

PSSE Contingency Analysis - Year 3, Topology 4

Jessla Varaparambil Abdul Kadher

February 21, 2026

Contents

1	Introduction	10
1.1	Study Description	10
1.2	Contingency Analysis	11
2	Branch Overload Violation	15
2.1	Introduction	15
2.2	Solar = 0 MW, Hydro = 400 MW, LLS	15
2.3	Solar = 0 MW, Hydro = 500 MW, LLS	16
2.4	Solar = 0 MW, Hydro = 600 MW, LLS	16
2.5	Solar = 0 MW, Hydro = 400 MW, RLS	17
2.6	Solar = 0 MW, Hydro = 500 MW, RLS	18
2.7	Solar = 0 MW, Hydro = 600 MW, RLS	18
2.8	Solar = 0 MW, Hydro = 400 MW, HLS	19
2.9	Solar = 0 MW, Hydro = 500 MW, HLS	20
2.10	Solar = 0 MW, Hydro = 600 MW, HLS	21
2.11	Solar = 50 MW, Hydro = 400 MW, LLS	22
2.12	Solar = 50 MW, Hydro = 500 MW, LLS	22
2.13	Solar = 50 MW, Hydro = 600 MW, LLS	23
2.14	Solar = 50 MW, Hydro = 400 MW, RLS	23
2.15	Solar = 50 MW, Hydro = 500 MW, RLS	24
2.16	Solar = 50 MW, Hydro = 600 MW, RLS	25
2.17	Solar = 50 MW, Hydro = 400 MW, HLS	25
2.18	Solar = 50 MW, Hydro = 500 MW, HLS	26
2.19	Solar = 50 MW, Hydro = 600 MW, HLS	27
2.20	Solar = 100 MW, Hydro = 400 MW, LLS	28
2.21	Solar = 100 MW, Hydro = 500 MW, LLS	28
2.22	Solar = 100 MW, Hydro = 600 MW, LLS	29
2.23	Solar = 100 MW, Hydro = 400 MW, RLS	29
2.24	Solar = 100 MW, Hydro = 500 MW, RLS	30
2.25	Solar = 100 MW, Hydro = 600 MW, RLS	30
2.26	Solar = 100 MW, Hydro = 400 MW, HLS	31
2.27	Solar = 100 MW, Hydro = 500 MW, HLS	32
2.28	Solar = 100 MW, Hydro = 600 MW, HLS	32
2.29	Result Summary	33
3	Upper Emergency Bus Voltage Violation	34
3.1	Introduction	34
3.2	Solar = 0 MW, Hydro = 600 MW, LLS	34
3.3	Solar = 0 MW, Hydro = 600 MW, HLS	34
3.4	Solar = 50 MW, Hydro = 600 MW, HLS	35
3.5	Solar = 100 MW, Hydro = 600 MW, LLS	35
3.6	Solar = 100 MW, Hydro = 400 MW, RLS	35
3.7	Solar = 100 MW, Hydro = 600 MW, HLS	36
3.8	Result Summary	36

4 Lower Emergency Bus Voltage violations	37
4.1 Introduction	37
4.2 Solar = 0 MW, Hydro = 400 MW, LLS	37
4.3 Solar = 0 MW, Hydro = 500 MW, LLS	38
4.4 Solar = 0 MW, Hydro = 600 MW, LLS	39
4.5 Solar = 0 MW, Hydro = 400 MW, RLS	39
4.6 Solar = 0 MW, Hydro = 500 MW, RLS	40
4.7 Solar = 0 MW, Hydro = 600 MW, RLS	40
4.8 Solar = 0 MW, Hydro = 400 MW, HLS	41
4.9 Solar = 0 MW, Hydro = 500 MW, HLS	41
4.10 Solar = 0 MW, Hydro = 600 MW, HLS	42
4.11 Solar = 50 MW, Hydro = 400 MW, LLS	42
4.12 Solar = 50 MW, Hydro = 500 MW, LLS	43
4.13 Solar = 50 MW, Hydro = 600 MW, LLS	44
4.14 Solar = 50 MW, Hydro = 400 MW, RLS	44
4.15 Solar = 50 MW, Hydro = 500 MW, RLS	45
4.16 Solar = 50 MW, Hydro = 600 MW, RLS	45
4.17 Solar = 50 MW, Hydro = 400 MW, HLS	46
4.18 Solar = 50 MW, Hydro = 500 MW, HLS	46
4.19 Solar = 50 MW, Hydro = 600 MW, HLS	47
4.20 Solar = 100 MW, Hydro = 400 MW, LLS	47
4.21 Solar = 100 MW, Hydro = 500 MW, LLS	48
4.22 Solar = 100 MW, Hydro = 600 MW, LLS	48
4.23 Solar = 100 MW, Hydro = 400 MW, RLS	49
4.24 Solar = 100 MW, Hydro = 500 MW, RLS	50
4.25 Solar = 100 MW, Hydro = 600 MW, RLS	50
4.26 Solar = 100 MW, Hydro = 400 MW, HLS	51
4.27 Solar = 100 MW, Hydro = 500 MW, HLS	51
4.28 Solar = 100 MW, Hydro = 600 MW, HLS	52
4.29 Result Summary	52
5 Conculsion	53
Appendix	54
5.1 Loading Violation > 100% Counts	54
5.1.1 Summary of Branch Overload grouped by Scenario and Contingency	54
5.1.2 Overload Count - Contingency	57
5.1.3 Overload Count - Scenario	58
5.2 Overload Count - Branch	58
5.3 Upper Voltage Limit Violation > 1.1PU Counts	59
5.3.1 Summary of upper limit voltage violation grouped by Scenario and Contingency	59
5.3.2 Upper Voltage Limit Counts - Scenario	59
5.3.3 Upper Voltage Limit Counts - Contingency	59
5.3.4 Upper Voltage Limit Counts - Bus	59
5.4 Lower Voltage Limit Violation < 0.9PU Counts	60
5.4.1 Summary of lower limit voltage violation grouped by Scenario and Contingency	60
5.4.2 Lower Voltage Limit Counts - Contingency	61
5.4.3 Lower Voltage Limit Counts - Bus	62
5.4.4 Lower Voltage Limit Counts - Scenario	62

List of Figures

1.1	Single Line Diagram Year 3, Topology 4	10
1.2	The subsystem file corresponding to Year 3 Topology 4	11
1.3	The monitored file corresponding to Year 3 Topology 4	11
1.4	The contingency file corresponding to Year 3 Topology 4	11

List of Tables

2.1	Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, LLS	15
2.2	Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, LLS	15
2.3	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, LLS	15
2.4	Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, LLS	16
2.5	Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, LLS	16
2.6	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, LLS	16
2.7	Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, LLS	16
2.8	Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, LLS	17
2.9	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, LLS	17
2.10	Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, RLS	17
2.11	Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, RLS	17
2.12	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, RLS	18
2.13	Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, RLS	18
2.14	Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, RLS	18
2.15	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, RLS	18
2.16	Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, RLS	19
2.17	Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, RLS	19
2.18	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, RLS	19
2.19	Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, HLS	19
2.20	Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, HLS	20
2.21	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 400 MW, HLS	20
2.22	Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, HLS	20
2.23	Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, HLS	20

2.24	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 500 MW, HLS	21
2.25	Unit faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, HLS	21
2.26	Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, HLS	21
2.27	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, HLS	21
2.28	Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, LLS	22
2.29	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, LLS	22
2.30	Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, LLS	22
2.31	Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, LLS	22
2.32	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, LLS	23
2.33	Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, LLS	23
2.34	Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, LLS	23
2.35	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, LLS	23
2.36	Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, RLS	23
2.37	Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, RLS	24
2.38	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, RLS	24
2.39	Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, RLS	24
2.40	Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, RLS	24
2.41	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, RLS	24
2.42	Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, RLS	25
2.43	Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, RLS	25
2.44	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, RLS	25
2.45	Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, HLS	25
2.46	Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, HLS	26
2.47	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 400 MW, HLS	26
2.48	Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, HLS	26
2.49	Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, HLS	26
2.50	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 500 MW, HLS	27
2.51	Unit faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, HLS	27
2.52	Bus faults reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, HLS	27

2.53	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 50 MW, Hydro = 600 MW, HLS	27
2.54	Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, LLS	28
2.55	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, LLS	28
2.56	Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, LLS	28
2.57	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, LLS	28
2.58	Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, LLS	29
2.59	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, LLS	29
2.60	Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, RLS	29
2.61	Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, RLS	29
2.62	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, RLS	30
2.63	Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, RLS	30
2.64	Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, RLS	30
2.65	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, RLS	30
2.66	Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, RLS	31
2.67	Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, RLS	31
2.68	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, RLS	31
2.69	Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, HLS	31
2.70	Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, HLS	31
2.71	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 400 MW, HLS	32
2.72	Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, HLS	32
2.73	Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, HLS	32
2.74	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 500 MW, HLS	32
2.75	Unit faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, HLS	32
2.76	Bus faults reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, HLS	33
2.77	Single line open contingencies reporting branch flow greater than 100% for scenario Solar = 100 MW, Hydro = 600 MW, HLS	33
3.1	Unit faults reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 0 MW, Hydro = 600 MW, LLS	34
3.2	Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 0 MW, Hydro = 600 MW, LLS	34
3.3	Bus faults reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 0 MW, Hydro = 600 MW, HLS	35

3.4	Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 50 MW, Hydro = 600 MW, HLS	35
3.5	Bus faults reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 100 MW, Hydro = 600 MW, LLS	35
3.6	Unit faults reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 100 MW, Hydro = 400 MW, RLS	35
3.7	Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 100 MW, Hydro = 400 MW, RLS	35
3.8	Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 100 MW, Hydro = 600 MW, HLS	36
4.1	Unit faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 400 MW, LLS	37
4.2	Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 400 MW, LLS	37
4.3	Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 400 MW, LLS	38
4.4	Unit faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 500 MW, LLS	38
4.5	Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 500 MW, LLS	38
4.6	Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 500 MW, LLS	38
4.7	Unit faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, LLS	39
4.8	Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, LLS	39
4.9	Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, LLS	39
4.10	Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 400 MW, RLS	39
4.11	Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 400 MW, RLS	40
4.12	Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 500 MW, RLS	40
4.13	Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, RLS	40
4.14	Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, RLS	40
4.15	Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 400 MW, HLS	41
4.16	Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 400 MW, HLS	41
4.17	Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 500 MW, HLS	41
4.18	Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 500 MW, HLS	42
4.19	Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, HLS	42
4.20	Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 0 MW, Hydro = 600 MW, HLS	42
4.21	Unit faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 400 MW, LLS	43
4.22	Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 400 MW, LLS	43
4.23	Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 50 MW, Hydro = 400 MW, LLS	43

4.53	Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 600 MW, RLS	51
4.54	Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 400 MW, HLS	51
4.55	Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 500 MW, HLS	51
4.56	Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 500 MW, HLS	51
4.57	Bus faults reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 600 MW, HLS	52
4.58	Single line open contingencies reporting bus voltages lower than emergency voltage of 0.9 PU for scenario Solar = 100 MW, Hydro = 600 MW, HLS	52
5.1	Count of scenarios for which tested contingency failed to converge	53
5.2	Summary of Branch Overload grouped by Scenario and Contingency	54
5.3	Summary of Branch Overload grouped by Scenario and Contingency - continued	55
5.4	Summary of Branch Overload grouped by Scenario and Contingency - continued	56
5.5	Summary of Branch Overload grouped by Scenario and Contingency - continued	57
5.6	Overload Count - Contingency	57
5.7	Overload Count - Scenario	58
5.8	Overload Count - Branch	58
5.9	Summary of upper limit voltage violation grouped by Scenario and Contingency	59
5.10	Upper Voltage Limit Counts - Scenario	59
5.11	Upper Voltage Limit Counts - Contingency	59
5.12	Upper Voltage Limit Counts - Bus	59
5.13	Summary of lower limit voltage violation grouped by Scenario and Contingency	60
5.14	Summary of lower limit voltage violation grouped by Scenario and Contingency - Continued	61
5.15	Lower Voltage Limit Counts - Scenario	61
5.16	Lower Voltage Limit Counts - Bus	62
5.17	Lower Voltage Limit Counts - Scenario	62

Chapter 1

Introduction

1.1 Study Description

The Year 3 Topology 4 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.

Topology 4 is the system in Year 3 with the Hydro generator coming online at Bus 212 with the completion of multiple transmission system upgrades. The added hydro generator adds to the firm capacity of the system, giving the total firm capacity of the system to be 4769.5 MW with the non-firm capacity remaining the same. For the Year 3 Topology 4, a wet, dry and average hydrological scenarios were tested to account for the variability in hydro resource availability. The updated systems single line diagram with the Hydro Generator and transmission system upgrades can be seen in Figure 1.1 for Year 3 Topology 4.

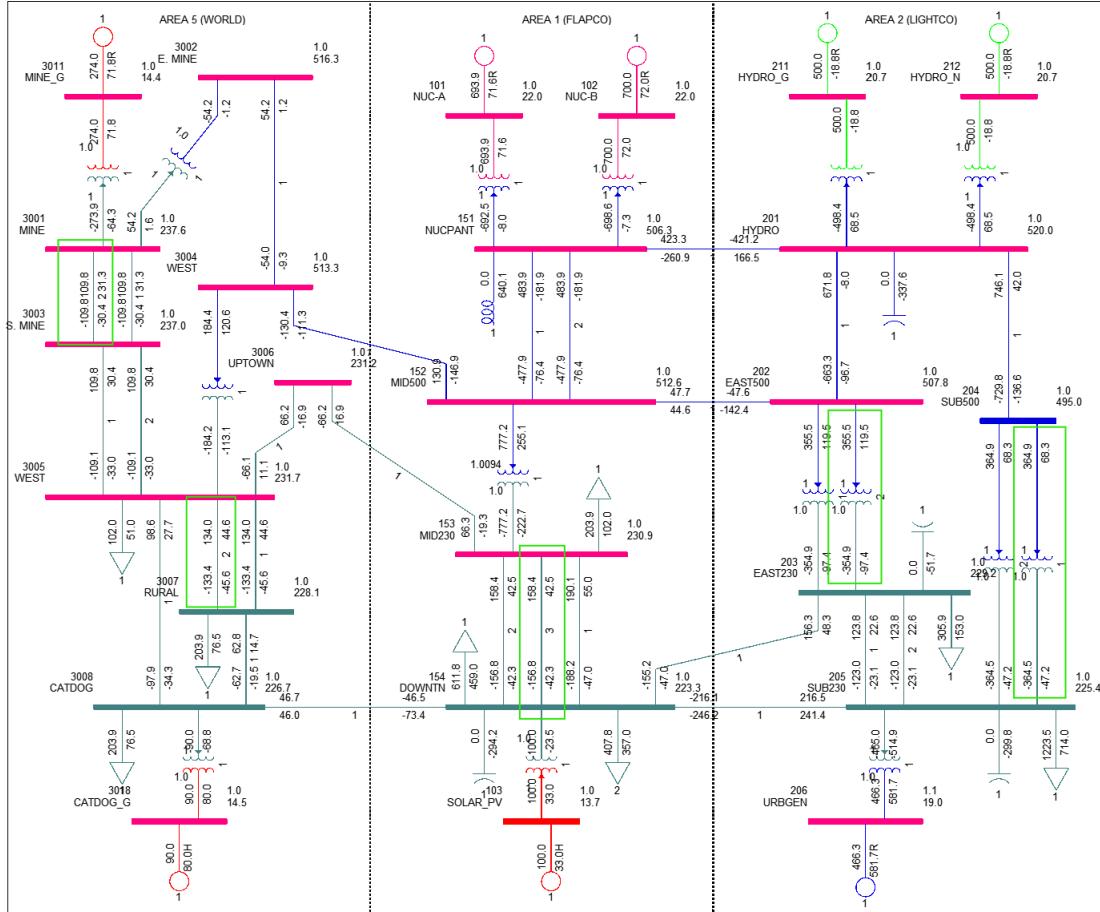


Figure 1.1: Single Line Diagram Year 3, Topology 4

Detailed analysis of Year 3 Topology 4 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 4. 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 4

```

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 4

