WORLD BANK/UNDP/BILATERAL AID
ENERGY SECTOR MANAGEMENT
ASSISTANCE PROGRAMME (ESMAP)

ANGOLA

POWER REHABILITATION AND TECHNICAL ASSISTANCE

DISTRIBUTION SECTOR REHABILITATION AND EXTENSION OF THE ELECTRIC SYSTEMS IN THE LUANDA AND LOBITO-BENGUELA PROVINCES

Consultant's Report

October 1991

Foreword

This report has been prepared by ESMAP consultants, Messrs. G. Brambilla and M. Scarfi' from ENEL (Ente Nazionale per l'Energia Elettrica - Italy) during an ESMAP mission to Angola from January 23 to February 23, 1990. The mission consisted of Messrs. Michel Del Buono, Mission Leader; Kurt F. Schenk, Power Specialist, Deputy Mission Leader; Ms. E. Battaglini, Economist; Messrs. J. Baptista, Power Engineer/Economist; C. Alves da Cruz and C. Ferreira da Silva, Hydro Plant Specialists; C. Madureira, Power Systems Planner; P. Bernardin, Accounting, Organizational and Institutional Expert; L. Rivera, Financial Analysis; G. Selleri, Hydro Plant Planning and Construction Expert; A. Corsini, Thermal Generation and Transmission Line Expert; G. Brambilla and M. Scarfi', Electric Distribution Experts; Ms. M. Kronen, Environmental Expert.

The report examines the distribution systems in Luanda and Lobito-Benguela and provides recommendations for the rehabilitation of the HV-MV and LV distribution networks in these cities. The report also recommends an extensive technical assistance program, particularly in manpower training.

The 1990 mission was followed by another ESMAP mission in early June 1991 which reviewed and revised many of the conclusions and recommendations of the 1990 mission in the light of the recent peace agreement of May 1991.

The cooperation by the Government of Angola, particularly the Secretariat of Energy and Water (formerly the Ministry of Energy and Petroleum); the electric utilities ENE, SONEFE, EDEL and CELB (now incorporated within ENE); and GAMEK, in charge of the development of the River Kwanza, is gratefully acknowledged. Funding for this project has been provided by UNDP (United Nation Development Program) and SIDA (Swedish International Development Agency).

The Blue Cover Report entitled: "Angola" Power Rehabilitation and Technical Assistance -Priorities for Investment and Technical Assistance in the Electric Power Sector", was published in October 1991.

TABLE OF CONTENTS

ELECTRICITY DISTRIBUTION SYSTEM IN THE LUANDA AND BENGUELA PROVINCES

Foreword

This report was drafted by consultants Gianluigi Brambilla and Matteo Scarfi for the World Bank. It covers problems of electricity distribution in the Luanda province (Northern System) and in the Benguela-Lobito province (Central System).

The consultants visited Angola, namely the towns of Luanda and Lobito, from Jan. 25 to Feb. 24, 1990.

During their mission, they met various officers from local electric utilities (EDEL, SONEFE, ENE, CELB), with whom they reviewed the major aspects of the problem and from whom they received data to prepare this report. The following people were contacted:

- Mr. RUI TITO, Technical Advisor, MEP
- Mr. LOUIS MOURAO, Head of Operation & Maintenance Department, ENE
- Mr. JOAO SIMAO SILVA, Head of Research & Development Department, ENE
- Mr. ANTONIO DE SAURA MARTINS, Managing Director, EDEL
- Mr. ANTONIO LUCAS PEREIRA DA SILVA, Head of Operation & Maintenance Department, EDEL
- Mr. VICTOR FONTES, Head of Planning Office, EDEL
- Mr. NSIANSOKI MAYAMONA, Head of Research & Development Department, EDEL
- Mr. HELENIO DUARTE, Head of Research & Development Department, SONEFE
- Mr. MARCAL PEREIRA, Manager of HV/MV Network, SONEFE
- Mr. JERONIMO ADAO, Regional Director, CELB
- Mr. GOMES PINTO, Head of Studies and Methods Office, CELB.

The report consists of 6 chapters:

I - Introduction, comments and suggestions;
II - Distribution system in the Luanda province;
III - Distribution system in the Benguela-Lobito province;
IV - Operation and maintenance activities;
V - Education and training of personnel;
VI - Technical assistance by foreign experts.

CHAPTER I

Introduction

The study on and suggestions for rehabilitation of the electric system in point involves a plan for upgrading and retrofitting of the HV-MV-LV distribution networks in the towns of Luanda, Lobito, Benguela and Catumbela, in order to face obsolescence of systems and demand growth.

The study also envisages a number of efforts to reorganize the operation groups of EDEL and CELB, as well as an extensive personnel education and training program.

The study spans a 10-year timescale, i.e. from 1991 to 2000. This timescale was further split into two five-year periods. During the first period (1991-1995), the planned efforts shall cover rehabilitation proper and part of rehabilitation-connected extensions. In the second period, the system shall be expanded to respond to the anticipated demand growth.

The study was focused on:

* primary HV power distribution system and its components (lines and substations)
* secondary MV power distribution system and its components (lines and secondary MV/LV transforming substations)
* LV networks and public lighting.

Solutions were selected on the basis of a technical-economic optimization and by relying, to the largest possible extent, on materials and components commonly and currently used in Angola.

The main stages of the study were:

* data collection
* checking of system performance and related comments
* description of rehabilitation works and related cost estimate
* definition of demand growth and related location
* description of extension works and related cost estimate.

The poor performance of the electricity distribution system in the Luanda and Benguela-Lobito provinces is due to four determinants, which are thoroughly investigated in the following chapters.

These determinants are:

1) system obsolescence;
2) incorrect system operation;
3) inefficient corporate organization and management;
4) low qualifications of personnel.

Each of the above determinants equally contributes to the end-result: poor performance and weaknesses in the system. Consequently, only huge investments in materials, human resources and good will can help redress the Angolan problems in this sector.

The problems are interdependent and equally critical and, albeit with a different priority, they must be solved, so as to enhance the efficiency of the system and achieve a real development of the sector.

Comments and suggestions

System rehabilitation

As elaborated on hereafter, the HV power distribution systems have fairly acceptable physical conditions.

The same applies to the MV systems, except for secondary MV/LV transforming stations, which demand radical works, since their performance and safety are low.

Conversely, the LV and public lighting network has such catastrophic conditions as to suggest its reconstruction, in that remedial maintenance is not considered as cost-effective.

To rehabilitate the distribution system in the two provinces, a number of works was planned with a view to make the primary power service more efficient and more continuous.

This goal shall be reached through total reconstruction of some systems and retrofitting of other existing systems.

Obviously, in planning of rehabilitation works, consideration was also given to extensions which are closely connected with reconstruction of the systems.

As a whole, rehabilitation works in the Luanda and Benguela-Lobito provinces will imply an overall expenditure of 152,267,600$ over a three-year period. In the first two years, the utilities will be involved in engineering of the works and administrative procedures related to contract awarding.

To complete the planned works, the Angolan utilities are required to be assisted by foreign experts. The program, to be agreed upon, will imply an expenditure of 1,800,000$.

System extension

In our opinion, the demand growth projections, made by the planning expert as part of the ANG 89/30 project, exceed the actual potential of the country. Costly and extensive construction works will be needed to cover the electricity demand which was anticipated up to the year 2000.

We did not deem it appropriate to indicate time schedules. In effect, in the first five-year period (1991-1995), the utilities will be heavily involved in rehabilitation of the current system.

Provided that financial resources are found, the planned extension works in the two provinces (total expenditure 256,879,000$) are assumed to start in 1996, with huge investments at least until the year 2000.

Both rehabilitation and extension of the electricity distribution system in the two provinces will significantly contribute to curb the currently recorded technical losses. Unfortunately, scarcity of data on current technical losses did not allow to quantify the expected improvement. At any rate, based on experience with similar electric systems, they are assumed to drop by at least 30%.

System operation - Corporate organization and management

Operation of the current systems is rather inefficient owing to: inadequate organization of skilled workers; shortage of facilities; and structural weaknesses of the system due to lack of or poor performance of some equipment.

Finally, mention is to be made of the inefficient operation of the MV network in the Luanda province, due to coexistence of two utilities (EDEL and SONEFE) in charge of the same network, with waste and redundance of resources.

The need arises for unifying the MV network operation, to achieve complete integration of the two networks and streamline their operation.

In 1989, Norconsult worked out a project for the organization of EDEL that EDEL managers are trying to implement.

We feel that the poor excitement of EDEL managers in implementing the suggested organization depends on the low qualifications of available human resources, insufficient funds, difficulties in changing deep-rooted habits and pace of work.

All this adds to the fact that the headquarters building is inadequate to accommodate General Management, Technical and Administrative Offices, field personnel as well as equipment and materials.

The flow of data between the various offices is practically non-existent and deficient between the different groups of the same office.

Another major organizational weakness is the lack of procedures and documentation for: planning of jobs, control of their correct performance, accounting and quality control, updating of the cadastre of installations. No routine maintenance scheduling is in use. As collection of statistical data on faults is poor, no corrective maintenance programs exist.

In this area, technical assistance by foreign experts (with a cost of 1,980,000$) can allow to suggest and implement all the organizational changes which are absolutely necessary for a correct functioning of the utilities.

Personnel education and training

One of the most urgent problems to be addressed is scarcity of skilled and adequately trained labor.

This problem worsened in the last decade because of the continuous exodus of the most qualified personnel. It requires urgent action to ensure correct operation of the existing facilities and to train the technical personnel required for rehabilitation and extension of the system.

In this connection, a program is proposed to train both technicians and workers, taking into account the actual needs of the utilities and the educational background of their current workforce.

The program, to be implemented in 30 months, will involve an aggregate expenditure of 8,521,000$ for foreign experts' services and for setup and organization of training centers.

Summary of expenses

II.3	- System rehabilitation, Luanda Province	$	97.014.000
II.5	- System extension, Luanda Province Stage 1	$	71.590.000
	- System extension, Luanda Province Stage 2	$	125.580.000
III.2	- System rehabilitation, Benguela - Lobito Province	$	55.253.600
III.4	- System extension, Benguela - Lobito Province Stage 1	$	21.830.000
	- Sustem extension, Benguela - Lobito Province Stage 2	$	37.879.000
V	- Personnel education & training	$	8.716.000
VI	- Technical assistance	$	1.800.000
Totale		$	419.662.600

CHAPTER II

LUANDA PROVINCE

II.1 - DATA COLLECTION

The Luanda province extends over 380 sq.km, 80 sq.km of which are urban and 300 sq.km suburban (Table 1).

At present, electricity in the Luanda province is distributed by EDEL and SONEFE.

EDEL is in charge of electricity distribution and public lighting in the urban center, whereas SONEFE directly feeds industrial HV and MV consumers, generally located in the suburban area.

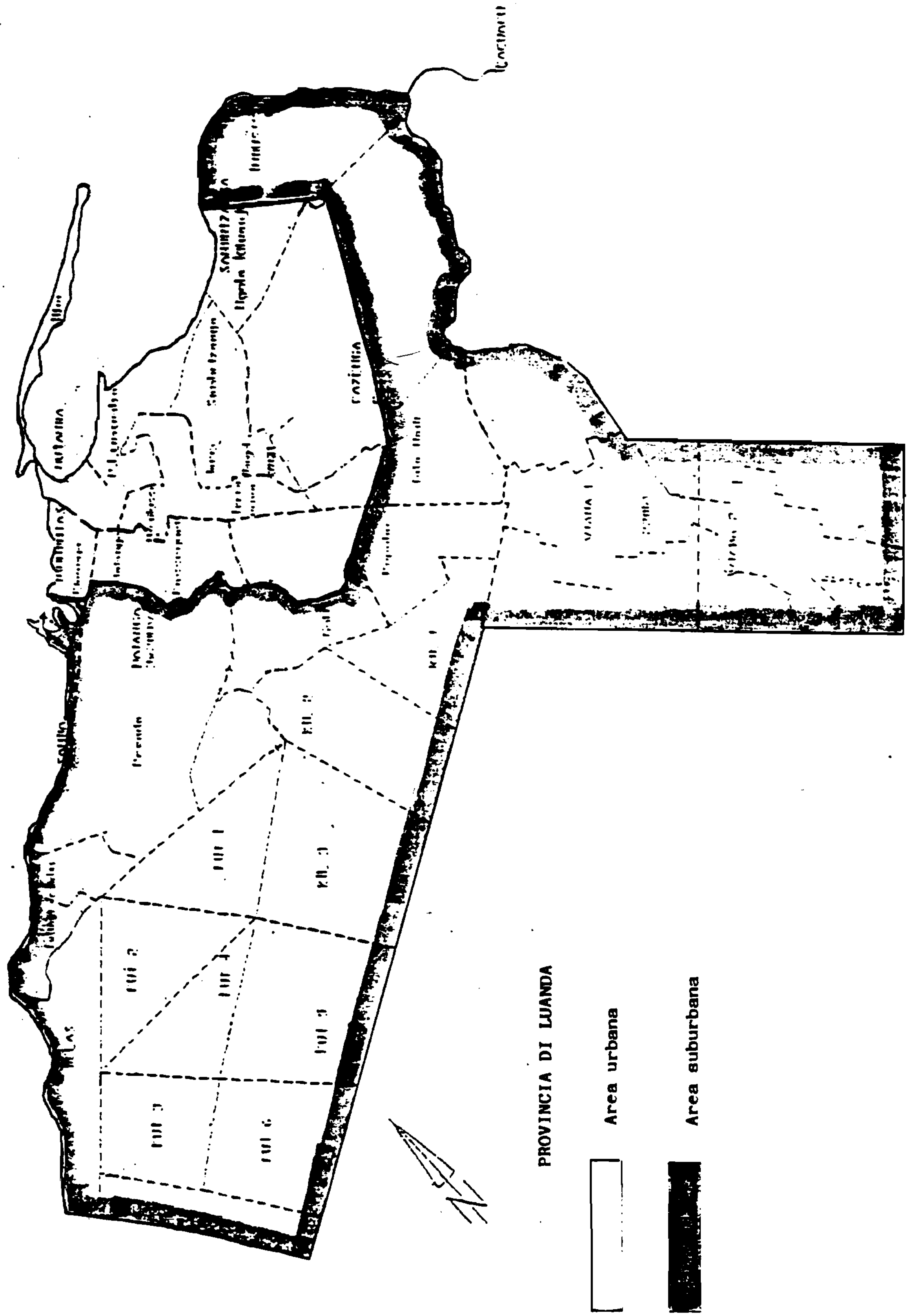
The preliminary project for rehabilitation of the electric system in the city of Luanda called for collection of a large number of data on size, characteristics and current performance of the electric network.

