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THE EXPANSION OF THE ELECTRICITY SECTOR IN
LATIN AMERICA IN 1960-70

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NOTE BY THE SECRETARIAT

The secretariat has the honour to submit to the Governments members of the Commission a synopsis of the studies made on Latin America's electricity needs and the corresponding financial requirements. The matters outlined here are dealt with in greater detail in the documents prepared by the secretariat for the Latin American Electric Power Seminar which is to be held in Mexico from 31 July to 12 August 1961.

/THE EXPANSION

THE EXPANSION OF THE ELECTRICITY SECTOR IN LATIN AMERICA
IN 1960-70

In 1959 Latin America produced 61,000 million kWh with an installed capacity of 16 million kW, 42 per cent of which represented hydraulic capacity.

The estimated power requirements for 1970 are about 200,000 million kWh, and an installed capacity of some 44 million kW will be required to generate this amount of power. If the expansion programmes now in progress in Latin American countries are properly carried out, this amount of capacity will be available at the end of the decade. The predominance of hydro-electricity in these programmes, especially in the main producing countries, will reverse the proportion between hydraulic and thermal capacity, since there will be some 23 million kW of the former compared with 21 million kW of the latter.

In order to achieve this expansion, the Latin American countries will have to invest some 13,000 million dollars, which represents about 10 per cent of the total funds required for investment in conditions of normal and balance growth.

Nearly 40 per cent of the investment in the electricity sector will have to be spent abroad. This would absorb about 6 per cent of the foreign exchange that will be available according to forecasts of the capacity to import during the period in question.

1. The demand for electricity up to 1970

In 1959 Latin America consumed 51,000 million kWh, which represented a generating level of 61,300 million kWh. The difference represents transmission and distribution losses, which amounted to 17 per cent of the total power generated. Consequently per capita generation was 310 kWh and per capita consumption 250 kWh.

Projections of demand, taking account of the combined effect of a number of different factors, give a figure of the order of 175,000 million kWh of final consumption for 1970, which amounts to a per capita consumption of 660 kWh. In arriving at this total two different methods were used,
/namely, extrapolating

namely, extrapolating the trend for a representative base period, and relating electricity consumption to economic expansion and possible structural changes of the economy in the near future.

It may be assumed that one result of the expansion and modernization of electricity networks, with respect both to transmission and to primary and secondary distribution, will be to reduce the present excessive percentage power loss. It is considered that a reasonable goal would be the reduction of this loss by the end of the decade to an average value of some 13 per cent of the power generated.

The two values assumed for consumption and losses give an estimated generation of some 200,000 million kWh for 1970.

Extrapolation of the experience of the last decade - which can be regarded as a good representative average, since it includes both prosperous years and years of economic contraction - indicates that electricity generation in Latin America in 1970 should be between 2.6 and 3.75 times that for 1959, which, as stated above, amounted to 61,000 kWh. These values are at the 95 per cent confidence limits for 1959 according to the methods used. The multiplier corresponding to the trend is 3.2; if this value is applied, the annual generation at the end of the decade would be 196,000 million kWh, a figure very close to that represented by the electricity expansion plans of the Latin American countries.

It is interesting to compare the figures arrived at by extrapolation of recent experience with those obtained by indirect or secondary projection, that is, that based on the tempo of economic development and the rate of industrialization.

For this purpose, since results could be obtained by the second method only for the countries that have an index of industrial production, the figures for Argentina, Brazil, Chile, Mexico and Venezuela were added and then divided by 4/5, which corresponds to the proportion of the total installed capacity and generation for the region represented by these countries.

The figure thus obtained to meet consumption requirements in 1970 is 176,000 kWh; if transmission and distribution losses could be reduced to the desired level indicated above, that is, 4 percentage points below the

/present level

present level of 17 per cent, this consumption figure would require a generation of 202,000 million kWh, which is only 3 per cent more than that obtained by a simple extrapolation in time.

Thus it may be concluded that the results of the electricity programme correspond to an assumed average or standard growth rate of a 2 per cent annual increase in the per capita gross product and a 5 per cent annual increase in industrial production.

However, it should not be forgotten that these regional generalizations cover great differences between the various countries. Thus, the five countries that represent 80 per cent of the electricity industry in Latin America include the very different cases of Brazil, Mexico and Venezuela, on the one hand, which have had high rates of economic growth during the last decade, and Argentina and Chile on the other, which during the same period have had inadequate growth rates that are among the lowest in Latin America.

It is inevitable that any plan relating to the future reflects the situation at the moment of its conception. Thus it is natural that in the last two countries referred to, especially Argentina, the objectives selected for the basic programmes are comparatively modest.

Consequently, it is desirable that present plans should be revised and extended before 1965, especially if the economic development of these two countries during the next five years is better than expected.

2. Electricity capacity: present situation and future outlook

It is possible to estimate, from the generation envisaged for a given year, the capacity required to obtain that level of generation, assuming a specific level of utilization. Account also has to be taken of the fact that capacity must not only be sufficient to meet the total demand for power throughout the year, but because of the special nature of the electricity industry, which cannot accumulate stocks for future consumption, it must also ensure that it can meet maximum power demand. In other words, both the ordinates and the whole area of the load diagram establish limits to the generating capacity.

