

DAFTAR PUSTAKA

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LAMPIRAN

Hasil Simulasi untuk Skenario 1 IEEE 14 Bus (Sistem AC saja)

Simulasi 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

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| Bus Data |
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Bus #	Voltage		Generation		Load	
	Mag(pu)	Ang(deg)	P (MW)	Q (MVar)	P (MW)	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) Q (MVar)	To Bus Injection P (MW) Q (MVar)	Loss (I ² * Z) P (MW) 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

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 | System Summary |
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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

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 | Bus Data |
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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 P (MW)	Injection Q (MVar)	To Bus P (MW)	Injection Q (MVar)	Loss (I ² * Z)		
							P (MW)	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		Converter Voltage		Reactor loss		Converter loss		P (MW)	
	P (MW)	Q (MVar)	Mag(pu)	Ang(deg)	P (MW)	Q (MVar)	P (MW)			
1	-33.30	-14.73	0.996	-7.370	0.00	0.25	1.41			
2	30.51	-12.88	0.937	1.034	0.00	0.25	1.34			
							Total:	2.75		
Bus DC#	Converter power P (MW)	Q (MVar)	Filter Q (MVar)	Transfo loss P (MW)	Q (MVar)	Reactor loss P (MW)	Q (MVar)	Converter loss P (MW)		
1	-33.28	-21.90	-8.85	0.02	1.44	0.00	0.25	1.39		

2	30.53	-16.74	-8.63	0.02	1.23	0.00	3.54	1.32
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Total:				0.04	2.67	0.00	3.79	2.72
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Bus Power	Grid power	Traf	Filt.Power	Filter	Conv	Filt. Pwr	Converter
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

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| DC branch data |

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Brnch #	From Bus	To Bus	From Bus P (MW)	To Bus P (MW)	Loss 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)	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		Converter Voltage		Total loss	
	P (MW)	Q (MVar)	Mag(pu)	Ang(deg)	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		Filter	Transfo loss		Reactor loss		Converter loss
	P (MW)	Q (MVar)	Q (MVar)	P (MW)	Q (MVar)	P (MW)	Q (MVar)	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 Power	Grid power	Traf	Filt.Power	Filter	Conv	Filt. Pwr	Converter
DC#	P (MW)	Q (MVar)	P (MW)	Q (MVar)	Q (MVar)	Q (MVar)	P (MW) 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 P (MW)	Injection Q (MVar)	To Bus P (MW)	Injection Q (MVar)	Loss (I ² * Z)		
							P (MW)	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 P (MW)	Injection Q (MVar)	To Bus P (MW)	Injection Q (MVar)	Loss (I ² * Z)	
							P (MW)	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 |
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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 |
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Bus DC#	Bus injection		Converter Voltage		Total loss
	P (MW)	Q (MVar)	Mag(pu)	Ang(deg)	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		Filter	Transfo loss		Reactor loss		Converter loss	
	P (MW)	Q (MVar)	Q (MVar)	P (MW)	Q (MVar)	P (MW)	Q (MVar)	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		Traf Filt.Power		Filter	Conv Filt. Pwr		Converter	
	P (MW)	Q (MVar)	P (MW)	Q (MVar)	Q (MVar)	Q (MVar)		P (MW)	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

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| DC branch data |
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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

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=====
|      System Summary      |
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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

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|      Bus Data      |
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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
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Branch Data									
Brnch #	From Bus	To Bus	From Bus P (MW)	Injection Q (MVar)	To Bus P (MW)	Injection Q (MVar)	Loss (I ² * Z)		
							P (MW)	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

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

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| VSC Converter Data |
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Bus DC#	Bus injection		Converter Voltage		Total loss
	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 DC#	Converter power		Filter	Transfo loss		Reactor loss		Converter loss
	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 DC#	Grid power		Traf Filt. Power		Filter	Conv Filt. Pwr	Converter	
	P (MW)	Q (MVar)	P (MW)	Q (MVar)	Q (MVar)	Q (MVar)	P (MW)	Q
		(MVar)						(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

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