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FINANCING OF ELECTRIC POWER EXPANSION IN THE STATE  
OF MINAS GERAIS

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NOTE: This text is subject to editorial revision.

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### Introduction

The State of Minas Gerais comprises an area of 593,000 sq. km., representing 7 per cent of the Brazilian territory, being slightly larger than France. The present population is estimated at 9 million inhabitants mostly concentrated in the south-center region (see figure I).

The State has 57 per cent of its area located above 600m and it is drained by 13 hydrographic basins which descend to the Atlantic, the largest being those of Sao Francisco (248,600 sq.km.), Grande-Paraná (145,500 sq. km.) and Doce (75,200 sq.km.). Minas' economical hydro-electric potential is estimated in 10 million kW.

The State name defines its characteristics: it is really the state of the general mines. The largest Brazilian reserves in iron ore are concentrated in Minas (estimated in 25 billion tons) and the State also possesses other valuable deposits such as aluminium, tin, zinc, manganese, gold, columbium, limestone, mica, graphite, phosphates and uranium. However, there are no known deposits of fossile fuels and very few possibilities in this respect.

#### 1. The electric power industry prior to 1950

In 1940 Minas had a total installed capacity of 128,000 kW which in 1950 had reached 200,000 kW. During this period the electrical power industry main characteristic was the great number of small isolated power plants serving scattered population centers and explored by hundreds of small utility companies. This situation resulted from the population dispersion and the low index of formation of private capital. Minas did not attract the large amounts of United States and Canadian capital and the technical know-how, that came together, and resulted in the large electrical systems of São Paulo and Rio de Janeiro.

The State intervention in the power industry became a necessity and the several state administrations acted in this direction, constructing first small hydro-electric plants such as Cafanhoto (13,000 kW) in 1940 and later on in 1948, launching a more ambitious enterprise, the Salto Grande hydroelectric plant (100,000 kW).

/2. CEMIG:

## 2. CEMIG: a State Government agency in corporation form

In 1951 the State administration saw clearly that only a concentrated and organized effort could supply the power needed by the growing industrialization movement that followed the Second World War. It decided to create a holding company - Centrais Elétricas de Minas Gerais S.A. (CEMIG), - organized as a corporation, having preponderance of State capital, but open to private participation. This corporation would control several subsidiary companies operating in the several regions.

CEMIG thus was able to centralize the government electrification policy and provide the necessary technical and financial basis to carry out the required expansion.

## 3. Financing of CEMIG

State laws issued in 1951/57 awarded CEMIG a quota of a special state sales tax and also the reinvestment of the dividends to which the State is entitled as a shareholder.

