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THE ELECTRIC POWER INDUSTRY IN LATIN AMERICA: PRESENT STATUS AND RECENT DEVELOPMENTS*

* The present text, which is subject to editorial revision, is a summary of a paper with a similar title (ST/ECLA/CONF.7/L.1.01) that is to be submitted to the Latin American Electric Power Seminar, to be held in Mexico from 31 July to 12 August 1961.

CONTENTS

	Page
INTRODUCTION	1
Chapter I: POWER CONSUMPTION IN LATIN AMERICA AND IN THE WORLD	5
1. Total power consumption	5
2. Electric power	6
Chapter II: POWER CONSUMPTION AND ECONOMIC DEVELOPMENT	9
Chapter III: ELECTRICITY PRODUCTION IN LATIN AMERICA	15
1. General observations	15
2. Generation	16
(a) Public utilities and self-suppliers	16
(b) Share of public utilities in total generation	16
(c) Generation per country and per capita (1959)	16
3. Sources of energy	17
4. Fuel consumption in thermal generation	19
Chapter IV: INSTALLED CAPACITY IN LATIN AMERICA	21
1. Public services and self-suppliers	21
2. Sources of electric power	22
3. Size of plants	23
4. Plant utilization	23
Chapter V: CONSUMPTION OF ELECTRICITY BY SECTORS	25
1. Distribution losses and net consumption	25
2. General observations on consumption by sectors	26
(a) Relationship between electric power consumption as an end use and the gross national product other than agriculture and mining	26
(b) Relationship between industrial and mining consumption and the contribution of these sectors to the gross product	27

Page

3. Non-industrial urban consumption 28
   (a) Domestic consumption 29
   (b) Commercial consumption 30
   (c) Public lighting 30
   (d) Transport and other 30
4. Industrial and mining consumption 30
5. Share of public utilities in industrial and mining electric power consumption 32

Chapter VI: MAIN ELECTRICITY SYSTEMS 33

1. Distribution of electricity for consumption within each country 34
2. Size of electricity systems and inter-connexions 35
3. Reserve Capacity 36
4. Frequencies 36
5. Transmission voltages and low utilization voltages 37
6. Price of electricity 37

Annex I: TABLES (in Spanish text only)

Annex II: FIGURES (in Spanish text only)

INTRODUCTION

The present document is a summary of a paper with the same title prepared by the secretariat for submission to the Latin American Electric Power Seminar, to be held in Mexico from 31 July to 12 August, under the auspices of ECLA, the Bureau of Technical Assistance Operations, the Resources and Transport Economics Branch and the Government of Mexico.

Chapter I places Latin America's situation against the background of world power consumption, mainly with respect to electric power. In 1959 the average regional per capita consumption recorded at the power stations was 310 kWh, compared with the world average of 720 kWh. During the last ten years the figure for Latin America has increased at the annual cumulative rate of 6.6 per cent, while the corresponding increase for world consumption was 12.6 per cent. The increase in the relative importance of electric power compared with other forms of power is demonstrated by the fact that the region's share of world power consumption in 1937 was 17 per cent, in 1949 was 22 per cent, and at present is about 35 per cent. The chapter concludes by examining the factors that have led to this change.

Chapter II supplements and brings up to date the information on the relation between electricity consumption and general economic development contained in Energy in Latin America (E/CN.12/384/Rev.1),[1/] again confirming the close link between the two. However, it is explained that this interdependence does not imply that a country's level of income automatically determines its level of electricity consumption, which is influenced by such other factors as the structure of the production system, income distribution, climate, and so forth; special attention is drawn to the importance of the general process of innovation and technological progress in giving a dynamic character to the electrification process.

Chapter III examines advances in total and per capita production of electricity during the last 20 years in Latin America. Of Latin America's total production (61,000 kWh in 1959), the average contribution of the public services was 79 per cent, the rest being made up by self-suppliers;

1/ United Nations Publication, Sales N°.: 1957.II.G.2.

/the share

the share of the former group has increased during the last two decades. The contribution of water power to total power generated is given by country; for Latin America as a whole, this share amounted to 52 per cent for the whole sector, whereas for the public services alone the share was 60 per cent, with a trend towards a further increase.

The chapter continues with an evaluation of the amounts of fuel used in each country for the production of electricity, and reaches the conclusion that for the region as a whole over 17 per cent of the consumption of the commercial fuels specified is for this purpose, and that their imports weigh heavily on the balance of payments of some countries. The most commonly used fuels are the petroleum derivatives; next comes coal, but at a much lower level. The chapter continues with an examination of the features of the installations required for production.

Chapter IV is devoted to a study of the development of installed capacity over the last two decades; in 1959 this amounted to 16 million kW for the region as a whole. The generating capacity of the public services, which represents about 75 per cent of this total, is about equally divided between thermal and hydro-electric plants. In 1959 about 70 per cent of the capacity under construction was of the hydro-electric type.

Over the years a marked trend has developed in the region towards the construction of plants with a higher potential and the use of units of higher capacity.

The average figure for plant utilization in 1959 was 3,900 hours, but the figure for the public service hydraulic plants was over 4,700 hours.

Reserve capacity is usually inadequate, and except for a few systems the margin between installed potential and demand is dangerously narrow.

The first part of chapter V establishes the relationship between production and consumption of electricity. An average of 17.3 per cent of the regional power generated corresponded to losses, unrecorded consumption and consumption at the plants themselves. At peak hours the situation is even worse, and it is estimated that the losses to the consumer may be over 20 per cent. The second part of the chapter examines for each country the consumption of the various sectors - industrial, domestic, commercial, public lighting, transport and other, grouping them

/according to

according to the way in which the power is used, that is, as a factor of production or consumer good, and establishing correlations with other economic factors, on the basis of this classification.

Of the 40,100 million kWh of total net consumption by the public services in the region in 1959, 61 per cent represented urban non-industrial consumption, and of this domestic consumption, the principal constituent, alone represented over 32 per cent. This level of domestic consumption represented an average of about 150 kWh per urban inhabitant, and is twice as high as it was 10 years before.

Industrial and mining consumption in the region amounted to 27,500 million kWh, 56 per cent of this being provided by the public services, and the remainder by self-supply. The annual growth rate of this consumption is increasing, but not as rapidly as that of the consumption of electricity as an end product. Consequently the proportion of total consumption represented by industrial and mining consumption dropped from 62 per cent in 1938 to 54.9 per cent in 1959.

To supplement the economic analysis of electricity at the national and regional level, chapter VI examines the electricity system as the basic functional unit and gives an account of some of the most representative systems in the region.

The following main conclusions can be drawn from this chapter:

(a) There is a wide variation in the consumption pattern of electricity from one country to another.

(b) There is a strong trend towards the interconnexion of systems in some countries in order to make better use of equipment and to supplement various hydrologic systems.