Lack of data and narrow time schedules prevented us from gaining a comprehensive understanding of the electric system under review. Nevertheless, the collected data were regarded as sufficient for drafting of a preliminary project.

Presently, the electric system in the Luanda province relies on 4 voltage levels, namely:

- 220 kV for primary supply of the Luanda 2 and Viana substations, which practically feed the whole province;
- 60 kV for supply of the distribution system through 6 substations (Luanda 2, Viana, Cuca, Maianga, Quifangondo, Belas);
- 15 kV for supply of secondary substations in the suburban area, for feeders linking the 18 shunting substations of the urban center, as well as for secondary MV/LV transforming stations;
- 6.6 kV for the secondary network in the old historical center of Luanda; this network is being phased out as part of a conversion-to-15 kV program implemented by the firm Montreal. At present, EDEL is completing the work through commissioning of 15/0.380 kV substations.

TAV. 1



The system is also equipped with a 30 kV MV line outgoing from the Quifangondo substation and supplying the Radio Station.

The electric system in the Luanda province consists of the following facilities:

- 220 kV lines on steel pylons,		
operated by SONEFE	km	350
- 60 kV HV lines on varius types of poles,		
operated by SONEFE	km	35
- 60 k-v HV underground lines,		
operated by SONEFE	km	2
and by EDEL	km	26

- Luanda 2 substation, operated by SONEFE,
  220/60/15 kV trasformation
  installed capacity 4 x 60 MVA
- Viana substation, operated by SONEFE
  220/60 kV and 60/30 kV
  installed capacity 1 x 60 MVA
- Cuca substation, operated by EDEL
  60/15 kV trasformation
  installed capacity 4 x 20 MVA
- Maianga substation, oeprated by EDEL
  60/15 kV trasformation
  installata capacity 3 x 20 MVA
- Quifangondo substation, operated by SONEFE
  60/30 kV trasformation
  installed capacity 1 x 7.5 MVA
- Belas substation, operated by SONEFE
  60/15 kV trasformation
  installed capacity 2 x 1 MVA
- Raffinery substation supplied by the SONEFE network
  60/15 kV trasformation
  installed capacity 1 x 7.5 MVA
  The substation is owned by the consumer who handles its operation and maintenance.

- Steel mill substation, supplied by the SONEFE network
  60/15 kV trasformation
  installed capacity 1 x 15 MVA.
  The substation is owned by the consumer who handles its operation and maintenance.
- Cimangol substation, supplied by the SONEFE network
  60/15 kV trasformation
  The substation is owned by the consumer who handles its operation and maintenance.

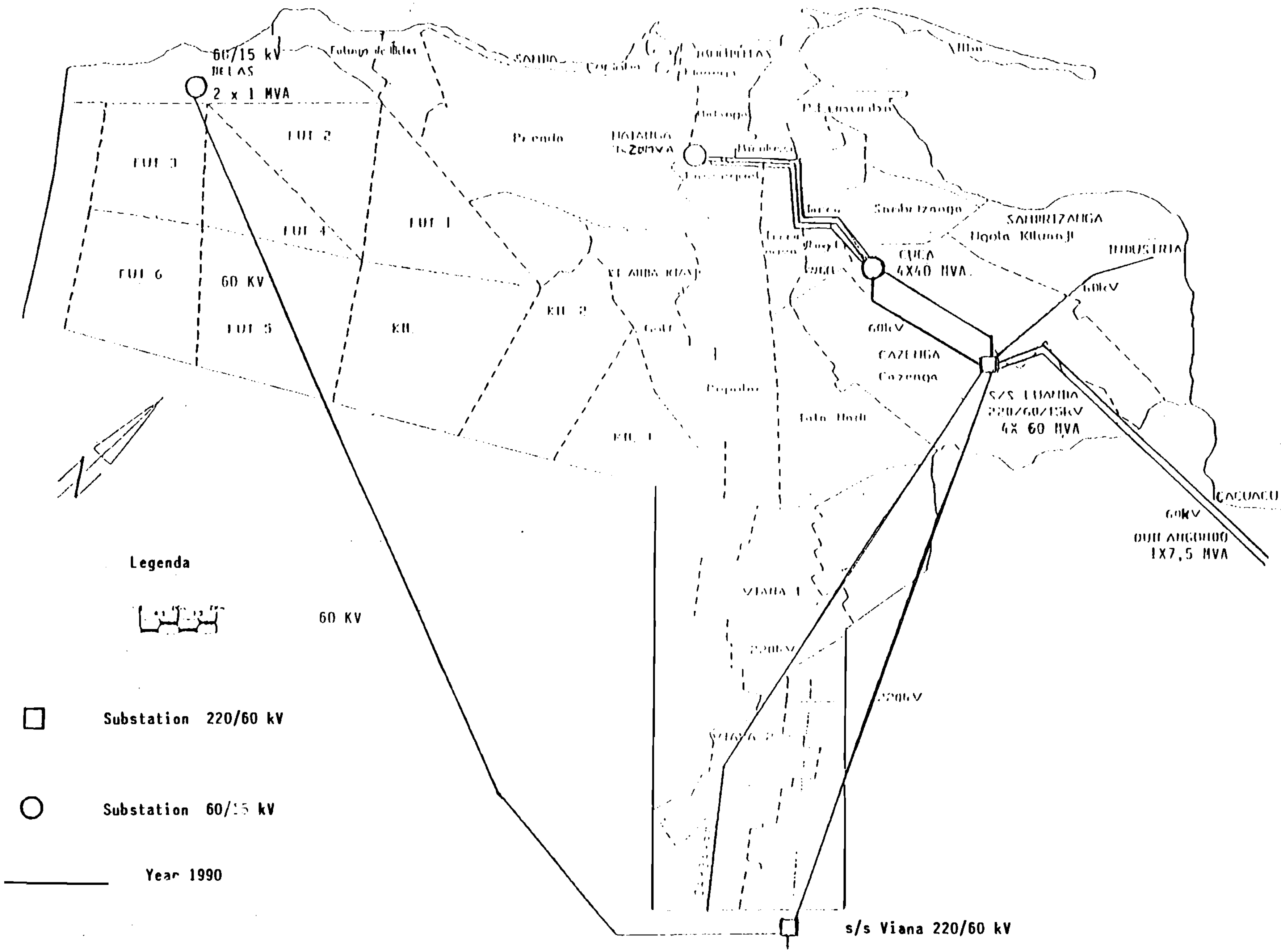
Secondary MV network

- 30 kV overhead lines	operated by SONEFE	20 km
- 15 kV overhead lines	operated by SONEFE	200 km
	operated by EDEL	25 Km
- 15 kV underground lines	operated by SONEFE	2.5 km
	operated by EDEL	225 km
- transforming substations	operated by EDEL	535 n.
- MV power supply substations	operated by SONEFE	373 n.
	operated by EDEL	31 n.
- shunting substations	operated by EDEL	18 n.

LV network

- Overhead and underground distribution lines	850 km
- LV supply terminals	67,000 n.

It was impossible to gather data on size and characteristics of the public lighting system. However, after a rough site inspection, the lighting points are supposed to total approx. 4,000.


60/15 kV
2 x 1 MVA
FUT 3
FUT 2
FUT 1
FUT 4
FUT 6
60 KV
FUT 5
KIL
KIL 2
KIL 1
SAMBIZANGA
INDUSTRIA
CUCA
4X40 MVA
60kV
CAZENGA
Cazenga
S/S LUANDA
220/60/15kV
4X 60 MVA
CACUACO
60kV
1X7,5 MVA
VIANA 1
220kV
VIANA 2
Legenda
60 KV
Substation 220/60 kV
Substation 60/15 kV
Year 1990
s/s Viana 220/60 kV

II.2 - CHECKING OF THE PERFORMANCE OF CURRENT SYSTEMS PRIORITY MEASURES TO BE TAKEN FOR THEIR REHABILITATION

The electricity distributed throughout the Luanda province is almost entirely generated by the Cambambe power plant (the Mabubas plant provides a moderate amount).

The Cambambe energy is transmitted to Luanda by two 220 kV lines, which stop at the Luanda 2 substation, one directly and the other passing through the Viana substation.

The Luanda 2 substation is fitted with 4 x 60 MVA transformers, three of which 220/60/15 kV and one 220/60 kV.

In 1989, the peak demand was 160 MVA, 125 of which distributed by EDEL and 35 directly by SONEFE.

The above infers that the installed capacity in the Luanda 2 substation widely covers the peak load which was recorded during the first months of 1990, with a margin of as much as 100 MVA.

Primary 60 kV systems

All EDEL consumers in the urban center of Luanda are powered by the Cuca and Maianga substations, linked with the Luanda 2 substation via one double-circuit line (Luanda 2-Cuca) on 409 sq.mm cross-sectional area aluminum cable steel-reinforced (ACSR) and three underground lines (Cuca-Maianga) on 95 sq.mm cross-sectional area copper conductors.

At full load, the Luanda 2-Cuca double-circuit line is used at 94% of its thermal limit transmission capacity. This evidences that a possible fault on a circuit obliges the distributor to reduce the load.

The situation is even worse when, to repair a fault on one of the two circuits, the entire double-circuit line is to be put out of service for safety reasons, at least for the time interval required for the repair. This fact may interrupt the supply of electricity to the whole urban area, since no duplicate supply is planned.

In view of the above, to make operation of the two substations more rational and efficient, it is necessary to double their link by immediately installing two single-circuit lines on 409 sq.mm cross-sectional area ACSR.

This measure will also enable to cover the expected demand increase up to 1995 and to substantially cut down the energy losses which are now recorded on such link.

As to 60/15 kV substations, another 60 kV injection point with related 60/15 kV transformation is to be planned, in order to improve reliability of the system and face the expected load increase. The injection point shall be preferably installed in the Mutamba district and supplied by the 60 kV Cuca substation via two underground circuits on 3 x (1 x 300 sq.mm cross sectional area) conductors with extruded insulation.

The 60 kV overhead lines, entirely operated by SONEFE, are rather obsolete but generally in acceptable condition.

For a more complete rehabilitation of these lines, a number of minor corrective maintenance jobs shall be performed, such as:

- repainting of all steel supports
- reconstruction of some foundation blocks
- replacement of some supports.

Secondary 15 kV systems

Urban center

All the consumers of the Luanda urban center, supplied - as previously mentioned - by EDEL, are fed via the 15 kV network departing from the Cuca and Maianga substations. These substations are linked via some primary MV feeders in mass-impregnated, belted, three-pole underground cable on 185 sq.mm cross-sectional area copper conductors. The secondary 15 kV network is mostly made up of underground cables with 70 sq.mm copper conductors.

Generally, the performance of such cables is rather good, since they appear to have never been overloaded. It follows that they may be kept in service for at least another decade.

The situation is different in terms of electric operation of the cables.

Under the present circumstances, in case of total outage of the Maianga substation, its load might be covered by the Cuca substation, by overloading the Cuca transformers. However, this action would be nullified by the fact that the feeders outgoing from such substation would not be capable of carrying the entire load owing to the insufficient cross-sectional area of their conductors.

The same applies to possible outages in the Cuca substation. In effect, owing to insufficient power rating of transformers and to limited transmission capacity of feeders, the Maianga substation would not be capable of ensuring the duplicate supply of the MV network.

The above drawbacks can be overcome with the construction of the new Mutamba substation and the laying of short lengths of 15 kV underground cable, which would allow to better operate the current links across the various shunting substations.

The near-totality of the secondary MV/LV transforming stations are generally in bad condition owing to lack of maintenance, especially on LV units.

Maintenance of MV/LV substations was totally ignored. This accelerated deterioration of premises and of their switchgear, making the substations poorly reliable, unsafe for the personnel and prone to frequent faults which disconnect a large number of consumers for rather long periods.

As a result, it is necessary to totally reconstruct 110 secondary transforming substations and to replace the switchgear in another 90 stations, with both major and minor works.

The above is valid provided that EDEL soon completes its current work for connection of the former 6.6 kV substations to the 15 kV network.

Suburban area

The 15 kV lines, through which SONEFE supplies industrial consumers in the suburban area of Luanda, are all radially operated from the Luanda 2 substation.

