PSSE Resources Integration Study

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February 5, 2026

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Summary

For the hypothetical SAVNW study system, load forecasts indicate the need for addition of new resources. The expected load growth is most in urban areas of LIGHCO region followed by load growth due to industrial and population growth in FLAPCO region. Addition of new resources are climate policy driven as in resources added will be renewable resources. In the last Long Term Resource Plan it was decided to add a solar farm in area 1, a hydro generator within the existing hydro plant in area 2 and a wind farm in area 5. The solar farm is expected to come online in year 1 of this planning horizon and the hydro power plant in year 3 of this planning horizon and wind farm in year 4. The addition of the hydro power plant adds firm capacity to the system while solar and wind resources adds non-firm capacity to the system. Figure 1 shows the locations of upcoming resources.

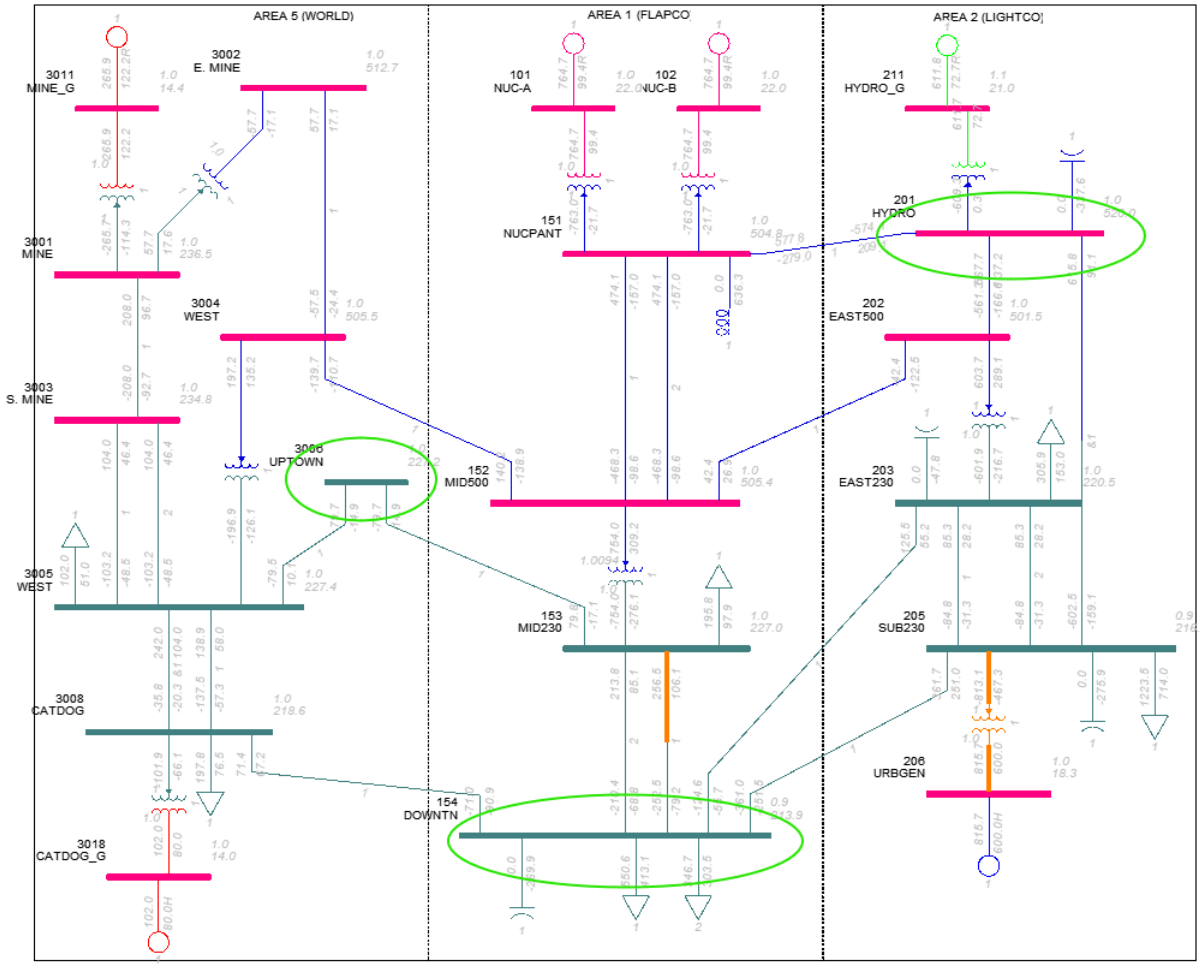

Figure 1: Proposed System Upgrade Locations

The hypothetical SAVNW system is a winter peaking system. During the planning horizon, the system peak load is expected to increase in all areas. Three load scenarios considered for load forecasting are: reference load scenario, low load scenario and high load scenario. In year 1 of the planning horizon, the solar farm in Area 1 would be operational providing non-firm capacity to the system. In year 2, there is an increase in all three forecasted

load scenarios and there are no new resources coming in service with the existing supply side resources enough to meet the peak system demand. In year 3 of the planning horizon, when the hydro generator comes into service, additional capacity of 600MW is added to the system. There are two topologies studied for year 3 with and without transmission structure upgrades. Even though violations are reported, the added capacity is enough to meet the peak demand of all 3 load scenarios. In year 4, the windfarm consisting of 40 wind generators each with a capacity of 2 MW will be connected to the system giving an additional capacity of 80 MW. The capacity provided by the windfarm is not firm capacity and adds to the non-firm capacity of the system. For various windfarm power outputs, the ability to meet the various load scenarios in year 4 was found to be satisfactory. In year 5 of the planning horizon, there are no new resources coming in service. For the studied load and variable supply scenarios, the resources available are sufficient to meet the demand of year 5.

The conducted study considers variability of renewable resources to meet the forecasted load scenarios. A total of 7 system topologies spanning 5 years are studied for its ability to meet forecasted load scenarios. There are branch loadings and bus voltage violations observed for some of the studied scenarios which needs to be studied further and corresponding system upgrade requirement needs to be assessed.

Chapter 1

System and Study Description

1.1 System Description

The present study is carried out in PSSE on the hypothetical SAVNW study system. The SAVNW system has 6 generators connected to it. The generators are connected on buses 101, 102, 211, 206, 3008 and 3011 as can be seen from Figure 1. The SAVNW system is divided into 3 areas. Each of these 3 areas have 2 generating units. The areas are interconnected to other areas via ties. To this system new resources are added to buses 3006 in area 5, 154 in area 1, and 201 in area 2 as shown in Figure 1.

1.2 Study Description

For the next 5 years of the planning horizon, it was decided to add three new supply side resources to the system. The type of energy resource chosen is driven by climate policy and hence are renewable in nature. The addition of these resources will help to reduce the GHG emission from the existing coal generator connected at bus 206 by reducing the dependence on it. The present study focuses on analysing the results obtained from load flow analysis when supply side resources are added to meet the load demands of various scenarios. In this study on hypothetical SAVNW system, power flow analysis is conducted in PSSE with automatic adjustment options used to allow maneuvering of the system to meet area net interchange schedules. When this automatic adjustment option is enabled, an adjustment of the area swing generators in areas keeps the net interchange on schedule. The swing generators for area 1, 2, and 5 are 101 - NUC-A, 206 URBGEN, and 3011 MINE_G respectively. The rest of the generators in the system are delivering their nominal output power. For the year 0, year 1 and year 2 analysis, the hydrology considered is the average hydrology. When a new hydro generator is added to the same Dam in year 3, wet and dry hydrology along with the average hydrology is considered year 3 onwards for both hydro generators. The solar resource coming online in year 2 and the wind resource coming online in year 4 are intermittent resources. For this reason, 3 scenarios of power outputs are considered for each of these resources along with the 3 hydrology scenarios for Hydro Generator. The installed capacities of Solar Farm, Wind Farm and Hydro generators are 117 MW, 80 MW and 616.5 MW respectively. Power flow analysis is carried out, and solution is observed for solar farm outputs of [0 MW, 50 MW, 100 MW] and Wind Farm outputs of [0 MW, 40 MW and 75 MW]. For three hydrological scenarios generator outputs considered are 400 MW, 500 MW and 600 MW respectively.

Following 7 topologies are studied in Chapter 2 to understand the systems capability to meet the forecasted system demand for various load scenarios:

- Topology 0 of the system represents the present year system as shown in Figure 1
- Topology 1 is the system in year 1 with solar farm in service with the addition of transformer to connect to the main system
- Topology 2 is the system in Year 2 which has the same system Topology as Year 1 with increased load in all areas
- Topology 3 is the system in Year 3 with a new Hydro generator coming online at Bus 212 with transformer to connect to the system at Bus 201 without transmission system upgrades
- Topology 4 is the system in Year 3 with the Hydro generator coming in online at Bus 212 with the completion of multiple transmission system upgrades

- Topology 5 is the system in Year 4 with the wind farm in area 5 coming online with the grid transformer to connect to the main grid
- Topology 6 is the system in Year 5 without any new resource addition or transmission upgrades with increased load in all areas

For each of these topologies, the voltage and overloading violations are observed. The violated scenarios are reported to further conduct transmission system studies for system reinforcements to ensure system operates within the desired operational limits. Threshold set for lines and transformer branches percentage overloading is 80%. The normal voltage range of operation for the system considered is 0.95 to 1.05 PU.

Chapter 2

Topology Studies

2.1 Introduction

In this chapter results of PSSE load flow is analysed corresponding to seven topologies mentioned in Chapter 1 to meet the three forecasted load scenarios in the upcoming 5 years. In order to study the various generation and load scenarios corresponding to the seven topologies, a python automation script is developed which loops through various load and demand scenarios, updating the desired machines and loads. A power flow activity is run on the updated data, and each scenarios output is saved to a (.sav) case file. Using the saved case file for each scenario studied python automation scripts are developed for extracting system totals, generation, branch loading, and bus voltage. The python scripts developed for obtaining the .sav case files, and extracting the data corresponding to these sav files are given in the appendix 5 of this document.

There are 4 sets of data obtained after the data extraction. The extracted data is obtained in CSV format, which is further processed to filter the overloaded and out of voltage limit scenarios from all the studied scenarios using python programming and is uploaded in GitHub for access. The filtered results are summarised in subsections under each section for considered Topologies. The scenarios that need further assessment is tabulated in the appendix with corresponding Branch, Bus information.

2.2 Year - 0, Topology - 0

Year 0 Topology 0 analysis was carried out with the Base system described in Chapter 1. The Year 0 Topology 0 consists of 6 generators in 3 areas. Total installed capacity of the system is 4153.25 MW. The system total for the studied Year 0 Topology 0 is as shown Figure 2.1.

Detailed analysis of Year 0 Topology can be found here. The combined total generation in all areas 2765 MW is serving a total load of 2723 MW with the generators 102 NUC-B, 211-HYDRO_G, 3018-CATDOG_G operating at their nominal power output of 700 MW, 500 MW and 90 MW respectively. The swing generator in each area operates to meet the load, loss and interchange criteria. Table 2.1 gives the breakdown of generation, maximum power capacity and reserve available for each of these generators.The desired interchange for all the scenarios studied is highlighted in Figure 2.1. For all the scenarios studied the desired interchange from FLAPCO to LIGHTCO is 100 MW, and from FLAPCO to WORLD is 150 MW.

	FROM ------AT AREA BUSES-------				TO		TO XFRMR			-NET INTERCHANGE-			
X-- AREA --X	GENE-RATION	FROM IND GENERATN	TO IND MOTORS	TO LOAD	TO BUS SHUNT	GNE BUS DEVICES	TO LINE SHUNT	MAGNE-TIZING	FROM CHARGING	TO LOSSES	TO TIE LINES	TO TIES + LOADS	DESIRED NET INT
1	1288.6	0.0	0.0	1021.9	0.0	0.0	0.0	0.0	0.0	15.3	251.5	1103.0	250.0
FLAPCO	-8.2	0.0	0.0	766.7	355.0	0.0	-0.0	-0.0	878.1	317.3	-569.2	112.3	
2	1199.8	0.0	0.0	1277.3	0.0	0.0	0.0	0.0	0.0	21.1	-98.6	-950.2	-100.0
LIGHTCO	101.5	0.0	0.0	724.1	-701.1	0.0	-0.0	-0.0	651.0	396.2	333.3	-348.2	
5	276.9	0.0	0.0	425.7	0.0	0.0	0.0	0.0	0.0	4.1	-152.9	-152.9	-150.0
WORLD	96.0	0.0	0.0	170.4	-0.0	0.0	-0.0	-0.0	366.0	55.8	235.9	235.9	
COLUMN	2765.3	0.0	0.0	2724.8	0.0	0.0	0.0	0.0	0.0	40.5	0.0	0.0	0.0
TOTALS	189.3	0.0	0.0	1661.2	-346.1	0.0	0.0	0.0	1895.2	769.3	0.0	0.0	

Figure 2.1: System Totals for Year - 0, Topology - 0

Bus Number	Bus Name	Area	Pgen	Pmax	Reserve
101	NUC-A	1	588.59	810.0	221.41
102	NUC-B	1	700.0	810.0	110.0
206	URBGEN	2	699.84	900.0	200.16
211	HYDRO_G	2	500.0	616.25	116.25
3011	MINE_G	5	186.88	900.0	713.12
3018	CATDOG_G	5	90.0	117.0	27.0

Table 2.1: Area totals for Year - 0, Topology - 0

Limit violation check was carried out to find out the overloaded branches and buses outside of the required voltage range. It was seen that none of the line branches exceeded the overload threshold of 80%. The transformer branch with slight overloading greater than 80% loading is '3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1'. The buses exceeding the upper voltage limit of 1.05 were Buses 201 and 3018.

2.3 Year - 1, Topology - 1

In year 1, the solar farm in area 2 is operational. The solar farm has an installed capacity of 117 MW. For the Year 1 - Topology 1, there are 7 generators in 3 areas. Total installed capacity of the system is a combination of firm capacity provided by already existing 6 generating units of 4153.25 MW and the non-firm capacity 117 MW added to the system by the solar farm at Bus 103. Solar being an intermittent resource, the output is varying with no output expected from it at night. In this study the intermittent behaviour of solar farm in taken into account by considering 3 output cases. A 0 MW output case is considered when there is no output from solar farm along with an average expected output of 50 MW and a maximum expected output of 100 MW. For Year 1 topology in addition to the three generation scenarios, three forecasted load scenarios are also studied. The updated systems single line diagram with the new solar farm can be seen in Figure 2.2 for Year 1 Topology 1.

Detailed analysis of Year 1 Topology 1 was carried out in two sections. 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.

Limit violation check was carried out to find out the overloaded branches, and buses outside of the required voltage range. It was seen that no overloading was reported for any branches. For transformer branches for considered solar output and load scenarios, a slight overloading was reported for '3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1'. The buses reported to be exceeding the upper voltage limit of 1.05 are Bus 152, Bus 201 and Bus 3018.

2.4 Year - 2, Topology - 2

In year 2, the load in all areas increases for the three forecasted scenarios. There are no new resources coming online and hence resources and correspondingly the installed capacity remains the same. With the increased load scenarios, the power flow analysis was carried out, and overload and voltage violation reports are studied. 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. Limit violation check was carried out to find out the overloaded branches, and buses outside of the required voltage range. The branches exceeding the overload threshold of 80% and the buses exceeding the upper voltage limit of 1.05 are listed below:

- Overloading of greater than 80% was reported for following branches and transformers for considered solar output and load scenarios
    - Branch 153 MID230 230.00 154 DOWNTN 230.00 Ckt ID 1
    - Branch 154 DOWNTN 230.00 to 153 MID230 230.00 1

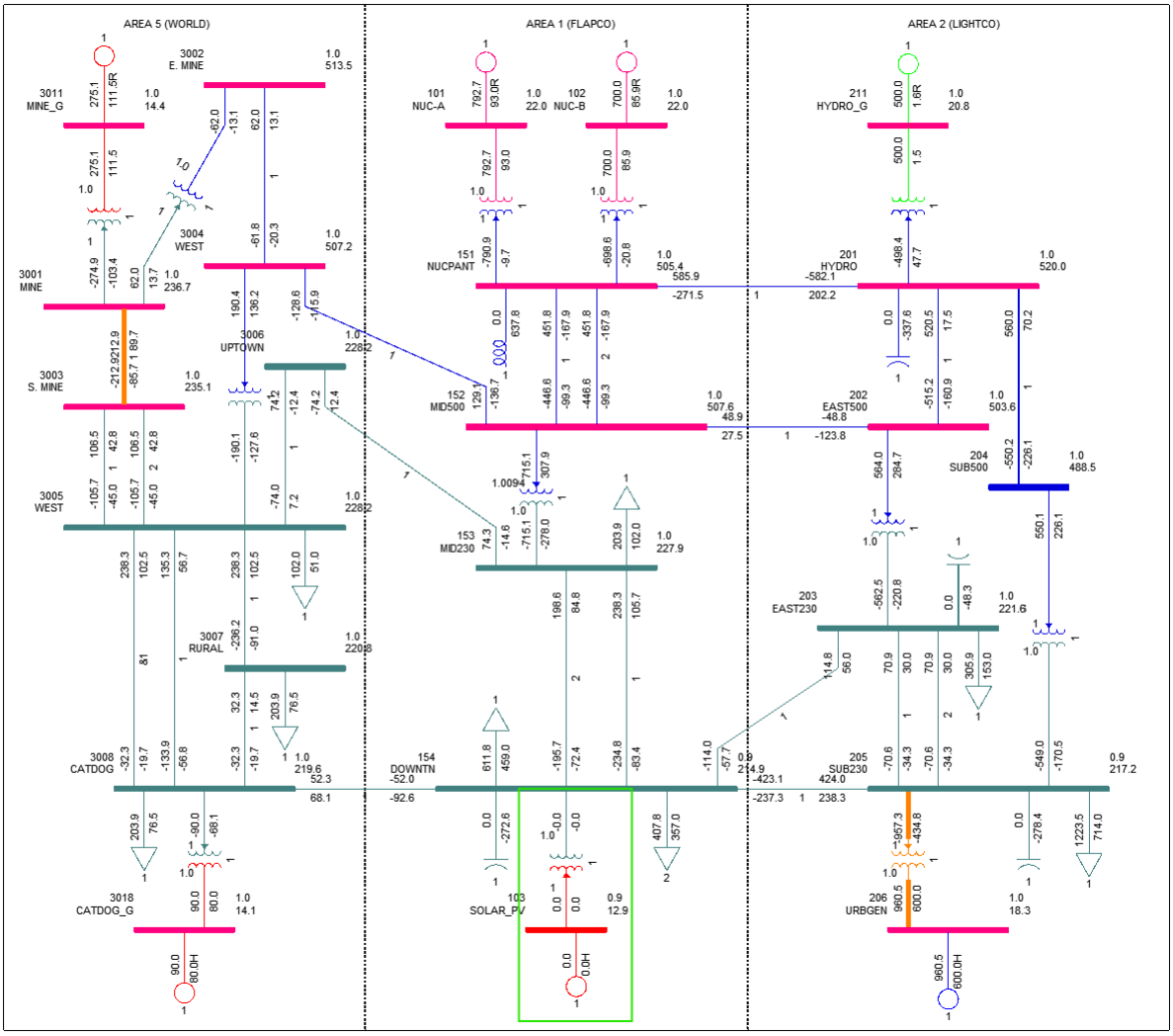

Figure 2.2: Single Line Diagram Year 1, Topology 1

- Transformer 205 SUB230 230.00 206 URBGEN 18.000
- Transformer 3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1
- Transformer 206 URBGEN 18.000 to 205 SUB230 230.00 1

- The buses violating the upper voltage limit for various scenarios
  - Buses 201, 3018

2.5 Year - 3, Topology - 3

In year 3, for the demand side, there is load increase in all areas for the three forecasted scenarios. There is hydro generator expected to come in service at Bus 212. Planned transmission upgrades from last Long-Term planning is expected to be operational. There are 2 topologies studied for Year 3. As the latest assessment shows, there is a possibility of the transmission upgrades being delayed and there is a possibility of system needing to meet the high forecasted load with existing transmission structure. While adjusting the non-swing generator to load the lines evenly could solve some of the loading issues, in this study the non-swing generators are operated at their nominal value for consistency of reporting. Because of this reason, there are 2 topologies tested for year-3, with and without transmission upgrade. 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 both year 3 topologies, 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 can be seen in Figure 2.3 for Year 3 Topology 3.

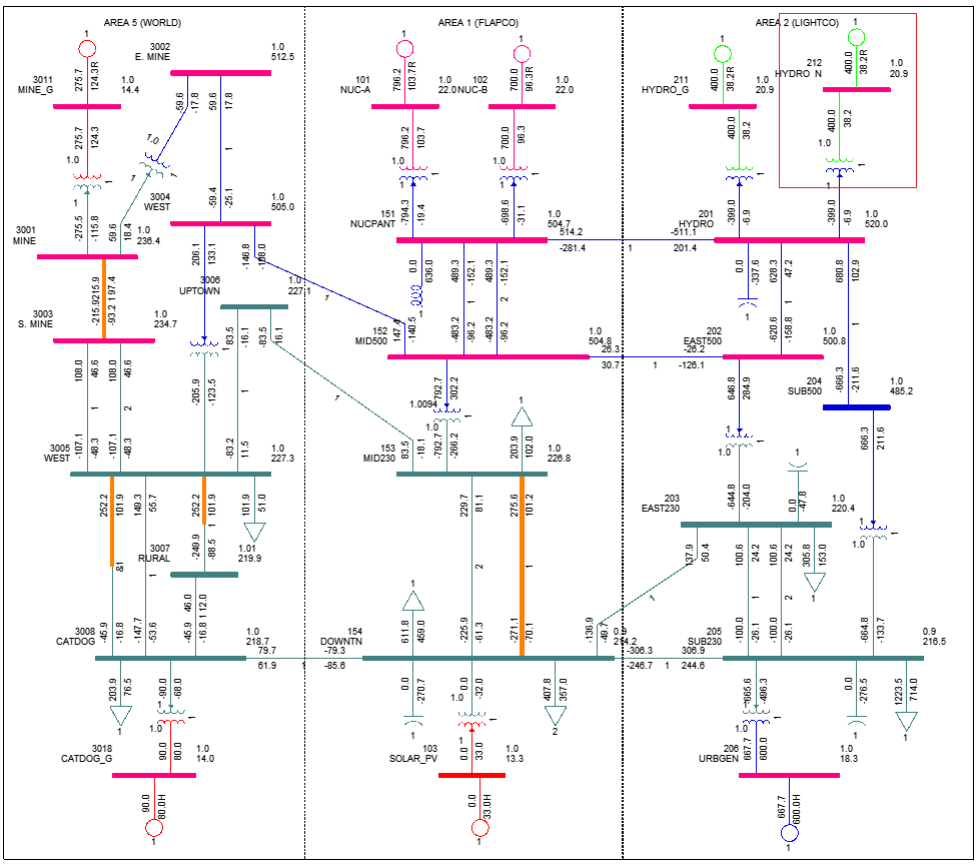

Figure 2.3: Single Line Diagram Year 3, Topology 3

In year 3, there is load increase in all areas for the three forecasted scenarios. There are no new resource coming online and hence resources remain the same and the installed capacity remains the same. With the increased load scenarios, the power flow analysis was carried out, and the overload and voltage violation reports are studied. 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.

Limit violation check was carried out to find out the overloaded branches, and buses outside of the required voltage range. The branches exceeding the overload threshold of 80% and the buses outside of the upper voltage limit of 1.05 PU and the lower voltage limit of 0.95 PU are listed below:

- Overloading of greater than 80% was reported for following branches and transformers for considered solar output and load scenarios
  - Branch 153 MID230 230.00 to 154 DOWNTN 230.00 1
  - Branch 154 DOWNTN 230.00 to 153 MID230 230.00 1
  - Branch 3001 MINE 230.00 to 3003 S. MINE 230.00 1
  - Branch 3003 S. MINE 230.00 to 3001 MINE 230.00 1
  - Branch 3005 WEST 230.00 to 3007 RURAL 230.00 1
  - Branch 3007 RURAL 230.00 to 3005 WEST 230.00 1
  - Branch 153 MID230 230.00 to 154 DOWNTN 230.00 2
  - Branch 154 DOWNTN 230.00 to 153 MID230 230.00 2
  - Branch 154 DOWNTN 230.00 to 203 EAST230 230.00 1
  - Branch 203 EAST230 230.00 to 154 DOWNTN 230.00 1
  - Transformer 202 EAST500 500.00 to 203 EAST230 230.00 1

- Transformer 204 SUB500 500.00 to 205 SUB230 230.00 1
- Transformer 205 SUB230 230.00 to 204 SUB500 500.00 1
- Transformer 3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1
- Transformer 203 EAST230 230.00 to 202 EAST500 500.00 1

- The buses violating the upper voltage limit for various scenarios
  - Buses 211, 212
- The buses violating the lower voltage limit for various scenarios
  - Buses 154, 205, 103, 203, 3007, 3008, 204

2.6 Year - 3, Topology - 4

The second topology studied for Year 3 has the same installed firm and non-firm capacity as the Topology 3. The total load on the system is also the same. This topology assumes that the proposed transmission upgrades are complete. The updated systems single line diagram with hydro generator and transmission upgrades can be seen in Figure 2.4 for Year 3 Topology 4.

