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LAMPIRAN

Hasil Simulasi untuk Skenario 1 IEEE 14 Bus (Sistem AC saja)
Simlasi dilakukan sebanyak 100 kali percobaan dan berikut ini adalah hasil terbaik yang didapatkan

How many?		How much?	P (MW)	Q (MVAr)
Buses	14	Total Gen Capacity	772.4	-52.0 to 148.0
Generators	5	On-line Capacity	772.4	-52.0 to 148.0
Committed Gens	5	Generation (actual)	271.3	98.8
Loads	11	Load	259.0	73.5
Fixed	11	Fixed	259.0	73.5
Dispatchable	0	Dispatchable	-0.0 of -0.0	-0.0
Shunts	1	Shunt (inj)	-0.0	0.1
Branches	20	Losses (I^2 * Z)	12.29	51.83
Transformers	3	Branch Charging (inj)	-	26.5
Inter-ties	0	Total Inter-tie Flow	0.0	0.0
Areas	1			

	Minimum	Maximum
Voltage Magnitude	1.014 p.u. @ bus 14	1.103 p.u. @ bus 1
Voltage Angle	-15.49 deg @ bus 14	0.00 deg @ bus 1
P Losses (I^2*R)	-	3.88 MW @ line 1-2
Q Losses (I^2*X)	-	11.84 MVAr @ line 1-2

Bus Data

Bus #	Voltage Mag(pu)	Voltage Ang(deg)	Generation P (MW)	Generation Q (MVAr)	Load P (MW)	Load Q (MVAr)
1	1.103	0.000*	231.29	-10.77	-	-
2	1.085	-4.508	40.00	25.49	21.70	12.70
3	1.056	-11.703	0.00	28.26	94.20	19.00
4	1.061	-9.453	-	-	47.80	-3.90
5	1.067	-8.087	-	-	7.60	1.60
6	1.051	-13.769	0.00	27.89	11.20	7.50
7	1.055	-12.587	-	-	-	-
8	1.099	-12.587	0.00	27.91	-	-
9	1.034	-14.250	-	-	29.50	16.60
10	1.029	-14.461	-	-	9.00	5.80
11	1.036	-14.248	-	-	3.50	1.80
12	1.035	-14.639	-	-	6.10	1.60
13	1.030	-14.702	-	-	13.50	5.80
14	1.014	-15.488	-	-	14.90	5.00
		Total:	271.29	98.77	259.00	73.50

Branch Data

Brnch #	From Bus	To Bus	From Bus Injection P (MW)	From Bus Injection Q (MVAr)	To Bus Injection P (MW)	To Bus Injection Q (MVAr)	Loss (I^2 * Z) P (MW)	Loss (I^2 * Z) Q (MVAr)
1	1	2	155.81	-12.97	-151.93	18.49	3.879	11.84
2	1	5	75.49	2.19	-72.95	2.50	2.541	10.49
3	2	3	73.17	0.51	-71.03	3.50	2.142	9.02
4	2	4	55.83	-3.23	-54.29	3.99	1.541	4.67
5	2	5	41.22	-2.97	-40.40	1.48	0.823	2.51
6	3	4	-23.17	5.75	23.52	-6.30	0.348	0.89
7	4	5	-62.26	5.63	62.73	-4.16	0.464	1.46
8	4	7	28.76	-4.99	-28.76	6.63	0.000	1.64
9	4	9	16.47	5.57	-16.47	-4.07	0.000	1.50
10	5	6	43.02	-1.42	-43.02	5.72	0.000	4.30
11	6	11	6.67	4.39	-6.62	-4.27	0.055	0.11
12	6	12	7.73	2.63	-7.65	-2.48	0.074	0.15
13	6	13	17.42	7.65	-17.20	-7.23	0.217	0.43
14	7	8	-0.00	-26.77	0.00	27.91	0.000	1.14
15	7	9	28.76	20.15	-28.76	-18.93	0.000	1.22
16	9	10	5.91	3.39	-5.89	-3.35	0.014	0.04
17	9	14	9.83	3.08	-9.70	-2.81	0.126	0.27
18	10	11	-3.11	-2.45	3.12	2.47	0.012	0.03
19	12	13	1.55	0.88	-1.54	-0.87	0.007	0.01
20	13	14	5.25	2.29	-5.20	-2.19	0.053	0.11
						Total:	12.294	51.83

Hasil Simulasi Skenario 2 untuk sistem IEEE 14 Bus (dengan VSC point-to-point)

Simulasi dilakukan dengan 100 kali percobaan dan hasil dibawah ini merupakan hasil terbaik
yang didapatkan

System Summary

How many?		How much?	P (MW)	Q (MVAr)
Buses	14	Total Gen Capacity	772.4	-52.0 to 148.0
Generators	5	On-line Capacity	772.4	-52.0 to 148.0
Committed Gens	5	Generation (actual)	161.0	56.7
Loads	11	Load	154.0	34.5
Fixed	11	Fixed	154.0	34.5
Dispatchable	0	Dispatchable	-0.0 of -0.0	-0.0
Shunts	5	Shunt (inj)	-0.0	0.4
Branches	19	Losses (I^2 * Z)	4.20	18.68
Transformers	4	Branch Charging (inj)	-	23.8
Inter-ties	0	Total Inter-tie Flow	0.0	0.0
Areas	1			

