Appendix C NDEX Wind Injection

Mon File - Con File - Exc File -	C:\MP-MH-EHV\Wark\Bison-Zion\MUST-Input\MP_MH_EHV.sub C:\MP-MH-EHV\Wark\Bison-Zion\MUST-Input\MP-MH.mon C:\MP-MH-EHV\Wark\Bison-Zion\MUST-Input\MP_MH_EHV-W1A.con		Transfer To: EAST_MISO Transfer Level: 2000 MW Transfer Goal: 2000 MW System Intact DF 5.%	MW*DF as % of Line Rating Cutof	f: 9999.%
			Contingency DF 5.%		
Transfer MW	Limiting Facility	Outage	DF%	Remedy	SM
-3560	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL	Open 601061 DBCOMPN 500 667500 DORSEY 2	500 1 10.7	DC Runback	0
	Zero Miles Roseau N-Roseau S Series Caps 500 kV			-	
-3490	at 110% of 1732 MVA (2000 amps) Owner(s): XCEL	Open 601060 BISON 500 601062 DBCOMPS 5	001 10.7	DC Runback	o
	Zero Miles Roseau N-Roseau S Series Caps 500 kV				
-3490	at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	Open 501051 DBCOMPN 500 501052 DBCOMPS	500 1 10.7	DC Runback	٥
	Roseau N-Roseau S Series Caps 500 kV	The second se			-
-235	at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	Open 501045 ALEXSS3 345 501057 BISON 3 34 Open 501045 ALEXSS3 345 501057 BISON 3 34		DC Runback	ø
	Roseau N-Roseau S Series Caps 500 kV				-
185	at 110% of 1732 MVA (2000 amps) Owner(s): XCEL	Open 601046 ALEXSS3 345 601047 QUARRY3 3 Open 601046 ALEXSS3 345 601047 QUARRY3 3		DC Runback	0
	Zero Miles Quarry-St. Cloud 115-kV				1
355	at 100% of 239 MVA (1200 amps) Owner(s): XCEL	Open 501010 MNTCELO3 345 501047 QUARRY3 Open 501010 MNTCELO3 345 501047 QUARRY3		DC Runback	٥
	19 Miles Roseau N-Roseau S Series Caps - 500 KV				
430	at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	System Intact	15.1	Construct Bison-Brookings 345 kV line (to get 545.1 MW transfer) \$270M	\$270.0
	Broadland 345/230 kV bx				
495	at 120% of 400 MVA Owner(s): 559	Open 652505 FTTHOMP3 345 659105 LELANDO3	345 1 7.3	Upgrade To 572 MVA	\$8.00
510	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA	Open 652506 FTTHOMP3 345 659105 LELANDO3	345 1 7.3	Upgrade to 1479 Amps (795 ACSS)	\$4.80
	*3 Miles				
590	Roseau N-Roseau S Series Caps: 500 kV at 110% of 1732 MVA (2000 amps) Owner(5): XCEL	Open 601046 ALEXSS3 345 601047 QUARRY3 3 Open 601046 ALEXSS3 345 601047 QUARRY3 3			
	Zero Miles	a series of a second	· · · · · · · · · · · · · · · · · · ·	-	
377-	Quarry-St. Cloud 115 kV at 100% of 239 MVA (1200 amps)	Open 501010 MNTCELO3 345 501047 QUARRY3	345 1	1	-0
700	Owner(s): XCEL -9 Miles	Open 501010 MNTCELO3 345 501047 QUARRY3		DC Runback	0
	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps)				
705	Owner(s): XCEL	System Intact	13.7	Roseau Series Cap 2000 A Limit	
	Zero Miles Broadland 345/23D kV tx				
710	at 120% of 400 MVA Owner(s): 659	Open 659105 LELANDO3 345 659160 GROTON 3	3451 5.7		
	Arpin 345/138 kV Tx	Longer Contractor			1.440
855	at 113% of 336 MVA Owner(s): 591 Broadland 35/230 kV tx	Open Arpin-Rocky run 345 kV	5.0	Upgrade To 550 MVA	\$7.50
870	at 100% of 400 MVA	System Intact	5.3		
22	Owner(s): 559			-	
880	Broadland 345/230 kV tx at 100% of 400 MVA	System Intact	5.3		
	Owner(s): 659				-
885	Huron-Broadland 230 kV at 100% of 400 MVA (1004 amps) Owner(s): WAPA	System Intact	5.3		
	~3 Miles Huron-Broadland 230 kV				-
930	at 120% of 400 MVA (1004 amps) Owner(s): WAPA	Open 559105 LELANDO3 - 345 659160 GROTON 3	3451 E.2		
	-3 Miles Coon Creek-Kohlman Lake 345 kV			6	1
960	at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~15 Miles	Open Coon Creek-Terminal 345 kV	6.9	Upgrade (Terminal Equipment)	5.50
	"15 Milles Sigel-Arpin 138 kV"			P	
1095	at 100% of 287 MVA (1201 amps) Owner(s): 691	Open Arpin-Rocky run 345 kV	51	Upgrade to 1394 Amps (795 ACSS)	\$7.85
	5.23 Miles Bismarck-Glenham 230 kV				
1120	at 110% of 240 MVA (502 amps) Owner(s): WAPA ~97 Miles	Open 552505 FTTHOMP3 345 659105 LELANDO3	345 1 5.0	Upgrade to 774 Amps (336 ACSS)	\$151.3
	-97 Miles Quarry-St. Cloud 115 kV	Open 501010 MNTCELO3 345 601047 QUARRY3	345 1		
1165	at 100% of 239 MVA (1200 amps) Owner(s): XCEL	Open 501010 MNTCELO3 345 501047 QUARRY3 Change bus 557033 DORSEYS4 230 load by	345 2	Upgrade to 1704 Amps (954 ACSS)	\$9.09
	"9 Miles Roseau N-Roseau S Series Caps 500 kV	dispatch			1
1165	at 210% of 1732 MVA (2000 amps) Owner(s)- XCEL	Open Ridgeway-Richer 230 kV	14.2		11.7
	Zero Miles Roseau N-Roseau S Series Caps 500 kV		-	£	-
1195	at 110% of 1732 MVA (2000 amps) Owner(s): XCEL	Open Shannon-Running 230 kV	14.2	-	
	Zero Miles Roseau N-Roseau S Series Caps 500 kV			-	1
1235	kolselu n-kolseau Saries Laps Subikv at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	Open 501045 ALEXSS3 345 501047 QUARRV3 3 Open 501045 ALEXSS3 345 501057 BISON 3 34 Open Alexandria 345/115 kV Tx		Roseau Series Cap 2000 & Limit	

1305	Antelope Valley-Broadland 345 kV at 110% of 478 MVA (800 amps) Owner(s): 559 ~198 Miles	Open 552506 FTTHOMP3 345 659105 LELANDO3 345 1	5.9	Upgrade to 1200 Amp (Terminal Equipment)	\$1.00M
1435	652470 BISON 4 230 561047 HETINGR4 230 3 at 100% of 216.1 MVA (542 amps) Owner(s): WAPA 	Open 552505 FTTHOMP3 345 659105 LELANDO3 345 1	5.6	Upgrade to 522 Amps (266 ACSS)	\$\$7.35M
1560	Quarry 345/115 KV Tx at 115% of 448 MVA Dwner(s): XCEL	Open 501010 MNTCELO3 345 501047 QUARRY3 345 1 Open 501010 MNTCELO3 345 501047 QUARRY3 345 2	7.7	DC Runback	o.
1595	Broadland 345/230 kV bx at 120% of 400 MVA Owner(s): 559	Open 552529 WATERTN3 345 559150 GROTON 3 345 1	5.8		
1605	Huron-Forosciland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA "3 Miles	Open 552529 WATERTN3 345 659160 GROTON 3 345 1	5.B		1.2
1635	52470 BISON 4 230 561047 HETINGR4 230 1 at 100% of 216.1 MVA (542 amps) Owner(s): WAPA 	Open Antelope Valley-Broadland 345 kV	5.4		
1635	652470 BISON 4 230 661047 HETINGR4 230 1 at 100% of 215.1 MVA (542 amps) Owner(s): WAPA -37 Miles	Open Broadland 345/230 kV b:	5.4		
1635	65.470 BISON 4 230 661047 HETINGRA 230 3 at 100% of 215.1 MVA (542 amps) Owner(s): WAPA -37 Miles	Open Broadland 345/230 KV b:	5,4		
1635	652470 6ISON 4 230 561047 HETINGR4 230 1 at 100% of 215.1 MVA (542 amps) Owner (s): WAPA 	Open Huron-Broadland 230 kV	5.4		1.7
1635	Broadland 345/230 kV tx at 120% of 400 MVA Owner(s): 559	Open Buffalo-Jamestown 345 kV	\$.7		
1535	Coon Creek-Kohiman Lake 345 kV at 100% of 717 MVA (1200 amps) Owner(s): XCEL -15 Miles	Open Coon Creek-Terminal 345 kV Open 601034 TERMINIA 345 60588 TERMID19 11010 Open 603110 TERMINIT 115 60588 TERMID19 11010 Open 605515 TERTER19 34.5 505585 TERMID19 11010	6,9		
1650	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~55 Miles	Open AS King-Eau Claire 345 kV Open Eau Claire-Argin 345 kV Open 7-corners-Wien 115 kV Open Council Creek-Timberwolf 59 kV Open Mauston-Hilltop 59 kV	12.9	Upgrade to (2-795 ACSS)	\$159.04
1650	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA -3 Miles	Open Buffalo-Jamestown 345 KV	5.7		11
1655	Antelope Valley-Broadland 345 kV at 110% of 478 MVA (800 amps) Dwner(s): 559 	Open 559105 LELANDO3 345 659160 GROTON 3 345 1	£.2		
1650	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2005 amps) Owner(s): NA 	Open Eau Claire-Arpin 345 kV Open T-Corners-Wien 135 kV Open Council Creek-Timberwalf 59 kV Open Maustan-Hilltop 59 kV	12.9		1
1675	Electric Jct-Nelson 345 KV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~55 Miles	Open AS King-Eau Claire 345 kV Open EB2 Claire-Arpin 345 kV Open ES2705 WIEN 115 ES9710 STRATFRO 115 1 Open Council Creek-Timberwolf 65 kV Open Maustan-Hiltop 95 kV Open 880242 UBLIN 59 0 880505 LAKEHEAD 69.0 1	12.7		
1675	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~SS Miles	Open AS King-Eau Claire 345 kV Open E89 Claire-Arpin 345 kV Open 699 700 KVTKN 115 599 710 STRATFRD 115 1 Open Council Creek-Timberwolf 59 kV Open Maustan-Hiltop 59 kV Open 880 242 UBUIN 59 0 580 505 LAKEHEAD 59.0 1	12.7		Л
1700	Electric Jct-Nelson 345 KV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~55 Miles	Open Eau Claire-Arpin 345 kV Open 599705 WIEN 115 599710 STRATFRD 115 1 Open Council Creek-Timberwolf 59 kV Open Mauston-Hilltop 59 kV Open 680242 (UBLIN 59 05 680505 LAKEHEAD 59:01	12,7		
1780	Broadland 345/230 kV tx at 120% of 400 MVA Owner(s): 559	Open Jamestown-Center 345 kV	5.5		
1795	Huron-Broadland 230 kV at 20% of 400 MVA (1004 amps) Owner(s): WAPA "3 Miles	Open Jamestown-Center 345 kV	5.6		
1805	Whitlock-Glenham 230 kV at 10% of 240 MVA (502 amps) Owner(s): WAPA -39 Miles	Open 552506 FTTHOMP3 345 559105 LELANDO3 345 1	5,6	Upgrade to 590 Amps (336 ACSS)	\$60.84M
1875	Sully Buttes-Whitlock 230 kV a1 10% of 240 MVA (602 amps) Owner(s): WAPA ~22 Miles	Open 552505 FTTHOMP3 345 559105 LELANDO3 345 1	5.9	Upgrade to 681 Amps (336 ACSS)	\$34.32
1955	Oshe-Sully Buttes 230 kV at 10% of 240 MVA (602 amps) Owner(s): WAPA ~20 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	6.2	Upgrade to 670 Amps (336 ACSS)	\$31.200
1995	Chisago County 500/345/34.5 KV Tx #10 st 115% of 1203 MVA Owner(s): XCEL	Open Chisago County 500/345/34.5 KV Tx #9	14,1	Upgrade To Beyond Single Tx	\$25.004
1995	Chisago County 500/345/34.5 KV Tx #9 at 115% of 1203 MVA Owner(s): XCEL	Open Chikago County 500/345/34.5 kV Tx #10	14.1	Upgrade To Beyond Single Tx	\$25.006