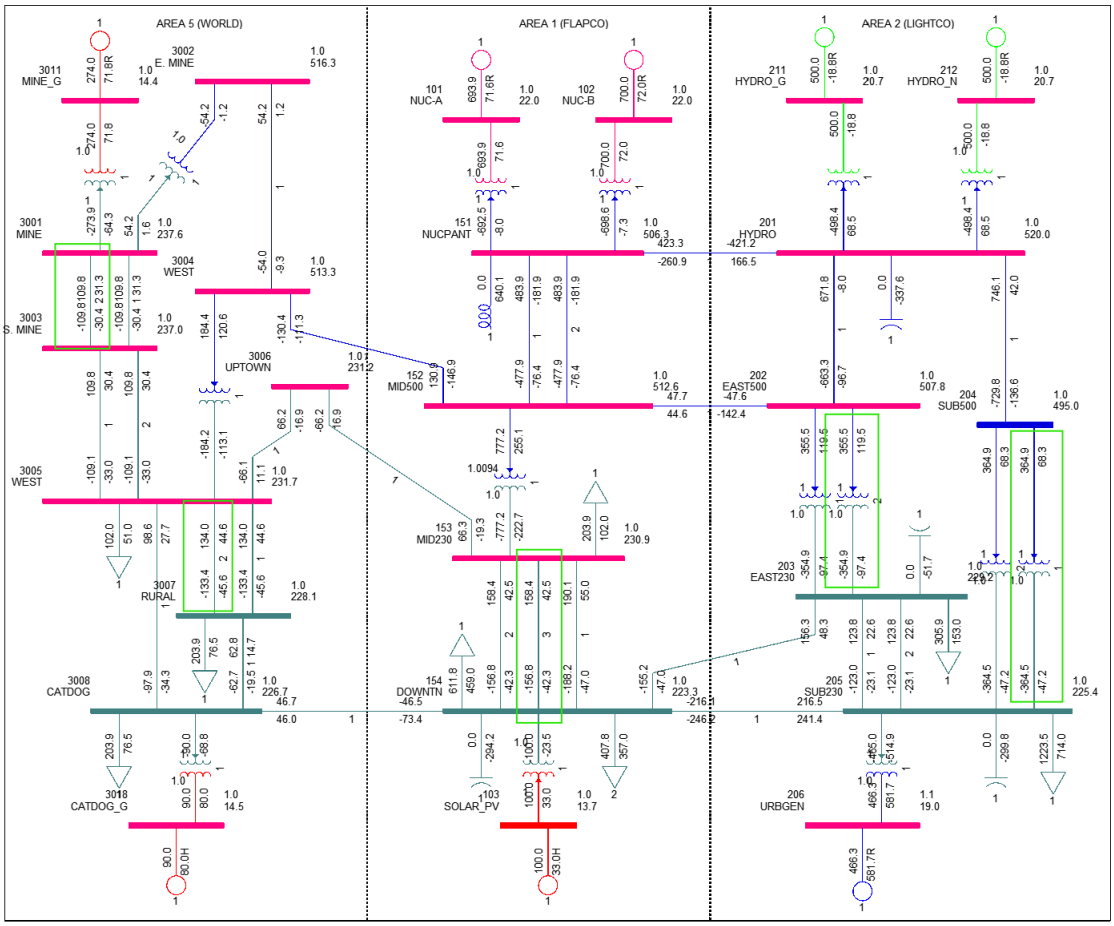

Figure 2.4: Single Line Diagram Year 3, Topology 4

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. Limit violation check was carried out to find out the overloaded branches, and buses outside of the required voltage range. The branches exceeding the overload threshold of 80% and the buses exceeding the upper voltage limit of 1.05 are listed below:

- Overloading of greater than 80% was reported for following branches and transformers for considered solar output and load scenarios

- Branch 154 DOWNTN 230.00 to 203 EAST230 230.00 1
- Branch 203 EAST230 230.00 to 154 DOWNTN 230.00 1
- Transformer 3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1

- The buses violating the upper voltage limit for various scenarios
  - Buses 206, 211, 212

As the generation at the bus 212 increases, the corresponding tie line flow increases as well. The solution to this would be to limit the tie line flow through the line or transmission reinforcements. another alternative would be to decrease the genearation from hydro generators and increase the generation from URBGEN.

2.7 Year - 4, Topology - 5

In Year 4, Topology 5, there is a wind farm coming online in area 5 with all 3 forecasted load scenarios expected to increase. Wind being an intermittent resource and output being depended on wind gust, it does not add to the firm capacity of the system. The total firm installed capacity of the system remains the same at 4769.5 MW and non-firm capacity increases to 197 MW.

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. Wind being an intermittent resource, the output from the resource is varying and hence the varying behaviour of the wind farm is studied by considering three output scenarios like solar farm. A 0 MW output case is considered when there is no output from wind farm along with an average expected output of 40 MW and a maximum expected output of 75 MW.

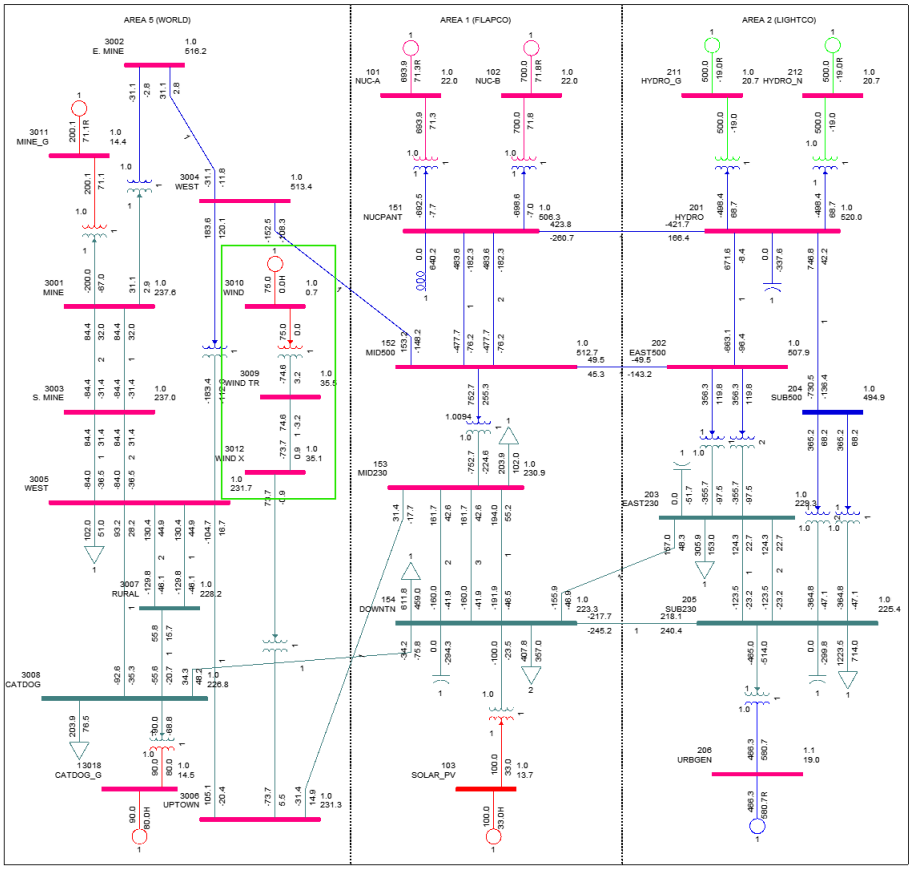

Figure 2.5: Single Line Diagram Year 4, Topology 5

Limit violation check was carried out to find out the overloaded branches, and buses outside of the required voltage range. The branches exceeding the overload threshold of 80% when measurement was taken from the metered end and the buses exceeding the upper voltage limit of 1.05 and lower limit of 0.95 are listed below:

- Overloading of greater than 80% was reported for following branches and transformers for considered solar output and load scenarios
  - Transformer 3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1
  - Transformer 206 URBGEN 18.000 to 205 SUB230 230.00 1
  - Branch 154 DOWNTN 230.00 to 203 EAST230 230.00 1
  - Branch 203 EAST230 230.00 to 154 DOWNTN 230.00 1
  - Branch 153 MID230 230.00 to 154 DOWNTN 230.00 1
  - Branch 154 DOWNTN 230.00 to 153 MID230 230.00 1
  - Branch 203 EAST230 230.00 to 205 SUB230 230.00 1
  - Branch 203 EAST230 230.00 to 205 SUB230 230.00 2
  - Branch 205 SUB230 230.00 to 203 EAST230 230.00 1
  - Branch 205 SUB230 230.00 to 203 EAST230 230.00 2
- The buses violating the upper voltage limit for various scenarios
  - Buses 3018, 206, 211, 212
- The buses violating the lower voltage limit for various scenarios
  - Buses 154, 205

2.8 Year - 5, Topology - 6

At the end of year 4, there are 9 resources in service in the Hypothetical SAVNW system. The total installed firm capacity and non-firm capacity of the system is same as Year 5, Topology 6 and is 4769.5 MW and 197 MW respectively. In year 5, there are no new resources added to the system, the already existing resources serves the increased load in all areas. With the increased load scenarios, the power flow analysis was carried out, and the overload and voltage violation reports are studied. 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.

Limit violation check was carried out to find out the overloaded branches, and buses outside of the required voltage range. The branches exceeding the overload threshold of 80% and the buses outside the upper voltage limit of 1.05 and lower limit of 0.95 are listed below:

- Overloading of greater than 80% was reported for following branches and transformers for considered solar output and load scenarios
  - Branch 154 DOWNTN 230.00 to 203 EAST230 230.00 1
  - Branch 154 DOWNTN 230.00 to 205 SUB230 230.00 1
  - Branch 153 MID230 230.00 to 154 DOWNTN 230.00 1
  - Branch 205 SUB230 230.00 to 203 EAST230 230.00 1
  - Branch 205 SUB230 230.00 to 203 EAST230 230.00 2
  - Transformer 205 SUB230 230.00 206 URBGEN 18.000
- The buses violating the upper voltage limit for various scenarios
  - Buses 206, 211, 212
- The buses violating the lower voltage limit for various scenarios
  - Buses 154, 205, 3008, 103, 203, 204, 3007, 153, 3012

2.9 Observations

Conducting load flow study and checking for overload and voltage limit violations gave an insight into the systems behaviour when new resources were added. The scenarios of overloading and voltage violations needed to be studied further and appropriate transmission upgrades needs to be planned to ensure system operates in safe, secure and reliable manner.

Chapter 3

Topology Analysis

3.1 Introduction

In this chapter, the loading and voltage violations summarised in Chapter 2 are analysed in more detail. Number of scenarios studied for Topology 0, 1 and 2 for the 3 load scenarios can be analysed easily in tabular form since there are 1, 9, 9 scenarios respectively for these topologies. But as more resources comes online and the number of scenarios studied increases to 27 for topology 3 and 4, and 81 for topologies 5 and 6. Analysing these results in tabular form becomes cumbersome and hence are analysed in graphical format by separating overloaded voltages and buses for easier understanding.

3.2 Year 0, Topology 0

For the hypothetical SAVNW system, Year 0, Topology 0 branch overload and voltage limit violations are analysed. For base case scenario, for year 0 topology 0, transformer branch loading of greater than 80% and buses with voltage greater than 1.05 PU were reported. These reported limit violations are slightly above their threshold value. The behaviour of these violations would need further studying by conducting the (N-1) analysis.

3.2.1 Transformer branch overload - Year 0, Topology 0

For the transformer branch violation 3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 , refer Table 3.1, it was seen that re-dispatching the generator connected at Bus 3018 would keep the loading of the transformer below threshold.

Branch	Branch MVA	%MVA
3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1	120.42	80.28

Table 3.1: Transformer loaded more than 80% of thermal rating - Year 0, Topology 0

3.2.2 Bus voltage upper limit violation - Year 0, Topology 0

For the buses 201 and 3018 as can be seen from the Table 3.2, voltages reported are slightly more than the threshold of 1.05PU.

Bus Number	Bus Name	Bus Voltage(PU)
201	HYDRO	1.058
3018	CATDOG_G	1.057

Table 3.2: Buses with voltages greater than 1.05PU - Year 0, Topology 0

3.3 Year 1, Topology 1

For the hypothetical SAVNW system, Year 1, Topology 1 branch overload and voltage limit violations are analysed. For base case scenario, for year 1 topology 1, transformer branch loading of greater than 80% and buses with voltage greater than 1.05 PU were reported. These reported limit violations are slightly above their threshold value.

3.3.1 Transformer branch overload - Year 1, Topology 1

For the reported 3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1 violation, operating the connected generator at slightly below the current operating value brings the loading to below the set threshold of 80%. This was tested with operating the machine at 80 MW, 10 MW less than its operation in the studied cases. Additional generation required to meet the are load demand and interarea schedule was met with the swing bus operating in that area.

Branch	Scenario and Loading
3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1	[('Solar = 0 MW, LLS', 80.28), ('Solar = 0 MW, RLS', 80.28), ('Solar = 0 MW, HLS', 80.28), ('Solar = 50 MW, LLS', 80.28), ('Solar = 50 MW, RLS', 80.28), ('Solar = 50 MW, HLS', 80.28), ('Solar = 100 MW, LLS', 80.28), ('Solar = 100 MW, RLS', 80.28), ('Solar = 100 MW, HLS', 80.28)]

Table 3.3: Transformer loaded more than 80% of thermal rating - Year 1, Topology 1

3.3.2 Bus voltage upper limit violation - Year 1, Topology 1

Bus voltage with upper limit violation for year 1, topology 1 were reported for buses 201, 3018, and 152 for the scenarios shown in Table 3.4. These violations are slightly above their normal operating range but way below their upper emergency voltage limit of 1.1 PU and can be adjusted to operate within normal operating voltage range.

Bus Number	Bus Name	Scenario and Vpu
201	HYDRO	[('Solar = 0 MW, LLS', 1.059), ('Solar = 0 MW, RLS', 1.056), ('Solar = 0 MW, HLS', 1.054), ('Solar = 50 MW, LLS', 1.06), ('Solar = 50 MW, RLS', 1.058), ('Solar = 50 MW, HLS', 1.056), ('Solar = 100 MW, LLS', 1.061), ('Solar = 100 MW, RLS', 1.059), ('Solar = 100 MW, HLS', 1.057)]
3018	CATDOG_G	[('Solar = 0 MW, LLS', 1.058), ('Solar = 0 MW, RLS', 1.055), ('Solar = 0 MW, HLS', 1.052), ('Solar = 50 MW, LLS', 1.059), ('Solar = 50 MW, RLS', 1.056), ('Solar = 50 MW, HLS', 1.053), ('Solar = 100 MW, LLS', 1.059), ('Solar = 100 MW, RLS', 1.056), ('Solar = 100 MW, HLS', 1.053)]
152	MID500	[('Solar = 100 MW, LLS', 1.051)]

Table 3.4: Buses with voltages greater than 1.05PU - Year 1, Topology 1

3.4 Year 2, Topology 2

In this section, for the hypothetical SAVNW system, Year 2, Topology 2 branch overload and voltage limit violations are analysed. Year 2, Topology 2 has same generating scenarios as Year 1, Topology 1 with increase in load in all areas.

3.4.1 Transformer branch overload - Year 2, Topology 2

For Year 2, Topology 2 transformer overload violations are reported for the transformers connecting 205 SUB230 to 230.00 206 URBGEN 18.000, 3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1, and 206 URBGEN 18.000 to 205 SUB230 230.00 1. As these transformers are heavily loaded for base case scenario itself, these violations could be more significant and could cause system to operate in an unstable manner in case of a N-1 contingency.

Branch	Scenario and Loading
3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1	[('Solar = 0 MW, LLS', 80.28), ('Solar = 0 MW, RLS', 80.28), ('Solar = 0 MW, HLS', 80.28), ('Solar = 50 MW, LLS', 80.28), ('Solar = 50 MW, RLS', 80.28), ('Solar = 50 MW, HLS', 80.28), ('Solar = 100 MW, LLS', 80.28), ('Solar = 100 MW, RLS', 80.28), ('Solar = 100 MW, HLS', 80.28)]
206 URBGEN 18.000 to 205 SUB230 230.00 1	[('Solar = 0 MW, RLS', 80.18), ('Solar = 0 MW, HLS', 89.72), ('Solar = 50 MW, HLS', 88.52), ('Solar = 100 MW, HLS', 87.62)]
205 SUB230 230.00 to 206 URBGEN 18.000 1	[('Solar = 0 MW, HLS', 84.13), ('Solar = 50 MW, HLS', 83.24), ('Solar = 100 MW, HLS', 82.58)]

Table 3.5: Transformer loaded more than 80% of thermal rating - Year 2, Topology 2

3.4.2 Transmission line branch overload - Year 2, Topology 2

The transmission line reporting slight overload of above 80% is the branch 153 MID230 230.00 to 154 DOWNTN 230.00 (Table 3.6 gives measurement from both ends of the branch) for high load scenario with no solar generation.

Branch	Scenario and Loading
153 MID230 230.00 to 154 DOWNTN 230.00 1	[('Solar = 0 MW, HLS', 80.41)]
154 DOWNTN 230.00 to 153 MID230 230.00 1	[('Solar = 0 MW, HLS', 81.45)]

Table 3.6: Transmission line loaded more than 80% of thermal rating - Year 2, Topology 2

3.4.3 Bus voltage upper limit violation - Year 2, Topology 2

The bus voltage violations of greater than 1.05PU is reported for buses 201 and 3018 as seen in Table **??**.

Bus Number	Bus Name	Scenario and Vpu
201	HYDRO	[('Solar = 0 MW, LLS', 1.056), ('Solar = 0 MW, RLS', 1.054), ('Solar = 0 MW, HLS', 1.051), ('Solar = 50 MW, LLS', 1.058), ('Solar = 50 MW, RLS', 1.055), ('Solar = 50 MW, HLS', 1.053), ('Solar = 100 MW, LLS', 1.059), ('Solar = 100 MW, RLS', 1.056), ('Solar = 100 MW, HLS', 1.054)]
3018	CATDOG_G	[('Solar = 0 MW, LLS', 1.055), ('Solar = 0 MW, RLS', 1.051), ('Solar = 50 MW, LLS', 1.056), ('Solar = 50 MW, RLS', 1.052), ('Solar = 100 MW, LLS', 1.056), ('Solar = 100 MW, RLS', 1.053)]

Table 3.7: Buses with voltages greater than 1.05PU - Year 2, Topology 2

With the addition of the Hydro generator, the number of scenarios studied has increased as there are 2 different generators whose variability is studied for 2 sets of 3 generation scenarios along with the 3 load scenarios, giving a total of 27 scenarios to be studied. Understanding the results in graphical form is more desirable than in a tabular form as have been done so far. Hence for topology 3 onwards line graphs are plotted to understand the loading and out of bound voltage violations.

3.5 Year 3, Topology 3

In this section, for the hypothetical SAVNW system, Year 3, Topology 3 branch overload and voltage limit violations are analysed. The year 3, topology 3 is the system with the new hydro generator at bus 212 online without the completion of the proposed transmission line upgrades.

3.5.1 Transformer branch overload - Year 3, Topology 3

For year 3, topology 3 the transformer branch overload violations observed are as shown in Figure 3.1. Tables 5.6, 5.7, 5.8 in Appendix of this document gives the data in tabular form.

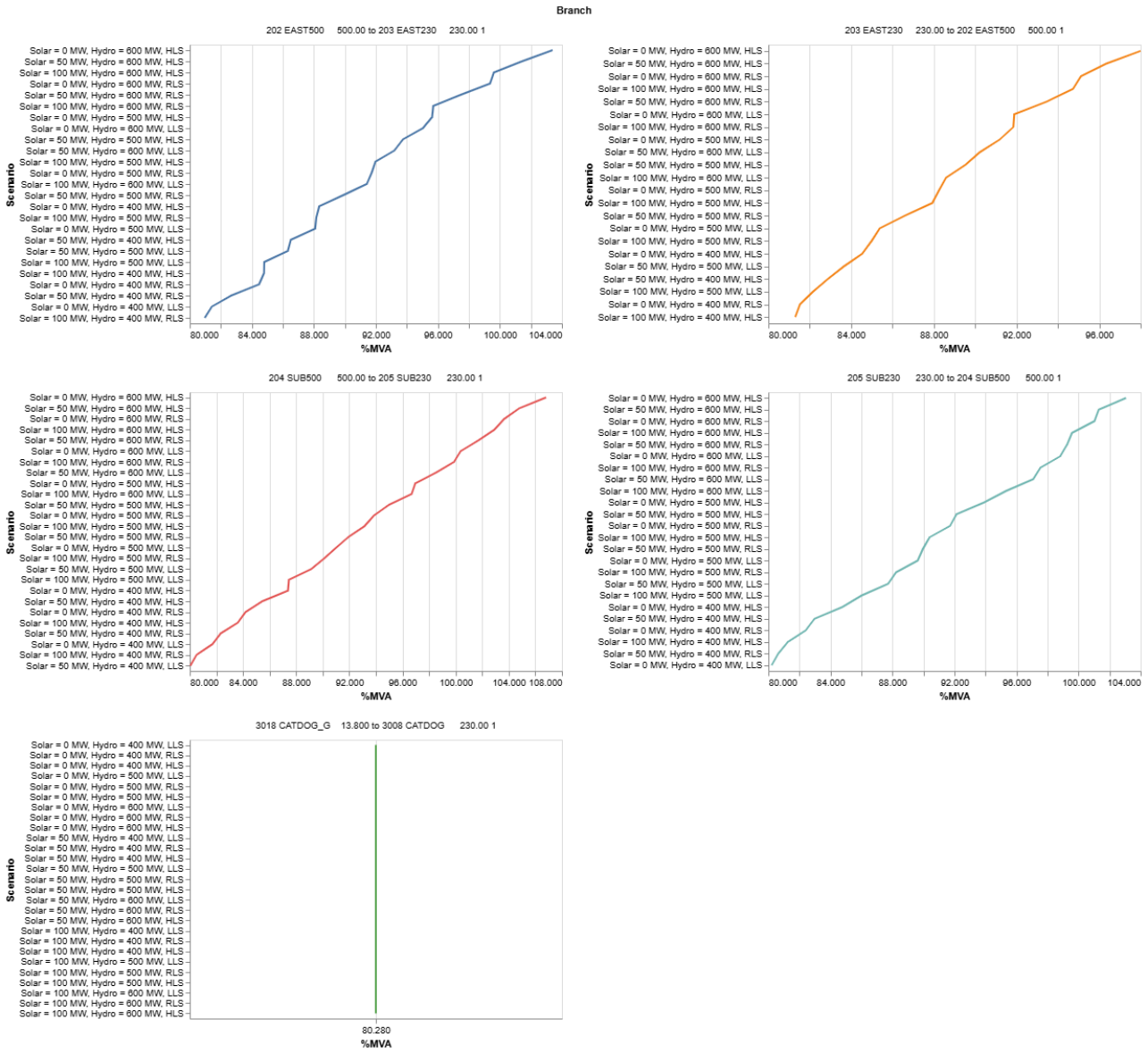

Figure 3.1: Transformer loaded more than 80% of thermal rating - Year 3, Topology 3

As can be seen from Figure 3.1, transformer 3018 to 3008 1 is lightly loaded for all the studied scenarios as was seen in previous topologies and can be brought under 80% by reducing the generation from CATDOG_G. The other two transformers violating loading are 202 to 203 1 and 204 to 205 1 (plot shows loading measures from both ends of the bus to which they are connected) are heavily loaded for base case scenario itself with loading going above 100% for some scenarios. In case transmission upgrade is not complete when the forecasted peak loading may occur in the future, demand side measures needed to be planned to ensure system operates in reliable manner.

3.5.2 Transmission line branch overload Year 3, Topology 3

The transmission line overload violations observed are as shown in Figures 3.2, 3.3 with appendix of the document giving the data in tabular form (Tables 5.3, 5.4, 5.5).

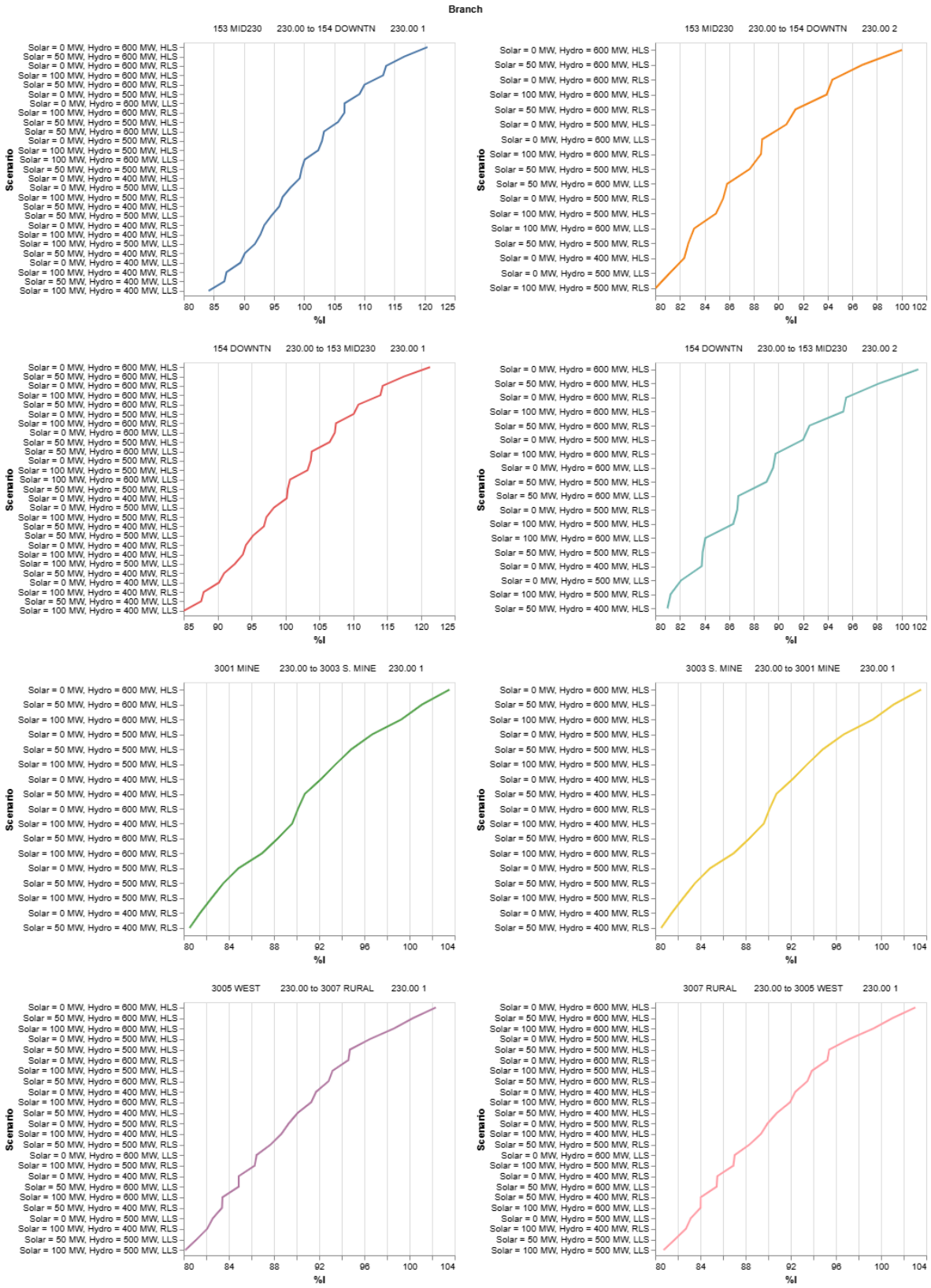

Figure 3.2: Transmission line loaded more than 80% of thermal rating - Year 3, Topology 3

As can be seen from the figures, all the transmission lines are heavily loaded and has loading greater than 95% for at least one studied scenario for the base case. Moreover, except for the tie 154 203 1 from Area 1 to Area 2, all other branches has loading of more than 100% for at least one scenario. As the load connected at the bus is expected to increase in the coming years, transmission upgrades in this area is a necessity or else strict demand side measures needs to be taken to ensure system reliability. An N-1 contingency for this system is expected to lead the system into an unstable operating condition. The most overloaded line reported is the transmission line 153 to 154 1 whose loading goes above 100% for most of the studied scenarios.