(c) In a number of countries there are systems operating on both 50 and 60 cycles; this lack of uniformity in frequency constitutes a serious economic problem in the integration of networks, which should be dealt with immediately in order to minimize future ill-effects.

/(d) There

(d) There is also a wide range of both high tension voltages and low utilization voltages; these should be standardized for obvious economic reasons, namely, reduction of spare-part inventories and standardization of industrial production in the region.

(e) In general the price of electricity has lagged far behind that of other prices, which has had a harmful effect on electrical development; in this field also there are certain discrepancies as between the various components of the energy sector.

Chapter I

POWER CONSUMPTION IN LATIN AMERICA AND IN THE WORLD

1. Total power consumption

The average amount of petroleum, natural gas, coal and hydro-electricity used in Latin America to supply power per inhabitant is comparatively small, in line with the level of income, and in 1958 was the equivalent of a little over 400 kilogrammes of petroleum, or 45 per cent of the corresponding figure (910 kilogrammes) for world consumption (see table I-1).[1/] Although there is a wide gap between the Latin American figure and the corresponding figures of 1,800 kilogrammes for Europe and 5,200 kilogrammes for the United States, progress in this field is more rapid in Latin America, and consequently its relative position has improved from 1.8 per cent of total consumption twenty years ago, to 2.5 per cent ten years ago and to 3.1 per cent in 1958. The annual growth rate of *per capita* consumption during the last decade was 5.1 per cent, whereas the world rate was 3.3 per cent. It is possible that the expansion in Latin America, as in all other under-developed countries that have a more rapid growth rate than the average, may be somewhat less than the figures would appear to indicate, in view of the fact that in such countries the coverage of statistics is continually improving, and there is also a rapid substitution of non-commercial fuels such as wood.

The importance of such fuels, whose total can only be estimated, is made clear by the fact that in 1955 they may have represented as much as 28 per cent of the total consumption of energy in Latin America. This proportion has decreased steadily, as usually happens when economic development takes place; in the least developed countries the proportion was about 50 per cent in 1955, whereas it was between 5 and 10 per cent in Europe and 3 per cent in the United States.

1/ The roman numerals correspond to the chapters of the complete study in which the tables will eventually be included. The tables themselves constitute Annex I of the Spanish version of the present document, but are not available in English. They should be regarded purely as reference material.

/With respect

With respect to the so-called commercial sources of power - petroleum, coal and hydro-electricity - it is interesting to note that, in line with a world trend, petroleum has come to be of great importance in Latin America, where it meets 79 per cent of requirements, a higher percentage than for any other large group of countries (see table I-4). This level had already been practically reached in 1955, and was not much less in 1949, after a fairly rapid increase during the previous decade; this seems to indicate that the maximum level of participation of such fuels is now being reached.

The contribution of hydro-electric resources has tended to increase in recent years. In 1958 it was about 15 per cent, after having been about 13 per cent during the previous twenty years. This proportion is also high compared with the rest of the world, and is exceeded only by countries which, like Latin America, are well endowed with such resources, such as Canada and New Zealand.

2. Electric power

With respect to the production of electricity, a comparison between Latin America and the groups of countries previously selected shows a striking similarity of the relative positions (see table I-6). In 1959 the region attained a per capita production of 310 kWh, representing 43 per cent of the world average of 720 kWh.

However, there is cause for concern in the fact that the region is losing ground compared with other countries. Its total production of 60,000 million kWh represented 2.9 per cent of the world total, a level which was not much above that of 1937, much the same as for 1955, and lower than the 3.3 per cent attained in 1949. The growth rate of 6.6 per cent in per capita production during the last decade was one of the lowest among these groups of countries, obviously as a result of the rate of the population growth in Latin America, which is one of the highest in the world.

In fact the increase in production in Latin America in absolute terms has not been low (9 per cent in 1949-59), despite the relative economic stagnation in these countries in recent years. The wide margin for expansion that remains is obvious from the fact that such highly electrified countries as the United States have annual growth rates of about 10 per cent.

/As a

As a result of the large share of such countries in world production, the world rate of electrification is high. Thus in 1937 the proportion of world commercial power consumption in the form of electricity was 17 per cent, in 1949 it was 22 per cent, and it has now reached the level of 35 per cent. The corresponding figures for Latin America and some of the other under-developed countries are higher, but mainly because of the high proportion of non-commercial fuels that help to meet their energy requirements, which do not figure in the comparison. In fact, whereas during the last decade the world annual growth rate of the electrification factor may have been over 5 per cent, the rate for Latin America was only something over 3 per cent, and in the other under-developed countries the situation remained static.

This is the result of the generally limited supply of electricity in such areas. As electricity is a highly developed form of power that requires large investments for its generation and distribution, and long-term programming, such countries sometimes resort to the use of petroleum derivatives in its stead for various purposes because they are readily available on the international market.

However, the possession of abundant hydro-electric resources undoubtedly encourages electrification, as evidenced by the fact that the countries with the highest proportion of hydraulic power in their electricity production (see table I-10) also have the highest degree of electrification; this applies to the group "other developed countries" (Canada, Japan, etc.), Latin America and Western Europe.

It is none the less true that countries with abundant deposits of fuels that lend themselves to highly economic exploitation are also most favourably situated to provide themselves with a supply of electricity.

In Latin America the proportion of hydro-electric generation has remained stationary at about 50 per cent during the last twenty years, whereas its proportion in the world total has decreased from 43 per cent in 1937 to 32 per cent in 1959. The more developed countries have already included all the most economic sites in their production, and consequently in relative terms their interest in this resource is decreasing. Many under-developed countries, too, under pressure from

/the industries

the industries in the course of development, and the demand for higher standards of living, and handicapped by the lack of information about their hydraulic resources, have elected to establish thermal plants, which can be built more rapidly and cheaply. This tendency is even found in some Latin American countries that are comparatively well endowed with hydro-electric potential.

Chapter II

POWER CONSUMPTION AND ECONOMIC DEVELOPMENT

Power in almost all its forms - electricity, liquid fuel, coal, etc. - has a two-fold part to play in the economic system. It is at once a final consumer good and an intermediate commodity, and hence an essential element in almost all productive processes whether of goods or of services, although it is used predominantly for consumption in the industrial sector.

The level of power input is one of the factors determining productivity in manufacturing which in its turn directly influences the level of per capita income of the community. The level of per capita income in itself has a direct influence on power consumption by final consumers, not so much owing to purchasing power for power in itself as in relation to the means to acquire durable consumer goods which need power in its various forms for their operation.

