

PSSE Contingency Analysis - Year 3, Topology 3

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February 20, 2026

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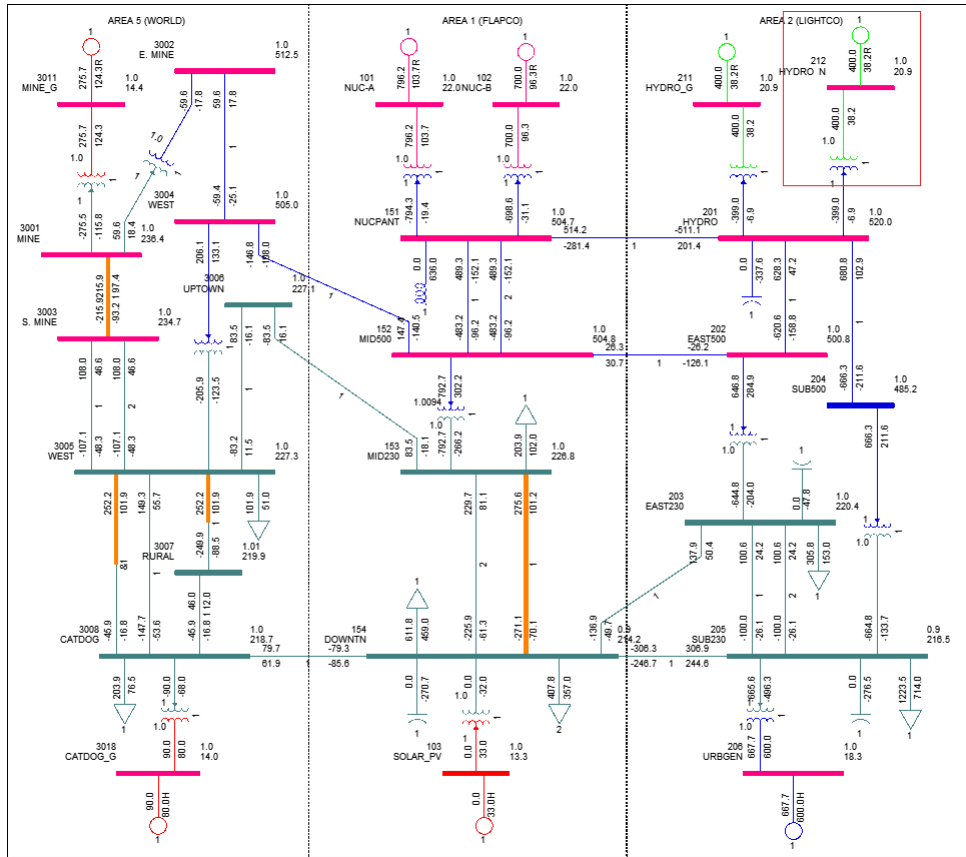
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Chapter 1

Introduction

1.1 Study Description

The Year 3 Topology 3 contingency analysis of the hypothetical SAVNW system is carried out to report the branches reporting loading greater than 100% and buses reporting upper and lower voltage limit violations.



Similar to the analysis carried out for Year 1 and Year 2, solar generators intermittent behaviour is studied by considering 3 Solar output cases. A 0 MW output case is considered when there is no output from solar farm along with an average expected output of 50 MW and a maximum expected output of 100 MW. For Year 3, Topology 3, in addition to each of the hydro and wind generator output scenarios, three forecasted load scenarios are also studied. With all the generation and load scenario considerations, the total of scenarios studies totals 27.

Detailed analysis of Year 3 Topology 3 Base Case was carried out. Analysis of system totals by area, generator contributions to each scenario and the considered load scenarios can be found here. The overload and voltage violations can be found here.

1.2 Contingency Analysis

AC contingency calculation was conducted on the hypothetical SAVNW system for 27 different scenarios and hence on 27 different case files corresponding to Topology 3. The same configuration files are used for the 27 scenarios and are:

- Subsystem file savnw.sub - Studied subsystems of the studied scenario/ case are defined via the Subsystem Definition data file (Figure 1.2)
- Monitor file savnw.mon - Monitored Element Data File identifies the branches that are to be monitored for flow violations and the buses that are to be monitored for voltage violations (Figure 1.3)
- Contingency file savnw.con - Contingency cases that are to be tested are defined in the Contingency Definition data file (Figure 1.4)

```
SUBSYSTEM CON
AREA 1
AREA 2
AREA 5
END

SUBSYSTEM MON
AREA 1
AREA 2
AREA 5
END

END
```

Figure 1.2: The subsystem file corresponding to Year 3 Topology 3

```
MONITOR VOLTAGE RANGE ALL BUSES 0.9 1.1
MONITOR ALL BRANCHES
MONITOR TIES FROM AREA 1 TO AREAS 2 5
MONITOR TIES FROM AREA 2 TO AREA 5
END
END
```

Figure 1.3: The monitored file corresponding to Year 3 Topology 3

```
SINGLE BRANCH IN AREA 1
SINGLE BRANCH IN AREA 2
SINGLE BRANCH IN AREA 5
SINGLE BUS IN AREA 1
SINGLE BUS IN AREA 2
SINGLE BUS IN AREA 5
SINGLE MACHINE IN AREA 1
SINGLE MACHINE IN AREA 2
SINGLE MACHINE IN AREA 5
END
```

Figure 1.4: The contingency file corresponding to Year 3 Topology 3

For each of the 27 studied scenarios, the API DFAX.2 is used to construct 27 different distribution factor data files corresponding to each .sav file, and the above defined .sub, .mon, .con configuration files. For each of the

27 scenarios, by running the AC contingency calculation function `ACCC_WITH_DSP_3`, the contingency solution output `.acc` files are obtained.

Python code to conduct AC contingency calculation is:

```
import psspy
list_gens = [0,50,100]
list_lsc = ['lls','rls','hls']
list_gen_hydro = [400,500,600]
for gen in list_gens:
    for lsc in list_lsc:
        for gen_hy in list_gen_hydro:
            file_in = 'sav\savnw_sol_' + str(gen) + '_hy_' + str(gen_hy) + '_' + str(lsc) + '.sav'
            file_dist = 'savnw_sol_' + str(gen) + '_hy_' + str(gen_hy) + '_' + str(lsc) + '.dfx'
            file_out = 'savnw_sol_' + str(gen) + '_hy_' + str(gen_hy) + '_' + str(lsc) + '.acc'
            file_sav = r"{}".format(file_in)
            file_dfx = r"{}".format(file_dist)
            file_acc = r"{}".format(file_out)
            psspy.case(file_in)
            psspy.fdns([0,1,0,0,0,0,0,0])
            psspy.dfax_2([1,1,0],r""savnw.sub"",r""savnw.mon"",r""savnw.con"",file_dfx)
            psspy.accc_with_dsp_3(0.1,[0,1,0,0,0,0,0,0,0,0,0,0],"",file_dfx,file_acc,"","")
```

For each of the 27 scenarios, using the contingency solution output files, the results are exported as excel files for further analysis. The results exported are ACCC Analysis Summary, Monitored Branch Flows (MVA), Monitored Bus Voltages.

Python code to export AC contingency solution output file as excel is:

```
import pssexcel
list_gens = [0,50,100]
list_lsc = ['lls','rls','hls']
list_gen_hydro = [400,500,600]
for gen in list_gens:
    for lsc in list_lsc:
        for gen_hy in list_gen_hydro:
            file_in = 'acc\savnw_sol_' + str(gen) + '_hy_' + str(gen_hy) + '_' + str(lsc) + '.acc'
            file_out = 'savnw_sol_' + str(gen) + '_hy_' + str(gen_hy) + '_' + str(lsc) + '.xlsx'
            file_acc = r"{}".format(file_in)
            file_xlsx = r"{}".format(file_out)
            pssexcel.accc(file_acc, ['s','v','g','l','b','i','n','w'], colabel='', stype='
                                     contingency', busmsm=0.5, sysmsm=5.0,
                                     rating='a', namesplit=False, xlsfile=file_out, sheet='', overwritesheet=True,
                                     , show=False, ratecon='b',
                                     baseflowvio=True, basevoltvio=True, flowlimit=100.0, flowchange=0.0,
                                     voltchange=0.0, swdrating='
                                     a',
                                     swdratecon='b', baseswdfio=False, basenodevoltvio=False, overloadreport=
                                     False)
```

Contingency analysis was carried out in PSSE for each of the studied scenario for Year 3 Topology 3. It was seen that the power flow solution did not converge for some of the tested contingencies for the studied scenario.

For each of the scenario, the contingencies for which power flow solution did not converge are: For each of the scenario, the contingencies for which power flow solution did not converge are:

- Solar = 0 MW, Hydro = 400 MW, LLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205
- Solar = 0 MW, Hydro = 500 MW, LLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205
- Solar = 0 MW, Hydro = 600 MW, LLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1), BUS 203
- Solar = 0 MW, Hydro = 400 MW, RLS

- SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1)
- Solar = 0 MW, Hydro = 500 MW, RLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1)
- Solar = 0 MW, Hydro = 600 MW, RLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), SING OPN LIN 6 152-153(1), UNIT 206(1), SING OPN LIN 5 151-152(2), BUS 153, SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1), SING OPN LIN 4 151-152(1), BUS 203
- Solar = 0 MW, Hydro = 400 MW, HLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1)
- Solar = 0 MW, Hydro = 500 MW, HLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), SING OPN LIN 6 152-153(1), UNIT 206(1), BUS 153, SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1), BUS 203
- Solar = 0 MW, Hydro = 600 MW, HLS
 - SING OPN LIN 18 3001-3003(1), BUS 205, BUS 203, BUS 151, BUS 3003, BUS 202, BUS 3004, SING OPN LIN 6 152-153(1), UNIT 206(1), SING OPN LIN 4 151-152(1), SING OPN LIN 9 201-202(1), SING OPN LIN 10 201-205(&1), BUS 3005, SING OPN LIN 13 202-203(1), SING OPN LIN 16 205-206(1), BUS 152, BUS 201, BUS 153, SING OPN LIN 5 151-152(2)
- Solar = 50 MW, Hydro = 400 MW, LLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, UNIT 206(1), SING OPN LIN 10 201-205(&1)
- Solar = 50 MW, Hydro = 500 MW, LLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205
- Solar = 50 MW, Hydro = 600 MW, LLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1)
- Solar = 50 MW, Hydro = 400 MW, RLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1)
- Solar = 50 MW, Hydro = 500 MW, RLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1)
- Solar = 50 MW, Hydro = 600 MW, RLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), SING OPN LIN 6 152-153(1), UNIT 206(1), BUS 153, SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1), BUS 203
- Solar = 50 MW, Hydro = 400 MW, HLS

- SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), SING OPN LIN 6 152-153(1), UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1)
- Solar = 50 MW, Hydro = 500 MW, HLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), SING OPN LIN 6 152-153(1), UNIT 206(1), BUS 153, SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1), BUS 203
- Solar = 50 MW, Hydro = 600 MW, HLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), SING OPN LIN 6 152-153(1), UNIT 206(1), SING OPN LIN 5 151-152(2), BUS 153, SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1), SING OPN LIN 4 151-152(1), BUS 203
- Solar = 100 MW, Hydro = 400 MW, LLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, UNIT 206(1), SING OPN LIN 10 201-205(&1)
- Solar = 100 MW, Hydro = 500 MW, LLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205
- Solar = 100 MW, Hydro = 600 MW, LLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1)
- Solar = 100 MW, Hydro = 400 MW, RLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205
- Solar = 100 MW, Hydro = 500 MW, RLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1)
- Solar = 100 MW, Hydro = 600 MW, RLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), SING OPN LIN 6 152-153(1), UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1), BUS 203
- Solar = 100 MW, Hydro = 400 MW, HLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1)
- Solar = 100 MW, Hydro = 500 MW, HLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), SING OPN LIN 6 152-153(1), UNIT 206(1), SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1), BUS 203
- Solar = 100 MW, Hydro = 600 MW, HLS
 - SING OPN LIN 16 205-206(1), BUS 152, BUS 151, BUS 201, BUS 202, SING OPN LIN 9 201-202(1), SING OPN LIN 6 152-153(1), UNIT 206(1), SING OPN LIN 5 151-152(2), BUS 153, SING OPN LIN 10 201-205(&1), BUS 205, SING OPN LIN 13 202-203(1), SING OPN LIN 4 151-152(1), BUS 203

For the converged contingencies for each of the studied scenario, the results of the contingency analysis were analysed to check for branch overload ($> 100\%$) and out of range bus voltage violations (lower emergency limit $< 0.9PU$ and upper emergency limit $> 1.1PU$). It was seen that for some of the contingencies there were no branch overload or bus voltage violations reported. Rest of the contingencies violating branch overload and bus voltage emergency ranges are reported in the subsequent chapters. Chapter 2 of this document gives the observed branch flow violations for each of the studied scenario. Chapter 4 gives the lower voltage violations reported for each of the studied scenarios. Chapter 3 gives the upper voltage violations reported for each of the studied scenarios. To conclude, Chapter 5 summarises the result of the contingency analysis carried out on Year 3, Topology 3 of the hypothetical SAVNW system.

Chapter 2

Branch Overload Violation

2.1 Introduction

In this chapter, for each of the studied scenario, the branches that are loaded more than 100% of their rating is tabulated. Branches that are loaded more than 130% of the rating are said to be severely/ critically loaded and are noted down for reporting as operating these branches for prolonged duration is not recommended for a safe and reliable power system.

2.2 Solar = 0 MW, Hydro = 400 MW, LLS

For the studied scenario Solar = 0 MW, Hydro = 400 MW, LLS, loading greater than 130% were reported for the branch 3001-3003(1) for the unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1), and for the branches 153-154(1) for single line open contingency SING OPN LIN 13 202-203(1).

Table 2.1: Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	636.39	619.96	300.00	206.65
101-151(1)	UNIT 102(1)	1398.83	1398.83	1350.00	103.62

Table 2.2: Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	243.79	259.25	250.00	103.70
153-154(1)	BUS 203	-421.03	452.35	350.00	129.24
153-154(2)	BUS 203	-351.29	377.42	350.00	107.83

Table 2.3: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	636.59	620.15	300.00	206.72
101-151(1)	SING OPN LIN 2 102-151(1)	1398.83	1398.83	1350.00	103.62
154-203(1)	SING OPN LIN 6 152-153(1)	254.84	278.40	250.00	111.36
154-205(1)	SING OPN LIN 6 152-153(1)	641.35	700.64	660.00	106.16
153-154(1)	SING OPN LIN 13 202-203(1)	-427.86	487.55	350.00	139.30
153-154(2)	SING OPN LIN 13 202-203(1)	-357.16	406.99	350.00	116.28

2.3 Solar = 0 MW, Hydro = 500 MW, LLS

For the studied scenario Solar = 0 MW, Hydro = 500 MW, LLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1), for the branch 153-154(1) for bus fault contingency BUS 203 and for single line open contingency SING OPN LIN 13 202-203(1) and for the branch 153-154(2) for single line open contingency SING OPN LIN 13 202-203(1).

Table 2.4: Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	639.60	623.63	300.00	207.88
101-151(1)	UNIT 102(1)	1402.53	1402.53	1350.00	103.89

Table 2.5: Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	266.96	291.66	250.00	116.66
202-203(1)	BUS 153	1045.19	1045.19	1040.00	100.50
153-154(1)	BUS 203	-459.15	515.05	350.00	147.16
153-154(2)	BUS 203	-383.04	429.67	350.00	122.76
153-154(1)	BUS 3005	-340.68	354.31	350.00	101.23

Table 2.6: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	639.61	623.63	300.00	207.88
101-151(1)	SING OPN LIN 2 102-151(1)	1402.53	1402.53	1350.00	103.89
154-203(1)	SING OPN LIN 6 152-153(1)	275.71	310.31	250.00	124.12
154-205(1)	SING OPN LIN 6 152-153(1)	592.29	666.62	660.00	101.00
202-203(1)	SING OPN LIN 6 152-153(1)	1074.95	1074.95	1040.00	103.36
153-154(1)	SING OPN LIN 8 153-154(2)	-364.60	380.63	350.00	108.75
153-154(1)	SING OPN LIN 13 202-203(1)	-465.44	565.61	350.00	161.60
153-154(2)	SING OPN LIN 13 202-203(1)	-388.42	472.01	350.00	134.86
3005-3007(1)	SING OPN LIN 13 202-203(1)	-336.18	377.43	350.00	107.84

2.4 Solar = 0 MW, Hydro = 600 MW, LLS

For the studied scenario Solar = 0 MW, Hydro = 600 MW, LLS, loading greater than 130% were reported for the branches 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1), and for the branch 154-203(1) for bus fault contingency BUS 153 and for single line open contingency SING OPN LIN 6 152-153(1).

Table 2.7: Base Case reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-308.86	321.95	300.00	107.32
204-205(1)	BASE CASE	803.05	803.05	800.00	100.38

Table 2.8: Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	647.15	632.39	300.00	210.80
101-151(1)	UNIT 102(1)	1409.19	1409.19	1350.00	104.38

Table 2.9: Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	289.89	330.70	250.00	132.28
202-203(1)	BUS 153	1149.76	1149.76	1040.00	110.55
203-205(1)	BUS 153	-227.56	255.94	250.00	102.38
203-205(2)	BUS 153	-227.56	255.94	250.00	102.38
3005-3007(1)	BUS 153	-329.47	354.22	350.00	101.20

Table 2.10: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	639.60	624.67	300.00	208.22
101-151(1)	SING OPN LIN 2 102-151(1)	1409.20	1409.20	1350.00	104.38
154-203(1)	SING OPN LIN 6 152-153(1)	295.64	349.32	250.00	139.73
202-203(1)	SING OPN LIN 6 152-153(1)	1174.72	1174.72	1040.00	112.95
203-205(1)	SING OPN LIN 6 152-153(1)	-228.96	266.41	250.00	106.56
203-205(2)	SING OPN LIN 6 152-153(1)	-228.96	266.41	250.00	106.56
3001-3003(1)	SING OPN LIN 6 152-153(1)	334.58	331.11	300.00	110.37
153-154(2)	SING OPN LIN 7 153-154(1)	-349.41	375.20	350.00	107.20
3005-3007(1)	SING OPN LIN 26 3005-3008(1)	-340.02	351.82	350.00	100.52

2.5 Solar = 0 MW, Hydro = 400 MW, RLS

For the studied scenario Solar = 0 MW, Hydro = 400 MW, RLS, loading greater than 130% were reported for the branch 3001-3003(1) for the unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1), and for the branch 153-154(1) for the bus fault contingency BUS 203.

Table 2.11: Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	703.58	689.99	300.00	230.00
3005-3007(1)	UNIT 101(1)	-335.11	350.10	350.00	100.03
101-151(1)	UNIT 102(1)	1466.75	1466.75	1350.00	108.65

Table 2.12: Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	253.62	285.63	250.00	114.25
154-205(1)	BUS 153	627.56	706.76	660.00	107.08
153-154(1)	BUS 203	-436.87	496.74	350.00	141.93
153-154(2)	BUS 203	-364.60	414.57	350.00	118.45
3005-3007(1)	BUS 203	-325.53	351.35	350.00	100.38
3001-3003(1)	BUS 3004	314.94	308.20	300.00	102.73

Table 2.13: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	703.46	689.86	300.00	229.95
3005-3007(1)	SING OPN LIN 1 101-151(1)	-335.08	350.06	350.00	100.02
101-151(1)	SING OPN LIN 2 102-151(1)	1466.76	1466.76	1350.00	108.65
154-203(1)	SING OPN LIN 6 152-153(1)	263.70	308.20	250.00	123.28
154-205(1)	SING OPN LIN 6 152-153(1)	685.83	801.58	660.00	121.45
202-203(1)	SING OPN LIN 6 152-153(1)	1059.52	1059.52	1040.00	101.88
3001-3003(1)	SING OPN LIN 6 152-153(1)	330.65	326.40	300.00	108.80
153-154(1)	SING OPN LIN 8 153-154(2)	-348.64	371.95	350.00	106.27

2.6 Solar = 0 MW, Hydro = 500 MW, RLS

For the studied scenario Solar = 0 MW, Hydro = 500 MW, RLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1), for the branch 153-154(2) for the bus fault contingency BUS 203, and for the branch 154-203(1) for single line open contingency SING OPN LIN 6 152-153(1).