```

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 4

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],"",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', baseswdflowvio=False, basenodevoltvio=False, overloadreport=
                           False)

```

Contingency analysis was carried out in PSSE for each of the studied scenario for Year 3, Topology 4. 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:

- Solar = 0 MW, Hydro = 400 MW, LLS
 - BUS 152, BUS 151, BUS 201, BUS 154
- Solar = 0 MW, Hydro = 500 MW, LLS
 - BUS 152, BUS 151, BUS 201
- Solar = 0 MW, Hydro = 600 MW, LLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, BUS 205, BUS 152
- Solar = 0 MW, Hydro = 400 MW, RLS
 - BUS 151, BUS 201, UNIT 206(1), SING OPN LIN 20 205-206(1), BUS 152
- Solar = 0 MW, Hydro = 500 MW, RLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), BUS 205, SING OPN LIN 20 205-206(1), BUS 152
- Solar = 0 MW, Hydro = 600 MW, RLS

- BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), BUS 205, SING OPN LIN 20 205-206(1), BUS 152
- Solar = 0 MW, Hydro = 400 MW, HLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), SING OPN LIN 20 205-206(1), BUS 152
- Solar = 0 MW, Hydro = 500 MW, HLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), BUS 205, SING OPN LIN 20 205-206(1), BUS 152
- Solar = 0 MW, Hydro = 600 MW, HLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, SING OPN LIN 10 201-202(1), UNIT 206(1), BUS 205, SING OPN LIN 20 205-206(1), BUS 152
- Solar = 50 MW, Hydro = 400 MW, LLS
 - BUS 152, BUS 151, BUS 201, BUS 154
- Solar = 50 MW, Hydro = 500 MW, LLS
 - BUS 152, BUS 201
- Solar = 50 MW, Hydro = 600 MW, LLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, BUS 205, BUS 152
- Solar = 50 MW, Hydro = 400 MW, RLS
 - BUS 151, BUS 201, UNIT 206(1), SING OPN LIN 20 205-206(1), BUS 152
- Solar = 50 MW, Hydro = 500 MW, RLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), BUS 205, SING OPN LIN 20 205-206(1), BUS 152
- Solar = 50 MW, Hydro = 600 MW, RLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), BUS 205, SING OPN LIN 20 205-206(1), BUS 152
- Solar = 50 MW, Hydro = 400 MW, HLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), SING OPN LIN 20 205-206(1), BUS 152
- Solar = 50 MW, Hydro = 500 MW, HLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), BUS 205, SING OPN LIN 20 205-206(1), BUS 152
- Solar = 50 MW, Hydro = 600 MW, HLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), BUS 205, SING OPN LIN 20 205-206(1), BUS 152
- Solar = 100 MW, Hydro = 400 MW, LLS
 - BUS 152, BUS 151, BUS 201, BUS 154
- Solar = 100 MW, Hydro = 500 MW, LLS
 - BUS 152, BUS 201
- Solar = 100 MW, Hydro = 600 MW, LLS

- BUS 204, BUS 201, SING OPN LIN 11 201-204(1), BUS 205, BUS 152
- Solar = 100 MW, Hydro = 400 MW, RLS
 - BUS 152, BUS 151, BUS 201
- Solar = 100 MW, Hydro = 500 MW, RLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), SING OPN LIN 20 205-206(1), BUS 152
- Solar = 100 MW, Hydro = 600 MW, RLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), BUS 205, SING OPN LIN 20 205-206(1), BUS 152
- Solar = 100 MW, Hydro = 400 MW, HLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), SING OPN LIN 20 205-206(1), BUS 152
- Solar = 100 MW, Hydro = 500 MW, HLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), BUS 205, SING OPN LIN 20 205-206(1), BUS 152
- Solar = 100 MW, Hydro = 600 MW, HLS
 - BUS 204, BUS 151, BUS 202, SING OPN LIN 11 201-204(1), BUS 201, UNIT 206(1), BUS 205, SING OPN LIN 20 205-206(1), BUS 152

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 3 gives the upper voltage violations reported for each of the studied scenarios. Chapter 4 gives the lower 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 4 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% was reported for the branch 154-203(1) for bus fault contingency BUS 205.

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)	327.35	318.83	300.00	106.28
3001-3003(2)	UNIT 101(1)	327.35	318.83	300.00	106.28
101-151(1)	UNIT 102(1)	1397.18	1397.18	1350.00	103.49

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	264.51	272.85	250.00	109.14
154-203(1)	BUS 204	237.92	260.85	250.00	104.34
154-203(1)	BUS 205	357.32	417.08	250.00	166.83

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)	327.31	318.79	300.00	106.26
3001-3003(2)	SING OPN LIN 1 101-151(1)	327.31	318.79	300.00	106.26
101-151(1)	SING OPN LIN 2 102-151(1)	1397.18	1397.18	1350.00	103.49
154-203(1)	SING OPN LIN 6 152-153(1)	280.12	289.30	250.00	115.72
154-205(1)	SING OPN LIN 6 152-153(1)	672.12	694.16	660.00	105.18
154-203(1)	SING OPN LIN 11 201-204(1)	237.92	260.85	250.00	104.34

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

For the studied scenario Solar = 0 MW, Hydro = 500 MW, LLS, loading greater than 130% was reported for the branch 154-203(1) for bus fault contingency BUS 205.

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)	328.85	320.41	300.00	106.80
3001-3003(2)	UNIT 101(1)	328.85	320.41	300.00	106.80
101-151(1)	UNIT 102(1)	1400.18	1400.18	1350.00	103.72

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	287.21	296.40	250.00	118.56
154-203(1)	BUS 204	263.26	306.21	250.00	122.48
203-205(1)	BUS 204	-253.29	292.89	250.00	117.16
203-205(2)	BUS 204	-253.29	292.89	250.00	117.16
153-3006(1)	BUS 205	320.96	366.92	350.00	104.83
154-203(1)	BUS 205	382.93	477.72	250.00	191.09
3005-3006(1)	BUS 205	-322.02	366.47	350.00	104.71

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)	328.81	320.37	300.00	106.79
3001-3003(2)	SING OPN LIN 1 101-151(1)	328.81	320.37	300.00	106.79
101-151(1)	SING OPN LIN 2 102-151(1)	1400.18	1400.18	1350.00	103.72
154-203(1)	SING OPN LIN 6 152-153(1)	302.78	315.94	250.00	126.38
154-203(1)	SING OPN LIN 11 201-204(1)	263.26	306.22	250.00	122.49
203-205(1)	SING OPN LIN 11 201-204(1)	-253.29	292.90	250.00	117.16
203-205(2)	SING OPN LIN 11 201-204(1)	-253.29	292.90	250.00	117.16

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

For the studied scenario Solar = 0 MW, Hydro = 600 MW, LLS, loading greater than 130% was reported 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: 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)	330.42	322.07	300.00	107.36
3001-3003(2)	UNIT 101(1)	330.42	322.07	300.00	107.36
101-151(1)	UNIT 102(1)	1403.49	1403.49	1350.00	103.96

Table 2.8: 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	311.67	325.11	250.00	130.04
203-205(1)	BUS 153	-244.60	252.20	250.00	100.88
203-205(2)	BUS 153	-244.60	252.20	250.00	100.88
153-154(1)	BUS 203	-357.60	381.28	350.00	108.94

Table 2.9: 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)	330.38	322.03	300.00	107.34
3001-3003(2)	SING OPN LIN 1 101-151(1)	330.38	322.03	300.00	107.34
101-151(1)	SING OPN LIN 2 102-151(1)	1403.49	1403.49	1350.00	103.96
154-203(1)	SING OPN LIN 6 152-153(1)	325.62	346.36	250.00	138.55
203-205(1)	SING OPN LIN 6 152-153(1)	-252.18	264.92	250.00	105.97
203-205(2)	SING OPN LIN 6 152-153(1)	-252.18	264.92	250.00	105.97

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

For the studied scenario Solar = 0 MW, Hydro = 400 MW, RLS, loading greater than 130% was reported for the branch 154-203(1) for bus fault contingency BUS 205.

Table 2.10: 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)	359.89	351.71	300.00	117.24
3001-3003(2)	UNIT 101(1)	359.89	351.71	300.00	117.24
3003-3005(1)	UNIT 101(1)	-349.94	351.92	350.00	100.55
3003-3005(2)	UNIT 101(1)	-349.94	351.92	350.00	100.55
101-151(1)	UNIT 102(1)	1462.55	1462.55	1350.00	108.34

Table 2.11: 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	271.16	282.88	250.00	113.15
154-205(1)	BUS 153	653.89	682.15	660.00	103.36
154-203(1)	BUS 204	246.77	298.43	250.00	119.37
203-205(1)	BUS 204	-226.61	272.77	250.00	109.11
203-205(2)	BUS 204	-226.61	272.77	250.00	109.11
154-203(1)	BUS 205	370.27	456.79	250.00	182.72

Table 2.12: 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)	359.84	351.65	300.00	117.22
3001-3003(2)	SING OPN LIN 1 101-151(1)	359.84	351.65	300.00	117.22
3003-3005(1)	SING OPN LIN 1 101-151(1)	-349.89	351.87	350.00	100.53
3003-3005(2)	SING OPN LIN 1 101-151(1)	-349.89	351.87	350.00	100.53
101-151(1)	SING OPN LIN 2 102-151(1)	1462.55	1462.55	1350.00	108.34
154-203(1)	SING OPN LIN 6 152-153(1)	289.39	308.38	250.00	123.35
154-205(1)	SING OPN LIN 6 152-153(1)	723.74	771.25	660.00	116.86
154-203(1)	SING OPN LIN 11 201-204(1)	246.76	298.40	250.00	119.36
203-205(1)	SING OPN LIN 11 201-204(1)	-226.61	272.75	250.00	109.10
203-205(2)	SING OPN LIN 11 201-204(1)	-226.61	272.75	250.00	109.10

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

For the studied scenario Solar = 0 MW, Hydro = 500 MW, RLS, loading greater than 130% was reported for the branch 154-203(1) for single line open contingency SING OPN LIN 6 152-153(1).

Table 2.13: 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)	361.46	353.38	300.00	117.79
3001-3003(2)	UNIT 101(1)	361.46	353.38	300.00	117.79
3003-3005(1)	UNIT 101(1)	-351.23	353.62	350.00	101.03
3003-3005(2)	UNIT 101(1)	-351.23	353.62	350.00	101.03
101-151(1)	UNIT 102(1)	1465.75	1465.75	1350.00	108.57

Table 2.14: 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	295.94	313.28	250.00	125.31
153-154(1)	BUS 203	-340.71	365.45	350.00	104.41

Table 2.15: 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)	361.40	353.33	300.00	117.78
3001-3003(2)	SING OPN LIN 1 101-151(1)	361.40	353.33	300.00	117.78
3003-3005(1)	SING OPN LIN 1 101-151(1)	-351.17	353.56	350.00	101.02
3003-3005(2)	SING OPN LIN 1 101-151(1)	-351.17	353.56	350.00	101.02
101-151(1)	SING OPN LIN 2 102-151(1)	1465.75	1465.75	1350.00	108.57
154-203(1)	SING OPN LIN 6 152-153(1)	312.03	337.88	250.00	135.15
154-205(1)	SING OPN LIN 6 152-153(1)	678.18	734.37	660.00	111.27

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

For the studied scenario Solar = 0 MW, Hydro = 600 MW, RLS, loading greater than 130% was reported 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 2.16: 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)	363.04	355.09	300.00	118.36
3001-3003(2)	UNIT 101(1)	363.04	355.09	300.00	118.36
3003-3005(1)	UNIT 101(1)	-352.50	355.36	350.00	101.53
3003-3005(2)	UNIT 101(1)	-352.50	355.36	350.00	101.53
101-151(1)	UNIT 102(1)	1469.27	1469.27	1350.00	108.83

Table 2.17: 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
154-203(1)	BUS 153	320.13	345.97	250.00	138.39
203-205(1)	BUS 153	-248.64	265.10	250.00	106.04
203-205(2)	BUS 153	-248.64	265.10	250.00	106.04
153-154(1)	BUS 203	-368.00	408.38	350.00	116.68
154-203(1)	BUS 3005	237.16	261.34	250.00	104.54

Table 2.18: 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)	362.98	355.03	300.00	118.34
3001-3003(2)	SING OPN LIN 1 101-151(1)	362.98	355.03	300.00	118.34
3003-3005(1)	SING OPN LIN 1 101-151(1)	-352.44	355.29	350.00	101.51
3003-3005(2)	SING OPN LIN 1 101-151(1)	-352.44	355.29	350.00	101.51
101-151(1)	SING OPN LIN 2 102-151(1)	1469.27	1469.27	1350.00	108.83
154-203(1)	SING OPN LIN 6 152-153(1)	334.13	370.07	250.00	148.03
154-205(1)	SING OPN LIN 6 152-153(1)	632.91	700.98	660.00	106.21
203-205(1)	SING OPN LIN 6 152-153(1)	-256.04	279.48	250.00	111.79
203-205(2)	SING OPN LIN 6 152-153(1)	-256.04	279.48	250.00	111.79
201-204(1)	SING OPN LIN 10 201-202(1)	-1179.93	1324.48	1300.00	101.88

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

For the studied scenario Solar = 0 MW, Hydro = 400 MW, HLS, loading greater than 130% was reported for the branch 154-203(1) for bus fault contingency BUS 205 and for single line open contingency SING OPN LIN 6 152-153(1).

Table 2.19: 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)	386.25	378.61	300.00	126.20
3001-3003(2)	UNIT 101(1)	386.25	378.61	300.00	126.20
3003-3005(1)	UNIT 101(1)	-374.48	378.84	350.00	108.24
3003-3005(2)	UNIT 101(1)	-374.48	378.84	350.00	108.24
101-151(1)	UNIT 102(1)	1515.14	1515.14	1350.00	112.23

Table 2.20: 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	280.43	301.39	250.00	120.55
154-205(1)	BUS 153	683.84	734.94	660.00	111.36
153-154(1)	BUS 205	-276.15	363.55	350.00	103.87
154-203(1)	BUS 205	380.28	500.63	250.00	200.25

Table 2.21: 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)	386.18	378.54	300.00	126.18
3001-3003(2)	SING OPN LIN 1 101-151(1)	386.18	378.54	300.00	126.18
3003-3005(1)	SING OPN LIN 1 101-151(1)	-374.42	378.77	350.00	108.22
3003-3005(2)	SING OPN LIN 1 101-151(1)	-374.42	378.77	350.00	108.22
101-151(1)	SING OPN LIN 2 102-151(1)	1515.14	1515.14	1350.00	112.23
154-203(1)	SING OPN LIN 6 152-153(1)	298.03	328.52	250.00	131.41
154-205(1)	SING OPN LIN 6 152-153(1)	761.10	838.95	660.00	127.11

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

For the studied scenario Solar = 0 MW, Hydro = 500 MW, HLS, loading greater than 130% was reported 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 2.22: 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)	388.44	381.34	300.00	127.11
3001-3003(2)	UNIT 101(1)	388.44	381.34	300.00	127.11
3003-3005(1)	UNIT 101(1)	-375.53	381.67	350.00	109.05
3003-3005(2)	UNIT 101(1)	-375.53	381.67	350.00	109.05
101-151(1)	UNIT 102(1)	1519.68	1519.68	1350.00	112.57

Table 2.23: 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
154-203(1)	BUS 153	303.78	331.70	250.00	132.68
154-205(1)	BUS 153	643.73	702.89	660.00	106.50
153-154(1)	BUS 203	-349.41	387.07	350.00	110.59
154-203(1)	BUS 3005	229.18	257.23	250.00	102.89

Table 2.24: 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)	388.37	381.26	300.00	127.09
3001-3003(2)	SING OPN LIN 1 101-151(1)	388.37	381.26	300.00	127.09
3003-3005(1)	SING OPN LIN 1 101-151(1)	-375.45	381.59	350.00	109.03
3003-3005(2)	SING OPN LIN 1 101-151(1)	-375.45	381.59	350.00	109.03
101-151(1)	SING OPN LIN 2 102-151(1)	1519.69	1519.69	1350.00	112.57
154-203(1)	SING OPN LIN 6 152-153(1)	319.40	358.40	250.00	143.36