The foregoing remarks illustrate the close inter-dependence not only between income levels and power consumption but also between the latter and the rate of investment in the economy. It is to be noted that, in general, increased use of power supply both as a productive factor and as a final consumption good requires prior investment by the purchaser. In this sense then, the demand for power is a "derivative" of investment in equipment and machinery which require power supply as input. The fact that such inter-dependence should exist at all means that the level of income unquestionably determines the level of total power consumption and to a much lesser extent the level of electricity consumption since there are occasions when one form of power is substituted by another. The rate of such substitution is measured by variations in the coefficient of electrification.

The reasons for their being no simple functional relationship between income and power consumption are many and fairly obvious. One of these for instance is the structure of the system of production. Different countries may achieve the same level of income with a very different breakdown in their output; this will make power consumption patterns different, since power input as a productive factor per unit product varies considerably between the agricultural sector, services and

/manufacturing. Average

manufacturing. Average input will also vary from one sector to another according to the particular sector's composition in terms of its basic activities.

In an earlier publication,[1/] using the information collected for the average of the years 1949-51 covering some 50 countries - including all the Latin American countries - an analysis was made of the relationship between net consumption of total energy and gross product measured in 1950 prices. (See figure II - I.) A similar study has now been made of the correlation between net consumption of commercial energy and gross product on the basis of information corresponding to the average for 1955-58 relating to 55 countries. (See figure II - II.)

An analysis of both figures would seem to confirm a hypothesis already shown to be valid on other occasions; that is that the elasticity-income of total energy - the relationship between percentage increases in power consumption and in gross product - is slight at low income levels, rises considerably at intermediate income levels, only to decline again at the higher income levels. The decline in the latter instance should be attributed basically to an increase in the yield from power use.

The aforementioned study contained an analysis for a number of Latin American countries of the historical changes in the consumption of total power as related to fluctuations in income levels. The conclusion reached was that consumption of total power had grown somewhat more slowly than gross product. The efficiency of use of energy in the area has not yet improved at a rate rapid enough to explain such a phenomenon, particularly if it is realized that in the Latin American countries there has been a fair increase in production in the sectors which are the largest specific consumers of power. The cause of this would then seem to be trends in demand for power as a consumer goods. Household consumption has not fluctuated greatly as income has not reached levels at which consumption-income elasticity is high.

1/ Energy in Latin America (E/CN.12/384/Rev.1), op.cit.

/Most of

Most of the general observations made regarding total power are also valid if applied exclusively to demand for electric power. The latter, however, has its own special characteristics closely linked to the general process of innovation and technical advances, and this explains why, historically, the rate of increase of electricity consumption greatly exceeds the rate of increase of gross product. Consumption of electricity has even been known to increase during periods when gross product has fallen.

Even taking into account the limitations of the simple correlation method, particularly if applied to economic series which by their nature increase with time, it was thought as well to compare the regression line on the gross product-electricity consumption diagram (expressed in logarithmic co-ordinates) corresponding to the years 1949-51 for 55 countries (including Latin America, the United States, Canada and Western Europe)[2/] with the line obtained in the same way and for the same countries but for the years 1955-58 (See figure II-III).

Both the degree of correlation and the angular coefficient of both lines - equal to consumption-income elasticity - turned out to be practically the same. The regression line, however, corresponding to the more recent period lay above the line for the earlier period with a vertical shift of approximately 60 per cent in comparison with the ordinates of the previous line.

The value of such a comparison lies in the fact that the vertical shift of the regression line over a period of seven years may be taken as an index of the rate of electrification in the economy, or the degree to which - for a given level of income - average electricity consumption has increased in the world. In other words, the vertical shift of the regression line is an indication of the internal dynamics of the electrification process and makes it possible to analyse that process separately from what might be called the natural increase in electricity consumption coinciding more directly with rises in gross product.

2/ Ibidem, figure III, p. 32.

/In terms

In terms of this diagram the increase in demand for electricity in a given country may be described over time as the result of two concurrent movements or, in geometric terms, as the sum of two vectors, the first of which would be a movement along the consumption-income regression line corresponding to increases in consumption and income, and the second a vertical shift of the line itself resulting from technical advances and the replacement of other forms of power by electricity.

Clearly that does not mean that both movements are independent; on the contrary, it is well known that innovations and technical advances coupled with wider income distribution which taken together largely explain the growing rate of electrification per unit of gross product, are in their turn one of the main forces behind investment and the general process of economic development.

This phenomenon is equally true in Latin America where the operation which has just been described was repeated for the same period and for the Latin American countries alone. (See figure II-IV.) The results are, however, quantitatively less conclusive because of the more widely scattered and smaller number of points of reference.

A separate diagram (figure II-V) shows, also in logarithmic co-ordinates, the relationship for each country between net per capita consumption of electricity and gross per capita product for the averages of the years 1948-50 and 1956-58. The vectors for each country and for the area joining the extremes permit an appraisal of the characteristics and intensity of trends in electricity consumption during the eight years of the period under consideration. The slope of the vector representing Latin America as a whole is approximately 3. This means that electricity consumption increased as almost the cube of gross product. In the countries of Western Europe as a whole, however, for the period 1950-57 electricity consumption varied approximately as the square of gross product. This does not necessarily mean that such a difference is an automatic result of the different level of economic development in the two areas. In the United States, for example, the economy has over the last fifteen years grown at a rate of some 3 per cent per annum,

/which is

which is considerably below the average for Western Europe and none the less electricity consumption increased there at a rate of nearly 10 per cent.

The importance of electricity consumption in relation to other less advanced forms of commercial power use and its trends in recent years can be examined through a study of the coefficient of electrification. The values of that coefficient for Latin America as a whole were 0.695, 0.685 and 0.936 in 1937, 1949 and 1959 respectively. This rate of growth is very far below the world average as a result of the fact that electricity supply in the majority of the Latin American countries has never been sufficient to meet demand.

Chapter III

ELECTRICITY PRODUCTION IN LATIN AMERICA

1. General observations

It has already been seen that electricity production and consumption in Latin America have risen more rapidly than average income. In fact, the relation kWh per dollar of gross product increased at the cumulative annual rate of 4.3 per cent during the '50's. But this is by no means an indication that the supply has been adequate. On the contrary, after the second World War, the shortage of electricity in a number of countries was a serious impediment to the development of their economies, discouraging the creation of new industries in some cases and hampering the expansion or mechanization of those already in existence.

A great many systems which are faced with a demand that is above their capacity have had to cope with requirements under deficient conditions, i.e. low voltages, frequency instability, interruptions, rationing, and restrictions on the admission of new consumers or on any expansion in demand among old subscribers.

The low yields for generation and distribution by these overburdened systems, which have been unable properly to replace or enlarge their installations - usually for lack of funds - have led to even greater savings on the part of the institutions running them. Hence industries have often been forced to set up their own thermoelectric plants, with components that are unrelated to their own technical processes, because of the shortcomings in the public utility. The main consequence of electricity production in private plants with a small capacity is the high cost of the kWh.