Table 2.14: Base Case reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-294.27	311.25	300.00	103.75

Table 2.15: Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	711.47	699.55	300.00	233.18
3003-3005(1)	UNIT 101(1)	-341.86	350.29	350.00	100.08
3003-3005(2)	UNIT 101(1)	-341.86	350.29	350.00	100.08
3005-3007(1)	UNIT 101(1)	-344.98	364.30	350.00	104.09
101-151(1)	UNIT 102(1)	1473.33	1473.33	1350.00	109.14

Table 2.16: Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	275.86	322.69	250.00	129.08
154-205(1)	BUS 153	584.25	683.42	660.00	103.55
202-203(1)	BUS 153	1123.16	1123.16	1040.00	108.00
3005-3007(1)	BUS 153	-336.13	367.18	350.00	104.91
153-154(2)	BUS 203	-395.27	480.88	350.00	137.40
3001-3003(1)	BUS 203	304.49	300.50	300.00	100.17
3005-3007(1)	BUS 203	-348.49	393.37	350.00	112.39
3001-3003(1)	BUS 3004	331.78	325.47	300.00	108.49

Table 2.17: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	711.27	699.34	300.00	233.11
3003-3005(1)	SING OPN LIN 1 101-151(1)	-341.77	350.18	350.00	100.05
3003-3005(2)	SING OPN LIN 1 101-151(1)	-341.77	350.18	350.00	100.05
3005-3007(1)	SING OPN LIN 1 101-151(1)	-344.93	364.24	350.00	104.07
101-151(1)	SING OPN LIN 2 102-151(1)	1473.33	1473.33	1350.00	109.14
154-203(1)	SING OPN LIN 6 152-153(1)	283.28	347.17	250.00	138.87
154-205(1)	SING OPN LIN 6 152-153(1)	636.73	780.33	660.00	118.23
202-203(1)	SING OPN LIN 6 152-153(1)	1159.55	1159.55	1040.00	111.50
203-205(1)	SING OPN LIN 6 152-153(1)	-209.66	252.37	250.00	100.95
203-205(2)	SING OPN LIN 6 152-153(1)	-209.66	252.37	250.00	100.95
3001-3003(1)	SING OPN LIN 6 152-153(1)	372.31	370.30	300.00	123.43
153-154(2)	SING OPN LIN 7 153-154(1)	-335.11	366.56	350.00	104.73
3001-3003(1)	SING OPN LIN 23 3004-3005(1)	317.29	308.68	300.00	102.89
3005-3007(1)	SING OPN LIN 26 3005-3008(1)	-345.69	362.15	350.00	103.47

2.7 Solar = 0 MW, Hydro = 600 MW, RLS

For the studied scenario Solar = 0 MW, Hydro = 600 MW, RLS, loading greater than 130% were reported for the branch 3001-3003(1) for the unit fault contingency UNIT 101(1) and for the branch 3001-3003(1) for single line open contingency SING OPN LIN 1 101-151(1).

Table 2.18: Base Case reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-317.77	343.15	300.00	114.38
204-205(1)	BASE CASE	829.19	829.19	800.00	103.65

Table 2.19: Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	720.48	710.94	300.00	236.98
3003-3005(1)	UNIT 101(1)	-343.52	356.24	350.00	101.78
3003-3005(2)	UNIT 101(1)	-343.52	356.24	350.00	101.78
3005-3007(1)	UNIT 101(1)	-354.95	380.55	350.00	108.73
101-151(1)	UNIT 102(1)	1482.24	1482.24	1350.00	109.80
3001-3003(1)	UNIT 3018(1)	307.93	301.68	300.00	100.56

Table 2.20: Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	BUS 3004	358.39	352.83	300.00	117.61
153-154(2)	BUS 3005	-321.39	364.87	350.00	104.25

Table 2.21: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	720.46	710.91	300.00	236.97
3003-3005(1)	SING OPN LIN 1 101-151(1)	-343.51	356.22	350.00	101.78
3003-3005(2)	SING OPN LIN 1 101-151(1)	-343.51	356.22	350.00	101.78
3005-3007(1)	SING OPN LIN 1 101-151(1)	-354.95	380.54	350.00	108.73
101-151(1)	SING OPN LIN 2 102-151(1)	1482.24	1482.24	1350.00	109.80
153-154(2)	SING OPN LIN 7 153-154(1)	-359.98	405.25	350.00	115.79
3001-3003(1)	SING OPN LIN 23 3004-3005(1)	337.86	329.93	300.00	109.98
3005-3007(1)	SING OPN LIN 26 3005-3008(1)	-363.43	387.57	350.00	110.73
3001-3003(1)	SING OPN LIN 27 3008-3018(1)	307.93	301.68	300.00	100.56

2.8 Solar = 0 MW, Hydro = 400 MW, HLS

For the studied scenario Solar = 0 MW, Hydro = 400 MW, HLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingencies SING OPN LIN 1 101-151(1) and SING OPN LIN 6 152-153(1), for the branch 153-154(2) for bus fault contingency BUS 203, and for the branches 154-203(1) and 154-205(1) for single line open contingency SING OPN LIN 6 152-153(1).

Table 2.22: Base Case reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-280.03	300.67	300.00	100.22

Table 2.23: Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	764.79	756.59	300.00	252.20
3003-3005(1)	UNIT 101(1)	-363.91	378.99	350.00	108.28
3003-3005(2)	UNIT 101(1)	-363.91	378.99	350.00	108.28
3005-3007(1)	UNIT 101(1)	-352.39	379.62	350.00	108.46
101-151(1)	UNIT 102(1)	1524.83	1524.83	1350.00	112.95
3001-3003(1)	UNIT 3018(1)	312.11	305.32	300.00	101.77

Table 2.24: Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	262.87	317.14	250.00	126.85
154-205(1)	BUS 153	659.88	796.11	660.00	120.62
202-203(1)	BUS 153	1099.29	1099.29	1040.00	105.70
3001-3003(1)	BUS 153	307.95	302.48	300.00	100.83
3005-3007(1)	BUS 153	-341.50	379.99	350.00	108.57
153-154(2)	BUS 203	-376.29	457.97	350.00	130.85
3001-3003(1)	BUS 203	318.06	313.82	300.00	104.61
3005-3007(1)	BUS 203	-348.08	393.01	350.00	112.29
3001-3003(1)	BUS 3004	362.80	356.73	300.00	118.91

Table 2.25: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	764.48	756.26	300.00	252.09
3003-3005(1)	SING OPN LIN 1 101-151(1)	-363.78	378.82	350.00	108.24
3003-3005(2)	SING OPN LIN 1 101-151(1)	-363.78	378.82	350.00	108.24
3005-3007(1)	SING OPN LIN 1 101-151(1)	-352.32	379.53	350.00	108.44
101-151(1)	SING OPN LIN 2 102-151(1)	1524.84	1524.84	1350.00	112.95
154-203(1)	SING OPN LIN 6 152-153(1)	271.88	351.49	250.00	140.60
154-205(1)	SING OPN LIN 6 152-153(1)	717.71	927.86	660.00	140.58
202-203(1)	SING OPN LIN 6 152-153(1)	1154.77	1154.77	1040.00	111.04
3001-3003(1)	SING OPN LIN 6 152-153(1)	418.63	419.25	300.00	139.75
153-154(2)	SING OPN LIN 7 153-154(1)	-319.57	356.10	350.00	101.74
3001-3003(1)	SING OPN LIN 23 3004-3005(1)	337.18	328.78	300.00	109.59
3005-3007(1)	SING OPN LIN 26 3005-3008(1)	-349.93	371.13	350.00	106.04
3001-3003(1)	SING OPN LIN 27 3008-3018(1)	312.11	305.32	300.00	101.77

2.9 Solar = 0 MW, Hydro = 500 MW, HLS

For the studied scenario Solar = 0 MW, Hydro = 500 MW, HLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1).

Table 2.26: Base Case reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-302.75	330.34	300.00	110.11

Table 2.27: Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	775.35	769.41	300.00	256.47
3003-3005(1)	UNIT 101(1)	-366.50	385.57	350.00	110.16
3003-3005(2)	UNIT 101(1)	-366.50	385.57	350.00	110.16
3005-3007(1)	UNIT 101(1)	-362.37	395.37	350.00	112.96
101-151(1)	UNIT 102(1)	1532.64	1532.64	1350.00	113.53
3001-3003(1)	UNIT 3018(1)	325.22	319.15	300.00	106.38

Table 2.28: Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	BUS 3002	310.89	303.14	300.00	101.05
3001-3003(1)	BUS 3004	384.16	378.81	300.00	126.27
153-154(2)	BUS 3005	-307.73	354.38	350.00	101.25

Table 2.29: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	774.91	768.95	300.00	256.32
3003-3005(1)	SING OPN LIN 1 101-151(1)	-366.31	385.34	350.00	110.10
3003-3005(2)	SING OPN LIN 1 101-151(1)	-366.31	385.34	350.00	110.10
3005-3007(1)	SING OPN LIN 1 101-151(1)	-362.28	395.23	350.00	112.92
101-151(1)	SING OPN LIN 2 102-151(1)	1532.65	1532.65	1350.00	113.53
153-154(2)	SING OPN LIN 7 153-154(1)	-345.21	394.06	350.00	112.59
3001-3003(1)	SING OPN LIN 17 3001-3002(1)	308.87	301.05	300.00	100.35
3001-3003(1)	SING OPN LIN 20 3002-3004(1)	310.89	303.14	300.00	101.05
3001-3003(1)	SING OPN LIN 23 3004-3005(1)	354.95	347.16	300.00	115.72
3005-3007(1)	SING OPN LIN 26 3005-3008(1)	-366.27	394.05	350.00	112.59
3001-3003(1)	SING OPN LIN 27 3008-3018(1)	325.22	319.15	300.00	106.38

2.10 Solar = 0 MW, Hydro = 600 MW, HLS

There were no contingencies for which the studied scenario Solar = 0 MW, Hydro = 600 MW, HLS, reported a loading greater than 130%.

Table 2.30: Base Case reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-325.80	364.12	300.00	121.37
153-154(2)	BASE CASE	-272.09	304.09	300.00	101.36
204-205(1)	BASE CASE	854.37	854.37	800.00	106.80
202-203(1)	BASE CASE	827.17	827.17	800.00	103.40
3001-3003(1)	BASE CASE	264.28	258.85	250.00	103.54
3005-3007(1)	BASE CASE	-286.92	309.09	300.00	103.03

Table 2.31: Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3003-3005(1)	UNIT 101(1)	-369.94	395.24	350.00	112.93
3003-3005(2)	UNIT 101(1)	-369.94	395.24	350.00	112.93
101-151(1)	UNIT 102(1)	1543.51	1543.51	1350.00	114.33

Table 2.32: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3003-3005(1)	SING OPN LIN 1 101-151(1)	-369.67	394.89	350.00	112.82
3003-3005(2)	SING OPN LIN 1 101-151(1)	-369.67	394.89	350.00	112.82
101-151(1)	SING OPN LIN 2 102-151(1)	1543.53	1543.53	1350.00	114.34
154-203(1)	SING OPN LIN 7 153-154(1)	214.95	254.54	250.00	101.81

2.11 Solar = 50 MW, Hydro = 400 MW, LLS

For the studied scenario Solar = 50 MW, Hydro = 400 MW, LLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN

1 101-151(1), for the branch 153-154(1) for single line open contingency SING OPN LIN 13 202-203(1), and for the branch 154-203(1) for bus fault contingency BUS 205.

Table 2.33: Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	594.28	577.83	300.00	192.61

Table 2.34: Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BUS 203	-409.88	436.61	350.00	124.74
153-154(2)	BUS 203	-342.01	364.31	350.00	104.09
153-154(1)	BUS 205	-335.79	435.07	350.00	124.31
153-154(2)	BUS 205	-280.58	363.53	350.00	103.87
154-203(1)	BUS 205	328.33	425.41	250.00	170.16
3001-3003(1)	BUS 205	351.96	353.52	300.00	117.84

Table 2.35: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	594.28	577.83	300.00	192.61
154-203(1)	SING OPN LIN 6 152-153(1)	246.50	266.86	250.00	106.75
154-205(1)	SING OPN LIN 6 152-153(1)	616.81	667.77	660.00	101.18
153-154(1)	SING OPN LIN 13 202-203(1)	-416.50	468.20	350.00	133.77
153-154(2)	SING OPN LIN 13 202-203(1)	-347.72	390.89	350.00	111.68

2.12 Solar = 50 MW, Hydro = 500 MW, LLS

For the studied scenario Solar = 50 MW, Hydro = 500 MW, LLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1), and for the branch 153-154(1) for bus fault contingency BUS 203 and for single line open contingency SING OPN LIN 13 202-203(1).

Table 2.36: Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	598.49	582.47	300.00	194.16

Table 2.37: Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	258.32	279.45	250.00	111.78
153-154(1)	BUS 203	-448.00	496.37	350.00	141.82
153-154(2)	BUS 203	-373.76	414.11	350.00	118.32

Table 2.38: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	598.49	582.47	300.00	194.16
154-203(1)	SING OPN LIN 6 152-153(1)	267.75	297.94	250.00	119.18
202-203(1)	SING OPN LIN 6 152-153(1)	1049.01	1049.01	1040.00	100.87
153-154(1)	SING OPN LIN 8 153-154(2)	-355.38	369.08	350.00	105.45
153-154(1)	SING OPN LIN 13 202-203(1)	-454.46	539.09	350.00	154.03
153-154(2)	SING OPN LIN 13 202-203(1)	-379.28	449.92	350.00	128.55
3005-3007(1)	SING OPN LIN 13 202-203(1)	-328.51	363.06	350.00	103.73

2.13 Solar = 50 MW, Hydro = 600 MW, LLS

For the studied scenario Solar = 50 MW, Hydro = 600 MW, LLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1), for the branch 153-154(2) for bus fault contingency BUS 203, and for the branch 154-203(1) for single line open contingency SING OPN LIN 6 152-153(1).

Table 2.39: Base Case reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-300.70	311.73	300.00	103.91

Table 2.40: Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	603.38	587.85	300.00	195.95
101-151(1)	UNIT 102(1)	1354.76	1354.76	1350.00	100.35

Table 2.41: Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	281.39	316.43	250.00	126.57
202-203(1)	BUS 153	1119.64	1119.64	1040.00	107.66
153-154(2)	BUS 203	-405.13	481.79	350.00	137.65
3005-3007(1)	BUS 203	-340.72	378.52	350.00	108.15

Table 2.42: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	603.38	587.84	300.00	195.95
101-151(1)	SING OPN LIN 2 102-151(1)	1354.76	1354.76	1350.00	100.35
154-203(1)	SING OPN LIN 6 152-153(1)	288.40	335.34	250.00	134.14
202-203(1)	SING OPN LIN 6 152-153(1)	1147.26	1147.26	1040.00	110.31
203-205(1)	SING OPN LIN 6 152-153(1)	-224.52	257.22	250.00	102.89
203-205(2)	SING OPN LIN 6 152-153(1)	-224.52	257.22	250.00	102.89
3001-3003(1)	SING OPN LIN 6 152-153(1)	320.41	316.26	300.00	105.42
153-154(2)	SING OPN LIN 7 153-154(1)	-342.09	365.05	350.00	104.30

2.14 Solar = 50 MW, Hydro = 400 MW, RLS

For the studied scenario Solar = 50 MW, Hydro = 400 MW, RLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1), and for the branch 153-154(1) for the bus fault contingency BUS 203.

Table 2.43: Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	666.13	651.41	300.00	217.14
101-151(1)	UNIT 102(1)	1412.65	1412.65	1350.00	104.64

Table 2.44: Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	245.05	272.90	250.00	109.16
154-205(1)	BUS 153	601.35	669.71	660.00	101.47
153-154(1)	BUS 203	-425.73	478.11	350.00	136.60
153-154(2)	BUS 203	-355.34	399.06	350.00	114.02
3001-3003(1)	BUS 3004	310.10	303.22	300.00	101.07

Table 2.45: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	665.91	651.18	300.00	217.06
101-151(1)	SING OPN LIN 2 102-151(1)	1412.56	1412.56	1350.00	104.63
154-203(1)	SING OPN LIN 6 152-153(1)	256.23	295.56	250.00	118.22
154-205(1)	SING OPN LIN 6 152-153(1)	659.78	761.05	660.00	115.31
3001-3003(1)	SING OPN LIN 6 152-153(1)	319.24	314.47	300.00	104.82
153-154(1)	SING OPN LIN 8 153-154(2)	-338.40	358.86	350.00	102.53

2.15 Solar = 50 MW, Hydro = 500 MW, RLS

For the studied scenario Solar = 50 MW, Hydro = 500 MW, RLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1), and for the branch 153-154(2) for bus fault contingency BUS 203, and for the branch 154-203(1) for single line open contingency SING OPN LIN 6 152-153(1).

Table 2.46: Base Case reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-286.27	301.13	300.00	100.38

Table 2.47: Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	673.12	659.83	300.00	219.94
3005-3007(1)	UNIT 101(1)	-335.87	351.82	350.00	100.52
101-151(1)	UNIT 102(1)	1418.63	1418.63	1350.00	105.08

Table 2.48: Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	267.38	307.90	250.00	123.16
202-203(1)	BUS 153	1091.78	1091.78	1040.00	104.98
3005-3007(1)	BUS 153	-328.96	355.72	350.00	101.63
153-154(2)	BUS 203	-387.13	461.01	350.00	131.72
3005-3007(1)	BUS 203	-343.05	381.77	350.00	109.08
3001-3003(1)	BUS 3004	325.10	318.62	300.00	106.21

Table 2.49: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	672.97	659.68	300.00	219.89
3005-3007(1)	SING OPN LIN 1 101-151(1)	-335.83	351.78	350.00	100.51
101-151(1)	SING OPN LIN 2 102-151(1)	1418.63	1418.63	1350.00	105.08
154-203(1)	SING OPN LIN 6 152-153(1)	275.93	331.33	250.00	132.53
154-205(1)	SING OPN LIN 6 152-153(1)	611.97	734.85	660.00	111.34
202-203(1)	SING OPN LIN 6 152-153(1)	1128.29	1128.29	1040.00	108.49
3001-3003(1)	SING OPN LIN 6 152-153(1)	354.86	351.83	300.00	117.28
153-154(2)	SING OPN LIN 7 153-154(1)	-326.09	353.95	350.00	101.13
3001-3003(1)	SING OPN LIN 23 3004-3005(1)	311.58	302.80	300.00	100.93
3005-3007(1)	SING OPN LIN 26 3005-3008(1)	-340.06	354.56	350.00	101.30

2.16 Solar = 50 MW, Hydro = 600 MW, RLS

For the studied scenario Solar = 50 MW, Hydro = 600 MW, RLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1).

Table 2.50: Base Case reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-309.85	332.39	300.00	110.80
204-205(1)	BASE CASE	813.80	813.80	800.00	101.73

Table 2.51: Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	681.54	670.31	300.00	223.44
3005-3007(1)	UNIT 101(1)	-345.94	367.53	350.00	105.01
101-151(1)	UNIT 102(1)	1426.83	1426.83	1350.00	105.69

Table 2.52: Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	BUS 3004	349.35	343.53	300.00	114.51
153-154(2)	BUS 3005	-313.25	350.98	350.00	100.28

Table 2.53: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	681.53	670.29	300.00	223.43
3005-3007(1)	SING OPN LIN 1 101-151(1)	-345.93	367.52	350.00	105.01
101-151(1)	SING OPN LIN 2 102-151(1)	1426.83	1426.83	1350.00	105.69
153-154(2)	SING OPN LIN 7 153-154(1)	-352.87	393.98	350.00	112.57
3001-3003(1)	SING OPN LIN 23 3004-3005(1)	330.95	322.78	300.00	107.59
3005-3007(1)	SING OPN LIN 26 3005-3008(1)	-357.52	379.06	350.00	108.30

2.17 Solar = 50 MW, Hydro = 400 MW, HLS

For the studied scenario Solar = 50 MW, Hydro = 400 MW, HLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1) and for the branch 153-154(1) for bus fault contingency BUS 203.

