PSSE Generator replacement study

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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 1.1. 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. The hypothetical SAVNW system under study is assumed to be a winter peaking system.

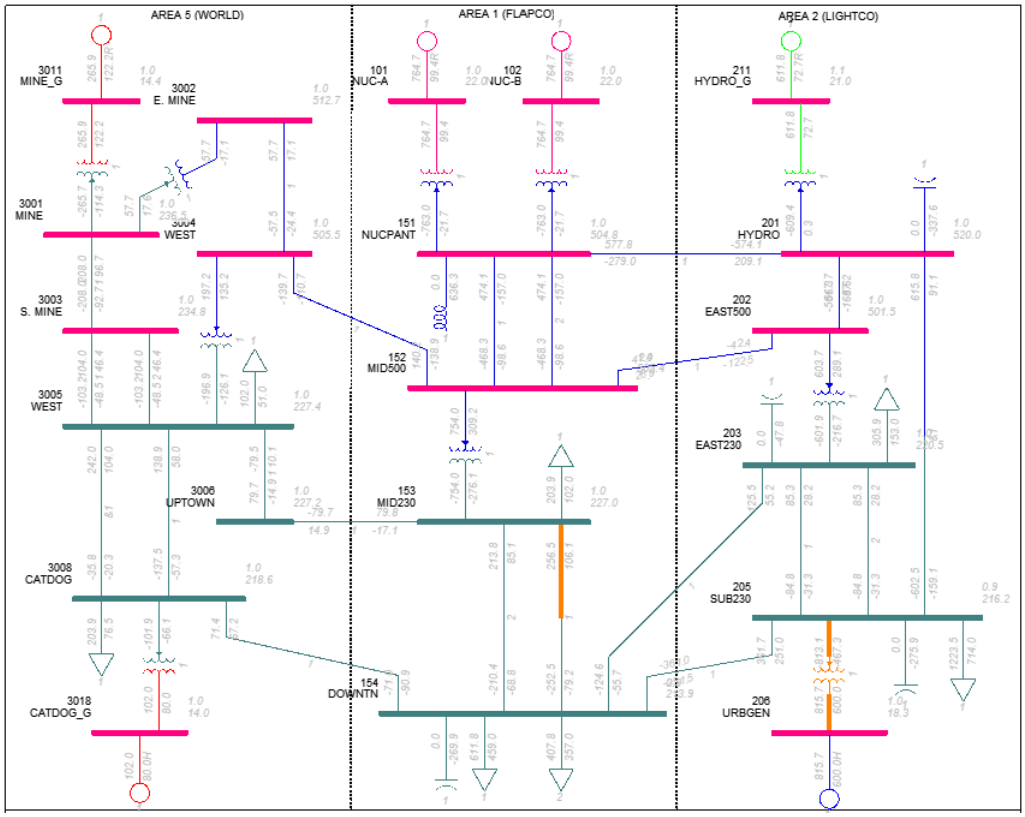

Figure 1.1: System Considered for Dynamic Simulation Study

1.2 Study Description

The present study focuses on supply side resources that will be needed to compensate for the generator taken out of service at bus 206. The plan is to take the generator at BUS 206 out of service in the coming 4 years. The

generating equipment is old, expensive to maintain, and approaching the end of its service life. It was decided not to replace the generator because of the plant's high greenhouse gas emissions.

Current generating capacity of the machine is 900 MW, taking the generator out of service will be a big generation reduction in the main load center area of LIGHTCO. For the forecasted winter peak load of 1529.38 MW with the currently installed voltage support equipment, the system is steady state and dynamic stable for the current operating conditions (refer Figure 1.2). The generation distribution at various buses can be seen from Figure 1.3 and the connected loads are seen from Figure 1.4.

```
---------------------BUSES----------------------        -----GENERATION----- ----SHUNTS----- -IND MACHS- FACTS   GNE
 TOTAL  PQ<>0.  PQ=0.  PE/E   PE/Q  SWING  OTHER  LOADS PLANTS MACHNS   WIND  FIXED SWITCHED GENS MOTORS  DEVS  DEVS
    23      7     10      3      2      1      0      8      6      6      0      5      0      0      0     0     0
------------------AC BRANCHES------------------- 3WIND MULTI-SECTION ---DC LINES--                  AREA X------- SWING BUSES -------X
 TOTAL    RXB     RX    RXT   RX=0.    IN    OUT XFORM  LINES SECTNS 2TRM MTRM VSC AREAS ZONES OWNRS TRANS   3011     MINE_G      13.800
    34     22      1     11      0     34      0     0      2      4    0    0   0     4     4     7     4
     ----GENERATION---- INDUCTION                                      GNE
TOTAL   SYNCHR  INDUCTN   MOTORS   PQLOAD   I LOAD   Y LOAD   SHUNTS  DEVICES CHARGING   LOSSES    SWING
MW      3324.7     0.0      0.0   3262.7      0.0      0.0      0.0      0.0      0.0     62.0    265.9
MVAR    1073.7     0.0      0.0   1989.0      0.0      0.0   -294.8      0.0   1794.8   1174.3    122.2
```

