3.6 Workshop for Maintenance and Repair

(1) Power Generation Division

Maintenance and management of the power generating facilities is essential for assuring a reliable, stable supply of high-quality power and a most important area of activity for SENELEC as a commercial operation. On the premises of the Bel-Air and Cap des Biches power stations, SENELEC has mechanical workshops designed to provide the maintenance and repair backup needed for the regular inspection and repair of the power generating facilities and the various machines.

Apart from routine inspections and repair on the power generating facilities, these mechanical workshops also manufacture parts which ought to be furnished by the manufacturers of the equipment. The main reasons for the need to manufacture parts in-house are as follows:

a. SENELEC's power generating facilities is old and the manufacturers thereof have ceased to produce parts for the equipment.

b. Imported parts are expensive and also take a long time for transportation to the site.

As a result, parts such as the vanes of large pumps and fans are manufactured at SENELEC's in-house workshops which also carry out the build up welding.

The following outline descriptions features the Bel-Air and Cap des Bisches Mechanical Workshops.

1) Bel-Air mechanical workshop and equipment/machinery available

- Repair Shop 360m²
- Equipment & Machinery

Lathe	Cutting length	3,000mm
Lathe	Cutting length	3,000mm
Lathe	Cutting length	2,500mm
Milling Machine	Bore length	1,000mm
Milling Machine	Bore length	1,000mm
Drilling Machine	Height	1,800mm
Drilling Machine	Height	1,500mm
Grinder		

2) Cap des Biches mechanical workshop and equipment/machinery available

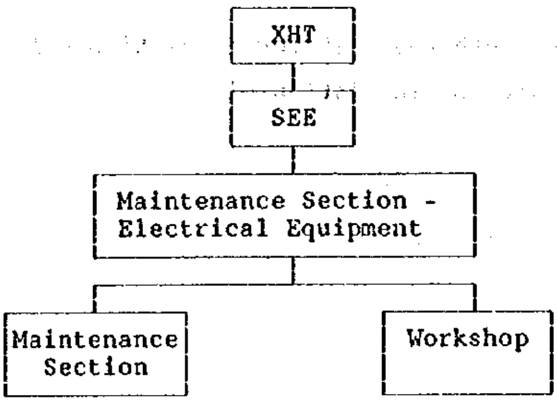
- Repair Shop 360m²
- Equipment & Machinery

Lathe	Cutting length	3,000mm
Lathe	Cutting length	2,500mm
Drilling Machine	Height	2,000mm
Drilling Machine	Height	1,800mm
Drilling Machine	Height	1,400mm
Press Machine		49ton
Milling Machine	Cutting length	1,000mm
Sawing machine		
Grinder		

The above two Mechanical Workshops provide a fair working environment with proper working space, They are well equipped with machine tools. It is desirable, however, to expand the availability of special tools and essential spare parts in the workshops so that the power generating facilities can be inspected on a regular basis and equipment repaired in a planned manner and with a rapid response.

(2) Electrical Division

The Electrical Workshop of SENELEC's electrical division is part of the High-Voltage Department (XHT - Departement Haute Tension). The organization chart is as follows:



SENELEC's most typical Electrical Workshop can be found on the premises of the Bel-Air power station. Its main works consists of the repairing of transformers and circuit breakers. The following list gives the tools, machines, and measuring instruments the Bel-Air Electrical Workshop has. The machines and measuring instruments have aged and deteriorated. Nor is the working environment in the shop satisfactory. It will therefore be desirable to upgrade the workshop's equipment outfit and also its working environment.

1) Tools
   a. Spanners
   b. Rulers, tape measures
   c. SF6 has filling unit and testing unit
   d. Hydraulic inspecting unit

2) Machines
   a. Oil pump
   b. 16.5 ton hoist
   c. Boring machine
   d. Spares for transformers and circuit breakers

3) Measuring instruments

a. Medium-voltage/Low-voltage transformer testing bench (capable of performing the following measurements)

- Coil resistance measurement
- Coil insulation resistance measurement
- Dielectric strength test

b. Transformers

c. Dielectric strength test set for insulation oil

d. Dehydrating unit for insulation oil

Table 3.1-1 Specification of Generating Facilities

1. Bel-Air

(1) CI : Diesel unit

Item	Unit	G105	G106			Remarks
Manufacturer	-	Mitsubishi				
Rated output	kW	5,000	5,000			
Number of cylinder	-	12	12			
Diameter of cylinder	cm					
Rated speed	rpm	750	750			

(2) CII : Steam turbine

Item	Unit	G101	G102	G103	G104	Remarks
Boiler :						
Manufacturer	-	Bubcock, Wilcock				
Normal pressure	bar	43	43	43	43	
Vapor temperature	℃	450	450	450	450	
Maximum vapor	T/H	65	65	65	65	
Turbine :						
Manufacturer	-	CEM				
Output	KW	12,800	12,800	12,800	12,800	
Inlet temperature	℃	425	425	425	425	
Inlet pressure	bar	40	40	40	40	
Rated speed	rpm	3,000	3,000	3,000	3,000	

2. Cap des Biches

(1) CIII : Steam turbine and gas turbine

Item	Unit	G101	G102	G103		Remarks
Boiler :						
Manufacturer	-	Bubcock				
Normal pressure	bar	76	75	75		
Vapor temperature	℃	510	500	500		
Maximum vapor	T/H	120	120	120		
Turbine :						
Manufacturer	-					
Output	KW	27,500	30,000	30,000		
Inlet temperature	℃	66	66	66		
Inlet pressure	bar	500	500	500		
Rated speed	rpm	3,000	3,000	3,000		

Gas turbine :

Item	Unit	TAG1	TAG2			Remarks
Manufacturer	-					
Output	kW	16,650	20,000			
Rated speed	rpm	5,100	5,100			

(2) CIV : Diesel unit

Item	Unit	G401	G402			Remarks
Manufacturer	-	Pielstick				
Rated output	kW	20,000	20,000			
Number of cylinder	-	18	18			
Diameter of cylinder	cm	60	60			
Rated speed	rpm	428	428			

Source : SENELEC (August 1994)

Table 3.1-2 Capacity of Generating Facilities

As of August 1994

Region	Name of station	Name of unit	Type	Fuel used	Number of unit	Capacity Rated (kW)	Capacity Short time rated (kW)	Capacity Short time rated (Hour)	Capacity Economical (kW)	Capacity Actual limit (kW)	Fuel consumption rate at Rated (g/kWh)	Fuel consumption rate at Economical (g/kWh)	Fuel consumption rate at Actual limit (g/kWh)	Lub. oil consumption at Rated (g)	Lub. oil consumption at Economical (g)	Year of Commissioning	Year of Rehabilitation	Year of Retirement	Remarks
Dakar	Bel-Air (CI)	G105	Diesel	HSD+Heavy Oil	1	5,000	5,500	1	4,500	5,000	210	204	-	2.0	1.7	1991			
		G106	Diesel	HSD+Heavy Oil	1	5,000	5,500	1	4,500	5,000	210	204	-	2.0	1.7	1991			
	Bel-Air (CII)	G101	Steam	Heavy Oil	1	12,800	-	-	-	5,000	290	-	450	-	-	1953			
		G102	Steam	Heavy Oil	1	12,800	-	-	-	9,000	300	-	430	-	-	1955			
		G103	Steam	Heavy Oil	1	12,800	-	-	-	11,000	300	-	420	-	-	1959			
		G104	Steam	Heavy Oil	1	12,800	-	-	-	5,000	480	-	450	-	-	1961			
	Sub Total				6	61,200	-		-	40,000									
Rufisque	Cap des Biches (CIII)	G301	Steam	Heavy Oil	1	27,500	-	-	-	27,500	290	-	310	-	-	1965			
		G302	Steam	Heavy Oil	1	30,000	-	-	-	20,000	300	-	335	-	-	1975	1982		
		G303	Steam	Heavy Oil	1	30,000	-	-	-	15,000	300	-	335	-	-	1978	1985		
		TAG1	Gas	HSD Natural gas	1	16,500	-	-	15,000	15,000	480	-	500	-	-	1972			
		TAG2	Gas	HSD Natural gas	1	21,500	-	-	20,000	19,000	450	-	520	-	-	1984			
	Cap des Biches (CIV)	G401	Diesel	HSD+Heavy Oil	1	20,000	-	-	-	20,000	210	200	230	2.0	1.7	1990			
		G402	Diesel	HSD+Heavy Oil	1	20,000	23,000	1	18,000	20,000	210	200	230	2.0	1.7	1990			
	Sub total				7	165,500	-		-	136,500									
Saint-Louis			Diesel	HSD+Heavy Oil	1	3,250	3,738	1	2,925	3,250						1979			
			Diesel	HSD+Heavy Oil	1	3,250	3,738	1	2,925	3,250						1979			
			Diesel	HSD+Heavy Oil	1	2,000	2,300	1	1,800	2,000						1980			
			Diesel	HSD+Heavy Oil	1	2,000	2,300	1	1,800	2,000						1980			
	Sub total				4	10,500	12,075		9,450	10,500									
Kaolack			Diesel	HSD+Heavy Oil	1	3,500	4,025	1	3,150	3,500						1982			
			Diesel	HSD+Heavy Oil	1	3,500	4,025	1	3,150	3,500						1982			
			Diesel	HSD+Heavy Oil	1	3,500	4,025	1	3,150	3,500						1987			
			Diesel	HSD+Heavy Oil	1	3,500	4,025	1	3,150	3,500						1988			
	Sub total				4	14,000	16,100		12,600	14,000									
	Total				21	251,200	-		-	201,000									

Source : Statistical Operation Record by SENELEC (August 1994)

Table 3.1-3 Evolution of Rating for Generating Facilities

- RG1:Existing Generating Facilities

Item	Name Type	Capacity	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Remarks
Bel-Air (CI)	G105	Rated																	5,000	5,000	5,000	
	-	Economical																	4,500	4,500	4,500	
	-	Short time																	5,500	5,500	5,500	
	Diesel	Actual limit																	5,000	5,000	5,000	
	G105	Rated																	5,000	5,000	5,000	
	-	Economical																	4,500	4,500	4,500	
	-	Short time																	5,500	5,500	5,500	
	Diesel	Actual limit																	5,000	5,000	5,000	
Bel-Air (CII)	G101	Rated	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	
	Steam	Actual limit																			-	Resumption at output 5,000kW in 1994
	G102	Rated	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	
	Steam	Actual limit																			9,000	As of August 1994
	G103	Rated	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	
	Steam	Actual limit																			11,000	As of August 1994
	G104	Rated	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800	
	Steam	Actual limit																			5,000	As of August 1994
Cap des Biches (CIII)	G301	Rated	27,500	27,500	27,500	27,500	27,500	27,500	27,500	27,500	27,500	27,500	27,500	27,500	27,500	27,500	27,500	27,500	27,500	27,500	27,500	
	Steam	Actual limit																			27,500	As of August 1994
	G302	Rated	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	
	Steam	Actual limit																			20,000	As of August 1994
	G309	Rated				30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	
	Steam	Actual limit																			15,000	As of August 1994
	TAG1	Rated	18,500	18,500	18,500	18,500	18,500	18,500	18,500	18,500	18,500	18,500	18,600	18,500	18,500	18,500	18,500	18,500	18,500	18,500	18,500	
	-	Economical	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	16,000	15,000	
	Gas	Actual limit																			15,000	As of August 1994
	TAG2	Rated										21,500	21,500	21,500	21,500	21,500	21,500	21,500	21,500	21,500	21,500	
	-	Economical										15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	
	Gas	Actual limit																			19,000	As of August 1994
Cap des Biches (CIV)	G401	Rated																20,000	20,000	20,000	20,000	
	-	Economical																18,000	18,000	18,000	18,000	
	-	Short time																23,000	23,000	23,000	23,000	
	Steam	Actual limit																			20,000	
	G402	Rated																20,000	20,000	20,000	20,000	
	-	Economical																18,000	18,000	18,000	18,000	
	-	Short time																23,000	23,000	23,000	23,000	
	Steam	Actual limit																			20,000	
Saint-Louis	-	Rated					3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	
	-	Economical					2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	estimated as 90% of rated
	-	Short time					3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	estimated as 110% of rated
	Diesel	Actual limit																			3,250	
	-	Rated					3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	
	-	Economical					2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	estimated as 90% of rated
	-	Short time					3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	3,575	estimated as 110% of rated
	Diesel	Actual limit																			3,250	
	-	Rated						2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	
	-	Economical						1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	estimated as 90% of rated
	-	Short time						2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	estimated as 110% of rated
	Diesel	Actual limit																			2,000	
	-	Rated						2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	
	-	Economical						1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	estimated as 90% of rated
	-	Short time						2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	estimated as 110% of rated
	Diesel	Actual limit																			2,000	
Kaolack	-	Rated								3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	
	-	Economical								3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	estimated as 90% of rated
	-	Short time								3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	estimated as 110% of rated
	Diesel	Actual limit																			3,500	
	-	Rated								3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	
	-	Economical								3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	estimated as 90% of rated
	-	Short time								3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	estimated as 110% of rated
	Diesel	Actual limit																			3,500	
	-	Rated													3,500	3,500	3,500	3,500	3,500	3,500	3,500	
	-	Economical													3,150	3,150	3,150	3,150	3,150	3,150	3,150	estimated as 90% of rated
	-	Short time													3,850	3,850	3,850	3,850	3,850	3,860	3,850	estimated as 110% of rated
	Diesel	Actual limit																			3,500	
	-	Rated														3,500	3,500	3,500	3,500	3,500	3,500	
	-	Economical														3,150	3,150	3,150	3,150	3,150	3,150	estimated as 90% of rated
	-	Short time														3,860	3,850	3,860	3,850	3,850	3,850	estimated as 110% of rated
	Diesel	Actual limit																			3,500	

Source : Statistical operation record by SENELEC (August 1994)
Both power systems SAINT-LOUIS and KAOLACK have not yet been interconnected to RG1 during above period.

Table 3.3-1 Line Length of 30 kV Distribution Feeders

Name of feeders	Overhead line		Underground		Total
	Support etc.	(km)	Type of inst.	(km)	(km)
Rufsac	Concrete pole	10.60	Conduit	1.45	12.05
	(148 sqmm almelec)	10.60			
Sies	Concrete pole	11.40	Direct bury	2.29	13.69
	(148 sqmm almelec)	10.25			
	H-steel				
	(38 sqmm Cu)	1.15			
Villa Cap Biches (CIII)		8.03	Direct bury	1.17	9.20
	(38 sqmm Cu)	4.90			
	(148 sqmm almelec)	3.13			
Km 22	H-steel	12.70			12.70
	(38 sqmm Cu)	11.60			
	(148 sqmm almelec)	1.10			
Rufisque Nord	Concrete & H-steel	100.86	Direct bury	1.16	102.02
	(148 sqmm almelec)	100.54			
	(38 sqmm Cu)	0.32			
Total Cap des Biches CIII		143.59		6.07	149.66
Amerger			Direct bury	21.28	21.28
Hann Percheus	Concrete pole	5.25	Direct bury	19.45	24.70
	(148 sqmm almelec)	5.25			
Center Ville			Direct bury	8.70	8.70
Bel-Air			Direct bury	5.75	5.75
Hlm Patte d'Oie			Direct bury	40.27	40.27
Hann Labo			Direct bury	1.20	1.20
Universite			Direct bury	7.20	7.20
Aeroport Yoff			Direct bury	8.39	8.39
Soprim			Direct bury	23.43	23.43
Total Hann		5.25		135.67	140.92
Grand Total		148.84		141.74	290.58

Table 3.3-2 Line Length of 6.6kV Feeders and Number of Distribution Poste

Name of feeders	Line length (km)		Total	Max. demand	Kind of poste			
	Overhead	Underground	length (km)	(kVA)	Costomer	SENELEC	Mixed	Total
Arsenal	0.00	3.65	3.65	2,133	5	4	3	12
Elmaf Fumor	0.00	2.93	2.93	230	1	1	0	2
Port Sud	1.83	7.52	9.35	786	9	6	0	15
Dispansaire	10.59	8.39	18.98	3,125	55	12	1	68
Dakar Est	0.00	5.36	5.36	2,422	12	6	7	25
Yoff	7.02	5.65	12.67	1,500	7	7	1	15
Grand Dakar	5.86	4.23	10.09	1,800	7	9	0	16
Grande Voirie	0.42	6.39	6.81	2,183	20	13	2	35
Tolbiac	0.00	4.36	4.36	630	3	4	0	7
Soto	0.00	7.13	7.13	1,722	9	3	1	13
Sileye Guisse	0.00	5.44	5.44	1,312	5	10	0	15
Medina	1.20	6.80	8.00	2,740	6	15	1	22
Consession	8.15	5.17	13.32	2,222	28	12	0	40
Total Bel-Air	35.07	73.02	108.09	22,805	167	102	16	285
Nina Hotel	0.00	6.36	6.36	902	12	4	2	18
Rssidanca Cap Vert	0.16	1.29	1.45	1,400	7	6	2	15
Fonciere Zola	0.30	2.00	2.30	1,900	7	4	4	15
Credit Foncier	0.00	3.88	3.88	1,278	10	12	1	23
Mohamed V Carrot	0.00	3.91	3.91	1,666	10	12	2	24
Blanchot Lam Sow	0.00	5.92	5.92	1,322	14	9	0	23
Total Centre Ville	0.46	23.36	23.82	8,468	60	47	11	118
Fann	0.42	8.84	9.26	1,758	14	16	1	31
Mermoz	6.68	1.30	7.98	1,540	11	13	0	24
Point E	3.30	2.45	5.75	2,600	9	22	1	32
Mermoz de Secours	0.00	3.65	3.65	250	1	2	0	3
Abass N'Dao	0.40	7.85	8.25	1,720	7	6	1	14
Iut	0.00	2.17	2.17	800	6	2	0	8
Total Universite	10.80	26.26	37.06	8,668	48	61	3	112
Batterie Yoff	2.06	9.29	11.35	1,728	10	16	1	27
Air Senegal	5.52	9.74	15.26	904	8	5	0	13
Terme Sud	5.87	10.45	16.32	2,078	13	9	0	22
Total Yoff	13.45	29.48	42.93	4,710	31	30	1	62
Front de Terre	4.80	3.80	8.60	2,754	1	13	0	14
Sibras	1.61	0.65	2.26	2,176	31	2	3	36
Hann 6.6kV	5.71	0.68	6.39	1,192	9	5	2	16
Puits 12	9.99	2.17	12.16	3,140	12	18	3	33
Diauppeul Ecole	1.41	2.41	3.82	1,500	1	10	0	11
Sodia	2.37	1.13	3.50	1,612	4	11	0	15
Total Usine des Eaux	25.89	10.84	36.73	12,374	58	59	8	125
Labo Pacherie	2.84	5.05	7.89	1,364	20	8	0	28
Yeumbeul	16.04	14.08	30.12	1,321	8	25	0	33
Route de Rufisque	13.09	0.72	13.81	1,650	27	20	0	47
Dagoudane Pikine	6.90	0.00	6.90	1,894	1	11	1	13
Icotaf	0.00	9.89	9.89	1,000	0	7	0	7
Total Thiaroye	38.87	29.74	68.61	7,229	56	71	1	128
Grand Total	124.54	192.70	317.24	64,254	420	370	40	830

Note : Maximum demand of each feeder is the value as of July 1992.

Table 3.3-3 Number of Distribution Poste of 30 kV Feeders

Name of feeders	Line length (km) Overhead	Underground	Max. demand (kVA)	Kind of poste Consumer	SENELEC	Mixed	Total
Rufsac	10.60	1.45	C. BLOQUE	2	7	0	9
Sies	11.40	2.29	4,476	20	2	0	22
Villa Cap des Biches (CIII)	8.03	1.17	1,992	11	21	0	32
Km 22	12.70		1,260	3	3	0	6
Rufisque Nord	100.86	1.16	5,346	16	29	2	47
Total Cap des Biches CIII	143.59	6.07	13,074	52	62	2	116
Amerger		21.28	10,042	53	2	0	55
Hann Pecheurs	5.25	19.45	6,871	27	9	0	36
Centre Ville		8.70	10,140	0	2	0	2
Bel-Air		5.75	600	2	29	0	31
Hlm Patte d'Oie		40.27	3,731	9	1	0	10
Hann Labo		1.20	10,891	0	0	0	0
Universite		7.20	9,271	1	2	0	3
Aeroport Yoff		8.39	8,200	10	29	0	39
Soprim		23.43	4,714	6			6
Total Hann	5.25	135.67	64,460	108	74	0	182
Mtoa		14.75					
Grand Total	148.84	156.49	77,534	160	136	2	298

Note : Maximum demand of each feeder is the value as of July, 1992.