The private (self-supplying) sector accounted in 1959 for 25 per cent of installed capacity in the region as a whole and 21 per cent of total electricity production. These figures should be accepted with the reservation that the pertinent data are usually incomplete, although there has been some improvement in this respect during the last few years.

/2. Generation

2. Generation

(a) Public utilities and self-suppliers

In 1959, joint electricity generation by the public and private sectors in Latin America amounted to 61,300 million kWh, at an annual rate of growth that rose progressively from 7.8 per cent in 1938-59 to 8.8 per cent in 1949-59 and 9.6 per cent in 1955-59.

(b) Share of public utilities in total generation

The share of Latin America's public utilities in total electricity generation showed a tendency to expand slightly. Thus, from 70.4 per cent in 1938 it increased to 79.1 per cent in 1959. During the Second World War and the years immediatly after a decline took place, their share dropping to approximately 65 per cent in 1947, but it was only a short-lived reaction to abnormalities in the supply of equipment and materials, as explained in chapter IV.

As the supply of heavy equipment on the international market - manufactured to buyers' specifications - subsequently reverted to normal, and at the same time the Governments began to programme and systematize electric power development, the public utilities reacted favourably and enlarged their share of total generation. In 1959, the situation varied considerably from one country to another (see table III-2). At one extreme was Uruguay, where there is practically no generation of electricity for private use, and at the other, the countries, such as Surinam, Peru, Honduras and Chile, where productive activities have a high consumption level and the participation of the public utilities was less than 50 per cent.

During the last five years, public utilities played an increasingly important part in generation. The only exceptions were Colombia and Ecuador, where their share remained the same, and Argentina, where it decreased. These exceptions reflect inadequate investment in the production and distribution of electric power in relation to the overall development of the country's activities.

(c) Generation per country and per capita (1959)

With respect to per capita generation by the public and private sectors in conjunction - especially when regarded as an index of economic development - three different groups of countries may be established in relation

/to the

to the current regional average of 312 kWh/per capita: those that exceed it by a wide margin, those that are close to it and those that fall well below it (see table III-4). Although these divisions are arbitrarily fixed, they make it easier to analyse electric power development in the different countries. Most of the countries show an increasingly rapid trend of annual growth, except for Chile and Uruguay in the first group; Costa Rica and Colombia in the second; and Bolivia, Ecuador and Paraguay in the third (see table III-5). In the third group, the absolute per capita increment is small and is often less than the regional average (30 kWh/per capita). This is true of El Salvador, for instance, where the rate of growth is 12.8 per cent and the per capita increment 12 kWh.

During the three years up to 1960, it was noted that the public utilities showed a declining rate of growth in most countries. The main reasons for this were as follows:

(a) After 1955 there was a general weakening of the international markets for the majority of Latin America's exports; the effects of this were enhanced by the economic recession that began in the United States at the end of 1956;

(b) The limited amount of internal resources available for financing electric power installations, which has recently become a more acute problem in a good many countries;

(c) The lack of sufficient foreign exchange to import the necessary materials and equipment;

(d) The drastic measures taken by certain Governments during the same period to curb inflation. These measures had a restraining effect on public investment and on various branches of activity, reducing the latter's electric power consumption.

3. Sources of energy

Although the contribution of water resources to Latin America's total electricity production remained virtually the same during the last 20 years (51.8 per cent in 1959), it increased in the case of public utilities from 43.4 in 1938 to 55.4 in 1955 and 59.6 in 1959.

But very little use is made of water for this purpose. It is estimated that if the relevant demand materialised, it would be possible to install

on known, economically-exploitable sites throughout Latin America, a capacity of some 150 million kW. Not even 4.5 per cent of this potential was used in 1959. In absolute terms, the major producer of hydroelectricity in 1959 was Brazil with 16,900 million kWh. Next came Mexico, Chile and Colombia with 5,900, 2,900 and 2,200 million kWh respectively. These four countries together provide 88 per cent of the total amount of hydraulic energy generated in Latin America.

The countries in which hydroelectricity accounted for the largest part of the public utility electricity supplied in 1959 were El Salvador, Bolivia, Chile, Costa Rica and Brasil, with proportions ranging from 99.6 per cent for the first-named to 85.3 per cent for the last. On the other hand, up to the same year hydroelectric production did not reach significant proportions in Cuba, Haiti, Paraguay, the Dominican Republic and Surinam (see tables III-6 and III-7).

The participation of water resources in electricity generation has increased appreciably in some countries, particularly in the course of the last decade. This is particularly true of Uruguay, El Salvador, Chile, Mexico and, to a certain extent, of Argentina and Honduras, although it is still limited in the last two. There are hopes that the proportion will expand in the next few years for Latin America as a whole, since most of the countries have specific projects and plans - some already under way - for developing their water resources, not only for power production but on an integrated multi-purpose basis.

With respect to thermal generation, Latin America shows the same trend as that hitherto observable in more developed countries. The internal combustion engine is gradually taking a smaller part, being confined to public power stations in small urban centres where, because demand is small, they are far from hydraulic resources or are short of water for steam generation, there are practically no other possibilities to choose from. Nevertheless, numerous diesel plants have been set up as a rapid and temporary solution to the problem, and are often to be found, as an emergency measure, in towns that have neglected the programming and expansion of their electricity services. In the self-supplying sector, and manufacturing industry in particular, internal combustion engines are used extensively in areas that are outside the scope of the public utility,

/or as

or as an emergency measure when the latter's electricity supply is inadequate. Table III-9 shows the respective participation of steam turbines and internal combustion engines in the thermal generation of electric power for public utilities. There are gas-turbine plants in Ecuador, Peru and Venezuela, which account for less than 150,000 kW in all, and in the first-and last-named countries are connected with the petroleum industry. In the tables belonging to annex I gas turbines have been included under the head of internal combustion power stations.

4. Fuel consumption in thermal generation

No satisfactory data are available on fuel consumption for electricity generation in the different Latin American countries. An incomplete analysis, which should be considered as no more than a provisional estimate of yield in relation to thermoelectric generation, gave rise to the following main conclusions:

(a) Fuel consumption per kWh generated varied considerably, ranging from the high figure of 0.74 kilogrammes of petroleum equivalent for a public utility plant (cf 17 megawatts, fuelled mainly by wood) to a little under 0.25 kilogrammes in numerous diesel plants and some big modern steam plants.

(b) On the whole, improvement is slow and in some cases there has even been a retrogression;

(c) The regional average would be about 0.40 to 0.42 kilogrammes of petroleum equivalent per kWh, on the assumption that during the Second World War and the early years of the recovery it was 0.48 kg/kWh.

In order to study fuel consumption for electricity production by countries and to assess its proportion of total fuel consumption, the estimates were based on thermal generation and on yields calculated for more or less representative samples (see table III-12).

