IEEE 118-bus, 54-unit, 24-hour system

Unit and Network Data

****

Fig. 1. The 118-bus system

table 1 generator data

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **U** | **Bus No.** | **Unit Cost Coefficients** | | | **Pmax (MW)** | **Pmin (MW)** | **Qmax**  **(MVAR)** | **Qmin**  **(MVAR)** | **Ini.**  **State**  **(h)** | **Min**  **Off**  **(h)** | **Min**  **On**  **(h)** | **Ramp**  **(MW/h)** | **Start**  **Up**  **(MBtu)** | **Fuel**  **Price**  **($/**  **MBtu)** |
| **a**  **(MBtu)** | **b**  **(MBtu/**  **MW)** | **c**  **(MBtu/MW2)** |
| 1 | 4 | 31.67 | 26.2438 | 0.069663 | 30 | 5 | 300 | -300 | 1 | 1 | 1 | 15 | 40 | 1 |
| 2 | 6 | 31.67 | 26.2438 | 0.069663 | 30 | 5 | 50 | -13 | 1 | 1 | 1 | 15 | 40 | 1 |
| 3 | 8 | 31.67 | 26.2438 | 0.069663 | 30 | 5 | 300 | -300 | 1 | 1 | 1 | 15 | 40 | 1 |
| 4 | 10 | 6.78 | 12.8875 | 0.010875 | 300 | 150 | 200 | -147 | 8 | 8 | 8 | 150 | 440 | 1 |
| 5 | 12 | 6.78 | 12.8875 | 0.010875 | 300 | 100 | 120 | -35 | 8 | 8 | 8 | 150 | 110 | 1 |
| 6 | 15 | 31.67 | 26.2438 | 0.069663 | 30 | 10 | 30 | -10 | 1 | 1 | 1 | 15 | 40 | 1 |
| 7 | 18 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 50 | -16 | 5 | 5 | 5 | 50 | 50 | 1 |
| 8 | 19 | 31.67 | 26.2438 | 0.069663 | 30 | 5 | 24 | -8 | 1 | 1 | 1 | 15 | 40 | 1 |
| 9 | 24 | 31.67 | 26.2438 | 0.069663 | 30 | 5 | 300 | -300 | 1 | 1 | 1 | 15 | 40 | 1 |
| 10 | 25 | 6.78 | 12.8875 | 0.010875 | 300 | 100 | 140 | -47 | 8 | 8 | 8 | 150 | 100 | 1 |
| 11 | 26 | 32.96 | 10.7600 | 0.003000 | 350 | 100 | 1000 | -1000 | 8 | 8 | 8 | 175 | 100 | 1 |
| 12 | 27 | 31.67 | 26.2438 | 0.069663 | 30 | 8 | 300 | -300 | 1 | 1 | 1 | 15 | 40 | 1 |
| 13 | 31 | 31.67 | 26.2438 | 0.069663 | 30 | 8 | 300 | -300 | 1 | 1 | 1 | 15 | 40 | 1 |
| 14 | 32 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 42 | -14 | 5 | 5 | 5 | 50 | 50 | 1 |
| 15 | 34 | 31.67 | 26.2438 | 0.069663 | 30 | 8 | 24 | -8 | 1 | 1 | 1 | 15 | 40 | 1 |
| 16 | 36 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 24 | -8 | 5 | 5 | 5 | 50 | 50 | 1 |
| 17 | 40 | 31.67 | 26.2438 | 0.069663 | 30 | 8 | 300 | -300 | 1 | 1 | 1 | 15 | 40 | 1 |
| 18 | 42 | 31.67 | 26.2438 | 0.069663 | 30 | 8 | 300 | -300 | 1 | 1 | 1 | 15 | 40 | 1 |
| 19 | 46 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 100 | -100 | 5 | 5 | 5 | 50 | 59 | 1 |
| 20 | 49 | 28 | 12.3299 | 0.002401 | 250 | 50 | 210 | -85 | 8 | 8 | 8 | 125 | 100 | 1 |
| 21 | 54 | 28 | 12.3299 | 0.002401 | 250 | 50 | 300 | -300 | 8 | 8 | 8 | 125 | 100 | 1 |
| 22 | 55 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 23 | -8 | 5 | 5 | 5 | 50 | 50 | 1 |
| 23 | 56 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 15 | -8 | 5 | 5 | 5 | 50 | 50 | 1 |
| 24 | 59 | 39 | 13.2900 | 0.004400 | 200 | 50 | 180 | -60 | 10 | 8 | 8 | 100 | 100 | 1 |