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Transfer MW	Limiting Facility	Outage	DF%	Remedy	SM
665	Chisago County 500/345/34.5 kV Tx #10 at 115% of 1203 MVA	Once Chicago County EOD/24E/24 E MITH #0	120	Linnada Ta Bayand Carda Tu	535 0044
665	Owner(s): XCEL	Open Chisago County 500/345/34.5 kV Tx #9	12,0	Upgrade To Beyond Single Tx	\$25.00M
665	Chicago County 500/345/34.5 kV Tx 29 at 115% of 1203 MVA	Open Chisago County 500/345/34.5 KV Tx #10	12.0	Upgrade To Beyond Single Tx	\$25.00M
665	Owner(s): XCEL	open charge county see stars at 1 x 20		epgrade to beyond single th	525.000
685	Broadland 345/230 kV tx at 120% of 400 MVA	Open 552505 FTTHOMP3 345 659105 LELANDO3	345 1 7.6	Upgrade To 672 MVA	\$8.00M
	Owner(s): 659		0.042		- ALCONY
- A -	Huron-Broadland 230 kV at 120% of 400 MVA (1804 amps)	and manufactures and been a second		and the second second second second	10000
695	Owner(s): WAPA *3 Miles	Open 652505 FTTHOMP3 345 659105 LELANDO3	345 1 7.6	Upgrade to 1453 Amps (795 ACSS)	\$4.80M
	Broadland 345/230 kV tx		Seat 1 Links		
890	at 120% of 400 MVA Owner(s): 659	Open 659105 LELANDO3 345 659160 GROTON 3	3451 7.0		
	Huron-Broadland 230 kV		21 - 17 Page		
905	at 120% of 400 MVA (1004 amps) Owner(s): WAPA	Open 659105 LELANDO3 345 659160 GROTON 3	345 1 7,0		
	*3 Miles Recording 345/380 W/tv				
915	Broadland 345/230 kV tx at 100% of 400 MVA	System Intact	5.B		1.1.1.1
	Owner(s): 659 Huron-Broadland 230 kV				
930	at 100% of 400 MVA (1004 amps)	System Intact	5.8		
	Owner(s): WAPA ~3 Miles			1	
	Blackberry-Boswell 230 2		11 20	and a ball of the	1 Autor
1060	at 110% of 399 MVA (1002 amps) Owner(s): MP	Open Blackberry-Boswell 230 1	5.8	Upgrade to 1235 Amps (636 ACSS)	528.62M
	- 18 Miles Bismarck-Glenham 230 kV				
1185	at 110% of 240 MVA (602 amps)	Open 552506 FTTHOMP3 345 559105 LELANDO3	345 1. 5.6	Upgrade to 777 Amps (336 ACSS)	\$151.32M
0000	Owner(s): WAPA -97 Miles		(C.D.)		
1230	Arpin 345/138 kV Tx at 113% of 336 MVA	Open Arpin-Rocky run 345 KV	5.6	Upgrade To 448 MVA	\$5.00M
	Owner(s): 691	open alpha nacey ten ses tr		Spanner in separate	
1.70	Antelope Valley-Broadland 345 kV at 110% of 478 MVA (800 amps)	Section of the section of the section of the	aba linat		10000
1295	Owner(s): 659	Open 552505 FTTHOMP3 345 659105 LELANDO3	345 1 7.6	Upgrade to 1200 Amp (Terminal Equipment)	\$1.00M
	~198 Miles 652470 BISON 4 230 661047 HETINGR4 230 1				-
1465	at 100% of 216.1 MVA (542 amps) Owner(s)- WAPA	Open 652506 FTTHOMP3 345 659105 LELANDO3	345 1 5.9	Upgrade to 622 Amps (266 ACSS)	\$57.35M
	~37 Miles				
1495	Broadland 345/230 kV tx at 120% of 400 MVA.	Open 552529 WATERTN3 345 659160 GROTON 3	3451 5.5		
	Owner(s): 659 Huron-Broadland 230 kV				-
1505	at 120% of 400 MVA (1004 amps)	Open 652529 WATERTN3 345 659160 GROTON 3	3451 6.5		
	Owner(s): WAPA ~3 Miles				
	Antelope Valley-Broadland 345 kV		- 14 H	- C	
1555	at 110% of 478 MVA (800 amps) Owner(s): 559	Open 659105 LELANDO3 345 659160 GROTON 3	3451 7.0		
-	~198 Miles Bismarck-Glenham 230 KV				-
1630	at 110% of 240 MVA (502 amps)	Open Antelope Valley-Broadland 345 kV	51		
	Owner(s): WAPA ~97 Miles				
	Bismarck-Glenham 230 KV at 210% of 240 MVA (602 amps)	the second second	1		
1630	Owner(s): WAPA	Open Broadland 345/230 kV tx	5.1		
	~97 Miles Bismarck-Glenham 230 kV				1
1630	at 110% of 240 MVA (602 amps) Owner(s): WAPA	Open Broadland 345/230 kV tx	5.1		
211	-97 Miles				-
- 222	Bismarck-Glenham 230 kV at 110% of 240 MVA (502 amps)	1	101		
1635	Owner(s): WAPA -97 Miles	Open Huron-Broadland 230 kV	5.1		
-	652470 BISON 4 230 661047 HETINGR4 230 1				
1650	at 100% of 215.1 MVA (542 amps) Owner(s): WAPA	Open Antelope Valley-Broadland 345 kV	5.7		
	-37 Miles 652470 BISON 4 230 651047 HETINGR4 230 1				
1650	at 100% of 216.1 MVA (542 amps)	Open Broadland 345/230 kV tx	5.7		
1000	Owner(s): WAPA ~37 Miles		2.7		
	652470 BISON 4 230 561047 HETINGR4 230 1		-	-	
1650	at 100% of 215.1 MVA (542 amps) Owner(s): WAPA	Open Broadland 345/230 KV tx	5.7		
	~37 Miles 652470 BISON 4 230 551047 HETINGR4 230 9				
1650	at 100% of 215.1 MVA (542 amps)	Open Huron-Broadland 230 kV	5.7		
0.000	Owner(s): WAPA ~37 Miles	Contraction of the second s			
1680	Broadland 345/230 KV tx at 120% of 400 MVA	Open Buffalo-Jamestown 345 kV	5.0		
1000	Owner(s): 659	Sken pundursanitstawn 343 KV	2.0	S	1000
No.	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps)				
1590	Owner(s): WAPA	Open Buffalo-Jamestown 345 KV	5.0		1.0.00

1770	Electric Jct-Neison 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A -55 Miles	Open AS King-Esa Ukine 345 KV Open Esa Ukine-Arpin 345 KV Open 7-Corners-Wien 115 kV Open Council Creek-Timberwolf 69 kV Open Mauston-Hiltico 59 kV	12.7	Upgrade to (2-795 ACSS)	\$159.04
1775	Electric Ict-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~55 Miles	Open Eau Claire-Arpin 345 KV Open T-Corners/Wien 115 KV Open Council Creek-Timberwolf 65 KV Open Muston-Hilliop 69 KV	12.7		
1780	Broadland 345/230 kV tx at 120% of 400 MVA Dwner(s): 559	Open Bismarck-Glenham 230 KV	6,4		
1790	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~56 Miles	Open AS King-Eau Claire 345 kV Open Eau Claire-Arpin 345 kV Open 699706 WICH 115 699710 STRATFRD 315 1 Open Council Creek-Timberwolf 59 kV Open Mauston-Hilliop 59 kV Open 680242 LUBLIN 55.0 680505 LAKEHEAD 59.0 1	12.5		
1790	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA -3 Miles	Open Bismarck-Glenham 230 kV	6.4		
1790	Whitlock-Glenham 230 kV at 110% of 240 MVA (502 amps) Owner(s): WAPA "39 Miles	Open 552505 FTTHOMP3 345 659105 LELANDO3 345 1	5.2	Upgrade to 595 Amps (336 ACSS)	\$50.841
1810	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A -56 Miles	Open Eau Claire-Arpin 345 kV Open E99706 WIRN 115 699710 STRATFRD 115 1 Open Council Creek-Timberwolf 59 kV Open Mauston-Hillop 69 kV Open 6800474 LUBLIN 55.0 680505 LAKEHEAD 69.0 1	12.5		
1850	Sully Buttes-Whitlock 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~22 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	5.5	Upgrade to 587 Amps (336 ACSS)	\$34.32
1855	Electric Int-Nelson 345 kV at 100% of 1334 MVA (2065 amps) Owner(s): N/A ~56 Miles	Open Arrowhead-Stone Lake 345 KV	12.2		
1925	Garrison-Jamestown 230 kV at 110% of 318 MVA (798 amps) Owner(s): WAPA -138 Milles	Open 552441 GARRISN4 250 559284 HILKEN 4 230 1 Open Garrison-Leland Okis 230 kV	5.1	Upgrade to 888 Amps (477 ACSS)	\$175.26
1925	Oahe-Sully Buttes 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~20 Miles	Open 552505 FTTHOMP3 345 659305 LELANDO3 345 1	5,8	Upgrade to 576 Amps (336 ACSS)	\$31.20

Appendix D Costs

The costs used in this study are based on engineering judgment. Costs used in various studies were updated based on feedback of actual construction costs from various sources. The costs used are in 2012 dollars.