154-205(1)	SING OPN LIN 6 152-153(1)	717.31	804.90	660.00	121.95
203-205(1)	SING OPN LIN 6 152-153(1)	-235.62	260.20	250.00	104.08
203-205(2)	SING OPN LIN 6 152-153(1)	-235.62	260.20	250.00	104.08

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

For the studied scenario Solar = 0 MW, Hydro = 600 MW, HLS, loading greater than 130% was reported 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 2.25: 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
3001-3003(1)	UNIT 101(1)	391.73	385.47	300.00	128.49
3001-3003(2)	UNIT 101(1)	391.73	385.47	300.00	128.49
3003-3005(1)	UNIT 101(1)	-376.98	385.96	350.00	110.28
3003-3005(2)	UNIT 101(1)	-376.98	385.96	350.00	110.28
101-151(1)	UNIT 102(1)	1525.94	1525.94	1350.00	113.03

Table 2.26: Bus faults reporting branch flow greater than 100% for scenario Solar = 0 MW, Hydro = 600 MW, HLS

Branch	Contingency	MVA Flow	AMP Flow	Rate	Loading
154-203(1)	BUS 153	327.36	365.98	250.00	146.39
154-205(1)	BUS 153	603.27	674.45	660.00	102.19
203-205(1)	BUS 153	-252.37	277.86	250.00	111.15
203-205(2)	BUS 153	-252.37	277.86	250.00	111.15
153-154(1)	BUS 203	-376.75	435.26	350.00	124.36
153-154(2)	BUS 203	-314.50	363.33	350.00	103.81
153-154(3)	BUS 203	-314.50	363.33	350.00	103.81
154-203(1)	BUS 3005	246.09	284.80	250.00	113.92

Table 2.27: 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
3001-3003(1)	SING OPN LIN 1 101-151(1)	391.61	385.35	300.00	128.45
3001-3003(2)	SING OPN LIN 1 101-151(1)	391.61	385.35	300.00	128.45
3003-3005(1)	SING OPN LIN 1 101-151(1)	-376.87	385.84	350.00	110.24
3003-3005(2)	SING OPN LIN 1 101-151(1)	-376.87	385.84	350.00	110.24
101-151(1)	SING OPN LIN 2 102-151(1)	1525.94	1525.94	1350.00	113.03
154-203(1)	SING OPN LIN 6 152-153(1)	341.13	393.40	250.00	157.36
154-205(1)	SING OPN LIN 6 152-153(1)	671.79	774.73	660.00	117.38
203-205(1)	SING OPN LIN 6 152-153(1)	-259.42	294.24	250.00	117.70
203-205(2)	SING OPN LIN 6 152-153(1)	-259.42	294.24	250.00	117.70

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

For the studied scenario Solar = 50 MW, Hydro = 400 MW, LLS, loading greater than 130% was reported for the branch 154-203(1) for bus fault contingency BUS 205.

Table 2.28: 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
154-203(1)	BUS 153	256.30	264.30	250.00	105.72
154-203(1)	BUS 205	344.83	397.40	250.00	158.96

Table 2.29: 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
154-203(1)	SING OPN LIN 6 152-153(1)	271.88	280.72	250.00	112.29
154-205(1)	SING OPN LIN 6 152-153(1)	642.06	662.92	660.00	100.44

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 branches 3001-3003(1), 3001-3003(2), 3003-3005(1), 3003-3005(2) for bus fault contingency BUS 151, and for the branch 154-203(1) for bus fault contingency BUS 205.

Table 2.30: 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)	310.52	302.12	300.00	100.71
3001-3003(2)	UNIT 101(1)	310.52	302.12	300.00	100.71

Table 2.31: 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
153-3006(1)	BUS 151	-338.85	387.76	350.00	110.79
154-3008(1)	BUS 151	-408.09	477.01	440.00	108.41
3001-3003(1)	BUS 151	602.30	625.73	300.00	208.58
3001-3003(2)	BUS 151	602.30	625.73	300.00	208.58
3001-3011(1)	BUS 151	-1877.20	1877.20	1560.00	120.33
3003-3005(1)	BUS 151	-541.76	626.79	350.00	179.08
3003-3005(2)	BUS 151	-541.76	626.79	350.00	179.08
3005-3006(1)	BUS 151	336.18	388.94	350.00	111.13
154-203(1)	BUS 153	278.62	287.46	250.00	114.98
154-203(1)	BUS 204	255.85	291.55	250.00	116.62
203-205(1)	BUS 204	-247.72	280.62	250.00	112.25
203-205(2)	BUS 204	-247.72	280.62	250.00	112.25
153-3006(1)	BUS 205	318.62	358.63	350.00	102.47
154-203(1)	BUS 205	370.88	453.05	250.00	181.22
3005-3006(1)	BUS 205	-319.45	358.20	350.00	102.34

Table 2.32: 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)	310.55	302.15	300.00	100.72
3001-3003(2)	SING OPN LIN 1 101-151(1)	310.55	302.15	300.00	100.72
154-203(1)	SING OPN LIN 6 152-153(1)	293.72	304.80	250.00	121.92
154-203(1)	SING OPN LIN 11 201-204(1)	255.85	291.55	250.00	116.62
203-205(1)	SING OPN LIN 11 201-204(1)	-247.73	280.63	250.00	112.25
203-205(2)	SING OPN LIN 11 201-204(1)	-247.73	280.63	250.00	112.25

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

For the studied scenario Solar = 50 MW, Hydro = 600 MW, LLS, loading greater than 130% was reported for the branch 154-203(1) for single line open contingency SING OPN LIN 6 152-153(1).

Table 2.33: 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)	312.06	303.74	300.00	101.25
3001-3003(2)	UNIT 101(1)	312.06	303.74	300.00	101.25
101-151(1)	UNIT 102(1)	1350.27	1350.27	1350.00	100.02

Table 2.34: 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	302.50	313.76	250.00	125.50
153-154(1)	BUS 203	-349.22	369.77	350.00	105.65

Table 2.35: 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)	312.02	303.71	300.00	101.24
3001-3003(2)	SING OPN LIN 1 101-151(1)	312.02	303.71	300.00	101.24
101-151(1)	SING OPN LIN 2 102-151(1)	1350.27	1350.27	1350.00	100.02
154-203(1)	SING OPN LIN 6 152-153(1)	317.20	335.36	250.00	134.14
203-205(1)	SING OPN LIN 6 152-153(1)	-246.79	257.74	250.00	103.09
203-205(2)	SING OPN LIN 6 152-153(1)	-246.79	257.74	250.00	103.09

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

For the studied scenario Solar = 50 MW, Hydro = 400 MW, RLS, loading greater than 130% was reported for the branch 154-203(1) for bus fault contingency BUS 205.

Table 2.36: 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)	341.35	333.05	300.00	111.02
3001-3003(2)	UNIT 101(1)	341.35	333.05	300.00	111.02
101-151(1)	UNIT 102(1)	1409.35	1409.35	1350.00	104.40

Table 2.37: 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	262.73	272.79	250.00	109.11
154-203(1)	BUS 204	239.19	282.02	250.00	112.81
203-205(1)	BUS 204	-220.79	259.05	250.00	103.62
203-205(2)	BUS 204	-220.79	259.05	250.00	103.62
154-203(1)	BUS 205	358.09	433.78	250.00	173.51

Table 2.38: 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)	341.31	333.00	300.00	111.00
3001-3003(2)	SING OPN LIN 1 101-151(1)	341.31	333.00	300.00	111.00
101-151(1)	SING OPN LIN 2 102-151(1)	1409.35	1409.35	1350.00	104.40
154-203(1)	SING OPN LIN 6 152-153(1)	281.00	297.80	250.00	119.12
154-205(1)	SING OPN LIN 6 152-153(1)	696.22	737.83	660.00	111.79
154-203(1)	SING OPN LIN 11 201-204(1)	239.19	282.01	250.00	112.80
203-205(1)	SING OPN LIN 11 201-204(1)	-220.79	259.04	250.00	103.62
203-205(2)	SING OPN LIN 11 201-204(1)	-220.79	259.04	250.00	103.62

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

For the studied scenario Solar = 50 MW, Hydro = 500 MW, RLS, loading greater than 130% was reported for the branch 154-203(1) for single line open contingency SING OPN LIN 6 152-153(1).

Table 2.39: 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)	342.84	334.62	300.00	111.54
3001-3003(2)	UNIT 101(1)	342.84	334.62	300.00	111.54
101-151(1)	UNIT 102(1)	1412.39	1412.39	1350.00	104.62

Table 2.40: 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	286.87	301.94	250.00	120.78
153-154(1)	BUS 203	-332.39	354.14	350.00	101.18

Table 2.41: 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)	342.79	334.58	300.00	111.53
3001-3003(2)	SING OPN LIN 1 101-151(1)	342.79	334.58	300.00	111.53
101-151(1)	SING OPN LIN 2 102-151(1)	1412.39	1412.39	1350.00	104.62
154-203(1)	SING OPN LIN 6 152-153(1)	303.30	326.22	250.00	130.49
154-205(1)	SING OPN LIN 6 152-153(1)	652.25	701.54	660.00	106.29

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

For the studied scenario Solar = 50 MW, Hydro = 600 MW, RLS, loading greater than 130% was reported 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 2.42: 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)	344.43	336.33	300.00	112.11
3001-3003(2)	UNIT 101(1)	344.43	336.33	300.00	112.11
101-151(1)	UNIT 102(1)	1415.75	1415.75	1350.00	104.87

Table 2.43: 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
154-203(1)	BUS 153	311.16	333.94	250.00	133.58
203-205(1)	BUS 153	-242.75	257.11	250.00	102.84
203-205(2)	BUS 153	-242.75	257.11	250.00	102.84
153-154(1)	BUS 203	-359.81	395.78	350.00	113.08
154-203(1)	BUS 3005	230.84	252.33	250.00	100.93

Table 2.44: 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)	344.38	336.27	300.00	112.09
3001-3003(2)	SING OPN LIN 1 101-151(1)	344.38	336.27	300.00	112.09
101-151(1)	SING OPN LIN 2 102-151(1)	1415.75	1415.75	1350.00	104.87
154-203(1)	SING OPN LIN 6 152-153(1)	325.96	358.25	250.00	143.30
154-205(1)	SING OPN LIN 6 152-153(1)	606.47	666.54	660.00	100.99
203-205(1)	SING OPN LIN 6 152-153(1)	-250.83	271.77	250.00	108.71
203-205(2)	SING OPN LIN 6 152-153(1)	-250.83	271.77	250.00	108.71

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

For the studied scenario Solar = 50 MW, Hydro = 400 MW, HLS, loading greater than 130% was reported for the branch 154-203(1) for bus fault contingency BUS 205.

Table 2.45: 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)	367.48	359.56	300.00	119.85
3001-3003(2)	UNIT 101(1)	367.48	359.56	300.00	119.85
3003-3005(1)	UNIT 101(1)	-356.75	359.81	350.00	102.80
3003-3005(2)	UNIT 101(1)	-356.75	359.81	350.00	102.80
101-151(1)	UNIT 102(1)	1461.70	1461.70	1350.00	108.27

Table 2.46: 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	271.48	290.03	250.00	116.01
154-205(1)	BUS 153	656.18	701.04	660.00	106.22
154-203(1)	BUS 205	368.67	471.76	250.00	188.70

Table 2.47: 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)	367.42	359.50	300.00	119.83
3001-3003(2)	SING OPN LIN 1 101-151(1)	367.42	359.50	300.00	119.83
3003-3005(1)	SING OPN LIN 1 101-151(1)	-356.70	359.75	350.00	102.79
3003-3005(2)	SING OPN LIN 1 101-151(1)	-356.70	359.75	350.00	102.79
101-151(1)	SING OPN LIN 2 102-151(1)	1461.70	1461.70	1350.00	108.27
154-203(1)	SING OPN LIN 6 152-153(1)	289.84	317.33	250.00	126.93
154-205(1)	SING OPN LIN 6 152-153(1)	733.59	803.18	660.00	121.69

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

For the studied scenario Solar = 50 MW, Hydro = 500 MW, HLS, loading greater than 130% was reported for the branch 154-203(1) for single line open contingency SING OPN LIN 6 152-153(1).

Table 2.48: 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)	369.20	361.48	300.00	120.49
3001-3003(2)	UNIT 101(1)	369.20	361.48	300.00	120.49
3003-3005(1)	UNIT 101(1)	-358.00	361.77	350.00	103.36
3003-3005(2)	UNIT 101(1)	-358.00	361.77	350.00	103.36
101-151(1)	UNIT 102(1)	1465.29	1465.29	1350.00	108.54

Table 2.49: 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
154-203(1)	BUS 153	294.89	319.77	250.00	127.91
154-205(1)	BUS 153	616.79	668.83	660.00	101.34
153-154(1)	BUS 203	-341.26	374.99	350.00	107.14

Table 2.50: 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)	369.14	361.41	300.00	120.47
3001-3003(2)	SING OPN LIN 1 101-151(1)	369.14	361.41	300.00	120.47
3003-3005(1)	SING OPN LIN 1 101-151(1)	-357.95	361.71	350.00	103.35
3003-3005(2)	SING OPN LIN 1 101-151(1)	-357.95	361.71	350.00	103.35
101-151(1)	SING OPN LIN 2 102-151(1)	1465.29	1465.29	1350.00	108.54
154-203(1)	SING OPN LIN 6 152-153(1)	311.33	346.60	250.00	138.64
154-205(1)	SING OPN LIN 6 152-153(1)	690.21	768.41	660.00	116.43
203-205(1)	SING OPN LIN 6 152-153(1)	-230.44	252.57	250.00	101.03
203-205(2)	SING OPN LIN 6 152-153(1)	-230.44	252.57	250.00	101.03

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

For the studied scenario Solar = 50 MW, Hydro = 600 MW, HLS, loading greater than 130% was reported 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 2.51: 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
3001-3003(1)	UNIT 101(1)	372.10	365.12	300.00	121.71
3001-3003(2)	UNIT 101(1)	372.10	365.12	300.00	121.71
3003-3005(1)	UNIT 101(1)	-359.28	365.58	350.00	104.45
3003-3005(2)	UNIT 101(1)	-359.28	365.58	350.00	104.45
101-151(1)	UNIT 102(1)	1471.22	1471.22	1350.00	108.98

Table 2.52: 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
154-203(1)	BUS 153	318.55	353.13	250.00	141.25
203-205(1)	BUS 153	-246.57	269.28	250.00	107.71
203-205(2)	BUS 153	-246.57	269.28	250.00	107.71
153-154(1)	BUS 203	-368.70	421.09	350.00	120.31
153-154(2)	BUS 203	-307.81	351.55	350.00	100.44
153-154(3)	BUS 203	-307.81	351.55	350.00	100.44
154-203(1)	BUS 3005	239.77	274.37	250.00	109.75

Table 2.53: 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
3001-3003(1)	SING OPN LIN 1 101-151(1)	372.01	365.03	300.00	121.68
3001-3003(2)	SING OPN LIN 1 101-151(1)	372.01	365.03	300.00	121.68
3003-3005(1)	SING OPN LIN 1 101-151(1)	-359.20	365.49	350.00	104.43
3003-3005(2)	SING OPN LIN 1 101-151(1)	-359.20	365.49	350.00	104.43
101-151(1)	SING OPN LIN 2 102-151(1)	1471.22	1471.22	1350.00	108.98
154-203(1)	SING OPN LIN 6 152-153(1)	333.22	380.51	250.00	152.20
154-205(1)	SING OPN LIN 6 152-153(1)	645.20	736.77	660.00	111.63
203-205(1)	SING OPN LIN 6 152-153(1)	-254.38	285.81	250.00	114.32
203-205(2)	SING OPN LIN 6 152-153(1)	-254.38	285.81	250.00	114.32
201-204(1)	SING OPN LIN 10 201-202(1)	-1192.47	1404.13	1300.00	108.01

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

For the studied scenario Solar = 100 MW, Hydro = 400 MW, LLS, loading greater than 130% was reported for the branch 154-203(1) for bus fault contingency BUS 205.

Table 2.54: 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
154-203(1)	BUS 153	248.24	255.95	250.00	102.38
154-203(1)	BUS 205	332.65	380.04	250.00	152.02

Table 2.55: 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
154-203(1)	SING OPN LIN 6 152-153(1)	263.73	272.27	250.00	108.91

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 branches 3001-3003(1), 3001-3003(2), 3003-3005(1), 3003-3005(2) for bus fault contingency BUS 151 and for the branch 154-203(1) for bus fault contingency BUS 205.

Table 2.56: 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
153-3006(1)	BUS 151	-322.48	359.15	350.00	102.61
154-3008(1)	BUS 151	-388.23	440.54	440.00	100.12
3001-3003(1)	BUS 151	571.33	586.54	300.00	195.51
