Table 3-6 Power Generation of SNI (As of Jan. 1993)

(1) Thermal Generation				
Enterprise	Installed Capacity (MW)	Rehabilitation Capacity (MW)	Operationable Capacity (MW)	Effective Output (MW)
Electric power Companies*	416.5	111.7	304.8	248.9
INECEL	391.6	30.9	360.7	334.3
SUM	808.1	142.6	665.5	583.2
(2) Hydro Generation				
Enterprise	Installed Capacity (MW)	Rehabilitation Capacity (MW)	Operational Capacity (MW)	Guaranteed Output (MW)
Electric Power Companies*	169.9	0	169.9	91.2
INECEL	1,300.2	0	1,300.2	1,118.2
SUM	1,470.1	-	1,470.1	1,209.4
(3) Total of (1)&(2)	2,278.2	142.6	2,135.6	1,792.6

Note: * mark means electric power companies interconnected to SNI, but not included Orient and Galapagos
Power generation at the terminal of generator is applied

Table 3-7 Existing Hydro Power Station

Number of Power Station	Installed Capacity (MW)	Nos. of Unit	Firm Output (MW)	Available Power Energy (Gwh)	Actual Power Energy per Year (Gwh)	Year of Operation
Pisayambo	69.2	2	65.4	215.9	260.8	1977
Paute (Phase A&B)	500.0	5	438.5	2,456.7	3,481.9	1983
Paute (Phase C)	575.0	5	459.4	-	1,883.0	1992
Agoyán	156.0	2	154.9	724.9	1,119.0	1987
Others	169.9		91.2	558.9	821.8	-
Total	1,470.1	-	1,209.4	-	7,566.5	-

Table 3-8 Generation Capability of Hydro Power Stations in Regional System (As of January, 1993)[1),2)]

Power Station	Installed Capacity (MW)	Firm Output (MW)	Energy (GWh/Year)	
			Primary	Average
A. North Zone	135.55	64.00	436.95	621.06
- North System	13.43	5.68	32.26	46.98
San Miguel de Car	2.90	2.50	11.30	16.90
La Playa	1.20	0.20	5.61	7.48
El Ambi	8.00	2.00	11.50	18.25
Otras[3)]	1.33	0.98	3.85	4.35
- Pichincha System	92.98	44.74	314.16	415.31
Cumbayá	40.00	17.65	123.67	163.52
Nayón	29.70	14.00	98.40	134.08
Guangopolo	15.52	9.00	63.07	67.84
Pasochoa	4.50	2.25	16.12	26.39
Los Chillos	1.76	0.86	6.03	11.25
Machachi	1.50	0.98	6.87	12.23
- Central North System	29.14	13.58	40.53	158.77
Illuchi	9.40	4.20	29.43	50.46
Miraflores	0.97	0.29	2.35	10.28
La Penlinsula	3.75	1.12	7.88	17.52
Alao	10.50	6.00	42.05	63.07
Cordovez	0.68	0.15	1.05	2.52
Chimbo	1.58	0.45	3.15	5.42
Otras[3)]	0.56	0.37	2.59	3.38
B. South Zone	34.32	27.23	121.98	200.74
- Central South System	31.92	26.03	113.57	187.43
Saymirin	6.43	4.91	42.79	49.48
Saucay	24.00	20.76	68.26	135.45
Otras[3)]	1.49	0.36	2.52	2.50
- South System	2.40	1.20	8.41	13.31
San Francisco	2.40	1.20	8.41	13.31
C. Total (A + B)	169.87	91.23	558.93	821.80

1) Energy production at the terminal of generator is applied.
2) Not included the power facilities of Municipal Corporation and Oriental area (IC=1.69 MW, Fo=0.94 MW), and the facilities of Sucumbios Power Company (IC=0.40 MW, Fo=0.30 MW) which are not interconnected to SNI.
3) The Capacity of "Others" includes small power Stations with the capaicty less than 500 KW.

Table 3-9 Existing Thermal Power Station
(As of January, 1993)

Name of Power Station	Installed Capacity (MW)	Nos. of Unit	Available Output (MW)	Available Power Energy (GWh)	Year of Operation	Actual Operation (%)	Enterprises
Esmeraldas (Vapor)	132.5	1	125.0	985.5	1981	90	INECEL
Estero Salado (Vapor)	146.0	2	130.4	971.0	1978/80	85	INECEL
Gas Quito (Santa Rosa)	51.0	3	45.0	157.7	1981	40	INECEL
Gas Guayaquil	30.9	1	0.0	0.0	1976	40	INECEL
Diesel Guangopolo	31.2	6	24.3	127.7	1977	60	INECEL
Guayaquil Vapor #1	10.0	2	9.4	74.1	1954/7	90	EMELEC
Guayaquil Vapor #2	20.0	2	19.0	149.8	1958/62	90	EMELEC
Guayaquil Gas	13.5	1	12.0	42.0	1968	40	EMELEC
Estero Salado	33.0	1	31.6	249.1	1970	90	EMELEC
Estero Salado Gas	90.0	4	80.0	280.4	1977/8	40	EMELEC
Estero Salado Gas	21.2	1	15.0	52.6	1972/5	40	EMELEC
Diesel Bunker Quito	34.3	6	10.0	52.6	1980	60	EEQ
S. Regionales Diesel	122.4	55	40.5	106.4		30	
S. Regionales Bunker	72.1	17	31.4	165.0		60	
Total	808.1		573.6	3,413.9			

Table 3 - 10 Thermal Power Stations of Regional Electric Powr Companies (1/4)

No.	Electric Power Company	Power Station	Operationable Capacity		Capacity of Rehabilitation		Kind of Fuel
			Installation Cap. (KW)	Capability (KW)	Installation Cap. (KW)	Capability (KW)	
1	Manabi	Miraflores	3400	2000	0	0	Bunker
2	Manabi	Miraflores	3400	2000	0	0	Bunker
3	Manabi	Miraflores	0	0	2500	2000	Diesel
4	Manabi	Miraflores	0	0	2500	2000	Diesel
5	Manabi	Miraflores	2500	2000	0	0	Diesel
6	Manabi	Miraflores	2500	2000	0	0	Diesel
7	Manabi	Miraflores	0	0	2500	2000	Diesel
8	Manabi	Miraflores	2500	2000	0	0	Diesel
9	Manabi	Miraflores	0	0	2500	2000	Diesel
10	Manabi	Miraflores	0	0	2500	2000	Diesel
11	Manabi	Miraflores	2500	2000	0	0	Diesel
12	Manabi	Miraflores	0	0	2500	2000	Diesel
		Sum	16800	10200	15000	12000	
13	Emeloro	Machala	2144	700	0	0	Diesel
14	Emeloro	Machala	2500	2000	0	0	Diesel
15	Emeloro	Machala	0	0	2500	2000	Diesel
16	Emeloro	El Cambio	0	0	4088	3000	Bunker
17	Emeloro	El Cambio	0	0	4088	3000	Bunker
18	Emeloro	El Cambio	5450	3200	0	0	Bunker
19	Emeloro	El Cambio	5450	3200	0	0	Bunker
		Sum	15544	9100	10676	8000	
20	S. Elena	Libertad	0	0	2500	2000	Diesel
21	S. Elena	Libertad	600	300	0	0	Diesel
22	S. Elena	Libertad	2840	1800	0	0	Diesel
23	S. Elena	Libertad	4440	2500	0	0	Bunker
24	S. Elena	Libertad	4440	2500	0	0	Bunker
25	S. Elena	Libertad	2500	1500	0	0	Diesel
26	S. Elena	Libertad	0	0	2500	2000	Diesel
27	S. Elena	Libertad	0	0	2500	2000	Diesel
28	S. Elena	Playas	0	0	1200	60	Diesel
29	S. Elena	Posorja	0	0	2840	2000	Diesel
		Sum	14820	8600	11540	8600	

Table 3 - 10 Thermal Power Stations of Regional Electric Powr Companies (2/4)

No.	Electric Power Company	Power Station	Operationable Capacity		Capacity of Rehabilitation		Kind of Fuel
			Installation Cap. (KW)	Capability (KW)	Installation Cap. (KW)	Capability (KW)	
30	Sur	Catamayo	0	0	1280	900	Diesel
31	Sur	Catamayo	1280	900	0	0	Diesel
32	Sur	Catamayo	1575	1300	0	0	Diesel
33	Sur	Catamayo	0	0	1575	1300	Diesel
34	Sur	Catamayo	2880	1800	0	0	Diesel
35	Sur	Catamayo	2880	1800	0	0	Diesel
36	Sur	Catamayo	0	0	2500	2000	Diesel
37	Sur	Catamayo	0	0	2500	2000	Diesel
38	Sur	Catamayo	2500	1800	0	0	Diesel
		Sum	11115	7600	7855	6200	
39	Quito	G.Hernández	0	0	5720	5000	Bunker
40	Quito	G.Hernández	5720	5000	0	0	Bunker
41	Quito	G.Hernández	5720	5000	0	0	Bunker
42	Quito	G.Hernández	0	0	5720	5000	Bunker
43	Quito	G.Hernández	0	0	5720	5000	Bunker
44	Quito	G.Hernández	0	0	5720	5000	Bunker
45	Quito	Luluncoto	0	0	5720	2600	Bunker
46	Quito	Luluncoto	0	0	3097	2600	Bunker
47	Quito	Luluncoto	0	0	3097	2600	Bunker
		Sum	11440	10000	32171	27800	
48	Milagro	Milagrol	1500	900	0	0	Diesel
49	Milagro	Milagrol	1500	900	0	0	Diesel
50	Milagro	Milagrol	0	0	2500	2000	Diesel
51	Milagro	Milagrol	1410	700	0	0	Diesel
52	Milagro	Milagrol	0	0	2500	2000	Diesel
53	Milagro	Milagrol	2500	1500	0	0	Diesel
54	Milagro	Milagrol	0	0	2500	2000	Diesel
55	Milagro	Milagrol	0	0	2500	2000	Diesel
56	Milagro	Milagrol	2500	2000	0	0	Diesel
		Sum	9140	6000	10000	8000	

Table 3 - 10 Thermal Power Stations of Regional Electric Powr Companies (3/4)

No.	Electric Power Company	Power Station	Operationable Capacity Installa-tion Cap. (KW)	Operationable Capacity Capability (KW)	Capacity of Rehabilitation Installa-tion Cap. (KW)	Capacity of Rehabilitation Capability (KW)	Kind of Fuel
57	Ambato	El Batán	750	500	0	0	Diesel
58	Ambato	El Batán	2980	2200	0	0	Diesel
59	Ambato	Lligua	2500	2000	0	0	Diesel
		Sum	6230	4700	0	0	
60	Riobamba	Riobamba	2500	2000	0	0	Diesel
		Sum	2500	2000	0	0	
61	Esmeraldas	S. Vainas	0	0	2500	2000	Diesel
62	Esmeraldas	S. Vainas	0	0	2500	2000	Diesel
63	Esmeraldas	S. Vainas	0	0	2500	2000	Diesel
64	Esmeraldas	La Propicia	0	0	4416	3000	Bunker
65	Esmeraldas	La Propicia	0	0	4416	3000	Bunker
		Sum	0	0	16332	12000	
66	Emelnorte	S.Francisco	2500	1500	0	0	Diesel
		Sum	2500	1500	0	0	
67	S. Domingo	Toachi	0	0	2500	2000	Diesel
68	S. Domingo	Toachi	0	0	1575	1200	Diesel
69	S. Domingo	Toachi	0	0	2500	2000	Diesel
		Sum	0	0	6575	5200	
70	Centro Sur	Monay	1500	1200	0	0	Diesel
71	Centro Sur	Monay	1500	1200	0	0	Diesel
72	Centro Sur	Monay	2375	1000	0	0	Diesel
73	Centro Sur	Monay	2375	1000	0	0	Diesel
74	Centro Sur	El Descanso	4800	4000	0	0	Bunker
75	Centro Sur	El Descanso	4800	4000	0	0	Bunker
76	Centro Sur	El Descanso	4800	4000	0	0	Bunker
77	Centro Sur	El Descanso	4800	4000	0	0	Bunker
		Sum	26950	20400	0	0	
78	Bolivar	Guaranda	0	0	1575	1200	Diesel
		Sum	0	0	1575	1200	

Table 3 - 10 Thermal Power Stations of Regional Electric Powr Companies (4/4)

No.	Electric Power Company	Power Station	Operationable Capacity		Capacity of Rehabilitation		Kind of Fuel
			Installation Cap. (KW)	Capability (KW)	Installation Cap. (KW)	Capability (KW)	
79	Emelec	Guayaquil	5000	4700	0	0	T.Vapor
80	Emelec	Guayaquil	5000	4700	0	0	T.Vapor
81	Emelec	Guayaquil	10000	9500	0	0	T.Vapor
82	Emelec	Guayaquil	10000	9500	0	0	T.Vapor
83	Emelec	Guayaquil	13500	12000	0	0	T.Gas
84	Emelec	E. Salado	33000	31600	0	0	T.Vapor
85	Emelec	E. Salado	21250	15000	0	0	T.Gas
86	Emelec	E. Salado	22500	20000	0	0	T.Gas
87	Emelec	E. Salado	22500	20000	0	0	T.Gas
88	Emelec	E. Salado	22500	20000	0	0	T.Gas
89	Emelec	E. Salado	22500	20000	0	0	T.Gas
		Sum	187750	167000	0	0	
		Total	304789	247100	111724	89000	

Table 3 - 11 Existing Substation (As of December, 1992) (1/4)

Name of Sub-station	Voltage (kV)	Transformer Rating									Year of Opera -tion
		Capacity (MVA)			Cooling Method	Cap. of Tertiary (MVA)	Type	Units	Connect-tion	LTC	
		OA	FA	FOA							
(1) 230 kV Substaion											
Pascuales	230/138/13.8	225	300	375	OA/FA/FOA	60/80/100	1ϕ/auto	4	YYΔ	-	1982
Quevedo	230/138/13.8	100	133	167	OA/FA/FOA	27/36/45	"	4	YYΔ	-	1982
Sta.Rosa	230/138/13.8	225	300	375	ONAN/ONAF/OFAF	60/80/100	"	4	YYΔ	-	1982
Sto.Domingo	230/138/13.8	100	133	167	OA/FA/FOA	27/36/45	"	3	YYΔ	-	1982
Milagro	230/69/13.8	100	133	167	OA/FA/FOA	27/39/45	"	3	YYΔ	-	1983
Totoras	230/138/13.8	60	80	100	OA/FA/FA	20/27/33	"	4	YYΔ	-	1987
Riobamba	230/69/13.8	60	80	100	OA/FA/FOA	20/27/33	1ϕ	3	YYΔ	Yes	1989
Sum		870	1,159	1,451							
(2) 138 kV Substation											
Vicentina	138/46/13.8	33	44	44	ONAN/ONAF	11/14	3ϕ		YYΔ	-	1976
	138/46/13.8	33	44	44	ONAN/ONAF	11/14	3ϕ		YYΔ	-	1976
Ambato	138/69/13.8	33	44	44	ONAN/ONAF	11/14	1ϕ/Auto		YYΔ	-	1977
Ibarra	138/34.5/13.8	30	40	50	OA/FA/FA	10	3ϕ		YYΔ	Yes	1979
Salitral	138/69/13.8	90	120	150	OA/FA/FOA	30	1ϕ/Auto	4	YYΔ	-	1980
Sta.Rosa	138/46/13.8	45	60	75	OA/FA/FA	15/20/25	3ϕ		YYΔ	Yes	1980
Esmeraldas	138/69/13.8	45	60	75	ONAN/ONAF/OFAF	15/20/25	3ϕ/Auto		YYΔ	Yes	1981
Portoviejo	138/69/13.8	45	60	75	ONAN/ONAF/OFAF	15/20/25	3ϕ/Auto		YYΔ	Yes	1981

Table 3 - 11 Existing Substation (As of December, 1992) (2/4)

Name of Sub-station	Voltage (kV)	Transformer Rating									Year of Opera-tion
		Capacity (MVA)			Cooling Method	Cap. of Tertiary (MVA)	Type	Units	Connect-tion	LTC	
		OA	FA	FOA							
Quevedo	138/69/13.8	20	27	33	OA/FA/FOA	20	3φ		YYΔ	Yes	1981
Reserva	138/69/13.8	(20)	(27)	(33)	OA/FA/FOA	-	3φ		YYΔ	Yes	1981
Sto.Domingo	138/69/13.8	60	80	100	OA/FA/FOA	16/22/27	1φ/Auto	3	YYΔ	-	1981
Cuenca	138/69/13.8	60	80	100	OA/FA/FOA	16/22/27	1φ/Auto	4	YYΔ	-	1983
Babahoyo (mobile)	138/69/46	30	30	30	OA	-	3φ		-	-	1985
Pascuales	138/69/13.8	90	120	150	OA/FA/FOA	30/40/50	1φ/Auto	4	YYΔ	Yes	1985
Totoras	138/69/13.8	60	80	100	OA/FA/FA	20/27/33	1φ/Auto	4	YYΔ	-	1986
Loja	138/69/13.8	40	53	66	OA/FA/FOA	14/18/22	3φ/Auto		YYΔ	Yes	1987
Machala	138/69/13.8	60	80	100	OA/FA/FOA	20/27/33	1φ/Auto	3	YYΔ	Yes	1987
Milagro	138/69/13.8	60	80	100	OA/FA/FOA	20/27/33	1φ/Auto	3	YYΔ	Yes	1987
Posorja	138/69/13.8	20	27	33	OA/FA/FOA	7/9/11	3φ/Auto		YYΔ	Yes	1987
Sta.Elena	138/69/13.8	40	53	66	OA/FA/FOA	14/18/22	3φ/Auto		YYΔ	Yes	1987
Policentro	138/69/13.8	90	120	150	OA/FA/FOA	30/40/50	1φ/Auto	3	YYΔ	Yes	1990
Ibarra	138/69/13.8	20	27	33	OA/FA/FOA	7/9/11	3φ/Auto		YYΔ	Yes	1991
Sum		1,004 (20)	1,329 (27)	1,618 (33)							
Total(1)+(2)		1,874	2,488	3,069							
		(20)	(27)	(33)							

Table 3 - 11 Existing Substation (As of December, 1992) (3/4)

(3) Step-up Substation for Power Station

Name of Sub-station	Voltage (kV)	Transformer Rating									Year of Opera-tion
		Capacity (MVA)			Cooling Method	Cap. of Tertiary (MVA)	Type	Units	Connect-tion	LTC	
		OA	FA	FOA							
Guangopolo	6.6/138	15	20	20	ONAN/ONAF	-	3ϕ		ΔY	-	1976
	6.6/138	15	20	20	ONAN/ONAF	-	3ϕ		ΔY	-	1976
Pisayambo	13.8/138	40	40	40	FOA	-	3ϕ		ΔY	-	1977
	13.8/138	40	40	40	FOA	-	3ϕ		ΔY	-	1977
Sta. Rosa	13.8/138	28	28	28	ONAN		3ϕ		ΔY	-	1980
	13.8/138	28	28	28	ONAN		3ϕ		ΔY	-	1980
	13.8/138	28	28	28	ONAN		3ϕ		ΔY	-	1980
E. Salado-V2	13.2/69	52	70	86	OA/FA/FOA		3ϕ		ΔY	-	1980
E. Salado-V3	13.2/69	52	70	86	OA/FA/FOA		3ϕ		ΔY	-	1980
E. Salado-G4	13.8/69	26	35	35	OA/FA		3ϕ		ΔY	-	1980
Esmeraldas	13.8/147.5	90	120	160	ONAN/ONAF/ OFAF		3ϕ		ΔY	-	1981
Paute	13.8/138	114	114	114	OFWF		3ϕ		ΔY	-	1983
	13.8/138	114	114	114	OFWF		3ϕ		ΔY	-	1983
	13.8/138	114	114	114	OFWF		3ϕ		ΔY	-	1983
	13.8/138	114	114	114	OFWF		3ϕ		ΔY	-	1983
	13.8/138	114	114	114	OFWF		3ϕ		ΔY	-	1983
	13.8/230/13.8	225	300	375	OA/FA/FOA	60/80/100	1ϕ/Auto	4	YYΔ	-	1983
		225	300	375	OA/FA/FOA	60/80/100	1ϕ/Auto	4	YYΔ	-	1983

Table 3 - 11 Existing Substation (As of December, 1992) (4/4)

Name of Sub-station	Voltage (kV)	Transformer Rating									Year of Opera-tion
		Capacity (MVA)			Cooling Method	Cap. of Tertiary (MVA)	Type	Units	Connect-tion	LTC	
		OA	FA	FOA							
Agoyán	13.8/145	85	85	85	FOA	-	3φ		ΔY	-	1987
	13.8/145	85	85	85	FOA	-	3φ		ΔY	-	1987
Paute C	13.8/246.3	134	134	134	OFWF	-	3φ		ΔY	-	1992
	13.8/246.3	134	134	134	OFWF	-	3φ		ΔY	-	1992
	13.8/246.3	134	134	134	OFWF	-	3φ		ΔY	-	1992
	13.8/246.3	134	134	134	OFWF	-	3φ		ΔY	-	1992
	13.8/246.3	134	134	134	OFWF	-	3φ		ΔY	-	1992
Sum		2,274	2,509	2,731							
Total (1)+(2)+(3)		4,148 (20)	4,997 (27)	5,800 (33)							

Note: Number inside a parenthesis shows the capacity of stand-by facility, the Number is not included in the total capacity.

Table 3-12 230 kV Transmission Line

(a) Existing 230 kV Transmission Line of - SNI -

Name of the Line	Number of Cct.	Length km	Conductor MCM	Year of Operation
Quevedo-Santo Domingo	2	105	ACSR 1113MCM	1980
Santo Domingo-Santa Rosa	2	78	ACSR 1113MCM	1980
Paute-Milagro	2	141	ACSR 1113MCM	1983
Milagro-Pascuales	2	42	ACSR 1113MCM	1983
Pascuales-Quevedo	2	144	ACSR 1113MCM	1983
Santa Rosa-Totoras	2	105	ACSR 1113MCM	1985
Totoras-Riobamba	2	42	ACSR 1113MCM	1989
Riobamba-Paute	2	163	ACSR 1113MCM	1992
Subtotal 230 kV	-	820	-	-

(b) 230 kV Under Construction Line of - SNI -

Name of the Line	Number of Cct.	Length (km)	Conductor (MCM)	Note
Paute-Pascuales	2	190	ACSR 1113MCM	Operation in 1995
Pascuales-Trinitaria	2	25	ACSR 1113MCM	
-	-	215	-	-

Table 3-13 <u>Characteristics Parameter of SNI's Transmission Lines</u>

Voltage (kV)	No. of Circuits	Zone	Cable Size (MCM)	Z1 R (Ω/km)	Z1 X (Ω/km)	Z0 R (Ω/km)	Z0 X (Ω/km)	Zm R (Ω/km)	Zm X (Ω/km)	Y1 (μMHO/km)	Z(+) Caract. (Ω)	Z(0) Caract. (Ω)	Charging (kVAR/km)
69.0	1	2	266.3	0.24047	0.45706	0.54119	1.80836	0.00000	0.00000	3.61213	378.1	966.9	17.20
69.0	1	1	336.0	0.19087	0.44963	0.47331	1.22608	0.00000	0.00000	3.67597	364.5	937.0	17.50
69.0	2	1	336.0	0.19097	0.46609	0.46048	1.77591	0.26654	1.14241	3.55905	376.2	941.0	16.94
138.0	1	2	266.8	0.24046	0.51737	0.49482	1.70628	0.00000	0.00000	3.17720	423.8	937.2	60.51
138.0	1	1	397.5	0.16168	0.47758	0.41730	1.66841	0.00000	0.00000	3.44550	382.5	929.1	65.62
138.0	1	2	397.5	0.16166	0.50403	0.41602	1.69294	0.00000	0.00000	3.26863	402.4	920.0	62.25
138.0	2	1	397.5	0.16185	0.49583	0.40893	1.63596	0.24733	1.09763	3.35950	394.0	863.8	63.98
138.0	2	2	397.5	0.16207	0.50367	0.48648	1.63230	0.32482	1.06753	3.30970	399.8	869.1	63.03
138.0	1	1	477.0	0.13478	0.47089	0.39040	1.66172	0.00000	0.00000	3.49810	374.2	921.6	66.62
138.0	1	2	477.0	0.13476	0.49734	0.38912	1.68626	0.00000	0.00000	3.31599	394.2	912.5	63.15
138.0	2	1	477.0	0.13495	0.48914	0.38203	1.62928	0.24733	1.09673	3.40989	385.8	855.8	64.94
138.0	2	2	477.0	0.13517	0.49699	0.45958	1.62562	0.32482	1.06753	3.35850	391.6	860.9	63.96
138.0	1	1	636.0	0.10138	0.46000	0.35700	1.65083	0.00000	0.00000	3.58421	362.5	910.3	68.26
138.0	1	2	636.0	0.10136	0.48645	0.35572	1.67536	0.00000	0.00000	3.39335	382.7	901.3	64.62
138.0	2	1	636.0	0.10155	0.47825	0.34863	1.61838	0.24733	1.09673	3.49234	374.2	843.6	66.51
138.0	2	2	636.0	0.10177	0.48609	0.42618	1.61472	0.32482	1.06753	3.43831	380.1	848.6	65.48
138.0	2	1	1113.0	0.05915	0.46009	0.30623	1.60023	0.24733	1.09673	3.64722	356.6	823.5	69.46
138.0	2	2	1113.0	0.05937	0.46794	0.38378	1.59657	0.32482	1.06753	3.58804	362.6	828.5	68.33
230.0	2	1	636.0	0.10149	0.49082	0.33719	1.59919	0.23588	1.02722	3.38481	384.8	868.6	179.06
230.0	2	2	636.0	0.10178	0.50886	0.40807	1.58171	0.30662	0.98573	3.27244	398.2	861.9	173.11
230.0	2	2	795.0	0.08178	0.50037	0.38807	1.57322	0.30662	0.98573	3.33060	390.2	853.1	176.19
230.0	2	1	1113.0	0.05909	0.47267	0.29479	1.58104	0.23588	1.02722	3.52987	367.4	849.1	186.73
230.0	2	2	1113.0	0.05938	0.49071	0.36567	1.56356	0.30662	0.98573	3.40761	380.9	842.3	180.26