Table 2.54: Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	725.25	714.95	300.00	238.32
3003-3005(1)	UNIT 101(1)	-346.75	358.13	350.00	102.32
3003-3005(2)	UNIT 101(1)	-346.75	358.13	350.00	102.32
3005-3007(1)	UNIT 101(1)	-343.46	366.53	350.00	104.72
101-151(1)	UNIT 102(1)	1469.91	1469.91	1350.00	108.88
3001-3003(1)	UNIT 3018(1)	307.84	300.81	300.00	100.27

Table 2.55: Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	254.40	301.37	250.00	120.55
154-205(1)	BUS 153	634.07	751.11	660.00	113.81
202-203(1)	BUS 153	1065.73	1065.73	1040.00	102.47
3005-3007(1)	BUS 153	-333.93	367.29	350.00	104.94
153-154(1)	BUS 203	-439.55	524.05	350.00	149.73
153-154(2)	BUS 203	-366.92	437.45	350.00	124.99
3005-3007(1)	BUS 203	-340.55	379.25	350.00	108.36
3001-3003(1)	BUS 3004	355.84	349.55	300.00	116.52
153-154(1)	BUS 3005	-330.66	365.18	350.00	104.34

Table 2.56: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	725.02	714.71	300.00	238.24
3003-3005(1)	SING OPN LIN 1 101-151(1)	-346.65	358.01	350.00	102.29
3003-3005(2)	SING OPN LIN 1 101-151(1)	-346.65	358.01	350.00	102.29
3005-3007(1)	SING OPN LIN 1 101-151(1)	-343.41	366.46	350.00	104.70
101-151(1)	SING OPN LIN 2 102-151(1)	1469.92	1469.92	1350.00	108.88
153-154(1)	SING OPN LIN 8 153-154(2)	-350.48	384.89	350.00	109.97
3001-3003(1)	SING OPN LIN 23 3004-3005(1)	331.22	322.64	300.00	107.55
3005-3007(1)	SING OPN LIN 26 3005-3008(1)	-344.27	363.35	350.00	103.81
3001-3003(1)	SING OPN LIN 27 3008-3018(1)	307.84	300.81	300.00	100.27

2.18 Solar = 50 MW, Hydro = 500 MW, HLS

For the studied scenario Solar = 50 MW, Hydro = 500 MW, HLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1).

Table 2.57: Base Case reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-294.91	319.67	300.00	106.56

Table 2.58: Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	734.64	726.24	300.00	242.08
3003-3005(1)	UNIT 101(1)	-349.15	363.95	350.00	103.99
3003-3005(2)	UNIT 101(1)	-349.15	363.95	350.00	103.99
3005-3007(1)	UNIT 101(1)	-353.41	381.53	350.00	109.01
101-151(1)	UNIT 102(1)	1477.11	1477.11	1350.00	109.42
3001-3003(1)	UNIT 3018(1)	319.87	313.50	300.00	104.50

Table 2.59: Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	BUS 3004	375.21	369.55	300.00	123.18

Table 2.60: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	734.31	725.89	300.00	241.96
3003-3005(1)	SING OPN LIN 1 101-151(1)	-349.01	363.77	350.00	103.94
3003-3005(2)	SING OPN LIN 1 101-151(1)	-349.01	363.77	350.00	103.94
3005-3007(1)	SING OPN LIN 1 101-151(1)	-353.34	381.43	350.00	108.98
101-151(1)	SING OPN LIN 2 102-151(1)	1477.11	1477.11	1350.00	109.42
153-154(2)	SING OPN LIN 7 153-154(1)	-334.71	377.82	350.00	107.95
3001-3003(1)	SING OPN LIN 23 3004-3005(1)	347.98	339.93	300.00	113.31
3005-3007(1)	SING OPN LIN 26 3005-3008(1)	-360.39	385.47	350.00	110.13
3001-3003(1)	SING OPN LIN 27 3008-3018(1)	319.87	313.50	300.00	104.50

2.19 Solar = 50 MW, Hydro = 600 MW, HLS

There were no contingencies for which the studied scenario Solar = 50 MW, Hydro = 600 MW, HLS, reported a loading greater than 130%.

Table 2.61: Base Case reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-318.04	352.58	300.00	117.53
204-205(1)	BASE CASE	838.38	838.38	800.00	104.80
202-203(1)	BASE CASE	811.48	811.48	800.00	101.44
3001-3003(1)	BASE CASE	258.43	252.78	250.00	101.11
3005-3007(1)	BASE CASE	-283.04	303.09	300.00	101.03

Table 2.62: Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3003-3005(1)	UNIT 101(1)	-352.27	372.31	350.00	106.38
3003-3005(2)	UNIT 101(1)	-352.27	372.31	350.00	106.38
101-151(1)	UNIT 102(1)	1487.07	1487.07	1350.00	110.15

Table 2.63: Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(2)	BUS 3005	-321.25	382.77	350.00	109.36

Table 2.64: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3003-3005(1)	SING OPN LIN 1 101-151(1)	-352.06	372.04	350.00	106.30
3003-3005(2)	SING OPN LIN 1 101-151(1)	-352.06	372.04	350.00	106.30
101-151(1)	SING OPN LIN 2 102-151(1)	1487.08	1487.08	1350.00	110.15
153-154(2)	SING OPN LIN 7 153-154(1)	-360.67	421.41	350.00	120.40

2.20 Solar = 100 MW, Hydro = 400 MW, LLS

For the studied scenario Solar = 100 MW, Hydro = 400 MW, LLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1) and for the branch 154-203(1) for bus fault contingency BUS 205.

Table 2.65: Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	559.69	543.42	300.00	181.14

Table 2.66: Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BUS 203	-399.01	422.46	350.00	120.70
153-154(2)	BUS 203	-332.98	352.55	350.00	100.73
153-154(1)	BUS 205	-324.61	411.74	350.00	117.64
154-203(1)	BUS 205	316.74	401.76	250.00	160.70
3001-3003(1)	BUS 205	337.65	338.09	300.00	112.70

Table 2.67: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	559.69	543.42	300.00	181.14
154-203(1)	SING OPN LIN 6 152-153(1)	239.44	257.85	250.00	103.14
153-154(1)	SING OPN LIN 13 202-203(1)	-405.47	451.57	350.00	129.02
153-154(2)	SING OPN LIN 13 202-203(1)	-338.56	377.05	350.00	107.73

2.21 Solar = 100 MW, Hydro = 500 MW, LLS

For the studied scenario Solar = 100 MW, Hydro = 500 MW, LLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1), and for the branch 153-154(1) for bus fault contingency BUS 203 and for single line open contingency SING OPN LIN 13 202-203(1).

Table 2.68: Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	563.62	547.77	300.00	182.59

Table 2.69: Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	249.83	268.37	250.00	107.35
153-154(1)	BUS 203	-436.99	479.91	350.00	137.12
153-154(2)	BUS 203	-364.61	400.42	350.00	114.41

Table 2.70: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	563.62	547.77	300.00	182.59
154-203(1)	SING OPN LIN 6 152-153(1)	260.12	287.23	250.00	114.89
153-154(1)	SING OPN LIN 8 153-154(2)	-344.92	356.73	350.00	101.92
153-154(1)	SING OPN LIN 13 202-203(1)	-443.52	518.05	350.00	148.01
153-154(2)	SING OPN LIN 13 202-203(1)	-370.19	432.41	350.00	123.55
3005-3007(1)	SING OPN LIN 13 202-203(1)	-322.02	352.21	350.00	100.63

2.22 Solar = 100 MW, Hydro = 600 MW, LLS

For the studied scenario Solar = 100 MW, Hydro = 600 MW, LLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1) and for the branch 153-154(2) for bus fault contingency BUS 203.

Table 2.71: Base Case reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-292.59	302.11	300.00	100.70

Table 2.72: Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	568.11	552.47	300.00	184.16

Table 2.73: Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	273.04	304.02	250.00	121.61
202-203(1)	BUS 153	1092.87	1092.87	1040.00	105.08
153-154(2)	BUS 203	-397.19	465.27	350.00	132.94
3005-3007(1)	BUS 203	-336.48	369.98	350.00	105.71

Table 2.74: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, LLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	568.11	552.47	300.00	184.16
154-203(1)	SING OPN LIN 6 152-153(1)	280.77	322.63	250.00	129.05
202-203(1)	SING OPN LIN 6 152-153(1)	1121.26	1121.26	1040.00	107.81
3001-3003(1)	SING OPN LIN 6 152-153(1)	309.56	304.94	300.00	101.65
153-154(2)	SING OPN LIN 7 153-154(1)	-332.98	353.37	350.00	100.96
204-205(1)	SING OPN LIN 9 201-202(1)	1084.72	1084.72	1040.00	104.30

2.23 Solar = 100 MW, Hydro = 400 MW, RLS

For the studied scenario Solar = 100 MW, Hydro = 400 MW, RLS, loading greater than 130% were reported for the branch 153-154(1) for bus fault contingency BUS 203 and for single line open contingency SING OPN LIN

13 202-203(1), and for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1).

Table 2.75: Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	628.61	612.54	300.00	204.18
101-151(1)	UNIT 102(1)	1359.13	1359.13	1350.00	100.68

Table 2.76: Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	236.82	261.75	250.00	104.70
153-154(1)	BUS 203	-414.42	461.27	350.00	131.79
153-154(2)	BUS 203	-345.95	385.05	350.00	110.01

Table 2.77: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	628.54	612.47	300.00	204.16
101-151(1)	SING OPN LIN 2 102-151(1)	1358.97	1358.97	1350.00	100.66
154-203(1)	SING OPN LIN 6 152-153(1)	248.86	284.49	250.00	113.80
154-205(1)	SING OPN LIN 6 152-153(1)	635.63	726.66	660.00	110.10
3001-3003(1)	SING OPN LIN 6 152-153(1)	310.86	305.74	300.00	101.91
153-154(1)	SING OPN LIN 13 202-203(1)	-428.60	530.62	350.00	151.61
153-154(2)	SING OPN LIN 13 202-203(1)	-357.92	443.12	350.00	126.60
3005-3007(1)	SING OPN LIN 13 202-203(1)	-333.34	377.91	350.00	107.98

2.24 Solar = 100 MW, Hydro = 500 MW, RLS

For the studied scenario Solar = 100 MW, Hydro = 500 MW, RLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1) and for the branch 153-154(1) for bus fault contingency BUS 203.

Table 2.78: Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	635.79	621.66	300.00	207.22
101-151(1)	UNIT 102(1)	1364.51	1364.51	1350.00	101.07

Table 2.79: Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	259.21	295.40	250.00	118.16
202-203(1)	BUS 153	1064.67	1064.67	1040.00	102.37
153-154(1)	BUS 203	-453.16	531.82	350.00	151.95
153-154(2)	BUS 203	-378.17	443.82	350.00	126.81
3005-3007(1)	BUS 203	-336.69	370.92	350.00	105.98
3001-3003(1)	BUS 3004	320.19	313.59	300.00	104.53
153-154(1)	BUS 3005	-336.34	361.43	350.00	103.26

Table 2.80: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	635.69	621.55	300.00	207.18
101-151(1)	SING OPN LIN 2 102-151(1)	1364.51	1364.51	1350.00	101.07
154-203(1)	SING OPN LIN 6 152-153(1)	268.81	318.70	250.00	127.48
154-205(1)	SING OPN LIN 6 152-153(1)	588.85	698.12	660.00	105.78
202-203(1)	SING OPN LIN 6 152-153(1)	1102.74	1102.74	1040.00	106.03
3001-3003(1)	SING OPN LIN 6 152-153(1)	343.18	339.54	300.00	113.18
153-154(1)	SING OPN LIN 8 153-154(2)	-358.13	384.53	350.00	109.86

2.25 Solar = 100 MW, Hydro = 600 MW, RLS

For the studied scenario Solar = 100 MW, Hydro = 600 MW, RLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1), and for the branch 154-203(1) for bus fault contingency BUS 153.

Table 2.81: Base Case reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-302.02	322.45	300.00	107.48

Table 2.82: Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	644.58	632.27	300.00	210.76
3005-3007(1)	UNIT 101(1)	-337.17	355.73	350.00	101.64
101-151(1)	UNIT 102(1)	1372.10	1372.10	1350.00	101.64

Table 2.83: Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	281.39	338.34	250.00	135.33
202-203(1)	BUS 153	1176.82	1176.82	1040.00	113.16
203-205(1)	BUS 153	-220.49	260.65	250.00	104.26
203-205(2)	BUS 153	-220.49	260.65	250.00	104.26
3005-3007(1)	BUS 153	-345.07	383.38	350.00	109.54
3001-3003(1)	BUS 3004	342.72	336.71	300.00	112.24

Table 2.84: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, RLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	644.39	632.08	300.00	210.69
3005-3007(1)	SING OPN LIN 1 101-151(1)	-337.13	355.67	350.00	101.62
101-151(1)	SING OPN LIN 2 102-151(1)	1372.10	1372.10	1350.00	101.64
153-154(2)	SING OPN LIN 7 153-154(1)	-344.10	381.46	350.00	108.99
3001-3003(1)	SING OPN LIN 23 3004-3005(1)	325.37	317.04	300.00	105.68
3005-3007(1)	SING OPN LIN 26 3005-3008(1)	-352.09	371.68	350.00	106.19

2.26 Solar = 100 MW, Hydro = 400 MW, HLS

For the studied scenario Solar = 100 MW, Hydro = 400 MW, HLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1) and for the branch 153-154(1) for bus fault contingency BUS 203.

Table 2.85: Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	687.04	675.30	300.00	225.10
3005-3007(1)	UNIT 101(1)	-334.62	354.47	350.00	101.28
101-151(1)	UNIT 102(1)	1415.60	1415.60	1350.00	104.86

Table 2.86: Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	246.45	288.61	250.00	115.45
154-205(1)	BUS 153	610.24	714.65	660.00	108.28
3005-3007(1)	BUS 153	-327.72	357.75	350.00	102.21
153-154(1)	BUS 203	-428.96	504.80	350.00	144.23
153-154(2)	BUS 203	-358.12	421.44	350.00	120.41
3005-3007(1)	BUS 203	-334.57	369.25	350.00	105.50
3001-3003(1)	BUS 3004	350.86	344.41	300.00	114.80
153-154(1)	BUS 3005	-321.29	352.37	350.00	100.68

Table 2.87: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	686.86	675.11	300.00	225.04
3005-3007(1)	SING OPN LIN 1 101-151(1)	-334.58	354.42	350.00	101.26
101-151(1)	SING OPN LIN 2 102-151(1)	1415.61	1415.61	1350.00	104.86
154-203(1)	SING OPN LIN 6 152-153(1)	257.65	317.63	250.00	127.05
154-205(1)	SING OPN LIN 6 152-153(1)	669.37	825.19	660.00	125.03
202-203(1)	SING OPN LIN 6 152-153(1)	1087.69	1087.69	1040.00	104.59
3001-3003(1)	SING OPN LIN 6 152-153(1)	378.73	376.65	300.00	125.55
153-154(1)	SING OPN LIN 8 153-154(2)	-340.69	372.21	350.00	106.35
3001-3003(1)	SING OPN LIN 23 3004-3005(1)	326.43	317.72	300.00	105.91
3005-3007(1)	SING OPN LIN 26 3005-3008(1)	-339.10	356.62	350.00	101.89

2.27 Solar = 100 MW, Hydro = 500 MW, HLS

For the studied scenario Solar = 100 MW, Hydro = 500 MW, HLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1), and for the branch 154-203(1) for bus fault contingency BUS 153.

Table 2.88: Base Case reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-287.23	309.88	300.00	103.29

Table 2.89: Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	695.57	685.45	300.00	228.48
3005-3007(1)	UNIT 101(1)	-344.54	368.91	350.00	105.40
101-151(1)	UNIT 102(1)	1422.29	1422.29	1350.00	105.35
3001-3003(1)	UNIT 3018(1)	315.84	309.25	300.00	103.08

Table 2.90: Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	267.74	328.04	250.00	131.21
154-205(1)	BUS 153	570.45	698.92	660.00	105.90
202-203(1)	BUS 153	1143.23	1143.23	1040.00	109.93
3001-3003(1)	BUS 153	317.68	312.64	300.00	104.21
3005-3007(1)	BUS 153	-347.88	390.92	350.00	111.69
3001-3003(1)	BUS 3004	368.79	362.91	300.00	120.97

Table 2.91: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	695.31	685.18	300.00	228.39
3005-3007(1)	SING OPN LIN 1 101-151(1)	-344.48	368.83	350.00	105.38
101-151(1)	SING OPN LIN 2 102-151(1)	1422.30	1422.30	1350.00	105.36
153-154(2)	SING OPN LIN 7 153-154(1)	-327.76	367.82	350.00	105.09
3001-3003(1)	SING OPN LIN 23 3004-3005(1)	342.43	334.19	300.00	111.40
3005-3007(1)	SING OPN LIN 26 3005-3008(1)	-355.03	378.12	350.00	108.03
3001-3003(1)	SING OPN LIN 27 3008-3018(1)	315.83	309.24	300.00	103.08

2.28 Solar = 100 MW, Hydro = 600 MW, HLS

For the studied scenario Solar = 100 MW, Hydro = 600 MW, HLS, loading greater than 130% were reported for the branch 3001-3003(1) for unit fault contingency UNIT 101(1) and for single line open contingency SING OPN LIN 1 101-151(1).

Table 2.92: Base Case reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
153-154(1)	BASE CASE	-310.42	342.13	300.00	114.04
204-205(1)	BASE CASE	823.29	823.29	800.00	102.91

Table 2.93: Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	UNIT 101(1)	707.51	699.87	300.00	233.29
3003-3005(1)	UNIT 101(1)	-334.91	351.00	350.00	100.29
3003-3005(2)	UNIT 101(1)	-334.91	351.00	350.00	100.29
3005-3007(1)	UNIT 101(1)	-355.08	386.36	350.00	110.39
101-151(1)	UNIT 102(1)	1431.54	1431.54	1350.00	106.04
3001-3003(1)	UNIT 3018(1)	332.84	327.22	300.00	109.07

Table 2.94: Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	BUS 3002	318.16	310.66	300.00	103.55
3001-3003(1)	BUS 3004	387.12	382.32	300.00	127.44
153-154(2)	BUS 3005	-313.84	368.81	350.00	105.37

Table 2.95: Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
3001-3003(1)	SING OPN LIN 1 101-151(1)	707.11	699.45	300.00	233.15
3003-3005(1)	SING OPN LIN 1 101-151(1)	-334.74	350.79	350.00	100.23
3003-3005(2)	SING OPN LIN 1 101-151(1)	-334.74	350.79	350.00	100.23
3005-3007(1)	SING OPN LIN 1 101-151(1)	-355.00	386.23	350.00	110.35
101-151(1)	SING OPN LIN 2 102-151(1)	1431.54	1431.54	1350.00	106.04
153-154(2)	SING OPN LIN 7 153-154(1)	-352.36	407.93	350.00	116.55
3005-3007(1)	SING OPN LIN 7 153-154(1)	-320.99	351.69	350.00	100.48
3001-3003(1)	SING OPN LIN 17 3001-3002(1)	315.93	308.36	300.00	102.79
3001-3003(1)	SING OPN LIN 20 3002-3004(1)	318.16	310.66	300.00	103.55
3001-3003(1)	SING OPN LIN 23 3004-3005(1)	364.30	356.91	300.00	118.97
3005-3007(1)	SING OPN LIN 26 3005-3008(1)	-372.91	404.64	350.00	115.61
3001-3003(1)	SING OPN LIN 27 3008-3018(1)	332.84	327.22	300.00	109.07

2.29 Results Summary

The Tables 5.2, 5.3, 5.4, 5.5, 5.6 summarises the results of the AC contingency calculation carried out on the hypothetical SAVNW system for Topology 3 for branch overload violations, by tabulating the summary of branch load violation grouped by scenario and contingency to give the branches overloaded and count of the branches overloaded for each of the grouped scenario and contingency. For the Base case out of the 27 scenarios studied 15 scenarios reported overload with Solar = 0 MW, Hydro = 600 MW, HLS scenario reporting 6 overloaded branches in Table 5.2. It was noted that none of these violations reported a loading greater than 130% for any of the studied scenario. The Solar = 0 MW, Hydro = 500 MW, RLS scenario with single open line contingency SING OPN LIN 6 152-153(1) also reported 6 overload violations with 4 cases of reported loading of greater than 130%.