| 25 | 61 | 39 | 13.2900 | 0.004400 | 200 | 50 | 300 | -100 | 10 | 8 | 8 | 100 | 100 | 1 |
| 26 | 62 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 20 | -20 | 5 | 5 | 5 | 50 | 50 | 1 |
| 27 | 65 | 64.16 | 8.3391 | 0.010590 | 420 | 100 | 200 | -67 | 10 | 10 | 10 | 210 | 250 | 1 |
| 28 | 66 | 64.16 | 8.3391 | 0.010590 | 420 | 100 | 200 | -67 | 10 | 10 | 10 | 210 | 250 | 1 |
| 29 | 69 | 6.78 | 12.8875 | 0.010875 | 300 | 80 | 99999 | -99999 | 10 | 8 | 8 | 150 | 100 | 1 |
| 30 | 70 | 74.33 | 15.4708 | 0.045923 | 80 | 30 | 32 | -10 | 4 | 4 | 4 | 40 | 45 | 1 |
| 31 | 72 | 31.67 | 26.2438 | 0.069663 | 30 | 10 | 100 | -100 | 1 | 1 | 1 | 15 | 40 | 1 |
| 32 | 73 | 31.67 | 26.2438 | 0.069663 | 30 | 5 | 100 | -100 | 1 | 1 | 1 | 15 | 40 | 1 |
| 33 | 74 | 17.95 | 37.6968 | 0.028302 | 20 | 5 | 9 | -6 | 1 | 1 | 1 | 10 | 30 | 1 |
| 34 | 76 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 23 | -8 | 5 | 5 | 5 | 50 | 50 | 1 |
| 35 | 77 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 70 | -20 | 5 | 5 | 5 | 50 | 50 | 1 |
| 36 | 80 | 6.78 | 12.8875 | 0.010875 | 300 | 150 | 280 | -165 | 10 | 8 | 8 | 150 | 440 | 1 |
| 37 | 82 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 9900 | -9900 | 5 | 5 | 5 | 50 | 50 | 1 |
| 38 | 85 | 31.67 | 26.2438 | 0.069663 | 30 | 10 | 23 | -8 | 1 | 1 | 1 | 15 | 40 | 1 |
| 39 | 87 | 32.96 | 10.7600 | 0.003000 | 300 | 100 | 1000 | -100 | 10 | 8 | 8 | 150 | 440 | 1 |
| 40 | 89 | 6.78 | 12.8875 | 0.010875 | 200 | 50 | 300 | -210 | 10 | 8 | 8 | 100 | 400 | 1 |
| 41 | 90 | 17.95 | 37.6968 | 0.028302 | 20 | 8 | 300 | -300 | 1 | 1 | 1 | 10 | 30 | 1 |
| 42 | 91 | 58.81 | 22.9423 | 0.009774 | 50 | 20 | 100 | -100 | 1 | 1 | 1 | 25 | 45 | 1 |
| 43 | 92 | 6.78 | 12.8875 | 0.010875 | 300 | 100 | 9 | -3 | 8 | 8 | 8 | 150 | 100 | 1 |
| 44 | 99 | 6.78 | 12.8875 | 0.010875 | 300 | 100 | 100 | -100 | 8 | 8 | 8 | 150 | 100 | 1 |
| 45 | 100 | 6.78 | 12.8875 | 0.010875 | 300 | 100 | 155 | -50 | 8 | 8 | 8 | 150 | 110 | 1 |
| 46 | 103 | 17.95 | 37.6968 | 0.028302 | 20 | 8 | 40 | -15 | 1 | 1 | 1 | 10 | 30 | 1 |
| 47 | 104 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 23 | -8 | 5 | 5 | 5 | 50 | 50 | 1 |
| 48 | 105 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 23 | -8 | 5 | 5 | 5 | 50 | 50 | 1 |
| 49 | 107 | 17.95 | 37.6968 | 0.028302 | 20 | 8 | 200 | -200 | 1 | 1 | 1 | 10 | 30 | 1 |
| 50 | 110 | 58.81 | 22.9423 | 0.009774 | 50 | 25 | 23 | -8 | 2 | 2 | 2 | 25 | 45 | 1 |
| 51 | 111 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 1000 | -100 | 5 | 5 | 5 | 50 | 50 | 1 |
| 52 | 112 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 1000 | -100 | 5 | 5 | 5 | 50 | 50 | 1 |
| 53 | 113 | 10.15 | 17.8200 | 0.012800 | 100 | 25 | 200 | -100 | 5 | 5 | 5 | 50 | 50 | 1 |
| 54 | 116 | 58.81 | 22.9423 | 0.009774 | 50 | 25 | 1000 | -1000 | 2 | 2 | 2 | 25 | 45 | 1 |

