Appendix-F

Case Development for Stability Analysis

1. Case Development

Studies are carried out on the summer off-peak 2003 case (***ug4-so03aa.withbrdg.sav)*** with maximum simultaneous transfers on the interfaces of NDEX (≈1950MW), MHEX (≈2175MW), and MWSI (≈1480MW). Basecase information summary as follows:

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                        P O W E R   F L O W   S U M M A R Y
-------------------------------------------------------------------------------
               NDEX:      1954 MW         ECL-ARP:  691 MW
               MHEX:      2174 MW         PRI-BYN:  786 MW
               MWSI:      1477 MW         LKM-WFB:   24 MW
                                          NI-WUMS:  468 MW
               COOPER S:   629 MW         WNE-WKS:  547 MW
               FTCAL S:    590 MW         GGS:     1801 MW
               GRIS-LNC:   905 MW         QC WEST:   41 MW

           LOAD LEVELS AS PERCENT OF 2003 SUMMER PEAK:
           NORTH DAKOTA (ZONE 90,990) 1978.5 MW,  75.2% OF  2632.4 MW
           NSP             (AREA 600) 7989.5 MW,  88.0% OF  9083.5 MW
           MAN HYDRO       (AREA 667) 2264.9 MW,  85.0% OF  2663.8 MW


Load/Losses   MW  / MW       Generation        MW       Export            MW
----------- ------ -----     --------------- ------     --------------- ------
Manitoba      2264/ 364      MH total gross    4954     MN-WUMS            874
Ont. total   22604/ 534         Wpg River       560     MN-IOWA            162
     NW        745/  65         7 Sisters       163     MNEX              2296
Sask.         2384/  78      OH total gross   23193     East Bias          261
MP            1717/ 111         northwest       964     SPC>WAPA (B10T)    165
NSP           7989/ 488      SPC total gross   2627     MH>SPC  (3-230)     74
N. Dakota     1978/ 278      MP total gross    2155     MH>SPC  (FALLS)    -71
Manitoba       556 MVARS     ND Cfd AC gross   3262     OH>MH  @Kenora    -196
Ont. total   13227 MVARS              net      3091     OH>MP  @Ft Fran    150
     NW        421 MVARS     NSP East gross    2144     OH E>W @Wawa      -201
Sask.          569 MVARS              net      2038     OH>East USA         -2
MP             461 MVARS         West gross    2931     F601C  @Forbes    1831
NSP           1376 MVARS              net      2769     D602F  @Dorsey    1755
N. Dakota      418 MVARS         Total net     6188     L20D   @Letell     269
                             WAPA SD Hydro     1479     R50M   @Richer     137
                             Pleasant Valley      0     G82R   @Glenboro    10
                             Lakefield Gen        0
                             Buffalo Ridge      178
                             Swing Bus          655
                             Coalition net        0


Tfmrs          MVA/ Load     Ph Shifters  Deg/  MW      DC Lines          MW
------------- ---- -----     ------------ --- -----     --------------- ------
Wshell #1 7-7   99/  49%     Stinson       43/  113     CU (1,2)         1104
Wshell #2 7-7   99/  49%     Boundary Dam  16/  165     Miles City E>W    -150
Drayton#1 4-7   50/  36%     Whiteshell    -2/  199     SQ BU (3,4)       455
Drayton#2 4-7   64/  34%     Int Falls     14/  150     MH Bipole 1      1512
Dorsey #1 2-4  820/  68%     St. Lawrence   7/    2     MH Bipole 2      1712
Dorsey #2 2-4  961/  80%                                MH (BP1+BP2)     3224
Forbes    2-4   92/  13%
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Dorsey SC's		I/S	MVAR	Qmax/ Qmin
MIL 7-9G	17.0	2	498	600/ -330
SCE 1-3G	18.2	3	399	480/ -240
SCA 4-6G	18.2	3	399	480/ -240
Total			1297	1560/ -810
Margin			263	