	Minimum	Maximum
Voltage Magnitude	1.000 p.u. @ bus 3	1.045 p.u. @ bus 8
Voltage Angle	-9.37 deg @ bus 14	0.00 deg @ bus 1
P Losses (I^2*R)	-	1.10 MW @ line 1-2
Q Losses (I^2*X)	-	3.74 MVAr @ line 1-5

Bus Data

Bus	Voltage		Generation		Load	
#	Mag(pu)	Ang(deg)	P (MW)	Q (MVAr)	P (MW)	Q (MVAr)
1	1.044	0.000*	120.98	4.23	-	-
2	1.027	-2.433	40.00	7.42	11.70	7.70
3	1.000	-7.056	0.00	7.12	53.20	8.00
4	1.000	-5.829	-	-	26.80	-3.90
5	1.015	-4.981	-	-	7.60	1.60
6	1.027	-8.756	0.00	26.37	10.20	3.50
7	1.025	-7.885	-	-	-	-
8	1.045	-7.885	0.00	11.52	-	-
9	1.015	-8.975	-	-	17.50	6.60
10	1.011	-9.297	-	-	9.00	2.80
11	1.012	-9.173	-	-	3.50	1.80
12	1.016	-9.298	-	-	6.10	1.60
13	1.018	-9.105	-	-	3.50	2.80
14	1.010	-9.366	-	-	4.90	2.00
		Total:	160.98	56.65	154.00	34.50

Branch Data

Brnch #	From Bus	To Bus	From Bus Injection P (MW)	From Bus Injection Q (MVAr)	To Bus Injection P (MW)	To Bus Injection Q (MVAr)	Loss (I^2 * Z) P (MW)	Loss (I^2 * Z) Q (MVAr)
1	1	2	78.55	2.02	-77.45	-4.31	1.102	3.36
2	1	5	42.43	2.21	-41.53	-3.69	0.905	3.74
3	2	3	43.19	3.46	-42.34	-4.40	0.845	3.56
4	2	4	36.18	3.27	-35.45	-4.53	0.735	2.23
5	2	5	26.38	-2.69	-26.00	0.23	0.376	1.15
6	3	4	-10.86	3.61	10.95	-4.66	0.091	0.23
7	4	7	17.99	-1.06	-17.99	1.71	0.000	0.65
8	4	9	10.22	1.27	-10.22	-0.71	0.000	0.57
9	5	6	26.63	-12.87	-26.63	15.11	0.000	2.24
10	6	11	4.73	1.98	-4.70	-1.93	0.024	0.05
11	6	12	4.88	2.12	-4.85	-2.05	0.033	0.07
12	6	13	6.82	3.82	-6.78	-3.74	0.038	0.08
13	7	8	0.00	-11.34	-0.00	11.55	0.000	0.22
14	7	9	17.99	9.63	-17.99	-9.19	0.000	0.44
15	9	10	7.82	2.65	-7.80	-2.60	0.021	0.06
16	9	14	2.90	0.66	-2.88	-0.64	0.011	0.02
17	10	11	-1.20	-0.13	1.20	0.13	0.001	0.00
18	12	13	-1.25	0.45	1.26	-0.44	0.004	0.00
19	13	14	2.03	1.38	-2.02	-1.36	0.010	0.02
						Total:	4.195	18.68

DC bus data

Bus DC #	Bus AC #	Voltage Mag(pu)	Power P (MW)
1	5	1.001	-31.890
2	4	1.000	31.856

VSC Converter Data

Bus DC#	Bus injection P (MW)	Bus injection Q (MVAr)	Converter Voltage Mag(pu)	Converter Voltage Ang(deg)	Total loss P (MW)
1	-33.30	-14.73	0.996	-7.370	1.41
2	30.51	-12.88	0.937	1.034	1.34
				Total:	2.75

Bus DC#	Converter power P (MW)	Converter power Q (MVAr)	Filter Q (MVAr)	Transfo loss P (MW)	Transfo loss Q (MVAr)	Reactor loss P (MW)	Reactor loss Q (MVAr)	Converter loss P (MW)
1	-33.28	-21.90	-8.85	0.02	1.44	0.00	0.25	1.39

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   2    30.53  -16.74   -8.63     0.02    1.23     0.00    3.54        1.32
                                 ------ --------  ------ -------- --------------
                     Total:       0.04    2.67     0.00    3.79        2.72

 Bus  Grid power       Traf Filt.Power  Filter    Conv Filt. Pwr   Converter
Power
 DC#  P (MW) Q (MVAr)  P (MW) Q (MVAr)  Q (MVAr)  Q (MVAr)         P (MW) Q
(MVAr)
----- ------ --------  ------ --------  --------  --------------   ------
--------
   1   -33.30  -14.73  -33.28   -13.29   -8.85     -22.14          -33.28  -21.90
   2    30.51  -12.88   30.53   -11.65   -8.63     -20.28           30.53  -16.74
================================================================================
|     DC branch data                                                           |
================================================================================
Brnch   From   To     From Bus    To Bus      Loss
  #     Bus    Bus    P (MW)      P (MW)      P (MW)
-----  -----  -----  --------    --------    --------
   1      1      2     31.89      -31.86        0.03
                                             --------
                                 Total:         0.03
```

Hasil Simulasi Skenario 3 Sistem IEEE 14 Bus (VSC Multiterminal)

Simulasi dilakukan dengan 100 kali percobaan dan hasil dibawah ini merupakan hasil yang terbaik yang didapatkan