As can be seen from the Appendix, Table 5.9, the contingencies causing the most number of overload violations are SING OPN LIN 1 101-151(1), SING OPN LIN 6 152-153(1), and UNIT 101(1) reporting 56 violations each followed by BUS 153 reporting 50 and BUS 203 with 40 overload violations. The complete counts of contingencies causing overload violations is given in Table 5.9.

The branch reporting the most number of violations is the branch 3001-3003(1), which reported 116 loading violation followed by 3005-3007(1) with 63, 153-154(1) with 48, 153-154(2) with 45, and 101-151(1) with 44 overloading violations. The complete counts of each of the branch reporting overloads are given in Table 5.8.

Out of all the studied scenarios, the scenario reporting the greatest number of violations is the scenario Solar = 0 MW, Hydro = 400 MW, HLS with 29 violations, followed by Solar = 0 MW, Hydro = 500 MW, RLS with 28 and, Solar = 50 MW, Hydro = 400 MW, HLS with 24 loading violations. The complete counts of scenarios reporting overload violations is given in Table 5.7.

Chapter 3

Upper Emergency Bus Voltage Violation

3.1 Introduction

In this chapter the upper voltage limit violations are reported by bus faults, unit faults and single line faults for each of the studied scenario. The violations are reported in tabular format, and in the reported table, Base Voltage is PU base case voltage, Contingency Voltage is PU contingency case voltage, Deviation is difference between contingency case and base case voltage, Range Violation is range violations calculated as Contingency Voltage - maximum range limit (1.1 PU for the upper emergency range).

It was seen that for Topology 3, only the scenarios, Solar = 0 MW, Hydro = 500 MW, RLS Solar = 0 MW, Hydro = 400 MW, HLS Solar = 0 MW, Hydro = 500 MW, HLS Solar = 0 MW, Hydro = 600 MW, HLS Solar = 50 MW, Hydro = 600 MW, RLS Solar = 50 MW, Hydro = 500 MW, HLS Solar = 50 MW, Hydro = 600 MW, HLS Solar = 100 MW, Hydro = 600 MW, RLS Solar = 100 MW, Hydro = 500 MW, HLS Solar = 100 MW, Hydro = 600 MW, HLS reported upper voltage limit violations.

3.2 Solar = 0 MW, Hydro = 500 MW, RLS

For the studied scenario Solar = 0 MW, Hydro = 500 MW, RLS, the buses violating the Upper voltage limits are buses 211, 212. The buses 211, 212 reported violation for the single line open fault SING OPN LIN 6 152-153(1).

Table 3.1: Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 0 MW, Hydro = 500 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	SING OPN LIN 6 152-153(1)	1.04	1.10	0.06	0.05
212	SING OPN LIN 6 152-153(1)	1.04	1.10	0.06	0.05

3.3 Solar = 0 MW, Hydro = 400 MW, HLS

For the studied scenario Solar = 0 MW, Hydro = 400 MW, HLS, the buses violating the Upper voltage limits are buses 211, 212. The buses 211, 212 reported violation for the single line open fault SING OPN LIN 6 152-153(1).

Table 3.2: Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 0 MW, Hydro = 400 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	SING OPN LIN 6 152-153(1)	1.05	1.12	0.07	0.07
212	SING OPN LIN 6 152-153(1)	1.05	1.12	0.07	0.07

3.4 Solar = 0 MW, Hydro = 500 MW, HLS

For the studied scenario Solar = 0 MW, Hydro = 500 MW, HLS, the buses violating the Upper voltage limits are buses 211, 212. The buses 211, 212 reported violation for the single line open fault SING OPN LIN 4 151-152(1).

Table 3.3: Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 0 MW, Hydro = 500 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	SING OPN LIN 4 151-152(1)	1.06	1.11	0.05	0.06
212	SING OPN LIN 4 151-152(1)	1.06	1.11	0.05	0.06

3.5 Solar = 0 MW, Hydro = 600 MW, HLS

For the studied scenario Solar = 0 MW, Hydro = 600 MW, HLS, the buses violating the Upper voltage limits are buses 211, 212. The buses 211, 212 reported violation for the single line open fault SING OPN LIN 7 153-154(1).

Table 3.4: Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 0 MW, Hydro = 600 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	SING OPN LIN 7 153-154(1)	1.08	1.10	0.02	0.05
212	SING OPN LIN 7 153-154(1)	1.08	1.10	0.02	0.05

3.6 Solar = 50 MW, Hydro = 600 MW, RLS

For the studied scenario Solar = 50 MW, Hydro = 600 MW, RLS, the buses violating the Upper voltage limits are buses 211, 212. The buses 211, 212 reported violation for the single line open fault SING OPN LIN 4 151-152(1).

Table 3.5: Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 50 MW, Hydro = 600 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	SING OPN LIN 4 151-152(1)	1.06	1.11	0.05	0.06
212	SING OPN LIN 4 151-152(1)	1.06	1.11	0.05	0.06

3.7 Solar = 50 MW, Hydro = 500 MW, HLS

For the studied scenario Solar = 50 MW, Hydro = 500 MW, HLS, the buses violating the Upper voltage limits are buses 211, 212. The buses 211, 212 reported violation for the single line open fault SING OPN LIN 4 151-152(1).

Table 3.6: Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 50 MW, Hydro = 500 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	SING OPN LIN 4 151-152(1)	1.06	1.11	0.05	0.06
212	SING OPN LIN 4 151-152(1)	1.06	1.11	0.05	0.06

3.8 Solar = 50 MW, Hydro = 600 MW, HLS

For the studied scenario Solar = 50 MW, Hydro = 600 MW, HLS, the buses violating the Upper voltage limits are buses 211, 212. The buses 211, 212 reported violation for the bus fault BUS 3003 and for the single line open fault SING OPN LIN 18 3001-3003(1).

Table 3.7: Bus faults reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 50 MW, Hydro = 600 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	BUS 3003	1.07	1.11	0.03	0.06
212	BUS 3003	1.07	1.11	0.03	0.06

Table 3.8: Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 50 MW, Hydro = 600 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	SING OPN LIN 18 3001-3003(1)	1.07	1.10	0.03	0.05
212	SING OPN LIN 18 3001-3003(1)	1.07	1.10	0.03	0.05

3.9 Solar = 100 MW, Hydro = 600 MW, RLS

For the studied scenario Solar = 100 MW, Hydro = 600 MW, RLS, the buses violating the Upper voltage limits are buses 211, 212. The buses 211, 212 reported violation for the single line open fault SING OPN LIN 4 151-152(1).

Table 3.9: Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 100 MW, Hydro = 600 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	SING OPN LIN 4 151-152(1)	1.05	1.10	0.05	0.05
212	SING OPN LIN 4 151-152(1)	1.05	1.10	0.05	0.05

3.10 Solar = 100 MW, Hydro = 500 MW, HLS

For the studied scenario Solar = 100 MW, Hydro = 500 MW, HLS, the buses violating the Upper voltage limits are buses 211, 212. The buses 211, 212 reported violation for the single line open fault SING OPN LIN 4 151-152(1).

Table 3.10: Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 100 MW, Hydro = 500 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	SING OPN LIN 4 151-152(1)	1.05	1.10	0.05	0.05
212	SING OPN LIN 4 151-152(1)	1.05	1.10	0.05	0.05

3.11 Solar = 100 MW, Hydro = 600 MW, HLS

For the studied scenario Solar = 100 MW, Hydro = 600 MW, HLS, the buses violating the Upper voltage limits are buses 211, 212. The buses 211, 212 reported violation for the bus fault BUS 3003.

Table 3.11: Bus faults reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 100 MW, Hydro = 600 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	BUS 3003	1.07	1.10	0.03	0.05
212	BUS 3003	1.07	1.10	0.03	0.05

3.12 Results Summary

The Table 5.10 summarises the results of the AC contingency calculation carried out on the hypothetical SAVNW system for Topology 3 for upper emergency bus voltage violations by tabulating the summary of upper voltage violations grouped by scenario and contingency to give the buses reporting upper voltage range violations and the count of upper voltage range violations. It can be seen that only the buses 211 and 212 are reporting the upper voltage range violation across all the studied scenarios and contingencies. It was noted that for all the grouped scenarios and contingencies, both Bus 211 and 212 reported violations together.

The scenario for which most number of overvoltage violations were reported were for Solar = 50 MW, Hydro = 600 MW, HLS with 16 violations. The complete counts of each of the scenario reporting upper limit voltage violations are given in Table 5.11.

The contingencies causing the most number of overvoltage violations are single line contingencies labelled SING OPN LIN 4 151-152(1) and SING OPN LIN 5 151-152(2) with 20 violations each. The complete counts of each of the contingency causing upper limit violations is given in Table 5.13.

Chapter 4

Lower Emergency Bus Voltage Violation

4.1 Introduction

In this chapter the lower voltage limit violations are reported by: bus faults, unit faults and single line faults for each of the studied scenario in a tabular format. In the reported tables, Base Voltage is PU base case voltage, Contingency Voltage is PU contingency case voltage, Deviation is difference between contingency case and base case voltage, Range Violation is range violations calculated as Contingency Voltage - minimum range limit (0.9 PU for lower emergency range).

4.2 Solar = 0 MW, Hydro = 400 MW, LLS

For the studied scenario Solar = 0 MW, Hydro = 400 MW, LLS, the buses reporting lower emergency range violations are the buses 154, 203, 205 . The buses 154, 203, 205 reported violation for the single line open fault SING OPN LIN 13 202-203(1).

Table 4.1: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 400 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	SING OPN LIN 13 202-203(1)	0.972	0.878	-0.094	-0.072
203	SING OPN LIN 13 202-203(1)	0.993	0.861	-0.132	-0.089
205	SING OPN LIN 13 202-203(1)	0.980	0.885	-0.095	-0.065

4.3 Solar = 0 MW, Hydro = 500 MW, LLS

For the studied scenario Solar = 0 MW, Hydro = 500 MW, LLS, the buses reporting lower emergency range violations are the buses 153, 154, 203, 205, 103, 204, 3007, 3008 . The buses 154, 205 reported violation for the bus fault BUS 203.

Table 4.2: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 500 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	BUS 203	0.971	0.891	-0.080	-0.059
205	BUS 203	0.980	0.899	-0.081	-0.051

The buses 153, 154 reported violation for the single line open fault SING OPN LIN 6 152-153(1). The buses 203, 205 reported violation for the single line open fault SING OPN LIN 9 201-202(1). The buses 103, 204, 3007, 3008 reported violation for the single line open fault SING OPN LIN 13 202-203(1).

Table 4.3: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 500 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
153	SING OPN LIN 6 152-153(1)	1.011	0.894	-0.117	-0.056
154	SING OPN LIN 6 152-153(1)	0.971	0.888	-0.083	-0.062
203	SING OPN LIN 9 201-202(1)	0.991	0.896	-0.095	-0.054
205	SING OPN LIN 9 201-202(1)	0.980	0.887	-0.093	-0.063
103	SING OPN LIN 13 202-203(1)	0.999	0.856	-0.144	-0.094
204	SING OPN LIN 13 202-203(1)	0.995	0.877	-0.118	-0.073
3007	SING OPN LIN 13 202-203(1)	0.987	0.891	-0.096	-0.059
3008	SING OPN LIN 13 202-203(1)	0.985	0.869	-0.116	-0.081

4.4 Solar = 0 MW, Hydro = 600 MW, LLS

For the studied scenario Solar = 0 MW, Hydro = 600 MW, LLS, the buses reporting lower emergency range violations are the buses 103, 153, 154, 203, 204, 205, 3006, 3007, 3008 . The buses 154, 205 reported violation for the bus fault BUS 153.

Table 4.4: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	BUS 153	0.959	0.877	-0.083	-0.073
205	BUS 153	0.968	0.889	-0.079	-0.061

The buses 103, 153, 154, 203, 204, 205, 3006, 3007, 3008 reported violation for the single line open fault SING OPN LIN 6 152-153(1).

Table 4.5: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	SING OPN LIN 6 152-153(1)	0.988	0.878	-0.109	-0.072
153	SING OPN LIN 6 152-153(1)	1.001	0.855	-0.146	-0.095
154	SING OPN LIN 6 152-153(1)	0.959	0.846	-0.113	-0.104
203	SING OPN LIN 6 152-153(1)	0.979	0.896	-0.084	-0.054
204	SING OPN LIN 6 152-153(1)	0.984	0.897	-0.087	-0.053
205	SING OPN LIN 6 152-153(1)	0.968	0.859	-0.109	-0.091
3006	SING OPN LIN 6 152-153(1)	1.003	0.874	-0.129	-0.076
3007	SING OPN LIN 6 152-153(1)	0.978	0.888	-0.090	-0.062
3008	SING OPN LIN 6 152-153(1)	0.975	0.877	-0.099	-0.073

4.5 Solar = 0 MW, Hydro = 400 MW, RLS

For the studied scenario Solar = 0 MW, Hydro = 400 MW, RLS, the buses reporting lower emergency range violations are the buses 103, 153, 154, 205, 3006, 3007, 3008, 202, 203, 204 . The buses 154 reported violation for the bus fault BUS 153. The buses 205 reported violation for the bus fault BUS 203.

Table 4.6: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 400 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	BUS 153	0.959	0.888	-0.071	-0.062
205	BUS 203	0.969	0.888	-0.081	-0.062

The buses 103, 153, 154, 205, 3006, 3007, 3008 reported violation for the single line open fault SING OPN LIN 6 152-153(1). The buses 202, 203, 204 reported violation for the single line open fault SING OPN LIN 9 201-202(1).

Table 4.7: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 400 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	SING OPN LIN 6 152-153(1)	0.988	0.887	-0.100	-0.063
153	SING OPN LIN 6 152-153(1)	1.004	0.864	-0.140	-0.086
154	SING OPN LIN 6 152-153(1)	0.959	0.856	-0.104	-0.094
205	SING OPN LIN 6 152-153(1)	0.969	0.870	-0.099	-0.080
3006	SING OPN LIN 6 152-153(1)	1.005	0.882	-0.122	-0.068
3007	SING OPN LIN 6 152-153(1)	0.977	0.895	-0.082	-0.055
3008	SING OPN LIN 6 152-153(1)	0.975	0.885	-0.090	-0.065
202	SING OPN LIN 9 201-202(1)	1.017	0.900	-0.117	-0.050
203	SING OPN LIN 9 201-202(1)	0.981	0.861	-0.121	-0.089
204	SING OPN LIN 9 201-202(1)	0.990	0.892	-0.098	-0.058

4.6 Solar = 0 MW, Hydro = 500 MW, RLS

For the studied scenario Solar = 0 MW, Hydro = 500 MW, RLS, the buses reporting lower emergency range violations are the buses 103, 153, 154, 203, 204, 205, 3006, 3007, 3008 . The buses 103, 154, 205, 3008 reported violation for the bus fault BUS 153. The buses 204, 3007 reported violation for the bus fault BUS 203.

Table 4.8: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 500 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	BUS 153	0.974	0.887	-0.088	-0.063
154	BUS 153	0.945	0.855	-0.091	-0.095
205	BUS 153	0.955	0.869	-0.086	-0.081
3008	BUS 153	0.963	0.896	-0.066	-0.054
204	BUS 203	0.977	0.876	-0.101	-0.074
3007	BUS 203	0.967	0.886	-0.081	-0.064

The buses 103, 153, 154, 203, 204, 205, 3006, 3007, 3008 reported violation for the single line open fault SING OPN LIN 6 152-153(1).

Table 4.9: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 500 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	SING OPN LIN 6 152-153(1)	0.974	0.849	-0.125	-0.101
153	SING OPN LIN 6 152-153(1)	0.994	0.827	-0.166	-0.123
154	SING OPN LIN 6 152-153(1)	0.945	0.816	-0.129	-0.134
203	SING OPN LIN 6 152-153(1)	0.969	0.875	-0.094	-0.075
204	SING OPN LIN 6 152-153(1)	0.977	0.881	-0.097	-0.069
205	SING OPN LIN 6 152-153(1)	0.955	0.831	-0.124	-0.119
3006	SING OPN LIN 6 152-153(1)	0.995	0.849	-0.146	-0.101
3007	SING OPN LIN 6 152-153(1)	0.967	0.864	-0.102	-0.086
3008	SING OPN LIN 6 152-153(1)	0.963	0.850	-0.113	-0.100

4.7 Solar = 0 MW, Hydro = 600 MW, RLS

For the studied scenario Solar = 0 MW, Hydro = 600 MW, RLS, the buses reporting lower emergency range violations are the buses 154, 205, 3007, 3008 . The buses 154, 205 reported violation for the bus fault BUS 3003. The buses 3007, 3008 reported violation for the bus fault BUS 3004.

Table 4.10: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	BUS 3003	0.926	0.887	-0.039	-0.063
205	BUS 3003	0.935	0.898	-0.037	-0.052
3007	BUS 3004	0.952	0.896	-0.057	-0.054
3008	BUS 3004	0.946	0.891	-0.055	-0.059

The buses 154, 205 reported violation for the single line open fault SING OPN LIN 7 153-154(1).

Table 4.11: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	SING OPN LIN 7 153-154(1)	0.926	0.888	-0.038	-0.062
205	SING OPN LIN 7 153-154(1)	0.935	0.899	-0.036	-0.051

4.8 Solar = 0 MW, Hydro = 400 MW, HLS

For the studied scenario Solar = 0 MW, Hydro = 400 MW, HLS, the buses reporting lower emergency range violations are the buses 154, 205, 103, 153, 203, 204, 206, 3005, 3006, 3007, 3008, 3018 . The buses 103, 154, 203, 204, 205, 3007, 3008 reported violation for the bus fault BUS 153.

Table 4.12: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 400 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	BUS 153	0.961	0.861	-0.099	-0.089
154	BUS 153	0.931	0.829	-0.102	-0.121
203	BUS 153	0.958	0.892	-0.067	-0.058
204	BUS 153	0.970	0.897	-0.074	-0.053
205	BUS 153	0.941	0.844	-0.097	-0.106
3007	BUS 153	0.956	0.899	-0.057	-0.051
3008	BUS 153	0.951	0.876	-0.075	-0.074

The buses 154, 205 reported violation for the single line open fault SING OPN LIN 4 151-152(1). The buses 103, 153, 203, 204, 206, 3005, 3006, 3007, 3008, 3018 reported violation for the single line open fault SING OPN LIN 6 152-153(1).

Table 4.13: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 400 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	SING OPN LIN 4 151-152(1)	0.931	0.883	-0.048	-0.067
205	SING OPN LIN 4 151-152(1)	0.941	0.894	-0.047	-0.056
103	SING OPN LIN 6 152-153(1)	0.961	0.808	-0.152	-0.142
153	SING OPN LIN 6 152-153(1)	0.986	0.789	-0.197	-0.161
203	SING OPN LIN 6 152-153(1)	0.958	0.845	-0.113	-0.105
204	SING OPN LIN 6 152-153(1)	0.970	0.856	-0.115	-0.094
206	SING OPN LIN 6 152-153(1)	1.018	0.876	-0.142	-0.074
3005	SING OPN LIN 6 152-153(1)	0.988	0.883	-0.105	-0.067
3006	SING OPN LIN 6 152-153(1)	0.987	0.814	-0.173	-0.136
3007	SING OPN LIN 6 152-153(1)	0.956	0.833	-0.124	-0.117
3008	SING OPN LIN 6 152-153(1)	0.951	0.814	-0.136	-0.136
3018	SING OPN LIN 6 152-153(1)	1.015	0.887	-0.128	-0.063

4.9 Solar = 0 MW, Hydro = 500 MW, HLS

For the studied scenario Solar = 0 MW, Hydro = 500 MW, HLS, the buses reporting lower emergency range violations are the buses 103, 154, 203, 205, 3007, 3008 . The buses 154 reported violation for the unit fault UNIT 3018(1).