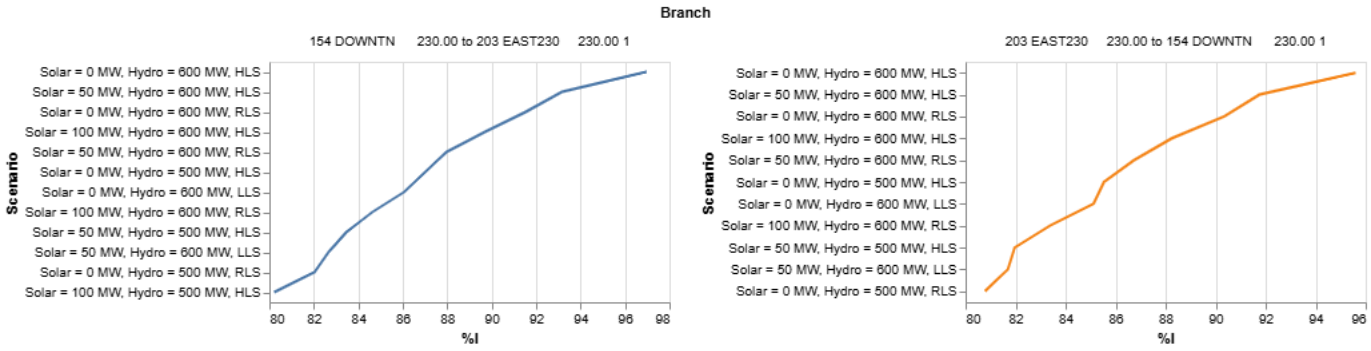

Figure 3.3: Transmission line loaded more than 80% of thermal rating - Year 3, Topology 3

3.5.3 Bus voltage upper limit violation - Year 3, Topology 3

The bus violations with voltage more than 1.05 is as shown in Figure 3.4. The buses reporting voltages above the upper threshold of 1.05 PU are the generator buses 206, 211 and 212 in area 2 with the hydro generators 211 and 212 reporting 1.08PU for wet hydrological high load scenario. None of the bus operates above the emergency high voltage limit of 1.1PU. Table 5.2 in Appendix of this document gives the data in tabular form.

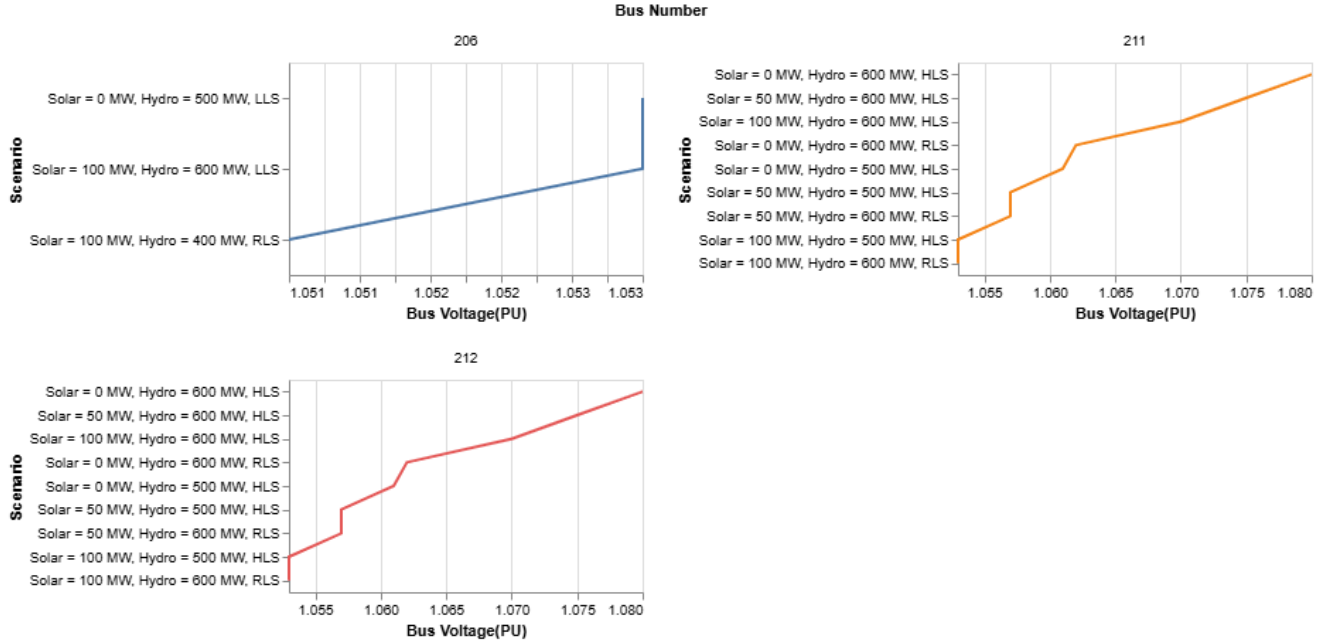

Figure 3.4: Buses with voltages greater than 1.05PU - Year 3, Topology 3

3.5.4 Bus voltage lower limit violation Year 3, Topology 3

The bus violations with voltage less than 0.95 PU is as shown in Figure 3.5. The buses reporting voltages less than normal operating value of 0.95 PU are mostly buses connected with loads and as seen in Figure 3.2 and are connected to overloaded branches. None of these buses violates the emergency low limit of 0.90 PU. Table 5.1 in Appendix of this document gives the data in tabular form.

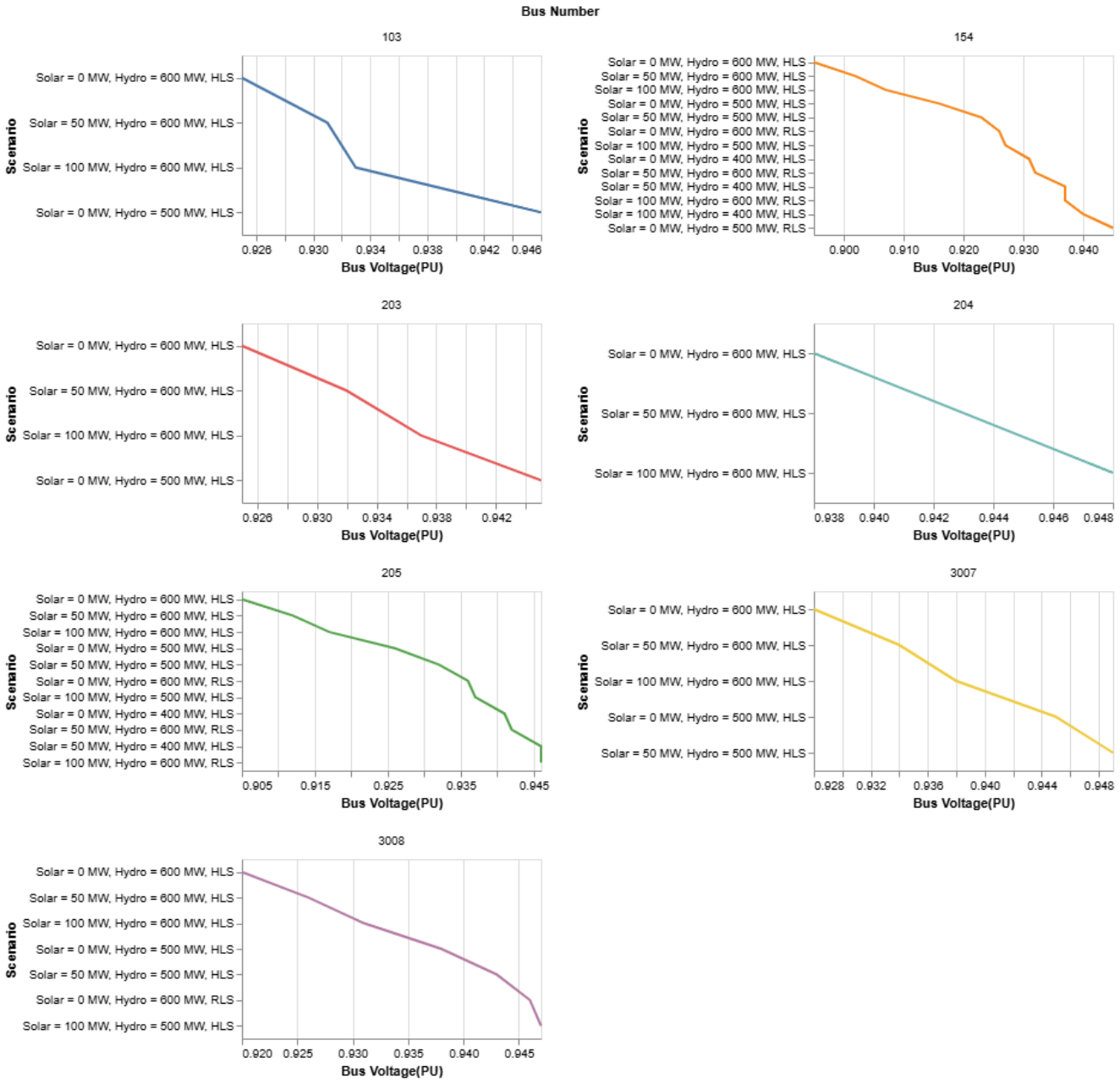

Figure 3.5: Buses with voltages lower than 0.95PU - Year 3, Topology 3

3.6 Year 3, Topology 4

In this section, for the hypothetical SAVNW system, Year 3, Topology 4 branch overload and voltage limit violations are analysed. The year 3, topology 4 is the system with the new hydro generator at bus 212 online with the completion of the proposed transmission line upgrades.

3.6.1 Transformer branch overload - Year 3, Topology 4

In Year 3, Topology 3 the transformers loaded greater than 80% of the threshold were the slightly overloaded transformer connecting buses 3018 to 3008, and heavily loaded transformers connecting buses 202 to 203 and 204 to 205. In Year 3, Topology 4, when the transmission upgrades are complete, two more transformers are expected to be operational with one each between 202 to 203 and 204 to 205. By conducting load flow analysis on the system and observing loading violations only violation reported is the slight overload of transformer 3018 to 3008 as seen in Figure 3.6. Appendix of this document gives the data in a tabular form (Table 5.9).

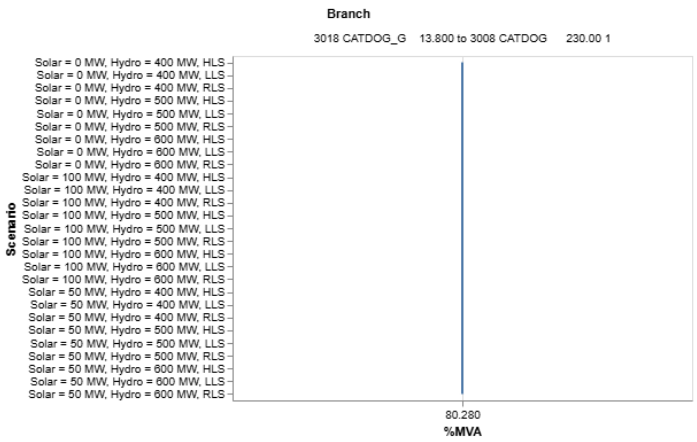

Figure 3.6: Transformer loaded more than 80% of thermal rating - Year 3, Topology 4

3.6.2 Transmission line branch overload Year 3, Topology 4

The transmission line overload violations observed are as shown in Figure 3.7 with appendix of the document giving the data in tabular form (Table 5.10).

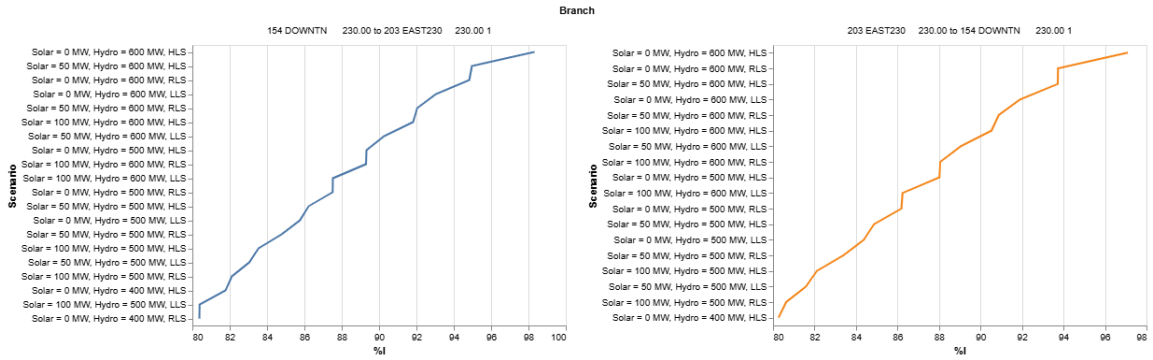

Figure 3.7: Transmission line loaded more than 80% of thermal rating - Year 3, Topology 4

In year 3, topology 3, there were multiple branches reporting branch overloading. With the completion of various transmission upgrades, it can be seen that the only violation reported is the transmission tie line from area 1 to area 2 (branch 154 to 203).

3.6.3 Bus voltage upper limit violation - Year 3, Topology 4

The bus violations with voltage more than 1.05 is as shown in Figure 3.8. Buses reporting overvoltage violations are buses 206, 211, 212, 3018 and can be seen that these violation is only slightly greater than the threshold of 1.05PU than the larger deviation observed for Year 3, Topology 3. Appendix of this document gives the data in a tabular form (Table 5.11).

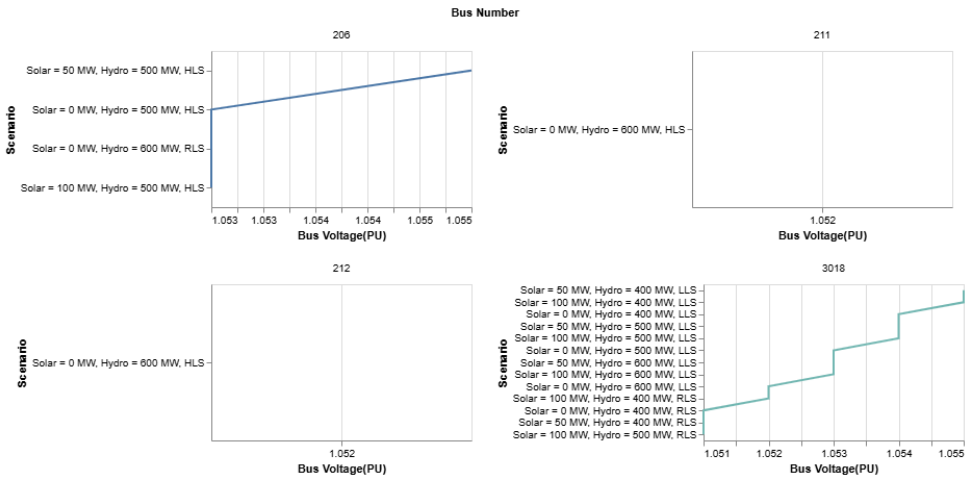

Figure 3.8: Buses with voltages greater than 1.05PU - Year 3, Topology 4

3.7 Year 4, Topology 5

In this section, for the hypothetical SAVNW system, Year 4, Topology 5 branch overload and voltage limit violations are analysed. Year 4, topology 5 is the system with wind farm coming operational in area 5.

3.7.1 Transformer branch overload - Year 4, Topology 5

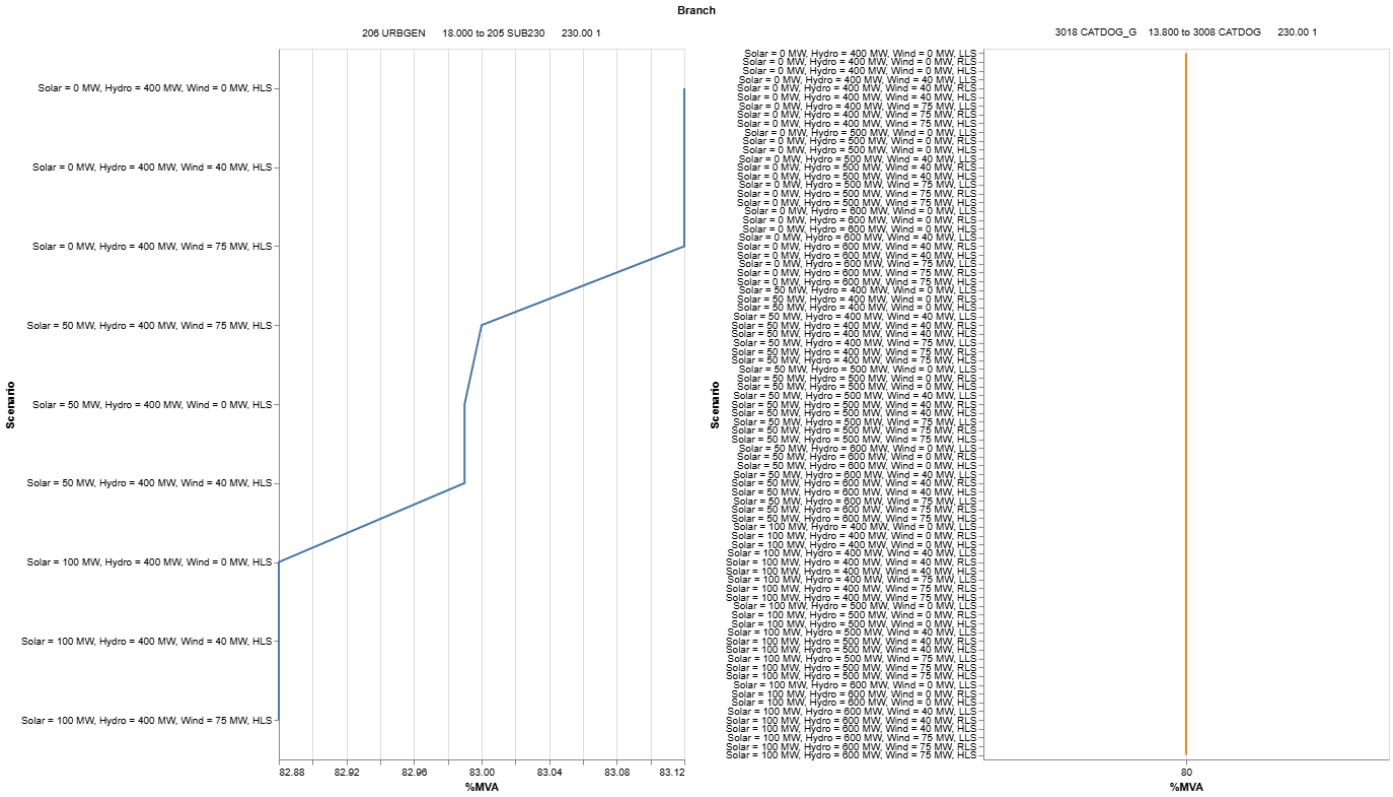

Figure 3.9: Transformer loaded more than 80% of thermal rating - Year 4, Topology 5

For the year 4, topology 5, loading greater than 80% were reported for transformers 206 to 205 and 3018 to 3008. The transformer branch overload violations observed are as shown in Figure 3.9. Appendix of this document gives the data in a tabular form (Table 5.12).

3.7.2 Transmission line branch overload Year 4, Topology 5

Figures 3.10 and 3.11 shows the transmission line overloading violations reported for branches with appendix of the document giving the data in tabular form (Tables 5.13, 5.14, 5.15).

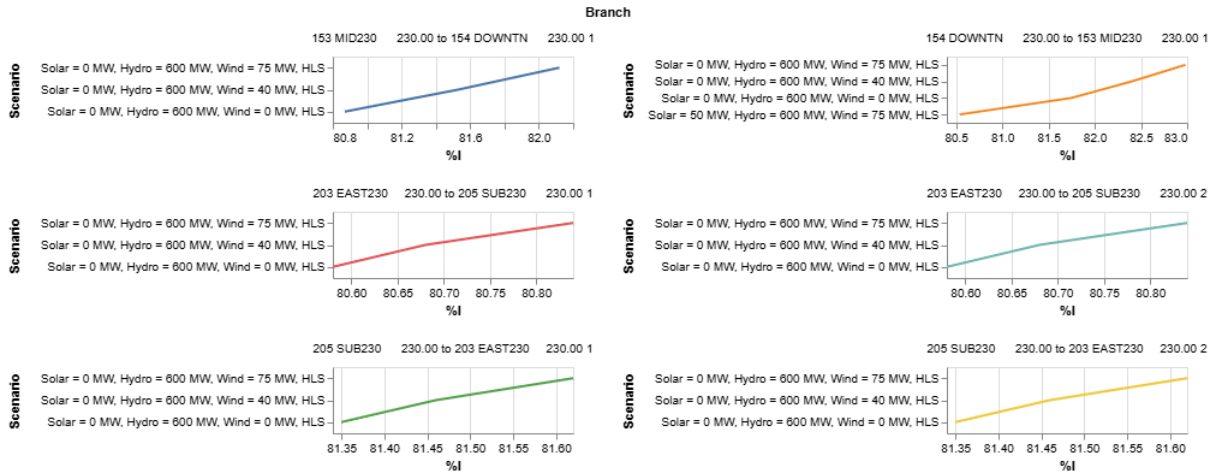

Figure 3.10: Transmission line loaded more than 80% of thermal rating - Year 4, Topology 5

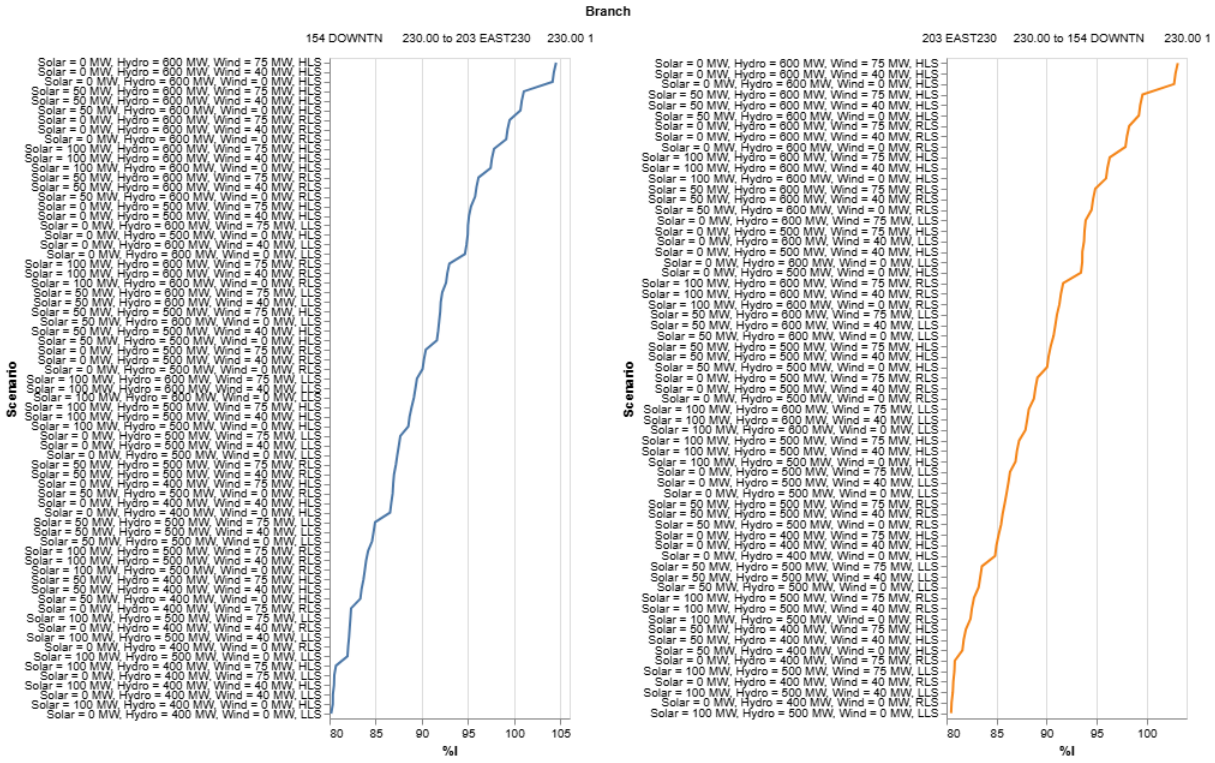

Figure 3.11: Transmission line loaded more than 80% of thermal rating - Year 4, Topology 5

It can be seen that except for the tie from 154 to 203, rest of the reported lines are only slightly overloaded.

3.7.3 Bus voltage upper limit violation - Year 4, Topology 5

For year 4, topology 5, the buses reporting voltage greater than 1.05 are all generator buses 206, 211, 212 and 3018. The bus violations with voltage more than 1.05 is as shown in Figure 3.12. Detailed data for bus voltage violation in tabular form is given in (Table 5.16).