Table 3-14 138 kV Transmission Line

(a) Existing 138 kV Transmission Line of - SNI -

Name of the Line	Number of Cct.	Length km	Conductor MCM	Year of Operation
Pisayambo - Ambato	1	30.0	ACSR 477	1977
Pisayambo - Sta. Rosa	1	107.0	ACSR 477	1977
Vicentina - Guangopolo	1	7.0	ASCR 477	1977
Vicentina - Ibarra	1	80.0	ACSR 477	1979
Pascuales - Salitral	2	17.0	ACSR 477	1980
Sta. Rosa - Vicentina	2	18.5	ACSR 477	1980
Quevedo - Portoviejo	2	107.0	ACSR 397.5	1981
Sto.Domingo-Esmeraldas	2	154.0	ACSR 397.5	1981
Paute-Cuenca	2	70.0	ACSR 397.5	1983
Milagro - Babahoyo	1	47.0	ACSR 397.5	1984
Baños - Puyo	1	53.0	ACSR 266.8	1986
Cuenca - Loja	1	135.0	ACSR 397.5	1987
Pascuales - Las Juntas	2	45.0	ACSR 397.5	1987
Las Junta - Sta. Elena	1	62.0	ACSR 397.5	1987
Las Juntas - Posorja	1	53.0	ACSR 397.5	1987
Milagro - Machala	2	129	ACSR 397.5	1987
Totoras - Agoyán	2	33	ACSR 636	1987
Totoras - Ambato	1	7.0	ACSR 397.5	1988
Pascuales - Policentro	2	16.0	ACSR 477	1990
Subtotal 138 kV		1,170.5		
Total Inecel (230 kV+138 kV)		1,990.5		-

(b) 138 kV Under Construction Line of - SNI -

Name of the Line	Number of Cct.	Length km	Conductor MCM	Year of Operation
Ibarra-Tulcán	1	70	477	Op. in 1944
Vicentina-Ibarra	1	80	477	Amp. I Ctt.
				Op. in 1993
Cuenca-Limón	1	80	266.8	Op. in 1993
Loja -Cumbaratza	1	52	266.8	Op. in 1993
	-	282	-	-

Table 3-15 Interrupted for Origin of - SNI - Line Faults

Name of Transmission Line	1990		1991		1992	
	Nos.	Hours	Nos.	Hours	Nos.	Hours
230 kV Line						
Sta.Rosa-Sto. Domingo	0	0	0	0	1	0.62
Sto.Domingo-Quevedo	0	0	2	0.76	0	0
Quevedo-Pascuales	0	0	0	0	0	0
Pascuales-Milagro	1	0.77	2	1.71	0	0
Milagro-Paute	3	2.40	3	1.03	9	9.54
Paute-Riobamba	-	-	-	-	1	0.44
Riobamba-Totoras	2	0.33	0	0	1	0.39
Totoras-Sta.Rosa	0	0	1	0.65	0	0
Subtotal	6	3.5	8	4.15	12	10.99
138 kV Line						
Pisayambo-Ambato	0	0	0	0	0	0
Pisayambo-Vicentina	0	0	2	0.24	0	0
Vicentina-Ibarra	3	1.11	2	1.97	1	0.35
Guangopolo-Vicentina	0	0	0	0	0	0
Vicentina-Sta.Rosa	0	0	0	0	1	0.83
S.Domingo-Esmeraldas	3	1.75	6	21.65	4	2.73
Quevedo-Portoviejo	0	0	1	0.27	1	0.13
Pascuales-Salitral	0	0	0	0	0	0
Paute-Cuenca	1	0.17	0	0	1	0
Milagro-Babahoyo	0	0	1	0.13	2	0.32
Agoyán-Totoras	0	0	0	0	0	0
Pascuales-Sta.Elena	6	2.95	6	2.83	0	0
Pascuales-Posorja	6	1.93	4	1.77	1	0.15
Milagro-Machala	5	5.30	4	1.19	8	19.17
Cuenca-Loja	4	1.72	3	0.47	1	0.23
Totoras-Ambato	0	0	1	2.65	0	0
Pascuales-Policentro	1	0.20	2	0.68	1	0.15
Subtotal	28	15.13	32	33.85	19	23.91
Total	34	18.63	40	38.00	31	34.9

Table 3-16 Programmed Interruption of - SNI - Transmission Lines

Name of Transmission Line	1990		1991		1992	
	Nos.	Hours	Nos.	Hours	Nos.	Hours
230 kV Line						
Sta.Rosa-Sto. Domingo	0	0	0	0	0	0
Sto.Domingo-Quevedo	0	0	0	0	0	0
Quevedo-Pascuales	0	0	0	0	0	0
Pascuales-Milagro	0	0	0	0	0	0
Milagro-Paute	0	0	0	0	0	0
Paute-Riobamba	-	-	-	-	1	0.55
Riobamba-Totoras	1	6.50	0	0	0	0
Totoras-Sta.Rosa	0	0	0	0	0	0
Subtotal	1	6.50	0	0.00	1	0.55
138 kV Line						
Pisayambo-Ambato	0	0	0	0	0	0
Pisayambo-Vicentina	0	0	0	0	0	0
Vicentina-Ibarra	1	0	2	14.85	0	0
Guangopolo-Vicentina	0	0	0	0	0	0
Vicentina-Sta.Rosa	0	0	0	0	0	0
S.Domingo-Esmeraldas	1	6.97	0	0	2	21.55
Quevedo-Portoviejo	2	37.48	1	1.17	1	1.5
Pascuales-Salitral	0	0	0	0	0	0
Paute-Cuenca	0	0	0	0	1	11.25
Milagro-Babahoyo	0	0	0	0	0	0
Agoyán-Totoras	0	0	0	0	0	0
Pascuales-Sta.Elena	8	65.89	2	16.55	2	14.00
Pascuales-Posorja	6	53.53	8	56.92	2	15.26
Milagro-Machala	0	0	3	5.70	3	16.29
Cuenca-Loja	1	5.05	1	8.75	2	12.40
Totoras-Ambato	2	24.07	0	0	0	0
Pascuales-Policentro	0	0	0	0	0	0
Subtotal	18	168.91	17	103.94	13	92.25
Total	19	175.41	17	103.94	14	92.80

CHAPTER 4 POWER DEMAND PROJECTION AND SUPPLY PLAN

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CHAPTER 4 POWER DEMAND PROJECTION AND SUPPLY PLAN

4.1 Power Demand Projection

4.1.1 Past Trend of Power Demand and Economic Growth

Generally speaking, power demand of a nation grows with the growth of its GDP. The past trend of GDP and power demand in Ecuador have been studied, and their correlation is illustrated in Table 4-1.

In reference to Table 4-1, the economic growth rate has been from 5% to 10% during the recent period from 1990 to 1992. It is expected that the economic growth of this country continues to exhibit this trend after 1992. (INECEL's material)

On the other hand, the rate of population growth has been 2.7% in annual average until early 1980's, but it showed a tendency of gradual slow down in 1990's, which was 2.4% in 1990. According to INECEL's materials (Table 3-2), it is estimated that the population growth rate of 2.4% will continue in the future.

4.1.2 Power Demand Projection Methodology

Generally speaking, there are two methods to project the power demand of a nation. One is the macroscopic method by which the long to medium term power demand is projected based on macroscopic indices such as the growth rate of economic and social activities and the structural changes of industries. Another method is the microscopic method by which the short time projection of power demand is projected by the trend in the business cycle. In this study, the power demand is projected for the period from 1993 to 2010 by the macroscopic method.

- Brief Description of Macroscopic Method

The macroscopic methodology of power demand projection adopted in this study is based on the correlation between the power consumption per capita and the economic growth rate. This methodology is the defined in the paper, "Method of Long Range Demand Forecast of Energy for Developing Countries from World-Wide Standpoint" edited by EPDC in September, 1985.

In this method, the past records of average power demand growth rate and the GDP growth rate per capita, which are typically illustrated in Fig. 4-1 and Fig. 4-2 respectively, are plotted for typical nations of the world, and the past statistics of the country under study are also plotted in these figures.

Usually, the curve of the plots for a developing nation falls near the world's average growth curve, and moves from the lower point on the curve to the higher point as the country develops. We usually extrapolate the plots of the developing nation in question, seek the intersection of this extrapolation with the global average curve, and then assume that the developing nation will follow the world's average development curve in future from the intersection point.

For some developing nations, the power demand may grow faster than the global average (high growth case), but it is assumed that the plot curve approaches the average curve in a long run.

For Ecuador, it is expected that its plot curve will intersect the global average curve by year 1994, based on the past data of this country.

4.1.3 Calculation Conditions

(1) Projection Period; 18 years (1993 to 2010)

Since the power demand growth has been studied up to year 2010 in INECEL's Long Term Power Supply Development Plan, the period of this study was made to coincide this period, or 18 years from 1993 to 2010.

(2) Base Year; 1994

In view of the past records in the last 28 years (1965 to 1992), the time when the plot curve of Ecuador reaches the global average growth curve in Fig. 4-1, which is 1994, has been selected as the "base year" for the power demand projection study. The power demand and GDP of 1994 have not been calculated at the time of the study, and these values were calculated by the least square method based on the past records.

(3) GDP Per Capita; 1,322 US$/cap.

The GDP data of the Ecuadorian Central Bank, which has been made available by INECEL, and the data of OECD Annual Report-1992 were examined, and then the data of GDP per capita were determined.

In this calculation, the exchange rate between sucre and U.S. dollars, and the price escalation were taken into account.

Finally, the GDP per capita was estimated as 1,322 US$/cap (year 1994). The growth rate of GDP per capita was approximately 1.2% in the recent period from 1988 to 1992. This growth rate is lower than the global average growth of approximately 5%.

(4) Population; 11,303 thousands (1994)

The population of 11,303 thousands, which is INECEL's estimated value for year 1994, has been used.

It was assumed that the population growth rate per annum of 2.44%, which has been the average growth rate in the 5 years from 1988 to 1992, will continue for the period from 1993 to 2010.

(5) Electrical Energy Consumption per Capita; 732.9 kWh (1994)

The value of electrical energy consumption per capita was determined by dividing the projected energy demand in the Base Year of 1994, which was obtained by the least square method, with the population of that year, 11,303 thousands. This value is 732.9 kWh.

(6) Annual Load Factor

The records of annual load factor for the period from 1988 to 1992 has values somewhere between 57.1% and 60.8%. This value fluctuates around the base value of 60%. Therefore, it was assumed that the value of load factor will remain practically the same in future, and will not be reduced by the peak demand such as air conditioner load. The annual load factor is assumed to be 60%.

4.1.4 Result of Power Demand Projection

The macroscopic projection of power demand as established by this methodology is given in Table 4-3, 4-4 and Fig. 4-3, 4-4.

The values are low as a whole compared the power demand projection of INECEL.

The difference, in 2003, is about 3.5% in terms of energy demand, and there is a relatively good correlation between the two.

The differences in result of power demand projection results of INECEL and JICA are small, but in the demand and supply balance plan, the power demand projection results of INECEL which are on the larger side are to be adopted taking into consideration a margin of safety.

4.2 Power Supply Plan

4.2.1 Electric Power Development Plan

In the Republic of Ecuador, with the precipitation almost entirely flowing from the longitudinally running high Andes westward into the Pacific, and eastward into the Amazon, the water for electric power generation is ample both in quantity and in head. The total potential power available for development (water resources technically available for electric power generation) of the 21 main rivers is said to be 22,000 MW with the energy supply potential of 90 billion kWh.

The electric power development plan of INECEL is based on the utilization of this rich water resource, and in its electrification master plan (1993 - 2002) MARZO-1993-3, the development of hydroelectric power plants is the mainstay with the construction of thermal electric plants supplementing the deficit.

The development projects in this master plan are as follows:

Power plant type	Installed capacity (MW)	Year of operation start
Gas. Electroquil	75	Jan. 1993
Gas. Electroquito	33	Feb. 1993
Thermal, Rehabilitation	112	Apr.-Oct.1993
Gas turbine	80	Dec.1993
Gas turbine	80	Dec.1994
Steam turbine	125	Dec.1995
* Daule-Peripa Hydro	130	Dec.1996
Steam turbine	140	Dec.1997
* San Francisco Hydro	230	Dec.1999
Gas turbine	80	Jan.2001
* Mazar Hydro	180	Dec.2001

* Hydro power plants

4.2.2 Power Demand/Supply Balance

In our present plan, basically, the power demand/supply balance was examined, with the electric power development plan of INECEL taken into consideration.

The power demand/supply balance was examined in both the kW capacity and in the kWh capacity, for the period between 1993 and 2003.

The kW balance was studied for a peak day in the month of December when the power demand peaks and the water supply is most scarce.

On the other hand, the kWh balance was studied for the annual total power demand.

(1) Study conditions

(a) Hydroelectric power plant

- Retirement: No station is to be retired between 1993 and 2003, and therefore no station retiring is considered in the power supply plan.

- Outage: The dropout of the largest unit (115 MW unit in Paute station) during the heaviest peak day is assumed.
  However, the unit is assumed to recover after a few days, and therefore, no effect on the annual electric energy plan is assumed.

- Water volume fluctuation: The firm electric power output and the annual firm energy are assumed.

(b) Thermal power plant

- Retirement: The retiring schedule of INECEL is noted.

- Failure: In the kW balance study, the dropout of the largest unit during the heaviest peak day is assumed. However, the unit is assumed to recover after a few days, so that no effect on the annual electric energy plan is assumed.

- Utilization factor: The base thermal electric factor is assumed to be 70%, and the gas thermal electric power factor in the peak period is assumed to be 40%.

- Repair schedule: No repair is assumed to be made during the peak months.

(c) Power import

In the study of both the kW peak balance and the kWh energy balance, no electric power import is assumed.

(d) Others: As per the Master Plan prepared by INECEL. Due to the time constraint, it is impossible to change until 1995.

(2) Summary of study results

The results of the study on the electric power development plan from 1993 to 2003 conducted by INECEL and JICA are shown in Table 4-5, Fig. 4-5 and Fig. 4-6.

In the kW and kWh balances study for the INECEL plan, the firm output and firm energy are examined, for the hydroelectric power plants.

With respect to the thermal power plants, the effective output and the effective energy are studied for demand-supply balance.

The effective energy in this study is calculated from the base thermal power station capacities (vapor and diesel) with annual plant utilization factor of 90% and 85% respectively for vapor and diesel. The plant utilization factor for the peak stand-by thermal power station (gas) is assumed to be 40%.

In the JICA's proposal, the annual plant utilization factor for the base thermal power plant output (vapor and diesel) is assumed to be 70%. This annual plant utilization factor of 70% is the long-term utilization factor in which annual inspection (15 - 20%) and the power loss resulting from load adjustment (5%) is taken into consideration.

In other respects, the concept is the same between the INECEL plan and the JICA plan.

As a result, it is possible that the kWh balance will not be satisfied until 1995 with the JICA plan. (Without a new power source, the energy shortage will be brought about in case of water shortage.) For this reason, new thermal power plants are required to deal with this supply shortage. However, it would be difficult to construct new thermal power plant in time in view of the construction lead time of such power plants, and the best we can hope for is that Paute Power Plant is provided with sufficient river runoff during this period.

INECEL is planning gas thermal power plants which can be constructed quickly for the purpose of resolving the kWh shortage during this period. In view of little time available, such a plan would be excusable. Daule Peripa Hydropower Station (130 MW) and Manta Thermal Power Station (140 MW) are scheduled to be commissioned in 1996. The kWh balance will be satisfied in this year, however, energy will be shortened again in 1997. Therefore, an addition of 125 MW (Vapor) base thermal power generation facility to the plan of INECEL will be required. Instead, however, this JICA adjustment makes the 30 MW (gas) thermal power plant planned for 2003 in the INECEL scenario superfluous, but requires all the other thermal power plants to advance their operation start by one year.

With respect to the kW balance, in the INECEL plan, as well as in the JICA's adjustment proposal, the total capacity is so large that even when both the largest hydroelectric unit and the largest thermal power unit fail on the peak demand day, there will be no power shortage, and no possibility of kW imbalance.

Since the newly to be built hydroelectric power plants are large ones in SNI, scheduled to assume vital roles in both kW balance and kWh balance, their delay in operation start would possibly cause power deficit again as in 1992, so that their development strictly on schedule is very important.

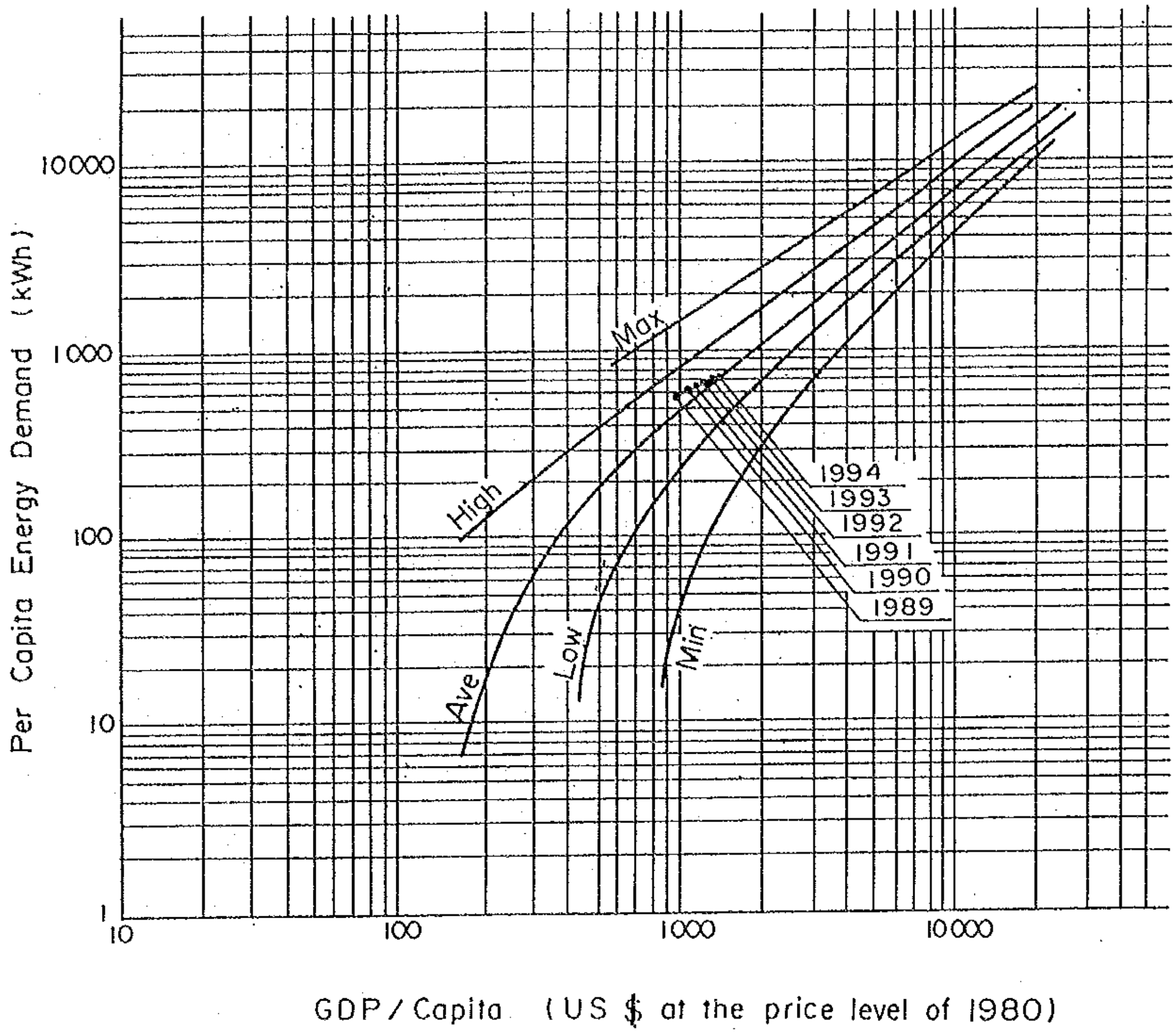

Fig. 4 - 1 Demand Pass Chart

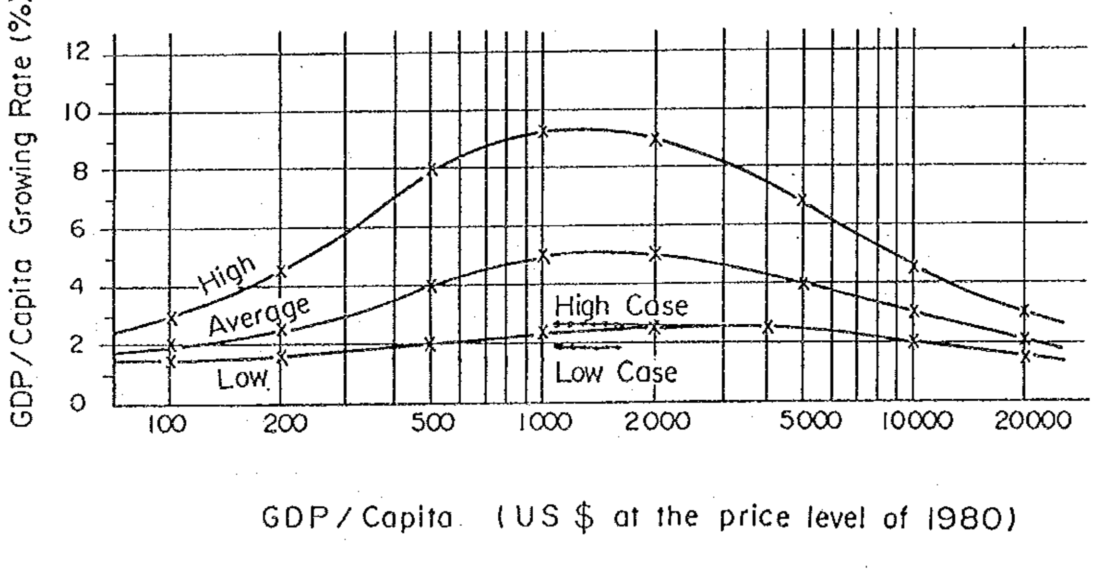

Fig. 4 - 2 GDP/Capita and its Growth Rate

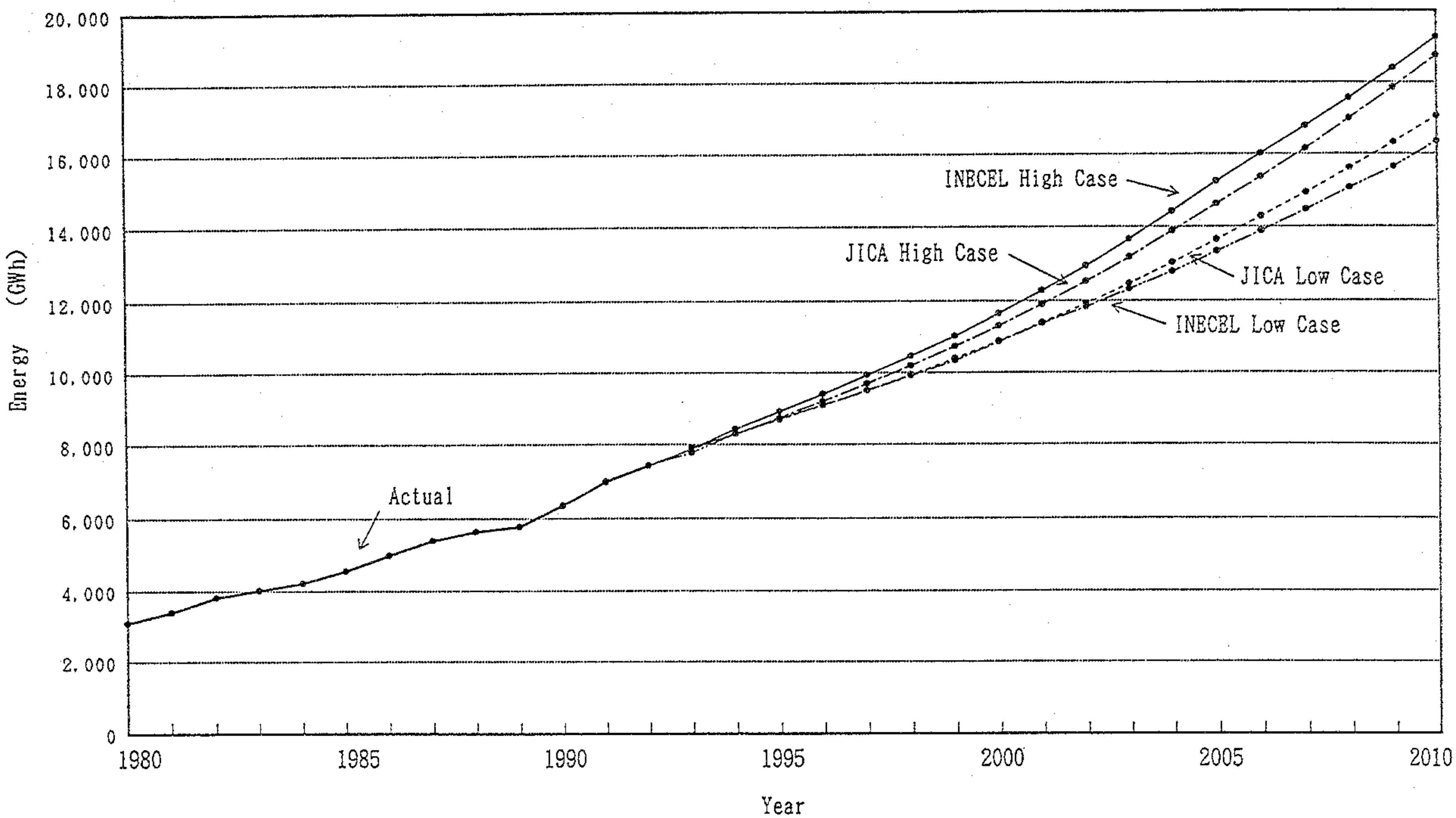

Fig. 4-3 Demand Forecast of Ecuador (1980-2010)

