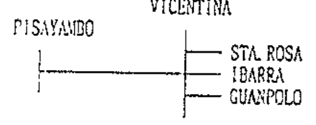
1 3 8 kV SNI PROTECTION

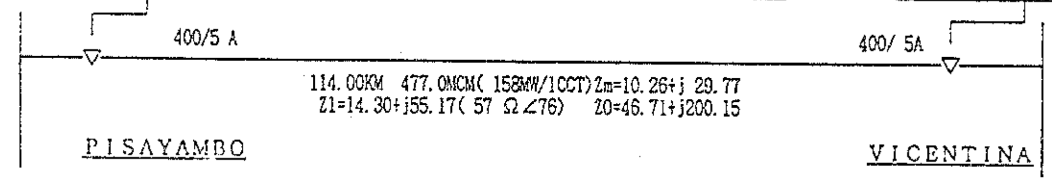


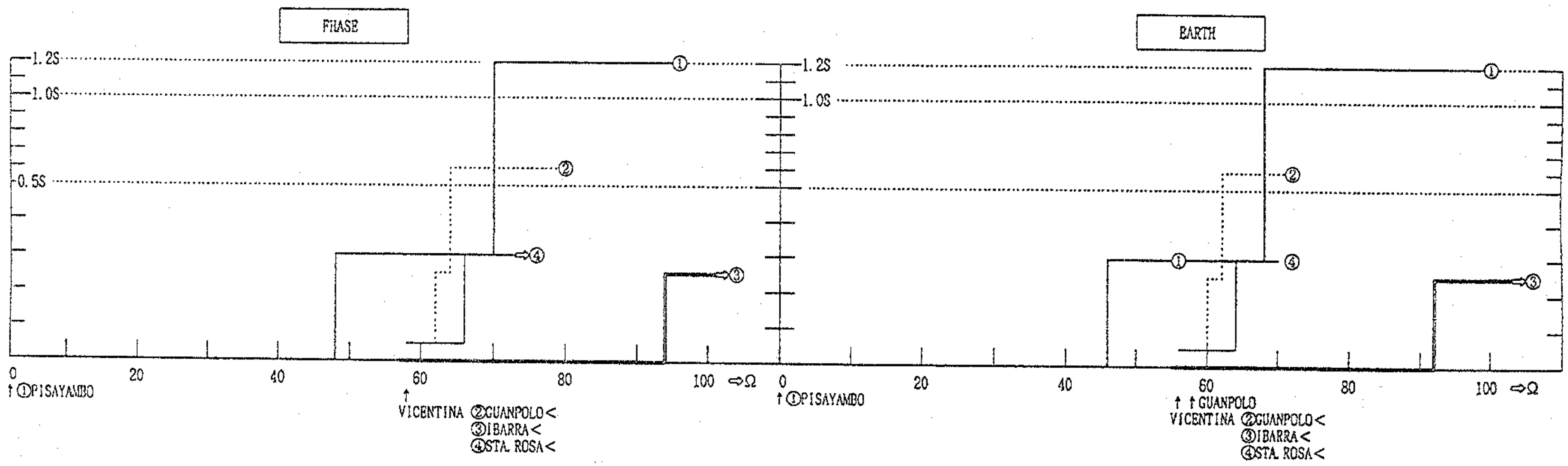
	MAIN	SECONDARY	BLOCK
FHASE	Ω(s)	Ω(s)	RE: /CO: Ω(s)
EARTH	Ω(s)	Ω(s)	

BLOCK: BLOCK OSCILLATION
RE:REACHC
CO:COMPENSATION
( ):ZONE/TIMING DETECTION
CT: PRIMARY / SECONDARYA

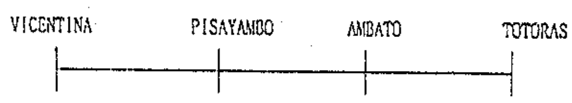
	MAIN	SECONDARY			BLOCK
Ω(s)	RE	ZONE1	ZONE2	ZONE3	RE: / CO:
FHASE	——	48.45(-)	68.25(0.3)	90.00(1.2)	— / —
EARTH	——	45.45(-)	68.25(0.3)	100.05(1.2)	

	MAIN	SECONDARY			BLOCK
Ω(s)	RE	ZONE1	ZONE2	ZONE3	RE: / CO:
FHASE	——	48.00(-)	70.50(0.3)	90.00(1.0)	— / —
EARTH	——	44.10(-)	75.00(0.3)	108.45(1.0)	





1 3 8 kV SNI PROTECTION

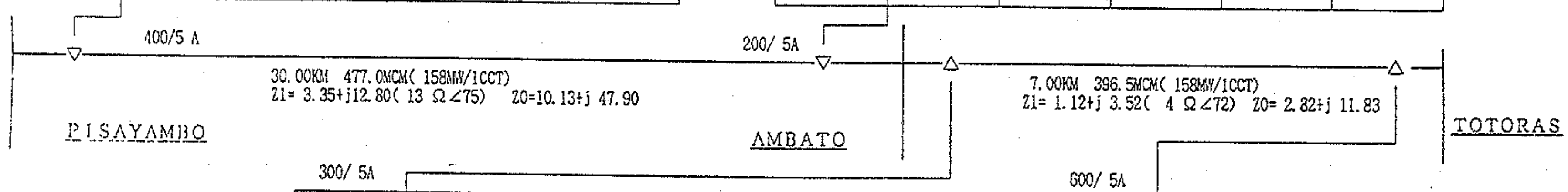


	MAIN	SECONDARY	BLOCK
FHASE	Ω(s)	Ω(s)	RE: /CO: Ω(s)
EARTH	Ω(s)	Ω(s)	

BLOCK: BLOCK OSCILLATION
RE:REACHC
CO:COMPENSATION
( ):ZONE/TIMING DETECTION
CT: PRIMARY / SECONDARYA

	MAIN	SECONDARY			BLOCK
Ω(s)	RE	ZONE1	ZONE2	ZONE3	RE: / CO:
FHASE	——	10.20(-)	15.45(0.4)	21.45(1.2)	— / —
EARTH	——	10.20(-)	15.45(0.4)	21.45(1.2)	

	MAIN	SECONDARY			BLOCK
Ω(s)	RE	ZONE1	ZONE2	ZONE3	RE: / CO:
FHASE	——	10.50(-)	23.10(0.25)	60.00(0.8)	— / —
EARTH	——	10.20(-)	23.40(0.25)	60.00(0.8)	



	MAIN	SECONDARY			BLOCK
Ω(s)	RE	ZONE1	ZONE2	ZONE3	RE: / CO:
FHASE	——	>I:TAP 6 amp DIAL 1.5 INST: 7 amp			— / —
EARTH	——	>I:TAP 2.5 amp DIAL 3.0 INST: 8 amp			

	MAIN	SECONDARY			BLOCK
Ω(s)	RE	ZONE1	ZONE2	ZONE3	RE: / CO:
FHASE	——	>I:TAP 5 amp DIAL 0.3 INST: 13 amp			— / —
EARTH	——	>I:TAP 2 amp DIAL 0.5 INST: 2.5 amp			

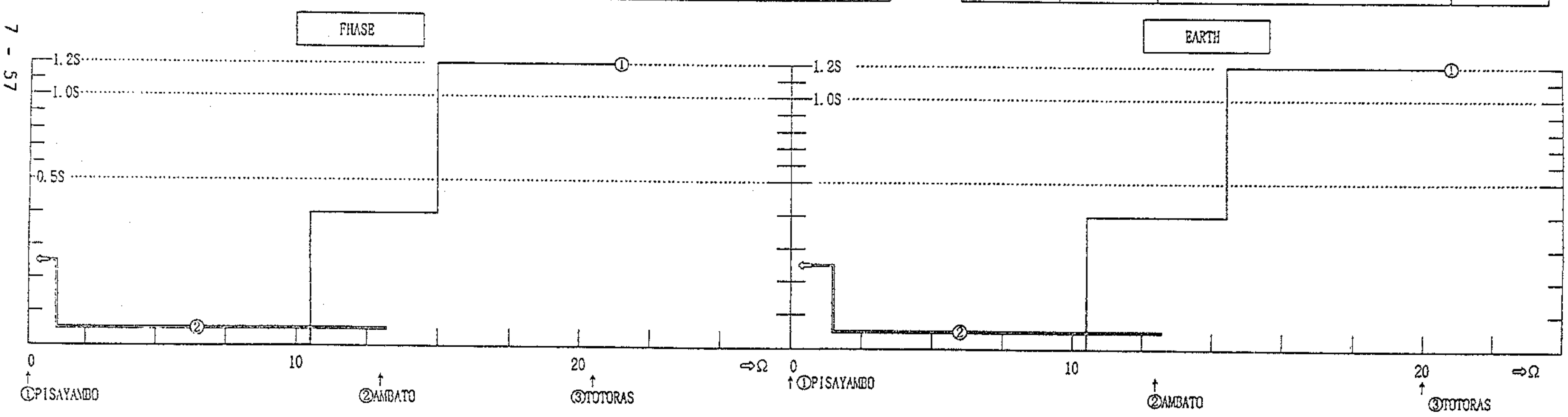
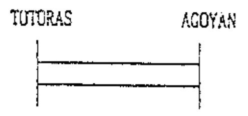


Fig. 7-6 138kV SNI Protection (8/9)

138kV SNI PROTECTION

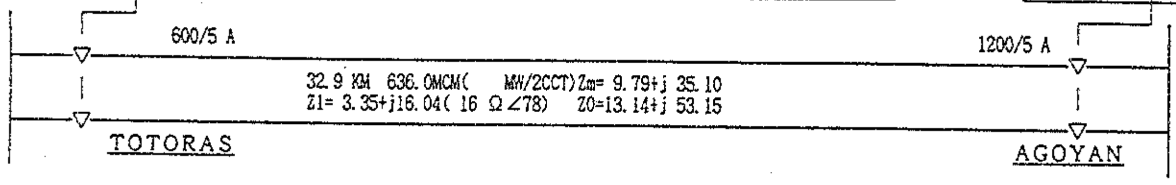


	MAIN	SECONDARY	BLOCK
FHASE	Ω(s)	Ω(s)	RE: /CO: Ω(s)
EARTH	Ω(s)	Ω(s)	

BLOCK: BLOCK OSCILLATION
RE:REACHC
CO:COMPENSATION
( ):ZONE/TIMING DETECTION
CT: PRIMARY / SECONDARYA

Ω(s)	MAIN	BLOCK	SECONDARY			BLOCK
	RE	RE: / CO:	ZONE1	ZONE2	ZONE3	RE: / CO:
FHASE	30.30(-)	35.80/5.50 (0.08)	13.70(-)	23.70(0.25)	36.30(1.0)	45.60/15.20 (0.08)
EARTH	30.30(-)		14.60(-)	23.80(0.25)	35.10(1.0)	

Ω(s)	MAIN	BLOCK	SECONDARY			BLOCK
	RE	RE: / CO:	ZONE1	ZONE2	ZONE3	RE: / CO:
FHASE	35.30(-)	44.65/5.0	13.05(-)	23.10(0.45)	——	44.65/5.00
EARTH	36.25(-)		13.65(-)	26.55(0.45)	——	



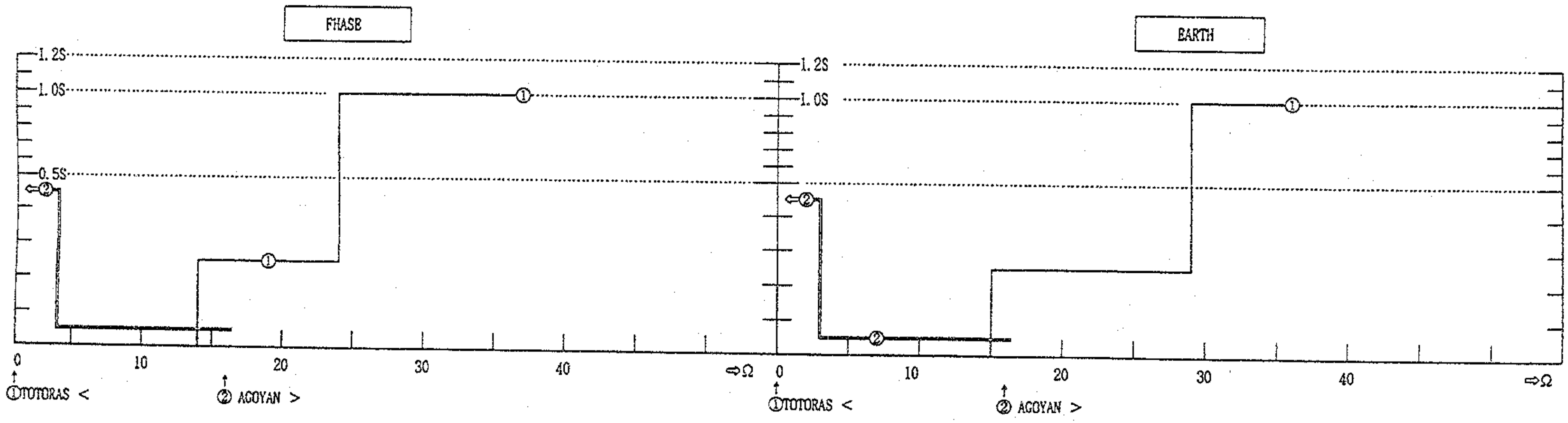


Fig. 7-6 138kV SNI Protection (9/9)

Table 7-1 Number of faults

REPORT OF FAULTS IN THE ELEMENT OF S.N.I

NAME OF ELEMENT	1991				1992				1992/1991	
	FAULTS		FAULTS WITH DISC/LOAD		FAULTS		FAULTS WITH DISC/LOAD		(C)-(A) / (A)	(D)-(B) / (B)
	(A)	%	(B)	%	(C)	%	(D)	%	%	%
LINES OF 230KV	15	12.61	11	9.24	35	20.00	14	8.00	133.33	27.27
LINES OF 138KV	47	39.50	29	24.37	59	33.71	27	15.43	25.53	-6.9
POWER PLANT	37	31.09	20	16.81	61	34.86	27	15.43	64.86	35.00
SUBSTATION	20	16.81	17	14.29	20	11.43	19	10.86	0.00	11.76
TOTAL	119	100.00	77	64.71	175	100.00	87	49.71	47.06	12.99

Table 7-2 Causes of Faults (1/3)

REPORT OF FAULTS IN THE CAUSES OF S.N.I
FAULTS IN 1991

230 KV TRANSMISSION LINES	PROTECTIVE RELAYS	CONTROL SYSTEMS	PROTECTIVE RELAYS SETTING	MAIN PROTECTION	MECHANICAL TROUBLE	VEGETATION	INSULATION CLEARANCE	METEOROLOGIC AL CONDITIONS	DROUGT	POWER SWING	SABO-TAGE	HUMAN ERRORS	OTRAS CAUSES	NO REPORTING	TOTAL	%	FAULT WITH DISC LOAD	%
①SAT. ROSA-STO DOMINGO	0	0	0	0	0	1	0	0	0	0	1	0	0	0	2	13.33	1	6.67
②STO DOMINGO-QUEVEDO	0	0	0	0	0	1	1	0	0	0	0	0	0	2	4	26.67	3	20.00
③QUEVEDO-PASCUALES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
④PASCUALES-MILAGRO	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	13.33	1	6.67
⑤MILAGRO-PAUTE	0	0	0	0	0	0	0	0	0	2	0	0	0	3	5	33.33	5	33.33
⑥SANTA ROSA-TOTORAS	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	13.33	1	6.67
⑦TOTORAS-RIOBAMBA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
⑧RIOBAMBA-PAUTE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
⑨TOTORAS-PAUTE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
TOTAL	0	0	0	0	0	4	1	0	0	2	2	0	0	6	15		11	
%	0.00	0.00	0.00	0.00	0.00	26.67	6.6	0.00	0.00	13.33	13.33	0.00	0.00	40.00		100.0		73.33

REPORT OF FAULTS IN THE CAUSES OF S.N.I
FAULTS IN 1992

230 KV TRANSMISSION LINES	PROTECTIVE RELAYS	CONTROL SYSTEMS	PROTECTIVE RELAYS SETTING	MAIN PROTECTION	MECHANICAL TROUBLE	VEGETATION	INSULATION CLEARANCE	METEOROLOGIC AL CONDITIONS	DROUGT	POWER SWING	SABO-TAGE	HUMAN ERRORS	OTRAS CAUSES	NO REPORTING	TOTAL	%	FAULT WITH DISC LOAD	%
①SAT. ROSA-STO DOMINGO	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	2.86	1	2.86
②STO DOMINGO-QUEVEDO	0	0	0	0	0	1	0	3	0	0	0	0	0	0	4	11.43	0	0.00
③QUEVEDO-PASCUALES	0	0	0	0	0	7	0	0	0	0	0	0	0	0	7	20.00	0	0.00
④PASCUALES-MILAGRO	0	0	0	0	4	0	0	1	0	0	0	0	0	1	6	17.14	5	14.29
⑤MILAGRO-PAUTE	0	0	0	0	0	1	0	0	0	0	0	0	2	3	6	17.14	5	14.29
⑥SANTA ROSA-TOTORAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
⑦TOTORAS-RIOBAMBA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2.86	0	0.00
⑧RIOBAMBA-PAUTE	0	0	0	0	0	0	2	0	0	0	0	0	2	1	5	14.29	3	8.57
⑨TOTORAS-PAUTE	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	14.29	0	0.00
TOTAL	0	0	0	0	4	9	2	5	0	0	0	0	4	11	35		14	
%	0.00	0.00	0.00	0.00	1.43	25.71	5.7	14.29	0.00	0.00	0.00	0.00	11.43	31.43		100.00		40.00

Table 7-2 Causes of Faults (2/3)

