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THE NEW OIL PRICES AND THE LATIN AMERICAN ELECTRICITY INDUSTRY

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CONTENTS

/Note by

Note by the Secretariat

This document has been prepared pursuant to the wish expressed by the Member States of ECLA at the Eighth Extraordinary Session of the Committee of the Whole (New York, 24 and 25 January 1974) that the secretariat intensify its efforts in the field of energy and prepare appropriate technical reports in order to determine the impact of energy problems on the economies of the region.

This working document is submitted to the participants in the Technical Symposium on Latin America and the Current Energy Problems for their consideration, and the information provided and observations made by them can contribute greatly to its enrichment and improvement.

/Introduction

Introduction

This study analyses the main short- and long-term effects of the January 1973 - April 1974 increases in oil prices on the production of electrical energy in Latin America, as well as possible lines of action for reducing their impact. Its purpose is to complement the information which the ECLA secretariat will place before the participants in the symposium on Latin America and the current energy problems.

The study comprises four parts. Part A outlines some major features of energy economics in the region, such as the high dependence on oil products and the scarcity of national sources of these in the majority of countries, with its resulting effect on their balance-of-payments situation. The desirability of replacing them with other sources of energy, primarily of national origin, is pointed out, and in conclusion a study is made of the consumer sectors where such substitution seems possible (industry, domestic use, transport, public service, electricity generation).

Part B discusses the present situation and recent trends in the electricity sector, showing the major sources of primary energy available apart from oil, as well as the relevant aspects of installed capacity, generation and consumption. Some of the factors responsible for unnecessarily high fuel inputs which can be corrected with resulting savings are noted, such as excessive power losses in distribution networks, the relatively high heat consumption in thermal generation per kWh produced, etc., as well as others which would reduce dependence on oil products in the generation of electricity, such as the extension of grid networks and, of course, the progressive substitution of those power stations which use oil products, as already envisaged in the plans for expanding the sector.

In view of the considerable proportion of power stations using diesel motors and steam turbines in exisiting networks, part C analyses the immediate increases in generating costs resulting from the increase in the price of fuel. Taking into account the prices of diesel and

/fuel oil

fuel oil in the importing countries at the beginning of 1973, and the corresponding prices prevailing in the second quarter of 1974, estimates are made of the effects of such increases on electricity rates and consumption.

The last part, part D, examines possible lines of medium- and long-term action that may shape the electricity supply pattern for the next decade or two. The relatively more advantageous conditions which exist at present for the development of electricity production through the use of water or nuclear power are described, together with a breakdown of the production costs per kWh for different values of the main parametres. In conclusion - taking as a basis the general analysis made in the second part - some specific measures are suggested which would help to relieve the problems raised by the new levels of fuel prices for the electricity industry in particular and the economy in general.

Summary and Conclusions

1. Hydrocarbons are the source of energy most used in Latin America thus making the area the most dependent on oil and natural gas of all the main regions of the world.

However, only five countries (Venezuela, Ecuador, Bolivia, Trinidad and Tobago, and Colombia) have known reserves of hydrocarbons big enough to make them self-sufficient. Five others (Mexico, Argentina, Chile, Peru and Brazil) have reserves which only cover part of their consumption, and the remaining fourteen countries have to import all their oil requirements.

2. Any policy aimed at replacing part of Latin America's high consumption of oil with other energy sources depends on the exploitation of hydroelectric and other local resources such as natural gas, coal, geothermal energy, radioactive minerals, etc. There are substantial reserves of these resources in the region: in the present state of technology some of them must be converted into electricity to be used, and all of them are capable of being used in this form. For this reason, it is expected that the relative share of electrical energy will now increase more rapidly.

3. Latin America has plentiful economically exploitable hydropower estimated to amount to at least 2,800 x 10^9 kWh per year. Of the total electrical output for 1973, which was calculated to be 197 x 10^9 kWh, 55 per cent was hydropower and the remainder was produced in thermal stations. The hydropower used at present is therefore less than 4 per cent of its estimated potential. Among the reasons for this are (i) the abundant supply of cheap oil up to a short time ago; (ii) the paucity of basic data - especially hydrological data - required for implementing projects designed to make use of water power; (iii) the bigger initial investment involved, etc.

Installed electrical capacity in 1973 amounted to 51.4 million kW, made up of approximately equal proportions of hydropower and thermal power. The fuels used in 72 per cent of the thermal generating capacity were oil products, and they accounted for 16 per cent of the total oil consumption of the region.

4. Twelve per cent of the electricity produced in Latin America in 1973 was not generated by public utilities but by self-suppliers. Most of this electricity was produced in thermal stations at high rates of fuel consumption per kWh. It is estimated that approximately half of this energy (some 12,000 million kWh per year) could be economically supplied by public utilities, where the share of hydroelectricity is large and increasing, thus permitting; some 4,500,000 kW of private generating capacity to be dispensed with.

5. In eight important public utility networks, the average input of fuel in 1970 was 3,245 kcal/kWh. It would appear to be possible to reduce the average consumption in stations using fuel oil and diesel oil to approximately 2,800 kcal/kWh for only a modest expenditure of foreign exchange, and the reduction in the consumption of fuel would mean savings of some 150 million dollars per year at present prices.

6. Although transmission and distribution losses in public utility networks have been declining in recent years, they are still high, and in 1973, they amounted to 16.2 per cent of generated output.

/If they

If they could be reduced to about 10 per cent (the exact figure being established in each case on the basis of economic considerations), savings in fuel would at present be some 200 million dollars per year. Such a reduction could be achieved in a relatively short period with modest investments. There appears to be ample scope for action in this field in Panama, the Dominican Republic, El Salvador, Haiti and Honduras.

7. Since the majority of the Latin American countries depend on imported oil, electricity sectors planners in several of them were already pointing to the need to reduce consumption of this fuel in the generation of electricity before 1973. As a result, the new power station building programmes up to 1980 envisage that only 10 per cent of the new units will be dependent on petroleum products. In the total generating capacity scheduled for 1980, 57.1 million kW (58.4 per cent) are expected to be supplied by hydroelectric power stations; 22 million (22.5 per cent) by power stations using petroleum products; 11.8 million (12 per cent) by those using natural gas, and the remainder by power stations using coal, nuclear energy, and geothermic energy.

With respect to the oil importing countries it is worth emphasizing that the high proportion of hydroelectric power will avoid heavy outlays of foreign exchange, both because the foreign currency component in the initial investment is less than for a corresponding thermal unit, and because there is no yearly expenditure on fuels.

8. The effects of the rise in oil prices for consumers of electrical energy vary greatly depending on the characteristics of the electricity systems. The countries hardest hit are likely to be Cuba, Guyana, the Dominican Republic, Panama and Guatemala, since thermal power stations predominate in these countries.

9. The increase in the price of fuels has had a marked effect on the competitive strength of oil-fired power stations, in which the corresponding increases in the cost per kWh are estimated to range between 35 and 85 per cent, depending on the size of the units and

/the coefficient

the coefficient of utilization. These power stations could now advantageously be replaced by hydroelectric stations having a relatively high cost per installed kW in some cases, or by relatively small (150-200 MW) nuclear units. Prior to the rise in oil prices, nuclear power stations were not economically competitive unless they were over 500 MW, and this was a major obstacle to their use in Latin American systems.

10. Since the consumer prices of energy generated by public utilities reflect not only generating but also transmission and distribution costs, it is probably correct to suppose that, on average, the rates may rise by approximately 60 per cent of the increase in generating costs in small networks, and by 50 per cent of the increases in medium-sized and large ones.

The incidence of the price of electrical energy on industrial production costs averages less than 2.5 per cent. It does not, therefore, seem likely that an increase of 30 to 40 per cent (at the worst) in the price of this input can affect the development of the sector. Neither there seem to be any likelihood of a major cutback in household consumption.

11. Measures are already being implemented in some countries of the region to reduce the dependence of the electricity industry on oil products, the aim being to reduce generating costs, save foreign exchange, and guarantee supplies. It is possible that these and other measures indicated below may also be of use in other areas.

12. The use of oil should be restricted, and it should be replaced with other local energy sources.

(a) Oil importing countries which have oil-fired steam power stations and also produce coal and/or natural gas (Argentina, Brazil, Chile, Mexico) could consider the possiblity of converting such stations to use the latter fuels, depending on their availability. Even where such conversion is economically feasible, however, it could not normally be completed in the short term in view of the time required to do the work and the considerable investment needed.

/(b) The

(b) The development of hydroelectric resources should be stepped up in the majority of the countries of the region, even in those producing oil, because of the prospects of making oil available for export.

Hydroelectric power stations differ greatly both in their physical characteristics and in the supply functions they are called on to fulfil, so unit costs also vary considerably. However, it can generally be said that their competitive strength has increased substantially vis-à-vis oil-fired power stations, and hydroelectric resources which were not economic prior to the rise in oil prices have now become so.

(c) The prospects for nuclear energy in Latin America are now brighter, and the use of this type of energy now seems within closer reach than was foreseen at the end of the last decade. It would therefore be advisable to study its possibilities in each case.

Since nuclear power stations of as little as 150,000 to 200,000 kW are now competitive with conventional thermal stations, they can economically be installed in networks with a deemand of more than 1.5 million kW, thus opening up prospects for their use in a larger number of countries (Argentina, Brazil, Mexico, Chile, Peru, Cuba, Jamaica, Uruguay, etc.).

It should, however, be pointed out that the hydroelectric and nuclear projects which are now to be preferred in many cases to the thermal alternative will require much higher initial investments (60-120 per cent higher) with resulting pressure on domestic and foreign financing. Another factor which continues to favour oil-fired power stations is the shorter period of design and construction involved, since they are relatively standard. Thus, whereas thermal stations may require a total of 4-6 years to build, hydroelectric stations (provided that reliable data on water resources are available) and nuclear ones may require 7-10 year.

/13. The

13. The linking of public utility electric networks by internal or international connexions should be considered a priority area for investment in Latin America, on account of the advantages it offers as regards the saving of fuel (greater use of hydroelectricity, larger and therefore more efficient thermal units, scrapping of the small thermal units serving isolated centres, etc.).

International grid systems facilitate the use of multinational resources, or permit the complementation of electricity networks (complementation of hydroelectric power with thermal generation, for example). There are several projects of this kind, mainly in the Central American countries and the countries of the River Plate Basin, whose completion should give excellent results in the present circumstances.

THE NEW OIL PRICES AND THE LATINA AMERICAN ELECTRICITY INDUSTRY

A. GENERAL CONSIDERATIONS

Before reviewing the immediate effects of the oil price rises in 1973 and early 1974 on the Latin American electrical energy industry and its future prospects, mention should be made of some of the outstanding features of the general energy economics of the region.1/

1. The energy supply structure and the available local resources

The total consumption of energy in Latin America during 1973 was estimated at 246 million tons of oil equivalent, broken down as follows: hydrocarbons, 157 million (oil 125 and natural gas 32); vegetable fuels, 49 million; hydroelectricity 2/ 30 million; and coal, 10 million.

1/ A more detailed analysis of the electrical energy sector and its place in the general energy picture is given in the chapter on recent production and consumption of energy in Latin America in the Economic Survey of Latin America, 1972, (United Nations publication, Sales No. E.74.II.G.1).

2/ The conversion of hydroelectricity to oil was carried out on the basis of 1 kWh = 3,200 kcal, which corresponds to the average caloric energy needed in thermal power stations in the region to generate 1 kWh.