Table 3.3-4 Transformers Installed and Operating Condition for Each Distribution Substation

Name of substation	Quantity (Sets)	Number of overloaded Tr (Sets)	Number of light-load Tr (Sets)
Aeroport	30	1	9
Bel-Air	110	6	28
Cap des Biches	44	1	25
Centre Ville	52	0	22
Hann	59	9	7
Universite	59	3	7
Usine des Eaux	58	5	7
Thiaroye	66	2	21
Total	478	27	126

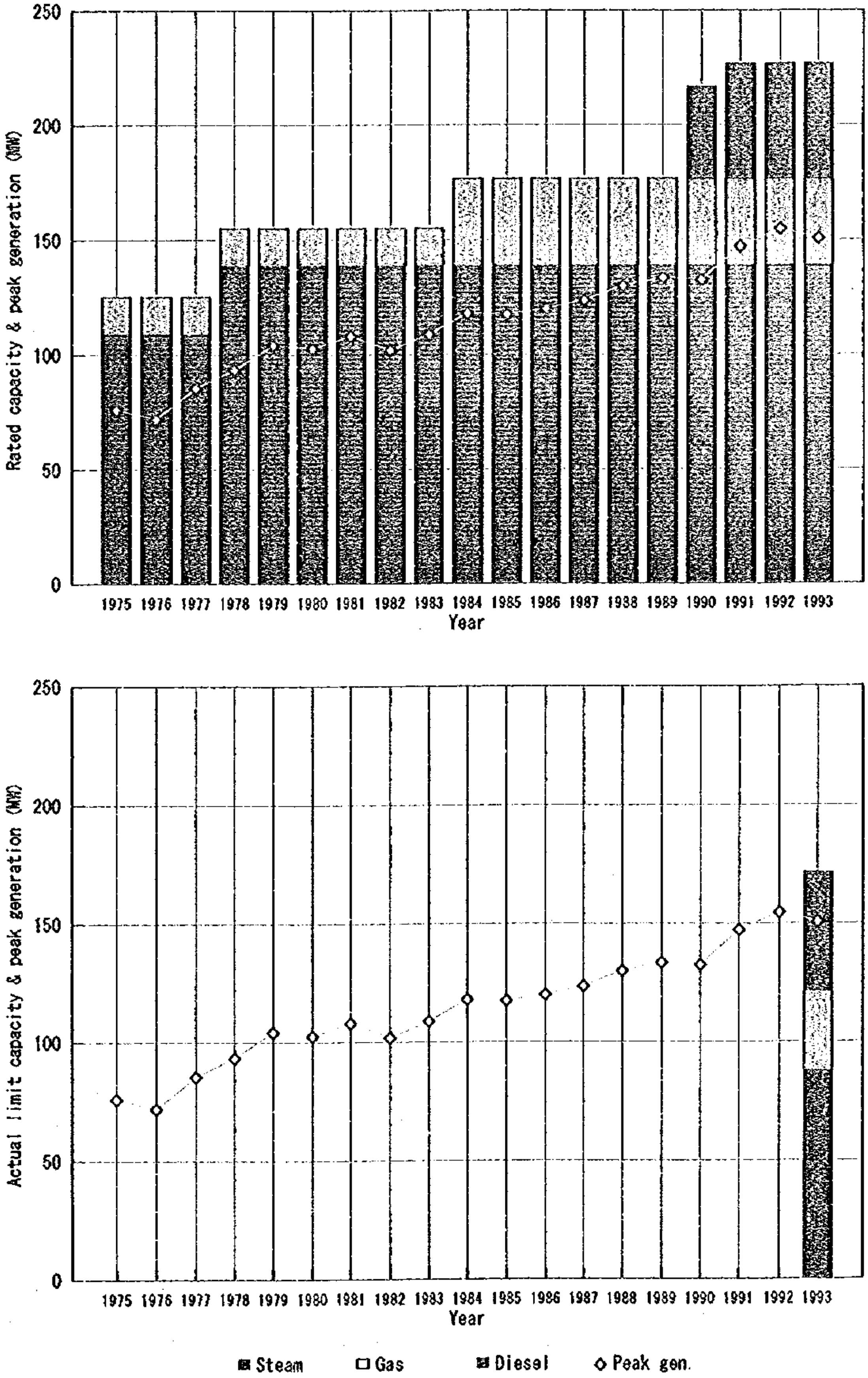
Table 3.3-5 Installed Number of Transformers and Operating Condition for Each Capacity

Transformer capacity (kVA)	Quantity (Sets)	Number of overloaded Tr (Sets)	Number of light-load Tr (Sets)
50	6	0	4
100	44	1	21
125	21	2	3
160	135	7	45
210	18	3	4
250	198	13	36
400	35	0	6
630	2	0	2
Others	19	1	5
Total	478	27	126

Table 3.4-1 Facilities of Each Substation

Name of Substation	Capacity of Main Transformer	Indoor or Outdoor	Feeders (Recieving)		Feeders (Sending)		Year of Commissioning
			90 kV	30 kV	30 kV	6.6 kV	
Cap des Biches	33 MVA x 2	Outdoor	6		5		1965
Hann	80 MVA x 1 40 MVA x 2	Outdoor	6		8 6		1979
Bel-Air	10 MVA x 3 (90kV/6.6kV) 7.975 MVA x 2 (30kV/6.6kV) 20 MVA x 2 (6.6kV/6.6kV)		2	2		13	1951
Usine des Eaux	15 MVA x 2	Outdoor		3		7	Oct. 1968
Thiaroye	7.975 MVA x 2	Outdoor		4		5	Oct. 1969
Aeroport Yoff	7.975 MVA x 2	Outdoor		4		4	Oct. 1970
Centre Ville	15 MVA x 2	Outdoor		3		6	Jan. 1974
Universite	15 MVA x 2	Outdoor		3		6	June 1976

Graph 3.1-1 Evolution of Capacity for Generating Facilities



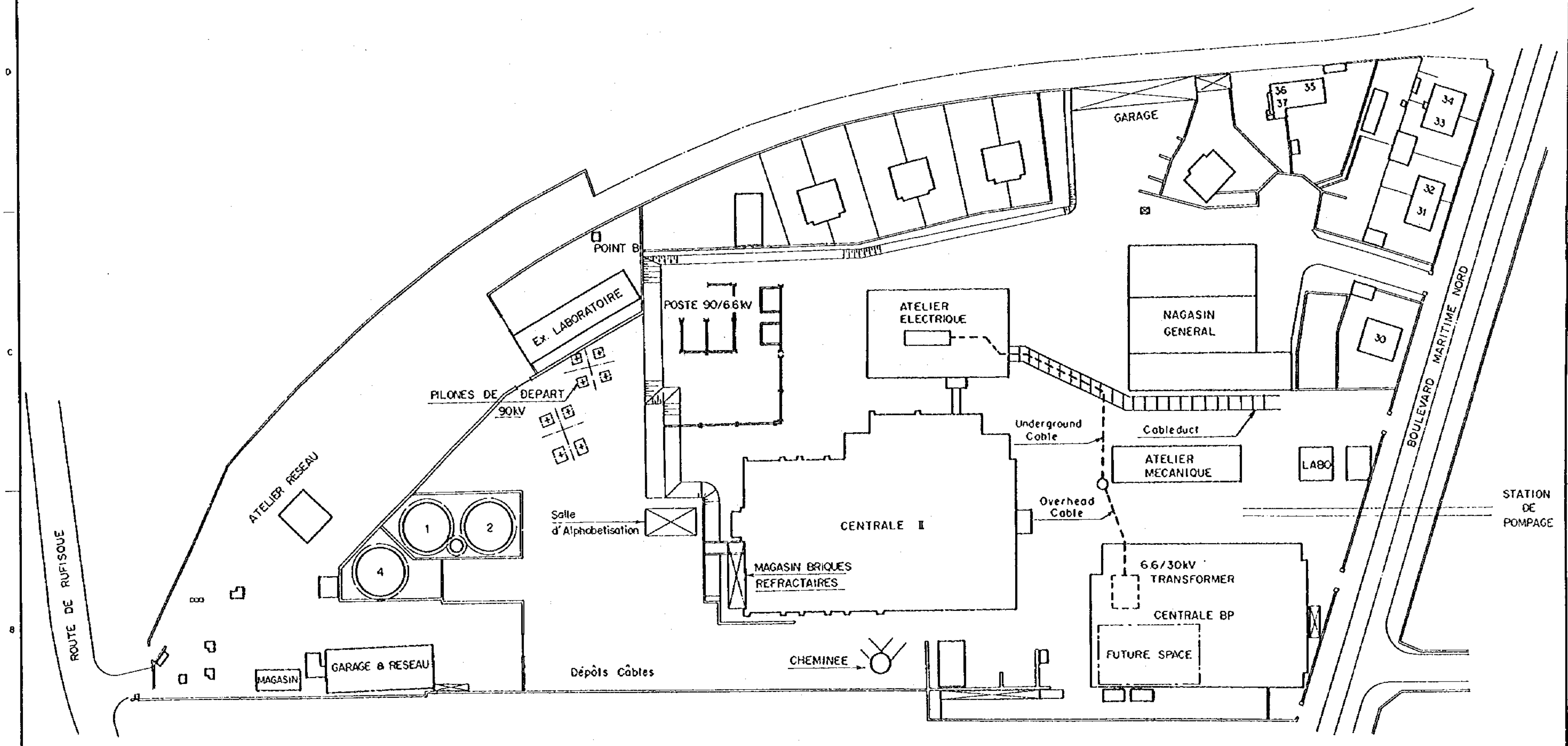


Fig. 3. 1-1

Ground Plan of Bel-Air Power Complex (C-I and C-II)

EPDC International Ltd TOKYO JAPAN

LOCATION	DATE	DESCRIPTION	BY
REVISION			

SUBMITTED:
RECOMMENDED:
APPROVED:

DATE

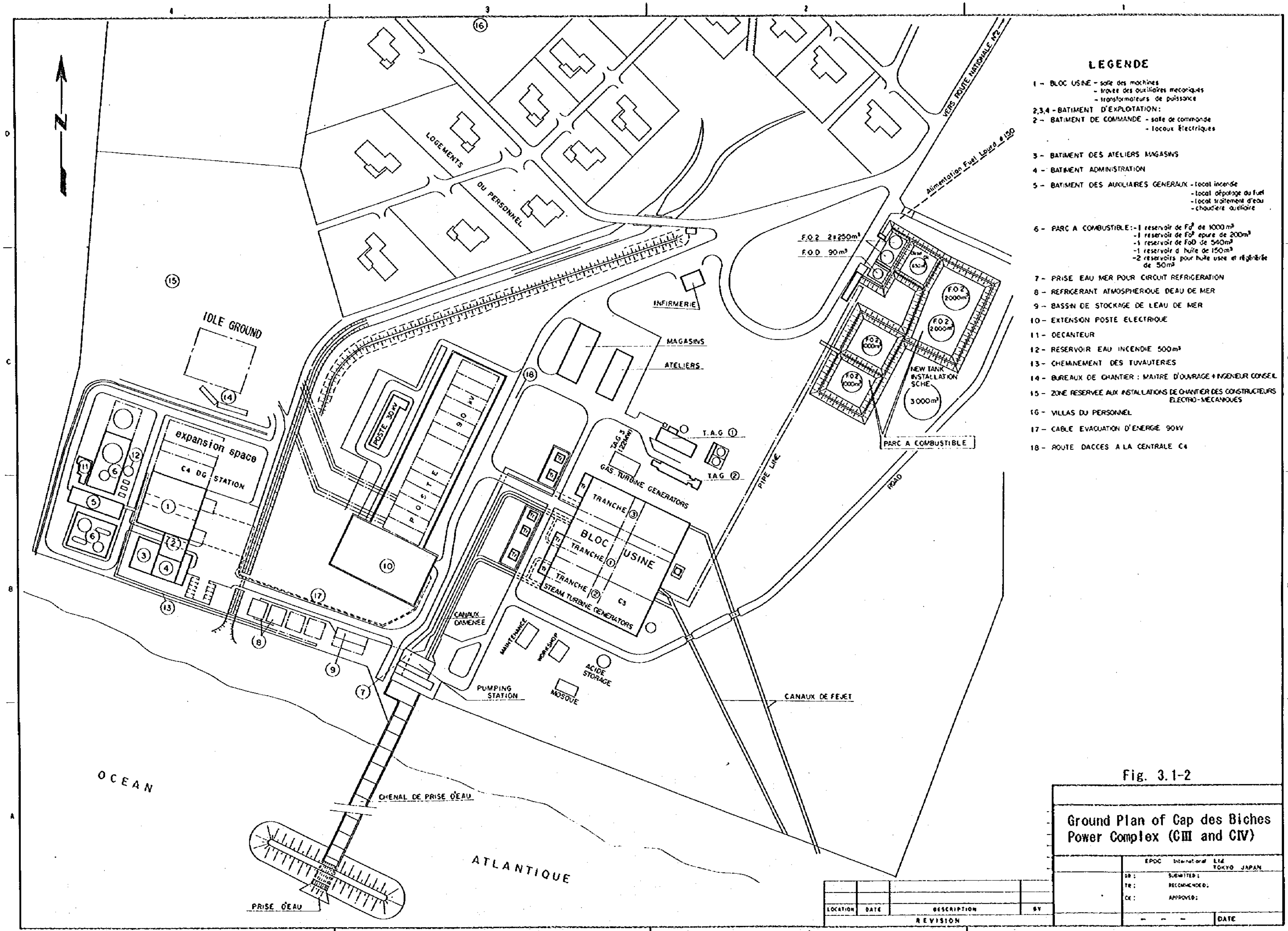


Fig. 3.1-2

Ground Plan of Cap des Biches Power Complex (CIII and CIV)

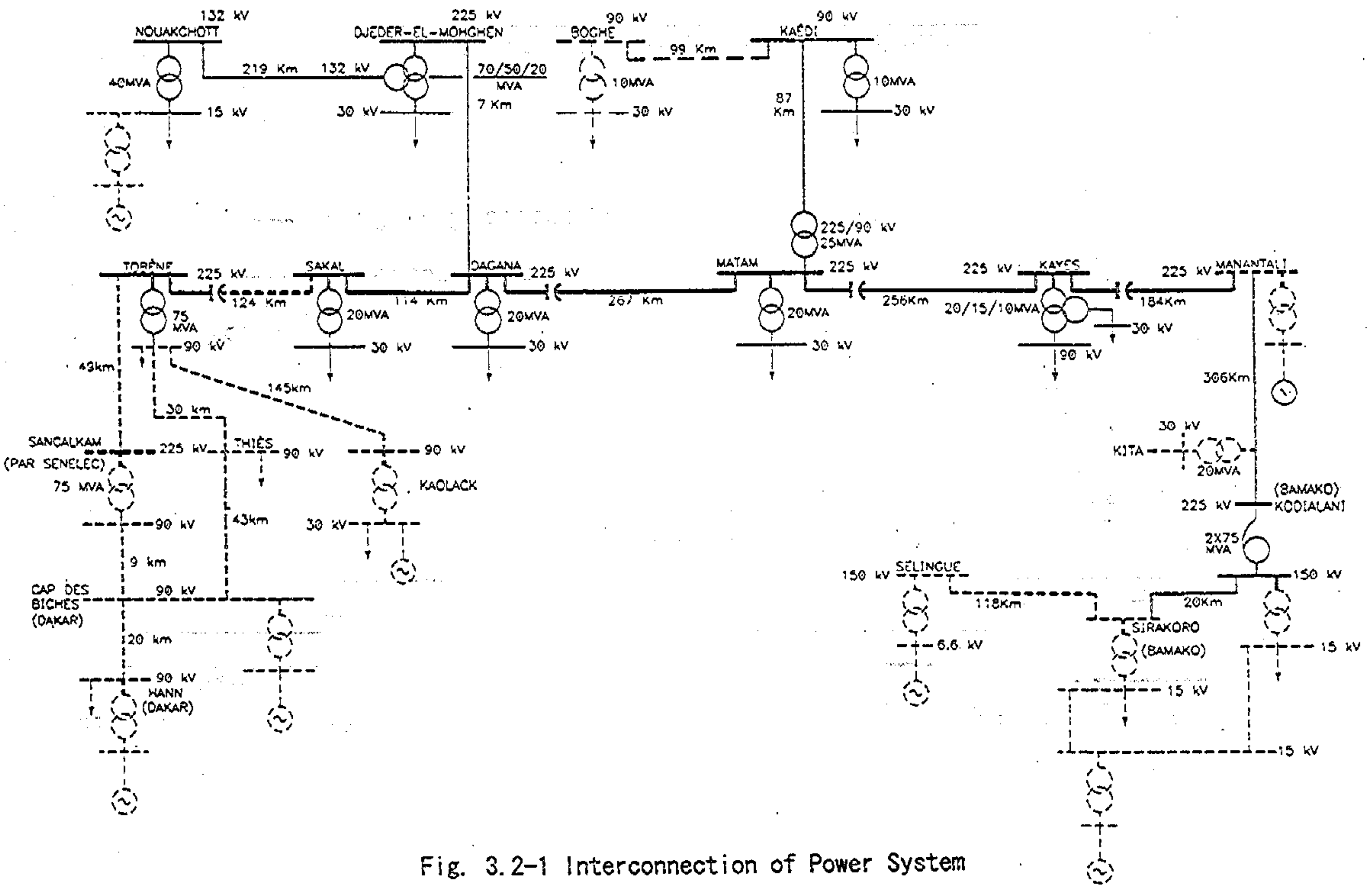


Fig. 3.2-1 Interconnection of Power System

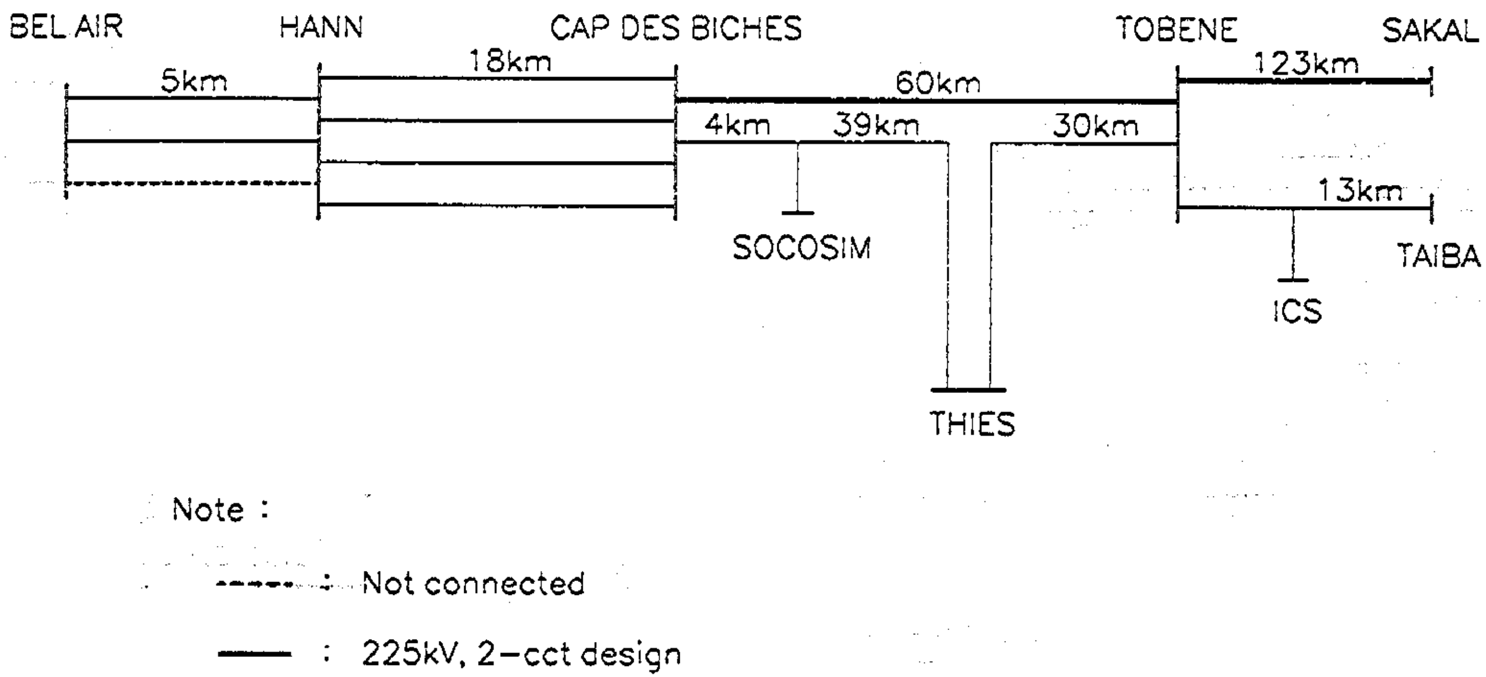


Fig. 3.2−2 90kV Transmission Line System

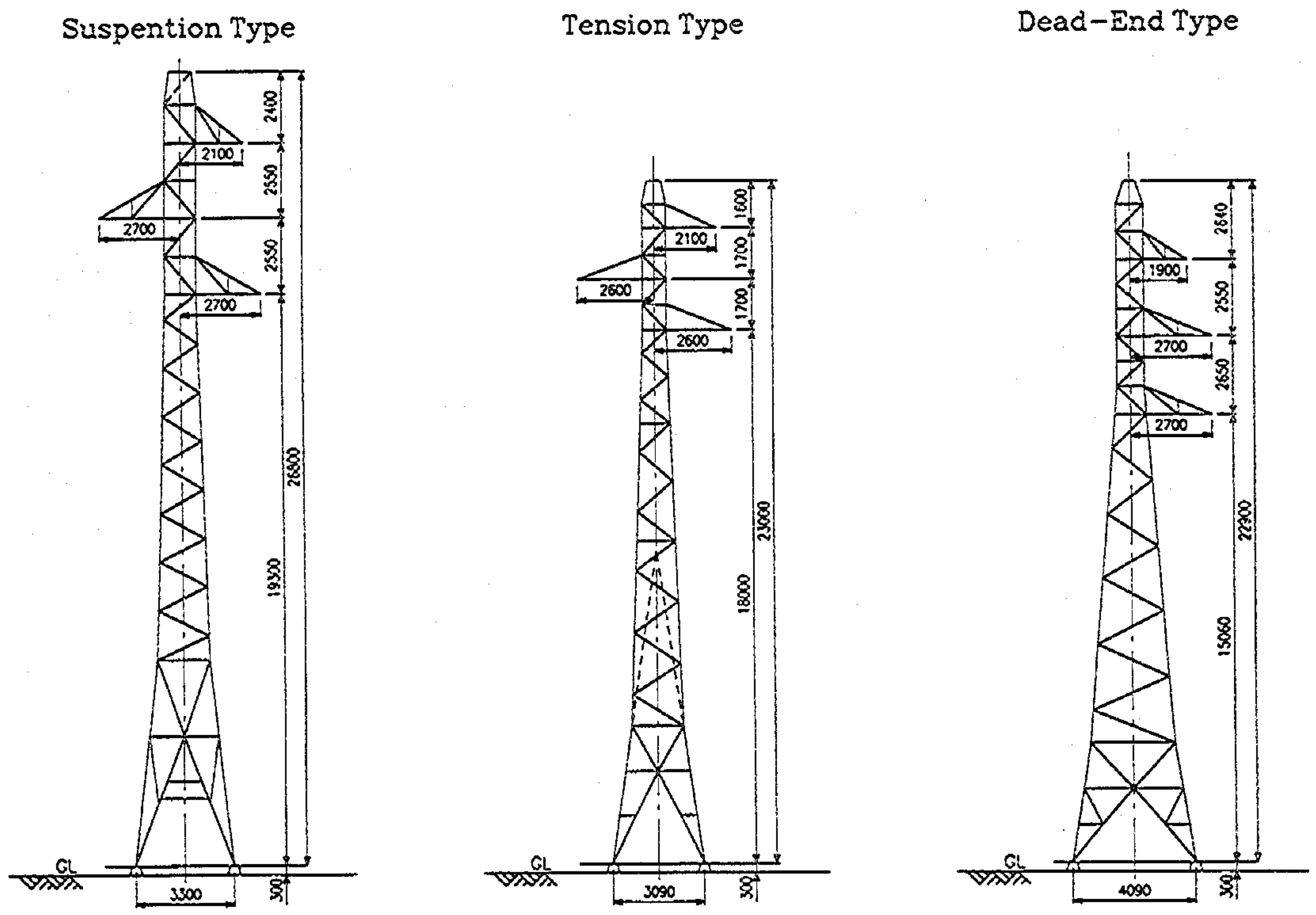


Fig. 3.2-3 Existing Steel Towers (90 kV)