```
================================================================================
|     System Summary                                                           |
================================================================================

How many?                How much?              P (MW)            Q (MVAr)
---------------------    -------------------  -------------  -----------------
Buses              14     Total Gen Capacity     640.0        -192.0 to 228.0
Generators          5     On-line Capacity       640.0        -192.0 to 228.0
Committed Gens      5     Generation (actual)    279.6              26.6
Loads              11     Load                   259.0              81.4
  Fixed            11       Fixed                259.0              81.4
  Dispatchable      0       Dispatchable          -0.0 of -0.0      -0.0
Shunts              2     Shunt (inj)             -0.0              -0.3
Branches           17     Losses (I^2 * Z)         4.91             20.98
Transformers        4     Branch Charging (inj)     -               19.4
Inter-ties          0     Total Inter-tie Flow     0.0               0.0
Areas               1

                          Minimum                      Maximum
                 -------------------------  --------------------------------
Voltage Magnitude   1.000 p.u. @ bus 4          1.099 p.u. @ bus 8
Voltage Angle      -6.27 deg   @ bus 6          0.00 deg   @ bus 1
P Losses (I^2*R)             -                  1.62 MW    @ line 6-4
Q Losses (I^2*X)             -                  4.50 MVAr  @ line 2-6

================================================================================
|     Bus Data                                                                 |
================================================================================
 Bus      Voltage          Generation             Load
  #   Mag(pu) Ang(deg)   P (MW)   Q (MVAr)   P (MW)   Q (MVAr)
----- ------- --------  --------  --------  --------  --------
    1  1.063    0.000*    96.03     -2.26       -         -
    2  1.053   -1.430    113.98    -37.15     21.70     12.70
    3  1.049   -3.036     69.63     24.55     11.20      7.50
    4  1.000   -1.119       -         -       47.80      4.00
    5  1.044   -5.495       -         -        7.60      1.60
    6  1.010   -6.273      0.00     19.09     94.20     19.00
    7  1.064   -3.639       -         -         -         -
    8  1.099   -3.639      0.00     22.34       -         -
    9  1.033   -5.027       -         -       29.50     16.60
   10  1.028   -4.975       -         -        9.00      5.80
   11  1.035   -4.149       -         -        3.50      1.80
   12  1.034   -4.013       -         -        6.10      1.60
   13  1.029   -4.185       -         -       13.50      5.80
   14  1.013   -5.707       -         -       14.90      5.00
                        --------  --------  --------  --------
               Total:    279.64     26.57    259.00     81.40
```

Branch Data

Brnch #	From Bus	To Bus	From Bus Injection P (MW)	From Bus Injection Q (MVAr)	To Bus Injection P (MW)	To Bus Injection Q (MVAr)	Loss (I^2 * Z) P (MW)	Loss (I^2 * Z) Q (MVAr)
1	1	2	48.41	0.72	-48.00	-5.39	0.404	1.23
2	1	5	47.62	-2.98	-46.54	1.99	1.084	4.47
3	2	6	48.45	10.63	-47.38	-10.79	1.068	4.50
4	3	11	11.66	2.20	-11.54	-1.95	0.121	0.25
5	3	12	8.31	2.25	-8.23	-2.08	0.083	0.17
6	3	13	19.96	6.59	-19.69	-6.06	0.265	0.52
7	4	7	24.21	10.01	-24.21	-8.78	0.000	1.23
8	4	9	13.10	-0.56	-13.10	1.46	0.000	0.90
9	5	3	-18.50	-5.14	18.50	6.01	0.000	0.87
10	6	4	-46.82	11.05	48.44	-10.32	1.622	4.14
11	7	8	0.00	-21.18	-0.00	21.88	0.000	0.70
12	7	9	24.21	29.97	-24.21	-28.53	0.000	1.44
13	9	10	1.02	5.80	-1.01	-5.77	0.010	0.03
14	9	14	6.78	4.67	-6.70	-4.49	0.081	0.17
15	10	11	-7.99	-0.03	8.04	0.15	0.050	0.12
16	12	13	2.13	0.48	-2.12	-0.47	0.010	0.01
17	13	14	8.31	0.73	-8.20	-0.51	0.112	0.23
						Total:	4.910	20.98

DC bus data

Bus DC #	Bus AC #	Voltage Mag(pu)	Power P (MW)
1	5	1.006	-55.029
2	4	1.000	141.375
3	2	1.015	-88.009

VSC Converter Data

Bus DC#	Bus injection P (MW)	Bus injection Q (MVAr)	Converter Voltage Mag(pu)	Converter Voltage Ang(deg)	Total loss P (MW)
1	-57.44	-1.55	1.021	-13.850	2.41
2	133.55	3.13	1.097	18.505	7.83
3	-91.83	55.08	1.192	-13.383	3.83
				Total:	14.07

Bus DC#	Converter power P (MW)	Converter power Q (MVAr)	Filter Q (MVAr)	Transfo loss P (MW)	Transfo loss Q (MVAr)	Reactor loss P (MW)	Reactor loss Q (MVAr)	Converter loss P (MW)
1	-56.60	-2.75	-9.66	0.05	3.39	0.79	5.06	1.58
2	138.79	42.74	-9.17	0.27	20.00	4.98	28.77	2.58

3	-90.26	70.88	-11.02	0.16	11.60	1.42	15.22	2.25