Table 4.14: Unit faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 500 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	UNIT 3018(1)	0.916	0.892	-0.025	-0.058

The buses 154, 205, 3007, 3008 reported violation for the bus fault BUS 3003. The buses 103, 203 reported violation for the bus fault BUS 3004.

Table 4.15: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 500 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	BUS 3003	0.916	0.872	-0.044	-0.078
205	BUS 3003	0.926	0.884	-0.042	-0.066
3007	BUS 3003	0.945	0.889	-0.056	-0.061
3008	BUS 3003	0.938	0.886	-0.052	-0.064
103	BUS 3004	0.946	0.894	-0.052	-0.056
203	BUS 3004	0.945	0.897	-0.047	-0.053

The buses 103, 154, 203, 205, 3007, 3008 reported violation for the single line open fault SING OPN LIN 4 151-152(1).

Table 4.16: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 500 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	SING OPN LIN 4 151-152(1)	0.946	0.891	-0.055	-0.059
154	SING OPN LIN 4 151-152(1)	0.916	0.860	-0.057	-0.090
203	SING OPN LIN 4 151-152(1)	0.945	0.892	-0.053	-0.058
205	SING OPN LIN 4 151-152(1)	0.926	0.871	-0.056	-0.079
3007	SING OPN LIN 4 151-152(1)	0.945	0.899	-0.046	-0.051
3008	SING OPN LIN 4 151-152(1)	0.938	0.888	-0.050	-0.062

4.10 Solar = 0 MW, Hydro = 600 MW, HLS

For the studied scenario Solar = 0 MW, Hydro = 600 MW, HLS, the buses reporting lower emergency range violations are the buses 205, 3007, 3008, 103, 203, 3018 . The buses 205, 3007, 3008 reported violation for the unit fault UNIT 101(1). The buses 103, 3018 reported violation for the unit fault UNIT 3018(1).

Table 4.17: Unit faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
205	UNIT 101(1)	0.905	0.896	-0.009	-0.054
3007	UNIT 101(1)	0.928	0.899	-0.029	-0.051
3008	UNIT 101(1)	0.920	0.895	-0.025	-0.055
103	UNIT 3018(1)	0.925	0.898	-0.027	-0.052
3018	UNIT 3018(1)	0.986	0.883	-0.103	-0.067

The buses 205 reported violation for the bus fault BUS 3002. The buses 103 reported violation for the bus fault BUS 3008.

Table 4.18: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
205	BUS 3002	0.905	0.897	-0.008	-0.053
103	BUS 3008	0.925	0.897	-0.028	-0.053

The buses 205, 3007, 3008 reported violation for the single line open fault SING OPN LIN 1 101-151(1). The buses 103, 203 reported violation for the single line open fault SING OPN LIN 7 153-154(1).

Table 4.19: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
205	SING OPN LIN 1 101-151(1)	0.905	0.896	-0.009	-0.054
3007	SING OPN LIN 1 101-151(1)	0.928	0.899	-0.029	-0.051
3008	SING OPN LIN 1 101-151(1)	0.920	0.895	-0.025	-0.055
103	SING OPN LIN 7 153-154(1)	0.925	0.876	-0.049	-0.074
203	SING OPN LIN 7 153-154(1)	0.925	0.888	-0.037	-0.062

4.11 Solar = 50 MW, Hydro = 400 MW, LLS

For the studied scenario Solar = 50 MW, Hydro = 400 MW, LLS, the buses reporting lower emergency range violations are the buses 154, 203, 205, 103, 153, 3005, 3006, 3007, 3008, 3018 . The buses 103, 153, 154, 203, 3005, 3006, 3007, 3008, 3018 reported violation for the bus fault BUS 205.

Table 4.20: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 400 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	BUS 205	1.000	0.805	-0.195	-0.145
153	BUS 205	1.014	0.881	-0.133	-0.069
154	BUS 205	0.972	0.772	-0.201	-0.178
203	BUS 205	0.993	0.857	-0.136	-0.093
3005	BUS 205	1.015	0.894	-0.121	-0.056
3006	BUS 205	1.015	0.884	-0.131	-0.066
3007	BUS 205	0.989	0.844	-0.145	-0.106
3008	BUS 205	0.987	0.822	-0.165	-0.128
3018	BUS 205	1.050	0.894	-0.156	-0.056

The buses 154, 203, 205 reported violation for the single line open fault SING OPN LIN 13 202-203(1).

Table 4.21: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 400 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	SING OPN LIN 13 202-203(1)	0.972	0.890	-0.083	-0.060
203	SING OPN LIN 13 202-203(1)	0.993	0.873	-0.120	-0.077
205	SING OPN LIN 13 202-203(1)	0.980	0.897	-0.083	-0.053

4.12 Solar = 50 MW, Hydro = 500 MW, LLS

For the studied scenario Solar = 50 MW, Hydro = 500 MW, LLS, the buses reporting lower emergency range violations are the buses 154, 103, 203, 204, 205, 3008 . The buses 154 reported violation for the single line open fault SING OPN LIN 6 152-153(1). The buses 103, 203, 204, 205, 3008 reported violation for the single line open fault SING OPN LIN 13 202-203(1).

Table 4.22: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 500 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	SING OPN LIN 6 152-153(1)	0.972	0.899	-0.073	-0.051
103	SING OPN LIN 13 202-203(1)	0.999	0.874	-0.125	-0.076
203	SING OPN LIN 13 202-203(1)	0.991	0.824	-0.167	-0.126
204	SING OPN LIN 13 202-203(1)	0.996	0.893	-0.103	-0.057
205	SING OPN LIN 13 202-203(1)	0.980	0.850	-0.130	-0.100
3008	SING OPN LIN 13 202-203(1)	0.986	0.885	-0.101	-0.065

4.13 Solar = 50 MW, Hydro = 600 MW, LLS

For the studied scenario Solar = 50 MW, Hydro = 600 MW, LLS, the buses reporting lower emergency range violations are the buses 103, 153, 154, 205, 3006, 3007, 3008, 204 . The buses 154 reported violation for the bus fault BUS 153. The buses 103, 204, 205, 3008 reported violation for the bus fault BUS 203.

Table 4.23: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 600 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	BUS 153	0.965	0.889	-0.075	-0.061
103	BUS 203	0.992	0.872	-0.120	-0.078
204	BUS 203	0.988	0.885	-0.103	-0.065
205	BUS 203	0.973	0.848	-0.125	-0.102
3008	BUS 203	0.980	0.881	-0.098	-0.069

The buses 103, 153, 154, 205, 3006, 3007, 3008 reported violation for the single line open fault SING OPN LIN 6 152-153(1).

Table 4.24: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 600 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	SING OPN LIN 6 152-153(1)	0.992	0.890	-0.102	-0.060
153	SING OPN LIN 6 152-153(1)	1.005	0.868	-0.137	-0.082
154	SING OPN LIN 6 152-153(1)	0.965	0.860	-0.105	-0.090
205	SING OPN LIN 6 152-153(1)	0.973	0.873	-0.101	-0.077
3006	SING OPN LIN 6 152-153(1)	1.007	0.886	-0.121	-0.064
3007	SING OPN LIN 6 152-153(1)	0.982	0.898	-0.083	-0.052
3008	SING OPN LIN 6 152-153(1)	0.980	0.888	-0.091	-0.062

4.14 Solar = 50 MW, Hydro = 400 MW, RLS

For the studied scenario Solar = 50 MW, Hydro = 400 MW, RLS, the buses reporting lower emergency range violations are the buses 103, 153, 154, 205, 3006, 3008, 203, 3007 . The buses 154 reported violation for the bus fault BUS 153. The buses 205 reported violation for the bus fault BUS 203.

Table 4.25: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 400 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	BUS 153	0.964	0.898	-0.066	-0.052
205	BUS 203	0.973	0.899	-0.074	-0.051

The buses 103, 153, 154, 205, 3006, 3008 reported violation for the single line open fault SING OPN LIN 6 152-153(1). The buses 203, 3007 reported violation for the single line open fault SING OPN LIN 9 201-202(1).

Table 4.26: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 400 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	SING OPN LIN 6 152-153(1)	0.991	0.897	-0.094	-0.053
153	SING OPN LIN 6 152-153(1)	1.007	0.874	-0.134	-0.076
154	SING OPN LIN 6 152-153(1)	0.964	0.867	-0.097	-0.083
205	SING OPN LIN 6 152-153(1)	0.973	0.881	-0.092	-0.069
3006	SING OPN LIN 6 152-153(1)	1.008	0.892	-0.116	-0.058
3008	SING OPN LIN 6 152-153(1)	0.979	0.894	-0.084	-0.056
203	SING OPN LIN 9 201-202(1)	0.985	0.880	-0.106	-0.070
3007	SING OPN LIN 9 201-202(1)	0.981	0.900	-0.081	-0.050

4.15 Solar = 50 MW, Hydro = 500 MW, RLS

For the studied scenario Solar = 50 MW, Hydro = 500 MW, RLS, the buses reporting lower emergency range violations are the buses 103, 153, 154, 203, 204, 205, 3006, 3007, 3008 . The buses 103, 154, 205 reported violation for the bus fault BUS 153. The buses 204, 3007, 3008 reported violation for the bus fault BUS 203.

Table 4.27: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 500 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	BUS 153	0.978	0.898	-0.080	-0.052
154	BUS 153	0.951	0.868	-0.082	-0.082
205	BUS 153	0.960	0.882	-0.078	-0.068
204	BUS 203	0.981	0.890	-0.091	-0.060
3007	BUS 203	0.971	0.899	-0.072	-0.051
3008	BUS 203	0.967	0.880	-0.087	-0.070

The buses 103, 153, 154, 203, 204, 205, 3006, 3007, 3008 reported violation for the single line open fault SING OPN LIN 6 152-153(1).

Table 4.28: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 500 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	SING OPN LIN 6 152-153(1)	0.978	0.864	-0.115	-0.086
153	SING OPN LIN 6 152-153(1)	0.998	0.843	-0.155	-0.107
154	SING OPN LIN 6 152-153(1)	0.951	0.833	-0.118	-0.117
203	SING OPN LIN 6 152-153(1)	0.974	0.889	-0.085	-0.061
204	SING OPN LIN 6 152-153(1)	0.981	0.894	-0.088	-0.056
205	SING OPN LIN 6 152-153(1)	0.960	0.847	-0.113	-0.103
3006	SING OPN LIN 6 152-153(1)	0.999	0.863	-0.136	-0.087
3007	SING OPN LIN 6 152-153(1)	0.971	0.877	-0.093	-0.073
3008	SING OPN LIN 6 152-153(1)	0.967	0.865	-0.103	-0.085

4.16 Solar = 50 MW, Hydro = 600 MW, RLS

For the studied scenario Solar = 50 MW, Hydro = 600 MW, RLS, the buses reporting lower emergency range violations are the buses 154, 205, 3008 . The buses 154 reported violation for the bus fault BUS 3003. The buses 205, 3008 reported violation for the bus fault BUS 3004.

Table 4.29: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 600 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	BUS 3003	0.932	0.897	-0.035	-0.053
205	BUS 3004	0.942	0.893	-0.049	-0.057
3008	BUS 3004	0.952	0.899	-0.053	-0.051

The buses 154, 205 reported violation for the single line open fault SING OPN LIN 4 151-152(1).

Table 4.30: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 600 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	SING OPN LIN 4 151-152(1)	0.932	0.881	-0.051	-0.069
205	SING OPN LIN 4 151-152(1)	0.942	0.891	-0.051	-0.059

4.17 Solar = 50 MW, Hydro = 400 MW, HLS

For the studied scenario Solar = 50 MW, Hydro = 400 MW, HLS, the buses reporting lower emergency range violations are the buses 154, 103, 205, 3008, 204, 3007 . The buses 103, 154, 205, 3008 reported violation for the bus fault BUS 153. The buses 204, 3007 reported violation for the bus fault BUS 203.

Table 4.31: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 400 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	BUS 153	0.965	0.875	-0.090	-0.075
154	BUS 153	0.937	0.844	-0.092	-0.106
205	BUS 153	0.946	0.859	-0.087	-0.091
3008	BUS 153	0.955	0.889	-0.067	-0.061
204	BUS 203	0.975	0.895	-0.080	-0.055
3007	BUS 203	0.960	0.898	-0.062	-0.052

The buses 154 reported violation for the single line open fault SING OPN LIN 4 151-152(1).

Table 4.32: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 400 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	SING OPN LIN 4 151-152(1)	0.937	0.891	-0.045	-0.059

4.18 Solar = 50 MW, Hydro = 500 MW, HLS

For the studied scenario Solar = 50 MW, Hydro = 500 MW, HLS, the buses reporting lower emergency range violations are the buses 103, 154, 205, 3008, 3007 . The buses 154 reported violation for the unit fault UNIT 3018(1).

Table 4.33: Unit faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 500 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	UNIT 3018(1)	0.923	0.899	-0.024	-0.051

The buses 154, 205, 3007, 3008 reported violation for the bus fault BUS 3003.

Table 4.34: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 500 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	BUS 3003	0.923	0.882	-0.040	-0.068
205	BUS 3003	0.932	0.894	-0.038	-0.056
3007	BUS 3003	0.949	0.898	-0.052	-0.052
3008	BUS 3003	0.943	0.896	-0.048	-0.054

The buses 103, 154, 205, 3008 reported violation for the single line open fault SING OPN LIN 4 151-152(1).

Table 4.35: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 500 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	SING OPN LIN 4 151-152(1)	0.951	0.899	-0.052	-0.051
154	SING OPN LIN 4 151-152(1)	0.923	0.869	-0.053	-0.081
205	SING OPN LIN 4 151-152(1)	0.932	0.880	-0.052	-0.070
3008	SING OPN LIN 4 151-152(1)	0.943	0.896	-0.047	-0.054

4.19 Solar = 50 MW, Hydro = 600 MW, HLS

For the studied scenario Solar = 50 MW, Hydro = 600 MW, HLS, the buses reporting lower emergency range violations are the buses 154, 205, 103, 203, 3008, 3007, 204, 3018 . The buses 154 reported violation for the unit fault UNIT 101(1). The buses 103, 205 reported violation for the unit fault UNIT 103(1). The buses 3008, 3018 reported violation for the unit fault UNIT 3018(1).

Table 4.36: Unit faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 600 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	UNIT 101(1)	0.902	0.895	-0.007	-0.055
103	UNIT 103(1)	0.931	0.884	-0.047	-0.066
205	UNIT 103(1)	0.912	0.894	-0.018	-0.056
3008	UNIT 3018(1)	0.926	0.890	-0.036	-0.060
3018	UNIT 3018(1)	0.991	0.890	-0.101	-0.060

The buses 154 reported violation for the bus fault BUS 3002. The buses 103, 203, 205, 3007, 3008 reported violation for the bus fault BUS 3003. The buses 204 reported violation for the bus fault BUS 3005.

Table 4.37: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 600 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	BUS 3002	0.902	0.895	-0.007	-0.055
103	BUS 3003	0.931	0.878	-0.053	-0.072
203	BUS 3003	0.932	0.885	-0.046	-0.065
205	BUS 3003	0.912	0.860	-0.052	-0.090
3007	BUS 3003	0.934	0.866	-0.067	-0.084
3008	BUS 3003	0.926	0.863	-0.063	-0.087
204	BUS 3005	0.943	0.899	-0.044	-0.051

The buses 154 reported violation for the single line open fault SING OPN LIN 1 101-151(1). The buses 205 reported violation for the single line open fault SING OPN LIN 3 103-154(1). The buses 103, 203, 3008 reported violation for the single line open fault SING OPN LIN 7 153-154(1). The buses 3007 reported violation for the single line open fault SING OPN LIN 18 3001-3003(1).

Table 4.38: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 600 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	SING OPN LIN 1 101-151(1)	0.902	0.895	-0.007	-0.055
205	SING OPN LIN 3 103-154(1)	0.912	0.894	-0.018	-0.056
103	SING OPN LIN 7 153-154(1)	0.931	0.886	-0.045	-0.064
203	SING OPN LIN 7 153-154(1)	0.932	0.898	-0.034	-0.052
3008	SING OPN LIN 7 153-154(1)	0.926	0.891	-0.035	-0.059
3007	SING OPN LIN 18 3001-3003(1)	0.934	0.873	-0.061	-0.077

4.20 Solar = 100 MW, Hydro = 400 MW, LLS

For the studied scenario Solar = 100 MW, Hydro = 400 MW, LLS, the buses reporting lower emergency range violations are the buses 154, 203, 103, 153, 3006, 3007, 3008 . The buses 103, 153, 154, 203, 3006, 3007, 3008 reported violation for the bus fault BUS 205.

Table 4.39: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 400 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	BUS 205	0.997	0.816	-0.181	-0.134
153	BUS 205	1.015	0.893	-0.122	-0.057
154	BUS 205	0.973	0.788	-0.184	-0.162
203	BUS 205	0.994	0.871	-0.123	-0.079
3006	BUS 205	1.016	0.896	-0.120	-0.054
3007	BUS 205	0.990	0.857	-0.133	-0.093
3008	BUS 205	0.988	0.836	-0.152	-0.114

The buses 154, 203 reported violation for the single line open fault SING OPN LIN 13 202-203(1).

Table 4.40: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 400 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	SING OPN LIN 13 202-203(1)	0.973	0.898	-0.075	-0.052
203	SING OPN LIN 13 202-203(1)	0.994	0.882	-0.112	-0.068

4.21 Solar = 100 MW, Hydro = 500 MW, LLS

For the studied scenario Solar = 100 MW, Hydro = 500 MW, LLS, the buses reporting lower emergency range violations are the buses 103, 154, 203, 205, 3008 . The buses 103, 154, 203, 205, 3008 reported violation for the single line open fault SING OPN LIN 13 202-203(1).

Table 4.41: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 500 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	SING OPN LIN 13 202-203(1)	0.996	0.883	-0.114	-0.067
154	SING OPN LIN 13 202-203(1)	0.972	0.856	-0.116	-0.094
203	SING OPN LIN 13 202-203(1)	0.992	0.838	-0.154	-0.112
205	SING OPN LIN 13 202-203(1)	0.980	0.863	-0.117	-0.087
3008	SING OPN LIN 13 202-203(1)	0.987	0.896	-0.090	-0.054

4.22 Solar = 100 MW, Hydro = 600 MW, LLS

For the studied scenario Solar = 100 MW, Hydro = 600 MW, LLS, the buses reporting lower emergency range violations are the buses 103, 153, 154, 205, 3006, 3008, 202, 203, 204, 3007 . The buses 154 reported violation for the bus fault BUS 153. The buses 103, 204, 205, 3008 reported violation for the bus fault BUS 203.

Table 4.42: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 600 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	BUS 153	0.968	0.898	-0.070	-0.052
103	BUS 203	0.993	0.880	-0.113	-0.070
204	BUS 203	0.991	0.896	-0.095	-0.054
205	BUS 203	0.977	0.861	-0.116	-0.089
3008	BUS 203	0.983	0.892	-0.091	-0.058

The buses 103, 153, 154, 205, 3006, 3008 reported violation for the single line open fault SING OPN LIN 6 152-153(1). The buses 202, 203, 204, 3007 reported violation for the single line open fault SING OPN LIN 9 201-202(1).