Figure 1.2: Study System Summary

```
BUS#-SCT X-- NAME --X BASKV CD ID ST  PGEN   QGEN   QMAX   QMIN   PMAX   PMIN BSFL OWN FRACT  OWN FRACT  MBASE  Z S O R C E    X T R A N    GENTAP WMOD
 101     NUC-A       21.600  2 1  1  764.7   99.4  600.0 -100.0  810.0    0.0   0   11 0.667    1 0.333  900.0 0.0100 0.3000
 102     NUC-B       21.600  2 1  1  764.7   99.4  600.0 -100.0  810.0    0.0   0   11 0.667    1 0.333  900.0 0.0100 0.3000
 206     URBGEN      18.000 -2 1  1  815.7  600.0  600.0    0.0  900.0    0.0   0    2 0.400   22 0.600 1000.0 0.0100 0.2500
 211     HYDRO_G     20.000  2 1  1  611.8   72.7  400.0 -100.0  616.2    0.0   0    2 0.400   22 0.600  725.0 0.0100 0.2600
3011     MINE_G      13.800  3 1  1  265.9  122.2  600.0 -100.0  900.0    0.0   0   55 0.385    5 0.308 1000.0 0.0100 0.3500
                                                                                  22 0.231   11 0.077
3018     CATDOG_G    13.800 -2 1  1  102.0   80.0   80.0    0.0  117.0    0.0   0   55 0.556    5 0.444  130.0 0.0100 0.3500
```

Figure 1.3: Study System Initial Generation

```
BUS#-SCT X-- NAME --X BASKV ID CD ST   PSI     MVA-LOAD      CUR-LOAD      Y - LOAD  AREA ZONE OWNER SCALE INTRPT DGEN[--MVA--- FLAG] X-LOAD TYPE-X
 153     MID230      230.00 1   1 1  1.000  203.9  102.0    0.0    0.0    0.0    0.0    1    1    1   YES     NO     0.0    0.0  OFF
 154     DOWNTN      230.00 1   1 1  1.000  611.8  459.0    0.0    0.0    0.0    0.0    1    1    1   YES     NO     0.0    0.0  OFF
 154     DOWNTN      230.00 2   1 1  1.000  407.8  357.0    0.0    0.0    0.0    0.0    1    1  100   YES     NO     0.0    0.0  OFF
 203     EAST230     230.00 1   1 1  1.000  305.9  153.0    0.0    0.0    0.0    0.0    2    2    2   YES     NO     0.0    0.0  OFF
 205     SUB230      230.00 1   1 1  1.000 1223.5  714.0    0.0    0.0    0.0    0.0    2    2    2   YES     NO     0.0    0.0  OFF
3005     WEST        230.00 1   1 1  1.000  102.0   51.0    0.0    0.0    0.0    0.0    5    5    5   YES     NO     0.0    0.0  OFF
3007     RURAL       230.00 1   1 1  1.000  203.9   76.5    0.0    0.0    0.0    0.0    5    5    5   YES     NO     0.0    0.0  OFF
3008     CATDOG      230.00 1   1 1  1.000  203.9   76.5    0.0    0.0    0.0    0.0    5    5    5   YES     NO     0.0    0.0  OFF
```

Figure 1.4: Study System Initial Load

When the generator is taken out of service from 206, there will be 900 MW installed capacity loss from the area. As LIGHTCO being the main load area, the area can not rely only on other areas transmission service to meet the load demand of the area. There needs to be new resources that need development in the area. In the long-term planning the need to replace the generator at bus 206 was assessed and from the resources options the following were chosen to align with planning objectives:

- Adding a utility scale battery in the generator bus 206
- Adding a new unit in the same plant as HYDRO_G
  - With transmission line upgrades from Bus 201 to 202, and
  - Reactive power support at bus 206

In the Chapter 2, the following 3 scenarios steady state operation to meet the forecasted winter peak load demand when the generator at bus 206 is phased out of service in the next 4 years is studied.