The cost used for line rebuilds and reconductor is shown below.

kV	\$M/mile
0	0.2
41.6	0.4
69	0.75
115	0.75
138	0.8
161	1
230	1.3
345	2.8
500	4
765	5

The cost used for transformer replacement is shown below.

MVA	\$M
0	1.2
70	1.4
112	1.6
187	2
224	4
336	6
448	7.5
550	8
672	9
800	20
1203	25
9999	30

The build out cost for the Fargo and Iron Range Options are shown below:

West Option	Units	Cost \$M	Total	East Option	Units	Cost \$M	Total
WIA				A1A			
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1 & #2	2	80	16	Blackberry 500/345 kV Tx #1 & #2	2	80	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	20	2.5	175
			0	Blackberry 345/230 kV TX	1	9	9
Bison-Alexandria-Quarry-Monticello 345 kV line #2	203.2	0.5	101.6	Bison-Alexandria-Quarry-Monticello 345 kV line #2	203.2	0.5	101.6
Total			942.6	Total			1206.1
WIAP				_			
W1 with phase shirt transformer (PST) on Glenboro-Harvey 230 kV line at Glenboro	1	10	10	-	1	10	10
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1 & #2	2	80	16	Blackberry 500/345 kVTx #1 & #2	2	80	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	20	2.5	175
			_		H	9	_
Bison-Alexandria-Quarry-Monticello 345 kV line #2	203.2	0.5	101.6	Bison-Alexandria-Quarry-Monticello 345 kV line #2	203.2	0.5	101.6
Total			952.6	Total			1216.1
W1B				YIB			
W1 without Bison-Alexandria-Quarry-Monticello 345 kV line #2			0	Y1 without Bison-Alexandria-Quarry-Monticello 345 kV line #2			0
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3,3	907.5
Bison 500/345 kv Tx #1 & #2	2	80	-		2	80	16
			0	1221	20	2.5	17
				Blackberry 345/230 kV TX	1	9	9
			0				
Total			841	Total			1104.5
WIC				Y1C			
W1 with MVP not already in case added			0	Y1 with MVP not already in case added			0
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1 & #2	2	8	16	Blackberry 500/345 kVTx #1& #2	2	80	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	70	2.5	175
			0	Blackberry 345/230 kV TX	1	9	9
Bison-Alexandria-Quarry-Monticello 345 kV line #2	203.2	0.5	101.6	Bison-Alexandria-Quarry-Monticello 345 kV line #2	203.2	0.5	101.6
Total			942.6	Total			1206.1
W2A				Y2A			
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1	F	80	80	Blackberry 500/345 kV Tx #1 & #2	2	80	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	70	2.5	175
			0	Blackberry 345/230 kV TX	-1	9	9
Bison-Brookings County 500 kV line 50% series compensated	180	3.3	594	-	180	3.3	594
Brooking County 500/345 kV Tx #1 & #2	2	8	16	Brooking County 500/345 kV Tx #1 & #2	2	8	16

1014			2444	0181			P-47 /T
W2B				Y2B			
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1	1	80	80	Blackberry 500/345 kVTx #1 & #2	2	80	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	70	2.5	175
			0	Blackberry 345/230 kV TX	1	9	9
Bison-Brookings County345 kV line	180	1.5	270	Bison-Brookings County 345 kV line	180	1.5	270
Total			1103	Total			1374.5
W6A				YEA			Ì
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1	1	80	80	Blackberry 500/345 kVTx#1 & #2	2	80	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	70	2.5	175
			0	Blackberry 345/230 kV TX	H	9	9
Bison-Brookings County 500 kV line 50% series compensated	180	3.3	594	Bison-Brookings County 500 kV line 50% series compensated	180	3.3	594
Brooking County 500/345 kV Tx #1 & #2	2	80	16	Brooking County 500/345 kV Tx #1 & #2	2	80	16
Brooking County-Split Rock 500 kV line	60	m	180	Brooking County-Split Rock 500 kV line	60	æ	180
Split Rock 500/345 kV TX #1 & #2	2	80	16	Split Rock 500/345 kV TX #1 & #2	2	80	16
Bison-Alexandria-Quarry-Monticello 345 kV line #2	203	0.5	101.5	Bison-Alexandria-Quarry-Monticello 345 kV line #2	203	0.5	101.5
Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	III	2.5	277.5	Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	111	2.5	277.5
Corridor Txs	2	m	9	Corridor Txs	2	m	9
Brookings County-Lyon County 345 kV line #2	50	0.5	25	Brookings County-Lyon County 345 kV line #2	50	0.5	25
Helena-Lake Marion-Hampton Corner 345 kV line #2	198	0.5	66	Helena-Lake Marion-Hampton Corner 345 kV line #2	198	0.5	66
Total			2148	Total			2419.5
W6B				Y6B			
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1	1	80	80	Blackberry 500/345 kV Tx #1 & #2	2	80	16
				Blackberry-Arrowhead 345 kv lines #1 & #2	70	2.5	175
			-	Blackberry 345/230 kV TX	1	9	9
Bison-Alexandria-Quarry-Monticello 345 kV line #2	203	0.5	101.5	Bison-Alexandria-Quarry-Monticello 345 kV line #2	203	0.5	101.5
Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	III	2.5	277.5	Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	111	2.5	277.5
Corridor Txs	2	m	9	Corridor Txs	2	m	9
Brookings County-Lyon County 345 kV line #2	57	0.5	28.5	Brookings County-Lyon County 345 kV line #2	57	0.5	28.5
Helena-Lake Marion-Hampton Corner 345 kV line #2	80	0.5	40	Helena-Lake Marion-Hampton Corner 345 kV line #2	80	0.5	40
Total		-	1286.5	Total			1558

Appendix E Iron Range Option With Fargo Tap Sensitivity

E.1 Summary

The scenario of a tap on the Winnipeg-Iron Range line going to Fargo was added to the eastern configuration and studied.

E.1.1 Fargo Injection

The most limiting first contingency incremental transfer for the Fargo wind injection is shown in Table E.1-1.

Option	MW	Limiting Facility	Outage	Case
West	-240	Bison-Maple River 230 kV line	Bison-Maple River 345 kV line	W1B1
East	670	Bison-Maple River 230 kV line	Bison-Maple River 345 kV line Maple River 345/230 kV tx 2 Maple River 345/230 kV tx 1	Y1B1
East with Fargo Tap	-340	Stone Lake 345/161 kV Tx	Stone Lake-Gardner Park 345 kV line	T1B1

Table E.1-1 Worst Case Limiters Fargo Wind Injection

Eastern 500 kV Line with Fargo Tap

The Eastern 500 kV with Fargo Tap provides a path that balances the 500 kV lines from Manitoba better than without the Fargo Tap. The tap line provides a path parallel to the CapX Fargo-Twin Cities to get wind injection out of the Red River Valley. Higher levels of wind injection can be reached before additional transmission lines are required. Being the power has a more direct connection to the Arrowhead area, the Roseau capacitors and Stone Lake transformers need upgrading, which is not required without the Fargo Tap line.

E.1.2 Fargo/Brookings County Injection

The most limiting first contingency incremental transfer for the Fargo/Brookings wind injection is shown in Table E.1-2.

Option	MW	Limiting Facility	Outage	Case
West	-530	Bison-Maple River 230 kV line	Bison-Maple River 345 kV line	W1B2
East	1130	Split Rock-White 345 kV line	Brookings Co-Lyon Co 345 kV line	Y1B2
East with Fargo Tap	1125	Split Rock-White 345 kV line	Brookings Co-Lyon Co 345 kV line	T1B2

Table E.1-2 Worst Case Limiters Fargo/Brookings Wind Injection

Eastern 500 kV Line with Fargo Tap

The Eastern Line with Fargo Tap provides for more wind injection with less transmission improvements then the western line but slightly less than the eastern line without the tap. The benefit of the eastern line with the Fargo tap is it ties the Red River Valley into the eastern side of Minnesota for wind injection while providing Manitoba power to the Red River Valley when needed.

E.2 Study Options

For the purpose of this study, there were three main transmission options: the west (Bison) or east (Blackberry) 500 kV lines coming out of Dorsey and the east (Blackberry) 500 kV line with a 345 kV line from Fargo tapping the Dorsey to Blackberry 500 kV line. The cases studied are listed in Table E.2-1 Study Options. With the wind injection at the Bison 345 kV bus or at the Bison and Brooking County 345 kV buses.