Table 4.43: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 600 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	SING OPN LIN 6 152-153(1)	0.993	0.897	-0.097	-0.053
153	SING OPN LIN 6 152-153(1)	1.009	0.877	-0.131	-0.073
154	SING OPN LIN 6 152-153(1)	0.968	0.870	-0.098	-0.080
205	SING OPN LIN 6 152-153(1)	0.977	0.883	-0.094	-0.067
3006	SING OPN LIN 6 152-153(1)	1.010	0.894	-0.115	-0.056
3008	SING OPN LIN 6 152-153(1)	0.983	0.897	-0.086	-0.053
202	SING OPN LIN 9 201-202(1)	1.019	0.896	-0.124	-0.054
203	SING OPN LIN 9 201-202(1)	0.988	0.858	-0.129	-0.092
204	SING OPN LIN 9 201-202(1)	0.991	0.880	-0.111	-0.070
3007	SING OPN LIN 9 201-202(1)	0.985	0.885	-0.100	-0.065

4.23 Solar = 100 MW, Hydro = 400 MW, RLS

For the studied scenario Solar = 100 MW, Hydro = 400 MW, RLS, the buses reporting lower emergency range violations are the buses 153, 154, 205, 3006, 103, 203, 204, 3007, 3008 . The buses 154 reported violation for the bus fault BUS 203.

Table 4.44: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 400 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	BUS 203	0.967	0.898	-0.069	-0.052

The buses 153, 154, 205, 3006 reported violation for the single line open fault SING OPN LIN 6 152-153(1). The buses 103, 203 reported violation for the single line open fault SING OPN LIN 9 201-202(1). The buses 204, 3007, 3008 reported violation for the single line open fault SING OPN LIN 13 202-203(1).

Table 4.45: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 400 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
153	SING OPN LIN 6 152-153(1)	1.010	0.881	-0.129	-0.069
154	SING OPN LIN 6 152-153(1)	0.967	0.875	-0.092	-0.075
205	SING OPN LIN 6 152-153(1)	0.976	0.889	-0.088	-0.061
3006	SING OPN LIN 6 152-153(1)	1.011	0.899	-0.112	-0.051
103	SING OPN LIN 9 201-202(1)	0.992	0.898	-0.093	-0.052
203	SING OPN LIN 9 201-202(1)	0.988	0.893	-0.096	-0.057
204	SING OPN LIN 13 202-203(1)	0.996	0.874	-0.123	-0.076
3007	SING OPN LIN 13 202-203(1)	0.983	0.882	-0.101	-0.068
3008	SING OPN LIN 13 202-203(1)	0.981	0.858	-0.123	-0.092

4.24 Solar = 100 MW, Hydro = 500 MW, RLS

For the studied scenario Solar = 100 MW, Hydro = 500 MW, RLS, the buses reporting lower emergency range violations are the buses 103, 153, 154, 203, 205, 3006, 3007, 3008 . The buses 154, 205 reported violation for the bus fault BUS 153. The buses 103, 3008 reported violation for the bus fault BUS 203.

Table 4.46: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 500 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	BUS 153	0.954	0.877	-0.077	-0.073
205	BUS 153	0.964	0.891	-0.073	-0.059
103	BUS 203	0.979	0.879	-0.101	-0.071
3008	BUS 203	0.971	0.890	-0.080	-0.060

The buses 103, 153, 154, 203, 205, 3006, 3007, 3008 reported violation for the single line open fault SING OPN LIN 6 152-153(1).

Table 4.47: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 500 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	SING OPN LIN 6 152-153(1)	0.979	0.870	-0.109	-0.080
153	SING OPN LIN 6 152-153(1)	1.001	0.853	-0.148	-0.097
154	SING OPN LIN 6 152-153(1)	0.954	0.843	-0.111	-0.107
203	SING OPN LIN 6 152-153(1)	0.977	0.898	-0.079	-0.052
205	SING OPN LIN 6 152-153(1)	0.964	0.858	-0.106	-0.092
3006	SING OPN LIN 6 152-153(1)	1.002	0.872	-0.129	-0.078
3007	SING OPN LIN 6 152-153(1)	0.974	0.886	-0.088	-0.064
3008	SING OPN LIN 6 152-153(1)	0.971	0.874	-0.097	-0.076

4.25 Solar = 100 MW, Hydro = 600 MW, RLS

For the studied scenario Solar = 100 MW, Hydro = 600 MW, RLS, the buses reporting lower emergency range violations are the buses 154, 205, 103, 203, 204, 3008 . The buses 103, 154, 203, 204, 205, 3008 reported violation for the bus fault BUS 153.

Table 4.48: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 600 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	BUS 153	0.962	0.859	-0.103	-0.091
154	BUS 153	0.937	0.832	-0.105	-0.118
203	BUS 153	0.961	0.890	-0.071	-0.060
204	BUS 153	0.969	0.891	-0.078	-0.059
205	BUS 153	0.946	0.846	-0.100	-0.104
3008	BUS 153	0.956	0.878	-0.078	-0.072

The buses 154, 205 reported violation for the single line open fault SING OPN LIN 4 151-152(1).

Table 4.49: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 600 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	SING OPN LIN 4 151-152(1)	0.937	0.888	-0.049	-0.062
205	SING OPN LIN 4 151-152(1)	0.946	0.898	-0.048	-0.052

4.26 Solar = 100 MW, Hydro = 400 MW, HLS

For the studied scenario Solar = 100 MW, Hydro = 400 MW, HLS, the buses reporting lower emergency range violations are the buses 154, 103, 153, 203, 204, 205, 3006, 3007, 3008 . The buses 103, 154, 205, 3008 reported violation for the bus fault BUS 153.

Table 4.50: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 400 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	BUS 153	0.965	0.881	-0.085	-0.069
154	BUS 153	0.940	0.854	-0.086	-0.096
205	BUS 153	0.950	0.869	-0.081	-0.081
3008	BUS 153	0.959	0.897	-0.062	-0.053

The buses 154 reported violation for the single line open fault SING OPN LIN 4 151-152(1). The buses 103, 153, 203, 204, 205, 3006, 3007, 3008 reported violation for the single line open fault SING OPN LIN 6 152-153(1).

Table 4.51: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 400 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	SING OPN LIN 4 151-152(1)	0.940	0.897	-0.043	-0.053
103	SING OPN LIN 6 152-153(1)	0.965	0.839	-0.127	-0.111
153	SING OPN LIN 6 152-153(1)	0.993	0.823	-0.169	-0.127
203	SING OPN LIN 6 152-153(1)	0.966	0.876	-0.091	-0.074
204	SING OPN LIN 6 152-153(1)	0.978	0.884	-0.093	-0.066
205	SING OPN LIN 6 152-153(1)	0.950	0.827	-0.123	-0.123
3006	SING OPN LIN 6 152-153(1)	0.994	0.846	-0.148	-0.104
3007	SING OPN LIN 6 152-153(1)	0.963	0.862	-0.102	-0.088
3008	SING OPN LIN 6 152-153(1)	0.959	0.847	-0.112	-0.103

4.27 Solar = 100 MW, Hydro = 500 MW, HLS

For the studied scenario Solar = 100 MW, Hydro = 500 MW, HLS, the buses reporting lower emergency range violations are the buses 154, 205, 103, 203, 204, 3007, 3008 . The buses 103, 154, 203, 204, 205, 3007, 3008 reported violation for the bus fault BUS 153.

Table 4.52: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 500 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	BUS 153	0.952	0.843	-0.109	-0.107
154	BUS 153	0.927	0.816	-0.111	-0.134
203	BUS 153	0.954	0.881	-0.073	-0.069
204	BUS 153	0.965	0.885	-0.080	-0.065
205	BUS 153	0.937	0.832	-0.105	-0.118
3007	BUS 153	0.953	0.890	-0.063	-0.060
3008	BUS 153	0.947	0.866	-0.081	-0.084

The buses 154, 205 reported violation for the single line open fault SING OPN LIN 4 151-152(1).

Table 4.53: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 500 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	SING OPN LIN 4 151-152(1)	0.927	0.876	-0.050	-0.074
205	SING OPN LIN 4 151-152(1)	0.937	0.887	-0.050	-0.063

4.28 Solar = 100 MW, Hydro = 600 MW, HLS

For the studied scenario Solar = 100 MW, Hydro = 600 MW, HLS, the buses reporting lower emergency range violations are the buses 154, 205, 103, 3008, 203, 3007, 3018 . The buses 103, 154, 205 reported violation for the unit fault UNIT 103(1). The buses 3008, 3018 reported violation for the unit fault UNIT 3018(1).

Table 4.54: Unit faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 600 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	UNIT 103(1)	0.933	0.884	-0.050	-0.066
154	UNIT 103(1)	0.907	0.884	-0.024	-0.066
205	UNIT 103(1)	0.917	0.894	-0.023	-0.056
3008	UNIT 3018(1)	0.931	0.896	-0.035	-0.054
3018	UNIT 3018(1)	0.996	0.896	-0.100	-0.054

The buses 103, 154, 203, 205, 3007, 3008 reported violation for the bus fault BUS 3003.

Table 4.55: Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 600 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
103	BUS 3003	0.933	0.884	-0.049	-0.066
154	BUS 3003	0.907	0.857	-0.050	-0.093
203	BUS 3003	0.937	0.894	-0.043	-0.056
205	BUS 3003	0.917	0.869	-0.048	-0.081
3007	BUS 3003	0.938	0.875	-0.063	-0.075
3008	BUS 3003	0.931	0.872	-0.058	-0.078

The buses 154, 205 reported violation for the single line open fault SING OPN LIN 3 103-154(1). The buses 103, 3008 reported violation for the single line open fault SING OPN LIN 7 153-154(1). The buses 203, 3007 reported violation for the single line open fault SING OPN LIN 18 3001-3003(1).

Table 4.56: Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 600 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
154	SING OPN LIN 3 103-154(1)	0.907	0.884	-0.024	-0.066
205	SING OPN LIN 3 103-154(1)	0.917	0.894	-0.023	-0.056
103	SING OPN LIN 7 153-154(1)	0.933	0.890	-0.043	-0.060
3008	SING OPN LIN 7 153-154(1)	0.931	0.898	-0.032	-0.052
203	SING OPN LIN 18 3001-3003(1)	0.937	0.898	-0.038	-0.052
3007	SING OPN LIN 18 3001-3003(1)	0.938	0.882	-0.056	-0.068

4.29 Results Summary

The Tables 5.14, 5.15, 5.16 summarises the results of the AC contingency calculation carried out on the hypothetical SAVNW system for Topology 3 for lower emergency bus voltage violations by tabulating the summary of lower voltage violations grouped by scenario and contingency to give the buses reporting lower voltage range violation and count of the lower voltage range violations.

It was seen that the scenario Solar = 0 MW, Hydro = 400 MW, HLS reported the most number of lower limit violation for SING OPN LIN 6 152-153(1) with 12 buses reporting violation. The complete counts of each of the scenario reporting lower limit voltage violations are given in Table 5.18.

The bus reporting the most number of lower voltage limit violation is the bus 154 with 308 violations followed by bus 205 with 236 violations. The Table 5.17 in the Appendix gives the count of times a bus violate the lower voltage limit $< 0.9PU$.

The contingency causing the most number of lower voltage limit violation is the single open line fault SING OPN LIN 6 152-153(1) with 178, followed by BUS 203 with 98, BUS 153 with 86, and BUS 3004 with 82 lower limit violation across all the studied scenarios. The Table 5.19 in the Appendix gives the contingencies and no of times a contingency causes a lower voltage limit violation $< 0.9PU$.

The scenario reporting the most number of lower voltage limit violation is the scenario Solar = 50 MW, Hydro = 600 MW, HLS with 132 followed by Solar = 100 MW, Hydro = 600 MW, HLS with 102 reported violations. Table 5.18 in the Appendix gives the number of times a studied scenario reported a lower voltage limit violation $< 0.9PU$.

Chapter 5

Conculsion

The contingency analysis was carried out on the hypothetical SAVNW study system for the Year 3, Topology 3 for 27 study scenarios for (N-1) bus, single line open, unit contingencies. Out of all the studied (N-1) contingencies, the contingencies for which the system did not converge are tabulated in Table 5.1 with the corresponding number of scenarios.

It can be seen from the Table 5.1, for the (N-1) contingencies corresponding to bus faults BUS 151, BUS 152, BUS 201, BUS 202, unit fault corresponding to UNIT 206(1), and single line open contingencies corresponding to SING OPN LIN 205-206(1), SING OPN LIN 201-205(&1) load flow did not converge for any of the 27 studied scenarios. For the (N-1) contingency BUS 205 load flow did not converge for 25 of the studied scenarios, followed by SING OPN LIN 202-203(1) for 20 scenarios and SING OPN LIN 201-202(1) for 17 of the studied scenarios each.

Table 5.1: Count of scenarios in Topology 3 for which tested contingency failed to converge

Contingency	Count of Scenarios
BUS 151	27
SING OPN LIN 10 201-205(&1)	27
BUS 152	27
BUS 202	27
UNIT 206(1)	27
SING OPN LIN 16 205-206(1)	27
BUS 201	27
BUS 205	25
SING OPN LIN 13 202-203(1)	20
SING OPN LIN 9 201-202(1)	17
BUS 203	10
SING OPN LIN 6 152-153(1)	10
BUS 153	7
SING OPN LIN 5 151-152(2)	4
SING OPN LIN 4 151-152(1)	4
BUS 3005	1
SING OPN LIN 18 3001-3003(1)	1
BUS 3003	1
BUS 3004	1

For the converged contingency scenarios, Chapter 2 studied the branch overload violations, Chapter 3 studied the upper limit voltage violation, and Chapter 4 studied the lower limit voltage violations.

In the Chapter 2 branches reporting loading greater than 100% were tabulated for each scenario and from the table, branches reporting loading greater than 130% were also noted down. It was seen that the branch with most number of overload violation were reported for branch 3001-3003(1) with 116 loading violation followed by branches 3005-3007(1) with 63, 153-154(1) with 48, 153-154(2) with 45, and 101-151(1) with 44 violations.

In the Chapter 3 buses reporting voltage greater than 1.1 PU (violation of upper limit) were studied and it was seen that the generator buses 211 and 212 reported the upper limit violation of 38 times each. In the Chapter 4 buses reporting voltage less than 0.9 PU (violation of lower limit) were tabulated, there were multiple buses reporting lower limit violations and the Bus 154 with 308 violations, followed by Bus 205 with 236, 3008 with 154, and 103 with 120 violations constituted to the top number of violations.

The system scenarios for which the faults caused violation needs to be studied for long term planning for system reinforcements, and for alternate dispatch arrangements and demand side measures for operational planning to ensure system operates within the specified tolerance levels when such a contingency occurs.

Appendix

5.1 Loading > 100% Counts

5.1.1 Summary of Branch Overload grouped by Scenario and Contingency

Table 5.2: Summary of Branch Overload grouped by Scenario and Contingency

Scenario	Contingency	Branches	Branch Count
Solar = 0 MW, Hydro = 600 MW, HLS	BASE CASE	153-154(1),153-154(2),202-203(1),204-205(1),3001-3003(1),3005-3007(1)	6
Solar = 0 MW, Hydro = 500 MW, RLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),202-203(1),203-205(1),203-205(2),3001-3003(1)	6
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 153	154-203(1),154-205(1),202-203(1),3001-3003(1),3005-3007(1)	5
Solar = 100 MW, Hydro = 600 MW, RLS	BUS 153	154-203(1),202-203(1),203-205(1),203-205(2),3005-3007(1)	5
Solar = 50 MW, Hydro = 600 MW, HLS	BASE CASE	153-154(1),202-203(1),204-205(1),3001-3003(1),3005-3007(1)	5
Solar = 100 MW, Hydro = 500 MW, HLS	BUS 153	154-203(1),154-205(1),202-203(1),3001-3003(1),3005-3007(1)	5
Solar = 50 MW, Hydro = 600 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1),202-203(1),203-205(1),203-205(2),3001-3003(1)	5
Solar = 0 MW, Hydro = 600 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1),202-203(1),203-205(1),203-205(2),3001-3003(1)	5
Solar = 0 MW, Hydro = 600 MW, LLS	BUS 153	154-203(1),202-203(1),203-205(1),203-205(2),3005-3007(1)	5
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 0 MW, Hydro = 500 MW, HLS	UNIT 101(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 50 MW, Hydro = 500 MW, RLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),202-203(1),3001-3003(1)	4
Solar = 0 MW, Hydro = 500 MW, RLS	BUS 153	154-203(1),154-205(1),202-203(1),3005-3007(1)	4
Solar = 0 MW, Hydro = 500 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 100 MW, Hydro = 600 MW, HLS	UNIT 101(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 0 MW, Hydro = 500 MW, RLS	UNIT 101(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 0 MW, Hydro = 400 MW, RLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),202-203(1),3001-3003(1)	4
Solar = 50 MW, Hydro = 500 MW, HLS	UNIT 101(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 50 MW, Hydro = 400 MW, HLS	BUS 153	154-203(1),154-205(1),202-203(1),3005-3007(1)	4
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 50 MW, Hydro = 400 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 0 MW, Hydro = 600 MW, RLS	UNIT 101(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 100 MW, Hydro = 400 MW, HLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),202-203(1),3001-3003(1)	4
Solar = 50 MW, Hydro = 400 MW, LLS	BUS 205	153-154(1),153-154(2),154-203(1),3001-3003(1)	4
Solar = 100 MW, Hydro = 500 MW, RLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),202-203(1),3001-3003(1)	4
Solar = 50 MW, Hydro = 400 MW, HLS	UNIT 101(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 0 MW, Hydro = 400 MW, HLS	UNIT 101(1)	3001-3003(1),3003-3005(1),3003-3005(2),3005-3007(1)	4
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),202-203(1),3001-3003(1)	4
Solar = 100 MW, Hydro = 400 MW, RLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),3001-3003(1)	3
Solar = 50 MW, Hydro = 500 MW, LLS	SING OPN LIN 13 202-203(1)	153-154(1),153-154(2),3005-3007(1)	3
Solar = 50 MW, Hydro = 400 MW, HLS	BUS 203	153-154(1),153-154(2),3005-3007(1)	3
Solar = 0 MW, Hydro = 500 MW, RLS	BUS 203	153-154(2),3001-3003(1),3005-3007(1)	3
Solar = 100 MW, Hydro = 600 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1),202-203(1),3001-3003(1)	3
Solar = 50 MW, Hydro = 500 MW, RLS	BUS 153	154-203(1),202-203(1),3005-3007(1)	3
Solar = 0 MW, Hydro = 500 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),202-203(1)	3
Solar = 0 MW, Hydro = 500 MW, LLS	SING OPN LIN 13 202-203(1)	153-154(1),153-154(2),3005-3007(1)	3
Solar = 50 MW, Hydro = 400 MW, RLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),3001-3003(1)	3
Solar = 100 MW, Hydro = 400 MW, HLS	BUS 153	154-203(1),154-205(1),3005-3007(1)	3
Solar = 100 MW, Hydro = 400 MW, HLS	BUS 203	153-154(1),153-154(2),3005-3007(1)	3
Solar = 100 MW, Hydro = 500 MW, LLS	SING OPN LIN 13 202-203(1)	153-154(1),153-154(2),3005-3007(1)	3
Solar = 0 MW, Hydro = 400 MW, RLS	BUS 203	153-154(1),153-154(2),3005-3007(1)	3
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 203	153-154(2),3001-3003(1),3005-3007(1)	3

Table 5.3: Summary of Branch Overload grouped by Scenario and Contingency - Continued