REPORT OF FAULTS IN THE CAUSES OF S.N.I
FAULTS IN 1991

138 KV TRANSMISSION LINES	CAUSES																	
	PROTECTIVE RELAYS	CONTROL SYSTEMS	PROTECTIVE RELAYS SETTING	MAIN PROTECTION	MECHANICAL TROUBLE	VEGETATION	INSULATION CLEARANCE	METEOROLOGICAL CONDITIONS	DROUGT	POWER SWING	SABO-TAGE	HUMAN ERRORS	OTRAS CAUSES	NO REPORTING	TOTAL	%	FAULT WITH DISC.LOAD	%
①VINCENTINA-IBARARA	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4.26	2	4.26
②VINCENTINA-GUANGOPOLO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
③VINCENTINA-PUCARA	0	0	0	0	0	1	0	0	0	0	0	1	0	1	3	6.38	1	2.13
④PISAYAMBO-AMBATO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
⑤TOTORAS-AMBATO	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2.13	1	2.13
⑥TOTORAS-AGOYAN	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2.13	0	0.00
⑦STO DOMINGO-ESMERALDAS	0	0	1	0	0	4	0	2	0	0	0	0	1	3	11	23.40	6	12.77
⑧QUEVEDO-PORTOVIEJO	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2.13	1	2.13
⑨PASCUALES-SALITRAL	0	0	0	0	0	0	1	0	0	0	0	0	0	1	2	4.26	0	0.00
⑩PASCUALES-STA ELENA	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	12.77	6	12.77
⑪PASCUALES-POSORJA	0	0	0	0	0	0	1	0	0	0	0	0	2	1	4	8.51	4	8.51
⑫MILAGRO-MACHALA	0	0	0	0	0	8	0	0	0	0	0	0	0	1	9	19.15	2	4.26
⑬PAUTE-CUENCA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2.13	0	0.00
⑭CUENCA-LOJA	0	0	0	0	0	0	0	1	0	0	0	0	0	1	2	4.26	2	4.26
⑮SANTA ROSA-VICENTINA	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2.13	1	2.13
⑯PASCUALES-POLICENTRO	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	4.26	2	4.26
⑰MILAGRO-BABAHOYO	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2.13	1	2.13
TOTAL	0	0	1	0	0	13	4	3	0	2	0	1	3	20	47		29	
%	0.00	0.00	2.13	0.00	0.00	27.66	8.5	6.38	0.00	4.26	0.00	2.13	3.68	42.55		100.00		61.70

Table 7-2 Causes of Faults (3/3)

REPORT OF FAULTS IN THE CAUSES OF S.N.I
FAULTS IN 1992

138 KV TRANSMISSION LINES	CAUSES																	
	PROTECTIVE RELAYS	CONTROL SYSTEMS	PROTECTIVE RELAYS SETTING	MAIN PROTECTION	MECHANICAL TROUBLE	VEGETATION	INSULATION CLEARANCE	METEOROLOGICAL CONDITIONS	DROUGT	POWER SWING	SABOTAGE	HUMAN ERRORS	OTRAS CAUSES	NO REPORTING	TOTAL	%	FAULT WITH DISC. LOAD	%
① VINCENTINA-IBARARA	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1.69	1	1.69
② VINCENTINA-GUANGOPOLO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
③ VINCENTINA-PUCARA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1.69	0	0.00
④ PISAYAMBO-AMBATO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
⑤ TOTORAS-AMBATO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
⑥ TOTORAS-AGOYAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
⑦ STO DOMINGO-ESMERALDAS	6	0	0	0	2	3	3	7	0	0	0	0	1	0	22	37.29	5	8.47
⑧ QUEVEDO-PORTOVIEJO	0	0	0	0	0	0	0	1	0	0	0	0	1	1	3	5.08	3	5.08
⑨ PASCUALES-SALITRAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
⑩ PASCUALES-STA ELENA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
⑪ PASCUALES-POSORJA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1.69	1	1.69
⑫ MILAGRO-MACHALA	0	0	0	0	5	7	3	0	4	0	0	0	3	3	25	42.37	14	23.73
⑬ PAUTE-CUENCA	0	0	0	0	0	0	0	1	0	0	0	1	0	0	2	3.39	0	0.00
⑭ CUENCA-LOJA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1.69	1	1.69
⑮ SANTA ROSA-VICENTINA	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1.69	1	1.69
⑯ PASCUALES-POLICENTRO	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	3.39	1	1.69
⑰ MILAGRO-BABAHOYO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
TOTAL	6	0	0	2	7	11	6	9	4	0	0	3	5	6	59		27	
%	10.17	0.00	0.00	3.39	11.86	18.64	10.1	15.25	6.78	0.00	0.00	5.08	8.47	10.17		100.00		45.76

Table 7-3 Characteristics for Protective Relay Systems

<1> Directional Comparison Relay System

Advantage:

0 This relay system can clear the fault simultaneously at both terminals irrespective of the fault location with relatively high speed.

0 The signal transmission channels required are small, and the power line carrier system can be easily adopted.

0 The high speed reclosing system can be easily applied.

0 The system is relatively immune to the back impedance.

Disadvantage:

0 It is difficult to apply the multiple-phase reclosing system because the faulted phase can not be identified in a multiple fault.

0 The system may miss-operate in out of step with a high speed.

0 The detection sensitivity and the operating time coordination are required to make it certain that the relay is locked at outside faults, and this setting is difficult.

<2> Distance Relay System

Advantage:

0 This relay system is relatively simple in configuration and it has high reliability, because the fault is detected by the information of its own terminal. (No signal transmission system is required.)

0 The identification of the faulted section is relatively certain, and the fault in the first stage section can be cleared quickly. The second and higher stages are set to time delay clearing, and the coordination with other sections is relatively easy.

0 The operation time is little affected by the power source capacity at the back.

Disadvantage:

0 The system can be applied only to the power source terminals.

0 The fault clearing action at the opposite terminal is a two-stage action (for 15~20% of the line section), and high speed clearing is not possible. (The high speed reclosing is not applicable.)

0 Failure of relay operation could occur in multiple faults.

0 The system may miss-operate with an outside fault when a long distance, heavy load transmission line has a heavy load, and there is arcing resistance.

0 The system may be miss-operated by load impedance in a long distance, heavy load transmission line, and countermeasures are required. (Installing blinder relays.)

<3> Overcurrent Relay System

Advantage:

0 The equipment is simple, has a relatively high operating reliability, and economical in cost.

0 With an overcurrent relay with instantaneous element, high speed clearing is possible depending on the conditions of the power system to be applied. The faulted phase of the transmission line can be identified.

0 The system can be used for protection of overloading.

Disadvantage:

0 The system can be applied only to terminals having power sources.

0 As the system has no directional function, the operation time coordination is difficult when both terminals have power sources, and the system is generally not applicable to such cases.

0 The operation time changes when the back impedance changes.

0 The system could miss-operate in out of step or power swing by picking up and accumulating the current signal.

CHAPTER 8 POWER FACILITIES EXPANSION PLAN

CONTENTS

List of Tables

CHAPTER 8 POWER FACILITIES EXPANSION PLAN

In Ecuador, electric power demand is increasing with the development of economy and social activities. In response, the power facilities including the power stations have been augmenting, and the scale of the electric power system has been expanding. Because of the enormous capital requirement and long years for the expansion of the power system, the funding and construction work for the power facilities must be advanced with the future change and development in the power demand and new technology fully taken into consideration from a long-term viewpoint.

The basic power system of Ecuador consists of the 230 kV system with two circuits in a loop form, which pools the power received from the respective power sources for allocation to the regional main substations. In this way, the supply-demand imbalance in the respective regions is compensated, and at the same time, various power supply sources within the system are operated with economical advantages.

In this chapter, the expansion plan up to 2003 for the power generation, the power transmission line and the substation facilities, based on the power system analysis and supply reliability analysis conducted by the JICA investigation mission, which in turn is based on the development plan of the electric power facilities of INECEL, is described.

8.1 Power Generation Facility

8.1.1 Selection of Facility Expansion Plan

The main point in the decision of electric power generation expansion plan is the decision on the optimum development sequence for satisfying the electric power and electric energy demand at each respective time point with the investment of minimum cost.

In selecting the optimum facility expansion plan, the computer models in its study of the master plan by INECEL were utilized. With the model which allows year by year evaluation of expansion, and which allows electric system simulation study for the annual demand compliance possibility of various facility expansion scenarios, the model for sequential generation and the model for operation simulation, the setting of the current values of the annual expenses of the representative expansion proposals and plans was possible.

(1) Method of selection

The selection process of facility expansion plans can be divided into the following three steps.

(a) Analysis of current facility expansion plan

In this step, if the necessity of change in the operation start time of the finalized power generation facility expansion plan is confirmed, the decision on the introduction time for the new power generation project is to be made.

(b) Finalizing facility expansion plan

Although the analysis period for the facility expansion is from 1997 to 2002, the concept plan up to 2005 shall be worked out for the purpose of fixing the investment amount for checking the financing plan.

This is necessary in order to make a decision on launching the hydroelectric power plant projects which are to be incorporated in SNI for operation start up to 2002.

(c) Economy analysis

The economy analysis shall be made for the purpose of making decision on the optimum facility expansion plan proposal, on the basis of the minimum expense standard, by calculating the cost by present value method for the invested capital, operation-maintenance expenses and fuel expenses at a discount rate of 10%.

To make allowance for the instable fossil fuel price, the sensitivity analysis for economy analysis is executed and annual 3% escalation is assumed. (2) Reference information used

(2) Reference information used

(a) Demand plan

The estimated demand for SNI's electric energy and power corresponding to the maximum demand background between 1993 and 2005 is outlined below.

Estimation of SNI Electric Energy and Power Demand (1993-2005)

Year	Electric Energy (GWh)	Power (MW)
1993	7,868	1,532
1994	8,414	1,628
1995	8,897	1,710
1996	9,394	1,794
1997	9,925	1,892
1998	10,462	1,991
1999	11,029	2,096
2000	11,641	21,165
2001	12,272	2,332
2002	12,949	2,461
2003	13,654	2,595
2004	14,405	2,679
2005	15,236	2,895

(b) Available power generation facilities

In order to study the power generation facility expansion for SNI, the state of the power generation facilities in the nation as of January 1993 must be known.

This data is especially important in the case of the thermal power stations, with regard to the operation characteristics, service life limit, scrapping time, decline of power generation performance due to decrepitude, etc.

(c) Expected electric power generation of respective hydroelectric power development projects

In examining the hydroelectric power generation projects, dam operation simulation study was conducted by means of computer models.

The standardization of power generation for the hydroelectric power generation projects makes the firm power, the primary electric energy and the secondary electric energy known. These energy parameters are calculated on the basis of the flow rate data for the past 26 years, as shown in Table 8-1.

(d) Investment amount and investment schedule

Table 8-2 shows the expenses including the direct expenses, technology expenses, management expenses and reserve expenses, converted to the value as of January 1992, and their investment schedule.

(e) Operation and maintenance (OM) expenses

The operation and maintenance expenses were divided into the fixed expenses and the variable expenses. The fixed expenses of hydroelectric power stations are mainly dependent on their output, and are expressed in US$/kW. For those hydroelectric power generation projects with which feasibility studies and further studies have been made, the operation and maintenance expenses are know, so that the known values are used, while for other power generation projects, 1.2% of the invested amount is assumed as the OM expenses, and for the power transmission and related facilities, 2% of the investment amount was assumed as the OM expenses.

For thermal power stations, the fixed components of the OM expenses were estimated in accordance with the power generation type and the facility output, and the variable part of the OM expenses were calculated for the fuel type and the power generation types, at the internal fuel cost as of June 1992.

Fuel type	CIF cost (US$/barrel) as of June, 1992
Crude oil	19.10
Fuel oil C	14.62
Diesel oil	24.62

Table 8-3 shows OM and combustion expenses for each power generation type and installed capacity of thermal power projects applied in this study.

8.1.2 Power Generation Facility Expansion Plan

The power generation facility expansion plan worked out to meet the electric power demand during the immediate future decade (1993 - 2002) is as follows:

(1) Existing power generation facilities

SNI comprises the facilities of INECEL and other local power companies connected to the 230 kV circle grid, and as of January 1993, of the national total power generation capacity of 2,278.2 MW (hydroelectric: 1,470.1 MW, thermal power: 808.1 MW) the share of INECEL is 1,691.8 MW (hydroelectric: 1,300.2 MW, thermal power: 391.6 MW). (refer to 3.3.1 Power generation facilities)

(2) Power generation facilities under construction

(a) Gas turbine power stations of private power generation utilities

Motivated by the power deficit resulting from the abnormal water shortage in 1992, the construction of Electro Quil gas turbine power station, 75 MW (25 MW x 1 and 50 MW x 1) and Electro Quito gas turbine power station, 33 MW, was started for completion in 1993.

(b) Rehabilitation of thermal power stations

According to the recent survey on the thermal power generation facilities currently in operation belonging to regional power systems, the total installed output capacity is 304,789 kW and the maximum generation capacity is 248,900 kW, as of January 1993, and according to the survey on the thermal power generation facilities requiring rehabilitation, the total installed output capacity is 111,724 kW and the maximum available generation capacity is 89,000 kW.

The rehabilitation work is scheduled for completion within 1993, to increase the power output total of SNI.

The details of the operatable thermal power generation facilities in the various regional power systems are given in Table 3-10.

(c) Gas turbine power stations of INECEL

In 1992, not only the rivers supplying water to the main hydroelectric power stations recorded extreme water shortage, but also the overall power demand rose above the level assumed by the facility plans of all the power generation plants in that year. As a result, the whole nation was forced to accept a power supply restriction which severely damaged the social and economical activities. In order to exclude the possibility of power shortage in the future, INECEL reviewed the power development plan up to 1996, and as a result, decided to construct two emergency gas turbine power stations, 30.9 MW and 80 MW, by December 1993, and according to a technology-economy study, Estero Salado power station in Guayaquil City and SNI Pascuales power station were selected as the sites of these gas turbine power units.

With these gas turbine power generation units to be incorporated into SNI, sufficient power will be supplied during the water shortage months of January and February in 1994, to create great reliability and assurance for SNI.

Since December 1993, Estero Salado Power Station has been under commercial operation, but Pascuales Power Station has been in course of construction and will be put into operation by December 1994.

(d) The steam turbine power stations of INECEL

Because of the decision to delay the construction start and operation start of DAULE PERIRA hydroelectric power station, the incorporation into SNI of a 125 MW steam turbine thermal electric power station and its operation start in December 1995 became necessary. As a result of various technology-economy studies, the Trinitaria district in Guayaquil City was selected as the site for this power station.

The award of the contract to purchase the facility units for the power station with a SPAIN loan was made, and the fund for the construction work is raising.

(e) DAULE PERIPA hydroelectric power station

The project involving this power station is a multi-purpose project incorporating irrigation, flood control, salt damage prevention, utility water, and power generation, and its construction is currently underway at the site 250 km north of Guayaquil City by Guayas River Basin Development Committee (CEDEGE).

The main part of the project, JAIME ROLDOS AGULERA reservoir, is located in the riverbed of Daule River, 10 km downstream from the converging point of Peripa River. The dam, an earth dam, 78 m in height, with a total water storage capacity of 6,000 x 10^6 m^3, has already been completed.

The power station, receiving water at a rate of 244 m^3/sec, through a circular tube tunnel, 7 m in diameter and 430 m in length, has two vertical Francis turbine generators (output: 65 MW).

The project is scheduled for operation start under SNI towards the end of 1996, but it appears to be rather delaying about two years in the present situation.

(3) Power generation facilities scheduled for development

(a) Large capacity hydroelectric power stations

The electric power generation master plan worked out by INECEL specifies a hydroelectric power generation plans with outputs larger than 100 MW. The projects included 40 medium-term to long-term electric power development plans, but through investigations and individual technical feasibility studies, conducted on the basis of economical indexes, they were reduced to 23 hydroelectric power generation plans, each forming a minimum cost power generation plan.

Table 8-4 shows the name, output, required number of construction years, and the current study state for these projects.

(b) Medium capacity hydroelectric power stations

For the purpose of adding medium-capacity hydroelectric power stations to SNI's power generation facility expansion program, development study was conducted, and 10 hydroelectric power station plans were selected, as listed below:

Medium Capacity Hydroelectric Power Generation Plans

Project Name	River System	Output (MW)	No. of Work Years
Angamarca*	Guayas	50	5
Chota	Mira	31	5
Abitagua	Pastaza	68	4
Apaqui*	Mira	36	6
Sabanilla	Zamora	18	4
Cuyes	Zamora	28	5
Soñaderos	Zamora	15	4
Tisai	Canar	11	4
Pilaton-Santa Ana	Esmeraldas	36	5
Sigchos	Esmeraldas	11	5

Note: * F/S is completed.

(c) Thermal electric power station

As substitutes for the SNI's prioritized hydroelectric power generation projects that form the SNI's optimum electric power development facility expansion plan, steam turbine thermal, gas turbine thermal, combined cycle thermal diesel thermal and nuclear power stations are conceivable.

Among these diverse substitute systems, steam turbine and gas turbine power stations are most feasible because of their low kWh cost and short construction time. The operation expenses for these thermal electric power stations are shown in Table 8-3.

(d) Geothermal electric power generation

The utilization of the geothermal energy for power development is conceivable for near future. The areas most feasible for geothermal electric power generation are Turino, Chalucas and Chachimbiro.

The Tufino project was also reportedly named for incorporation in the 10-year project starting shortly, and is in the need of fund for investigation and concept-level study, but the future facility plan appears to be rather delaying.

(4) Power generation facility development plan

For the purpose of meeting the power demand during the period from 1993 to 2004, the following prioritized development plans are recommended as a JICA proposal, as a minimum cost power generation facility plan. This JICA plan is based on the INECEL master plan with some modification made in consideration of the supply-demand balance (kWh).

Project Name	Station Output (MW)	Operation Start Year
T. gas (Estero Salado)	30.9	1993
Rehabilitation - Diesel	62.5	
Rehabilitation - Bunker	49.2	
T. gas (Electro Quil)[1]	75.0	
T. gas (Electro Quito)[1]	33.0	
T. gas (Pascuales)	80.0	
Rehabilitation (Estero Salado)	146.0	
T. gas (Machala)	125.0	1995
T. Vapor (Trinitaria)	80.0	1994
Daule Peripa[2]	130.0	1996
T. vapor (Manta)	140.0	
T. vapor	125.0	1997
San Francisco[2]	230.0	1999
T. gas (Santa Rosa)	80.0	2000
Mazar[2]	180.0	2001
Toachi[2]	150.0	2003
T. vapor (Santa Elena)	125.0	2004

Note: 1) Power facility of private utilities, 2) Hydroelectric power station

8.2 Transmission Line and Substation Expansion Plan

The transmission line and substation expansion plan for the immediate 10 years is divided to the short-term plan (1993 to 1995), the medium-term plan (1996 to 1998) and the long term plan (1993 to 2002). These plans are described below.