Fargo Option	Iron Range Option	Iron Range with Fargo Tap Option
W1A	Y1A	TIA
Dorsey-Bison 500 kV line 50% series compensated Bison 500/345 kv Tx #1 & #2 Bison-Alexandria-Quarry-Monticello 345 kV line #2	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Alexandria-Quarry-Monticello 345 kV line #2	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Alexandria-Quarry-Monticello 345 kV line #2 T Tap-Bison 345 kv lines #1 & #2
	The second s	T Tap 345/230 kV TX
W1AP W1 with phase shirt transformer (PST) on Glenboro-Harvey 230 kV line at Glenboro	Y1AP Y1 with phase shirt transformer (PST) on Glenboro-Harvey 230 kV line at Glenboro	
Dorsey-Bison 500 kV line 50% series compensated Bison 500/345 kv Tx #1 & #2	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX	
Bison-Alexandria-Quarry-Monticello 345 kV line #2	Bison-Alexandria-Quarry-Monticello 345 kV line #2	
W1 Without Bison-Alexandria-Quarry-Monticello 345 kV line #2	Y1B Y1 without Bison-Alexandria-Quarry-Monticello 345 kV line #2	T1B Y1 without Bison-Alexandria-Quarry-Monticello 345 kV line #2 + T Tap
Dorsey-Bison 500 kV line 50% series compensated Bison 500/345 kv Tx #1 & #2	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX T Tap-Bison 345 kv lines #1 & #2 T Tap 345/230 kV TX
W1C	YIC	
W1 with MVP not already in case added	Y1 with MVP not already in case added	/
Dorsey-Bison 500 kV line 50% series compensated	Dorsey-Blackberry 500 kV line 50% series compensated	

Table E.2-1 Study Options

Bison 500/345 kv Tx #1 & #2 Bison-Alexandria-Quarry-Monticello 345 kV line #2	Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Alexandria-Quarry-Monticello 345 kV line #2	
W2A	YZA	
Dorsey-Bison 500 kV line 50% series compensated Bison 500/345 kv Tx #1 Bison-Brookings County 500 kV line 50% series compensated Brooking County 500/345 kV Tx #1 & #2	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Brookings County 500 kV line 50% series compensated Brooking County 500/345 kV Tx #1 & #2	
W2B	У2В	Т2В
Dorsey-Bison 500 kV line 50% series compensated Bison 500/345 kv Tx #1 Bison-Brookings County345 kV line	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Brookings County 345 kV line	Dorsey-Blackberry 500 kV line 50% series commenced end Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Brookings County 345 kV line T Tap-Bison 345 kv lines #1 & #2 T Tap 345/230 kV TX
W6A	Y6A	
Dorsey-Bison 500 kV line 50% series compensated Bison 500/345 kv Tx #1	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX	
Bison-Brookings County 500 kV line 50% series compensated	Bison-Brookings County 500 kV line 50% series compensated	
Brooking County 500/345 kV Tx #1 & #2	Brooking County 500/345 kV Tx #1 & #2	
Brooking County-Split Rock 500 kV line	Brooking County-Split Rock 500 kV line	
Split Rock 500/345 kV TX #1 & #2	Split Rock 500/345 kV TX #1 & #2	
Bison-Alexandria-Quarry-Monticello 345 kV line #2	Bison-Alexandria-Quarry-Monticello 345 kV line #2	
Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	

Corridor Txs Brookings County-Lyon County 345 kV line #2 Helena-Lake Marion-Hampton Corner 345 kV line #2	Corridor Txs Brookings County-Lyon County 345 kV line #2 Helena-Lake Marion-Hampton Corner 345 kV line #2	
W6B	Y6B	
Dorsey-Bison 500 kV line 50% series compensated	Dorsey-Blackberry 500 kV line 50% series compensated	
Bison 500/345 kv Tx #1	Blackberry 500/345 kV Tx #1 & #2	
	Blackberry-Arrowhead 345 kv lines #1 & #2	
	Blackberry 345/230 kV TX	
Bison-Alexandria-Quarry-Monticello 345 kV line #2	Bison-Alexandria-Quarry-Monticello 345 kV line #2	
Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	
Corridor Txs	Corridor Txs	
Brookings County-Lyon County 345 kV line #2	Brookings County-Lyon County 345 kV line #2	
Helena-Lake Marion-Hampton Corner 345 kV line #2	Helena-Lake Marion-Hampton Corner 345 kV line #2	

Maps showing the options studied are included in Figure E.2-2 and Figure E.2-3.

Figure E.2-2 T1A and T1B Map

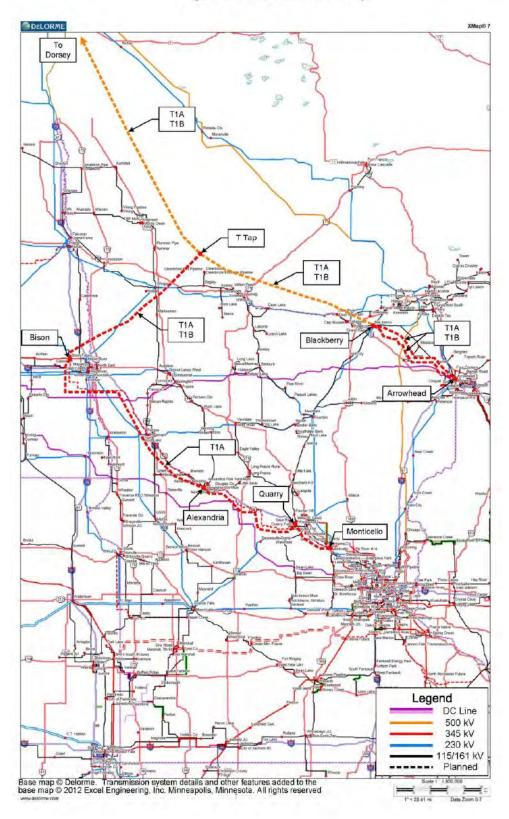
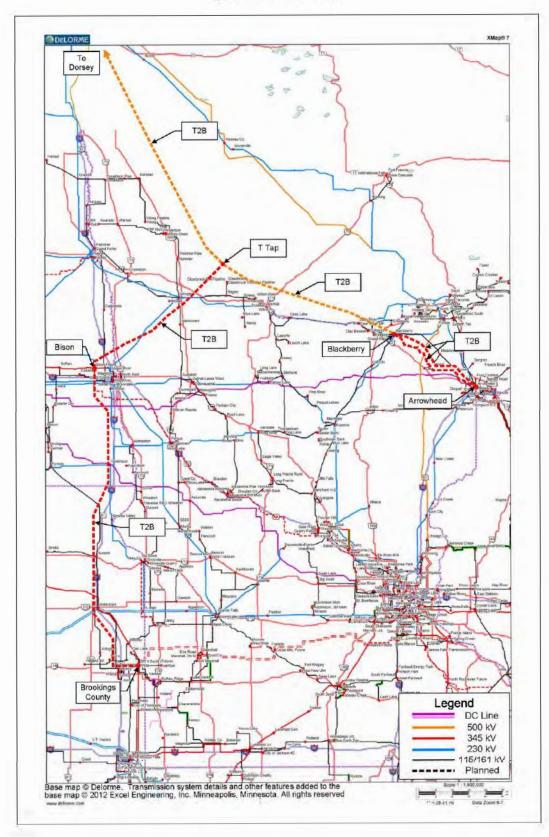


Figure E.2-3 T2B Map



E.3 Results

All comparisons were done using incremental costs. When a phase shifter was added to the Harvey-Glenboro 230 kV line, it made minimal differences in the overall results. The phase shifter was too far west of the injected areas to have a major effect on the study area.

E3.1 Fargo Wind Injection Results

Eastern Option with Fargo Tap Fargo Wind Injection

The eastern option with the Fargo tap scenarios all have a 500 kV line from Dorsey to the Blackberry with 50% series compensation with the line tapped (T-Tap) south of the series compensation, a double circuit 345 kV line from T-Tap to Bison, a double circuit 345 kV line from the Blackberry to Arrowhead, two 500/345 kV transformers at Blackberry, one 345/230 kV transformer at Blackberry, and one 500/345 kV transformers at T-Tap. Only three scenarios were evaluated for this option, T1A, T1B, and T2B. With these scenarios, the Manitoba power and the wind injection are entering the 345 kV system at totally different points but are tied together. Most of the same upgrades due to CapX line outage are still required but at higher wind injection. Some occur after the 2000 MW cutoff. The Roseau capacitors overload for two of the three scenarios and the Stone Lake 345/161 kV transformer overloads for all of the three scenarios. The best performing scenario was the T1A which can go to the 2000 MW transfer level without the Roseau series capacitors system intact overloads. The Roseau series capacitors system intact overloads occur at higher transfer levels than the Fargo option.

The Bison-Maple River 345 kV, Bison-Maple River 230 kV, Maple River-Sheyenne 230 kV, Fargo-Moorhead 230 kV, Maple River-Frontier 230 kV, and Sheyenne-Audubon 230 kV lines and the Maple River 345/230 kV transformers overload for the loss of Bison-Alexandria 345 kV line are over 1000 MW wind injections when there is not an additional outlet for the wind injection out of the Fargo area. These lines still overload for some other scenarios but at higher wind injection levels. When the loss is the Alexandria-Quarry 345 kV, line the 115 kV system in the Alexandria area in addition to the Fargo area 230 kV system overloads. For T1A scenario, it occurs before the Fargo area overloads, -150. For a loss of the Quarry-Monticello 345 kV line, the 115 kV system in the St. Cloud area, Alexandria, and Fargo 230 and 115 kV system overloads. The overload output for all scenarios ran is in Appendix E.

The scenario with the lowest incremental cost is T2B but it only allows a transfer of 1820 MW. The second lowest incremental cost is T1A which is the Fargo Tap option and it is able to transfer 2000 MW. A chart showing the incremental cost is in Figure E3.1-1. The scenario with the highest incremental cost is T1B.