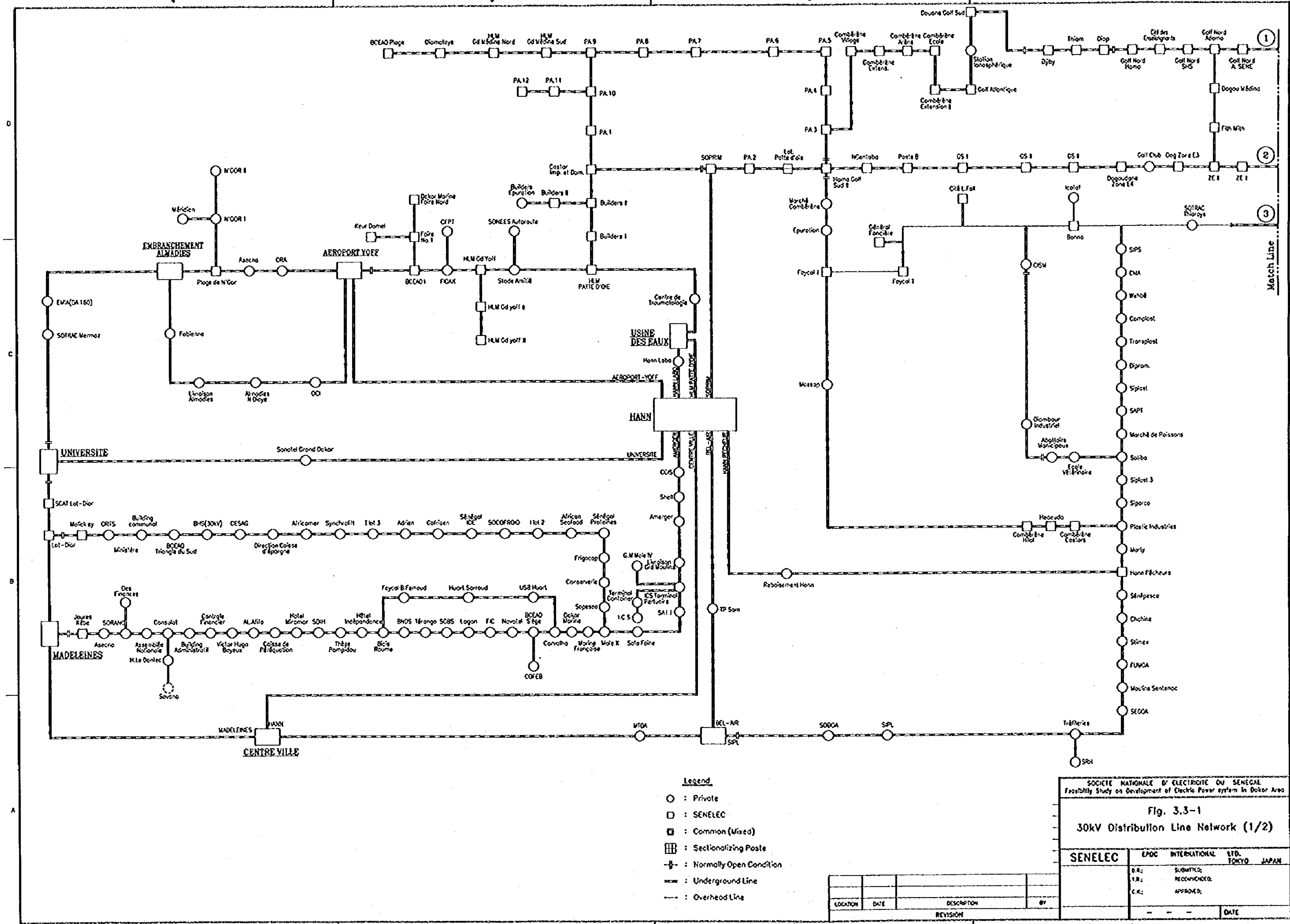


Fig. 3.3-1
30kV Distribution Line Network (1/2)

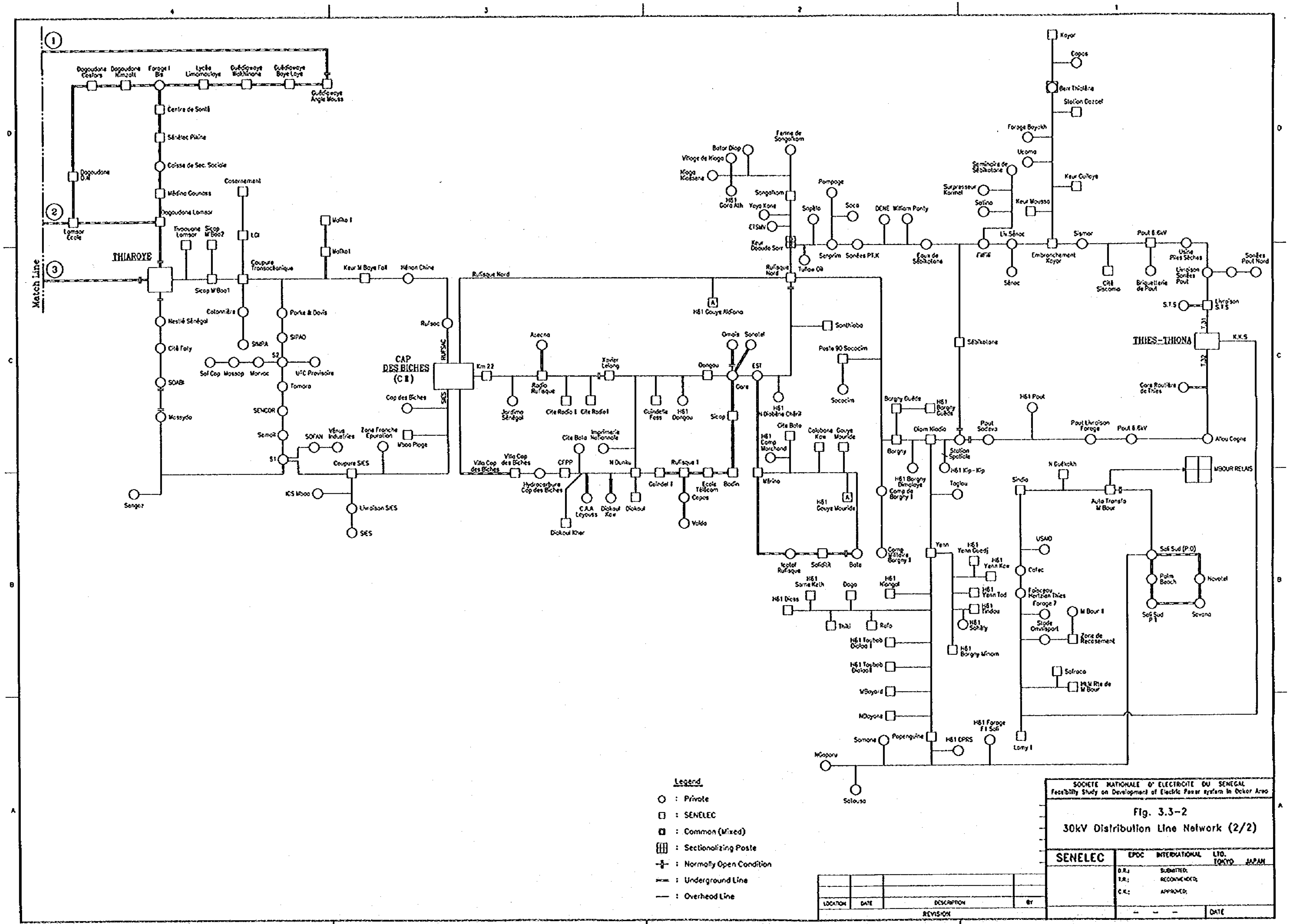


Fig. 3.3-2
30kV Distribution Line Network (2/2)

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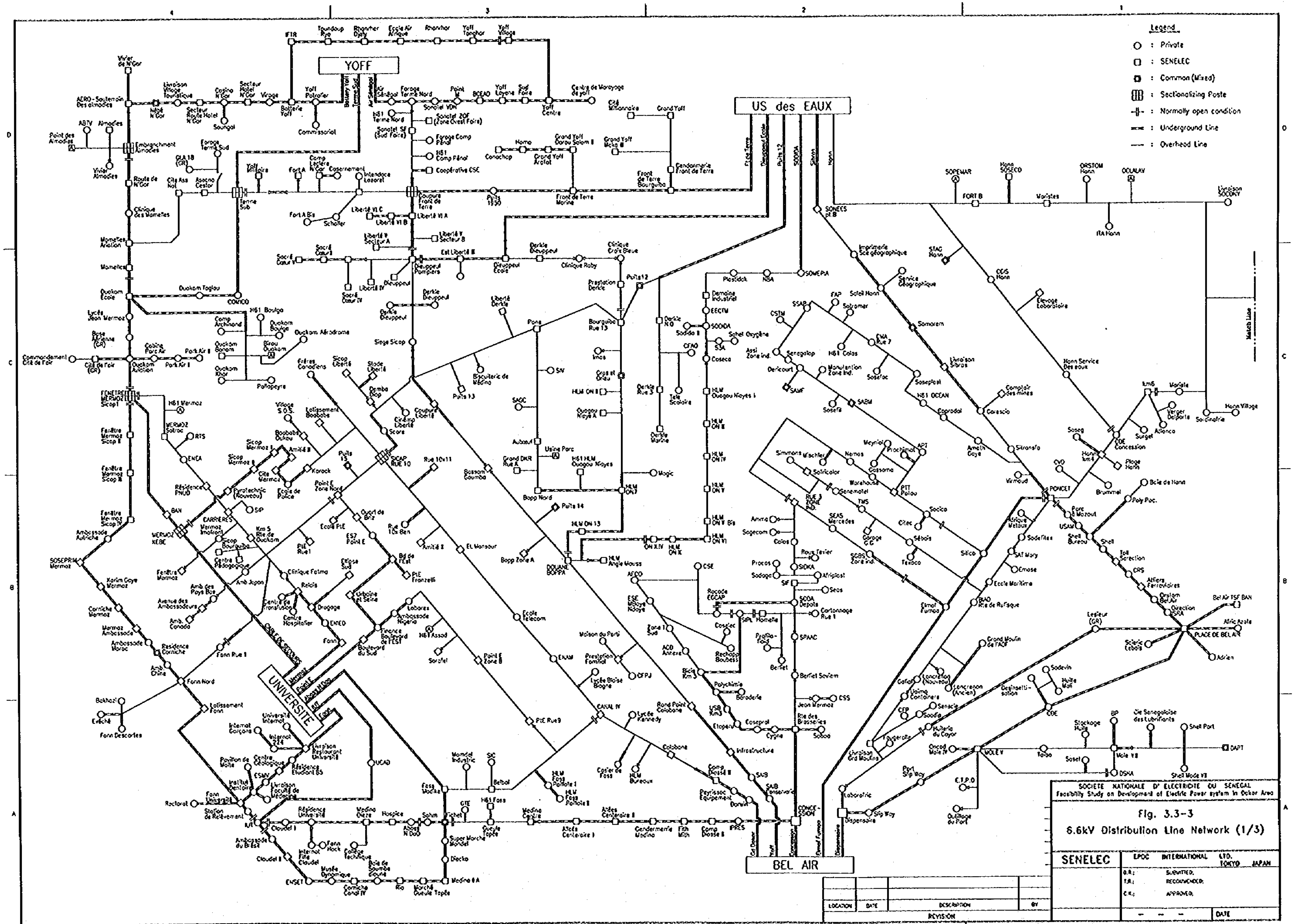

Fig. 3.3-3 6.6kV Distribution Line Network (1/3)

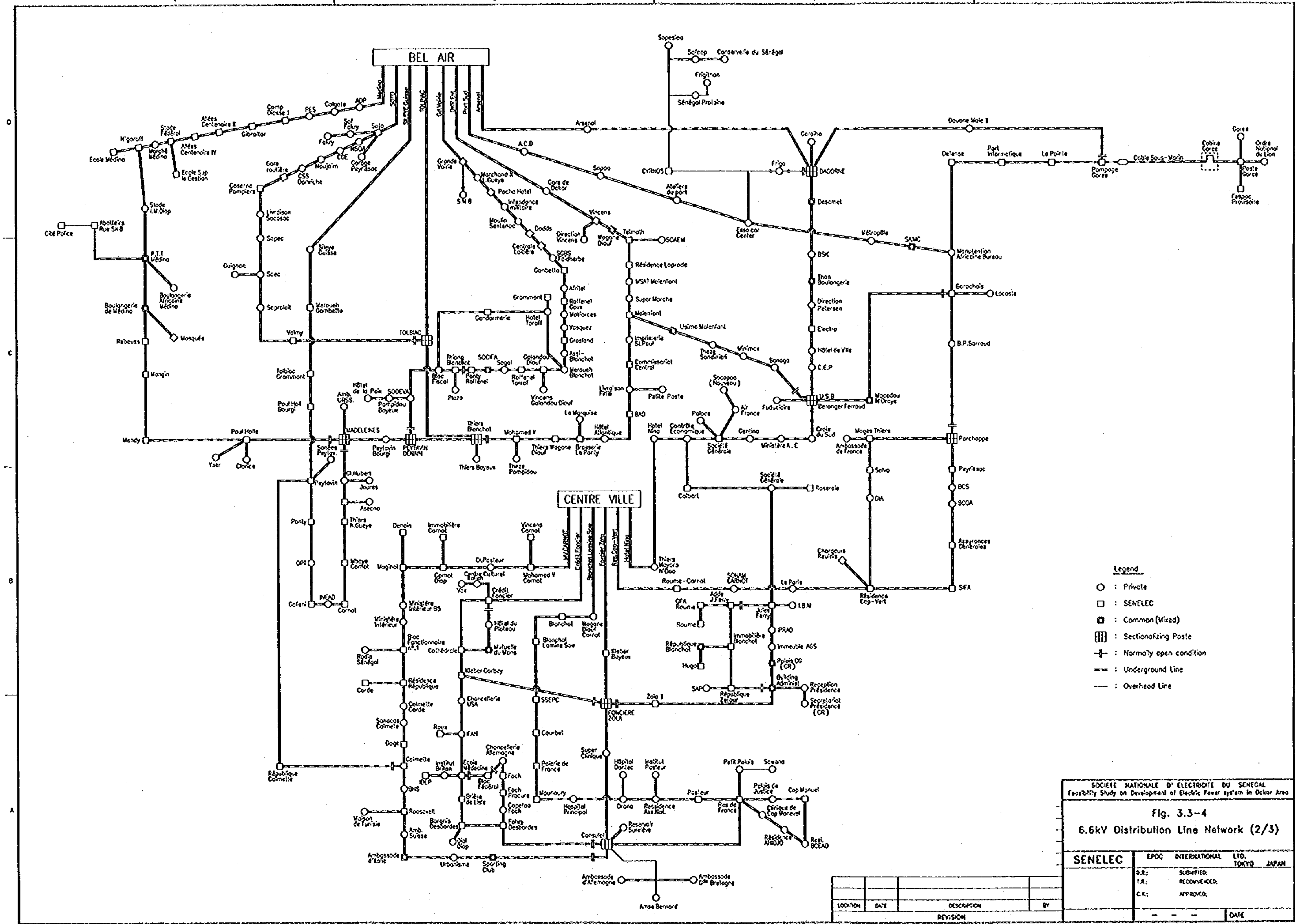

Fig. 3.3-4
6.6kV Distribution Line Network (2/3)

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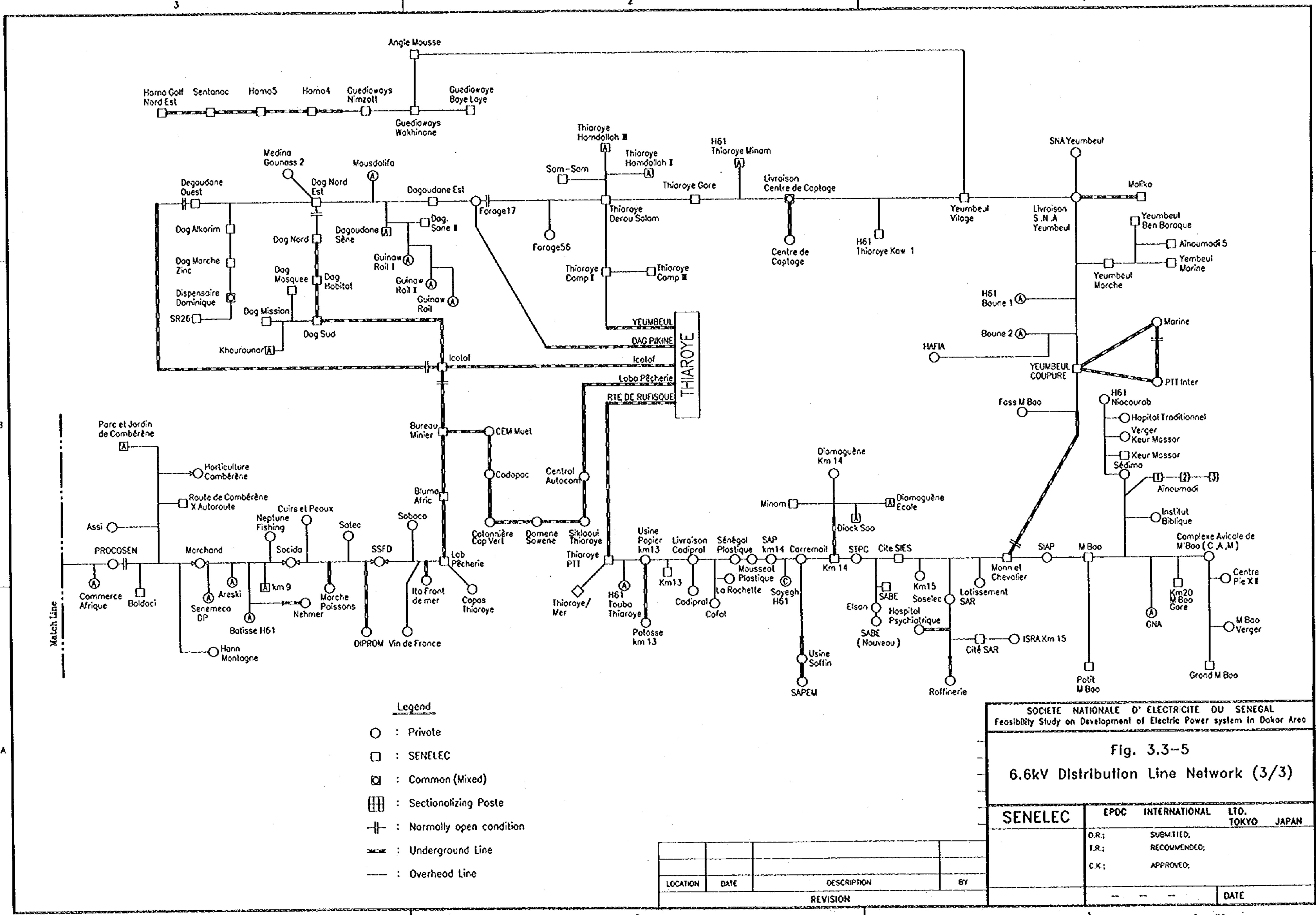


Fig. 3.3-5 6.6kV Distribution Line Network (3/3)