(1) Short-Term Plan

(a) SNI Phase-C

- Ibarra-Tulcan Transmission line:
  138 kV, 1 cct., 70 km — 1994
- Tulcan Substation:
  40/53/66 MVA, 138/69 kV — 1994
- Ibarra Substation:
  Installation of additional 138 kV, 1 cct. bay — 1994
- Each substation of SNI:
  Purchase and installation of condensers with total capacity of 138 MVA — 1994

(b) SNI Phase-D1

- Loja-Cumbaratza Transmission line:
  138 kV, 1 cct., 52 km — 1994
- Vicentina (Quito)-Ibarra Transmission Line:
  Additional 1 cct. of 138 kV — 1993
- Mulalo Substation:
  40/53/66 MVA, 138/69 kV — 1994
- Babahoyo Substation:
  40/53/66 MVA, 138/69 kV
- Vincentina Substation:
  Installation of additional 138 kV, 1 cct. bay — 1994
- Loja Substation and Cuenca Substation:
  Installation of additional 69 kV, 1 cct. bay — 1994

(c) SNI Phase-D2

- Paute-Pascuales-Trinitaria Transmission line:
  230 kV, 2 cct., 218 km — 1995

- Trinitaria Substation:
  225/300/375 MVA, 230/138 kV 1995
  90/120/150 MVA, 138/69 kV
- Puascuales Substation:
  Installation of additional 230 kV, 4 cct. bay 1995

(d) Cuenca-Limón Transmission Line
- Cuenca-Limón Transmission line:
  138 kV, 1 cct., 70 km
  (initially operated at 69 kV) 1993

(e) Expansion of Portoviejo Substation
Portoviejo Substation:
Installation of additional 138 kV, 1 cct. bay and
69 kV, 2 cct. bays
Installation of 45/60/75 MVA, 138/69 kV transformer 1993

(f) Expansion of SNI's Each Substation
- Santa Rosa Substation:
  45/60/75 MVA, 138/46 kV transformer
- Milagro Substation:
  33/44/55 MVA, 230/138 kV transformer
- Cumbaratza Substation (newly constructed)
  20/27/55 MVA, 138/69 kV 1995
- Purchase of new transformer (for reserve):
  20/27/33 MVA, 1ϕ, 138/69 kV transformer (for Milagro)
  20/27/33 MVA, 1ϕ, 230/69 kV transformer (for Riobamba)
- Mobile substation:
  45/50 MVA, 138/69 kV, mobile type 1993

(g) Puyo-Tena-Coca Transmission System
- Puyo-Tena Transmission Line:
  138 kV, 1 cct, 65 km 1995
- Tena-Coca Transmission Line:
  138 kV, 1 cct, 130 km (initially operated at 69 kV)
- Puyo Substation:
  20/27/33 MVA, 138/69 kV

- Tena Substation:
  20/27/33 MVA, 230/69 kV
- Agoyan Substation:
  Installation of additional 138 kV, 1 cct. bay

(h) New Thermal Power Plant Interconnection Facility

- Gas turbine 1993: 60/80/100 MVA, 13.8/69 kV
- Gas turbine 1994: 60/80/100 MVA, 13.8/69 kV
- Steam turbine 1995: 90/120/150 MVA, 13.8/69 kV

(2) Medium-Term Plan

(i) Milagro-Machala Transmission System

- Milagro-Machala Transmission line:
  230 kV, 1 cct., 129 km
- Moving of transformer (Milagro → Machala):
  100/133/167 MVA, 230/138 kV
- Milagro Substation:
  Installation of additional 230 kV, 1 cct. bay 1997

(j) Daule-Peripa Hydroelectric Power Plant Interconnection Facility

- Daule-Peripa-Pichincha Transmission Line:
  138 kV, 4 cct. 15 km
- Daule-Peripa Substation:
  Installation of additional 138 kV, 4 cct. bay 1996

(k) Daule Peripa-Chone Transmission System

- Daule Peripa-Chone Transmission Line:
  138 kV, 1 cct. 53 km 1997
- Chone Substation:
  20/27/33 MVA, 138/69 kV 1997
- Daule Peripa Power Plant:
  Installation of additional 138 kV, 1 cct. bay 1997

(l) Expansion of SNI's Transmission Line and Substation Facilities

- Cuenca Substation:
  Installation of 20/30/40 MVA, 138/69 kV transformer — 1997
- New Construction of Guayaquil Substation (location not determined):
  30/40/50 MVA, 138/69 kV — 1996
- Cuenca-Loja Transmission Line:
  Additional installation of 138 kV, 1 cct. — 1998
- Cuenca Substation:
  Installation of additional 138 kV, 1 cct. bay — 1998
- Loja Substation:
  Installation of additional 138 kV, 1 cct. bay — 1998

(m) Thermal Power Plant Interconnection Facility

- Steam turbine 1997: 52/70/86 MVA, 13.8/69 kV — 1997

(3) Long-Term Plan

(n) San Francisco Hydroelectric Power Plant Interconnection Facility

- San Francisco-Totoras Transmission Line:
  230 kV, 2 cct. 42 km — 1999
- Totoras Substation:
  Installation of additional 230 kV, 2 cct. bay — 1999

(o) Santa Rosa-Pomasqui Transmission System

- Santa Rosa-Pomasqui Transmission Line:
  230 kV, 2 cct. 30 km — 2000
- Pomasqui Substation:
  225/300/375 MVA, 230/138 kV — 2000
- Santa Rosa Substation:
  Installation of additional 230 kV, 2 cct. bays — 2000

(p) Expansion of SNI's Transmission Line and Substation Facilities

- Guayaquil Substation:
  Installation of 75/100/125 MVA,
  230/138 kV transformer 2000
- Mazar-Cuenca Transmission Line:
  138 kV, 2 cct., 55 km 2001
- Cuenca Substation:
  Installation of additional 138 kV, 2 cct. bays 2001
- Pascuares-Santa Elena Transmission Line:
  138 kV, 1 cct., 107 km 2001
- Mulalo Substation:
  Additional 40/53/60 MVA, 138/69 kV transformer 2000
- Coca Substation:
  New 20/27/33 MVA, 138/69 kV transformer 2001
- Tena Substation:
  Installation of additional 138 kV, 1 cct. bay 2001

(q) Power Plant Interconnection Facility

- Gas turbine 2000: 60/80/100 MVA, 13.8/69 kV 2000
- Mazar Substation:
  Installation of additional 138 kV, 4 cct. bays 2001
- Toachi Substation:
  Installation of additional 230 kV, 4 cct. bays 2003

(4) Improvement Plan of Substation Facilities

Generally speaking, the power system is operated by the constant voltage system, and the system is operated with the target of maintaining the sending and receiving end voltage at constant values even when the load changes. The following methods may be employed to attain this target.

(a) Adjusting the voltage with the on-load tap changers of transformers.

(b) Adjusting the line reactance by such devices as the series condenser.

(c) Adjusting the reactive power in the loads.

These methods are used either independently or in combination. According to the survey of JICA Study Mission, methods (1) and (3) are suitable, and the conclusion on the voltage adjustment method is described below based on our power system analysis results.

Transformer Tap Positions and Phase Compensating Condensers

Substation Name	1998	2003
Transformer Tap		
Selva Alegre	105%	110%
Kennedy	105%	110%
No. 18	105%	110%
Pomasqui	110%	110%
Chillogallo	-	110%
Tena	-	105%
Ambato	-	105%
Phase Compensating Condenser		
Vicentina	12 MVar	12 MVar
Salitral	12 MVar	12 mVar
Pascuales	36 MVar	36 MVar
Santa Rosa	36 MVar	36 MVar
Ibarra	-	18 MVar

Note: The phase compensating condensers are composed of single phase condensers, and the condensers of each phase are connected by a star connection, and a series reactor is inserted at the neutral point.

As illustrated in the table above, there are some substations in the northern regions of SNI where it is difficult to maintain the normal operating voltage. It seems that the on-load tap changers have to be installed in these substations, and the phase compensating condensers must be installed on the busses or the tertiary windings of transformers in other substations.

(5) Policy of Installing Spare Transformers

When we look at the conditions of installation of spare transformers in overseas nations (refer to Appendix A-1-5), single phase transformers are provided in major substations of primary transmission systems in developing nations, and in most cases, one unit of single phase transformer is installed as a spare transformer for the whole substation, irrespective of the total number of transformer banks of the substation. It is deemed that the rule of installation of spare transformers in the major 230 kV substations of SNI is also appropriate. In future, as the power demand grows, it will be required to install one unit each of single phase transformer for spare at Milagro, Sto. Domingo and Quevedo Substations.

In the advanced industrialized nations, the power systems are large, and 2 banks or more transformers are installed in major substations. In such countries, there are transformer manufacturing factories where transformers can be repaired in relatively short time to avoid a long supply interruption. Therefore, the general trend is not to install spare transformers in substations. In the secondary power systems, the recent trend is to adopt 3-phase transformers, because of high reliability of modern transformers, and not to install spare transformers. However, the concept of installing common spares to 138 kV substation must be introduced to SNI in order to avoid elongated supply interruptions, and new 138 kV substations must be so designed that spare facilities can be installed as power demand grows. Since many of main transformer failures in SIN are caused by oil leakage from bushing and tank cover packing, it is required to maintain spare parts of bushing and gaskets in order to prevent elongated supply interruptions.

8.3 Construction Schedule and Construction Cost

(1) Power Generating Facilities

The JICA Plan for power generation and supply, which has been designed to meet the power demand increase during the period from 1993 to 2003, is described in the Power Generation Facility Expansion Plan of Section 8.1. It is required to somewhat revise the schedule dates of commissioning of power plants in this Plan, considering the current progress in construction works and fund preparations. The revised construction schedule is presented in Table 8-5, and the construction costs and the investment schedule are presented in Table 8-6.

In reference to this modified construction schedule, there will be a period during which the supply energy falls short of the energy demand from 1994 to 1998. During this period, power supply interruptions will occur frequently during the dry season if it becomes difficult to secure sufficient energy supply by hydroelectric plants such as Paute. Such a situation could make it difficult to secure sufficient level of energy supply reliability, thereby seriously impeding the social and economic development of this nation.

In view of this situation, it is required to make all efforts on the early procurement of construction funds and assurance of construction schedule, so that the Power Generation Facility Expansion Plan is implemented according to the original schedule.

(2) Transmission and Substation Facilities

The Transmission and Substation Facilities Expansion Plan of SNI is as presented in Section 8.2 The schedules of this series of expansion plans is presented in Table 8-7, and the necessary investment schedule is presented in Table 8-8.

This Expansion Plan requires a total funding of US$ 110,682,000 for the 10 year period from 1994 to 2003.

(3) Construction Cost

This Expansion Plan (period 1994 to 2003) requires a total funding of US$ 1,528,442,000. (Power facilities US$ 1,417,760,000, Transmission and Substation facilities US$ 110,682,000).

Table 8-1 Principal Data of Hydroelectric Project (1/2)

Name of Project	Name of River	Energy Production					Economic Data (2)	
		Output (MW)		Energy (GWh) (1)			Cost of Investment 10^3US$	Cost of Ave. Energy (US$/MWh)
		Installed	Guaranteed	Primary	Secondary	Average		
Daule - Peripa	Guayas	130	77.1	428.7	168.2	596.9	154,000.00	36.11
Angamarca	Guayas	50	44.0	155.0	163.9	318.9	51,045.49	27.50
Apaquí	Mira	36	32.0	156.0	73.6	229.6	36,596.17	28.79
San Francisco	Pastaza	230	201.8	968.0	622.0	1,590.0	195,867.00	18.76(4)
Mazar	Santiago	180	96.3	446.1	327.0	773.1	559,638.85	43.76
Mazar (Nueva versión)	Santiago	180	96.3	446.1	327.0	773.1	308,999.00	31.43(4)(5)
Chesli	Esmeraldas	167	146.5	532.1	397.2	929.3	236,660.31	39.16
Toachi	Esmeraldas	300	130.3	554.8	797.7	1,352.7	587,928.79	70.63
Toachi (Nueva versión)	Esmeraldas	150	115.0	600.0	380.0	980.0	229,840.00	32.71(4)
Sopladora(A)	Santiago	210	183.0	1,453.0	302.0	1,755.0	229,595.00	19.57
Sopladora(1)	Santiago	312	274.0	1,998.0	536.0	2,533.0	254,846.00	15.00
Villadora	Esmeraldas	300	220.7	803.9	575.1	1,379.0	497,559.36	60.62
Minas	Jubones	350	277.5	1,194.0	467.0	1,661.0	659,276.95	66.89
Gualaquiza	Zamora	800	651.0	5,201.0	954.0	6,155.0	707,520.00	16.21
C. Sinclair IE	Coca	425	372.6	2,868.3	23.0	2,891.4	448,290.00	28.72
C. Sinclair 2E	Coca	420	368.5	2,837.2	23.6	2,860.9	294,190.00	17.70
Negro	Santiago	90	75.6	549.5	0.0	549.5	189,899.70	56.46(4)

Table 8-1 Principal Data of Hydroelectric Project (2/2)

Name of Project	Name of River	Energy Production					Economic Data (2)	
		Output (MW)		Energy (GWh) (1)			Cost of Investment 10^3US$	Cost of Ave. Energy (US$/MWh)
		Installed	Guaranteed	Primary	Secondary	Average		
Cascabel(A)	Santiago	280	245.7	1,117.7	721.1	1,838.8	275,952.00	29.63(4)
El Retorno	Zamora	280	215.3	867.6	488.3	1,355.9	625,434.10	80.51(4)
San Miguel(I)	Zamora	1,600	734.6	5,029.5	0.0	5,029.5	1,507,177.10	61.09(4)
Cedroyacu(A)	Napo	250	210.0	1,487.6	38.7	1,526.3	359,425.70	42.92(4)
Catachi	Napo	720	564.1	1,802.9	1,183.2	2,986.1	841,955.50	54.27(4)
Maiza	Santiago	840	526.3	3,452.3	151.0	3,603.3	946,272.29	53.10(4)
Verdeyacu Chico	Napo	1,120	808.7	3,399.5	2,137.5	5,537.0	1,160,911.40	43.17(4)

Note:
(A) Individual Operation, (I) Interpal Operation with the Upper Stream Projects
(1) Numbers excluded the station service and transmission losses.
(2) Price level as of Jan. 1991.
(3) Electification factor 10%
(4) Price level as of Jan. 1992
(5) Numbers considered secondary enery of 70 Gwh due to energy increase at the Paute Powerstation

Table 8-2 Investment Cost and Schedule for Future Projects of the Power Generation and Transmission in SNI

Power station	Output (MW)	Generation System: Total Cost	Generation Investment Schedule 1	2	3	4	5	Transmission System: Total Cost	Transmission Investment Schedule 1	2	3	4
San Francisco	230	195,867	7,320	45,589	56,039	58,015	28,904	19,484	1,364	10,521	3,897	3,702
Mazar	180	308,999	16,890	53,439	110,214	90,819	37,637	11,103	666	7,550	2,887	
Toachi	150	229,840	39,073	45,968	57,460	68,952	18,387	9,555	669	5,160	1,911	1,815
Apaquí	36	36,596	7,320	12,074	15,006	2,196		7,172	430	4,877	1,865	
Angamarca	50	51,045	6,125	18,374	23,483	3,063		7,561	454	5,141	1,966	
Turbina Vapor	70	89,404	15,199	25,033	40,232	8,940		2,558	154	1,739	665	
Turbina Vapor	125	141,989	63,895	63,895	14,199			4,083	245	2,776	1,062	
Turbina Gas	30	14,117	12,705	1,412					Por definir la ubicación			
	60	23,106	20,795	2,311					Por definir la ubicación			
	90	30,826	27,743	3,083				2,997	180	2,038	779	
Tur. Gas Natural	30	14,117	12,705	1,412					Por definir la ubicación			
	60	23,106	20,795	2,311					Por definir la ubicación			
	90	30,826	27,743	3,083					Por definir la ubicación			
T.Ciclo Combinado	100	73,093	21,928	43,856	7,309				Por definir la ubicación			
Tur. Vapor Oglan	70	89,404	15,199	25,033	40,232	8,940			Por definir la ubicación			
Tur.Vapor Bunker	70	92,447	15,716	25,885	41,601	9,245			Por definir la ubicación			
	125	141,989	24,138	39,757	63,895	14,199			Por definir la ubicación			
	300	285,484	48,532	79,936	128,468	28,548			Por definir la ubicación			
Bibliao Carbón N.	100	137,087	23,305	38,384	41,126	20,563	13,709		Por definir la ubicación			
Babia Carbón I.	150	189,445	32,206	53,045	56,833	28,417	18,944		Por definir la ubicación			
	300	329,340	55,988	92,215	98,802	49,401	32,934		Por definir la ubicación			
	600	572,540	97,332	160,311	171,762	85,881	57,254		Por definir la ubicación			

Price level : As of Jan. 1992

Table 8-3 Annual Cost of Future Thermal Power Projects

Price Level: as of June, 1992

PROJECT				Annual Cost of Operation & Maintenance				Capital Cost (1) (US$/MWh)	Total Cost (US$/MWh)
Type	Site	Fuel	Effective Output (MW)	Fixed (US$/Kwe)	Variable (US$/MWh)	Combust (US$/MWh)	Total O&M (US$MWh)		
Turb-Gas	Sta.Rosa	Diesel	21.2	5.73	2.08	52.22	56.30	39.00	95.31
			42.3	3.61	1.77	50.53	53.55	31.92	85.47
			63.5	2.83	1.61	49.56	52.16	28.39	80.55
Turb-Gas	Guayas	Diesel	26.4	4.60	1.75	51.67	55.03	31.27	86.30
			52.8	2.89	1.49	50.00	52.50	25.59	78.09
			79.2	2.27	1.36	49.04	51.20	22.76	73.96
Turb-Gas	Guayas	Gas-Nat.	26.9	4.51	1.46	19.60	22.64	30.66	53.30
			53.9	2.84	1.22	18.96	21.18	25.09	46.27
			80.8	2.23	1.10	18.60	20.48	22.31	42.80
C.Combin	Guayas	Diesel	97.0	4.12	1.72	37.47	40.27	29.51	69.78
	Guayas	Gas-Nat.	97.0	4.12	1.53	14.18	16.80	29.51	46.30
T-Vapor	Oglan	Petro-12	65.8	15.98	2.50	28.17	33.07	28.13	61.20
	Litoral	Bunker	68.6	15.77	2.44	23.16	27.97	27.89	55.86
			117.5	13.51	2.20	22.10	26.33	25.02	51.34
			282.0	10.96	1.86	20.46	23.97	20.96	44.93
	Biblian	Carbón N	94.0	15.95	2.66	27.97	33.04	32.54	65.57
	Bahia C.	Carbón I	141.0	14.34	2.46	26.99	31.61	29.98	61.58
			282.0	12.23	2.16	25.40	29.40	26.06	55.45
			564.0	10.64	1.89	23.90	27.39	22.65	50.04
Nuclear	Coca	Uranio X	558.0	15.52	4.12	9.86	16.46	77.67	94.13
			930.0	10.23	3.28	9.86	14.77	52.97	67.74