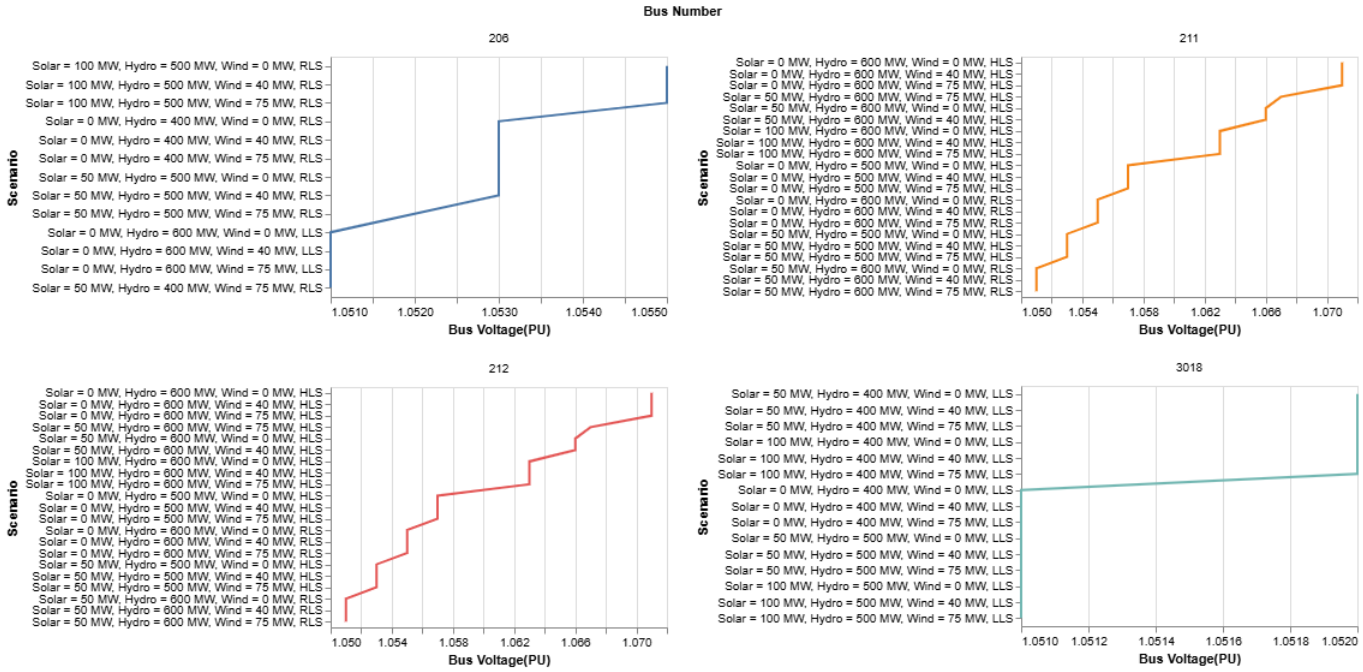

Figure 3.12: Buses with voltages greater than 1.05PU - Year 4, Topology 5

3.7.4 Bus voltage lower limit violation Year 4, Topology 5

The bus violations with voltage less than 0.95 PU is as shown in Figure 3.13. Detailed data for bus voltage violation in tabular form is given in the appendix(Table 5.17).

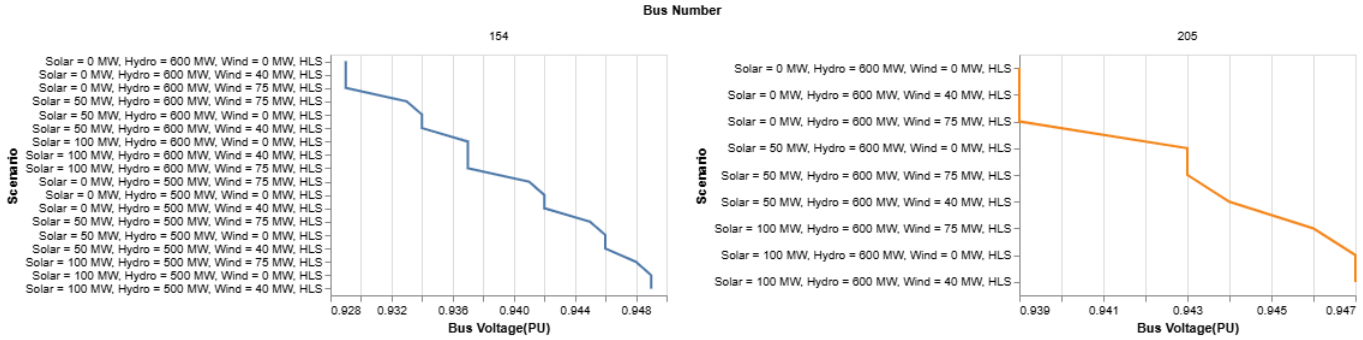

Figure 3.13: Buses with voltages lower than 0.95PU - Year 4, Topology 5

3.8 Year 5, Topology 6

Year 5, Topology 6 is the system without any new resource addition or transmission upgrades, but has increased load in all areas. In this section, for the hypothetical SAVNW system, Year 5, Topology 6 branch overload and voltage limit violations are analysed.

3.8.1 Transformer branch overload - Year 5, Topology 6

For year 5, topology 6 the transformer branch overload violations observed are as shown in Figure 3.14 and 3.14. Appendix of this document gives the data in a tabular form (Table 5.18). For the studied scenarios of Year 5, Topology 6, the transformer connecting Bus 3018 and 3008 loading can be reduced by redispatching the generator at bus 3018. It can be seen that most of the reported violations were corresponding to high load scenarios. Transmission upgrades or demand side measures would be needed to meet such high load scenarios.

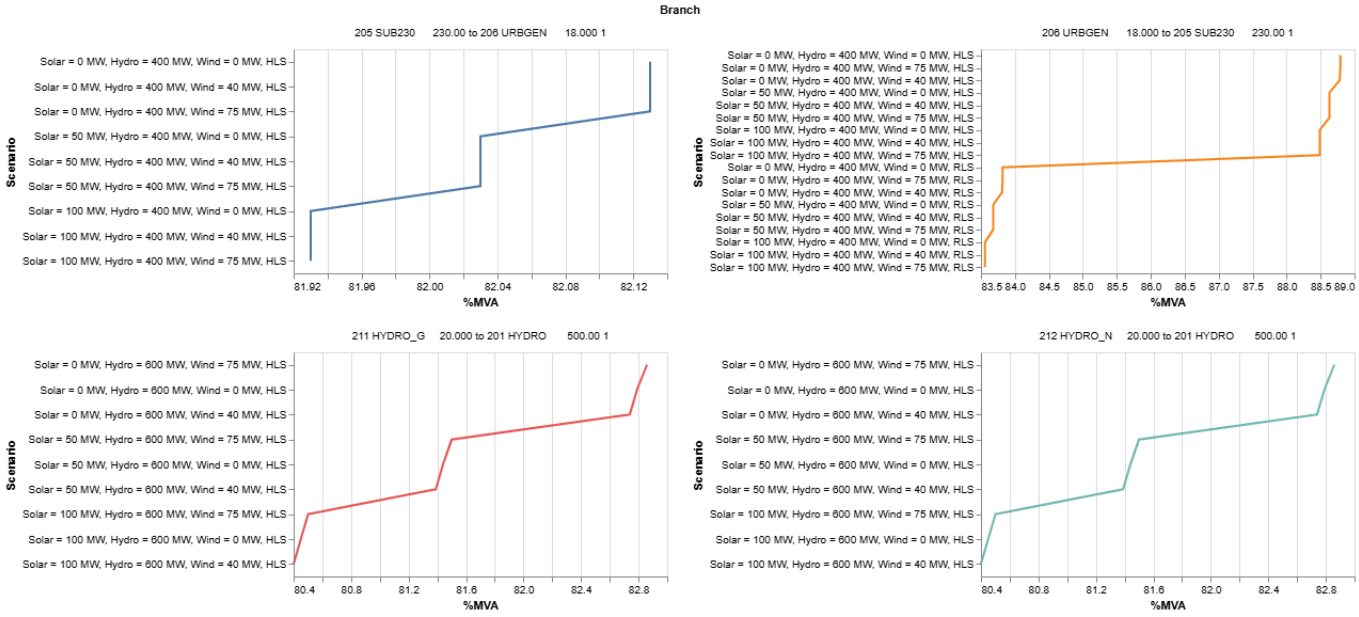

Figure 3.14: Transformer loaded more than 80% of thermal rating - Year 5, Topology 6

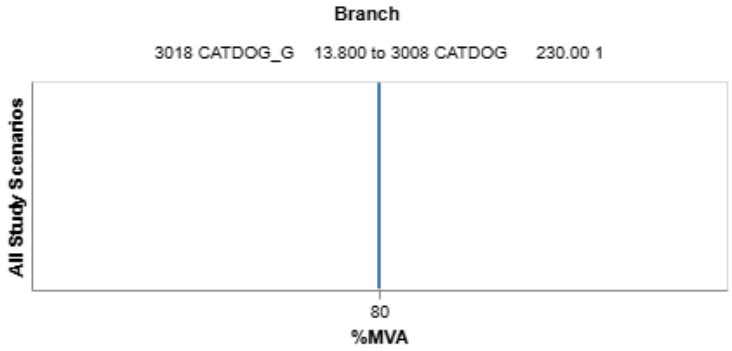

Figure 3.15: Transformer loaded more than 80% of thermal rating - Year 5, Topology 6

3.8.2 Transmission line branch overload Year 5, Topology 6

The transmission line overload violations observed are as shown in Figure 3.16, 3.17 with appendix of the document giving the data in tabular form (Tables 5.19, 5.20, 5.21, 5.22). Most transmission line loading violations were observed for the branches 154 DOWNTN 230.00 to 203 EAST230 230.00 and 203 EAST230 230.00 to 154 DOWNTN 230.00 1. For the 81 studied scenarios, these branches reported violations for 75 and 72 times respectively. Not only number of these violations were high in number, but in magnitude as well with some studied scenarios reporting more than 100% loading. For the rest of the reported violations, the % loading was below 90%.

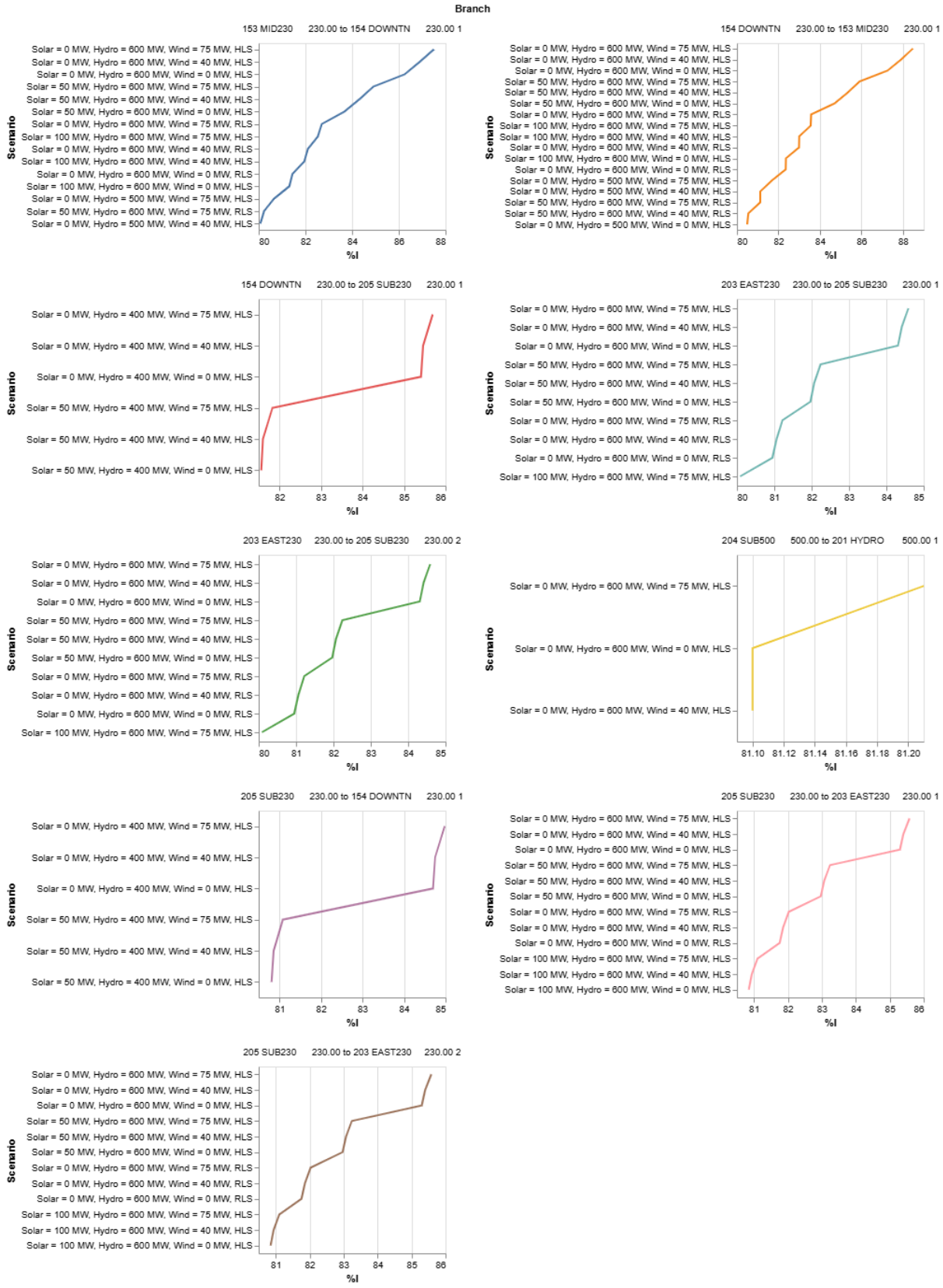

Figure 3.16: Transformer loaded more than 80% of thermal rating - Year 5, Topology 6

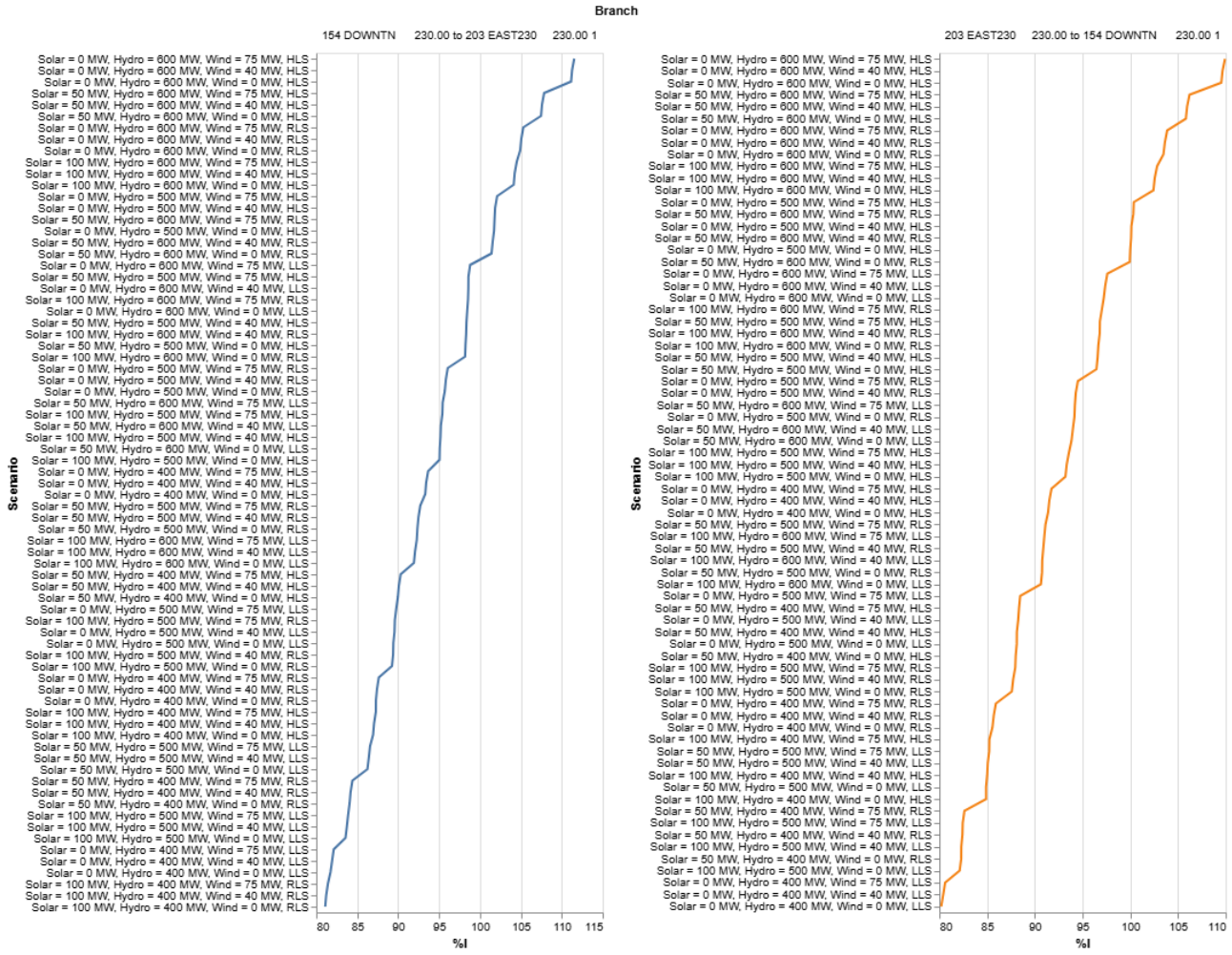

Figure 3.17: Transformer loaded more than 80% of thermal rating - Year 5, Topology 6

3.8.3 Bus voltage upper limit violation - Year 5, Topology 6

The bus violations with voltage more than 1.05 is as shown in Figure 3.18. Tables 5.23, 5.24 in the appendix of this document gives the data in tabular form.

For Year 5, Topology 6 the upper voltage violations were observed for the generator buses 206, 211, 212. For the generator bus at 206, the high voltages were observed for low load scenario only and the deviation from upper limit of 1.05 is very small. For generator buses at 211 and 212 the voltage violations were observed for all 3 load scenarios and the variation from upper limits were high, going as high as 1.092PU. The Y axis of the plot is sorted in a decreasing magnitude of the violation. It was seen that for the studied scenarios for both buses, cases of no solar generation, maximum hydro generation and all 3 outputs of wind generation, the hydro generator output voltage recorded the maximum value of 1.092 PU.

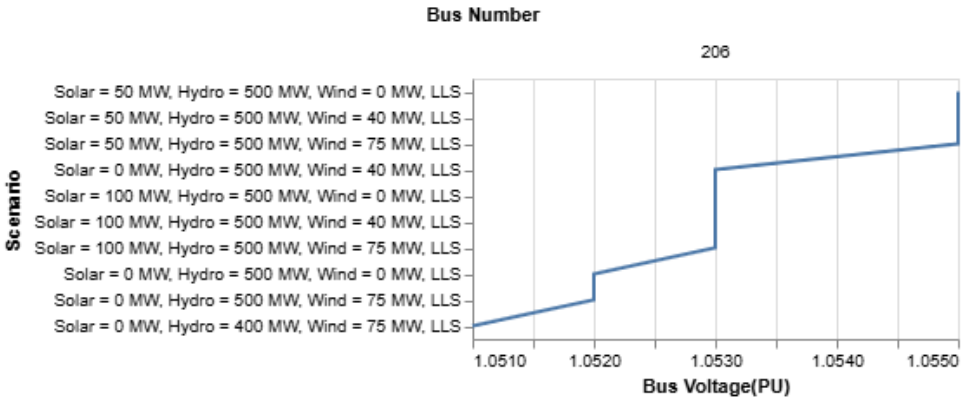

Figure 3.18: Buses with voltages greater than 1.05PU - Year 5, Topology 6

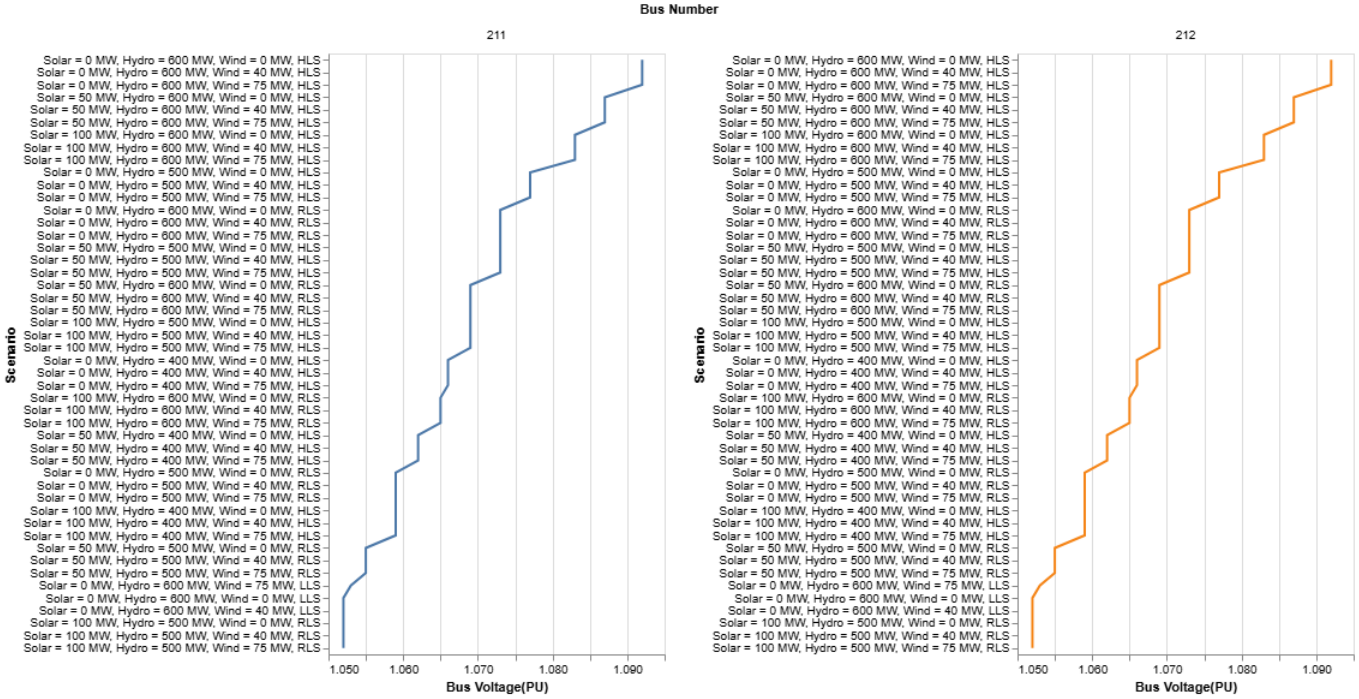

Figure 3.19: Buses with voltages greater than 1.05PU - Year 5, Topology 6

3.8.4 Bus voltage lower limit violation Year 5, Topology 6

The bus violations with voltage less than 0.95 PU is as shown in Figures 3.20, , 3.21, 3.22. Tables 5.25, 5.26, 5.27 in the appendix of this document gives the data in tabular form. For Year 5, Topology 6 the lower voltage violations were observed for the following 9 buses 103, 153, 154, 203, 204, 205, 3007, 3008 and 3012. Figures 3.20, 3.21, 3.22 gives the plotted violations. It was seen that none of these violations were lower than the emergency voltage limit of 0.9PU. The lowest value was reported for scenarios in which the generators at buses 211 and 212 operating at their maximum output and the power needed to be transmitted to the load at bus 154 located long distance from the supply. It was seen that re-dispatching the generator brought the voltage under the normal range.

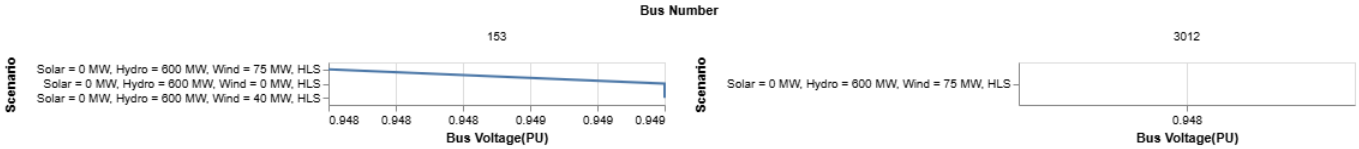

Figure 3.20: Buses with voltages lower than 0.95PU - Year 5, Topology 6

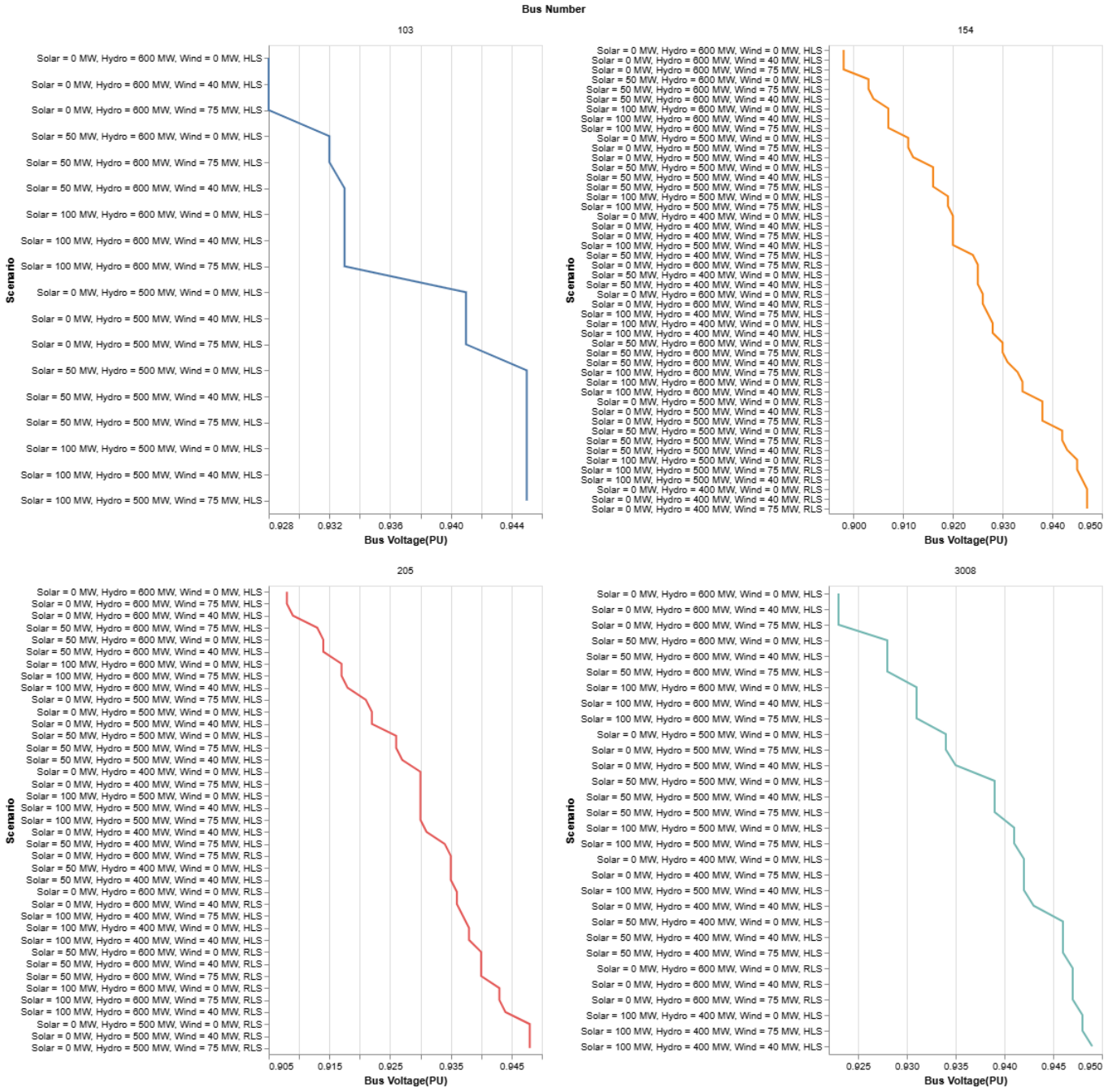

Figure 3.21: Buses with voltages lower than 0.95PU - Year 5, Topology 6

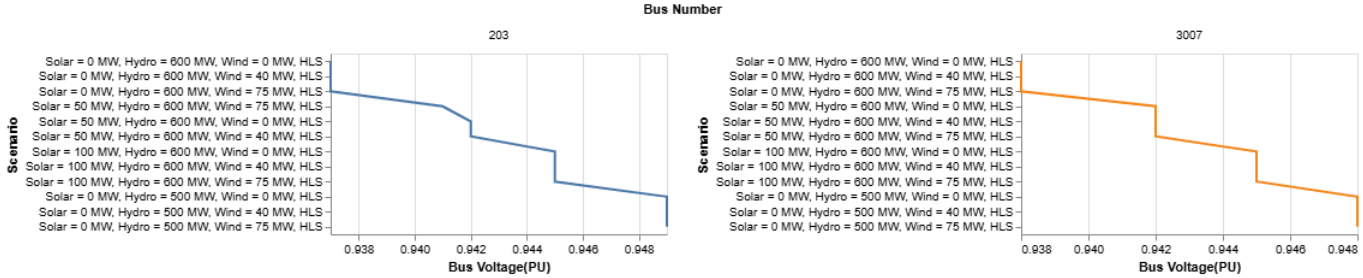

Figure 3.22: Buses with voltages lower than 0.95PU - Year 5, Topology 6

Chapter 4

Summary

4.1 Introduction

This section provides a summary of all the studied scenarios by summarising the number of times a bus, branch violates the voltage, loading respectively. The summary of the topology analysis is tabulated in Tables 4.1, 4.2, 4.3, 4.4.