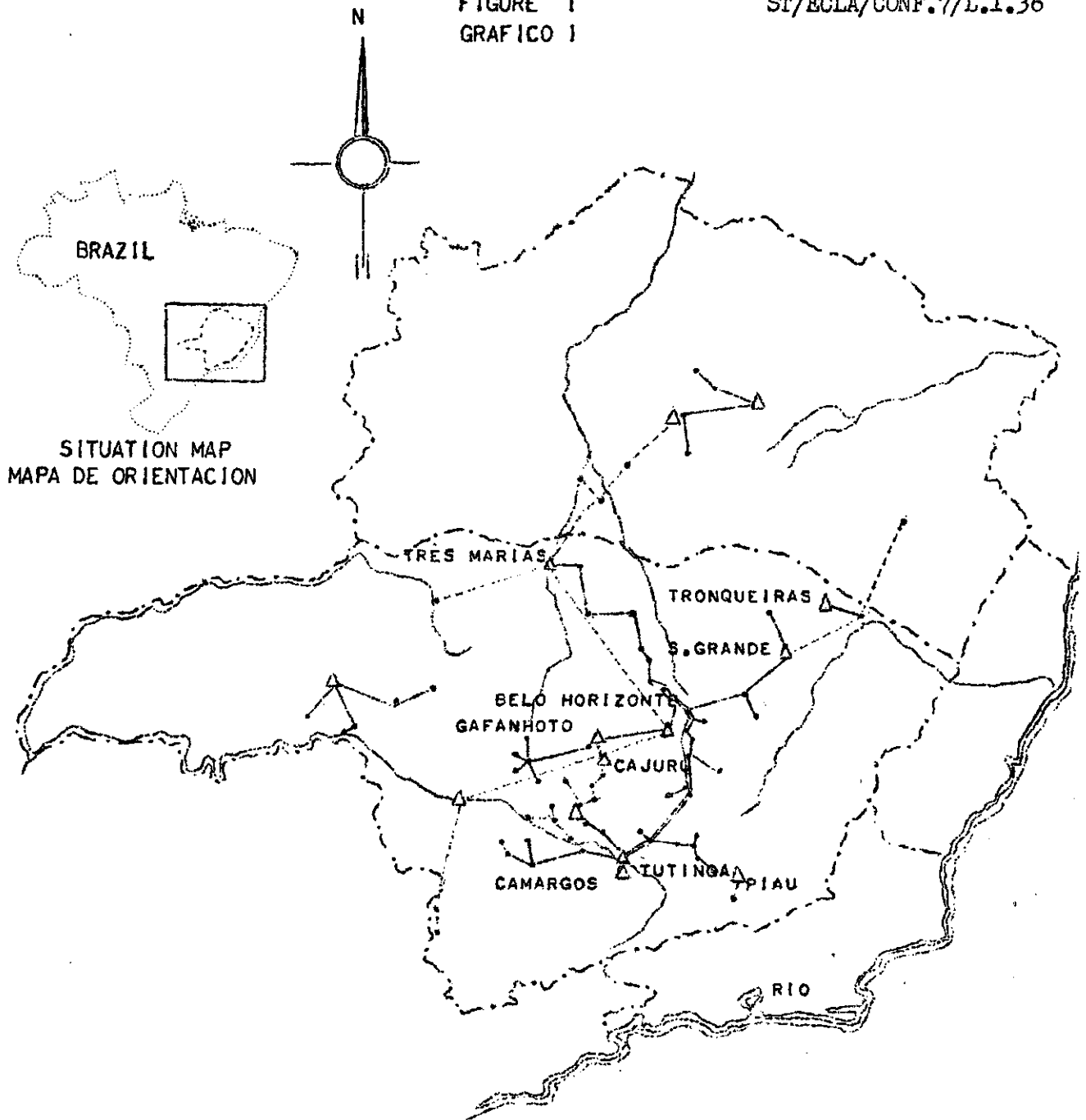
The Brazilian Federal Legislation permits a 10 per cent return on total historical investment and CEMIG, since its foundation set a rate policy to achieve this return. As a result of this policy, the amount resulting from the State dividends that have been reinvested, has proved to be an important source of income and at the same time private participation has been encouraged and has reached significant values. However, under the present circumstances in Brazil there is no market for public utility shares or bonds and private participation in CEMIG comes mainly from two sources: large industrial consumers and the population of the towns and villages that need to be served.

These capital resources have been complemented by long term loans from the National Economic Development Bank (ENDE).

Regarding the foreign sources funds, necessary to buy equipment not made in the country and to pay for services, expenses and fees of foreign contractors and engineering firms, the main source of funds have been the Export-Import Bank (EXIM), the International Bank for Reconstruction and Development (IBRD) and financing from United States and European manufacturers of electrical power system equipment.

FIGURE 1  
GRAFICO 1

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MAP OF MINAS GERAIS INDICATING THE SOUTH CENTRE REGION AND THE CEMIG SYSTEM

- △ POWER PLANTS
- EXISTING LINES
- - - MAIN LINES OF FUTURE SYSTEM

MAPA DE MINAS GERAIS EN DONDE SE INDICA LA REGION CENTRAL-SUR Y LA RED CEMIG

- △ PLANTAS DE ENERGIA
- LINEAS EXISTENTES
- - - LINEAS TRONCALES DE LA RED FUTURA



4. The initial plan: 250,000 kW system in 10 years

The initial plan (1951-60), consisted in the construction of the following hydro plants: (see fig. 1) Salto Grande (100,000 kW), Itutinga (50,000 kW), Camargos (45,000 kW), Piau (18,000 kW), Cajuru (7,500 kW), Tronqueiras (3,600 kW), which, together with the existing Gafanhoto (13,000 kW) and other smaller plants will bring the total installed capacity up to 250,000 kW by the end of 1960.