/Thus the

Thus the critical periods result from a shortage of power or energy. In a country where the generating capacity is wholly or predominantly thermal, only the first of these shortages is important. In a country where on the other hand capacity is wholly or predominantly hydraulic, with large storage plants, there is nearly always enough power to meet peak demand; it is the periods of prolonged drought that are critical for the producer and ultimately for the consumer as well.

At the end of 1959, the installed capacity of Latin America in the public utilities and industrial self-suppliers was some 16 million kW, of which 12 million kW represented the public utilities. Of these 12 million kW, a little over half represented hydroelectric capacity, but of the total amount the proportion represented by hydroelectric capacity was only 42 per cent, as a result of the predominance of thermal units (in a proportion of 6 to 1) in the group of self-suppliers.

Of the total of 16 million kW 75 per cent was represented by the five main producers of electric power - Argentina, Brazil, Chile, Mexico and Venezuela (in round figures, Brazil 4 million kW, Argentina and Mexico 3 million each and Chile and Venezuela 1 million each).

If the electricity plans already adopted or under study by Latin American governments, and especially by the five main producers, are properly carried out, by 1970 some 28 million kW of new capacity will have been added, bringing total installed capacity up to 44 million kW (see table 1).

In addition to this net increase of 28 million kW, the proper replacement of some existing equipment will have to be provided for, amounting to between 3 million and 5 million kW.

The analysis of the region's electricity plans in table 1 shows that the proportion of the total new generating capacity that will be hydroelectric will vary between 55 and 62 per cent. Whether the proportion is nearer to the upper or lower figure will depend essentially on the policy of the Argentine Government with respect to the execution of the large-scale hydroelectric works planned for that country.

/Table 1

Table 1

LATIN AMERICA: PROJECTIONS OF ELECTRIC POWER AND INSTALLED CAPACITY
REQUIRED IN 1970

	1959		1970		
	Power (Thousands of millions of kWh)	Installed capacity (MW)	Power (Thousands of millions of kWh)	Installed capacity (MW)	Hydroelectric capacity (percentage)
Brasil	23.1	3.9	70	14	64
México	9.8	2.7	35	8	66
Argentina	9.6	3.0	25	5.5	25.5
Chile	4.6	1.1	12	2.6	57.8
Venezuela	4.3	1.3	15	3.5	57
Colombia	3.3	0.9	10	2.5	68
Cuba	2.8	0.9	9	2.5	2
Peru	2.2	0.7	8	2	65
Uruguay	1.2	0.3	3	1	50
Central America	1.1	0.4	3.3	0.8	50
Other countries	2.3	0.7	6.1	1.8	41.6
<u>Total</u>	<u>61.3</u>	<u>15.9</u>	<u>196.4</u>	<u>44.2</u>	<u>54.2</u>

Source: ECLA, on the basis of direct information and various documents.

Thus it can be seen that, even on the assumption that electricity expansion in Argentina during the present decade is almost entirely in the thermal sector, the proportion of hydroelectric generation will increase in the next few years. This is due mainly to the effect of the Brazilian programme on the total figures for the region, since the proposed expansion in that country represents over a third of the total expansion in Latin America, and nearly half the proposed new hydroelectric potential. It should be emphasized that this assessment is in absolute terms, since in relative terms the proportion of hydroelectric potential is higher in the Chilean programme, for example, in which 80 per cent of the new capacity is hydroelectric, than in Brazil, where the proportion represented by hydroelectric capacity in the goal set for 1966 is something over 66 per cent.

/Latin American

Latin America now has some 7 million kW of capacity under construction, while projects under study (which does not in every case mean that full draft plans have been drawn up) represent an additional capacity of 28 million kW.

As stated above, account should be taken not only of the new installed capacity envisaged for the next decade, but also of the replacement of obsolete equipment, both generating equipment and equipment for transmission and distribution. Unlike the addition of new capacity, the replacement of equipment, especially of low-yield thermal equipment, is to some extent optional, since it depends on the return that the investment in replacement will produce compared with the return on other possible uses of the funds concerned, either in the electricity sector itself or in other sectors of the economy.

Much the same is true with respect to the gradual elimination of the self-supplying plants, especially diesel plants, in countries where, as in Argentina, there is a considerable proportion of such installations.

Self-supply is common in Latin American industry, which is hampered by restrictions on consumption by the public service enterprises, but except in special circumstances (industries that can undertake the installation of generating plants of adequate capacity, cases where the generation of electric power is economic because of the burden of which it relieves the public service generating plants, or cases where the nature of the manufacturing process, usually involving the use of steam, makes self-supply rational) self-supply is anti-economic on two levels: firstly, it involves a higher investment per kW of installed capacity than is needed for the generating plant of the electricity supply enterprise, and secondly, the direct input required is also higher. It has been estimated that the higher investment burden can amount to as much as 100 per cent, while the level of direct costs can be 10 to 15 per cent higher than for a high-capacity public service plant.

Hence a rational electricity policy should discourage self-supply, except for the special cases referred to, when additional generating capacity is being considered. But the question remains of what the policy should be with respect to the existing self-supply plants. From the economic standpoint, as opposed to the accountancy standpoint, former or original investment costs /should no

should no longer be taken into account, and that moreover the resale value of such equipment is very low in comparison with the considerable cost of removal, transport and new equipment, although the self-supply plants can fulfil the useful economic function of providing service in remote areas where consumption is low. Consequently, in determining the policy to be followed with respect to use of the existing thermal self-supply capacity, the saving in fuel (direct input) must be compared with the greater investment involved in replacing it by public service capacity. Thus the question is analogous to the replacement of out-of-date equipment with a high specific consumption by new equipment at the large public service thermal plants. There are also points of similarity with the choice between hydraulic and thermal plants, which will be further discussed below.