Note: (1) Including Initial Cost and Intermediate Reposition, Discount rate: 10%

Table 8-4 Middle and Long Term Electric Power Development Projects in S.N.I. Considered Alternative Generation

Name of Project	Installed Capacity (MW)	Const. Year	Actual Level of Study	Outward Flow
Hydro Electric Project				
Middle Team				
Apaqui	36	5	Fact. Avanzada	Pacifico
Angamarca	50	5	Fact. Avanzada	Pacifico
San Francisco	230	5	Diseño Licit.	Amazonas
Mazar (revisado)	180	5	Factivilidad	Amazonas
Toachi-Pilatón (revisado)	150	5	Prefactibil.	Pacifico
Marcabelí	155	6	Factibilidad	Pacifico
Sopladora	312	6	Factibilidad	Amazonas
Villadora	300	6	Factivilidad	Pacifico
Minas	350	6	Factibilidad	Pacifico
Codo Sinclair, Etapa 1	425	7	Factibilidad	Amazonas
Codo Sinclair, Etapa 2	420	5	Factibilidad	Amazonas
Chespi	167	5	Factibvilidad	pacifico
Gualaquiza	800	6	Prefactibil.	Amazonas
Long Term				
Cardenillo	300	8	Prefactibil.	amazonas
Cascabel	200	4	Inventario	Amazonas
Cedroyacu	250	6	Inventario	Amazonas
San Miguel	1,600	8	Inventario	Amazonas
San Antonio	920	7	Inventario	Amazonas
Naiza	840	8	Inventario	Amazonas
Verdeyacu Chico	1,120	8	Inventario	Amazonas
Catachi	720	7	Inventario	Amazonas
El Retorno	280	5	Inventario	Amazonas
Negro	90	4	Inventario	Amazonas
Thermal Electric Project				
T. Gas-Diesel 1	30	2		
T. Gas-Diesel 2	60	2		
T. Gas-Diesel 3	90	2		
T. Vapor-Bunker 1	73	4		
T. Vapor-Bunker 2	125	4		
T. Vapor-Bunker 3	300	5		
T. Vapor-Carbón 1	150	5		
T. Vapor-Carbón 2	300	5		
T. Vapor-Carbón 3	600	5		
Nuclear-Uranio	600-1,000	8		

Table 8-5 Construction Schedule of Power Generation Facilities

Project	Year												
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
T. Gas (Pascuales)		Operation ▼											
T. Gas (Machala)	Construction ▼		Operation ▼										
T. Vapor (Trinitaria)	Construction ▼			Operation ▼									
T. Vapor (Manta)		Construction ▼			Operation ▼								
Hydro (Daule Peripa)	Completion of Design ▼	Finance ▼	Construction ▼			Operation ▼							
T. Vapor (-)		Construction ▼				Operaton ▼							
Hydro (S. Francisco)		Finance ▼	Const-ruction ▼				Operation ▼						
T. Gas (Santa Rosa)					Finance ▼	Construction ▼		Operation ▼					
Hydro (Mazar)		Completion of Design ▼	Finance ▼	Construction ▼									
Hydro (Toachi)				Completion of Design ▼	Finance ▼	Construction ▼				Operation ▼			
T. Vapor (St. Elena)						Finance ▼	Construction ▼					Operation ▼	

Table 8-6 Investment Schedule of Power Facilities Plan

Unit: 10^3 US$

Project	Operation Year	Installed Capacity (MW)	Total Cost	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
T.Gas (Pascuales)	94/12	80	30,826	30,826									
T.Gas (Machala)	95/12	80	30,826	27,743	3,083								
T. Vapor (Trinitaria)	96/12	125	141,989	63,895	63,895	14,199							
T. Vapor (Manta)	97/12	270	178,808		30,398	50,066	80,464	17,880					
Hydro (Daule Peripa)	98/12	130	-	-	-	-	-						
T. Vapor (-)	98/12	80	141,989		24,138	39,757	63,895	14,199					
Hydro (S.Francisco)	99/12	230	195,867		7,320	45,589	56,039	58,015	28,904				
T.Gas (Santa Rosa)	2000/12	80	30,826						27,743	3,083			
Hydro (Mazar)	01/12	180	308,999				16,890	53,439	110,214	90,819	37,637		
Hydro (Toachi)	03/12	150	229,840						39,073	45,968	57,460	68,952	18,387
T. Vapor (St. Elena)	04/12	125	127,790								24,138	39,757	63,895
Total			1,417,760	122,464	128,834	149,611	217,288	143,533	205,934	139,870	119,235	108,709	82,282

Table 8-7 Construction Schedule of SNI Transmission Line and Substation

Project	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Note
A. Short Term Plan :											
1. SNI Phase C	----										
2. SNI Phase D1	----										
3. SNI Phase D2	----	----									
4. Cuenca - Limon T/L											Completed in 1993
5. Portoviejo S/S Expansion											Completed in 1993
6. SNI S/Ss Expansion	----	----									
7. Agoyan S/S 138kV 1 Bay Expansion	----	----									
8. Puyo - Tena - Coca T/L	----	----									
9. Pascuales G/T, T/L											Completed in 1993
10. Machala G/T, T/L	----										
11. Trinitaria V/T, T/L	----	----									
B. Medium Term Plan :											
1. Milagro - Machala 230kV T/L	----	----	----	----							
2. Daule P - Chone 138kV T/L		----	----	----							
3. Cuenca S/S Transformer 60 MVA		----	----	----							
4. Pascuales S/S Transformer 90MVA	----	----	----								
5. Cuenca - Loja 2nd Circuit T/L			----	----	----						
6. Manta V/T, T/L		----	----	----							
C. Long Term Plan :											
1. S. Francisco - Totoras T/L				----	----	----					
2. Sta. Rosa - Pomasqui T/L				----	----	----	----				
3. Pascuales S/S Transformer 225 MVA				----	----	----	----				
4. Mulalo S/S Transformer 40 MVA				----	----	----	----				
5. Coca, Tena S/S Expansion						----	----	----			
6. G/T 2001 T/L						----	----				
7. Mazar H/P 138kV 5 Bay						----	----	----			
8. Mazar - Cuenca T/L							----	----	----		
9. Toachi H/P 230kV 4 Bay										----	
10. Pascuales - Sta. Elena 138kV T/L						----	----	----			

Table 8-8 Investment Schedule of SNI Transmission Line and Substation (1/2)

Unit : 10^3US$
Exchage rate: 1US$=1,283 Sucres(Jan/1992)

Project	Budget Total	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Note
A. Short Term Plan												
1. SNI Phase C	1,048	1,048										
2. SNI Phase D1	926	443	483									
3. SNI Phase D2	11,169	8,724	2,445									
4. Cuenca - Limon T/L	0											Completed in 1993
5. Portoviejo S/S Expansion	0											Completed in 1993
6. SNI S/Ss Expansion	6,400	6,400										
7. Agoyán S/S 138kV 1 Bay Expansion	758	591	167									
8. Puyo - Tena - Coca T/L	13,075	9,134	3,941									
9. Pascuales G/T, T/L	0											Completed in 1993
10. Machala G/T, T/L	1,343	1,343										
11. Trinitaria V/T, T/L	2,089	1,257	832									
B. Medium Term Plan:												
1. Milagro-Machala 230kV T/L	14,553	948	7,350	3,334	2,921							
2. Daule P. - Chone 138kV T/L	5,287		289	3,532	1,466							
3. Cuenca S/S Transformer 60 MVA	1,651		98	1,125	428							
4. Pascuales S/S Transformer 90 MVA	1,971	119	1,338	514								
5. Cuenca - Loja 2nd circuit T/L	3,383			209	2,302	872						
6. Manta V/T, T/L	4,819			285	3,278	1,256						

Table 8-8 Investment Schedule of SNI Transmission Line and Substation (2/2)

Unit : 10^3US$
Exchage rate: 1US$=1,283 Sucres(Jan/1992)

Project	Budget	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Note
	Total											
C. Long Term Plan:												
1. S. Francisco - Totoras T/L	8,189				493	5,574	2,122					
2. Sta. Rosa - Pomasqui T/L	11,608				711	5,558	3,028	2,311				
3. Pascuales S/S Transformer 225 MVA	3,368				236	1,815	672	645				
4. Mulalo S/S Transformer 40 MVA	1,523					96	1,035	392				
5. Coca, Tena S/S Expansion	2,885						107	1,766	1,012			
6. G/T 2001 T/L	1,319						789	530				
7. Mazar H/P 138kV 5 Bay	2,408							147	1,635	626		
8. Mazar - Cuenca T/L	2,778						162	1,891	725			
9. Toachi H/P 230kV 4 Bay	1,772										1,772	
10. Pascuales - Sta. Elena 138kV T/L	6,360						382	4,327	1,651			
Total	110,682	30,007	16,943	8,999	11,835	15,171	8,297	12,009	5,023	626	1,772	

Appendix

Appendix

Appendix A-1 Example of Maintenances of Generation, Substation and Transmission Line Equipment

Appendix A-1 Example of Maintenance of Generation, Substation and Transmission Line Equipment

List of Table

Table A-1-1 Repair/Replacement of Hydroelectric Power Plant Equipment (1/3)

Water Turbine

Equipment Item	Repair/Replacement Item	Effect		Note
		Performance Improvement	Maintainability Reliability Improvement	
Water Turbine Proper	Total Replacement	o	o	Modification of type, number, etc.
	Runner	o	o	New manufacture, overlay repair.
	Guide Vane	o	o	New manufacture, overlay repair.
	Main Bearing	-	o	Oil self-contained, self-cooled, water lubricated bearing, etc.
	Guide Vane Bearing	-	o	Non-oiling bearing.
	Water sealing unit	-	o	Ceramic seal, labyrinth seal, packing system.
	Liners	-	o	
	Packing and consumables	-	o	
Water Turbine Auxiliary Equipments	Servo Motor	o	o	Motor driven or hydraulic.
	Inlet Valve	o	o	Replacement, modification of type, sealing method.
	Governor	o	o	Mechanical to electrical (digital) system.
	Hydraulic System	-	o	Modification to centralized system, unit system, M-M system, bladder type accumulator, etc.
	Pressure Regulator	-	o	New manufacture, repair or removal.
	Water Supply System	-	o	Replacement or removal of strainer.
	Drainage System	-	o	
	Control System	-	o	

Table A-1-1 Repair/Replacement of Hydroelectric Power Plant Equipment (2/3)

Generator

Equipment Item	Repair/Replacement Item	Effect		Note
		Performance Improvement	Maintainability Reliability Improvement	
Generator Proper	Total Replacement	o	o	Modification of type, number, etc.
	Stator Coil	o	o	Epoxy resin insulation.
	Stator Core	o	o	New materials, end-less lamination.
	Excitation Field Coil	o	o	New insulation materials.
	Thrust Bearing	o	o	Pivot spring type, modification to air cooled type, etc.
	Guide Bearing	o	o	Modification to oil self-contained type, air cooled type, oil leak prevention structure, etc.
	Slip Ring	o	o	Improved type.
	Brake	o	o	Pivot type or electromagnetic type.
Excitor System	Excitor	o	o	Modification of type, adoption of thyristor, brushless type, static type.
	AVR	o	o	Contact type to thyristor type.

Table A-1-1 Repair/Replacement of Hydroelectric Power Plant Equipment (3/3)

Control Board and Switching Equipment

Equipment Item	Repair/Replacement Item	Effect		Note
		Performance Improvement	Maintainability Reliability Improvement	
Control Board	Total Replacement	o	o	Improvement of control system; automation and centralization.
	Control Board	o	o	Water level regulator, process control board, etc.
	Automatic Synchronizing Board	o	o	Vacuum tube type to transistor type.
	AVR Board	o	o	Contact type to thyristor type.
	NGR Board		o	
Main Circuit Board	Total Replacement	o	o	Enclosed switchboard.
	Partial Replacement			
	Circuit Breaker	o	o	Vacuum circuit breaker.
	House Transformer	o	o	Resin mold type.
	Instrument Transformer	o	o	Dry type, epoxy mold type.
Out door Equipment	Replacement of Main Transformer	o	o	
	Partial Repair of Main Transformer		o	Energy conservation of coolers, improved pressure relief valve.
	Circuit Breaker	o	o	Gas circuit breaker, vacuum circuit breaker.
	Line Switch	o	o	
	Arrester	o	o	
	Instrument Transformer	o	o	

Table A-1-2 Aging Diagnosis of Hydroelectric Plant Equipment (1/2)

1. Inspection Spots and Methods of Water Turbine

Equipment	Component	Major Spots for Inspection	Inspection Method								
			Flaw Detection				Inspection and Measurement				
			Magetic Particle	Penetrant	Radiation	Ultrasonic	Stress	Structure	Material	Wall Thick-ness	Depth
Runner	Runner	Vane roots (runner band, runner crown welds.	●	●		○		○	○	○	○
Flow Regulator	Guide vane	Spindle roots, spots where shape changes.	●	●				○	○	○	
Main Shaft	Main shaft Inter-mediate shaft	Rounded corners of flange Fits to runner Around attach bolts or fits	●	●		○		○	○		○
Casing	Casing Manhole (including hand holes) Drainage pipes Drainage valves	Rounded corners of flanges Rivetted parts Rib root welds Rounded corners of flanges Bolted holes Attaching bolt roots Rounded corners of flanges	●	●	○	○	○	○	○	○	○
Speed Ring	Speed ring Shell Stay vane Stay bolt	Welds Welds to shell Roots of screwed parts	●	●	○	○	○	○	○	○	○

Note: Item marked by ●; must be performed.
Item marked by ○; to be performed as required.

Table A-1-2 Aging Diagnosis of Hydroelectric Plant Equipment (2/2)

2. Diagnosis Items and Procedures for Generator

Component Name	Diagnosis Item	Procedures
Stator Coil	Insulation diagnosis. Checking loose wedge.	Visual inspection, polarization coefficient, tanδ, AC current, partial discharge, D Map method, N-Y map method. Sounding inspection.
Stator Core	Wavy deformation. Vibration distribution. Rust	Wavy deformation, upward deformation of abutment. Electromagnetic vibration, mechanical vibration. Surface rusting, fretting corrosion.
Stator Coil	Visual inspection. Insulation characteristics.	Decoloration, cracking, loose or popping up insulators. Insulation resistance, polarization coefficient, voltage distribution between poles.
Major Structural Components (Main shaft, spike, yoke, washer ring, etc.)	Deformation, crack. Vibration	Visual inspection, dye penetrant test, magnetic particle (ultrasonic) flaw test. Balancing
Bearing	Vibration Unusual noise Temperature Oil leakage	Wear, gap.
Slip Ring	Visual inspection Temperature	Decoloration, aging, cracking and surface wear of insulators. Overheating and decoloration of brushes and brush holders.

Table A-1-3 Aging Refurbishment and Facility Improvement for Thermal Power Plant

Equipment	Aging Refurbishment	Facility Improvement	
		Performance/Function Improvement	Life Extension
Boiler Plant	* Refurbishment of pressure boundaries (superheater, reheater, water wall, etc. * Auxiliary equipment refurbishment (mill, etc.)	* Adoption of spiral water wall. * Combustion improvement.	* Improved startup valve.
Turbine Plant	* Replacement of rotor, casing and main valve. * Replacement of feedwater heater. * Replacement of boiler feedwater pump internal casing.	* High efficiency blade. * New blade design for the last stage blade. * Adoption of variable pitch blade for recirculation pump.	* Nozzle box replacement. * Improved startup procedure.
Generator Electrical Components	* Generator coil re-winding (rotor and stator) * Motor coil re-winding. Replacement of high-voltage power supply board and control center.		* Improvement of insulation strength of generator rotor retaining coil. * Corrosion resistant retaining ring material.
Instrumentation and Control	* Replacement of control systems and excitation systems. * Replacement of protective relays. * Replacement of converters and instruments.	* Converting control systems to digital systems. * Expansion of automation functions. * Converting to centralized control system.	