This network configuration causes significant problems of power supply to industrial consumers. As no duplicate supply is in place, these consumers are disconnected in case of line faults.

At present, the suburban area consumers are supplied via:

SAIDA 1 line, outgoing from the Luanda 2 substation, feeding the consumers in the South-East area, without duplicate supply;

SAIDA 2 line, outgoing from the Luanda 2 substation, feeding the consumers of the West area, without duplicate supply;

SAIDA 3 line, outgoing from the Luanda 2 substation, feeding the industrial consumers of the urban center, without duplicate supply;

SAIDA 5 LINE, outgoing from the Luanda 2 substation, feeding the consumers of the East area, without duplicate supply.

This type of operation does not optimize the use of the network for either of the following reasons: duplication of lines operated by EDEL, with consequent redundant investments; non-use of the possibility of closing meshes, which would facilitate both elimination of some radially-operated lines and ensure the duplicate supply of some network lines.

This fact evidences the need that these lines be entrusted to EDEL, so as to rationally integrate them within its network. This migration would eliminate malfunctions which, as previously observed, are due to the lack of duplicate supply, which generates considerable problems for industrial consumers.

Entrusting the operation of the entire MV network to a single utility would also streamline the service, favoring a prompter response to possible widespread outages.

After transferring the network to EDEL, the above problems can be eliminated in the following way:

SAIDA 1 line, reconstruction of the line by increasing the conductor cross-sectional area and by extending the line as far the Viana substation, where a 60/15 kV unit, presently non-existent, should be installed;

SAIDA 2 line, reconstruction of part of the SAIDA 2 line by increasing the conductor cross-sectional area and by extending the line as far as the Belas substation;

SAIDA 3 line, linking of the line with the Cuca substation, to ensure duplicate supply;

SAIDA 5 line, reconstruction of the line by increasing the conductor cross-sectional area and by extending the line as far as the Quifagondo substation, where a 60/15 kV unit, presently non-existent, should be installed.

The MV overhead line, currently operated by SONEFE, has a rather good performance. Nonetheless, some measures should be taken to avoid bottlenecks or dangerous situations arising from the fact that numerous masonry huts were recently built just under the lines.

The near-totality of the MV power supply substations generally have a bad performance owing to lack of maintenance.

The switchgear needs to be replaced in at least 300 MV power supply substations.

LV systems and public lighting

The entire LV network is extremely obsolete and prone to frequent and prolonged faults, due to ageing of and high overload on existing cables.

Generally, there is no coordination between protections and transmission capacity of LV cables and this obviously impairs network operation.

Most of the distribution cabinets located on feeders and installed along the roads are deprived of protection doors and at any rate ill-maintained.

Both multiple and single consumer supply lines are very unsafe and poorly performing.

The precarious conditions of the network allowed numerous illegal connections, which worsens the economic-financial situation of EDEL. EDEL experts estimated the number of these illegal connections at approximately 30,000.

The same applies to the public lighting system.

Part of the system is out of service, especially in peripheral roads and green spaces.

The underground network feeding the lighting points is faulted in many portions and replaced by temporary overhead lines.

Lighting fittings are obsolete and in bad condition.

The overall LV network and public lighting situation discourages any corrective maintenance since the latter would be very costly and ineffective.

To redress the above weaknesses and at the same time to cover the demand in the next few years, it is necessary to reconstruct and increase the transmission capacity of 600 km of LV underground lines and 250 km of LV overhead lines. Moreover, at least 30,000 supply terminals in very bad condition shall be totally reconstructed. The 30,000 illegal connections shall be identified and legalized through construction of standard supply terminals. Additionally, 4,000 new lighting points with adequate lighting features shall be constructed to replace existing ones.

II.3 - DESCRIPTION OF REHABILITATION WORKS AND RELATED COST ESTIMATE

Taking into account that the system rehabilitation works should be on the priority list, they shall be completed in the first five-year period (1991-1995), so as to make the system more reliable and efficient.

Primary HV systems (Table 3)

A1.1 * Luanda 2 substation * construction of lines to Cuca substation
- 2 x 60 kV line units
- 1 busbar unit

A1.2 * Cuca substation * construction of new feeders between Luanda 2 and Mutamba substations
- 4 x 60 kV line units
- 1 busbar unit

A1.3 * Mutamba substation * construction of a new substation equipped as follows:
- 2 x 60 kV line units for line from Cuca substation
- 1 x 60 kV busbar unit
- 1 x 60 kV transformer unit
- 1 monitoring and control unit for 13 MV lines
- 2 x 60/15 kV, three-phase transformers, 1 x 20 MVA + 1 x 40 MVA
- 1 MV monitoring and control unit
- 1 room and civil works

A1.4 * Viana substation * construction of a new 60/15 kV unit consisting of:
- 1 x 60 kV busbar unit
- 1 x 60 kV transformer unit
- 1 monitoring and control unit for 3 MV lines
- 1 x 60/15 kV, 20 MVA, three-phase transformer
- 1 HV monitoring and control unit

A1.5 * Quifangondo substation * construction of a new 60/15 kV unit including:
- 1 x 60 kV busbar unit
- 1 x 60 kV transformer unit
- 1 monitoring and control unit for 3 MV lines
- 1 x 60/15 kV, 20 MVA, three-phase transformer
- 1 HV monitoring and control unit

A1.6 * Belas substation * replacement of the 2 x 60/15 kV, 1 MVA tranformers with 1 x 20 MVA transformer

A1.7 * construction of 2 x 60 kV single-circuit lines on steel pylons, with cap and pin insulators and 409 sq.mm ACSR, for a total of 8 km, to double the current link between the Luanda 2 and Cuca substations

A1.8 * construction of 2 x 60 kV underground lines, 3 x (1 x 300) sq.mm copper conductors, to feed the new Mutamba substations, for a total of 12 km

Secondary MV systems

A2.1 * construction of 27 km of 15 kV line outgoing from the Viana substation on reinforced concrete supports, with cap and pin insulators, 150 sq.mm ACSR, to replace the existing Saida 1 line

A2.2 * construction of 20 km of 15 kV line outgoing from the Quifangondo substation on reinforced concrete supports, with cap and pin insulators, 150 sq.mm ACSR, to replace the existing Saida 5 line

A2.3 * construction of 16 km of 15 kV line outgoing from the Belas substation on reinforced concrete supports, with cap and pin insulators, 150 sq.mm ACSR, to replace the existing Saida 2 line

A2.4 * reconstruction of 110 existing secondary transforming substations with installation of power factor correction capacitors

A2.5 * maintenance and reconstruction of switchgear in 690 existing secondary transforming substations with installation of power factor correction capacitors

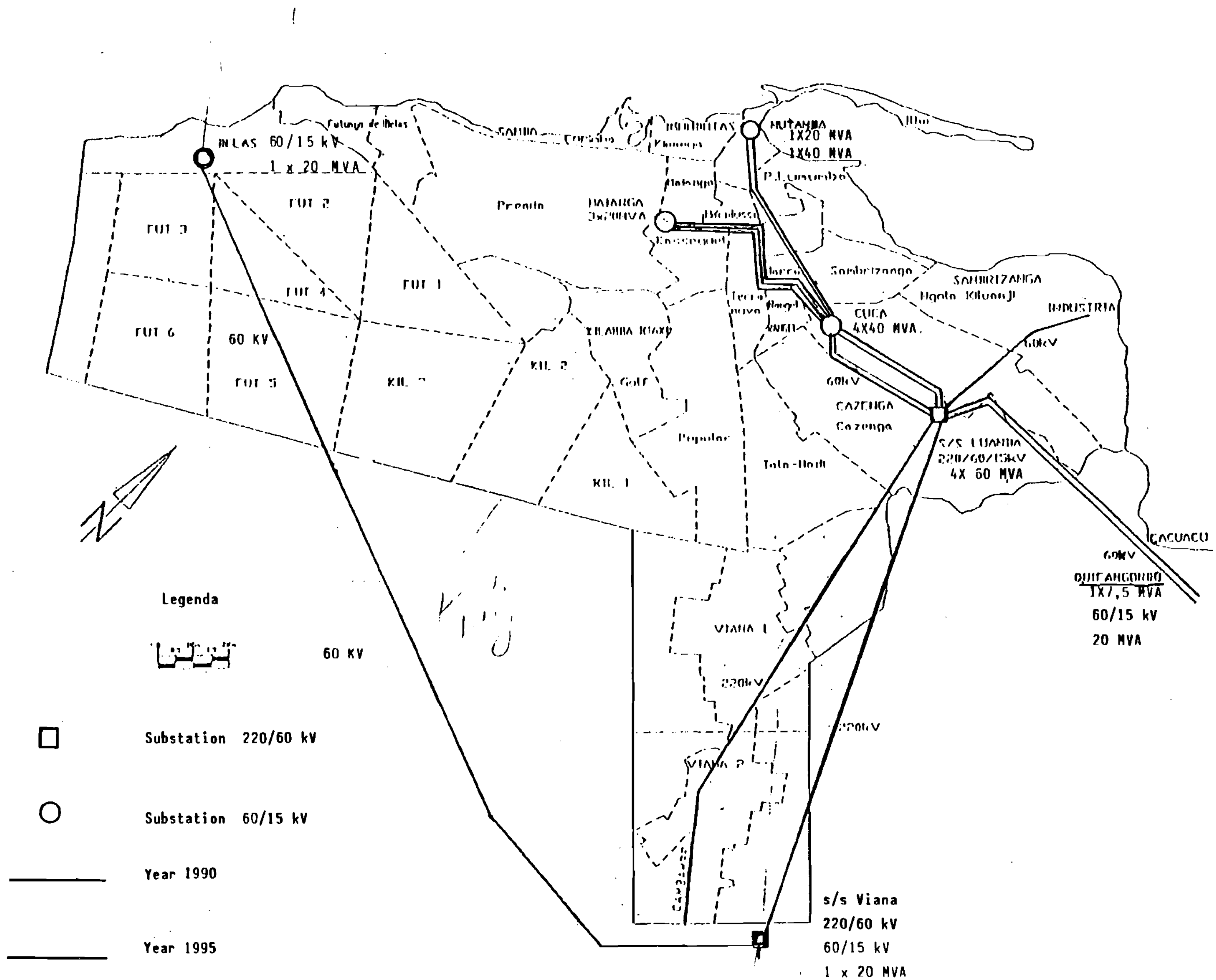
LV systems

A3.1 * construction of 600 km of underground lines on 3.5 x 95 sq.mm and 3.5 x 50 sq.mm copper conductors, to replace the existing obsolete network

A3.2 * construction of 250 km of LV lines on reinforced concrete poles and wall brackets with 4 x 70 sq.mm and 4 x 35 sq.mm "câbles torsadés", to replace the existing obsolete network

A3.3 * construction of 60,000 supply terminals to eliminate illegal connections and reconstruction of existing supply terminals

A3.4 * reconstruction of existing public lighting system with underground cables for 4,000 lighting points.


INLAS 60/15 kV
1 x 20 MVA
FUT 2
FUT 3
FUT 1
FUT 4
FUT 6
60 KV
FUT 5
Prenda
KIL 2
KIL 1
Golf
Popular
Tala-Hadi
MUTAMBA
1X20 MVA
1X40 MVA
CUCA
4X40 MVA.
CAZENGA
Cazenga
60kV
SAMBIZANGA
INDUSTRIA
S/S LUANDA
220/60/15kV
4X 60 MVA
CACUACO
60kV
QUIFANGONDO
1X7,5 MVA
60/15 kV
20 MVA
VIANA 1
220kV
VIANA 2
s/s Viana
220/60 kV
60/15 kV
1 x 20 MVA
Legenda
60 KV
Substation 220/60 kV
Substation 60/15 kV
Year 1990
Year 1995

Cost estimate of rehabilitation works (1990 COSTS)

A1.1 Luanda 2 substation	n.	1 x	$ 850.000 =	$	850.000
A1.2 Cuca substation	n.	1 x	$ 1.550.000 =	$	1.550.000
A1.3 Mutamba substation	n.	1 x	$ 3.000.000 =	$	3.000.000
A1.4 Viana substation	n.	1 x	$ 1.700.000 =	$	1.700.000
A1.5 Quifangondo substation	n.	1 x	$ 1.700.000 =	$	1.700.000
A1.6 Belas substation	n.	1 x	$ 230.000 =	$	230.000
A1.7 60 kV overhead lines, 409 sq.mm	Km	8 x	$ 80.000 =	$	640.000
A1.8 60 kV underground lines	Km	12 x	$ 230.000 =	$	2.760.000
A2.1 15 kV overhead lines 150 sq.mm ACSR	Km	27 x	$ 58.000 =	$	1.566.000
A2.2 15 kV overhead lines, 150 sq.mm ACSR	Km	20 x	$ 58.000 =	$	1.160.000
A2.3 15 kV overheas line 150 sq.mm ACSR	Km	16 x	$ 58.000 =	$	928.000
A2.4 reconstruction of sec. transforming subst.	n.	110 x	$ 25.000 =	$	2.750.000
A2.5 maintenance on sec. transforming subst.	n.	690 x	$ 12.000 =	$	8.280.000
A3.1 LV underground lines	Km	600 x	$ 68.000 =	$	40.800.000
A3.2 LV overhead lines	Km	250 x	$ 26.000 =	$	6.500.000
A3.3 supply terminals with meter	n.	30.000 x	$ 360 =	$	10.800.000
A3.3 supply terminals without meter	n.	30.000 x	$ 260 =	$	7.800.000
A3.4 public lighting points	n.	4.000 x	$ 1.000 =	$	4.000.000
Total				$	97.014.000

N.B. The Joint Angolan Government-Italian Ministry of Foreign Affairs Commission agreed on a soft loan for rehabilitation of part of the Luanda electric system, namely the LV distribution network and the Mutamba substation. The soft loan is supposed to amount to 15.1 million ECU. Nonetheless, this funding is not expected to materialize until 1993.