3001-3003(2)	BUS 151	571.33	586.54	300.00	195.51
3001-3011(1)	BUS 151	-1758.61	1758.61	1560.00	112.73
3003-3005(1)	BUS 151	-522.80	587.48	350.00	167.85
3003-3005(2)	BUS 151	-522.80	587.48	350.00	167.85
3005-3006(1)	BUS 151	320.66	360.33	350.00	102.95
154-203(1)	BUS 153	270.02	278.56	250.00	111.42
154-203(1)	BUS 204	248.43	279.13	250.00	111.65
203-205(1)	BUS 204	-242.04	270.33	250.00	108.13
203-205(2)	BUS 204	-242.04	270.33	250.00	108.13
153-3006(1)	BUS 205	316.59	352.68	350.00	100.77
154-203(1)	BUS 205	359.14	432.91	250.00	173.17
3005-3006(1)	BUS 205	-317.26	352.27	350.00	100.65

Table 2.57: 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
154-203(1)	SING OPN LIN 6 152-153(1)	285.60	295.33	250.00	118.13
154-203(1)	SING OPN LIN 11 201-204(1)	248.43	279.14	250.00	111.66
203-205(1)	SING OPN LIN 11 201-204(1)	-242.05	270.34	250.00	108.14
203-205(2)	SING OPN LIN 11 201-204(1)	-242.05	270.34	250.00	108.14

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 branches 3001-3003(1), 3001-3003(2), 3003-3005(1), 3003-3005(2) for bus fault contingency BUS 151.

Table 2.58: 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
153-3006(1)	BUS 151	-320.73	365.83	350.00	104.52
154-3008(1)	BUS 151	-396.34	461.80	440.00	104.96
3001-3003(1)	BUS 151	582.05	602.10	300.00	200.70
3001-3003(2)	BUS 151	582.05	602.10	300.00	200.70
3001-3011(1)	BUS 151	-1803.33	1803.33	1560.00	115.60
3003-3005(1)	BUS 151	-524.83	603.23	350.00	172.35
3003-3005(2)	BUS 151	-524.83	603.23	350.00	172.35
3005-3006(1)	BUS 151	319.21	366.90	350.00	104.83
154-203(1)	BUS 153	293.42	303.09	250.00	121.24
153-154(1)	BUS 202	-291.00	350.94	350.00	100.27
201-204(1)	BUS 202	-1208.27	1414.39	1300.00	108.80
153-154(1)	BUS 203	-340.87	359.05	350.00	102.59

Table 2.59: 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
154-203(1)	SING OPN LIN 6 152-153(1)	308.79	325.00	250.00	130.00
203-205(1)	SING OPN LIN 6 152-153(1)	-241.36	250.95	250.00	100.38
203-205(2)	SING OPN LIN 6 152-153(1)	-241.36	250.95	250.00	100.38

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

For the studied scenario Solar = 100 MW, Hydro = 400 MW, RLS, loading greater than 130% was reported for the branch 154-203(1) for bus fault contingency BUS 205.

Table 2.60: 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)	319.43	311.11	300.00	103.70
3001-3003(2)	UNIT 101(1)	319.43	311.11	300.00	103.70
101-151(1)	UNIT 102(1)	1356.38	1356.38	1350.00	100.47
3001-3003(1)	UNIT 206(1)	348.18	347.87	300.00	115.96
3001-3003(2)	UNIT 206(1)	348.18	347.87	300.00	115.96
3003-3005(1)	UNIT 206(1)	-321.95	350.21	350.00	100.06
3003-3005(2)	UNIT 206(1)	-321.95	350.21	350.00	100.06

Table 2.61: 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	254.19	262.64	250.00	105.05
154-203(1)	BUS 204	231.84	269.01	250.00	107.60
154-203(1)	BUS 205	346.34	414.63	250.00	165.85

Table 2.62: 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)	319.43	311.11	300.00	103.70
3001-3003(2)	SING OPN LIN 1 101-151(1)	319.43	311.11	300.00	103.70
101-151(1)	SING OPN LIN 2 102-151(1)	1356.38	1356.38	1350.00	100.47
154-203(1)	SING OPN LIN 6 152-153(1)	272.75	287.92	250.00	115.17
154-205(1)	SING OPN LIN 6 152-153(1)	670.39	707.66	660.00	107.22
154-203(1)	SING OPN LIN 11 201-204(1)	231.84	268.99	250.00	107.60
3001-3003(1)	SING OPN LIN 20 205-206(1)	348.18	347.87	300.00	115.96
3001-3003(2)	SING OPN LIN 20 205-206(1)	348.18	347.87	300.00	115.96
3003-3005(1)	SING OPN LIN 20 205-206(1)	-321.95	350.21	350.00	100.06
3003-3005(2)	SING OPN LIN 20 205-206(1)	-321.95	350.21	350.00	100.06

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

For the studied scenario Solar = 100 MW, Hydro = 500 MW, RLS, loading greater than 130% was reported for the branch 154-203(1) for bus fault contingency BUS 205.

Table 2.63: 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)	324.42	316.18	300.00	105.39
3001-3003(2)	UNIT 101(1)	324.42	316.18	300.00	105.39
101-151(1)	UNIT 102(1)	1359.28	1359.28	1350.00	100.69

Table 2.64: 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	277.97	291.37	250.00	116.55
153-3006(1)	BUS 205	313.09	365.25	350.00	104.36
154-203(1)	BUS 205	371.07	479.35	250.00	191.74
3005-3006(1)	BUS 205	-314.34	364.78	350.00	104.22

Table 2.65: 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)	324.38	316.14	300.00	105.38
3001-3003(2)	SING OPN LIN 1 101-151(1)	324.38	316.14	300.00	105.38
101-151(1)	SING OPN LIN 2 102-151(1)	1359.28	1359.28	1350.00	100.69
154-203(1)	SING OPN LIN 6 152-153(1)	295.10	315.94	250.00	126.38
154-205(1)	SING OPN LIN 6 152-153(1)	627.04	671.34	660.00	101.72

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

For the studied scenario Solar = 100 MW, Hydro = 600 MW, RLS, loading greater than 130% was reported for the branch 154-203(1) for single line open contingency SING OPN LIN 6 152-153(1).

Table 2.66: 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)	325.99	317.84	300.00	105.95
3001-3003(2)	UNIT 101(1)	325.99	317.84	300.00	105.95
101-151(1)	UNIT 102(1)	1362.49	1362.49	1350.00	100.93

Table 2.67: 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	302.30	322.83	250.00	129.13
153-154(1)	BUS 203	-351.69	384.36	350.00	109.82

Table 2.68: 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)	325.94	317.79	300.00	105.93
3001-3003(2)	SING OPN LIN 1 101-151(1)	325.94	317.79	300.00	105.93
101-151(1)	SING OPN LIN 2 102-151(1)	1362.49	1362.49	1350.00	100.92
154-203(1)	SING OPN LIN 6 152-153(1)	317.83	347.36	250.00	138.94
203-205(1)	SING OPN LIN 6 152-153(1)	-245.58	264.63	250.00	105.85
203-205(2)	SING OPN LIN 6 152-153(1)	-245.58	264.63	250.00	105.85

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

For the studied scenario Solar = 100 MW, Hydro = 400 MW, HLS, loading greater than 130% was reported for the branch 154-203(1) for bus fault contingency BUS 205.

Table 2.69: 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)	345.22	337.11	300.00	112.37
3001-3003(2)	UNIT 101(1)	345.22	337.11	300.00	112.37
101-151(1)	UNIT 102(1)	1408.52	1408.52	1350.00	104.33

Table 2.70: 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	262.83	279.65	250.00	111.86
154-205(1)	BUS 153	630.47	670.83	660.00	101.64
154-203(1)	BUS 205	357.27	449.36	250.00	179.74

Table 2.71: 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)	345.22	337.11	300.00	112.37
3001-3003(2)	SING OPN LIN 1 101-151(1)	345.22	337.11	300.00	112.37
101-151(1)	SING OPN LIN 2 102-151(1)	1408.52	1408.52	1350.00	104.33
154-203(1)	SING OPN LIN 6 152-153(1)	281.81	307.08	250.00	122.83
154-205(1)	SING OPN LIN 6 152-153(1)	707.72	771.18	660.00	116.84

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

For the studied scenario Solar = 100 MW, Hydro = 500 MW, HLS, loading greater than 130% was reported for the branch 154-203(1) for single line open contingency SING OPN LIN 6 152-153(1).

Table 2.72: 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)	350.42	342.42	300.00	114.14
3001-3003(2)	UNIT 101(1)	350.42	342.42	300.00	114.14
101-151(1)	UNIT 102(1)	1411.51	1411.51	1350.00	104.56

Table 2.73: 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	286.21	308.86	250.00	123.54
153-154(1)	BUS 203	-333.26	364.05	350.00	104.01

Table 2.74: 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)	350.37	342.37	300.00	114.12
3001-3003(2)	SING OPN LIN 1 101-151(1)	350.37	342.37	300.00	114.12
101-151(1)	SING OPN LIN 2 102-151(1)	1411.51	1411.51	1350.00	104.56
154-203(1)	SING OPN LIN 6 152-153(1)	303.38	335.86	250.00	134.34
154-205(1)	SING OPN LIN 6 152-153(1)	665.02	736.23	660.00	111.55

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

For the studied scenario Solar = 100 MW, Hydro = 600 MW, HLS, loading greater than 130% was reported 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 2.75: 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)	352.91	345.46	300.00	115.15
3001-3003(2)	UNIT 101(1)	352.91	345.46	300.00	115.15
101-151(1)	UNIT 102(1)	1417.03	1417.03	1350.00	104.96

Table 2.76: 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
154-203(1)	BUS 153	309.91	341.50	250.00	136.60
203-205(1)	BUS 153	-240.85	261.51	250.00	104.60
203-205(2)	BUS 153	-240.85	261.51	250.00	104.60
153-154(1)	BUS 203	-360.76	408.67	350.00	116.76
154-203(1)	BUS 3005	233.70	265.31	250.00	106.12

Table 2.77: 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)	352.84	345.39	300.00	115.13
3001-3003(2)	SING OPN LIN 1 101-151(1)	352.84	345.39	300.00	115.13
101-151(1)	SING OPN LIN 2 102-151(1)	1417.03	1417.03	1350.00	104.96
154-203(1)	SING OPN LIN 6 152-153(1)	324.95	368.28	250.00	147.31
154-205(1)	SING OPN LIN 6 152-153(1)	621.56	704.43	660.00	106.73
203-205(1)	SING OPN LIN 6 152-153(1)	-248.89	277.59	250.00	111.04
203-205(2)	SING OPN LIN 6 152-153(1)	-248.89	277.59	250.00	111.04
201-204(1)	SING OPN LIN 10 201-202(1)	-1170.81	1354.95	1300.00	104.23

2.29 Result Summary

The Tables 5.2, 5.3, 5.4, and 5.5 summarises the results of the AC contingency calculation carried out on the hypothetical SAVNW system for Topology 4 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 Topology 4, Tables gives the branch overload violation count in descending order, and as can be seen, the scenarios with the greatest number of violations grouped by Scenario and contingency is reported by scenarios: Solar = 50 MW, Hydro = 500 MW, LLS; Solar = 100 MW, Hydro = 500 MW, LLS; Solar = 100 MW, Hydro = 600 MW, LLS for the bus fault labelled BUS 151 with each of these scenarios reporting in 8 branch overload violations each.

The contingencies causing the most number of overload violations is the SING OPN LIN 6 152-153(1) with 68 violations followed by SING OPN LIN 1 101-151(1) and UNIT 101(1) reporting 64 violations each. The complete counts of contingencies causing overload violations is given in Table 5.6.

The branch reporting the most number of violations is the branch 154-203 with 87 violations followed by the branches 3001-3003(1) and 3001-3003(2) with 51 violations each. 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 = 50 MW, Hydro = 500 MW, LLS with 23 violations, followed by Solar = 50 MW, Hydro = 600 MW, HLS and Solar = 0 MW, Hydro = 600 MW, HLS with 22 violations each. 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 4, only the scenarios, Solar = 0 MW, Hydro = 600 MW, LLS, Solar = 0 MW, Hydro = 600 MW, HLS, Solar = 50 MW, Hydro = 600 MW, HLS, Solar = 100 MW, Hydro = 600 MW, LLS, Solar = 100 MW, Hydro = 400 MW, RLS, Solar = 100 MW, Hydro = 600 MW, HLS reported upper voltage limit violations.

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

For the studied scenario Solar = 0 MW, Hydro = 600 MW, LLS, the buses violating the Upper voltage limits are buses 211, 212. The buses 211, 212 reported violations for unit fault UNIT 206(1) and for single line open fault SING OPN LIN 20 205-206(1).

Table 3.1: Unit faults reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 0 MW, Hydro = 600 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	UNIT 206(1)	1.04	1.10	0.06	0.05
212	UNIT 206(1)	1.04	1.10	0.06	0.05

Table 3.2: Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 0 MW, Hydro = 600 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	SING OPN LIN 20 205-206(1)	1.04	1.10	0.06	0.05
212	SING OPN LIN 20 205-206(1)	1.04	1.10	0.06	0.05

3.3 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 bus fault BUS 3005.

Table 3.3: Bus faults 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	BUS 3005	1.05	1.11	0.05	0.06
212	BUS 3005	1.05	1.11	0.05	0.06

3.4 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 single line open fault SING OPN LIN 10 201-202(1).

Table 3.4: 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 10 201-202(1)	1.05	1.11	0.07	0.06
212	SING OPN LIN 10 201-202(1)	1.05	1.11	0.07	0.06

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

For the studied scenario Solar = 100 MW, Hydro = 600 MW, LLS, the buses violating the Upper voltage limits are buses 211, 212. The buses 211, 212 reported violation for bus fault BUS 202.

Table 3.5: Bus faults reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 100 MW, Hydro = 600 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	BUS 202	1.04	1.11	0.07	0.06
212	BUS 202	1.04	1.11	0.07	0.06

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

For the studied scenario Solar = 100 MW, Hydro = 400 MW, RLS, the buses violating the Upper voltage limits are buses 211, 212.

Table 3.6: Unit faults reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 100 MW, Hydro = 400 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	UNIT 206(1)	1.03	1.11	0.09	0.06
212	UNIT 206(1)	1.03	1.11	0.09	0.06

The buses 211, 212 reported violations for unit fault UNIT 206(1) and for single line open fault SING OPN LIN 20 205-206(1).

Table 3.7: Single line open contingencies reporting bus voltages greater than emergency voltage of 1.1 PU for scenario Solar = 100 MW, Hydro = 400 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range Violation
211	SING OPN LIN 20 205-206(1)	1.03	1.11	0.09	0.06
212	SING OPN LIN 20 205-206(1)	1.03	1.11	0.09	0.06

3.7 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 for single line open fault SING OPN LIN 10 201-202(1).

Table 3.8: Single line open contingencies 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	SING OPN LIN 10 201-202(1)	1.05	1.11	0.06	0.06
212	SING OPN LIN 10 201-202(1)	1.05	1.11	0.06	0.06

3.8 Result Summary

The Table 5.9 summarises the results of the AC contingency calculation carried out on the hypothetical SAVNW system for Topology 4 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 = 0 MW, Hydro = 600 MW, LLS & Solar = 100 MW, Hydro = 400 MW, RLS with 8 violations each. The complete counts of each of the scenario reporting upper limit voltage violations are given in Table 5.10.