table 2 bus data

|  |  |  |
| --- | --- | --- |
| **Bus No.** | **Voltage-Max (pu)** | **Voltage-Min (pu)** |
| 1 | 1.05 | 0.94 |
| 2 | 1.06 | 0.95 |
| 3 | 1.06 | 0.95 |
| 4 | 1.09 | 0.99 |
| 5 | 1.09 | 0.99 |
| 6 | 1.09 | 0.97 |
| 7 | 1.09 | 0.97 |
| 8 | 1.09 | 0.98 |
| 9 | 1.09 | 0.98 |
| 10 | 1.09 | 0.98 |
| 11 | 1.08 | 0.97 |
| 12 | 1.09 | 0.98 |
| 13 | 1.05 | 0.95 |
| 14 | 1.07 | 0.98 |
| 15 | 1.05 | 0.98 |
| 16 | 1.07 | 0.98 |
| 17 | 1.09 | 0.98 |
| 18 | 1.07 | 0.98 |
| 19 | 1.06 | 0.98 |
| 20 | 1.04 | 0.96 |
| 21 | 1.03 | 0.95 |
| 22 | 1.04 | 0.97 |
| 23 | 1.09 | 0.98 |
| 24 | 1.09 | 0.98 |
| 25 | 1.09 | 0.98 |
| 26 | 1.09 | 0.98 |
| 27 | 1.09 | 0.96 |
| 28 | 1.08 | 0.94 |
| 29 | 1.08 | 0.93 |
| 30 | 1.06 | 0.98 |
| 31 | 1.09 | 0.94 |
| 32 | 1.08 | 0.97 |
| 33 | 1.04 | 0.96 |
| 34 | 1.08 | 0.97 |
| 35 | 1.08 | 0.96 |
| 36 | 1.08 | 0.96 |
| 37 | 1.09 | 0.98 |
| 38 | 1.04 | 0.95 |
| 39 | 1.09 | 0.93 |
| 40 | 1.09 | 0.93 |
| 41 | 1.09 | 0.93 |
| 42 | 1.09 | 0.92 |
| 43 | 1.06 | 0.96 |
| 44 | 1.06 | 0.97 |
| 45 | 1.06 | 0.98 |
| 46 | 1.09 | 0.98 |
| 47 | 1.09 | 0.98 |
| 48 | 1.09 | 0.98 |
| 49 | 1.09 | 0.98 |
| 50 | 1.09 | 0.99 |
| 51 | 1.07 | 0.97 |
| 52 | 1.06 | 0.97 |
| 53 | 1.06 | 0.96 |
| 54 | 1.09 | 0.97 |
| 55 | 1.09 | 0.97 |
| 56 | 1.09 | 0.97 |
| 57 | 1.08 | 0.98 |
| 58 | 1.07 | 0.97 |
| 59 | 1.09 | 0.98 |
| 60 | 1.09 | 0.99 |
| 61 | 1.09 | 0.99 |
| 62 | 1.09 | 0.98 |
| 63 | 1.06 | 0.96 |
| 64 | 1.07 | 0.98 |
| 65 | 1.07 | 0.98 |
| 66 | 1.09 | 0.98 |
| 67 | 1.09 | 0.98 |
| 68 | 1.08 | 0.98 |
| 69 | 1.09 | 0.98 |
| 70 | 1.06 | 0.98 |
| 71 | 1.06 | 0.99 |
| 72 | 1.09 | 0.99 |
| 73 | 1.06 | 0.99 |
| 74 | 1.03 | 0.93 |
| 75 | 1.04 | 0.94 |
| 76 | 1.02 | 0.93 |
| 77 | 1.08 | 0.98 |
| 78 | 1.07 | 0.99 |
| 79 | 1.07 | 0.99 |
| 80 | 1.09 | 0.99 |
| 81 | 1.07 | 0.98 |
| 82 | 1.09 | 0.98 |
| 83 | 1.07 | 0.99 |
| 84 | 1.03 | 0.96 |
| 85 | 1.02 | 0.96 |
| 86 | 0.96 | 0.93 |
| 87 | 1.09 | 0.98 |
| 88 | 1.06 | 0.98 |
| 89 | 1.09 | 0.98 |
| 90 | 1.09 | 0.98 |
| 91 | 1.09 | 0.98 |
| 92 | 1.09 | 0.98 |
| 93 | 1.08 | 0.98 |
| 94 | 1.07 | 0.98 |
| 95 | 1.05 | 0.98 |
| 96 | 1.07 | 0.98 |
| 97 | 1.08 | 0.98 |
| 98 | 1.08 | 0.98 |
| 99 | 1.09 | 0.98 |
| 100 | 1.09 | 0.98 |
| 101 | 1.08 | 0.98 |
| 102 | 1.09 | 0.98 |
| 103 | 1.09 | 0.98 |
| 104 | 1.08 | 0.99 |
| 105 | 1.08 | 0.98 |
| 106 | 1.07 | 0.96 |
| 107 | 1.06 | 0.94 |
| 108 | 1.08 | 0.98 |
| 109 | 1.08 | 0.98 |
| 110 | 1.09 | 0.97 |
| 111 | 1.09 | 0.97 |
| 112 | 1.09 | 0.97 |
| 113 | 1.09 | 0.98 |
| 114 | 1.08 | 0.96 |
| 115 | 1.08 | 0.96 |
| 116 | 1.09 | 0.98 |
| 117 | 1.06 | 0.95 |
| 118 | 1.03 | 0.93 |