Table A-1-4 Preventive Maintenance and Reliability Improvement Technology of Turbine Generator Major Components

Component Name	Reliability Control Parts	Reliability Control Item	Inspection Method	Aging Cause	Preventive Maintenance	Reliability Improvement Technology
Rotor	Rotor shaft center hole	* Low-cycle fatigue (checking flaw and crack, and their propagation)	UT MT VI	* Startup and shutdown	* Evaluation of residual life * Elimination of crack	* Improvement of materials
	Rotor shaft journal	* Torsional fatigue (checking flaw)	MT PT	* Power system fault * Short circuit fault * Excessive vibration	* Evaluation of cumulative consumption of residual life	* Improvement of torsional vibration strength of journal by 2-stage adjustment method
	Rotor core	* Fretting fatigue (checking cracks)	MT	* Operating hours	* Removal of cracks * Changing the contacting end points	* Improvement of fretting strength of core teeth.
	Rotor wedge	* Fatigue and creep (checking cracks)	PT MT	* Startup/shut-down and cumulative high temperature	* Evaluation of residual life * Wedge replacement and improvement of geometry	* Improvement of geometry
	Retaining ring	* Stress corrosion cracking	PT UT	* Moisture	* Removal of cracks * Evaluation of residual life	* New inspection technology * Improvement of material * Polyamide varnish processing
	Inter-pole bonding cable	* Low cycle fatigue (checking cracks)	VI PT	* Startup/shut-down	* Evaluation of residual life * Improvement to ling-life structure	* Improvement to long-life structure
	Coil and insulation	* Wear of inter-coil contacting surfaces and production of copper powder	VI	* Rotations by turning gear	* Evaluation of wear, overhaul and inspection * Recurrence prevention measures	* Improvement of structure to prevent wear
		* Insulation degradation	VI	* Operating hours * Start-stop cycles	* Evaluation of residual life	* Replacement of insulator
	Collector ring	Brush sliding surface resistance	DI HT	* Operating hours	* Evaluation of residual life, machining or replacement	* Early detection of anomaly by spark detector
	Bearing and bearing system	Shaft vibration	Vibration meter	Settlement of supporting base	Shaft vibration diagnosis	* Thermal balance
Stator	Stator coil	* Insulation degradation * Loose wedge * Loose fixing * Condition of insulator surface	VI Insulation diagnosis	* Load change * Cumulative high temperature * Faults and vibration	* Evaluation of residual life of insulation * Replacement of insulation	* Heat cycle resistance improvement technology * Loosening prevention technology
	Stator core	* Aging of stator varnish, loosening	VI Roof heat test	* Operating hours	* Evaluation of residual life * Partial replacement	* Core temperature reduction technology * Core monitor
Bearing, Shield Ring	Sliding parts	Wear	DI VI	Startup/shut-down cycle, operating hours	* Evaluation of residual life * Machining or replacement	* Technologies for improvement of friction loss and stability
Lead Bushing	Cemented parts	* Cracking and hydrogen leak of cemented parts	VI PT	* Heat cycle	* Evaluation of residual life * Bushing replacement	* Improvement of bushing geometry
Hydrogen Cooler	Cooler	* Thinning of cooler tubes	VI ET	* Wear	* Wall thickness measurement * Replacement of cooler tubes	* Improvement of cooling performance

Note: UT; ultrasonic flaw detection MT; magnetic particle test PT; dye penetrant test
HT; temperature measurement VI; visual inspection DI; dimension inspection ET; eddy current test

Table A-1-5 Reserve Transformer by Country

Country	Primary Transmission System	Secondary Transmission System	Note
Turkey	380 kV, 1ϕ x 3 Transformer, 1ϕ x 1 spare for each substation	154 kV, 3ϕ Transformer, no spare	Transformers become so reliable recently. Therefore, there is a tendency to adopt 3ϕ type and to provide no spare.
Philippines	230 kV, 3ϕ Transformer, no spare	132 kV, 3ϕ Transformer no spare	
India	500 kV, 1ϕ x 3 Transformer, 1ϕ x 1 spare for each substation	220 kV or 132 kV, 3ϕ Transformer, no spare	
Indonesia	500 Kv, 1ϕ x 3 Transformer, 1ϕ x 1 spare for each substation	150 Kv or 70 kV, 3ϕ Transformer, no spare	
Bangladesh		132 kV, 1ϕ x 3 Transformer, 1ϕ x 1 spare for each substation	
Taiwan	345 kV, 3ϕ, Transformer, no spare	161 kV, 3ϕ Transformer, no spare	
Pakistan	500 kV, 1ϕ x 3 Transformer, 1ϕ x 1 spare for each substation	220 kv, 1ϕ x 3 Transformer, 1ϕ x 1 spare for each substation	
Sri Lanca	230 kV 1ϕ x 3 Transformer, 1ϕ x 1 spare for each substation	132 kV, 1ϕ x 3 Transformer, 1ϕ x 1 spare for each substation	
Tanzania	220 kV, 3ϕ Transformer, no spare	132 kV, 3ϕ Transformer, no spare	
Peru	220 kV, 3ϕ, Transformer, no spare	138 kV, 3ϕ Transformer, no spare	Lima - Chimbote, Transmission Line Project
Paraguay	220 kV, 1ϕ x 3 Transformer, 1ϕ x 1 spare for each substation	66 kV, 3ϕ Transformer, no spare	
Thailand	500 kV or 230 kV, 1ϕ x 3 Transformer, 1ϕ x 1 spare for each substation	132 kV, 3ϕ Transformer, no spare	There is a tendency to provide no spare recently.
Japan	500 kV or 275 kV, 1ϕ x 3 or 3ϕ Transformer, no spare	154 kV or 110 kV, 3ϕ Transformer, no spare	
China	500 kV or 230 kV, 1ϕ x 3 or 3ϕ Transformer, no spare		

Table A-1-6 Example of Major Facility Refurbishment in Thermal Power Plant (1/3)

Refurbishment Year	Unit	Boiler Facility	Turbine Facility	Electrical and Instrumentation	Flue Gas Desulfurization System	Note
1981	Unit-1	* Primary fan blade disk replacement	* 5A feedwater heater replacement	* Converters and control system parts replacement * Control battery replacement		
	Unit-2		* 5A, 5B feedwater heater replacement * High pressure 1st stage nozzle box replacement * Main steam stop valve replacement	* Turbine monitoring instrument replacement		
1982	Unit-1	* Hanging type reheater replacement * Primary fan blade disk replacement (3/4)	* Bearing cooling water cooler replacement * High pressure 1st stage nozzle box replacement * No. 1, 2 feedwater heater tube replacement	* Mill control system replacement * Turbine monitoring instrument replacement		
	Unit-2	* Hanging type reheater replacement (1/4) * Primary fan blade disk replacement	* DFP booster pump casing replacement			
1983	Unit-1	* Hanging type reheater replacement (1/4)				
	Unit-2	* Hanging type reheater replacement (3/4) * SH joint replacement	* Bearing cooling water cooler replacement * No. 1, 2 A feedwater heater tube replacement	* Mill control system replacement * Instrument battery replacement		
1984	Unit-1	* Horizontal RH tube replacement * Hanging type secondary SH joint replacement * AH element, seal replacement * Ash treatment pump replacement (A, B)	* Turbine efficiency improvement measures (replacement of high and medium pressure rotor, rotor blades and stator blades) * No. 1, 2 A feedwater heater tube replacement	* Boiler ABC system replacement * ALR, LRSC replacement		
	Unit-2					
1985	Unit-1		* Turbine MSV valve replacement			
	Unit-2	* Horizontal RH tube replacement * Hanging type secondary SH joint replacement * AH element, seal replacement	* Turbine efficiency improvement measures * Turbine MSV valve replacement * UFP booster pump casing replacement * Installation of high pressure heater bypass pipe	* Computer replacement * Boiler ABC system replacement * ALR, LRSC replacement * OF cable replacement (partially)		
1986	Unit-1		* Steam regulator valve replacement (high pressure casing with valve, etc.)	* Excitation system replacement (AVR)		
	Unit-2	* Horizontal type RH tube replacement				

Table A-1-6 Example of Major Facility Refurbishment in Thermal Power Plant (2/3)

Refurbishment Year	Unit	Boiler Facility	Turbine Facility	Electrical and Instrumentation	Flue Gas Desul-furization System	Note
1987	Unit-1		* Feedwater heater casing replacement			
	Unit-2	* Boiler crown penetration ceiling exhaust tube replacement				
1988	Unit-1	* Boiler crown penetration ceiling exhaust tube replacement * IDF blade disk replacement	* Feedwater pump casing replacement (B,C) * 3B feedwater heater bundle replacement	* Mill related control drive replacement (24) * Auxiliary fan motor replacement * Auxiliary equipment bearing monitoring system replacement		
	Unit-2		* Feedwater pump casing replacement (D)	* Auxiliary equipment bearing monitoring system replacement		
1989	Unit-1		* 6A, B feedwater heater replacement			
	Unit-2		* Feedwater pump casing replacement (A,B,C)	* Excitation system replacement (AVR) * OF cable replacement		
1990	Unit-1	* Hanging type primary SH replacement (whole)	* ICV valve replacement * Feedwater pump casing replacement (A) * 3A feedwater heater bundle replacement	* EP major component replacement (discharge plate, collector, etc.)	* BUF casing replacement (A)	
	Unit-2					
1991	Unit-1		* 5B feedwater heater replacement			
	Unit-2	* Hanging type primary SH replacement (whole) * C ring gear replacement	* ICV, RSV valve box replacement	* EP major component replacement (discharge plate, collector, etc.)		
1992	Unit-1	* Hanging type RH inlet header, snub tube replacement * Boiler water wall tube replacement (1/5) * Hanging type secondary SH tube replacement * Radiant secondary SH joint replacement * AH carbon circum-seal replacement	* RSV valve box replacement * Medium pressure turbine inner chamber replacement * Medium turbine inlet tube replacement * High pressure turbine 1st stage nozzle box replacement * High pressure turbine upper casing inlet pipe replacement	* Increasing capacity of start-up transformer (installation of cooling fans) * Computer power supply (CVCF) replacement	* BUF casing replacement	
	Unit-2					

Table A-1-6 Example of Major Facility Refurbishment in Thermal Power Plant (3/3)

Refurbishment Year	Unit	Boiler Facility	Turbine Facility	Electrical and Instrumentation	Flue Gas Desulfurization System	Note
1993	Unit-1		* High pressure 5A feedwater heater replacement	* Sealing oil system, vacuum pump replacement		
	Unit-2	* Right water wall replacement (1/5) * Hanging type secondary SH panel replacement * Flue gas duct and hanger modification * Radiant secondary SH joint replacement * Pulverized coal burner replacement * Boiler spray nozzle replacement * B-mill ring gear replacement * AH carbon circum-seal replacement	* High pressure turbine 1st stage nozzle replacement * High pressure turbine upper casing inlet pipe replacement * Medium pressure turbine inner chamber replacement * Medium pressure turbine inlet pipe replacement * 3A feedwater heater bundle replacement	* Sealing oil system, vacuum pump replacement		

Table A-1-7 Reliability Improvement Measures in Hardware

Equipment	Stage of Implementation	Timing of Implementation	Reliability Improvement Measures
Transformer	Design	Present Time	* The water proof designs of auxiliary equipment (pressure relief system, pressure relays) terminal boxes are strengthened.
		Future	* The designs of control devices and contacts will be changed to sealed structures.
	Manufacture/ Construction	Present Time	* Improvement of quality control, including inspection of materials and parts, and intensive inspections during assembly works. * Elimination of blunders by improving jigs and checking systems.
	Maintenance	Present Time	* Upgrading of periodical inspection procedures by improvement of inspection/check list contents, parts replacement, and establishment of standards. * Review of frequency of analysis of gas in oil (increasing frequency of analysis on aged equipments). * Early replacement of aged transformers.
		Future	* Development of insulation degradation diagnosis technology.
Circuit Breaker	Design	Present Time	* Intensification of design such as elimination of mechanical stress concentration in operating mechanisms, adoption of proper friction coefficient, and increase in mechanism resetting force. * Intensification of counter-foreign-object designs such as reduction of electric field intensity below tank and arrangement of sliding components. * Strengthening of lightning protection design by installing arresters at transmission line entrance. * Improvement of fixing method of charging parts. * Improvement of insulation materials.
		Future	* Adoption of appropriate lubrication material. * Employing smaller energy in breaking part and operating device. * Redundant control circuits. * Prevention of water and dew, and sealing of contacts. * Addition of automatic inspection circuits to control circuits. * Improvement of counter-contamination performance, including counter-foreign-object measure of GCB (GIS).
	Manufacture/ Construction	Present Time	* Adoption of standardized and adjustment-free parts by preparing appropriate machining tools and jigs. * Early discovery of initial faults by applying breaking-in operations to operating mechanisms. * Improved quality control by eliminating burs and improving work procedures. * Education/training of workers.
		Future	* Improvement of plating technique for auxiliary circuits.
	Maintenance	Present Time	* Improvement of periodical inspection, including clarification of standards for replacement of aged parts and use of appropriate lubricant. * Education of maintenance personnel.
		Future	* Introduction of preventive maintenance.
Line Switch	Design	Present Time	* Designs simplifying adjustment of misaligned contacts.
		Future	* Adoption of wear-resistant structure for rotating charged parts. * Elimination of lubrication at rotating mechanism and sealing of conducting parts (use of SF_6 gas, etc.)
	Manufacture/ Construction	Present Time	* Improvement of quality control. * Reducing the size of site-assembled components by increasing the size of transportation.
	Maintenance	Present Time	* Improvement of periodical inspection, including clarification of aged parts replacement standard and clarification of inspection standard. * Periodical replacement of pneumatic system packing.
Relays and Control Boards	Design	Present Time	* Standardization of component circuits, reduction of quantity and standardization of parts. * Application of counter-noise and counter-surge designs.
		Future	Addition of automatic monitoring functions to relays, and conversion to contact-less relays.
	Manufacture/ Construction	Present Time	* Improvement of quality control. * Intensification of reliability verification test after assembly and intermediate tests (cleaning and aging).
		Future	* Simplification of on-site tests.
	Maintenance	Present Time	* Replacement of aged parts by establishing replacement standards and repair standards. * Intensification of inspection procedures, including improvement of inspection/adjustment check lists and procedures of inspection/adjustment works.

Table A-1-8 Reliability Improvement Measures in Software

Classification	Timing of Implementation	Reliability Improvement Measures
Fault Prevention	Present Time	* Installation of line arrester (prevention of lightning fault). * Closure of equipment openings (prevention of entrance of small animals). * Insulation of charged parts (prevention of entrance of small animals). * Adoption of enclosed equipments, such as GIS, in replacement of equipments (prevention of contact by flying objects). * Conversion of existing substations to indoor type substations (prevention of contact by flying objects).
Localization of Faults and Reduction of Fault Duration	Present Time	* Installing two transformer banks (dispersion of load and improvement of switching functions). * Introduction of remote control schemes of equipments (improvement of switching functions).
	Future	* Installation of fault point identification devices (improvement of fault point discrimination function).
Prevention of Rare Faults	Future	* Review of the desirable configuration of the upper hierarchy systems (trunk systems). * Review of interconnection method between stations. * Improvement of designs of integrated equipments (particularly GIS) to localize the effect of faults and to improve and simplify recovery procedures.

Table A-1-9 Reliability Improvement Measures for Operation and Maintenance

Classification	Area of Implementation	Timing of Implementation	Reliability Improvement Measures
Operation	Improvement of Monitoring Function	Present Time	* Automatic monitoring of power system conditions (power flow, load, voltage, etc.). * Monitoring of entrance into premises (entrance monitoring system, ITV, etc.).
		Future	* Integrated monitoring system (monitoring of all aspects of electric station by ITV).
	Improvement of Operation Function	Present Time	* Automation of normal operations (switching of systems, transformers, etc.). * Automation of fault recovery operations (automatic fault recovery system, receiving system switching system, etc.). * Training of operating procedures (simulator, etc.). * Replenishment of operation error prevention system (interlock, etc.).
	Improvement of Management Function	Present Time	* Automatic collection and processing of records.
Maintenance	Improvement of Patrol Technology	Future	* Integrated monitoring system (monitoring of equipment operating conditions by ITV). * Constant surveillance system (detection of electrical anomalies of equipment).
	Improvement of Inspection Technology	Present Time	* Training of inspection techniques (technical qualification system, etc.). * Prevention of operation errors. * Constant surveillance of protective relays (automatic inspection, automatic monitoring).
		Future	* Constant surveillance of equipments (for partial discharge, abnormal vibration, excessive temperature rise, etc.).
	Improvement of Fault Recovery Technology	Present Time	* Training of provisional fault recovery actions. * Preparation of fault recovery materials/equipments (spare parts, transportation facilities, etc.).
		Future	* Improved identification of fault locations (proper location of CTs, fault locator relays, proper division of gas compartments, etc.).
	Improvement of Management Technology	Present Time (Future)	* Computerization of maintenance management works.

Table A-1-10 Maintenance of Transmission Line (1/2)

Item	Engineering Department	Transmission Maintenance Section	Transmission Maintenance Section
Management works			
(1) planning for maintenance	○	○	
(2) planning for allocation of employee	○	○	
(3) planning & execution of training and education	○	○	○
(4) planning for allocation of vehicles and wireless apparatus	○	○	
(5) planning for scheduled outage	○	○	
(6) management of maintenance sheets and records	○	○	○
(7) minor research and experiment	○	○	○
(8) management of standards	○	○	○
(9) management of Maintenance Center	○		
Negotiation works			
(1) investigation			○
(2) negotiation		○	○
(3) plannig and execution of counter measure		○	○
Budget for maintenance and construction			
(1) basic consideration for budget	○		
(2) composition of budget scheme	○		
(3) offering necessary information for budget scheme		○	○
(4) management of budget	○	○	
(5) design of construction work		○	○
(6) checking constructed lines in another dept.as specified			○
(7) processing for scheduled outage			○
(8) supervising major construction work conducted in another dept.			○

Table A-1-10 Maintenance of Transmission Line (2/2)

Item	Engineering Department	Transmission Maintenance Office	Transmission Maintenance Office
Patrol and inspection			
(1) operation schedule of helicopter	○		
(2) planning for patrol and inspection		○	
(3) execution of patrol and repair work		○	
Treatment of line failure for safety			
(1) planning and execution for safety	○		
(2) education and training to contractor's safety	○	○	
(3) emergency patrol and repair work			○
(4) management of repair work		○	
(5) planning for counter measures to prevent fault		○	○
(6) execution of counter measures			○

Table A-1-11 Frequency of Patrol and Inspection

Item			Period
Patrol	ordinary patrol	normal patrol	once/3 months
		seecific patrol	over once/month
	preventional patrol		as required
	emergency patrol		as required
	special patrol		as required
Inspection	support	normal inspection	once/5 years
		initial inspection	once/1-3 years after const.
		regular inspection	once/10 years
	conductor	normal inspection	once/5 years
		initial inspection	once/1-3 years after const.
		regular inspection	once/10 years
	insulator	normal inspection	once/5 years
		initial inspection	once/1-3 years after const.
		regular inspection	once/10 years

Table A-1-12 Classification of Inspection (1/2)

<table>
<tr><th>Classification</th><th>Difinition</th></tr>
<tr><td>Normal inspection</td><td>Normal inspection about transmission line is following
<table>
<tr><th>Kind</th><th>Description</th></tr>
<tr><td>Normal inspection</td><td>• The inspection by seeing from ground.
• At period specified by security regulation.</td></tr>
<tr><td>Initial inspection</td><td>The inspection for initial failure caused by topographic and weather condition, which is performed in 1 - 3 years after construction.</td></tr>
<tr><td>Regular inspection</td><td>The inspection performed regularly with a starting date the time of initial inspection</td></tr>
</table>
</td></tr>
<tr><td>Special inspection</td><td>This is a inspection performed in case of following, which performed regularty or temporally except about the items of regular inspection, with measuring instrument;

a) Inspection which is performed about special items about equipment subjected to special inspection.
b) Inspection of equipment except ones subjected to tregular inspection.
c) Inspection for preventive maintenance such as a preventive countermeasure of reoccurrence of same kind of failure.</td></tr>
</table>

Table A-1-12 Classification of Inspection (2/2)

Kind	difinition	Remarks
(b) Emergency patrol	This is patrol performed to find out the spot and to grasp the condition when an accident or damage of line happened.	
(c) Special parol	This is a patrol performed by chief of maintenance center to grasp as a whole the condition of equipment and surround the line concerned.	The purpose is to make it use for maintenance and inprovement of equipment, and supervision of business concerned, by electricity supply center chief.