At the same time, 1,600 km of transmission lines were built (13.8 kV to 138 kV) with the respective substations forming an interconnected system in the central region and two isolated systems around the region of Montes Claros and Governador Valadares.

Distribution lines were also constructed and, although the main scope of this system was to supply bulk power to industrial consumers and other utilities, approximately 40 towns and villages have low voltage distribution by CEMIG and by the end of 1960, approximately 80,000 consumers will be served.

Figure II indicates the evolution of the generation in the 1951-1960<sup>1/</sup> period both for the CEMIG system and for the State.

From the total CEMIG generation in 1959, 75 per cent were taken by industrial consumers (mainly metalurgical), 16 per cent by other utilities and the remaining by residential, commercial and other classes.

5. Cost of the original plan

The 250,000 kW system cost Cr\$5.654 million plus US\$30,075,000. Considering the present day value of the local currency,<sup>2/</sup> the corrected values should be Cr\$8.450 million plus US\$30,075,000 admitting no loss of value in the dollar.

In terms of dollars the corrected values are:

Cost in local currency	47,000,000
Cost in foreign currency	<u>30,075,000</u>
	77,075,000

<sup>1/</sup> Last quarter of 1960 is estimated.

<sup>2/</sup> The average exchange rate during the period 1951-1960 was Cr\$120 per dollar. Present value was taken at Cr\$180 per dollar.

The resulting costs per kW installed were:

Generation	210	68 %
Transmission and distribution	100	32 %
	<hr/>	<hr/>
	310	100 %

The investment in generation is relatively high as compared with the transmission and distribution, as a result of there being relatively few large industrial consumers taking the bulk of the power, and a relatively small number of residential consumers.

The source of funds can be seen in figure III, from which two points can be noticed at once: the preponderance of the State capital in the local funds, resulting from the proceeds of the above mentioned sales; the important contribution of Export-Import Bank and the International Bank.

The foreign funds were used in the following proportions:

