**Table 1**.Assessment of the 28-bus 330 kV NGP base case using the NVSP.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From | Bus Name | To | Bus Name | NVSP |
| 3 | Aja | 1 | Egbin | 0.0087 |
| 4 | Akangba | 5 | Ikeja-west | 0.1033 |
| 1 | Egbin | 5 | Ikeja-west | 0.0777 |
| 5 | Ikeja-west | 8 | Benin | 0.9673 |
| 5 | Ikeja-west | 9 | Ayede | 0.3404 |
| 5 | Ikeja-west | 10 | Osogbo | 0.4711 |
| 6 | Ajaokuta | 8 | Benin | 0.5410 |
| 2 | Delta | 8 | Benin | 0.3432 |
| 2 | Delta | 7 | Aladja | 0.0242 |
| 7 | Aladja | 24 | Sapele | 0.0109 |
| 8 | Benin | 14 | Onitsha | 0.2159 |
| 8 | Benin | 10 | Osogbo | 0.4213 |
| 8 | Benin | 24 | Sapele | 0.0080 |
| 9 | Aiyede | 10 | Osogbo | 0.2290 |
| 15 | Birnin | 21 | Kanji | 0.0171 |
| 10 | Osogbo | 14 | Jebba TS | 0.0153 |
| 11 | AFAM | 12 | Alaoji | 0.0818 |
| 12 | Alaoji | 14 | Onitsha | 0.2210 |
| 13 | New Haven | 14 | Onitsha | 0.1656 |
| 16 | Gombe | 19 | Jos | 0.1335 |
| 17 | Jebba TS | 18 | Jebba GS | 0.0000 |
| 17 | Jebba TS | 23 | Shiroro | 0.0986 |
| 17 | Jebba TS | 21 | Kanji | 0.0041 |
| 19 | Jos | 20 | Kaduna | 0.0275 |
| 20 | Kaduna | 22 | Kano | 0.3689 |
| 20 | Kaduna | 23 | Shiroro | 0.0389 |
| 23 | Shiroro | 26 | Katempe | 0.2223 |
| 12 | Alaoji | 25 | Calabar | 0.1797 |
| 14 | Onitsha | 27 | Okpai | 0.0000 |
| 25 | Calabar | 27 | Okpai | 0.0000 |
| 5 | Ikeja-west | 28 | AES GS | 0.0000 |

**Table 2.** Contingency Ranking of the NGP buses and lines.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Ranking | Bus Name | From | To | NVSP | Voltage Mag. (p.u) | Qmax (MVar) |
| 1 | Gombe | Gombe | Jos | 0.1358 | 1.1230 | 100.9 |
| 2 | Jos | Gombe | Jos | 0.6662 | 0.8860 | 142.7 |
| 3 | Kano | Kaduna | Kano | 0.6185 | 0.8080 | 210.9 |
| 4 | Birni-Kebbi | Birni-Kebbi | Kainji | 0.3560 | 0.7470 | 285.9 |
| 5 | Benin | Ikeja-west | Benin | 0.9944 | 1.0390 | 295.5 |
| 6 | Osogbo | Ikeja-west | Osogbo | 0.9501 | 0.9840 | 300.9 |
| 7 | Kaduna | Jos | Kaduna | 0.9508 | 0.9120 | 332.7 |
| 8 | Ajaokuta | Ajaokuta | Benin | 0.9980 | 0.7960 | 355.3 |
| 9 | Calabar | Alaoji | Calabar | 0.9517 | 0.9050 | 459 |
| 10 | Katampe | Shiroro | Katampe | 0.7128 | 0.7980 | 465 |
| 11 | Jebba TS | Osogbo | Jebba TS | 0.9436 | 1.0390 | 500.2 |
| 12 | Onitsha | Alaoji | Onitsha | 0.9787 | 0.9840 | 605.4 |
| 13 | New Haven | New Haven | Onitsha | 0.3602 | 0.6740 | 633.4 |
| 14 | Ikeja-west | Ikeja-west | Benin | 1.0077 | 0.9760 | 774.9 |
| 15 | Ayede | Ayede | Osogbo | 0.6678 | 0.5650 | 906.8 |
| 16 | Akangba | Akangba | Ikeja-west | 0.2527 | 0.6270 | 2050.8 |
| 17 | Aladja | Delta | Alajda | 0.9946 | 0.8280 | 2972.4 |
| 18 | Alaoji | Afam | Alaoji | 0.9763 | 0.7450 | 3820.2 |
| 19 | Aja | Aja | Egbin | 0.0260 | 0.6000 | 6005.58 |