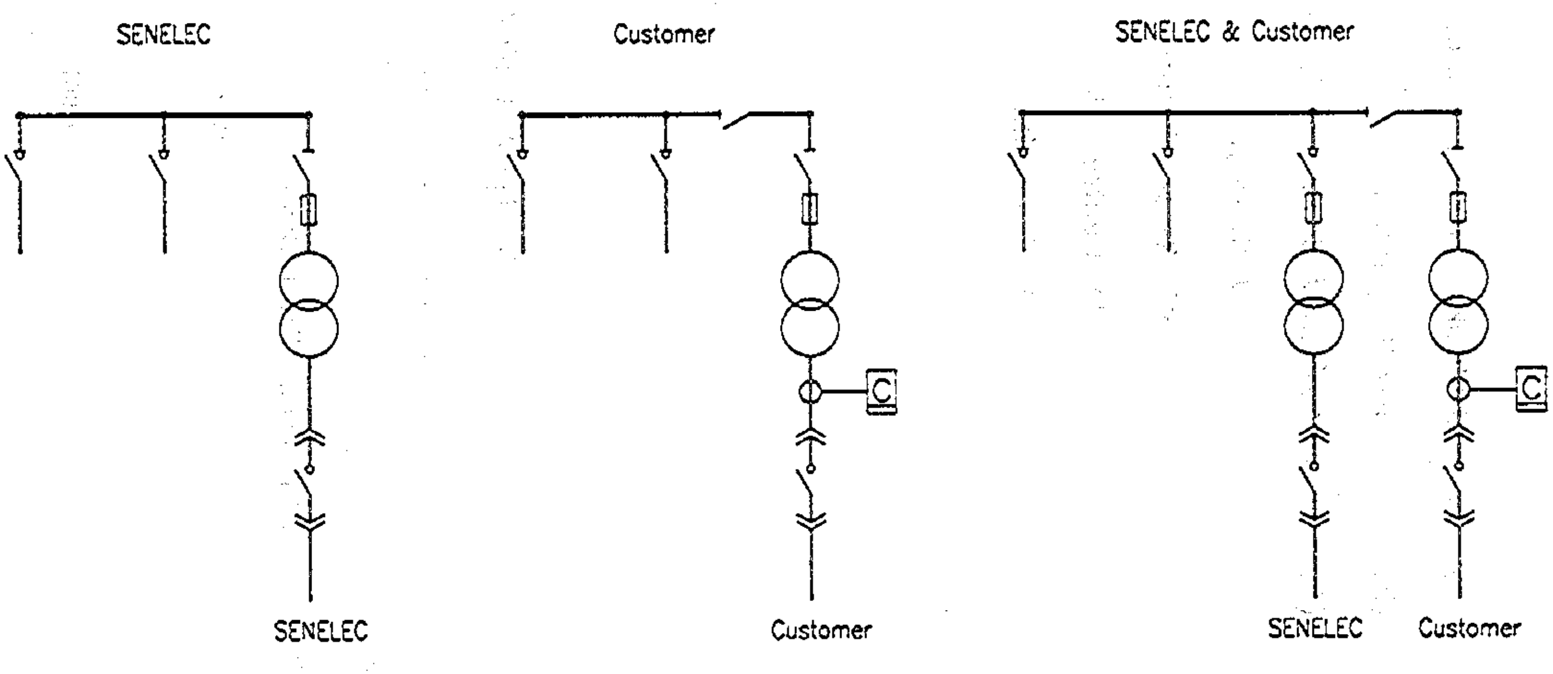


Fig. 3.3-6 Single Line Diagram of Distribution Poste

(1) Poste 90/30kV Cap des Bishes

(2) Poste 90/30kV Hann

(3) Poste 30/6.6kV Usine des Eaux

(4) Poste 30/6.6kV Thiaroye

(5) Poste 30/6.6kV Aéroport Yoff

(6) Poste 30/6.6kV Centre Ville

(7) Poste 30/6.6kV Université

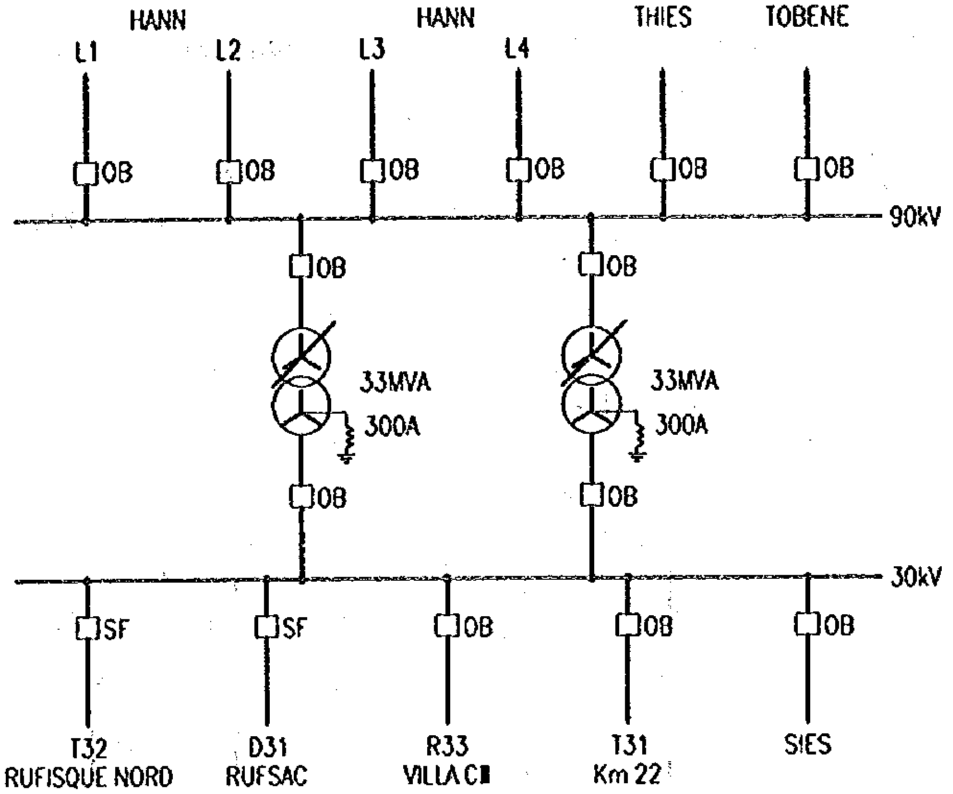
(8) Poste 90/30/6.6kV Bel Air

LEGEND

—/—	Disconnecting Switch
□	Circuit Breaker with No Remote Control
⊠	Circuit Breaker with Remote Control
SF	SF_6 Type Circuit Breaker
OB	Oil Immersed Circuit Breaker
MB	Magne Brust Type Circuit Breaker
OO	Transformer
—⊖—	Analog Measuring Point for Current

Fig. 3.4-1 Single Line Diagrams (1/5)

(1) Poste 90/30kV Cap des Biches



(2) Poste 90/30kV Hann

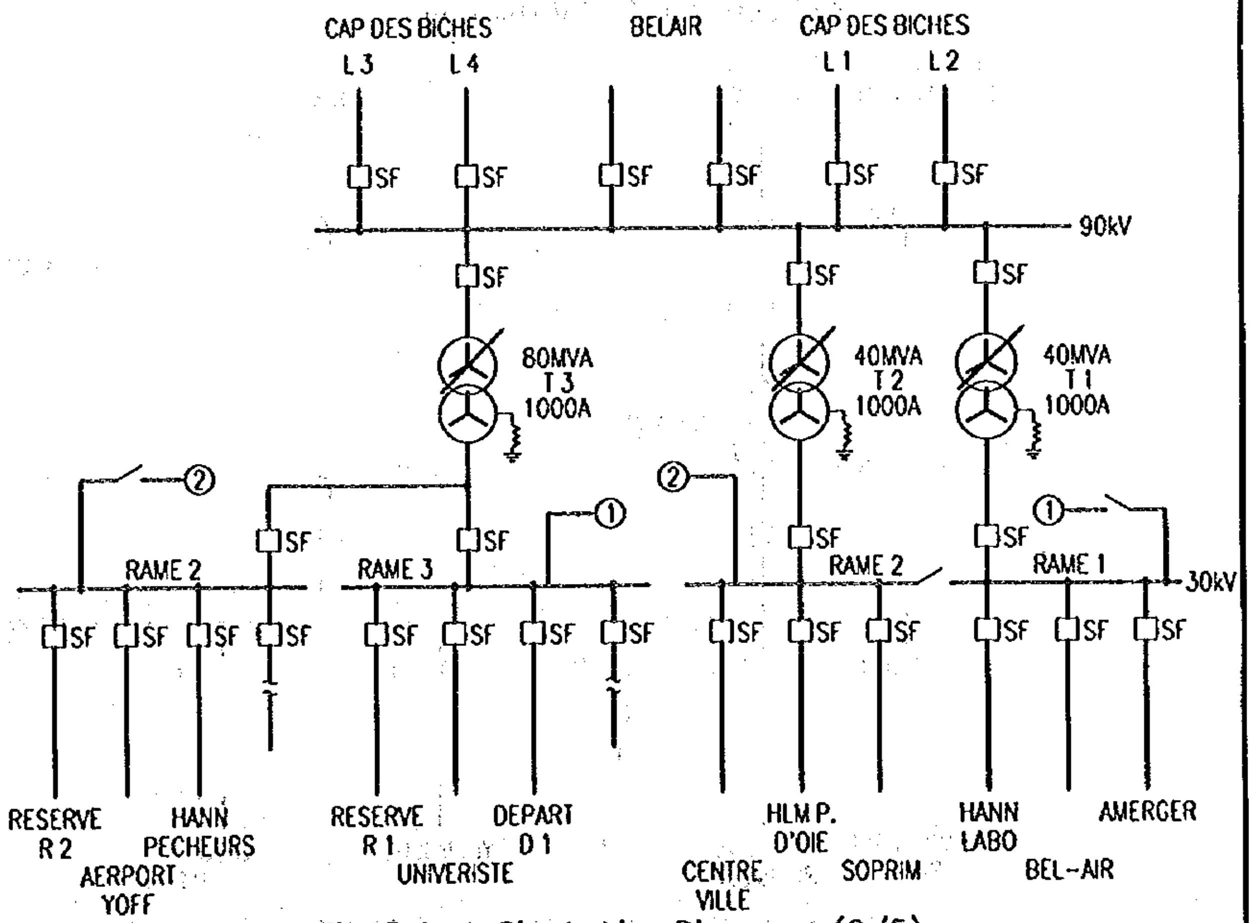
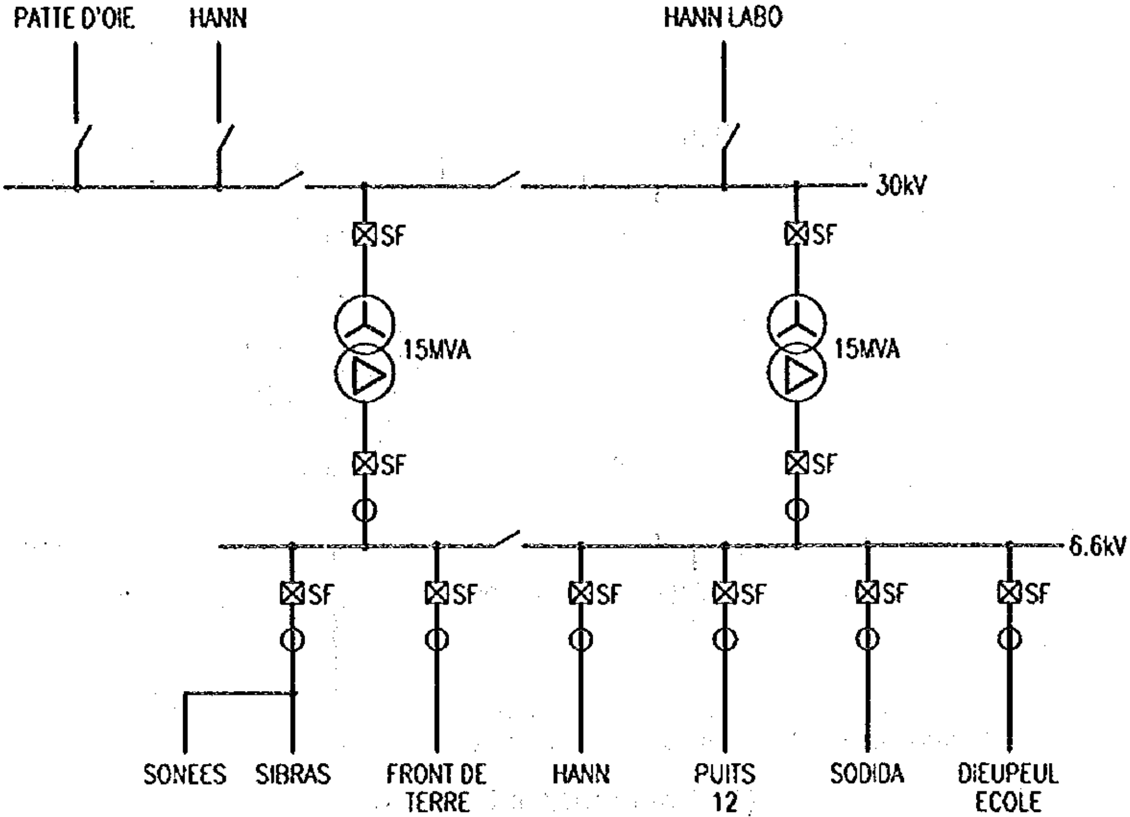


Fig. 3.4-1 Single Line Diagrams (2/5)

(3) Poste 30/6.6kV Usine des Eaux



(4) Poste 30/6.6kV Thiaroye

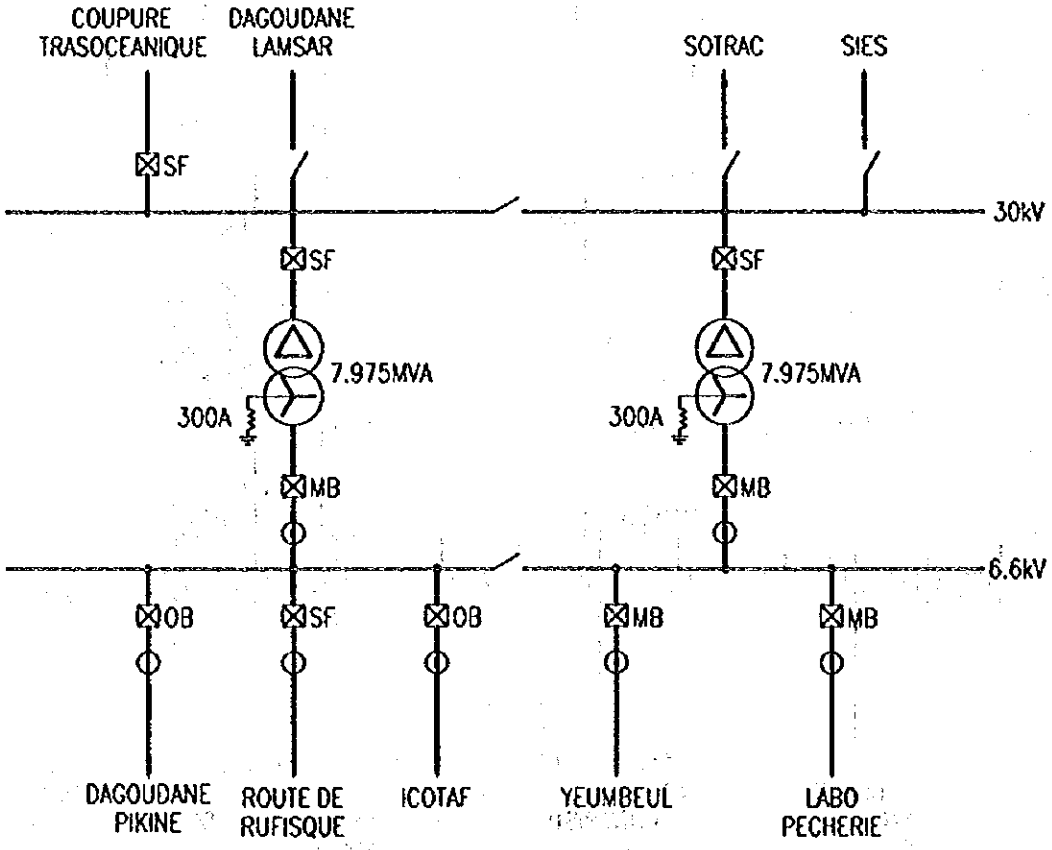
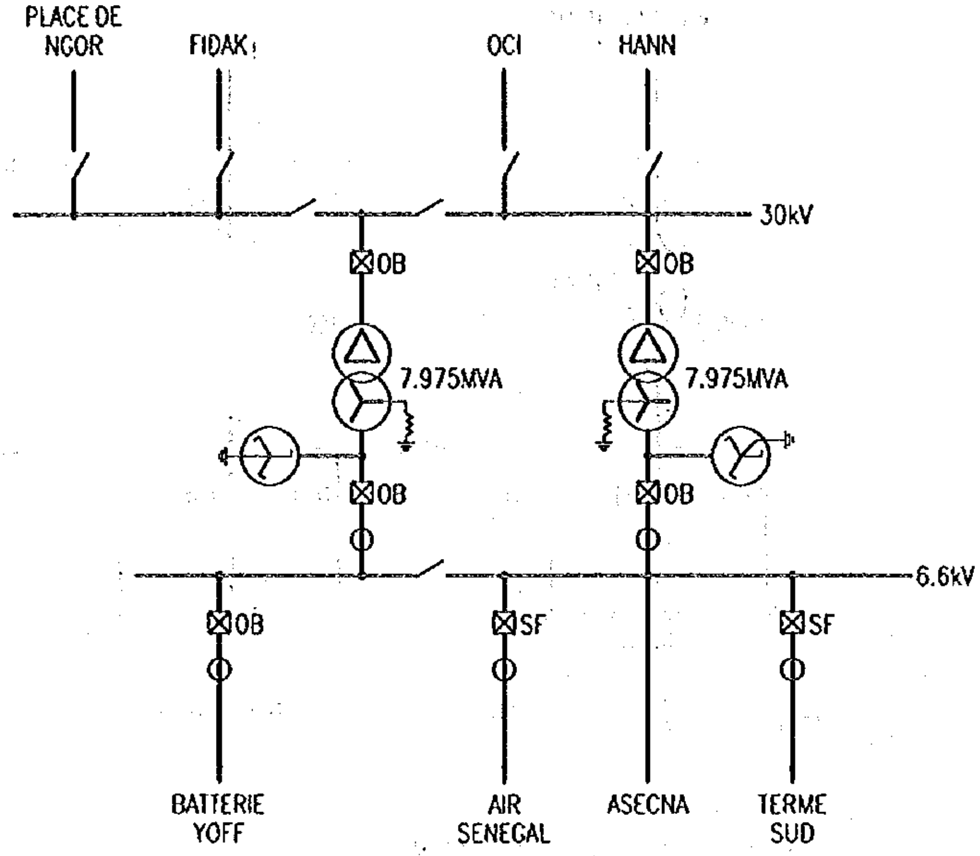


Fig. 3.4-1 Single Line Diograms (3/5)

(5) Poste 30/6.6kV Aéroport Yoff



(6) Poste 30/6.6kV Centre Ville

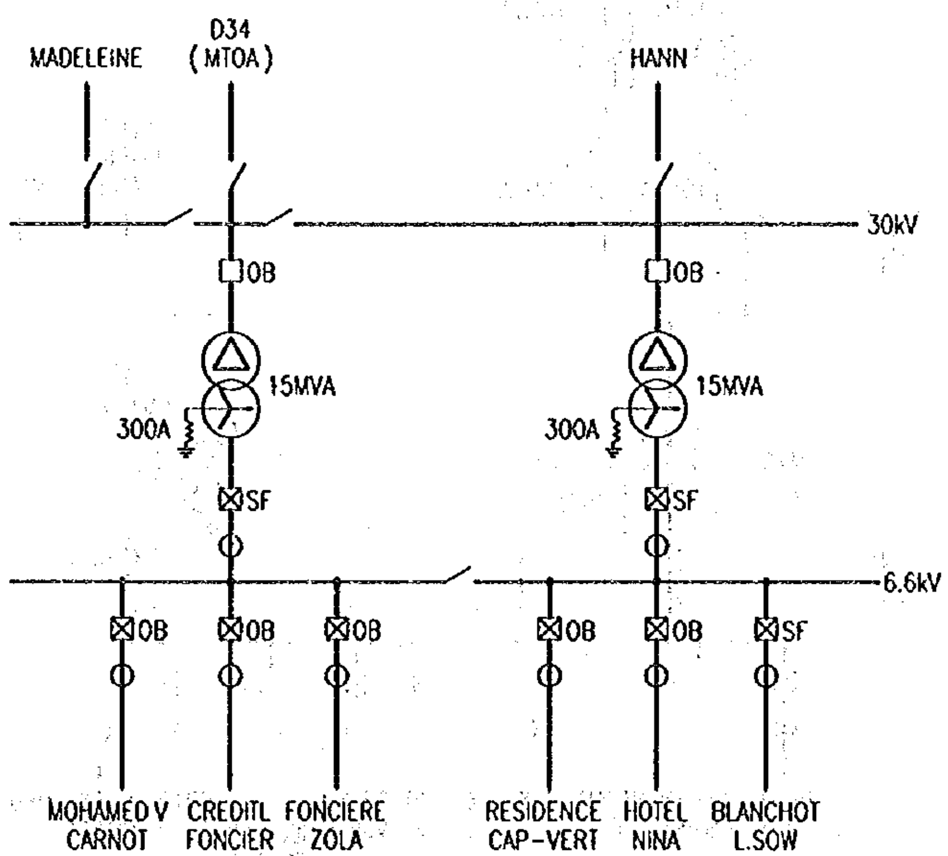
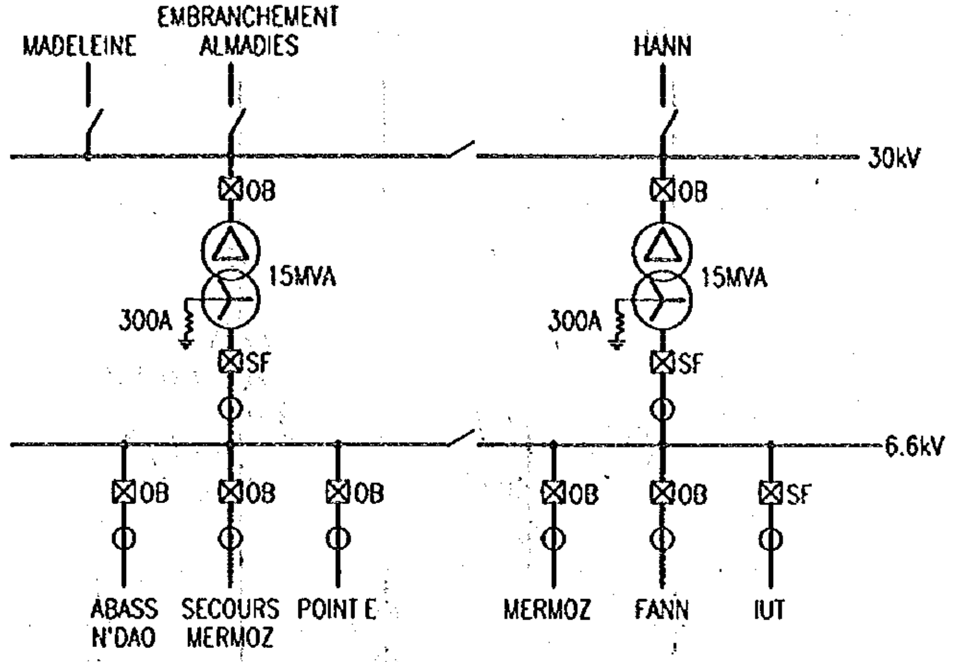


Fig. 3.4-1 Single Line Diagrams (4/5)

