11765

UNITED NATIONS

ECONOMIC AND SOCIAL COUNCIL

GENERAL
E/CN.12/373/Rev.1
12 July 1955

ENGLISH
ORIGINAL: SPANISH

ECONOMIC COMMISSION FOR LATIN AMERICA
Sixth Session
Bogota, Colombia
29 August 1955

A SUMMARY OF THE PRELIMINARY REPORT ON THE DEVELOPMENT OF ENERGY PRODUCTION AND UTILIZATION IN LATIN AMERICA - POSSIBILITIES AND PROBLEMS

NOTE: This is a summary of a full report being prepared by the secretariat for publication at a later date. The text and statistics must be considered as provisional and are subject to subsequent revision.

TABLE OF CONTENTS

/CHAPTER VI.

INDEX OF TABLES

INDEX OF CHARTS

/EXPLANATION OF

EXPLANATION OF SYMBOLS

The following symbols have been used throughout this report:

Two dots (..) indicate that data are not available or are not separately reported

A dash (-) indicates that the amount is nil or negligible

A minus sign (-300) indicates a deficit or a decrease

A full stop (.) is used for decimals

A comma (,) is employed to distinguish thousands and millions

References to "tons" indicate metric tons, and to "dollars" United States dollars, unless otherwise stated

Minor discrepancies in totals and percentages are due to rounding.

/CHAPTER I

CHAPTER I

THE SETTING OF THE PROBLEM

Energy in its commercial form is not only a component of the productive process but represents a fundamental element in general welfare. Consequently, it is very suitable that at the outset a distinction should be drawn between energy which reaches the community directly as a consumer service and energy which is used as a factor of production.

Direct consumption of energy by the public depends, as do most other consumer goods and services, upon available per capita income and the nature of its distribution. Since energy is a vitally important element for which no substitute can readily be found, its demand is so dynamic that to some extent it may be compared with foodstuffs; the income-elasticity is low at very reduced levels of consumption, rising sharply at intermediate levels and again contracting at the highest levels, where consumer needs tend to reach saturation point.

In addition to the direct consumption of energy by the public, urbanization increases the indirect demand through services rendered on a collective basis.

Among rural population of an under-developed economy, much of the energy consumption has the character of a self service. The demand for common services is small and the utilization of energy in its commercial form is also limited. During the process of development, when the rural population migrates to the cities, wuch shifts tend to add to the market for energy, causing a two-fold process: a relative reduction in the consumtpion of non-commercial fuels and an expansion in the demand for commercial energy.

Despite its importance as a consumer service, energy may be more profitably studied as a production factor in the context of development. Briefly, economic development represents an increase in the average productivity of the labour force. Such increase is directly influenced by the amount of energy which man is in a position to incorporate into the productive process and by the ways in which he does so.

/The volume

The volume of the energy consumed in the productive process, per gainfully-employed person, may provide a first indication of the degree of development of a given economy. But it is much more limited as a measure of the rate and characteristics of that development, because it ignores the basic fact that, as efficiency in the use of energy improves, technical progress permits increased productivity per unit of energy and enables the availability of energy to be expanded through a diversification of the sources of supply and their use over ever-increasing distances.

During the early stages of development, when mechanization begins to penetrate agriculture and transport, and the process of substituting manufacturing activities for those of an artisanal nature reaches its greatest intensity, the consumption of energy per gainfully-employed person tends to rise sharply. This increase partially conceals the substitution of modern forms of commercial energy for animate energy and vegetable fuels, not computed statistically. The substitution is generally sufficiently intense to cause an increase in the consumption of inanimate energy both per unit of product and on a per capita basis. In the subsequent stages, continued technical progress enables energy to be used in an increasingly efficient form, for which reason the consumption of energy per unit of product tends to decrease. Nevertheless, this effect may be offset by the simultaneous industrialization and diversification of the economy, which imply a greater consumption of energy per unit of product than in the previous stage of development.