II.4 - DEFINITION OF DEMAND GROWTH AND OF ITS LOCATION

Based on the indications provided by the planning expert of the ANG 89/30 MISSION on the expected growth of electricity demand in Angola, two scenarios can be projected:

	FIRST PERIOD 1991 - 1995	SECOND PERIOD 1996 - 2000
HIGH SCENARIO	+ 8.37 %	+ 10.4 %
LOW SCENARIO	+ 5.3 %	+ 5 %

The maximum demand in MVA was computed taking into account the energy which is assumed to be distributed in 1990, a load factor of 0.63 and a power factor of 0.75.

Consequently, the maximum demand in the Luanda province will be as follows:

	HIGH SCENARIO	LOW SCENARIO
MAX DEMAND IN 1990	165 MVA	165 MVA
FIRST PERIOD 1991-1995	246 MVA	213 MVA
SECOND PERIOD 1996-2000	403 MVA	272 MVA

In view of the suggestions made by the above expert, of the data collected and of the observations made, the urban center is supposed to record a moderate load growth in the high scenario. Conversely, in the same scenario, suburban and industrial areas will experience a substantial load development. These areas, in effect, are already the focus of numerous and disorderly settlements with dwellers coming from nearby inland areas.

The above is corroborated by the 1988 BEP study, approved by the Luanda Ministry of Energy and Petroleum, on growth of population and on its location by district.

The study predicts that the purely urban districts (Ilha do Cabo, Kinanga, Lumumbo, Rangel) will not show any significant population increase at least until the year 2000.

By contrast, the study foresees major population increases in suburban areas, as shown in the following table.

Projected population growth by district (thousand inhabitants)

	1990	1995	2000
TALA HADI	37	37	38
GOLFE	123	142	162
POPULAR	97	108	122
CORIMBA	22	22	22
FUTUNGO	1	1	0
FUT 1	25	37	51
FUT 2	54	82	111
FUT 3	37	90	144
FUT 4	22	34	47
FUT 5	16	51	89
FUT 6	15	82	156
KIL 1	27	42	57
KIL 2	50	97	145
KIL 3	10	55	104
EXT 1	4	43	91
EXT 2	0	5	64
VIANA 1	13	21	30
VIANA 2	39	46	55
TOTAL	592	995	1.488

Consequently, the number of consumers is anticipated to rise as follows:

1991-1995 + 60,000
1996-2000 + 76,000

Ultimately, for sizing of systems in the Province, the following load growth is assumed in the two periods:

		1991 - 1995	1996 - 2000
Urban area	MVA	21	37
Suburbana area	MVA	60	120
	MVA	81	157

Considering the above and the predicted demand growth up to the year 2000, a number of extension works on the existing network appears as needed:

- 1 new 220/60/15 kV substation, 3 x 60 MVA at KIL 3
- 1 new 60/15 substation, 1 x 20 MVA + 1 x 40 MVA, at Golfe
- 21 km of 220 kV tie line between the Viana and the KIL 3 substations
- 18 km of 220 kV tie line between the KIL 3 and Luanda 2 substations
- 17 km of 60 kV line
- 760 km of 15 kV, MV lines
- 1,210 secondary MV/LV transforming stations
- 2,300 km of LV line
- 136,000 new supply terminals
- 3,000 lighting points.

II.5 - DESCRIPTION OF EXTENSION WORKS AND RELATED COST ESTIMATE

The works indicated below are expected to extend the electric system in the province to meet the projected rise in electricity demand and number of consumers over a 10-year timeespan (1991-2000).

Obviously, the related expenditure shall be modulated during the above period taking into account the actual demand growth and the available financial resources.

Indicatively, assuming a linear demand growth in the period, the total expenditure was split into two stages, bearing in mind the technical priority of the works to be completed.

B - FIRST STAGE

Primary HV systems (Table 4)

B1.1 * installation of a 2nd, 60/15 kV, 20 MVA transformer in the Belas substation

Secondary MV systems

B2.1 * construction of 100 km of 15 kV line on reinforced concrete supports, with cap and pin insulators, 150 sq.mm ACSR, for supplying new secondary transforming substations

B2.2 * construction of 150 km of 15 kV line on reinforced concrete supports, with cap and pin insulators, 35 sq.mm copper conductors, for supplying new secondary transforming substations

B2.3 * construction of 10 km of 15 kV underground line, 3 x 70 sq. mm copper conductors, for supplying new secondary transforming substations in the urban center

B2.4 * construction of 100 x 15/0.380 kV, 100 kVA pole-type transformers and power factor correction capacitors

B.2.5 * construction of 210 box-type secondary transforming substations with 15/0.380 kV, 250 kVA transformers and power factor correction capacitors

B2.6 * construction of 100 box-type secondary transforming substations with 15/0.280 kV, 400 kVA transformers and power factor correction capacitors

LV systems

B3.1 * construction of 800 km of LV lines on reinforced concrete supports with 4 x 70 sq.mm and 4 x 35 sq.mm aluminum "câbles torsadés", for network extension

B3.2 * construction of 60,000 new supply terminals

B3.3 * construction of public lighting system with overhead lines for 1,500 lighting points

C - SECOND STAGE

Primary HV systems (Table 4)

C1.1 * KIL 3 substation * construction of a new 220/60/15 kV substation equipped as follows:

- 2 x 220 kV line units for incoming lines;
- 1 x 220 kV busbar unit;
- 1 x 220 kV transformer unit for three transformers;
- 4 monitoring and control units for 4 x 60 kV lines;
- 1 monitoring and control unit for 5 MV lines;
- 1 x 60 kV busbar unit;
- 3 x 220/60/15 kV, 60 MVA, three-phase transformers;
- 1 HV protection and control unit;
- 1 room.

C1.2 * Luanda 2 substation * extension of the substation with:
- 1 monitoring and control unit for 4 x 15 kV lines;
- 1 x 220 kV line unit.

C.1.3 * Golfe substation * construction of new substation equipped as follows:
- 2 x 60 kV line unit for incoming line from the KIL 3 substation;
- 1 x 60 kV busbar unit;
- 1 x 60 kV transformer unit;
- 1 monitoring and control unit for 12 MV lines;
- 2 x 60/15 kV, 1 x 20 MVA + 1 x 40 MVA, three-phase transformers;
- 1 HV protection and control unit;
- 1 room.

C1.4 * Viana substation * extension of the substation with:
- 1 x 220 kV line unit;
- 1 x 220 kV busbar unit;
- 1 monitoring and control unit for 6 MV lines;
- 1 x 60 kV transformer unit;
- 1 x 60/15 kV, 20 MVA, three-phase transformer.

C1.5 * construction of a 220 kV single-circuit line with steel pylons, cap and pin insulators and 409 sq.mm ACSR, for a total of 21 km, for linking the Viana and KIL 3 substations

C1.6 * construction of a 220 kV single-circuit line with steel pylons, cap and pin insulators and 409 sq.mm ACSR, for a total of 18 km, for linking the KIL 3 and Luanda 2 substations

C1.7 * construction of 2 x 60 kV single-circuit lines with steel pylons, cap and pin insulators and 409 sq.mm ACSR for a total of 15 km, for linking the KIL3 and Golfe substations

C1.8 * construction of 2 x 60 kV single-circuit lines with steel pylons, cap and pin insulators, 116 sq.mm ACSR, for a total of 2 km, for linking the KIL 3 and Belas - Viana substations

Secondary MV systems

C2.1 * construction of 100 km of 15 kV line on reinforced concrete supports, with cap and pin insulators, 150 sq.mm ACSR, for supplying new secondary transforming substations

C2.2 * construction of 400 km of 15 kV line on reinforced concrete supports, pin insulators, 35 sq.mm copper conductors, for supplying new secondary transforming substations

C2.3 * construction of 500 x 15/0.380 kV, 250 kVA pole-type transformers and power factor correction capacitors

C2.4 * construction of 300 box-type secondary transforming substations with 15/0.380 kV, 250 kVA transformers and power factor correction capacitors.

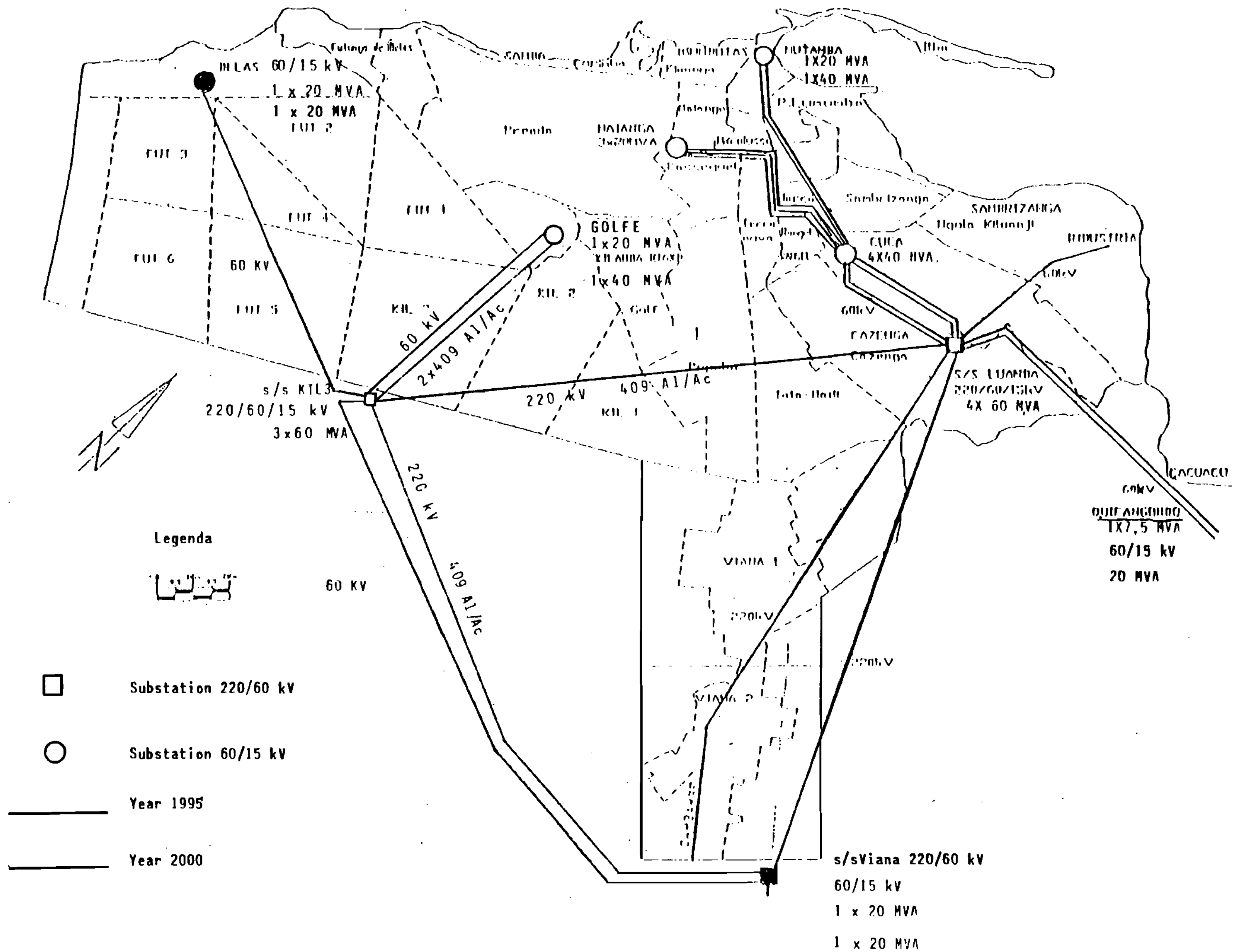
LV systems

C3.1 * construction of 1,500 km of LV lines on reinforced concrete supports with 4 x 70 sq.mm aluminum "câbles torsadés", for network extension.

C3.2 * construction of 76,000 new supply terminals.

C3.3 * construction of public lighting system with overhead line for 1,500 lighting points.