(7) Poste 30/6.6kV Université



(8) Poste 90/30/6.6kV Bel-Air

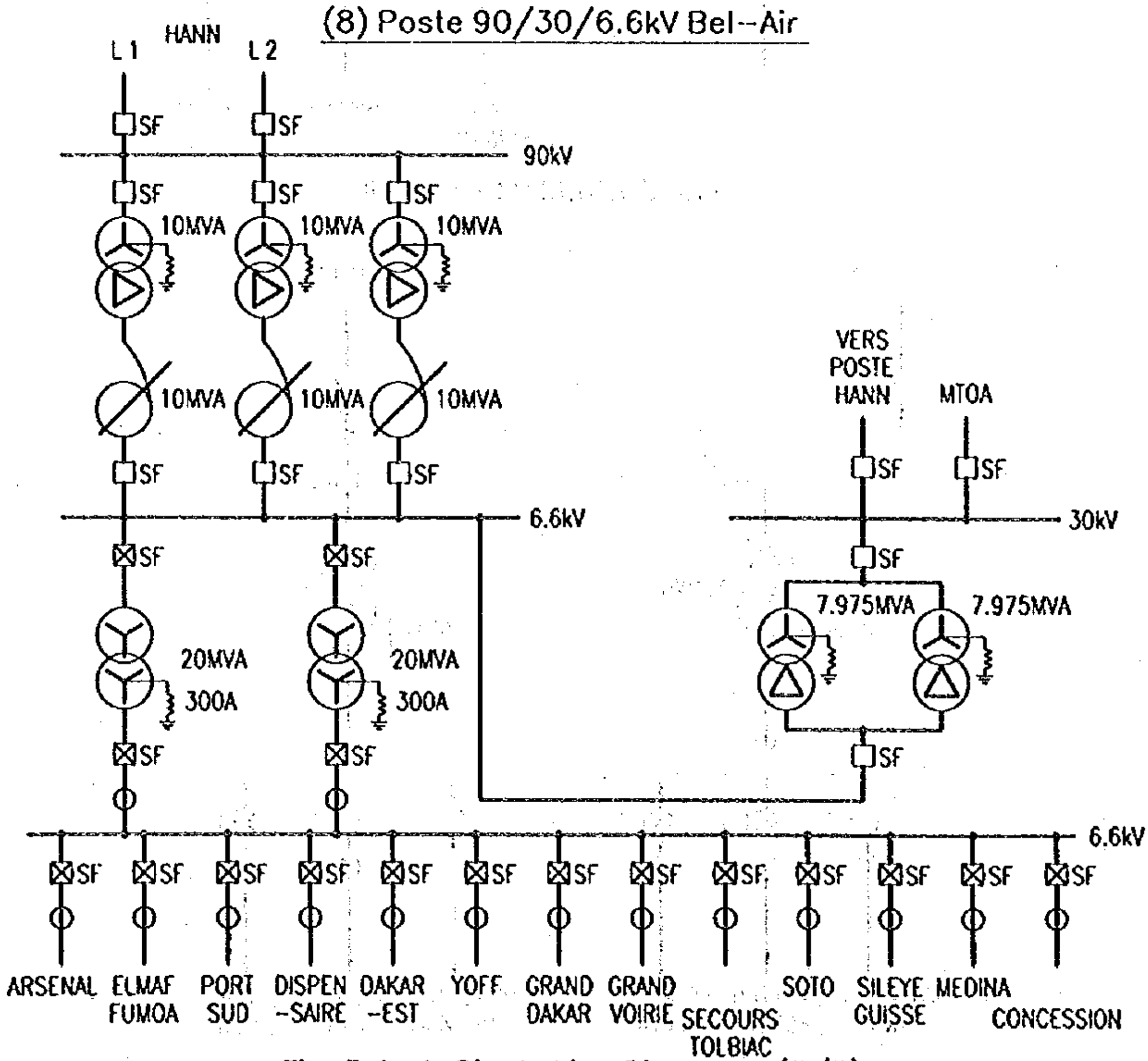


Fig. 3.4-1 Single Line Diograms (5/5)

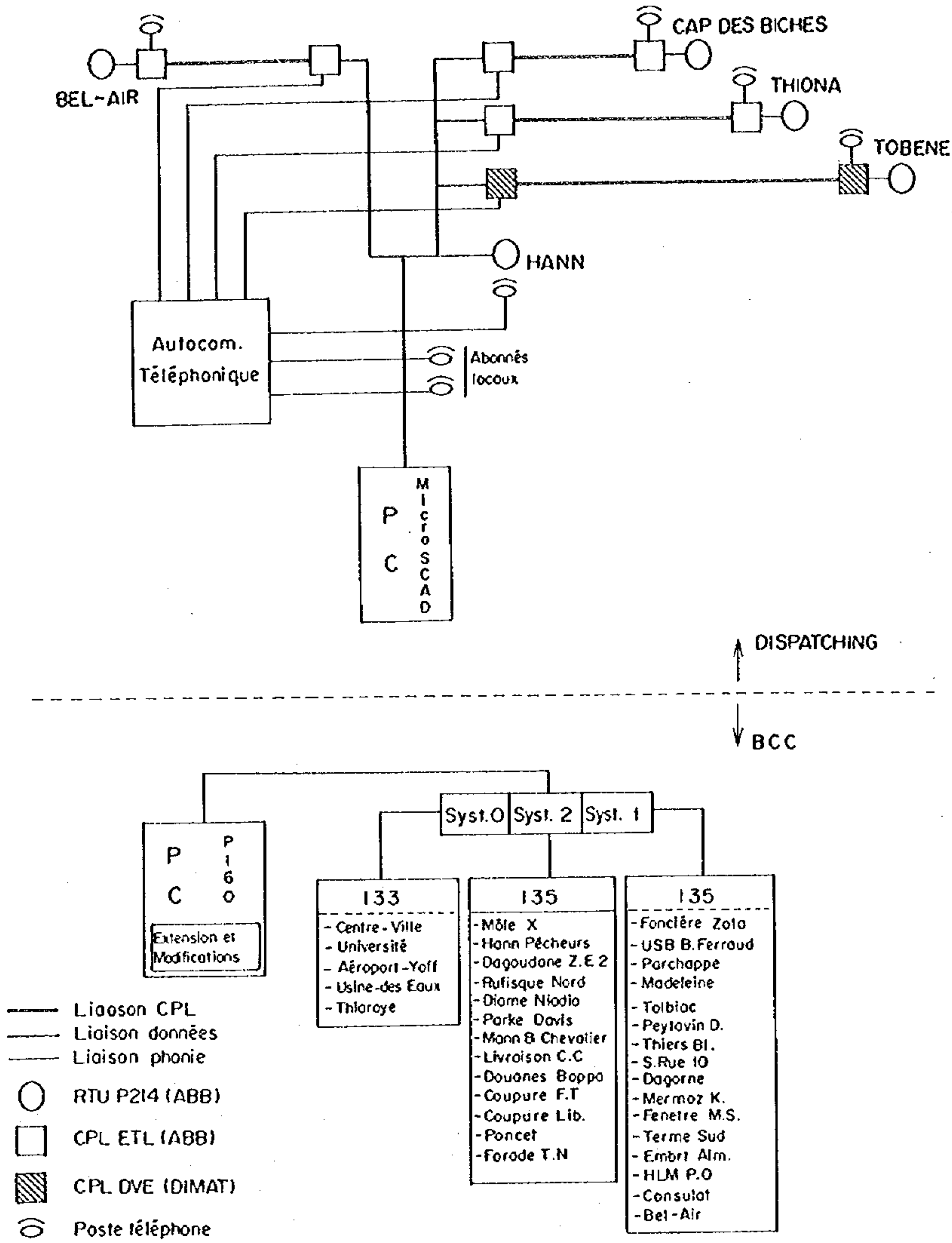


Fig. 3.5-1 Communication Network

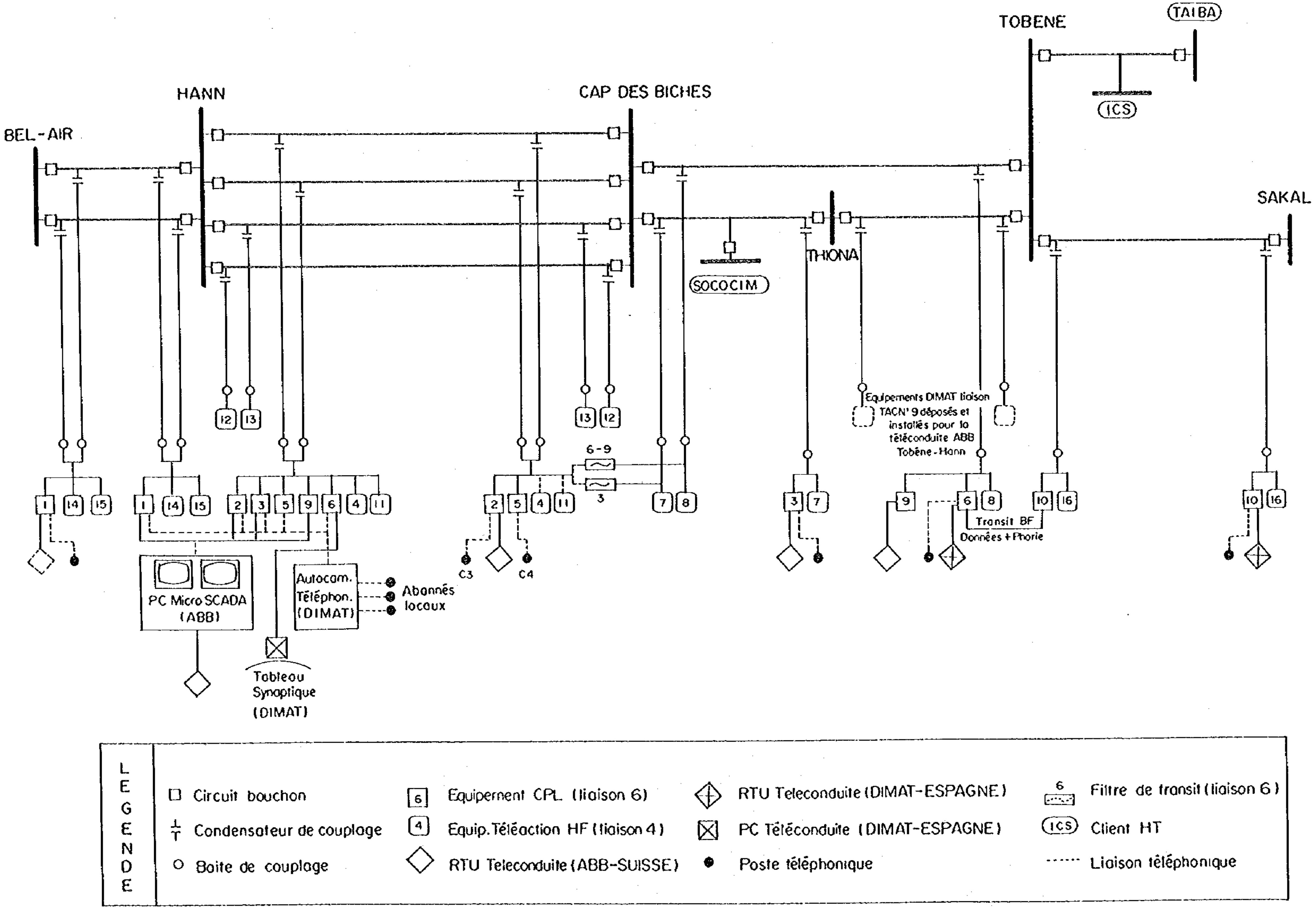


Fig. 3.5-2 PLC Communication Network

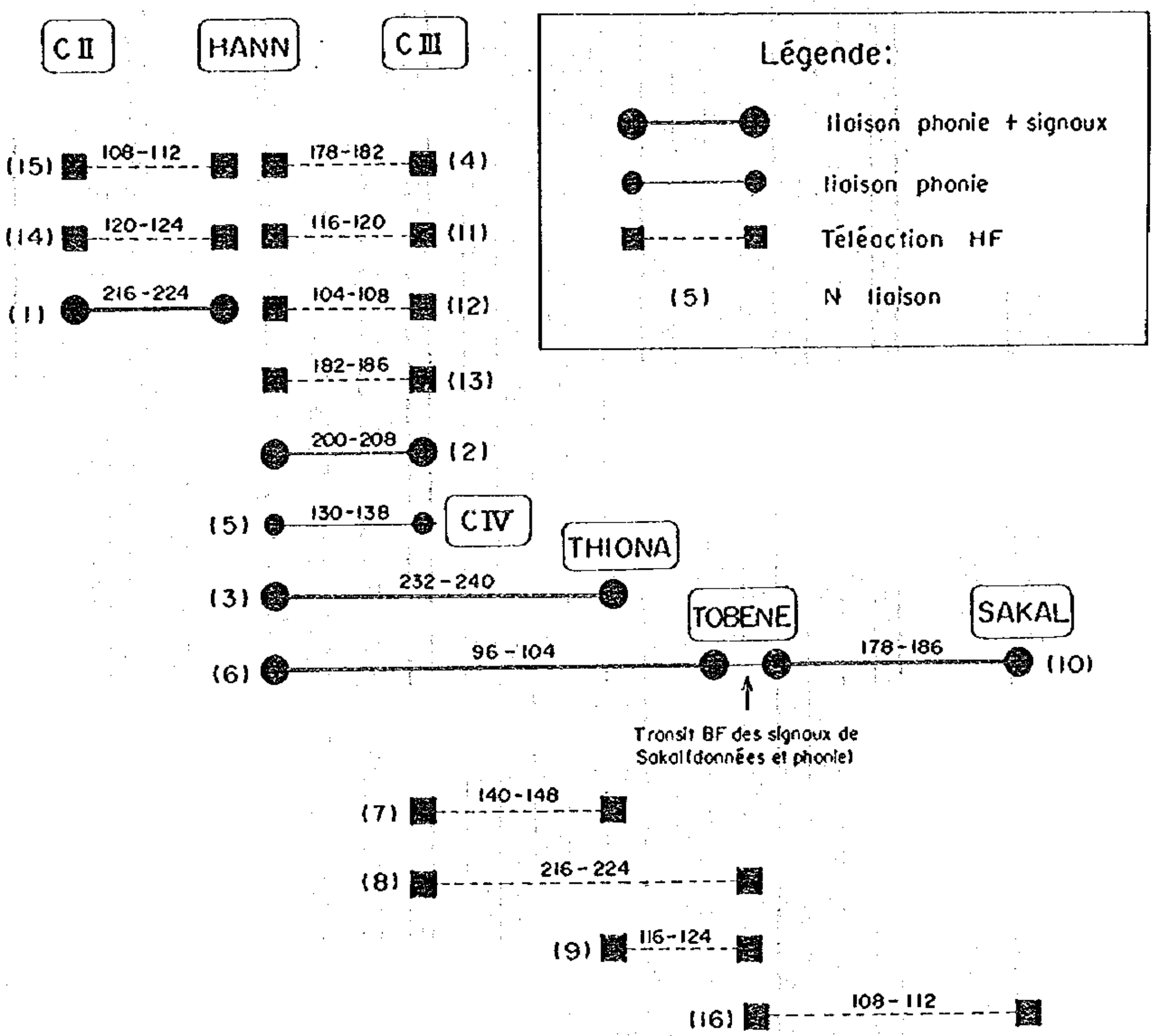


Fig. 3.5-3 PLC Frequency Assignment (kHz)

PROGRAMME JOURNALIER DE LA PRODUCTION DU R. I.

JOURNEE DU : SAMEDI 27 AOUT 1994

HEURES		00–01	01–02	02–03	03–04	04–05	05–06	06–07	07–08	08–09	09–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	18–19	19–20	20–21	21–22	22–23	23–24	TOTAL (MW)
BEL	CI	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	28
	CII	30	28	28	25	25	24	15	16	16	21	24	25	23	23	21	20	21	22	24	28	32	32	30	28	581
AIR	TOTAL	34	32	28	25	25	24	15	16	16	21	24	25	23	23	21	20	21	22	24	32	36	36	34	32	609
CAP	CS/TV	50	50	50	50	49	50	58	52	53	55	55	54	53	53	52	50	50	50	51	53	58	58	58	57	1269
DES	CS/TG	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	11	8	7	46
BICHES	CIV	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	360
	TOTAL	72	65	65	65	64	65	73	67	68	70	70	69	68	68	67	65	65	65	66	68	86	84	81	79	1675
KAHONE		6	6	6	6	6	5	5	6	6	5	5	6	6	6	4	4	4	5	6	6	9	9	9	8	144
SAINT LOUIS		3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	19
PRODUCTION		115	105	101	96	95	94	93	89	90	96	99	100	97	97	92	89	90	92	96	106	134	132	127	122	2447
PREVISION		115	105	101	96	95	94	93	89	90	96	99	100	97	97	92	89	90	92	96	106	134	132	127	122	2447
DEFICIT		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REALISATION																										
HEURES		00–01	01–02	02–03	03–04	04–05	05–06	06–07	07–08	08–09	09–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	18–19	19–20	20–21	21–22	22–23	23–24	

OBSERVATIONS

CI : 1 GR 00H–02H et 19H–24H; GR 105 PMAX: 04,5MW EN DO ; GR 106 :INDISPONIBLE.

CII : 4 GR 00H–06H ET 19H–24H;3 GR 06H–19H;GR 101(05MW);GR 102(09MW);GR 103(11MW);GR 104(07MW) .

CIII : 3 GR 00H–24H;GR 301 (26MW):CONDENSEUR 00H–06H;GR 302:(20MW);GR 303(15MW); TAGI(15MW);TAGII(16MW)
TAG I : 00H–01H ET 20H–24H ; TAGII :

CIV :1 GR 00H–24H ; GR 401 : PMAX 15,5MW ; GR 402: INDISPONIBLE.

SAINT LOUIS : 2 GR 00H–06H ET 20H–24H;GR 87(1,5MW);GR 82(1,5MW);GR 88(1,5MW) ;GR 83:INDISPONIBLE.

KAHONE: 3 GR 00H–24H;GR 93(3MW);GR 149(3MW);GR 94(3MW) ET GR 150 :INDISPONIBLE

TAIBA : BAISSE DE 14MW DE 00H00–24H00

Fig. 3.5-4 Generation Schedule

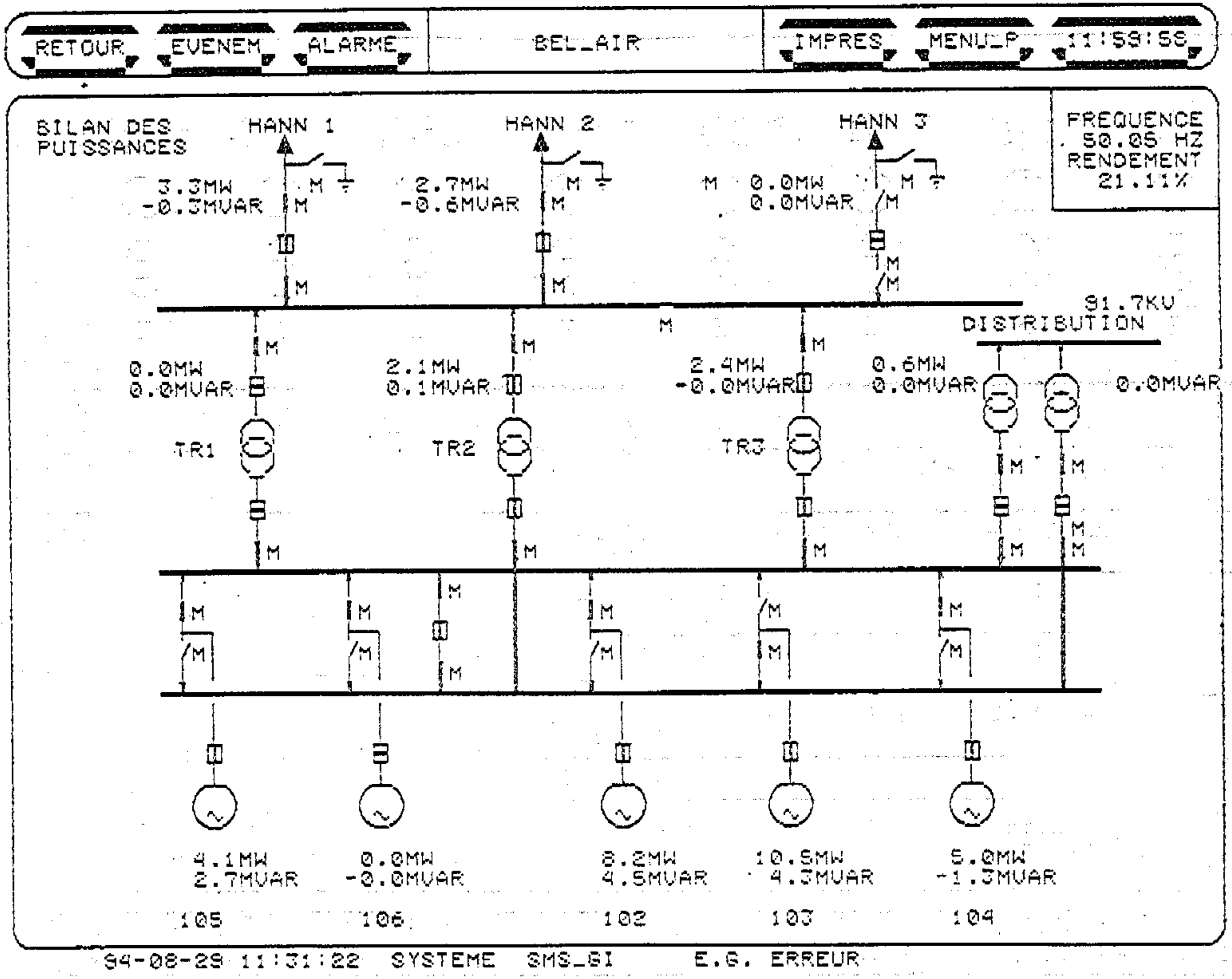


Fig. 3.5-5(1) Station Overview Display (Bel-Air)