The contingencies causing the most number of overvoltage violations are single line contingencies labelled SING OPN LIN 20 205-206(1), SING OPN LIN 10 201-202(1), and unit fault contingency UNIT 206(1) with 8 violations each. The complete counts of each of the contingency causing upper limit violations is given in Table 5.11.

Chapter 4

Lower Emergency Bus Voltage violations

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. 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 violations 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, 205, 203, 103, 3008, 206. The buses 154, 205, 206 reported violations for unit fault UNIT 206(1).

Table 4.1: Unit faults 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 violations
154	UNIT 206(1)	0.975	0.876	-0.098	-0.074
205	UNIT 206(1)	0.980	0.878	-0.102	-0.072
206	UNIT 206(1)	1.022	0.878	-0.144	-0.072

The bus 203 reported violations for bus fault BUS 202, and the buses 103, 154, 3008 reported violations for bus fault BUS 205.

Table 4.2: Bus faults 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 violations
203	BUS 202	1.001	0.889	-0.112	-0.061
103	BUS 205	1.000	0.888	-0.112	-0.062
154	BUS 205	0.975	0.857	-0.118	-0.093
3008	BUS 205	0.992	0.894	-0.098	-0.056

The buses 154, 205 reported violations for single line open fault SING OPN LIN 20 205-206(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 = 400 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range violations
154	SING OPN LIN 20 205-206(1)	0.975	0.876	-0.098	-0.074
205	SING OPN LIN 20 205-206(1)	0.980	0.878	-0.102	-0.072

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 103, 154, 203, 204, 205, 3008, 153, 3005, 3006, 3007, 206. The buses 154, 205, 206 reported violations for unit fault UNIT 206(1).

Table 4.4: Unit 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 violations
154	UNIT 206(1)	0.974	0.878	-0.096	-0.072
205	UNIT 206(1)	0.980	0.879	-0.101	-0.071
206	UNIT 206(1)	1.029	0.879	-0.150	-0.071

The buses 103, 154, 203, 204, 205 reported violations for bus fault BUS 202, the bus 3008 reported violations for bus fault BUS 204, and the buses 153, 3005, 3006, 3007 reported violations for bus fault BUS 205.

Table 4.5: 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 violations
103	BUS 202	1.000	0.896	-0.104	-0.054
154	BUS 202	0.974	0.864	-0.110	-0.086
203	BUS 202	1.000	0.847	-0.153	-0.103
204	BUS 202	0.990	0.888	-0.102	-0.062
205	BUS 202	0.980	0.871	-0.109	-0.079
3008	BUS 204	0.991	0.895	-0.096	-0.055
153	BUS 205	1.008	0.875	-0.133	-0.075
3005	BUS 205	1.012	0.893	-0.119	-0.057
3006	BUS 205	1.009	0.879	-0.131	-0.071
3007	BUS 205	0.998	0.869	-0.129	-0.081

The buses 103, 154, 203, 204, 205, 3008 reported violations for single line open fault SING OPN LIN 11 201-204(1).

Table 4.6: 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 violations
103	SING OPN LIN 11 201-204(1)	1.000	0.891	-0.109	-0.059
154	SING OPN LIN 11 201-204(1)	0.974	0.860	-0.114	-0.090
203	SING OPN LIN 11 201-204(1)	1.000	0.899	-0.101	-0.051
204	SING OPN LIN 11 201-204(1)	0.990	0.865	-0.125	-0.085
205	SING OPN LIN 11 201-204(1)	0.980	0.865	-0.115	-0.085
3008	SING OPN LIN 11 201-204(1)	0.991	0.895	-0.096	-0.055

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 154, 205, 3007, 206. The buses 154, 205, 206 reported violations for unit fault UNIT 206(1).

Table 4.7: Unit 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 violations
154	UNIT 206(1)	0.974	0.875	-0.099	-0.075
205	UNIT 206(1)	0.980	0.875	-0.105	-0.075
206	UNIT 206(1)	1.037	0.875	-0.163	-0.075

The bus 3007 reported violations for bus fault BUS 3005.

Table 4.8: 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 violations
3007	BUS 3005	0.996	0.896	-0.100	-0.054

The buses 154, 205 reported violations for single line open fault SING OPN LIN 20 205-206(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 = 600 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range violations
154	SING OPN LIN 20 205-206(1)	0.974	0.875	-0.099	-0.075
205	SING OPN LIN 20 205-206(1)	0.980	0.875	-0.105	-0.075

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, 203, 204, 205, 3007, 3008, 3006. The buses 103, 154, 203, 204, 205, 3007, 3008 reported violations for bus fault BUS 202, the bus 153 reported violations for bus fault BUS 204, and the bus 3006 reported violations for bus fault BUS 205.

Table 4.10: 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 violations
103	BUS 202	1.000	0.857	-0.143	-0.093
154	BUS 202	0.973	0.824	-0.149	-0.126
203	BUS 202	0.999	0.802	-0.197	-0.148
204	BUS 202	0.991	0.858	-0.134	-0.092
205	BUS 202	0.980	0.831	-0.149	-0.119
3007	BUS 202	0.995	0.896	-0.100	-0.054
3008	BUS 202	0.989	0.869	-0.120	-0.081
153	BUS 204	1.006	0.895	-0.111	-0.055
3006	BUS 205	1.008	0.893	-0.115	-0.057

The buses 103, 153, 154, 203, 204, 205, 3007, 3008 reported violations for single line open fault SING OPN LIN 11 201-204(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 = 400 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range violations
103	SING OPN LIN 11 201-204(1)	1.000	0.860	-0.140	-0.090
153	SING OPN LIN 11 201-204(1)	1.006	0.895	-0.111	-0.055
154	SING OPN LIN 11 201-204(1)	0.973	0.827	-0.146	-0.123
203	SING OPN LIN 11 201-204(1)	0.999	0.876	-0.123	-0.074
204	SING OPN LIN 11 201-204(1)	0.991	0.831	-0.160	-0.119
205	SING OPN LIN 11 201-204(1)	0.980	0.831	-0.149	-0.119
3007	SING OPN LIN 11 201-204(1)	0.995	0.894	-0.101	-0.056
3008	SING OPN LIN 11 201-204(1)	0.989	0.869	-0.120	-0.081

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 3007, 3008. The buses 3007, 3008 reported violations for bus fault BUS 3005.

Table 4.12: 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 violations
3007	BUS 3005	0.994	0.869	-0.125	-0.081
3008	BUS 3005	0.988	0.898	-0.089	-0.052

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 103, 154, 203, 204, 205, 3008, 3007. The buses 3007, 3008 reported violations for bus fault BUS 3005.

Table 4.13: 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 violations
3007	BUS 3005	0.993	0.845	-0.147	-0.105
3008	BUS 3005	0.987	0.875	-0.112	-0.075

The buses 103, 154, 203, 204, 205, 3008 reported violations for single line open fault SING OPN LIN 10 201-202(1).

Table 4.14: 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 violations
103	SING OPN LIN 10 201-202(1)	1.000	0.899	-0.100	-0.051
154	SING OPN LIN 10 201-202(1)	0.971	0.868	-0.103	-0.082
203	SING OPN LIN 10 201-202(1)	0.996	0.889	-0.106	-0.061
204	SING OPN LIN 10 201-202(1)	0.988	0.891	-0.097	-0.059
205	SING OPN LIN 10 201-202(1)	0.980	0.877	-0.103	-0.073
3008	SING OPN LIN 10 201-202(1)	0.987	0.899	-0.088	-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, 103, 152, 153, 202, 203, 3004, 3005, 3006, 3007, 3008, 3018. The buses 103, 152, 153, 154, 202, 203, 3004, 3005, 3006, 3007, 3008, 3018 reported violations for bus fault BUS 205.

Table 4.15: 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 violations
103	BUS 205	0.999	0.795	-0.204	-0.155
152	BUS 205	1.026	0.888	-0.137	-0.062
153	BUS 205	1.004	0.850	-0.154	-0.100
154	BUS 205	0.971	0.760	-0.211	-0.190
202	BUS 205	1.016	0.895	-0.122	-0.055
203	BUS 205	0.997	0.860	-0.137	-0.090
3004	BUS 205	1.027	0.898	-0.129	-0.052
3005	BUS 205	1.007	0.876	-0.131	-0.074
3006	BUS 205	1.006	0.857	-0.149	-0.093
3007	BUS 205	0.992	0.846	-0.147	-0.104
3008	BUS 205	0.986	0.813	-0.173	-0.137
3018	BUS 205	1.048	0.885	-0.163	-0.065

The bus 154 reported violations for single line open fault SING OPN LIN 10 201-202(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 = 400 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range violations
154	SING OPN LIN 10 201-202(1)	0.971	0.892	-0.079	-0.058

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 153, 154, 103, 203, 204, 205, 3008, 3007. The buses 154, 3007, 3008 reported violations for bus fault BUS 3005.

Table 4.17: 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 violations
154	BUS 3005	0.968	0.891	-0.077	-0.059
3007	BUS 3005	0.989	0.822	-0.167	-0.128
3008	BUS 3005	0.983	0.854	-0.129	-0.096

The buses 153, 154 reported violations for single line open fault SING OPN LIN 6 152-153(1), and the buses 103, 203, 204, 205, 3008 reported violations for single line open fault SING OPN LIN 10 201-202(1).

Table 4.18: 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 violations
153	SING OPN LIN 6 152-153(1)	1.000	0.894	-0.107	-0.056
154	SING OPN LIN 6 152-153(1)	0.968	0.891	-0.077	-0.059
103	SING OPN LIN 10 201-202(1)	0.996	0.890	-0.106	-0.060
203	SING OPN LIN 10 201-202(1)	0.994	0.881	-0.112	-0.069
204	SING OPN LIN 10 201-202(1)	0.987	0.887	-0.100	-0.063
205	SING OPN LIN 10 201-202(1)	0.977	0.869	-0.109	-0.081
3008	SING OPN LIN 10 201-202(1)	0.983	0.890	-0.092	-0.060

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 103, 153, 154, 205, 3006, 3008, 204, 3007, 3018. The buses 154 reported violations for bus fault BUS 153, the buses 103, 204, 205 reported violations for bus fault BUS 203, and the buses 3007, 3008, 3018 reported violations for bus fault BUS 3005.

Table 4.19: 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 violations
154	BUS 153	0.956	0.894	-0.062	-0.056
103	BUS 203	0.985	0.897	-0.088	-0.053
204	BUS 203	0.975	0.891	-0.085	-0.059
205	BUS 203	0.965	0.873	-0.093	-0.077
3007	BUS 3005	0.981	0.791	-0.189	-0.159
3008	BUS 3005	0.973	0.825	-0.148	-0.125
3018	BUS 3005	1.036	0.897	-0.139	-0.053

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

Table 4.20: 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 violations
103	SING OPN LIN 6 152-153(1)	0.985	0.898	-0.086	-0.052
153	SING OPN LIN 6 152-153(1)	0.991	0.871	-0.120	-0.079
154	SING OPN LIN 6 152-153(1)	0.956	0.867	-0.089	-0.083
205	SING OPN LIN 6 152-153(1)	0.965	0.882	-0.084	-0.068
3006	SING OPN LIN 6 152-153(1)	0.993	0.889	-0.104	-0.061
3008	SING OPN LIN 6 152-153(1)	0.973	0.897	-0.076	-0.053

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, 205, 203, 103, 206. The buses 154, 205, 206 reported violations for unit fault UNIT 206(1).

Table 4.21: Unit 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 violations
154	UNIT 206(1)	0.975	0.881	-0.094	-0.069
205	UNIT 206(1)	0.980	0.883	-0.097	-0.067
206	UNIT 206(1)	1.020	0.883	-0.137	-0.067

The bus 203 reported violations for bus fault BUS 202, and the buses 103, 154 reported violations for bus fault BUS 205.

Table 4.22: 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 violations
203	BUS 202	1.002	0.899	-0.102	-0.051
103	BUS 205	1.000	0.898	-0.102	-0.052
154	BUS 205	0.975	0.868	-0.107	-0.082

The buses 154, 205 reported violations for single line open fault SING OPN LIN 20 205-206(1).

Table 4.23: 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 violations
154	SING OPN LIN 20 205-206(1)	0.975	0.881	-0.094	-0.069
205	SING OPN LIN 20 205-206(1)	0.980	0.883	-0.097	-0.067

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, 204, 205, 103, 153, 3004, 3005, 3006, 3007, 3008, 203, 206. The buses 154, 205, 206 reported violations for unit fault UNIT 206(1).

Table 4.24: Unit faults 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 violations
154	UNIT 206(1)	0.974	0.883	-0.091	-0.067
205	UNIT 206(1)	0.980	0.884	-0.096	-0.066
206	UNIT 206(1)	1.027	0.884	-0.143	-0.066

The buses 103, 153, 154, 205, 3004, 3005, 3006, 3007, 3008 reported violations for bus fault BUS 151, and the bus 203 reported violations for bus fault BUS 202.

Table 4.25: Bus faults 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 violations
103	BUS 151	1.000	0.900	-0.100	-0.050
153	BUS 151	1.008	0.883	-0.125	-0.067
154	BUS 151	0.974	0.870	-0.105	-0.080
205	BUS 151	0.980	0.889	-0.091	-0.061
3004	BUS 151	1.031	0.885	-0.146	-0.065
3005	BUS 151	1.012	0.864	-0.148	-0.086
3006	BUS 151	1.010	0.874	-0.136	-0.076
3007	BUS 151	0.998	0.850	-0.148	-0.100
3008	BUS 151	0.992	0.856	-0.136	-0.094
203	BUS 202	1.000	0.861	-0.139	-0.089

The buses 154, 204, 205 reported violations for single line open fault SING OPN LIN 11 201-204(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 = 500 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range violations
154	SING OPN LIN 11 201-204(1)	0.974	0.878	-0.097	-0.072
204	SING OPN LIN 11 201-204(1)	0.990	0.883	-0.107	-0.067
205	SING OPN LIN 11 201-204(1)	0.980	0.883	-0.097	-0.067

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 154, 205, 206. The buses 154, 205, 206 reported violations for unit fault UNIT 206(1).

Table 4.27: Unit 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 violations
154	UNIT 206(1)	0.974	0.880	-0.094	-0.070
205	UNIT 206(1)	0.980	0.880	-0.100	-0.070
206	UNIT 206(1)	1.035	0.880	-0.155	-0.070

The buses 154, 205 reported violations for single line open fault SING OPN LIN 20 205-206(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 = 600 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range violations
154	SING OPN LIN 20 205-206(1)	0.974	0.880	-0.094	-0.070
205	SING OPN LIN 20 205-206(1)	0.980	0.880	-0.100	-0.070

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, 154, 203, 204, 205, 3008, 153, 3007. The buses 103, 154, 203, 204, 205, 3008 reported violations for bus fault BUS 202, and the buses 153, 3007 reported violations for bus fault BUS 205.

Table 4.29: 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 violations
103	BUS 202	1.000	0.873	-0.127	-0.077
154	BUS 202	0.973	0.842	-0.131	-0.108
203	BUS 202	1.000	0.822	-0.178	-0.128
204	BUS 202	0.992	0.874	-0.118	-0.076
205	BUS 202	0.980	0.849	-0.131	-0.101
3008	BUS 202	0.989	0.884	-0.105	-0.066
153	BUS 205	1.007	0.899	-0.108	-0.051
3007	BUS 205	0.996	0.892	-0.104	-0.058

The buses 103, 154, 203, 204, 205, 3008 reported violations for single line open fault SING OPN LIN 11 201-204(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 = 400 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range violations
103	SING OPN LIN 11 201-204(1)	1.000	0.879	-0.121	-0.071