In all these cases the economic merits of present investment must be balanced against higher operating costs in the future.

For all these reasons the estimated replacement requirements represent a fairly wide margin of uncertainty, all the more so since the interconnexion of existing thermal plants with other generating plants - notably hydraulic plants - increases the economic yield in both cases, and thus alters the degree of relative obsolescence. Thus a thermal plant that is anti-economic when operating in isolation may well prove to be economic, and therefore not need to be replaced by a new plant, if used, with a plant factor appreciably lower than before, as capacity to supplement a hydroelectric or as a peak unit in an integrated electricity system.

Subject to these reservations, it can be stated purely by way of indication that the replacement of existing generating plants over the next decade will amount to between 3 million and 5 million kW.

As the economically useful life of hydroelectric plants is longer than that of thermal plants, and many of the former are of relatively recent construction, it seems likely that a higher proportion of thermal plants will need to be replaced.

Thus it emerges that the total capacity installed during 1960-70 would be between 31 million and 33 million kW, including replacement.

/Almost the

Almost the whole of this total would represent new installed capacity in the public services. In fact, taking into account all the relevant factors, it is believed that the existing self-supply capacity (4 million kW) will not increase by more than 50 per cent during the next decade. It should be noted that, with respect to consumer goods industries, much self-supply equipment will be eliminated in some countries - especially Argentina - as the restrictions on the supply of electricity that led to their installation are removed. Thus the new capacity will be added in the basic industries sector, where high inputs sometimes justify the installation of individual plants, or when the industrial process concerned makes it economical to produce joint steam-electric power, and in mining, where an expansion in such fields as copper and petroleum is to be expected. However, even in the last case, the excess of existing productive capacity in the equipment concerned, and the unfavourable outlook for world demand, conduce to the view that this increase in self-supply capacity is hardly likely to exceed 50 per cent for the whole decade.

As already stated, electrification plans or projects for Latin American countries, if properly executed, will make possible a generating capacity of some 44 million kW by 1970, which means, if the proposed target of 200,000 million kWh of power by 1970 is to be attained, a level of plant utilization of 4,550 hours a year. The average level of utilization in 1959 was 3,850 hours (61,500 million kWh with 16 million kW of installed capacity).

In other words, in order to reconcile these statistics, the annual utilization factor will have to increase during the next ten years by 700 hours, that is, by 18 per cent. There are two components of this factor to be analysed, namely the load factor and the proportion of reserve capacity in the generating plants. Although there are reasons why the load factor should increase, the principal reason being the industrialization of the region's economies, it must be remembered that the removal of the restrictions on supply contemplated for major systems in the region in the near future will tend to reduce the level of the load factor, at least on a short-term basis. An analysis of the figures and of the situation in the various countries, and
/the consideration

the consideration that the effect of abolishing restrictions will be less gradual than the advance in industrialization, leads to the conclusion that generally speaking there is not likely to be a substantial improvement in the load factor in the Latin American electricity systems.

The outlook is more favourable with respect to reserve capacity, although it should be emphasized that at present this margin is very narrow. Through the gradual interconnexion of power plants, there is a trend towards an appreciable reduction in reserve capacity requirements, which in the case of isolated plants are generally imposed by the need to use the largest generating unit for this purpose.

The interconnexion of consumer centres also tends to improve the load factors of the systems concerned by making it possible to take advantage of the differences between the demand diagrams. The extent of this improvement varies with the heterogeneity of the consumer centres that become a part of the network of consumption.

It should also be remembered that the present statistics of the region under-estimate the degree of utilization of installed capacity, since they include in this capacity many generating units, especially thermal units, which are virtually out of operation, being used only at peak periods.

For all these reasons, it appears that an average utilization level of the order of 4,500 hours, is a feasible aim to set for the end of the decade, although it represents a considerable increase compared with the present level, which is very low. According to figures that have been worked out, there would at that time be some 23 million kW of hydroelectric capacity and some 21 million kW of thermal capacity. It goes without saying that if this increase in the level of utilization cannot be attained, a proportional increase in installed capacity would be required, involving additional investment.

In a normal year the same level of utilization as for 1959 (4,750 hours) might be assumed for hydroelectric power, or perhaps a slightly higher figure by reason of improved design in hydroelectric plants and an increase in relative storage capacity. In these circumstances, all hydroelectric plants could generate some 115,000 kW a year. This would leave 85,000 million kWh to be

/generated by

generated by the thermal plants, which might require as much as 25 million tons of petroleum equivalent. In relation to an installed capacity of 21 million kW, this would mean an average utilization of 4,350 hours, and although this figure is fairly high compared with that attained in recent years (3,300 hours in 1959), it is perfectly feasible in view of the fact that a substantial part of this thermal capacity would be of recent installation.

Even if average hydrologic conditions are extremely unfavourable or even critical - for example, if the level of utilization for hydroelectric plants is only 3,000 hours - a similar calculation will give a result of 6,200 hours, as the level of utilization required for thermal plants, which should be easily attained in view of the considerations outlined above.