			Total:	0.47	35.00	7.19	49.05	6.41

Bus DC#	Grid power P (MW)	Grid power Q (MVAr)	Traf Filt.Power P (MW)	Traf Filt.Power Q (MVAr)	Filter Q (MVAr)	Conv Filt. Pwr Q (MVAr)	Converter Power P (MW)	Converter Power Q (MVAr)
1	-57.44	-1.55	-57.40	1.84	-9.66	-7.82	-56.60	-2.75
2	133.55	3.13	133.81	23.13	-9.17	13.96	138.79	42.74
3	-91.83	55.08	-91.68	66.68	-11.02	55.67	-90.26	70.88

DC branch data

Brnch #	From Bus	To Bus	From Bus P (MW)	To Bus P (MW)	Loss P (MW)
1	1	2	88.71	-88.19	0.52
2	2	3	-53.19	54.01	0.82
3	1	3	-33.68	34.00	0.32
				Total:	1.66

Hasil Simulasi Skenario 1 Sistem IEEE 30 Bus (Sistem AC saja)

Simulasi dilakukan dengan 100 kali percobaan dan hasil dibawah ini merupakan hasil yang terbaik yang didapatkan

System Summary

How many?		How much?	P (MW)	Q (MVAr)
Buses	30	Total Gen Capacity	900.2	-102.0 to 188.0
Generators	6	On-line Capacity	900.2	-102.0 to 188.0
Committed Gens	6	Generation (actual)	299.5	153.9
Loads	21	Load	283.4	126.2
Fixed	21	Fixed	283.4	126.2
Dispatchable	0	Dispatchable	-0.0 of -0.0	-0.0
Shunts	2	Shunt (inj)	-0.0	0.3
Branches	41	Losses (I^2 * Z)	16.14	65.81
Transformers	4	Branch Charging (inj)	-	37.8
Inter-ties	0	Total Inter-tie Flow	0.0	0.0
Areas	1			

	Minimum	Maximum
Voltage Magnitude	1.011 p.u. @ bus 26	1.102 p.u. @ bus 1
Voltage Angle	-16.77 deg @ bus 30	0.00 deg @ bus 1
P Losses (I^2*R)	-	4.76 MW @ line 1-2
Q Losses (I^2*X)	-	14.26 MVAr @ line 1-2

Bus Data

Bus	Voltage		Generation		Load	
#	Mag(pu)	Ang(deg)	P (MW)	Q (MVAr)	P (MW)	Q (MVAr)
1	1.102	0.000*	259.54	-27.93	-	-
2	1.088	-4.944	40.00	48.59	21.70	12.70
3	1.073	-7.011	-	-	2.40	1.20
4	1.066	-8.627	-	-	7.60	1.60
5	1.053	-12.974	0.00	32.39	94.20	19.00
6	1.057	-10.187	-	-	-	-
7	1.048	-11.817	-	-	22.80	10.90
8	1.058	-10.907	0.00	43.24	30.00	30.00
9	1.066	-13.185	-	-	-	-
10	1.043	-14.823	-	-	5.80	2.00
11	1.099	-13.185	0.00	17.60	-	-
12	1.050	-14.322	-	-	11.20	7.50
13	1.101	-14.322	0.00	39.97	-	-
14	1.036	-15.176	-	-	6.20	1.60
15	1.032	-15.231	-	-	8.20	2.50
16	1.040	-14.809	-	-	3.50	1.80
17	1.037	-15.032	-	-	9.00	5.80
18	1.024	-15.788	-	-	3.20	0.90

19	1.022	-15.925	-	-	9.50	3.40
20	1.026	-15.707	-	-	2.20	0.70
21	1.030	-15.250	-	-	17.50	11.20
22	1.031	-15.230	-	-	-	-
23	1.022	-15.503	-	-	3.20	1.60
24	1.018	-15.516	-	-	8.70	6.70
25	1.029	-15.201	-	-	-	-
26	1.011	-15.612	-	-	3.50	2.30
27	1.043	-14.741	-	-	-	-
28	1.052	-10.775	-	-	-	-
29	1.024	-15.922	-	-	2.40	0.90
30	1.013	-16.770	-	-	10.60	1.90
		Total:	299.54	153.86	283.40	126.20

Branch Data

Brnch #	From Bus	To Bus	From Bus Injection P (MW)	From Bus Injection Q (MVAr)	To Bus Injection P (MW)	To Bus Injection Q (MVAr)	Loss (I^2 * Z) P (MW)	Loss (I^2 * Z) Q (MVAr)
1	1	2	171.99	-26.22	-167.23	34.15	4.761	14.26
2	1	3	87.55	-1.71	-84.70	7.31	2.854	10.43
3	2	4	43.21	-1.20	-42.31	-0.33	0.900	2.74
4	3	4	82.30	-8.51	-81.51	9.80	0.784	2.25
5	2	5	81.99	2.87	-79.29	3.64	2.692	11.31
6	2	6	60.33	0.06	-58.54	1.07	1.789	5.43
7	4	6	75.17	3.29	-74.57	-2.24	0.593	2.06
8	5	7	-14.91	9.75	15.05	-11.64	0.141	0.36
9	6	7	38.20	-1.55	-37.85	0.74	0.349	1.07
10	6	8	29.92	-12.85	-29.80	12.24	0.113	0.39
11	6	9	28.87	6.77	-28.87	-5.19	0.000	1.58
12	6	10	16.29	6.73	-16.29	-5.23	0.000	1.50
13	9	11	-0.00	-17.07	0.00	17.60	0.000	0.53
14	9	10	28.87	22.26	-28.87	-20.97	0.000	1.29
15	4	12	41.06	-14.36	-41.06	19.12	0.000	4.76
16	12	13	-0.00	-38.12	0.00	39.97	0.000	1.84
17	12	14	7.47	2.37	-7.41	-2.23	0.069	0.14
18	12	15	16.44	6.43	-16.25	-6.06	0.187	0.37
19	12	16	5.95	2.70	-5.91	-2.62	0.037	0.08
20	14	15	1.21	0.63	-1.20	-0.63	0.004	0.00
21	16	17	2.41	0.82	-2.41	-0.81	0.003	0.01
22	15	18	5.34	1.30	-5.31	-1.23	0.030	0.06
23	18	19	2.11	0.33	-2.10	-0.33	0.003	0.01
24	19	20	-7.40	-3.07	7.42	3.11	0.021	0.04
25	10	20	9.71	4.03	-9.62	-3.81	0.095	0.21
26	10	17	6.61	5.04	-6.59	-4.99	0.021	0.05
27	10	21	15.56	10.46	-15.45	-10.22	0.112	0.24
28	10	22	7.47	4.90	-7.42	-4.79	0.053	0.11
29	21	22	-2.05	-0.98	2.05	0.98	0.001	0.00
30	15	23	3.91	2.89	-3.89	-2.84	0.022	0.04
31	22	24	5.37	3.80	-5.32	-3.73	0.047	0.07

32	23	24	0.69	1.24	-0.69	-1.24	0.003	0.01
33	24	25	-2.69	-1.64	2.70	1.67	0.018	0.03
34	25	26	3.54	2.37	-3.50	-2.30	0.044	0.07
35	25	27	-6.25	-4.03	6.30	4.14	0.057	0.11
36	28	27	19.58	9.05	-19.58	-7.45	0.000	1.60
37	27	29	6.18	1.66	-6.10	-1.50	0.083	0.16
38	27	30	7.09	1.65	-6.93	-1.36	0.156	0.29
39	29	30	3.70	0.60	-3.67	-0.54	0.032	0.06
40	8	28	-0.20	1.00	0.20	-5.75	0.007	0.02
41	6	28	19.84	2.08	-19.78	-3.30	0.061	0.22
							--------	--------
						Total:	16.139	65.81

Hasil Simulasi Skenario 2 Sistem IEEE 30 Bus (VSC point-to-point)

Simulasi dilakukan dengan 100 kali percobaan dan hasil dibawah ini merupakan hasil yang terbaik yang didapatkan