/Taking only

Taking only sources of commercial energy 3/ the percentage shares were: hydrocarbons 80 per cent (oil 64 and natural gas 16); hydroelectricity, 15 per cent; coal, 5 per cent. Table 1 gives country figures for the year 1972.

Hydrocarbons account for the biggest share of the energy resources consumed in Latin America, which is therefore in relative terms the major world region most dependent on oil and natural gas for satisfying its needs (table 2).

The commercial energy consumption structure in several countries of the region is not in keeping with the available resources. Thus, for example, taking the two main sources of supply, it is clear that:

(a) Although the consumption of hydrocarbons is generalized and high, according to known reserves only five countries (Venezuela, Ecuador, Bolivia, Trinidad and Tobago and Colombia) are self-sufficient. Five others (Mexico, Argentina, Peru, Chile and Brazil) can only cover part of their domestic consumption, and the remaining fourteen have to import their entire petroleum needs. The deficit for all the importing countries together amounted to more than 50 million tons in 1973.

(b) In contrast, water power potential is estimated to be considerable in two-thirds of the countries of the region, being very small only in five countries (Trinidad and Tobago, Jamaica, Haiti, El Salvador and Cuba), but it is still very under-exploited in general.

3/ Excluding vegetable fuels.

Table 1

LATIN AMERICA: PRODUCTION AND CONSUMPTION OF COMMERCIAL ENERGY AND VEGETABLE FUELS, 1972

Provisional figures

(Thousands of tons of petroleum equivalent at 10 700 kcal/kg)

Country	Production						Consumption					
	Coal	Crude oil	Natural gas a/	Hydro-electricity b/	Vegetable fuels c/	Total	Coal	Petroleum products	Natural gas a/	Hydro-electricity b/	Vegetable fuels c/	Total
Argentina	386	22 653	6 840	433	1 564	31 876	714	21 658	5 424	433	1 564	29 793
Barbados	-	-	-	-	90	90	-	200	-	-	90	290
Bolivia	-	2 082	2 978	232	866	6 158	-	562	28	232	866	1 688
Brazil	1 310	8 352	1 081	13 756	16 974	41 473	2 472	28 235	198	13 756	16 974	61 635
Chile	940	1 633	7 024	1 563	1 084	12 244	1 091	5 009	469	1 563	1 084	9 216
Colombia	1 685	9 914	2 848	2 248	3 738	20 433	1 685	4 953	1 496	2 248	3 738	14 120
Costa Rica	-	-	-	332	351	683	-	461	-	332	351	1 144
Cuba	-	-	-	-	3 622	3 622	...	7 260	-	-	3 622	10 882
Ecuador	-	3 772	77	138	1 482	5 469	-	1 290	47	138	1 482	2 957
El Salvador	-	-	-	147	694	841	-	580	-	147	694	1 421
Guatemala	-	-	-	85	1 056	1 141	-	830	-	85	1 056	1 971
Guyana	-	-	-	-	307	307	-	480	-	-	307	787
Haiti	-	-	-	27	1 150	1 177	-	130	-	27	1 150	1 307
Honduras	-	-	-	95	580	625	-	410	-	95	530	1 035
Jamaica	-	-	-	38	522	560	-	1 550	-	38	522	2 110
Mexico	2 447	26 241	16 260	4 667	7 294	56 915	3 230	25 013	10 878	4 667	7 294	51 082
Nicaragua	-	-	-	82	445	527	-	520	-	82	445	1 047
Panama	-	-	-	22	200	222	-	600	-	22	200	822
Paraguay	-	-	-	51	476	527	-	210	-	51	476	737
Peru	45	3 158	1 593	1 434	2 075	8 305	98	4 740	360	1 434	2 075	8 707
Dominican Republic	-	-	-	22	1 185	1 207	-	480	-	22	1 185	1 687
Trinidad and Tobago	-	7 328	2 408	-	297	10 033	-	1 870	1 408	-	297	3 575
Uruguay	-	-	-	298	110	408	25	1 705	-	298	110	2 138
Venezuela	31	168 628	40 037	1 849	831	211 376	240	7 015	8 286	1 849	831	18 221
Latin America	6 844	253 761	81 152	27 519	46 943	416 219	9 555	115 761	28 594	27 519	46 943	228 372

Source: ECLA, on the basis of official data.

a/ Production appears to be considerably more than consumption owing to the inclusion of the unused surplus of gas which is flared off or reinjected into the wells.

b/ To express the hydro-electricity generated in terms of its oil equivalent the formula 1 kWh = 3 200 kcal was used, since this corresponds to the average caloric energy required in the area to generate 1 kWh.

c/ Includes the consumption of the population and the sugar industry only.

/Table 2

Table 2

SHARE OF HYDROCARBONS AND HYDRO-ELECTRICITY IN THE GROSS CONSUMPTION OF COMMERCIAL ENERGY

(Percentages)

Region or area	Hydrocarbons						Hydro-electricity b/	
	Total		Petroleum products		Natural gas a/			
	1961	1971	1961	1971	1961	1971	1961	1971
Latin America	80.2	80.4	67.6	64.9	12.6	15.5	12.3	14.4
Western Europe	31.4	61.1	29.3	51.9	2.1	9.2	15.4	12.0
Eastern Europe (including Soviet Union)	29.6	48.1	19.8	27.2	9.8	20.9	4.1	4.1
United States	72.4	75.4	39.5	39.8	32.9	35.6	6.1	6.0
Other developed countries	38.7	59.1	33.3	49.9	5.4	9.2	23.2	16.1
World	46.8	60.2	31.6	40.1	15.2	20.1	9.7	8.2

Source: United Nations, World Energy Supplies.

a/ The statistical series used generally give only the output of natural gas used as fuel, the surplus flared off or reinjected being excluded.

b/ Production is taken to be equal to consumption.

/Although certain

Although certain technical circles in some Latin American countries have been pointing out for years the economic advantage of converting to energy sources more in keeping with those countries' own natural resources, it is only recently, as a result of the measures adopted by the OPEC (Organization of Petroleum Exporting Countries) members on prices and supply restrictions that general concern has arisen about the uncomfortable dependence of many Latin American countries on external supplies for their energy needs. The petroleum importing countries have seen their balance of payments position change sharply, and the importation of quantities of oil similar to those of 1973 would mean, at present prices, the expenditure of some 3,500 million dollars more than was paid for the corresponding volume of imports in 1972.

Moreover, fears that the traditional world reserves of oil will be exhausted in a few more decades if consumption continues to increase at the present rate, and the rather widely held belief that it is in the general interest to reserve the use of hydrocarbons for more essential needs of mankind (such as possible sources of proteins) than as mere fuels, are further reasons why countries should try to diversify their energy sources in the years ahead, giving the highest priority to the development of their own national resources.

2. Possible changes in the supply of energy and the role of electricity

The policies aimed at finding substitutes for part of Latin America's present high volume of oil consumption propose, in addition to the use of hydroelectric resources, energy sources such as natural gas, coal, geothermic energy, nuclear fuels, vegetable fuels, and, looking further ahead, oil shales and sands, to say nothing of solar and wind energy.

It should be pointed out here that water, geothermic and nuclear resources are predominantly used in the form of electrical energy, and it is for this reason that their development will influence the accelerated growth of electricity services.

/The greater

The greater part of the fuel consumed is used for heating (mainly in the domestic and industrial sectors) and motive force (transport, industry, agriculture, etc.). The first of these applications may be satisfied, generally speaking, by using alternative sources such as coal, natural gas, wood, etc., and, in some special cases, hydroelectricity, so that there is a wide range of possible substitutes for oil products.

The range of alternatives for providing motive force is narrower, however. In the case of stationary motors, electricity usually has an advantage over other types of energy, since there is practically no substitute for small electric motors, but where motor vehicles are concerned, there is no effective substitute for the internal combustion engine at present.

Thus, in the domestic and industrial sectors, where, considerable use is made of heat energy and stationary motors, it is quite possible to find a substitute for petroleum products, the obvious solution in the latter case being the use of electrical energy. These two sectors accounted for 10 and 25 per cent respectively of the total consumption of hydrocarbons in Latin America in 1970.

In the transport sector, in contrast, which is the main consumer of petroleum products in the region (approximately 46 per cent in the year in question) the internal combustion engine can only be supplanted by electricity in the case of rail transport and trolleybuses.

The electrical energy industry is also an important consumer of petroleum products (15 per cent of total consumption in 1970) however, since it uses oil to produce heat for the generation of electricity. When this process is carried out in steam turbine powered stations, where most of the thermal electricity in the region is produced, technically any source of heat can be used, making it possible to use a wide range of substitutes for petroleum products. Of the total commercial energy consumed in the region in 1973, the equivalent of 142 million tons of oil (72 per cent) was used directly as fuel, while the equivalent of 55 million tons (28 per cent) was converted into electrical energy.

/The constant

The constant increase in the consumption of energy in the form of electricity becomes clear by comparing the changes in the ratio of electrification (the consumption of electricity, expressed in kWh, over net consumption 4/ of commercial fuels, measured in kgs of oil equivalent). For Latin America as a whole the ratios were 1.07 in 1961, 1.25 in 1970 and 1.33 in 1972 (see table 3).

The versatility of electrical energy both as regards the way it can be generated (using various sources of primary energy) and the many uses to which it can be put makes it certain that its relative importance will continue to increase and that it will be one of the major means of overcoming the difficulties which the world has to face in securing its supplies of energy in the medium and long term.

In concluding this overall picture of the supply of energy in Latin America in the light of the new oil prices, it should be pointed out that, particularly in the electrical sector, investment selection and network operation policies will have to be thoroughly revised. For example, hydroelectric projects which were conceived and designed on the basis of strict economic criteria for linking up with thermal power stations using fuel oil at 2 dollars per million kcals would not be fully used now because the price of heat has more than doubled. The extension of existing hydroelectric power stations could therefore be justified, despite the difficulties it entails, and the operational plans could be modified considerably.

In other cases, it may be advisable to study the immediate economic advantage of closing down those thermal units whose operation proves costly because of physical wear and tear, and bringing forward the construction of hydroelectric, nuclear or even thermal power stations of higher efficiency. Given the relatively long planning and construction period that these require, such a decision would, as in the previous case, only yield results after several years.

4/ Excluding that used in the generation of thermal electricity.

/Table 3

Table 3

COEFFICIENT OF ELECTRIFICATION[a], 1961, 1970 AND 1972

Country	1961	1970	1972
Argentina	0.87	1.08	1.18
Bolivia	1.62	1.52	1.56
Brazil	1.82	1.90	1.98
Chile	1.48	1.44	1.64
Colombia	0.81	1.27	1.60
Costa Rica	3.26	2.62	2.87
Cuba	1.04	0.76	0.91
Ecuador	1.01	1.02	0.98
El Salvador	1.47	1.41	1.68
Guatemala	0.78	1.07	1.34
Guyana	0.47	0.94	0.89
Haiti	2.38	1.69	1.62
Honduras	0.52	0.90	1.02
Jamaica	1.21	1.58	1.99
Mexico	0.74	0.95	1.05
Nicaragua	1.38	1.43	1.89
Panama	0.94	2.86	3.47
Paraguay	1.16	1.25	1.57
Peru	1.21	1.32	1.28
Dominican Republic	2.17	4.89	8.24
Trinidad and Tobago	0.30	0.44	0.39
Uruguay	1.23	1.70	1.81
Venezuela	0.78	1.06	0.86
Latin America	1.07	1.25	1.31

Source: ECLA, on the basis of official data.

a/ The relation between the consumption of electricity in kWh and the consumption of commercial fuels as such, expressed in terms of oil equivalent.