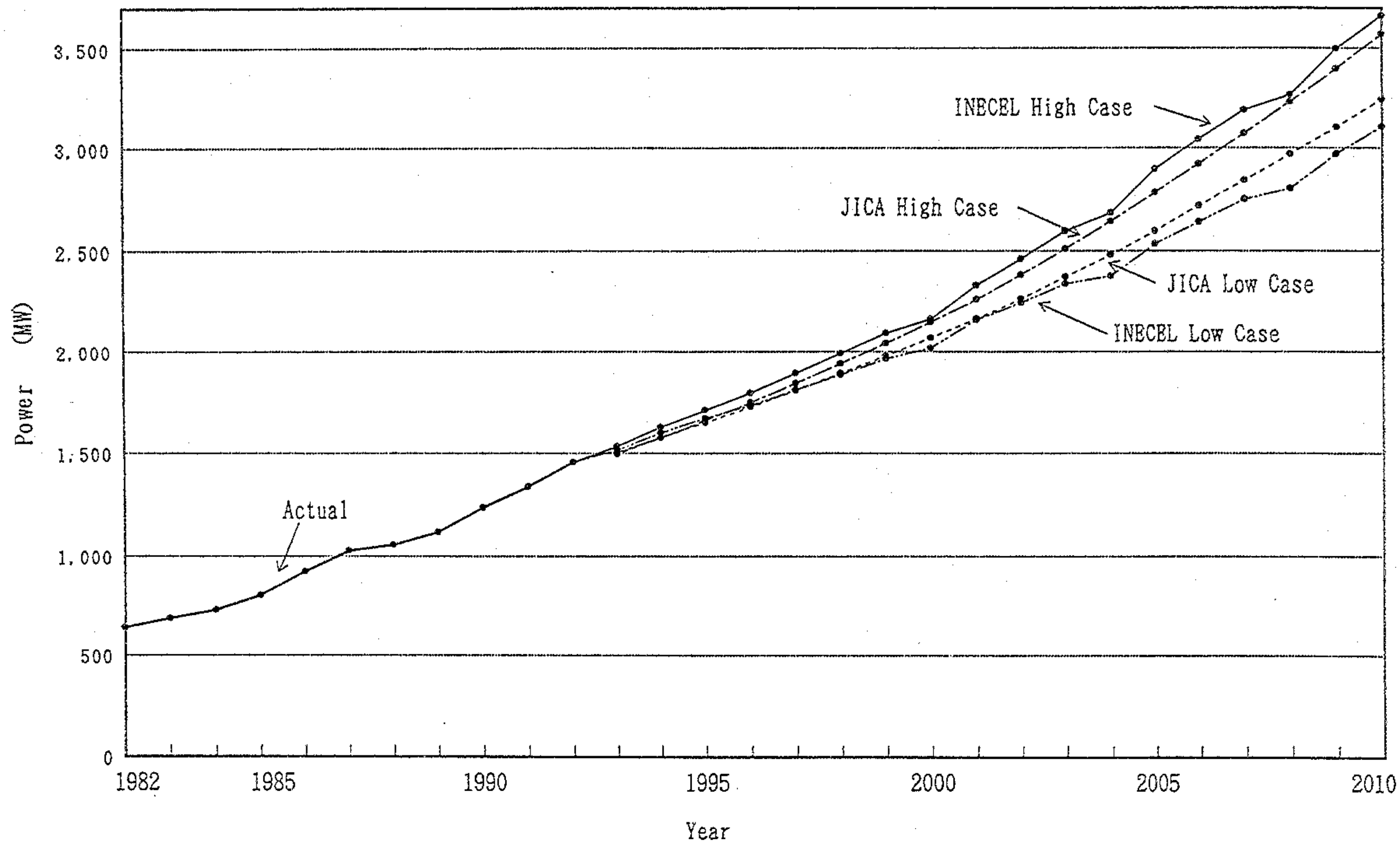

Fig. 4-4 Peak Power Forecast (1982-2010)

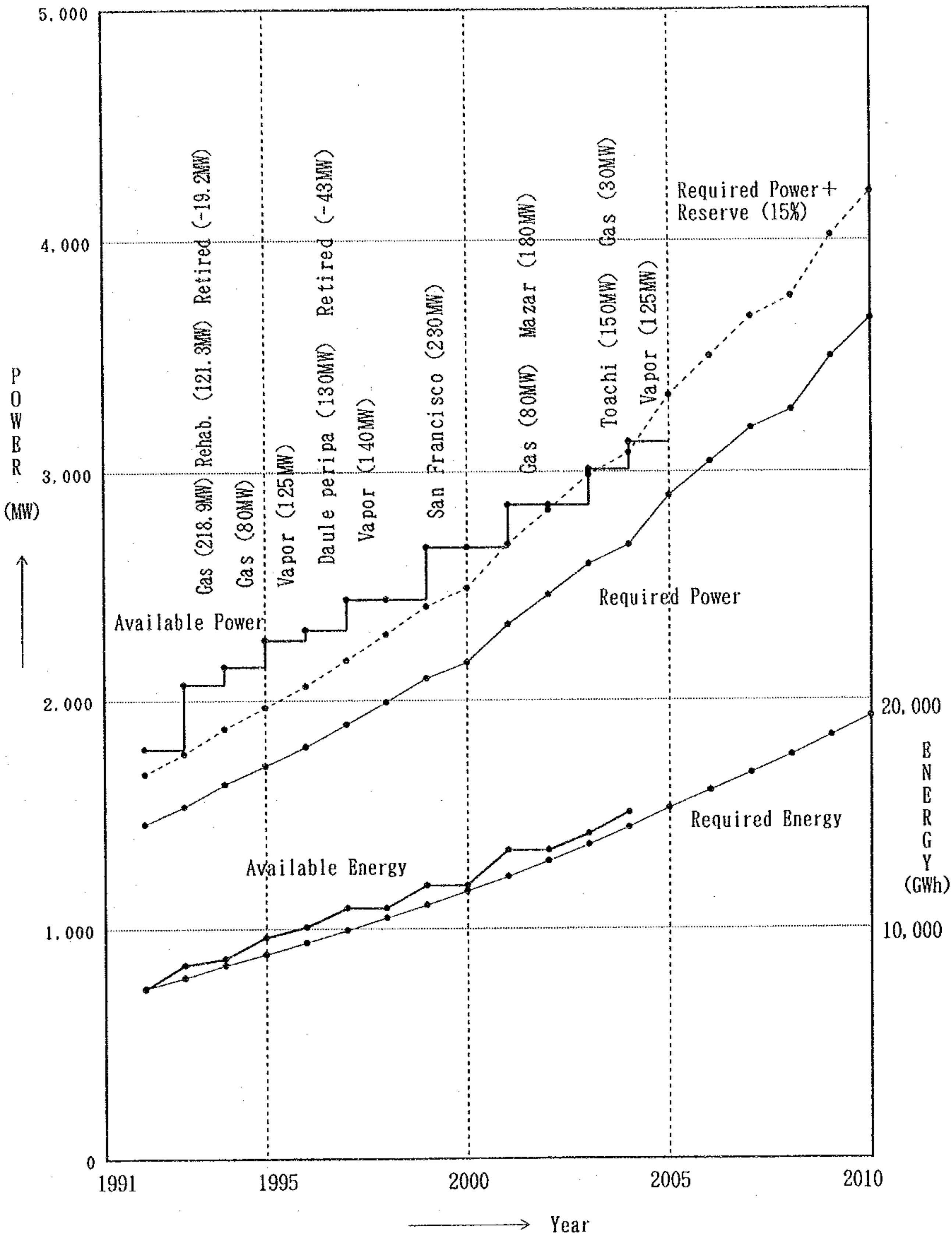

Fig. 4-5 Power Balance and Energy Balance
Alternative 1 (INECEL Plan)

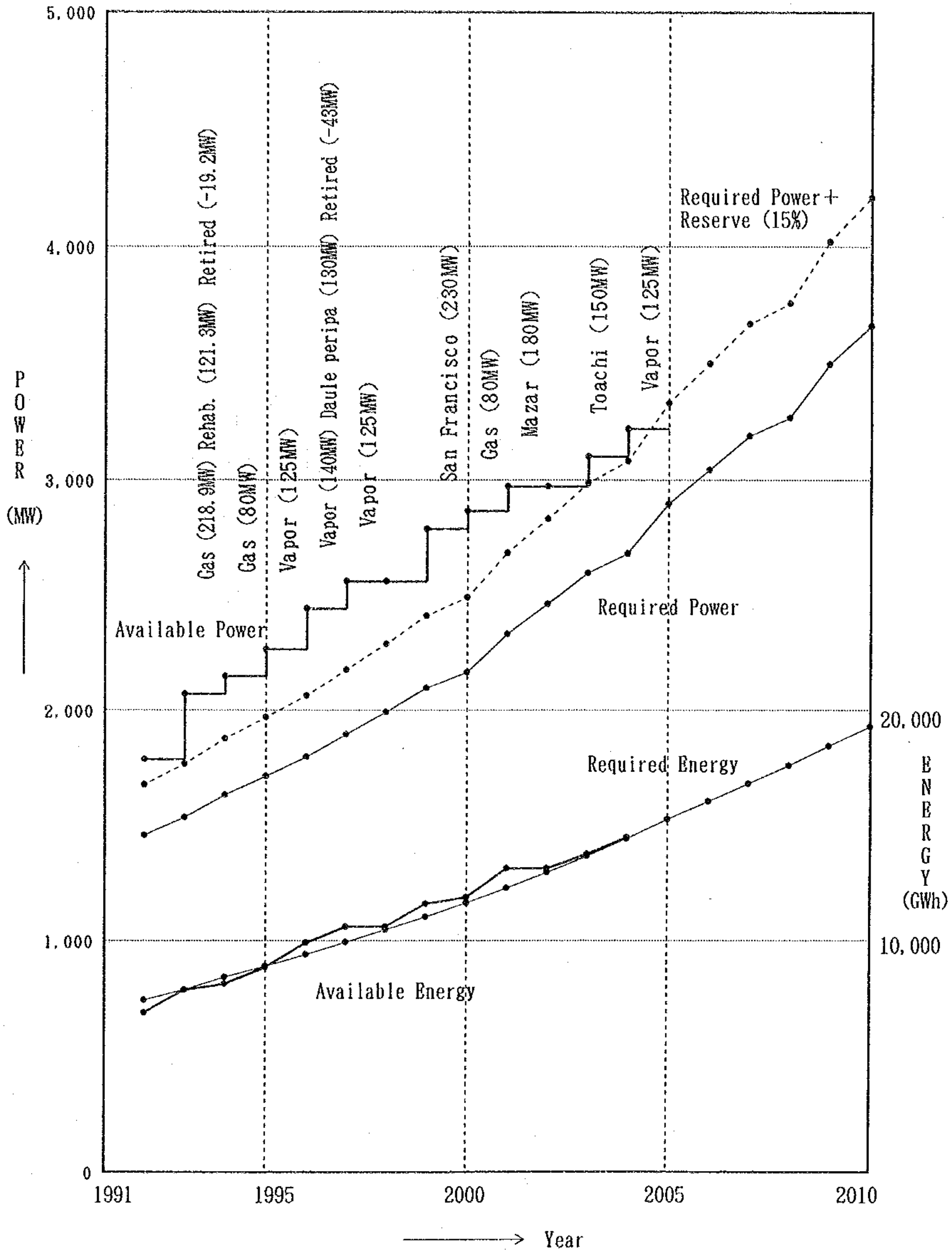

Fig. 4-6 Power Balance and Energy Balance
Alternative 2 (JICA Plan)

Table 4-1 Basic Data for Demand Forecast

(at the price levels and exchange rate of 1980)

	G.D.P (US$)		Energy Demand		Population		G.D.P./Capita		Energy/Capita		Power
Year	(Million)	Rate (%)	(GWh)	Rate (%)	(thousand)	Rate (%)	(US$)	Rate %	(kWh)	rate (%)	(MW)
1970	1,681.2		786		5,969.92		281.6		131,700		
1971	1,586.1	-5.66	865	10.05	6,146.60	2.96	258.0	-1.91	140,700	3.40	
1972	1,855.8	17.00	957	10.64	6,328.51	2.96	293.2	5.75	151,200	3.59	
1973	2,491.2	34.24	1046	9.30	6,515.80	2.96	382.3	11.57	160,500	3.14	
1974	3,718.0	49.25	1221	16.73	6,708.64	2.96	554.2	16.64	182,000	5.65	
1975	4,318.2	16.14	1423	16.54	6,907.19	2.96	625.2	5.45	206,000	5.59	
1976	4,888.3	13.20	1663	16.87	7,106.22	2.88	687.9	4.58	234,000	5.85	
1977	6,155.2	25.92	1977	18.88	7,311.00	2.88	841.9	8.99	270,400	6.55	
1978	7,217.8	17.26	2351	18.92	7,521.67	2.88	959.6	5.99	312,600	6.57	
1979	8,639.7	19.70	2718	15.61	7,738.41	2.88	1,116.5	6.84	351,200	5.42	
1980	10,804.3	25.05	3081	13.36	7,961.40	2.88	1,357.1	8.69	387,000	4.63	
1981	12,505.8	15.75	3393	10.13	8,176.90	2.71	1,529.4	5.82	414,900	3.74	
1982	12,187.5	-2.55	3819	12.56	8,398.24	2.71	1,451.2	-0.94	454,700	4.64	638
1983	6,732.4	-44.76	4015	5.13	8,625.57	2.71	780.5	-16.54	465,500	1.90	684
1984	8,771.0	30.28	4217	5.03	8,859.05	2.71	990.1	11.19	476,000	1.86	726
1985	11,502.0	31.14	4546	7.80	9,098.85	2.71	1,264.1	11.50	499,600	2.88	800
1986	11,207.5	-2.56	4972	9.37	9,320.81	2.44	1,202.4	-1.05	533,400	3.84	922
1987	10,495.4	-6.35	5388	8.37	9,548.18	2.44	1,099.2	-2.60	564,300	3.43	1,027
1988	9,776.4	-6.85	5632	4.53	9,781.11	2.44	999.5	-2.81	575,800	1.86	1,057
1989	9,538.1	-2.44	5770	2.45	10,019.71	2.44	951.9	-1.00	575,900	1.00	1,120
1990	10,522.3	10.32	6360	10.23	10,264.13	2.44	1,025.2	4.23	619,600	4.19	1,240
1991	11,457.0	8.88	6988	9.87	10,514.52	2.44	1,089.6	3.64	664,600	4.05	1,340
1992	12,016.3	4.88	7422	6.21	10,771.01	2.44	1,115.6	2.00	670,300	2.55	1,442

Table 4-2 Energy Demand Forecast by INECEL

Autor: Superintendencia de Planificación
Ecónomica - Financiera
II/ME/803/92 Marzo 1992

Year	High Case					Low Case				
	Energy (GWh)	Rate (%)	Power (MW)	Rate (%)	L.f (%)	Energy (GWh)	Rate (%)	Power (MW)	Rate (%)	L.f (%)
1992	7,422.0		1,455.0		58.2	7,422.0		1,455.0		58.2
1993	7,868.0	6.01	1,532.0	5.29	58.6	7,775.0	4.76	1,514.0	4.05	58.6
1994	8,414.0	6.94	1,628.0	6.27	59.0	8,272.0	6.39	1,600.0	5.68	59.0
1995	8,897.0	5.74	1,710.0	5.04	59.4	8,696.0	5.13	1,672.0	4.50	59.4
1996	9,394.0	5.59	1,794.0	4.91	59.8	9,084.0	4.46	1,735.0	3.77	59.8
1997	9,925.0	5.65	1,892.0	5.46	59.9	9,491.0	4.48	1,809.0	4.27	59.9
1998	10,462.0	5.41	1,991.0	5.23	60.0	9,906.0	4.37	1,885.0	4.20	60.0
1999	11,029.0	5.42	2,096.0	5.27	60.1	10,332.0	4.30	1,963.0	4.14	60.1
2000	11,641.0	5.55	2,165.0	3.29	61.4	10,858.0	5.09	2,019.0	2.85	61.4
2001	12,272.0	5.42	2,332.0	7.71	60.1	11,377.0	4.78	2,162.0	7.08	60.1
2002	12,949.0	5.52	2,461.0	5.53	60.1	11,824.0	3.93	2,247.0	3.93	60.1
2003	13,654.0	5.44	2,595.0	5.44	60.1	12,312.0	4.13	2,340.0	4.14	60.1
2004	14,405.0	5.50	2,679.0	3.24	61.4	12,793.0	3.91	2,379.0	1.67	61.4
2005	15,236.0	5.77	2,895.0	8.06	60.1	13,337.0	4.25	2,534.0	6.52	60.1
2006	16,006.0	5.05	3,042.0	5.08	60.1	13,878.0	4.06	2,637.0	4.06	60.1
2007	16,777.0	4.82	3,188.0	4.80	60.1	14,454.0	4.15	2,747.0	4.17	60.1
2008	17,559.0	4.66	3,265.0	2.42	61.4	15,053.0	4.14	2,799.0	1.89	61.4
2009	18,398.0	4.78	3,496.0	7.08	60.1	15,637.0	3.88	2,971.0	6.15	60.1
2010	19,262.0	4.70	3,660.0	4.69	60.1	16,341.0	4.50	3,105.0	4.51	60.1

* Generating end

Table 4-3 Demand Forecast by Macro Method (High Case)

(at the price levels and exchange rate of 1980)

	G.D.P / Capita		Energy / Capita		Population		G.D.P. (US$)		Energy Demand		Power	
Year	(US$)	Rate (%)	(kWh)	Rate (%)	(thousand)	Rate (%)	(Million)	Rate (%)	(GWh)	Rate (%)	(MW)	Rate (%)
1993	1,300		716.7		11,033.82		14,344		7,908		1504	
1994	1,322	1.69	732.9	2.26	11,303.05	2.44	14,943	4.18	8,284	4.75	1576	4.79
1995	1,350	2.12	753.5	2.81	11,578.84	2.44	15,631	4.60	8,725	5.32	1660	5.33
1996	1,379	2.15	774.9	2.84	11,861.34	2.44	16,357	4.64	9,191	5.34	1748	5.30
1997	1,409	2.18	797.1	2.86	12,150.78	2.44	17,120	4.66	9,685	5.37	1842	5.38
1998	1,439	2.13	819.3	2.79	12,447.26	2.44	17,912	4.63	10,198	5.30	1940	5.32
1999	1,470	2.15	842.3	2.81	12,750.97	2.44	18,744	4.64	10,740	5.31	2043	5.31
2000	1,501	2.11	865.4	2.74	13,062.10	2.44	19,606	4.60	11,304	5.25	2151	5.29
2001	1,533	2.13	889.2	2.75	13,380.81	2.44	20,513	4.63	11,898	5.25	2264	5.25
2002	1,566	2.15	913.8	2.77	13,707.30	2.44	21,466	4.65	12,526	5.28	2383	5.26
2003	1,600	2.17	939.2	2.78	14,041.76	2.44	22,467	4.66	13,188	5.29	2509	5.29
2004	1,634	2.13	964.7	2.72	14,384.38	2.44	23,504	4.62	13,877	5.22	2640	5.22
2005	1,669	2.14	990.9	2.72	14,735.36	2.44	24,593	4.63	14,601	5.22	2778	5.23
2006	1,704	2.10	1,017.1	2.64	15,094.90	2.44	25,722	4.59	15,353	5.15	2921	5.15
2007	1,740	2.11	1,044.2	2.66	15,463.22	2.44	26,906	4.60	16,147	5.17	3072	5.17
2008	1,777	2.13	1,072.0	2.66	15,840.52	2.44	28,149	4.62	16,981	5.17	3230	5.14
2009	1,814	2.08	1,099.9	2.60	16,227.03	2.44	29,436	4.57	17,848	5.11	3396	5.14
2010	1,852	2.09	1,128.5	2.60	16,622.97	2.44	30,786	4.59	18,759	5.10	3569	5.09

* Generating end

Table 4-4 Demand Forecast by Macro Method (Low Case)

(at the price levels and exchange rate of 1980)

	G.D.P / Capita		Energy / Capita		Population		G.D.P. (US$)		Energy Demand		Power	
Year	(US$)	Rate (%)	(kWh)	Rate (%)	(thousand)	Rate (%)	(Million)	Rate (%)	(GWh)	Rate (%)	(MW)	Rate (%)
1993	1,294		712.3		11,033.82		14,278		7,859		1495	
1994	1,322	2.16	732.9	2.89	11,303.05	2.44	14,943	4.66	8,284	5.41	1576	5.42
1995	1,344	1.66	749.1	2.21	11,578.84	2.44	15,562	4.14	8,674	4.71	1650	4.70
1996	1,366	1.64	765.3	2.16	11,861.34	2.44	16,203	4.12	9,077	4.65	1727	4.67
1997	1,388	1.61	781.5	2.12	12,150.78	2.44	22,843	40.98	9,496	4.62	1807	4.63
1998	1,411	1.66	798.6	2.19	12,447.26	2.44	17,563	-23.11	9,940	4.68	1891	4.65
1999	1,434	1.63	815.6	2.13	12,750.97	2.44	18,285	4.11	10,400	4.63	1979	4.65
2000	1,458	1.67	833.4	2.18	13,062.10	2.44	19,045	4.16	10,886	4.67	2071	4.65
2001	1,482	1.65	851.3	2.15	13,380.81	2.44	19,830	4.12	11,391	4.64	2167	4.64
2002	1,506	1.62	869.1	2.09	13,707.30	2.44	20,643	4.10	11,913	4.58	2266	4.57
2003	1,531	1.66	887.7	2.14	14,041.76	2.44	21,498	4.14	12,465	4.63	2372	4.68
2004	1,556	1.63	906.4	2.11	14,384.38	2.44	22,382	4.11	13,038	4.60	2481	4.60
2005	1,582	1.67	925.8	2.14	14,735.36	2.44	23,311	4.15	13,642	4.63	2595	4.59
2006	1,608	1.64	945.2	2.10	15,094.90	2.44	24,273	4.13	14,268	4.59	2715	4.62
2007	1,634	1.62	964.7	2.06	15,463.22	2.44	25,267	4.10	14,917	4.55	2838	4.53
2008	1,661	1.65	984.9	2.09	15,840.52	2.44	26,311	4.13	15,601	4.59	2968	4.58
2009	1,688	1.63	1,005.2	2.06	16,227.03	2.44	27,391	4.10	16,311	4.55	3103	4.55
2010	1,715	1.60	1,025.4	2.01	16,622.97	2.44	28,508	4.08	17,045	4.50	3243	4.51

Table 4-5 Power (kW) Balance and Energy (kWh) Balance

Alternative − 1 (INECEL plan)