TAV. 4



MILAS 60/15 kV
1 x 20 MVA
1 x 20 MVA
FUT 2
FUT 3
FUT 4
FUT 6
60 KV
FUT 5
FUT 1
s/s KIL3
220/60/15 kV
3x60 MVA
60 kV
2x409 Al/Ac
GOLFE
1x20 MVA
1x40 MVA
KIL 2
220 kV
409 Al/Ac
KIL 1
NUTAMBA
1X20 MVA
1X40 MVA
CUCA
4X40 MVA.
S/S LUANDA
220/60/15kV
4X 60 MVA
SAMBIZANGA
INDUSTRIA
CACUACO
60kV
1X7,5 MVA
60/15 kV
20 MVA
VIANA 1
220kV
VIANA 2
s/sViana 220/60 kV
60/15 kV
1 x 20 MVA
1 x 20 MVA
220 kV
409 Al/Ac
Legenda
60 KV
Substation 220/60 kV
Substation 60/15 kV
Year 1995
Year 2000

Cost estimate of extension works (1990 costs)

B - FIRST STAGE

B1.1 - Belas substation	n.	1 x	$	230.000 =	$	230.000
B2.1 15 kV overhead line 150 Al/Ac	Km	100 x	$	58.000 =	$	5.800.000
B2.2 15 kV line 35 Copper	Km	150 x	$	37.000 =	$	5.550.000
B2.3 15 kV underground 3 x 70 Cu	Km	10 x	$	100.000 =	$	1.000.000
B2.4 pole-type transformers palo	n.	100 x	$	10.000 =	$	1.000.000
B2.5 box-type transforming 250 KVA	n.	210 x	$	46.000 =	$	9.660.000
B2.6 box-type transforming 400 KVA	n.	100 x	$	49.000 =	$	4.900.000
B3.1 LV overhead lines	Km	800 x	$	26.000 =	$	20.800.000
B3.2 new supply terminals with meter	n.	60.000 x	$	360 =	$	21.600.000
B3.3 public lighting points	n.	1.500 x	$	700 =	$	1.050.000
Total					$	71.590.000

C - SECOND STAGE

C1.1 KIL 3 substation	n.	1 x	$	7.500.000 =	$	7.500.000
C1.2 Luanda 2 substation	n.	1 x	$	650.000 =	$	650.000
C1.3 Golfe substation	n.	1 x	$	3.000.000 =	$	3.000.000
C1.4 Viana substation	n.	1 x	$	2.000.000 =	$	2.000.000
C1.5 220 kV lines 409 ACSR	Km	21 x	$	110.000 =	$	2.310.000
C1.6 220 kV lines 409 ACSR	Km	18 x	$	110.000 =	$	1.980.000
C1.7 60 kV lines 409 ACSR	Km	15 x	$	80.000 =	$	1.200.000
C1.8 60 kV lines 116 ACSR	Km	2 x	$	65.000 =	$	130.000
C2.1 15 kV lines 150 ACSR	Km	100 x	$	58.000 =	$	5.800.000
C2.2 15 kV overhead lines 35 Copper	Km	400 x	$	37.000 =	$	14.800.000
C2.3 pole-type, transformers	n.	500 x	$	10.000 =	$	5.000.000
C2.4 box-type, 250 kVA, sec. trans. subst.	n.	300 x	$	46.000 =	$	13.800.000
C3.1 LV overhead lines	Km	1500 x	$	26.000 =	$	39.000.000
C3.2 supply terminals with meter	n.	76.000 x	$	360 =	$	27.360.000
C3.3 public lighting points	n.	1500 x	$	700 =	$	1.050.000
Total					$	125.580.000

CHAPTER III

BENGUELA-LOBITO PROVINCE

III.1 - DATA COLLECTION

At present, electricity distribution in the Benguela-Lobito province is ensured by CELB and coordinated by ENE.

The above towns are located on the Atlantic coast, in the central part of Angola, south of Luanda (approx. 500 km).

Formulation of the preliminary project for rehabilitation of the electric system in the province demanded the collection of a large number of data on the makeup of the electric network and on its present performance.

Lack of data and short time allowance prevented us from gaining a complete understanding of the electric system in point. Nevertheless, the collected data were regarded as sufficient for drafting of a preliminary project.

The energy distributed in the Benguela-Lobito province is generated by the gas turbine (10 MVA) and hydro (18 MVA) plant of Biopio as well as by the diesel plant of Lobito (20 MVA).

Currently, the electric system in the Benguela-Lobito province is based on 4 voltage levels, i.e.:

- 150 kV or the primary supply of the Quileva substation, feeding part of the province;
- 60 kV for the supply of the remaining distribution system through the Catumbela substation;
- 30 kV for the supply of the secondary 30/0.380 kV substations of the Catumbela area, of the Lobito suburbs and of the Baia Farta area, as well as for the supply of the 30/20 kV substations of Lobito and Benguela;
- 20 kV for the supply of the remaining secondary 20/0.380 kV substations of the province.

The electric system of the province includes the following components:

Primary 150 and 60 kV network (Table 5)

- 150 kV HV lines on steel pylons 18 km
- 60 kV HV lines on steel pylons
- Quileva substation

150/30 kV transformation
installed capacity 2 x 30 MVA

- Catumbela substation

60/30 kV transformation
installed capacity 5 x 4.5 MVA

- Lobito substation

30/20 kV transformation
installed capacity 2 x 7.5 MVA

- Benguela substation

30/20 kV transformation
installed capacity 2 x 7.5 MVA

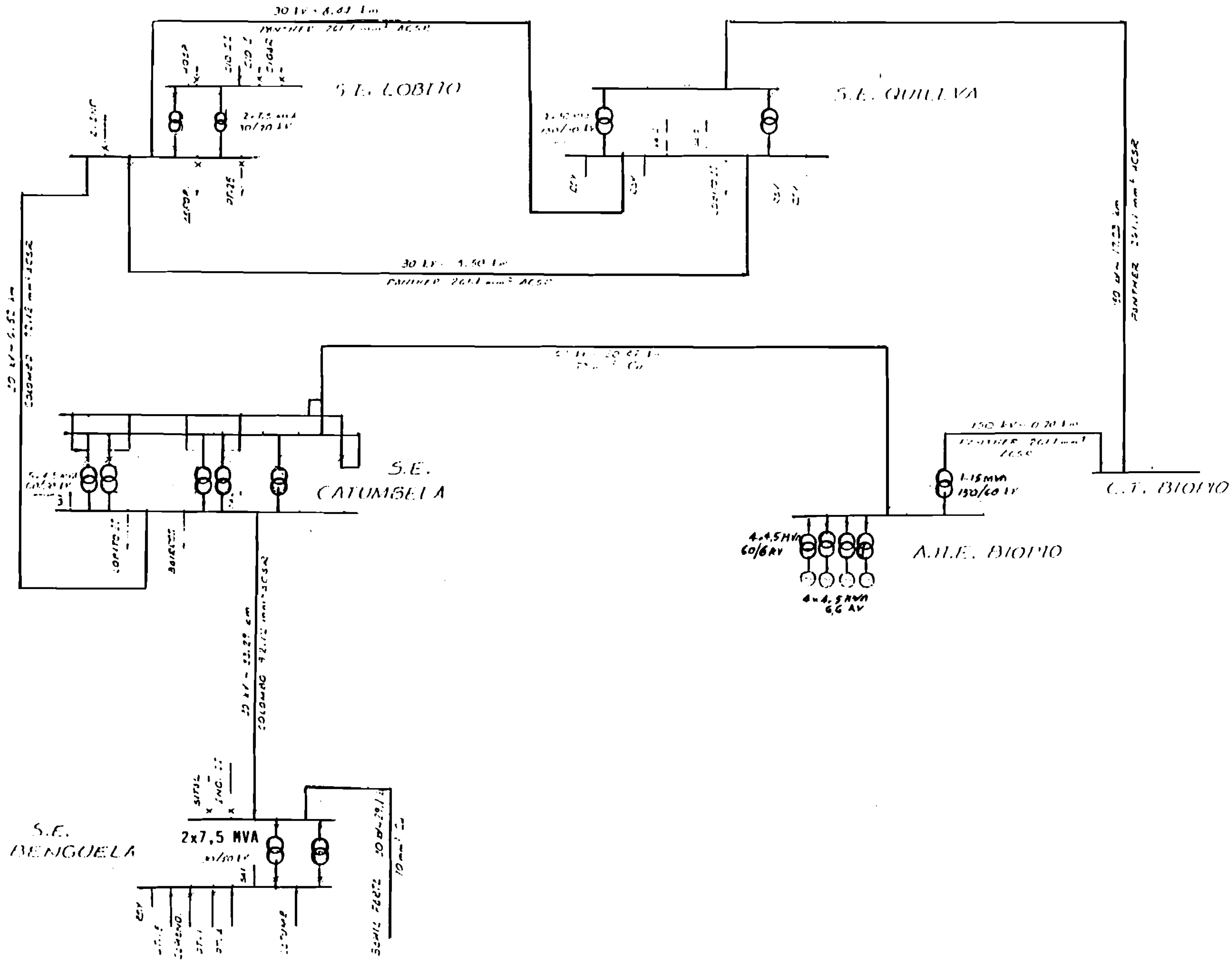
Secondary MV network

- 30 kV overhead lines
- 20 kV underground and overhead lines
- secondary MV/LV transforming and power supply substations

LV network

- LV overhead and underground lines
- LV supply terminals

It was not possible to collect data on the public lighting system. However, site inspections allowed to estimate the number of lighting points at 1,100.


S.E. LOBITO
S.E. QUILEVA
S.E. CATUMBELA
C.T. BIOPIO
A.H.E. BIOPIO
S.E. BENGUELA
2x7,5 MVA
4x4,5 MVA
60/6 kV
4x4,5 MVA
6,6 kV
150/60 kV
PANTHER

TAV. 5

III.2 - CHECKING OF THE PERFORMANCE OF CURRENT SYSTEMS PRIORITY MEASURES TO BE TAKEN FOR THEIR REHABILITATION

The province is part of the Central System and is supplied via 150 and 60 kV lines by the thermal and hydro plant of Biopio and by the diesel plant of Lobito.

Primary 150 kV systems

The 150 kV overhead line linking the substation of the Biopio thermal plant with the Quileva substation is in good condition and, in principle, does not need corrective maintenance.

Primary 60 kV systems

The 60 kV overhead line linking the Biopio and the Catumbela substations is rather old but generally in good condition. The line is designed for accommodating a second circuit of conductors.

For a comprehensive rehabilitation, moderate corrective maintenance jobs are required, such as:

- repainting of all steel supports;
- reconstruction of some foundation blocks;
- replacement of some supports.

The Lobito and Quileva substations, recently built, do not require corrective maintenance.

The Catumbela and Benguela substations need a number of corrective maintenance jobs, especially on the MV unit, within a short time.

Secondary MV systems

The network operation is quite cumbersome. In effect, while Baia Farta and Catumbela have a single 30 kV voltage level, Benguela and Lobito have two levels, 20 and 30 kV.

At present, a fault on the single 30 kV line connecting the Catumbela and Benguela substations would put the small town of Benguela and Baia Farta out of service.

Generally, the performance of the overhead MV network, both at 30 and at 20 kV, is good.

Conversely, the underground network is in very bad condition, with frequent power supply disruptions.

The cause of the outages is ascribable to corrosion in the lead of the armored MV cables by the saltwater with which the subsoil is impregnated.

The secondary MV/LV transforming substations are in generally good condition, especially the MV unit. However, the LV unit is not compliant with basic injury prevention standards, although it does not require immediate action.

LV systems and public lighting

The entire LV network is extremely obsolete and subject to frequent and prolonged faults, due to both ageing and to high overload.

The same lead corrosion on the MV network was observed on the LV underground network.

Generally, there is no coordination between protections and transmission capacity of LV cables. This obviously worsens the network operation.

The supports of the public lighting network, recently repainted, showed corrosion at their base. CELB experts plan a reinforcement ring at the base of the supports. In our opinion, this operation would be very time-consuming and of little help.

The underground network which feeds the lighting points is faulted in many portions and replaced by provisional overhead lines.

The armors are obsolete and in bad condition.

The overall situation of the LV network and of the public lighting system discourages corrective maintenance, which would prove to be very costly and ineffective.

During meetings with ENE managers, it turned out that a number of retrofits and extensions of the distribution system in the province has just begun.

These works were planned by ENE under the supervision of ELECNOR S.A. and almostly entirely funded (18 million $) by the Spanish FAD.