- Case 1 - As the machine at Bus 206 is nearing its end of service, the maximum capacity it can provide to the system is eroding. Because of this and to reduce the green house gas emission, the generator will be operated at half its capacity in the coming year.

- Case 2 - The Installed utility scale battery at Bus 206 will be in service in 1 year. Along with the battery installation, the generator at 206 is operated at 50% of its capacity to reduce the dependence on transmission service.
- Case 3 - In the 4th year - The generator at Bus 206 is out of service. The generator is in service at bus 212 with the transmission and reactive power support upgrades.

Results obtained from the PSSE activity AREA_2 will be used to compare the results of the steady state scenarios discussed above.

Chapter 2

Scenario Studies

2.1 Introduction

The need to take the Generator at Bus 206 out of service was discussed in Chapter 1. In this chapter PSSE load flow analysis is conducted corresponding to the 3 scenarios mentioned in Chapter 1 to meet the forecasted winter peak load demand when the generator at bus 206 is phased out of service in the next 4 years. The initial system totals for Area LIGHTCO to meet the forecasted winter peak demand is given in Figure 2.1.

	FROM ------AT AREA BUSES-------				TO		TO XFRMR				-NET INTERCHANGE-	
	GENE-	FROM IND	TO IND	TO	TO BUS	GNE BUS	TO LINE	MAGNE-	FROM	TO	TO TIE	TO TIES
X-- AREA --X	RATION	GENERATN	MOTORS	LOAD	SHUNT	DEVICES	SHUNT	TIZING	CHARGING	LOSSES	LINES	+ LOADS
2	1427.4	0.0	0.0	1529.4	0.0	0.0	0.0	0.0	0.0	32.6	-134.5	-1154.1
LIGHTCO	672.7	0.0	0.0	867.0	-661.3	0.0	-0.0	-0.0	619.4	622.6	463.7	-352.3

Figure 2.1: System initial area totals corresponding to winter peak load

As can be seen from Figure 2.1, the generation in the area 1427.4 MW combined with the transmission service import of 134.5 MW is needed to meet the load and losses in the area LIGHTCO.

2.2 Generator at Bus 206 operated at Half the installed Capacity

As the machine at Bus 206 is nearing its end of service, the maximum capacity it can provide to the system is eroding. Because of this and to reduce the green house gas emission, the generator will be operated at half its capacity in the coming year. For this considered scenario, to meet the forecasted peak demand of the Area, there would be need for additional transmission service from nearby area.

	FROM ------AT AREA BUSES-------				TO		TO XFRMR				-NET INTERCHANGE-	
	GENE-	FROM IND	TO IND	TO	TO BUS	GNE BUS	TO LINE	MAGNE-	FROM	TO	TO TIE	TO TIES
X-- AREA --X	RATION	GENERATN	MOTORS	LOAD	SHUNT	DEVICES	SHUNT	TIZING	CHARGING	LOSSES	LINES	+ LOADS
2	1061.8	0.0	0.0	1529.4	0.0	0.0	0.0	0.0	0.0	36.4	-504.0	-1523.6
LIGHTCO	800.9	0.0	0.0	867.0	-649.2	0.0	-0.0	-0.0	612.0	646.1	549.1	-266.9

Figure 2.2: System initial area totals corresponding to winter peak load

As can be seen from Figure 2.2, when the generator at Bus 206 was operated at half the capacity, total generation available from the area was reduced to 1061.8 MW with other opeartions remaining the same as before. This generation combined with the transmission service import of 504 MW is needed to meet the load and losses in the area LIGHTCO.

2.3 Generator at Bus 206 operated at half the installed Capacity, Battery in service

Installing a new battery near to the current generation site of Bus 206 was the first option considered in the long-term planning. This option was chosen because of the short lead time for the installation of utility scale battery to reduce the reliance on the transmission service from nearby area. The choice of the site for the battery installation near to the current generation site of Bus 206 was because it can make use of the already existing transmission structure making it a cost-effective option. The construction has already begun for the installation, and the battery would be in service in one year. Along with the battery, the generator at 206 would continue to operate at 50% of its capacity to reduce the dependence on transmission service.