154	SING OPN LIN 11 201-204(1)	0.973	0.848	-0.125	-0.102
203	SING OPN LIN 11 201-204(1)	1.000	0.894	-0.106	-0.056
204	SING OPN LIN 11 201-204(1)	0.992	0.852	-0.139	-0.098
205	SING OPN LIN 11 201-204(1)	0.980	0.852	-0.128	-0.098
3008	SING OPN LIN 11 201-204(1)	0.989	0.886	-0.103	-0.064

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 is the bus 3007 for bus fault BUS 3005.

Table 4.31: 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 violations
3007	BUS 3005	0.995	0.876	-0.118	-0.074

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, 3007, 3008. The buses 3007, 3008 reported violations for bus fault BUS 3005.

Table 4.32: 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 violations
3007	BUS 3005	0.993	0.853	-0.140	-0.097
3008	BUS 3005	0.987	0.883	-0.104	-0.067

The buses 154, 205 reported violations for single line open fault SING OPN LIN 10 201-202(1).

Table 4.33: 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 violations
154	SING OPN LIN 10 201-202(1)	0.972	0.882	-0.090	-0.068
205	SING OPN LIN 10 201-202(1)	0.980	0.891	-0.089	-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 103, 153, 154, 203, 3005, 3006, 3007, 3008. The buses 103, 153, 154, 203, 3005, 3006, 3007, 3008 reported violations for bus fault BUS 205.

Table 4.34: 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 violations
103	BUS 205	0.999	0.814	-0.184	-0.136
153	BUS 205	1.005	0.867	-0.138	-0.083
154	BUS 205	0.971	0.781	-0.190	-0.169
203	BUS 205	0.998	0.876	-0.122	-0.074
3005	BUS 205	1.008	0.890	-0.118	-0.060
3006	BUS 205	1.006	0.873	-0.133	-0.077
3007	BUS 205	0.993	0.861	-0.132	-0.089
3008	BUS 205	0.986	0.831	-0.155	-0.119

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 154, 203, 204, 205, 3007, 3008. The buses 154, 3007, 3008 reported violations for bus fault BUS 3005.

Table 4.35: 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 violations
154	BUS 3005	0.971	0.899	-0.072	-0.051
3007	BUS 3005	0.991	0.831	-0.161	-0.119
3008	BUS 3005	0.985	0.863	-0.123	-0.087

The buses 154 reported violations for single line open fault SING OPN LIN 6 152-153(1), and the buses 203, 204, 205 reported violations for single line open fault SING OPN LIN 10 201-202(1).

Table 4.36: 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 violations
154	SING OPN LIN 6 152-153(1)	0.971	0.898	-0.073	-0.052
203	SING OPN LIN 10 201-202(1)	0.996	0.894	-0.102	-0.056
204	SING OPN LIN 10 201-202(1)	0.990	0.899	-0.090	-0.051
205	SING OPN LIN 10 201-202(1)	0.980	0.882	-0.098	-0.068

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 153, 154, 205, 3006, 103, 152, 202, 203, 204, 3007, 3008. The buses 154, 204, 205 reported violations for bus fault BUS 203, and the buses 3007, 3008 reported violations for 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 violations
154	BUS 203	0.960	0.876	-0.084	-0.074
204	BUS 203	0.979	0.900	-0.079	-0.050
205	BUS 203	0.969	0.883	-0.087	-0.067
3007	BUS 3005	0.984	0.803	-0.181	-0.147
3008	BUS 3005	0.976	0.836	-0.141	-0.114

The buses 153, 154, 205, 3006 reported violations for single line open fault SING OPN LIN 6 152-153(1), and the buses 103, 152, 202, 203, 204, 3007, 3008 reported violations for single line open fault SING OPN LIN 10 201-202(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 violations
153	SING OPN LIN 6 152-153(1)	0.994	0.879	-0.115	-0.071
154	SING OPN LIN 6 152-153(1)	0.960	0.876	-0.084	-0.074
205	SING OPN LIN 6 152-153(1)	0.969	0.890	-0.079	-0.060
3006	SING OPN LIN 6 152-153(1)	0.996	0.896	-0.100	-0.054
103	SING OPN LIN 10 201-202(1)	0.988	0.850	-0.138	-0.100
152	SING OPN LIN 10 201-202(1)	1.016	0.893	-0.123	-0.057
202	SING OPN LIN 10 201-202(1)	1.006	0.864	-0.142	-0.086
203	SING OPN LIN 10 201-202(1)	0.987	0.843	-0.144	-0.107
204	SING OPN LIN 10 201-202(1)	0.979	0.849	-0.130	-0.101
3007	SING OPN LIN 10 201-202(1)	0.984	0.879	-0.105	-0.071
3008	SING OPN LIN 10 201-202(1)	0.976	0.856	-0.120	-0.094

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, 205, 206. The buses 154, 205, 206 reported violations for unit fault UNIT 206(1).

Table 4.39: Unit 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 violations
154	UNIT 206(1)	0.975	0.885	-0.090	-0.065
205	UNIT 206(1)	0.980	0.886	-0.094	-0.064
206	UNIT 206(1)	1.018	0.886	-0.132	-0.064

The bus 154 reported violations for bus fault BUS 205.

Table 4.40: 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 violations
154	BUS 205	0.975	0.875	-0.100	-0.075

The buses 154, 205 reported violations for single line open fault SING OPN LIN 20 205-206(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 = 400 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range violations
154	SING OPN LIN 20 205-206(1)	0.975	0.885	-0.090	-0.065
205	SING OPN LIN 20 205-206(1)	0.980	0.886	-0.094	-0.064

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 154, 204, 205, 3005, 3006, 3007, 3008, 203, 103, 153, 206. The buses 154, 205, 206 reported violations for unit fault UNIT 206(1).

Table 4.42: Unit faults 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 violations
154	UNIT 206(1)	0.975	0.887	-0.088	-0.063
205	UNIT 206(1)	0.980	0.887	-0.093	-0.063
206	UNIT 206(1)	1.025	0.887	-0.138	-0.063

The buses 154, 3005, 3006, 3007, 3008 reported violations for bus fault BUS 151, the buses 203, 205 reported violations for bus fault BUS 202, and the buses 103, 153 reported violations for bus fault BUS 205.

Table 4.43: Bus faults 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 violations
154	BUS 151	0.975	0.893	-0.082	-0.057
3005	BUS 151	1.013	0.890	-0.123	-0.060
3006	BUS 151	1.011	0.898	-0.113	-0.052
3007	BUS 151	0.999	0.877	-0.122	-0.073
3008	BUS 151	0.992	0.881	-0.111	-0.069
203	BUS 202	1.001	0.872	-0.129	-0.078
205	BUS 202	0.980	0.895	-0.085	-0.055
103	BUS 205	0.999	0.857	-0.143	-0.093
153	BUS 205	1.009	0.898	-0.111	-0.052

The buses 154, 204, 205 reported violations for single line open fault SING OPN LIN 11 201-204(1).

Table 4.44: 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 violations
154	SING OPN LIN 11 201-204(1)	0.975	0.890	-0.085	-0.060
204	SING OPN LIN 11 201-204(1)	0.991	0.895	-0.095	-0.055
205	SING OPN LIN 11 201-204(1)	0.980	0.895	-0.085	-0.055

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 154, 205, 103, 153, 3004, 3005, 3006, 3007, 3008, 203, 204, 206. The buses 154, 205, 206 reported violations for unit fault UNIT 206(1).

Table 4.45: Unit 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 violations
154	UNIT 206(1)	0.974	0.884	-0.090	-0.066
205	UNIT 206(1)	0.980	0.884	-0.096	-0.066
206	UNIT 206(1)	1.033	0.884	-0.149	-0.066

The buses 103, 153, 154, 205, 3004, 3005, 3006, 3007, 3008 reported violations for bus fault BUS 151, and the buses 203, 204 reported violations for bus fault BUS 202.

Table 4.46: 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 violations
103	BUS 151	0.999	0.895	-0.104	-0.055
153	BUS 151	1.007	0.884	-0.123	-0.066
154	BUS 151	0.974	0.869	-0.105	-0.081
205	BUS 151	0.980	0.887	-0.093	-0.063
3004	BUS 151	1.030	0.891	-0.139	-0.059
3005	BUS 151	1.012	0.870	-0.142	-0.080
3006	BUS 151	1.009	0.877	-0.132	-0.073
3007	BUS 151	0.998	0.855	-0.142	-0.095
3008	BUS 151	0.991	0.858	-0.133	-0.092
203	BUS 202	0.999	0.809	-0.190	-0.141
204	BUS 202	0.989	0.854	-0.134	-0.096

The buses 154, 205 reported violations for single line open fault SING OPN LIN 20 205-206(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 = 600 MW, LLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range violations
154	SING OPN LIN 20 205-206(1)	0.974	0.884	-0.090	-0.066
205	SING OPN LIN 20 205-206(1)	0.980	0.884	-0.096	-0.066

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 103, 154, 204, 205, 3008, 203, 3007, 206. The buses 103, 154, 203, 204, 205, 206, 3007, 3008 reported violations for unit fault UNIT 206(1).

Table 4.48: Unit 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 violations
103	UNIT 206(1)	0.998	0.865	-0.133	-0.085
154	UNIT 206(1)	0.973	0.838	-0.135	-0.112
203	UNIT 206(1)	1.000	0.896	-0.104	-0.054
204	UNIT 206(1)	0.992	0.875	-0.117	-0.075
205	UNIT 206(1)	0.980	0.840	-0.140	-0.110
206	UNIT 206(1)	1.034	0.840	-0.194	-0.110
3007	UNIT 206(1)	0.996	0.894	-0.102	-0.056
3008	UNIT 206(1)	0.989	0.872	-0.118	-0.078

The buses 103, 154, 203, 204, 205, 3008 reported violations for bus fault BUS 202, and the bus 3007 reported violations for bus fault BUS 205.

Table 4.49: 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 violations
103	BUS 202	0.998	0.881	-0.117	-0.069
154	BUS 202	0.973	0.854	-0.119	-0.096
203	BUS 202	1.000	0.835	-0.166	-0.115
204	BUS 202	0.992	0.885	-0.107	-0.065
205	BUS 202	0.980	0.861	-0.119	-0.089
3008	BUS 202	0.989	0.894	-0.095	-0.056
3007	BUS 205	0.996	0.899	-0.097	-0.051

The buses 103, 154, 204, 205, 3008 reported violations for single line open fault SING OPN LIN 11 201-204(1), and the buses 203, 3007 reported violations for single line open fault SING OPN LIN 20 205-206(1).

Table 4.50: 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 violations
103	SING OPN LIN 11 201-204(1)	0.998	0.888	-0.109	-0.062
154	SING OPN LIN 11 201-204(1)	0.973	0.862	-0.111	-0.088
204	SING OPN LIN 11 201-204(1)	0.992	0.866	-0.126	-0.084
205	SING OPN LIN 11 201-204(1)	0.980	0.866	-0.114	-0.084
3008	SING OPN LIN 11 201-204(1)	0.989	0.898	-0.092	-0.052
203	SING OPN LIN 20 205-206(1)	1.000	0.896	-0.104	-0.054
3007	SING OPN LIN 20 205-206(1)	0.996	0.894	-0.102	-0.056

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, 152, 153, 154, 202, 203, 3004, 3005, 3006, 3007, 3008, 3018. The buses 103, 152, 153, 154, 202, 203, 3004, 3005, 3006, 3007, 3008, 3018 reported violations for bus fault BUS 205.

Table 4.51: 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 violations
103	BUS 205	0.997	0.802	-0.195	-0.148
152	BUS 205	1.027	0.893	-0.135	-0.057
153	BUS 205	1.006	0.857	-0.149	-0.093
154	BUS 205	0.973	0.774	-0.199	-0.176
202	BUS 205	1.017	0.900	-0.118	-0.050
203	BUS 205	0.999	0.867	-0.131	-0.083
3004	BUS 205	1.029	0.897	-0.132	-0.053
3005	BUS 205	1.010	0.878	-0.132	-0.072
3006	BUS 205	1.008	0.862	-0.146	-0.088
3007	BUS 205	0.995	0.850	-0.145	-0.100
3008	BUS 205	0.989	0.822	-0.167	-0.128
3018	BUS 205	1.051	0.893	-0.157	-0.057

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, 3007, 3008. The buses 3007, 3008 reported violations for bus fault BUS 3005.

Table 4.52: 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 violations
3007	BUS 3005	0.994	0.859	-0.134	-0.091
3008	BUS 3005	0.987	0.889	-0.099	-0.061

The bus 154 reported violations for single line open fault SING OPN LIN 10 201-202(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 = 600 MW, RLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range violations
154	SING OPN LIN 10 201-202(1)	0.972	0.892	-0.080	-0.058

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 103, 153, 154, 203, 3005, 3006, 3007, 3008. The buses 103, 153, 154, 203, 3005, 3006, 3007, 3008 reported violations for bus fault BUS 205.

Table 4.54: 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 violations
103	BUS 205	0.996	0.823	-0.173	-0.127
153	BUS 205	1.006	0.878	-0.127	-0.072
154	BUS 205	0.972	0.795	-0.176	-0.155
203	BUS 205	0.998	0.887	-0.112	-0.063
3005	BUS 205	1.008	0.899	-0.109	-0.051
3006	BUS 205	1.007	0.884	-0.123	-0.066
3007	BUS 205	0.993	0.871	-0.122	-0.079
3008	BUS 205	0.987	0.843	-0.144	-0.107

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, 3007, 3008. The buses 3007, 3008 reported violations for bus fault BUS 3005.

Table 4.55: 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 violations
3007	BUS 3005	0.992	0.837	-0.155	-0.113
3008	BUS 3005	0.986	0.869	-0.117	-0.081

The buses 154, 205 reported violations for single line open fault SING OPN LIN 10 201-202(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 = 500 MW, HLS

Bus Number	Contingency	Base Voltage	Contingency Voltage	Deviation	Range violations
154	SING OPN LIN 10 201-202(1)	0.971	0.882	-0.089	-0.068
205	SING OPN LIN 10 201-202(1)	0.980	0.892	-0.088	-0.058

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 153, 154, 205, 103, 202, 203, 204, 3006, 3007, 3008. The buses 154, 205 reported violations for bus fault BUS 203, and the buses 3007, 3008 reported violations for bus fault BUS 3005.

Table 4.57: 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 violations
154	BUS 203	0.963	0.883	-0.080	-0.067
205	BUS 203	0.972	0.890	-0.082	-0.060
3007	BUS 3005	0.986	0.811	-0.175	-0.139
3008	BUS 3005	0.979	0.843	-0.136	-0.107

The buses 153, 154, 205 reported violations for single line open fault SING OPN LIN 6 152-153(1), and the buses 103, 202, 203, 204, 3006, 3007, 3008 reported violations for single line open fault SING OPN LIN 10 201-202(1).

Table 4.58: 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 violations
153	SING OPN LIN 6 152-153(1)	0.997	0.886	-0.111	-0.064
154	SING OPN LIN 6 152-153(1)	0.963	0.882	-0.081	-0.068
205	SING OPN LIN 6 152-153(1)	0.972	0.897	-0.076	-0.053
103	SING OPN LIN 10 201-202(1)	0.988	0.862	-0.126	-0.088
202	SING OPN LIN 10 201-202(1)	1.009	0.880	-0.129	-0.070
203	SING OPN LIN 10 201-202(1)	0.989	0.859	-0.130	-0.091
204	SING OPN LIN 10 201-202(1)	0.982	0.864	-0.118	-0.086
3006	SING OPN LIN 10 201-202(1)	0.999	0.893	-0.105	-0.057
3007	SING OPN LIN 10 201-202(1)	0.986	0.891	-0.095	-0.059
3008	SING OPN LIN 10 201-202(1)	0.979	0.870	-0.108	-0.080

4.29 Result Summary

The Tables 5.13 and 5.14 summarises the results of the AC contingency calculation carried out on the hypothetical SAVNW system for Topology 4 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 scenarios Solar = 0 MW, Hydro = 400 MW, HLS and Solar = 100 MW, Hydro = 500 MW, RLS for the bus fault BUS 205 reported the highest number of lower limit violation with 12 buses reporting violations.