Scenario	Contingency	Branches	Branch Count
Solar = 100 MW, Hydro = 400 MW, LLS	BUS 205	153-154(1),154-203(1),3001-3003(1)	3
Solar = 100 MW, Hydro = 400 MW, RLS	SING OPN LIN 13 202-203(1)	153-154(1),153-154(2),3005-3007(1)	3
Solar = 100 MW, Hydro = 500 MW, RLS	BUS 203	153-154(1),153-154(2),3005-3007(1)	3
Solar = 100 MW, Hydro = 400 MW, HLS	UNIT 101(1)	3001-3003(1),3005-3007(1)	2
Solar = 0 MW, Hydro = 600 MW, HLS	UNIT 101(1)	3003-3005(1),3003-3005(2)	2
Solar = 100 MW, Hydro = 500 MW, HLS	UNIT 101(1)	3001-3003(1),3005-3007(1)	2
Solar = 0 MW, Hydro = 600 MW, LLS	BASE CASE	153-154(1),204-205(1)	2
Solar = 50 MW, Hydro = 400 MW, LLS	BUS 203	153-154(1),153-154(2)	2
Solar = 100 MW, Hydro = 400 MW, LLS	SING OPN LIN 13 202-203(1)	153-154(1),153-154(2)	2
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3005-3007(1)	2
Solar = 100 MW, Hydro = 400 MW, LLS	BUS 203	153-154(1),153-154(2)	2
Solar = 50 MW, Hydro = 400 MW, RLS	BUS 203	153-154(1),153-154(2)	2
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 7 153-154(1)	153-154(2),3005-3007(1)	2
Solar = 0 MW, Hydro = 600 MW, RLS	BASE CASE	153-154(1),204-205(1)	2
Solar = 50 MW, Hydro = 400 MW, LLS	SING OPN LIN 13 202-203(1)	153-154(1),153-154(2)	2
Solar = 100 MW, Hydro = 600 MW, LLS	BUS 153	154-203(1),202-203(1)	2
Solar = 50 MW, Hydro = 600 MW, RLS	UNIT 101(1)	3001-3003(1),3005-3007(1)	2
Solar = 100 MW, Hydro = 400 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3005-3007(1)	2
Solar = 50 MW, Hydro = 400 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1)	2
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 1 101-151(1)	3003-3005(1),3003-3005(2)	2
Solar = 50 MW, Hydro = 400 MW, RLS	BUS 153	154-203(1),154-205(1)	2
Solar = 100 MW, Hydro = 400 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3005-3007(1)	2
Solar = 50 MW, Hydro = 600 MW, LLS	BUS 203	153-154(2),3005-3007(1)	2
Solar = 100 MW, Hydro = 600 MW, RLS	UNIT 101(1)	3001-3003(1),3005-3007(1)	2
Solar = 100 MW, Hydro = 600 MW, LLS	BUS 203	153-154(2),3005-3007(1)	2
Solar = 50 MW, Hydro = 600 MW, HLS	UNIT 101(1)	3003-3005(1),3003-3005(2)	2
Solar = 0 MW, Hydro = 500 MW, LLS	BUS 153	154-203(1),202-203(1)	2
Solar = 100 MW, Hydro = 600 MW, HLS	BASE CASE	153-154(1),204-205(1)	2
Solar = 50 MW, Hydro = 500 MW, RLS	UNIT 101(1)	3001-3003(1),3005-3007(1)	2
Solar = 0 MW, Hydro = 500 MW, LLS	BUS 203	153-154(1),153-154(2)	2
Solar = 50 MW, Hydro = 500 MW, LLS	BUS 203	153-154(1),153-154(2)	2
Solar = 100 MW, Hydro = 600 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3005-3007(1)	2
Solar = 0 MW, Hydro = 400 MW, RLS	BUS 153	154-203(1),154-205(1)	2
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 1 101-151(1)	3003-3005(1),3003-3005(2)	2
Solar = 50 MW, Hydro = 500 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3005-3007(1)	2
Solar = 0 MW, Hydro = 400 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1)	2
Solar = 100 MW, Hydro = 500 MW, RLS	BUS 153	154-203(1),202-203(1)	2
Solar = 0 MW, Hydro = 400 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3005-3007(1)	2
Solar = 50 MW, Hydro = 500 MW, RLS	BUS 203	153-154(2),3005-3007(1)	2
Solar = 100 MW, Hydro = 400 MW, RLS	BUS 203	153-154(1),153-154(2)	2
Solar = 0 MW, Hydro = 400 MW, LLS	SING OPN LIN 13 202-203(1)	153-154(1),153-154(2)	2
Solar = 100 MW, Hydro = 500 MW, LLS	BUS 203	153-154(1),153-154(2)	2
Solar = 50 MW, Hydro = 500 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1),202-203(1)	2
Solar = 50 MW, Hydro = 600 MW, LLS	BUS 153	154-203(1),202-203(1)	2
Solar = 0 MW, Hydro = 400 MW, LLS	BUS 203	153-154(1),153-154(2)	2
Solar = 50 MW, Hydro = 600 MW, RLS	BASE CASE	153-154(1),204-205(1)	2
Solar = 0 MW, Hydro = 400 MW, RLS	UNIT 101(1)	3001-3003(1),3005-3007(1)	2
Solar = 100 MW, Hydro = 600 MW, LLS	SING OPN LIN 7 153-154(1)	153-154(2)	1
Solar = 100 MW, Hydro = 600 MW, LLS	UNIT 101(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 600 MW, RLS	BUS 3004	3001-3003(1)	1
Solar = 50 MW, Hydro = 400 MW, HLS	SING OPN LIN 8 153-154(2)	153-154(1)	1
Solar = 100 MW, Hydro = 600 MW, RLS	BASE CASE	153-154(1)	1
Solar = 100 MW, Hydro = 600 MW, RLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 50 MW, Hydro = 400 MW, HLS	SING OPN LIN 27 3008-3018(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 400 MW, HLS	SING OPN LIN 26 3005-3008(1)	3005-3007(1)	1
Solar = 50 MW, Hydro = 400 MW, HLS	SING OPN LIN 23 3004-3005(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 400 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 100 MW, Hydro = 600 MW, RLS	SING OPN LIN 23 3004-3005(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	UNIT 3018(1)	3001-3003(1)	1

Table 5.4: Summary of Branch Overload grouped by Scenario and Contingency - Continued

Scenario	Contingency	Branches	Branch Count
Solar = 100 MW, Hydro = 600 MW, LLS	BASE CASE	153-154(1)	1
Solar = 100 MW, Hydro = 600 MW, RLS	SING OPN LIN 26 3005-3008(1)	3005-3007(1)	1
Solar = 50 MW, Hydro = 400 MW, HLS	BUS 3005	153-154(1)	1
Solar = 50 MW, Hydro = 400 MW, HLS	BUS 3004	3001-3003(1)	1
Solar = 100 MW, Hydro = 600 MW, RLS	SING OPN LIN 7 153-154(1)	153-154(2)	1
Solar = 100 MW, Hydro = 600 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 600 MW, RLS	UNIT 102(1)	101-151(1)	1
Solar = 100 MW, Hydro = 600 MW, LLS	SING OPN LIN 9 201-202(1)	204-205(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	BASE CASE	153-154(1)	1
Solar = 50 MW, Hydro = 400 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 600 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 500 MW, RLS	SING OPN LIN 23 3004-3005(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 500 MW, RLS	SING OPN LIN 26 3005-3008(1)	3005-3007(1)	1
Solar = 50 MW, Hydro = 500 MW, RLS	SING OPN LIN 7 153-154(1)	153-154(2)	1
Solar = 50 MW, Hydro = 500 MW, RLS	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 3005	153-154(2)	1
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 7 153-154(1)	153-154(2)	1
Solar = 50 MW, Hydro = 600 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 600 MW, LLS	BASE CASE	153-154(1)	1
Solar = 50 MW, Hydro = 600 MW, LLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 50 MW, Hydro = 400 MW, HLS	UNIT 3018(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 600 MW, LLS	SING OPN LIN 7 153-154(1)	153-154(2)	1
Solar = 50 MW, Hydro = 600 MW, LLS	UNIT 101(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 600 MW, LLS	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 600 MW, RLS	BUS 3004	3001-3003(1)	1
Solar = 50 MW, Hydro = 600 MW, RLS	BUS 3005	153-154(2)	1
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 23 3004-3005(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 26 3005-3008(1)	3005-3007(1)	1
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 7 153-154(1)	153-154(2)	1
Solar = 50 MW, Hydro = 500 MW, RLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 50 MW, Hydro = 500 MW, RLS	BUS 3004	3001-3003(1)	1
Solar = 50 MW, Hydro = 500 MW, RLS	BASE CASE	153-154(1)	1
Solar = 50 MW, Hydro = 500 MW, LLS	UNIT 101(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 400 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 400 MW, LLS	UNIT 101(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 400 MW, RLS	BUS 3004	3001-3003(1)	1
Solar = 50 MW, Hydro = 400 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 400 MW, RLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 50 MW, Hydro = 400 MW, RLS	SING OPN LIN 8 153-154(2)	153-154(1)	1
Solar = 50 MW, Hydro = 400 MW, RLS	UNIT 101(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 400 MW, RLS	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 500 MW, HLS	BASE CASE	153-154(1)	1
Solar = 50 MW, Hydro = 500 MW, HLS	BUS 3004	3001-3003(1)	1
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 23 3004-3005(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 27 3008-3018(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 7 153-154(1)	153-154(2)	1
Solar = 50 MW, Hydro = 500 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 500 MW, HLS	UNIT 3018(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 500 MW, LLS	BUS 153	154-203(1)	1
Solar = 50 MW, Hydro = 500 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1)	1
Solar = 50 MW, Hydro = 500 MW, LLS	SING OPN LIN 8 153-154(2)	153-154(1)	1
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 26 3005-3008(1)	3005-3007(1)	1
Solar = 100 MW, Hydro = 500 MW, LLS	BUS 153	154-203(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 27 3008-3018(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 26 3005-3008(1)	3005-3007(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 7 153-154(1)	153-154(2)	1
Solar = 0 MW, Hydro = 500 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	UNIT 3018(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 500 MW, LLS	BUS 3005	153-154(1)	1
Solar = 0 MW, Hydro = 500 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 500 MW, LLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 0 MW, Hydro = 500 MW, LLS	SING OPN LIN 8 153-154(2)	153-154(1)	1
Solar = 0 MW, Hydro = 500 MW, LLS	UNIT 101(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 500 MW, LLS	UNIT 102(1)	101-151(1)	1

Table 5.5: Summary of Branch Overload grouped by Scenario and Contingency - Continued

Scenario	Contingency	Branches	Branch Count
Solar = 0 MW, Hydro = 500 MW, RLS	BASE CASE	153-154(1)	1
Solar = 0 MW, Hydro = 500 MW, RLS	BUS 3004	3001-3003(1)	1
Solar = 0 MW, Hydro = 500 MW, RLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 0 MW, Hydro = 500 MW, RLS	SING OPN LIN 23 3004-3005(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 500 MW, RLS	SING OPN LIN 26 3005-3008(1)	3005-3007(1)	1
Solar = 0 MW, Hydro = 500 MW, RLS	SING OPN LIN 7 153-154(1)	153-154(2)	1
Solar = 0 MW, Hydro = 500 MW, RLS	UNIT 102(1)	101-151(1)	1
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 7 153-154(1)	154-203(1)	1
Solar = 0 MW, Hydro = 600 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 0 MW, Hydro = 600 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 600 MW, LLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 0 MW, Hydro = 600 MW, LLS	SING OPN LIN 26 3005-3008(1)	3005-3007(1)	1
Solar = 0 MW, Hydro = 600 MW, LLS	SING OPN LIN 7 153-154(1)	153-154(2)	1
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 27 3008-3018(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 23 3004-3005(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 26 3005-3008(1)	3005-3007(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 20 3002-3004(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 3004	3001-3003(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 23 3004-3005(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 26 3005-3008(1)	3005-3007(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 27 3008-3018(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 7 153-154(1)	153-154(2)	1
Solar = 0 MW, Hydro = 400 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	UNIT 3018(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 400 MW, LLS	BUS 153	154-203(1)	1
Solar = 0 MW, Hydro = 400 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 400 MW, LLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 0 MW, Hydro = 400 MW, LLS	UNIT 101(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 400 MW, LLS	UNIT 102(1)	101-151(1)	1
Solar = 0 MW, Hydro = 400 MW, RLS	BUS 3004	3001-3003(1)	1
Solar = 0 MW, Hydro = 400 MW, RLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 0 MW, Hydro = 400 MW, RLS	SING OPN LIN 8 153-154(2)	153-154(1)	1
Solar = 0 MW, Hydro = 400 MW, RLS	UNIT 102(1)	101-151(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	BASE CASE	153-154(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	BUS 3002	3001-3003(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	BUS 3004	3001-3003(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	BUS 3005	153-154(2)	1
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 17 3001-3002(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 0 MW, Hydro = 600 MW, LLS	UNIT 101(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 600 MW, LLS	UNIT 102(1)	101-151(1)	1
Solar = 0 MW, Hydro = 600 MW, RLS	BUS 3004	3001-3003(1)	1
Solar = 0 MW, Hydro = 600 MW, RLS	BUS 3005	153-154(2)	1
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 26 3005-3008(1)	3005-3007(1)	1
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 27 3008-3018(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 7 153-154(1)	153-154(2)	1
Solar = 100 MW, Hydro = 500 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 100 MW, Hydro = 500 MW, HLS	UNIT 3018(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 500 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 500 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1)	1
Solar = 100 MW, Hydro = 500 MW, LLS	SING OPN LIN 8 153-154(2)	153-154(1)	1
Solar = 100 MW, Hydro = 500 MW, LLS	UNIT 101(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 500 MW, RLS	BUS 3004	3001-3003(1)	1
Solar = 100 MW, Hydro = 500 MW, RLS	BUS 3005	153-154(1)	1
Solar = 100 MW, Hydro = 500 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 500 MW, RLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 100 MW, Hydro = 500 MW, RLS	SING OPN LIN 8 153-154(2)	153-154(1)	1
Solar = 100 MW, Hydro = 500 MW, RLS	UNIT 101(1)	3001-3003(1)	1

Table 5.6: Summary of Branch Overload grouped by Scenario and Contingency - Continued

Scenario	Contingency	Branches	Branch Count
Solar = 100 MW, Hydro = 500 MW, RLS	UNIT 102(1)	101-151(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	BUS 3002	3001-3003(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	BUS 3004	3001-3003(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	BUS 3005	153-154(2)	1
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 17 3001-3002(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 20 3002-3004(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 23 3004-3005(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 23 3004-3005(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 100 MW, Hydro = 500 MW, HLS	BUS 3004	3001-3003(1)	1
Solar = 100 MW, Hydro = 400 MW, HLS	SING OPN LIN 23 3004-3005(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 23 3004-3005(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 26 3005-3008(1)	3005-3007(1)	1
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 27 3008-3018(1)	3001-3003(1)	1
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 7 153-154(1)	153-154(2)	1
Solar = 0 MW, Hydro = 600 MW, RLS	UNIT 102(1)	101-151(1)	1
Solar = 0 MW, Hydro = 600 MW, RLS	UNIT 3018(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 400 MW, HLS	BUS 3004	3001-3003(1)	1
Solar = 100 MW, Hydro = 400 MW, HLS	BUS 3005	153-154(1)	1
Solar = 100 MW, Hydro = 400 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 100 MW, Hydro = 400 MW, HLS	SING OPN LIN 26 3005-3008(1)	3005-3007(1)	1
Solar = 100 MW, Hydro = 500 MW, HLS	BASE CASE	153-154(1)	1
Solar = 100 MW, Hydro = 400 MW, HLS	SING OPN LIN 8 153-154(2)	153-154(1)	1
Solar = 100 MW, Hydro = 400 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 100 MW, Hydro = 400 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 400 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1)	1
Solar = 100 MW, Hydro = 400 MW, LLS	UNIT 101(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 400 MW, RLS	BUS 153	154-203(1)	1
Solar = 100 MW, Hydro = 400 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 400 MW, RLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 100 MW, Hydro = 400 MW, RLS	UNIT 101(1)	3001-3003(1)	1
Solar = 100 MW, Hydro = 400 MW, RLS	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 600 MW, RLS	UNIT 102(1)	101-151(1)	1

5.1.2 Overload Count - Scenario

Table 5.7: Overload Count - Scenario

Scenario	Overload Counts
Solar = 0 MW, Hydro = 400 MW, HLS	29
Solar = 0 MW, Hydro = 500 MW, RLS	28
Solar = 50 MW, Hydro = 400 MW, HLS	24
Solar = 100 MW, Hydro = 600 MW, HLS	23
Solar = 100 MW, Hydro = 400 MW, HLS	21
Solar = 0 MW, Hydro = 500 MW, HLS	21
Solar = 50 MW, Hydro = 500 MW, RLS	20
Solar = 0 MW, Hydro = 600 MW, RLS	19
Solar = 100 MW, Hydro = 500 MW, HLS	18
Solar = 0 MW, Hydro = 600 MW, LLS	18
Solar = 0 MW, Hydro = 400 MW, RLS	17
Solar = 50 MW, Hydro = 500 MW, HLS	17
Solar = 100 MW, Hydro = 600 MW, RLS	16
Solar = 0 MW, Hydro = 500 MW, LLS	16
Solar = 100 MW, Hydro = 500 MW, RLS	16
Solar = 50 MW, Hydro = 600 MW, LLS	15
Solar = 100 MW, Hydro = 400 MW, RLS	13
Solar = 50 MW, Hydro = 600 MW, HLS	13
Solar = 0 MW, Hydro = 600 MW, HLS	13
Solar = 50 MW, Hydro = 600 MW, RLS	13
Solar = 50 MW, Hydro = 400 MW, RLS	13
Solar = 100 MW, Hydro = 600 MW, LLS	12
Solar = 50 MW, Hydro = 400 MW, LLS	12
Solar = 50 MW, Hydro = 500 MW, LLS	11
Solar = 0 MW, Hydro = 400 MW, LLS	11
Solar = 100 MW, Hydro = 400 MW, LLS	10
Solar = 100 MW, Hydro = 500 MW, LLS	10

5.1.3 Overload Count - Branch

Table 5.8: Overload Count - Branch

Branch	Overload Counts
3001-3003(1)	116
3005-3007(1)	63
153-154(1)	48
153-154(2)	45
101-151(1)	44
154-203(1)	38
202-203(1)	24
154-205(1)	18
3003-3005(1)	18
3003-3005(2)	18
204-205(1)	7
203-205(1)	5
203-205(2)	5

5.1.4 Overload Count - Contingency

Table 5.9: Overload Count - Contingency

Contingency	Overload Counts
SING OPN LIN 1 101-151(1)	56
SING OPN LIN 6 152-153(1)	56
UNIT 101(1)	56
BUS 153	50
BUS 203	40
BASE CASE	28
UNIT 102(1)	22
SING OPN LIN 2 102-151(1)	22
SING OPN LIN 13 202-203(1)	18
SING OPN LIN 7 153-154(1)	16
BUS 3004	15
SING OPN LIN 26 3005-3008(1)	13
SING OPN LIN 23 3004-3005(1)	12
BUS 3005	9
SING OPN LIN 8 153-154(2)	8
SING OPN LIN 27 3008-3018(1)	7
UNIT 3018(1)	7
BUS 205	7
SING OPN LIN 17 3001-3002(1)	2
SING OPN LIN 20 3002-3004(1)	2
BUS 3002	2
SING OPN LIN 9 201-202(1)	1

5.2 Upper Voltage Limit Violation $> 1.1PU$ Counts

5.2.1 Summary of upper limit voltage violation grouped by Scenario and Contingency

Table 5.10: Summary of upper limit voltage violation grouped by Scenario and Contingency

Scenario	Contingency	Buses	Bus Count
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 6 152-153(1)	211,212	2
Solar = 100 MW, Hydro = 600 MW, RLS	SING OPN LIN 5 151-152(2)	211,212	2
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 4 151-152(1)	211,212	2
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 18 3001-3003(1)	211,212	2
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 3005	211,212	2
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 3004	211,212	2
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 3003	211,212	2
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 5 151-152(2)	211,212	2
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 4 151-152(1)	211,212	2
Solar = 100 MW, Hydro = 600 MW, RLS	SING OPN LIN 4 151-152(1)	211,212	2
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 4 151-152(1)	211,212	2
Solar = 100 MW, Hydro = 600 MW, HLS	BUS 3004	211,212	2
Solar = 100 MW, Hydro = 600 MW, HLS	BUS 3003	211,212	2
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 5 151-152(2)	211,212	2
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 4 151-152(1)	211,212	2
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 7 153-154(1)	211,212	2
Solar = 0 MW, Hydro = 500 MW, RLS	SING OPN LIN 6 152-153(1)	211,212	2
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 5 151-152(2)	211,212	2
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 5 151-152(2)	211,212	2