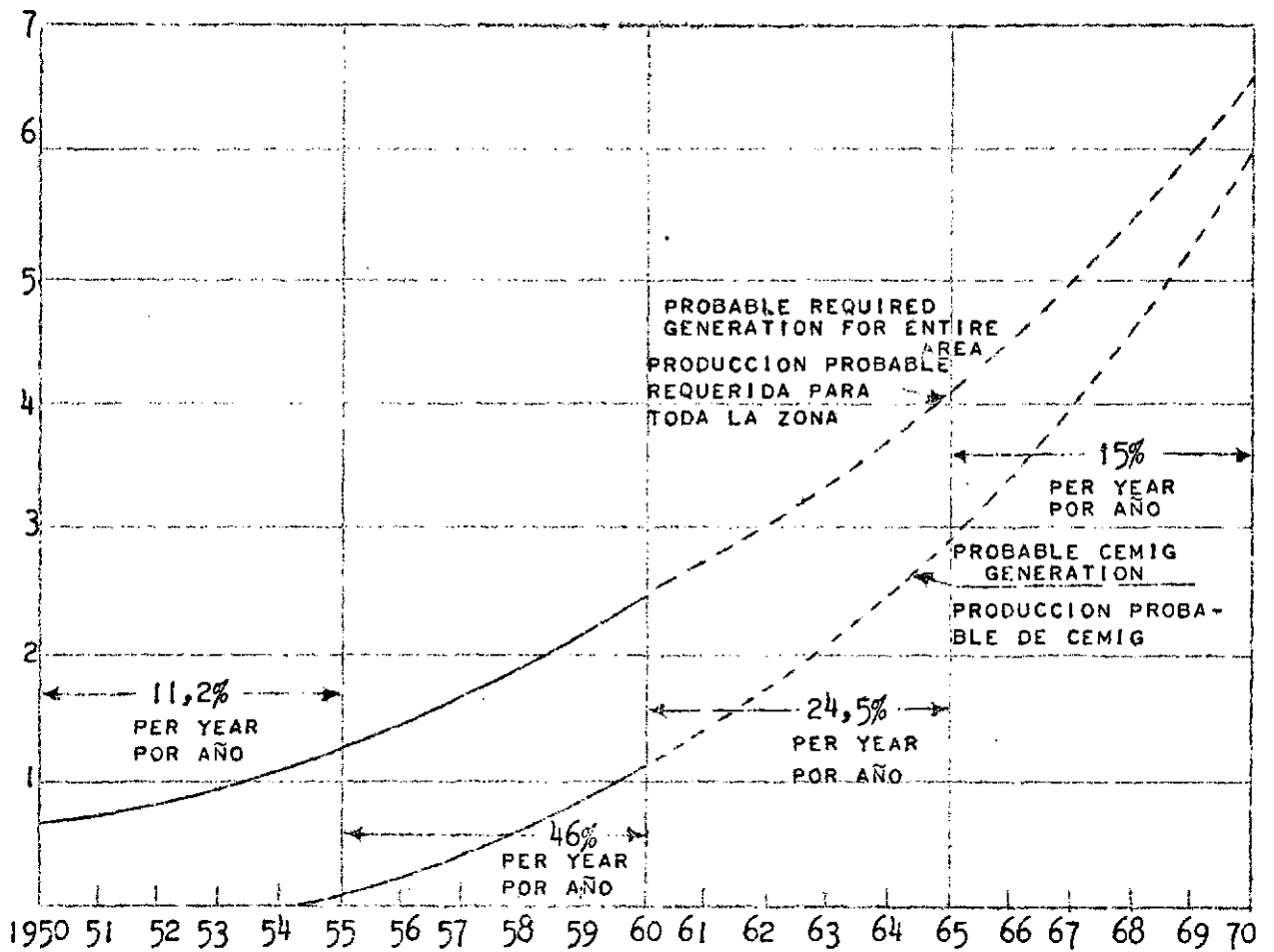
	<u>Percentage</u>
Power plant	52.67
Transmission line	13.80
Substations	13.98
Distribution	2.13
Services and expenses	6.02
Construction equipment	9.80
Other equipment	1.60
	<hr/>
	100.00

It can be seen that the bulk of generating, transmission, substation and construction equipment was financed with foreign funds, the national industry supplying mainly distribution equipment such as transformers, cables, meters, lighting fixtures, etc..