4.2 Summary Table Transformer branch loading >80%

Transformer reporting loading violations are given in Table 4.1. Even though the most violation is shown by the 3018 CATDOG_G 13.800 to 3008 CATDOG 230 1 branch, redispatching the generator to supply less helps in keeping the loading under 80%. Addition of second set of transformers between branches 204 to 205 and 202 to 203 as a part of the transmission system upgrades in year 3 has helped keep the loading below 80% for the violations reported for the first set of transformers. For transformer between 205 to 206, loading of the transformer ranges between 80-90%. For transformers connected to the hydro generators, the high loading is reported on the transformers when the generators output is 600 MW for High load scenarios.

Branch	Count
3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1	234
206 URBGEN 18.000 to 205 SUB230 230.00 1	31
204 SUB500 500.00 to 205 SUB230 230.00 1	26
202 EAST500 500.00 to 203 EAST230 230.00 1	25
205 SUB230 230.00 to 204 SUB500 500.00 1	24
203 EAST230 230.00 to 202 EAST500 500.00 1	22
205 SUB230 230.00 to 206 URBGEN 18.000 1	12
211 HYDRO_G 20.000 to 201 HYDRO 500.00 1	9
212 HYDRO_N 20.000 to 201 HYDRO 500.00 1	9

Table 4.1: Count of transformer branches loaded greater than 80%

4.3 Summary Table Transmission line branch loading >80%

From Table 4.2, it was seen that the branch violating the loading the greatest number of times is the tie 154 DOWNTN 230.00 to 203 EAST230 230.00 1 from area 1 to area 2. There was no upgrade to the branch from the bus 154 to 203 planned in last long-term plan. This branch is heavily loaded including reporting of more than 100% loading in some of the scenarios. It can also be seen that after the completion of upgrades in year 3 the branches in Area 5 did not show loading greater than 80% for studied scenarios. The loading value for rest of the overload reported branches lies between 80-85% and does not exceed 100% for any of the studied scenarios. An N-1 contingency for this system could lead the system to unstable operating situation.

4.4 Summary Table Bus voltage >1.05 PU

High bus voltages are reported for the generator buses with only exceptions being the slightly high voltage of 1.051 reported by bus 152 for scenario Solar = 100 MW, LLS, and bus 201, which is connected to the secondary side

Branch	Count
154 DOWNTN 230.00 to 203 EAST230 230.00 1	176
203 EAST230 230.00 to 154 DOWNTN 230.00 1	164
154 DOWNTN 230.00 to 153 MID230 230.00 1	49
153 MID230 230.00 to 154 DOWNTN 230.00 1	46
3005 WEST 230.00 to 3007 RURAL 230.00 1	24
3007 RURAL 230.00 to 3005 WEST 230.00 1	24
154 DOWNTN 230.00 to 153 MID230 230.00 2	18
153 MID230 230.00 to 154 DOWNTN 230.00 2	17
3003 S. MINE 230.00 to 3001 MINE 230.00 1	17
3001 MINE 230.00 to 3003 S. MINE 230.00 1	17
205 SUB230 230.00 to 203 EAST230 230.00 1	15
205 SUB230 230.00 to 203 EAST230 230.00 2	15
203 EAST230 230.00 to 205 SUB230 230.00 1	13
203 EAST230 230.00 to 205 SUB230 230.00 2	13
154 DOWNTN 230.00 to 205 SUB230 230.00 1	6
205 SUB230 230.00 to 154 DOWNTN 230.00 1	6
204 SUB500 500.00 to 201 HYDRO 500.00 1	3

Table 4.2: Count of transmission line branches loaded greater than 80%

of the transformer connecting to the hydro generator bus. It was also seen that the bus 201 did not report any violation after the year transmission upgrades were completed.

Bus Number	Bus Name	Count
211	HYDRO_G	79
212	HYDRO_N	79
3018	CATDOG_G	43
206	URBGEN	30
201	HYDRO	18
152	MID500	1

Table 4.3: Count of buses with voltage greater than 1.05PU

4.5 Summary Table Bus voltage <0.95 PU

Low bus voltages are reported predominantly for load buses with bus 154 in area 1 reporting most number of violations followed by bus 205 in area 1. It was also seen that no low voltage violations were reported for Year 0, Year 1 and Year 2. After the first low bus voltage reporting for Year 3, Topology 3, there were no bus voltage violations reported for year 3, topology 4 with the transmission upgrade. In year 4, topology 5, buses 154 and 205 reported violation, and in year 5 all of the buses in Table 4.4 reported violation.

Bus Number	Bus Name	Count
154	DOWNTN	79
205	SUB230	59
3008	CATDOG	37
103	SOLAR_PV	22
204	SUB500	21
3007	RURAL	17
203	EAST230	16
153	MID230	3
3012	WIND X	1

Table 4.4: Count of buses with voltages less than 0.95PU

For these reported branches and buses, transmission system studies need to be carried out to plan system upgrades. In any scenario the upgrade can not be completed on time, demand side measures need to be taken to ensure system operated in a reliable manner.

Chapter 5

Conclusions

PSSE load flow analysis was carried out to check if system is operating within the specified limits as new resources comes online in the system as the demand increases. 7 topologies spanning 5 years for various generation and load scenarios were studied. It was seen that the load flow converged for all the studied scenarios. There were loading and voltage limit violations reported for various scenarios. The detailed analysis for each scenario can be found here.

By completing studies for the considered scenarios, it was seen there is adequate supply side resources to meet the load demand for the planning horizon. As there were branch flow overloading and bus voltage violations observed for various buses, it was seen that transmission system needs upgrading to ensure operational reliability and flexibility.

In case of hypothetical SAVNW system, transmission upgrade timelines were not properly incorporated into generation planning which has caused system to have enough supply side resources to meet the load, but not enough transmission resources to transfer the power from supply side to demand side to meet all the planning objectives. For example, the overload in the tie-line form 154 203 could be avoided if there were additional circuit to supply power from Bus 203 to 154, leading to a need to rely on the generator connected at bus 206, which is a coal generator resulting in more GHG emissions and unable to meet the clean energy policy requirements. It was verified that addition of reactive power support at Bus 154 would help eliminate various loading, under voltage violations observed at Bus 154 for various scenarios. Redispatching can help relieve burden of transformer and transmission line branches as seen in case of transformer branch connected to Bus 3018. It can be concluded that detailed transmission study is needed to be performed and will inform necessary transmission upgrade options needed for hypothetical SAVNW systems safe and reliable operation. If the transmission upgrades are not completed on time, there will be a need to ramp up customer programs and demand side measures to ensure the demands of the customers can be met in a reliable manner.

Appendix

5.1 PSSE Python automation script to generate case .sav files

```
# Base case sav file
psspy.case(r"""savnw_solar_hydro_wind.sav""")
# list of generators
list_gens = [0,50,100] # for 3 solar irradiance scenarios
list_gen_hydro = [400,500,600] # for dry, average, wet hydological scenarios
list_gen_wind = [0,40,75] # for 3 wind gust scenarios
# looping through the studied load and demand scenarios
for gen in list_gens:
    # updating the solar generator
    psspy.machine_chng_4(103,r"""1""",[_i,_i,_i,_i,_i,_i,_i],[gen,_f,_f,_f,_f,_f,_f,_f,_f,_f,_f,_f
                                                    ,_f,_f,_f,_f,_f],"")
    for gen_hy in list_gen_hydro:
        # updating the hydro generator
        psspy.machine_chng_4(211,r"""1""",[_i,_i,_i,_i,_i,_i,_i],[gen_hy,_f,_f,_f,_f,_f,_f,_f,_f,
                                                    _f,_f,_f,_f,_f,_f,_f,_f],"")
        psspy.machine_chng_4(212,r"""1""",[_i,_i,_i,_i,_i,_i,_i],[gen_hy,_f,_f,_f,_f,_f,_f,_f,_f,
                                                    _f,_f,_f,_f,_f,_f,_f,_f],"")
        for gen_wi in list_gen_wind:
            # updating the wind generator
            psspy.machine_chng_4(3010,r"""1""",[_i,_i,_i,_i,_i,_i,_i],[gen_wi,_f,_f,_f,_f,_f,_f,_f
                                                        ,_f,_f,_f,_f,_f,_f,_f,_f,_f],"")
            list_loads =   [[('LLS', 153, 1, 204.1, 102.1),('LLS', 154, 1, 612.41, 459.46),
          ('LLS', 154, 2, 408.21, 357.36),('LLS', 203, 1, 306.11, 153.15),
          ('LLS', 205, 1, 1224.72, 714.71),('LLS', 3005, 1, 102.0, 51.05),
          ('LLS', 3007, 1, 204.1, 76.58),('LLS', 3008, 1, 204.1, 76.58)],
         [('RLS', 153, 1, 215.32, 107.71),('RLS', 154, 1, 646.06, 484.7),
         ('RLS', 154, 2, 430.64, 376.99),('RLS', 203, 1, 322.92, 161.57),
         ('RLS', 205, 1, 1292.02, 753.98),('RLS', 3005, 1, 107.61, 53.86),
           ('RLS', 3007, 1, 215.32, 80.78),('RLS', 3008, 1, 215.32, 80.78)],
         [('HLS', 153, 1, 224.29, 112.2),('HLS', 154, 1, 672.98, 504.9),
          ('HLS', 154, 2, 448.58, 392.7),('HLS', 203, 1, 336.38, 168.3),
          ('HLS', 205, 1, 1345.85, 785.4),('HLS', 3005, 1, 112.09, 56.1),
             ('HLS', 3007, 1, 224.29, 84.15),('HLS', 3008, 1, 224.29, 84.15)]]
            for load in list_loads:
                for tuple in load:
                    # updating the load real and reactive power
                    psspy.load_chng_6(int(tuple[1]),str(tuple[2]),[_i,_i,_i,_i,_i,_i,_i],[tuple[3]
                                                            ,_f,_f,_f,_f,_f,_f,_f],"")
                    psspy.load_chng_6(int(tuple[1]),str(tuple[2]),[_i,_i,_i,_i,_i,_i,_i],[_f,tuple
                                                            [4],_f,_f,_f,_f,_f,_f],"")
                    # conducting load flow
                    psspy.fdns([0,1,0,0,0,0,0,0])
                    file_name_out = 'savnw_sol_' + str(gen) +'_hy_' +str(gen_hy) +  '_wi_' + str(
                                                            gen_wi)+ '_' + str(tuple[0])+
                                                            '.sav'
                    # saving the case file
                    file_out= r"{}".format(file_name_out)
                    psspy.save(file_out)
```

5.2 PSSE Python automation script to extract area totals

```
# PSSE automation script to extract area totals
def array2dict(dict_keys, dict_values):
    '''Convert array to dictionary of arrays. Returns dictionary as {dict_keys:dict_values}
    '''
    tmpdict = {}
    for i in range(len(dict_keys)):
        tmpdict[dict_keys[i].lower()] = dict_values[i]
    return tmpdict

def brnflows_csv(savfile,csvfile):
    '''
    Generates area totals in CSV format
    '''
    import psspy
    psspy.psseinit()
    psspy.case(savfile)
    csvfile_h = open(csvfile,'w')
    report    = csvfile_h.write
    istring= ['number']
    ierr, iarray = psspy.aareaint(sid=-1, flag=2, string=istring)
    if ierr != 0: return
    iareanumb = array2dict(istring, iarray)
    cstring = ['areaname']
    ierr, carray = psspy.aareachar(sid=-1, flag=2, string=cstring)
    if ierr != 0: return
    iareaname = array2dict(cstring, carray)
    astring = ['pdes','ptol','pload','qload','ploadld','qloadld','pgen','qgen','ploss','qloss',
         'pxfrmag','qxfrmag','pint','qint','o_pdes','o_ptol','o_pload','o_qload','o_ploadld',
         'o_qloadld','o_pgen','o_qgen','o_ploss','o_qloss','o_pxfrmag','o_qxfrmag','o_pint','
                                                                o_qint']
    ierr, rarray = psspy.aareareal(sid=-1,flag=2,string=astring)
    if ierr != 0: return
    iareadata = array2dict(astring, rarray)
    clnttls = "%4s,%6s,%10s,%6s,%10s,%8s\n" %('Area','Number','From Generation','To Load','To(+)/
                                                    From(-) Ties','To Losses')
    report(clnttls)
    for i in range(len(iareaname['areaname'])):
        area   = iareaname['areaname'][i]
        number = iareanumb['number'][i]
        pgen   = iareadata['pgen'][i]
        pload  = iareadata['pload'][i]
        pint   = iareadata['pint'][i]
        ploss  = iareadata['ploss'][i]
        report("%(area)6s,%(number)6d,%(pgen)6d,%(pload)6d,%(pint)6d,%(ploss)6d\n" %vars())
    csvfile_h.close()

def run_brnflows_csv():
    list_gens = [0,50,100]  # for 3 solar irradiances
    list_lsc = ['LLS','RLS','HLS'] # for three load scenarios
    list_gen_hydro = [400,500,600] #dry, average, wet hydological scenarios
    list_gen_wind = [0,40,75] # for 3 wind gusts
    for gen in list_gens:
        for gen_hy in list_gen_hydro:
            for gen_wi in list_gen_wind:
                for lsc in list_lsc:
                    file_sav_in = 'savnw_sol_' + str(gen) +'_hy_' +str(gen_hy) +'_wi_' + str(
                                                                gen_wi) + '_' + str(lsc)+'.
                                                                sav'
                    file_csv_out = 'savnw_sol_' + str(gen) +'_hy_' +str(gen_hy) +  '_wi_' + str(
                                                                gen_wi) + '_' + str(lsc)+'
                                                                _tot.csv'
                    brnflows_csv(file_sav_in, file_csv_out)

if __name__ == '__main__':
    import psse35
    run_brnflows_csv()
```

5.3 PSSE Python automation script to extract generator outputs

```
"""
Program to extarct active power output of in-service machines at aplant, in MW and
to calculate spinning reserve available from machines of this plant. Power flow is
conducted with automatic adjustment option for the system to meet area net interchange schedules
"""
def array2dict(dict_keys, dict_values):
    '''Convert array to dictionary of arrays. Returns dictionary as {dict_keys:dict_values}
    '''
    tmpdict = {}
    for i in range(len(dict_keys)):
        tmpdict[dict_keys[i].lower()] = dict_values[i]
    return tmpdict
def brnflows_csv(savfile,csvfile):
    import psspy
    psspy.psseinit()
    psspy.case(savfile)
    csvfile_h = open(csvfile,'w')
    report    = csvfile_h.write
    # Generator Data
    # Generator Data - Integer
    istrings = ['number','area',]
    ierr, idata = psspy.agenbusint(sid = -1, flag = 4,string=istrings)
    if ierr != 0: return
    iflow = array2dict(istrings, idata)
    # Generator Data - Real
    rstrings = ['base','pu','kv','pgen','pmax']
    ierr, rdata = psspy.agenbusreal(sid = -1, flag = 4,string=rstrings)
    if ierr != 0: return
    rflow = array2dict(rstrings, rdata)
    # Generator Data - Character
    cstrings = ['name','exname']
    ierr, cdata = psspy.agenbuschar(sid = -1, flag = 4,string=cstrings)
    if ierr != 0: return
    cflow = array2dict(cstrings, cdata)
    report("Branch flows from Saved case: %s\n" %savfile)
    clnttls= "%6s,%4s,%4s,%4s,%4s,%7s\n" %('Number','Name','Area','Pgen','Pmax','Reserve')
    report(clnttls)
    for i in range(len(iflow['number'])):
        fromnum    = iflow['number'][i]
        fromexname = cflow['name'][i]
        tonum      = iflow['area'][i]
        pgen       = rflow['pgen'][i]
        pmax       = rflow['pmax'][i]
        reserve    = rflow['pmax'][i] - rflow['pgen'][i]
        report("%(fromnum)6d,%(fromexname)18s,%(tonum)6d,%(pgen)9.2F,%(pmax)9.2F,%(reserve)9.2F\n"
                                                    %vars())
    csvfile_h.close()
def run_brnflows_csv():
    list_gens = [0,50,100] # for 3 solar irradiances
    list_lsc = ['LLS','RLS','HLS'] # for three load scenarios
    list_gen_hydro = [400,500,600] #dry, average, wet hydological scenarios
    list_gen_wind = [0,40,75] # for 3 wind gust scenarios
    for gen in list_gens:
        for gen_hy in list_gen_hydro:
            for lsc in list_lsc:
                for gen_wi in list_gen_wind:
                    file_sav_in = 'savnw_sol_' + str(gen) +'_hy_' +str(gen_hy) +'_wi_' + str(
                                                                gen_wi) +'_' + str(lsc)+'.sav
                                                                '
                    file_csv_out = 'savnw_sol_' + str(gen) +'_hy_' +str(gen_hy) +'_wi_' + str(
                                                                gen_wi) +'_' + str(lsc)+'_gen
                                                                .csv'
                    brnflows_csv(file_sav_in, file_csv_out)
if __name__ == '__main__':
    import psse35
    run_brnflows_csv()
```

5.4 PSSE Python automation script to extract branch flows

```
def array2dict(dict_keys, dict_values):
    tmpdict = {}
    for i in range(len(dict_keys)):
        tmpdict[dict_keys[i].lower()] = dict_values[i]
    return tmpdict
def brnflows_csv(savfile,csvfile):
    import psspy
    psspy.psseinit()
    psspy.case(savfile)
    csvfile_h = open(csvfile,'w')
    report    = csvfile_h.write
    istrings = ['fromnumber','tonumber','nmeternumber']
    ierr, idata = psspy.aflowint(-1,1,5,1,istrings)
    if ierr != 0: return
    iflow = array2dict(istrings, idata)
    rstrings = ['amps','pctrate','pctmvarate','rate','p','q','mva','ploss','qloss',]
    ierr, rdata = psspy.aflowreal(-1,1,5,1,rstrings)
    if ierr != 0: return
    rflow = array2dict(rstrings, rdata)
    cstrings = ['id','fromname','fromexname','toname','toexname']
    ierr, cdata = psspy.aflowchar(-1,1,5,1,cstrings)
    if ierr != 0: return
    cflow = array2dict(cstrings, cdata)
    report("Branch flows from Saved case: %s\n" %savfile)
    clnttls = "%6s,%6s,%6s,%6s,%3s,%3s,%9s,%9s,%9s,%9s,%6s,%8s,%4s,%2s,%4s\n" %('From Bus',
             'From Bus Ext','To Bus','To Bus Ext','Ckt ID','Non Metered Bus','Branch I','Branch
              Flow MW','Branch Flow MVAR','Branch MVA','MW Loss','MVAR Loss','Rate','%I','%MVA')
    report(clnttls)
    for i in range(len(iflow['fromnumber'])):
        fromnum    = iflow['fromnumber'][i]
        fromexname = cflow['fromexname'][i]
        tonum      = iflow['tonumber'][i]
        toexname   = cflow['toexname'][i]
        ckt        = cflow['id'][i]
        nonmeter   = iflow['nmeternumber'][i]
        amps       = rflow['amps'][i]
        p          = rflow['p'][i]
        q          = rflow['q'][i]
        mva        = rflow['mva'][i]
        ploss      = rflow['ploss'][i]
        qloss      = rflow['qloss'][i]
        rate       = rflow['rate'][i]
        pcti       = rflow['pctrate'][i]
        pctr       = rflow['pctmvarate'][i]
        report("%(fromnum)7d,%(fromexname)10s,%(tonum)5d,%(toexname)8s,%(ckt)3s,%(nonmeter)3s,\
%(amps)4d,%(p)9.2F,%(q)9.2F,%(mva)9.2F,%(ploss)8.2F,%(qloss)8.2F,%(rate)6.2F,%(pcti)6.2F,%(pctr)8.
                                                2F\n" %vars())
    csvfile_h.close()

def run_brnflows_csv():
    list_gens = [0,50,100] # for 3 solar irradiances
    list_lsc = ['LLS','RLS','HLS'] # for three load scenarios
    list_gen_hydro = [400,500,600] #dry, average, wet hydological scenarios
    list_gen_wind = [0,40,75] # for 3 wind gust scenarios
    for gen in list_gens:
        for gen_hy in list_gen_hydro:
            for lsc in list_lsc:
                for gen_wi in list_gen_wind:
                    file_sav_in = 'savnw_sol_' + str(gen) +'_hy_' +str(gen_hy) +'_wi_' + str(
                                                                    gen_wi) +'_' + str(lsc)+'.sav
                                                                    '
                    file_csv_out = 'savnw_sol_' + str(gen) +'_hy_' +str(gen_hy) +'_wi_' + str(
                                                                    gen_wi) +'_' + str(lsc)+'_l.
                                                                    csv'
                    brnflows_csv(file_sav_in, file_csv_out)

if __name__ == '__main__':
    import psse35
    run_brnflows_csv()
```

5.5 PSSE Python automation script to extract bus voltages

```
def array2dict(dict_keys, dict_values):
    tmpdict = {}
    for i in range(len(dict_keys)):
        tmpdict[dict_keys[i].lower()] = dict_values[i]
    return tmpdict

def brnflows_csv(savfile,csvfile):
    import psspy
    psspy.psseinit()
    psspy.case(savfile)
    csvfile_h = open(csvfile,'w')
    report = csvfile_h.write
    istrings = ['number', 'type', 'area']
    ierr, idata = psspy.abusint(sid=-1,flag=2,string=istrings)
    if ierr != 0: return
    iflow = array2dict(istrings, idata)
    rstrings = ['base', 'pu', 'kv','angle','angled','nvlmhi','nvlmlo','evlmhi','evlmlo']
    ierr, rdata = psspy.abusreal(sid=-1,flag=2,string=rstrings)
    if ierr != 0: return
    rflow = array2dict(rstrings, rdata)
    cstrings = ['name','exname']
    ierr, cdata = psspy.abuschar(sid=-1,flag=2,string=cstrings)
    if ierr != 0: return
    cflow = array2dict(cstrings, cdata)
    report("Bus Data from Saved case: %s\n" %savfile)
    clnttls = "%9s,%7s,%4s,%10s,%10s,%10s\n" %('Bus Number','Bus Name','Area','Base Voltage', 'Bus
                                                Voltage(PU)', 'Bus Voltage(kV)')
    report(clnttls)
    for i in range(len(rflow['base'])):
        number      = iflow['number'][i]
        area        = iflow['area'][i]
        name        = cflow['name'][i]
        base        = rflow['base'][i]
        pu          = round(rflow['pu'][i],3)
        kv          = round(rflow['kv'][i],3)
        report("%(number)6d,%(name)6s,%(area)18s,%(base)6.8f,%(pu)6.8f,%(kv)6.8f\n" %vars())
    csvfile_h.close()

def run_brnflows_csv():
    list_gens = [0,50,100] # for 3 solar irradiances
    list_lsc = ['LLS','RLS','HLS'] # for three load scenarios
    list_gen_hydro = [400,500,600] #dry, average, wet hydological scenarios
    list_gen_wind = [0,40,75] # for 3 wind gust scenarios
    for gen in list_gens:
        for gen_hy in list_gen_hydro:
            for lsc in list_lsc:
                for gen_wi in list_gen_wind:
                    file_sav_in = 'savnw_sol_' + str(gen) +'_hy_' +str(gen_hy) +'_wi_' + str(
                                                                gen_wi) +'_' + str(lsc)+'.sav
                                                                '
                    file_csv_out = 'savnw_sol_' + str(gen) +'_hy_' +str(gen_hy) +'_wi_' + str(
                                                                gen_wi) +'_' + str(lsc)+'
                                                                _volt.csv'
                    brnflows_csv(file_sav_in, file_csv_out)

if __name__ == '__main__':
    import psse35
    run_brnflows_csv()
```