However, it should be remembered that in these circumstances the fuel consumption required to generate the corresponding 130,000 million kWh would amount to some 35 million tons of petroleum equivalent. Such a high level of consumption, which is almost triple that in 1959, would undoubtedly represent a very considerable drain on foreign exchange availabilities.

The rather optimistic conclusions that can apparently be drawn from the foregoing analysis are subject to one or two reservations. Firstly, a basic concern has been to attain a sufficiently large total supply of energy since Latin America's resources for the generation of electricity will be predominantly hydraulic. Consequently, critical situations will tend to arise generally as a result of a shortage of energy. However, there will be exceptions, and even if the proposed expansion plans are fulfilled to the letter, it does not seem likely, especially in relation to the large thermal systems supplying such urban centres as Greater Buenos Aires, that peak demand requirements could be fully met, particularly when restrictions are abolished and the tempo of economic development and industrialization increases.

Secondly, it should be remembered that the postulated increase in the level of utilization (18 per cent), although this constitutes a feasible goal, will not be easy to attain, especially in view of the narrow margin of reserve capacity with which the main Latin American systems are now being operated.

/Consequently it

Consequently it is desirable, especially in the case of certain countries, for present expansion programmes to be reviewed in the near future with a view to their possible broadening or amendment.

3. Cost and means of financing expansion of overall electricity facilities

In the foregoing sections it has been shown that to meet foreseeable demand up to 1970, the electricity industry in Latin America will have to add 28 million kilowatts to existing capacity and recondition 3 to 5 million kilowatts of existing capacity. An analysis is made below of the financing effort that will be required to achieve these aims.

A study of the expansion programmes in the different countries shows significant differences in unit costs. That was, however, to be expected in view of the heterogenous nature of available hydroelectric resources in Latin America, differences in utilization costs, situation of the centres of consumption as related to the optimum position of generating plants, etc.

Differences in unit costs of generation are far wider in hydroelectric plants than in thermal power stations. This does no more than confirm the experience of other areas. For example, a survey of recent installation costs in the United States shows that while such costs might vary between 100 and 600 dollars per kilowatt, for a hydroelectric plant in the case of thermal power stations the variation was substantially smaller running from a minimum of 120 to a maximum of 250 dollars per kilowatt. In Latin America, the cost of hydroelectric plants varies from about 200 dollars in the most favourable circumstances to about 500 - measuring supply at the plant bus bar - while the cost in thermal power stations varies between 150 and 250 dollars.

It will be noted not only that the margin of variation in costs is much smaller for thermal power stations, but that such variations can be largely explained by economies of scale. For instance, while a programme recommended by a group of experts for Argentina estimates the cost of thermal generation at an average of 150 dollars per installed kilowatt - this particularly for power stations of large capacity - the cost figure doubles as the size of the power plants is reduced, as a result of the smaller size of the consumer market in countries of small economic potential.

/As to

As to the cost of reconditioning existing facilities taking account of the fact that almost all such capacity will be thermal and that the size of the new power stations will tend to increase, an average cost of 200 dollars per kilowatt has been accepted.

The relative importance of fixed costs for the transmission of power from generating plants to consumption centres as part of the total cost of the electricity programme will, as is natural, depend on the percentage of power generated hydroelectrically and on the distance between the hydroelectric plants and the large urban centres in the country concerned. Here too, there is no general rule in Latin America, either as regards the proportion of power generated hydroelectrically (expansion programmes vary from those that are almost exclusively thermal to schemes providing for 75 per cent of new capacity to be generated hydroelectrically), or as to the distances to consumption centres (relatively short in Brazil and long in Argentina).

The cost of transmission lines, inclusive of sub-stations, seems to vary between 20,000 and 50,000 dollars per kilometre, according to the tension adopted, the amount of power to be transmitted and the nature of the terrain.

An analysis of the expansion programmes adopted or recommended in the various countries of the area shows, after certain adjustments have been made, that the average cost per kilowatt is about 440 dollars. (See table 2) To this should be added reconditioning, the unit cost of which is estimated at 200 dollars per kilowatt. In this way, the total of the financial resources needed can be calculated; it is of the order of 13,000 million dollars - this figure being reached by calculating 28 million kilowatts of new power at 440 dollars the kilowatt plus 4 million kilowatts at 200 dollars the kilowatt for reconditioning - which represents a unit investment of 440 dollars per kilowatt. This would correspond to generating and transmission costs of some 350 dollars per kilowatt.

Even taking account of the great technological progress made in the thermal generation of electricity, which has resulted in a gradual reduction in the installation costs of generating units to less than 150 dollars per kilowatt at least in large high pressure high/temperature units, and although

Table 2

LATIN AMERICA: INVESTMENT REQUIRED TO FULFIL THE ELECTRICITY
EQUIPMENT PROGRAMME TO 1970

	Investment (Thousands of millions of dollars)	New Equipment		Investment ^{a/} (dollars per kW)
		Total (MW)	Hydroelectric (%)	
Brazil	4	10.1	60	400
Mexico	2	5.3	75	380
Argentina	1.4	2.5	44	560
Chile	0.87	1.5	67	580
Venezuela	1.05	2.2	84	480
Colombia	0.8	1.6	62	500
Cuba	0.64	1.6	3	400
Peru	0.58	1.3	84	440
Uruguay	0.35	0.7	53	500
Central America	0.18	0.4	50	450
Other countries	0.53	1.1	42	480
<u>Total</u>	12.4	28.3	61	440

Source: ECLA, from information supplied direct and from various documents.

a/ In addition to generation and transmission, in many but not in all cases, these figures include improvements in distribution.

a great part of the hydraulic potential of the area is still usable at relatively low cost - for example, unit costs mentioned in connexion with the large hydroelectric plants under construction in Brazil such as Furnas and Tres Marias, amount to some 200 dollars when calculated at the plant bus bar - the resulting average figure is somewhat low. A partial explanation of this may possibly be found in the omission from some electricity plans of the costs represented by electric power distribution networks.