table 3 transmission line data

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Line No.** | **From Bus** | **To Bus** | **Circuit ID** | **R (pu)** | **X (pu)** | **B (pu)** | **Flow Limit (MW)** |
| 1 | 1 | 2 | 1 | 0.0303 | 0.0999 | 0.0254 | 175 |
| 2 | 1 | 3 | 1 | 0.0129 | 0.0424 | 0.01082 | 175 |
| 3 | 4 | 5 | 1 | 0.00176 | 0.00798 | 0.0021 | 500 |
| 4 | 3 | 5 | 1 | 0.0241 | 0.108 | 0.0284 | 175 |
| 5 | 5 | 6 | 1 | 0.0119 | 0.054 | 0.01426 | 175 |
| 6 | 6 | 7 | 1 | 0.00459 | 0.0208 | 0.0055 | 175 |
| 7 | 8 | 9 | 1 | 0.00244 | 0.0305 | 1.162 | 500 |
| 8 | 8 | 5 | 1 | 0 | 0.0267 | 0 | 500 |
| 9 | 9 | 10 | 1 | 0.00258 | 0.0322 | 1.23 | 500 |
| 10 | 4 | 11 | 1 | 0.0209 | 0.0688 | 0.01748 | 175 |
| 11 | 5 | 11 | 1 | 0.0203 | 0.0682 | 0.01738 | 175 |
| 12 | 11 | 12 | 1 | 0.00595 | 0.0196 | 0.00502 | 175 |
| 13 | 2 | 12 | 1 | 0.0187 | 0.0616 | 0.01572 | 175 |
| 14 | 3 | 12 | 1 | 0.0484 | 0.16 | 0.0406 | 175 |
| 15 | 7 | 12 | 1 | 0.00862 | 0.034 | 0.00874 | 175 |
| 16 | 11 | 13 | 1 | 0.02225 | 0.0731 | 0.01876 | 175 |
| 17 | 12 | 14 | 1 | 0.0215 | 0.0707 | 0.01816 | 175 |
| 18 | 13 | 15 | 1 | 0.0744 | 0.2444 | 0.06268 | 175 |
| 19 | 14 | 15 | 1 | 0.0595 | 0.195 | 0.0502 | 175 |
| 20 | 12 | 16 | 1 | 0.0212 | 0.0834 | 0.0214 | 175 |
| 21 | 15 | 17 | 1 | 0.0132 | 0.0437 | 0.0444 | 500 |
| 22 | 16 | 17 | 1 | 0.0454 | 0.1801 | 0.0466 | 175 |
| 23 | 17 | 18 | 1 | 0.0123 | 0.0505 | 0.01298 | 175 |
| 24 | 18 | 19 | 1 | 0.01119 | 0.0493 | 0.01142 | 175 |
| 25 | 19 | 20 | 1 | 0.0252 | 0.117 | 0.0298 | 175 |
| 26 | 15 | 19 | 1 | 0.012 | 0.0394 | 0.0101 | 175 |
| 27 | 20 | 21 | 1 | 0.0183 | 0.0849 | 0.0216 | 175 |
| 28 | 21 | 22 | 1 | 0.0209 | 0.097 | 0.0246 | 175 |
| 29 | 22 | 23 | 1 | 0.0342 | 0.159 | 0.0404 | 175 |
| 30 | 23 | 24 | 1 | 0.0135 | 0.0492 | 0.0498 | 175 |
| 31 | 23 | 25 | 1 | 0.0156 | 0.08 | 0.0864 | 500 |
| 32 | 26 | 25 | 1 | 0 | 0.0382 | 0 | 500 |
| 33 | 25 | 27 | 1 | 0.0318 | 0.163 | 0.1764 | 500 |
| 34 | 27 | 28 | 1 | 0.01913 | 0.0855 | 0.0216 | 175 |
| 35 | 28 | 29 | 1 | 0.0237 | 0.0943 | 0.0238 | 175 |
| 36 | 30 | 17 | 1 | 0 | 0.0388 | 0 | 500 |
| 37 | 8 | 30 | 1 | 0.00431 | 0.0504 | 0.514 | 175 |
| 38 | 26 | 30 | 1 | 0.00799 | 0.086 | 0.908 | 500 |
| 39 | 17 | 31 | 1 | 0.0474 | 0.1563 | 0.0399 | 175 |
| 40 | 29 | 31 | 1 | 0.0108 | 0.0331 | 0.0083 | 175 |
| 41 | 23 | 32 | 1 | 0.0317 | 0.1153 | 0.1173 | 140 |
| 42 | 31 | 32 | 1 | 0.0298 | 0.0985 | 0.0251 | 175 |
| 43 | 27 | 32 | 1 | 0.0229 | 0.0755 | 0.01926 | 175 |
| 44 | 15 | 33 | 1 | 0.038 | 0.1244 | 0.03194 | 175 |
| 45 | 19 | 34 | 1 | 0.0752 | 0.247 | 0.0632 | 175 |
| 46 | 35 | 36 | 1 | 0.00224 | 0.0102 | 0.00268 | 175 |
| 47 | 35 | 37 | 1 | 0.011 | 0.0497 | 0.01318 | 175 |
| 48 | 33 | 37 | 1 | 0.0415 | 0.142 | 0.0366 | 175 |
| 49 | 34 | 36 | 1 | 0.00871 | 0.0268 | 0.00568 | 175 |
| 50 | 34 | 37 | 1 | 0.00256 | 0.0094 | 0.00984 | 500 |
| 51 | 38 | 37 | 1 | 0 | 0.0375 | 0 | 500 |
| 52 | 37 | 39 | 1 | 0.0321 | 0.106 | 0.027 | 175 |
| 53 | 37 | 40 | 1 | 0.0593 | 0.168 | 0.042 | 175 |
| 54 | 30 | 38 | 1 | 0.00464 | 0.054 | 0.422 | 175 |
| 55 | 39 | 40 | 1 | 0.0184 | 0.0605 | 0.01552 | 175 |
| 56 | 40 | 41 | 1 | 0.0145 | 0.0487 | 0.01222 | 175 |
| 57 | 40 | 42 | 1 | 0.0555 | 0.183 | 0.0466 | 175 |
| 58 | 41 | 42 | 1 | 0.041 | 0.135 | 0.0344 | 175 |
| 59 | 43 | 44 | 1 | 0.0608 | 0.2454 | 0.06068 | 175 |
| 60 | 34 | 43 | 1 | 0.0413 | 0.1681 | 0.04226 | 175 |
| 61 | 44 | 45 | 1 | 0.0224 | 0.0901 | 0.0224 | 175 |