```
================================================================================
|     System Summary                                                           |
================================================================================

How many?                How much?              P (MW)            Q (MVAr)
---------------------    -------------------  -------------  -----------------
Buses              30     Total Gen Capacity     900.2        -102.0 to 188.0
Generators          6     On-line Capacity       900.2        -102.0 to 188.0
Committed Gens      6     Generation (actual)    300.3             234.4
Loads              21     Load                   283.4             126.2
  Fixed            21       Fixed                283.4             126.2
  Dispatchable      0       Dispatchable          -0.0 of -0.0      -0.0
Shunts              2     Shunt (inj)             -0.0               0.3
Branches           41     Losses (I^2 * Z)        12.58             46.91
Transformers        4     Branch Charging (inj)     -               34.3
Inter-ties          0     Total Inter-tie Flow     0.0               0.0
Areas               1

                          Minimum                      Maximum
                 -------------------------  --------------------------------
Voltage Magnitude   0.952 p.u. @ bus 26         1.065 p.u. @ bus 13
Voltage Angle     -14.50 deg   @ bus 30         0.00 deg   @ bus 1
P Losses (I^2*R)             -                  2.69 MW    @ line 2-5
Q Losses (I^2*X)             -                 11.28 MVAr  @ line 2-5

================================================================================
|     Bus Data                                                                 |
================================================================================
 Bus      Voltage          Generation             Load
  #   Mag(pu) Ang(deg)   P (MW)   Q (MVAr)   P (MW)   Q (MVAr)
----- ------- --------  --------  --------  --------  --------
    1  1.063    0.000*   170.33     18.16       -         -
    2  1.038   -3.080    130.00    108.36     21.70     12.70
    3  1.023   -5.241       -         -        2.40      1.20
    4  1.013   -6.433       -         -        7.60      1.60
    5  0.992  -11.376      0.00     24.65     94.20     19.00
    6  1.005   -7.868       -         -         -         -
    7  0.992   -9.846       -         -       22.80     10.90
    8  1.005   -8.630      0.00     40.27     30.00     30.00
    9  0.967   -9.572       -         -         -         -
   10  0.965  -10.470       -         -        5.80      2.00
   11  0.978   -9.572      0.00      5.29       -         -
   12  1.015   -9.891       -         -       11.20      7.50
   13  1.065   -9.891      0.00     37.73       -         -
   14  0.995  -10.903       -         -        6.20      1.60
   15  0.986  -10.944       -         -        8.20      2.50
   16  1.000   -7.265       -         -        3.50      1.80
   17  0.971   -9.738       -         -        9.00      5.80
   18  0.966  -11.564       -         -        3.20      0.90
```

19	0.957	-11.720	-	-	9.50	3.40
20	0.958	-11.469	-	-	2.20	0.70
21	0.954	-11.033	-	-	17.50	11.20
22	0.955	-11.031	-	-	-	-