It must be realized that the modernization and expansion of electricity lines and networks is not only a current additional investment amortized by
/reduced losses

reduced losses in the future, but that to a certain extent it takes the place of alternative investment in generating facilities. Losses on average represents 17 per cent of power supply, including losses during transmission and distribution, and consumption in the electricity generating stations themselves. Furthermore, as such losses are approximately proportionate to the square of the amperage transmitted, they reduce the power available for consumption, as compared with the power available at the plant bus bar, by more than 20 per cent during peak hours. Clearly then, any investment in transmission lines and distribution networks whether primary or secondary, which tends to reduce the amount of waste, will also contribute to reducing the investment required in new generating capacity for a given level of demand by consumers.

Apart from underestimation of the cost of improving and expanding distribution networks, which seems to occur in many government electricity plans, past experience has shown that the estimated cost of such plans is usually excessively optimistic; an analysis of the relative frequency of errors in estimating future costs shows that underestimates are more common than overestimates.

This means that even if a round figure of 13,000 million dollars is taken in estimating gross investment needed in the electricity sector to ensure an installed capacity of some 44 million kilowatts in 1970, it should not be forgotten that the real figure may in fact be higher. To this should be added the possibility that the programmes of some countries whose recent rate of economic growth has been unsatisfactory, will have to be revised upwards towards the middle of the decade. It is, however, believed unlikely that the final figure will be more than 15,000 million dollars.

As to the breakdown of this overall figure as between local and foreign currency expenditure, the regional average of relative participation - depending on how the plans work out in practice - is 38.5 per cent, fluctuating between a minimum of one third in the case of the country with the greatest internal capacity to provide its own heavy electrical equipment - namely, Brazil -, to two thirds or more in countries whose industrial structure is weakened. It should be observed in passing that a reduction in the relative
/participation of

participation of foreign currency in investment expenditure - which is of course a favourable circumstance from the point of view of general economic development - leads in some cases to financial difficulties since the provision of finance both by international institutions and by foreign private banks and also so-called consumer credit cover solely expenditure on equipment and materials purchased abroad. This means that the financing of expenditure in local currency is sometimes difficult, apart from the fact that when funds are provided by the State - either directly from the budget or indirectly through Government investment banks and other similar agencies - it is common for such financing to have inflationary effects on the national monetary systems.

An analysis must now be made of the relative importance of investment in electricity in relation to total investment required to ensure a satisfactory rate of economic development; a study must also be made of the amount of resources available and what part of them can be devoted to electricity capital formation which will, on a series of different assumptions, generate internal saving, both privately and publicly. A comparison of the two figures will show the deficit - or perhaps the surplus - which will have to be covered from foreign sources, if the area is to continue developing at the desired rate.

In determining these figures, the three basic macro-economic variables are the rate of growth of product, the relationship between product and capital and the coefficient of internal savings. Assuming such coefficients to have normal values, it can be estimated that the gross investment in the electricity sector will amount to some 10 per cent of the total amount of resources needed for capital formation nationally. Such a figure is reasonable, although it is seldom reached in the Latin American countries.

/Furthermore, a

Furthermore, a dynamic approach must be made to trends in the sectoral investment coefficient for the electricity industry. Considering that the coefficient of electrification of the economy - i.e., the number of kWh generated for each dollar of gross product - increases with product, a given rate of increase in product should be accompanied by a more than proportional increase in electricity consumption. This means that unless the coefficient of overall investment increases with product, investment in the electricity sector must represent an increasing percentage of total investment in the economy.

Even supposing that the coefficient of savings and the coefficient of investment increase gradually as is supposed in the majority of development programmes for the area, it does not seem likely that this will be sufficient to compensate for the increase in electrification. It is therefore reasonable to conclude that during the forthcoming years, the Latin American countries will have to devote the increasing proportion - and doubtless more than at present - to investment in the electricity sector and that this proportion will be larger the more intense the rate of economic development and the rate of investment in heavy industry.

Experience in some Latin American countries has shown that when the sectoral coefficient of investment was close to 10 per cent, the situation as regards electricity supply, was relatively satisfactory. This occurred for example in Chile, Mexico, Uruguay and Venezuela very recently. On the other hand, in other countries where the coefficient was much lower than 10 per cent, there were shortages of electricity supply. Such was the case in Argentina and Chile before 1958.

/4. Electricity

4. Electricity financing and the balance of payments

The analysis of the effect of the required expansion of the electricity system in Latin America on the balance of payments is of great importance in relation to the trade policy both of countries inside and outside the area, and of international finance agencies.