The project consists of the following works (Table 6):

a) construction of a new substation at Cavaco, 60/30 kV, 2 x 15 MVA;

b) construction of a 150 kV tie line between the Biopio and Quileva substations, at a later stage;

c) construction of two x 60 kV lines for the supply of the new Cavaco substation from the existing Catumbela substation, of which one to be built at a later stage;

d) construction of a second 60 kV tie line between the Catumbela and Biopio substations, to be installed on the existing poles;

e) construction of a 30 kV tie line between the Catumbela and Benguela substations;

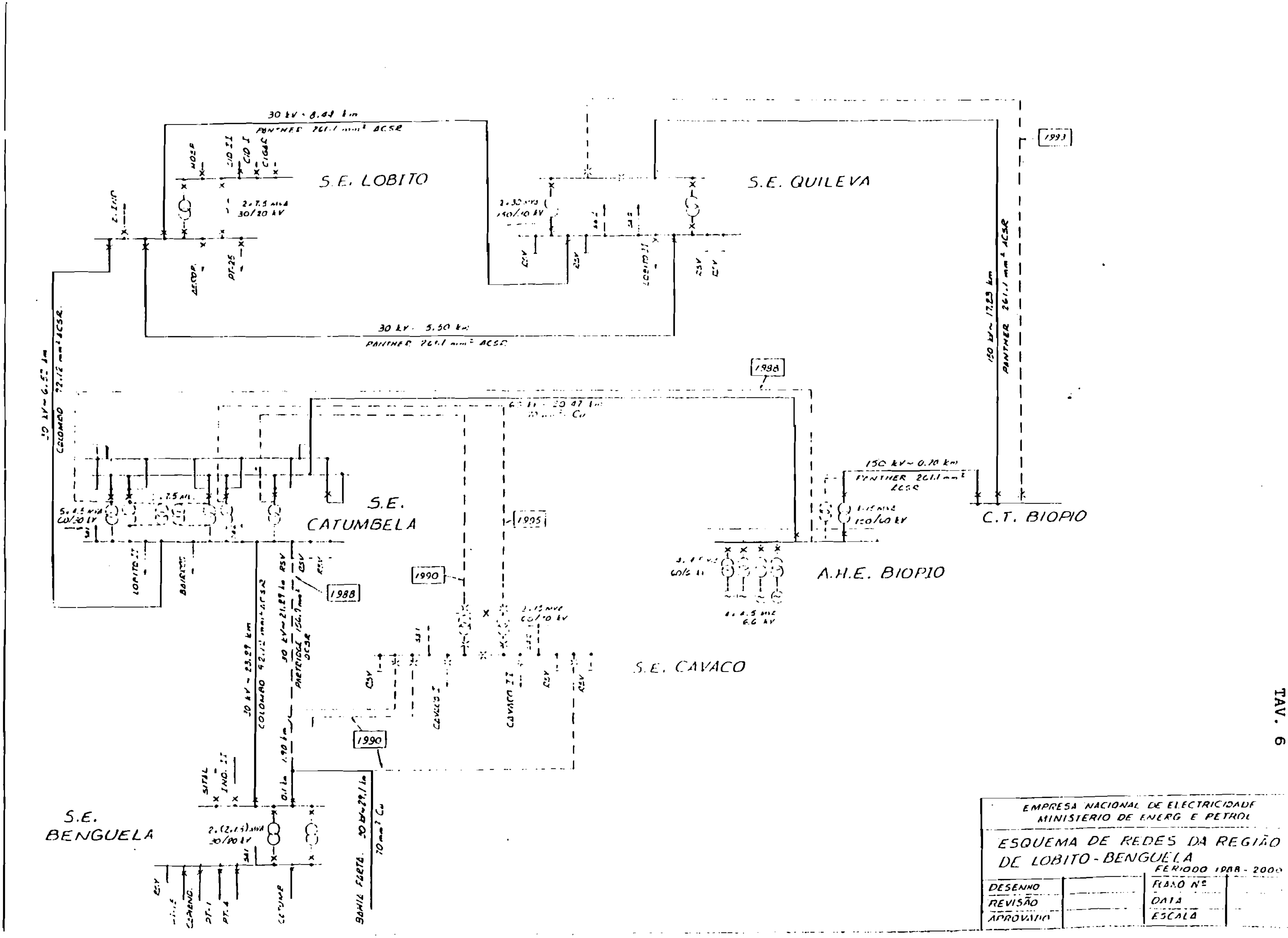
f) construction of a 30 kV double-circuit line, on common poles, connecting the new Cavaco substation with the Catumbela and Benguela substations;

g) various electrical works for retrofitting of the Benguela substation;

h) replacement of five x 30/30 kV, 4.5 MVA transformers with two x 60/30 kV, 7.5 MVA transformers;

i) construction of 55 km of 20 kV underground lines in the towns of Benguela, Lobito and Catumbela;

l) construction of 70 km of 30 kV overhead lines for supplying new secondary transforming substations in the Cavaco valley.


S.E. LOBITO
S.E. QUILEVA
S.E. CATUMBELA
S.E. CAVACO
S.E. BENGUELA
A.H.E. BIOPIO
C.T. BIOPIO
30 kV - 5.50 km
PANTHER 261.1 mm² ACSR
150 kV ~ 0.70 km
1993
1998
1995
1990
1988
1990
EMPRESA NACIONAL DE ELECTRICIDADE
MINISTERIO DE ENERG E PETROL
ESQUEMA DE REDES DA REGIÃO DE LOBITO-BENGUELA
DESENHO
REVISÃO
APROVADO
DATA
ESCALA

TAV. 6

Comments

The works indicated in items a),b),c),d),e),f),g),h, are mainly aimed at making the current primary 150/60/30 kV network more efficient and reliable, since all substations are planned to be closed in a ring configuration. The above works will also serve the purpose of covering the expected load increase during the next decade.

In our opinion, however, the proposed solution - to be implemented soon - has some shortcomings. These might be easily removed for a more correct and easier operation of the network as a whole.

In particular, the project involves extension of the 30 kV level, rather than its elimination. This voltage level is outdated, taking into account that the current MV distribution is based on the following voltage levels:

Lobito	20 KV
Benguela	20 kV
Catumbela	30 kV
Quileva	30 kV

Clearly, the 30 kV level should be eliminated, since it is more expensive and more demanding in terms of procurement of materials.

The project also envisages a network layout with construction of double-circuit lines on a single series of poles. This system, practically abandoned in Europe, may cause major difficulties in case of works on one of the two circuits. In effect, for safety reasons, the entire double circuit line should be de-energized.

Moreover, item l) of the project provides for construction of new 30 kV systems, which may instead be easily built at 20 kV.

Item i) involves laying of 20 kV underground cables. In the case of the town of Catumbela, they would be operated at 30 kV. This would undoubtedly shorten the lifetime of the cables.

In view of the above, to streamline and make the electric system more efficient, ensuring the double supply of the substations and eliminating the 30 kV level, the priority works to be performed immediately on the distribution lines and subsequently on the transmission lines should be the following ones:

Primary systems (Table 7)

A1.1 * Biopio substation - extension with installation of:
- 1 x 60 kV line unit
- 1 transformer unit
- 1 HV monitoring and control unit
- 1 x 150/60 kV, 30 MVA transformer

A1.2 * Cavaco substation - construction of a new 60/20 kV substation equipped with:
- 2 x 60 kV units
- 1 x 60 kV busbar unit
- 1 transformer unit
- 1 HV monitoring and control unit
- 2 x 60/20 kV, 20 MVA three-phase transformers
- 1 monitoring and control unit for 7 MV lines
- 1 room and civil works

A1.3 * Catumbela substation - retrofit of the substation with installation of:
- 1 x 60 kV line unit
- 1 HV monitoring and control unit
- 2 x 60/20 kV, 10 MVA transformers
- 1 monitoring and control unit for 5 MV lines

A1.4 * construction of a 60 kV single-circuit line with steel pylons, cap and pin insulators, 261 sq.mm ACSR for a total of 40 km for linking the Biopio substation with the new Cavaco substation

A1.5 * construction of a 60 kV single-circuit line with steel pylons, cap and pin insulators, 50 sq.mm ACSR for a total of 23.5 km for linking the Cavaco substation with the Catumbela substation

Secondary MV systems

A2.1 * replacement of 55 km of 20 kV underground cable with other EPR-insulated, 50 sq.mm copper cables

A2.2 * construction of a 20 kV line on reinforced concrete poles, with cap and pin insulators, 92.12 sq.mm ACSR, for a total of 1 km, to link the current Catumbela-Benguela line with the new Cavaco substation

A2.3 * construction of 3 x 20 kV underground lines, 3 x 1 x 150 sq.mm copper conductors, for a total of 1.5 km, to connect the new Cavaco substation with the Benguela substation, to be downgraded to simple shunting substation

A2.4 * construction of a 20 kV single-circuit line with reinforced concrete supports, cap and pin insulators, 150 sq.mm ACSR, for a total of 6.5 km, to create a new link between the Catumbela and Lobito substations

A2.5 * construction of a 20 kV line on reinforced concrete poles, with cap and pin insulators, 92.12 sq.mm ACSR, for a total of 2 km, to connect the current Benguela-Baia Farta line with the new Cavaco substation

LV systems

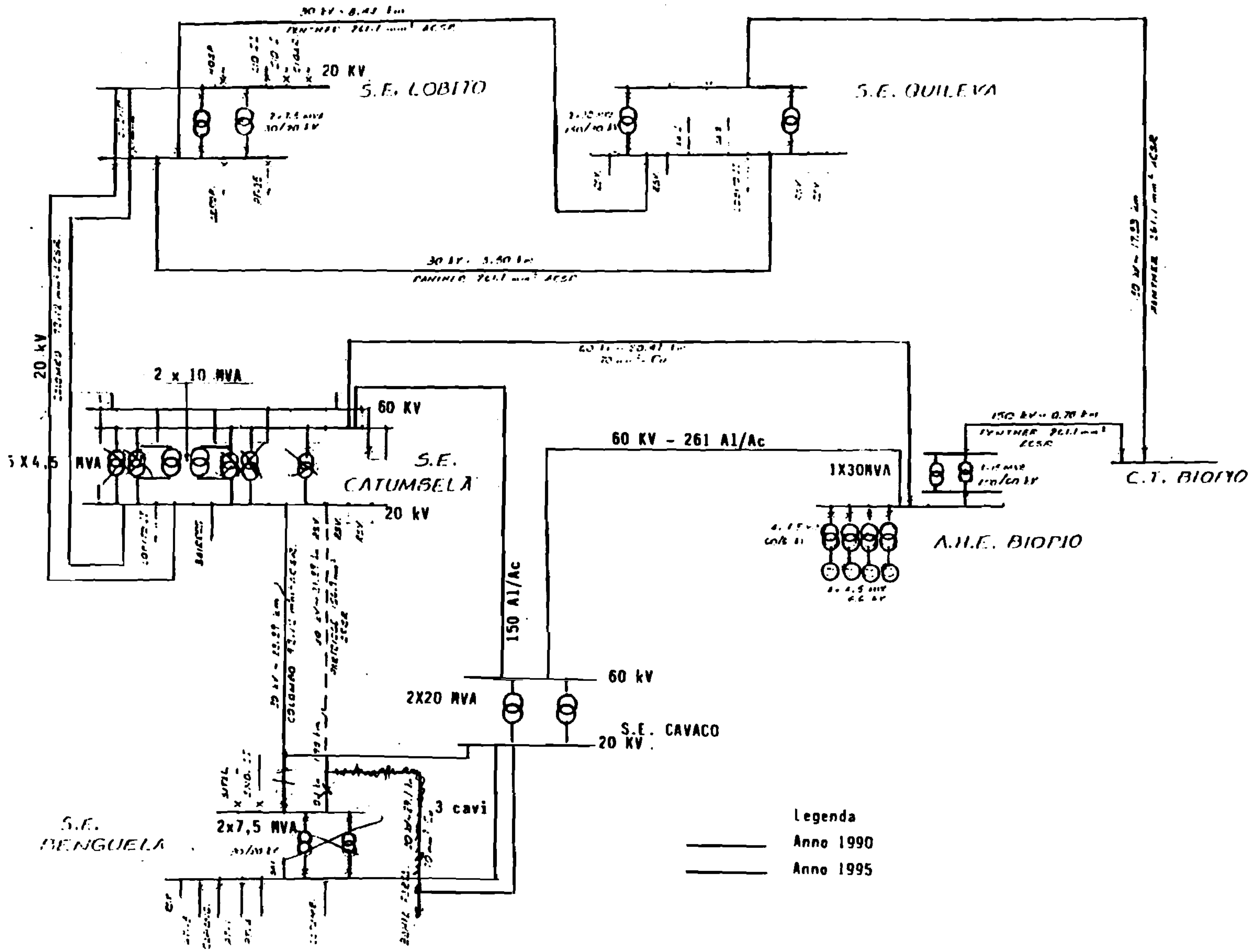
A3.1 * reconstruction of 450 km of LV underground lines in the towns of Lobito and Benguela to replace the obsolete network;

A3.2 * construction of 20,000 supply terminals to eliminate illegal connections and reconstruction of existing terminals;

A3.3 * reconstruction of existing public lighting system for 1,500 lighting points;

A3.4 * replacement of 124 transformers of various power ratings to change voltage from 30 to 20 kV;

A3.5 * siting of the LV unit in 150 secondary transforming substations.


20 KV
S.E. LOBITO
S.E. QUILEVA
20 kV
2 x 10 MVA
60 KV
5 X 4,5 MVA
S.E.
CATUMBELA
20 kV
60 KV - 261 Al/Ac
1X30MVA
C.T. BIOPIO
A.H.E. BIOPIO
150 Al/Ac
60 kV
2X20 MVA
S.E. CAVACO
20 KV
3 cavi
S.E.
BENGUELA
2x7,5 MVA
Legenda
Anno 1990
Anno 1995

TAV. 7

Cost estimate of rehabilitation works (1990 costs)

A1.1 Biopio substation	n.	1 x	$ 1.850.000 =	$ 1.850.000
A1.2 Cavaco substation	n.	1 x	$ 2.800.000 =	$ 2.800.000
A1.3 Catumbela substation	n.	1 x	$ 1.300.000 =	$ 1.300.000
A1.4 60 kV overhead line 261 ACSR	km	40 x	$ 67.000 =	$ 2.680.000
A1.5 60 kV overhead line 150 ACSR	km	23,5 x	$ 60.000 =	$ 1.410.000
A2.1 20 kV underground line 50 Copper	km	55 x	$ 100.000 =	$ 5.500.000
A2.2 20 kV overhead line 92,12 ACSR	km	1 x	$ 54.000 =	$ 54.000
A2.3 20 kV underg. line 3 x 150 Copper	km	1,5 x	$ 270.000 =	$ 405.000
A2.4 20 kV overhead line 150 ACSR	km	6,5 x	$ 58.000 =	$ 377.000
A2.5 20 kV overhead line 92,12 ACSR	km	2 x	$ 54.000 =	$ 108.000
A3.1 LV underground lines	km	450 x	$ 68.000 =	$30.600.000
A3.2 new supply terminals with meter	n.	5000 x	$ 360 =	$ 1.800.000
A3.2 new supply term. without meter	n.	15000 x	$ 260 =	$ 3.900.000
A3.3 public lighting points	n.	1500 x	$ 1.000 =	$ 1.500.000
A3.4 transformer replacement	n.	124 x	$ 5.400 =	$ 669.600
A3.5 reconstr. of LV unit of substation	n.	150 x	$ 2.000 =	$ 300.000
Total				$55.253.600

III.3 - DEFINITION OF DEMAND GROWTH AND RELATED LOCATION

Based on the indications provided by the planning expert from the ANG 89/30 MISSION on the likely growth in Angolan electricity demand and taking into account the maximum capacity reached in the Benguela-Lobito province in 1989, the growth path is as follows:

	FIRST PERIOD 1991 - 1995	SECOND PERIOD 1996 - 2000
HIGH SCENARIO	+ 14 %	+ 11,1 %
LOW SCENARIO	+ 5.3 %	+ 5 %

The maximum demand in MVA was calculated from the expected energy to be distributed in 1990, using a load factor of 0.625 (figure provided by the Angolan planning expert) and assuming a power factor of 0.8.