In 1959, fuel consumption for electricity generation was 11.8 million tons of petroleum equivalent, Argentina, Mexico, Venezuela and Brazil accounting for nearly 70 per cent of the regional total.

The increase in this consumption showed an average cumulative rate of growth of 6.9, 8.2 and 7.9 per cent annually in 1938-59, 1949-59 and 1955-59,

/respectively. The

respectively. The greatest development took place in Venezuela, Peru and Guatemala.

It may be noted that 17.3 per cent of total commercial fuel consumption in Latin America corresponded to electricity production. This proportion has been very nearly constant over the last 20 years.

If vegetable fuels are excluded, petroleum derivatives (fuel-oil, diesel-oil and gas-oil) may well constitute more than 90 per cent of the total, although the information on this is very fragmentary. They are followed in order of importance by coal, which is mainly used in Colombia, Argentina, Mexico and Chile. Wood and plant residues, which are important as sources of fuel for electricity generation in some countries - principally Paraguay, Haiti, the Dominican Republic and Cuba - are of no importance in Latin America as a whole.

In the petroleum-producing countries - Venezuela, Mexico, Colombia and Argentina - natural gas is beginning to play an important part. Years ago, this used to be employed in electricity generation within the petroleum industry itself, but on a small scale.

Fuels for electricity generation are a weighty item in the external balance of payments of certain countries such as Cuba, Uruguay, Panama, the Dominican Republic, Honduras, Nicaragua, Paraguay and Argentina, and constitute a large proportion of their imports.

Chapter IV

INSTALLED CAPACITY IN LATIN AMERICA

1. Public services and self-suppliers

The postwar picture in Latin America is generally one of imbalance between supply and demand in electricity. This imbalance persists in a number of countries as a chronic condition, due partly to lack of foresight and even more to lack of funds.

In many cases governments, much exercised by this problem, during the forties and the early fifties established various bodies for the purpose of planning the development of the supply of electricity, operating supply systems and acting as the channel for the investment of domestic public funds and the obtaining of foreign loans. At the end of 1959 such bodies represented about 25 per cent of public service capacity.

For the region as a whole, total installed potential at the end of 1959 amounted to about 16 million kW, of which the public services represent about 12 million. The corresponding per capita figures are 81 W and 61 W, respectively (see tables IV-1 and IV-2).

In the four years that preceded 1960 the increase in the installed capacity in the public services generally exceeded the increase in demand. This made it possible to meet some accumulated unsatisfied demand and to relax somewhat the restrictions on the supply of power within certain systems. This applied particularly to Costa Rica and Mexico, where for the last ten years the annual average increase in installed capacity has exceeded the increase in consumption (at their respective levels of consumption).

It will be easier to interpret the various statistical tables if the following points are borne in mind:

(a) The sizable increase in installed capacity recorded for some countries is more apparent than real, because it includes the capacity of some obsolete units (mainly thermal) which although they still exist are more or less out of operation;

/(b) In

(b) In many cases the interconnexion of generating plants made it possible to increase utilization and reduce the required margin of reserve for existing installed capacity;

(c) In 1959 a capacity of some 7.5 million kW was under construction, expected to begin operating in the public services before 1965, and projects under study amounted to approximately another 28 million kW.

2. Sources of electric power

Of the nearly 11.8 million kW of installed capacity in the public services in Latin America in 1959, 50.5 represented hydro-electric plants and 49.5 per cent thermal plants (see table IV-6). Of the latter, between 70 and 75 per cent represented steam plants and the remainder internal combustion plants. As stated above, although the proportion of hydro-electric capacity in total installed capacity fell by 0.5 per cent between 1955 and 1959, there was a relative increase in hydro-electric production, which in 1959 represented 59.6 per cent of the total in the public services. This is due to the higher plant factors that such plants acquire, for economic reasons, in systems where both types of generation are used.

The future equipment plans of a number of systems seem to indicate that gas turbines are likely to play a more prominent role in the public services during the next decade, mainly with respect to the supply of power during peak load hours.

In December 1959 over 70 per cent of the capacity of plants under construction in Latin America was hydro-electric. This proportion is of course much higher than that of the capacity that will actually begin operating during a given period, because of the longer construction time required for hydro-electric plants, which usually includes the basic civil engineering works, carried out as one stage, and subsequent equipment by successive stages.

/3. Size

3. Size of plants

In Latin America, as in other regions, there has always been a marked trend towards the construction of plants with a higher potential and the use of higher-capacity units, in order to reduce installation and operation costs (see table IV-7). Attention is drawn to the high percentage of plants of between 500 and 200 MW and of over 200 MW, especially if the plants under construction in the main electric power producer countries in the region are included.

4. Plant utilization

Average plant utilization is low in Latin America compared with the United States, but high compared with Europe. In 1959 the average for all plants amounted to 3,860 hours, the respective totals for the public services and for private concerns being 4,050 and 3,300. In 1949 average utilization was 3,570 hours. The increase over the ten-year period is attributable mainly to interconnexion, with the resulting reduction of reserve capacity in percentage terms, to the diversification of consumption, to restrictions imposed at peak load hours, and to the increase of industrial consumption (in the last five years) which increases the load factors.

With respect to utilization by the two types of plant, in 1959 the hydro-electric public service plants worked an average of 4,740 hours, and the thermal plants 3,330 hours.

It can also be seen from the relevant tables that, as might be expected, in countries with systems supplied by both hydro-electric and thermal plants the degree of utilization is higher in the former; it is often double or triple that for thermal plants. With few exceptions, the main electricity systems of the region are based on hydro-electric plants whose installed capacity generally reflects the high level of hydrologic reliability of the rivers concerned. It is also common in smaller systems for the base load to be supplied by run-of-river hydro-electric plants, while diesel plants are available for peak hours and emergency situations.

/For a

For a given system, reserve capacity is defined as the available installed capacity in excess of maximum demand. In 1959, the average reserve capacity estimated for the main systems in the region was about 10 per cent. However, there is rationing in a number of systems and, as pointed out above, some of this reserve capacity is fictitious in that the nominal available capacity includes obsolete units that in practice are out of operation. Consequently the gap between the region's installed capacity and demand is dangerously narrow.

Chapter V

CONSUMPTION OF ELECTRICITY BY SECTORS

1. Distribution losses and net consumption

Of the 48,500 million kWh generated by the public utilities in Latin America in 1959, only 40,100 million were registered as forming part of the area's economic activities.[1/] The balance (17.3 per cent) represented losses, unregistered consumption and consumption by central generating plants. Since about 40 per cent of the power output of public utilities is thermo-electric power, none of which is lost in transmission, this aspect of the overall situation in Latin America is not very satisfactory.[2/] Moreover, it has been gradually deteriorating over the past few years, the difference in 1949 amounting to only 15.2 per cent of the power generated. (See table V-1.)