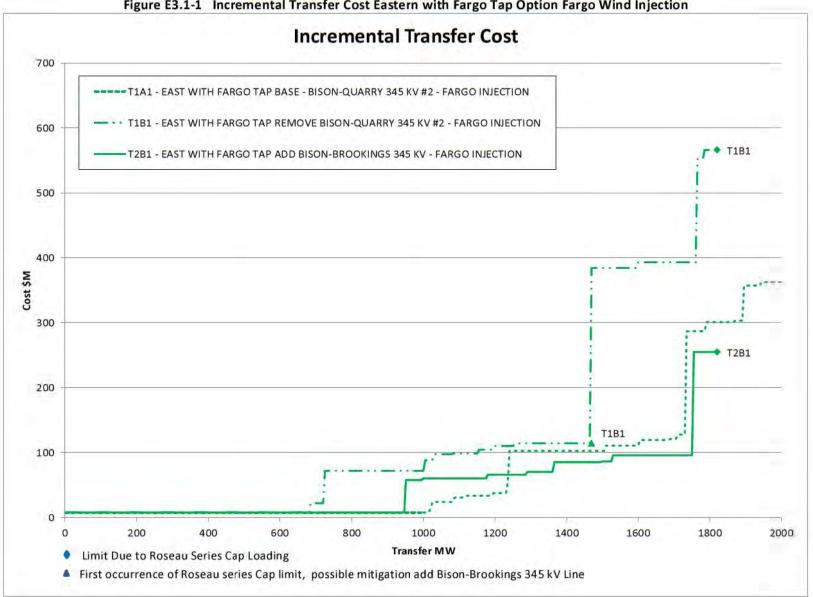


Figure E3.1-1 Incremental Transfer Cost Eastern with Fargo Tap Option Fargo Wind Injection

Comparison of Options Fargo Wind Injection

The least incremental cost scenario is Y2A, eastern option with 500 kV line Bison-Brookings County. The 500 kV line only goes from Bison to Brookings County with transformers required at both ends. It provides to two independent outlets from Fargo for the wind injection. The east option with only 345 kV line instead is ranked fourth. The eastern option with the tap overloads the east transmission more. The second least cost incremental is Y2B which includes Stone Lake and Chisago Country #1 and #2 transformers upgrades. T2B is not the least cost option, but it provides for three independent outlets for wind injection from Bison and provides for a tie to North Dakota for the Manitoba generation, but it only has a 1820 MW transfer capability. A table showing the incremental cost is in Table E3.1-1.

The most costly incremental is Y1A, there are no additional independent outlets for the wind injections and upgrades to the 115 and 230 kV system are extensive. The Fargo options are not capable of getting the 2000 MW transfer. The chart comparing the wind injection options is shown in Figure E3.1-2. In order to compare easier the following charts have the data separated into individual options with both the Fargo wind injection and the Fargo/Brookings wind injection Figure E3.1-3 to Figure E3.1-5.

The eastern option has the first limiters occurring at higher wind injection than the other two options. For the eastern option with the Fargo Tap Stone Lake 345/161 kV transformer is a negative number for the Fargo wind injection. For the western option the first limiter is the Roseau capacitor banks. See Table E3.1-6 for the complete list of first limiters.

The eastern options have fewer system intact overloads than the western options. Also they occur at higher wind injection levels. The eastern options with the Fargo tap have even few system intact overloads than without the tap. A table showing the system intact overloads is in Table E3.1-7.

	FARGO 500 MW	IRON RANGE 500 MW	IRON RANGE w/T Tap 500 MW	FARGO 1000 MW	IRON RANGE 1000 MW	IRON RANGE w/T Tap 1000 MW	FARGO 1500 MW	IRON RANGE 1500 MW	IRON RANGE w/T Tap 1500 MW	FARGO 2000 MW	IRON RANGE 2000 MW	IRON RANGE w/T Tap 2000 MW
1A Base Bison-Quarry #2	(273 @ 490 MW)	0	8	NA	42.5	8	NA	176	103	N/A	604	363
1A 60% 60% Series Comp new 500 kV	294	N/A	N/A	(294 @ 670 MW)	NA	N/A	NA	NA	N/A	N/A	N/A	N/A
1AP Add Glenboro Phase Shifter	284	0	N/A	(284 @ 680 MW)	48	N/A	NA	177	N/A	N/A	604	N/A
1B Remove Bison-Quarry #2	(285 @ 50 MW)	0	8	N/A	43	72	NA	304	384	N/A	558	(565 @ 1820 MW)
1B 60% 60% Series Comp new 500 kV	N/A	0	N/A	N/A	91	N/A	NA	360	N/A	N/A	614	N/A
1C Add All MVP	294	O	N/A	(294 @ 630 MW)	41	N/A	N/A	169	N/A	N/A	251	N/A
2A Add Bison-Brookings 500 kV with SC	(0 @ 375 MW)	0	N/A	N/A	0	N/A	N/A	9	N/A	N/A	193	N/A
2B Add Bison-Brookings 345 kV	(0 @ 0MW)	o	8	N/A	14	60	N/A	50	86	N/A	280	(255 @ 1820 MW)
6A Add Corridor Project Add Bison-Split Rock 500 kV with SC	0	o	N/A	8	o	N/A	(15 @ 1355 MW)	6	N/A	N/A	190	N/A
6B Add Corridor Project	287	D	N/A	(287 @ 580 MW)	36	N/A	N/A	180	N/A	N/A	615	N/A

Table E3.1-1 Cost Comparison Fargo Wind Injection

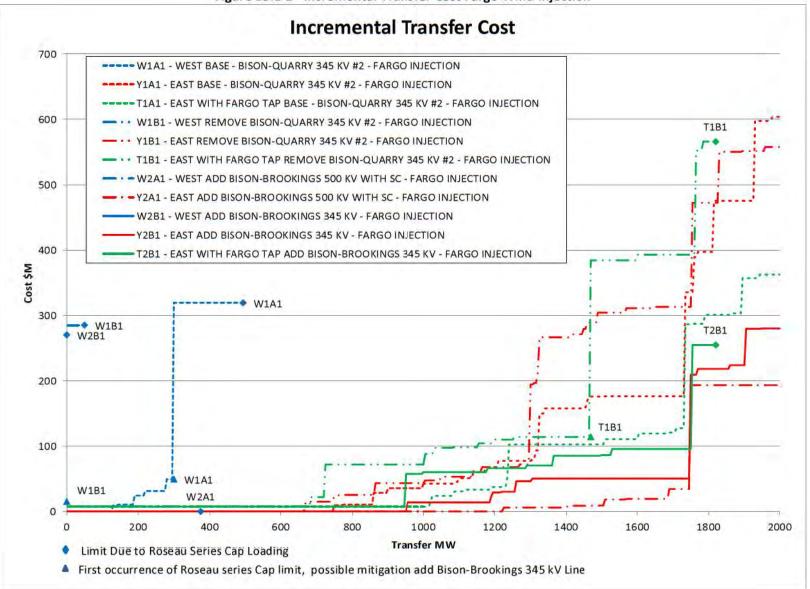


Figure E3.1-2 Incremental Transfer Cost Fargo Wind Injection

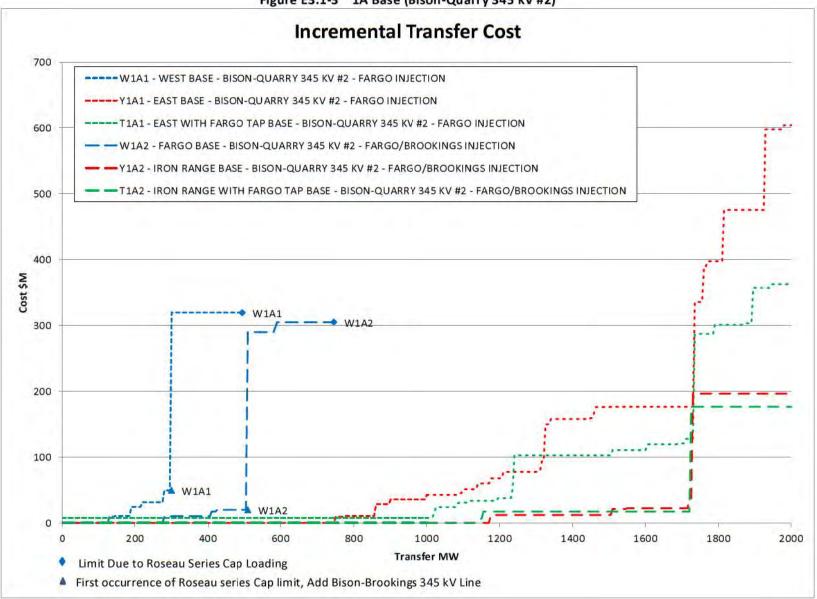


Figure E3.1-3 1A Base (Bison-Quarry 345 kV #2)