/In the

In the following chapters an attempt is made to provide a careful analysis of the electrical sector from the point of view of the impact of the new level of oil prices and its future prospective.

B. THE ELECTRICAL ENERGY INDUSTRY

1. Resources available for generating electricity, apart from oil

(a) Hydroelectric power

There is no direct evaluation of the economically usable hydroelectric potential of Latin America which has been prepared on the basis of uniform criteria and is fully comprehensive. The major obstacle to this has been the deficient knowledge of topography and hydrology. A few years ago ECLA carried out an indirect evaluation using only available rainfall and topographical data, the aim being to establish orders of magnitude for the countries by using standard criteria. The results of this study are given in table 4 (column 1). At that time it was estimated that the "economically usable" hydroelectric potential was approximately 20 per cent of the "technically usable" potential, thus giving a figure of some 2,800 GWh per year. Because of the present sharp increase in the generating costs of thermal power stations as a result of the rise in the prices of fuels, the percentage mentioned above is bound to be much figher now, although it is not yet possible to name a figure, for many hydroelectric projects which were not considered economic before are now economically feasible. By way of illustration, even the figure indicated above is 30 times higher than the actual hydroelectric generation in 1973, and it would be equivalent to 900 million tons of oil per year, if it were put exclusively to uses other than the mere production of heat, such as, the provision of motive power, electric lighting, electrometallurgical uses, etc. It may be noted that the total consumption of hydrocarbons in the region in 1973 amounted to 157 million tons of oil equivalent: i.e., only one-sixth of the above mentioned quantity. However, the use of this renewable and clean form of energy entails a high level of investment, intensive field research (mainly hydrological), and planning and project studies taking up a number of years: at least seven, if sufficiently reliable and extensive hydrological data are available, and 15 to 20 years or more if they are not.

/Table 4.

Table 4

LATIN AMERICA: HYDROELECTRIC ENERGY: PRESENT ECONOMIC POTENTIAL AND IDENTIFIED POTENTIAL, 1970

Country	Present economic potential a/		Identified potential b/		
	Total (thousands of GWh) (1)	Per km² (kW/km²) (2)	Capacity (MW) (3)	Generation (GWh) (4)	Ratio (4)/(1) (5)
Argentina	148.0	4.0	30 981	148 050	1.00
Bolivia	128.4	13.3	338	1 500	0.01
Brazil	900.5	12.2	80 000	360 000	0.40
Colombia	334.3	33.5	22 520	80 000	0.24
Costa Rica	30.9	41.1	687	3 830	0.12
Cuba	6.0	6.1	...	...	...
Chile	197.0	31.9	24 319	146 490	0.74
Ecuador	150.4	60.2	2 483	14 570	0.10
El Salvador	6.4	20.5	838	2 810	0.44
Guatemala	36.0	40.3	1 240	4 660	0.13
Guyana	40.8	18.5	...	...	...
Haiti	3.8	21.8	...	...	...
Honduras	30.8	15.4	340	1 360	0.04
Jamaica	2.4	31.3	25	...	...
Mexico	97.0	24.5	6 120	23 000	0.24
Nicaragua	20.0	5.6	306	1 670	0.08
Panama	27.4	15.7	...	5 360	0.20
Paraguay	47.1	31.6	6 500	30 000	0.64
Peru	286.8	13.3	34 000	155 000	0.54
Dominican Republic	7.0	25.5	...	...	...
Surinam	23.0	16.3	...	...	...
Trinidad and Tobago	1.0	18.2	...	...	...
Uruguay	7.5	4.9	1 268	4 460	0.59
Venezuela	304.0	38.1	3 700	14 000	0.05
Latin America	2 835.5	15.8	215 659	996 760	0.36

Source: ECLA.

a/ Estimates. "Latin America's hydroelectric potential", Economic Bulletin for Latin America, vol. XII, Nº 1.

b/ Based on field surveys, feasibility studies and power stations constructed.

/The hydroelectric

The hydroelectric projects identified in the region together represent almost one-third of the estimated economic potential (1970). In Argentina, the capacity of the projects identified is practically equal to the total of its potential, and in Chile, Paraguay, Peru and Uruguay the corresponding figures are relatively high, ranging between 54 and 74 per cent (see table 4). In other countries, however, the total capacity of identified hydroelectric projects is small in relation to the estimated total potential. Hydroelectric power is undoubtedly one of the main resources of Latin America which have so far been exploited only on a minor scale.

(b) Natural gas

In Latin America, natural gas is found mainly together with oil. In 1973 the reserves of natural gas in the region amounted to 2,586 million cubic metres, or almost 70 times the consumption in that year. Two-thirds of the proven reserves are located in three countries: Venezuela (45 per cent), Mexico (12 per cent) and Argentina (9 per cent). The remaining 34 per cent are shared between Bolivia, Brazil, Colombia, Chile, Peru and Trinidad and Tobago.

Four countries accounted for almost nine-tenths of the gross production of natural gas in the region in 1972: Venezuela (50 per cent), Mexico (20 per cent), Chile (9 per cent) and Argentina (8 per cent).

The ratio of consumption to net production of natural gas (excluding reinjected gas) is rising, although it is still relatively low, being approximately one-half in 1970. The increase reflects the bigger use being made of gas as a fuel in the major natural gas consumer centres (Argentina, Mexico, Trinidad and Tobago and Venezuela). Some of it is not used but is flared off at the wellhead. Although this practice is diminishing, it is still responsible for considerable wastage of an important energy resource of the region. Since it is estimated that in 1972, 31 per cent of the natural gas consumed was used in the production of electrical energy, the enormous future possibilities of this resource for electricity generation, even in

/international projects,

international projects, can easily be seen. Liquefied natural gas can be exported, or international gas pipelines can be used to permit the production of electricity in the consumer country (as in the export of gas from Bolivia to Argentina) or grid systems may be used to export the electrical energy directly from power stations located near the gas deposits.

(c) Coal

The main known deposits are in seven countries: Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela. Measured resources total 4,100 million tons, and potential resources are estimated at 60,000 million, whereas annual consumption is less than 15 million tons.5/ With such high potential, it is to be expected that this resource will have a greater part to play in the supply of electrical energy in the region, mainly through the construction of power stations at coal mine locations. A more detailed analysis of its possibilities and prospects is given in the document. The Latin American coal industry and its prospects.6/

(d) Geothermic energy

This resource seems to be available in a relatively favourable form in a belt running down the west side of Latin America, passing more or less parallel to the Sierra Madre Occidental in Mexico, continuing through the central zone of that country and the Central American isthmus, and later skirting the Andes in South America. It only began to be exploited on a fairly large scale quite recently, however, when a power station of this kind was brought into service (in 1972) in north-west Mexico (the 75 MW Cerro Prieto station in the Mexicali Valley, which will be increased to 360 MW).7/ Another country, El Salvador, is on the point of making use of this resource

5/ Unfortunately the available data are very deficient and do not permit the determination of the proportion of these resources considered economically exploitable.

6/ Ramón Suarez, El carbón latinoamericano y sus perspectivas, Information Document No. 3, 1974, prepared for this Symposium.

7/ Prior to this, as a pilot project, a 3,500 kW power station was built at Pathe in the State of Hidalgo.

/in the

in the 33 MW Ahuachapán station, and in Chile the installation of a power station at the Tatio geyser area in the province of Antofagasta is at an advanced planning stage. It is estimated that the total potential output could be approximately 100,000 kW, but the initial generating capacity will be no more than 15,000 kW. The remaining countries have not yet shown any definite interest in this resource. Research in this field is still at a preliminary stage, and regional figures for its potential are therefore not available.

(e) Radioactive minerals

Data on these resources are scarce, being considered confidential in some countries. The greatest efforts in prospection, still to be completed, have probably been made in Argentina, Brazil and Mexico, and it is precisely in these countries that the use of such minerals has begun or is about to begin. Up to 1973 8/ estimated reserves of U_3O_8 were 53,000 tons in Argentina (23,000 at less than 10 dollars/pound and 30,000 between 10 and 15 dollars), 73,000 tons in Brazil 9/ (2,500 at less than 10 dollars/pound and 700 between 10 and 15 dollars), and 1,900 tons in Mexico 10/ (1,000 at less than 10 dollars/pound and 900 between 10 and 15). To give an idea of requirements, the Atucha power station (340 MW) in Argentina will consume 50 tons annually and the Rio Tercero power station (600 MW) 80 tons. In breeder reactors (which are expected to come into operation commercially before 1990) the specific consumption of uranium will be only 2 per cent that of present reactors.

Brazil also has large deposits of thorium - possibly about 20 per cent of the world's known reserves of this element.

8/ International Atomic Energy Agency, Bulletin No. 1/2, 1974.

9/ Including some 70,000 tons associated with phosphate deposits.

10/ More recent data give the reserves as 4,300 tons.

/In brief,

In brief, all the resources examined above represent a sizeable reserve of energy for the region, the greater part of which can be economically used in the form of electricity.

2. Installed electricity generating capacity

In 1973, installed generating capacity in Latin America amounted to 51.4 million kW (see table 5), 84 per cent of which was accounted for by public utilities and 50 per cent (25.4 million kW) by hydroelectric stations.

The table shows a gradual increase in the share of hydroelectric power stations in the installed capacity of public utilities, the proportion in 1973 being 56 per cent, and a corresponding fall in the number of self-suppliers, primarily users of thermal power stations. Both events are positive from the point of view of savings in petroleum products. At the same time, however, the present limited use (less than 4 per cent) of the economically usable water resources contrasts markedly with the relatively high level of thermal production. Several factors have been responsible for this, such as:

- the availability of cheap oil and the downward trend of prices on international markets up to 1970; 11/
- financing problems and the highcost of capital, which affected hydroelectric power stations in particular because of the heavy initial investments usually required;
- the shortage of basic data (mainly hydrological) required for hydropower projects;
- emergency situations resulting from inadequate generating capacity, so that recourse had to be had to rapidly installed thermal power stations, thereby postponing the development of hydroelectric stations which offer greater advantages to the national economy;

11/ In many countries imported oil was cheaper than locally produced coal, in terms of caloric output.