The two main headings under which electricity generation affects the balance of payments are the import of equipment and material needed in the provision of electric power - for generation, transmission and distribution facilities - and the import - or in the case of producer countries the decline in exports - of fuels.

As has already been seen, the plans of the different countries and in particular of the main producers of electric energy provide for gross investment over the next decade of at least some 12,000 million dollars, somewhat less than 40 per cent of which or some 500 million dollars per year corresponds to imports.

The resulting figure should be compared with the current import capacity of the area which is equal to the value of exports plus the net balance on the services account, which was 7,140 million dollars in 1959. If the capacity to import remained invariable in absolute terms, the result would be that on an average the import of electrical equipment would require something less than 7 per cent of the foreign currency available in the area. This would be an extreme assumption, as it is highly improbable if not impossible that Latin America would maintain a satisfactory rate of development if the quantum and value of its exports, which are the main components of the capacity to import, remain invariable.

A somewhat more realistic assumption would, on the basis of various determining factors, lead to the conclusion that the value of exports might be as much as 10,000 million dollars at the end of the decade. Their aggregate value for the whole of the rest of the decade would accordingly be 85,000 million dollars, and imports of electric equipment and material would be about 5,000 million dollars or somewhat less than 6 per cent of exports.

/Foreign exchange

Foreign exchange requirements for electric equipment must furthermore be related to the breakdown of imports intended for capital formation in general, in order to see the effect of both factors (exports and imports) on the balance of payments of Latin America.

The imports of capital goods during the last five years represents approximately one third of total Latin American imports. The main increase in absolute terms is in machinery and equipment for the electricity industry which now absorbs more than half of total imports of electrical goods.

Gross internal fixed capital formation was approximately 10,000 million dollars in 1957-58, as calculated at 1950 prices. Calculated at current dollar prices, the figure would be about 12,000 million, which in comparison with gross internal product over the same period, shows an investment coefficient of the order of 1/6.

A comparison of the foregoing figures with imports of capital goods shows that in recent years imports have accounted for approximately 25 per cent of capital formation. This average percentage is somewhat lower than the figure estimated for the electricity sector where imports have accounted for 40 per cent of capital formation.

A given increase in product is normally accompanied by a more than proportionate expansion in electricity capacity, while the capacity to import tends to increase less than product; accordingly, it is to be noted that the faster the rate of growth of Latin America in the forthcoming years, the greater also will be the relative effect of electricity development on the area's balance-of-payments situation, unless import substitution in electric goods is sufficient to compensate the combined effect of the aforementioned phenomena.

As to fuels, it can be seen that approximately half of the total energy generated in 1959 was produced thermally, and that the greater installed capacity of thermal generating power is counterbalanced by its smaller degree of utilization in comparison with hydroelectric means of generation. Specific consumption of fuel for thermal generation was extremely high in 1959, as it is calculated at 0.4 kilogrammes of petroleum equivalent per kWh; this figure is an index of the low

/efficiency of

efficiency of a large part of the existing plants. Accordingly, fuel consumption in 1959 was some 12 million tons of petroleum equivalent.

An analysis of electricity expansion plans for the countries of Latin America has shown that the hydroelectric power proposed for the end of the decade was of the order of 24 million kilowatts. It has also been stated that in a year of normal conditions of water supply, 115,000 million kWh could be generated hydroelectrically, leaving 85,000 million kWh to be generated thermally.

It should be remembered that new thermal capacity, the installation of which during the decade is being advocated in replacement of obsolete equipment, will have a very much higher yield than at present which can be estimated at between 0.24 and 0.27 kg/kWh. Even taking account of the remaining stock of old units which have not been replaced and which it is supposed will be used less than the average of all thermal equipment, a figure in the neighbourhood of 0.3 kg/kWh can be accepted as a reasonable target to be reached towards 1970.

On the foregoing assumption, the proposed amount of current generated (some 85,000 million kWh of thermally generated current) would involve fuel consumption of the order of 25.5 million tons.

The unit value of such fuel is estimated at 15 dollars per ton, a figure which is closer to f.o.b. than c.i.f. quotations. In such circumstances, the amount of expenditure (or reduction in revenue) in the balance of payments of Latin America resulting from thermal generation of electricity would for 1970 be more than 380 million dollars. On the assumption of a linear variation in fuel consumption from the level of 12 million tons a year at present to 25.5 million at the end of the period, the total amount of such imports (or decline in potential exports) would be of the order of 2,800 million dollars.

If to foreign currency expenditure on equipment is added the foreign currency spent on fuels, the total figure amounts to 9 per cent of import capacity forecast for the period, always accepting the aforementioned assumptions.

/The real

The real effect will be smaller. It should be noted that if fuel production in the area increases, the decline in revenue which it was calculated would affect the balance of payments, will then represent a potential figure which could include exports of fuel. In no way would it suppose a real decline in present import capacity.

The foregoing analysis is valid only for an ideal average situation for Latin America as a whole. The actual situation in each country may well differ very considerably from the average as a result of a series of factors; among these, mention should be made of industrial production, the volume of national fuel production, decisions regarding the obtaining of foreign currency loans, foreign capital investment, etc.

What means could be found for financing the foreign currency share of investment in the electrical sector, an analysis of which has just been made? In view of the importance of the International Bank for Reconstruction and Development and the Export-Import Bank in this type of financing, it is worth giving a brief analysis of the role played by those agencies in the past and what can be expected not only of them but also of the newly established Inter-American Development Bank in the near future.