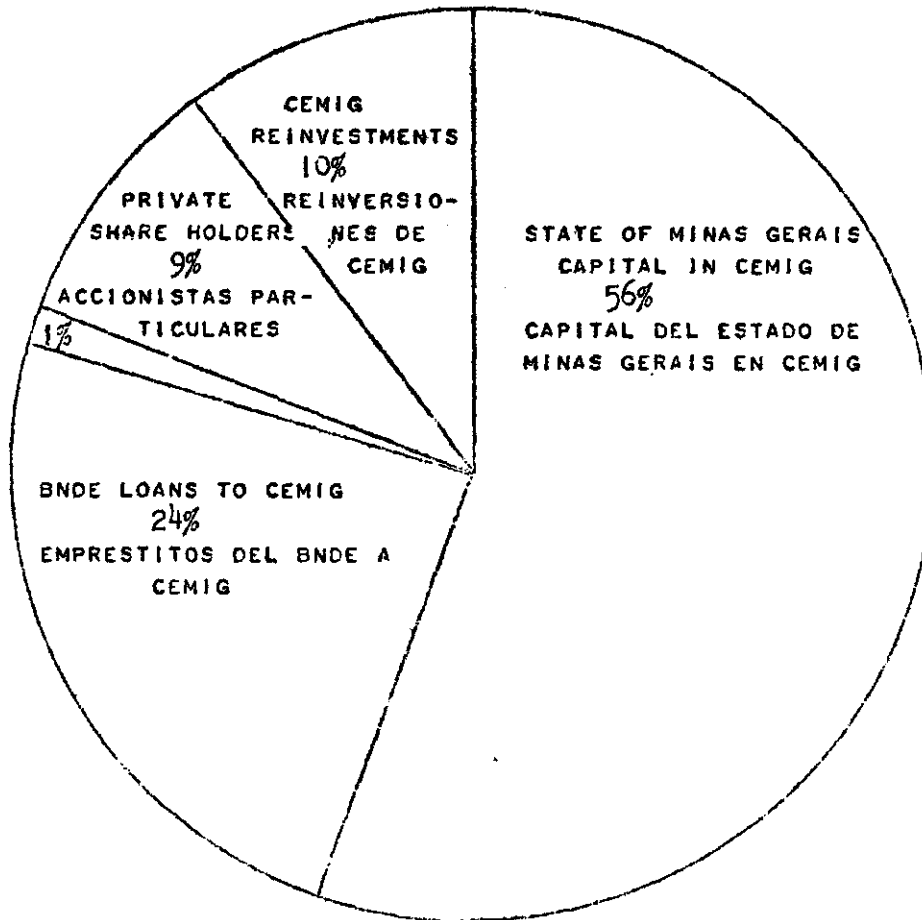
FIGURE II  
 GRAFICO II

GENERATION TENDENCIES FOR SOUTH CENTRE MINAS GERAIS AREA AND CEMIG

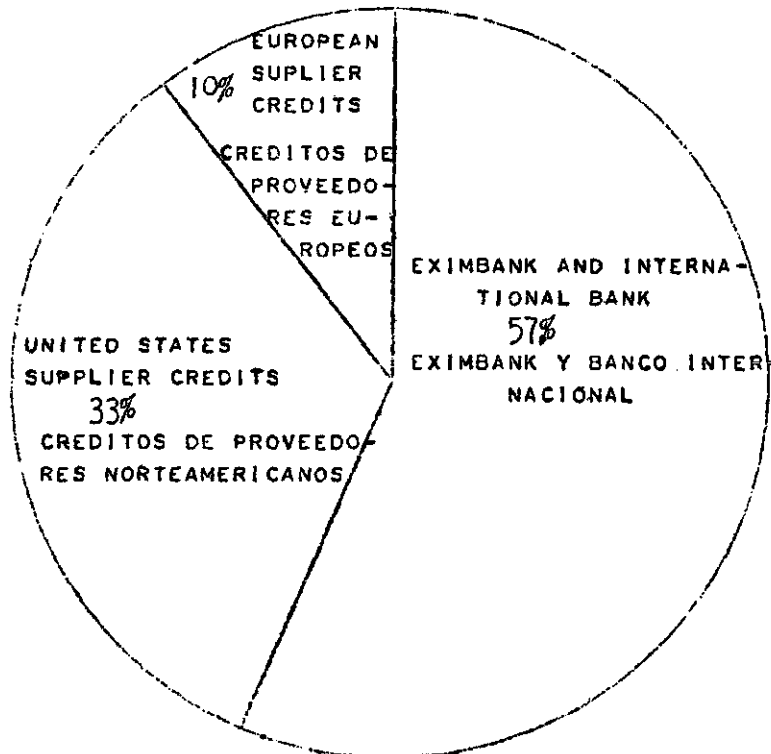
TENDENCIAS DE PRODUCCION PARA LA REGION CENTRAL-SUR DE MINAS GERAIS Y CEMIG







LOCAL CURRENCY \$47.000 000 MONEDA LOCAL



FOREIGN CURRENCY \$30.075 000 MONEDA EXTRANJERA



6. Evolution of the power market during 1951-1960

The conditions for a rapid development of basic industries that existed in the State and were dormant due to the lack of electrical power, came to life in 1955 when the first new plants were placed in operation.

Electric steel reduction plants, ferro-alloy plants, aluminium plants and cement mills took, from then on, half of the power produced. At the same time, the local production in the country of refrigerators, radios, TV sets and other appliances opened in the small cities and villages new horizons for a better standard of living.

Even with CEMIG's generation growing from 150 million kWh in 1955 to 1 billion in 1960, that is, almost 7 times in five years, the pressure of the growing market never ceased to exist.

Requests from large new consumers with high connected loads such as 20,000 kW for an automobile factory, 20,000 kW for an electrolic zinc mill, 60,000 kW for a 500,000 ton/year steel mill and 150,000 kW for three aluminium reducing plants, forced CEMIG to reevaluate the size and the scope of the electrification plan and decide to design and build hydroelectric plants, almost ten times the average size of the previous ones, namely Furnas in the Rio Grande with 1,100,000 kW final capacity and Tres Marias on the São Francisco river with 520,000 kW final capacity.