| 62 | 45 | 46 | 1 | 0.04 | 0.1356 | 0.0332 | 175 |
| 63 | 46 | 47 | 1 | 0.038 | 0.127 | 0.0316 | 175 |
| 64 | 46 | 48 | 1 | 0.0601 | 0.189 | 0.0472 | 175 |
| 65 | 47 | 49 | 1 | 0.0191 | 0.0625 | 0.01604 | 175 |
| 66 | 42 | 49 | 1 | 0.0715 | 0.323 | 0.086 | 175 |
| 67 | 42 | 49 | 2 | 0.0715 | 0.323 | 0.086 | 175 |
| 68 | 45 | 49 | 1 | 0.0684 | 0.186 | 0.0444 | 175 |
| 69 | 48 | 49 | 1 | 0.0179 | 0.0505 | 0.01258 | 175 |
| 70 | 49 | 50 | 1 | 0.0267 | 0.0752 | 0.01874 | 175 |
| 71 | 49 | 51 | 1 | 0.0486 | 0.137 | 0.0342 | 175 |
| 72 | 51 | 52 | 1 | 0.0203 | 0.0588 | 0.01396 | 175 |
| 73 | 52 | 53 | 1 | 0.0405 | 0.1635 | 0.04058 | 175 |
| 74 | 53 | 54 | 1 | 0.0263 | 0.122 | 0.031 | 175 |
| 75 | 49 | 54 | 1 | 0.073 | 0.289 | 0.0738 | 175 |
| 76 | 49 | 54 | 2 | 0.0869 | 0.291 | 0.073 | 175 |
| 77 | 54 | 55 | 1 | 0.0169 | 0.0707 | 0.0202 | 175 |
| 78 | 54 | 56 | 1 | 0.00275 | 0.00955 | 0.00732 | 175 |
| 79 | 55 | 56 | 1 | 0.00488 | 0.0151 | 0.00374 | 175 |
| 80 | 56 | 57 | 1 | 0.0343 | 0.0966 | 0.0242 | 175 |
| 81 | 50 | 57 | 1 | 0.0474 | 0.134 | 0.0332 | 175 |
| 82 | 56 | 58 | 1 | 0.0343 | 0.0966 | 0.0242 | 175 |
| 83 | 51 | 58 | 1 | 0.0255 | 0.0719 | 0.01788 | 175 |
| 84 | 54 | 59 | 1 | 0.0503 | 0.2293 | 0.0598 | 175 |
| 85 | 56 | 59 | 1 | 0.0825 | 0.251 | 0.0569 | 175 |
| 86 | 56 | 59 | 2 | 0.0803 | 0.239 | 0.0536 | 175 |
| 87 | 55 | 59 | 1 | 0.04739 | 0.2158 | 0.05646 | 175 |
| 88 | 59 | 60 | 1 | 0.0317 | 0.145 | 0.0376 | 175 |
| 89 | 59 | 61 | 1 | 0.0328 | 0.15 | 0.0388 | 175 |
| 90 | 60 | 61 | 1 | 0.00264 | 0.0135 | 0.01456 | 500 |
| 91 | 60 | 62 | 1 | 0.0123 | 0.0561 | 0.01468 | 175 |
| 92 | 61 | 62 | 1 | 0.00824 | 0.0376 | 0.0098 | 175 |
| 93 | 63 | 59 | 1 | 0 | 0.0386 | 0 | 500 |
| 94 | 63 | 64 | 1 | 0.00172 | 0.02 | 0.216 | 500 |
| 95 | 64 | 61 | 1 | 0 | 0.0268 | 0 | 500 |
| 96 | 38 | 65 | 1 | 0.00901 | 0.0986 | 1.046 | 500 |
| 97 | 64 | 65 | 1 | 0.00269 | 0.0302 | 0.38 | 500 |
| 98 | 49 | 66 | 1 | 0.018 | 0.0919 | 0.0248 | 500 |
| 99 | 49 | 66 | 2 | 0.018 | 0.0919 | 0.0248 | 500 |
| 100 | 62 | 66 | 1 | 0.0482 | 0.218 | 0.0578 | 175 |
| 101 | 62 | 67 | 1 | 0.0258 | 0.117 | 0.031 | 175 |
| 102 | 65 | 66 | 1 | 0 | 0.037 | 0 | 500 |
| 103 | 66 | 67 | 1 | 0.0224 | 0.1015 | 0.02682 | 175 |
| 104 | 65 | 68 | 1 | 0.00138 | 0.016 | 0.638 | 500 |
| 105 | 47 | 69 | 1 | 0.0844 | 0.2778 | 0.07092 | 175 |
| 106 | 49 | 69 | 1 | 0.0985 | 0.324 | 0.0828 | 175 |
| 107 | 68 | 69 | 1 | 0 | 0.037 | 0 | 500 |
| 108 | 69 | 70 | 1 | 0.03 | 0.127 | 0.122 | 500 |
| 109 | 24 | 70 | 1 | 0.00221 | 0.4115 | 0.10198 | 175 |
| 110 | 70 | 71 | 1 | 0.00882 | 0.0355 | 0.00878 | 175 |
| 111 | 24 | 72 | 1 | 0.0488 | 0.196 | 0.0488 | 175 |
| 112 | 71 | 72 | 1 | 0.0446 | 0.18 | 0.04444 | 175 |
| 113 | 71 | 73 | 1 | 0.00866 | 0.0454 | 0.01178 | 175 |
| 114 | 70 | 74 | 1 | 0.0401 | 0.1323 | 0.03368 | 175 |
| 115 | 70 | 75 | 1 | 0.0428 | 0.141 | 0.036 | 175 |
| 116 | 69 | 75 | 1 | 0.0405 | 0.122 | 0.124 | 500 |
| 117 | 74 | 75 | 1 | 0.0123 | 0.0406 | 0.01034 | 175 |
| 118 | 76 | 77 | 1 | 0.0444 | 0.148 | 0.0368 | 175 |
| 119 | 69 | 77 | 1 | 0.0309 | 0.101 | 0.1038 | 175 |
| 120 | 75 | 77 | 1 | 0.0601 | 0.1999 | 0.04978 | 175 |
| 121 | 77 | 78 | 1 | 0.00376 | 0.0124 | 0.01264 | 175 |
| 122 | 78 | 79 | 1 | 0.00546 | 0.0244 | 0.00648 | 175 |
| 123 | 77 | 80 | 1 | 0.017 | 0.0485 | 0.0472 | 500 |
| 124 | 77 | 80 | 2 | 0.0294 | 0.105 | 0.0228 | 500 |