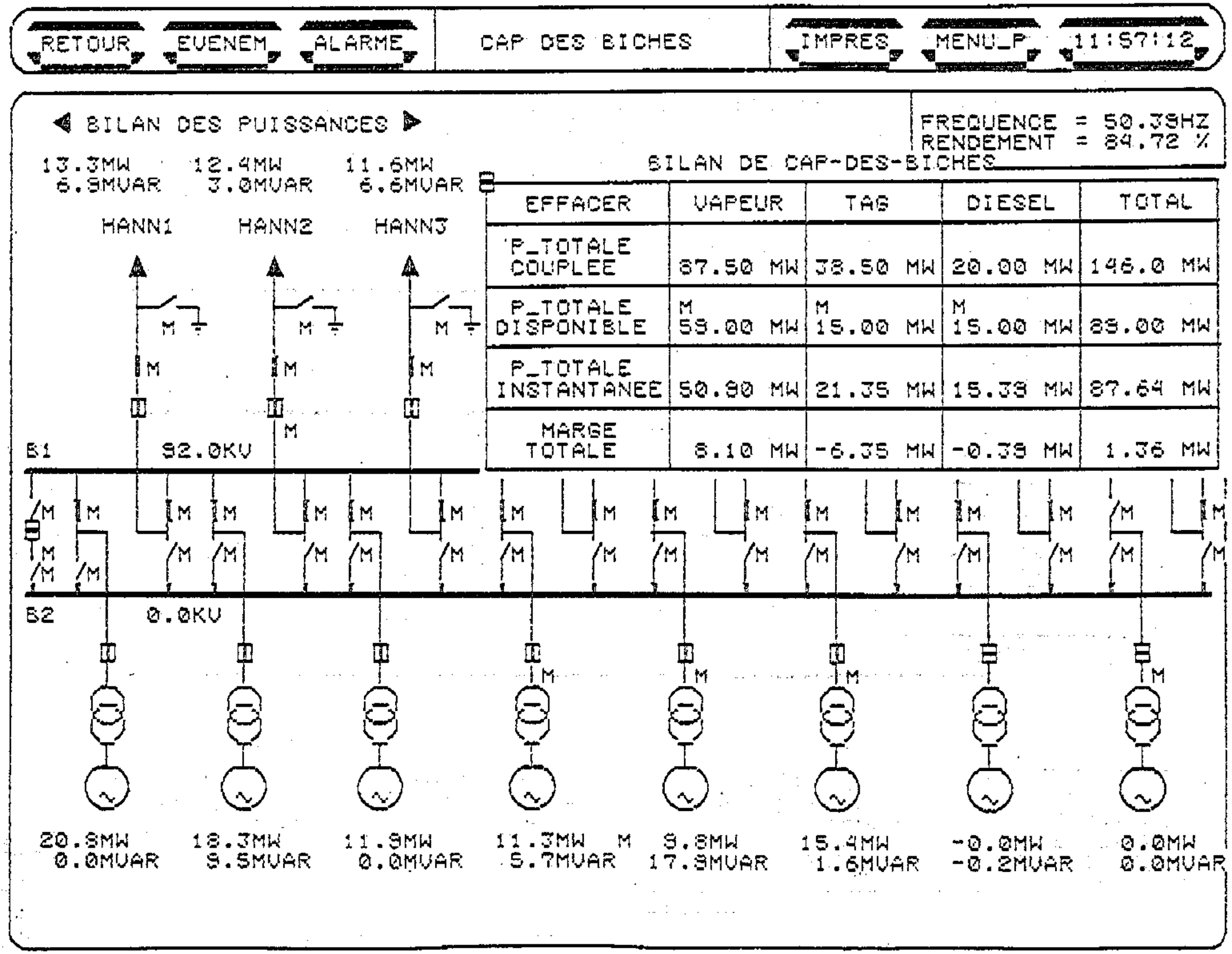


Fig. 3.5-5(2) Station Overview Display (Cap des Biches)

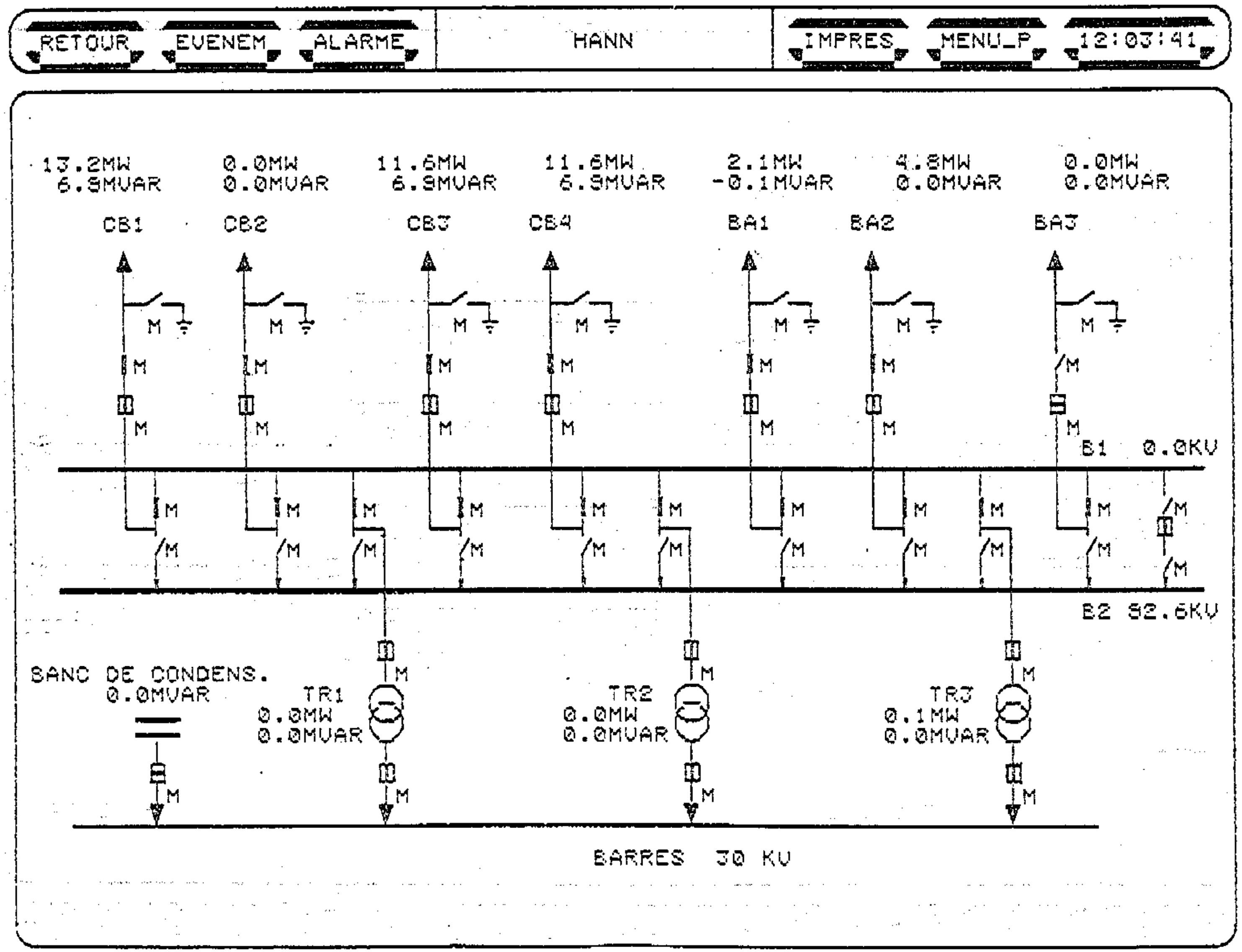


Fig. 3.5-5(3) Station Overview Display (Hann)

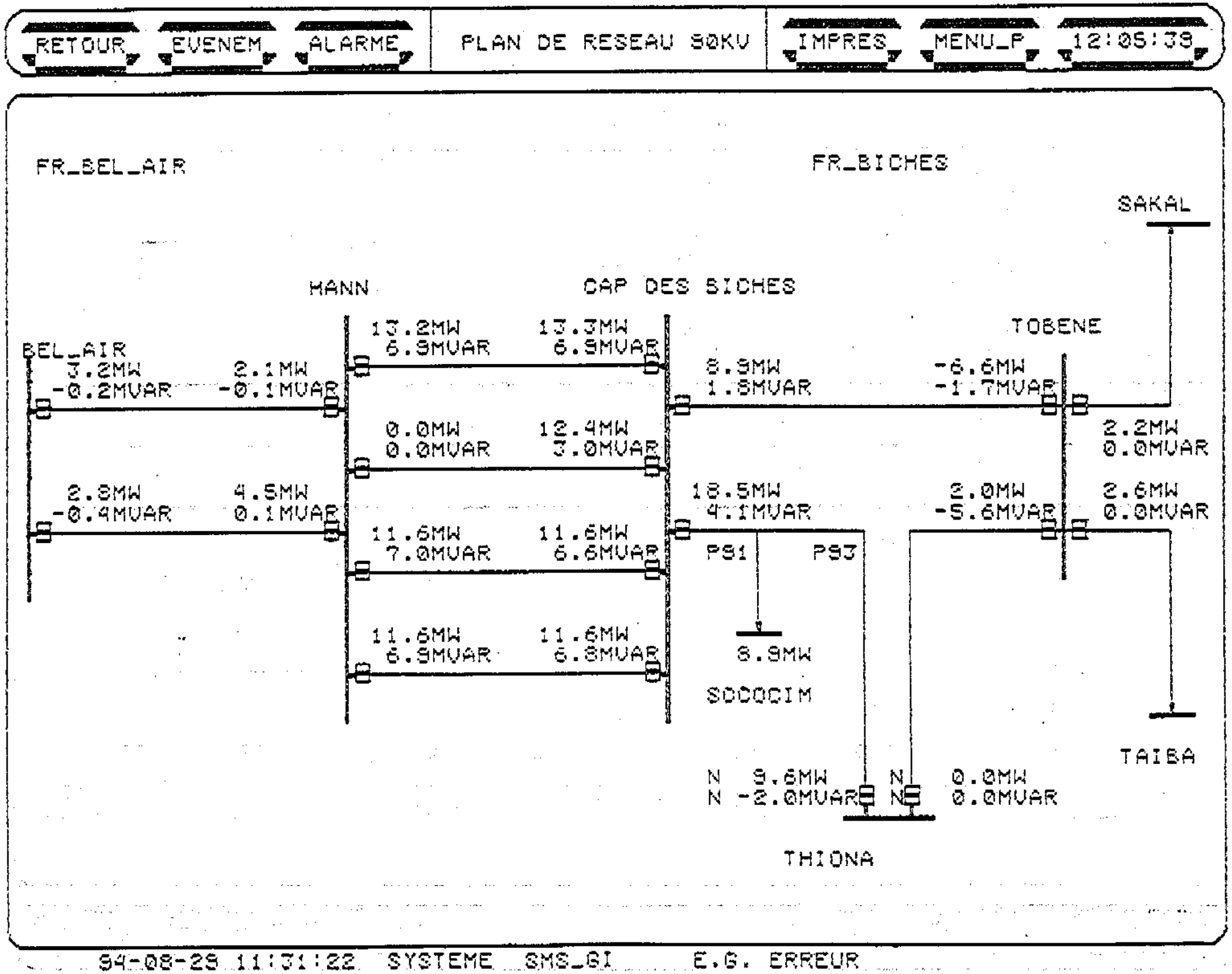


Fig. 3.5-5(4) Transmission Line Overview Display

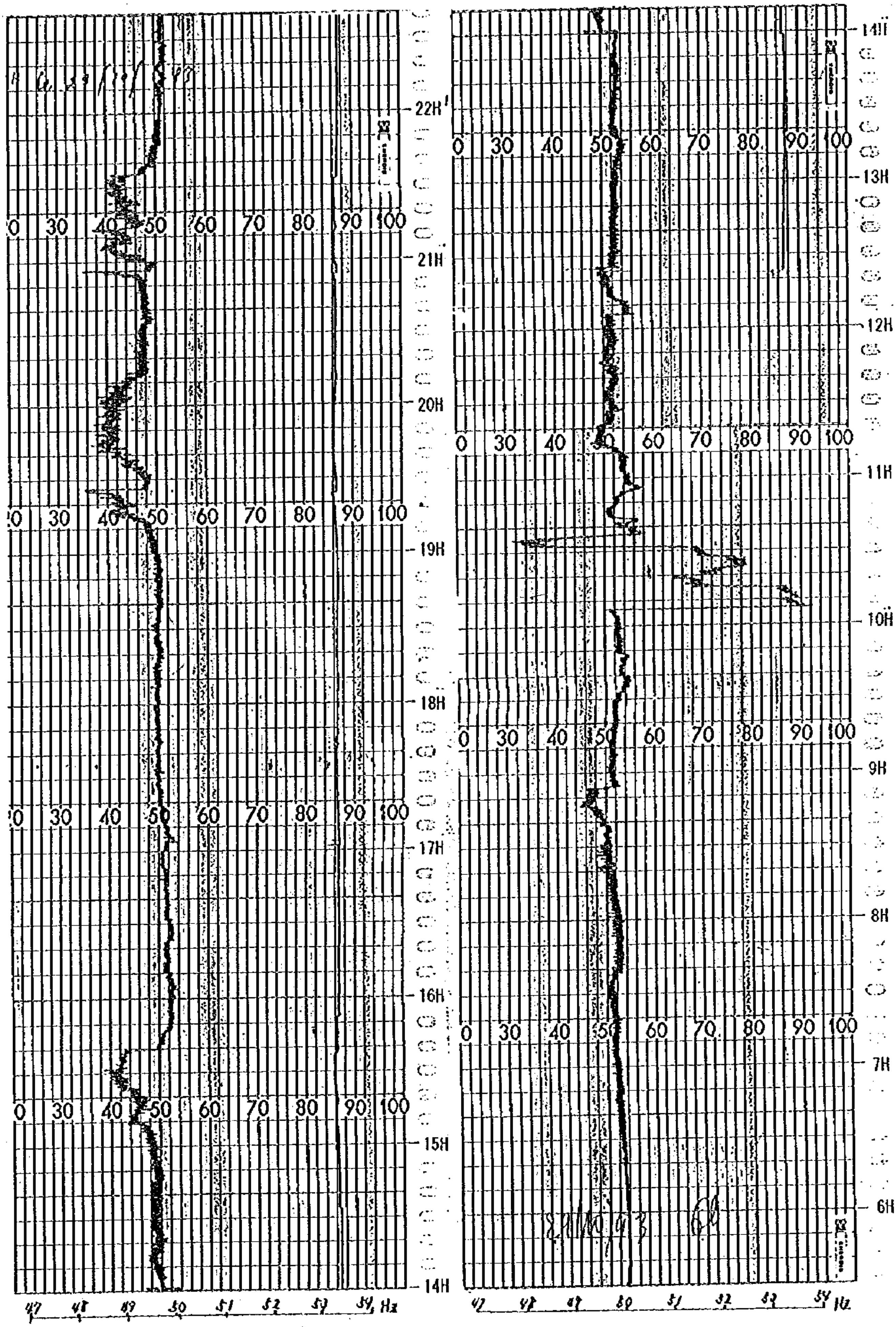


Fig. 3.5-6 Frequency Record Chart

CHAPTER 4

PRESENT SITUATION

OF

EXISTING POWER GENERATING FACILITIES

CHAPTER 4 PRESENT SITUATION OF EXISTING POWER GENERATING FACILITIES

4.1 Operation of Power Generating Facilities

4.1.1 Operational Records

SENELEC's power generating facilities, which are all thermal power generating facilities as described in Section 3.1.2, consist of the steam turbine, the gas turbine and the diesel unit. The operational records of the facilities in 1993 are described below. Table 4.1.1-1 shows the operational records of various power generating units at Bel-Air and Cap des Biches power stations. Table 4.1.1-2 shows fuel oil price in April, 1994.

(1) Bel-Air Power Station

a. CI: Diesel unit (G105) (1991)

The diesel unit (G105), installed by grant aid from Japan, started its operation in 1991. The annually possible generated energy by this facility, which uses heavy oil and diesel oil as fuels, is 43.8 GWh in terms of the rated output and 39.42 GWh in terms of the economical output, occupying about 2% of the possible generated energy of the RI system. The average output is 4,023 kW, thus close to the economical output 4,500 kW. This means that the diesel unit is maintaining almost a constant level of output, as can be seen from other power generation records.

The comparative short operation time in 1993 is due to trouble of the fuel supply system. Since the beginning of 1994, however, the diesel unit has already achieved a long-time operation as a base load generating facility. As the operation status indicates, the power factor at the time of survey is full 80% of the rating. From this fact, it is understood that, as a power plant close to the load center, the diesel unit is more like a power generating facility capable of fine adjustments rather than relying on coarse tap adjustment of voltages by the transformer.

b. CI: Diesel unit (G106) (1991)

As with G105, the diesel unit G106 is another power generating facility installed with grant aid from Japan. At the time of the survey, it was being overhauled by SENELEC technicians under the guidance of Japanese technical experts. The two units are based on the same specifications. The average output is 4,185 kW, thus even closer to the economical output 4,500 kW when compared with G105. As can be determined from other power generation records, this unit is also maintaining almost a constant level of output. Considering its small output scale, this unit is not used as a power generating facility for absorbing load fluctuations.

c. C II: Steam turbine (G101) (1953)

This is the oldest among SENELEC's power generating facilities.

Its operation was continued more than 40 years ago from 1953. Although its operation was stopped for the past several years, delay in introduction of new facilities caused it to restart its operation at 5 MW against the rated output of 12.8 MW when the repair work was finished in 1994. This heavy oil fired boiler has rather small output as a steam turbine. As its service life and operating time have already exceeded their respective limits, the facility should be abandoned as soon as possible.

d. C II: Steam turbine (G102) (1955)

This turbine is the oldest next to G101. With the same specifications as G101, G102 started its operation in 1955. Its actual limit output is 9 MW as to the rated 12.8 MW. Its fuel cost is 18.24 FCFA/kWh - the highest especially because data on G101 is unclear. The capacity utilization ratio of the unit is rather high as 60% though it is old facility. Both its service life and operating time have exceeded their respective limits, thus requiring abandonment as soon as possible. The average output is 6,378 kW, thus varying from the actual limit output of

9,000 kW. This shows that the steam turbine is used as the absorption source of the short period and sustained loads of the load fluctuation from its response speed.

e. C II: Steam turbine (G103) (1959)

With the same specifications as for G101, this power generating facility started its operation in 1959 with the rated output 12.8 MW. Although the turbine is an aged facility, its actual limit output is 11 MW and is still operating causing no major problems. Its annual generated energy is 35.1 GWh, occupying about 3.9% of the total energy. As with G102 unit, its fuel cost of 18.23 FCFA/kWh is rather high among steam turbines. The average output is 7,316 kW, thus varying from the actual limit output of 11,000 kW. This shows that, as with G102 unit, the steam turbine is used as the absorption source of the short period and sustained loads of the load fluctuation from its response speed.

f. C II: Steam turbine (G104) (1961)

This turbine is the same facility as G101 which started its operation in 1961. As 1993, its output was 5 MW as to the rated 12.5 MW; however, in 1995, it is said to be recovered up to 10 MW. Both the capacity utilization ratio, which is 71.8%, and the generated energy of 47 GWh (5.2% of the total generated energy of 901.2 GWh) show that the facility is highly used. The average output is 7,483 kW, thus exceeding the actual limit output of 5,000 kW. As with G102 unit, this steam turbine is used as the absorption source of the short period and sustained loads of the load fluctuation from its response speed.

(2) Cap des Biches Power Station

a. C III: Gas turbine (TAG1) (1972)

When the operating records of the gas turbine TAG1 is looked at, it can be said that the actual limit output of 15MW, the capacity utilization ratio of 61.2%, and the annual generated energy of 45.6 GWh (about 5% of the total generated energy of 901.2 GWh) not only play the role of absorption power generation facilities of the load fluctuation in peak load but as power sources of the intermediate load band. Fuels include the diesel oil and the natural gas; and the fuel cost is 46.4 FCFA/kWh, which is rather high.

Introducing a new gas turbine with high load following capability is considered indispensable in lifting the supply restrictions from the peak load band. However, it is necessary to handle the situation by utilizing the characteristics of the turbine if the rising and trailing edges of the peak load are drastic while using the load responsiveness of the diesel facility to absorb the fluctuating load band if its fluctuation is mild, thus broadening the range of responses by the gas turbine.

b. C III: Gas turbine (TAG2) (1984)

When compared with TAG1 unit, it can be said that its actual limit output of 19 MW, capacity utilization ratio of 36.3%, and annual generated energy of 32.4 GWh (about 3.6% of the total generated energy of 901.2 GWh) are enabling the turbine to play the role of absorption power generating facility of the load fluctuation in peak load.

The unit uses diesel oil as its fuel; and the fuel cost is the highest among all the power generating facilities. To be able to respond to load fluctuations throughout the year, one more gas turbine generating facility is desirable so that when one turbine has failed as the facility for absorbing the peak load, the other can take over. As the operation of a new turbine will start from 1995, it is highly hoped that this will contribute to solving the problem of supply shortage.

c. C IV: Diesel unit (G401) (1990)

The operating records of diesel G401 unit include its actual limit output of 20 MW, capacity utilization ratio of 76.3%, annual generated energy of 111.5 GWh reaching about 12.3% of the total generated energy of 901.2 GWh. Together with diesel G402 unit, this diesel boasts of the lowest fuel cost of 10.98 FCFA/kWh. Due to its fuel cost advantage, it is given the highest priority as the base load in generation planning.

The average output is 16,680 kW, varying from the actual limit output of 20,000 kW. This is to absorb the portion of the load fluctuation when the gas turbine could not absorb it or when the gas turbine was out of operation, considering that the diesel power generating facility has the ability of governing operation. Especially when the load declines rapidly as with the light load during the midnight band (occurring between 2 a.m. to 3 a.m.), this diesel is used as the absorption source of the fluctuated portion.

d. C IV: Diesel unit (G402) (1990)

The operating records of diesel G402 unit include its actual limit output of 20 MW, capacity utilization ratio of 77.3%, annual generated energy of 117.3 GWh reaching about 13% of the total generated energy of 901.2 GWh. Together with diesel G401 unit, this diesel boasts of the lowest fuel cost of 10.56 FCFA/kWh and thus is given the highest priority as the base load in generation planning.

G402's annual generated energy of 117.3 GWh is compared to the total generated energy of G102/103/104 of Bel-Air. Therefore, together with its high capacity utilization ratio, its impact on other facilities in case of unexpected faults is large.

The average output is 17,318 kW, varying from the actual limit output 20,000 kW. As with G401 unit, this is to absorb the portion of the load fluctuation when the gas turbine could not absorb it or when the gas turbine was out in operation, considering that the diesel power generating facility has the ability of governing operation.

e. C III: Steam turbine (G301) (1966)

The supply restriction due to shortage in power generation in the

RI system is judged by viewing G301's operating records. Its actual limit output is 27.5 MW; its capacity utilization ratio is 85.6%, and its annual generated energy of 170.6 GWh has reached about 18.9% of the total generated energy of 901.2 GWh. Its fuel cost of 12.74 FCFA/kWh is also the cheapest next to G401/402.

Especially, its annual operation time of 7,497 hours makes it impossible for the turbine to afford the annually required 1,344 hours for maintenance including detailed inspection. As of 1993, this power generating facility boasted of the largest output. Therefore, together with its high capacity utilization factor, its impact on other facilities in case of unexpected faults is large.