The cost of these large plants being above the possibilities of CEMIG alone, associations with others were studied resulting in the following arrangements:

(a) Furnas

A separate corporation - Central Elétrica de Furnas S.A. - was incorporated to be controlled by the Federal Government and having as main shareholders the São Paulo Light, the State of São Paulo through Cia. Hidroelétrica do Rio Pardo and the State of Minas Gerais through CEMIG, Central Elétrica de Furnas began the construction of the Furnas development in 1958 and expects to place in operation the first stage consisting of 4 x 137,000 kW units by 1963.

/Power will

Power will be supplied at 138 kV in the step-down substations that will tie the Furnas E.H.V. grid to the systems of São Paulo Light, CHERP and CEMIG.

Half of the production of Furnas will be supplied in bulk to CEMIG to be distributed in its system. The other half will be supplied to São Paulo Light and CHERP.

(b) Tres Marias

An agreement was made with the São Francisco Valley Commission (CVSF), a federal authority, by which this authority would build a large multi-purpose dam (for navigation improvement and flood control) in the upper São Francisco and CEMIG would build a plant at the foot of the dam. CEMIG was appointed general contractor for the entire scheme which was started in 1957. The first 4 x 65,000 kW units are scheduled for operation in the 1961-1963 period.

7. Evolution of the Brazilian manufacturing and construction industry during 1951-1960

Starting from production of cables, light bulbs, distribution transformers and kWh meters, this industry can by now supply almost the entire range of equipment necessary for an average hydroelectric scheme, say up to 20,000 kW, and many of the components for larger plants.

Almost all types of hydraulic gates and valves can now be produced locally, together with turbines, overhead cranes, pumps and other mechanical equipment.

In the electrical field, large water-wheel generators, transformers up to 275 kV, switches and breakers up to 69 kV can also be produced with plans to reach higher voltages soon.

Conductors of ACSR type or high voltage isolated cables, porcelain and glass insulators, transmission towers, hardware and fittings also are under production locally.

Other types of equipment used by the electric power industry, such as vehicles, construction plant, machine tools, etc., are now almost entirely supplied by Brazilian industry.

/This progress

This progress in the manufacturing industry has been followed in the engineering and construction fields. Large firms equipped with experienced personnel and adequate construction plant can today tackle almost any type of construction and engineering problems in the electrical power field. Some of these companies are purely Brazilian and others are associations of local and foreign companies working as Brazilian corporations.

On the other side, CEMIG itself developed an experienced group of engineers capable of designing and building lines, substations, powerhouses and dams and, if convenient, capable of constructing any of these items directly.

#### 8. Forecast for the period 1961-70

During the first five years (1961-65) (see figure II), it can be forecasted, based on power market studies, that the growth will continue at a rate of approximately 24.5 per cent per year accumulative. The required generation should grow from 1 billion kWh/year to 3 billion. From there on, on the basis of 15 per cent per year accumulative the required generation by 1970 should be over 6 billion kWh/year, corresponding to an installed capacity of approximately 1,100,000 kW. It is estimated that at this time, 90 per cent of the south-central zone of the State will be supplied by CEMIG.

The generation in the 1961-65 period will be supplied almost entirely by four units in Tres Marias and two in Furnas with a combined capacity of 535,000 kW. All these units are now either being installed or manufactured.

The generation for the 1965-70 period will be mostly supplied by the duplication of the same plants.

#### 9. Cost of expanding the power system from 250,000 kW to 1,350,000 kW

##### (a) Generation and high voltage grid

##### (i) Tres Marias

The final cost of this plant including the dam, power plant with 8 x 65,000 kW units, two 300 kV, 250 km lines step-down substation  
/(300/138 kv),

(300/138 kV), is estimated in US\$ 38,200,000 plus Cr\$ 11,200 million. On this basis, the cost per kW at the 138 kV bus of the step-down substation would be approximately US\$ 193/kW. For purposes of this paper it was assumed that two generators and two main transformer banks would be manufactured in the country as well as all the materials and equipment for the second 300 kV transmission circuit.