Table A-1-13 Explanation of Patrol

Kind		Definition	Remarks
(a) Ordinary patrol	Normal patrol	This is a patrol regularly performed along whole line to investigate the condition of the equipment concerned and the surronding condition of line. Such as over closing of house and tree to line, topographic, sinking of road and other construction crossing over closed.	• On food or by vehicle and/or helicopter
	Specific patrol	This is a patrol performed deciding specific zones/individual line to find out abnormality earier and prevent the damage, which is apt to happen where-construction such as building, reclamation, laying something underground, and road will be done within the area of security.	• The spot within security area where construction by crane is being done. • The spot where earth is being taken near by a support of line. • The spot where construction such as new or expanding house is going to be done under or near by line. • The spot where rail way, road or construction crosses line. • The zone where a nuimber of patrol should be increased from point of maintenance of old equipment. • The mountainous zone where is problematic with cable or wood-cutting.
	Preventional patrol	This is a patrol temporally performed to prevent damage during the time of typoon or abnormal weather, or in the zone of would-generate abnormality seasonally.	• Before and after the time of typoon, thunder-storm snow-fall and snow-malt. • After heavy rain • During and after long tain • Growing period of bamboo and crawling • Kiate flying season. • Tree cutting down season. • Insulator contaminating period

Table A-1-14 Table of Frequency of Method of Inspection for Overhead Transmission Line (1/2)

(1) Normal insepection

Item	Kind	Object	Period	Method
supoort steel tower concrete pole wood pole	normal	whole	Once/5 years	from ground
	initial	30% of whole	once/1-3 years after const.	climbing
	regular	whole	once/10years	climbing
faulty insulator detection	normal		—	—
	initial	> 275 kV	once/1-3 years after const.	climbing
	regular	> 275 kV	once/10 years	climbing, hot line
		< 154 kV const. after 1950	once/5 years	climbing
		< 154 kV const. befor 1949	once/3 years	climbing
insulator stringing hard ware	normal	whole	once/5 years	from ground of
	initial	30% of whole	once/1-3 years after const.	climbing
	regular	whole	at the same time with support insp.	climbing, but at 154 kV hot line, mirror
conductor	normal	whole	once/5 years	from ground or helicopter
	initial	30% of whole	once/1-3 years after const.	climbing
	regular	whole	once/10years	154 kV hot line, mirror
ground wire	normal	whole	once/5 years	from ground or helicopter
	initial	30% of whole	once/1-3 years after const.	climbing
	regular	whole	once/10years	climbing
telephone cable, protective wire	normal	whole	once/3 years	from ground
	initial	30% of whole	once/1-3 years after const.	climbing
	regular	whole	once/2 years	climbing
switch	refer to another standard of "Control station, hydroplant, substation, switching station".			
air-way obstruction light	regular	general type	once/2 years	lighting condition, wiring & lamp
		electrostatic induction type (SI)	at the same time with normal inspection and lamp inspection	Lighting condition
			once/1 year	wiring or lamp instrument
			same period with that of insulator stringing hard ware	insulator string hard ware of ground wire

Table A-1-14 Table of Frequency of Method of Inspection for Overhead Transmission Line (2/2)

(2) Special inspection

Item		Object
support	retightening of bolt	the ones which are found lossing at regular inspection
	measuring of uneven sinking of foundation and inclination of suppport	the supports in earth deforming area.
	measurment of grounding resistance	the support which is damaged by lighting
insulator	measuring of salt deposit	representative support and pirot insulator in contaminative zone
	electric test mechanical strength test	when a lot of failure insulators are found.
conductor ground wire	inspection with in clamp	the support which had an accident and ones neighbouring it.
	inspection of damper // of spacer	one under the same condition as one which is, to befound, lose or falling down.
	precise inspection of conductor and ground wire (use automatic conductor inspection device of transsit)	the zone of long span the zone of thunder accident the zone of snow accident
insulator stringing hard ware	insulation device	spot of long span or large slope of wire up or down
rough equipment	measurement of grounding resistance for electrostatic shield installations	
	operation test of live washing equipment	
others	measurement of electric field strengh under lines	school road, public road and children playing park under line >275 kV
	measurement of inductive voltage	metalic, construction or orchard metal wire fence under line >275 kV
	measurement of grounding resistance for conduction	3 rd grade electric grounding construction under line

Appendix A-2 Annual Facility Utilization Factor of Thermal Power Plants

Appendix A-2 Annual Facility Utilization of Thermal Power Plants

Appendix A-2 Annual Facility Utilization of Thermal Power Plants

List of Table

Appendix A-2 Annual Facility Utilization Factor of Thermal Power Plants

A-2-1 Planning Value of Annual Facility Utilization Factor

For the following reasons, the annual facility utilization factor of a new thermal power plant in Japan is planned at 70% in general.

(1) Regular inspection required by the Electricity Enterprises Act

(2) Output control by operating according to the daily demand curve and load restriction for maintenance

(3) Operation stop due to equipment trouble

However,

• Power cut-off ratio due to a regular inspection:	15% - 20%
• Output control and load restriction:	5%
• Operation stop ratio due to equipment trouble:	5% (initial) 2.5% (stable)

A-2-2 Annual Facility Utilization Factor of Thermal Power Plants

The annual facility utilization factor according to different combustion methods of the major 9 electric power companies in Japan is described in Table-1.

A-2-3 Concept of Annual Facility Utilization Factor of Thermal Power Plants in Central and South America

The annual facility utilization factor of new thermal power plants conducted by EPDC in Central and South America is described in Table-2.

Table A-2-1 Facility Utilization Factor of Thermal Power Plants in Japan

Year	Facility Utilization Factor (%)			Sum
	Oil Fired	Coal Fired	LNG Fired	
1989	33.0	69.0	52.1	43.6
1990	39.5	69.9	55.9	48.9
1991	43.6	67.6	57.2	51.5
1992	44.1	66.7	57.7	52.4
1993	39.1	71.0	56.1	50.0
Average	39.86	68.84	55.8	49.28

- Sum of 9 electric power companies (from 'Current State of Electric Power Demand and Supply')

Table A-2-2 Survey of Facility Utilization Factor of Thermal Power Plants (Central and South America Plan)

Country	P/S Characteristics					Utilization Factor (%)						
	Rated Power Output (MW)	Auxiliary Power Ratio (%)	Compensation Ratio (%)	Fault Ratio (%)	Annual Generation (MW/Y)	Coal Fired	Oil Fired	Diesel	Low-speed Diesel	Steam	Gas Turbine	Geo-thermal
Costa Rica	96.5	6	8	5	449	53						
	18				134.8				85			
	12				89.9				86			
	12				89				86			
	19				134.8				81			
	10				74.9				86			
Turkey	300				1,839.6	70						
Japan	250	4.8			1,533		70					
	500	4.8			3,066		70					
Honduras	20(19)	5			120			72				
	40	5			240			72				
	60	5			360			72				
	75				432				66			
	90				508					70		
Average						61.5	70.0	72	81.7	70.0		

Appendix A-3 Result of Power System Stability Analysis of 1996

Appendix A-3 Result of Power System Stability Analysis of 1996

Appendix A-3 Result of Power System Stability Analysis of 1996

List of Fig.

List of Table

Appendix A-3 Result of Power System Stability Analysis of 1996

A-3-1 Study Conditions

It has been studied to verify to what extent the output of Paute Power Plant can be increased with existing 2 circuit of Paute-Pascuales Transmission Line (230 kV, 2 cct) while maintaining the power system stability, in the event that the expansion of this transmission line and the construction of Daule Peripa Power Plant are not completed by 1996.

The power system configuration differs from 1998, as illustrated by the impedance map of Attached Figure-1, in that Paute-Pascuales Transmission Line has 2 cct, instead of 4 circuit, and Daule Peripa Power Plant does not exist.

The substation peak loads at June and December time sections of 1996 are presented in Attached Table-1.

A-3-2 Study Results

The power flow diagrams of June and December of 1996 are presented in Attached Figure-2 and Attached Figure-3, respectively.

The power system stability calculation results under these power flow conditions are presented in Attached Figure-4 and Attached Figure-5, respectively.

According to these results, the power system behaved unstable in the June time section of wet season with a total output of 842 MW from Paute A, B and C. The power system also behaved stable in December time section of dry season with a total output of 892 MW from Paute A, B and C, in case commissioning of Daule Peripa Power Plant is delayed.

When Paute Power Plant is operated effectively around installation capacity, it is necessary to contract four circuit line from Paute-

Milagro-Pascuales, i.e., early completion of the Phase D2 of SNI is required.

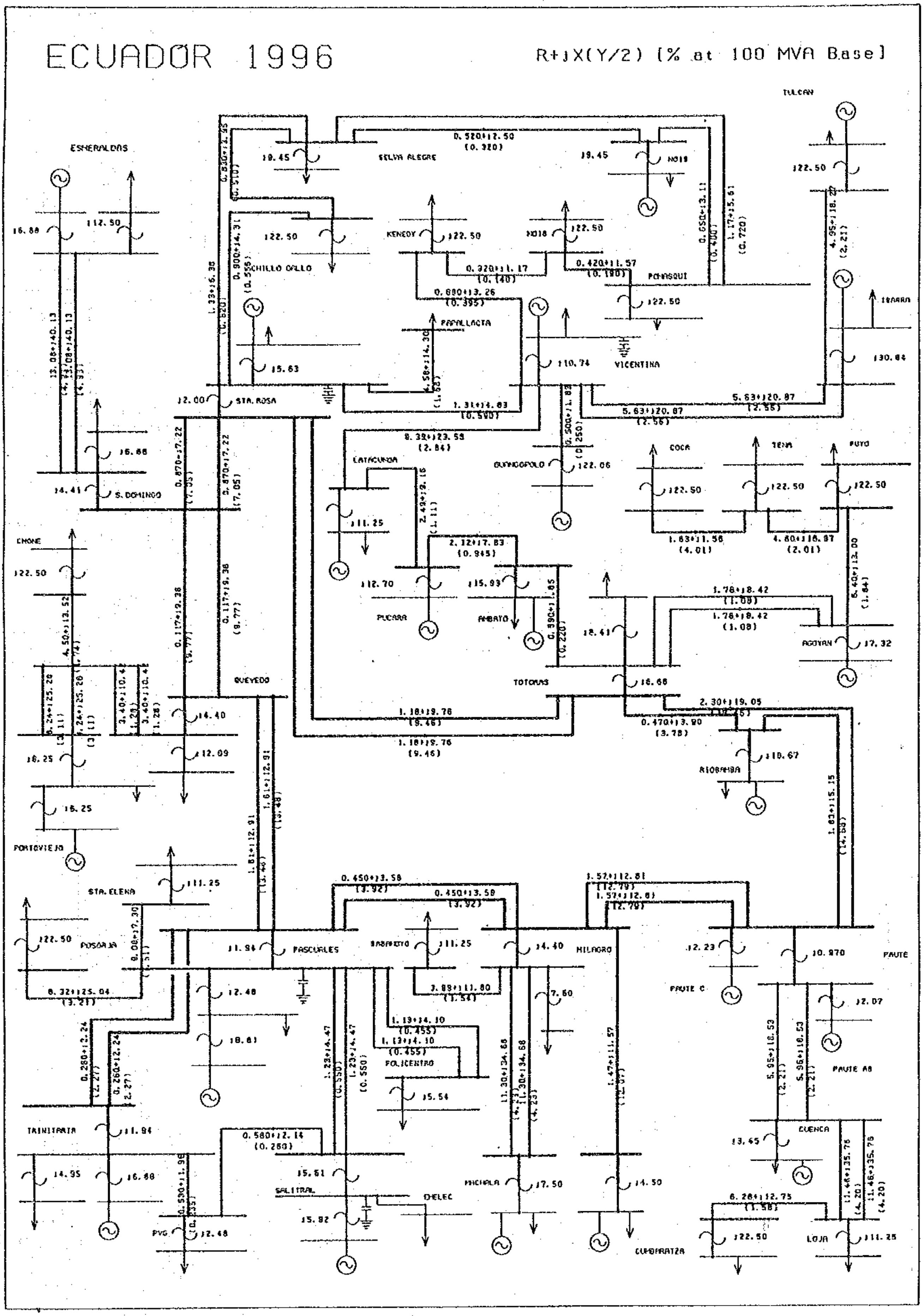


Fig. A-3-1 Impedance Map in 1996

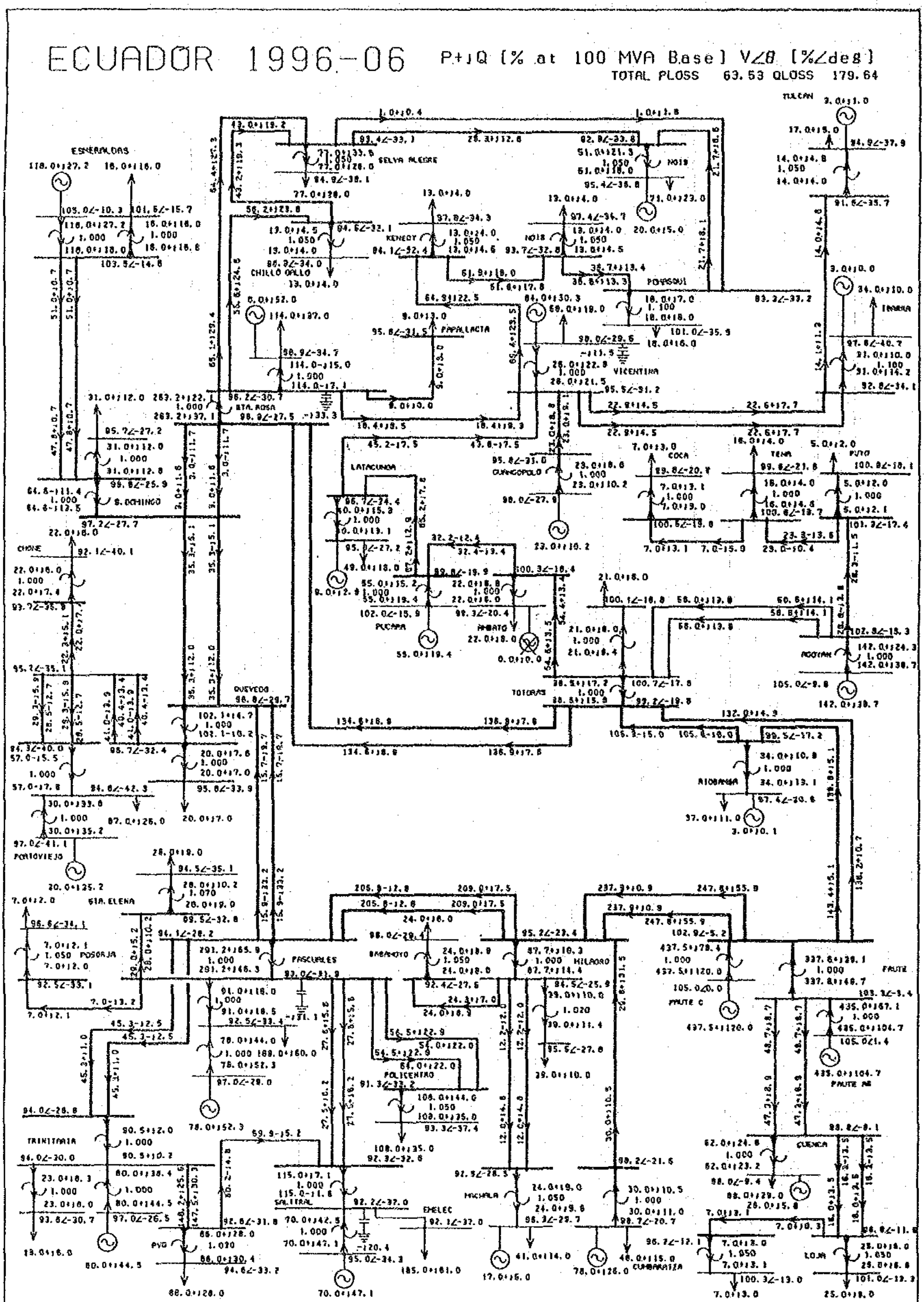


Fig. A-3-2 Power Flow in June, 1996

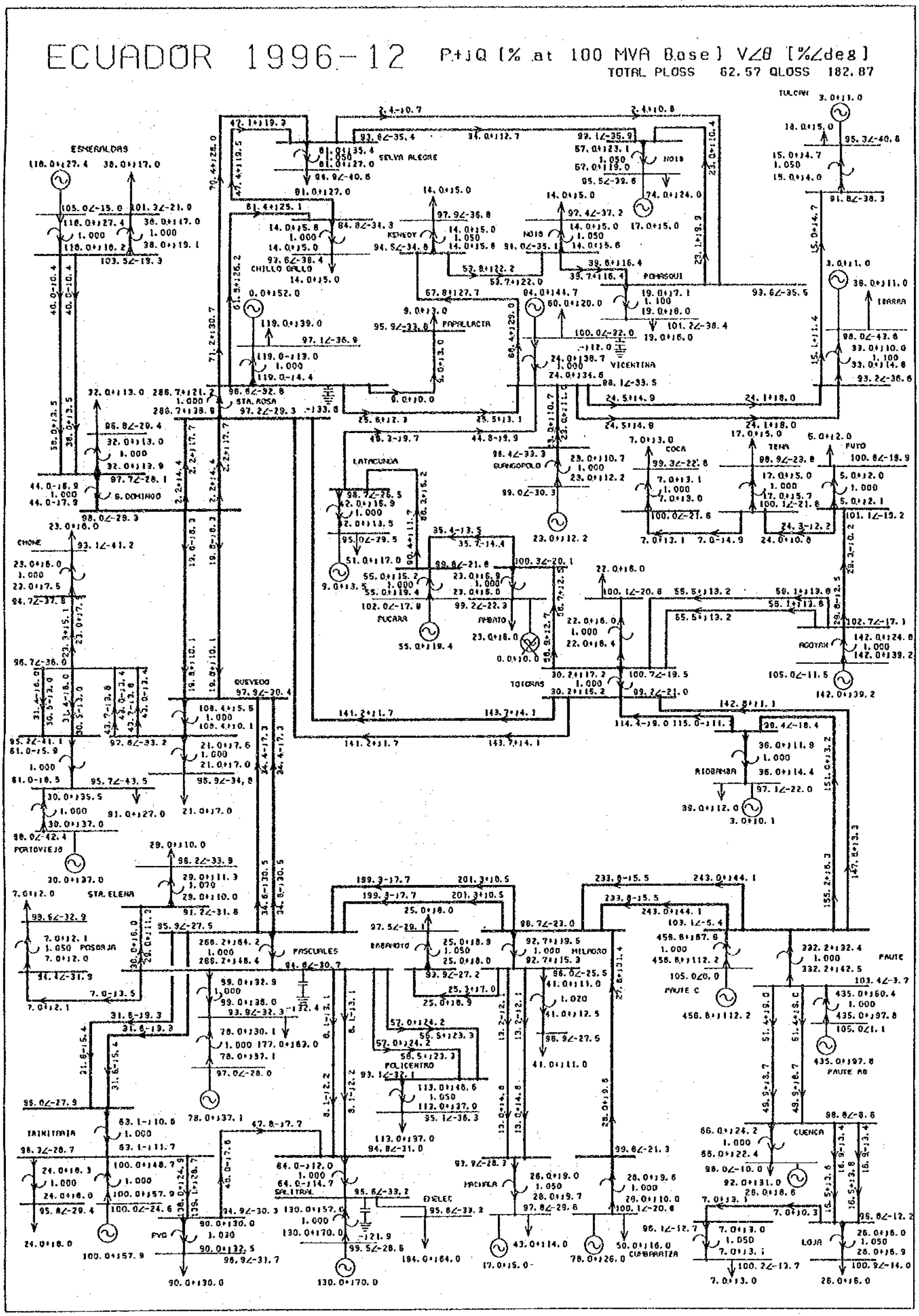
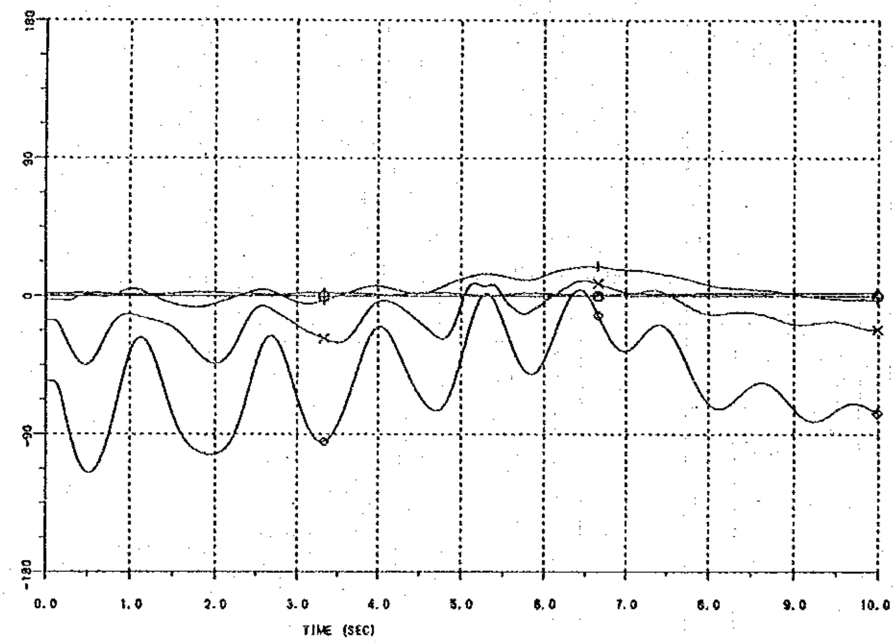