Losses and unregistered consumption are very high (over 22 per cent in 1959) in some countries, including Honduras, Nicaragua, Paraguay and Panama. There is even less justification for this in the countries concerned because output is based entirely on thermo-electric power in Paraguay and to a considerable extent in the other countries mentioned.

Considering that the main transmission and distribution losses vary in proportion to the square of the amperage, the power lost to consumption in peak load hours may very well exceed 20 per cent for Latin America as a whole, thus widening the gap between consumer demand and the power supplied.

The chief reason for this is the overloading of the networks and the defective construction of network expansions and extensions. This, in turn, is caused by:

1/ As no information is available on net consumption in Haiti, the Dominican Republic, British Guiana, the West Indies and Surinam, it is assumed that the percentage of losses is the same as for the rest of the area.

2/ For 1958 this percentage averaged 10 per cent in Europe and 8.2 per cent in the United States.

/(a) Lack

(a) Lack of overall planning for the technical and economically adequate development of each network;

(b) Lack of financial resources;

(c) Lack of technical standards or failure to meet them in the design and construction of distribution networks;

(d) Shortage of technical staff at various levels.

2. General observations on consumption by sectors

Analysis of electric power consumption by the various sectors which are part of a country's economic activities not only provides a better understanding of the differences in total consumption per unit of gross product in each country as a result of different economic structures, but also offers a basis on which to project future power requirements in line with overall economic development plans and assumptions.

The detailed examination which this question warrants is unfortunately precluded by the absence of basic statistics or by a lack of uniformity in such statistics as are available. There is, in fact, a difference in the way the countries concerned classify consumption (domestic, commercial, public lighting, transport, industrial, etc.).

For Latin America as a whole, the percentage distribution of the 50,100 million kWh consumed in 1959[3/] was approximately as follows: industry and mining, 55 per cent; household, 25 per cent; commercial, 7 per cent; public lighting, 2 per cent; transport and other, 11 per cent. This pattern of distribution has only changed slightly during the past ten years.

(a) Relationship between electric power consumption as an end use and the gross national product other than agriculture and mining

The combined total of household, commercial, public lighting and passenger transport consumption constitutes what might be called non-industrial urban consumption which, allowing for a tolerable margin of

3/ In the case of self-suppliers it is assumed that available data relates chiefly to consumption. Haiti, the Dominican Republic, British Guiana, the West Indies and Surinam, as well as plants with a capacity of less than 100 KW in Brazil, have been omitted for lack of consumption data.

error, represents electric power consumption as an end use or, more specifically, consumption which is related to available personal income. Granting this margin of error, which in practice can be as much as 10 per cent in arriving at electric power consumption strictly considered as an end use, the data available makes it possible to analyze the relationship between urban per capita consumption and income, the latter being determined by the gross national product other than agriculture and mining.

Unlike the industrial and mining sector, the domestic-commercial sector is the chief element of non-industrial urban consumption and is composed of a large number of consumers of the same type. This sector lends itself readily to the application of statistical analysis procedures the purpose of which is to reach findings applicable to under-developed countries, based on the experience of the more advanced countries. In studying consumption, however, the fact that for a number of purposes gas, kerosene, etc., is used instead of electricity and thus constitutes competition for the latter should be borne in mind.

The average 1956-58 figures for 32 countries, including 15 Latin American countries, serve as a basis for Diagram V-1 and the corresponding trend line which indicates an elasticity of 1.4 and a degree of correlation of about 0.80.

Of the Latin American countries appreciably below the trend line, Venezuela, Argentina and Peru - oil-producing countries - probably have a high consumption of hydrocarbons in the domestic, commercial and transport sectors which explain their low position in the diagram. It is nevertheless expected that these countries, as well as Paraguay, Guatemala, and Nicaragua will increase their consumption of electricity when supply conditions improve and thus follow the average trend in other countries in accordance with the corresponding urban income level.

(b) Relationship between industrial and mining consumption and the contribution of these sectors to the gross product

The industrial and mining sectors are generally the heaviest consumers of electricity in the various countries concerned. Of the 44 cases studied in Latin America and other regions, 33 (i.e. 75 per cent) showed an industrial and mining consumption of over 50 per cent of the total, consumption being more than 60 per cent of the total in 26 (50 per cent) of the countries concerned.

/Countries with

Countries with reduced industrial diversification may show a wide disparity in the relationship between electric power consumption and industry's contribution to the gross product. This disparity reflects the difference in electric power consumption required for unit production in each branch.

This observation notwithstanding, diagram V-II, indicating the per capita relationship between industrial and mining electric power consumption and their share of the gross national product expressed in 1950 dollars, was prepared on the basis of average data for 1956-58 in 24 countries, including 12 Latin American countries. Elasticity was low (1.27) and the degree of correlation was 0.90. This correlation and the one mentioned earlier relate to partial aspects of the broader process examined in diagram II-III which is based on a larger number of countries and shows a smaller loss rate.

Chile, Peru and Brazil are the Latin American countries often above the trend line. The mining industry is a heavy consumer of electric power in Chile and Peru, and consumption is high in Brazil because of its industrial development. Venezuela, which is very much below the trend line, shows that its most dynamic activity - petroleum - is not a large consumer of electric power per unit of production. The situation with respect to Argentina, Colombia, Panama, Honduras, Ecuador and Paraguay shows that in some cases their industrial and mining activities required a proportionally lower quantity of electric power and that in others there has been inadequate mechanization.

3. Non-industrial urban consumption

The total consumption of electric power supplied by public utilities in Latin America in 1959 was, as indicated earlier, 40,100 million kWh. Of this amount non-industrial urban consumption amounted to 24,500 million kWh, or 61 per cent. The urban population is estimated at 85 million and the average per capita consumption for that year was 289 kWh. Distribution of this consumption was rather irregular, as may be seen from table V-2 which shows a decreasing rate of consumption within the established groups.

/Only Cuba

Only Cuba and Venezuela are above the regional average in the first group and Costa Rica and Brazil in the second group. Costa Rica is far above the other countries in this respect as a result, inter alia, of its vast hydroelectric potential - in contrast with the shortage of other energy resources - and the vigorous electrification policy which it has instituted, particularly since 1949.

The percentage of this consumption represented by power supplied by public utilities shows a marked tendency to rise in a few countries, particularly in the 1949-55 period. These countries are Cuba, Argentina and Uruguay in the first group, Brazil and Mexico in the second group and Bolivia, El Salvador and Paraguay in the third group. Table V-4 gives an idea of the consumption by countries and its evolution over the years.

(a) Domestic consumption

This sector accounted for 56 per cent of non-industrial urban consumption[4/] in 1959, consuming a total of nearly 13,000 million kWh. (See table V-5.)