In the 1950-59 decade, loans granted by the two first named agencies for electricity development projects in Latin America amounted to some 600 million dollars, some two thirds of which were provided by the International Bank and one third by the Export-Import Bank. In view of the fact that in the next ten years, some 5,000 million dollars of foreign currency will be required for electricity expansion in the area, it is clear that unless the aforementioned agencies, with the assistance of the Inter-American Development Bank can bring about a marked increase in the rate of their electricity loans to the governments of the Latin American countries, the latter will have to turn to an ever increasing degree to other sources of finance, both internal and external.

It would seem neither feasible nor desirable that the aforementioned international agencies should devote to the electricity sector funds at present intended for other sectors. Already during the most recent period, the electrical development loans granted by the International Bank

/represented almost

represented almost 60 per cent of the total credit granted to Latin America by that agency. Although the proportion was 10 per cent less for the Export-Import Bank, electricity loans granted to the area represented some 57 per cent of the total of electricity credits granted by that agency throughout the world.

The best hope then is not that there will be a change in the breakdown of the loans granted by those agencies, but that they will have more finance available so that they can meet a larger proportion of the needs of the various sectors of the economy and particularly the electricity sector.

During the last ten years, contributions from international financing agencies have covered approximately one third of imports for capital formation in the electricity sector. For this proportion to be maintained, loans in this connexion should increase during the coming decade to an average figure of somewhat more than 150 million dollars a year; in the view of the rate of the granting of loans over the last eighteen months, this seems a reasonable target.

A substantial percentage would, however, still remain to be covered out of each country's current foreign currency revenue or from private foreign capital sources. As has already been mentioned, the share of foreign private capital in installed capacity in Latin America has been declining regularly; this means that foreign private capital can not be expected to share in financing expenditure abroad to a greater extent than at present, and the present figure is approximately 20 per cent. On this relatively optimistic assumption, foreign private capital would contribute some 100 million dollars a year in electrical capital goods purchased abroad.

Account should also be taken of the credit given by suppliers of equipment and material; such suppliers usually also help finance State export promotion bodies in the large industrial centres in the northern hemisphere. Although such credits may be of help as a momentary palliative in situation where external financing is precarious, they do not constitute a thorough solution, for operations of this kind are usually for the short or medium term and are hardly sufficient to meet the requirements of industries with high capital density and long amortization periods, as is the case in the electricity industry.

5. Some observations concerning decisions in the
electricity sector

The failure to undertake a thorough study of present conditions in the electricity sector, including plans for future action, has for many years constituted a serious impediment to an adequate development of the sector. The situation has improved considerably over the past few years and there is scarcely a country to-day that has not carried out this kind of study, conducted either by experts in government agencies responsible for electricity programmes, by international organizations or by foreign consultants.

A distinction should nevertheless be made between studies which, at the same time, constitute plans for action decided by the governments concerned and the national agencies responsible for the electricity sector, and those that are merely reports prepared by experts whose advice has been sought, without the government concerned having taken a decision regarding the recommended programme or any other plan. In such cases, therefore, the governments have not entrusted the implementation of the programme, or at least its supervision and co-ordination, to any specific government agency which would have the legal authority and practical means of discharging this responsibility. In the absence of any clear-cut decision by the government the programme, however thoroughly studied and prepared, can obviously be only an expression of opinion by its authors.

Even in cases where the government has decided upon a specific programme of action in a Latin American country, subsequent developments very often differ considerably from the estimates and the policy formulated in the plan. The reason for this is either a lack of funds to finance the proposed projects, lack of co-ordination with private concerns also providing public utility services or, again, the absence of an institutional structure for the electricity sector which would be compatible with the implementation of the programme decided upon.

For example, plans usually include provisions for an increase in the installed capacity of private companies. These provisions remain inoperative because the increase is in fact subject to prior conditions

/- e.g. adjustments

- e.g. adjustments in rates or amendments to legislation regulating public utilities and provisions to attract domestic and foreign capital - which are not fulfilled either implicitly or explicitly in accordance with the plans.

Another detrimental factor would be a delay in deciding on one of several widely varying alternatives when the decision, whatever it might be, has serious economic repercussions. This applies, for example, to Argentina with respect to the execution or postponement of projects such as Chocón and Salto Grande, and to Mexico and Venezuela with respect to standardizing the frequency of their networks and connecting the grids in their major cities with the network for the rest of the country.

In this connexion, it is advisable to review briefly the role of private enterprise in programming the expansion of the electricity sector and to stress the need for adequate co-ordination if such expansion is to be nationwide.

At the end of 1959 the share of private companies in the installed output of the electricity generating park was about one-third of the total. During 1960 this share dropped to one-fifth as a result of the expropriation of the Cuban company and the purchase by the Mexican Government of the two major electricity companies financed by foreign private capital. These two measures combined represented an addition of some 1.3 million kW to the capacity of State-owned plants and a corresponding reduction in the share of private companies.

The role of private enterprise in the distribution of electric power to the consumer and its resulting responsibility in the modernization and expansion of the networks concerned are much greater than in the case of power generation. In fact, some State-owned companies engage purely or chiefly in power generation and sell large quantities of power en bloc to private concessionaires - particularly in the major urban centres in the area - which, in turn, deliver it to the consumer.