Year	Name of Power Plant	Installed Capacity (MW)	Available Energy (GWh)	Available Power (MW)	Energy Balance (GWh) Required	Energy Balance (GWh) Available	Power Balance (MW) Required	Power Balance (MW) Available
1992	Existing Hydro	1,470.1	3,956.4	1,209.4	7,422	7,370.3	1,455	1,783.0
	Existing Thermal	808.1	3,413.9	573.6				
	Existing Total	2,278.2	7,370.3	1,783.0				
1993	Est. Salado(Gas)	30.9	70.1	20.0	7,868	8,425.9	1,532	2,069.6
	Rehab.-Diesel	62.5	129.3	49.2				
	Rehab.-Bunker	49.2	209.2	39.8				
	Electo Quil	75.0	226.9	74.0				
	Electo Quito	33.0	98.1	32.0				
	T. Gas(Pascuales)	80.0	273.3	78.0				
	Descanso-Cuenca	-19.2	-84.1	-16.0				
	Rehab. Est. Salado	146.0	132.8	9.6				
1994	T. Gas (Machala)	80.0	273.3	78.0	8,414	8,699.2	1,628	2,147.6
1995	T. Vapor(Trinitaria)	125.0	926.4	117.5	8,897	9,625.6	1,710	2,265.1
1996	D. Peripa	130.0	441.6	86.0	9,394	10,067.2	1,794	2,310.2
	Vap. Emelec	-10.0	-74.1	-9.4				
	Gas Emelec	-13.5	-42.0	-12.0				
	SR. Bunker	-5.0	-21.0	-4.0				
	SR Diesel	-15.5	-81.5	-15.5				
1997	T. Vapor(Manta)	140.0	1,040.7	132.0	9,925	10,889.3	1,892	2,442.2
1998					10,462	10,889.3	1,991	2,442.2
1999	San Francisco	230.0	997.0	226.0	11,029	11,886.3	2,096	2,668.2
2000					11,641	11,886.3	2,165	2,668.2
2001	T. Gas (Sta Rosa)	80.0	273.3	78.0	12,272	13,411.6	2,332	2,854.0
	Mazar	180.0	1,252.0	107.8				
2002					12,949	13,411.6	2,461	2,854.0
2003	Toachi	150.0	618.0	128.8	13,654	14,124.2	2,595	3,007.8
	T. Gas (Guamgopolo)	30.0	94.6	27.0				
2004	T. Vapor(Sta Elena)	125.0	926.4	117.5	14,405	15,050.6	2,679	3,127.3

Alternative − 2 (JICA plan)

Year	Name of Power Plant	Installed Capacity (MW)	Available Energy (GWh)	Available Power (MW)	Energy Balance (GWh) Required	Energy Balance (GWh) Available	Power Balance (MW) Required	Power Balance (MW) Available
1992	Existing Hydro	1,470.1	3,956.4	1,209.4	7,422	6,874.8	1,455	1,783.0
	Existing Thermal	808.1	2,918.4	573.6				
	Existing Total	2,278.2	6,874.8	1,783.0				
1993	Est. Salado(Gas)	30.9	70.1	20.0	7,868	7,856.5	1,532	2,069.6
	Rehab.-Diesel	62.5	129.3	49.2				
	Rehab.-Bunker	49.2	209.2	39.8				
	Electo Quil	75.0	226.9	74.0				
	Electo Quito	33.0	98.1	32.0				
	T. Gas(Pascuales)	80.0	273.3	78.0				
	Descanso-Cuenca	-19.2	-84.1	-16.0				
	Rehab. Est. Salado	146.0	58.9	9.6				
1994	T. Gas (Machala)	80.0	273.3	78.0	8,414	8,129.8	1,628	2,147.6
1995	T. Vapor(Trinitaria)	125.0	720.5	117.5	8,897	8,850.3	1,710	2,265.1
1996	D. Peripa	130.0	441.6	86.0	9,394	9,882.7	1,794	2,442.2
	Vap. Emelec	-10.0	-74.1	-9.4				
	Gas Emelec	-13.5	-42.0	-12.0				
	SR. Bunker	-5.0	-21.0	-4.0				
	SR Diesel	-15.5	-81.5	-15.5				
	T. Vapor(Manta)	140.0	809.4	132.0				
1997	T. Vapor	125.0	720.5	117.5	9,925	10,603.2	1,892	2,559.7
1998					10,462	10,603.2	1,991	2,559.7
1999	San Francisco	230.0	997.0	226.0	11,029	11,600.2	2,096	2,785.7
2000	T. Gas (Sta Rosa)	80.0	273.3	78.0	11,641	11,873.5	2,165	2,863.7
2001	Mazar	180.0	1,252.0	107.8	12,272	13,125.5	2,332	2,971.5
2002					12,949	13,125.5	2,461	2,971.5
2003	Toachi	150.0	618.0	128.8	13,654	13,743.5	2,595	3,100.3
2004	T. Vapor(Sta Elena)	125.0	720.5	117.5	14,405	14,464.0	2,679	3,217.8

CHAPTER 5 POWER SYSTEM ANALYSIS

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CHAPTER 5 POWER SYSTEM ANALYSIS

5.1 Study Conditions

The power systems were studied based on the power system expansion plan formulated by INECEL. The study was conducted for the following years mainly concerning the system voltages under steady state conditions and faulty conditions, overloading conditions of transmission lines and transformers, short circuit current values, and power system stability.

Years Studied: 1993, 1998, 2003

The studies on years 1998 and 2003 were conducted on two typical time sections of wet season (June) and dry season (December).

The peak load values at each substation in each study year are presented in Table 5-1. The related one-line diagrams are given in Fig. 5-1 through Fig. 5-3, and impedance maps in Fig. 5-4 through Fig. 5-6.

The standard voltage at load side during steady state operations and under faulty conditions are stipulated by INECEL as follows.

Normal Condition	Faulty Condition
97 - 103%	90 - 105%

A single failure (n - 1) criterion was adopted for the evaluation of power system stability. The faults condition assumed was an occurrence of permanent 3-phase short circuit on one circuit of transmission line, with successful clearing and no reclosing operation. In this report, Paute-Milagro 230 kV transmission line was selected as the faulted line. The fault clearing time was set at 5-cycle clearing operation, which is being applied to the 230 kV systems of INECEL. In addition, 2-circuit faults were also assumed on Paute-Milagro line for the studies of 1998 and 2003, although the frequency of such fault would be rare.

The generator constants and AVR, governor constants were adopted from the data of INECEL. The major generator constants are presented in Table 5-2.

5.2 Study of 1993 Time Section

(1) Power Flow

The power flow calculation result, which was calculated in reference to the real power flow in March, 1993, is presented in Fig. 5-7. In this case, the operating voltage values at load ends fell within the standard band, except at several locations such as Selva Alegre Substation. There was no transmission line or transformer that was overloaded.

(2) Short Circuit Current

As shown in Table 3-5, the short circuit current values at 230 kV busses and 138 kV busses did not exceed the rated rupturing current.

(3) Power System Stability

The power system stability calculation results, which were calculated for 1 circuit, 3LG-3LO faults on Paute-Milagro 230 kV transmission line under the power flow conditions described in Paragraph (1), are given in Fig. 5-8. The power system stability was maintained.

The power flow conditions which were observed after the faulted one circuit was cleared are shown in Fig. 5-9. There was no transmission line or transformer that was overloaded, except several substations including Selva Alegre substation.

5.3 Study of 1998 Time Section

(1) Power Flow

The power flow calculation results which were based on the demand projection of Table 5-1 are presented in Fig. 5-10 and Fig. 5-11.

The power flow in Fig. 5-10 is on the time section of June, while that of Fig. 5-12 is on the time section of December when Paute Power Plant is in the dry season, whereby the power generation of Paute Power Plant is reduced from 1,008 MW to 915 MW, and the power flow between Paute and Pascuales is light.

In both cases, the operating voltage values at load ends fell within the standard band, and there was no transmission line that was overloaded.

However, it was required to change the taps, in addition to the values given by INECEL's plan, of the transformers in the following substations.

Selva Alegre
Chillo Gallo
Kennedy
No. 18
No. 19
Pomasqui

In addition, the phase compensating condensers were required in the following substations.

Vicentina	12 MVar
Salitral	36 MVar
Pascuales	36 MVar
Santa Rosa	36 MVar
(Milagro)	(36 MVar)

(2) Short Circuit Current

As shown in Table 5-3, the short circuit current values at 230 kV busses and 138 kV busses did not exceed the rated rupturing current value.

(3) Power System Stability

(a) June Time Section

The results of power system stability calculations for single circuit, 3LG-3LO and double circuit, 3LG-3LO on Paute-Milagro 230 kV transmission line are presented in Fig. 5-12 and Fig. 5-13, respectively. As the power system was unstable under the power flow condition of Fig. 5-10, the power flow condition of Fig. 5-14, in which the power generation of Paute-C was reduced to 954 MW, was used. The results of these calculations were stable in both cases.

The power flow conditions after the clearing of one faulted circuit and two faulted circuits are shown in Fig. 5-15 and Fig. 5-16, respectively. The operating voltage values at load ends fell within the standard band. There was no line or transformer which was overloaded.

(b) December Time Section

The results of power system stability calculations for single circuit, 3LG-3LO and double circuit, 3LG-3LO on Paute-Milagro 230 kV transmission line are presented in Fig. 5-17 and Fig. 5-28, respectively. The power swing was less severer than in the case of Paragraph (a), and the power system was stable in both cases.

The power flow conditions after the clearing of one faulted circuit and 2 faulted circuits are shown in Fig. 5-19 and Fig. 5-20, respectively. The operating voltage values at load ends fell within the standard band. There was no line or transformer which was overloaded.

5.4 Study of 2003 Time Section

(1) Power Flow

The power flow calculation results which were based on the demand projection of Tale 5-1 are presented in Fig. 5-21 and Fig. 5-22. The power flow in Fig. 5-21 is the case where Pascuales Power Plant is in the wet season, or the June time section, and the power flow in Fig. 5-22 is for the dry season of December time section. In the dry season, the output of Paute Power Plant is reduced from 954 MW to 798 MW, and the power flow between Paute-Pascuales is lighter.

In both cases, the operating voltage values at load ends fell within the standard band. There was no transmission line or transformer that was overloaded.

However, it was required to change the taps, in addition to the values given by INECEL's plan, of the transformers in the following substations.

Selva Alegre
Chillo Gallo
Kennedy
No. 18
No. 19
Pomasqui
Tena
Ambato

In addition, the phase compensating condensers were required in the following substations.

Vicentina	12 MVar
Salitral	36 MVar
Pascuales	36 MVar
Santa Rosa	36 MVar
Ibarra	16 MVar (not included in INECEL's plan)

(2) Short Circuit Current

As shown in Table 5-3, the short circuit current values at 230 kV busses and 138 kV busses did not exceed the rated rupturing current value.

(3) Power System Stability

(a) June Time Section

The results of power system stability calculations for single circuit, 3LG-3LO and double circuit, 3LG-3LO on Paute-Milagro 230 kV transmission line are presented in Fig. 5-23 and Fig. 5-24, respectively. As the power system was unstable when a double circuit fault occurred under the power flow of Fig. 5-21, the power generation at Paute was reduced to 897 MW and power flow condition of Fig. 5-25 was used. The power system was stable in both cases.

The power flow conditions after the clearing of one circuit and 2 circuits are shown in Fig. 5-26 and Fig. 5-27, respectively. The operating voltage values at load ends fell within the standard band. There was no line or transformer which was overloaded.

(b) December Time Section

The results of power system stability calculations for single circuit, 3LG-3LO and double circuit, 3LG-3LO on Paute-Milagro 230 kV transmission line are presented in Fig. 5-28 and Fig. 5-29, respectively. The power swing was less severe than in the case of Paragraph (a), and the power system was stable in both cases.

The power flow conditions after the clearing of one circuit and 2 circuits are shown in Fig. 5-30 and Fig. 5-31, respectively. The operating voltage values at load ends fell within the standard band. There was no line or transformer which was overloaded.

5.5 Summary of Analytical Results

Although there was no particular problem with the short circuit current level and the overloading of transmission lines and transformers, concerning the operating voltage conditions in the 1993 time section, the operating voltage at a few substations in the northern region did not fell within the allowable range. Although the power system was stable in the 1993 time section, the system was near the stability limit.

In the study of 1993 time section, analytical studies were conducted on the actual power flow record at March time section. No particular countermeasure has been recommended. The above problems would be alleviated in 1998 and 2003 time sections as the transmission line from Paute to Pascuales is reinforced to 4 circuits, and the power development projects near Guayaquil and in the northern region are implemented according to INECEL's plan. This will enable to operate Paute Power Plant at approximately rated power in the wet season of June.

Year.Month	Paute Output (MW)	Stability Study Result	
		1 cct fault	2 cct faults
1988. 6	1,008 954	O O	x O
1998. 12	915	O	O
2003. 6	954 897	O O	x O
2003. 12	798	O	O

However, some transformer taps and phase compensating condensers will be required in some substations in the northern region power system in 1998 and 2003 time sections in order to maintain voltage in steady state operations.

5.6 Frequency Drop and Load

The frequency deviation, which is caused by the imbalance between supply and demand in a power system, is governed by the frequency characteristics of power sources and loads. The frequency characteristics of the power supply source is determined by the action of controllers which suppress the mechanical input to generators when the power system frequency rises (when the generator speed is increased), and boosts the mechanical input when the power system frequency drops. This action is normally implemented by the speed governors. On the other hand, the frequency characteristics of the loads are such that the power consumption increases as the frequency rises, and the power consumption decreases as the frequency drops. (According to INECEL, the power system of SNI has been operated at a frequency of 59.7 Hz when there wads an extreme imbalance between demand and supply.)

It would be possible to actually measure the frequency characteristics of supply sources and loads on the power system of SNI. However, INECEL has no record of actual measurement.

The sum of the total changes of the generator output and the total changes of loads for a frequency deviation of 0.1 Hz is call the frequency constant (K) of the power system, and this value represents the performance of generators and loads that constitute the power system. This value is normally in the range given below.

Power System Frequency Constant, K ≈ 1.20 --- 1.55 %MW/0.1 Hz

5.6.1 Load Shedding

The JICA Study Mission shall study the load shedding rules which are currently applied by INECEL based on the above range of power system frequency characteristics (K), to determine whether excessive loads are cut off under the current load shedding rule. INECEL has stipulated in its power supply contracts with each power companies that the frequency relays are installed on the switches of 13.8 kV distribution lines and other feeders to shed the loads in proportion to the magnitude of frequency drop in the event of loss of supply sources in the power system. This arrangement is made to separate the circuit breakers at interconnection points to maintain the power system frequency, and even under the worst circumstance, the power system stability is maintained and isolated power systems can survive.

The load shedding conditions currently set by INECEL is illustrated in Table 5-4. Out of the 7 steps of load shedding currently applied by INECEL, the amount of loads cut off above step 4 seems to be too large. Although the result of this study by JICA study mission has been obtained on the assumption of system frequency constant K = 1.38 %MW/0.1 Hz, this value is more or less the same in all power systems. Nevertheless, it is desirable to verify this value by actual measurement on the power system of INECEL.

When the power system frequency drops to 58.5 Hz or below, the power systems of EMELEC and EEQ are isolated to independent operations.

5.6.2 Actual Measurement of Frequency Constant (K)

Although it is desirable to measure the frequency constants of the power supply sources and those of the loads separately, it would be required, in order to measure the frequency constant of loads, to stall all the speed governors of generators and then take measurement by current off the loads several time at different load levels. Such measurement involves power supply interruption to the customers.

To measure the frequency constant of the power supply sources, it would also be required to cut off loads at several load levels while keeping the generator of Paute Hydroelectric Power Plant, which controls the frequency of the SNI Power System, in the governor-free operation mode. This method also involves power supply interruption to the customers, and would not be desirable. In essence, the separate measurement of power sources and load frequency characteristics involves power supply interruption to customers, and actual measurement would be difficult.

The power system frequency constant (K) can be obtained by examining the past records on the loss of supply events in the power system. In such an attempt, attention must be paid on the total capacity of generators which were connected to the power system, the size of loads, and the frequency drop observed in such an event. If these three variables can be determined, the frequency constant (K) of SNI Power System can be determined.