SVC's	MVAR	Qmax/ Qmin
Forbes	500	16 400/ -450
Fargo	13.2	0 20/ -135
Watertown	20.0	24 125/ -86

Series Caps	Num In Serv
Roseau 500	2 of 2
Chisago 500	1 of 1

Caps/Reactors	MVAR	Caps/Reactors	MVAR	Caps/Reactors	MVAR
Balta (FS) 230	0	Arrowhead 230	160	Chisago T 9 34.5	100
Drayton 115	40	Blackberry 230	47	Chisago T 10 34.5	50
Drayton 13.8	0	Minntac 115	45	Forbes 230	72
Eau Claire(FS) 161	356	Riverton 230	47	Forbes 500	600
Kohlman Lake 115	156	Roseau Co.(FS) 230	0		0
Parkers Lk(FS) 115	0	Running (FS) 230	0	Fargo 115	54
Prairie (FS) 115	40	Running react 230	0	Watertown 20	20
Ramsey (FS) 230	0	Shannon 230	72	Watertown 230	76
Red Rock 115	156		0		0
Rugby 13.8	-25	Glenboro 230	0		0
Split Rock(FS) 115	160	Laverendrye 110	98		0
Sheyenne (FS) 115	0	Richer react 230	0		0
Wilton/Bemidji 115	20	St Vital 110	98		0

Bus Voltages	V,pu	Bus Voltages	V,pu	Bus Voltages	V,kV
Adams 345	1.020	Arrowhead 230	1.029	Whiteshell 110	118.8
Alexandria 115	1.025	Badoura 115	1.018	Kenora 220	241.0
Audubon 115	1.033	Blackberry 230	1.028	Dryden 220	241.6
Bemidji 115	1.016	Boise Cascade 13.8	1.065	Fort Frances 220	235.8
Byron 345	1.027	Boise Cascade 115	1.012	Mackenzie 220	244.0
Chisago Co. 345	1.014	ETCO 115	1.003	Lakehead 220	245.9
Chisago Co. 500	1.008	Forbes 230	1.017	Marathon 220	240.3
Drayton 230	1.028	Forbes 500	1.010	Wawa 220	236.6
Eau Claire 345	1.003	Hubbard 115	1.008	Mississagi 220	233.1
Faribault,West 115	1.017	Intl Falls 115	1.012	Fort Frances 118	118.5
LaPorte 115	1.014	Minntac 115	1.009	Lakehead 118	123.6
Maple River 230	1.007	Moranville 230	1.028	Birch 118	121.5
Marshall Tap 115	1.014	Riverton 230	1.011	Marathon 118	124.8
Owatonna 161	1.001	Running 230	1.009		0.0
Prairie 115	1.006	Shannon 230	1.025		0.0
Prairie 230	1.027		0.000		0.0
Ramsey 230	1.027	Groton 345	1.015		0.0
Roseau County 230	1.029	Watertown 230	1.030		0.0
Roseau County 500	1.061	Watertown 345	1.031		0.0
Sheyenne 230	1.008		0.000		0.0
Thief R Falls 115	1.017	Dorsey 230	1.045		0.0
Tioga 230	1.038	Dorsey 500	1.033		0.0
Wahpeton 230	1.008		0.000		0.0
Winger 115	1.034		0.000		0.0

Steady State Relay Margins (measured from inner blinder)

Relay Location	Manuf/Type	PSS Model	South	North	Em North
1) B10T-Tioga (South)	GE OST	SLLP	340%	N/A	N/A
2) -Tioga (North)	GE OST	SLLP	699%	N/A	N/A
3) -Tioga (Em North)	GE OST	SLLP		N/A	N/A
4) D602F-Dorsey	ATP ???	SLINOS	388%	N/A	N/A
5) -Forbes (Normal)	ATP ???	SLINOS	245%	N/A	N/A
6) -Forbes (Em Nrth)	APT S-PRO	SLINOS		N/A	N/A