The bus reporting the highest number of lower voltage limit violation is the bus 154 with 156 violations followed by bus 205 with 114 violations. The Table 5.16 in the Appendix gives the count of times a bus violates the lower voltage limit $< 0.9PU$.

The contingency causing the greatest number of lower voltage limit violation is the bus fault BUS 205 with 164, followed by SING OPN LIN 10 201-202(1) with 86 and BUS 3005 with 84 violations across all the studied scenarios. The Table 5.15 in the Appendix gives the contingencies and no of times a contingency causes a lower voltage limit violation $< 0.9PU$.

The scenario reporting the greatest number of lower voltage limit violation is the scenario Solar = 100 MW, Hydro = 400 MW, RLS reporting 70 violations followed by the scenario Solar = 0 MW, Hydro = 400 MW, RLS reporting 60 violations. Table 5.17 in the Appendix gives the number of times a studied scenario reported a lower voltage limit violation $< 0.9PU$.

Chapter 5

Conclusion

The contingency analysis was carried out on the hypothetical SAVNW study system for the Year 3, Topology 4 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 152 and BUS 201 load flow did not converge for any of the 27 studied scenarios. For the (N-1) contingency BUS 151 load flow did not converge for 24 of the studied scenarios, followed by BUS 204 and SING OPN LIN 11 201-204(1) for 18 of the studied scenarios each.

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

Contingency	Count of Scenarios
BUS 152	27
BUS 201	27
BUS 151	24
BUS 204	18
SING OPN LIN 11 201-204(1)	18
BUS 202	17
UNIT 206(1)	17
SING OPN LIN 20 205-206(1)	17
BUS 205	14
BUS 154	3
SING OPN LIN 10 201-202(1)	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 154-203(1) with 87 loading violation followed by branches 3001-3003(1) and 3001-3003(2) with 51 violations, and branch 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 16 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 156 violations, followed by Bus 205 with 114, 3008 with 92, and 3007 with 80 violations reported 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 Violation $> 100\%$ 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 = 50 MW, Hydro = 500 MW, LLS	BUS 151	153-3006(1),154-3008(1),3001-3003(1),3001-3003(2),3001-3011(1),3003-3005(1),3003-3005(2),3005-3006(1)	8
Solar = 100 MW, Hydro = 500 MW, LLS	BUS 151	153-3006(1),154-3008(1),3001-3003(1),3001-3003(2),3001-3011(1),3003-3005(1),3003-3005(2),3005-3006(1)	8
Solar = 100 MW, Hydro = 600 MW, LLS	BUS 151	153-3006(1),154-3008(1),3001-3003(1),3001-3003(2),3001-3011(1),3003-3005(1),3003-3005(2),3005-3006(1)	8
Solar = 0 MW, Hydro = 600 MW, HLS	BUS 153	154-203(1),154-205(1),203-205(1),203-205(2)	4
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),203-205(1),203-205(2)	4
Solar = 0 MW, Hydro = 500 MW, HLS	UNIT 101(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 50 MW, Hydro = 600 MW, HLS	UNIT 101(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),203-205(1),203-205(2)	4
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 0 MW, Hydro = 500 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 0 MW, Hydro = 500 MW, RLS	UNIT 101(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 0 MW, Hydro = 400 MW, RLS	UNIT 101(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),203-205(1),203-205(2)	4
Solar = 0 MW, Hydro = 600 MW, HLS	UNIT 101(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 100 MW, Hydro = 400 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 100 MW, Hydro = 400 MW, RLS	UNIT 206(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 20 205-206(1)	154-203(1),154-205(1),203-205(1),203-205(2)	4
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 6 152-153(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 50 MW, Hydro = 500 MW, HLS	UNIT 101(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),203-205(1),203-205(2)	4
Solar = 0 MW, Hydro = 500 MW, HLS	UNIT 101(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 0 MW, Hydro = 400 MW, HLS	UNIT 101(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),203-205(1),203-205(2)	4
Solar = 0 MW, Hydro = 400 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),203-205(1),203-205(2)	4
Solar = 50 MW, Hydro = 400 MW, HLS	UNIT 101(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 50 MW, Hydro = 400 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 50 MW, Hydro = 400 MW, HLS	UNIT 101(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 50 MW, Hydro = 400 MW, HLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),203-205(1),203-205(2)	4
Solar = 0 MW, Hydro = 400 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1),203-205(1),203-205(2)	4
Solar = 50 MW, Hydro = 400 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2),3003-3005(1),3003-3005(2)	4
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 1 101-151(1)	154-203(1),154-205(1),203-205(1),203-205(2)	4
Solar = 0 MW, Hydro = 600 MW, LLS	BUS 153	154-203(1),154-205(1),203-205(1),203-205(2)	3
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 153	154-203(1),203-205(1),203-205(2)	3
Solar = 50 MW, Hydro = 600 MW, RLS	BUS 153	154-203(1),203-205(1),203-205(2)	3
Solar = 0 MW, Hydro = 600 MW, HLS	BUS 203	154-203(1),154-205(1),203-205(1),203-205(2)	3
Solar = 100 MW, Hydro = 600 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1),203-205(1),203-205(2)	3
Solar = 0 MW, Hydro = 600 MW, RLS	BUS 153	154-203(1),203-205(1),203-205(2)	3
Solar = 0 MW, Hydro = 600 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1),203-205(1),203-205(2)	3
Solar = 50 MW, Hydro = 500 MW, LLS	SING OPN LIN 11 201-204(1)	154-203(1),203-205(1),203-205(2)	3
Solar = 100 MW, Hydro = 600 MW, RLS	SING OPN LIN 6 152-153(1)	154-203(1),203-205(1),203-205(2)	3

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

Scenario	Contingency	Branches	Branch Count
Solar = 50 MW, Hydro = 500 MW, LLS	BUS 205	153-3006(1),154-203(1),3005-3006(1)	3
Solar = 50 MW, Hydro = 500 MW, LLS	BUS 204	154-203(1),203-205(1),203-205(2)	3
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 203	153-154(1),153-154(2),153-154(3)	3
Solar = 100 MW, Hydro = 500 MW, LLS	SING OPN LIN 11 201-204(1)	154-203(1),203-205(1),203-205(2)	3
Solar = 50 MW, Hydro = 400 MW, RLS	SING OPN LIN 11 201-204(1)	154-203(1),203-205(1),203-205(2)	3
Solar = 0 MW, Hydro = 400 MW, RLS	BUS 204	154-203(1),203-205(1),203-205(2)	3
Solar = 100 MW, Hydro = 500 MW, LLS	BUS 204	154-203(1),203-205(1),203-205(2)	3
Solar = 100 MW, Hydro = 500 MW, LLS	BUS 205	153-3006(1),154-203(1),3005-3006(1)	3
Solar = 0 MW, Hydro = 500 MW, LLS	BUS 205	153-3006(1),154-203(1),3005-3006(1)	3
Solar = 50 MW, Hydro = 400 MW, RLS	BUS 204	154-203(1),203-205(1),203-205(2)	3
Solar = 0 MW, Hydro = 500 MW, LLS	BUS 204	154-203(1),203-205(1),203-205(2)	3
Solar = 50 MW, Hydro = 600 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1),203-205(1),203-205(2)	3
Solar = 0 MW, Hydro = 400 MW, RLS	SING OPN LIN 11 201-204(1)	154-203(1),203-205(1),203-205(2)	3
Solar = 0 MW, Hydro = 500 MW, LLS	SING OPN LIN 11 201-204(1)	154-203(1),203-205(1),203-205(2)	3
Solar = 100 MW, Hydro = 500 MW, RLS	BUS 205	153-3006(1),154-203(1),3005-3006(1)	3
Solar = 100 MW, Hydro = 400 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 100 MW, Hydro = 600 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 50 MW, Hydro = 500 MW, HLS	BUS 153	154-203(1),154-205(1)	2
Solar = 50 MW, Hydro = 400 MW, HLS	BUS 153	154-203(1),154-205(1)	2
Solar = 100 MW, Hydro = 500 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 50 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	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1)	2
Solar = 100 MW, Hydro = 400 MW, RLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1)	2
Solar = 50 MW, Hydro = 400 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 100 MW, Hydro = 400 MW, RLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2
Solar = 100 MW, Hydro = 600 MW, HLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2
Solar = 50 MW, Hydro = 400 MW, RLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2
Solar = 50 MW, Hydro = 400 MW, RLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1)	2
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1)	2
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 100 MW, Hydro = 600 MW, LLS	BUS 202	153-154(1),201-204(1)	2
Solar = 100 MW, Hydro = 500 MW, HLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2
Solar = 50 MW, Hydro = 400 MW, HLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1)	2
Solar = 100 MW, Hydro = 500 MW, RLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2
Solar = 100 MW, Hydro = 400 MW, HLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 205	153-154(1),154-203(1)	2
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 153	154-203(1),154-205(1)	2
Solar = 0 MW, Hydro = 500 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 50 MW, Hydro = 600 MW, LLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2
Solar = 0 MW, Hydro = 500 MW, RLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1)	2
Solar = 0 MW, Hydro = 500 MW, LLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2
Solar = 100 MW, Hydro = 400 MW, HLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1)	2
Solar = 50 MW, Hydro = 600 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 0 MW, Hydro = 500 MW, HLS	BUS 153	154-203(1),154-205(1)	2
Solar = 0 MW, Hydro = 400 MW, RLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1)	2
Solar = 0 MW, Hydro = 400 MW, RLS	BUS 153	154-203(1),154-205(1)	2
Solar = 50 MW, Hydro = 500 MW, RLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1)	2
Solar = 0 MW, Hydro = 400 MW, LLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2
Solar = 0 MW, Hydro = 400 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1)	2
Solar = 0 MW, Hydro = 400 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 6 152-153(1)	154-203(1),154-205(1)	2
Solar = 50 MW, Hydro = 600 MW, RLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2
Solar = 50 MW, Hydro = 500 MW, RLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2
Solar = 100 MW, Hydro = 600 MW, RLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2
Solar = 50 MW, Hydro = 500 MW, LLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2

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

Scenario	Contingency	Branches	Branch Count
Solar = 0 MW, Hydro = 600 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 50 MW, Hydro = 500 MW, RLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 100 MW, Hydro = 400 MW, HLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 0 MW, Hydro = 600 MW, LLS	UNIT 101(1)	3001-3003(1),3001-3003(2)	2
Solar = 100 MW, Hydro = 400 MW, HLS	BUS 153	154-203(1),154-205(1)	2
Solar = 50 MW, Hydro = 500 MW, LLS	SING OPN LIN 1 101-151(1)	3001-3003(1),3001-3003(2)	2
Solar = 50 MW, Hydro = 600 MW, RLS	BUS 203	153-154(1)	1
Solar = 50 MW, Hydro = 400 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 500 MW, HLS	BUS 203	153-154(1)	1
Solar = 50 MW, Hydro = 600 MW, LLS	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 500 MW, LLS	SING OPN LIN 6 152-153(1)	154-203(1)	1
Solar = 50 MW, Hydro = 600 MW, RLS	BUS 3005	154-203(1)	1
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 2 102-151(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	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 400 MW, HLS	BUS 205	154-203(1)	1
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 50 MW, Hydro = 500 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 400 MW, LLS	BUS 153	154-203(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, HLS	BUS 205	154-203(1)	1
Solar = 50 MW, Hydro = 500 MW, LLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 50 MW, Hydro = 400 MW, LLS	BUS 153	154-203(1)	1
Solar = 50 MW, Hydro = 400 MW, RLS	BUS 203	153-154(1)	1
Solar = 50 MW, Hydro = 600 MW, LLS	BUS 203	153-154(1)	1
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 153	154-203(1)	1
Solar = 50 MW, Hydro = 600 MW, RLS	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 400 MW, HLS	BUS 205	154-203(1)	1
Solar = 50 MW, Hydro = 400 MW, RLS	UNIT 102(1)	101-151(1)	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 10 201-202(1)	201-204(1)	1
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 3005	154-203(1)	1
Solar = 50 MW, Hydro = 500 MW, RLS	UNIT 102(1)	101-151(1)	1
Solar = 50 MW, Hydro = 500 MW, HLS	BUS 153	154-203(1)	1
Solar = 100 MW, Hydro = 500 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 50 MW, Hydro = 500 MW, RLS	BUS 205	154-203(1)	1
Solar = 50 MW, Hydro = 600 MW, RLS	BUS 3005	154-203(1)	1
Solar = 0 MW, Hydro = 600 MW, LLS	UNIT 102(1)	101-151(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	BUS 203	153-154(1)	1
Solar = 0 MW, Hydro = 600 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 0 MW, Hydro = 600 MW, HLS	BUS 205	154-203(1)	1
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 0 MW, Hydro = 500 MW, RLS	BUS 3005	154-203(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	BUS 153	154-203(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	BUS 205	154-203(1)	1
Solar = 0 MW, Hydro = 500 MW, HLS	BUS 203	153-154(1)	1
Solar = 0 MW, Hydro = 400 MW, RLS	UNIT 102(1)	101-151(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	BUS 205	154-203(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	UNIT 102(1)	101-151(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 3005	154-203(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 203	153-154(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	UNIT 102(1)	101-151(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	BUS 153	154-203(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	UNIT 102(1)	101-151(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	BUS 205	154-203(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	UNIT 102(1)	101-151(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	BUS 205	154-203(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 11 201-204(1)	154-203(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 205	154-203(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 204	154-203(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 153	154-203(1)	1