5.2.2 Upper Voltage Limit Counts - Scenario

Table 5.11: Upper Voltage Limit Counts - Scenario

Scenario	Limit Violation Counts
Solar = 50 MW, Hydro = 600 MW, HLS	16
Solar = 0 MW, Hydro = 500 MW, HLS	8
Solar = 50 MW, Hydro = 600 MW, RLS	8
Solar = 50 MW, Hydro = 500 MW, HLS	8
Solar = 100 MW, Hydro = 600 MW, RLS	8
Solar = 100 MW, Hydro = 500 MW, HLS	8
Solar = 100 MW, Hydro = 600 MW, HLS	8
Solar = 0 MW, Hydro = 500 MW, RLS	4
Solar = 0 MW, Hydro = 400 MW, HLS	4
Solar = 0 MW, Hydro = 600 MW, HLS	4

5.2.3 Upper Voltage Limit Counts - Bus

Table 5.12: Upper Voltage Limit Counts - Bus

Bus	Limit Violation Counts
211	38
212	38

5.2.4 Upper Voltage Limit Counts - Contingency

Table 5.13: Upper Voltage Limit Counts - Contingency

Contingency	Limit Violation Counts
SING OPN LIN 4 151-152(1)	20
SING OPN LIN 5 151-152(2)	20
SING OPN LIN 6 152-153(1)	8
BUS 3003	8
BUS 3004	8
SING OPN LIN 7 153-154(1)	4
SING OPN LIN 18 3001-3003(1)	4
BUS 3005	4

5.3 Lower Voltage Limit Violation $< 0.9PU$ Counts

5.3.1 Summary of lower limit voltage violation grouped by Scenario and Contingency

Table 5.14: Summary of lower limit voltage violation grouped by Scenario and Contingency

Scenario	Contingency	Buses	Bus Count
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 6 152-153(1)	103,153,154,203,204,205,206,3005,3006,3007,3008,3018	12
Solar = 50 MW, Hydro = 400 MW, LLS	BUS 205	103,153,154,203,3005,3006,3007,3008,3018	9
Solar = 0 MW, Hydro = 600 MW, LLS	SING OPN LIN 6 152-153(1)	103,153,154,203,204,205,3006,3007,3008	9
Solar = 100 MW, Hydro = 400 MW, HLS	SING OPN LIN 6 152-153(1)	103,153,154,203,204,205,3006,3007,3008	9
Solar = 100 MW, Hydro = 600 MW, LLS	SING OPN LIN 9 201-202(1)	103,153,154,202,203,204,205,3007,3008	9
Solar = 50 MW, Hydro = 500 MW, RLS	SING OPN LIN 6 152-153(1)	103,153,154,203,204,205,3006,3007,3008	9
Solar = 0 MW, Hydro = 500 MW, RLS	SING OPN LIN 6 152-153(1)	103,153,154,203,204,205,3006,3007,3008	9
Solar = 0 MW, Hydro = 400 MW, RLS	SING OPN LIN 9 201-202(1)	103,154,202,203,204,205,3007,3008	8
Solar = 100 MW, Hydro = 500 MW, RLS	SING OPN LIN 6 152-153(1)	103,153,154,203,205,3006,3007,3008	8
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 153	103,154,203,204,205,3007,3008	7
Solar = 50 MW, Hydro = 600 MW, LLS	SING OPN LIN 6 152-153(1)	103,153,154,205,3006,3007,3008	7
Solar = 0 MW, Hydro = 500 MW, LLS	SING OPN LIN 13 202-203(1)	103,154,203,204,205,3007,3008	7
Solar = 0 MW, Hydro = 400 MW, RLS	SING OPN LIN 6 152-153(1)	103,153,154,205,3006,3007,3008	7
Solar = 100 MW, Hydro = 400 MW, LLS	BUS 205	103,153,154,203,3006,3007,3008	7
Solar = 100 MW, Hydro = 400 MW, RLS	SING OPN LIN 13 202-203(1)	103,154,203,204,205,3007,3008	7
Solar = 100 MW, Hydro = 500 MW, HLS	BUS 153	103,154,203,204,205,3007,3008	7
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 18 3001-3003(1)	103,154,203,205,3007,3008	6
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 18 3001-3003(1)	103,154,203,205,3007,3008	6
Solar = 100 MW, Hydro = 600 MW, HLS	BUS 3003	103,154,203,205,3007,3008	6
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 203	103,154,204,205,3007,3008	6
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 3003	103,154,203,205,3007,3008	6
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 3004	103,154,203,205,3007,3008	6
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 3005	103,154,203,204,205,3008	6
Solar = 100 MW, Hydro = 600 MW, RLS	BUS 153	103,154,203,204,205,3008	6
Solar = 50 MW, Hydro = 400 MW, HLS	BUS 203	103,154,204,205,3007,3008	6
Solar = 0 MW, Hydro = 500 MW, RLS	BUS 203	103,154,204,205,3007,3008	6
Solar = 50 MW, Hydro = 400 MW, RLS	SING OPN LIN 6 152-153(1)	103,153,154,205,3006,3008	6
Solar = 50 MW, Hydro = 400 MW, RLS	SING OPN LIN 9 201-202(1)	103,154,203,205,3007,3008	6
Solar = 50 MW, Hydro = 500 MW, LLS	SING OPN LIN 13 202-203(1)	103,154,203,204,205,3008	6
Solar = 50 MW, Hydro = 500 MW, RLS	BUS 203	103,154,204,205,3007,3008	6
Solar = 100 MW, Hydro = 600 MW, LLS	SING OPN LIN 6 152-153(1)	103,153,154,205,3006,3008	6
Solar = 100 MW, Hydro = 600 MW, HLS	BUS 3004	103,154,203,205,3007,3008	6
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 4 151-152(1)	103,154,203,205,3007,3008	6
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 5 151-152(2)	103,154,203,205,3007,3008	6
Solar = 0 MW, Hydro = 500 MW, HLS	BUS 3004	103,154,203,205,3007,3008	6
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 7 153-154(1)	103,203,205,3007,3008	5
Solar = 100 MW, Hydro = 600 MW, HLS	BUS 3005	103,154,203,205,3008	5
Solar = 100 MW, Hydro = 500 MW, LLS	SING OPN LIN 13 202-203(1)	103,154,203,205,3008	5
Solar = 0 MW, Hydro = 600 MW, HLS	UNIT 3018(1)	103,205,3007,3008,3018	5
Solar = 50 MW, Hydro = 600 MW, LLS	BUS 203	103,154,204,205,3008	5
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 7 153-154(1)	103,154,203,205,3008	5
Solar = 100 MW, Hydro = 600 MW, LLS	BUS 203	103,154,204,205,3008	5
Solar = 100 MW, Hydro = 400 MW, HLS	BUS 153	103,154,205,3008	4
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 4 151-152(1)	103,154,205,3008	4
Solar = 50 MW, Hydro = 500 MW, HLS	BUS 3003	154,205,3007,3008	4
Solar = 100 MW, Hydro = 400 MW, HLS	BUS 203	103,154,205,3008	4
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 8 153-154(2)	103,154,205,3008	4
Solar = 100 MW, Hydro = 400 MW, RLS	SING OPN LIN 9 201-202(1)	103,154,203,205	4
Solar = 0 MW, Hydro = 500 MW, RLS	BUS 153	103,154,205,3008	4
Solar = 100 MW, Hydro = 600 MW, HLS	UNIT 3018(1)	154,205,3008,3018	4
Solar = 100 MW, Hydro = 400 MW, RLS	SING OPN LIN 6 152-153(1)	153,154,205,3006	4
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 5 151-152(2)	103,154,205,3008	4
Solar = 100 MW, Hydro = 500 MW, HLS	BUS 3004	154,205,3007,3008	4
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 7 153-154(1)	103,154,205,3008	4
Solar = 0 MW, Hydro = 500 MW, HLS	BUS 3003	154,205,3007,3008	4
Solar = 100 MW, Hydro = 500 MW, RLS	BUS 203	103,154,205,3008	4
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 18 3001-3003(1)	154,205,3007,3008	4
Solar = 50 MW, Hydro = 500 MW, HLS	BUS 3004	154,205,3007,3008	4
Solar = 50 MW, Hydro = 400 MW, HLS	BUS 153	103,154,205,3008	4
Solar = 0 MW, Hydro = 500 MW, HLS	BUS 3005	103,154,205,3008	4

Table 5.15: Summary of lower limit voltage violation grouped by Scenario and Contingency - Continued

Scenario	Contingency	Buses	Bus Count
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 8 153-154(2)	103,203,205,3008	4
Solar = 50 MW, Hydro = 600 MW, HLS	UNIT 3018(1)	154,205,3008,3018	4
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 27 3008-3018(1)	103,205,3007,3008	4
Solar = 0 MW, Hydro = 600 MW, RLS	BUS 3004	154,205,3007,3008	4
Solar = 50 MW, Hydro = 400 MW, LLS	SING OPN LIN 13 202-203(1)	154,203,205	3
Solar = 50 MW, Hydro = 600 MW, RLS	BUS 3004	154,205,3008	3
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 27 3008-3018(1)	154,205,3008	3
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 1 101-151(1)	205,3007,3008	3
Solar = 50 MW, Hydro = 500 MW, RLS	BUS 153	103,154,205	3
Solar = 0 MW, Hydro = 400 MW, LLS	SING OPN LIN 13 202-203(1)	154,203,205	3
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 8 153-154(2)	103,154,205	3
Solar = 0 MW, Hydro = 600 MW, RLS	BUS 3005	154,205,3008	3
Solar = 50 MW, Hydro = 500 MW, HLS	BUS 3005	154,205,3008	3
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 27 3008-3018(1)	154,205,3008	3
Solar = 100 MW, Hydro = 600 MW, HLS	UNIT 103(1)	103,154,205	3
Solar = 0 MW, Hydro = 600 MW, HLS	UNIT 101(1)	205,3007,3008	3
Solar = 50 MW, Hydro = 600 MW, HLS	UNIT 103(1)	103,154,205	3
Solar = 0 MW, Hydro = 500 MW, LLS	SING OPN LIN 9 201-202(1)	154,203,205	3
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 3004	154,205,3008	3
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 26 3005-3008(1)	154,205,3008	3
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 3005	154,3008	2
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 4 151-152(1)	154,205	2
Solar = 0 MW, Hydro = 400 MW, RLS	BUS 203	154,205	2
Solar = 100 MW, Hydro = 600 MW, RLS	SING OPN LIN 5 151-152(2)	154,205	2
Solar = 50 MW, Hydro = 400 MW, RLS	BUS 203	154,205	2
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 26 3005-3008(1)	154,205	2
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 3 103-154(1)	154,205	2
Solar = 100 MW, Hydro = 600 MW, RLS	SING OPN LIN 4 151-152(1)	154,205	2
Solar = 100 MW, Hydro = 600 MW, RLS	BUS 3004	154,205	2
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 3008	154,205	2
Solar = 100 MW, Hydro = 500 MW, RLS	BUS 153	154,205	2
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 5 151-152(2)	154,205	2
Solar = 100 MW, Hydro = 600 MW, HLS	BUS 3008	154,205	2
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 7 153-154(1)	154,205	2
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 5 151-152(2)	154,205	2
Solar = 0 MW, Hydro = 600 MW, HLS	BUS 3008	103,205	2
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 4 151-152(1)	154,205	2
Solar = 50 MW, Hydro = 600 MW, RLS	BUS 3005	154,3008	2
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 7 153-154(1)	154,205	2
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 23 3004-3005(1)	205,3008	2
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 26 3005-3008(1)	205,3008	2
Solar = 0 MW, Hydro = 600 MW, LLS	BUS 153	154,205	2
Solar = 0 MW, Hydro = 600 MW, RLS	BUS 3003	154,205	2
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 7 153-154(1)	154,205	2
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 3 103-154(1)	154,205	2
Solar = 0 MW, Hydro = 500 MW, LLS	SING OPN LIN 6 152-153(1)	153,154	2
Solar = 0 MW, Hydro = 500 MW, LLS	BUS 203	154,205	2
Solar = 100 MW, Hydro = 400 MW, LLS	SING OPN LIN 13 202-203(1)	154,203	2
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 8 153-154(2)	154,205	2
Solar = 100 MW, Hydro = 500 MW, HLS	BUS 3005	154,3008	2
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 18 3001-3003(1)	154,205	2
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 4 151-152(1)	154,205	2
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 5 151-152(2)	154,205	2
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 22 3003-3005(2)	154,205	2
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 21 3003-3005(1)	154,205	2

Table 5.16: Summary of lower limit voltage violation grouped by Scenario and Contingency - Continued

Scenario	Contingency	Buses	Bus Count
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 3002	154	1
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 7 153-154(1)	154	1
Solar = 0 MW, Hydro = 500 MW, RLS	BUS 3004	154	1
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 3006	154	1
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 1 101-151(1)	154	1
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 14 203-205(1)	154	1
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 15 203-205(2)	154	1
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 17 3001-3002(1)	154	1
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 2 102-151(1)	154	1
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 20 3002-3004(1)	154	1
Solar = 50 MW, Hydro = 500 MW, LLS	SING OPN LIN 6 152-153(1)	154	1
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 23 3004-3005(1)	154	1
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 24 3005-3006(1)	154	1
Solar = 50 MW, Hydro = 600 MW, HLS	UNIT 101(1)	154	1
Solar = 50 MW, Hydro = 600 MW, HLS	UNIT 102(1)	154	1
Solar = 50 MW, Hydro = 600 MW, LLS	BUS 153	154	1
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 3003	154	1
Solar = 50 MW, Hydro = 600 MW, RLS	BUS 3003	154	1
Solar = 50 MW, Hydro = 500 MW, LLS	SING OPN LIN 9 201-202(1)	154	1
Solar = 100 MW, Hydro = 600 MW, LLS	BUS 153	154	1
Solar = 0 MW, Hydro = 400 MW, RLS	BUS 153	154	1
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 3 103-154(1)	205	1
Solar = 100 MW, Hydro = 400 MW, RLS	BUS 203	154	1
Solar = 100 MW, Hydro = 400 MW, HLS	SING OPN LIN 5 151-152(2)	154	1
Solar = 100 MW, Hydro = 400 MW, HLS	SING OPN LIN 4 151-152(1)	154	1
Solar = 100 MW, Hydro = 400 MW, HLS	BUS 3004	154	1
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 8 153-154(2)	154	1
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 18 3001-3003(1)	154	1
Solar = 0 MW, Hydro = 600 MW, HLS	UNIT 102(1)	205	1
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 22 3003-3005(2)	205	1
Solar = 100 MW, Hydro = 500 MW, HLS	BUS 3003	154	1
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 21 3003-3005(1)	205	1
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 20 3002-3004(1)	205	1
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 2 102-151(1)	205	1
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 17 3001-3002(1)	205	1
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 15 203-205(2)	205	1
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 14 203-205(1)	205	1
Solar = 0 MW, Hydro = 600 MW, HLS	BUS 3002	205	1
Solar = 0 MW, Hydro = 500 MW, HLS	UNIT 3018(1)	154	1
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 18 3001-3003(1)	154	1
Solar = 50 MW, Hydro = 500 MW, HLS	UNIT 3018(1)	154	1
Solar = 0 MW, Hydro = 500 MW, HLS	BUS 3008	154	1
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 8 153-154(2)	154	1
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 27 3008-3018(1)	154	1
Solar = 50 MW, Hydro = 400 MW, RLS	BUS 153	154	1
Solar = 50 MW, Hydro = 400 MW, HLS	SING OPN LIN 5 151-152(2)	154	1
Solar = 50 MW, Hydro = 400 MW, HLS	SING OPN LIN 4 151-152(1)	154	1
Solar = 50 MW, Hydro = 400 MW, HLS	BUS 3004	154	1
Solar = 100 MW, Hydro = 600 MW, RLS	BUS 3005	3008	1
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 26 3005-3008(1)	154	1
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 7 153-154(1)	154	1
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 23 3004-3005(1)	154	1
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 22 3003-3005(2)	154	1
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 21 3003-3005(1)	154	1
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 27 3008-3018(1)	154	1
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 15 203-205(2)	154	1
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 14 203-205(1)	154	1
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 8 153-154(2)	154	1
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 7 153-154(1)	154	1

5.3.2 Lower Voltage Limit Counts - Bus

Table 5.17: Lower Voltage Limit Counts - Bus

Bus	Limit Violation Counts
154	308
205	236
3008	154
103	120
3007	82
203	74
204	40
153	30
3006	26
3018	10
202	4
3005	4
206	2

5.3.3 Lower Voltage Limit Counts - Scenario

Table 5.18: Lower Voltage Limit Counts - Scenario

Scenario	Limit Violation Counts
Solar = 50 MW, Hydro = 600 MW, HLS	132
Solar = 100 MW, Hydro = 600 MW, HLS	102
Solar = 0 MW, Hydro = 600 MW, HLS	80
Solar = 0 MW, Hydro = 500 MW, HLS	76
Solar = 0 MW, Hydro = 400 MW, HLS	72
Solar = 50 MW, Hydro = 500 MW, HLS	52
Solar = 100 MW, Hydro = 500 MW, HLS	42
Solar = 100 MW, Hydro = 600 MW, LLS	42
Solar = 100 MW, Hydro = 400 MW, HLS	40
Solar = 0 MW, Hydro = 500 MW, RLS	40
Solar = 50 MW, Hydro = 500 MW, RLS	36
Solar = 0 MW, Hydro = 400 MW, RLS	36
Solar = 100 MW, Hydro = 400 MW, RLS	32
Solar = 50 MW, Hydro = 400 MW, RLS	30
Solar = 0 MW, Hydro = 500 MW, LLS	28
Solar = 100 MW, Hydro = 500 MW, RLS	28
Solar = 50 MW, Hydro = 600 MW, LLS	26
Solar = 50 MW, Hydro = 400 MW, HLS	26
Solar = 0 MW, Hydro = 600 MW, RLS	26
Solar = 100 MW, Hydro = 600 MW, RLS	26
Solar = 50 MW, Hydro = 400 MW, LLS	24
Solar = 50 MW, Hydro = 600 MW, RLS	22
Solar = 0 MW, Hydro = 600 MW, LLS	22
Solar = 100 MW, Hydro = 400 MW, LLS	18
Solar = 50 MW, Hydro = 500 MW, LLS	16
Solar = 100 MW, Hydro = 500 MW, LLS	10
Solar = 0 MW, Hydro = 400 MW, LLS	6

5.3.4 Lower Voltage Limit Counts - Contingency

Table 5.19: Lower Voltage Limit Counts - Scenario

Contingency	Limit Violation Counts
SING OPN LIN 6 152-153(1)	178
BUS 203	98
BUS 153	86
BUS 3004	82
SING OPN LIN 13 202-203(1)	66
SING OPN LIN 9 201-202(1)	62
BUS 3005	56
BUS 3003	50
SING OPN LIN 7 153-154(1)	46
SING OPN LIN 18 3001-3003(1)	40
SING OPN LIN 4 151-152(1)	40
SING OPN LIN 5 151-152(2)	40
SING OPN LIN 8 153-154(2)	32
BUS 205	32
UNIT 3018(1)	30
SING OPN LIN 27 3008-3018(1)	24
SING OPN LIN 26 3005-3008(1)	16
BUS 3008	14
UNIT 103(1)	12
SING OPN LIN 3 103-154(1)	10
SING OPN LIN 21 3003-3005(1)	8
SING OPN LIN 22 3003-3005(2)	8
SING OPN LIN 23 3004-3005(1)	8
UNIT 101(1)	8
SING OPN LIN 1 101-151(1)	8
SING OPN LIN 14 203-205(1)	6
SING OPN LIN 15 203-205(2)	6
SING OPN LIN 17 3001-3002(1)	4
SING OPN LIN 20 3002-3004(1)	4
BUS 3002	4
UNIT 102(1)	4
SING OPN LIN 2 102-151(1)	4
SING OPN LIN 24 3005-3006(1)	2
BUS 3006	2