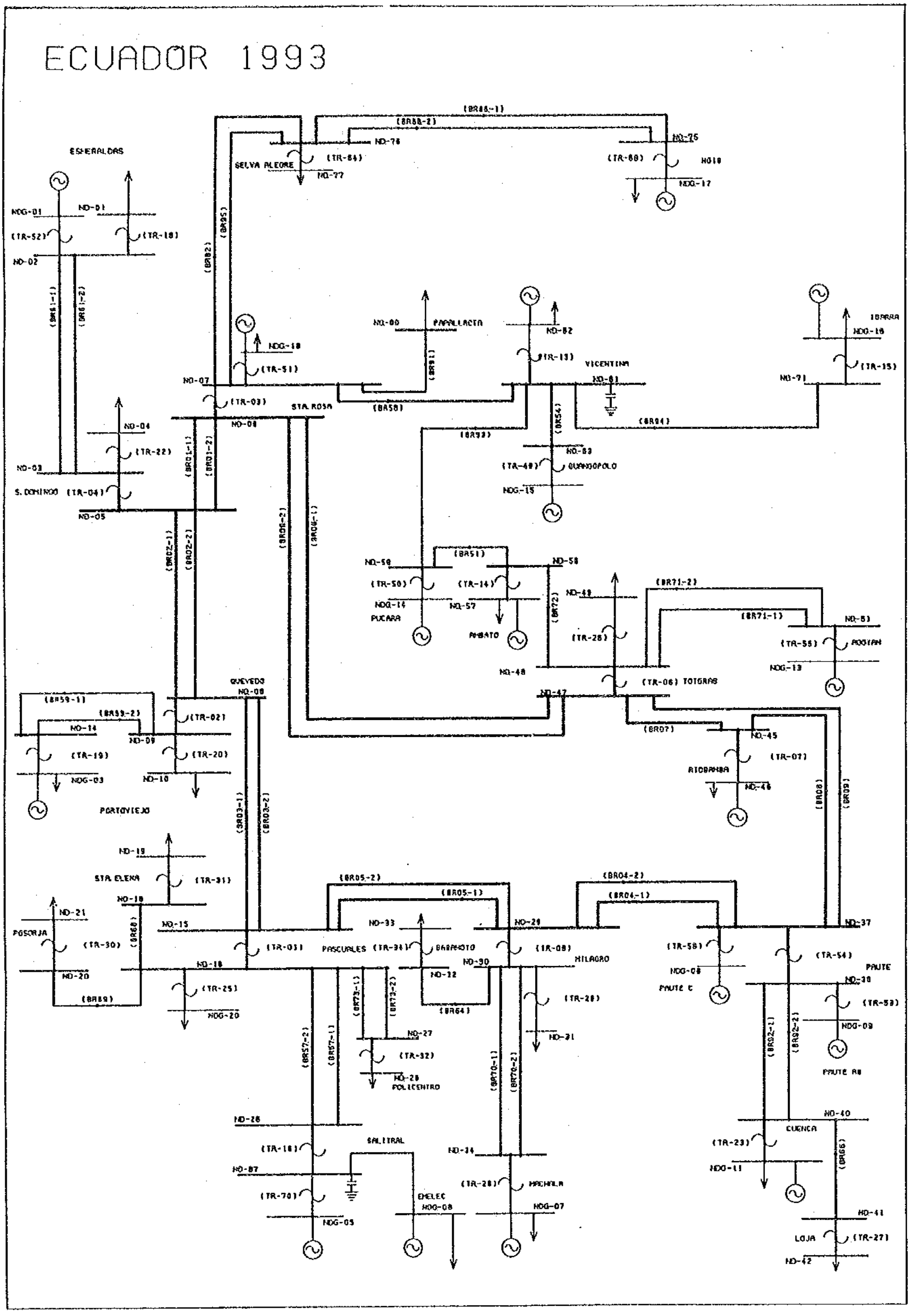


Fig. 5-1 SNI Power System Configuration in 1993

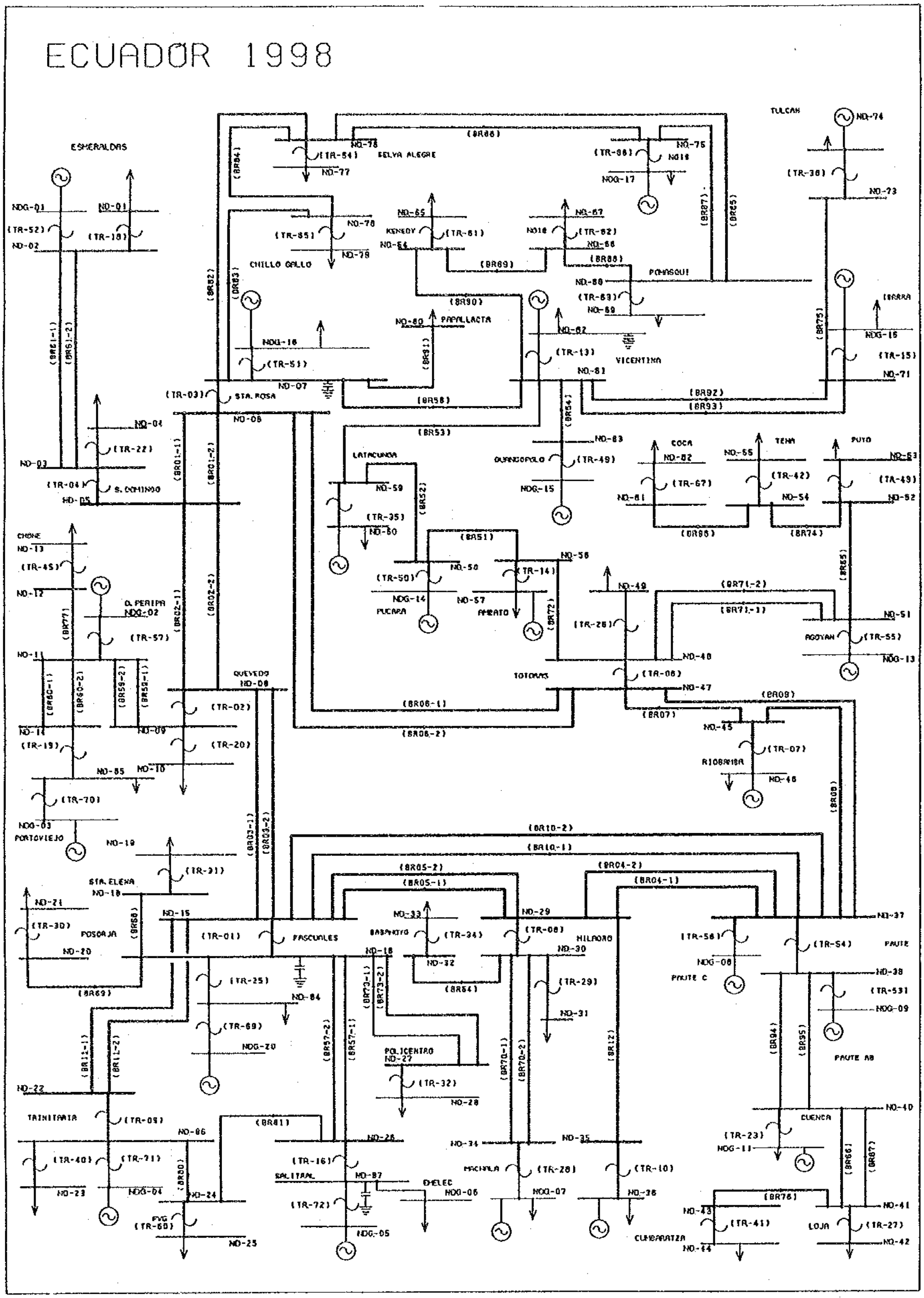


Fig. 5-2 SNI Power System Configuration in 1998

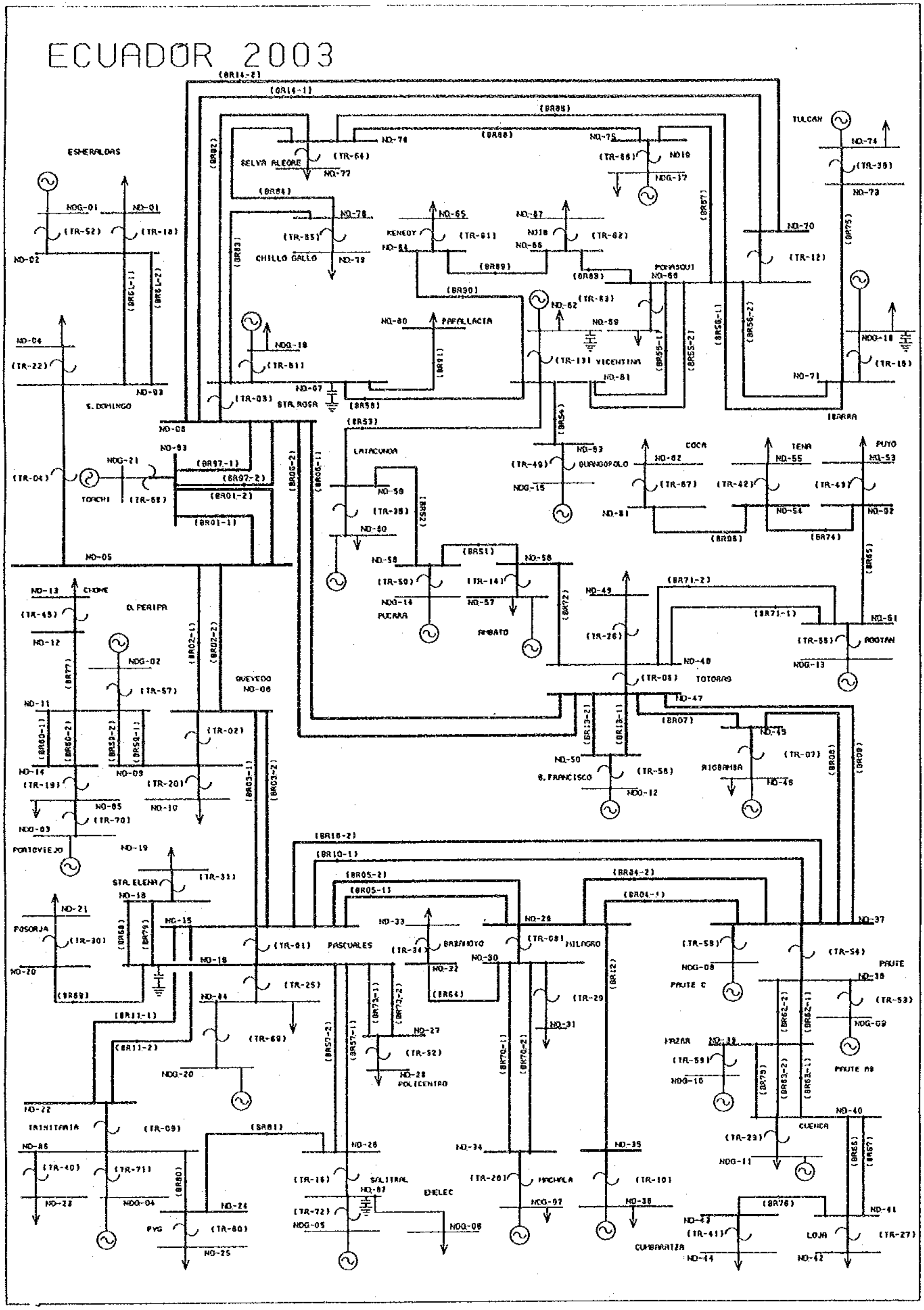


Fig. 5-3 SNI Power System Configuration in 2003

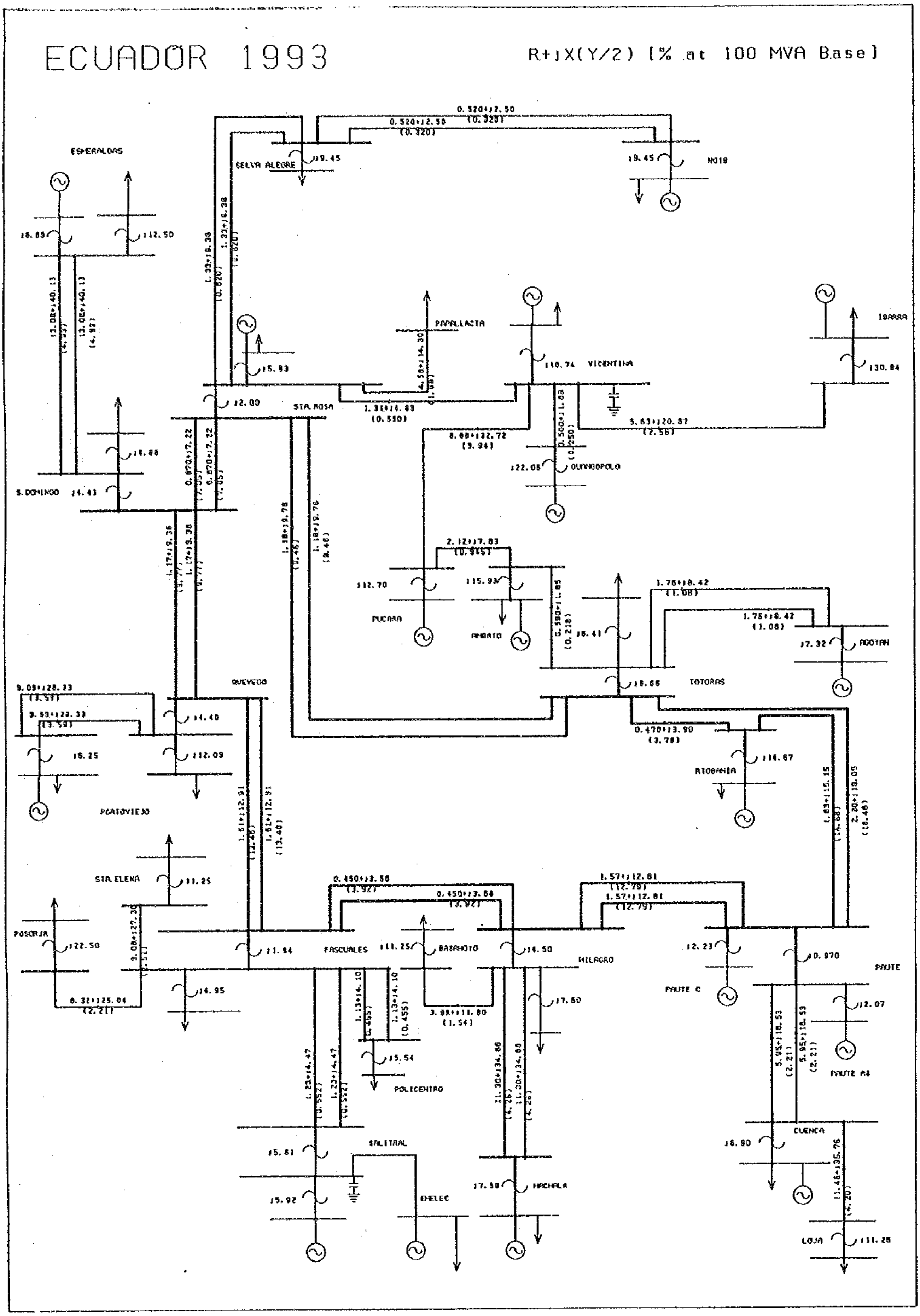


Fig. 5-4 Impedance Map in 1993

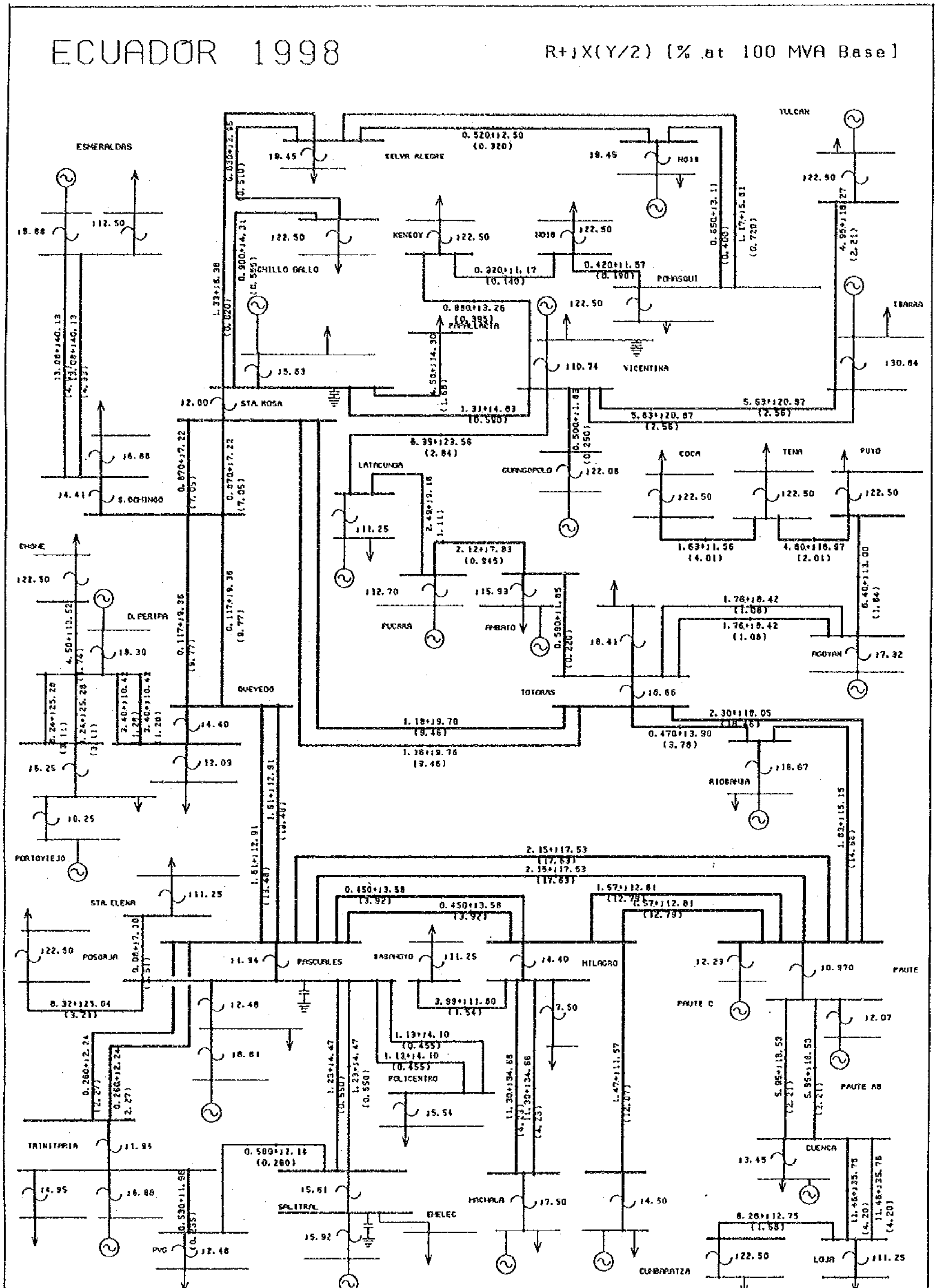


Fig. 5-5 Impedance Map in 1998

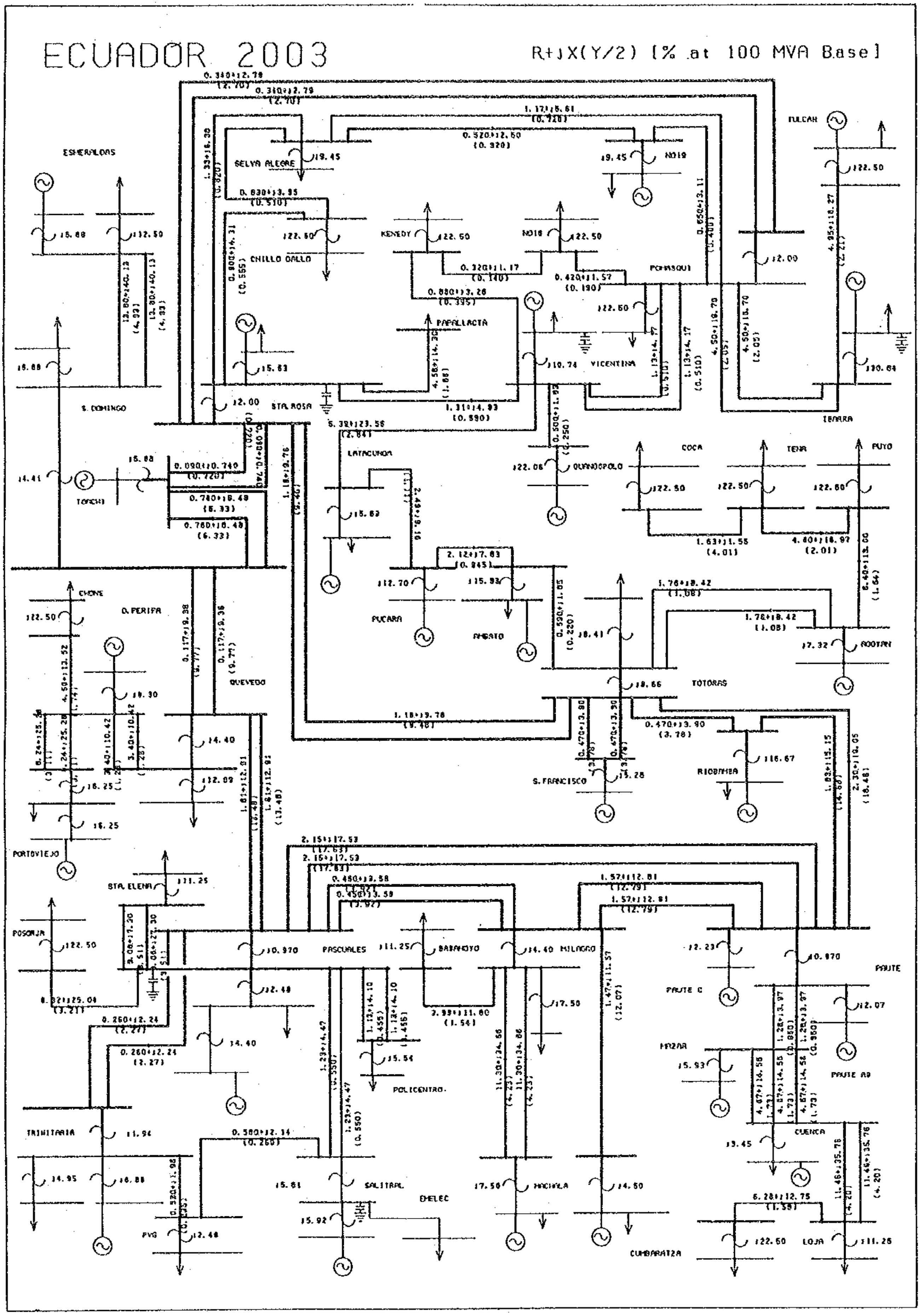


Fig. 5-6 Impedance Map in 2003

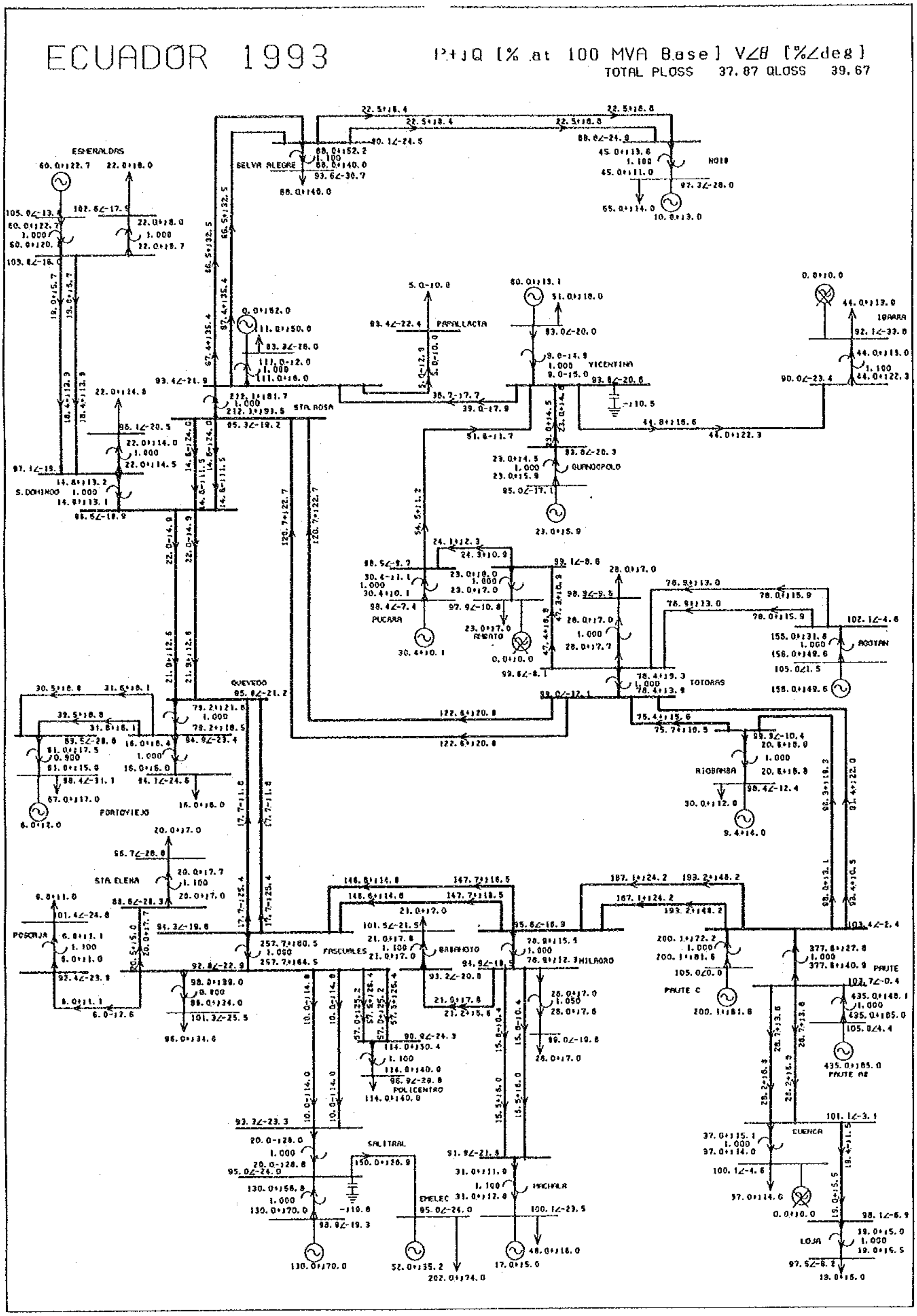
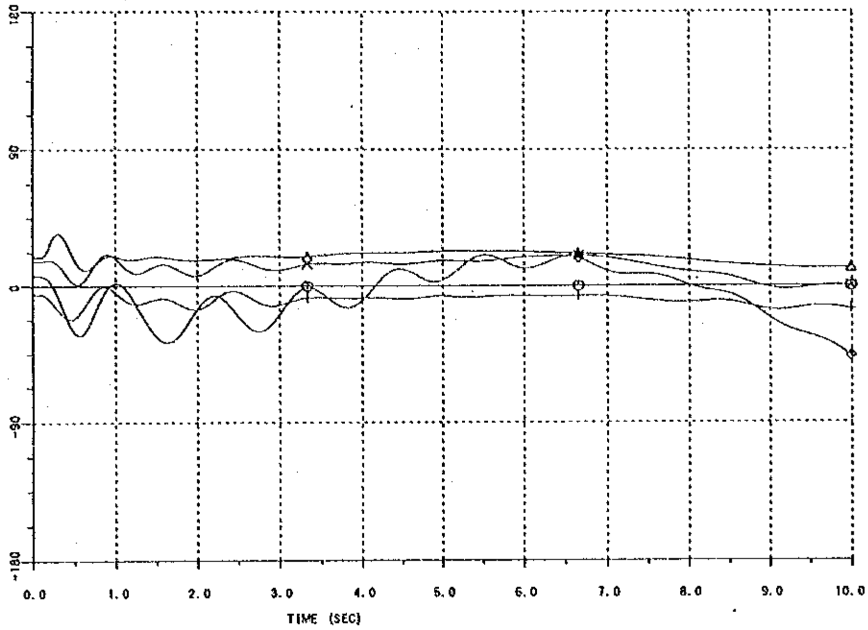


Fig. 5-7 Power Flow 1993

ECUADOR 1993 8R0‹-1 (PAUTE-MILAGRO) 3LG-O

	Code	Term	Comment	Max	Min	Initial	Final
1	NOG-08	ANG	PAUTE-C	0.00	0.00	0.00	0.00
2	NOG-09	ANG	PAUTE-AB	34.78	10.61	19.44	12.30
3	NOG-14	ANG	PISAYAMB	-0.48	-22.18	-5.58	-15.32
4	NOG-13	ANG	AGOYAN	21.27	-2.03	16.81	0.41
5	NOG-05	ANG	SALITRAL	20.70	-46.43	6.67	-46.43



ECUADOR 1993 8R04-1 (PAUTE-MILAGRO) 3LG-O

	Code	Term	Comment	Max	Min	Initial	Final
1	NOG-08	ANG	PAUTE-C	0.00	0.00	0.00	0.00
2	NOG-18	ANG	STA. ROSA	-5.06	-81.01	-36.22	-76.67
3	NOG-07	ANG	MACHALA	-0.82	-47.28	-12.37	-47.28
4	NOG-01	ANG	ESMERALD	30.09	-56.94	-5.57	-50.39

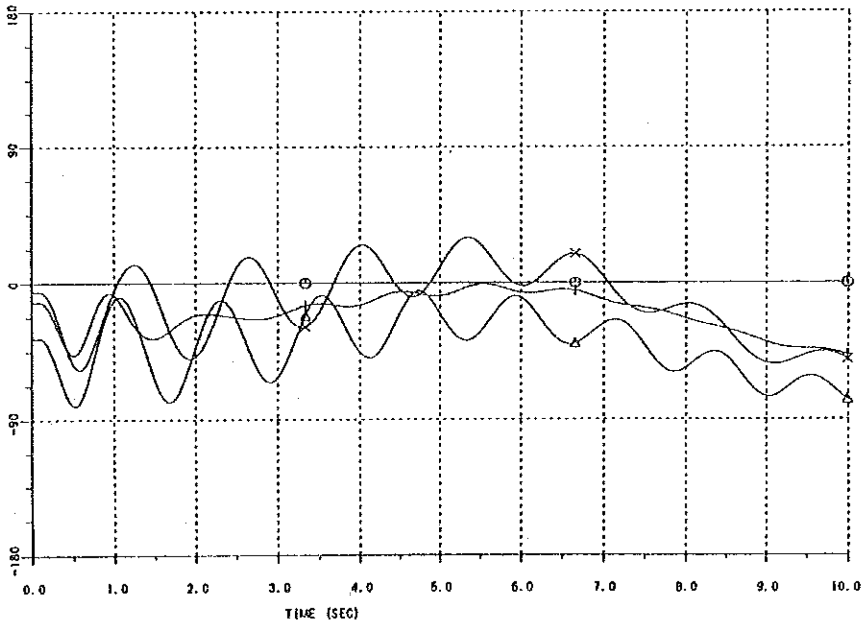


Fig. 5-8 Power System Stability Analisis at 1 CCT Line Fault (under power flow condition of Fig. 5-7)

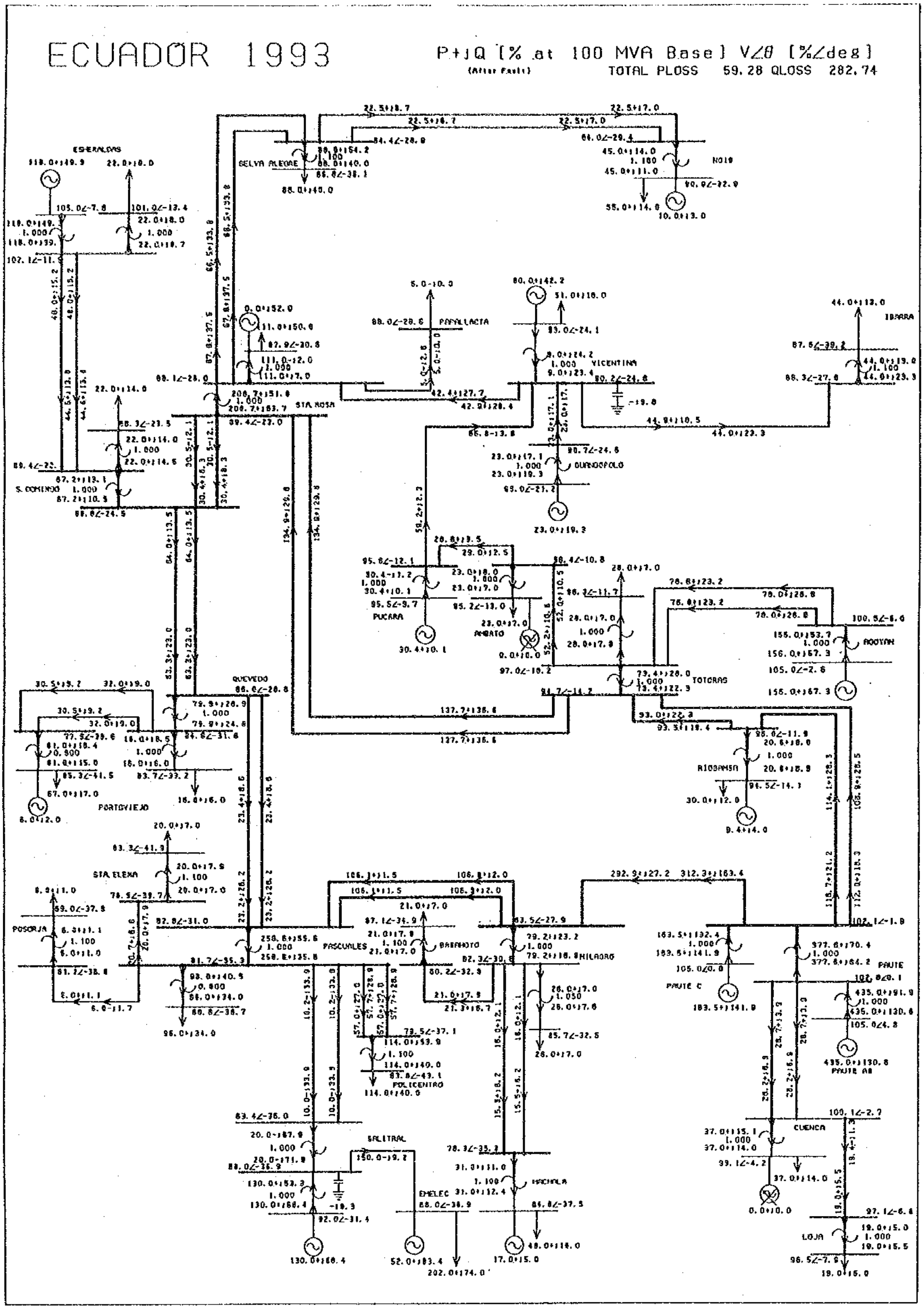


Fig. 5-9 Power Flow after Clearing of 1 CCT
(corresponding to Fig. 5-7)