The growth rate during the past ten years has remained steady at an annual cumulative rate of about 11 per cent for the countries as a whole. In 1959 it amounted to an urban per capita total of 150 kWh, twice the amount consumed in 1949.

The share of the total represented by public utilities was 33.2 per cent, ranging from the highest - Costa Rica with 73.2 per cent - to the lowest - Mexico with 15.6 per cent. Compared with other uses, it is heaviest in the first years of economic development and decreases as the development process continues, to rise subsequently to great heights (as in the United States).

In a few major urban centres (Buenos Aires, Santiago, Bogota, Caracas, etc.), the availability of gas has been largely responsible for limiting household use of electricity. Kerosene has had the same effect in smaller cities. In cities such as San Jose and La Paz, where hydroelectric power is available and gas supply facilities are lacking, consumption of electric power for cooking and ironing, for example, is very high.

4/ Excluding public utilities in Brazil with an output of less than 100 KW.

/(b) Commercial

(b) Commercial consumption

While there is no standard classification of commercial consumption, it usually consists of commercial activities, including small industry and workshops. For rate purposes, this consumption begins when the contracts for the supply of electric power are signed.

This consumption amounted to 3,400 million kWh in 1959 for Latin America as a whole, indicating an annual growth rate of 9.4 per cent for the period 1955-59. Commercial consumption accounted for 9 per cent of the power supplied by public utilities, and a country-by-country breakdown shows a range of about 8 to 20 per cent.[5/] The general trend indicates a relative increase in this type of consumption.

(c) Public lighting

In some systems this includes not only public lighting proper but also consumption by government offices. Here too, as in other cases, the data is therefore not uniform. In 1959 this consumption amounted to 810 million kWh for the region as a whole, with a growth rate of 9.7 per cent in the 1955-59 period. Its share of the power provided by public utilities was 2.1 per cent. The consumption trend is slightly downward.

(d) Transport and other

Data relating to this sector also lacks uniformity. In any case, transport accounts for most of this consumption, the main branch of transport in this respect being passenger traffic. Suburban transport is also an important item in Brazil, Mexico, Argentina and Chile.

This consumption for Latin America as a whole amounted to 5,800 million kWh in 1959, the cumulative annual growth rate being 4.4 per cent in the 1955-59 period. Its share of the power supplied by public utilities was 15.1 in 1959. The consumption trend remains steady.

4. Industrial and mining consumption

Of the total electricity consumed, Latin American industry and mining accounted for about 27,500 million kWh in 1959 (56 per cent supplied by public utilities and the rest by self-suppliers). More than four-fifths

5/ A different classification system is probably used in Panama, where the rate is over 30 per cent.

/of this

of this total (81.2 per cent) was consumed by five countries - Brazil, Argentina, Mexico, Chile and Venezuela.

Electricity represented 54.9 per cent of the total Latin American power consumption in 1959. A country-by-country breakdown is indicated in table V-11. Some 65 per cent or more of the total electric power consumption is represented within each group by industrial and mining consumption in countries with greater manufacturing output or where export activities require heavy consumption of electricity. These countries are Peru, Chile, Bolivia, Honduras, Nicaragua and Venezuela.

The growth rate of industrial and mining consumption is higher than the average annual cumulative rate. It increased from 6.4 per cent in the 1938-59 period to 7.3 per cent in the 1949-59 period and to 9.8 per cent in the 1955-59 period. (See table V-12.)

A comparison shows that this growth rate exceeded that of manufacturing output, which showed growth rates of only 5.6 per cent in 1949-59 and 5.9 per cent in 1955-59.

In view of the fact that mining production - including iron, petroleum and sulphur - increased at an annual rate of only 5.9 per cent, both in the periods 1950-59 and 1955-59, the increased consumption of electricity in the past few years reflects the greater mechanization of industry and an increase in production by activities with substantial electric power requirements.

Diagram V-III shows the trend of industrial and mining electricity consumption in some countries per dollar of gross national product at 1950 prices. With the exception of Brazil and Chile, the curves show a marked increase in the consumption of electricity per unit of production.

On the other hand, the share of industrial and mining activities in the total electric power consumption by Latin America as a whole is declining as a result of the more rapid increase in electric power consumption as an end use. The figure has dropped from 65.6 per cent in 1938 to 62 per cent in 1949 and 54.9 per cent in 1959. (See again table V-11.)

/The pattern

The pattern of electric power consumption thus reflects the efforts of Latin American countries to achieve higher levels of living more rapidly than the rate of increase in industrial and mining production since the increase in output per kWh cannot make up for the decrease in the share of total consumption represented by mining and industry.

5. Share of public utilities in industrial and mining electric power consumption

Generally speaking, the share of public utilities in the supply of electric power to the industrial sector is determined by the amount of electricity they can provide. With the exception of Uruguay, where public utilities can meet the country's total electric power requirements, there is a system of self-supply in Latin America much of which could very well be replaced. In fact, only mining activities far removed from urban centres and some manufacturing activities which complete their industrial processes with thermo-electric power can be considered beyond access by public utility networks able to supply ample electric power at reasonable cost.

It is a fact that every measure taken in the Latin American countries within the past 20 years either to expand or reduce electric power supplied by public utilities has rapidly resulted in a reduction or expansion, as the case may be, of self-suppliers.

For Latin America as a whole public utilities supplied about 56 per cent of the total industrial and mining electric power requirements in 1959. This figure has remained fairly constant over the past five years (55 per cent in 1955) but has increased sharply over 1949 (only 46 per cent) in spite of the shortage referred to in chapter IV.

Chapter VI

MAIN ELECTRICITY SYSTEMS

The foregoing chapters contained a survey of the main features of the electricity economies of the Latin American countries. Attention was particularly drawn to regional and national characteristics.

In order the better to understand the problems affecting electricity development, the basic functional unit should be considered at greater length. The unit concerned is the electricity system determined by a certain pattern of demand localized geographically, supply for which tends to be met from a nucleus of inter-connected power stations.

There now follows a brief analysis of some of the main electricity systems in the different countries of Latin America, the purpose here being to illustrate, through a study of more or less representative examples, other aspects of the electricity industry in the area not so far dealt with in earlier chapters which are deserving of greater attention in view of their economic importance for the area.

These questions are:

(a) Distribution of electricity consumption within each country;

(b) Size of the systems and inter-connexions;

(c) Reserve capacity and percentage of hydraulic power used for that purpose;

(d) Degree of uniformity in:

- frequencies (number of cycles per second);
- transmission tensions;
- low tension distribution systems;

(e) Variations in price per kWh, etc.

The various systems may be broken down into their main component parts in the manner shown in tables VI-1, VI-2 and VI-3.