| 125 | 79 | 80 | 1 | 0.0156 | 0.0704 | 0.0187 | 175 |
| 126 | 68 | 81 | 1 | 0.00175 | 0.0202 | 0.808 | 500 |
| 127 | 81 | 80 | 1 | 0 | 0.037 | 0 | 500 |
| 128 | 77 | 82 | 1 | 0.0298 | 0.0853 | 0.08174 | 200 |
| 129 | 82 | 83 | 1 | 0.0112 | 0.03665 | 0.03796 | 200 |
| 130 | 83 | 84 | 1 | 0.0625 | 0.132 | 0.0258 | 175 |
| 131 | 83 | 85 | 1 | 0.043 | 0.148 | 0.0348 | 175 |
| 132 | 84 | 85 | 1 | 0.0302 | 0.0641 | 0.01234 | 175 |
| 133 | 85 | 86 | 1 | 0.035 | 0.123 | 0.0276 | 500 |
| 134 | 86 | 87 | 1 | 0.02828 | 0.2074 | 0.0445 | 500 |
| 135 | 85 | 88 | 1 | 0.02 | 0.102 | 0.0276 | 175 |
| 136 | 85 | 89 | 1 | 0.0239 | 0.173 | 0.047 | 175 |
| 137 | 88 | 89 | 1 | 0.0139 | 0.0712 | 0.01934 | 500 |
| 138 | 89 | 90 | 1 | 0.0518 | 0.188 | 0.0528 | 500 |
| 139 | 89 | 90 | 2 | 0.0238 | 0.0997 | 0.106 | 500 |
| 140 | 90 | 91 | 1 | 0.0254 | 0.0836 | 0.0214 | 175 |
| 141 | 89 | 92 | 1 | 0.0099 | 0.0505 | 0.0548 | 500 |
| 142 | 89 | 92 | 2 | 0.0393 | 0.1581 | 0.0414 | 500 |
| 143 | 91 | 92 | 1 | 0.0387 | 0.1272 | 0.03268 | 175 |
| 144 | 92 | 93 | 1 | 0.0258 | 0.0848 | 0.0218 | 175 |
| 145 | 92 | 94 | 1 | 0.0481 | 0.158 | 0.0406 | 175 |
| 146 | 93 | 94 | 1 | 0.0223 | 0.0732 | 0.01876 | 175 |
| 147 | 94 | 95 | 1 | 0.0132 | 0.0434 | 0.0111 | 175 |
| 148 | 80 | 96 | 1 | 0.0356 | 0.182 | 0.0494 | 175 |
| 149 | 82 | 96 | 1 | 0.0162 | 0.053 | 0.0544 | 175 |
| 150 | 94 | 96 | 1 | 0.0269 | 0.0869 | 0.023 | 175 |
| 151 | 80 | 97 | 1 | 0.0183 | 0.0934 | 0.0254 | 175 |
| 152 | 80 | 98 | 1 | 0.0238 | 0.108 | 0.0286 | 175 |
| 153 | 80 | 99 | 1 | 0.0454 | 0.206 | 0.0546 | 200 |
| 154 | 92 | 100 | 1 | 0.0648 | 0.295 | 0.0472 | 175 |
| 155 | 94 | 100 | 1 | 0.0178 | 0.058 | 0.0604 | 175 |
| 156 | 95 | 96 | 1 | 0.0171 | 0.0547 | 0.01474 | 175 |
| 157 | 96 | 97 | 1 | 0.0173 | 0.0885 | 0.024 | 175 |
| 158 | 98 | 100 | 1 | 0.0397 | 0.179 | 0.0476 | 175 |
| 159 | 99 | 100 | 1 | 0.018 | 0.0813 | 0.0216 | 175 |
| 160 | 100 | 101 | 1 | 0.0277 | 0.1262 | 0.0328 | 175 |
| 161 | 92 | 102 | 1 | 0.0123 | 0.0559 | 0.01464 | 175 |
| 162 | 101 | 102 | 1 | 0.0246 | 0.112 | 0.0294 | 175 |
| 163 | 100 | 103 | 1 | 0.016 | 0.0525 | 0.0536 | 500 |
| 164 | 100 | 104 | 1 | 0.0451 | 0.204 | 0.0541 | 175 |
| 165 | 103 | 104 | 1 | 0.0466 | 0.1584 | 0.0407 | 175 |
| 166 | 103 | 105 | 1 | 0.0535 | 0.1625 | 0.0408 | 175 |
| 167 | 100 | 106 | 1 | 0.0605 | 0.229 | 0.062 | 175 |
| 168 | 104 | 105 | 1 | 0.00994 | 0.0378 | 0.00986 | 175 |
| 169 | 105 | 106 | 1 | 0.014 | 0.0547 | 0.01434 | 175 |
| 170 | 105 | 107 | 1 | 0.053 | 0.183 | 0.0472 | 175 |
| 171 | 105 | 108 | 1 | 0.0261 | 0.0703 | 0.01844 | 175 |
| 172 | 106 | 107 | 1 | 0.053 | 0.183 | 0.0472 | 175 |
| 173 | 108 | 109 | 1 | 0.0105 | 0.0288 | 0.0076 | 175 |
| 174 | 103 | 110 | 1 | 0.03906 | 0.1813 | 0.0461 | 175 |
| 175 | 109 | 110 | 1 | 0.0278 | 0.0762 | 0.0202 | 175 |
| 176 | 110 | 111 | 1 | 0.022 | 0.0755 | 0.02 | 175 |
| 177 | 110 | 112 | 1 | 0.0247 | 0.064 | 0.062 | 175 |
| 178 | 17 | 113 | 1 | 0.00913 | 0.0301 | 0.00768 | 175 |
| 179 | 32 | 113 | 1 | 0.0615 | 0.203 | 0.0518 | 500 |
| 180 | 32 | 114 | 1 | 0.0135 | 0.0612 | 0.01628 | 175 |
| 181 | 27 | 115 | 1 | 0.0164 | 0.0741 | 0.01972 | 175 |
| 182 | 114 | 115 | 1 | 0.0023 | 0.0104 | 0.00276 | 175 |
| 183 | 68 | 116 | 1 | 0.00034 | 0.00405 | 0.164 | 500 |
| 184 | 12 | 117 | 1 | 0.0329 | 0.14 | 0.0358 | 175 |
| 185 | 75 | 118 | 1 | 0.0145 | 0.0481 | 0.01198 | 175 |
| 186 | 76 | 118 | 1 | 0.0164 | 0.0544 | 0.01356 | 175 |