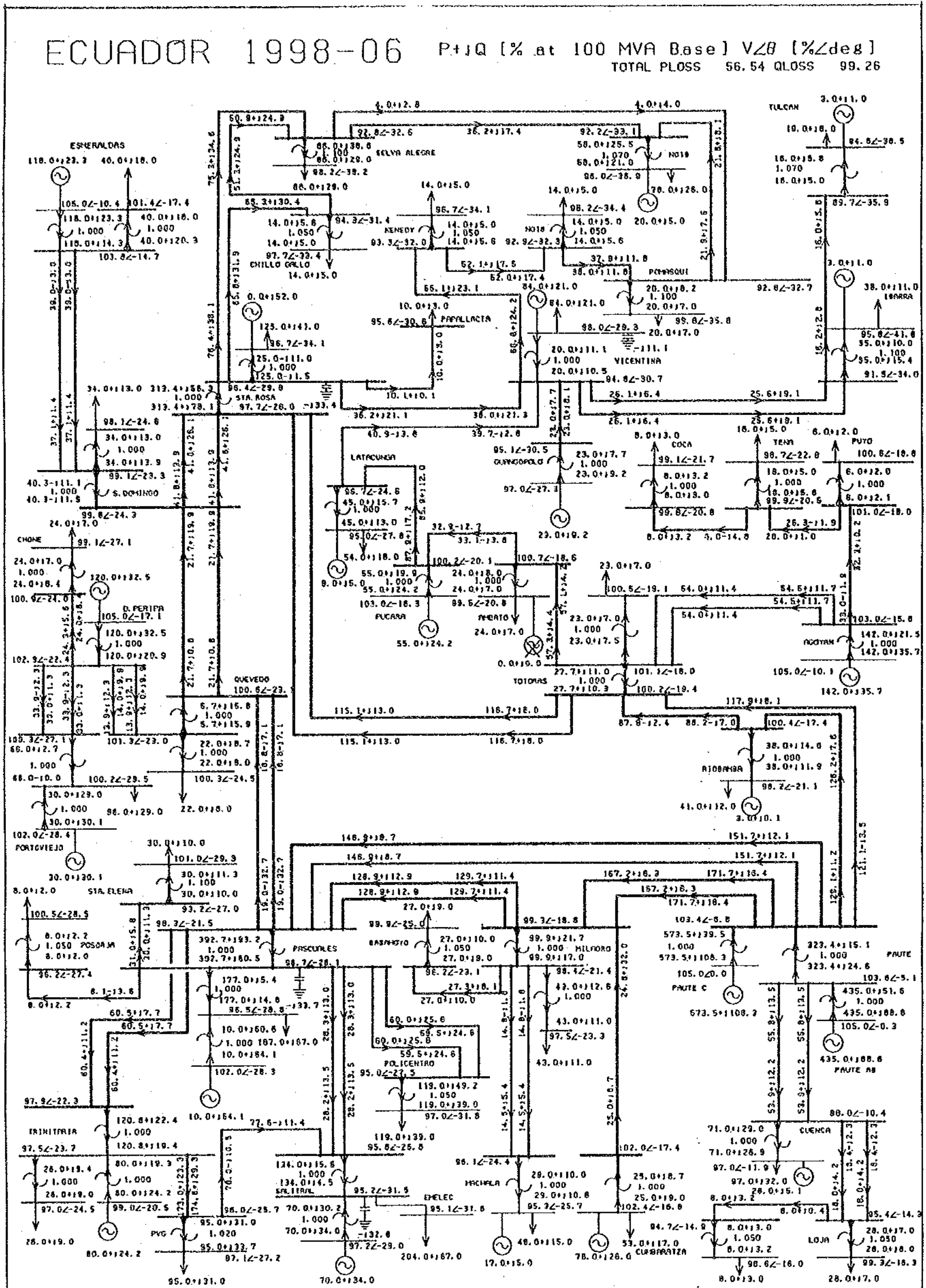


Fig. 5-10 Power Flow in June, 1998

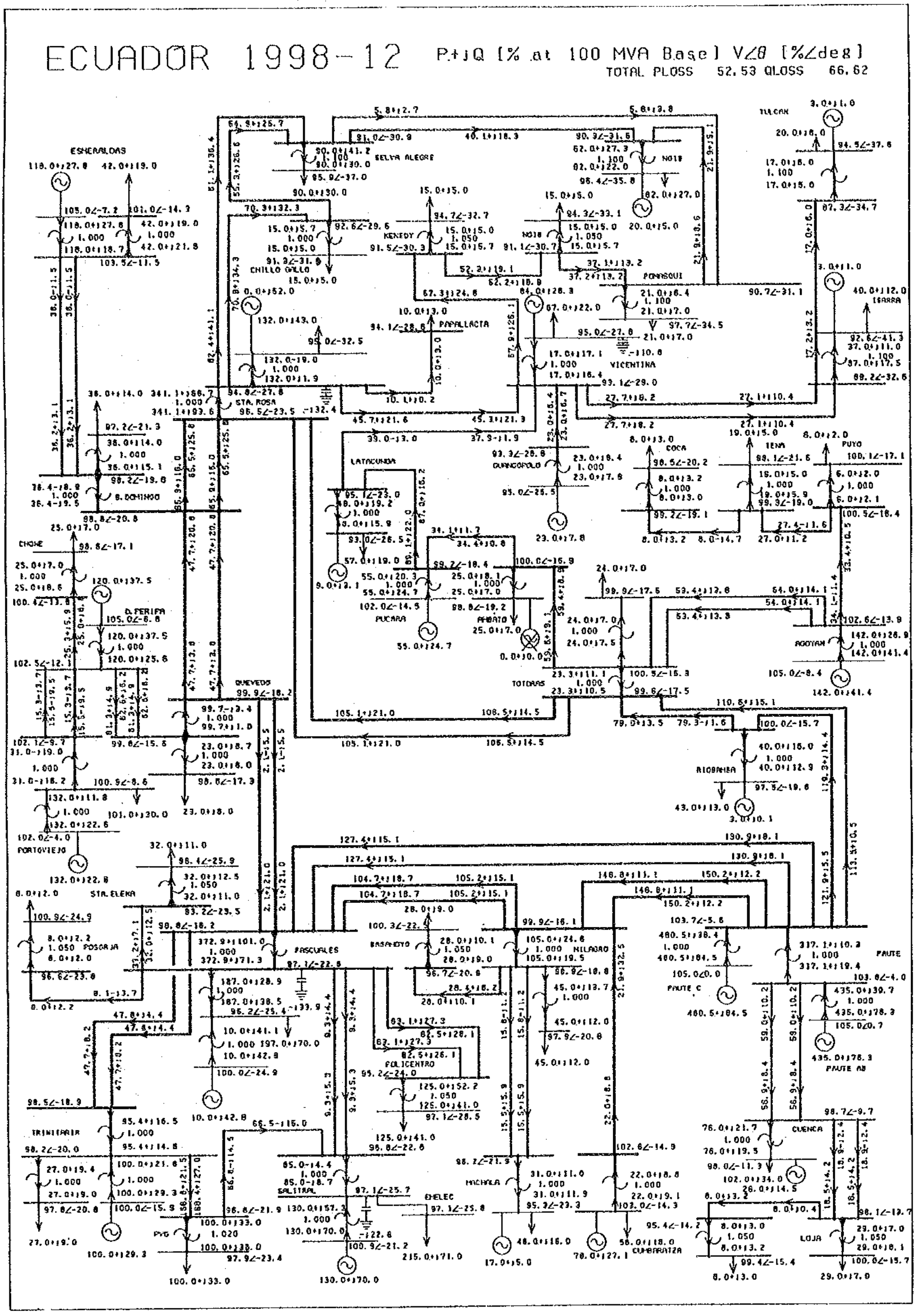
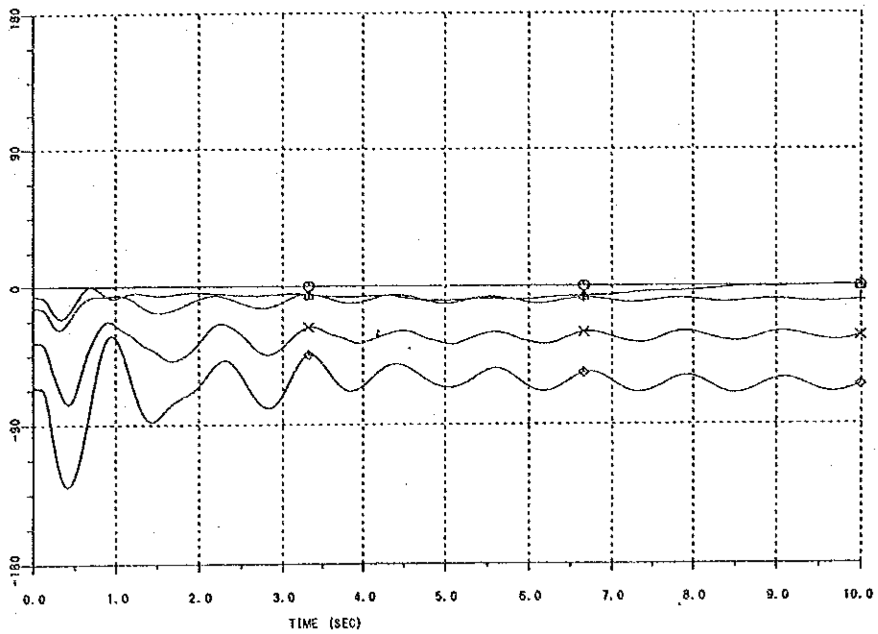


Fig. 5-11 Power Flow in December, 1998

ECUADOR 1998-08 BR04-1 (PAUTE-MILAGRO) 3LG-0

	Code	Term	Comment	Max	Min	Initial	Final
1	NDG-08	ANG	PAUTE-C	0.00	0.00	0.00	0.00
2	NDG-09	ANG	PAUTE-AB	0.68	-20.75	-6.34	0.42
3	NDG-11	ANG	CUENCA	-5.33	-27.73	-13.78	-9.38
4	ND-60	ANG	LATCUNGA	-22.68	-76.49	-36.45	-32.84
5	NDG-16	ANG	IBARRA	-32.02	-129.76	-65.92	-64.74



ECUADOR 1998-06 BR04-1 (PAUTE-MILAGRO) 3LG-0

	Code	Term	Comment	Max	Min	Initial	Final
1	NDG-08	ANG	PAUTE-C	0.00	0.00	0.00	0.00
2	NDG-05	ANG	SALITRAL	3.85	-119.57	-40.37	-31.38
3	ND-46	ANG	RIOBAMBA	-29.77	-80.30	-42.07	-38.71
4	NDG-01	ANG	ESMERALD	44.07	-85.35	-7.92	-6.40
5	NDG-15	ANG	GUANGOPL	-24.98	-78.75	-40.37	-37.69

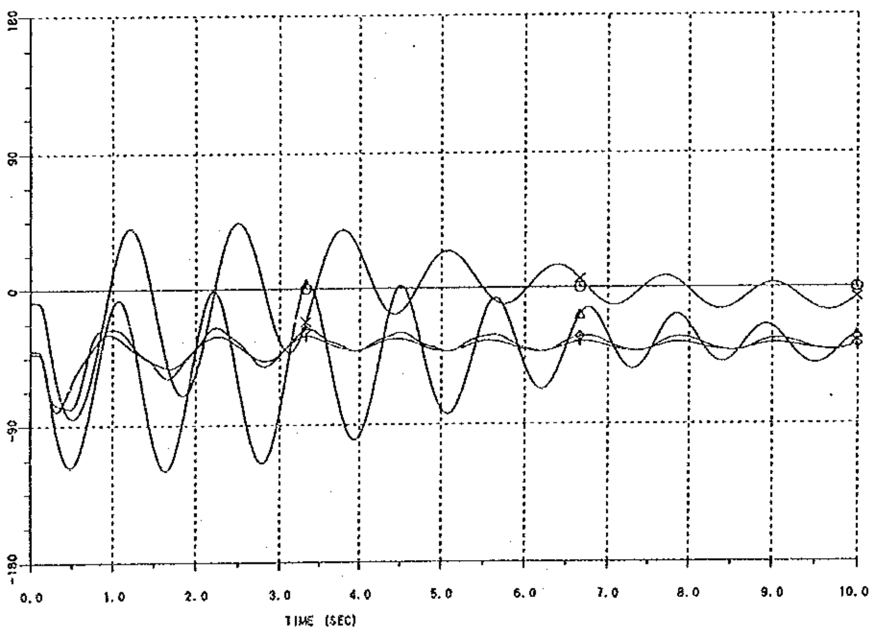
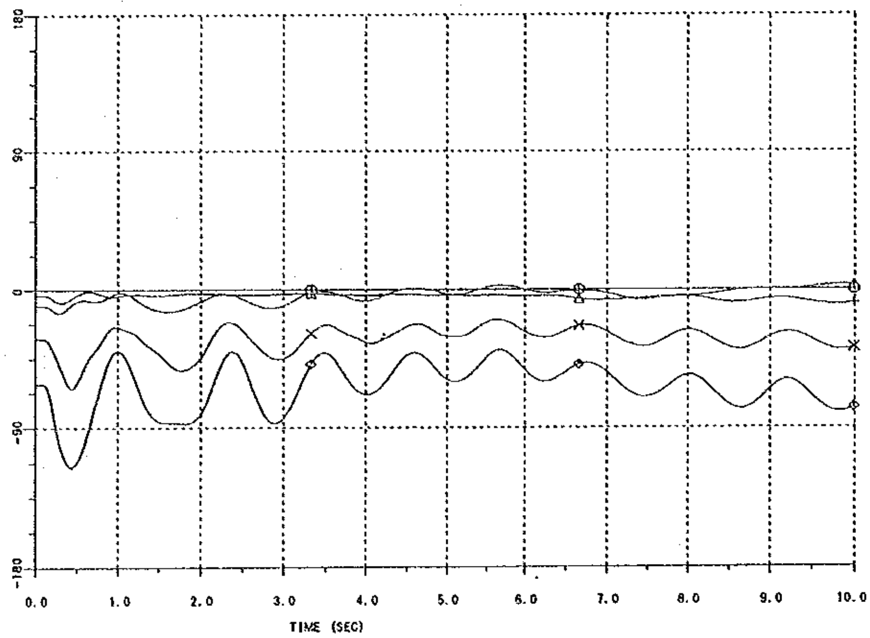


Fig. 5-12 Power System Stability after 1 CCT Line Fault (under power flow condition of Fig. 5-10)

ECUADOR 1995-06 2CCT (PAUTE-MILAGRO) 3LG-0

	Code	Term	Comment	Max	Min	Initial	Final
1	NOG-08	ANG	PAUTE-C	0.00	0.00	0.00	0.00
2	NOG-09	ANG	PAUTE-AB	3.19	-8.10	-3.41	2.93
3	NOG-11	ANG	CUENCA	2.63	-15.22	-10.45	-9.07
4	ND-60	ANG	LATCUNGA	-19.94	-64.49	-31.91	-38.18
5	NOG-16	ANG	IBARRA	-39.53	-115.09	-61.66	-77.00



ECUADOR 1998-06 2CCT (PAUTE-MILAGRO) 3LG-0

	Code	Term	Comment	Max	Min	Initial	Final
1	NOG-08	ANG	PAUTE-G	0.00	0.00	0.00	0.00
2	NOG-05	ANG	SALITRAL	11.99	-136.17	-36.64	-72.61
3	ND-46	ANG	RIOBAMBA	-24.54	-66.14	-38.56	-43.53
4	NOG-01	ANG	ESMERALD	56.12	-85.04	-3.30	-40.80
5	NOG-15	ANG	GUANGOPL	-20.14	-70.08	-36.06	-45.58

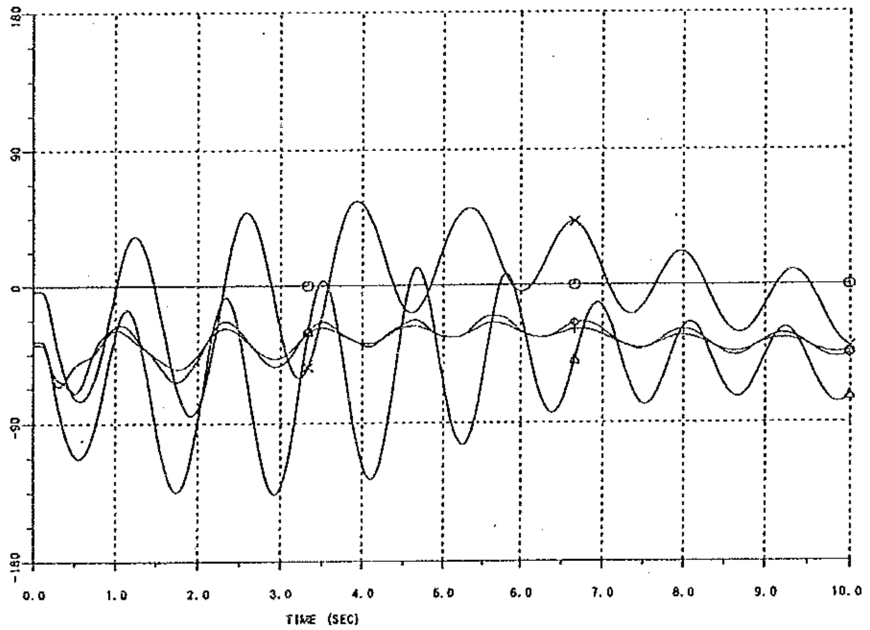


Fig. 5-13 Power System Stability under 2 CCT Line Fault (under power flow condition of Fig. 5-14)

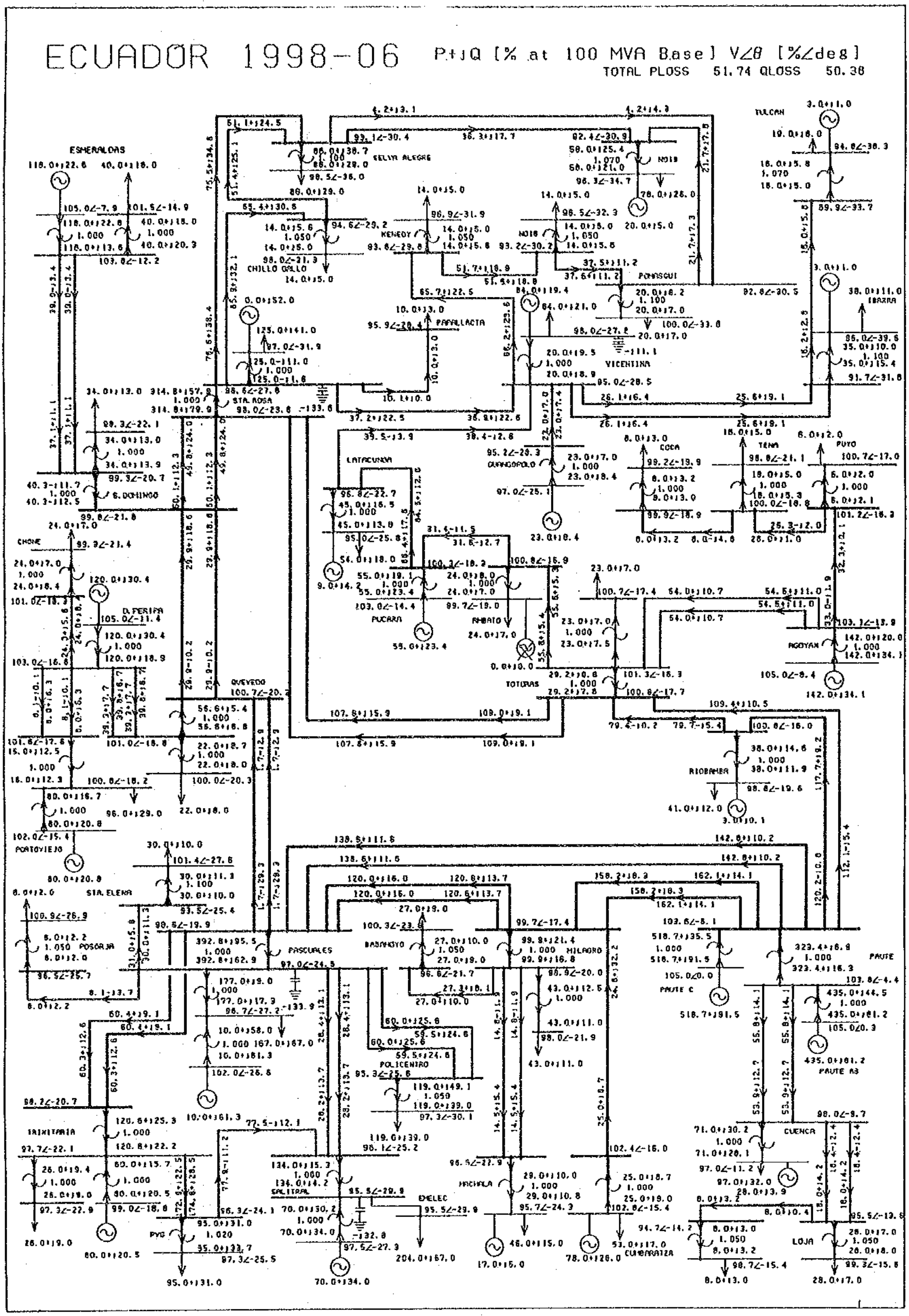


Fig. 5-14 Power Flow in June, 1998 (Case of small output at Paute)

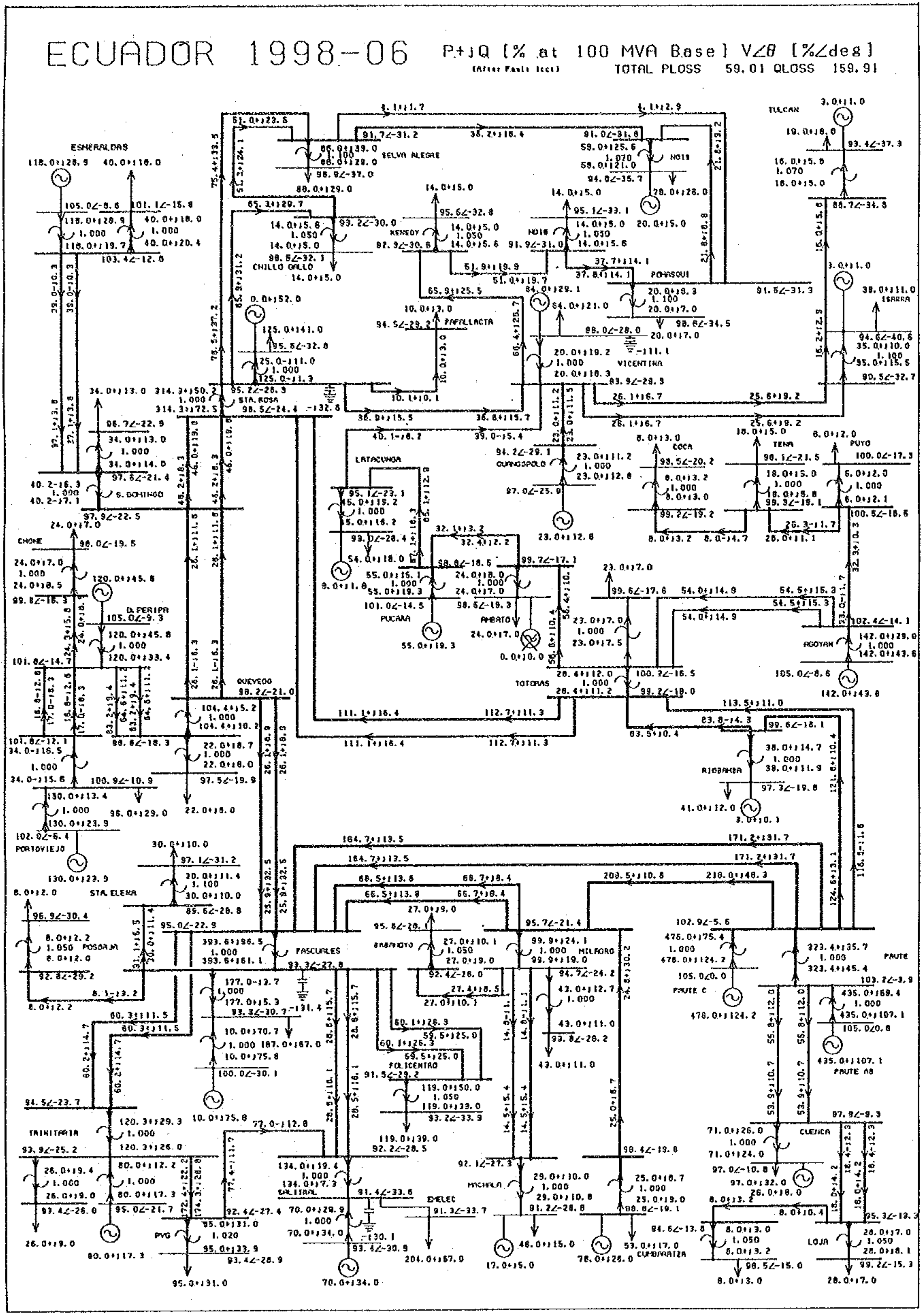


Fig. 5-15 Power Flow after Clearing of 1 CCT (corresponding to Fig. 5-10)