Table 5

LATIN AMERICA: GROWTH OF INSTALLED CAPACITY, 1958-1973

(MW)

Country	1958						1967						1973 a/					
	Public utility			Country total			Public utility			Country total			Public utility			Country total		
	Hydro	Thermal	Total	Hydro	Thermal	Total	Hydro	Thermal	Total	Hydro	Thermal	Total	Hydro	Thermal	Total	Hydro	Thermal	Total
Argentina	272	1 858	2 130	295	2 735	3 030	409	3 467	3 876	432	5 139	5 571	1 318	5 348	6 666	1 335	7 135	8 470
Bolivia	70	11	81	92	51	143	121	20	141	144	75	219	185	36	221	210	100	310
Brazil	3 021	604	3 626	3 223	769	3 993	5 344	1 456	6 800	5 692	2 016	7 708	12 452	2 286	14 738	12 835	3 080	15 915
Chile	411	123	534	522	492	972	608	348	956	720	848	1 568	1 157	551	1 708	1 270	1 175	2 445
Colombia	453	177	630	490	368	858	1 191	490	1 681	1 276	785	2 061	1 878	915	2 793	2 005	1 140	3 145
Costa Rica	73	25	98	81	29	110	168	41	209	176	56	232	262	50	312	275	105	380
Cuba	-	469	469	-	854	854	-	666	666	-	1 110	1 110	-	1 500	1 500	-	2 000	2 000
Ecuador	31	54	85	37	57	94	80	110	190	83	147	230	98	214	312	105	280	385
El Salvador	56	9	65	56	18	74	109	46	155	109	63	172	109	79	188	110	105	215
Guatemala	25	19	44	25	32	57	40	76	116	44	87	131	125	124	249	125	145	270
Guyana	-	15	15	-	35	35	-	40	40	-	100	100	-	80	80	-	120	120
Haiti	-	12	12	-	27	27	-	20	20	-	45	45	48	21	69	50	45	95
Honduras	3	12	15	3	26	29	31	28	59	32	44	76	72	63	135	72	81	153
Jamaica	13	52	65	13	108	121	22	130	152	22	220	242	16	412	428	16	512	528
Mexico	1 111	888	1 999	1 159	1 401	2 560	2 520	2 364	4 884	2 640	3 161	5 801	3 839	3 956	7 795	3 930	5 270	9 200
Nicaragua	1	50	51	1	75	76	51	65	116	58	97	155	100	117	217	110	160	270
Panama	7	42	49				15	106	121	62	191	253	22	177	199	22	208	230
Paraguay	-	29	29	-	34	34	1	43	44	1	66	67	90	37	127	90	64	154
Peru	213	78	291	401	252	653	581	248	829	871	646	1 517	1 008	332	1 340	1 290	920	2 210
Dominican Republic	-	87	87	-	117	117	15	123	138	15	173	188	55	242	297	55	312	367
Trinidad and Tobago	-	61	61	-	109	109	-	203	203	-	253	253	-	264	264	-	314	314
Uruguay	128	203	331	128	203	331	236	224	460	236	224	460	252	307	559	252	307	559
Venezuela	35	621	656	35	993	1 028	380	1 480	1 860	380	2 040	2 420	1 243	1 884	3 127	1 243	2 400	3 643
Latin America	5 923	5 499	11 422	6 561	8 785	15 346	11 922	11 794	23 716	12 993	17 586	30 579	24 329	18 995	43 324	25 400	25 978	51 378

Source: ECLA, on the basis of official data.

a/ Provisional figures.

/the

- the large number of small- and medium-size pockets of consumers scattered over mountainous terrain, which can most easily be supplied by isolated thermal power stations;
- the distance of hydroelectric resources from the consumer centres and, in some countries, the problem raised by the fact that the limited size of the market does not permit major hydropower development, and these would prove uneconomical if carried out slowly.12/

The situation has undoubtedly improved in the last few years, as is reflected in the recent increase in the relative share of hydroelectric power stations (see table 5).

Table 6 shows the distribution of installed capacity in thermal power stations classified according to the heat source used. It can be seen that 72 per cent of the power stations used oil products in 1973. The major consumers among these are the fuel-oil-fired steam power stations (48 per cent), although some similar stations use coal or natural gas because they are located in areas producing such fuels.

A marked drop has been noticeable in recent years in the growth of diesel-powered stations, as a result of both the linking of networks by establishing grid systems, and the increase in the use of gas turbine generators.

12/ The economic transmission of electrical energy over great distances is a technique which is in the process of rapid change. In the 1950s the maximum distance was some 500 kms, but many resources which could not be fully used then are today in use or about to be brought into use, for transmitting energy over a distance of 2,000 kms is no longer a problem.
At the same time the increase in the use of "extra high" and "ultra high" voltages offers considerable economies and improves the competitive strength of remote hydroelectric resources, as well as facilitating the establishment of interconnected systems.

/Table 6

Table 6

LATIN AMERICA: TOTAL INSTALLED CAPACITY OF THERMAL POWER STATIONS, BY HEAT SOURCE USED

(Thousands of MW)

	1961	1970	1973
Fuel oil	4.7	9.8	12.3
Diesel oil	3.6	6.0	6.3
Natural gas	1.9	3.3	4.7
Coal	0.5	1.3	1.3
Vegetable fuels	1.0	1.2	1.2
Geothermic	-	-	0.1
Total	11.7	21.6	25.9

Source: ECLA, on the basis of official data.

/3. The

3. The generation of electrical energy

The total production of electrical energy in the region in 1973 amounted to 197,000 GWh,13/ of which 88,000 were generated in thermal power stations (45 per cent) and the remainder (55 per cent) in hydropower stations. The percentage of hydroelectric power generated in the various countries varies a great deal from the regional average. In three countries (Cuba, Guyana, and Trinidad and Tobago), for example, thermal power stations accounted for almost all the energy generated, whereas in four others hydroelectricity was responsible for three-quarters or more of the electrical energy generated: Bolivia (88 per cent), Brazil (88 per cent) Costa Rica (81 per cent) and Paraguay (77 per cent). Table 7 shows how these figures have varied over the last fifteen years.

Of the total generated, some 19,000 GWh (10 per cent) were produced by self-suppliers in their own thermal power stations. This figure includes the production of oil companies in their refineries and oil fields, as well as that of a large number of establishments which, because of the nature of their industrial processes, can generate electrical energy at very low costs without increasing consumption of commercial fuels considerably as a result. These industries, whose installed capacity is estimated at between 2,000,000 and 2,500,000 kW, have no need to link up with the public service.

A large percentage of the thermal capacity of self-suppliers is kept as a reserve to be used only in cases of emergy, judging from the extremely low average annual utilization of these power stations (2,640 hours).14/ The output of self-suppliers will diminish in relative terms as the public services extend their transmission range and improve the quality of the service provided. Thus, it is estimated that some 4,500,000 thermal kW could be taken up by the public service systems, or, in terms of energy, some 12,000 million kWh per year. The economic advantages of this are evident: greater use of hydroelectricity, improved efficiency of thermal generation, and greater use of installed capacity.

13/ 1 GWh = 1, ,000 kWh.

14/ The average utilization of hydroelectric power stations by these self-suppliers is, 4,590 hours per year.

/Table 7

Table 7

LATIN AMERICA: GROWTH OF GENERATION OF ELECTRICAL ENERGY, 1958-1973

(GWH)

Country	1958 Public utility Hydro	1958 Public utility Thermal	1958 Public utility Total	1958 Country total Hydro	1958 Country total Thermal	1958 Country total Total	1967 Public utility Hydro	1967 Public utility Thermal	1967 Public utility Total	1967 Country total Hydro	1967 Country total Thermal	1967 Country total Total	1973a/ Public utility Hydro	1973a/ Public utility Thermal	1973a/ Public utility Total	1973a/ Country total Hydro	1973a/ Country total Thermal	1973a/ Country total Total
Argentine	665	6 710	7 375	665	8 754	9 419	1 188	11 191	12 379	1 260	15 447	16 707	2 853	18 833	21 686	2 900	23 800	26 700
Bolivia	238	17	255	332	112	444	412	21	433	512	83	595	570	80	650	780	110	890
Brazil	16 489	1 808	18 297	17 404	2 281	19 765	27 442	3 833	31 275	29 189	5 049	34 238	56 800	5 500	62 300	57 900	7 900	65 800
Chile	1 897	157	2 054	2 661	1 485	4 146	3 456	810	4 266	4 255	2 636	6 891	4 200	1 800	6 000	5 280	3 120	8 400
Colombia	1 930	520	2 450	2 030	1 020	3 050	3 850	1 697	5 547	4 650	2 017	6 667	7 240	2 640	9 880	7 800	3 800	11 600
Costa Rica	274	69	337	291	74	365	674	28	702	692	60	752	1 338	270	1 608	1 360	320	1 680
Cuba	-	1 867	1 867	-	2 588	2 588	-	3 050	3 050	-	4 000	4 000	-	4 900	4 900	-	5 700	5 700
Ecuador	134	126	260	159	165	324	330	320	650	360	400	760	440	710	1 150	470	930	1 400
El Salvador	203	3	206	203	10	213	426	65	491	426	90	516	479	490	969	480	520	1 000
Guatemala	106	72	178	106	122	228	146	338	484	158	373	531	296	529	825	300	680	980
Guyana	-	40	40	-	67	67	-	95	95	-	230	230	-	185	185	-	360	360
Haiti	-	47	47	-	90	90	-	75	75	-	115	115	110	10	120	110	60	170
Honduras	11	28	39	11	69	80	152	47	199	154	78	232	408	49	457	410	70	480
Jamaica	85	123	208	85	343	428	150	450	600	150	800	950	140	1 095	1 235	140	2 000	2 140
Mexico	4 156	3 250	7 406	4 296	4 761	9 057	10 440	6 989	17 429	11 206	9 720	20 926	17 000	17 856	34 856	17 250	21 410	38 660
Nicaragua	3	68	71	33	107	140	172	138	310	177	220	397	343	423	766	380	490	870
Panama	14	158	172	246	196	442	52	428	480	362	789	1 151	100	1 243	1 343	100	1 350	1 450
Paraguay	-	66	66	-	81	81	-	116	116	-	125	125	300	10	310	300	90	390
Peru	630	263	893	1 399	613	2 011	2 016	232	2 248	3 166	1 577	4 743	3 850	350	4 200	5 270	1 870	7 140
Dominican Republic	-	225	225	-	284	284	60	530	590	60	660	720	60	1 201	1 261	60	1 260	1 320
Trinidad and Tobago	-	186	186	-	383	333	-	731	731	-	1 035	1 035	-	1 090	1 090	-	1 340	1 340
Uruguay	760	476	1 236	760	476	1 23[illegible]	1 319	585	1 904	1 319	585	1 904	1 560	900	2 460	1 560	900	2 460
Venezuela	138	2 112	2 250	138	3 653	3 791	1 200	5 500	6 700	1 300	7 300	9 200	6 250	7 010	13 260	6 400	9 400	15 800
Latin America	27 733	18 385	46 118	30 899	27 734	58 633	53 485	37 269	90 754	59 336	53 989	113 385	104 337	67 174	171 511	109 250	87 480	196 730

Source: ECLA, on the basis of official data.

a/ Provisional figures.

/Data available

Data available on physical efficiency in the use of fuels in thermal power stations in the region show a variety of situations among countries. In the public service systems of 8 of them the average input of fuel in 1970 was 3,245 kcal/kWh (see table 8),15/ whereas the latest comparable figures from the European Economic Community and the United States are in the region of 2,400 and 2,600 kcal/kWh respectively. The coefficients of thermal efficiency in Argentina, Mexico and Venezuela are of special relevance for the regional average, since these three countries produce approximately two-thirds of the thermal electricity generated in Latin America. The biggest units in the region (300,000 KW), operating on full load, attain efficiencies of approximately 2,200 kcal/kWh, which are appreciably better than the average indicated above.

Given the characteristics of the networks of the region, a rapid reduction in average consumption to some 2,800 kcal/kWh,16/ in public utility generation using fuel and diesel oil, seems feasible. Savings on both these fuels would amount to some 150 million dollars per year at present prices. In the last three years some networks have installed generating units using gas turbines, several of which use oil products. Although their objective is to operate at the peak hours of demand, their high unit consumption (4,000 kcal/kWh) is unfavourable from the above point of view.

4. Consumption and losses

The percentage distribution of energy generated by public utilities in 1973 and changes in this distribution over the last fifteen years are shown in table 9. The trend has been towards more economical operation of the electricity industry, and improvement in this direction has been marked in recent times.