It should be pointed out that although the tables in general show per capita consumption figures above national and regional averages, there are certain high consumption areas which result from special causes. For instance, high consumption rates in São Paulo, Rio de Janeiro and Buenos Aires can be explained by the high degree of industrialization and the high income levels of the population served; high consumption

/in Caracas

in Caracas is due chiefly to high income levels and high consumption at Medellín and San Jose de Costa Rica to the extremely low price of electric power and the active encouragement given to its use for domestic purposes.

Buenos Aires also provides an illustration of how the severe restrictions on industrial and the household consumption which have been in force for the last ten years, can bring down consumption levels which would have been much higher in the absence of restrictions. Variations in the distribution pattern for consumption as between industry and households shows the relative importance attached to development in the systems considered. Special mention should be made of the Grupo Light in Brazil and the central grid system of Mexico, where the preponderance of industrial consumption is a reflection of the impressive industrial development of recent years.

There follows a summary of the conclusions which should be drawn after consideration of the aspects mentioned above.

1. Distribution of electricity for consumption within each country

The consumption of electricity (kWh/per capita) is very irregularly distributed within each country. While the main population centres and certain industries using high electrical input (mines, sugar factory, etc;) consume a large amount of power per capita, smaller towns and wide rural areas have no electricity for lack of means of supply or because demand is scanty and scattered. For instance, in 1959 there were areas where net consumption per capita was above 800 and up to 1,000 kWh per capita, while other large areas within the same country consumed less than 50 kWh per capita. (See figures VI-1 and VI-2.)

Within the principal systems, the distribution of electricity to different types of consumer does not differ very much in any instance from the pattern recorded for public utilities in general in each country. This is to be expected in view of the preponderant influence of electricity consumption over total national power consumption. It is, however, possible that, overall, there is proportionately a slightly higher incidence of electricity consumption as a final consumer good than as a factor in production. (See table VI-2.)

/2. Size

2. Size of electricity systems and inter-connexions

In many countries, the main electricity systems have developed in complete isolation round capital cities and other major towns. In other countries, however, this stage is already being passed. In this respect, Chile is in the forefront of the Latin American countries. The system known as the "inter-connected system" which already covers 6.5 degrees of latitude - and will later cover 12 degrees - included in 1959, 98 per cent of the installed capacity of public utilities and covered 96 per cent of their production. Throughout the system, large scale transfers of power occur using various, partly natural, hydrological systems and storage capacity throughout the country. In Uruguay, for its part, the Montevideo-Rincón del Bonete system accounted in 1958 for 94.2 per cent of power generated by public utilities, combining thermal generation in Montevideo with hydro-electric generation at the first power station at Rio Negro. In Brazil, the system serving the Rio de Janeiro and São Paulo areas which in 1959 already accounted for 56 per cent of power generation for public utilities in the country, is partially connected with the Sistema Paulista de Fôrça e Luz (State of São Paulo Power and Light System). Work is being carried out on the Furnas-Peixoto, Furnas-São Paulo and Furnas-Belo Horizonte lines, with a view to ensuring their inter-connexion with the Minas Gerais system (CEMIG) for the more efficient utilization of various water systems in the southern-central area of the country. This inter-connected system also includes thermal power stations, and it may within a few years boast a nuclear power station. This will lead to the concentration of approximately 65 per cent of consumption in the country.

The rate of growth of the systems considered is the same in each of the countries as it is for public utilities as a whole. There are, however, cases - such as Buenos Aires and Caracas - where the rate of growth is comparatively slower, and others - such as the central inter-connected system of Mexico, Bogotá and Montevideo - where it is higher.

/3. Reserve

3. Reserve Capacity

The reserve capacity of the majority of the systems considered tends to be in the neighbourhood of 10 to 20 per cent. As already stated several times, however, it should be stressed that this is a nominal figure based solely on power ratings. Such figures are frequently far from accurate as a result of wear and tear on equipment and because actual power in run-of-the-river power stations is usually lower. If account is taken of the rate of annual increase in demand, it is to be concluded that with few exceptions there are practically no reserves and this means that rationing is frequent particularly during peak hours; it is, however, applied by various different means.

As to supply, broken down by type of source, in most systems hydroelectric and thermal production are combined, with predominance of the former. Exceptions are Buenos Aires, Caracas[1/] and Guayaquil where electricity is generated purely by thermal means. In such cases the hydroelectric power stations would appear at the base of the load diagram, despite the fact that those which have storage facilities also operate at peak loads.

4. Frequencies

In Latin America direct current is to be found only on some small systems of slight importance, the use of alternating current being more usual.

In the majority of the Latin American countries, some systems operate on 50 cycles per second and others on 60 cycles. This is a serious problem which not only affects users as a result of the changes they have to make to their electric appliances and equipment when moving over from one system to another, but is also a grave hindrance to the connexion of systems between themselves. As time goes by, this problem will become more serious and harder to resolve. Failure to deal with it immediately will seriously restrict the integration of networks, with all the economic consequences resulting therefrom.

1/ In Caracas electricity is produced hydroelectrically on a very small scale and the service is being suspended at least in part.

/In Brazil

In Brazil and Venezuela this factor is already a heavy burden on the electrification plants. In both countries 60 cycles has been adopted as the standard frequency. In the meantime, while the frequency standardization is being carried out, some generating units capable of operating at both frequencies have had to be installed in the main systems, which operate at 50 cycles. This increases the cost of generation.

5. Transmission voltages and low utilization voltages

The great range of high voltages used in the various countries, and even within single systems (with some exceptions) makes any attempt at classification pointless. Low utilization voltages also vary considerably.

Although neither of these problems is as serious as differences in frequency, standardization should be introduced in each country by means of interchangeable parts and reduction of spare part inventories, and in the region as a whole, by standardizing industrial production.2/

6. Price of electricity

With the inflation that has prevailed in varying degree throughout Latin America in recent years, electricity prices have gradually increased, but only slowly, and substantially less than the prices of most other goods and services. This has considerably weakened the financial position of many electricity enterprises, and consequently has reduced any possibility of expanding the systems they operate.

Calculation of the ratios between the average kWh price indices and the cost of living for 1959 (100 = 1938 or some other year for which the relevant information is available) gave value of much less than unity for the systems examined (with one exception). This indicates how far electricity prices have lagged behind others over the years in Latin American countries (see table VI-4).

To show the possible margin of substitution of other fuels by public service electricity in certain industrial activities, table VI-4 gives for each of the various systems the average price equivalent for

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2/ See International Electrotechnical Commission (IEC) publication N° 38, IEC standard system voltage.

/the industrial

the industrial consumer of 1,000 kWh in terms of coal or petroleum derivatives. The figures lack consistency as between systems even within one country. This indicates the lack of uniformity in, where there is not a complete absence of, a national price policy for the power sector and for its various components.