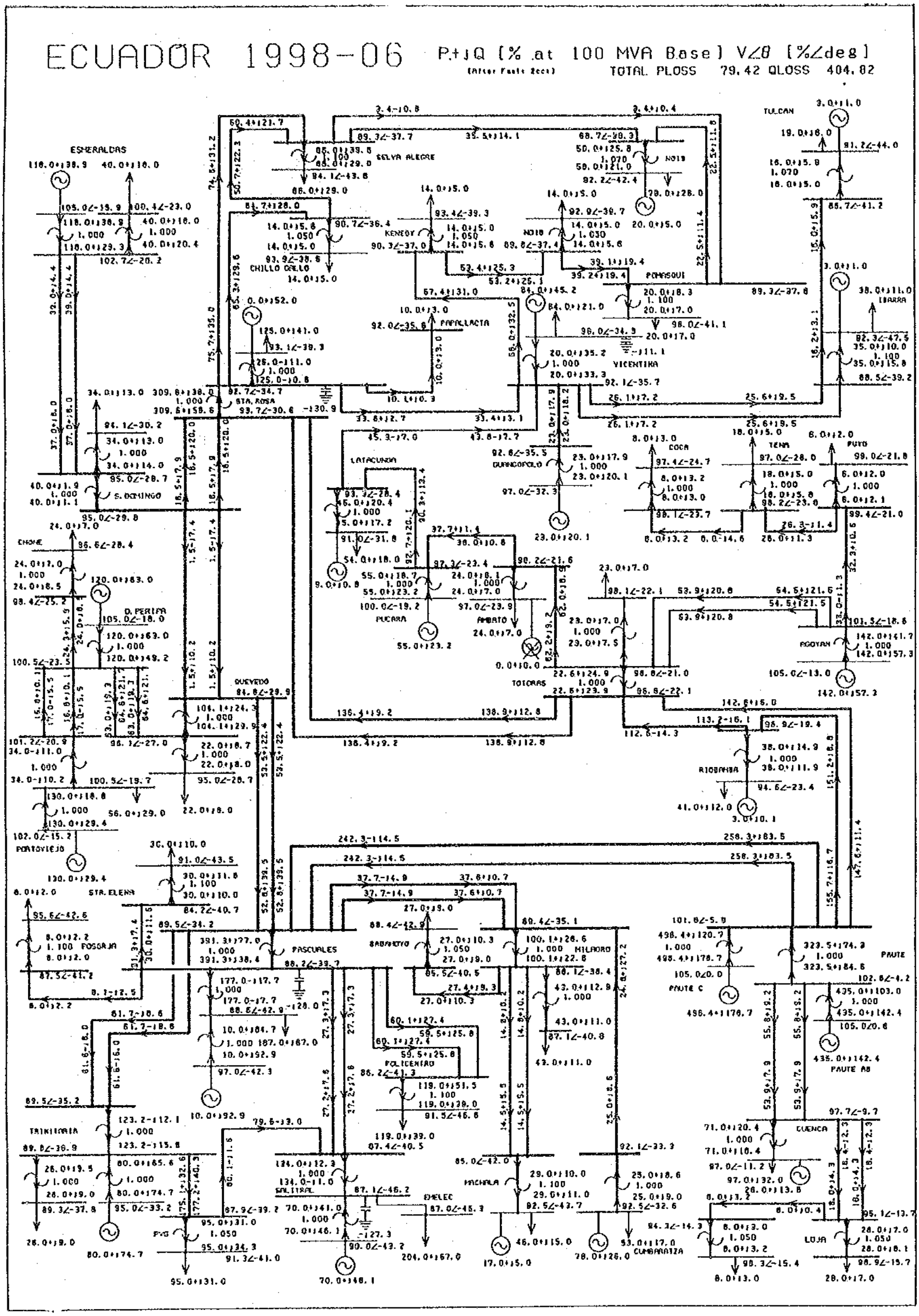
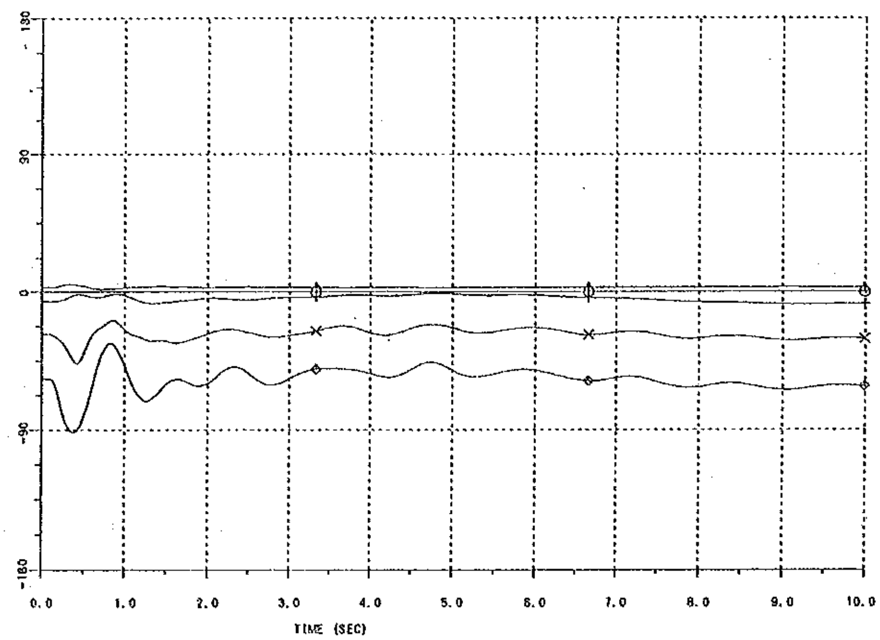


Fig. 5-16 Power Flow after Clearing of 2 CCT
(corresponding to Fig. 5-14)

ECUADOR 1998-12 BR(4-1 (PAUTE-MILAGRO) 3LG-0

	Code	Term	Comment	Max	Min	Initial	Final
1	NDG-08	ANG	PAUTE-C	0.00	0.00	0.00	0.00
2	NDG-09	ANG	PAUTE-AB	5.02	1.73	2.93	3.09
3	NDG-11	ANG	CUENCA	-1.05	-8.21	-6.18	-7.97
4	ND-60	ANG	LATCUNGA	-18.56	-46.74	-27.66	-30.51
5	NDG-16	ANG	IBARRA	-33.74	-91.10	-56.56	-61.46



ECUADOR 1998-12 BR04-1 (PAUTE-MILAGRO) 3LG-0

	Code	Term	Comment	Max	Min	Initial	Final
1	NDG-08	ANG	PAUTE-C	0.00	0.00	0.00	0.00
2	NDG-05	ANG	SALITRAL	5.21	-45.02	-7.70	-20.97
3	ND-46	ANG	RIOBAMBA	-25.76	-50.89	-32.38	-34.91
4	NDG-01	ANG	ESMERALD	33.05	-41.07	3.62	2.65
5	NDG-15	ANG	GUANGOPL	-20.66	-45.47	-30.19	-33.86

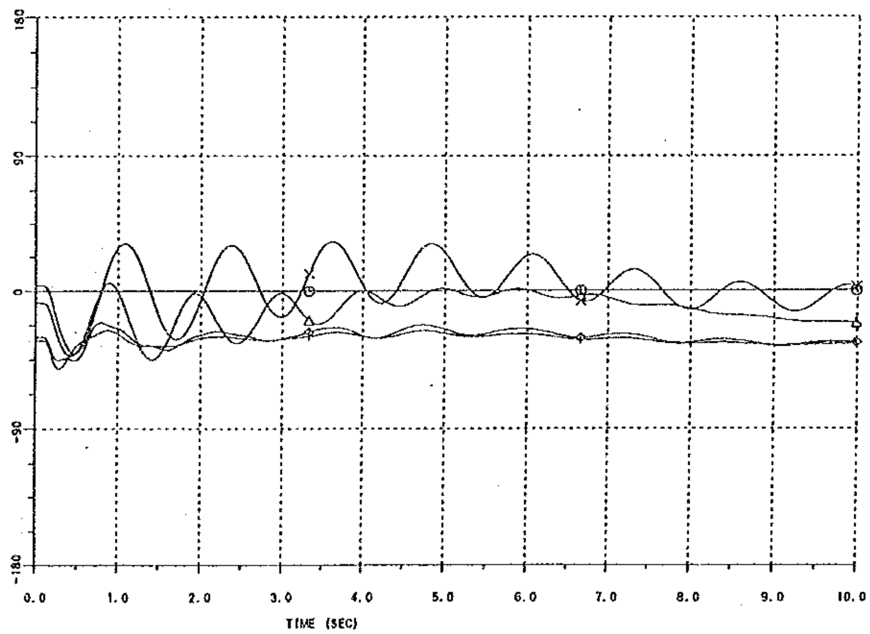
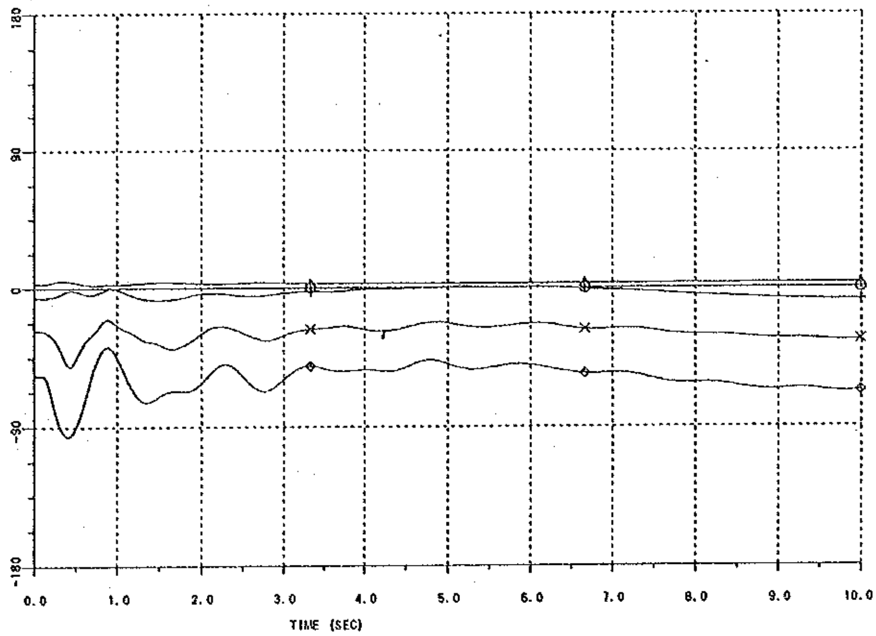


Fig. 5-17 Power System Stability after 1 CCT Line Fault (under power flow condition of Fig. 5-11)

ECUADOR 1998-12 2CCT (PAUTE-MILAGRO) 3LG-0

	Code	Term	Comment	Max	Min	Initial	Final
1	NOG-08	ANG	PAUTE-C	0.00	0.00	0.00	0.00
2	NOG-09	ANG	PAUTE-AB	4.89	2.14	2.93	3.28
3	NOG-11	ANG	CUENCA	1.01	-7.85	-6.18	-7.77
4	ND-60	ANG	LATCUNGA	-20.35	-50.55	-27.66	-33.81
5	NOG-16	ANG	IBARRA	-38.02	-96.11	-56.56	-66.78



ECUADOR 1998-12 2CCT (PAUTE-MILAGRO) 3LG-0

	Code	Term	Comment	Max	Min	Initial	Final
1	NOG-08	ANG	PAUTE-C	0.00	0.00	0.00	0.00
2	NOG-05	ANG	SALITRAL	-0.23	-61.49	-7.70	-33.12
3	ND-46	ANG	RIOBAMBA	-25.60	-51.56	-32.38	-37.09
4	NOG-01	ANG	ESMERALD	37.41	-50.56	3.62	-3.03
5	NOG-15	ANG	GUANGOPL	-23.45	-52.29	-30.19	-37.98

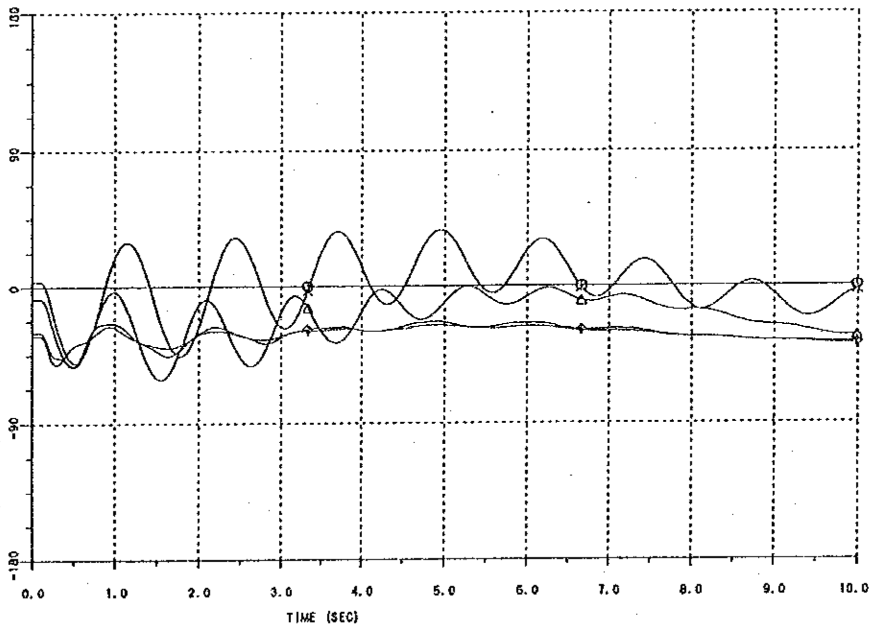


Fig. 5-18 Power System Stability after 2 CCT Line Fault (under power flow condition of Fig. 5-11)

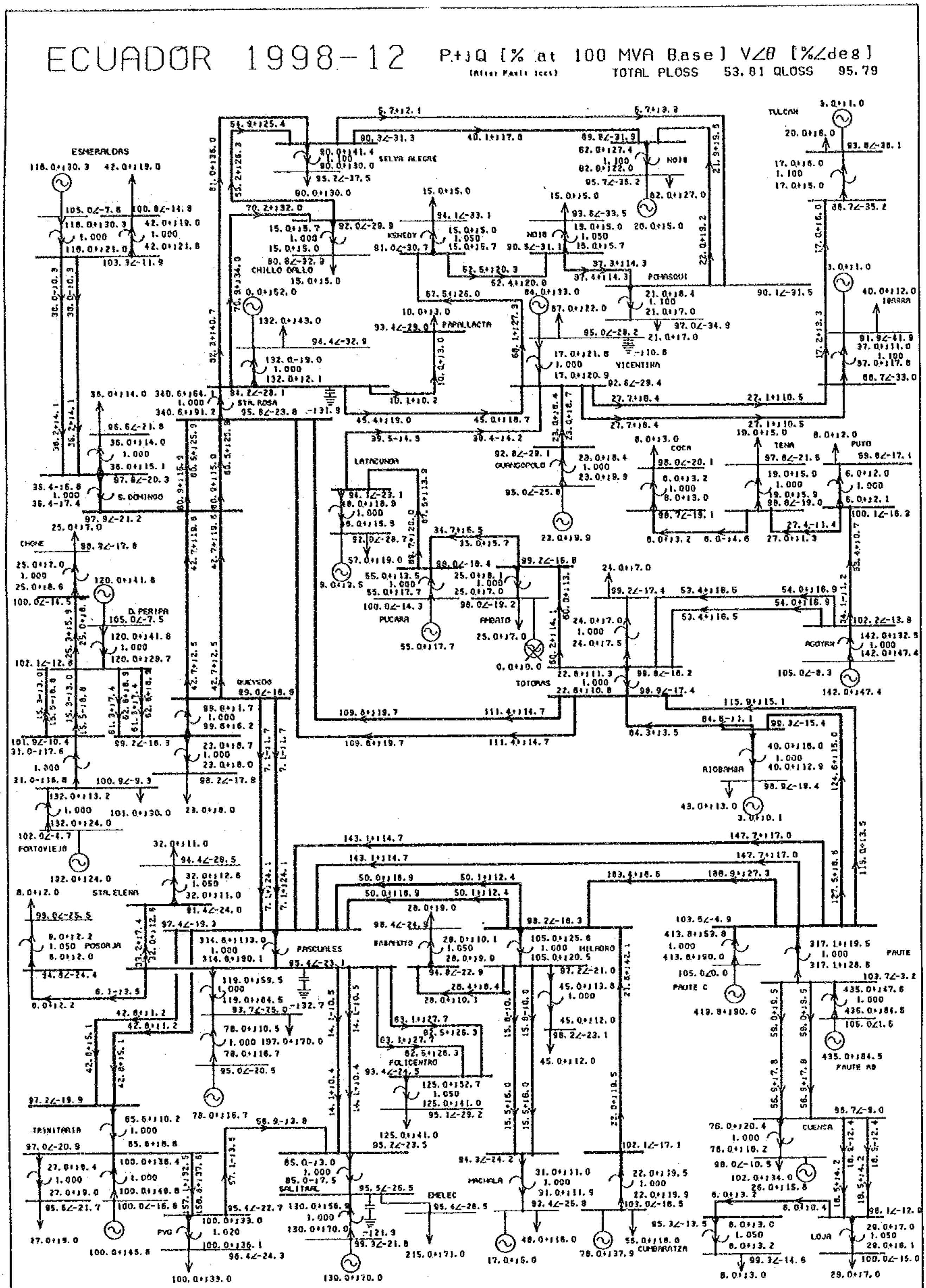


Fig. 5-19 Power Flow after Clearing of 1 CCT in (corresponding to Fig. 5-11)

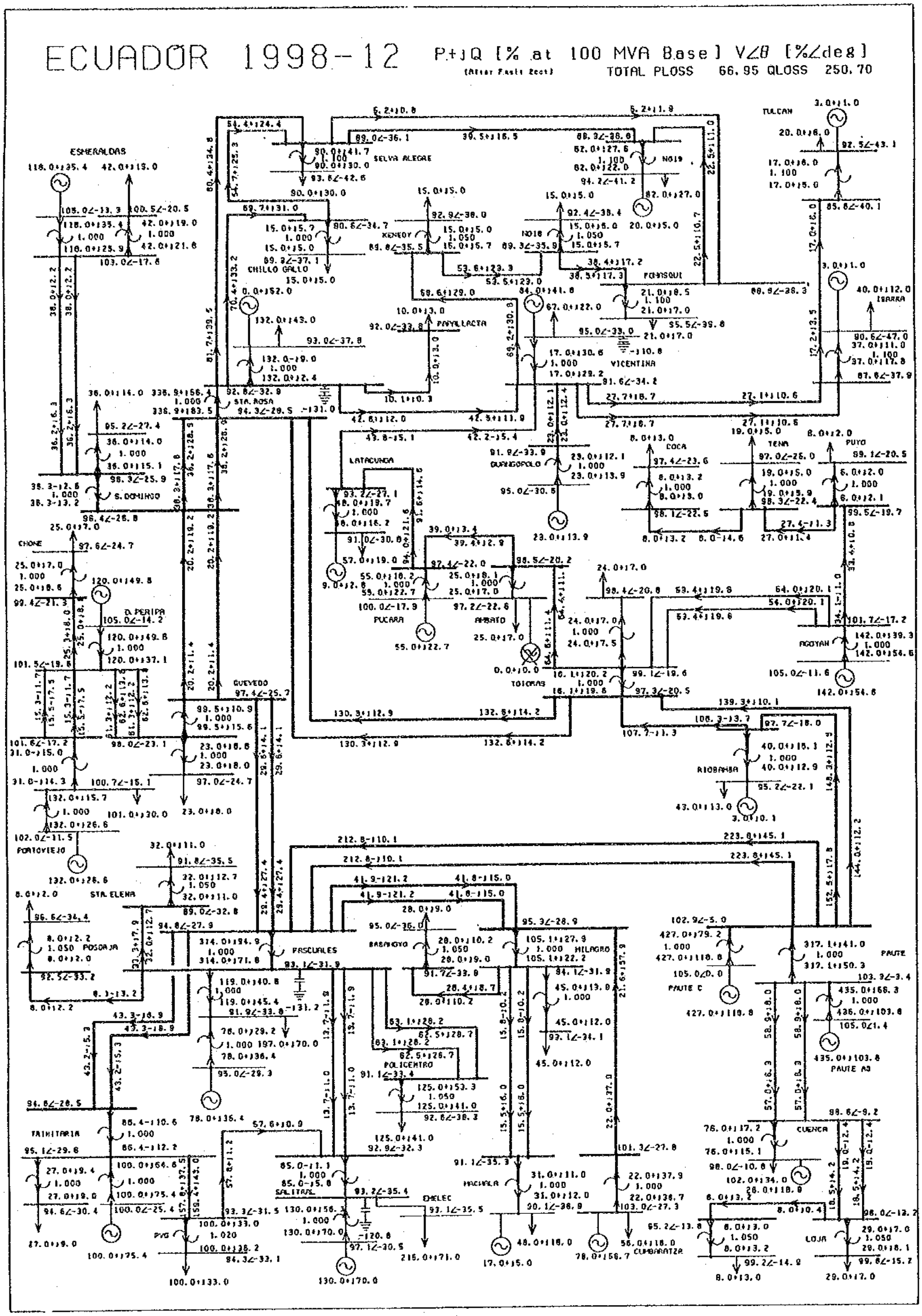


Fig. 5-20 Power Flow after Clearing of 2 CCT Line (corresponding to Fig. 5-11)