table 4 tap changing transformer data

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Transformer No.** | **From Bus** | **To**  **Bus** | **Circuit ID** | **Tap Initial** | **Tap**  **Max** | **Tap**  **Min** | **Angle Initial** | **Angle**  **Max** | **Angle**  **Min** |
| 1 | 8 | 5 | 1 | 0.985 | 0 | 0 | 0 | 0 | 0 |
| 2 | 26 | 25 | 1 | 0.96 | 0 | 0 | 0 | 0 | 0 |
| 3 | 30 | 17 | 1 | 0.96 | 0 | 0 | 0 | 0 | 0 |
| 4 | 38 | 37 | 1 | 0.935 | 0 | 0 | 0 | 0 | 0 |
| 5 | 63 | 59 | 1 | 0.96 | 0 | 0 | 0 | 0 | 0 |
| 6 | 64 | 61 | 1 | 0.985 | 0 | 0 | 0 | 0 | 0 |
| 7 | 65 | 66 | 1 | 0.935 | 0 | 0 | 0 | 0 | 0 |
| 8 | 68 | 69 | 1 | 0.935 | 0 | 0 | 0 | 0 | 0 |
| 9 | 81 | 80 | 1 | 0.935 | 0 | 0 | 3.57 | -15 | 15 |

table 5 hourly load and Ancillary Services

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **H** | **Real Load**  **(MW)** | **Reactive Load**  **(MVAR)** | **Regulation Down (MW)** | **Regulation Up (MW)** | **Spinning Reserve (MW)** | **Non-spinning Reserve (MW)** | **Operating Reserve (MW)** |
| 1 | 4200 | 1623.47 | 42 | 42 | 84 | 84 | 210 |
| 2 | 3960 | 1530.70 | 39.6 | 39.6 | 79.2 | 79.2 | 198 |
| 3 | 3480 | 1345.16 | 34.8 | 34.8 | 69.6 | 69.6 | 174 |
| 4 | 2400 | 927.70 | 24 | 24 | 48 | 48 | 120 |
| 5 | 3000 | 1159.62 | 30 | 30 | 60 | 60 | 150 |
| 6 | 3600 | 1391.54 | 36 | 36 | 72 | 72 | 180 |
| 7 | 4200 | 1623.47 | 42 | 42 | 84 | 84 | 210 |
| 8 | 4680 | 1809.01 | 46.8 | 46.8 | 93.6 | 93.6 | 234 |
| 9 | 4920 | 1901.78 | 49.2 | 49.2 | 98.4 | 98.4 | 246 |
| 10 | 5280 | 2040.93 | 52.8 | 52.8 | 105.6 | 105.6 | 264 |
| 11 | 5340 | 2064.12 | 53.4 | 53.4 | 106.8 | 106.8 | 267 |
| 12 | 5040 | 1948.16 | 50.4 | 50.4 | 100.8 | 100.8 | 252 |
| 13 | 4800 | 1855.39 | 48 | 48 | 96 | 96 | 240 |
| 14 | 4560 | 1762.62 | 45.6 | 45.6 | 91.2 | 91.2 | 228 |
| 15 | 5280 | 2040.93 | 52.8 | 52.8 | 105.6 | 105.6 | 264 |
| 16 | 5400 | 2087.31 | 54 | 54 | 108 | 108 | 270 |
| 17 | 5100 | 1971.35 | 51 | 51 | 102 | 102 | 255 |
| 18 | 5340 | 2064.12 | 53.4 | 53.4 | 106.8 | 106.8 | 267 |
| 19 | 5640 | 2180.08 | 56.4 | 56.4 | 112.8 | 112.8 | 282 |
| 20 | 5880 | 2272.85 | 58.8 | 58.8 | 117.6 | 117.6 | 294 |
| 21 | 6000 | 2319.24 | 60 | 60 | 120 | 120 | 300 |
| 22 | 5400 | 2087.31 | 54 | 54 | 108 | 108 | 270 |
| 23 | 5220 | 2017.74 | 52.2 | 52.2 | 104.4 | 104.4 | 261 |
| 24 | 4920 | 1901.78 | 49.2 | 49.2 | 98.4 | 98.4 | 246 |