15/ Efficiency of 26.5 per cent.

16/ Efficiency of 30.7 per cent.

Table 8

LATIN AMERICA: EFFICIENCIES OF THERMAL POWER STATIONS IN SELECTED COUNTRIES, 1970

Country	Enterprise	Generation (millions of kWh)	Heat consumption (thousands of millions of kcals)	Efficiency (kcal/kWh)
Argentina	Total public utilities	15 372.2	45 177.8	2 947
Mexico	Total public utilities	11 224.9	36 261.0	3 230
Brazil	Total country	5 248.3	20 408.1	3 888
Venezuela	CADAFE	1 932.0	7 537.9	3 902
Venezuela	CALECA	2 419.4	7 306.6	3 020
Chile	Total country	3 243.5	9 830.4	3 030
Colombia	Total public utilities	1 916.0	7 670.2	4 003
Dominican Republic	CDE	831.0	2 590.2	3 117
Total		42 142.3	136 782.2	3 245

Source: ECLA, on the basis of official data.

/Table 9

Table 9

LATIN AMERICA: PERCENTAGE DISTRIBUTION OF CONSUMPTION OF ELECTRICAL ENERGY PROVIDED BY PUBLIC UTILITIES

Sector	1958	1970	1973
Industrial	29.9	36.6	44.0
Residential and commercial	38.0	33.1	28.7
Other	14.6	13.1	11.1
Losses	17.5	17.2	16.2
Total	100.0	100.0	100.0

Source: ECLA, on the basis of official data.

/On one

On one hand there has been an increase in electricity sales by the public utilities to industrial consumers, which in 1973 amounted to 44 per cent of the total output, with the advantages already noted. On the other hand, while the wastage in transmission and distribution continues to be high (16.2 per cent of output), it has been falling, particularly in the last three years. To the extent that power losses could be economically reduced, this wastage represents unwarranted additional investment in generating capacity and increases the financial difficulties of the enterprises. Moreover, since a large share of output is provided by thermal units, there has been a substantial rise in costs as a result of the prices of fuel. The wastage in excess of the averages customary in developed countries (economic optimum) is estimated at 6 per cent of total output, so that the costs for fuel burned without providing any benefit whatever are at present approximately 200 million dollars per year, and the needlessly larger capacity of the units requires a non-productive investment equivalent to some 1,500 million dollars.

5. Generating system expansion programmes

The programmes for the installation of power stations which it has been possible to compile, although incomplete in some cases, provide for the incorporation of some 50 million kW up to 1980 (see table 10).

The trend towards building electric power stations which do not use petroleum products as a primary source of energy is more marked than it was in the 1960s. It should be noted that most of these programmes were formulated at the end of the last decade and the beggining of the present one, i.e., a long time before the rapid rise in oil prices, but it is possible that the trend noted has at least some of its roots in the Teheran Agreements (February 1971). This would mean that the planners of the electrical sector is the region already foresaw at that time that there would be important changes in oil prices which would have an important effect on annual foreign exchange expenditure. The fruits of such foresight are now beginning to appear, since only about 9 per cent of the total generating capacity which will become operational between 1974 and 1980, will be oil-fired.

/Table 10

Table 10

LATIN AMERICA: POWER STATION INSTALLATION PROGRAMMES, 1974-1980 ON THE BASIS OF AVAILABLE DATA

(Thousands of kW)

	Hydro-electric	Thermal			Other		Subtotal	Total
		Oil products	Natural gas	Coal	Nuclear	Geo-thermic		
Installed capacity at 31 Dec 1973	25 400	18 600	4 700	1 300	-	75	24 675	50 075
Planned new capacity, 1 Jan 1974 to 31 Dec 1980	32 349	5 444	7 072	2 267	2 885	318	18 001	50 350
Argentina	6 680	-	1 200	565	920	-	2 685	9 365
Bolivia	66	-	12	-	-	-	12	78
Brazil	14 000	1 499	-	-	625	-	2 124	16 124
Chile	820	275	-	360	-	15	650	1 470
Colombia	1 654	410	-	382	-	-	792	2 446
Costa Rica	180	30	-	-	-	-	30	210
Cuba	...	...	-	-	-	-		
Ecuador	507	321	-	-	-	-	321	828
El Salvador	189	-	-	-	-	33	33	222
Guatemala	188	157	-	-	-	-	157	345
Guyana			-	-	-	-		
Haiti			-	-	-	-		
Honduras	340	24	-	-	-	-	24	364
Jamaica	-	68	-	-	-	-	68	68
Mexico	3 300	1 322	3 500	960	1 340	285	7 407	10 707
Nicaragua	-	200	-	-	-	-	200	200
Panama	470	238	-	-	-	-	238	708
Paraguay	90	40	-	-	-	-	40	130
Peru	1 965	216	-	-	-	-	216	2 181
Dominican Republic	40	269	-	-	-	-	269	309
Trinidad and Tobago	-	-	160	-	-	-	160	160
Uruguay	570	375	-	-	-	-	375	945
Venezuela	1 290	-	2 200	-	-	-	2 200	3 490
Withdrawals, 1 Jan 1974 to 31 Dec 1980	600	2 000					2 000	2 600
Installed capacity at 31 Dec 1980	57 149	22 044	11 772	3 567	2 885	393	40 676	97 825

Source: ECLA, on the basis of official data.

/The programmes

The programmes mentioned include 32.3 million kW of new capacity in hydroelectric power stations, 2.9 million kW in nuclear power stations, 0.3 million kW in geothermic power stations, 7.1 million kW in those using natural gas and 2.3 million kW in those using coal. The remainder, a little more than 5.4 million kW, corresponds to oil-fired steam turbine stations.

It is not expected that any further sizeable reduction can be made in the latter capacity by speeding up or introducing new hydroelectric projects to counter the effects of the new oil prices, owing to the long and relatively fixed period between the planning and operational stages of new power stations of this kind.

However, given the relative flexibility of steam turbines as regards the type of fuel used, there is reason to hope in the present circumstances that some oil importing countries will find it possible to replace oil later on with coal or natural gas,17/ depending on which type of fuel is available locally.

Subtracting the installed capacity which will become obsolete by the end of the 1970s (0.6 million hydropower kW and 2.0 million thermal kW) it is expected that by the end of the decade the total generating capacity of Latin America will be 57.1 million hydropowered kW, 22 million kW from oil-fired power stations, and 18.6 million from stations using other primary sources of energy (see table 10).

As regards the petroleum importing countries it should be stressed that a high proportion of hydroelectricity would avoid big foreign exchange costs (the main problem of the "crisis"), both because the foreign currency component of the initial investment is smaller than in the alternative thermal power stations, and because no further annual expenditure is required in respect of fuel.

17/ It should be borne in mind that a considerable proportion of the natural gas produced in the region is associated with the extraction of petroleum, with the result that the available volume exceeds domestic consumption requirements, and that to date a large proportion of the output is flared off without being put to productive use. The laying of a pipeline to transport the gas may now be justified, whereas this was not possible before because of the low price of oil.

/Together with

Together with the extensive programmes for the construction of hydroelectric power stations, mention should be made of the advances planned in the linking up of systems through successive interconnexions which would help in the gradual buildings up of electrical networks offering wide territorial coverage by 1980.18/

C. THE INCREASE IN GENERATING COSTS

The effect of the rise in oil prices on consumers of electrical energy varies widely depending on the supply characteristics of the electrical network. For this reason, each case must be studied separately. In this paper, only a very general view of the problem is given.

There are countries where the generation of electricity is predominantly thermal (using hydrocarbons). Such is the case in Cuba, Guyana, Trinidad and Tobago, the Dominican Republic, Panama, Argentina and Guatemala, where the share of thermal power stations varies from 100 to 68 per cent (1973). In these countries the impact of the higher oil prices will be great, except in the cases of Trinidad and Tobago and Argentina, where the use of natural gas obtained in the course of the extraction of locally-produced petroleum is predominant: the former is an oil exporting country, while the second is almost self-sufficient, and also uses locally-produced coal.

There are other countries where the production of hydroelectricity is predominant and as a result the impact is reduced, because of the small volume of thermal generation. This is so in Costa Rica, Brazil, Bolivia (an oil-exporting country), Honduras, Peru, Colombia, and Paraguay, where the share of thermal electricity varies between 9 and 29 per cent.

18/ Those countries with networks operating on different generation frequencies (Brazil, Mexico, Venezuela) first had to seek a solution to this serious obstacle to integration. Practically all the countries now have uniform frequencies, except Mexico and Guyana, where every effort is being made to standardize them.

/In those

In those countries which fall between the two extremes mentioned, the increase in oil prices will considerably affect the prices of electrical energy, although less severely than in those of the first group, and situations will vary from country to country (see table 7).

The strongest impact will be felt by the small electrical networks which depend on diesel power stations supplying sparsely populated isolated centres (many of them rural), and by self-suppliers with small-capacity plants.

Large- and medium-sized networks usually depend on a combination of hydroelectric power stations and steam thermal stations which can use fuels other than oil (coal, natural gas).

In order to examine the increase in the price of electrical energy generated in diesel and steam stations as a result of the increase in the prices in diesel and steam stations as a result of the increase in the prices of fuel, it is first of all necessary to establish the representative costs of diesel oil and fuel oil in January 1973 and as an average for the first half of 1974 for electricity companies in Latin American countries which import liquid hydrocarbons.

For this purpose, the prices of Saudi Arabian "light fuel-oil" and "53/57 diesel oil" FOB Ras Tanura were used.19/ Freight costs, insurance, and marketing costs and profits were then added to these prices.20/ Taxes were not taken into account because in many Latin American countries fuel for the generation of electricity is tax free.

19/ Petroleum Press Service (March 1973 and May 1974).

20/ The results, in dollars/barrel, are as follows:

	January-February 1973	March-April 1974
Fuel oil (FOB)	0.95	3.91
Freight and marketing	1.70	1.70
Profits (15 per cent)	0.40	0.84
Total	3.05	6.45
Diesel oil (FOB)	3.65	11.84
Freight and marketing	1.70	1.70
Profits (15 per cent)	0.80	2.03
Total	6.15	15.57

/1. Generating

1. Generating costs in diesel power stations

Table 11 and 12 show the capacity of the diesel electrical generators considered, together with a breakdown of the cost per kWh assuming a production of 2,000 kWh/kW and 3,500 kWh/kW respectively.21/ 22/ The rate of interest used was 10 per cent per year, and the useful life of the plant was estimated at 15 years.

Depending on the operating hypotheses considered, the increase in generating costs in such power stations may vary from 35 to 85 per cent.23/

It is also noted that the increased energy costs go up with the size of the unit and with the plant factor: i.e., as is logical in proportion as the influence of the fuel costs on the cost per kWh increases (see figure I). There are many scattered towns in Latin America, particularly in mountainous areas, which depend entirely on a diesel power station for their supply of electrical energy, as do some rural areas and small mining centres. Since in the majority of cases the power stations are made up of generators of 500 kW capacity or more, the increases in the cost of diesel-powered generation vary in practice between 50 and 85 per cent.

2. Generating costs in steam power stations

Tables 13, 14 and 15 give various capacities of oil-fired steam-powered generators, together with the fixed and variable components of the cost per kWh based on production of 3,000, 4,380 and 6,500 kWh/kW respectively.24/ The rate of interest used was 10 per cent and the useful life considered for purposes of depreciation was 25 years.