(ii) Furnas

The first stage of this plant, corresponding to the installation of four units aggregating 550,000 kW is estimated, at present day costs, in US\$ 53 million plus Cr\$ 16,000 million. The final cost should be US\$ 83 million plus Cr\$26,000 million, assuming that the main transformer banks, the transmission line material and the substation transformers were to be manufactured in Brazil.

The resulting cost per kW installed at the 138 kV side of the step-down substations would be US\$ 207.

Taking half of the Furnas cost as the share allocated to the supply of Minas Gerais State it will result in US\$41,500,000 plus Cr\$ 13,000 million.

It should be pointed out that neither the Tres Marias nor the Furnas costs indicated above, are costs to CEMIG, since the Federal Government is financing a large share of Furnas and Tres Marias.

The total cost of the generation and extra high voltage grid will be then US\$ 79,700,000 plus Cr\$ 24,200 million the combined cost, at present rate of exchange, being US\$ 212,700,000 or Cr\$ 38,000 million.

(b) Sub-transmission and distribution

Market studies indicate that by 1970 most of the towns and villages located in the south central region of Minas and some of the northern region will be supplied by the new system.

It is foreseen that approximately 150,000 new consumers will be supplied through existing utilities that will buy bulk power from CEMIG, and 350,000 will be served directly by CEMIG.

/The total

The total cost of the sub-transmission system (138 kV, 69 kV, 33 kV and 13.8 kV), including substations and distribution networks, has been estimated in US\$ 67 million or Cr\$ 12,000 million at the present rate. This amount will represent almost entirely cruzeiros costs as the local industry is, or will be soon, in a position of supplying the required equipment and the engineering and construction will also be done by local organizations.

Resuming, the addition of 1,100,000 kW planned for 1960-1970 should cost:

Local currency	US\$ 200,000,000
Foreign currency	<u>79,700,000</u>
Total	US\$ 279,700,000 or Cr\$50,000,000,000

The resulting cost per kW will be approximately US\$ 263 indicating the considerable economy that can be obtained with large plants when compared with the small plants built in the last decade. The new system will also have a higher density of transmission lines.

#### 10. Source of funds for the 1,100,000 kW expansion

Of the US\$ 79,700,000 required in foreign exchange to provide the expansion the major part is already assured.

In fact, the IBRD has granted a large loan for the Furnas construction from which US\$ 29 million have been allocated in this study.<sup>3/</sup>

Regarding Tres Marias, contracts on the basis of 5 to 10 years repayment have been made with the major equipment suppliers in a total of US\$ 31,600,000. It thus can be said that US\$ 60 million has been obtained leaving only US\$ 19,100,000 necessary to complete the US\$ 79,700,000 required. On a ten year basis, this is an average of only about 2 million dollars per year and presents no special financing problems.

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<sup>3/</sup> The loan in a total of US\$ 73 million can be divided in US\$58 million for equipment and services, the remaining being financial charges. For the purposes of this paper US\$ 29 million representing half of the US\$ 58 million and corresponding to the installation of 250,000 kW has been taken as the cost of the CEMIG expansion program.

The real problem will not, therefore be the foreign exchange parcel, but the cruzeiro parcel estimated in 36.2 billion cruzeiros or 200 million dollars. The required average investment will be 20 million dollars yearly.

On the basis of the present conditions it could be assumed that CEMIG will be able to raise approximately US\$ 65,000,000 over the next 10 years with proceedings of the electrification tax and reinvestments based on the maximum return permissible (10 per cent a.a).

On the other hand, Furnas, with resources of the Federal Electrification Fund, complemented by long term loans from the National Development Bank (BNDE) could raise approximately US\$ 60 million.

Taking in view the federal appropriations for Tres Marias with the participation also of BNDE, in a combined total of US\$ 30 million there still remains a balance to be raised on the order of US\$ 45 million. From this last amount, close to US\$ 30 million represents costs of fabrication of equipment previously imported and now produced in the country and of specialized engineering and construction personnel which will from now on be provided extensively by local firms.