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 8) F3M-Intl Falls         APT S-PRO    SLINOS       316%      N/A       N/A
 9) G82R-Rugby             APT          SLINOS      1283%      N/A       N/A
10) L20D-Drayton (Normal)  APT, ASEA    SLINOS       740%      N/A       N/A
11)     -Drayton (Em Nrth) ASEA RXZF2   SLINOS                 N/A       N/A
12) R50M-Moranville (Norm) APT, West    SLINOS       982%      N/A       N/A
13)     -Moranville (Em N) ASEA RXZF2   SLINOS                 N/A       N/A

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     SIMULATION CHECKS FOLLOW:
+    ________________________

 ITER DELTAV/TOL X------ AT BUS ------X  REAL(DELTAV)  IMAG(DELTAV)
    1 *********  82452 [EAR FLS 6.6000]    0.2314E+00    0.1281E+00
    2 *********  82452 [EAR FLS 6.6000]    0.1156E+00    0.6299E-01
    3  1459.453  82958 [CHAPL MS2.4000]   -0.1160E-02   -0.8856E-03
    4    33.200  82958 [CHAPL MS2.4000]    0.2676E-04    0.1966E-04
    5     4.818  67572 [RADSNDC6138.00]   -0.4668E-05   -0.1195E-05
    6     1.504  67565 [DORSEYT946.000]    0.2435E-06   -0.1484E-05
    7     1.460  67572 [RADSNDC6138.00]   -0.1442E-05    0.2238E-06
    8     0.719  67572 [RADSNDC6138.00]    0.4542E-06   -0.5568E-06

 REACHED TOLERANCE IN   8 ITERATIONS

 LARGEST MISMATCH:    0.00 MW    0.01 MVAR     0.01 MVA AT BUS 70787 [6SUMMER2230.00]
 SYSTEM TOTAL ABSOLUTE MISMATCH:               0.33 MVA

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 INITIAL CONDITION LOAD FLOW USED  1 ITERATIONS

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 INITIAL CONDITIONS SUSPECT:
     I   DSTATE(I)    STATE(I)     MODEL   STATE    BUS  X--- NAME ---X   ID
 18673  -0.35390E-03  0.32533E-01  EXAC3    K+2   53703  KNOXL5-121.000   1
 24934   0.10842      0.56633      GASTWD   K+5   65314  SARPY 4G13.800   4
 27811   0.40143      0.17530      GAST2A   K+5   68347  CORYGT1G13.800   1
 27824   0.45154      0.99128E-02  GAST2A   K+5   68348  CORYGT2G13.800   2
 27839   0.47956     -0.82553E-01  GAST2A   K+5   68367  MERGT 1G13.800   1
 27852   0.47956     -0.82553E-01  GAST2A   K+5   68368  MERGT 2G13.800   2
 27941  -0.70706E-04 -0.28694E-02  CIMTR3   K+1   60708  BUFFRIDG34.500   2


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 Initial     SLG-BF fault admittance (G + jB):    308.4  -4990.8
 Normal time SLG-BF fault admittance (G + jB):    286.7  -4787.1

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The manufacturers recommended fault ride through capability of DFIG units with under voltage and frequency protection are considered in the modeling of the machines for dynamics. DFIGPQ6 model for 1.5MW GE DFIG, VTGTRP model for voltage relay and FRQTRP model for frequency relay are used for new wind generation dynamic simulations as shown in following dyr files.