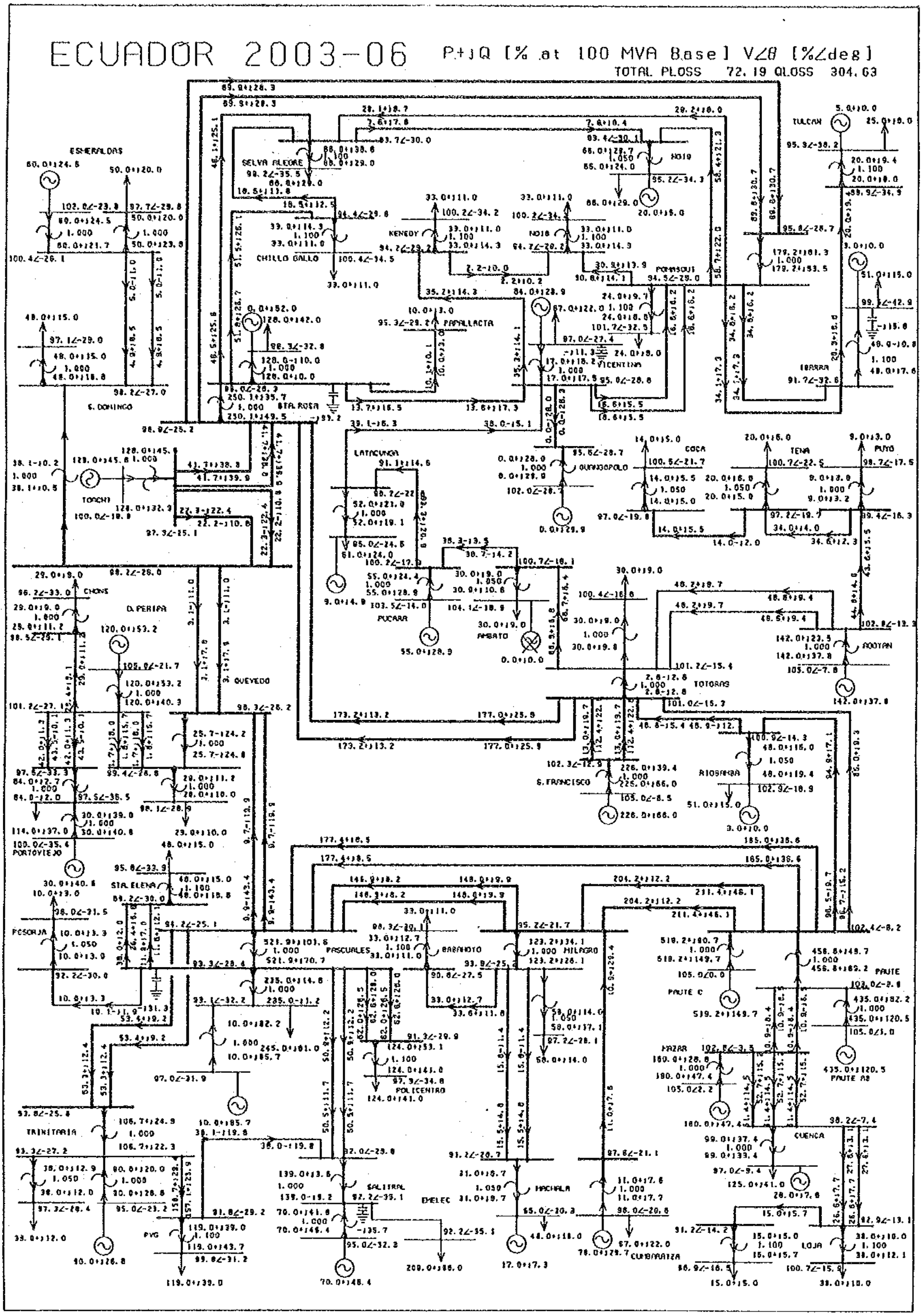


Fig. 5-21 Power Flow in June, 2003

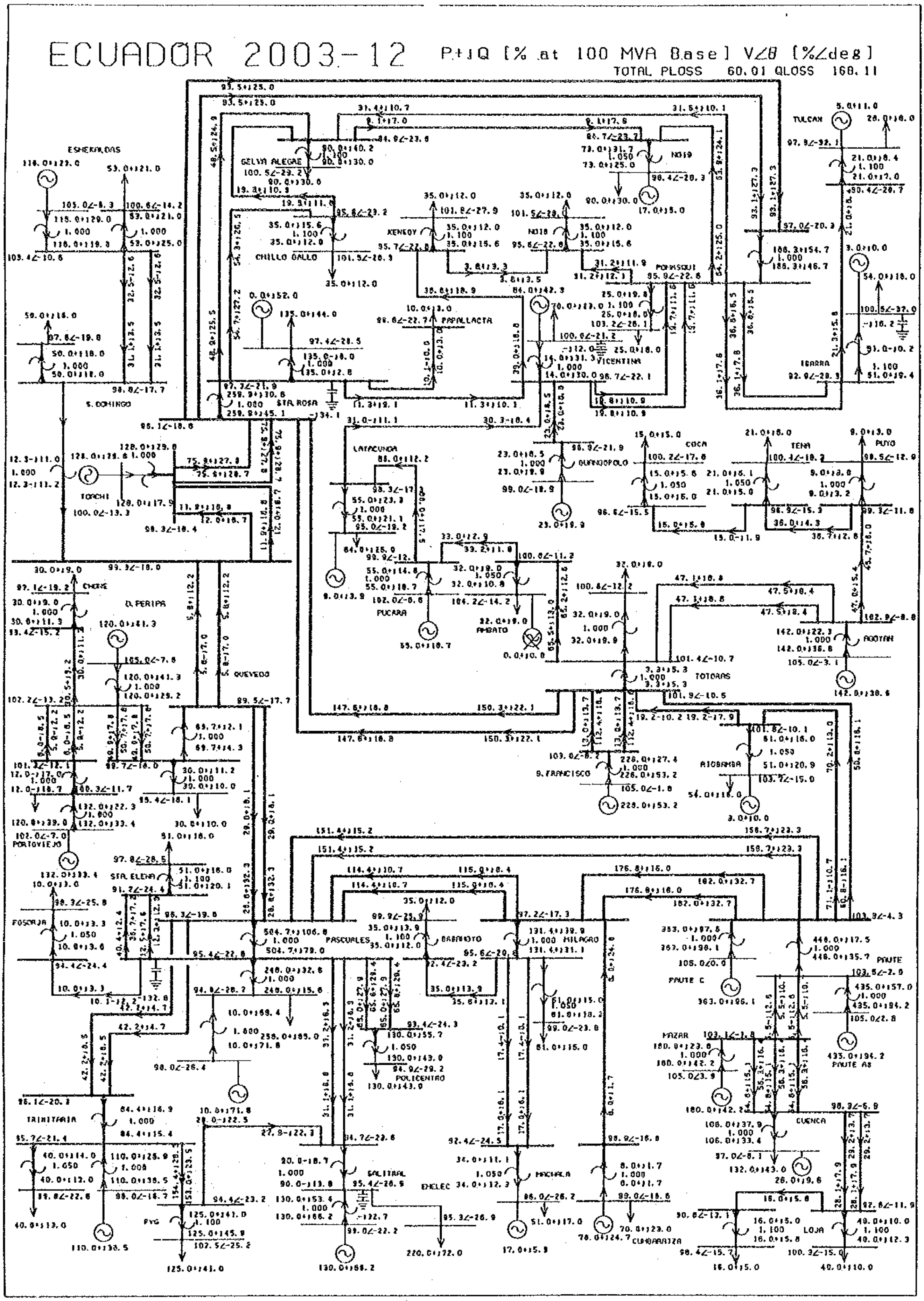
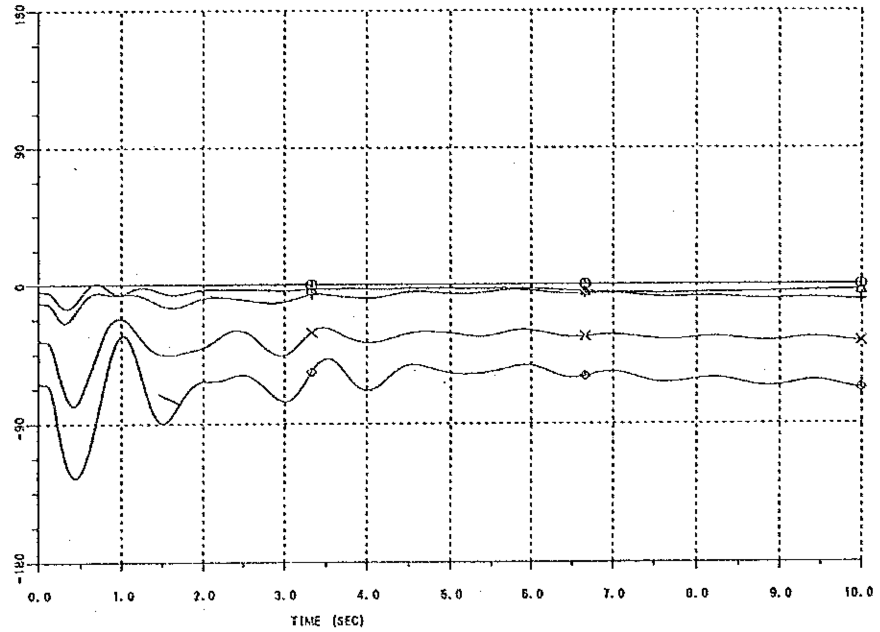


Fig. 5-22 Power Flow in December, 2003

ECUADOR 2003-06 8R04-1 (PAUTE-MILAGRO) 3LG-0

ANG (DEG)

	Code	Term	Comment	Max	Min	Initial	Final
1 —⊖—	NDG-08	ANG	PAUTE-C	0.00	0.00	0.00	0.00
2 —△—	NDG-09	ANG	PAUTE-AB	0.78	-15.51	-4.47	-3.46
3 —+—	NDG-11	ANG	CUENCA	-3.74	-24.60	-12.10	-9.93
4 —×—	ND-60	ANG	LATCUNGA	-22.15	-78.35	-36.74	-36.94
5 —◇—	NDG-16	ANG	IBARRA	-33.00	-126.13	-64.34	-66.98



ECUADOR 2003-06 8R04-1 (PAUTE-MILAGRO) 3LG-0

ANG (DEG)

	Code	Term	Comment	Max	Min	Initial	Final
1 —⊖—	NDG-08	ANG	PAUTE-C	0.00	0.00	0.00	0.00
2 —△—	NDG-05	ANG	SALITRAL	-15.93	-147.09	-68.99	-78.03
3 —+—	ND-46	ANG	RIOBAMBA	-25.00	-74.12	-38.75	-38.36
4 —×—	NDG-01	ANG	ESMERALD	32.76	-82.49	-9.82	-5.56
5 —◇—	NDG-15	ANG	GUANGOPL	-39.90	-101.98	-57.69	-59.10

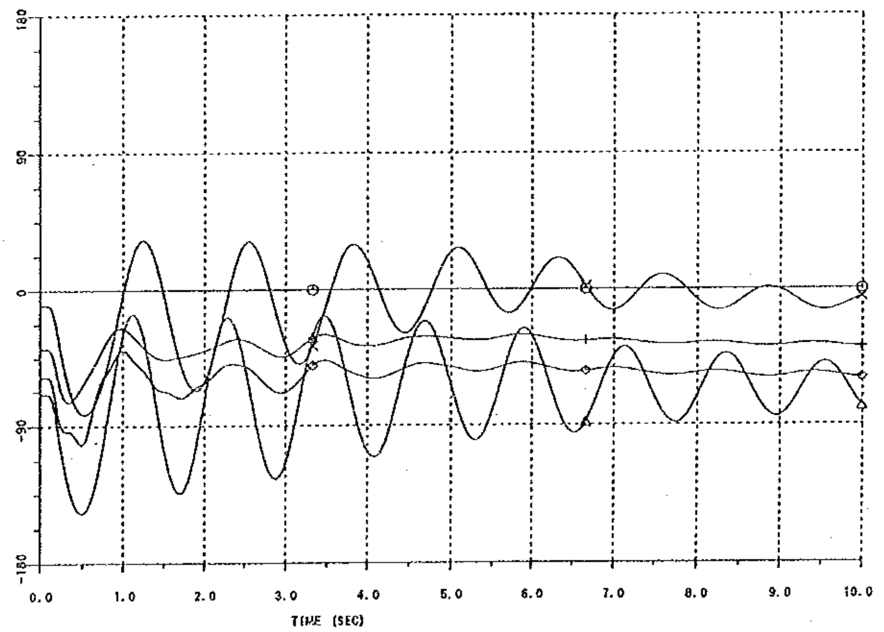
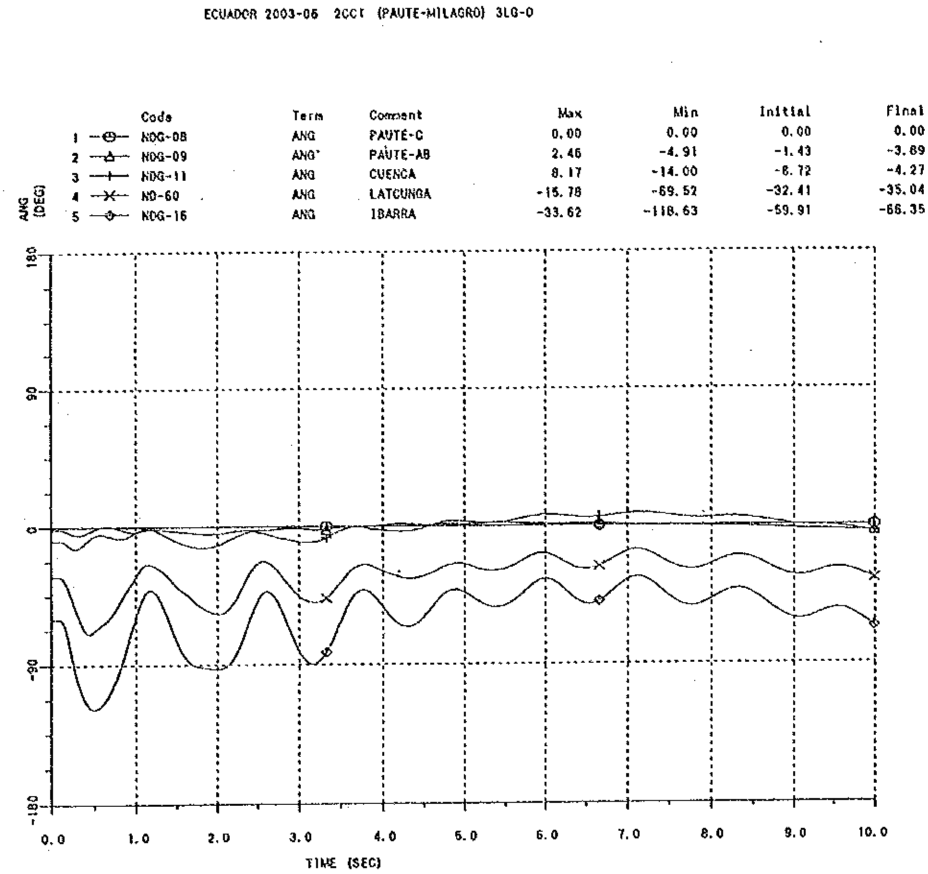


Fig. 5-23 Power System Stability after 1 CCT Line Fault (under power flow condition of Fig. 5-21)



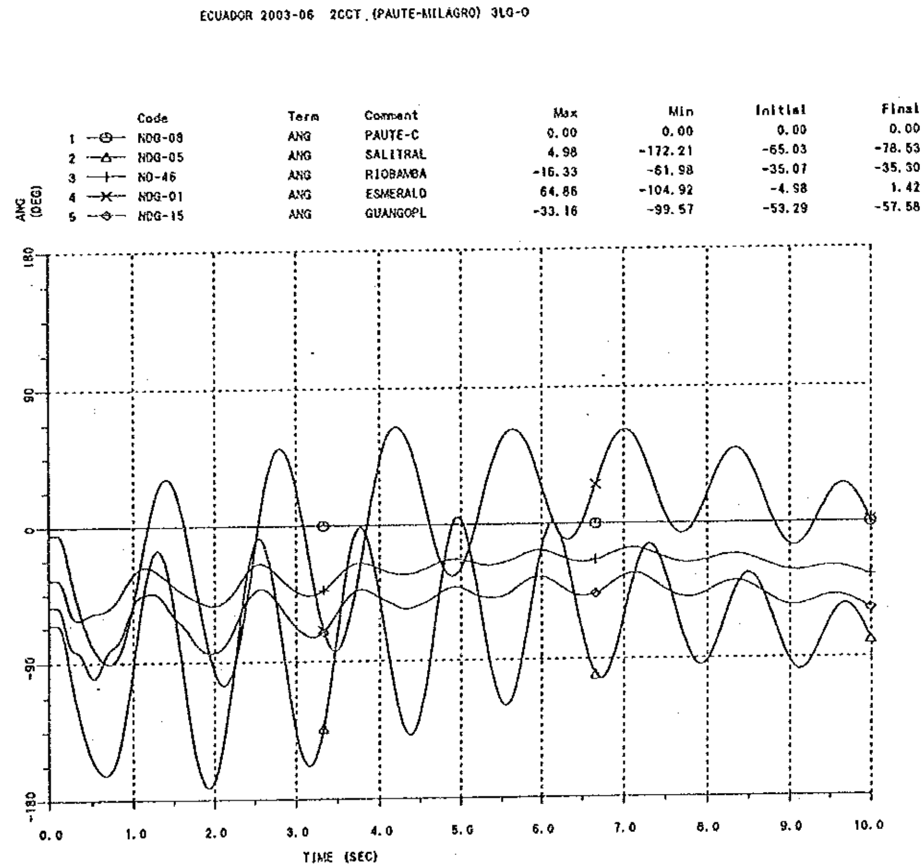


Fig. 5-24 Power System Stability Analysis at 2 CCT Line Fault (under power flow condition of Fig. 5-25)

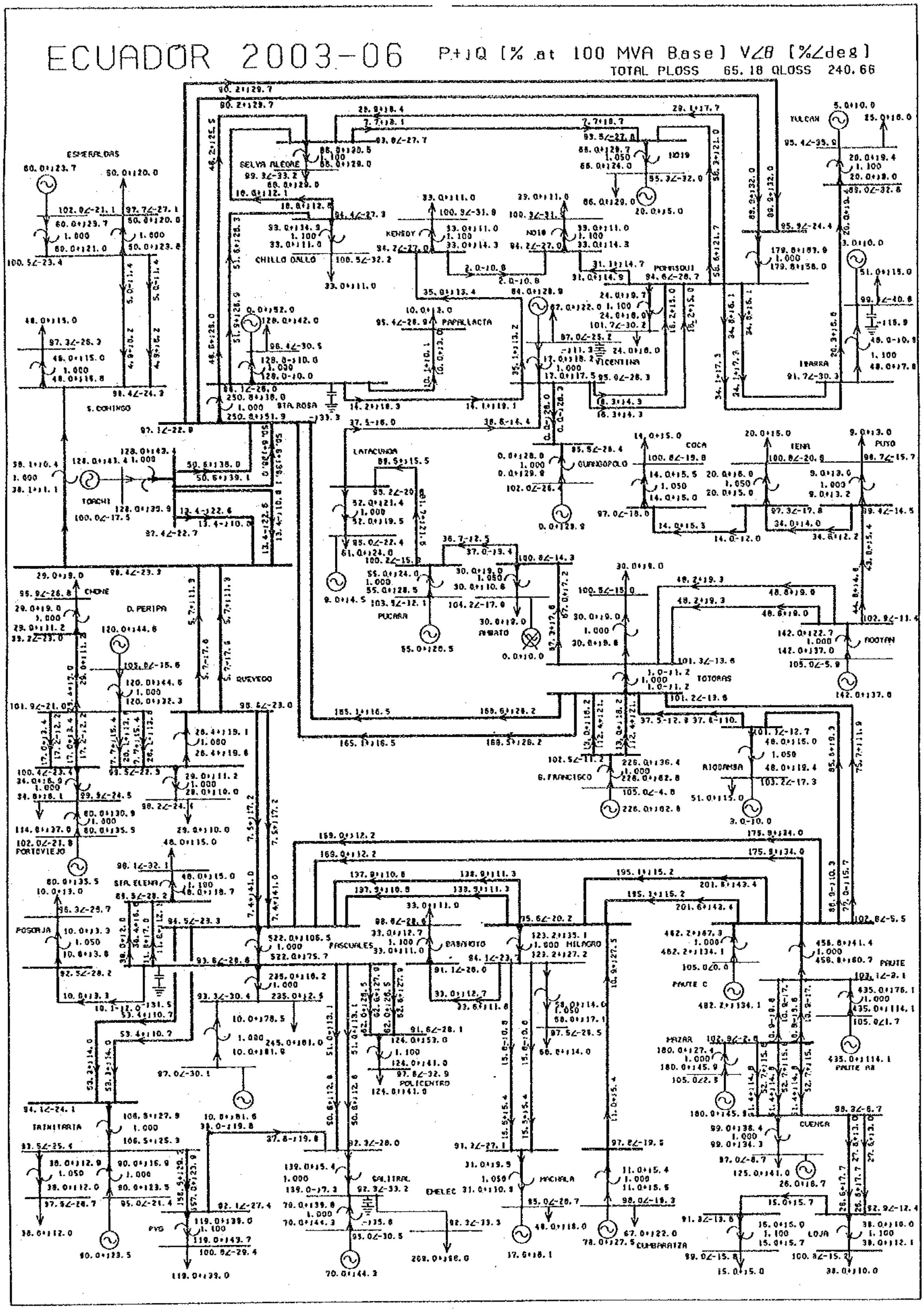


Fig. 5-25 Power Flow in June, 2003 (Case of small output at Paute)

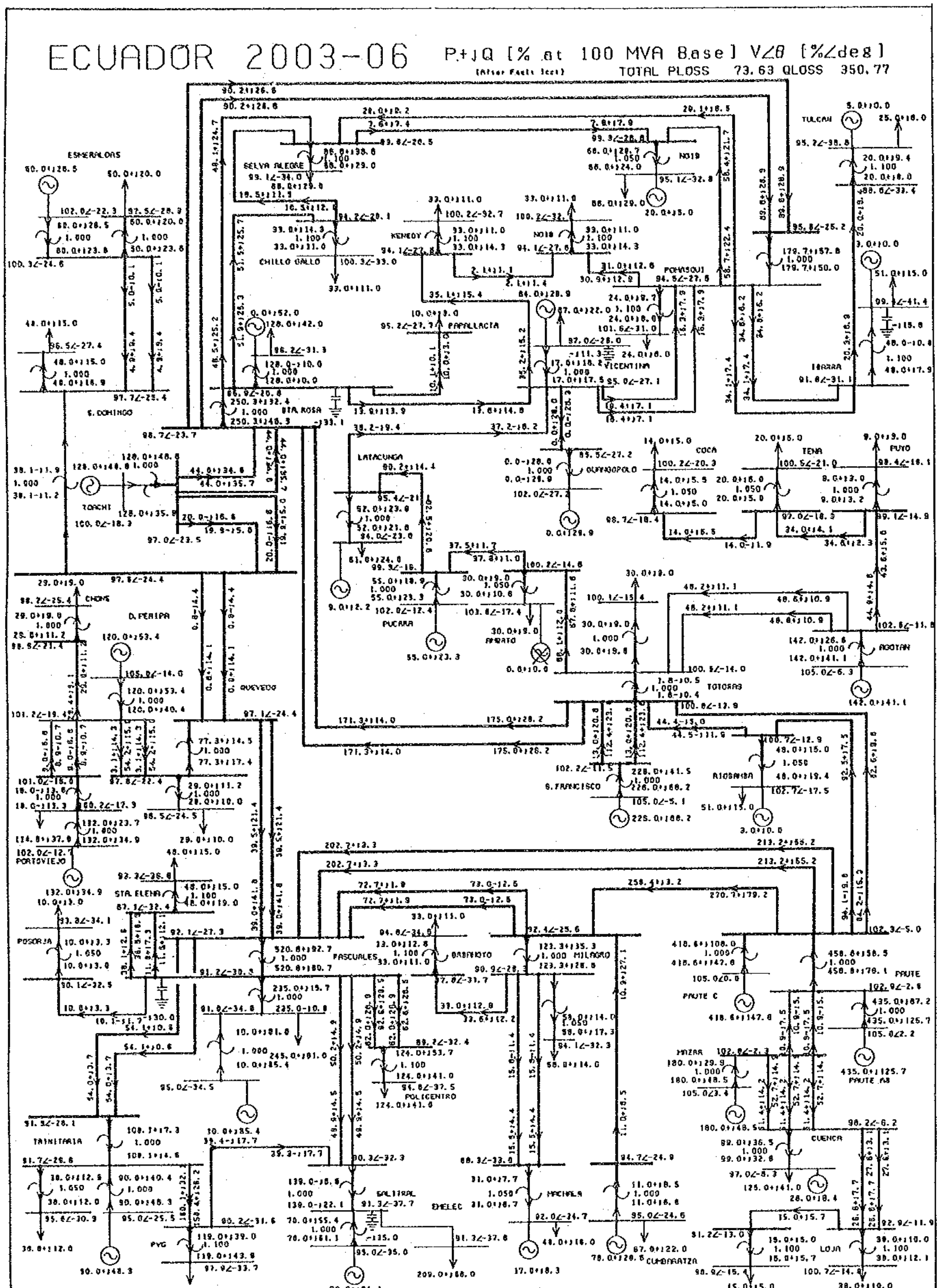


Fig. 5-26 Power Flow after Clearing of 1 CCT Line
(corresponding to Fig. 5-21)

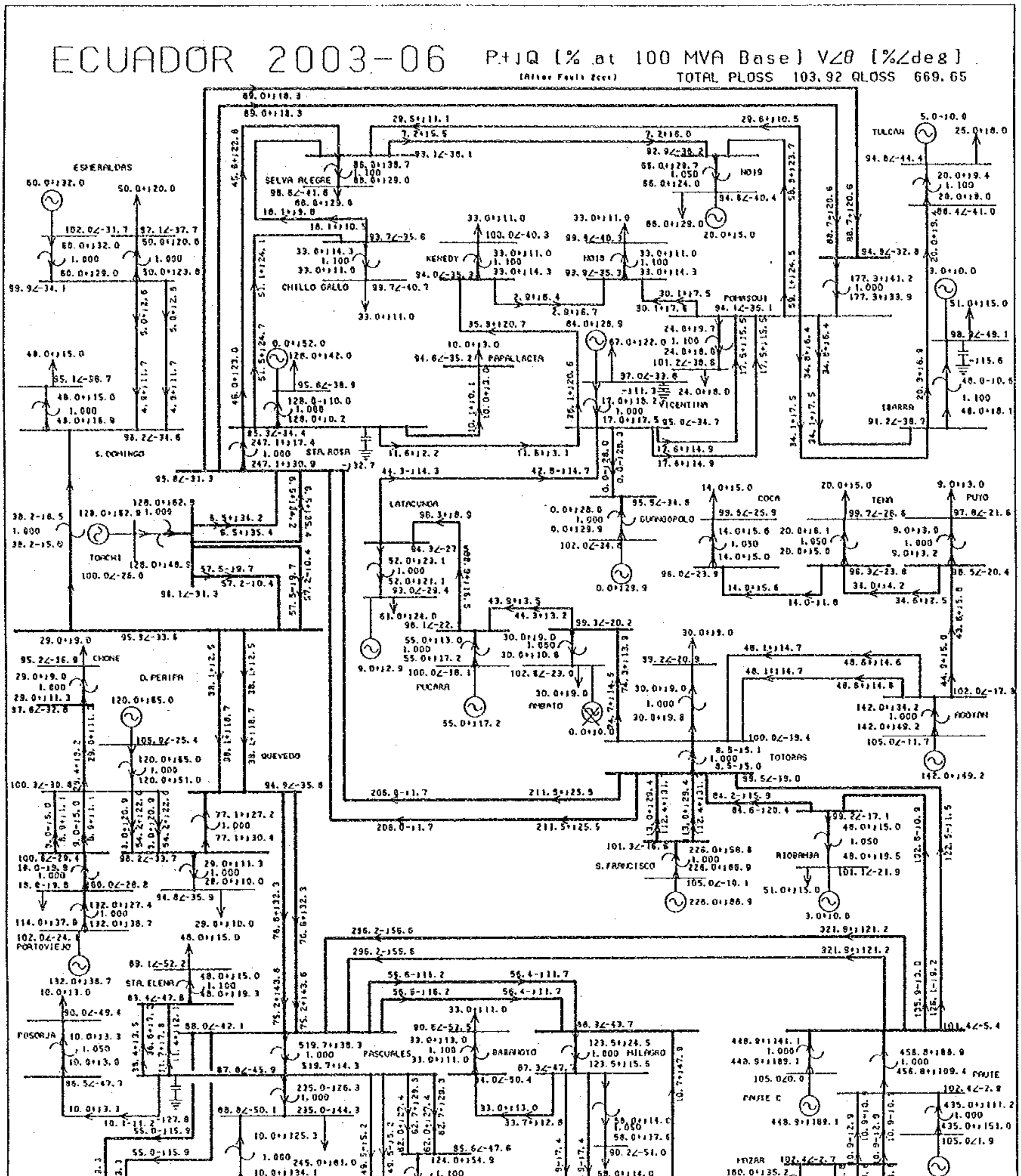


Fig. 5-27 Power Flow after Clearing of 2 CCT Line (corresponding to Fig. 5-25)