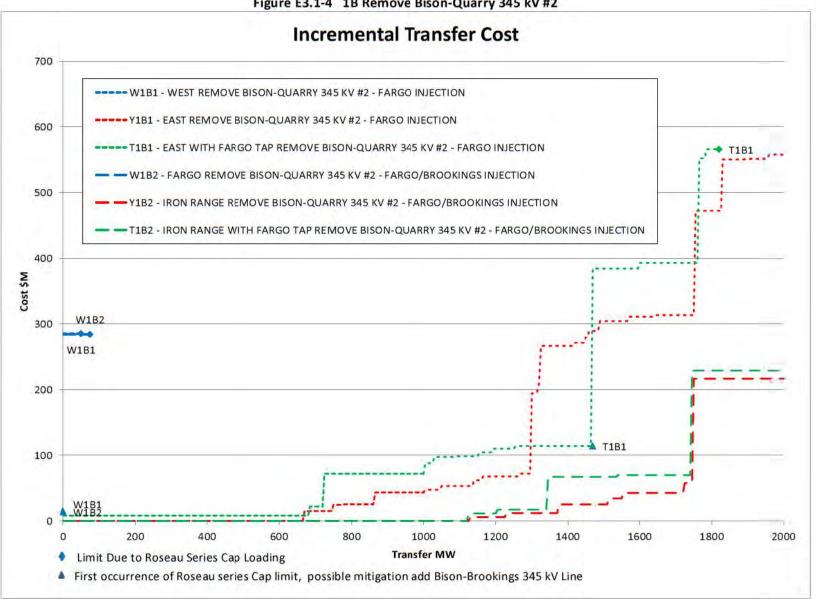


Figure E3.1-4 1B Remove Bison-Quarry 345 kV #2

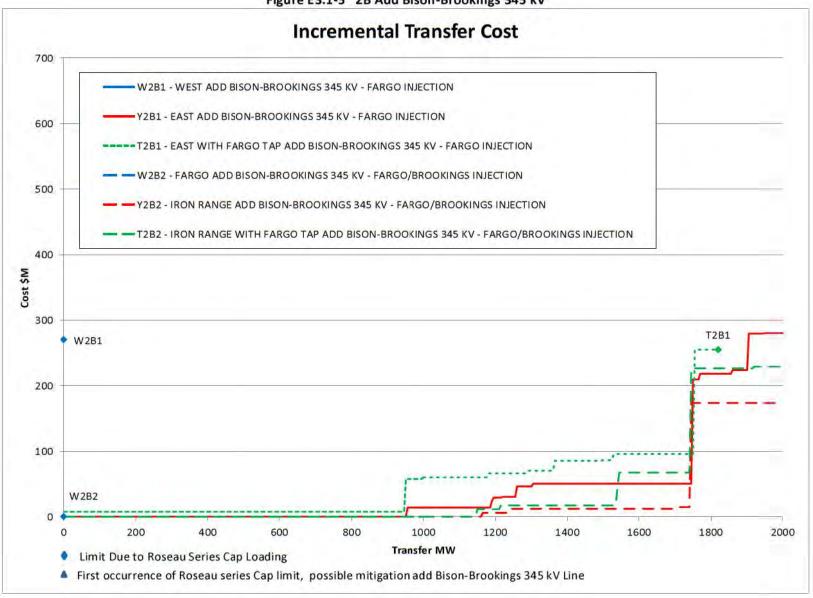


Figure E3.1-5 2B Add Bison-Brookings 345 kV

Fargo O	otion			Iron Ra	nge Option			Iron Ra	nge with Fargo Tap Option		
Trans fer MW	Limiting Facility	DF%	Outage	Trans fer MW	Limiting Facility	DF%	Outage	Trans fer MW	Limiting Facility	DF%	Outage
W1A	Fargo - Base - Bison-Qu	arry 345 k	V #2	Y1A	Iron Range - Base	- Bison-C	Quarry 345 kV #2	TIA	Iron Range with Fargo Tap -	Base - Bisor	Quarry 345 kV #2
W1A1	Fargo Wind Injection			Y1A1	Fargo Wind Inject	tion		T1A1	Fargo Wind Injection		
190	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	23.0	Open Bison-Maple River 345 kV	750	Sheyenne- Maple River 230 at 110% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	38.5	Open 601046 ALEXSS3 345 601067 BISON 3 345 1 Open 601046 ALEXSS3 345 601067 BISON 3 345 2	-205	602017 ST LAKE5 161 699450 ST LAKE 345 1 at 125% of 336 MVA Owner(s): N/A	5.5	Open Stone Lake- Gardner Park 345 kV
W1A2	Fargo/Brookings Wind	njection		Y1A2	Fargo/Brookings	Wind Inje	ection	T1A2	Fargo/Brookings Wind Inject	ion	
-255	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	19.0	Open 601046 ALEXSS3 345 601067 BISON 3 345 1 Open 601046 ALEXSS3 345 601067 BISON 3 345 2	1175	Split Rock- White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~60 Miles	28.6	Open 601031 BRKNGCO3 345 601048 LYON CO 3 345 1	1145	Arpin 345/138 kV Tx at 113% of 336 MVA Ownēr(š): 691	5.6	Open Arpin-Rocky run 345 kV
W1A6 0	Fargo - Base - Bison-Qu compensation on new !		The second second second second second								
W1A1 60	Fargo Wind Injection										
105	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	22.3	Open Bison-Maple River 345 kV								
W1A2		i Auri	1						-		
60	Fargo/Brookings Wind	njection		12.1						2.2	
W1A	DID NOT RUN				0					1	1.
Р	Fargo - Add Glenboro P	hase Shift	er	Y1AP	Iron Range - Add	Glenboro	Phase Shifter	T1AP	Iron Range with Fargo Tap -	Add Glenbo	ro Phase Shifter
W1A P1 280	Fargo Wind Injection Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	23.0	Open Bison-Maple River 345 kV Open Maple River 345/230 kV tx 2 Open Maple River 345/230 kV tx 1	Y1AP 1 745	Fargo Wind Inject Sheyenne- Maple River 230 at 110% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	38.5	Open 601046 ALEXSS3 345 601067 BISON 3 345 1 Open 601046 ALEXSS3 345 601067 BISON 3 345 2	1 1	Fargo Wind Injection		

Table E3.1-6 First Limiters For All Options

imiting Facility argo/Brookings Wind Ir ison-Maple River 30 kV at 100% of 520 MVA	DF%	Outage	Trans fer MW	Limiting	-	1	Trans			
ison-Maple River 30 kV	njection		Y1AP	Facility	DF%	Outage	fer MW T1AP	Limiting Facility	DF%	Outage
ison-Maple River 30 kV			2	Fargo/Brookings	Wind Inje	ction	2	Fargo/Brookings Wind Injectio	on	
1305 a mps) Dwner(s): MPC 0.37 Miles	10.2	Open Bison-Maple River 345 kV Open Maple River 345/230 kV tx 2 Open Maple River 345/230 kV tx 1	1160	Split Rock- White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~60 Miles	28.6	Open 601031 BRKNGCO3 345 601048 LYON CO 3 345 1		DID NOT RUN		
argo - Remove Bison-Q	uarry 345	kV #2	Y1B	Iron Range - Rem	ove Bison	Quarry 345 kV #2	T1B	Iron Range with Fargo Tap - Re	emove Bis	on-Quarry 345 kV #2
The local sector is a sector of the			1		3.1		1.2	CARLING IN		
argo Wind Injection			Y1B1		ion		T1B1	Fargo Wind Injection	-	1
lson-Maple River 30 kV at 100% of 520 MVA 1305 amps) 9wner(s): MPC 0.37 Miles	27.6	Open Bison-Maple River 345 kV	670	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	42.6	Open Bison-Maple River 345 kV Open Maple River 345/230 kV tx 2 Open Maple River 345/230 kV tx 1	-340	602017 ST LAKE5 161 699450 ST LAKE 345 1 at 125% of 336 MVA Owner(s): N/A	6.1	Open Stone Lake- Gardner Park 345 k
argo/Brookings Wind Ir	njection		¥182		Wind Inje	ction	T1B2	Fargo/Brookings Wind Injection	on	
ison-Maple River 30 kV at 100% of 520 MVA 1305 amps) Dwner(s): MPC 0.37 Miles	12.6	Open Bison-Maple River 345 kV	1130	Split Rock- White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~60 Miles	29.1	Open Brookings Co - Lyon Co 345 kV	1125	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	28.4	Open Brookings Co Lyon Co 345 kV
		· · · · · · · · · · · · · · · · · · ·	¥186	Iron Range - Rem	ove Bison	Quarry 345 kV #2, use	10. C		1	
			0	60% series compe	ensation	n new 500 kV line	-			
			Y1B1 60		ion					
			670	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	42.6	Open Bison-Maple River 345 kV				
			Y1B2 60	Fargo/Brookings	Wind Inie	ction				
a 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	rgo Wind Injection son-Maple River 0 kV 100% of 520 MVA 305 amps) vner(s): MPC .37 Miles rgo/Brookings Wind In son-Maple River 0 kV 100% of 520 MVA 305 amps) vner(s): MPC	rgo Wind Injection son-Maple River 0 kV 100% of 520 MVA 105 amps) vner(s): MPC .37 Miles 27.6 27.6 27.6 27.6 27.6 27.6 20.0	ion-Maple River 0 kV 100% of 520 MVA 305 amps) vner(s): MPC .37 Miles rgo/Brookings Wind Injection ion-Maple River 0 kV 100% of 520 MVA 305 amps) vner(s): MPC	rgo Wind Injection Y1B1 son-Maple River 0 kV 100% of 520 MVA 305 amps) vner(s): MPC .37 Miles Vind Injection Y1B2 rgo/Brookings Wind Injection Y1B2 ion-Maple River 0 kV 100% of 520 MVA 305 amps) vner(s): MPC .37 Miles 12.6 Open Bison-Maple River 345 kV 1130 V1B6 0 Y1B6 0 Y1B1 Frookings Vind Injection Y1B2 V1B2 V1B6 0 Frookings Vind Injection Y1B6 0 Y1B6 0 Frookings Vind Injection Y1B6 0 Frookings Vind Injection Y1B6 0 Frookings Vind Injection Y1B6 0 Y1B1 Frookings Vind Injection Y1B2 Y1B1	rgo - Remove Bison-Quarry 345 kV #2 rgo Wind Injection kon-Maple River 0 kV 100% of 520 MVA 105 amps) vner(s): MPC .37 Miles 27.6 Open Bison-Maple River 345 kV 0 pen Bison-Maple River 345 kV 0 pen Bison-Maple River 345 kV 1120 0 pen Bison-Maple River 345 kV 1130 12.6 0 pen Bison-Maple River 345 kV 0 pen Bison-Maple River 345 kV 1130	rgo - Remove Bison-Quarry 345 kV #2 Y1B Iron Range - Remove Bison rgo Wind Injection Fargo Wind Injection Fargo Wind Injection Open Bison-Maple River 345 kV Open Bison-Maple River 345 kV Fargo/Brookings Wind Injection Fargo Wind	rgo - Remove Bison-Quarry 345 kV #2 Y1B Iron Range - Remove Bison-Quarry 345 kV #2 rgo Wind Injection Down Maple River O kV ID0% of \$20 MVA I00% of \$20 MVA I0	rgo - Remove Bison-Quarry 345 kV #2 Y1B Iron Range - Remove Bison-Quarry 345 kV #2 T1B rgo Wind Injection Y1B Fargo Mind Injection T1B1 oon-Maple River 0 kV 0 kV 00 pen Bison-Maple River 345 kV Y1B1 Fargo Mind Injection T1B1 100% of 520 MVA 100% of 520 MVA 305 amps) 27.6 Open Bison-Maple River 345 kV Open Bison-Maple River 345 kV 42.6 Open Maple River 345/23 0 kV tx 2 -340 on-Maple River 345/23 0 kV tx 1 0.37 Miles Y1B2 Fargo/Brookings Wind Injection T1B2 rgo/Brookings Wind Injection Y1B2 Fargo/Brookings Wind Injection T1B2 on-Maple River 0 kV 12.6 Open Bison-Maple River 345 kV 1130 Split Rock- White 345 kV line 1 Open Brookings Co- Lyon Co 345 kV 1125 37 Miles 12.6 Open Bison-Maple River 345 kV 1130 Affician 29.1 Open Brookings Co- Lyon Co 345 kV 1125 37 Miles 12.6 V1B6 Fargo Wind Injection 1125 Open Bison-Maple River 30 kV at 100% of 520 mps) Open Bison-Maple River 345 kV 0 Open Bison-Maple River 345 kV 1125 60% series compensation on new 500 kV line 60% series compensation on new 500 kV line 0 0 71B2 0mer(s): MPC 0.07 0/182 0 0	rgo - Remove Bison-Quarry 345 kV #2 Y1B Iron Range - Remove Bison-Quarry 345 kV #2 T1B Iron Range with Fargo Tap - River 730 kV #2 rgo Wind Injection v1B1 Fargo Wind Injection T1B1 Fargo Wind Injection 0 KV 0 pen Bison-Maple River 345 V1B1 Fargo Wind Injection 602017 5T LARES 161 0 Sy amps) 0 pen Bison-Maple River 345 670 42.6 Open Maple River 345 kV 602017 5T LARES 151 0 Sy amps) 0 pen Kison Maple 0 pen Bison-Maple River 345 42.6 0 pen Maple River 345 kV 602017 5T LARES 151 0 pen Bison-Maple River 37 Wiles 0 pen Bison-Maple River 345 42.6 0 pen Maple River 345 kV -340 61250 633 6MVA 0 AV 100% of 520 MVA 12.6 Open Bison-Maple River 345 1130 501 RARE 42.6 0 pen Bison-Maple River 345 kV 1120 kV tz 2 0 AV 12.6 Open Bison-Maple River 345 1130 1130 1130 0 f 717 MVA (1200 amps) 0 AV 12.6 Open Bison-Maple River 345 1130 1130 670 Range - Remove Bison-Quarry 345 kV #2, use 60% series compensation on new 500 kV line 1125 Split Rock-White 345 kV line 1 100% of 520 MVA 12.6 Fargo Wind Injection 1126 1125 1125 1126 100% of 520 MVA	rgo - Remove Bison-Quarry 345 kV #2 Y1B From Range - Remove Bison-Quarry 345 kV #2 T1B Iron Range with Fargo Tap - Remove Bison-Maple River 30 kV rgo Wind Injection Y1B1 Fargo Wind Injection T1B1 Fargo Wind Injection 0.W 0.W 0.W 0.W 0.W 0.W 0.W 0.W