21/ In Latin America the use of power stations of this type usually ranges between these two figures.

22/ The calculations were based on the figures used in the document Small-Scale Power Generation (United Nations publication, Sales No. E.67.II.B.7).

23/ Similar tables were also prepared using a rate of interest of 12 per cent. The result is that the corresponding costs per kWh (january 1973 and April 1974) rise by approximately 2 mills, and the relative increase varies from 34 to 81 per cent.

24/ Calculations are based on the graphs in Small-Scale Power Generation, op. cit. and IAEA, Bulletin 1/2, 1974.

/Table 11

Table 11

GENERATING COSTS IN DIESEL POWER STATIONS

Production: 2 000 kWh/kW; PF = 0.23

(Interest rate: 10%; costs in 1974 US$)

Net capacity per unit (MW)	100	500	1 000	2 000	3 000	4 000
Total cost per installed kW (US$)	330	260	220	210	215	250
Fixed costs (mills/kWh)	35.4	22.7	19.5	17.6	17.7	19.5
Variable costs with diesel oil at US$ 6.15/barrel	21.0	15.0	14.0	13.0	12.0	12.0
Total cost per kWh, January 1973 (mills)	56.4	37.7	33.5	30.6	29.7	31.5
Variable costs with diesel oil at US$ 15.57/barrel (mills/kWh)	41.0	34.0	32.0	31.0	30.0	29.0
Total cost per kWh, April 1974 (mills)	76.4	56.7	51.5	48.6	47.7	48.5
Increase (percentage)	35	50	53	59	61	54

Source: ECLA, on the basis of Small Scale Power Generation, (United Nations publication, Sales N° E.67.II.B.7).

/Table 12

Table 12

GENERATING COSTS IN DIESEL POWER STATIONS

Production: 3 500 kWh/kW; PF = 0.40

(Interest rate: 10%; costs in 1974 US$)

Net capacity per unit (kW)	100	500	1 000	2 000	3 000	4 000
Total cost per installed kW (US$)	330	260	220	210	215	250
Fixed costs (mills/kWh)	20.8	12.6	11.9	9.0	9.2	10.7
Variable costs with diesel oil at US$ 6.15/barrel (mills/kWh)	21.0	15.0	14.0	13.0	12.0	12.0
Total cost per kWh, January 1973 (mills)	41.8	27.6	25.9	22.0	21.2	22.7
Variables costs with diesel oil at US$ 15.57/barrel (mills/kWh)	41.0	34.0	32.0	31.0	30.0	29.0
Total cost per kWh, April 1974 (mills)	61.8	46.6	43.9	40.0	39.2	39.7
Increase (percentage)	48	68	70	82	85	75

Source: ECLA, on the basis of Small Scale Power Generation, op.cit.

/Table 13

Table 13

GENERATING COSTS IN OIL-FIRED STEAM POWER STATIONS

Production: 3 000 kWh/kW; PF = 0.34

(Interest rate: 10%; costs in 1974 US$)

Net capacity per unit (MW)	50	100	150	200	250	300	350	400
Total cost per installed kW (US$)	382	330	301	278	254	241	225	219
Fixed costs (mills/kWh)	20.0	14.7	13.3	12.3	11.2	10.6	10.0	9.7
Variable costs with fuel oil at US$ 3.05/barrel (mills/kWh)	5.8	5.2	5.0	5.0	4.9	4.9	4.8	4.8
Total cost per kWh, January 1973 (mills)	25.8	19.9	18.3	17.3	16.1	15.5	14.8	14.5
Variable costs with fuel oil at US$ 6.45/barrel (mills/kWh)	14.4	13.5	13.0	12.7	12.6	12.5	12.4	12.3
Total cost per kWh, April 1974 (mills)	34.4	28.2	26.3	25.0	23.8	2[illegible].1	22.4	22.0
Increase (percentage)	33	42	44	45	48	49	51	52

Source: ECLA, on the basis of Small Scale Power Generation, op.cit., and IAEA Bulletin 1/2 - 1974.

/Table 14

Table 14

GENERATING COSTS IN OIL-FIRED STEAM POWER STATIONS

Production: 4 380 kWh/kW; PF = 0.5

(Interest rate: 10%; costs in 1974 US$)

Net capacity per unit (MW)	50	100	150	200	250	300	350	400
Total cost per installed kW (US$)	382	330	301	278	254	241	225	219
Fixed costs (mills/kWh)	12.4	10.2	9.1	8.3	7.7	7.3	6.7	6.5
Variable costs with fuel oil at US$ 3.05/barrel (mills/kWh)	5.8	5.2	5.0	5.0	4.9	4.9	4.8	4.8
Total cost per kWh, January 1973 (mills)	18.2	15.4	14.1	13.3	12.6	12.2	11.5	11.3
Variable costs with fuel oil at US$6.45/barrel (mills/kWh)	14.4	13.5	13.0	12.7	12.6	12.5	12.4	12.3
Total cost per kWh, April 1974 (mills)	26.8	23.7	22.1	21.0	20.3	19.8	19.1	18.8
Increase (percentage)	47	54	57	58	61	62	65	66

Source: Same as table 13.

/Table 15

Table 15

GENERATING COSTS IN OIL-FIRED STEAM POWER STATIONS

Production: 6 500 kWh/kW; PF = 0.74

(Interest rate: 10%; costs in 1974 US$)

Net capacity per unit (MW)	50	100	150	200	250	300	350	400
Cost per installed kW (US$)	382	330	301	278	254	241	225	219
Fixed costs (mills/kWh)	8.4	6.9	6.3	5.6	5.1	4.8	4.4	4.2
Variable costs with fuel oil at US$3.05/barrel (mills/kWh)	5.8	5.2	5.0	5.0	4.9	4.9	4.8	4.8
Total cost per kWh, January 1973 (mills)	14.2	12.1	11.3	10.6	10.0	9.7	9.2	9.0
Variable costs with fuel oil at US$6.45/barrel (mills/kWh)	14.4	13.5	13.0	12.7	12.6	12.5	12.4	12.3
Total cost per kWh, April 1974 (mills)	22.8	20.4	19.3	18.3	17.7	17.3	16.8	16.5
Increase (percentage)	61	69	71	73	77	78	82	83

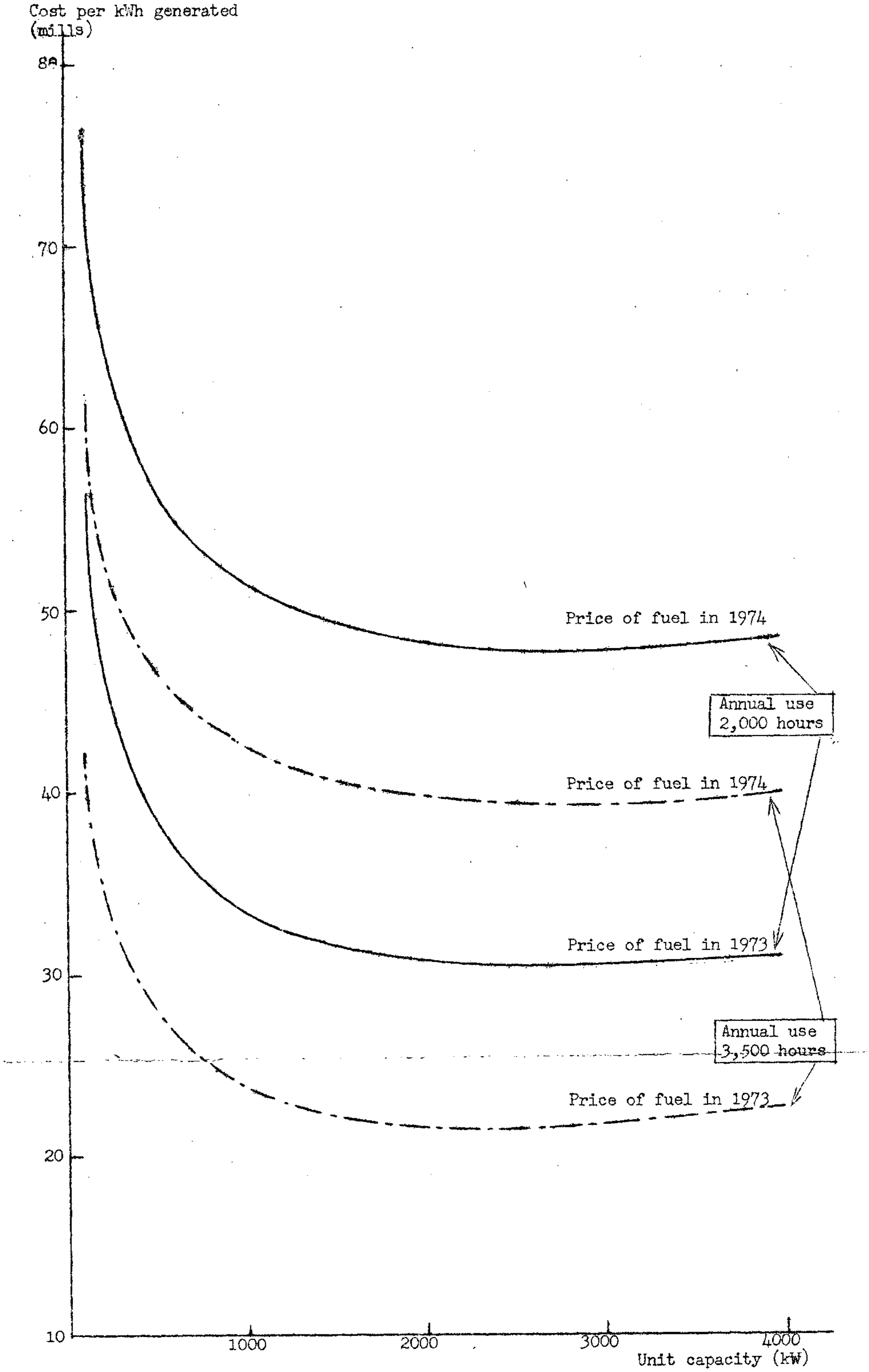
Source: Same as table 13.

/Figure I

Figure I

GENERATING COST IN DIESEL POWER STATIONS

Natural scale



/Examination of

Examination of these tables shows that the increase in the cost per kWh varies between 33 and 83 per cent, rising with the size of the unit and with the increase in the plant factor.25/ (See figure II.) In medium-sized and large systems in Latin America, supplied solely or mainly by thermal steam power stations, the increases in cost will exceed 40 per cent. Among such systems are those which supply the cities of Santo Domingo, Panama, Havana, Georgetown and Guatemala.

Latin America also has gas turbine powered units. However, the increase in generating costs of these is not dealt with here, because they are mainly found in oil-producing areas, or are fed by natural gas, so that they are not affected by the changes in imported oil prices which are being examined. Moreover, those public utility systems with gas turbine-powered generators usually use them to cover peak demand, and their weighting in the average cost of the corresponding kWh is therefore low. Nonetheless it should be borne in mind that since the unit consumption of fuel is high (around 4,000 kcal/kWh), cases where such units use imported oil products should be reappraised.

3. Increasing the price of electricity to consumers and its effect on consumption

In public utilities, the prices of energy to the consumer reflect not only generating costs but also distribution costs (which do not vary with the price of fuel). It is generally considered that in a country as a whole the investments in distribution networks are as high as those in generation and transmission.