Bus Number	Bus Name	Scenario	Bus Voltage(PU)
3008	CATDOG	Solar = 100 MW, Hydro = 500 MW, HLS	0.947
		Solar = 0 MW, Hydro = 600 MW, RLS	0.946
		Solar = 50 MW, Hydro = 500 MW, HLS	0.943
		Solar = 0 MW, Hydro = 500 MW, HLS	0.938
		Solar = 100 MW, Hydro = 600 MW, HLS	0.931
		Solar = 50 MW, Hydro = 600 MW, HLS	0.926
		Solar = 0 MW, Hydro = 600 MW, HLS	0.920
3007	RURAL	Solar = 50 MW, Hydro = 500 MW, HLS	0.949
		Solar = 0 MW, Hydro = 500 MW, HLS	0.945
		Solar = 100 MW, Hydro = 600 MW, HLS	0.938
		Solar = 50 MW, Hydro = 600 MW, HLS	0.934
		Solar = 0 MW, Hydro = 600 MW, HLS	0.928
205	SUB230	Solar = 50 MW, Hydro = 400 MW, HLS	0.946
		Solar = 100 MW, Hydro = 600 MW, RLS	0.946
		Solar = 50 MW, Hydro = 600 MW, RLS	0.942
		Solar = 0 MW, Hydro = 400 MW, HLS	0.941
		Solar = 100 MW, Hydro = 500 MW, HLS	0.937
		Solar = 0 MW, Hydro = 600 MW, RLS	0.936
		Solar = 50 MW, Hydro = 500 MW, HLS	0.932
		Solar = 0 MW, Hydro = 500 MW, HLS	0.926
		Solar = 100 MW, Hydro = 600 MW, HLS	0.917
		Solar = 50 MW, Hydro = 600 MW, HLS	0.912
		Solar = 0 MW, Hydro = 600 MW, HLS	0.905
204	SUB500	Solar = 100 MW, Hydro = 600 MW, HLS	0.948
		Solar = 50 MW, Hydro = 600 MW, HLS	0.943
		Solar = 0 MW, Hydro = 600 MW, HLS	0.938
203	EAST230	Solar = 0 MW, Hydro = 500 MW, HLS	0.945
		Solar = 100 MW, Hydro = 600 MW, HLS	0.937
		Solar = 50 MW, Hydro = 600 MW, HLS	0.932
		Solar = 0 MW, Hydro = 600 MW, HLS	0.925
154	DOWNTN	Solar = 0 MW, Hydro = 500 MW, RLS	0.945
		Solar = 100 MW, Hydro = 400 MW, HLS	0.940
		Solar = 50 MW, Hydro = 400 MW, HLS	0.937
		Solar = 100 MW, Hydro = 600 MW, RLS	0.937
		Solar = 50 MW, Hydro = 600 MW, RLS	0.932
		Solar = 0 MW, Hydro = 400 MW, HLS	0.931
		Solar = 100 MW, Hydro = 500 MW, HLS	0.927
		Solar = 0 MW, Hydro = 600 MW, RLS	0.926
		Solar = 50 MW, Hydro = 500 MW, HLS	0.923
		Solar = 0 MW, Hydro = 500 MW, HLS	0.916
		Solar = 100 MW, Hydro = 600 MW, HLS	0.907
		Solar = 50 MW, Hydro = 600 MW, HLS	0.902
		Solar = 0 MW, Hydro = 600 MW, HLS	0.895
103	SOLAR_PV	Solar = 0 MW, Hydro = 500 MW, HLS	0.946
		Solar = 100 MW, Hydro = 600 MW, HLS	0.933
		Solar = 50 MW, Hydro = 600 MW, HLS	0.931
		Solar = 0 MW, Hydro = 600 MW, HLS	0.925

Table 5.1: Buses with voltages lower than 0.95PU - Year 3, Topology 3

Bus Number	Bus Name	Scenario	Bus Voltage(PU)
212	HYDRO_N	Solar = 0 MW, Hydro = 600 MW, HLS	1.080
		Solar = 50 MW, Hydro = 600 MW, HLS	1.075
		Solar = 100 MW, Hydro = 600 MW, HLS	1.070
		Solar = 0 MW, Hydro = 600 MW, RLS	1.062
		Solar = 0 MW, Hydro = 500 MW, HLS	1.061
		Solar = 50 MW, Hydro = 500 MW, HLS	1.057
		Solar = 50 MW, Hydro = 600 MW, RLS	1.057
		Solar = 100 MW, Hydro = 500 MW, HLS	1.053
		Solar = 100 MW, Hydro = 600 MW, RLS	1.053
211	HYDRO_G	Solar = 0 MW, Hydro = 600 MW, HLS	1.080
		Solar = 50 MW, Hydro = 600 MW, HLS	1.075
		Solar = 100 MW, Hydro = 600 MW, HLS	1.070
		Solar = 0 MW, Hydro = 600 MW, RLS	1.062
		Solar = 0 MW, Hydro = 500 MW, HLS	1.061
		Solar = 50 MW, Hydro = 500 MW, HLS	1.057
		Solar = 50 MW, Hydro = 600 MW, RLS	1.057
		Solar = 100 MW, Hydro = 500 MW, HLS	1.053
		Solar = 100 MW, Hydro = 600 MW, RLS	1.053
206	URBGEN	Solar = 0 MW, Hydro = 500 MW, LLS	1.053
		Solar = 100 MW, Hydro = 600 MW, LLS	1.053
		Solar = 100 MW, Hydro = 400 MW, RLS	1.051

Table 5.2: Buses with voltages higer than 1.05PU - Year 3, Topology 3

Branch	Scenario	Branch I	Branch MVA	Rate	Loading
3007 RURAL 230.00 to 3005 WEST 230.00 1	Solar = 0 MW, Hydro = 600 MW, HLS	775	286.92	300.00	103.03
	Solar = 50 MW, Hydro = 600 MW, HLS	760	283.04	300.00	101.03
	Solar = 100 MW, Hydro = 600 MW, HLS	747	279.51	300.00	99.32
	Solar = 0 MW, Hydro = 500 MW, HLS	731	275.42	300.00	97.18
	Solar = 50 MW, Hydro = 500 MW, HLS	718	271.72	300.00	95.41
	Solar = 0 MW, Hydro = 600 MW, RLS	717	272.06	300.00	95.24
	Solar = 100 MW, Hydro = 500 MW, HLS	706	268.31	300.00	93.87
	Solar = 50 MW, Hydro = 600 MW, RLS	703	268.33	300.00	93.48
	Solar = 0 MW, Hydro = 400 MW, HLS	695	265.07	300.00	92.41
	Solar = 100 MW, Hydro = 600 MW, RLS	692	264.89	300.00	91.93
	Solar = 50 MW, Hydro = 400 MW, HLS	683	261.48	300.00	90.77
	Solar = 0 MW, Hydro = 500 MW, RLS	677	260.86	300.00	89.95
	Solar = 100 MW, Hydro = 400 MW, HLS	672	258.17	300.00	89.35
	Solar = 50 MW, Hydro = 500 MW, RLS	665	257.27	300.00	88.34
	Solar = 0 MW, Hydro = 600 MW, LLS	655	255.27	300.00	87.04
	Solar = 100 MW, Hydro = 500 MW, RLS	654	253.92	300.00	86.92
	Solar = 0 MW, Hydro = 400 MW, RLS	643	250.66	300.00	85.50
	Solar = 50 MW, Hydro = 600 MW, LLS	643	251.63	300.00	85.44
	Solar = 50 MW, Hydro = 400 MW, RLS	632	247.23	300.00	84.03
	Solar = 100 MW, Hydro = 600 MW, LLS	632	248.21	300.00	84.02
	Solar = 0 MW, Hydro = 500 MW, LLS	626	246.19	300.00	83.15
	Solar = 100 MW, Hydro = 400 MW, RLS	622	244.02	300.00	82.72
	Solar = 50 MW, Hydro = 500 MW, LLS	615	242.21	300.00	81.74
	Solar = 100 MW, Hydro = 500 MW, LLS	608	239.42	300.00	80.75
3005 WEST 230.00 to 3007 RURAL 230.00 1	Solar = 0 MW, Hydro = 600 MW, HLS	770	296.35	300.00	102.33
	Solar = 50 MW, Hydro = 600 MW, HLS	755	291.95	300.00	100.33
	Solar = 100 MW, Hydro = 600 MW, HLS	742	288.02	300.00	98.62
	Solar = 0 MW, Hydro = 500 MW, HLS	726	283.36	300.00	96.49
	Solar = 50 MW, Hydro = 500 MW, HLS	713	279.24	300.00	94.72
	Solar = 0 MW, Hydro = 600 MW, RLS	712	279.28	300.00	94.59
	Solar = 100 MW, Hydro = 500 MW, HLS	701	275.52	300.00	93.18
	Solar = 50 MW, Hydro = 600 MW, RLS	699	275.16	300.00	92.83
	Solar = 0 MW, Hydro = 400 MW, HLS	690	271.97	300.00	91.72
	Solar = 100 MW, Hydro = 600 MW, RLS	687	271.41	300.00	91.29
	Solar = 50 MW, Hydro = 400 MW, HLS	678	268.03	300.00	90.09
	Solar = 0 MW, Hydro = 500 MW, RLS	672	266.91	300.00	89.31
	Solar = 100 MW, Hydro = 400 MW, HLS	667	264.44	300.00	88.66
	Solar = 50 MW, Hydro = 500 MW, RLS	660	262.99	300.00	87.71
	Solar = 0 MW, Hydro = 600 MW, LLS	651	260.45	300.00	86.46
	Solar = 100 MW, Hydro = 500 MW, RLS	649	259.39	300.00	86.29
	Solar = 0 MW, Hydro = 400 MW, RLS	639	255.85	300.00	84.87
	Solar = 50 MW, Hydro = 600 MW, LLS	639	256.52	300.00	84.87
	Solar = 100 MW, Hydro = 600 MW, LLS	628	252.86	300.00	83.44
	Solar = 50 MW, Hydro = 400 MW, RLS	628	252.15	300.00	83.40
	Solar = 0 MW, Hydro = 500 MW, LLS	621	250.69	300.00	82.58
	Solar = 100 MW, Hydro = 400 MW, RLS	618	248.72	300.00	82.08
	Solar = 50 MW, Hydro = 500 MW, LLS	611	246.57	300.00	81.15
	Solar = 100 MW, Hydro = 500 MW, LLS	603	243.66	300.00	80.15
3003 S. MINE 230.00 to 3001 MINE 230.00 1	Solar = 0 MW, Hydro = 600 MW, HLS	649	261.40	250.00	103.54
	Solar = 50 MW, Hydro = 600 MW, HLS	634	255.80	250.00	101.11
	Solar = 100 MW, Hydro = 600 MW, HLS	622	251.55	250.00	99.27
	Solar = 0 MW, Hydro = 500 MW, HLS	606	245.62	250.00	96.70
	Solar = 50 MW, Hydro = 500 MW, HLS	595	241.37	250.00	94.86
	Solar = 100 MW, Hydro = 500 MW, HLS	586	238.13	250.00	93.47
	Solar = 0 MW, Hydro = 400 MW, HLS	578	235.16	250.00	92.18
	Solar = 50 MW, Hydro = 400 MW, HLS	569	231.78	250.00	90.72
	Solar = 0 MW, Hydro = 600 MW, RLS	565	229.46	250.00	90.13
	Solar = 100 MW, Hydro = 400 MW, HLS	562	229.20	250.00	89.61
	Solar = 50 MW, Hydro = 600 MW, RLS	554	225.25	250.00	88.32
	Solar = 100 MW, Hydro = 600 MW, RLS	545	222.00	250.00	86.93
	Solar = 0 MW, Hydro = 500 MW, RLS	532	217.23	250.00	84.86
	Solar = 50 MW, Hydro = 500 MW, RLS	524	214.09	250.00	83.52
	Solar = 100 MW, Hydro = 500 MW, RLS	517	211.66	250.00	82.47
	Solar = 0 MW, Hydro = 400 MW, RLS	511	209.31	250.00	81.45
	Solar = 50 MW, Hydro = 400 MW, RLS	505	207.21	250.00	80.53

Table 5.3: Transmission line loaded more than 80% of thermal rating - Year 3, Topology 3

Branch	Scenario	Branch I	Branch MVA	Rate	Loading
3001 MINE 230.00 to 3003 S. MINE 230.00 1	Solar = 0 MW, Hydro = 600 MW, HLS	649	264.28	250.00	103.54
	Solar = 50 MW, Hydro = 600 MW, HLS	634	258.42	250.00	101.11
	Solar = 100 MW, Hydro = 600 MW, HLS	622	253.99	250.00	99.27
	Solar = 0 MW, Hydro = 500 MW, HLS	606	247.78	250.00	96.70
	Solar = 50 MW, Hydro = 500 MW, HLS	595	243.35	250.00	94.86
	Solar = 100 MW, Hydro = 500 MW, HLS	586	239.98	250.00	93.47
	Solar = 0 MW, Hydro = 400 MW, HLS	578	236.87	250.00	92.18
	Solar = 50 MW, Hydro = 400 MW, HLS	569	233.34	250.00	90.72
	Solar = 0 MW, Hydro = 600 MW, RLS	565	231.30	250.00	90.13
	Solar = 100 MW, Hydro = 400 MW, HLS	562	230.65	250.00	89.61
	Solar = 50 MW, Hydro = 600 MW, RLS	554	226.91	250.00	88.32
	Solar = 100 MW, Hydro = 600 MW, RLS	545	223.52	250.00	86.93
	Solar = 0 MW, Hydro = 500 MW, RLS	532	218.54	250.00	84.86
	Solar = 50 MW, Hydro = 500 MW, RLS	524	215.28	250.00	83.52
	Solar = 100 MW, Hydro = 500 MW, RLS	517	212.75	250.00	82.47
	Solar = 0 MW, Hydro = 400 MW, RLS	511	210.29	250.00	81.45
	Solar = 50 MW, Hydro = 400 MW, RLS	505	208.08	250.00	80.53
203 EAST230 230.00 to 154 DOWNTN 230.00 1	Solar = 0 MW, Hydro = 600 MW, HLS	479	176.92	200.00	95.60
	Solar = 50 MW, Hydro = 600 MW, HLS	460	170.98	200.00	91.76
	Solar = 0 MW, Hydro = 600 MW, RLS	453	171.93	200.00	90.35
	Solar = 100 MW, Hydro = 600 MW, HLS	443	165.29	200.00	88.25
	Solar = 50 MW, Hydro = 600 MW, RLS	435	166.01	200.00	86.74
	Solar = 0 MW, Hydro = 500 MW, HLS	429	161.64	200.00	85.54
	Solar = 0 MW, Hydro = 600 MW, LLS	427	166.73	200.00	85.12
	Solar = 100 MW, Hydro = 600 MW, RLS	418	160.26	200.00	83.38
	Solar = 50 MW, Hydro = 500 MW, HLS	411	155.73	200.00	81.96
	Solar = 50 MW, Hydro = 600 MW, LLS	410	160.77	200.00	81.69
	Solar = 0 MW, Hydro = 500 MW, RLS	405	156.52	200.00	80.77
154 DOWNTN 230.00 to 203 EAST230 230.00 1	Solar = 0 MW, Hydro = 600 MW, HLS	486	173.53	200.00	96.97
	Solar = 50 MW, Hydro = 600 MW, HLS	467	168.06	200.00	93.16
	Solar = 0 MW, Hydro = 600 MW, RLS	459	169.53	200.00	91.53
	Solar = 100 MW, Hydro = 600 MW, HLS	450	162.77	200.00	89.70
	Solar = 50 MW, Hydro = 600 MW, RLS	441	163.98	200.00	87.96
	Solar = 0 MW, Hydro = 500 MW, HLS	436	159.48	200.00	87.01
	Solar = 0 MW, Hydro = 600 MW, LLS	432	165.13	200.00	86.06
	Solar = 100 MW, Hydro = 600 MW, RLS	424	158.56	200.00	84.64
	Solar = 50 MW, Hydro = 500 MW, HLS	419	153.99	200.00	83.46
	Solar = 50 MW, Hydro = 600 MW, LLS	414	159.45	200.00	82.65
	Solar = 0 MW, Hydro = 500 MW, RLS	411	155.11	200.00	82.03
	Solar = 100 MW, Hydro = 500 MW, HLS	402	148.71	200.00	80.22
154 DOWNTN 230.00 to 153 MID230 230.00 2	Solar = 0 MW, Hydro = 600 MW, HLS	763	272.09	300.00	101.36
	Solar = 50 MW, Hydro = 600 MW, HLS	739	265.64	300.00	98.16
	Solar = 0 MW, Hydro = 600 MW, RLS	719	265.32	300.00	95.50
	Solar = 100 MW, Hydro = 600 MW, HLS	717	259.33	300.00	95.27
	Solar = 50 MW, Hydro = 600 MW, RLS	696	258.74	300.00	92.52
	Solar = 0 MW, Hydro = 500 MW, HLS	692	252.94	300.00	92.00
	Solar = 100 MW, Hydro = 600 MW, RLS	676	252.25	300.00	89.77
	Solar = 0 MW, Hydro = 600 MW, LLS	674	257.79	300.00	89.57
	Solar = 50 MW, Hydro = 500 MW, HLS	670	246.43	300.00	89.04
	Solar = 50 MW, Hydro = 600 MW, LLS	653	251.00	300.00	86.74
	Solar = 0 MW, Hydro = 500 MW, RLS	652	245.79	300.00	86.65
	Solar = 100 MW, Hydro = 500 MW, HLS	650	240.07	300.00	86.33
	Solar = 100 MW, Hydro = 600 MW, LLS	633	244.27	300.00	84.07
	Solar = 50 MW, Hydro = 500 MW, RLS	631	239.14	300.00	83.85
	Solar = 0 MW, Hydro = 400 MW, HLS	630	234.10	300.00	83.78
	Solar = 0 MW, Hydro = 500 MW, LLS	618	239.23	300.00	82.10
	Solar = 100 MW, Hydro = 500 MW, RLS	611	232.61	300.00	81.24
	Solar = 50 MW, Hydro = 400 MW, HLS	609	227.56	300.00	80.99

Table 5.4: Transmission line loaded more than 80% of thermal rating - Year 3, Topology 3 - continued

Branch	Scenario	Branch I	Branch MVA	Rate	Loading
	Solar = 0 MW, Hydro = 600 MW, HLS	914	325.80	300.00	121.37
	Solar = 50 MW, Hydro = 600 MW, HLS	885	318.04	300.00	117.52
	Solar = 0 MW, Hydro = 600 MW, RLS	861	317.76	300.00	114.38
	Solar = 100 MW, Hydro = 600 MW, HLS	858	310.42	300.00	114.04
	Solar = 50 MW, Hydro = 600 MW, RLS	834	309.85	300.00	110.80
	Solar = 0 MW, Hydro = 500 MW, HLS	829	302.75	300.00	110.11
	Solar = 100 MW, Hydro = 600 MW, RLS	809	302.02	300.00	107.48
	Solar = 0 MW, Hydro = 600 MW, LLS	808	308.87	300.00	107.32
	Solar = 50 MW, Hydro = 500 MW, HLS	802	294.90	300.00	106.55
	Solar = 50 MW, Hydro = 600 MW, LLS	782	300.70	300.00	103.91
	Solar = 0 MW, Hydro = 500 MW, RLS	781	294.27	300.00	103.75
	Solar = 100 MW, Hydro = 500 MW, HLS	777	287.22	300.00	103.29
	Solar = 100 MW, Hydro = 600 MW, LLS	758	292.59	300.00	100.71
154 DOWNTN 230.00 to 153 MID230 230.00 1	Solar = 50 MW, Hydro = 500 MW, RLS	755	286.27	300.00	100.37
	Solar = 0 MW, Hydro = 400 MW, HLS	754	280.03	300.00	100.22
	Solar = 0 MW, Hydro = 500 MW, LLS	740	286.52	300.00	98.33
	Solar = 100 MW, Hydro = 500 MW, RLS	732	278.38	300.00	97.22
	Solar = 50 MW, Hydro = 400 MW, HLS	729	272.15	300.00	96.85
	Solar = 50 MW, Hydro = 500 MW, LLS	717	277.57	300.00	95.22
	Solar = 0 MW, Hydro = 400 MW, RLS	709	271.05	300.00	94.19
	Solar = 100 MW, Hydro = 400 MW, HLS	706	264.48	300.00	93.75
	Solar = 100 MW, Hydro = 500 MW, LLS	697	269.88	300.00	92.56
	Solar = 50 MW, Hydro = 400 MW, RLS	685	263.05	300.00	90.98
	Solar = 0 MW, Hydro = 400 MW, LLS	679	263.06	300.00	90.21
	Solar = 100 MW, Hydro = 400 MW, RLS	662	255.19	300.00	87.96
	Solar = 50 MW, Hydro = 400 MW, LLS	659	255.51	300.00	87.59
	Solar = 100 MW, Hydro = 400 MW, LLS	640	248.06	300.00	85.02
	Solar = 0 MW, Hydro = 600 MW, HLS	753	287.74	300.00	100.04
	Solar = 50 MW, Hydro = 600 MW, HLS	729	280.07	300.00	96.83
	Solar = 0 MW, Hydro = 600 MW, RLS	710	277.26	300.00	94.37
	Solar = 100 MW, Hydro = 600 MW, HLS	707	272.80	300.00	93.91
	Solar = 50 MW, Hydro = 600 MW, RLS	688	269.74	300.00	91.38
	Solar = 0 MW, Hydro = 500 MW, HLS	682	265.03	300.00	90.65
	Solar = 0 MW, Hydro = 600 MW, LLS	667	266.41	300.00	88.68
	Solar = 100 MW, Hydro = 600 MW, RLS	667	262.49	300.00	88.59
153 MID230 230.00 to 154 DOWNTN 230.00 2	Solar = 50 MW, Hydro = 500 MW, HLS	660	257.53	300.00	87.67
	Solar = 50 MW, Hydro = 600 MW, LLS	646	258.90	300.00	85.84
	Solar = 0 MW, Hydro = 500 MW, RLS	643	254.87	300.00	85.51
	Solar = 100 MW, Hydro = 500 MW, HLS	639	250.36	300.00	84.93
	Solar = 100 MW, Hydro = 600 MW, LLS	626	251.59	300.00	83.15
	Solar = 50 MW, Hydro = 500 MW, RLS	622	247.45	300.00	82.69
	Solar = 0 MW, Hydro = 400 MW, HLS	620	243.58	300.00	82.35
	Solar = 0 MW, Hydro = 500 MW, LLS	611	246.12	300.00	81.17
	Solar = 100 MW, Hydro = 500 MW, RLS	602	240.26	300.00	80.04
	Solar = 0 MW, Hydro = 600 MW, HLS	907	346.55	300.00	120.49
	Solar = 50 MW, Hydro = 600 MW, HLS	878	337.36	300.00	116.63
	Solar = 0 MW, Hydro = 600 MW, RLS	855	333.84	300.00	113.62
	Solar = 100 MW, Hydro = 600 MW, HLS	851	328.65	300.00	113.13
	Solar = 50 MW, Hydro = 600 MW, RLS	828	324.81	300.00	110.03
	Solar = 0 MW, Hydro = 500 MW, HLS	822	319.31	300.00	109.21
	Solar = 0 MW, Hydro = 600 MW, LLS	803	320.61	300.00	106.72
	Solar = 100 MW, Hydro = 600 MW, RLS	803	316.13	300.00	106.70
	Solar = 50 MW, Hydro = 500 MW, HLS	795	310.31	300.00	105.64
	Solar = 50 MW, Hydro = 600 MW, LLS	778	311.60	300.00	103.31
	Solar = 0 MW, Hydro = 500 MW, RLS	775	306.96	300.00	102.98
	Solar = 100 MW, Hydro = 500 MW, HLS	770	301.73	300.00	102.35
	Solar = 100 MW, Hydro = 600 MW, LLS	753	302.84	300.00	100.09
153 MID230 230.00 to 154 DOWNTN 230.00 1	Solar = 50 MW, Hydro = 500 MW, RLS	750	298.05	300.00	99.60
	Solar = 0 MW, Hydro = 400 MW, HLS	747	293.61	300.00	99.27
	Solar = 0 MW, Hydro = 500 MW, LLS	735	296.28	300.00	97.71
	Solar = 100 MW, Hydro = 500 MW, RLS	726	289.45	300.00	96.43
	Solar = 50 MW, Hydro = 400 MW, HLS	722	284.74	300.00	95.88
	Solar = 50 MW, Hydro = 500 MW, LLS	712	287.00	300.00	94.55
	Solar = 0 MW, Hydro = 400 MW, RLS	703	281.28	300.00	93.39
	Solar = 100 MW, Hydro = 400 MW, HLS	698	276.27	300.00	92.75
	Solar = 100 MW, Hydro = 500 MW, LLS	691	279.03	300.00	91.84
	Solar = 50 MW, Hydro = 400 MW, RLS	678	272.49	300.00	90.16
	Solar = 0 MW, Hydro = 400 MW, LLS	673	271.91	300.00	89.44
	Solar = 100 MW, Hydro = 400 MW, RLS	656	263.99	300.00	87.12
	Solar = 50 MW, Hydro = 400 MW, LLS	653	264.04	300.00	86.77
	Solar = 100 MW, Hydro = 400 MW, LLS	633	256.24	300.00	84.14

Table 5.5: Transmission line loaded more than 80% of thermal rating - Year 3, Topology 3 - continued