Fargo O	ption			Iron Ra	nge Option			Iron Ra	nge with Fargo Tap Option		
Trans fer MW	Limiting Facility	DF%	Outage	Trans fer MW	Limiting Facility	DF%	Outage	Trans fer MW	Limiting Facility	DF%	Outage
				-	DID NOT RUN		1				
wic	Fargo - Add All MVP			YIC	Iron Range - Add			TIC	Iron Range with Fargo Tap - /	Add All MV	Р
W1C1	Fargo Wind Injection			¥1C1	Fargo Wind Inject	tion		TICI	Fargo Wind Injection		
125	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	23.5	Open Bison-Maple River 345 kV	775	Sheyenne- Maple River 230 at 110% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	38.0	Open 601046 ALEXSS3 345 601067 BISON 3 345 1 Open 601046 ALEXSS3 345 601067 BISON 3 345 2		DID NOT RUN		
W1C2	Fargo/Brookings Wind	Injection		¥1C2	Fargo/Brookings	Wind Inje	ction	T1C2	Fargo/Brookings Wind Inject	ion	
	DID NOT RUN	I = I		1 - 1	DID NOT RUN				DID NOT RUN		
W2A	Fargo - Add Bison-Broo	kings 500 k	V with SC	YZA	Iron Range - Add	Bison-Bro	ookings 500 kV with SC	T2A	Iron Range with Fargo Tap - / SC	Add Bison-I	Brookings 500 kV with
W2A1	Fargo Wind Injection			Y2A1	Fargo Wind Inject	tion		T2A1	Fargo Wind Injection		
375	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	16.6	System Intact	1225	Arpin 345/138 kV Tx at 113% of 336 MVA Owner(s): 691	5.7	Open Arpin-Rocky run 345 kV		DID NOT RUN		
W2A2	Fargo/Brookings Wind	Injection		Y2A2	Fargo/Brookings	Wind Inje	ection	T2A2	Fargo/Brookings Wind Inject	ion	0
465	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	13.4	System Intact	1190	Split Rock- White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~60 Miles	31.3	Open 601031 BRKNGCO3 345 601048 LYON CO 3 345 1		DID NOT RUN		
W2B	Fargo - Add Bison-Broo	kings 345 k	v	Y2B	Iron Range - Add	Bison-Bro	ookings 345 kV	T2B	Iron Range with Fargo Tap - /	Add Bison-I	Brookings 345 kV
W2B1	Fargo Wind Injection		1	Y2B1	Fargo Wind Inject	ion		T2B1	Fargo Wind Injection	1	
-1145	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	6.7	Open Bison 500/345 kV Tx #1 Change bus 667033 DORSEYS4 230 load by 454.5 MW dispatch	955	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	31.2	Open Bison-Maple River 345 kV Open Maple River 345/230 kV tx 2 Open Maple River 345/230 kV tx 1	-315	602017 ST LAKE5 161 699450 ST LAKE 345 1 at 125% of 336 MVA Owner(s): N/A	5.4	Open Stone Lake- Gardner Park 345 k ¹
W2B2	Fargo/Brookings Wind	Injection		Y2B2	Fargo/Brookings	Wind Inie	ection	T282	Fargo/Brookings Wind Inject	ion	
	- Bel - s sumBe trille					and inge			Beterenings it in a lifett		

Fargo O	ption			Iron Ra	nge Option			Iron Ra	nge with Fargo Tap Option		
Trans fer MW	Limiting Facility	DF%	Outage	Trans fer MW	Limiting Facility	DF%	Outage	Trans fer MW	Limiting Facility	DF%	Outage
-30	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	14.2	System Intact	1165	Split Rock- White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~60 Miles	30.3	Open 601031 BRKNGCO3 345 601048 LYON CO 3 345 1	1150	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	28.5	Open Brookings C Lyon Co 345 kV
	Constant and the second		and an		Concerning the second se		Project and Bison-Split	1	Iron Range with Fargo Tap - Add Corridor Project and Bison-		
W6A	Fargo - Add Corridor Pr	oject and E	Bison-Split Rock 500 kV with SC	Y6A	Rock 500 kV with	SC		T6A	Split Rock 500 kV with SC		
W6A1	Fargo Wind Injection			Y6A1	Fargo Wind Inject	tion		T6A1	Fargo Wind Injection	2	
760	Arpin 345/138 kV Tx at 113% of 336 MVA Owner(s): 691	6.0	Open Arpin-Rocky run 345 kV	1115	Arpin 345/138 kV Tx at 113% of 336 MVA Owner(s): 691	5.7	Open Arpin-Rocky run 345 kV		DID NOT RUN		
W6A2	Fargo/Brookings Wind	Injection		Y6A2	Fargo/Brookings	Wind Inje	ction	TGAZ	Fargo/Brookings Wind Injection		
1000	DID NOT RUN			1	DID NOT RUN			-	DID NOT RUN		
W6B	Fargo - Add Corridor Pr	oject		Y6B	Iron Range - Add	Corridor I	Project	T6B	Iron Range with Fargo Tap - Add Corridor Project		
W6B1	Fargo Wind Injection			Y6B1	Fargo Wind Inject	tion		T681	Fargo Wind Injection		
165	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	23.2	Open Bison-Maple River 345 kV	745	Sheyenne- Maple River 230 at 110% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	38.5	Open 601046 ALEXSS3 345 601067 BISON 3 345 1 Open 601046 ALEXSS3 345 601067 BISON 3 345 2		DID NOT RUN		
W682	Fargo/Brookings Wind	Injection		Y6B2	Fargo/Brookings	Wind Inie	ction	T6B2	Fargo/Brookings Wind Injectio	m	
	DID NOT RUN				DID NOT RUN				DID NOT RUN		

Table E3.1-7	System Intact Overloads for All Options	

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DI %
W1A	Fargo - Base - Bison-Quarry 345 kV #2		Y1A	Iron Range - Base - Bison- Quarry 345 kV #2		T1A	Iron Range with Fargo Tap - Base - Bison-Quarry 345 kV #2	
W1A1	Fargo Wind Injection		Y1A1	Fargo Wind Injection		T1A1	Fargo Wind Injection	1
300	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	21.8	1785	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	15.7		NONE	
490	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	18.8	1785	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	15.7			
1495	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	9.2	1870	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	21.6			
1500	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	9.2	1940	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	31.4			
1700	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	12.9						
1755	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	18.4						
W1A2	Fargo/Brookings Wind Injection		¥1A2	Fargo/Brookings Wind Injection		T1A2	Fargo/Brookings Wind Injection	

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	0 F 200
510	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	12.8		NONE			NONE	
740	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	12.4						
1970	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	22.9						
W1A160	60% Series Comp New 500 kV Line							
W1A160	FargoWind Injection							
440	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	22.8		DID NOT RUN			DID NOT RUN	
670	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	19.7						
1425	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	9.0						
1430	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	9.0						

Fargo Option			Iron Range Option			T Tap Option		1
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
1645	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	12.6						
1695	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	18.0						
W1A260	Fargo/Brookings Wind Injection							
	DID NOT RUN							
W1AP	Fargo - Add Glenboro Phase Shifter		Y1AP	Iron Range - Add Glenboro Phase Shifter		T1AP	Iron Range with Fargo Tap - Add Glenboro Phase Shifter	
W1AP1	Fargo Wind Injection		Y1AP1	Fargo Wind Injection	- (j	T1AP1	Fargo Wind Injection	
460	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	21.8	1790	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	15.7		DID NOT RUN	
680	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	18.8	1790	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	15.7			
1600	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	9.2	1890	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	21.5			
1600	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	9,2	1945	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	31.4			

Fargo Option			Iron Range Option			T Tap Option		
Transfer	Lawrence and the	DF		La contra de la co	DF	Transfer		DF
MW 1830	Limiting Facility Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	12.9	Transfer MW	Limiting Facility	%	MW	Limiting Facility	%
1860	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	18.4						
W1AP2	Fargo/Brookings Wind Injection		Y1AP2	Fargo/Brookings Wind Injection		T1AP2	Fargo/Brookings Wind Injection	[]
785	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	12.8		NONE			DID NOT RUN	
1030	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	12.4						
1980	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	22.9						
W1B	Fargo - Remove Bison-Quarry 345 kV #2		Y1B	Iron Range - Remove Bison- Quarry 345 kV #2		T1B	Iron Range with Fargo Tap - Remove Bison-Quarry 345 kV #2	
W1B1	Fargo Wind Injection		Y1B1	Fargo Wind Injection	1	T1B1	Fargo Wind Injection	
-135	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	26.2	1265	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	19.6	1470	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	12.9
50	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps)	22.0	1265	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	19.6	1475	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	12.9