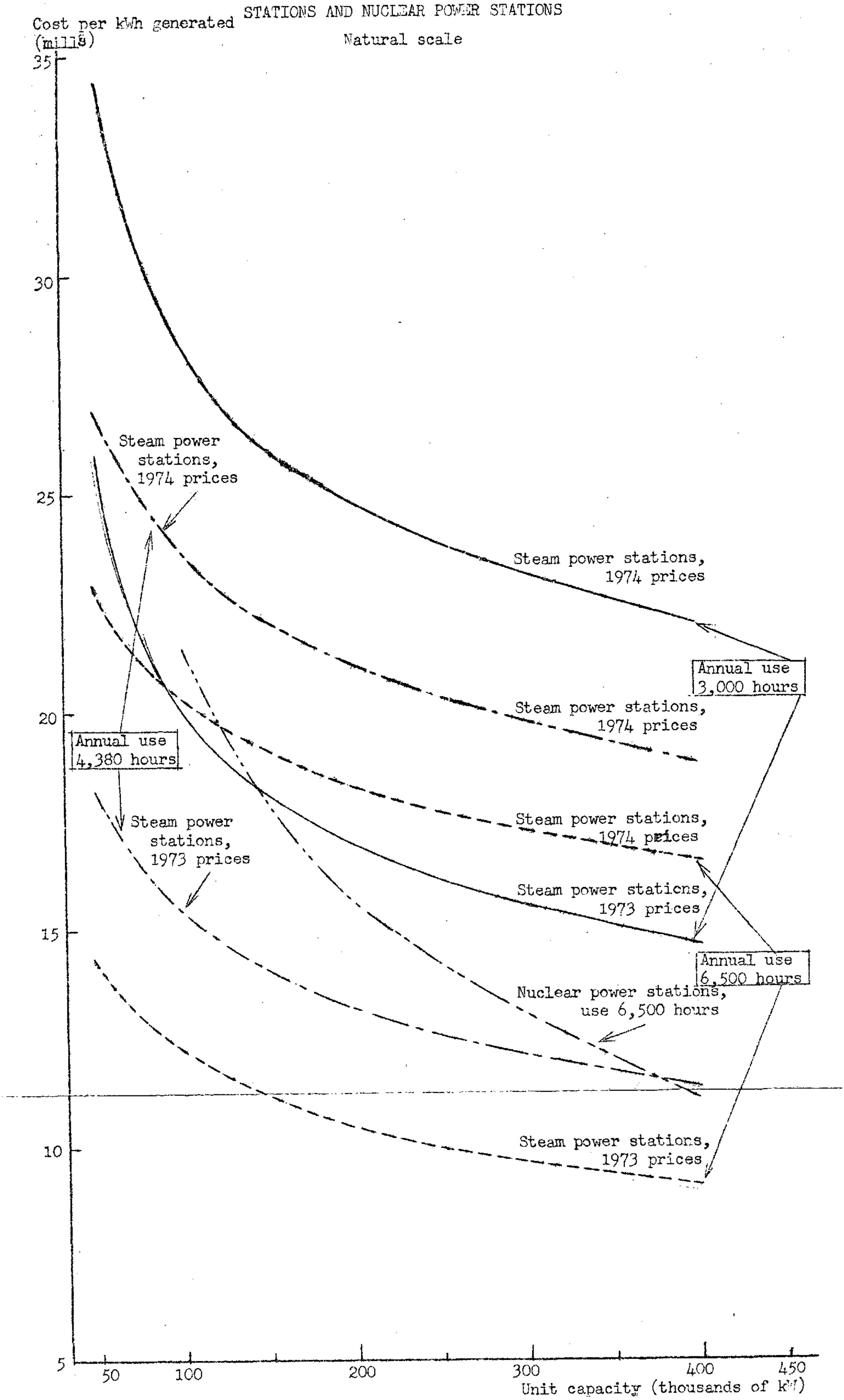
25/ Similar tables have been prepared using a rate of interest of 12 per cent. The result is that the corresponding cost per kWh rises 1.0-1.5 mills for prices prevailing in January 1973 and 1.0-2.0 mills for those prevailing in 1974, and the relative increase is between 23 and 50 per cent.

/Figure II

Figure II

GENERATING COSTS IN OIL-FUEL STEAM POWER STATIONS AND NUCLEAR POWER STATIONS

Natural scale



In Latin America, it can be said that on average distribution networks do not reach levels of efficiency and reliability comparable with those of power stations, and distribution costs ought to be lower than generating costs. For this reason, one probably would not be far wrong in supposing that on average consumer tariffs are likely to rise by approximately 60 per cent of the percentage increase in generating costs in small networks fed by diesel power stations, and by approximately 50 per cent of the corresponding increase in generating costs in medium-sized and large networks fed mainly by steam power stations.

Moreover, electricity rates are, of course, different for different types of consumers, those for domestic and commercial use being generally higher than those for industrial use. Currently, this reflects the distribution of the fixed costs of electricity companies, since commercial and domestic users are those most responsible for demand peaks and should therefore bear a bigger share of the proportional costs of the installed capacity.

Since the increase in fuel prices affects the variable costs, which are shared more or less equally between the various types of consumers, it can be said that proportionally this increase will have a greater incidence on the industrial rates.

The question now arises: to what extent will the increase in electricity rates affect consumption in general and the cost of industrial production? Past experience indicates that generally the increase in oil prices will not cause an appreciable drop in the consumption of electrical energy in Latin America in the short term. In the medium term, and even more so in the long term, however, an increase in the consumption of electrical energy is to be expected, as pointed out in the introduction, as a result of the increase in the prices of liquid hydrocarbons and the consequent greater use of other sources of energy which must first be converted into electricity (hydropower, nuclear and geothermic energy, etc.). In order to examine this resertion in more detail, the following aspects should be noted:

/(a) More

(a) More than 55 per cent of the electrical energy generated in Latin America is produced with primary sources of energy other than oil (mainly hydropower), and this trend will be accentuated since the plans at present being implemented to expand the generation of electrical energy (1974-1980) place greater emphasis on such sources.

(b) In the region, the industrial and mining sectors together account for almost 50 per cent of the total consumption of electricity (see table 9) and on average electrical energy represents less than 4 per cent of their production costs.26/ It does not, therefore, seem likely that industry in general is going to reduce its rate of expansion simply because a vital input, but one having only a limited incidence on costs, rises in price by 30-40 per cent at the worst. Furthermore, it is logical to suppose that those activities which depend most on electrical energy are located in areas where the corresponding rates are low and are therefore supplied from medium-sized or large electrical networks, where the production of hydroelectricity is probably considerable.

(c) As regards domestic use, no significant cutback in consumption is expected for the following reasons: (i) it is likely that on average the rise in rates will be less than 30 per cent; (ii) the incidence of the amount of the electricity bill for minimum lighting needs on the poorer households does not represent more than 2.5 to 3 per cent of income; (iii) the consumption-price elasticity of electricity in this sector appears to be low. In Latin America, the increase in per capita income and improved income distribution are reflected to a considerable extent in the purchase of durable household goods, many of which use electricity (refrigerators, mixers, radios, televisions, etc.), but in view of their cost the cost of the electricity they consume is of minor importance.

26/ In industrial sector proper electrical energy costs are estimated at less than 2.5 per cent of total production costs. In Mexico, the industrial products where the cost of electrical energy has the greatest incidence are cement, aluminium, iron and steel, glass, pulp and paper, the incidence being between 5 and 9 per cent and the general average less than 3 per cent (see Comisión de Tarifas de Electricidad y Gas de México, Breve análisis sectorial sobre energía eléctrica y gas, 1962-1972).

(d) In some Latin American cities, because of defective pricing policies for electricity and fuels excessive use is made of electricity for heating (cookers, stoves, water heaters, etc.). The rise in the price of oil will undoubtedly prompt the corresponding authorities to revise these policies, however, so that the prices and rates throughout the energy sector will be more representative of the respective costs.27/ It is possible, therefore, that in certain supply systems some electrical appliances used for heating may be replaced by others using kerosene or liquefied gas. The significance of such changes, both in national totals and in the region as a whole, is not expected to be very considerable, however.

D. POSSIBLE LINES OF ACTION

Mention has already been made of the fact that the problems caused by the new level of oil prices in the electrical energy sector vary widely from one country to another, and that in the development of electricity systems each case ought to be studied individually, since no general rule can be applied because of the innumerable and highly varied factors to be taken into consideration.

However, some lines of action may be worthy of consideration in a number of countries of the region.

1. Substitution of oil products and preference for the use of local energy resources

Two trends observed in recent years in Latin America in the generation of electrical energy will become further accentuated:

27/ In Latin America some 3,200 kcals are needed on average to produce one kWh; adding transmission and other losses, this figure probably rises above 3,600 kcals. On retransformation to caloric energy, one kWh only yields 860 kcals. On this basis, more than three-quarters of the fuel used in thermal power stations would be wasted. This is proof of the generally uneconomic nature of the production of heat from electrical energy generated in thermal stations, particularly with oil products. Quite apart from the low efficiency indicated, the investments required by the electrical network are sizeable, and a large part of them must be paid in foreign currency.

/-reduction

- reduction of the use of oil products;
- allocation of higher priority to the use of local energy resources.

This approach seems quite logical when it is considered that the useful life of thermal power stations is between 15 and 30 years, and this is too long a period, at present, to forecast the behaviour of international markets with regard to prices and guaranteed supplies of liquid hydrocarbons.

(a) Substitution of fuels

Oil-importing countries which have oil-fired steam power stations, but which also produce coal and/or natural gas (such as Argentina, Brazil, Chile and Mexico) should give consideration to the possibility of converting such power stations to use coal or natural gas, depending on the availability of these resources. Although this may be economically feasible, however, it is not usually a short-term possibility, since both aspects - the increase in the production of the coal mines, and the conversion of the power stations to use this fuel - will require time and investments. It is probable that the conversion costs, alone for modifying such units to use coal will be in the region of 50-70 dollars per installed kW. Similarly, the use of natural gas will require heavy investment and a long period of implementation, mainly in the construction of the necessary gas lines. For this reason it is unlikely that there will be any significant savings in fuel oil, in this respect, in the remainder of the 1970s.

(b) The use of hydropower

The development of hydroelectric resources will probably be stepped up in the majority of the countries of the region - even the oil-producing ones - because it enables those which are not completely self-sufficient to reduce imports, and those which are self-sufficient to increase their exports.