Branch	Scenario	Branch Flow MW	Branch Flow MVAR	Branch MVA	Rate	Loading
3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1	Solar = 0 MW, Hydro = 400 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 0 MW, Hydro = 400 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 0 MW, Hydro = 400 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 0 MW, Hydro = 500 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 0 MW, Hydro = 500 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 0 MW, Hydro = 500 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 0 MW, Hydro = 600 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 0 MW, Hydro = 600 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 0 MW, Hydro = 600 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 50 MW, Hydro = 400 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 50 MW, Hydro = 400 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 50 MW, Hydro = 400 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 50 MW, Hydro = 500 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 50 MW, Hydro = 500 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 50 MW, Hydro = 500 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 50 MW, Hydro = 600 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 50 MW, Hydro = 600 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 50 MW, Hydro = 600 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 100 MW, Hydro = 400 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 100 MW, Hydro = 400 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 100 MW, Hydro = 400 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 100 MW, Hydro = 500 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 100 MW, Hydro = 500 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 100 MW, Hydro = 500 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 100 MW, Hydro = 600 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 100 MW, Hydro = 600 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 100 MW, Hydro = 600 MW, HLS	90.00	80.00	120.41	150.00	80.28
205 SUB230 230.00 to 204 SUB500 500.00 1	Solar = 0 MW, Hydro = 600 MW, HLS	-815.29	-122.75	824.48	800.00	103.06
	Solar = 50 MW, Hydro = 600 MW, HLS	-801.61	-119.13	810.42	800.00	101.30
	Solar = 0 MW, Hydro = 600 MW, RLS	-803.98	-81.82	808.14	800.00	101.02
	Solar = 100 MW, Hydro = 600 MW, HLS	-787.88	-118.01	796.67	800.00	99.58
	Solar = 50 MW, Hydro = 600 MW, RLS	-790.25	-78.71	794.16	800.00	99.27
	Solar = 0 MW, Hydro = 600 MW, LLS	-789.83	-33.83	790.56	800.00	98.82
	Solar = 100 MW, Hydro = 600 MW, RLS	-776.48	-77.83	780.38	800.00	97.55
	Solar = 50 MW, Hydro = 600 MW, LLS	-775.92	-31.11	776.54	800.00	97.07
	Solar = 100 MW, Hydro = 600 MW, LLS	-762.02	-30.42	762.63	800.00	95.33
	Solar = 0 MW, Hydro = 500 MW, HLS	-740.64	-125.57	751.21	800.00	93.90
	Solar = 50 MW, Hydro = 500 MW, HLS	-726.83	-122.22	737.04	800.00	92.13
	Solar = 0 MW, Hydro = 500 MW, RLS	-728.94	-83.84	733.74	800.00	91.72
	Solar = 100 MW, Hydro = 500 MW, HLS	-712.99	-121.22	723.22	800.00	90.40
	Solar = 50 MW, Hydro = 500 MW, RLS	-715.10	-80.92	719.66	800.00	89.96
	Solar = 0 MW, Hydro = 500 MW, LLS	-715.63	-45.21	717.05	800.00	89.63
	Solar = 100 MW, Hydro = 500 MW, RLS	-701.25	-80.12	705.81	800.00	88.23
	Solar = 50 MW, Hydro = 500 MW, LLS	-699.87	-51.66	701.77	800.00	87.72
	Solar = 100 MW, Hydro = 500 MW, LLS	-685.74	-57.33	688.14	800.00	86.02
	Solar = 0 MW, Hydro = 400 MW, HLS	-664.76	-133.69	678.07	800.00	84.76
	Solar = 50 MW, Hydro = 400 MW, HLS	-650.87	-130.47	663.82	800.00	82.98
	Solar = 0 MW, Hydro = 400 MW, RLS	-652.94	-90.65	659.20	800.00	82.40
	Solar = 100 MW, Hydro = 400 MW, HLS	-636.96	-129.52	650.00	800.00	81.25
	Solar = 50 MW, Hydro = 400 MW, RLS	-639.03	-87.83	645.04	800.00	80.63
	Solar = 0 MW, Hydro = 400 MW, LLS	-637.17	-75.98	641.68	800.00	80.21

Table 5.6: Transformer loaded more than 80% of thermal rating - Year 3, Topology 3

Branch	Scenario	Branch Flow MW	Branch Flow MVAR	Branch MVA	Rate	Loading
204 SUB500 500.00 to 205 SUB230 230.00 1	Solar = 0 MW, Hydro = 600 MW, HLS	817.78	247.32	854.36	800.00	106.80
	Solar = 50 MW, Hydro = 600 MW, HLS	803.98	237.61	838.36	800.00	104.79
	Solar = 0 MW, Hydro = 600 MW, RLS	806.22	193.76	829.18	800.00	103.65
	Solar = 100 MW, Hydro = 600 MW, HLS	790.15	231.20	823.28	800.00	102.91
	Solar = 50 MW, Hydro = 600 MW, RLS	792.39	185.43	813.79	800.00	101.72
	Solar = 0 MW, Hydro = 600 MW, LLS	791.83	133.83	803.06	800.00	100.38
	Solar = 100 MW, Hydro = 600 MW, RLS	778.53	179.91	799.04	800.00	99.88
	Solar = 50 MW, Hydro = 600 MW, LLS	777.83	126.58	788.06	800.00	98.51
	Solar = 0 MW, Hydro = 500 MW, HLS	742.61	224.20	775.72	800.00	96.96
	Solar = 100 MW, Hydro = 600 MW, LLS	763.85	121.77	773.49	800.00	96.69
	Solar = 50 MW, Hydro = 500 MW, HLS	728.71	215.96	760.03	800.00	95.00
	Solar = 0 MW, Hydro = 500 MW, RLS	730.71	172.39	750.77	800.00	93.85
	Solar = 100 MW, Hydro = 500 MW, HLS	714.78	210.64	745.17	800.00	93.15
	Solar = 50 MW, Hydro = 500 MW, RLS	716.78	165.19	735.57	800.00	91.95
	Solar = 0 MW, Hydro = 500 MW, LLS	717.23	125.52	728.13	800.00	91.02
	Solar = 100 MW, Hydro = 500 MW, RLS	702.86	160.55	720.96	800.00	90.12
	Solar = 50 MW, Hydro = 500 MW, LLS	701.41	128.58	713.09	800.00	89.14
	Solar = 100 MW, Hydro = 500 MW, LLS	687.22	131.29	699.65	800.00	87.46
	Solar = 0 MW, Hydro = 400 MW, HLS	666.32	211.54	699.09	800.00	87.39
	Solar = 50 MW, Hydro = 400 MW, HLS	652.35	204.28	683.58	800.00	85.45
	Solar = 0 MW, Hydro = 400 MW, RLS	654.33	160.11	673.63	800.00	84.20
	Solar = 100 MW, Hydro = 400 MW, HLS	638.37	199.74	668.89	800.00	83.61
	Solar = 50 MW, Hydro = 400 MW, RLS	640.35	153.73	658.55	800.00	82.32
	Solar = 0 MW, Hydro = 400 MW, LLS	638.46	140.29	653.69	800.00	81.71
	Solar = 100 MW, Hydro = 400 MW, RLS	626.36	149.75	644.01	800.00	80.50
	Solar = 50 MW, Hydro = 400 MW, LLS	624.30	142.82	640.43	800.00	80.05
203 EAST230 230.00 to 202 EAST500 500.00 1	Solar = 0 MW, Hydro = 600 MW, HLS	-752.23	-220.99	784.02	800.00	98.00
	Solar = 50 MW, Hydro = 600 MW, HLS	-739.69	-216.36	770.68	800.00	96.34
	Solar = 0 MW, Hydro = 600 MW, RLS	-738.36	-183.93	760.93	800.00	95.12
	Solar = 100 MW, Hydro = 600 MW, HLS	-727.03	-214.02	757.88	800.00	94.73
	Solar = 50 MW, Hydro = 600 MW, RLS	-725.68	-180.00	747.67	800.00	93.46
	Solar = 0 MW, Hydro = 600 MW, LLS	-721.41	-141.46	735.15	800.00	91.89
	Solar = 100 MW, Hydro = 600 MW, RLS	-712.89	-178.07	734.80	800.00	91.85
	Solar = 0 MW, Hydro = 500 MW, HLS	-698.86	-209.02	729.45	800.00	91.18
	Solar = 50 MW, Hydro = 600 MW, LLS	-708.44	-138.07	721.77	800.00	90.22
	Solar = 50 MW, Hydro = 500 MW, HLS	-686.17	-205.16	716.18	800.00	89.52
	Solar = 100 MW, Hydro = 600 MW, LLS	-695.43	-136.44	708.69	800.00	88.59
	Solar = 0 MW, Hydro = 500 MW, RLS	-684.64	-172.39	706.00	800.00	88.25
	Solar = 100 MW, Hydro = 500 MW, HLS	-673.37	-203.38	703.41	800.00	87.93
	Solar = 50 MW, Hydro = 500 MW, RLS	-671.82	-169.07	692.77	800.00	86.60
	Solar = 0 MW, Hydro = 500 MW, LLS	-668.83	-138.80	683.08	800.00	85.39
	Solar = 100 MW, Hydro = 500 MW, RLS	-658.93	-167.59	679.91	800.00	84.99
	Solar = 0 MW, Hydro = 400 MW, HLS	-644.80	-204.00	676.30	800.00	84.54
	Solar = 50 MW, Hydro = 500 MW, LLS	-653.70	-143.17	669.19	800.00	83.65
	Solar = 50 MW, Hydro = 400 MW, HLS	-631.99	-200.65	663.08	800.00	82.88
	Solar = 100 MW, Hydro = 500 MW, LLS	-640.49	-147.08	657.16	800.00	82.15
	Solar = 0 MW, Hydro = 400 MW, RLS	-630.44	-167.02	652.18	800.00	81.52
	Solar = 100 MW, Hydro = 400 MW, HLS	-619.10	-199.27	650.38	800.00	81.30

Table 5.7: Transformer loaded more than 80% of thermal rating - Year 3, Topology 3 - continued

Branch	Scenario	Branch Flow MW	Branch Flow MVAR	Branch MVA	Rate	Loading
	Solar = 0 MW, Hydro = 600 MW, HLS	755.10	337.66	827.16	800.00	103.40
	Solar = 50 MW, Hydro = 600 MW, HLS	742.43	327.54	811.47	800.00	101.43
	Solar = 100 MW, Hydro = 600 MW, HLS	729.65	320.44	796.91	800.00	99.61
	Solar = 0 MW, Hydro = 600 MW, RLS	740.92	287.86	794.88	800.00	99.36
	Solar = 50 MW, Hydro = 600 MW, RLS	728.12	279.21	779.82	800.00	97.48
	Solar = 100 MW, Hydro = 600 MW, RLS	715.23	273.07	765.59	800.00	95.70
	Solar = 0 MW, Hydro = 500 MW, HLS	701.25	305.88	765.06	800.00	95.63
	Solar = 0 MW, Hydro = 600 MW, LLS	723.66	233.02	760.25	800.00	95.03
	Solar = 50 MW, Hydro = 500 MW, HLS	688.44	297.49	749.97	800.00	93.75
	Solar = 50 MW, Hydro = 600 MW, LLS	710.60	225.49	745.52	800.00	93.19
	Solar = 100 MW, Hydro = 500 MW, HLS	675.54	291.71	735.84	800.00	91.98
	Solar = 0 MW, Hydro = 500 MW, RLS	686.76	258.66	733.86	800.00	91.73
202 EAST500 500.00 to 203 EAST230 230.00 1	Solar = 100 MW, Hydro = 600 MW, LLS	697.49	220.12	731.40	800.00	91.42
	Solar = 50 MW, Hydro = 500 MW, RLS	673.85	251.35	719.20	800.00	89.90
	Solar = 0 MW, Hydro = 400 MW, HLS	646.79	284.91	706.76	800.00	88.35
	Solar = 100 MW, Hydro = 500 MW, RLS	660.86	246.29	705.27	800.00	88.16
	Solar = 0 MW, Hydro = 500 MW, LLS	670.74	216.08	704.68	800.00	88.09
	Solar = 50 MW, Hydro = 400 MW, HLS	633.89	277.69	692.04	800.00	86.51
	Solar = 50 MW, Hydro = 500 MW, LLS	655.52	217.24	690.58	800.00	86.32
	Solar = 100 MW, Hydro = 500 MW, LLS	642.25	218.43	678.38	800.00	84.80
	Solar = 100 MW, Hydro = 400 MW, HLS	620.92	272.87	678.23	800.00	84.78
	Solar = 0 MW, Hydro = 400 MW, RLS	632.20	238.77	675.79	800.00	84.47
	Solar = 50 MW, Hydro = 400 MW, RLS	619.25	232.45	661.44	800.00	82.68
	Solar = 0 MW, Hydro = 400 MW, LLS	613.40	219.17	651.38	800.00	81.42
	Solar = 100 MW, Hydro = 400 MW, RLS	606.22	228.22	647.76	800.00	80.97

Table 5.8: Transformer loaded more than 80% of thermal rating - Year 3, Topology 3 - continued

Branch	Scenario	Branch Flow MW	Branch Flow MVAR	Branch MVA	Rate	Loading
	Solar = 0 MW, Hydro = 400 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 0 MW, Hydro = 400 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 0 MW, Hydro = 400 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 0 MW, Hydro = 500 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 0 MW, Hydro = 500 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 0 MW, Hydro = 500 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 0 MW, Hydro = 600 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 0 MW, Hydro = 600 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 0 MW, Hydro = 600 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 50 MW, Hydro = 400 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 50 MW, Hydro = 400 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 50 MW, Hydro = 400 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 50 MW, Hydro = 500 MW, LLS	90.00	80.00	120.42	150.00	80.28
3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1	Solar = 50 MW, Hydro = 500 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 50 MW, Hydro = 500 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 50 MW, Hydro = 600 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 50 MW, Hydro = 600 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 50 MW, Hydro = 600 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 100 MW, Hydro = 400 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 100 MW, Hydro = 400 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 100 MW, Hydro = 400 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 100 MW, Hydro = 500 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 100 MW, Hydro = 500 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 100 MW, Hydro = 500 MW, HLS	90.00	80.00	120.41	150.00	80.28
	Solar = 100 MW, Hydro = 600 MW, LLS	90.00	80.00	120.42	150.00	80.28
	Solar = 100 MW, Hydro = 600 MW, RLS	90.00	80.00	120.41	150.00	80.28
	Solar = 100 MW, Hydro = 600 MW, HLS	90.00	80.00	120.41	150.00	80.28

Table 5.9: Transformer loaded more than 80% of thermal rating - Year 3, Topology 4

Branch	Scenario	Branch I	Branch MVA	Rate	Loading
203 EAST230 230.00 to 154 DOWNTN 230.00 1	Solar = 0 MW, Hydro = 600 MW, HLS	487	190.95	200.00	97.10
	Solar = 0 MW, Hydro = 600 MW, RLS	470	186.65	200.00	93.74
	Solar = 50 MW, Hydro = 600 MW, HLS	470	184.95	200.00	93.73
	Solar = 0 MW, Hydro = 600 MW, LLS	461	183.41	200.00	91.90
	Solar = 50 MW, Hydro = 600 MW, RLS	456	181.07	200.00	90.88
	Solar = 100 MW, Hydro = 600 MW, HLS	454	179.13	200.00	90.53
	Solar = 50 MW, Hydro = 600 MW, LLS	447	177.83	200.00	89.05
	Solar = 100 MW, Hydro = 600 MW, RLS	442	175.56	200.00	88.06
	Solar = 0 MW, Hydro = 500 MW, HLS	441	174.91	200.00	88.02
	Solar = 100 MW, Hydro = 600 MW, LLS	432	172.31	200.00	86.24
	Solar = 0 MW, Hydro = 500 MW, RLS	432	171.94	200.00	86.19
	Solar = 50 MW, Hydro = 500 MW, HLS	426	169.09	200.00	84.87
	Solar = 0 MW, Hydro = 500 MW, LLS	423	168.71	200.00	84.38
	Solar = 50 MW, Hydro = 500 MW, RLS	418	166.44	200.00	83.39
	Solar = 100 MW, Hydro = 500 MW, HLS	412	163.67	200.00	82.11
	Solar = 50 MW, Hydro = 500 MW, LLS	409	163.22	200.00	81.59
	Solar = 100 MW, Hydro = 500 MW, RLS	404	161.03	200.00	80.63
	Solar = 0 MW, Hydro = 400 MW, HLS	402	160.08	200.00	80.26
154 DOWNTN 230.00 to 203 EAST230 230.00 1	Solar = 0 MW, Hydro = 600 MW, HLS	493	187.99	200.00	98.32
	Solar = 50 MW, Hydro = 600 MW, HLS	476	182.35	200.00	94.97
	Solar = 0 MW, Hydro = 600 MW, RLS	476	184.25	200.00	94.83
	Solar = 0 MW, Hydro = 600 MW, LLS	467	181.15	200.00	93.04
	Solar = 50 MW, Hydro = 600 MW, RLS	462	178.89	200.00	92.04
	Solar = 100 MW, Hydro = 600 MW, HLS	460	176.85	200.00	91.82
	Solar = 50 MW, Hydro = 600 MW, LLS	453	175.81	200.00	90.26
	Solar = 0 MW, Hydro = 500 MW, HLS	448	172.90	200.00	89.33
	Solar = 100 MW, Hydro = 600 MW, RLS	448	173.61	200.00	89.30
	Solar = 100 MW, Hydro = 600 MW, LLS	439	170.53	200.00	87.53
	Solar = 0 MW, Hydro = 500 MW, RLS	439	170.14	200.00	87.51
	Solar = 50 MW, Hydro = 500 MW, HLS	432	167.40	200.00	86.23
	Solar = 0 MW, Hydro = 500 MW, LLS	430	167.08	200.00	85.76
	Solar = 50 MW, Hydro = 500 MW, RLS	425	164.89	200.00	84.78
	Solar = 100 MW, Hydro = 500 MW, HLS	419	162.24	200.00	83.55
	Solar = 50 MW, Hydro = 500 MW, LLS	416	161.85	200.00	83.05
	Solar = 100 MW, Hydro = 500 MW, RLS	412	159.75	200.00	82.12
	Solar = 0 MW, Hydro = 400 MW, HLS	410	158.82	200.00	81.78
	Solar = 100 MW, Hydro = 500 MW, LLS	403	156.71	200.00	80.39
	Solar = 0 MW, Hydro = 400 MW, RLS	403	156.36	200.00	80.37

Table 5.10: Transmission line loaded more than 80% of thermal rating - Year 3, Topology 4

Bus Number	Bus Name	Scenario	Bus Voltage(PU)
3018	CATDOG_G	Solar = 50 MW, Hydro = 400 MW, LLS	1.055
		Solar = 100 MW, Hydro = 400 MW, LLS	1.055
		Solar = 0 MW, Hydro = 400 MW, LLS	1.054
		Solar = 50 MW, Hydro = 500 MW, LLS	1.054
		Solar = 100 MW, Hydro = 500 MW, LLS	1.054
		Solar = 0 MW, Hydro = 500 MW, LLS	1.053
		Solar = 50 MW, Hydro = 600 MW, LLS	1.053
		Solar = 100 MW, Hydro = 600 MW, LLS	1.053
		Solar = 0 MW, Hydro = 600 MW, LLS	1.052
		Solar = 100 MW, Hydro = 400 MW, RLS	1.052
		Solar = 0 MW, Hydro = 400 MW, RLS	1.051
		Solar = 50 MW, Hydro = 400 MW, RLS	1.051
		Solar = 100 MW, Hydro = 500 MW, RLS	1.051
212	HYDRO_N	Solar = 0 MW, Hydro = 600 MW, HLS	1.052
211	HYDRO_G	Solar = 0 MW, Hydro = 600 MW, HLS	1.052
206	URBGEN	Solar = 50 MW, Hydro = 500 MW, HLS	1.055
		Solar = 0 MW, Hydro = 500 MW, HLS	1.053
		Solar = 0 MW, Hydro = 600 MW, RLS	1.053
		Solar = 100 MW, Hydro = 500 MW, HLS	1.053

Table 5.11: Buses with voltages greater than 1.05PU - Year 3, Topology 4

Branch	Scenario	Branch Flow MW	Branch Flow MVAR	Branch MVA	Rate	Loading
3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1	All the studied scenarios	90.00	80.00	120.42	150.00	80.28
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	744.11	600.00	955.88	1150.00	83.12
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	744.09	600.00	955.86	1150.00	83.12
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	744.14	600.00	955.90	1150.00	83.12
	Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	742.27	600.00	954.44	1150.00	83.00
206 URBGEN 18.000 to 205 SUB230 230.00 1	Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	742.24	600.00	954.42	1150.00	82.99
	Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	742.23	600.00	954.41	1150.00	82.99
	Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, HLS	740.55	600.00	953.11	1150.00	82.88
	Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, HLS	740.53	600.00	953.09	1150.00	82.88
	Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, HLS	740.58	600.00	953.13	1150.00	82.88

Table 5.12: Transformer loaded more than 80% of thermal rating - Year 4, Topology 5

Branch	Scenario	Branch I	Branch MVA	Rate	Loading
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	517	198.33	200.00	103.12
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	516	197.96	200.00	102.89
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	515	197.65	200.00	102.75
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	500	192.34	200.00	99.60
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	498	191.98	200.00	99.37
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	498	191.66	200.00	99.23
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	493	192.60	200.00	98.26
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	492	192.24	200.00	98.04
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	491	191.91	200.00	97.89
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	483	186.59	200.00	96.32
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	482	186.22	200.00	96.09
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	481	185.91	200.00	95.95
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, RLS	476	186.61	200.00	94.87
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, RLS	475	186.25	200.00	94.65
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, RLS	474	185.92	200.00	94.50
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, LLS	471	187.03	200.00	93.91
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	470	182.48	200.00	93.80
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, LLS	470	186.73	200.00	93.75
	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	469	182.12	200.00	93.58
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, LLS	469	186.37	200.00	93.57
	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	469	181.81	200.00	93.44
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, RLS	460	180.80	200.00	91.66
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, RLS	459	180.44	200.00	91.44
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, RLS	458	180.11	200.00	91.29
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, LLS	457	181.44	200.00	91.04
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, LLS	456	181.14	200.00	90.88
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, LLS	455	180.78	200.00	90.71
	Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	453	176.53	200.00	90.42
	Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	452	176.17	200.00	90.20
	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	452	175.86	200.00	90.06
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, RLS	447	176.50	200.00	89.09
203 EAST230 230.00 to 154 DOWNTN 230.00 1	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, RLS	446	176.16	200.00	88.89
	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, RLS	445	175.83	200.00	88.74
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, LLS	442	175.93	200.00	88.23
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, LLS	442	175.62	200.00	88.07
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, LLS	441	175.27	200.00	87.89
	Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, HLS	438	170.82	200.00	87.26
	Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, HLS	436	170.46	200.00	87.04
	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, HLS	436	170.15	200.00	86.90
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, LLS	433	172.29	200.00	86.35
	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, LLS	432	171.99	200.00	86.19
	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, LLS	431	171.64	200.00	86.01
	Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, RLS	430	170.55	200.00	85.82
	Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, RLS	429	170.20	200.00	85.61
	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, RLS	429	169.87	200.00	85.46
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	427	167.12	200.00	85.21
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	426	166.75	200.00	84.99
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	426	166.45	200.00	84.86
	Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, LLS	419	166.79	200.00	83.54
	Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, LLS	418	166.49	200.00	83.38
	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, LLS	417	166.13	200.00	83.21
	Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, RLS	415	164.84	200.00	82.75
	Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, RLS	414	164.49	200.00	82.54
	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, RLS	413	164.17	200.00	82.40
	Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	411	161.21	200.00	81.94
	Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	410	160.85	200.00	81.72
	Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	409	160.55	200.00	81.59
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, RLS	405	161.18	200.00	80.83
	Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, LLS	405	161.37	200.00	80.79
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, RLS	405	160.88	200.00	80.68
	Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, LLS	404	161.08	200.00	80.63
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, RLS	404	160.53	200.00	80.51
	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, LLS	403	160.72	200.00	80.46

Table 5.13: Transmission line loaded more than 80% of thermal rating - Year 4, Topology 5

Branch	Scenario	Branch I	Branch MVA	Rate	Loading
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	524	194.19	200.00	104.54
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	523	193.86	200.00	104.30
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	522	193.55	200.00	104.16
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	507	188.64	200.00	101.05
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	506	188.31	200.00	100.82
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	505	188.01	200.00	100.68
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	499	189.46	200.00	99.51
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	498	189.13	200.00	99.28
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	497	188.81	200.00	99.14
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	491	183.26	200.00	97.82
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	489	182.93	200.00	97.59
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	489	182.63	200.00	97.45
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, RLS	482	183.83	200.00	96.14
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, RLS	481	183.50	200.00	95.92
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, RLS	480	183.18	200.00	95.77
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	478	179.47	200.00	95.33
	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	477	179.14	200.00	95.11
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, LLS	476	184.61	200.00	95.00
	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	476	178.84	200.00	94.97
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, LLS	476	184.32	200.00	94.84
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, LLS	475	183.98	200.00	94.67
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, RLS	466	178.35	200.00	92.98
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, RLS	465	178.02	200.00	92.76
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, RLS	464	177.70	200.00	92.62
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, LLS	462	179.25	200.00	92.21
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, LLS	462	178.96	200.00	92.05
	Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	461	173.93	200.00	91.99
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, LLS	461	178.61	200.00	91.88
	Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	460	173.60	200.00	91.77
	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	460	173.30	200.00	91.63
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, RLS	454	174.34	200.00	90.43
	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, RLS	452	174.02	200.00	90.23
	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, RLS	452	173.70	200.00	90.08
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, LLS	449	173.96	200.00	89.47
154 DOWNTN 230.00 to 203 EAST230 230.00 1	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, LLS	448	173.67	200.00	89.31
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, LLS	447	173.33	200.00	89.14
	Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, HLS	446	168.59	200.00	88.89
	Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, HLS	445	168.26	200.00	88.67
	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, HLS	444	167.96	200.00	88.54
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, LLS	440	170.48	200.00	87.67
	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, LLS	439	170.19	200.00	87.51
	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, LLS	438	169.85	200.00	87.34
	Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, RLS	437	168.73	200.00	87.19
	Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, RLS	436	168.41	200.00	86.99
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	436	165.11	200.00	86.90
	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, RLS	435	168.09	200.00	86.84
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	435	164.78	200.00	86.69
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	434	164.49	200.00	86.56
	Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, LLS	426	165.23	200.00	84.94
	Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, LLS	425	164.94	200.00	84.78
	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, LLS	424	164.60	200.00	84.61
	Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, RLS	422	163.34	200.00	84.18
	Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, RLS	421	163.01	200.00	83.97
	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, RLS	420	162.70	200.00	83.83
	Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	420	159.61	200.00	83.68
	Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	419	159.28	200.00	83.47
	Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	418	158.99	200.00	83.34
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, RLS	413	159.87	200.00	82.34
	Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, LLS	413	160.08	200.00	82.27
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, RLS	412	159.58	200.00	82.19
	Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, LLS	412	159.80	200.00	82.12
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, RLS	411	159.25	200.00	82.02
	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, LLS	411	159.46	200.00	81.95
	Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, HLS	405	154.35	200.00	80.70
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, LLS	404	156.68	200.00	80.52
	Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, HLS	404	154.02	200.00	80.49
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, LLS	403	156.40	200.00	80.37
	Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, HLS	403	153.73	200.00	80.36
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, LLS	402	156.01	200.00	80.18