Fig. A-3-3 Power Flow in December, 1996

ECUADOR 1996-06 BR04-1 (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	2.76	0.32	1.76	2.20
3	NOG-11	ANG	CUENCA	19.42	-7.05	-2.33	-2.49
4	ND-60	ANG	LATCUNGA	10.38	-44.87	-15.70	-21.84
5	NOG-16	ANG	IBARRA	4.19	-115.26	-55.65	-78.44



ECUADOR 1996-06 BR04-1 (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	39.72	-168.44	-35.89	-50.54
3	ND-45	ANG	RIOBAMBA	-9.52	-59.60	-33.59	-39.42
4	NOG-01	ANG	ESMERALD	15525.59	-120.87	-2.52	15525.59
5	NOG-15	ANG	GUANGOPL	5.80	-65.71	-32.04	-40.41

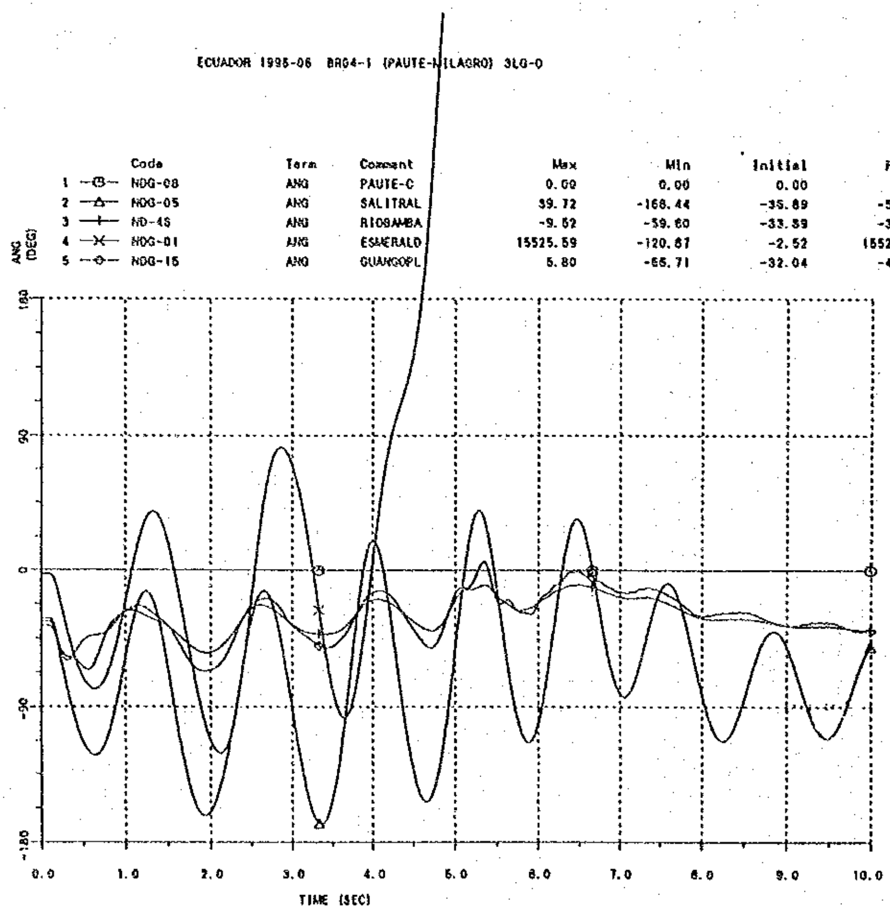
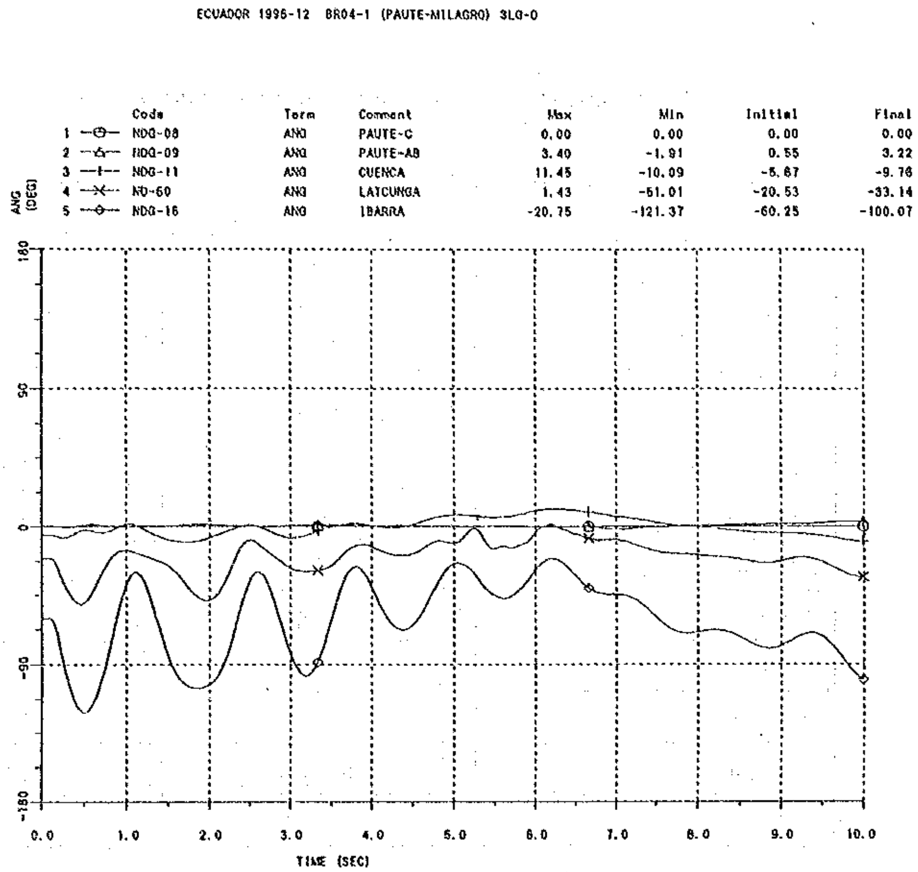


Fig. A-3-4 Power System Stability after 1 CCT Line Fault (June, 1996)



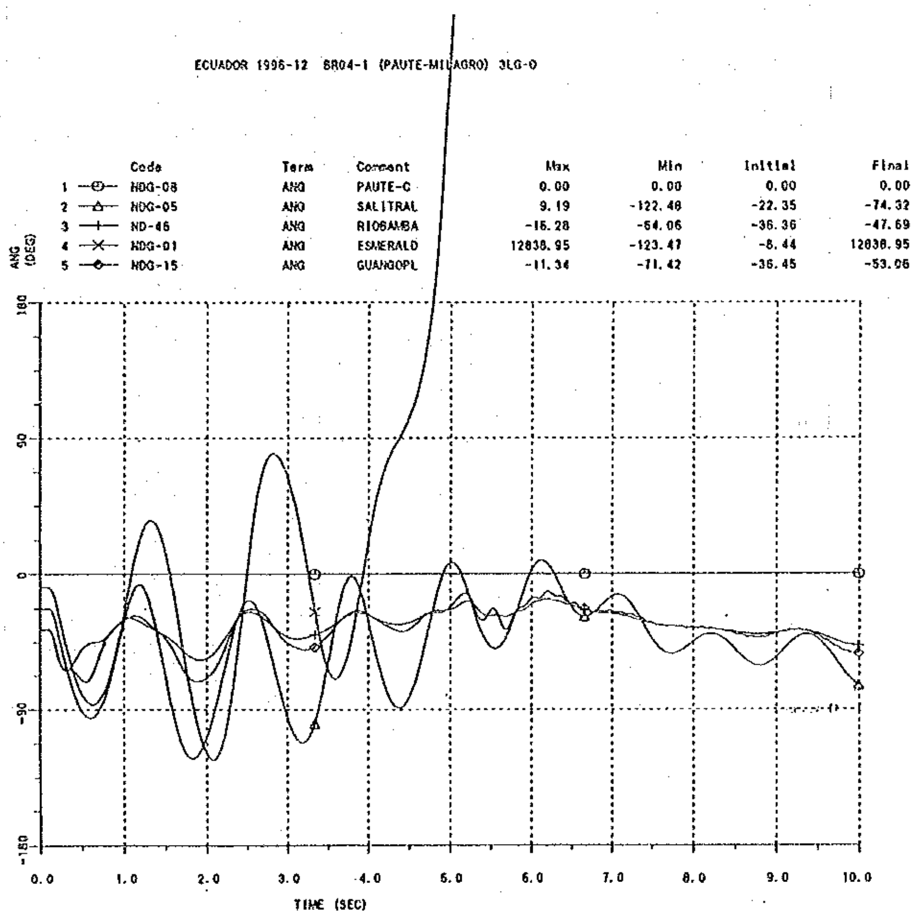


Fig. A-3-5 Power System Stability after 1 CCT Line Fault (December, 1996)

Table A-3-1 Peak Loads at Substations (MW + jMVar) (1/2)

Substation	1966	
	June	December
Santa Rosa	114+J37	119+j39
Vicentina	58+j19	60+j20
Pomasqui	18+j6	19+j6
Selva Alegre	77+j26	81+j27
S/E No. 19	71+j23	74+j24
S/E No. 18	13+j4	14+j5
Kennedy	13+j4	14+j5
Chillo Gallo	13+j4	14+j5
Papallacta	9+j3	9+j3
Ibarra	34+j10	36+j11
Tulcán	17+j5	18+j5
Santo Domingo	31+j12	32+j13
Esmeraldas	16+j16	38+j17
Quevedo	20+j7	21+j7
Portoviejo	87+j26	91+j27
Chone	22+j6	23+j6
Totoras	21+j6	22+j6
Ambato	22+j6	23+j6
Latacunga	49+j16	51+j17
Riobamba	37+j11	39+j12
Puyo	5+j2	5+j2
Tena	16+j4	17+j5
Coca	7+j3	7+j3

Table A-3-1 Peak Loads at Substations (MW + jMVar) (2/2)

Substation	1966	
	June	December
Cuenca	88+j29	92+j31
Loja	25+j6	26+j6
Cumbaratza	7+j3	7+j3
Machala (230 kV)	48+j15	50+j16
Machala (138 kV)	41+j14	43+j14
Milagro	39+j10	41+j11
Babahoyo	24+j8	25+j8
Pascuales	169+j60	177+j63
Policentro	108+j35	113+j37
Salitral	185+j61	194+j64
PVG	86+j28	90+j30
Trinitaria	23+j8	24+j8
Posorja	7+j2	7+j2
Sta. Elena	28+j9	29+j10
Total	1,648+j544	1,745+j574

Appendix A-4 Methodology of Reliability Analysis of SNI

Appendix A-4 Methodology of Reliability Analysis of SNI

Appendix A-4 Methodology of Reliability Analysis of SNI

List of Tables

Appendix A-4 Methodology of Reliability Analysis

A-4-1 Data for Reliability Analysis

(1) Demand Data

(a) 1991 Time Section

North/Year: December, 1991
Maximum Demand: North 536 [MW], South 804 [MW]

Table A-4-1 Demand in December, 1991

Date	North [MW]	South [MW]
*1 (Sun.)	462.5	693.9
2 (Mon.)	520.9	780.3
3 (Tue.)	531.7	795.4
4 (Wed.)	529.5	794.3
5 (Thu.)	513.3	769.5
6 (Fri.)	497.1	745.7
*7 (Sat.)	466.8	699.3
*8 (Sun.)	460.4	688.5
9 (Mon.)	526.3	788.9
10 (Tue.)	530.6	794.3
11 (Wed.)	536.0	804.0
12 (Thu.)	526.3	788.9
13 (Fri.)	525.2	786.7
*14 (Sat.)	475.5	711.2
*15 (Sun.)	469.0	703.6
16 (Mon.)	531.7	795.4
17 (Tue.)	531.7	796.4
18 (Wed.)	527.4	788.9
19 (Thu.)	520.9	780.3
20 (Fri.)	520.9	780.3
*21 (Sat.)	475.5	713.3
*22 (Sun.)	469.0	701.5
23 (Mon.)	500.3	750.0
24 (Tue.)	488.5	730.6
*25 (Wed.)	440.9	659.4
26 (Thu.)	513.3	769.5
27 (Fri.)	504.7	756.5
*28 (Sat.)	461.4	691.8
*29 (Sun.)	447.4	670.2
30 (Mon.)	497.1	744.6
*31 (Tue.)	462.5	692.8

*: Holiday

(b) 1998 Time Section

Month/Year	Maximum Demand
December, 1998	North 753.0 [MW], South 1,238.0 [MW]
December, 1991	North 536.0 [MW], South 804.0 [MW]

North: $\frac{753.0}{536.0}$ = 1.405 South: $\frac{1,238.0}{804.0}$ = 1.540

Table A-4-2 Demand in December, 1991 and 1998

Date	North [MW]		South [MW]	
	1991	1998	1991	1998
*1 (Sun.)	462.5	649.7	693.9	1,068.5
2 (Mon.)	520.9	731.9	780.3	1,201.5
3 (Tue.)	531.7	747.0	795.4	1,224.8
4 (Wed.)	529.5	743.9	794.3	1,223.1
5 (Thu.)	513.3	721.2	769.5	1,184.9
6 (Fri.)	497.1	698.4	745.7	1,148.2
*7 (Sat.)	466.8	655.8	699.3	1,076.8
*8 (Sun.)	460.4	646.8	688.5	1,060.2
9 (Mon.)	526.3	739.5	788.9	1,214.7
10 (Tue.)	530.0	745.5	794.3	1,223.1
11 (Wed.)	536.0	753.0	804.0	1,238.0
12 (Thu.)	526.3	739.4	788.9	1,214.7
13 (Fri.)	525.2	737.8	786.7	1,211.4
*14 (Sat.)	475.5	668.0	711.2	1,095.1
*15 (Sun.)	469.0	658.9	703.6	1,083.4
16 (Mon.)	531.7	747.0	795.4	1,224.8
17 (Tue.)	531.7	747.0	796.4	1,226.3
18 (Wed.)	527.4	740.9	788.9	1,214.7
19 (Thu.)	520.9	731.8	780.3	1,201.5
20 (Fri.)	520.9	731.8	780.3	1,201.5
*21 (Sat.)	475.5	668.0	713.3	1,098.3
*22 (Sun.)	469.0	658.9	701.5	1,080.2
23 (Mon.)	500.3	702.8	750.0	1,154.9
24 (Tue.)	488.5	686.3	730.6	1,125.0
*25 (Wed.)	440.9	619.4	659.4	1,015.3
26 (Thu.)	513.3	721.1	769.5	1,184.9
27 (Fri.)	504.7	709.0	756.5	1,164.9
*28 (Sat.)	461.4	648.2	691.8	1,065.2
*29 (Sun.)	477.4	628.5	670.2	1,032.0
30 (Mon.)	497.1	698.4	744.6	1,146.5
*31 (Tue.)	462.5	649.7	692.8	1,066.8

*: Holiday
Date: December, 1991

(c) 2003 Time Section

Month/Year	Maximum Demand
December, 2003	North 986.0 [MW], South 1,609.0 [MW]
December, 1991	North 536.0 [MW], South 804.0 [MW]

North: $\frac{986.0}{536.0} = 1.840$ South: $\frac{1,609.0}{804.0} = 2.001$

Table A-4-3 Demand in December, 1991 and 2003

Date	North [MW]		South [MW]	
	1991	2003	1991	2003
*1 (Sun.)	462.5	850.8	693.9	1,388.7
2 (Mon.)	520.9	958.2	780.3	1,561.6
3 (Tue.)	531.7	978.1	795.4	1,591.8
4 (Wed.)	529.5	974.0	794.3	1,589.6
5 (Thu.)	513.3	944.2	769.5	1,540.0
6 (Fri.)	497.1	914.4	745.7	1,492.3
*7 (Sat.)	466.8	858.7	699.3	1,399.5
*8 (Sun.)	460.4	846.9	688.5	1,377.9
9 (Mon.)	526.3	968.2	788.9	1,578.8
10 (Tue.)	530.0	976.1	804.0	1,589.6
11 (Wed.)	536.0	986.0	804.0	1,609.0
12 (Thu.)	526.3	968.2	788.9	1,578.8
13 (Fri.)	535.2	966.1	786.7	1,574.4
*14 (Sat.)	475.5	874.7	711.2	1,423.3
*15 (Sun.)	469.0	862.8	703.6	1,408.1
16 (Mon.)	531.7	978.1	795.4	1,591.8
17 (Tue.)	531.7	978.1	796.4	1,593.8
18 (Wed.)	527.4	970.2	788.9	1,578.8
19 (Thu.)	520.9	958.2	780.3	1,561.6
20 (Fri.)	520.9	958.2	780.3	1,561.6
*21 (Sat.)	475.5	874.7	713.3	1,427.5
*22 (Sun.)	469.0	862.8	701.5	1,403.9
23 (Mon.)	500.3	920.3	750.0	1,500.9
24 (Tue.)	488.5	898.6	730.6	1,462.1
25 (Wed.)	440.9	811.0	659.4	1,319.0
26 (Thu.)	513.3	944.2	769.5	1,540.0
27 (Fri.)	504.7	928.4	756.5	1,513.9
*28 (Sat.)	461.4	848.8	691.8	1,384.5
*29 (Sun.)	477.4	823.0	670.2	1,341.2
30 (Mon.)	497.1	914.4	744.6	1,490.1
*31 (Tue.)	462.5	850.8	692.8	1,386.5

*: Holiday
Date: December, 1991

(2) Calculation conditions

(a) 1991 Time Section

1) Demand diversity by a temperature is not considered.

