NUCLEAR POWER IN SOUTH-CENTRAL BRAZIL

1. GROWTH AND DEMAND

The region of South-Central Brazil includes the states of São Paulo, Rio de Janeiro, Guanabara and Minas Gerais. The most recent power study was made by Canambra Engineering Consultants Limited[1]. This group reported that the public-grid electricity output for the area in 1962 was 2.16 GW (average generation), with an installed capacity of 3.41 GW and annual mean load factor of 63.4; an increase in power requirements for 1970 was forecast, corresponding to an average output of 5.37 GW and an installed capacity of 8.3 GW. This forecast was based on an annual growth rate of 11.9% in generation. "The energy requirements have grown at an average annual rate of 10.9% since 1955; however, the present forecast is based on the assumption of power being available as required, and hence includes the suppressed demand resulting from existing restrictions in generating and distribution capacity."

More recent information by Canambra leads to the following forecasts (Table I), a provisional value of 0.65 being assumed everywhere for the annual mean load factor:

Table I

ELECTRIC POWER REQUIREMENTS

	Requirements for year:				
	1965	1970	1975	1980	1990
Average generation (GWh/h)					
high forecast	-	4.6	7.2	11.0	25.0
low forecast	-	4.1	5.9	8.3	16.0
mean forecast	2.65	4.35	6.55	9.65	20.5
Capacity to be installed (GW)	4.1	6.7	10.1	14.9	31.6

To check the values anticipated for the growth rate, let us consider the following figures relating to the annual growth rate in the consumption of commercial power for 1957-1960[2]:

Area	Annual growth rate (%)
Latin America	6.3
North America	2.8
Europe	2.8
USSR	5.8
Southern Asia and Far East	8.0
Middle East	8.7
Africa	3.0
China (continental)	46.8
World (average)	6.25

Attention ought to be paid to the fact that the growth rate is low in industrialized countries (USA, Europe) and in developing countries with insufficient development potential; it is high in developing countries capable of rapid industrial development (China). On this basis, it might be assumed that in South-Central Brazil the present growth rate which is actually 10.9% per annum will drop to, say, 9, 7 and 5% in the decades 1970, 1980 and 1990, respectively. On this assumption the power levels would correspond to the following requirements (Table II) for a mean load factor of 0.65:

Table II

ELECTRIC POWER REQUIREMENTS

	Requirements for year:				
	1962	1970	1980	1990	2000
Average generation (GWh/h)	2.16	4.35	10.30	20.26	33.0
Capacity to be installed (GW)	3.4	6.7	15.9	31.2	50.8

Figures in Table II are slightly less than those corresponding to the high forecast in Table I.

2. PER CAPITA CONSUMPTION

Calculation of future energy requirements can also be based on estimates of population growth and increases in energy consumption per capita. The annual growth rate for South-Central Brazil was reported to be 3.9% in 1962 [3]. Let us assume that this rate will gradually drop to 1.9% in the year 2000, which is the value assumed for average growth in the world population [1] in the period 1961 to 2000. Then, the population in South-Central Brazil will be as indicated in Table III.

On the other hand, the installed capacity in the same area was equivalent to 110 W per capita in 1962. One might assume that this would gradually increase so as to reach the value 700 W per capita in the year 2000, which is about 80% of the probable value (890 W per capita) corresponding to Europe at the same date 2000 AD. On this basis, Table III shows the values corresponding to the installed capacity that will be needed to meet electric energy requirements in South-Central Brazil between 1962 and 2000:

Table III

ELECTRIC POWER REQUIREMENTS

	Requirements for year:				
	1962	1970	1980	1990	2000
Population (millions)	31.0	42.0	57.4	74.2	89.2
Watts per capita	110	163	265	431	700
Capacity to be installed (GW)	3.4	6.8	15.2	32	62.4

These figures give a reasonable cross-check of the trends corresponding to the forecasts presented in Table I.

3. EXHAUSTION OF HYDRO POTENTIAL

Various estimates have been made of the hydro resources of the southern-central region of Brazil. A figure of 9100 MW was indicated some years ago by the Water Division of the National Department for Mineral Production. Revised estimates made by the Canambra consortium, which take account of the possibility of engineering changes in the basins of certain rivers, suggest a figure of 15.1 GW, not including major projects such as Sete Quedas, Rio Negro and Canoas Diversion. If a figure of 16.5 GW is assumed and the mean growth rate as shown in the last line of Table I is adopted, all hydro reserves will be fully utilized by 1987.

On the basis of lower and upper limits of 12.5 and 20.0 GW respectively, the saturation date would fall between 1983 and 1990. It would seem therefore that the hydro resources of South-Central Brazil would be fully utilized by 1987 or even earlier - if the reserves are actually less than anticipated, if requirements increase at a more rapid rate than indicated by the mean values in Table I, or if the utilization of particular waterfalls should prove to be too expensive.

In view of this situation, the Canambra report [1] emphasizes the need to install conventional or nuclear plants to supplement the hydro installations to be built in the years ahead.

The various advantages to be derived from establishing nuclear plants for this purpose may be summarized as follows:

(i) In a number of countries nuclear power can now compete with power based on fossil fuels. Recent studies suggest that South-Central Brazil might be such an area (nuclear fuelled plants versus plants fired with coal from the south of the country).

(ii) Use of nuclear fuels would make it possible to reserve fossil fuels for other industrial uses. Brazil is unlikely to be in a position for some time to supply its own oil requirements and the use of nuclear fuel would help save foreign currency.

(iii) A nuclear programme would produce all sorts of side benefits in Brazil : use of national ores, encouragement of research and development, production of reactor components, desalting, etc.

In conclusion, it is now the time to embark on a programme of nuclear power for the southern-central region of Brazil. Moreover, in view of the complexities involved, that programme should be a long-term one. Table IV shows estimates of the quantities of new thermal power (installed capacity) that will be required to supplement the power produced from hydro resources (assuming 16.5 GW as the maximum utilizable hydro potential and the values given in Table I as mean forecast of power requirements). The figure for the total average generation in the year 2000, taken from Table III, was adjusted to fit the corresponding vacant place in Table I.

Table IV

NEW THERMAL PLANTS

	Year: 1985	1990	2000
Total average generation (GWh/h)	14.4	20.5	43.8
Thermal supplement (GWh/h)	-	4.0	27.3
Thermal plant capacity (GW) to be installed if the load factor is:			
= 0.60	-	6.7	45.6
= 0.70	-	5.7	39.0
= 0.80	-	5.0	34.2

It is difficult to establish the proportion of this additional thermal plant power to be supplied from nuclear sources. A reasonable course open to Brazil would be to build as soon as possible one or two small- or medium-sized nuclear plants (60 to 300 MW) and increase their number and/or capacity in the light of experience. Studies for the construction of a first power reactor could start in 1966 and the plant could then come into operation by 1971 or 1972. This would give the country a six- to twelve-year margin before the date when it would become compulsory to utilize nuclear power plants in Brazil with a total installed capacity of several thousand megawatts.

REFERENCES

[1] Canambra Engineering Consultants Limited, Power Study of South-Central Brazil, in 5 vols (Dec. 1963).

[2] United Nations, Statistical Yearbook 1961.

[3] Instituto Brasileiro de Geografia e Estatística, Anuários Estatísticos do Brasil, 1962 and 1963.