Solar = 0 MW, Hydro = 400 MW, HLS	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 = 400 MW, HLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 0 MW, Hydro = 600 MW, RLS	BUS 203	153-154(1)	1
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 10 201-202(1)	201-204(1)	1
Solar = 100 MW, Hydro = 600 MW, RLS	BUS 203	153-154(1)	1
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 2 102-151(1)	101-151(1)	1
Solar = 100 MW, Hydro = 600 MW, RLS	BUS 153	154-203(1)	1
Solar = 100 MW, Hydro = 600 MW, LLS	BUS 203	153-154(1)	1
Solar = 100 MW, Hydro = 600 MW, LLS	BUS 153	154-203(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	UNIT 102(1)	101-151(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 10 201-202(1)	201-204(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	BUS 3005	154-203(1)	1
Solar = 100 MW, Hydro = 600 MW, HLS	BUS 203	153-154(1)	1
Solar = 100 MW, Hydro = 500 MW, RLS	UNIT 102(1)	101-151(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	BUS 153	154-203(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	BUS 153	154-203(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 203	153-154(1)	1
Solar = 100 MW, Hydro = 500 MW, HLS	BUS 153	154-203(1)	1
Solar = 100 MW, Hydro = 400 MW, RLS	UNIT 102(1)	101-151(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	SING OPN LIN 11 201-204(1)	154-203(1)	1
Solar = 100 MW, Hydro = 400 MW, RLS	BUS 205	154-203(1)	1
Solar = 100 MW, Hydro = 400 MW, RLS	BUS 204	154-203(1)	1
Solar = 100 MW, Hydro = 400 MW, RLS	BUS 153	154-203(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	BUS 205	154-203(1)	1
Solar = 100 MW, Hydro = 400 MW, LLS	BUS 153	154-203(1)	1
Solar = 100 MW, Hydro = 400 MW, HLS	UNIT 102(1)	101-151(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	BUS 205	154-203(1)	1
Solar = 0 MW, Hydro = 600 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 - Contingency

Table 5.6: Overload Count - Contingency

Contingency	Overload Counts
SING OPN LIN 6 152-153(1)	68
SING OPN LIN 1 101-151(1)	64
UNIT 101(1)	64
BUS 153	46
BUS 151	24
SING OPN LIN 2 102-151(1)	22
BUS 205	22
UNIT 102(1)	22
BUS 203	18
SING OPN LIN 11 201-204(1)	17
BUS 204	17
BUS 3005	6
SING OPN LIN 20 205-206(1)	4
UNIT 206(1)	4
SING OPN LIN 10 201-202(1)	3
BUS 202	2

5.1.3 Overload Count - Scenario

Table 5.7: Overload Count - Scenario

Scenario	Overload Counts
Solar = 50 MW, Hydro = 500 MW, LLS	23
Solar = 50 MW, Hydro = 600 MW, HLS	22
Solar = 0 MW, Hydro = 600 MW, HLS	22
Solar = 0 MW, Hydro = 400 MW, RLS	21
Solar = 0 MW, Hydro = 600 MW, RLS	20
Solar = 100 MW, Hydro = 400 MW, RLS	20
Solar = 100 MW, Hydro = 500 MW, LLS	19
Solar = 0 MW, Hydro = 500 MW, HLS	18
Solar = 50 MW, Hydro = 500 MW, HLS	17
Solar = 0 MW, Hydro = 500 MW, LLS	17
Solar = 100 MW, Hydro = 600 MW, HLS	16
Solar = 0 MW, Hydro = 400 MW, HLS	16
Solar = 50 MW, Hydro = 400 MW, RLS	16
Solar = 50 MW, Hydro = 400 MW, HLS	15
Solar = 100 MW, Hydro = 600 MW, LLS	15
Solar = 50 MW, Hydro = 600 MW, RLS	15
Solar = 0 MW, Hydro = 500 MW, RLS	14
Solar = 0 MW, Hydro = 600 MW, LLS	13
Solar = 100 MW, Hydro = 500 MW, RLS	12
Solar = 0 MW, Hydro = 400 MW, LLS	12
Solar = 50 MW, Hydro = 600 MW, LLS	11
Solar = 100 MW, Hydro = 600 MW, RLS	11
Solar = 100 MW, Hydro = 400 MW, HLS	11
Solar = 100 MW, Hydro = 500 MW, HLS	10
Solar = 50 MW, Hydro = 500 MW, RLS	10
Solar = 50 MW, Hydro = 400 MW, LLS	4
Solar = 100 MW, Hydro = 400 MW, LLS	3

5.2 Overload Count - Branch

Table 5.8: Overload Count - Branch

Branch	Overload Counts
154-203(1)	87
3001-3003(1)	51
3001-3003(2)	51
101-151(1)	44
203-205(1)	27
203-205(2)	27
154-205(1)	26
3003-3005(1)	23
3003-3005(2)	23
153-154(1)	16
3005-3006(1)	7
153-3006(1)	7
201-204(1)	4
154-3008(1)	3
3001-3011(1)	3
153-154(2)	2
153-154(3)	2

5.3 Upper Voltage Limit Violation $> 1.1PU$ Counts

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

Table 5.9: Summary of upper limit voltage violation grouped by Scenario and Contingency

Scenario	Contingency	Buses	Bus Count
Solar = 0 MW, Hydro = 600 MW, HLS	BUS 3005	211,212	2
Solar = 0 MW, Hydro = 600 MW, LLS	SING OPN LIN 20 205-206(1)	211,212	2
Solar = 0 MW, Hydro = 600 MW, LLS	UNIT 206(1)	211,212	2
Solar = 100 MW, Hydro = 400 MW, RLS	SING OPN LIN 20 205-206(1)	211,212	2
Solar = 100 MW, Hydro = 400 MW, RLS	UNIT 206(1)	211,212	2
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 10 201-202(1)	211,212	2
Solar = 100 MW, Hydro = 600 MW, LLS	BUS 202	211,212	2
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 10 201-202(1)	211,212	2

5.3.2 Upper Voltage Limit Counts - Scenario

Table 5.10: Upper Voltage Limit Counts - Scenario

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

5.3.3 Upper Voltage Limit Counts - Contingency

Table 5.11: Upper Voltage Limit Counts - Contingency

Contingency	Limit Violation Counts
SING OPN LIN 20 205-206(1)	8
UNIT 206(1)	8
SING OPN LIN 10 201-202(1)	8
BUS 3005	4
BUS 202	4

5.3.4 Upper Voltage Limit Counts - Bus

Table 5.12: Upper Voltage Limit Counts - Bus

Bus	Limit Violation Counts
211	16
212	16

5.4 Lower Voltage Limit Violation $< 0.9PU$ Counts

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

Table 5.13: Summary of lower limit voltage violation grouped by Scenario and Contingency

Scenario	Contingency	Buses	Bus Count
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 205	103,153,154,202,203,3005,3006,3007,3008,3018	12
Solar = 100 MW, Hydro = 500 MW, RLS	BUS 205	103,153,154,202,203,3005,3006,3007,3008,3018	12
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 10 201-202(1)	103,153,154,202,203,204,205,3006,3007,3008	11
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 10 201-202(1)	103,153,154,202,203,204,205,3006,3007,3008	10
Solar = 50 MW, Hydro = 500 MW, LLS	BUS 151	103,153,154,205,3005,3006,3007,3008	9
Solar = 100 MW, Hydro = 600 MW, LLS	BUS 151	103,153,154,205,3005,3006,3007,3008	9
Solar = 50 MW, Hydro = 400 MW, HLS	BUS 205	103,153,154,203,3005,3006,3007,3008	8
Solar = 0 MW, Hydro = 500 MW, LLS	BUS 205	103,153,154,203,3005,3006,3007,3008	8
Solar = 100 MW, Hydro = 400 MW, RLS	UNIT 206(1)	103,154,203,204,205,206,3007,3008	8
Solar = 0 MW, Hydro = 400 MW, RLS	SING OPN LIN 11 201-204(1)	103,153,154,203,204,205,3007,3008	8
Solar = 100 MW, Hydro = 400 MW, HLS	BUS 205	103,153,154,203,3005,3006,3007,3008	8
Solar = 100 MW, Hydro = 400 MW, RLS	SING OPN LIN 20 205-206(1)	103,154,203,204,205,3007,3008	7
Solar = 0 MW, Hydro = 400 MW, RLS	BUS 202	103,154,203,204,205,3007,3008	7
Solar = 100 MW, Hydro = 600 MW, LLS	BUS 202	103,154,203,204,205,3007,3008	7
Solar = 50 MW, Hydro = 500 MW, LLS	BUS 205	103,153,154,203,3006,3007,3008	7
Solar = 0 MW, Hydro = 400 MW, RLS	BUS 205	103,153,154,203,3006,3007,3008	7
Solar = 0 MW, Hydro = 400 MW, RLS	BUS 204	103,153,154,203,205,3007,3008	7
Solar = 0 MW, Hydro = 600 MW, HLS	SING OPN LIN 6 152-153(1)	103,153,154,205,3006,3008	6
Solar = 50 MW, Hydro = 400 MW, RLS	SING OPN LIN 11 201-204(1)	103,154,203,204,205,3008	6
Solar = 0 MW, Hydro = 500 MW, LLS	SING OPN LIN 11 201-204(1)	103,154,203,204,205,3008	6
Solar = 50 MW, Hydro = 400 MW, RLS	BUS 202	103,154,203,204,205,3008	6
Solar = 0 MW, Hydro = 600 MW, RLS	SING OPN LIN 10 201-202(1)	103,154,203,204,205,3008	6
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 10 201-202(1)	103,154,203,204,205,3008	6
Solar = 0 MW, Hydro = 600 MW, HLS	BUS 3005	103,154,205,3007,3008,3018	6
Solar = 100 MW, Hydro = 400 MW, RLS	BUS 202	103,154,203,204,205,3008	6
Solar = 100 MW, Hydro = 400 MW, RLS	SING OPN LIN 11 201-204(1)	103,154,204,205,3008	5
Solar = 0 MW, Hydro = 500 MW, LLS	BUS 202	103,154,203,204,205	5
Solar = 100 MW, Hydro = 500 MW, LLS	BUS 151	154,3005,3006,3007,3008	5
Solar = 50 MW, Hydro = 400 MW, RLS	BUS 205	103,153,154,3007,3008	5
Solar = 100 MW, Hydro = 500 MW, LLS	BUS 205	103,153,154,3007,3008	5
Solar = 50 MW, Hydro = 400 MW, RLS	BUS 204	103,154,203,205,3008	5
Solar = 0 MW, Hydro = 500 MW, LLS	BUS 204	103,154,203,205,3008	5
Solar = 100 MW, Hydro = 600 MW, HLS	BUS 3005	154,205,3007,3008	4
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 10 201-202(1)	154,203,204,205	4
Solar = 100 MW, Hydro = 400 MW, RLS	BUS 205	103,154,3007,3008	4
Solar = 100 MW, Hydro = 400 MW, RLS	BUS 204	103,154,205,3008	4
Solar = 50 MW, Hydro = 600 MW, HLS	SING OPN LIN 6 152-153(1)	153,154,205,3006	4
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 3005	154,205,3007,3008	4
Solar = 0 MW, Hydro = 600 MW, HLS	BUS 203	103,154,204,205	4
Solar = 100 MW, Hydro = 400 MW, LLS	UNIT 206(1)	154,205,206	3
Solar = 50 MW, Hydro = 600 MW, HLS	BUS 203	154,204,205	3
Solar = 100 MW, Hydro = 600 MW, HLS	SING OPN LIN 6 152-153(1)	153,154,205	3
Solar = 100 MW, Hydro = 600 MW, LLS	UNIT 206(1)	154,205,206	3
Solar = 50 MW, Hydro = 400 MW, LLS	UNIT 206(1)	154,205,206	3
Solar = 50 MW, Hydro = 600 MW, LLS	UNIT 206(1)	154,205,206	3
Solar = 100 MW, Hydro = 500 MW, LLS	UNIT 206(1)	154,205,206	3
Solar = 0 MW, Hydro = 500 MW, LLS	UNIT 206(1)	154,205,206	3
Solar = 100 MW, Hydro = 500 MW, LLS	SING OPN LIN 11 201-204(1)	154,204,205	3
Solar = 50 MW, Hydro = 500 MW, LLS	UNIT 206(1)	154,205,206	3
Solar = 0 MW, Hydro = 400 MW, LLS	BUS 205	103,154,3008	3
Solar = 100 MW, Hydro = 500 MW, LLS	BUS 202	154,203,205	3
Solar = 50 MW, Hydro = 500 MW, HLS	BUS 3005	154,3007,3008	3
Solar = 50 MW, Hydro = 500 MW, LLS	SING OPN LIN 11 201-204(1)	154,204,205	3
Solar = 0 MW, Hydro = 600 MW, LLS	UNIT 206(1)	154,205,206	3
Solar = 0 MW, Hydro = 500 MW, HLS	BUS 3005	154,3007,3008	3

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

Scenario	Contingency	Buses	Bus Count
Solar = 50 MW, Hydro = 500 MW, LLS	BUS 202	154,203,205	3
Solar = 0 MW, Hydro = 400 MW, LLS	UNIT 206(1)	154,205,206	3
Solar = 50 MW, Hydro = 400 MW, LLS	SING OPN LIN 20 205-206(1)	154,205	2
Solar = 50 MW, Hydro = 400 MW, LLS	BUS 205	103,154	2
Solar = 50 MW, Hydro = 500 MW, LLS	BUS 204	154,205	2
Solar = 50 MW, Hydro = 500 MW, LLS	SING OPN LIN 20 205-206(1)	154,205	2
Solar = 50 MW, Hydro = 600 MW, LLS	SING OPN LIN 20 205-206(1)	154,205	2
Solar = 50 MW, Hydro = 600 MW, RLS	BUS 3005	3007,3008	2
Solar = 50 MW, Hydro = 400 MW, HLS	BUS 3005	3007,3008	2
Solar = 100 MW, Hydro = 500 MW, LLS	BUS 204	154,205	2
Solar = 50 MW, Hydro = 600 MW, RLS	SING OPN LIN 10 201-202(1)	154,205	2
Solar = 100 MW, Hydro = 500 MW, HLS	SING OPN LIN 10 201-202(1)	154,205	2
Solar = 0 MW, Hydro = 500 MW, LLS	SING OPN LIN 20 205-206(1)	154,205	2
Solar = 0 MW, Hydro = 600 MW, LLS	SING OPN LIN 20 205-206(1)	154,205	2
Solar = 0 MW, Hydro = 600 MW, RLS	BUS 3005	3007,3008	2
Solar = 100 MW, Hydro = 400 MW, HLS	BUS 3005	3007,3008	2
Solar = 0 MW, Hydro = 500 MW, HLS	SING OPN LIN 6 152-153(1)	153,154	2
Solar = 100 MW, Hydro = 400 MW, LLS	SING OPN LIN 20 205-206(1)	154,205	2
Solar = 0 MW, Hydro = 400 MW, LLS	SING OPN LIN 20 205-206(1)	154,205	2
Solar = 100 MW, Hydro = 500 MW, HLS	BUS 3005	3007,3008	2
Solar = 0 MW, Hydro = 400 MW, HLS	BUS 3005	3007,3008	2
Solar = 100 MW, Hydro = 500 MW, LLS	SING OPN LIN 20 205-206(1)	154,205	2
Solar = 100 MW, Hydro = 600 MW, HLS	BUS 203	154,205	2
Solar = 100 MW, Hydro = 600 MW, LLS	SING OPN LIN 20 205-206(1)	154,205	2
Solar = 100 MW, Hydro = 600 MW, RLS	BUS 3005	3007,3008	2
Solar = 0 MW, Hydro = 500 MW, RLS	BUS 3005	3007,3008	2
Solar = 50 MW, Hydro = 500 MW, RLS	BUS 3005	3007	1
Solar = 0 MW, Hydro = 400 MW, LLS	BUS 202	203	1
Solar = 0 MW, Hydro = 400 MW, RLS	BUS 3005	3007	1
Solar = 0 MW, Hydro = 400 MW, HLS	SING OPN LIN 10 201-202(1)	154	1
Solar = 100 MW, Hydro = 600 MW, RLS	SING OPN LIN 10 201-202(1)	154	1
Solar = 0 MW, Hydro = 600 MW, HLS	BUS 153	154	1
Solar = 0 MW, Hydro = 600 MW, LLS	BUS 3005	3007	1
Solar = 50 MW, Hydro = 400 MW, LLS	BUS 202	203	1
Solar = 50 MW, Hydro = 500 MW, HLS	SING OPN LIN 6 152-153(1)	154	1
Solar = 100 MW, Hydro = 400 MW, RLS	BUS 3005	3007	1
Solar = 50 MW, Hydro = 400 MW, RLS	BUS 3005	3007	1
Solar = 100 MW, Hydro = 500 MW, RLS	BUS 3005	3007	1
Solar = 100 MW, Hydro = 400 MW, LLS	BUS 205	154	1

5.4.2 Lower Voltage Limit Counts - Contingency

Table 5.15: Lower Voltage Limit Counts - Scenario

Contingency	Limit Violation Counts
BUS 205	164
SING OPN LIN 10 201-202(1)	86
BUS 3005	84
BUS 202	78
UNIT 206(1)	70
SING OPN LIN 11 201-204(1)	62
SING OPN LIN 20 205-206(1)	50
BUS 204	50
BUS 151	46
SING OPN LIN 6 152-153(1)	32
BUS 203	18
BUS 153	2

5.4.3 Lower Voltage Limit Counts - Bus

Table 5.16: Lower Voltage Limit Counts - Bus

Bus	Limit Violation Counts
154	156
205	114
3008	92
3007	80
103	72
203	58
204	40
153	38
3006	28
206	20
3005	16
202	8
3004	8
152	6
3018	6

5.4.4 Lower Voltage Limit Counts - Scenario

Table 5.17: Lower Voltage Limit Counts - Scenario

Scenario	Limit Violation Counts
Solar = 100 MW, Hydro = 400 MW, RLS	70
Solar = 0 MW, Hydro = 400 MW, RLS	60
Solar = 50 MW, Hydro = 500 MW, LLS	58
Solar = 0 MW, Hydro = 500 MW, LLS	58
Solar = 100 MW, Hydro = 500 MW, LLS	46
Solar = 50 MW, Hydro = 400 MW, RLS	46
Solar = 50 MW, Hydro = 600 MW, HLS	44
Solar = 100 MW, Hydro = 600 MW, LLS	42
Solar = 100 MW, Hydro = 600 MW, HLS	38
Solar = 0 MW, Hydro = 600 MW, HLS	34
Solar = 0 MW, Hydro = 400 MW, HLS	30
Solar = 100 MW, Hydro = 500 MW, RLS	26
Solar = 0 MW, Hydro = 500 MW, HLS	22
Solar = 50 MW, Hydro = 400 MW, HLS	20
Solar = 100 MW, Hydro = 400 MW, HLS	20
Solar = 0 MW, Hydro = 400 MW, LLS	18
Solar = 50 MW, Hydro = 500 MW, HLS	16
Solar = 50 MW, Hydro = 400 MW, LLS	16
Solar = 0 MW, Hydro = 600 MW, RLS	16
Solar = 100 MW, Hydro = 400 MW, LLS	12
Solar = 0 MW, Hydro = 600 MW, LLS	12
Solar = 50 MW, Hydro = 600 MW, LLS	10
Solar = 50 MW, Hydro = 600 MW, RLS	8
Solar = 100 MW, Hydro = 500 MW, HLS	8
Solar = 100 MW, Hydro = 600 MW, RLS	6
Solar = 0 MW, Hydro = 500 MW, RLS	4
Solar = 50 MW, Hydro = 500 MW, RLS	2