23	0.968	-11.441	-	-	3.20	1.60
24	0.953	-11.730	-	-	8.70	6.70
25	0.970	-12.244	-	-	-	-
26	0.952	-12.706	-	-	3.50	2.30
27	0.990	-12.240	-	-	-	-
28	0.998	-8.422	-	-	-	-
29	0.970	-13.555	-	-	2.40	0.90
30	0.958	-14.500	-	-	10.60	1.90
		Total:	300.33	234.45	283.40	126.20

Branch Data

Brnch #	From Bus	To Bus	From Bus Injection P (MW)	From Bus Injection Q (MVAr)	To Bus Injection P (MW)	To Bus Injection Q (MVAr)	Loss (I^2 * Z) P (MW)	Loss (I^2 * Z) Q (MVAr)
1	1	2	107.21	9.43	-105.23	-9.33	1.981	5.93
2	1	3	63.12	8.72	-61.47	-7.15	1.644	6.01
3	2	4	36.68	1.90	-35.96	-3.57	0.720	2.19
4	3	4	59.07	5.95	-58.63	-5.55	0.445	1.28
5	2	5	77.54	8.64	-74.85	-1.67	2.686	11.28
6	2	6	50.95	2.72	-49.54	-2.34	1.412	4.28
7	4	6	62.43	2.34	-61.97	-1.68	0.453	1.58
8	5	7	-19.35	7.32	19.56	-8.81	0.207	0.52
9	6	7	42.84	1.90	-42.36	-2.09	0.487	1.50
10	6	8	29.47	-9.24	-29.36	8.72	0.112	0.39
11	6	9	13.29	-2.55	-13.29	2.97	0.000	0.41
12	6	10	7.95	8.28	-7.95	-7.56	0.000	0.72
13	9	11	-0.00	-5.23	0.00	5.29	0.000	0.06
14	9	10	13.29	2.27	-13.29	-2.05	0.000	0.21
15	4	12	24.56	5.18	-24.56	-3.65	0.000	1.53
16	12	13	0.00	-35.97	-0.00	37.73	0.000	1.76
17	12	14	8.77	3.73	-8.66	-3.51	0.108	0.23
18	12	15	20.43	12.46	-20.07	-11.74	0.368	0.72
19	12	16	-15.84	15.92	16.30	-14.95	0.462	0.97
20	14	15	2.46	1.91	-2.44	-1.89	0.022	0.02
21	16	17	24.21	8.90	-23.86	-7.62	0.349	1.28
22	15	18	7.48	5.64	-7.39	-5.44	0.097	0.20
23	18	19	4.19	4.54	-4.16	-4.49	0.026	0.05
24	19	20	-5.34	1.09	5.35	-1.06	0.011	0.02
25	10	20	7.61	-0.23	-7.55	0.36	0.058	0.13
26	10	17	-14.79	-1.62	14.86	1.82	0.077	0.20
27	10	21	15.32	6.98	-15.21	-6.75	0.106	0.23
28	10	22	7.29	2.62	-7.25	-2.52	0.047	0.10
29	21	22	-2.29	-4.45	2.29	4.45	0.003	0.01
30	15	23	6.82	5.49	-6.74	-5.33	0.079	0.16
31	22	24	4.96	-1.93	-4.92	1.99	0.036	0.06
32	23	24	3.54	3.73	-3.51	-3.65	0.037	0.08
33	24	25	-0.27	-4.88	0.32	4.97	0.050	0.09

34	25	26	3.55	2.37	-3.50	-2.30	0.049	0.07
35	25	27	-3.87	-7.34	3.95	7.49	0.080	0.15
36	28	27	17.26	12.54	-17.26	-10.86	0.000	1.68
37	27	29	6.20	1.69	-6.11	-1.51	0.092	0.17
38	27	30	7.10	1.68	-6.93	-1.36	0.174	0.33
39	29	30	3.71	0.61	-3.67	-0.54	0.036	0.07
40	8	28	-0.64	1.55	0.65	-5.81	0.009	0.03
41	6	28	17.97	5.64	-17.91	-6.73	0.061	0.21
						Total:	11.051	46.91

DC bus data

Bus DC #	Bus AC #	Voltage Mag(pu)	Power P (MW)
1	2	1.006	-45.718
2	16	1.000	45.441

VSC Converter Data

Bus DC#	Bus injection P (MW)	Bus injection Q (MVAr)	Converter Voltage Mag(pu)	Converter Voltage Ang(deg)	Total loss P (MW)
1	-48.36	-91.72	0.916	-7.004	2.64
2	44.02	-4.25	0.996	-4.035	1.43
				Total:	4.06

Bus DC#	Converter power P (MW)	Converter power Q (MVAr)	Filter Q (MVAr)	Transfo loss P (MW)	Transfo loss Q (MVAr)	Reactor loss P (MW)	Reactor loss Q (MVAr)	Converter loss P (MW)
1	-48.20	-85.42	-7.83	0.15	11.19	0.01	2.95	2.48
2	44.05	-10.56	-8.82	0.03	2.19	0.00	0.32	1.39
			Total:	0.18	13.38	0.01	3.26	3.87

Bus DC#	Grid power P (MW)	Grid power Q (MVAr)	Traf Filt.Power P (MW)	Traf Filt.Power Q (MVAr)	Filter Q (MVAr)	Conv Filt. Pwr Q (MVAr)	Converter Power P (MW)	Converter Power Q (MVAr)
1	-48.36	-91.72	-48.21	-80.53	-7.83	-88.36	-48.20	-85.42
2	44.02	-4.25	44.05	-2.06	-8.82	-10.88	44.05	-10.56

DC branch data

Brnch #	From Bus	To Bus	From Bus P (MW)	To Bus P (MW)	Loss P (MW)
1	1	2	45.72	-45.44	0.28