2) Demand diversity due to elements other than a temperature is calculated by a regular distribution based on the error rate of demand diversities as follows:

North: Average value -13.79 [MW], Standard deviation 26.83 [MW]
South: Average value -20.86 [MW], Standard deviation 41.09 [MW]

3) Inflow diversity distribution is not considered.

4) Sampling number is 5,000.

5) Interconnected capacity is assumed as follows:
North → South : 900 [MW]
South → North : 900 [MW]

(b) 1998 Time Section

1) Demand diversity by a temperature is not considered.

2) Demand diversity due to elements other than a temperature is calculated by a regular distribution based on the error rate of demand diversities as follows:

North: Average value -21.40 [MW], Standard deviation 39.62 [MW]
South: Average value -35.40 [MW], Standard deviation 66.31 [MW]

3) Inflow diversity distribution is not considered.

4) Sampling number is 5,000.

5) Interconnected capacity is assumed as follows:
North → South : 900 [MW]
South → North : 900 [MW]

(c) 2003 Time Section

1) Demand diversity by a temperature is not considered.

2) Demand diversity due to elements other than a temperature is calculated by a regular distribution based on the error rate of demand diversities as follows:

North: Average value -28.02 [MW], Standard deviation 51.88 [MW]
South: Average value -46.01 [MW], Standard deviation 86.19 [MW]

3) Inflow diversity distribution is not considered.

4) Sampling number is 5,000.

5) Interconnected capacity is assumed as follows:
North → South : 900 [MW]
South → North : 900 [MW]

AÑO: 1991

Table A-4-4 DEMANDA MAXIMA (MW)
(REAL)

EMPRESA ELECTRICA	ENE.	FEB.	MAR.	ABR.	MAY.	JUN.	JUL.	AGO.	SEP.	OCT.	NOV.	DIC.
NORTE	37.7	36.8	37.9	38.2	38.6	38.8	39.6	40.3	40.3	40.9	40.4	41.0
QUITO	284.6	282.4	287.1	286.9	289.8	287.7	287.7	282.7	282.4	302.9	305.3	310.8
STO.DOMINGO	21.0	20.5	21.0	20.8	22.0	22.0	22.3	23.0	23.8	23.8	23.7	23.9
COTOPAXI	19.7	19.7	20.5	20.8	20.9	21.0	22.0	21.9	20.6	23.0	23.0	22.7
AMBATO-PUYO	37.3	38.5	37.8	37.5	39.1	39.4	38.6	38.9	39.3	40.1	40.4	40.8
CHIMBORAZO	25.0	25.5	25.8	26.1	27.0	27.3	27.1	27.8	26.8	28.1	28.3	28.7
BOLIVAR	5.3	5.6	5.8	5.4	5.7	5.4	6.4	6.4	6.6	6.7	6.8	7.1
CENTRO SUR	57.2	56.2	55.9	57.5	60.0	60.1	59.4	58.9	60.5	63.0	63.4	67.0
SUR	19.3	19.0	19.4	19.8	19.9	20.1	20.9	20.3	20.7	21.3	21.7	22.2
ESMERALDAS	26.9	25.7	22.2	23.6	23.0	22.0	26.0	27.5	24.6	25.0	26.0	29.8
MANABI	73.0	72.7	75.5	72.5	74.0	74.6	75.0	76.1	76.5	78.0	78.0	81.7
SALINAS SANTA ELENA	27.1	27.5	26.0	25.0	23.7	22.0	23.0	20.9	21.3	22.2	22.0	25.7
GUAYAQUIL	375.8	379.5	379.4	388.5	391.6	374.2	370.3	377.0	374.5	374.5	413.0	407.4
DURAN-DAULE-BALZAR-QUEV.	49.9	49.6	49.7	50.7	51.1	50.2	51.6	52.6	54.3	55.7	57.5	60.4
BABAHOYO	20.5	18.0	18.9	19.9	21.7	21.0	20.4	21.4	22.6	22.7	21.7	21.7
MILAGRO-NARANJAL	23.7	24.8	25.8	25.8	27.5	26.6	24.6	25.8	27.9	29.9	28.6	31.9
EL ORO	46.1	48.1	45.9	49.3	47.7	48.1	48.2	46.0	46.0	46.0	48.0	52.0
ZONA NORTE	450.6	442.9	446.0	451.5	462.7	463.9	463.8	460.8	458.6	483.6	493.1	491.4
ZONA SUR	682.1	677.3	678.0	696.9	712.0	697.3	684.8	687.6	695.5	703.2	752.7	749.5
TOTAL (COINC.HORARIA)	1132.7	1120.2	1124.0	1148.4	1174.7	1161.2	1148.6	1148.4	1154.1	1186.8	1245.8	1240.9
* TOTAL (COINC.MENSUAL)	1150.1	1150.1	1154.6	1168.3	1183.3	1160.5	1163.1	1167.5	1168.7	1203.8	1247.8	1274.8

FORM 0.71

AÑO: 1991

Table A-4-5 DEMANDA MAXIMA (MW)

(PROGRAMADA)

EMPRESA ELECTRICA	ENE.	FEB.	MAR.	ABR.	MAY.	JUN.	JUL.	AGO.	SEP.	OCT.	NOV.	DIC.
NORTE	37.4	35.8	37.2	37.8	36.7	37.1	37.8	38.2	39.3	39.1	37.7	39.0
QUITO	282.6	274.8	282.2	283.8	275.3	275.1	274.6	268.1	275.7	289.6	285.0	295.7
STO.DOMINGO	20.9	19.9	20.6	20.6	20.9	21.0	21.3	21.8	23.2	22.8	22.1	22.7
COTOPAXI	19.6	19.2	20.1	20.6	19.9	20.1	21.0	20.8	20.1	22.0	21.5	21.6
AMBATO-PUYO	37.0	37.5	37.2	37.1	37.1	37.7	36.8	36.9	38.4	38.3	37.7	38.8
CHIMBORAZO	24.8	24.8	25.4	25.8	25.6	26.1	25.9	26.4	26.2	26.9	26.4	27.3
BOLIVAR	5.3	5.4	5.7	5.3	5.4	5.2	6.1	6.1	6.4	6.4	6.3	6.8
CENTRO SUR	56.8	54.7	54.9	56.9	57.0	57.5	56.7	55.9	59.1	60.2	59.2	63.7
SUR	19.2	18.5	19.1	19.6	18.9	19.2	19.9	19.2	20.2	20.4	20.3	21.1
ESMERALDAS	26.7	25.0	21.8	23.3	21.8	21.0	24.8	26.1	24.0	23.9	24.3	28.4
MANABI	72.5	70.7	74.2	71.7	70.3	71.3	71.6	72.2	74.7	74.6	72.8	77.7
SALINAS SANTA ELENA	26.9	26.8	25.6	24.7	22.5	21.0	22.0	19.8	20.8	21.2	20.5	24.5
GUAYAQUIL	373.1	369.2	372.9	384.3	372.0	357.8	353.4	357.5	365.6	358.1	385.5	387.6
DURAN DAULE BALZAR QUEV.	49.5	48.3	48.8	50.2	48.5	48.0	49.3	49.9	53.0	53.3	53.7	57.5
BABAHOYO	20.4	17.5	18.6	19.7	20.6	20.1	19.5	20.3	22.1	21.7	20.3	20.6
MILAGRO NARANJAL	23.5	24.1	25.4	25.5	26.1	25.4	23.5	24.5	27.2	28.6	26.7	30.4
EL ORO	45.8	46.8	45.1	48.8	45.3	46.0	46.0	43.6	44.9	44.0	44.8	49.5
ZONA NORTE	447.4	430.9	438.3	446.6	437.5	443.5	442.7	437.0	447.7	462.3	460.3	467.5
ZONA SUR	677.3	659.0	666.4	689.5	676.3	666.7	653.6	651.9	679.0	672.4	702.6	713.2
TOTAL (COINC.MENSUAL)	1124.7	1089.9	1104.7	1136.1	1115.8	1110.2	1096.3	1088.9	1126.7	1134.7	1162.9	1180.7

GENERACION HIDROTERMICA Y DEMANDAS DEL SISTEMA NACIONAL INTERCONECTADO **Table A-4-6 Hydroelectric Power Generation and Demand of SNI** DICIEMBRE 1991

DIA	CENTRAL PAUTE Cota (m)	Caudal (m3/s)	Mwh	Mw max	C. PUCARA Cota (m)	Caudal (m3/s)	Mwh	Mw max	C. AGOYAN Caudal (m3/s)	Mwh	Mw max	G.ZEVALLOS Mwh	Mw max	ESMERALD Mwh	Mw max	GUANGOP Mwh	Mw max	S. ROSA Mwh	Mw max	Gener. Inecel Hidro Gwh	%	Term Gwh	DEMANDAS Inecel Gwh	%	SNI Gwh (Aprx)	Inecel Mw	%	SNI Mw
(1)	83.64	92.34	7211	490	61.67	2.71	212	70	92.00	950	156	3272	136	2866	126					8.4	58	6.1	14.5	83	17.6	973	91	1071
2	84.23	82.53	8059	490	61.71	5.71	326	70	80.00	2696	156	3294	136	2850	126	53	14	85	30	11.1	64	6.3	17.4	83	20.9	1011	84	1205
3	84.14	68.66	8752	495	61.66	2.93	494	74	75.00	2509	156	3282	136	2770	125	75	14	128	30	11.8	65	6.3	18.0	83	21.8	1021	83	1229
4	83.68	60.91	9096	489	61.61	3.59	553	70	75.00	2327	156	3178	136	2860	126	102	14	88	30	12.0	66	6.2	18.2	83	21.9	1018	83	1226
5	83.01	57.27	9361	500	61.51	2.75	709	70	87.00	2781	156	1618	68	2887	126	48	14	191	45	12.9	73	4.7	17.6	82	21.4	955	81	1188
6	82.16	51.73	9268	492	61.47	1.36	307	70	78.00	2358	156	1617	68	2895	126	62	14	70	45	11.9	72	4.6	16.6	81	20.4	949	83	1151
7	81.81	58.40	8344	505	61.35	3.28	848	74	66.00	2027	156	1618	68	2325	126			31	14	11.2	74	4.0	15.2	81	18.8	932	86	1080
(8)	81.31	46.03	7328	515	61.33	1.97	269	74	62.00	2023	156	1620	69	2762	121			38	14	9.6	69	4.4	14.0	80	17.5	943	89	1064
9	79.83	40.84	9933	509	61.18	1.46	823	74	57.00	1793	156	2286	136	2757	123	87	14	79	30	12.5	71	5.2	17.8	82	21.6	1032	85	1218
10	78.76	51.03	9725	505	61.06	1.90	723	74	66.00	1817	156	2849	136	2754	122	99	14	151	45	12.3	68	5.9	18.1	83	21.9	1043	85	1227
11	77.22	47.07	10666	505	60.89	2.36	993	74	62.00	1866	156	1866	136	2570	121	133	14	263	44	13.5	74	4.8	18.4	82	22.4	1024	83	1241
12	75.26	36.82	10580	518	60.69	1.14	1020	74	57.00	1841	156	3168	136	1306	120	166	14	212	44	13.4	73	4.9	18.3	84	21.8	1016	83	1218
13	72.95	34.17	11087	500	60.47	0.79	1078	74	53.00	1780	156	2327	136	1820	118	164	14	99	30	13.9	76	4.4	18.4	83	22.0	1018	84	1215
14	71.08	34.46	9589	515	60.15	0.46	1502	74	68.00	2056	156	1357	106	1340	70	86	14	27	15	13.1	82	2.8	16.0	82	19.5	940	86	1099
(15)	69.95	40.62	8084	495	59.90	0.85	1213	70	70.00	1951	156	1324	136	1855	120					11.2	78	3.2	14.4	90	15.9	977	90	1086
16	68.17	34.69	9076	505	59.59	1.64	1551	74	59.00	1944	156	2261	136	2720	121	130	14			12.6	71	5.1	17.7	83	21.3	1000	81	1229
17	66.37	29.71	8368	505	59.24	0.64	1636	74	57.00	1878	156	3266	136	2716	120	210	14			11.9	66	6.2	18.1	83	21.8	1000	81	1230
18	64.20	26.33	8734	505	58.89	0.67	1631	74	60.00	1838	156	3236	136	2749	126	203	14			12.2	66	6.2	18.4	84	21.9	1003	82	1219
19	61.98	23.91	8331	501	58.55	1.37	1640	74	58.00	1770	156	3227	136	2820	126	210	14	116	44	11.7	65	6.4	18.1	84	21.7	1035	86	1205
20	59.93	25.96	7935	480	58.22	1.84	1630	70	58.00	1816	156	3261	136	2705	122	204	14	90	30	11.4	65	6.3	17.6	81	21.9	984	82	1205
21	59.28	30.55	5108	450	57.89	1.92	1629	70	65.00	2011	156	3256	136	2725	120	200	14	33	15	8.7	58	6.2	15.0	78	19.3	945	86	1101
(22)	60.21	51.25	3892	385	57.64	6.18	1648	70	59.00	1863	156	3265	136	2727	120	200	14	26	15	7.4	54	6.2	13.6	76	17.8	896	83	1064
23	58.97	28.26	6199	485	57.31	2.03	1624	70	57.00	1811	156	3266	136	2640	120	195	14	23	14	9.6	61	6.1	15.8	79	20.1	995	86	1158
24	57.60	29.66	6573	425	56.95	0.87	1643	74	57.00	1995	156	2856	136	2372	121	200	14	50	28	10.1	65	5.5	15.6	79	19.7	913	81	1129
25	57.73	33.65	3669	380	56.61	1.82	1631	70	57.00	1783	156	3284	136	2772	121	207	14	27	15	7.1	53	6.3	13.4	78	17.1	854	84	1019
26	56.40	24.64	5811	438	56.25	1.04	1638	70	59.00	1799	156	3187	136	2734	121	203	14	42	30	9.2	60	6.2	15.4	79	19.5	950	80	1188
27	54.95	27.63	6325	431	55.91	2.09	1635	70	59.00	1899	156	3065	136	2735	121	215	14	34	15	9.9	62	6.0	15.9	77	20.6	921	79	1168
28	55.37	38.82	3663	312	55.55	1.19	1630	70	61.00	1932	156	3050	136	2745	121	188	14	38	15	7.2	55	6.0	13.2	73	18.1	822	77	1068
(29)	57.56	73.66	3903	404	55.23	3.28	1635	70	56.00	72	78	3265	136	2737	121	182	14	82	45	5.6	47	6.3	11.9	69	17.1	789	76	1035
30	61.50	110.49	3939	384	54.90	1.47	1508	70	56.00	2327	156	3262	136	2741	120	202	14	30	15	7.8	55	6.2	14.0	72	19.5	895	78	1150
31	63.10	63.55	3628	339	54.56	1.36	1529	70	65.00	1968	156	3268	136	2716	120	216	14	18	14	7.1	53	6.2	13.3	72	18.4	822	77	1070
Tot/Prm/Mx		46.96	232237			2.02	36908		64.23	59381		84951		79971		4239		2070		328.5		171.2	499.8		621.1	1043		1241
%			46.5				7.4			11.9		17.0		16.0		0.8		0.4		65.7		34.3	80.5			84.0		
PROG	72.50	62.90	269100		56.00	3.50	32700		63.00	72032		67859		82287		2800		3600		373.8		156.5	530.4		630	1027		1289
			50.7				6.2			13.6		12.8		15.5		0.5		0.7		70.5		29.5	84.2			79.7		

○ : Sunday

(3) Fault Record

INECEL

(unit : %)

	1990	1991	1992	Average
Paute (Hydro)				
1	0.08	0.56	2.08	
2	0.08	0.02	0.45	
3	2.58	0.13	0.99	
4	0.10	0.06	1.62	
5	0.21	0.31	18.75	1.87
6			~~44.57~~ *	
7			~~27.96~~	
8			~~29.76~~	
9			~~18.01~~	
10			~~31.82~~	
Pisayambo (Hydro)				
1	1.86	0.54	0.55	0.66
2	1.02	0.00	0.01	
Agoyan (Hydro)				
1	0.07	0.25	0.15	0.14
2	-	0.25	0.00	
Esmeraldas (Vapor)				
1	0.04	0.13	2.24	0.80
Estero Salado (Vapor)				
Vap 2	1.27	0.60	0.25	
Vap 3	0.24	0.02	-	0.48
Vap 4	-	-	-	
Sta. Rosa (Gas)				
1	9.45	68.15	5.47	
2	2.68	0.26	2.67	20.23
3	18.61	1.44	12.67	
Guangopalo (Diesel)				
1	1.04	0.82	18.38	
2	0.82	-	0.51	
3	0.85	-	1.12	17.54
4	1.77	24.79	86.7	
5	0.96	8.24	69.11	
6	2.96	62.67	0.00	

* To neglect due to initial faults