This situation is the same in relation to the power expansion in other regions of the country. As any country going through the present stage of development, Brazil will require for many years the assistance of outside financing. However, as indicated above, the country in the last 10 years began the production of equipment and goods previously produced abroad. For this reason, the type of loan in foreign currency that will be required for the future expansion of the power industry should not be, up to now, for "exclusive use outside the country". The new foreign loans should have provision for using part of funds in purchases in the local industry.

Since a large number of manufacturers of power equipment now established in Brazil are either subsidiaries of large United States and European firms, or are associated to them in some way, it should be

/possible to

possible to study the possibility of manufacturing the components using one part of the foreign loan to buy abroad, and the other part to buy the components manufactured in the country, plus the assembly and testing.

This directive will be an important step in assisting the country's electric power expansion and a very logical one because Brazil is now, as many other Latin-American nations, entering a new phase of its development.

/SUMMARY

## SUMMARY

The State of Minas Gerais (593,000 sq. km., 9 million inhabitants), is very rich in minerals, but has had difficulties in developing its electrical industry prior to 1950.

In 1951 a State Government controlled corporation, Centrais Elétricas de Minas Gerais S.A. - CEMIG, was organized to carry out the electrification program. This corporation was financed with proceeds from a special sales tax and complemented by foreign funds coming mainly from the Export-Import Bank and International Bank.

The initial electrification plan (1951-1960) consisted in the construction of seven hydro plants with a combined capacity of 250,000 kW, plus 1,600 km of transmission lines and several substations and distribution networks in 40 towns.

The cost of this system in today's basis was Cr\$ 8,450 million plus US\$ 30,075,000 or a total of US\$ 77,075,000 resulting in a cost per kW of US\$310 (generation, transmission and distribution). The source of funds can be seen from figure III.

With the new stations there was a rapid industrial development, mainly electric steel reduction, ferro-alloy, aluminium and cement. The heavy demands forced CEMIG to reevaluate the size and scope of the electrification plan and to decide building much larger stations, two of which are now under construction:

Furnas

Controlled by a separate corporation, Furnas S.A., this plant will have 1,100,000 kW final capacity half of which will be supplied in bulk to CEMIG. The first units are scheduled for 1963.

Tres Marias

Constructed in cooperation with the São Francisco Valley Commission, this multi-purpose dam (navigation, flood control and power) will have 520,000 kW final capacity. The first units are scheduled for 1961.

For the past ten years the Brazilian manufacturing and construction industry has experienced rapid growth. Starting with the production of cables, light bulbs, small transformers and kWh meters the manufacturing industry can by now supply almost the entire range of equipment for a hydro-electrical scheme.

/This has

This has been followed by a similar progress in the engineering and construction fields. Large firms equipped with experienced personnel can now tackle almost any type of construction and engineering problems.

For the period 1961-70 an increase from 1 billion kWh/year to 3 billion can be forecasted. By 1970 the required generation will be 6 billion corresponding to 1,100,000 kW. This generation will be supplied by four units of Tres Marias and two of Furnas, with a combined capacity of 535,000 kW.

The cost of the power expansion from 250,000 kW to 1,350,000 kW has been estimated, at today's costs, in US\$ 200 million for local currency plus US\$ 79,700,000 for foreign costs in a total of US\$ 279,700,000, the resulting cost per kW being US\$ 263 (including generation, transmission and distribution).

From the US\$ 79,700,000 required for foreign funds US\$ 60 million have been secured through an International Bank loan and several supplier loans. The remaining US\$ 19,100,000 in ten years represents only 2 million dollars per year and presents no special problems. The real problem will be local currency required at a rate of US\$ 20 million per year. Taking in view the existing funds, there remain still to be raised US\$ 45 million from which 30 million represents costs of fabrication of previously imported equipment and now produced in the country.

As any country going through the present stage of development, Brazil requires assistance from outside financing. However, the country has in the last ten years begun the production of equipment and goods previously produced abroad. Therefore, the type of loan in foreign currency required for the future should not be "for exclusive use outside the country". The new foreign loans should have provision for using part of the funds in purchases in the local industry.

This directive will be an important step in assisting the country's power expansion because Brazil is entering a new stage of development.