Accordingly, the maximum demand values in the Benguela-Lobito province will be:

	HIGH SCENARIO	LOW SCENARIO
1990 MAXIMUM DEMAND	24 MVA	24 MVA
FIRST PERIOD 1991-1995	46 MVA	31 MVA
SECOND PERIOD 1996-2000	78 MVA	40 MVA

Given the short length of the visit and the communication difficulties between ENE, Luanda and CELB, Lobito, the data collected on urban development and population growth forecasts in the Benguela province are not exhaustive. Nevertheless, an increase of approximately 32,000 consumers can be assumed in the 1991-2000 decade.

The only significant data concern the planned construction of 120 pole-type transformers in the Cavaco valley to supply the numerous irrigation systems.

According to indications provided by the production experts, our project assumes that all the energy required by the province will be generated by the Biopio and Lomaum plants.

III.4 - DESCRIPTION OF EXTENSION WORKS AND RELATED COST ESTIMATE

The works indicated below refer to extension of the electric system in the province, so as to cover the expected demand and consumer increase in the timespan of 10 years (1991-2000).

Obviously, the related expenditure shall be modulated during the period, taking into account the actual demand growth and availability of funds.

Indicatively, assuming a linear growth of demand in the period, the total expense was split into two stages, taking into account technical priority of the works.

B - FIRST STAGE

Secondary MV systems

B1.1 * construction of 50 km of 20 kv line on reinforced concrete supports, with cap and pin insulators, 50 sq.mm copper conductors, to supply new secondary transforming substations;

B2.2 * construction of 80 km of 20 kV line on reinforced concrete supports, with cap and pin insulators, 25 sq.mm copper conductors, for the supply of new substations;

B1.3 * construction of 160 x 20/0.380 kV, 50-150 kVA pole-type transformers and power factor correction capacitors;

B1.4 * construction of 15 box-type secondary transforming substations with 20/0.380 kV, 250 kVA transformers and power factor correction capacitors;

B1.5 * construction of 10 box-type secondary transforming substations with 20/0.380 kV, 400 kVA transformers and power factor correction capacitors.

LV systems

B2.1 * construction of 330 km of overhead lines with 4 x 70 sq.mm and 4 x 35 sq.mm aluminum "câbles torsadés" for network extension;

B2.2 * construction of 13,000 supply terminals for connection of new consumers;

B2.3 * construction of public lighting system with 700 new lighting points.

C - SECOND STAGE

During this stage, assuming a value of 78 MVA for the peak load in the province by the year 2000, a second 150 kV supply to the Quileva substation is required.

Furthermore, to face demand growth in the town of Lobito, expected to reach 38 MVA by the year 2000:

it is necessary to complete the elimination of the 30 kV level, albeit used only for transmission, by replacing the 2 x 150/30 kV, 30 MVA transformers in the Quileva substation with 2 x 150/20 kV, 30 MVA transformers and by constructing a new 20 kV line between the Quileva substation and the Lobito substation, downgrading the latter to simple shunting substation.

In order to increase the transmission capacity of the Biopio substation-Catumbela substation line, thereby covering the expected load increase in the year 2000 and taking into account that the poles are designed for accommodating a double-circuit line, a second circuit of conductors is necessary with a cross-sectional area equal to the existing one (70 mm copper).

The fact that the above line would become double-circuit does not impact reliability of service. In case of outage on the Biopio-Catumbela link, the Biopio substation-Cavaco substation line can carry all the load of the Cavaco and Catumbela substations.

In view of the above, the systems to be built are:

Primary systems (Table 8)

C1.1 * construction of a 150 single-circuit line with steel pylons, cap and pin insulators and 261 sq.mm ACSR, for a total of 18 km, to create the second link between the Biopio and the Quileva substations;

C1.2 * Biopio substation, construction of new line to the Quileva substation
1 x 150 kV line unit
1 busbar unit

C1.3 * Quileva substation
1x 150 kV line unit
2 x 150/20 kV, 30 MVA transformers

C1.4 * installation of the second circuit of conductors on the specially designed poles of the 60 kV line between the Biopio and Catumbela substations, for 21 km

Secondary MV systems

C2.1 * construction of 8 km of 20 kV single-circuit line with steeel supports, cap and pin insulators and 261 sq.mm ACSR between the Quileva and Lobito substations;

C2.2 * construction of 60 km of 20 kV line on reinforced concrete supports, with cap and pin insulators, 50 sq.mm copper conductors, for supplying new secondary transforming substations;

C2.3 * construction of 150 km of 20 kV line on reinforced concrete supports, with cap and pin insulators, 25 sq.mm copper conductors, for supplying new secondary transforming substations;

C2.4 * construction of 250 x 20/0.380 kV, 50-150 kVA transformers and power factor correction capacitors;

C2.5 * construction of 25 box-type secondary transforming substations with 20/0.380 kV, 250 kVA transformers and power factor correction capacitors;

C2.6 * construction of 12 box-type secondary transforming substations with 20/0.380 kV, kVA transformers and power factor correction capacitors.

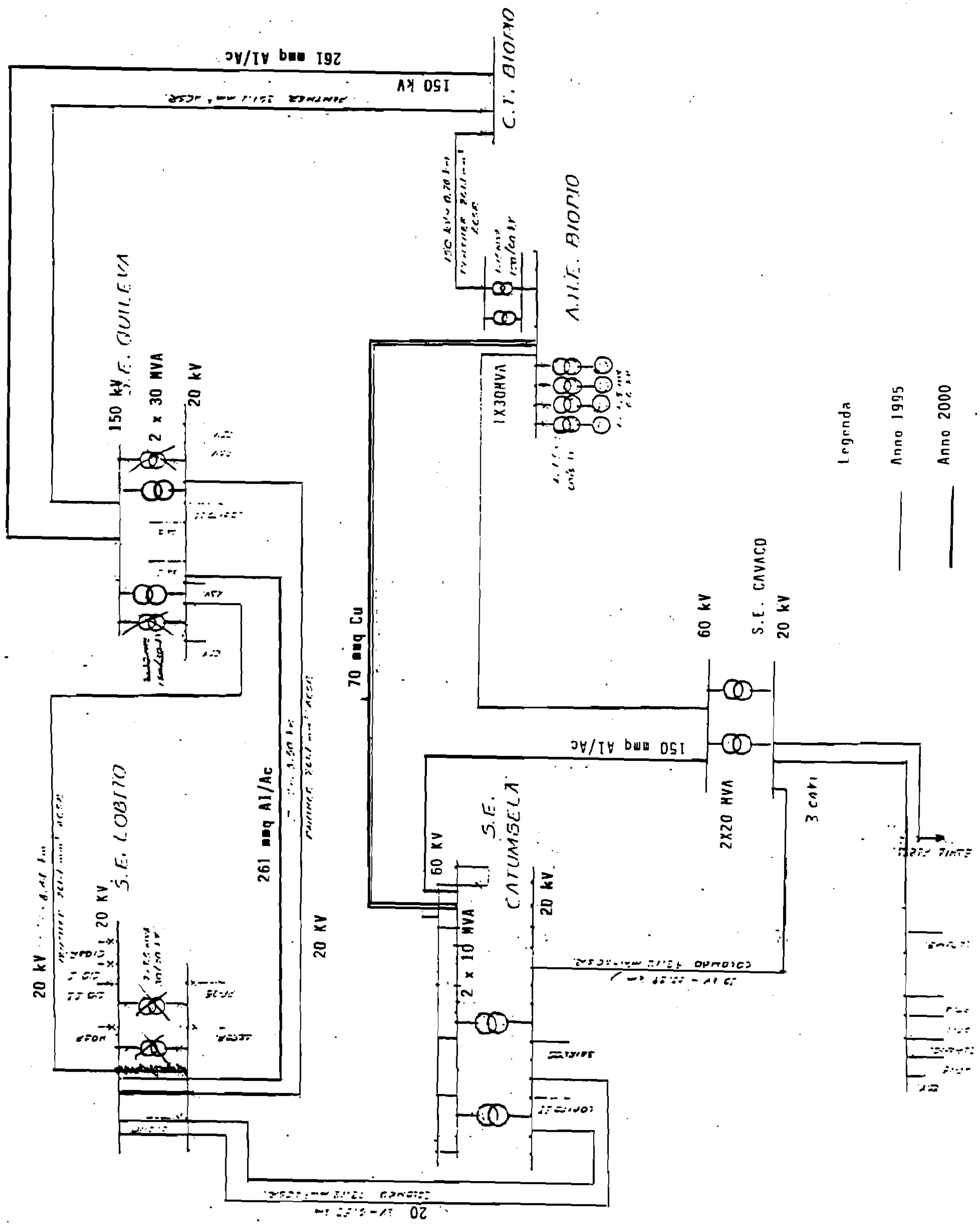
LV systems

C3.1 * construction of 520 km of LV lines on reinforced concrete supports, with 4 x 70 sq.mm and 4 x 35 sq.mm aluminum "câbles torsadés", for network extension;

C3.2 * construction of 19,000 supply terminals for new consumers;

C3.3 * construction of public lighting system with 800 new lighting points.

TAV. 8


C.T. BIOPIO
150 KV
261 mmq Al/Ac
A.H.E. BIOPIO
1X30MVA
S.E. QUILEVA
150 kV
2 x 30 MVA
20 kV
70 mmq Cu
S.E. CAVACO
60 kV
20 kV
150 mmq Al/Ac
2X20 MVA
3 cavi
S.E. LOBITO
20 kV
261 mmq Al/Ac
20 KV
S.E. CATUMBELA
60 kV
2 x 10 MVA
20 kV
Legenda
Anno 1995
Anno 2000

Cost estimate of extension works (1990 costs)

1st stage

B1.1 20 kV overhead line 50 sq.mm Copper	km	50 x	$	50.000 =	$	2.500.000
B1.2 20 kV overhead line 25 sq.mm Copper	km	80 x	$	35.000 =	$	2.800.000
B1.3 pole-type transformers	n.	160 x	$	10.000 =	$	1.600.000
B1.4 250 KVA box-type substations	n.	15 x	$	46.000 =	$	690.000
B1.5 400 KVA box-type substation	n.	10 x	$	49.000 =	$	490.000
B2.1 LV overhead lines	km	330 x	$	26.000 =	$	8.580.000
B2.2 new supply terminals with meter	n.	13.000 x	$	360 =	$	4.680.000
B2.3 public lighting points	n.	700 x	$	700 =	$	490.000
Total					$	21.830.000

2nd stage

C1.1 150 kV overhead lines 261 sq.mm ACSR	km	18 x	$	90.000 =	$	1.620.000
C1.2 Biopio substation	n.	1 x	$	650.000 =	$	650.000
C1.3 Quileva substation	n.	1 x	$	1.200.000 =	$	1.200.000
C1.4 circuit of 70 sq.mm Copper conductors	n.	21 x	$	21.000 =	$	441.000
C2.1 20 kV overhead line 261 sq.mm ACSR	km	8 x	$	70.000 =	$	560.000
C2.2 20 kV overhead line 50 sq.mm copper	km	60 x	$	50.000 =	$	3.000.000
C2.3 20 kV overhead line 25 sq.mm copper	km	150 x	$	35.000 =	$	5.250.000
C2.4 pole-type transformers	n.	250 x	$	10.000 =	$	2.500.000
C2.5 250 kVA box-type substation	n.	25 x	$	46.000 =	$	1.150.000
C2.6 400 kVA box-type substation	n.	12 x	$	49.000 =	$	588.000
C3.1 LV overhead lines	km	520 x	$	26.000 =	$	13.520.000
C3.2 new supply terminals with meter	n.	19.000 x	$	360 =	$	6.840.000
C3.3 public lighting points	n.	800 x	$	700 =	$	560.000
Total					$	37.879.000

CHAPTER IV

ORGANIZATION OF OPERATION AND MAINTENANCE ACTIVITES

IV.1 - LUANDA PROVINCE

Operation and maintenance activities reflect the crucial problem of resource management within EDEL and SONEFE.

This problem remains critical for the successful operation of the utilities, despite the fact that the top management tries to make the best possible use of available resources.

At present, there is no corporate plan or policy of resource management.

The paucity of data on corporate organization did not enable us to accurately take stock of the current situation.

At the time of the mission, the distribution system employees of EDEL and SONEFE were:

	EDEL	SONEFE
Managers	24	1
High-level technicians	14	2
Intermediate-level technicians	26	4
Workers	519	19
Administration and services	353	

Although employee attendance is recorded daily, the disorderly state of the records prevented us from analyzing the impact of absenteeism - apparently rather high -, the frequency of injuries and other elements to appreciate the situation.