	FROM ------AT AREA BUSES-------				TO		TO XFRMR			-NET INTERCHANGE-	
	GENE-	FROM IND	TO IND	TO	TO BUS	GNE BUS	TO LINE	MAGNE-	FROM	TO	TO TIE	TO TIES
X-- AREA --X	RATION	GENERATN	MOTORS	LOAD	SHUNT	DEVICES	SHUNT	TIZING	CHARGING	LOSSES	LINES	+ LOADS
2	1061.8	0.0	0.0	1129.4	0.0	0.0	0.0	0.0	0.0	30.1	-97.7	-1117.3
LIGHTCO	579.8	0.0	0.0	867.0	-673.7	0.0	-0.0	-0.0	625.7	539.9	472.3	-343.7

Figure 2.3: System initial area totals corresponding to winter peak load

As can be seen from Figure 2.3, the generation in the area 1061.8 MW along with the installed battery has helped reduce the dependence on transmission service to 97.7 MW to meet the load and losses in the area LIGHTCO.

2.4 Generator at Bus 206 taken out of service, Battery and Generator at Bus 212 in service

The second supply side resource option chosen in the long-term planning was addition of the new generating unit in the same plant as the existing generator at Bus 211. This generating unit will be connected to Bus 212 and voltage will be stepped up using the transformer to connect to Bus 201 for transmission. Along with the new generator at Bus 212, the long-term planning has decided on the need for upgrading the transmission line parallel to the already existing one from Bus 201 to 202. With the generator at bus 206 taken out of service, and the battery connected not providing reactive power support, the long-term plan had decided on the need for upgrading the capacitor station at Bus 206 to provide additional reactive power support needed. Parallel construction is going on with Generator at bus 212, transmission line from 201 to 202 and capacitor station upgrade at bus 206. All these projects are expected to complete in next 4 years and the generator at Bus 212 will be in service after 4 years.

	FROM ------AT AREA BUSES-------				TO		TO XFRMR			-NET INTERCHANGE-	
	GENE-	FROM IND	TO IND	TO	TO BUS	GNE BUS	TO LINE	MAGNE-	FROM	TO	TO TIE	TO TIES
X-- AREA --X	RATION	GENERATN	MOTORS	LOAD	SHUNT	DEVICES	SHUNT	TIZING	CHARGING	LOSSES	LINES	+ LOADS
2	1200.0	0.0	0.0	1129.4	0.0	0.0	0.0	0.0	0.0	51.8	18.7	-981.3
LIGHTCO	601.4	0.0	0.0	867.0	-807.9	0.0	-0.0	-0.0	801.6	870.3	473.6	-326.4

Figure 2.4: System initial area totals corresponding to winter peak load

As can be seen from Figure 2.4, with the new generator at Bus 212 and already operational battery, there is a surplus of capacity of 18.7 MW in the area after 4 years.

2.5 Summary

The summary of results of load flow studies to phase out Generator at Bus 206 is as given in Table 2.1.

Case	**Generation + Battery**	**Load**	**Losses**	**Net Area Inter-change**
Initial System	1427.4	1529.4	32.6	-134.5
When generator at bus 206 operating at half capacity	1061.8	1529.4	36.4	-504.0
When generator at bus 206 operating at half capacity and battery installed at bus 206 with capacity of 400 MW	1461.8	1529.4	30.1	-97.7
When generator came into service at bus 212, Generator at bus 206 taken out of service - battery installed at bus 206 with capacity of 400 MW	1600.0	1529.4	51.8	18.7

Table 2.1: Phasing out Generator at Bus 206 - studied scenarios summary

Chapter 3

Conclusions

This study examined the steady state operation of considered scenarios for phasing out the generator from Bus 206. The PSSE Area total Activity was used to get the area totals for considered scenarios. At present, the generation in the area is 1427.4 MW, transmission service import of 134.5 MW is needed to meet the peak demand in the area LIGHTCO. When the generator at Bus 206 is operated at half its capacity, the available capacity in area LIGHTCO reduces to 1061.8 MW, increasing the reliance on transmission service to 504 MW. When the capacity in the area is increased by adding a utility scale battery at Bus 206, the capacity increases to 1461.8 MW, reducing the dependence on transmission service to 97.7 MW. When the generator at Bus 206 is taken out of service with generator at bus 211 coming into service and battery installed, the capacity in the area increases to 1600.0 MW, resulting in a capacity surplus of 18.7 MW.