Dynamic Data for Various DFIG Models

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** DFIGPQ **
     RA        LA        LM        R1        L1        H         DAMP
   0.0071    0.1714    2.9040    0.0050    0.1563    0.5700    0.0000

      -SLIP
   0.2000

 ** CGECN2 **
     TFV      KPV      KIV       RC        XC        TFP         KPP
   0.2000    1.0000   10.0000    0.0000    0.0000    0.0500    3.0000

     KIP       PMX    PMN        QMX        QMN     IMAX     TRV
   0.6000    0.9100    0.0900    0.2980   -0.4400    1.1100    0.0500

     RPMX      RPMN
   0.4500   -0.4500

  ** TWIND1 **
     VWB     T1G      TG    MAXG     T1R     T2R    MAXR
  12.0009999.000   5.000  30.0009999.0009999.000  30.000

              Wind generator Bus #  90100
              Wind Generator ID        1

 ** TSHAFT **
          D12       K12         Ta1            p         Rq
      1.5000       1.1150       8.6400       3.0000      72.0000

              Wind Generator Bus #  90100
              Wind Generator ID        1
 ** GE15AE **
     VWinit      Lambda_Max      Lambda_Min   PITCH_MAX    PITCH_MIN      Ta
      12.0000      20.0000       0.0000      27.0000      -4.0000       0.5000


              Wind Generator Bus #  90100
              Wind Generator ID        1


 ** TGPTCH **
       Tp             Kpp        Kip            Kpc           Kic
      0.2000     150.0000      25.0000       3.0000      30.0000
        TetaMin   TetaMax   RTetaMin   RTetaMax    PMX
        -4.0000   27.0000  -10.0000   10.0000    0.9100

              Wind Generator Bus #  90100
              Wind Generator ID        1

              *** CALL VTGTRP(  4628, 68037,     0,  7122) ***

               BUS   NAME  BSKV        GENR BUS   NAME  BSKV
             90100 GARR-500.575           90100 GARR-500.575

                 I C O N S      C O N S       V A R
                 4628-4632    68037-68040     7122

                   VLO       VUP      PICKUP     TB
                   0.300     5.000     0.020     0.150

              *** CALL VTGTRP(  4633, 68041,     0,  7123) ***
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  BUS   NAME  BSKV        GENR BUS   NAME  BSKV
90100 GARR-500.575           90100 GARR-500.575

     I C O N S      C O N S       V A R
     4633-4637    68041-68044     7123

       VLO       VUP      PICKUP     TB
       0.700     5.000     0.100     0.150

 *** CALL VTGTRP(  4638, 68045,     0,  7124) ***

  BUS   NAME  BSKV        GENR BUS   NAME  BSKV
90100 GARR-500.575           90100 GARR-500.575

     I C O N S      C O N S       V A R
     4638-4642    68045-68048     7124

       VLO       VUP      PICKUP     TB
       0.750     5.000     1.000     0.150

 *** CALL VTGTRP(  4643, 68049,     0,  7125) ***

  BUS   NAME  BSKV        GENR BUS   NAME  BSKV
90100 GARR-500.575           90100 GARR-500.575

     I C O N S      C O N S       V A R
     4643-4647    68049-68052     7125

       VLO       VUP      PICKUP     TB
       0.850     5.000    10.000     0.150

 *** CALL VTGTRP(  4648, 68053,     0,  7126) ***

  BUS   NAME  BSKV        GENR BUS   NAME  BSKV
90100 GARR-500.575           90100 GARR-500.575

     I C O N S      C O N S       V A R
     4648-4652    68053-68056     7126

       VLO       VUP      PICKUP     TB
       0.000     1.100     1.000     0.150

 *** CALL VTGTRP(  4653, 68057,     0,  7127) ***

  BUS   NAME  BSKV        GENR BUS   NAME  BSKV
90100 GARR-500.575           90100 GARR-500.575

     I C O N S      C O N S       V A R
     4653-4657    68057-68060     7127

       VLO       VUP      PICKUP     TB
       0.000     1.150     0.100     0.150

 *** CALL VTGTRP(  4658, 68061,     0,  7128) ***

  BUS   NAME  BSKV        GENR BUS   NAME  BSKV
90100 GARR-500.575           90100 GARR-500.575

     I C O N S      C O N S       V A R
     4658-4662    68061-68064     7128

       VLO       VUP      PICKUP     TB
       0.000     1.300     0.020     0.150
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