/Hydroelectric projects

Hydroelectric projects vary greatly. Each one has its own characteristics, since it must fit the natural conditions (topography, geology, hydrology, etc.), the conditions of the system of which it is to form part (the demand curve, type and characteristics of other existing or planned power stations, etc.), other complementary uses of water, (irrigation, navigation, etc.), the possibilities of grid linkups, the general economic conditions of the country, etc.. Thus, these power stations differ greatly not only in their physical characteristics but also in their role in the supply of electricity. The availability or otherwise of a dam and its functioning (daily, seasonal and year-to-year flow regulation, etc.), play a very important part in defining the actual capacity and output of the power station, the thermoelectric support needed, the station's location and operational characteristics in the context of the demand curve, etc. By way of illustration, table 16 gives the estimated cost per hydroelectric kWh as a function of three parametres of special importance: the cost per installed kW, the annual utilization factor of the power station, and the annual interest on the capital (10 per cent). The examples chosen cover a range of normal situations in Latin America. Comparing the costs per kWh of this table with those which appear in tables 13, 14 and 15, it can be seen that the competitiveness of the hydroelectric power stations compared with thermal or oil-fired ones has improved considerably. Thus, for example, taking an annual plant factor of 0.5, thermal generation in 100,000 kW units would cost 15.4 mills/kWh with fuel oil at US$ 3.05/barrel. Under these circumstances, hydroelectric power stations would be competitive with investments equal to or lower than US$ 500/kW. If the same thermal unit were operated with fuel oil at US$ 6.45/barrel, however, the cost per kWh would be 23.7 mills, and hydroelectric power stations would be competitive with investments equal or lower than US$ 780/kW. The advantage is even greater if interest rates on capital are lower (8 per cent). For higher plant factors the economic competitiveness of the hydroelectric power stations is even greater. In this respect, measures to increase the

/Table 16

Table 16

COST PER KWH IN HYDRO-ELECTRIC POWER STATIONS

Total cost per installed kWh (US$) (including transmission lines)	300	400	500	600	700
Total annual charges at 12.63%a/ (US$)	37.9	50.5	63.2	75.8	88.4
Total annual charges per kWh (mills) with:b/					
3 000 kWh/kW	13.4	17.8	22.3	26.8	31.3
4 400 kWh/kW	9.1	12.2	15.2	18.2	21.3
6 500 kWh/kW	6.1	8.3	10.3	12.4	14.4
7 500 kWh/kW	5.1	6.7	8.4	10.1	11.8

Source: United Nations, Small Scale Power Generation, op.cit.

a/ Includes 10% interest on capital, depreciation by the sinking fund method, useful life of plant 80 and 35 years, operating and maintenance costs of 1.75%, and administration costs of 0.75%. Weighting factors 2/3 for equipment with a useful life of 80 years, and 1/3 for the remainder.

b/ Includes an additional 6% for transmission line losses.

/volume of

volume of water available to power stations by harnessing or diverting streams not originally used acquires greater importance. Projects of this kind have the enormous advantage of not being subject to fixed delivery times for equipment, which are now very long, nor do they entail foreign currency expenditure.

In many systems where hydroelectric power stations and thermal ones complement each other, it is possible to show the advantages of increasing the installed capacity of the former, although their base capacity may remain unaltered or may be increased in a lesser degree. The idea is that the marginal capacity and power thus gained (available only during some months of the year) justify the corresponding investment owing to the savings in fuel in the thermal power stations in the network. Thus, plans may be made to increase the capacity of some dams (marginal gain of energy) and the installed capacity of the power stations (marginal gain of energy and power).28/

Such extension plans, the civil engineering work involved, and the time required for delivery of equipment take up a number of years, however, so there would not be any significant oil savings during the reaminder of this decade.

(c) Nuclear energy

The prospects for the use of nuclear energy in Latin America are much brighter and much closer than was foreseen at the end of the past decade.

Two features are very important in the economics of nuclear power stations: (i) the cost per installed kW falls very rapidly with increase in the size of units; and (ii) they must operate at a high utilization factor (around 0.8).

28/ In other world, in many cases it might be justifiable to reduce the hydrological safety factor in designing the hydroelectric power stations in the network (provided there was adequate thermal backing to ensure supplies at "critical periods") because of the savings in fuel involved.

/Tables 17

Tables 17 and 18 provide an estimate of the amount of the initial investment and the cost per kW generated for nuclear power stations of different capacities. The calculations were based on an interest rate of 10 per cent per year (as in previous cases), a useful life of 30 years, and annual use factors of 6,500 kWh/kW and 7,000 kWh/kW respectively.

The figures confirm that the cost per installed kW in these power stations varies considerably with the capacity of the unit, from 980 dollars for 100,000 kW, to 510 dollars for 400,000 kW the corresponding figures for oil-fired steam power stations are 330 and 219 dollars.

With oil prices of less than 2.50 dollars/barrel (FOB Persian Gulf), nuclear power stations were more economical than traditional thermal ones only when they had a capacity of 500,000 kW or more, and such high capacity and high utilization requirements meant that the choice of using them in Latin America was open only to the biggest systems in Argentina, Brazil and Mexico (systems of 3 million or more kW).29/

At the present oil prices, however, nuclear stations are competitive with conventional thermal ones in smaller sizes (in the region of 150,000-200,000 kW) as may be seen from tables 17 and 18 (see also figure II).

This fact opens up new possibilities for the construction of such power stations in the smaller systems of the countries mentioned and in other countries such as Chile, Peru, Cuba, Jamaica and Uruguay. However, it should be stressed that nuclear power stations require high initial investments, mainly in foreign currency, as well as highly qualified staff for their installation and operation, and both of these are in short supply in the region.

29/ Reasons of reliability and economy make it advisable that the biggest units in a network should not provide more than 10-15 per cent of maximum demand.

Table 17

Table 17

GENERATING COSTS IN NUCLEAR POWER STATIONS

Production: 6 500 kWh/kW; PF = 0.74

(Interest rate: 10%)

Net capacity per unit (MW)	100	150	200	250	300	350	400
Total cost per installed kW (US$)	980	810	710	640	580	540	510
Cost of fixed capital and overheads (mills/kWh)	17.28	14.40	12.52	11.29	10.17	9.37	8.83
Costs of fuel, operating and maintenance (mills/kWh)	4.11	3.48	3.13	2.91	2.75	2.63	2.51
Total cost per kWh (mills)	21.39	17.88	15.65	14.20	12.92	12.00	11.34

Source: Same as table 13.

/Table 18

Table 18

GENERATING COSTS IN NUCLEAR POWER STATIONS

Production: 7 000 kWh/kW; PF = 0.80

(Interest rate: 10%)

Net capacity per unit (MW)	100	150	200	250	300	350	400
Total cost per installed kW (US$)	980	810	710	640	580	540	510
Cost of fixed capital and overheads (mills/kWh)	16.04	13.26	11.60	10.44	9.47	8.73	8.21
Costs of fuel, operation and maintenance (mills/kWh)	4.11	3.48	3.13	2.91	2.75	2.63	2.51
Total cost per kWh	20.15	16.74	14.73	13.35	12.22	11.36	10.72

Source: Same as table 13.

/For this

For this and other reasons the availability of sources of hydroelectric power (and to a lesser extent natural gas and coal) may postpone the use of nuclear energy to a greater or lesser degree, depending on the circumstances. It should be emphasized, however, that the characteristics of nuclear and hydroelectric power stations complement each other so well that they make possible more efficient use of the latter, since the nuclear power stations can provide the basic energy, while the hydroelectric stations with dams and a large installed capacity can cover the higher part of the demand curve, operating at low plant factors.

It should be noted that the hydroelectric and nuclear projects which will now be preferred in many cases to the corresponding thermal ones will require initial investments that are higher by 60-120 per cent, with consequent pressure on domestic and foreign sources of finance. At the same time, however, the major portion (60-80 per cent) of this investment in hydroelectric power stations will be in local currency, and it will have the favourable effect of providing more job opportunities during the construction stage (access roads, dams, spillways, canals, tunnels, etc.). In contrast, a large portion of the investment in nuclear stations must be made in foreign currency (approximately 60 per cent in the case of Atucha, for example).

A factor in favour of oil-fired thermal power stations is that they require shorter planning and construction periods because their engineering and electrical design, as well as the construction methods used, are relatively standard. Thus, while thermal stations may require 4-6 years in all, hydroelectric power stations (provided that reliable hydrological data is available) and nuclear plants may require 7-10 years. As a result, there will be pressure to accelerate the completion of studies and the implementation of expansion plans for electrical networks, and a larger number of qualified technicians will be required.

/2. Reduction

2. Reduction of transmission and distribution losses

Excessive wastage in distribution networks and transmission lines runs counter to the economic operation of any electrical system, but in those systems which make predominant use of oil-fired thermal generation, such wastage takes on alarming characteristics. The reduction of such wastage, which may be effected mainly by improving the design of the low tension network and the power factor of consumption (closed links, larger number and better location of distribution transformers, conductors of adequate cross-section, installation of condensers, tariffs which include a charge for reactive energy, etc.) will lead to great improvement in many systems, not only in the quality of service at peak hours, but also in savings of fuel. Good line maintenance and cleaning of insulation in areas of atmospheric pollution prevent considerable wastage through leakage. It was mentioned earlier that the public utilities of the whole region (with an average wastage of 16.2 per cent in 1973) could quite easily save 300 million dollars per year in this way, and it should be stressed that such savings could be achieved in a relatively short period and with modest investments. In Panama, the Dominican Republic, Haiti, Honduras and El Slavador there appears to be wide scope for action along these lines.

3. Integration of systems by interconnexion. Replacement of low-efficiency thermal plants

The integration of public utility electricity systems by domestic or international interconnexions should be considered a priority field for investment in Latin America. The advantages are well known, and some of them acquire special importance in view of the present prices of oil.

Since the generating capacity needed for a large integrated system is less than that required by several isolated networks. Moreover, it is possible to increase the utilization of the power stations with the higher levels of efficiency (the larger and more modern units) and thus reduce fuel consumption. In this respect, very careful programming of the operation and maintenance of the power

/stations is

stations is called for, so that each of them can be assigned the most advantageous relative position in the demand curve (economic optimization of the network), since the specific consumption of heat in each unit varies significantly with its design, size, state of maintenance and number of hours used per year. The integration of networks will also facilitate the construction of power stations which require large markets. This is the case, for example, with some hydroelectric projects which cannot be developed gradually and with nuclear power stations which are competitive provided the unit capacity is large.

Extensively integrated networks are better able to face emergency situations such as periods of drought which affect one area and not others, without recourse to thermal generation. Likewise, the integration of networks facilitates rural electrification and the replacement of small units (usually diesel) which supply small towns, as well as those operated by self-suppliers which usually have low plant factors and levels of thermal efficiency.

4. International grid networks

Where grid networks cross frontiers, they not only provide the advantages already noted, but also open up the extremely important possibility of using multinational resources. There are many such projects in Latin America, among which special mention may be made of the following in connexion with the increase in oil prices:

(a) The grid system linking Costa Rica, Panama and Nicaragua, which offers the possibility of using surplus hydroelectricity from the first country in the latter two, where power stations are predominantly thermal.

(b) The Rio Lindo and Cajon hydroelectric projects in Honduras, which would provide energy for export to neighbouring countries, especially Nicaragua, if the networks are linked up.

(c) The Salto Grande power station, a joint Argentina-Uruguay project on the Uruguay river, which will have an installed capacity of 1.6 million kW and will make it possible to link up the Rio Negro-

/Montevideo network

Montevideo network (installed capacity of approximately 500,000 kW, almost equally divided between hydroelectric and thermal generation) with the Buenos Aires system having a generating capacity of more than 3.1 million kW (2.6 million thermal, 0.32 million nuclear and 1.6 million hydroelectric).

(d) The hydroelectric station at Itaipú, a joint Brazilian-Paraguay project, which will provide an installed capacity of 10.7 million kW and will generate an average of 60×10^9 kWh per year (in 1972 the joint output of both countries totalled 57×10^9 kWh).

(e) Another multinational power station planned by Paraguay and Argentina on the Parana river at the Apipé falls (Mbaracayá), which is planned to have a capacity of 2.1 million kW.

All these projects will make it possible to make greater use of hydroelectric resources. There are also other multinational hydroelectric projects which are at a less advanced planning stage, but it is expected, in view of the present conditions, that these will be speeded up by using the experience gained in those mentioned above.