This creates a problem with respect to the programming of investment in the electricity sector because these privately financed companies, for reasons which need not be gone into here, often fail to modernize

/or expand

or expand the distribution network at a rate consistent with that of generation or transmission.

Lastly, the variety of services provided by the component sectors in their different stages of generation, carrying and distribution of power requires the establishment of economic tariff schemes which adequately reflect, at each level, both capital and current costs essential to the efficient provision of the service.

One of the chief problems in the formulation of any programme to expand the electricity sector is the selection of the type of generating plant to be installed, particularly the choice between thermal and hydro-electric plants. A few observations might be made here in view of the considerable discussion to which this point has given rise.

It should first be borne in mind that very seldom must a choice be made between a separate thermal and hydro-electric plant. It is usually a question of expanding an inter-connected system of generation and consumption. What has to be done, then, is to undertake an economic study of the original system supplemented in one case by a hydro-electric plant and in the other by a thermal plant. The difficulty increases when programmes include a series of successive stages covering a certain period of time because the inclusion of every new generating plant into the system alters the conditions under which that system operates and therefore affects the relative yield of the plants already in operation.

A similar situation arises with respect to the economic system in general in the analysis of alternative investment programmes. In view of the existence of external economies, each investment affects the yield of the others. Hence, it would be wrong to analyze projects individually or to compare their advantages and to give preference to any one of them over the others. The theoretically correct solution is to compare the advantages of the various alternative programmes considered together.

Similarly, it is usually meaningless to say that any particular hydro-electric plant is more or less suitable than an equivalent thermal plant. The proper course is to compare, inter alia, the overall electricity expansion programme with the hydro-electric plant and, as an alternative, with a thermal plant.

/In analyzing

In analyzing the relative advantages of the two different investment programmes in the electricity sector, another problem is that of the rate of interest and the periods of amortization decided upon. Generally speaking, a plan which provides for greater hydro-electric capacity will have a higher investment cost and a lower operating cost than an alternative plan providing for greater thermal capacity. In the final analysis, this means that a comparison must be made of the expense involved at various points over the period of time concerned, which must therefore be converted into a standard unit through the application of the rate of interest on the capital, a procedure by which the economic feasibility of a programme throughout its existence can be determined. A lower rate of interest means a smaller sacrifice in future consumption compared with the present cost and thus favours the relative position of larger capital investments. Accordingly, the influence of the interest rate means that hydro-electric power is relatively less desirable in as yet insufficiently developed economies, where the rate is higher because of the relatively greater shortage of capital.

It should nevertheless be noted that in the case of under-developed countries the increase in the interest rate is partially compensated by longer terms of amortization which can be used to compute the overall coefficient of capital investment because, in view of the price structure in those countries, equipment does not become obsolete as quickly as it does in more advanced economies. Accordingly, the increase in the co-efficient of capital investment will be smaller than that of the interest rate.

While the selection of the interest rate to be adopted in comparing the relative advantages of two or more electric power investment programmes is most difficult and requires more than a merely quantitative it is clear that in any event the factors mentioned above must be taken into consideration and that over-simplified, erroneous solutions - such as using the bank rate at which external funds are obtained or the bank rate predominating in the internal monetary system - should be avoided. A distinction should be made between the nominal cost of capital - either for the State or for private enterprise - and the

/actual cost

actual cost to the economy as a whole, taking particularly into consideration the fact that alternative investments within or outside the electricity sector itself are sacrificed. The yield of such alternative investments - e.g. other major public works to be undertaken by the State - is an adequate criterion to determine the interest rate to be used for the calculations.

In the case of multiple works such as hydro-electric projects, it should also be borne in mind that the investment corresponding to the use of electricity should remain lower in relation to the other benefits to be derived from such public works.

An analysis of existing plans to expand the electricity sector in Latin America seem to indicate that calculations of this kind are not usually made. In some cases there are practical reasons for this. One of them is that it is difficult for a government to negotiate financing arrangements with international agencies in respect of alternative investment projects which might use surplus funds from a predominantly hydro-electric plant as against a thermal plant, when studies similar to those carried out for electricity have not been made for other public investments.

Even if it is assumed that an adequate interest rate has been selected which represents the marginal yield of investment funds at the level provided for, it should not be forgotten that in making a comparative analysis based on average annual costs, the problem of priorities over the period of time concerned is largely ignored. Both in Latin America and in many other parts of the world, the need for a high short-term increase in the output growth rate is stressed. In the present situation, the computation of investment requirements exceeds the present level of savings not so much because of the low savings co-efficient as of the output co-efficient. Under these conditions, capital funds might well be concentrated on investments which contribute to a more rapid increase in the total output, which are not always those producing the highest yield over the long term.

This illustrates a fundamental point in selecting between hydro-electric and thermal plants in a plan for expansion of the electricity /sector. While

sector. While there has been much discussion on the subject, the position of the contending schools of thought has not always been clear with respect to the assumptions made. The fundamental difference, from the point of view to be stressed here, is the following: an investment plan to raise output as much as possible in 1965 can be very different - although in exceptional cases it may be the same - as a plan to raise output as much as possible in 1985.

Hence, while the most important matter for the government, for several reasons, is the short-term yield on investment, a comparison of the annual cost of net profits at present rates during the lifetime of the respective plants would not be a valid criterion for a decision to be taken.