```
                 --------
Total:              0.28
```

Hasil Simulasi Skenario 3 Sistem IEEE 30 Bus (VSC Multiterminal)

Simulasi dilakukan dengan 100 kali percobaan dan hasil dibawah ini merupakan hasil yang terbaik yang didapatkan

```
================================================================================
|     System Summary                                                           |
================================================================================

How many?                How much?              P (MW)            Q (MVAr)
---------------------    -------------------  -------------  -----------------
Buses             30     Total Gen Capacity     900.2       -102.0 to 188.0
Generators         6     On-line Capacity       900.2       -102.0 to 188.0
Committed Gens     6     Generation (actual)    299.4             55.4
Loads             21     Load                   283.4            126.2
  Fixed           21       Fixed                283.4            126.2
  Dispatchable     0       Dispatchable          -0.0 of -0.0      -0.0
Shunts             2     Shunt (inj)             -0.0               0.4
Branches          41     Losses (I^2 * Z)         7.69             35.05
Transformers       4     Branch Charging (inj)     -               34.0
Inter-ties         0     Total Inter-tie Flow     0.0               0.0
Areas              1

                          Minimum                      Maximum
                 -------------------------  --------------------------------
Voltage Magnitude   0.993 p.u. @ bus 7         1.099 p.u. @ bus 13
Voltage Angle     -13.44 deg   @ bus 30        0.00 deg   @ bus 1
P Losses (I^2*R)             -                 1.86 MW    @ line 1-2
Q Losses (I^2*X)             -                 5.56 MVAr  @ line 1-2

================================================================================
|     Bus Data                                                                 |
================================================================================
 Bus      Voltage          Generation             Load
  #   Mag(pu) Ang(deg)   P (MW)   Q (MVAr)   P (MW)   Q (MVAr)
----- ------- --------  --------  --------  --------  --------
    1  1.050    0.000*   259.40    -37.02       -         -
    2  1.031   -3.104     40.00     20.61     21.70     12.70
    3  1.016   -4.994       -         -        2.40      1.20
    4  1.008   -6.121       -         -        7.60      1.60
    5  1.002   -7.965      0.00     10.48     94.20     19.00
    6  1.000   -6.989       -         -         -         -
    7  0.993   -7.929       -         -       22.80     10.90
    8  0.997   -7.722      0.00     31.17     30.00     30.00
    9  1.083   -9.942       -         -         -         -
   10  1.063  -11.578       -         -        5.80      2.00
   11  1.093   -9.942      0.00      5.19       -         -
   12  1.067  -11.250       -         -       11.20      7.50
   13  1.099  -11.250      0.00     24.97       -         -
   14  1.053  -12.054       -         -        6.20      1.60
   15  1.050  -12.091       -         -        8.20      2.50
   16  1.058  -11.659       -         -        3.50      1.80
   17  1.057  -11.807       -         -        9.00      5.80
   18  1.043  -12.586       -         -        3.20      0.90
```

19	1.041	-12.693	-	-	9.50	3.40
20	1.046	-12.470	-	-	2.20	0.70
21	1.050	-11.995	-	-	17.50	11.20
22	1.051	-11.978	-	-	-	-
23	1.041	-12.315	-	-	3.20	1.60
24	1.037	-12.274	-	-	8.70	6.70
25	1.046	-11.937	-	-	-	-
26	1.029	-12.333	-	-	3.50	2.30
27	1.060	-11.472	-	-	-	-
28	0.994	-7.632	-	-	-	-
29	1.041	-12.617	-	-	2.40	0.90
30	1.030	-13.437	-	-	10.60	1.90
		Total:	299.40	55.39	283.40	126.20

Branch Data

Brnch #	From Bus	To Bus	From Bus Injection P (MW)	From Bus Injection Q (MVAr)	To Bus Injection P (MW)	To Bus Injection Q (MVAr)	Loss (I^2 * Z) P (MW)	Loss (I^2 * Z) Q (MVAr)
1	1	2	103.25	0.94	-101.39	-1.09	1.858	5.56
2	1	3	58.43	5.74	-57.01	-4.89	1.425	5.21
3	2	4	32.67	1.69	-32.09	-3.75	0.580	1.77
4	3	4	54.61	3.69	-54.22	-3.45	0.383	1.10
5	2	5	45.53	3.61	-44.60	-4.00	0.936	3.93
6	2	6	41.48	3.69	-40.53	-4.64	0.959	2.91
7	4	6	39.32	7.94	-39.14	-8.18	0.189	0.66
8	5	7	2.36	6.25	-2.33	-8.21	0.027	0.07
9	6	7	20.58	1.35	-20.47	-2.69	0.114	0.35
10	6	8	29.85	-2.18	-29.74	1.65	0.107	0.38
11	6	9	29.87	16.98	-29.87	-15.00	0.000	1.98
12	6	10	16.97	9.98	-16.97	-8.23	0.000	1.75
13	9	11	0.00	-5.14	-0.00	5.19	0.000	0.05
14	9	10	29.87	20.14	-29.87	-18.92	0.000	1.22
15	4	12	39.39	-2.33	-39.39	5.90	0.000	3.57
16	12	13	0.00	-24.25	-0.00	24.97	0.000	0.72
17	12	14	7.29	2.34	-7.23	-2.21	0.063	0.13
18	12	15	15.75	6.19	-15.58	-5.86	0.167	0.33
19	12	16	5.15	2.31	-5.13	-2.26	0.026	0.06
20	14	15	1.03	0.61	-1.02	-0.61	0.003	0.00
21	16	17	1.63	0.46	-1.63	-0.45	0.001	0.00
22	15	18	4.88	1.12	-4.85	-1.07	0.024	0.05
23	18	19	1.65	0.17	-1.65	-0.16	0.002	0.00
24	19	20	-7.85	-3.24	7.87	3.28	0.023	0.05
25	10	20	10.17	4.21	-10.07	-3.98	0.100	0.22
26	10	17	7.40	5.41	-7.37	-5.35	0.024	0.06
27	10	21	15.82	10.66	-15.71	-10.42	0.112	0.24
28	10	22	7.65	5.03	-7.59	-4.92	0.054	0.11
29	21	22	-1.79	-0.78	1.79	0.78	0.000	0.00
30	15	23	3.53	2.85	-3.51	-2.82	0.019	0.04
31	22	24	5.81	4.14	-5.75	-4.06	0.053	0.08
32	23	24	0.31	1.22	-0.31	-1.21	0.002	0.00
33	24	25	-2.64	-1.22	2.65	1.25	0.015	0.03