The average output is 17,318 kW, varying from the actual limit output of 27,500 kW. Blessed also by its actual limit output in 1993 being the largest, this indicates that the turbine is being used as the absorption source of comparatively long-period loads.

f. C III: Steam turbine (G302) (1975)

Its actual limit output is 20 MW; its capacity utilization ratio is 90.8%; its annual generated energy of 166 GWh has reached 18.4% of the total generated energy of 901.2 GWh; and its fuel cost of 13.16 FCFA/kWh is the lowest next to that of G301 unit. Its annual operation time of 7,954 hours is the longest among all the facilities, thus making an adequate maintenance work impossible. The actual limit output being 20 MW as to the rated capacity of 30 MW indicates that the facility is forced to continue its operation to maintain the power supply. Therefore, it is required that a detailed inspection is made and the operation be returned to the rated output at the earliest possible time. The average output is 20,867 kW, which indicates that the output has been almost constant as to the actual limit output of 20,000 kW.

g. C III: Steam turbine (G303) (1978)

At the time of the survey, this turbine was being overhauled for the purpose of detailed inspection because the actual limit output was reduced to 15 MW, which is half of the rated output of 30 MW. However, its capacity utilization ratio is 83.6%; its annual generated energy of 115.5 GWh has reached 12.8% of the total generated energy of 901.2 GWh; and its low fuel cost of 13.55 FCFA/kWh is next to that of G302 unit.

After the detailed inspection, the facility is expected to be recovered to its rated output operation. Its annual operation time of 7,237 hours indicates its capacity utilization ratio is the highest next to G301 unit.

The combined generated energy of 451.9 GWh of three C III power generating facilities amounts to 50% of the total generated energy of 901.2 GWh. Judging from the output scope and the annual generated energy, it can be said that their impact on other facilities is large. The average output is 15,944 kW, which indicates that the output has been almost constant as to the actual limit output of 15,000 kW.

4.1.2 Maintenance Performance Records

(1) Standard Maintenance and Operational Criteria

The standard maintenance and operational criteria for both Bel-Air and Cap-des-Biches power generating facilities are defined in Table 4.1.2-1. As can be judged from the operational performance records, they are in a situation difficult for routine maintenance partly due to shortage in the supply capacity.

Such a situation difficult for regular implementation of maintenance produces various negative results such as lowering of the power output and acceleration of equipment deterioration.

(2) Annual Operating Time and Maintenance

a. Annual operating time

For adequate maintenance and operation of power generating facilities, it is important to standardize the capacity utilization ratio for each year, thus avoiding excessive operation.

According to Table 4.1.2-1, three cases of operation are assumed from the standard maintenance and operational criteria. Case 1 applies to cases whose annual capacity utilization ratio is 70%, thus requiring the least amount of maintenance/stop. Case 2 applies to cases whose annual capacity utilization ratio is 75%, requiring medium term detailed inspections. Case 3 applies the cases whose capacity utilization ratio is 80%, requiring long-term detailed inspections.

Table 4.1.2-2 shows the number of inspection hours and days required assuming that inspections are conducted in a series on the power generating facilities at Bel-Air and Cap-des-Biches. According to this Table, case 1 requires the annual operation of 6,132 hours totaling 252 days; case 2 requires 6,570 hours amounting to 399 days; and case 3 requires 7,008 hours totaling 651 days. If detailed inspections are delayed as in case 3, it will lead to situations in which almost two facilities have to be stop simultaneously for inspection purposes.

According to the performance records of G302 and G303 of Cap-des-Biches in 1993, their actual limit outputs are 20,000 kW and 15,000 kW as against the rated output of 30,000 kW. It requires about five months to halt the generator and conduct repair work on the super heater. This is "5 months x 30 days x 24 hours = 3,660 hours," thus occupying 59% (capacity utilization ratio) of the operating time of 5,160 hours. The fact that their respective actual capacity utilization ratio are 90.8% and 82.6% means that they are major facilities for the RI system. In addition, considering the size of the impact which will be caused by stopping facilities of the largest capacity for a long period of time, it is understandable that they cannot be stopped even when their actual limit outputs are deteriorated. Fig. 4.1.2 shows a Annual maintenance schedule.

b. Annual generated energy

The relationship between the annual generated energy and the annual operating rate is important. Being equipped with a necessary reserve capacity is a precondition for operations at an adequate capacity utilization ratio. The fact that the actual capacity utilization ratio of G301, G302, and G303 in 1993 are extremely high means that the supply restraint on the kW output in the peak load and the supply shortage in the generated energy coexist; therefore, it is necessary to improve the present situation as soon as possible.

4.2 Operation of Transmission and Distribution Line Facilities

(1) Transmission Line Facilities

The transmission capacity is adequate for the 90kV transmission line in the Dakar region. As there are two or three routes installed between the grid substations, it may be concluded that the equipment provides a high reliability of supply.

The Dakar region is subject to salt corrosion problems due to air salinity so that regular cleaning of the insulators on the steel towers is being implemented once a year. On the transmission lines between Cap des Biches and Hann (one circuit), the overhead ground wire have been removed, and to protect the conductors from direct strokes of lightning, it is recommended to install the overhead ground wire.

(2) Distribution Line Facilities

a. 30kV distribution network

The distribution lines leaving the grid substations (90/30kV) are connected to other distribution substation through section switches. Practical service operation is on a normally open type loop basis. The disconnecting point is the distribution substation.

b. 6.6kV distribution network

Similarly to the 30kV distribution network, service operations takes place in a normally open type loop. For the 30kV distribution lines, the loop is formed between different substations, however, for the 6.6kV distribution lines, loops are formed not only between different distribution substations but also between the different distribution feeders run off from the same distribution substation. The disconnecting point is the distribution poste.

c. Installation of lightning arresters

The underground cables at the connecting point of the 30kV overhead lines and the underground cables are protected by gaps provided on insulator strings. The flash-over characteristics of these gaps are dependent on atmospheric pressure, ambient temperature and humidity and are thus not stable. To protect the underground cables from dielectric breakdown of cable insulation due to lightning surges, it is thus recommended to install lightning arresters on the connecting point between the overhead and underground lines.

d. Vehicles for restoration/repair work

As stated in section 4.6, there is a high incidence of fault occurring on the distribution lines. To minimize power losses (supply restriction energy), it is essential to perform rapid repair work to restore the power supply service. The main problem currently faced in the execution of repair work is the lack of vehicles required for transporting the maintenance operators and the necessary materials. Even the early detection of faults and the availability of maintenance staff on standby alert will not solve the problem and the line cannot be restored to normal service operation unless the means of transport are available to move personnel and materials. It is therefore concluded that it will be important to expand the vehicle fleet with vehicles equipped with communications equipment used for repair/line restoration work. This will be as important as the power facilities in resolving the problems currently faced by SENELEC.

4.3 Demand and Supply Balance

4.3.1 Quantity of Energy Consumption

(1) Outline

During the six years from 1975 until 1981, Senegal's power consumption increased from 362.19 GWh to 519.44 GWh on the RI system at the rate, expanding proportionally at the annual ratio of 6.2 % on the average. The power consumption after this period, however, repeated ups and downs, reflecting the slack especially in the primary industry and notably in the field of agriculture. In general, during the 18 years from 1975 until 1993, the power consumption increased at the annual average rate of 3.74 % from 362.19 GWh to 687.0 GWh; and, during the 7 years from 1986 until 1993, which showed a comparatively smooth GDP growth, the average annual increase was at the rate of 3.16 % from 553.16 GWh to 687.0 GWh.

(2) Power Consumption by Category

Power consumption by category is generally classified into two major categories in terms of the power types: one is the power demanded for public livelihood, which consists of the residential, commercial and the low voltage power; and the other is the power demanded for industrial purposes, which consists of the high voltage contract, large industrial and others. As a way of determining the trend of the quantity of the power consumption, SENELEC divides it into the low voltage demand, the medium voltage demand and the high voltage demand. Table 4.3.1 shows the growth of energy consumption by category from 1975 until 1993 as measured in accordance with this method and is summarized below. And, Graph 4.3.1, shows the annual evolution of the low voltage demand, the medium voltage demand, and the high voltage demand on the RI system as well as those of the low voltage demand and the medium voltage demand (no high-voltage demand) on the Saint-Louis and Kaolack systems. As is clearly shown on the graph and the table in the following page, it is understood that the growth of the low voltage demand on the RI system is remarkably larger than the medium voltage and high voltage demands. This can also be understood from the facts that the electrification records of households increased to 23.8 % in

1991 from 20.3 % in 1988 and that 60 % of the 214,290 households electrified in 1993 belong to the Dakar area. Furthermore, judging from the construction situation of new housing estate in the suburbs of Dakar, it is expected that the demand will continue to grow in the future. The annual average growth rate of the low voltage demand in the Thies and Taiba areas is 9.53 % in 1975 through 1993 and 8.61 % in 1986 through 1993, exceeding that of the Dakar area. Hereafter, it is expected that the low voltage demand will shift its growth from the Dakar area to regional areas.

The shares in 1993 as well as the annual average growth rates in 1975 through 1993 and in 1986 through 1993 are shown in the table below.

As with the energy consumption of the RI system, the energy consumption by category of RGI system is classified into the low voltage demand, the medium voltage demand and the high voltage demand. And, its growth from 1975 until 1993 is summarized below. As with the RI system, the growth rate of the low-voltage demand continues to be high.

		Annual average growth rate	
Voltage class	Share in 1993	1975 ~ 1993	1986 ~ 1993
Low voltage	37.4%	6.31%	5.64%
Medium voltage	39.3%	2.43%	1.98%
High voltage	23.3%	5.93%	2.27%
Total	100.0%	3.74%	3.16%

As with the Saint-Louis and Kaolack systems, the energy consumption is classified into the low voltage demand and the medium voltage demand. As a result, the growth of the energy consumption by category from 1975 until 1993 is summarized as follows:

		Annual average growth rate	
Voltage class	Share in 1993	1975 ~ 1993	1986 ~ 1993
Low voltage	56.8%	8.47%	8.14%
Medium voltage	43.2%	13.39%	8.97%
Total	100.0%	9.87%	8.21%

4.3.2 Generated Energy

Table 4.3.1 shows the evolution by year of the generated energy since 1975, together with that of the energy consumption. The generated energy in 1993 was 987.93 GWh throughout Senegal; 901.2 GWh on the RI system; and 947.9 GWh on RGI system. The RI system, which is being operated in and around Dakar, occupies 91.2 % of the total national power generation.

According to the power generation records on the RI system in 1993, the total generated energy was 901.2 GWh, the station service use energy was 61.2 GWh, and the energy at the sending end was 840 GWh, thus showing that the energy consumption rate within the power plants was 6.8 %.

4.3.3 Transmission/Distribution Losses at the Sending End

In working out the transmission/distribution loss factors at the sending ends of RGI system, no records were available on the loss factor of station use of the power plant in each year. Therefore, assuming that the loss factor in 1993 is 13.4% based on its performance, the loss factors for 1979, 1981, 1985 and 1989 turned out to be 12.7%, 9.7%, 11.8% and 18.3% respectively, thus showing the trend of annual increase. As of 1994, this factor is assumed to be somewhere between 13 % and 14 %. Therefore, it is necessary to work for improvement of the transmission/distribution network to cope with loads which will increase hereafter.

4.3.4 Peak Load

The situation of peak load increase from 1975 until 1983 is also shown in Table 4.3.1. However, it is evolved by year not as the sending end but as the generating end. The increase on the sending end of the RI system is 143.2 MW (148.4 MW on RGI systems) in 1993, assuming that the station service energy consumption rate was 5%. The annual average growth rate of the RI system is 4.1% from 1975 until 1993, and 3.7% from 1986 until 1993. On the RGI system, the rate is 4.3% from 1975 until 1993, and 3.5% from 1986 until 1993. As will be explained in Section 4.4, this is so as result of influences by the supply restraints which started from 1975. The actual peak load values are greater than those shown on Table 4.3.1. Considering that the peak load restraint during the summer of 1993 - a cooperation extended to SENELEC by the fertilizer company Taiba - is about 10 MW, the peak load on the RI system is estimated to range from 155 to 160 MW (from the operational records in 1994, 151.6 MW on the RI system and 156.3 MW on the RGI system are recorded).

4.3.5 Sending End Load Factor

In working out the sending-end load factor on the RI system, records are not available on the yearly peak load of the sending end as was described in Section 4.3.4. Therefore, assuming that the station service use kW consumption rate is 5% and the kWh energy consumption rate is 6.5% based on its operational performance in 1993, the load factors for 1997, 1981, 1985, 1989 and 1993 turned out to be 68.5%, 67.3%, 66.6%, 66.0% and 68.0% respectively. Combined with the influence by the supply restraint which started from 1981, the sending end load factor became lower than 1993's performance value of 68% as can be understood from the "annual load duration curve" in para. (3) of Section 4.3.6. As of 1994, this sending end load factor is assumed to be about 67% as long as the supply restraint continues. In reality, however, as the peak load increases more than the average power increase (in the state where the supply restraint is lifted), this figure is expected to lie between 61 and 62%. As the load factor gets smaller, it has become harder to adjust loads during the peak time zone, thus making it more and more inevitable for the RI system, which is not blessed with the hydroelectric power supply, to rely on generating facilities of better responsiveness.

4.3.6 Load Pattern

(1) Daily Load Curve

Tables 4.3.6-1(1) to (5) show the maximum daily generation records on the RI system. Graphs 4.3-6-1(1) to (3) show their trends. In addition to the influences by the power supply restraint which started from 1981, it is necessary to pay attention to the fact that the peak load part is not the same as the original record.

According to SENELEC's operational policy on its power generating facilities as described in Section 4.1, the power generation cost (FCFA/kWh) are used for application to the base load, the intermediate load, or the peak load. Although they are basically as shown below, decisions are made at each time in cases of maintenance and fault, etc.

Power generation cost (1993 performance records: FCFA/kWh)

G105	G106	G102	G103	G104	TAG1	TAG2	G401	G402	G301	G302	G303
16.3	14.5	18.2	18.2	18.2	46.4	58.0	10.9	10.6	12.7	13.1	13.5

a. Base load

Entered in order of the higher fuel efficiency: G401 -> G402 -> G301 -> G302 -> G303 -> G105 -> G106

b. Intermediate load

Entered in order of G101 -> G102 -> G103 -> G104

c. Peak load

TAG1, TAG2

A tendency of the energy consumption is detected from the daily load duration curve of the RI system (RGI system). Two peak loads appear: the first one (daytime peak) normally occurs between 10 a.m. and 12 noon; the second one (evening peak) occurs between 8 and 9 p.m.

There is the tendency that the evening peak is higher than the daytime one. However, according to the performance records in October, 1990, the daytime peak is higher. The evening peak is characterized by two points. One is that, judging from the performance records of May, 1993, its rising edges are sometimes extremely acute. Another point is that, if the system consists of heat engine generating facilities, adjustments to maintain the system frequency within the allowable value are difficult to make at the time of the peak load when the frequency fluctuates most violently, in a paging system where the load dispatching operator relies mainly on telephone communications and manual operations for output adjustment and start-stop, etc. of each facility accompanying the fluctuation in the width between a day's peak load and lowest load.

According to the operational records in Tables 4.3-6-1(1) to (5), the ratio of the lowest load of the RI system as to the peak load is 69.5% as of October 19, 1990; 72.4% as of October 30, 1991, 62.5% as of October 22, 1992, 55.9% as of May 3, 1993, and 69.6 % as of October 18, 1993. Together with the operating characteristics of each power generating facility, the above figures have resulted in looking for adjustment resources in diesels which are excellent in output responsiveness to maintain the system frequency for the following reasons, thus also resulting in putting a strain on the facilities.

Operating characteristics of steam turbine:

a. Lowest output

The lowest output of a once-through boiler is 20 to 30 % as to the rated output.

b. Output change

2 to 3 % per minute in the high load band.

c. Operation when the system frequency has dropped

Decrease in the system frequency during operation is caused by the resonance of the rotor blade of turbine and the decreased output of the auxiliary equipment. The threshold frequency which allows a continuous operation is a decline by 1.0 to 1.5 Hz (49.0 to 48.5 Hz).

Diesel:

a. Lowest output

No less than about 40 % of the rated output, considering the change caused by the load factor of the fuel consumption rate.

b. Output change

It is possible to make governing operation on a system whose frequency does not change so rapidly.

Gas turbine:

a. Lowest output

Varies in accordance with the load fluctuation from the zero output to the peak rating (SENELEC's short-time rating).

b. Output change

The gas turbine can fully cope with the frequency change on the RI system. As the gas turbine is used for short-time intermittent operations for peak load, thus resulting in many start-ups, it requires inspection and maintenance services (with increased maintenance costs) different from those operated continuously. A mild load fluctuation up to the base rated output does not affect the life span of parts too much. However, a drastic and frequently load fluctuation gives an impact similar to that of a start-stop and shortens it remarkably, thus raising the maintenance costs.

When the load is at its lowest, the operation of the equipment must be continued with a low output, considering that it is safer and economically desirable to do so. However, the following table shows the ratio (%) as to the rated output of the minimum load on the day which recorded the largest power generation in each year.

M/D/Y	G105	G106	G102	G103	G104	G301	G302	G303	G401	G402
10/19/90	-	-	34.3	-	17.1	40.0	52.3	70.0	75.5	82.5
10/30/91	90.0	-	10.0	37.5	-	90.0	60.0	70.0	82.5	91.0
10/22/92	44.0	-	39.0	46.8	39.0	43.6	53.3	50.0	34.0	41.0
05/03/93	46.0	58.0	31.2	-	39.0	40.0	53.3	50.0	74.0	47.0
10/18/93	-	50.0	-	27.0	39.0	76.3	56.6	43.3	24.5	22.0

The table above shows the day in each year which recorded the largest of power generation. Although it may be necessary to do research on data records other than these, it is understood that the ratios of the minimum loads of G401 and G402, which are major power generating facilities on Cap des Biches in the RI system, as to the peak load are going down year by year. They have already gone below the safety-operation objective 40% of the load factor, thus raising the fuel consumption rate and causing the concern that the generating facility may be affected. Graph 4.3.6-2 shows a trend in the evolution by year of the maximum daily power generation. The trend in October of each year does not show any major diversity. However, the power generation curve on May 3, 1993 shows noticeably that the ratio between its minimum and peak loads is large and the rising edge of the power generation between 19:00 and 21:00 o'clock is very steep.

(2) Monthly Load Duration Curve

Table 4.3.6-2 shows the evolution by year of the maximum and minimum monthly loads (generating end), starting from 1989. According to the table, the monthly peak occurs in October of each year except in 1993 when it occurs in May. SENELEC's statistics show the percentage of each month as to the annual total power generation and as to the annual peak as follows:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7.6	7.2	7.9	7.7	8.1	8.5	9.3	8.9	8.6	9.5	8.8	8.0
86.8	87.8	93.1	91.5	92.3	93.3	95.4	94.6	92.3	100.0	95.4	90.0

Note: The upper row of the table above indicates the percentage of each month as to the annual total; and the lower row indicates the percentage as to the annual peak.

According to the power and peak trends of each month in the table above, the occurrence of the maximum power and that of the maximum peak coincide with each other in October; however, this relationship does not continue in other months.

(3) Annual Load Duration Curve

Fig.4.3.6 shows the annual load duration curve on the RI system in 1991 and in 1993.

The peak load does not reflect the reality due to the supply restraints starting from 1981. However, the records of 1993 show that the electric energy by supply restraints was 4.4 GWh, amounting to 157 days or accumulated 442.8 hours. Considering that it is concentrated in the peak time zone, the relationship between the peak load and the sending end load factor of the annual load duration curve is summarized as follows with the station service loss factor fixed at 5%, generated energy at 947.9 GWh.

Supply restraint capacity	Peak load (generating end)	Peak load (sending end)	Sending end load factor
10MW	166.2MW	157.9MW	63.9%
20MW	176.2MW	167.4MW	60.3%

The sending end load factor is very low in the summary above, which indicates that the rising/trailing edges of the peak load are steep. However, the situation is expected to improve with the increased mean power along with the easing of supply restraints in the future.

4.3.7 Diversity Factor

As the ratio of the peak load in RGI system of the RI system (Rufisque, Thies, Dakar areas: RI) is about 97%, it was decided, in this project, not to consider the peak loads occurring at different times from area to area of RGI systems.

4.3.8 Performance Records of Demand and Supply Balance

Table 4.3.8 indicates the demand and supply balance from 1975 until 1993 under the following conditions.

1) Reserve capacity (1)

   A reserve capacity required for achieving adequate maintenance is found based on the following formula, assuming that the largest unit and the second unit are shut down.
   Demand and supply balance = Actual limit capacity - Total of 1st and 2nd unit capacities

2) Reserve capacity (2)

   The reserve capacity shall be 20% of the peak load.

   Demand and supply balance = Actual limit capacity - Peak load - 20% of the peak load
   The larger of the above two reserve capacities is selected.
   The demand and supply balance in 1993 showed a shortage of about 26 MW. If the adequate reserve capacity is included, the shortage is assumed to be about 40 MW.

3) Spinning reserve capacity

   The spinning reserve capacity is based on the following since no actual data by SENELEC is available. In view of the fact that the load fluctuation is considered to be proportional to the root-mean-square value of the system capacity, the proportional constant of the standard deviation (σp) of the load fluctuation volume shall be 0.3.

The adjusting capacity required for the load frequency control is determined aimed at adjusting 95% (equivalent to $2\sigma p$) of the total load fluctuation.

Required adjusting capacity $Q = 2(\sigma p - K \Delta F)$

K = System constant (12MW/0.1Hz)

ΔF = Frequency allowable deviation (1 Hz from SENELEC standards)

According to the performance records in 1993, the above can be absorbed by operating TAG2 as the power generation facility of the load fluctuation.

4) Selection of unit capacity

Determine a unit capacity allowable for the SENELEC's system.

Peak load band

For the frequency decrease caused by being dropped out of the maximum unit in the peak load band, 27.5 MW of G301 is selected as the relevant unit. The frequency decrease at the time of drop-out in 1993 is about 1.8 Hz (the actual value is slightly smaller than this due to self-regulation characteristics). And, if the allowable unit capacity is suppressed within the target frequency at the normal condition, the unit capacity is about 15 MW; if, however, measures such as load restraint and system separation can be taken within a short period of time, it becomes about 37 MW, considering that the frequency can be allowed to decrease by 2.5 Hz.