Table 5.14: Transmission line loaded more than 80% of thermal rating - Year 4, Topology 5 - Continued

Branch	Scenario	Branch I	Branch MVA	Rate	Loading
154 DOWNTN 230.00 to 153 MID230 230.00 1	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	624	231.21	300.00	82.98
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	620	229.72	300.00	82.40
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	615	227.85	300.00	81.75
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	606	225.53	300.00	80.54
153 MID230 230.00 to 154 DOWNTN 230.00 1	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	618	239.22	300.00	82.12
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	613	237.64	300.00	81.53
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	608	235.66	300.00	80.87
205 SUB230 230.00 to 203 EAST230 230.00 2	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	409	153.23	200.00	81.62
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	408	153.01	200.00	81.46
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	408	152.77	200.00	81.35
205 SUB230 230.00 to 203 EAST230 230.00 1	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	409	153.23	200.00	81.62
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	408	153.01	200.00	81.46
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	408	152.77	200.00	81.35
203 EAST230 230.00 to 205 SUB230 230.00 2	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	405	155.48	200.00	80.84
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	405	155.24	200.00	80.68
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	404	155.00	200.00	80.58
203 EAST230 230.00 to 205 SUB230 230.00 1	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	405	155.48	200.00	80.84
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	405	155.24	200.00	80.68
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	404	155.00	200.00	80.58

Table 5.15: Transmission line loaded more than 80% of thermal rating - Year 4, Topology 5 - Continued

Bus Number	Bus Name	Scenario	Bus Voltage(PU)
3018	CATDOG_G	Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, LLS	1.052
		Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, LLS	1.052
		Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, LLS	1.052
		Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, LLS	1.052
		Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, LLS	1.052
		Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, LLS	1.052
		Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, LLS	1.051
		Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, LLS	1.051
		Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, LLS	1.051
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, LLS	1.051
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, LLS	1.051
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, LLS	1.051
		Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, LLS	1.051
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, LLS	1.051
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, LLS	1.051
212	HYDRO_N	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	1.071
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	1.071
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	1.071
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	1.067
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	1.066
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	1.066
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	1.063
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	1.063
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	1.063
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	1.057
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	1.057
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	1.057
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	1.055
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	1.055
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	1.055
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	1.053
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	1.053
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	1.053
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, RLS	1.051
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, RLS	1.051
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, RLS	1.051
211	HYDRO_G	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	1.071
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	1.071
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	1.071
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	1.067
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	1.066
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	1.066
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	1.063
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	1.063
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	1.063
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	1.057
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	1.057
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	1.057
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	1.055
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	1.055
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	1.055
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	1.053
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	1.053
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	1.053
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, RLS	1.051
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, RLS	1.051
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, RLS	1.051
206	URBGEN	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, RLS	1.055
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, RLS	1.055
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, RLS	1.055
		Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, RLS	1.053
		Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, RLS	1.053
		Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, RLS	1.053
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, RLS	1.053
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, RLS	1.053
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, RLS	1.052
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, LLS	1.051
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, LLS	1.051
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, LLS	1.051
		Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, RLS	1.051

Table 5.16: Buses with voltages greater than 1.05PU - Year 4, Topology 5

Bus Number	Bus Name	Scenario	Bus Voltage(PU)
205	SUB230	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.947
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.947
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.946
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.944
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.943
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.943
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.939
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.939
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.939
154	DOWNTN	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.949
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.949
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.948
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.946
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.946
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.945
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.942
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.942
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.941
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.937
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.937
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.937
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.934
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.934
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.933
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.929
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.929
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.929

Table 5.17: Buses with voltages Lower than 0.95PU - Year 4, Topology 5

Branch	Scenario	Branch Flow MW	Branch Flow MVAR	Branch MVA	Rate	Loading
3018 CATDOG_G 13.800 to 3008 CATDOG 230.00 1	All studied scenarios	90.00	80.00	120.41	150.00	80.28
212 HYDRO_N 20.000 to 201 HYDRO 500.00 1	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	600.01	281.74	662.86	800.00	82.86
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	600.01	280.49	662.33	800.00	82.79
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	600.01	279.42	661.88	800.00	82.74
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	600.01	255.11	651.99	800.00	81.50
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	600.01	254.00	651.56	800.00	81.44
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	600.01	252.93	651.14	800.00	81.39
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	600.01	233.85	643.97	800.00	80.50
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	600.01	232.86	643.61	800.00	80.45
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	600.01	231.78	643.22	800.00	80.40
211 HYDRO_G 20.000 to 201 HYDRO 500.00 1	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	600.01	281.74	662.86	800.00	82.86
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	600.01	280.49	662.33	800.00	82.79
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	600.01	279.42	661.88	800.00	82.74
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	600.01	255.11	651.99	800.00	81.50
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	600.01	254.00	651.56	800.00	81.44
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	600.01	252.93	651.14	800.00	81.39
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	600.01	233.85	643.97	800.00	80.50
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	600.01	232.86	643.61	800.00	80.45
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	600.01	231.78	643.22	800.00	80.40
206 URBGEN 18.000 to 205 SUB230 230.00 1	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	826.15	599.99	1021.04	1150.00	88.79
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	826.16	599.99	1021.05	1150.00	88.79
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	826.10	599.99	1021.00	1150.00	88.78
	Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	823.92	599.99	1019.24	1150.00	88.63
	Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	823.88	599.99	1019.20	1150.00	88.63
	Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	823.93	599.99	1019.24	1150.00	88.63
	Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, HLS	821.94	599.99	1017.63	1150.00	88.49
	Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, HLS	821.90	599.99	1017.60	1150.00	88.49
	Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, HLS	821.95	599.99	1017.64	1150.00	88.49
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, RLS	754.37	600.00	963.88	1150.00	83.82
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, RLS	754.38	600.00	963.89	1150.00	83.82
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, RLS	754.34	600.00	963.85	1150.00	83.81
	Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, RLS	752.43	600.00	962.36	1150.00	83.68
	Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, RLS	752.40	600.00	962.34	1150.00	83.68
	Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, RLS	752.44	600.00	962.37	1150.00	83.68
	Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, RLS	750.66	600.00	960.98	1150.00	83.56
	Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, RLS	750.64	600.00	960.96	1150.00	83.56
	Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, RLS	750.67	600.00	960.99	1150.00	83.56
205 SUB230 230.00 to 206 URBGEN 18.000 1	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	-823.47	-462.59	944.51	1150.00	82.13
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	-823.42	-462.68	944.51	1150.00	82.13
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	-823.48	-462.54	944.49	1150.00	82.13
	Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	-821.28	-464.17	943.37	1150.00	82.03
	Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	-821.23	-464.25	943.37	1150.00	82.03
	Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	-821.28	-464.12	943.35	1150.00	82.03
	Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, HLS	-819.31	-465.35	942.25	1150.00	81.93
	Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, HLS	-819.27	-465.43	942.25	1150.00	81.93
	Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, HLS	-819.32	-465.31	942.23	1150.00	81.93

Table 5.18: Transformer loaded more than 80% of thermal rating - Year 5, Topology 6

Branch	Scenario	Branch I	Branch MVA	Rate	Loading
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	559	200.22	200.00	111.53
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	558	199.89	200.00	111.27
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	557	199.60	200.00	111.15
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	541	194.77	200.00	107.85
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	540	194.45	200.00	107.59
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	539	194.16	200.00	107.47
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	528	194.87	200.00	105.30
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	527	194.54	200.00	105.06
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	526	194.24	200.00	104.92
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	524	189.54	200.00	104.50
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	523	189.22	200.00	104.25
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	522	188.93	200.00	104.13
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	512	186.04	200.00	102.10
	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	511	185.71	200.00	101.86
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, RLS	511	189.34	200.00	101.79
	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	510	185.42	200.00	101.73
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, RLS	509	189.01	200.00	101.56
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, RLS	509	188.70	200.00	101.42
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, LLS	496	188.83	200.00	98.81
	Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	495	180.61	200.00	98.60
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, LLS	494	188.50	200.00	98.59
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, RLS	494	183.98	200.00	98.55
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, LLS	494	188.18	200.00	98.45
	Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	493	180.28	200.00	98.36
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, RLS	493	183.65	200.00	98.32
	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	493	180.00	200.00	98.24
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, RLS	492	183.35	200.00	98.19
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, RLS	482	180.21	200.00	96.07
	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, RLS	481	179.88	200.00	95.84
	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, RLS	480	179.58	200.00	95.71
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, LLS	479	183.18	200.00	95.45
	Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, HLS	479	175.42	200.00	95.41
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, LLS	478	182.85	200.00	95.23
	Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, HLS	477	175.09	200.00	95.18
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, LLS	477	182.53	200.00	95.09
	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, HLS	477	174.81	200.00	95.06
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	470	172.34	200.00	93.67
154 DOWNTN 230.00 to 203 EAST230 230.00 1	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	469	172.01	200.00	93.43
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	468	171.74	200.00	93.32
	Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, RLS	465	174.69	200.00	92.71
	Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, RLS	464	174.35	200.00	92.49
	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, RLS	463	174.06	200.00	92.36
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, LLS	463	177.65	200.00	92.28
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, LLS	462	177.32	200.00	92.07
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, LLS	461	177.01	200.00	91.93
	Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	453	166.97	200.00	90.31
	Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	452	166.64	200.00	90.09
	Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	451	166.36	200.00	89.97
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, LLS	450	173.69	200.00	89.77
	Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, RLS	449	169.36	200.00	89.60
	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, LLS	449	173.36	200.00	89.56
	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, LLS	448	173.04	200.00	89.42
	Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, RLS	448	169.03	200.00	89.39
	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, RLS	448	168.74	200.00	89.25
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, RLS	439	165.92	200.00	87.64
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, RLS	438	165.59	200.00	87.42
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, RLS	438	165.30	200.00	87.29
	Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, HLS	438	161.88	200.00	87.28
	Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, HLS	437	161.55	200.00	87.06
	Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, HLS	436	161.28	200.00	86.94
	Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, LLS	434	168.07	200.00	86.57
	Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, LLS	433	167.78	200.00	86.42
	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, LLS	432	167.45	200.00	86.25
	Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, RLS	423	160.44	200.00	84.41
	Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, RLS	422	160.11	200.00	84.19
	Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, RLS	422	159.82	200.00	84.07
	Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, LLS	421	162.90	200.00	83.89
	Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, LLS	420	162.61	200.00	83.74
	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, LLS	419	162.28	200.00	83.57
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, LLS	412	159.49	200.00	82.13
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, LLS	411	159.12	200.00	81.93
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, LLS	410	158.72	200.00	81.73
	Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, RLS	408	155.20	200.00	81.42
	Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, RLS	407	154.86	200.00	81.21
	Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, RLS	407	154.58	200.00	81.09

Table 5.19: Transmission line loaded more than 80% of thermal rating - Year 5, Topology 6

Branch	Scenario	Branch I	Branch MVA	Rate	Loading
203 EAST230 230.00 to 154 DOWNTN 230.00 1	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	551	205.97	200.00	109.93
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	550	205.60	200.00	109.67
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	549	205.30	200.00	109.54
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	533	199.98	200.00	106.21
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	531	199.61	200.00	105.96
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	531	199.31	200.00	105.83
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	521	199.18	200.00	103.87
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	520	198.81	200.00	103.63
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	519	198.49	200.00	103.48
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	516	194.29	200.00	102.81
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	514	193.92	200.00	102.56
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	514	193.63	200.00	102.43
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	503	190.46	200.00	100.37
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, RLS	503	193.19	200.00	100.32
	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	502	190.09	200.00	100.12
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, RLS	502	192.82	200.00	100.09
	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	502	189.79	200.00	100.00
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, RLS	501	192.51	200.00	99.95
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, LLS	489	191.85	200.00	97.60
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, LLS	488	191.49	200.00	97.38
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, LLS	488	191.16	200.00	97.23
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, RLS	487	187.45	200.00	97.03
	Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	486	184.52	200.00	96.82
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, RLS	485	187.08	200.00	96.80
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, RLS	485	186.77	200.00	96.66
	Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	484	184.15	200.00	96.58
	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	484	183.86	200.00	96.46
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, RLS	474	183.36	200.00	94.51
	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, RLS	473	183.00	200.00	94.29
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, LLS	472	185.83	200.00	94.20
	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, RLS	472	182.68	200.00	94.15
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, LLS	471	185.47	200.00	93.99
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, LLS	471	185.14	200.00	93.84
	Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, HLS	469	178.90	200.00	93.57
	Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, HLS	468	178.53	200.00	93.34
	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, HLS	467	178.24	200.00	93.21
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	460	175.62	200.00	91.75
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	459	175.25	200.00	91.52
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	458	174.97	200.00	91.39
	Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, RLS	457	177.41	200.00	91.12
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, LLS	456	179.99	200.00	91.00
	Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, RLS	456	177.05	200.00	90.89
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, LLS	455	179.63	200.00	90.78
	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, RLS	455	176.74	200.00	90.76
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, LLS	455	179.30	200.00	90.64
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, LLS	444	175.75	200.00	88.47
	Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	443	169.75	200.00	88.35
	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, LLS	443	175.39	200.00	88.26
	Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	442	169.39	200.00	88.12
	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, LLS	442	175.06	200.00	88.11
	Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	441	169.11	200.00	88.00
	Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, RLS	441	171.72	200.00	87.95
	Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, RLS	440	171.36	200.00	87.73
	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, RLS	439	171.05	200.00	87.59
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, RLS	431	168.05	200.00	85.92
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, RLS	430	167.69	200.00	85.70
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, RLS	429	167.38	200.00	85.56
	Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, HLS	427	164.24	200.00	85.24
	Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, LLS	427	169.79	200.00	85.22
	Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, LLS	427	169.49	200.00	85.07
	Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, HLS	426	163.87	200.00	85.01
	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, LLS	426	169.14	200.00	84.89
	Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, HLS	426	163.59	200.00	84.89
	Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, RLS	414	162.16	200.00	82.63
	Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, LLS	413	164.37	200.00	82.45
	Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, RLS	413	161.80	200.00	82.42
	Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, LLS	413	164.07	200.00	82.30
	Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, RLS	413	161.49	200.00	82.29
	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, LLS	412	163.71	200.00	82.13
	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, LLS	404	160.78	200.00	80.61
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, LLS	403	160.39	200.00	80.41
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, LLS	402	159.97	200.00	80.20

Table 5.20: Transmission line loaded more than 80% of thermal rating - Year 5, Topology 6 - Continued

Branch	Scenario	Branch I	Branch MVA	Rate	Loading
205 SUB230 230.00 to 203 EAST230 230.00 2	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	429	155.42	200.00	85.58
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	428	155.20	200.00	85.40
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	428	154.97	200.00	85.30
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	417	152.06	200.00	83.24
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	417	151.84	200.00	83.07
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	416	151.62	200.00	82.97
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	411	153.43	200.00	82.03
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	410	153.21	200.00	81.86
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	410	152.98	200.00	81.76
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	407	148.80	200.00	81.11
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	406	148.57	200.00	80.94
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	405	148.35	200.00	80.85
205 SUB230 230.00 to 203 EAST230 230.00 1	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	429	155.42	200.00	85.58
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	428	155.20	200.00	85.40
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	428	154.97	200.00	85.30
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	417	152.06	200.00	83.24
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	417	151.84	200.00	83.07
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	416	151.62	200.00	82.97
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	411	153.43	200.00	82.03
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	410	153.21	200.00	81.86
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	410	152.98	200.00	81.76
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	407	148.80	200.00	81.11
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	406	148.57	200.00	80.94
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	405	148.35	200.00	80.85
205 SUB230 230.00 to 154 DOWNTN 230.00 1	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	1279	474.27	600.00	84.98
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	1276	473.22	600.00	84.75
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	1275	472.80	600.00	84.70
	Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	1221	454.58	600.00	81.08
	Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	1217	453.54	600.00	80.86
	Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	1217	453.15	600.00	80.81
204 SUB500 500.00 to 201 HYDRO 500.00 1	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	1125	903.65	1200.00	81.21
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	1123	902.75	1200.00	81.10
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	1123	902.93	1200.00	81.10
203 EAST230 230.00 to 205 SUB230 230.00 2	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	424	158.49	200.00	84.59
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	423	158.24	200.00	84.41
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	423	158.01	200.00	84.31
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	412	154.85	200.00	82.24
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	412	154.61	200.00	82.07
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	411	154.38	200.00	81.97
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	407	155.76	200.00	81.22
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	406	155.52	200.00	81.06
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	406	155.28	200.00	80.95
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	402	151.36	200.00	80.09
203 EAST230 230.00 to 205 SUB230 230.00 1	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	424	158.49	200.00	84.59
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	423	158.24	200.00	84.41
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	423	158.01	200.00	84.31
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	412	154.85	200.00	82.24
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	412	154.61	200.00	82.07
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	411	154.38	200.00	81.97
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	407	155.76	200.00	81.22
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	406	155.52	200.00	81.06
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	406	155.28	200.00	80.95
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	402	151.36	200.00	80.09
153 MID230 230.00 to 154 DOWNTN 230.00 1	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	658	248.89	300.00	87.50
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	654	247.37	300.00	86.90
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	649	245.44	300.00	86.25
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	639	242.66	300.00	84.91
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	634	241.14	300.00	84.32
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	630	239.21	300.00	83.67
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	622	240.28	300.00	82.70
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	621	236.72	300.00	82.53
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	618	238.71	300.00	82.11
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	617	235.20	300.00	81.95
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	613	236.73	300.00	81.45
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	612	233.28	300.00	81.31
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	607	232.10	300.00	80.65
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, RLS	604	234.05	300.00	80.23
	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	603	230.58	300.00	80.07

Table 5.21: Transmission line loaded more than 80% of thermal rating - Year 5, Topology 6 - Continued

Branch	Scenario	Branch I	Branch MVA	Rate	Loading
154 DOWNTN 230.00 to 205 SUB230 230.00 1	Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	1290	473.00	600.00	85.69
	Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	1287	471.98	600.00	85.46
	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	1286	471.57	600.00	85.41
	Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	1232	453.82	600.00	81.83
	Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	1229	452.81	600.00	81.60
	Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	1228	452.42	600.00	81.56
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	666	238.26	300.00	88.48
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	661	236.85	300.00	87.90
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	657	235.05	300.00	87.26
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	646	232.74	300.00	85.91
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	642	231.33	300.00	85.34
	Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	637	229.53	300.00	84.70
	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	629	232.00	300.00	83.58
	Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	629	227.36	300.00	83.56
	Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	625	225.96	300.00	83.00
	Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	625	230.52	300.00	82.99
	Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	620	224.16	300.00	82.36
	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	620	228.66	300.00	82.35
	Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	615	223.28	300.00	81.69
	Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	610	221.87	300.00	81.13
	Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, RLS	610	226.34	300.00	81.12
	Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, RLS	606	224.86	300.00	80.55
	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	606	220.08	300.00	80.50

Table 5.22: Transmission line loaded more than 80% of thermal rating - Year 5, Topology 6 - Continued

Bus Number	Bus Name	Scenario	Bus Voltage(PU)
212	HYDRO_N	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	1.092
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	1.092
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	1.092
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	1.087
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	1.087
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	1.087
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	1.083
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	1.083
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	1.083
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	1.077
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	1.077
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	1.077
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	1.073
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	1.073
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	1.073
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	1.073
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	1.073
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	1.073
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, RLS	1.069
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, RLS	1.069
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, RLS	1.069
		Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, HLS	1.069
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, HLS	1.069
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, HLS	1.069
		Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	1.066
		Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	1.066
		Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	1.066
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, RLS	1.065
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, RLS	1.065
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, RLS	1.065
		Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	1.062
		Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	1.062
		Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	1.062
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, RLS	1.059
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, RLS	1.059
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, RLS	1.059
		Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, HLS	1.059
		Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, HLS	1.059
		Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, HLS	1.059
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, RLS	1.055
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, RLS	1.055
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, RLS	1.055
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, LLS	1.053
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, LLS	1.052
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, LLS	1.052
		Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, RLS	1.052
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, RLS	1.052
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, RLS	1.052

Table 5.23: Buses with voltages greater than 1.05PU - Year 5, Topology 6

Bus Number	Bus Name	Scenario	Bus Voltage(PU)
211	HYDRO_G	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	1.092
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	1.092
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	1.092
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	1.087
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	1.087
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	1.087
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	1.083
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	1.083
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	1.083
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	1.077
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	1.077
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	1.077
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	1.073
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	1.073
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	1.073
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	1.073
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	1.073
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	1.073
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, RLS	1.069
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, RLS	1.069
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, RLS	1.069
		Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, HLS	1.069
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, HLS	1.069
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, HLS	1.069
		Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	1.066
		Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	1.066
		Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	1.066
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, RLS	1.065
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, RLS	1.065
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, RLS	1.065
		Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	1.062
		Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	1.062
		Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	1.062
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, RLS	1.059
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, RLS	1.059
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, RLS	1.059
		Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, HLS	1.059
		Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, HLS	1.059
		Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, HLS	1.059
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, RLS	1.055
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, RLS	1.055
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, RLS	1.055
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, LLS	1.053
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, LLS	1.052
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, LLS	1.052
		Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, RLS	1.052
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, RLS	1.052
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, RLS	1.052
206	URBGEN	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, LLS	1.055
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, LLS	1.055
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, LLS	1.055
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, LLS	1.053
		Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, LLS	1.053
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, LLS	1.053
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, LLS	1.053
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, LLS	1.052
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, LLS	1.052
		Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, LLS	1.051

Table 5.24: Buses with voltages greater than 1.05PU - Year 5, Topology 6 - Continued

Bus Number	Bus Name	Scenario	Bus Voltage(PU)
3012	WIND X	Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.948
3008	CATDOG	Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, HLS	0.949
		Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, HLS	0.948
		Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, HLS	0.948
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	0.947
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	0.947
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	0.947
		Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	0.946
		Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	0.946
		Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	0.946
		Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	0.943
		Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	0.942
		Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	0.942
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.942
		Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.941
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.941
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.939
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.939
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.939
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.935
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.934
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.934
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.931
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.931
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.931
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.928
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.928
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.928
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.923
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.923
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.923
3007	RURAL	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.948
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.948
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.948
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.945
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.945
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.945
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.942
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.942
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.942
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.938
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.938
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.938

Table 5.25: Buses with voltages lower than 0.95PU - Year 5, Topology 6

Bus Number	Bus Name	Scenario	Bus Voltage(PU)
205	SUB230	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, RLS	0.948
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, RLS	0.948
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, RLS	0.948
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, RLS	0.944
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, RLS	0.943
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, RLS	0.943
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, RLS	0.940
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, RLS	0.940
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, RLS	0.940
		Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, HLS	0.938
		Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, HLS	0.938
		Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, HLS	0.937
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	0.936
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	0.936
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	0.935
		Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	0.935
		Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	0.935
		Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	0.934
		Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	0.931
		Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	0.930
		Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	0.930
		Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.930
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.930
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.930
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.927
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.926
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.926
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.922
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.922
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.921
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.918
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.917
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.917
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.914
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.914
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.913
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.909
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.908
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.908
204	SUB500	Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.948
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.948
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.948
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.945
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.945
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.945
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.941
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.941
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.941
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.936
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.936
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.936
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.933
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.932
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.932
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.928
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.928
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.927
203	EAST230	Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.949
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.949
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.949
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.945
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.945
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.945
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.942
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.942
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.941
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.937
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.937
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.937

Table 5.26: Buses with voltages lower than 0.95PU - Year 5, Topology 6 - Continued

Bus Number	Bus Name	Scenario	Bus Voltage(PU)
154	DOWNTN	Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, RLS	0.947
		Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, RLS	0.947
		Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, RLS	0.947
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, RLS	0.946
		Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, RLS	0.945
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, RLS	0.945
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, RLS	0.943
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, RLS	0.942
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, RLS	0.942
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, RLS	0.938
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, RLS	0.938
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, RLS	0.938
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, RLS	0.934
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, RLS	0.934
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, RLS	0.933
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, RLS	0.931
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, RLS	0.930
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, RLS	0.930
		Solar = 100 MW, Hydro = 400 MW, Wind = 0 MW, HLS	0.928
		Solar = 100 MW, Hydro = 400 MW, Wind = 40 MW, HLS	0.928
		Solar = 100 MW, Hydro = 400 MW, Wind = 75 MW, HLS	0.927
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, RLS	0.926
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, RLS	0.926
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, RLS	0.925
		Solar = 50 MW, Hydro = 400 MW, Wind = 0 MW, HLS	0.925
		Solar = 50 MW, Hydro = 400 MW, Wind = 40 MW, HLS	0.925
		Solar = 50 MW, Hydro = 400 MW, Wind = 75 MW, HLS	0.924
		Solar = 0 MW, Hydro = 400 MW, Wind = 0 MW, HLS	0.920
		Solar = 0 MW, Hydro = 400 MW, Wind = 40 MW, HLS	0.920
		Solar = 0 MW, Hydro = 400 MW, Wind = 75 MW, HLS	0.920
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.920
		Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.919
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.919
		Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.916
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.916
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.916
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.912
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.911
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.911
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.907
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.907
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.907
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.904
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.903
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.903
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.898
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.898
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.898
153	MID230	Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.949
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.949
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.948
103	SOLAR_PV	Solar = 50 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.945
		Solar = 50 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.945
		Solar = 50 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.945
		Solar = 100 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.945
		Solar = 100 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.945
		Solar = 100 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.945
		Solar = 0 MW, Hydro = 500 MW, Wind = 0 MW, HLS	0.941
		Solar = 0 MW, Hydro = 500 MW, Wind = 40 MW, HLS	0.941
		Solar = 0 MW, Hydro = 500 MW, Wind = 75 MW, HLS	0.941
		Solar = 50 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.933
		Solar = 100 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.933
		Solar = 100 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.933
		Solar = 100 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.933
		Solar = 50 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.932
		Solar = 50 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.932
		Solar = 0 MW, Hydro = 600 MW, Wind = 0 MW, HLS	0.928
		Solar = 0 MW, Hydro = 600 MW, Wind = 40 MW, HLS	0.928
		Solar = 0 MW, Hydro = 600 MW, Wind = 75 MW, HLS	0.928

Table 5.27: Buses with voltages lower than 0.95PU - Year 5, Topology 6 - Continued