```
 34     25     26      3.54      2.36     -3.50     -2.30     0.042      0.06
 35     25     27     -6.20     -3.61      6.25      3.71     0.051      0.10
 36     28     27     19.51      8.52    -19.51     -7.00     0.000      1.51
 37     27     29      6.18      1.65     -6.10     -1.50     0.080      0.15
 38     27     30      7.08      1.64     -6.93     -1.36     0.151      0.28
 39     29     30      3.70      0.60     -3.67     -0.54     0.031      0.06
 40      8     28     -0.26     -0.49      0.26     -3.75     0.002      0.01
 41      6     28     19.84      3.72    -19.77     -4.76     0.070      0.25
                                                          --------  --------
                                                 Total:     7.694     35.05

================================================================================
|     DC bus data                                                              |
================================================================================
 Bus   Bus   Voltage    Power
 DC #  AC #  Mag(pu)    P (MW)
-----  ----  ---------  --------
   1     1     1.024    -95.278
   2     6     1.000     38.809
   3     5     0.986     53.454

================================================================================
|     VSC Converter Data                                                       |
================================================================================
 Bus     Bus injection          Converter Voltage                 Total loss
 DC#   P (MW)   Q (MVAr)        Mag(pu) Ang(deg)                   P (MW)
-----  -------  --------        ------- --------                 -----------
   1   -97.72    43.70           1.111   -6.647                      2.44
   2    37.45    17.04           1.022   -4.331                      1.36
   3    51.96    10.77           1.018   -3.885                      1.49
                                                                   ------
                                                        Total:      5.29

 Bus  Converter power   Filter   Transfo loss     Reactor loss    Converter loss
 DC#  P (MW) Q (MVAr)  Q (MVAr)  P (MW) Q (MVAr)  P (MW) Q (MVAr)    P (MW)
----- ------- -------  --------  ------ --------  ------ -------- --------------
   1   -97.55   47.04  -10.74     0.16   11.64     0.01    2.44        2.28
   2    37.48    9.92   -9.24     0.03    1.90     0.00    0.22        1.33
   3    52.01    5.49   -9.17     0.04    3.14     0.00    0.74        1.45
                                 ------ --------  ------ -------- --------------
                      Total:      0.22   16.68     0.01    3.41        5.05

 Bus  Grid power        Traf Filt.Power  Filter    Conv Filt. Pwr   Converter
Power
 DC#  P (MW) Q (MVAr)  P (MW) Q (MVAr)  Q (MVAr)  Q (MVAr)          P (MW) Q
(MVAr)
----- ------ --------  ------ --------  --------  --------------   ------
--------
   1   -97.72   43.70  -97.56    55.34  -10.74      44.60          -97.55   47.04
   2    37.45   17.04   37.48    18.94   -9.24       9.70           37.48    9.92
   3    51.96   10.77   52.00    13.91   -9.17       4.74           52.01    5.49
================================================================================
|     DC branch data                                                           |
================================================================================
```

Brnch #	From Bus	To Bus	From Bus P (MW)	To Bus P (MW)	Loss P (MW)
1	1	2	95.28	-93.03	2.25
2	2	3	54.22	-53.45	0.76
				Total:	3.01