Non-peak load band

In the case of a off peak load band, the frequency is decreased by 2.2 Hz and the allowable unit capacity is about 18 MW, assuming that G301's operating capacity is reduced to 60%.

4.4 Supply Restraints

The power generation project to cope with the ever-increasing demand in SENELEC's electric power system, especially in its RI system, was drafted early. However, up to 1992, starting the operation of power generating facilities amounting to about 60 MW was delayed. This led to a situation requiring restraints on power supply. It causes problems, on the supplying side, such as extension of the interval of the required inspection, resulting reduction in the dependable capacity, increase in fuel consumption rate, and accelerated deterioration of facilities. On the consumers' side, there are many cases of complaints on deterioration in refrigerated products due to service interruption, operational failure of electrical appliances, and accelerated equipment degradation.

The operational statuses of power generating facilities at the time of survey (from August until September, 1994): G303 (rated 30 MW) and G402 (rated 20 MW) are being overhauled and TAG1 (rated 16.5 MW) is out of order, thus showing the sign of a shortage of power generating facilities. Therefore, shutting down more of the presently operating facilities would give a grave impact to the electric power system.

4.4.1 History of Supply Restraints

The restraints on power supply were started in 1981. The amount of the supply restriction energy is as follows on the demand end:

Unit: GWh

81	82	83	84	85	86	87	88	89	90	91	92	93	94
0.6	0.82	1.56	3.77	1.56	0.43	0.28	2.4	0.51	0.82	0.37	0.27	4.42	5.24

Since no actual records are available, the figures above regarding the amount of the supply restriction energy are only estimate. This is because the time zone when the restriction occurs is the peak time, and the load is limited at the point when the frequency has started to go below the default value as to the allowed generated power, thus making it impossible to clearly grasp the figures on the actual limiting load capacity.

In 1993, the supply restraints was implemented for 157 days, amounting to accumulated total of 442.8 hours. At the time of field survey in 1994, this was found to occur once every two weeks on the average. According to a reply by the staff of the load dispatching center, the implementation of the supply restraint is definitely becoming more and more frequent.

4.4.2 Supply Restraint by SENELEC

(1) Supply Restraint Frequency

The basics of the operating frequency for SENELEC's system operation are as follows:

- Usual allowable frequency: 2 % (49 to 50 Hz)
- First stage load limiting frequency: 48.5 Hz
- Second stage load limiting frequency: 48.0 Hz
- Third stage load limiting frequency: 47.5 Hz
- Fourth stage load limiting frequency: 47.0 Hz

That the usual allowable frequency is allowed to decline by as much as 1 Hz has forced the frequency adjustment to be dependent on the frequency response of the gas turbine, not only because all the power generating facilities are based on heat engine but because the automatic frequency control system is not installed. Further reasons are assumed to include the difficulty of operating the gas turbine throughout the year in view of the cost per kWh; few large load of the unit capacity which affect on the system frequency; and manual adjustment of the frequency, etc.

The relationship between the frequency fluctuation and the generated output is determined with the system constant. As of 1993, this constant at the load dispatching center is 1% MW/0.1 Hz and the peak generated output of the RI system is 150.7 MW, thus corresponding to 15 MW per cycle.

As shown in the annual maintenance schedule of Fig. 4.1.2 established by SENELEC for fiscal 1995, the rehabilitation work on the existing power generating facilities, including the G302 and G303 units currently at Cap des Biches is being carried out, and it is seen as unavoidable that the system frequency in the peak load time band should be within the permissible frequency range for normal operation (49 - 50 Hz) and in some cases it may also be necessary to continue operation at one cycle lower.

(2) Priority in Supply Restraints

According to the supply restraints, the order of shutting down the target circuits is determined from the viewpoint of security: first, general consumers, then, commercial/industrial consumers, public facilities, military facilities, and lastly hospitals. Each poste determines beforehand the target circuits for supply restraint, based on the combined data on the frequency detection, the configuration of the circuit selected for shutoff, and the remote control circuit, etc.

(3) Implementation of Supply Restraints

If the implementation of the supply restraint is automatic, the relevant circuit breaker is automatically opened by frequency detection. If the shutoff was forced by the load dispatching center, the relevant circuit breaker is opened from the distribution control center as instructed by the load dispatching center. Automatic load shutoff cases are limited to where a special frequency decline has occurred. In most of the cases where a frequency decline has occurred or is expected to occur, the load shutoff is implemented manually as instructed by the staff of the load dispatching center.
In the case of 90/6.6 kV Poste Hann, the circuit breakers for "Soprim" and "Hlm P. d'Oie" are opened by the first-stage frequency detection; the circuit breakers for "Universite" and "Bel-Air" are opened by the second-stage frequency detection; and the circuit breakers for "Hann Pecheur" and "Aeroport Yoff" are opened by the fourth-stage frequency detection. In the same manner, other postes decide on the circuits to be shut off and consider the priority.

(4) Contact with Consumers

Supply restrains are enforced without a prior confirmation with the consumer, apparently for lack of time, especially because the frequency fluctuation at peak load occurs in a drastic manner. In the same manner, lifting the restraints is done without any notice to the consumer.

There are few cases of automatic supply restraints. As the frequency decline can be judged beforehand, normally the relevant circuits are manually shut down by the load dispatcher.

(5) Time Zone for Supply Restraint Occurrence

The supply restraints occur during the peak load time zone. The yearly peak for 1993 occurred in May, while in other years the peak normally occurs in October. This is estimated to be the result of the supply restraints being more concentrated in October than in other months. (The difference between October's 149.2 MW and May's 150.7 MW is mere 1.5 MW.)

(6) Annual Output Fluctuation and Supply Restraints

As a result of implementing the supply restraint measure, the ratio of the peak load of each month as to the annual peak load has varied less compared with the ratios in the past. This indicates that the value of peak load does not vary so much throughout the year. In other words, it indicates that the supply restraints need to be implemented not in the month whose peak load is the largest but in the peak load time zone throughout the year. Therefore, it is urgent for SENELEC to return to an operation system of power generating facilities which are equipped with an adequate reserve capacity.

(7) Supply Restraint Capacity

As was described in the previous section, it is impossible for even a load dispatcher to know the supply restraint capacity accurately.

Therefore, the supply restraint capacity is based on an assumption. The time zone requiring supply restraints is at peak load. As the amount of the electric energy is not so large during this time as was previously described, restriction of the peak output can cause problems. In addition, since the restriction on the peak output is applied throughout the year within the power capacity generatable at the moment, it may be hard to determine the supply restraint capacity in a sweeping manner.

Accordingly, judging from the demand forecast based on actual demands, it is considered that SENELEC's power generating facilities equipped with a required reserve capacity are sufficient for operation of its RI system.

The demand forecast for power generating facilities of the RI system in 1994 is estimated as 183.7 MW. The current supply capacity of power generating facilities as against this figure is 187 MW in terms of the actual limit capacity, thus their difference being 3.3 MW. If the required reserve capacity (as the sum of the outputs of the first and second largest facilities: 47.5 MW) is added to this, the power generating facilities required for a sound operation amounts to about 45 MW.

Many years of supply restraints have brought about the following three problems from the viewpoint of power system management.

1. Shortage in power generating facility output
   The shortage in power generating facility output is being expressed in the form of supply restraints at peak load, thus leading to lack of reliability between the power supplier and the consumer.

2. Decrease in the generated energy
   The shortage in the power generating facility outputs naturally results in more operation of facilities except those being inspected or fault stoppage, thus inviting a substantial increase in the annual operating time. As is described in Section 4.1 "Operation of Power Generating Facilities", the capacity utilization ratio of Cap des Biches CIII power generating facilities G301, G302, and G303 have reached 85.6%, 90.8%, and 82.6% respectively. In addition, these three power generating facilities generate 50% of the total generated energy of the Dakar system, thus reflecting a high level of dependence. In this regard, it is desirable that these facilities are allowed to return to their rated outputs as soon as possible.

3. Increased workload for load dispatchers
   The shortage in power generating facility outputs came to be felt

in the form of increased workload of load dispatchers, thus sometimes making excessive operations inevitable due to the limited number of facilities. Up to 1992, the construction of almost 60 MW power generating facilities are not realized though these were scheduled to construct. In this regard, to make the management of the electric power system a healthy one, the following methods are suggested.

- To introduce power generating facilities such as diesel allotted with the base load, aimed at a larger operating range as the spinning reserve capacity of the gas turbine. This is also necessary for shortening the operating time of power generating facilities whose capacity utilization ratio is high and power generating facilities G301 to G303 of Cap-des-Biches.

- To use the existing power generating facilities currently in operation for the base and intermediate load parts and to introduce facilities with satisfactory frequency response such as gas turbines for the peak load part, aimed at lifting supply restraints at the time of peak load. According to the operational records of 1993, the capacity utilization ratio of gas turbine power generating facilities TAG1 and TAG2 are 61.2% and 36.3% respectively; and their amount of generated energy are 45.5 GWh and 32.4 GWh respectively totaling 77.6 GWh, thus amounting to 8.6% of the total power generation 901.2 GWh. This indicates that the newly introduced facilities not only respond to fluctuations at peak load but contribute to increased volume of the generated energy, thus making it possible to cope responsively with drastic load fluctuations at rising/declining edges and reduce the load fluctuation portion of other power generating facilities.

- To introduce power generating facilities coping with base load and those coping with peak load, aimed at increased operating range of the spinning reserve capacity and relaxed supply restraints at the time of peak load.

It is important to apply the methods suggested above to put the maintenance plan of existing facilities back on track, thus lifting the restraints currently being applied to the actual limit capacity so that operations approaching those based on the rated capacity are possible as soon as possible by putting the maintenance plan of existing facilities back on track.

4.5 Power Supply from Private Enterprises

4.5.1 Existing Large-scale Private Companies

Private companies, of which electric power facilities may be connected to RGI system; in and around the Dakar area include:

- Taiba Phosphoric Acid Factory
- Sococim Cement Factory
- ICS Chemical Industry Company
- CSS Sugar Refinery Company
- Sonacos Senegal Edible Oil Company

(1) Taiba Phoshoric Acid Factory

In its competition with other phosphoric acid exporting countries, the power consumption by the Taiba Phosphoric Acid Factory in 1993 was reduced by about 21 % as compared with that in the previous year. Although its annual production capacity is 2,200,000 tons, the company is currently producing 1,500,000 tons.

The power demand by the Taiba Company is large from the viewpoint of its power management: 99.07 GWh as of 1993. From 1995, its production will be recovered to 2,000,000 tons and its power demand will also be 126.8 GWh, thus occupying about 13 to 14% of the forecasted value of the entire RGI systems.

Therefore, this company, whose maximum demand is about 20 MW, has a big impact on the total demand. The company also has a record of having complied with the peak load cut about 10 MW in 1993, which was requested by SENELEC, although it is saying that no assurance can be made to a similar request from 1994.

The Taiba Company is considering installation of non-utility generating facilities by 2,000.

(2) Sococim Cement Company

The production capacity of the Sococim Cement Company is 800,000 tons. However, its current production is estimated to be 650,000 tons. The power demand in 1993 was 60.9 GWh, which is expected to continue hereafter.

(3) ICS Senegal Chemical Industry Company

This is one of the companies equipped with non-utility generating facilities. It has also a contract on mutual power interchange with SENELEC. The amount of power supply was 6.1 GWh in 1991, and 3.7 GWh in 1992.

(4) CSS Sugar Refinery Company

Like ICS, this company also is equipped with non-utility power generating facilities and has a contract on mutual power interchange with SENELEC. Its amount of power supply was 1.6 GWh in 1991, and 0.87 GWh in 1992.

(5) Sonacos Senegal Edible Oil Company

Like ICS, this company also is equipped with non-utility power generating facilities and has a contract on mutual power interchange with SENELEC. Its amount of power supply was 0.99 GWh in 1991, and 0.9 GWh in 1992.

4.5.2 Newly-emerged Large-scale Private Enterprises

At the time of field survey of this project in 1994, no large company other than the existing large consumers above was exchanging contracts on receiving of power from RGI systems or mutual power interchange with SENELEC.

4.6 Service Interruption Due to Faults

(1) Medium Voltage Distribution Network

Tables 4.6-1 ~ -6 shows the energy subject to supply restrictions and the fault records by cause for the two medium voltage distribution networks, i.e., the 30 kV and 6.6 kV distribution networks. Tables 4.6-7 ~ -12 give the fault records broken down by equipment. The main factors for supply restriction due to faults in the distribution networks are thus broken down by the fault causes and by the types of equipment affected by the faults. The following examination will assess these causal factors and the equipment faults in somewhat fuller detail.

1) Causes of Fault

The main causes of fault in the 30 kV distribution network are as follows.

a. Equipment failure
b. Rain
c. Protection system
d. Humidity

The following table gives a breakdown of the frequency of faults as they occurred (in 1992, 1993, and 1994) as a result of the above four main causes as well as for "unidentified causes" and "miscellaneous causes". The table also gives the share of these causes in the energy subject to supply restriction.

	1992		1993		1994	
	No. of faults (%)	Supply restriction, energy (%)	No. of faults (%)	Supply restriction energy (%)	No. of faults (%)	Supply restriction energy (%)
Equipment failure	13.31	34.39	7.45	35.64	11.01	24.93
Rain	4.44	4.99	8.33	15.40	8.99	19.12
Protection system	12.63	7.66	9.22	7.99	16.70	10.91
Humidity	5.80	5.92	3.01	1.49	10.09	11.57
Sub-total	36.18	52.96	28.01	60.52	46.79	66.53
Unidentified causes	47.10	4.83	54.08	20.65	29.54	9.13
Miscellaneous causes	16.72	42.21	17.91	18.83	23.67	24.34
Total	100.00	100.00	100.00	100.00	100.00	100.00

It is estimated that equipment failure and faults due to problems with the protection system are due to the obsolescence of the various types of equipment concerned. Faults due to rain occurs primarily in the underground cables whose insulation materials have deteriorated as a result of aging. Faults caused by humidity affects primarily the insulators which are damaged by the leakage current resulting from salt contamination.

On the 6.6 kV medium voltage distribution network, the main causes of faults are due to:

a. Equipment failure
b. Rain
c. Protection system
d. Accidental shock

The following table again gives a breakdown of the frequency of faults as they occurred (in 1992, 1993, and 1994) as a result of the above four main causes as well as for "unidentified causes" and "miscellaneous causes". The table also gives the share of these causes in the energy subject to supply restriction.

	1992		1993		1994	
	No. of faults (%)	Supply restriction energy (%)	No. of faults (%)	Supply restriction energy (%)	No. of faults (%)	Supply restriction energy (%)
Equipment failure	9.43	18.64	8.29	20.58	16.05	37.79
Rain	11.01	18.80	10.19	27.24	5.79	24.64
Protection system	6.60	10.01	7.82	17.42	10.79	4.54
Accidental shock	2.52	12.82	3.79	7.30	2,37	5.36
Sub-total	29.56	60.27	30.09	72.54	35.00	72.33
Unidentified causes	54.72	11.49	54.27	14.20	36,58	7.79
Miscellaneous causes	15.72	28.24	15.64	13.26	28.42	19.88
Total	100.00	100.00	100.00	100.00	100.00	100.00

The faults due to equipment failure and problems with the protection systems are attributed to the obsolescence or aging of the equipment, similarly to the 30 kV distribution system. Faults caused to the underground cable by rain are believed to be the result mainly of the deterioration of the insulation materials. While there have been incidents of accidental shock also on the 30 kV distribution network, the cause of such accidents is believed be due to vehicles colliding with the supports of the overhead lines.

2) Equipment Failure

Faults on the 30 kV distribution network are believed to be due mainly to the following:

a. Underground cables
b. Medium/low voltage transformers
c. Conductors
d. Insulators

The following table presents a breakdown of the frequency of faults as they occurred (in 1992, 1993, and 1994) as a result of the above four main causal areas as well as for 'without damage' and 'miscellaneous causes'. The table also gives the share of these causes in the energy subject to supply restriction.

	1992		1993		1994	
	No. of faults (%)	Supply restriction energy (%)	No. of faults (%)	Supply restriction energy (%)	No. of faults (%)	Supply restriction energy (%)
Cable	7.17	14.60	5.67	16.45	2.94	17.36
MT/BT transformer	2.05	19.23	1.42	1.84	2.94	6.32
Conductor	6.48	5.68	6.56	10.35	4.59	4.31
Insulator	4.78	3.51	1.06	1.84	3.12	8.73
Sub-total	20.48	43.02	14.71	30.48	13.59	36.72
Without damage	71.67	46.51	77.84	41.49	67.16	32.39
Miscellaneous causes	7.85	10.47	7.45	28.03	19.25	30.89
Total	100.00	100.00	100.00	100.00	100.00	100.00

It is estimated that the faults occurring in the cables as stated in the table above were encountered mainly in rainy conditions in the underground cables whose insulation materials had deteriorated because of aging and that the cause. Faults in the medium/low voltage equipment were in all probability caused by direct lightning stroke or overload affecting the transformers installed on the poles.

Faults occurring in the insulators are believed to be the result of corrosion of hardwares or damage caused to the insulators by flashover due to salt contamination.

On the 6.6 kV medium voltage distribution network, the main causes of problems are due to:

a. Insulators

b. Conductors

c. Underground cables

The following table presents a breakdown of the frequency of faults as they occurred (in 1992, 1993, and 1994) as a result of the above three main causal areas as well as for "without damage" and "miscellaneous causes". The table also gives the share of these causes in the energy subject to supply restriction.

	1992		1993		1994	
	No. of faults (%)	Supply restriction energy (%)	No. of faults (%)	Supply restriction energy (%)	No. of faults (%)	Supply restriction energy (%)
Insulator	4.08	26.34	2.84	20.41	4.74	14.31
Conductor	4.42	15.97	9.00	13.36	5.53	13.24
Underground cable	4.08	8.24	3.32	8.22	4.74	16.19
Sub-total	12.58	50.55	15.16	41.99	15.01	43.74
Without damage	75.51	31.50	71.56	30.01	68.68	31.08
Miscellaneous causes	11.91	17.95	13.28	28.00	16.31	25.18
Total	100.00	100.00	100.00	100.00	100.00	100.00

It is estimated that the faults associated with the insulators as stated above, are due to corrosion of the pins of pin insulators or damage caused to the insulators by flashover resulting from salt contamination.

The above data suggest that the following problems are encountered with the present equipment.

a. Frequent fault due to the aging of equipment
b. Operational errors of the protective systems due to the aging of the protection system
c. Deterioration of insulation of underground cables due to aging and overload
d. Conductor failure due to material deterioration as a result of defective installation and/or overload.
e. Pin corrosion of insulators caused by salt contamination, reduction of dielectric strength due to salt.

From a different viewpoint the above problem can be classified into those due to equipment and/or material aging (deterioration) and those due to ambient conditions (salt contamination). Electrical equipment fault causes disruptions of the electricity supply directly to the consumers.

This means that it has a direct effect on the life of the inhabitants of Dakar and the business activities. As SENELEC does have a statutory obligation to offer to its consumers a reliable high-quality supply of power, such disruptions in power supply are violation of this obligation. Power equipment failure also causes damage to SENELEC in reducing its revenue from electricity charges because of the supply restriction energy they cause.

A reliable, stable power supply is of critical importance to the maintaining of ordinary standards of life for the general public and to assuring dynamic business activities. This involves the need to find an early solution to the above problems. It will therefore be necessary to take the following actions on an urgent basis.

a. Replacement of aged equipment
b. Replacement of aged protection system
c. Replacement of aged and overloaded overhead lines and underground cables
   In contrast to overhead lines, fault in underground cables are difficult to identify and take a longer time to repair and restore. Repairs of underground cables involve service interruption to consumers and are highly disruptive to ordinary public life.

d. Replacement of overhead conductors and insulators
   Problems associated with insulator include the destruction of insulator due to pin corrosion, flash-over due to salt contamination and conductor destruction due to flash-over. To prevent such fault on insulators it is necessary to select insulator with a suitable leakage distance.

e. Supports

Breakdown on supports have been reported only once on the 30 kV and once on the 6.6 kV networks. Fatal breakdowns leading to the destruction of the supports are very serious not only because of the considerable time required to restore the power system to service but also because of their immediate threat to the safety of the civilian population and traffic. As is stated in Chapter 12 "Environmental Assessment" the supports on the medium voltage distribution lines in the Dakar region present the following problems.

- H-section steel corrosion due to salt contamination
- Cracks in the concrete poles

It is conceivable that these supports may break or collapse completely, with the risk of the conductors falling. In view of the immediate threat to the safety of civilian life and traffic this would cause, it is considered essential to ensure the early replacement of the above supports.

(2) Low Voltage Distribution Network

Tables 4.6-13 ~ -15 present itemized records of fault on the low voltage distribution network for the period 1990 - 1992 relating to the various types of equipment. These fault records can be summed up as follows.

Breakdown	1990	1991	1992
	Share (%)	Share (%)	Share (%)
Consumer-related facilities	30.8	72.4	74.9
Distribution postes	1.9	3.2	2.4
Distribution lines	10.2	21.1	20.2
Others	57.0	3.4	2.5
Total	100.0	100.0	100.0

The Table above indicates that the item "Others" records a high proportional share of all fault in fiscal 1990. The reason is that this item includes a 44% load shedding. The majority of all faults occurred on consumer-related equipment. This underlines the desirability to improve consumer-related facilities. On SENELEC facilities, however, most faults occur on the distribution lines. The largest share of these problems is due to fault on the connectors and underground cables. The most likely causes of fault in the connecting point include incorrect installation, connector deterioration, and the use of improper materials due to material shortages.

The main causes of fault in the underground cable include the deterioration of the insulation due to aging (Insulation aging is accelerated by high temperatures due to overload.), dielectric breakdown of insulation due to the ingress of water, mechanical destruction of the insulation during excavation work.

In the distribution poste, fault due to fusing of low voltage fuse, this means the overloaded condition of low voltage distribution feeders. It was observed that copper wire was inserted instead of fuse element.

It is necessary to use the specified fuse to protect the distribution feeders (underground cable, overhead line) from overloaded operation.

Fault in the consumer-related facilities occurs primarily on the connecting point and fuses. Fault at the connecting point in the consumer-related facilities may be due to the same causes as those listed for SENELEC's cases above, and the fusing of fuses may be due to overload on the low-voltage distribution lines.

To resolve these problems, the following actions may be taken:

- Connection of underground cables and conductors with the proper materials
- Replacement of aged underground cables
- PR activities for excavation work