It was not until recently that, based on an organizational project produced by Norconsult International, that EDEL decided to initiate a progressive corporate reorganization, taking into account availability of financial resources and of employees with acceptable qualifications.

The managers have fair qualifications but are daily struggling against "red tape" hindrances.

High-level technicians have a fair technical education but lack practice and their number is insufficient. Several positions in the organizational chart of EDEL have not yet been filled.

By contrast, workers are numerous but very few know how to work correctly. At least 30% of the workers are illiterate. The remaining share has a rather low educational background.

Efficiency of the field personnel is very poor, due to both redundancy of workers and to scarcity of transportation vehicles and facilities.

For operation and maintenance of systems, EDEL has a "department", which consists of 5 groups with the following resources:

1 - Network dispatching:
- 1 group head
- 1 intermediate-level technician
- 23 workers
- 1 off-road vehicle

This group handles network dispatching and jobs on substations to change the network layout as a result of faults on primary power supply systems or of generation failures.

2 - Laboratory:
- 1 laboratory head
- 1 intermediate-level technician
- 23 workers
- 1 off-road vehicle

This group carries out repair jobs and calibration on meters, maintenance of measuring instruments, as well as troubleshooting on the underground cable network.

Efficiency of this group is poor owing to lack of skilled workers and of suitable instrumentation.

3 - Substations - shunting and transforming:
- 1 group head
- 11 intermediate-level technicians
- 38 workers
- 1 off-road vehicle

This group is mainly in charge of construction, operation and maintenance of all secondary shunting and/or transforming susbtations, as well as of attendance and maintenance of the substations with part of the available workers.

4 - Network:
- 1 group head
- 6 intermediate-level technicians
- 125 workers
- 2 off-road vehicles

The chief activity of this group is repair of faults on the LV network, as well as design and development of minor network extensions, new supply terminals or change of existing supply terminals.

5 - Public lighting:
- 1 group head
- 1 intermediate-level technician
- 64 workers
- 1 off-road vehicle
- 2 crane trucks

The entire public lighting system is operated by this group, which replaces bulbs and carries out jobs on the network as a result of faults.

The Department also resorts to the vehicles and facilities of the Transportation Department, depending on their availability.

Generally speaking, this organization may be considered as viable, in spite of redundancy of workers and lack of specific skills.

Futhermore, the number of vehicles and special facilities available for the personnel is inadequate. In effect, all the employees of the Operation Department (272) have 7 off-road vehicles only.

This situation obviously impairs both efficiency of employees, already very low, and speed of service.

Finally, it should be stressed that the situation is worsened by malfunctioning of the warehouse.

The warehouse suffers from outstanding difficulties, which depend on procurement of materials mostly from foreign countries and on inefficient inventory control. No valid procedure is used to timely report out-of-stock conditions and to schedule short- and medium-term requirements. This is due to the lack of accounting of incoming/outgoing materials.

Suggestions

As previously pointed out, the MV networks of the two distributing utilities intersect or duplicate each oother in some areas of the province. This fact makes operation of the entire network inefficient. Consequently, the entire MV network should fall under the responsibility of a single utility, in order to expedite jobs on the network, thereby enhancing quality of service.

Notwithstanding the previously described allocation of tasks and organization of activities, the workforce should be scaled down and adequately trained.

The Department needs suitable transportation vehicles, i.e. at least 10 light trucks and 10 off-road vehicles.

Additionally, the following steps should be taken: to intensify collection of data on network management; to improve the cadastre of installations by breaking down data into voltage levels; to refine the system for collection of statistical data on amount of work produced; to identify and track faults so as to derive indicators for management of systems and resources.

Furthermore, all the personnel should be provided with appropriate individual safety apparel as well as with suitable crew facilities.

Finally, the warehouse should urgently be organized as follows:

- assignment of experienced employees to its control
- issuing of procedures to record handling of materials and to forecast short- and medium-term needs
- removal of obsolete or unusable materials, which are quite numerous
- reduction in the inventory of some materials, which are now redundant
- streamlining of the organization of rooms and shelves for material storage.

To implement the above suggestions, EDEL and SONEFE should be assisted by foreign experts, as detailed in Chapter VI.

IV.2 - BENGUELA-LOBITO PROVINCE

Also in this case, system operation and maintenance activities are impaired by the inefficient organization of CELB, as well as by lack of routine and corrective maintenance plans.

One of the main reasons for the lack of activity in this area is also due to shortage of suitable materials and facilities.

The poor data available and the short length of our visit to CELB did not allow us to accurately take stock of the current situation.

At the time of the mission, the distribution-assigned CELB employees were:

Managers	7
High-level technicians	3
Intermediate-level technicians	7
Workers	353
Clerical personnel	46

The number of workers is redundant with respect to the activities carried out. Therefore, a careful external action is required to create a more efficient organization and train skilled workers, thereby enabling the utility to work more effectively.

The suggestions aimed at changing and thus improving the current situation are similar to the ones given for the Luanda province.

CHAPTER V

PERSONNEL EDUCATION AND TRAINING

Foreword

The review of the organizational structure of EDEL, SONEFE, CELB and ENE evidences a significant redundance of workers with respect to the size of the network and to the amount of works carried out.

Indicatively, it is worth pointing out that the Luanda province employs 0.46 workers/km of network (summation of the HV, MV and LV networks). This indicator is at least 5 times higher than the corresponding European one.

In our opinion, this situation does not only originate from organizational factors, but also and above all frow the low qualifications of technicians and skilled workers.

The well-known socio-political events in Angola brought about a massive exodus of skilled workers and technicians, increasingly depleting available human resources.

In the past few years, also with the cooperation of foreign experts, the top management of the local electric utilities succeeded in operating the distribution network with the few available qualified employees. In spite of this, the network deteriorated.

The data gathered during the mission revealed that even employees who are considered as the most qualified have a rough technical education and ignore basic safety standards.

In view of the above, it is absolutely necessary and urgent to organize a number of education and training courses for workers and technicians of the Angolan electric utilities, according to the program indicated below.

The goals to be achieved are as follows:

workers:

a) to standardize basic technical knowledge;
b) to train the personnel to work under safety conditions;
c) to train the personnel to work in teams, also including a high number of members;
d) to provide specific training, targeted at the skills and know-hows for the job to which the individual workers are expected to be assigned.

Technicians:

a) to refine specialist knowledge in terms of procedures, techniques and technologies applicable to distribution activities;
b) to promote practical experience, allowing performance of tasks and jobs typical of the functional area to which the technicians are expected to be assigned;
c) to facilitate a prompter understanding of technical, organizational and injury prevention problems.

Participants, organization and duration of the courses

The following table displays the total number of employees assigned to distribution in the 4 Angolan electric utilities:

Number of distribution employees

Title	EDEL	SONEFE	CELB	ENE	Total
High-level technicians	14	2	3	26	45
Intermediate-level technicians	26	4	7	9	46
Workers	519	19	353	595	1486

Courses for high-level technicians

As previously noted, the high-level technicians have a good technical education but lack specific experience.

This suggests that all the 45 high-level technicians should receive specific training. This training should enable them to have a prompter understanding of technical, economic, organizational, injury prevention, environmental and management problems arising from the accomplishment of typical tasks.

The training shall be both practical and technical-formal.

The practical training shall provide the basics of labor organization within workers' crews and of enforcement of technical and injury prevention standards. Formal-technical training, instead, shall involve lessons, discussions and drills to improve knowledge on technical, regulatory and procedural aspects.

Each course shall have a duration of 4 weeks and be followed by an on-the-job training period of equal duration within European electric utilities.

In order to maximize the efficiency of the courses and to avoid prolonged periods of absence from the job, the number of participants shall be limited to 12 for each course. Moreover, the expected four weeks shall be alternated with regular work weeks.

The anticipated total number of courses is 4.

Courses for intermediate-level technicians

As previously indicated, these technicians have a rather poor formal-technical and practical background.

This infers that all the 46 intermediate-level technicians should receive practical training.

These courses shall allow to acquire experience through performance of distribution-typical assignments.

This goal can be achieved by organizing the course in two stages.

During the first stage (2 weeks), the technicians shall be introduced to knowledge of distribution-specific activities.

During the second stage, the technicians shall join the workers' courses (8 weeks), as described hereafter.

Their training shall be complemented with a set of meetings with instructors. These meetings shall last half a day and take place at the end of each training week.

Courses for workers

Based on the collected data and on direct observations, at least 50% of the workers in Angolan utilities are unskilled, owing to inadequate formal education or to illiteracy (roughly 30% of the workforce).

As a result, the workers to be educated and trained over time amount to 750.

To achieve good results, the number of participants in each 8- consecutive-week course should be limited to 20 and the courses should be completed within 30 months. Consequently, the required course organization should be as follows:

38 courses, broken down into 10 4-course groups.

Each course shall consist of the following 3 stages:

Stage 1 Review of basics in arithmetics, physics and electromechanics.

Length 1 week.

Stage 2 Lab and field drills concerning basic jobs, whose knowledge is necessary for an effective crew work.

Length 3 week.

Stage 3 Training on typical jobs of the functional area to which the participants shall be assigned.

Length 4 week.

The training shall be of a predominantly practical nature and involve both the individual worker and the entire crew.

Particular emphasis should be put on enforcement of safety standards.

Venue of the courses

In order to minimize and economize on transfers of participants, training centers shall be set up in the following towns:

- Luanda:

. courses for all high-level technicians

. courses for intermediate-level technicians and workers of EDEL, SONEFE and of ENE for the Cabinda and Malanje locations

- Lobito:

. courses for intermediate-level technicians and workers of CELB and of ENE for the Lubango, Nabibe and Huambo locations

Cost estimate

- facilities for organization of the training centers of Luanda and Lobito, including camps	$ 100.000
- equipment for 4 groups of 20 workers	$ 100.000
- consumables for 38 courses	$ 700.000
- 1 coordinator for 30 months = 30 man/months	$ 600.000
- 10 instructors for 30 months (workers and intermediate-level technicians) = 300 man/months	$ 3.600.000
- 10 assistant instructors for 30 months (workers and intermediate-level technicians) = 300 man/months	$ 3.000.000
- 1 instructor for 18 months (high-level technicians) = 18 man/months	$ 216.000
- 1 assistant for 18 months (high-level technicians) = 18 man/months	$ 180.000
- on-the-job training for high-level technicians 48 man/months	$ 220.000
Total	$ 8.716.000

N.B. Based on data obtained from Edf, Edf signed an agreement with the Angolan Ministry of Energy and Petroleum to complete a training program, funded for 60,000,000 FF by the French Economic Cooperation Fund.

CHAPTER VI

TECHNICAL ASSISTANCE BY FOREIGN EXPERTS

As stressed in the previous chapters, field and managerial capabilities of EDEL and CELB are rather weak.

The limited number of qualified technical and managerial employees cannot cope with the technical problems arising from electricity distribution in the Luanda and Benguela provinces.

By contrast, redundant workers with poor qualifications worsen the problem.

In our opinion, the problem should be on the priority list. It should be solved by balancing the workforce of the utilities (ENE, EDEL, CELB, SONEFE) and making a better use of it. This should also favor a radical restructuring of the electricity industry, assigning specified roles to each utility and creating integrated working procedures, to facilitate comparisons between the utilities and, above all, control by the MEP.

The programs of development and rehabilitation of the electricity distribution system in the Luanda and Benguela provinces, described in the previous chapters, will call for major efforts by the utilities involved in the 1991-1995 period.

Considering the limited capabilities of the utilities, the need for not nullifying the investments to be made and for correcting the above weaknesses, a prolonged technical assistance by foreign countries is required.

The education and training program outlined in Chapter V is expected to be completed within the first two years of the period. The program will certainly enhance the qualifications of the Angolan technicians. The foreign input might be organized as follows:

Program of technical rehabilitation

The technical assistance shall total 150 man/months, with an expenditure of 1,800,000$. This assistance might be organized as follows:

a) drafting of preliminary projects with specifications for call for tenders

Luanda province	4 man/months
Benguela-Lobito province	2 man/months

b) review of projects and of tenders submitted by the invited tenderers

Luanda province	1 man/month
Benguela-Lobito province	1 man/month

c) technical assistance during completion of the planned works, construction and related testing

Luanda province	108 man/months
Benguela-Lobito province	34 man/months

Program of system extension

As to the remaining extensions of the electric system, to be completed from 1996 on, it is too early and poorly indicative to state the amount of technical assistance to be provided by foreign experts.

Consideration is to be given to the fact that the experience acquired by local technicians during the rehabilitation works will certainly contribute to minimize foreign technical assistance.

Reorganization of operation and maintenance groups

The planned technical assistance shall involve a total of 15 man/months with an expense of 180,000$. This assistance shall be organized as follows:

- for unification of the EDEL and SONEFE MV network	2 man/months
- for definition of optimum network layouts and preparation of system maintenance programs	4 man/months
- for organization of the warehouse and preparation of inventory control procedures	3 man/months
- for organization of static and dynamic network data and procedures for monitoring works carried out and identification of network faults	6 man/months

The above assistance shall involve ancillary expenses, such as:

- procurement of vehicles	$ 1.000.000
- procurement of individual and crew facilities	$ 700.000
- procurement of warehouse facilities	$ 100.000
Total	$ 1.800.000