Procedure

1. Consider the IEEE 33-bus distribution network of Figure 1, along with the data in Table 1.

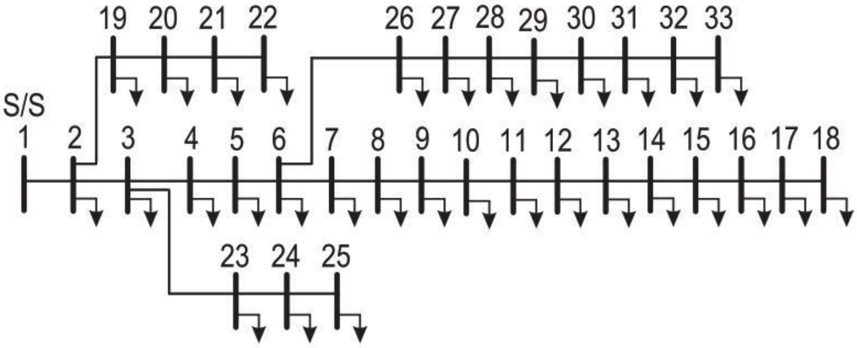

Figure 1. Single-line diagram of IEEE 33-bus distribution system.

Table 1. Data for the IEEE 33-bus distribution system.

Line number	Sending Bus	Receiving Bus	Resistance (Ω)	Reactance (Ω)	Load at Receiving End Bus	
					Real Power (kW)	Reactive Power (kVAr)
1	1 Main SS	2	0.0922	0.0477	100.0	60.0
2	2	3	0.4930	0.2511	90.0	40.0
3	3	4	0.3660	0.1864	120.0	80.0
4	4	5	0.3811	0.1941	60.0	30.0
5	5	6	0.8190	0.7070	60.0	20.0
6	6	7	0.1872	0.6188	200.0	100.0
7	7	8	1.7114	1.2351	200.0	100.0
8	8	9	1.0300	0.7400	60.0	20.0
9	9	10	1.0400	0.7400	60.0	20.0
10	10	11	0.1966	0.0650	45.0	30.0
11	11	12	0.3744	0.1238	60.0	35.0
12	12	13	1.4680	1.1550	60.0	35.0
13	13	14	0.5416	0.7129	120.0	80.0
14	14	15	0.5910	0.5260	60.0	10.0
15	15	16	0.7463	0.5450	60.0	20.0
16	16	17	1.2890	1.7210	60.0	20.0
17	17	18	0.7320	0.5740	90.0	40.0
18	2	19	0.1640	0.1565	90.0	40.0
19	19	20	1.5042	1.3554	90.0	40.0
20	20	21	0.4095	0.4784	90.0	40.0
21	21	22	0.7089	0.9373	90.0	40.0
22	3	23	0.4512	0.3083	90.0	50.0
23	23	24	0.8980	0.7091	420.0	200.0
24	24	25	0.8960	0.7011	420.0	200.0
25	6	26	0.2030	0.1034	60.0	25.0
26	26	27	0.2842	0.1447	60.0	25.0
27	27	28	1.0590	0.9337	60.0	20.0
28	28	29	0.8042	0.7006	120.0	70.0
29	29	30	0.5075	0.2585	200.0	600.0
30	30	31	0.9744	0.9630	150.0	70.0
31	31	32	0.3105	0.3619	210.0	100.0
32	32	33	0.3410	0.5302	60.0	40.0

2. Build the complete model in PowerFactory. Use a substation voltage of 12.66 kV and consider ±5% voltage deviation limit for each bus. Use a base power of 10 MVA (see *8.1.2 Project Settings* in the *User Manual*, access via *Help* menu).
3. Connect an external grid to Bus 1.
4. Add wind-based and photovoltaics (PV) Distributed Generation (DG) to simulate a high DG penetration scenario (PV DG could represent aggregated generation seen at the installed bus). Two wind DG of 1 MW are sited at buses 18 and 24. Three 400 kVA PV DG are installed at buses 5, 21, and 31, and four 500 kVA PV DG are installed at buses 8, 12, 28, and 33. Consider 85% wind and solar injection (MW) of total capacity on load flow page of wind and solar DG. It is assumed that the loads follow the IEEE-RTS model as illustrated in Figure 2 and the load composition is set to $a_p = a_q = 0.4$, $b_p = b_q = 0.3$, and $c_p = c_q = 0.3$. The output generation from wind and PV DG is also expected to follow the curves in Figure 2. Assign the characteristics of Figure 2 to the model (see *18.2 Parameter Characteristics* in the *User Manual*).

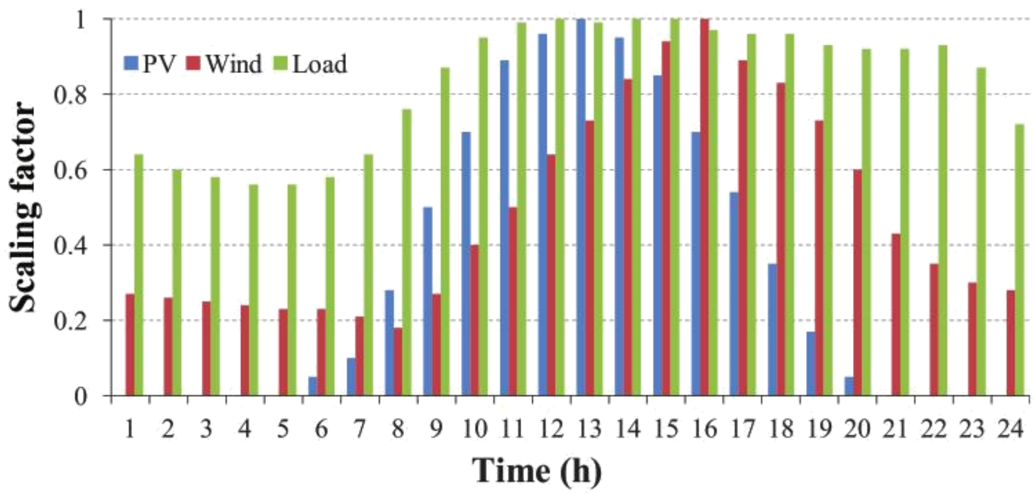

Figure 2. Scaling factors of time-variant load and generation.

5. Define a feeder from Bus 1 (see *15.5 Feeders* in the *User Manual*). Scale the feeder with load composition 3.715 MW and 2.3 MVar.
6. Conduct load flow studies for different times during the day corresponding to Figure 2 (you can do this by changing the *Study Time*).
7. Plot the voltage profile of the feeder for different times during the day corresponding to Figure 2.
8. Calculate % voltage deviation at each bus, as well as real, reactive, total losses and % loading of each line for different times during the day corresponding to Figure 2 (see *10.6 The Flexible Data Page Tab* in the *User Manual*).

9. Plot the results obtained in the previous two steps, over the whole day corresponding to Figure 2, by using Excel (see *10.9.1 Export to Spreadsheet Programs* in the *User Manual*).
10. Present the resulting information in a suitably formatted (including background, objectives, methodology, results and analysis, discussion) and electronically edited (reports with scanned hand-written content will **not** be accepted) design report.