**Table 3**.Linear load dynamics at Gombe bus in the 28-bus NGP.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Bus Name** | **Critical Line** | | **Load Dynamics** | | **NVSP** | **Voltage Mag. (p.u)** |
| From | To | Active Power, P, (MW) | Reactive Power, Q, (MVar) |
| Gombe | Gombe | Jos | 60.0 | 70.0 | Non-convergence | - |
| 90.6 | 50.9 | 0.1242 | 1.174 |
| 95.0 | 105.0 | 0.1284 | 1.155 |
| 100.0 | 110.0 | 0.1331 | 1.134 |
| 105.0 | 115.0 | 0.1385 | 1.112 |
| 125.0 | 135.0 | 0.1711 | 1.000 |
| 145.0 | 150.0 | Non-convergence | - |

**Table 4**.Linear load dynamics at Jos bus in the 28-bus NGP.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Bus Name** | **Critical line** | | **Load Dynamics** | | **NVSP** | **Voltage Mag. (p.u)** |
| From | To | Active Power, P, (MW) | Reactive Power, Q, (MVar) |
| Jos | Gombe | Jos | 40.3 | 55.7 | 0.1372 | 1.140 |
| 30.3 | 45.7 | 0.1079 | 1.161 |
| 20.0 | 25.7 | 0.0567 | 1.195 |
| 10.0 | 10.0 | 0.0210 | 1.221 |
| 100.0 | 85.0 | 0.2604 | 1.042 |
| 120.0 | 105.0 | 0.3936 | 0.962 |
| 140.0 | 125.0 | Non-convergence | - |

**Table 5**.Linear load dynamics at Kano bus in the 28-bus NGP.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Bus Name** | **Critical Line** | | **Load Dynamics** | | **NVSP** | **Voltage Mag.** (**p**.**u**) |
| From | To | Active Power, P, (MW) | Reactive Power, Q, (MVar) |
| Kano | Kaduna | Kano | 50.6 | 40.0 | Non-convergence | - |
| 80.6 | 90.9 | 0.2091 | 1.112 |
| 100.0 | 120.0 | 0.2848 | 1.068 |
| 150.0 | 120.0 | 0.3206 | 1.033 |
| 250.0 | 150.0 | 0.4006 | 0.933 |
| 350.0 | 250.0 | Non-convergence | - |

**Table 6**.Non-linear load dynamics at Gombe bus in the 28-bus NGP.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Bus Name** | **Critical Line** | | **Load Dynamics** | | **NVSP** | **Voltage Mag. (p.u)** |
| From | To | Active Power, P, (MW) | Reactive Power, Q, (MVar) |
| Gombe | Gombe | Jos | 50.6 | 120.9 | 0.1291 | 1.152 |
| 170.6 | 40.9 | 0.1119 | 1.237 |
| 250.6 | 20.9 | 0.1278 | 1.157 |
| 40.0 | 200.0 | Non-convergence | - |

**Table 7**.Non-linear load dynamics at Jos bus in the 28-bus NGP.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Bus Name** | **Critical Line** | | **Load Dynamics** | | **NVSP** | **Voltage Mag. (p.u)** |
| From | To | Active Power, P, (MW) | Reactive Power, Q, (MVar) |
| Jos | Gombe | Jos | 30.0 | 90.7 | 0.2511 | 1.086 |
| 20.0 | 100.7 | 0.2868 | 1.073 |
| 10.0 | 250.7 | Non-convergence | - |
| 150.0 | 30.7 | 0.0815 | 1.050 |
| 350.0 | 20.0 | Non-convergence | - |

**Table 8**.The non-linear load dynamics at Kano bus in the 28-bus NGP.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Bus Name** | **Critical Line** | | **Load Dynamics** | | **NVSP** | **Voltage Mag. (p.u)** |
| From | To | Active Power, P, (MW) | Reactive Power, Q, (MVar) |
| Kano | Kaduna | Kano | 90.6 | 182.9 | 0.4664 | 0.977 |
| 70.6 | 200.0 | 0.5124 | 0.955 |
| 50.6 | 220.0 | 0.5752 | 0.925 |
| 30.0 | 280.0 | 0.8250 | 0.768 |
| 10.0 | 300.0 | Non-convergence | - |
| 350.0 | 50.0 | 0.1272 | 1.019 |
| 450 | 30.0 | 0.0865 | 0.914 |
| 650 | 20.0 | Non-convergence | - |