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
	Owner(s): XCEL after Bison-Brookings 345 kV added							
930	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	10.6	1340	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	26.8	1480	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	12.9
930	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	10.6	1385	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	39.1	1580	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	18.
1130	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	14.9	1740	Frontier-Maple River 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~11 Miles	13.0	1665	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	25.
1155	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	21.3	1745	Wahpeton-Frontier 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~44 Miles	13.0			
1785	Frontier-Maple River 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~11 Miles	7.6						
1810	Wahpeton-Frontier 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~44 Miles	7.6						
W1B2	Fargo/Brookings Wind Injection		Y1B2	Fargo/Brookings Wind Injection		T1B2	Fargo/Brookings Wind Injection	
-235	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	15.2						

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF 30
75	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	14.4						
1755	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	5.6						
1755	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	5.6						
1855	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	23.4		NONE		1	NONE	
1.00			VIDCO	60% Series Comp New 500 kV	1.01	-		
			¥1B60	Line			6	
-	6	-	Y1B160	Fargo Wind Injection			6	
			1265	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	19.6			
			1265	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	19.6			
			1340	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	26.8			
			1385	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	39,1			
			1750	Frontier-Maple River 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~11 Miles	13.0			

Fargo Option			Iron Range Option			T Tap Option		
Transfer	1 faulting Profiling	DF		I fandafara Pandidan	DF	Transfer	T far taken Transition	D
MW	Limiting Facility	%	Transfer MW	Limiting Facility Wahpeton-Frontier 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~44 Miles	<u>%</u> 13.0	MW	Limiting Facility	9
			Y1B260	Fargo/Brookings Wind Injection				
		_		DID NOT RUN	100			-
W1C	Fargo - Add All MVP		Y1C	Iron Range - Add All MVP			Iron Range with Fargo Tap - Add All MVP	
W1C1	Fargo Wind Injection		¥1C1	Fargo Wind Injection		T1C1	Fargo Wind Injection	11
425	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	21.3	1735	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	15.9		DID NOT RUN	
630	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	18.4	1735	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	15.9			
1390	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	9.4	1870	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	21.5			
1390	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	9.4	1885	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	31.8			
1645	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	18.8						
1650	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL	13.0				н.		

Fargo Option			Iron Range Option		01:10	T Tap Option		
Transfer	The second second	DF			DF	Transfer	1	DF
MW	Limiting Facility	%	Transfer MW	Limiting Facility	%	MW	Limiting Facility	%
	~7 Miles							
W1C2	Fargo/Brookings Wind Injection		¥1C2	Fargo/Brookings Wind Injection		T1C2	Fargo/Brookings Wind Injection	
	DID NOT RUN	-		DID NOT RUN	-		DID NOT RUN	111
	Fargo - Add Bison-Brookings			Iron Range - Add Bison-		and a	Iron Range with Fargo Tap - Add	
W2A	500 kV with SC		Y2A	Brookings 500 kV with SC		T2A	Bison-Brookings 500 kV with SC	
W2A1	Fargo Wind Injection		Y2A1	Fargo Wind Injection		T2A1	Fargo Wind Injection	
375	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	16.6		NONE			DID NOT RUN	
1605	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	8.6						
1605	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	8.6				1		
1860	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	11.9						
1885	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	17.1						
1945	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	19.2						
W2A2	Fargo/Brookings Wind Injection		Y2A2	Fargo/Brookings Wind Injection		T2A2	Fargo/Brookings Wind Injection	1

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	D y
465	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	13.4	1990	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	25.6		DID NOT RUN	
1550	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	24.0						
W2B	Fargo - Add Bison-Brookings 345 kV		Y2B	Iron Range - Add Bison- Brookings 345 kV		T2B	Iron Range with Fargo Tap - Add Bison-Brookings 345 kV	
W2B1	Fargo Wind Injection		Y2B1	Fargo Wind Injection		T2B1	Fargo Wind Injection	
-20	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	21.6	1675	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	14.9	1820	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	10
965	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	10.8	1680	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	14.9	1945	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	10
965	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	10.8	1785	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	20.4	1945	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	10
1160	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	15.0	1840	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	29.8			
1185	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	21.5						
1800	Frontier-Maple River 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~11 Miles	7.6						

Fargo Option			Iron Range Option			T Tap Option		1
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
1825	Wahpeton-Frontier 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~44 Miles	7.6						
W2B2	Fargo/Brookings Wind Injection		Y2B2	Fargo/Brookings Wind Injection		T2B2	Fargo/Brookings Wind Injection	<u> </u>] =
-30	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	14.2		NONE			NONE	
1815	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	5.7						
1820	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	5.7						
1870	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	23.4						
W6A	Fargo - Add Corridor Project and Bison-Split Rock 500 kV with SC		¥6А	Iron Range - Add Corridor Project and Bison-Split Rock 500 kV with SC		T6A	Iron Range with Fargo Tap - Add Corridor Project and Bison-Split Rock 500 kV with SC	
W6A1	Fargo Wind Injection		Y6A1	Fargo Wind Injection	(T6A1	Fargo Wind Injection	
1355	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	13.0		NONE			DID NOT RUN	
W6A2	Fargo/Brookings Wind Injection		Y6A2	Fargo/Brookings Wind Injection		T6A2	Fargo/Brookings Wind Injection	
	DID NOT RUN			DID NOT RUN			DID NOT RUN	(-
W6B	Fargo - Add Corridor Project		Y6B	Iron Range - Add Corridor Project		т6в	Iron Range with Fargo Tap - Add Corridor Project	
W6B1	Fargo Wind Injection		Y6B1	Fargo Wind Injection		T6B1	Fargo Wind Injection	

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
315	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	21.4	1750	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	15.7		DID NOT RUN	
580	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	18.2	1750	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	15.7			
1525	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	9,3	1825	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	21.6			
1525	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	9.3	1900	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	31.4			
1705	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	13.1				·		
1780	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	18.6						
W6B2	Fargo/Brookings Wind Injection		¥6B2	Fargo/Brookings Wind Injection		T6B2	Fargo/Brookings Wind Injection	164
	DID NOT RUN	1		DID NOT RUN	1 (tr		DID NOT RUN	

E3.2 Fargo and Brookings Wind Injection Results

The Fargo/Brookings wind injection did not have as many cases that were ran as for the Fargo only wind injection. The wind injection is split 50/50 between Fargo and Brookings Co sites. The same amount of maximum power of 2000MW was used.

Eastern Option with Fargo Tap Fargo/Brookings Wind Injection

The eastern Fargo tap scenarios all have a 500 kV line from Dorsey to the Blackberry with 50% series compensation with the line tapped (T-Tap) south of the series compensation, a double circuit 345 kV line from T-Tap to Bison, a double circuit 345 kV line from the Blackberry to Arrowhead, two 500/345 kV transformers at Blackberry, one 345/230 kV transformer at Blackberry, and one 500/345 kV transformers at T-Tap. Only three scenarios were run for this option: T1A, T1B, and T2B. With these scenarios the Manitoba power and the Fargo wind injection are entering the 345 kV system at totally different points but are tied together. Being one half the wind injection is at Brookings Co, only the Bison-Maple River 230 kV line upgrade due to CapX line outages still required. The Chisago 500/345 kV transformer #1 and #2 upgrades are required for loss of the other transformer except for T1A which has the double circuit CapX Fargo-Twin Cities. The Roseau capacitors or the Stone Lake 345/161 kV transformer do not overload with only half the wind being injected at Fargo. The best performing scenario was the T1A; it provides for an independent outlet from Bison but does not tie the Bison and Brookings Co. wind injection areas together directly.

The scenario with the lowest incremental cost is T1A (Fargo Tap option with CapX Fargo-Twin Cites 345 kV double circuit line). The other two scenarios are the same cost. A chart showing the incremental cost is in Figure E3.2-1. The scenario with the highest incremental cost is T1A.



Figure E3.2-1 Incremental Transfer Cost Eastern with Fargo Tap Option Fargo/Brookings Wind Injection

Comparison of Options Fargo/Brookings Wind Injection

The least incremental cost scenario is Y2A, eastern option with 500 kV line Bison-Brookings County. The 500 kV line only goes from Bison to Brookings County with transformers required at both ends. It provides to two independent outlets from Fargo for the wind injection. The eastern option with a 345 kV line is a very close second. The eastern option with the tap T1A ties the Manitoba power and both wind injection sites together, overloading the Split Rock-White 345 kV line requiring an upgrade. T1A also includes Stone Lake and Chisago Country #1 and #2 transformers upgrades. A chart showing the incremental cost is in Figure E3.2-3. A table with the incremental costs is shown in Table E3.2-2.

The most costly incremental is W1A, there are no additional independent outlets for the wind injections and upgrades to the 230 kV system in the Red River Valley.

The eastern option has the first limiters occurring at higher wind injection than the other two options. For the eastern option with and without the tap the Split Rock-White 345 kV line is usually the first limiter. For the western option the Roseau capacitor bank is the first limiter. See Table E3.1-6 for the complete list of first limiters.

The eastern option only had one system intact overload, Y2A, Split Rock-White 345 kV line at 1990 MW. The eastern option with the Fargo tap had none. The western option had the Roseau capacitor bank and Split Rock-White 345 kV line for some of the scenarios. A table showing the system intact overloads is in TableE3.1-7.

	FARGO 500 MW	IRON RANGE 500 MW	IRON RANGE w/ T Tap 500 MW	FARGO 1000 MW	IRON RANGE 1000 MW	IRON RANGE w/ T Tap 1000 MW	FARGO 1500 MW	IRON RANGE 1500 MW	IRON RANGE w/ T Tap 1500 MW	FARGO 2000 MW	IRÓN RANGE 2000 MW	IRON RANGE w/ T Tap 2000 MW
1A :Base Bison-Quarry #2	3	0	0	(273 @ 740 MW)	0	o	N/A	12	17	N/A	196	176
1AP Add Glenboro Phase Shifter	0	0	N/A	292	0	N/A	(292 @ 1030 MW)	26	N/A	N/A	209	N/A
1B Remove Bison-Quarry #2	(284 @ 75 MW)	0	0	N/A	0	o	N/A	25	67	N/A	217	229
2A Add Bison-Brookings 500 kV with SC	(0 @ 465 MW)	0	N/A	N/A	o	N/A	N/A	12	N/A	N/A	171	N/A
2B Add Bison-Brookings 345 kV	(0 @ 0 MW)	0	o	N/A	0	0	N/A	12	17	N/A	174	229

Table E3.2-2 Cost Comparison Fargo/Brookings Wind Injection