Table 6 Bus Load Distribution Profile

|  |  |  |
| --- | --- | --- |
| **Bus No** | **Pd**  **(MW)** | **Qd**  **(MVAR)** |
| 1 | 54.14 | 8.66 |
| 2 | 21.23 | 9.55 |
| 3 | 41.4 | 10.62 |
| 4 | 31.85 | 12.74 |
| 6 | 55.2 | 23.35 |
| 7 | 20.17 | 2.12 |
| 11 | 74.31 | 24.42 |
| 12 | 49.89 | 10.62 |
| 13 | 36.09 | 16.99 |
| 14 | 14.86 | 1.06 |
| 15 | 95.54 | 31.85 |
| 16 | 26.54 | 10.62 |
| 17 | 11.68 | 3.18 |
| 18 | 63.69 | 36.09 |
| 19 | 47.77 | 26.54 |
| 20 | 19.11 | 3.18 |
| 21 | 14.86 | 8.49 |
| 22 | 10.62 | 5.31 |
| 23 | 7.43 | 3.18 |
| 27 | 65.82 | 13.8 |
| 28 | 18.05 | 7.43 |
| 29 | 25.48 | 4.25 |
| 31 | 45.65 | 28.66 |
| 32 | 62.63 | 24.42 |
| 33 | 24.42 | 9.55 |
| 34 | 62.63 | 27.6 |
| 35 | 35.03 | 9.55 |
| 36 | 32.91 | 18.05 |
| 39 | 27 | 11 |
| 40 | 20 | 23 |
| 41 | 37 | 10 |
| 42 | 37 | 23 |
| 43 | 18 | 7 |
| 44 | 16 | 8 |
| 45 | 53 | 22 |
| 46 | 28 | 10 |
| 47 | 34 | 0 |
| 48 | 20 | 11 |
| 49 | 87 | 30 |
| 50 | 17 | 4 |
| 51 | 17 | 8 |
| 52 | 18 | 5 |
| 53 | 23 | 11 |
| 54 | 113 | 32 |
| 55 | 63 | 22 |
| 56 | 84 | 18 |
| 57 | 12 | 3 |
| 58 | 12 | 3 |
| 59 | 277 | 113 |
| 60 | 78 | 3 |
| 62 | 77 | 14 |
| 66 | 39 | 18 |
| 67 | 28 | 7 |
| 70 | 66 | 20 |
| 74 | 68 | 27 |
| 75 | 47 | 11 |
| 76 | 68 | 36 |
| 77 | 61 | 28 |
| 78 | 71 | 26 |
| 79 | 39 | 32 |
| 80 | 130 | 26 |
| 82 | 54 | 27 |
| 83 | 20 | 10 |
| 84 | 11 | 7 |
| 85 | 24 | 15 |
| 86 | 21 | 10 |
| 88 | 48 | 10 |
| 90 | 78 | 42 |
| 92 | 65 | 10 |
| 93 | 12 | 7 |
| 94 | 30 | 16 |
| 95 | 42 | 31 |
| 96 | 38 | 15 |
| 97 | 15 | 9 |
| 98 | 34 | 8 |
| 100 | 37 | 18 |
| 101 | 22 | 15 |
| 102 | 5 | 3 |
| 103 | 23 | 16 |
| 104 | 38 | 25 |
| 105 | 31 | 26 |
| 106 | 43 | 16 |
| 107 | 28 | 12 |
| 108 | 2 | 1 |
| 109 | 8 | 3 |
| 110 | 39 | 30 |
| 112 | 25 | 13 |
| 114 | 8.49 | 3.18 |
| 115 | 23.35 | 7.43 |
| 117 | 21.23 | 8.49 |
| 118 | 33 | 15 |

Table 7 Hourly Ancillary Services Dispatch

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hour | Regulation  Up  (MW) | Spinning Reserve  (MW) | Non-spinning Reserve  (MW) | Operating Reserve  (MW) |
| 1 | 68.8 | 260 | 91.17 | 0 |
| 2 | 76.8 | 275.2 | 44.05 | 0 |
| 3 | 76.8 | 271.19 | 0 | 0 |
| 4 | 96.8 | 143.2 | 0 | 0 |
| 5 | 76.8 | 223.18 | 0 | 0 |
| 6 | 76.8 | 275.2 | 7.96 | 0 |
| 7 | 68.8 | 260 | 91.17 | 0 |
| 8 | 98.8 | 363.1 | 6.07 | 0 |
| 9 | 98.8 | 312 | 81.19 | 0 |
| 10 | 98.8 | 312 | 117.27 | 0 |
| 11 | 98.8 | 312 | 123.21 | 0 |
| 12 | 98.8 | 312 | 93.19 | 0 |
| 13 | 98.8 | 325.34 | 55.89 | 0 |
| 14 | 98.8 | 357.2 | 0 | 0 |
| 15 | 100.8 | 320 | 107.27 | 0 |
| 16 | 100.8 | 320 | 119.22 | 0 |
| 17 | 100.8 | 320 | 89.16 | 0 |
| 18 | 100.8 | 320 | 113.24 | 0 |
| 19 | 80 | 320 | 164.04 | 0 |
| 20 | 80 | 320 | 187.97 | 0 |
| 21 | 80.99 | 320 | 199 | 0 |
| 22 | 100.8 | 320 | 119.24 | 0 |
| 23 | 100.8 | 320 | 101.26 | 0 |
| 24 | 98.8 | 312 | 81.19 | 0 |