishment of a parallel 115 kV path.

The Black Dog substation also presents electrical limitations because the existing ring bus today is operated "split" whenever necessary to reduce fault currents to levels within the ratings of the existing 115 kV breakers. This condition is only present when all Black Dog generators are on line. Regardless of which option is chosen for relieving the Blue Lk-Black Dog 115 kV overload, the fault level at Black Dog 115 kV will rise, as will also the necessary steady-state ampere ratings required for the various sections of the ring bus will also increase. For the purpose of this analysis it is assumed that the Black Dog 115 kV breakers would be replaced, and the buswork upgraded to present-day standards with respect to capacity and configuration.

The following set of improvements addresses the need for additional Blue Lake outlet capacity arising from the termination of the new 345 kV line at Blue Lake 345 kV.

	$1,000's
Blue Lk Sub: add row of 3 115 kV breakers (for loop-in of Hyland Lk-Dean Lk)	2,700
Blue Lk Sub: line work for loop-in of Hyland Lk-Dean Lk 115 kV	500
Savage Sub: establish 6-position 115 kV ring bus	4,000
Loop-in of Hyland Lk-Dean Lk 115 kV to Savage (2 mi double ckt 2312 kcm ACSR)	2,000
Savage-Black Dog 115 kV: reconductor to 310 MVA (3.8 mi)	460
Black Dog Sub: replace breakers & rebuild 115 kV to breaker-and-a-half	15,000
Blue Lk-Dean Lk 115 kV: reconductor to 310 MVA (3.3 mi)	400
Relaying revisions at adj subs (Scott Co, Blue Lk, Savage, Wilson, PKN, CEV, Glendale)	1,000
Total Blue Lake outlet improvements	**$ 26,060**

WAPA Transmission Service Charges

The “Base Configuration” (Brookings Co-Lyon Co-Franklin-Helena-Lk Marion-Hampton Corner 345 kV) has the desirable characteristic that at the 2000 MW Buffalo Ridge generation level, during system intact conditions, there is less than 100 MW of injection of power into the WAPA system at the Brookings Co-White interface. In contrast, under the “System Alternative” configuration, there is over 450 MW of power injection into the WAPA system at White. Based on recent experience, WAPA will demand purchase of transmission service under their tariff for such deliveries through their transmission system.

The WAPA tariff is presently $2.77/kW-month, which equates to $33.24/kW-yr. If the “System Alternative” were to require approximately 350 MW of additional service to be purchased for a 20-year term, the cumulative present worth cost (assuming a 6.0% discount rate) would be

350,000 kW * 33.24/kW-yr * 11.47 = $133,400,000.

Converting this to an equivalent amount of transmission investment, (assuming the same 6.0% discount rate, a 35-yr facility life, and a 15% fixed charge rate):

133,400,000/(14.50*0.150) = **$61,300,000**

Consequently, the cumulative present worth of 350 MW of WAPA transmission service purchase for a 20-year term is equivalent to the cumulative present worth of $61.3 million of transmission installation.

An additional cost associated with WAPA transmission service is compensation for losses. WAPA’s loss charge is 4% of the energy delivery. Assuming a 30% capacity factor on 350 MW of delivery, this is 36,800 MWh per year:

350 MW * 8760 hr/yr * .300 *.0400 = 36,800 MWh

If the average cost of energy is taken as $25/MWh, this is an additional payment of 36,800 * 25 = $920,000 per year.

Looking at a 20-year term, the equivalent installed cost is

920,000 * 11.47 / (14.50 * .150) = **$4,850,000**

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