It is, however, a characteristic of under-developed countries that technical progress only partially penetrates the economy. In summary, this phenomenon reflects the shortage of investment resources and, during the intermediate stages of development, leads to a situation where, rather than replacing equipment which is technically out of date, more modern equipment is added to the old, which continues to be operated until its physical exhaustion is well advanced. 1/ The resulting heterogeneity of techniques

1/ Out-of-date equipment may be used in industries which are less advanced or in areas where development has made less progress and where marginal increases in productivity even justify the use of such equipment. In this way, outmoded equipment can still be useful, although only in sectors of the economy where they represent a relatively maximum efficiency.

/in the

in the productive system, in these cases, leads to greatly reduced efficiency in the final use of energy when compared with more advanced economies.

The foregoing conclusion has wide practical scope, since it implies that the demand for energy as a production factor increases more rapidly for a given rate of growth at the stage of development now reached by the principal Latin American countries than at the stage attained by nations with a more mature economy. The relative waste of energy in Latin America, to which many references are made in this study, should to some extent be considered as a characteristic phenomenon of the stage of development in the region. Nevertheless, it would be wrong to conclude that such losses are entirely without a remedy. On the contrary, efficiency in the use of energy can be improved and losses can be curtailed by a wide dissemination of suitable techniques.

To summarize the preceding paragraphs, energy consumption as a production factor tends to expand comparatively rapidly during the intermediate stages of economic development. Among the main causes of this greater demand for energy are: a) the replacement of animate by inanimate forms of energy, particularly in transport and to a lesser degree in agriculture; b) the way in which techniques permeate the economy by the juxtaposition of new and technically obsolete equipment, 2/ causing lower efficiency in the use of energy when compared with economies making use of more up-to-date and homogeneous technologies; c) the growth of industrialization which involves the introduction of activities with a relatively greater consumption of inanimate energy per unit of product.

Hence, if it is borne in mind that at this same stage of economic development the demand for energy as a consumer service presents a relatively high income-elasticity (as noted earlier), it will readily be understood how the combined effect of both factors contributes to substantial increases in the demand. This is also the reason for the high pressure which the energy sector exercises upon the capacity for investment during the stage of development now reached by most of the Latin American countries.

2/ This is principally because of the desire to use fixed capital intensively, irrespective of excessive surcharges on current expenditure.

/Three fundamental

Three fundamental characteristics are revealed by a more direct examination of the problem arising from the interdependence of the energy supply and economic growth. The first of these represents the fact that energy is a fundamental service, that is, of universal use. The second is that, in contrast to manpower - with which energy has much in common and which is replaced or whose efficiency is increased by use of energy - the relative prices of energy tend to decline as investment progresses. The third characteristic is the high density of capital per unit of product.

Taking into account these three characteristics - universal use, decline in relative prices and high capital density per unit of product - it is clear why the energy supply becomes more and more a public utility. Furthermore, the availability of inanimate energy is more important to the entrepreneur than its cost, because energy becomes an indispensable element in production, without its incidence on industrial costs necessarily tending to rise after a certain stage. 3/

The preceding paragraph distinctly shows the strategic importance of the energy supply for economic development. An increase in its supply is almost always a pre-requisite for the economic use of new investments in the other productive sectors. On the other hand, if investment in energy lags behind and the supply of this service becomes inelastic, it is almost certain that idle capacity will develop in the other sectors of the economy. The existence of reserve capacity in the energy sector is thus a pre-requisite for development to continue with a minimum waste of capital, which represents the scarcest factor.

Considering that, at the present stage of development of most of the Latin American countries, the demand for energy grows particularly strongly and that its supply fills a strategic role in all phases of economic development, the conclusion is inevitable that a dynamic policy in the energy sector is of prime importance for accelerating the rate of growth. It is equally evident that the chronic shortage of energy which exists in many countries of the region today represents a deterrent to economic growth.

3/ It would be extremely interesting to study in detail the complex process of substitution of mechanization for manual labour - a process in which economic, technological and social factors all play a part.

/To formulate

To formulate an adequate development policy for the energy sector, it must be related to the framework of a general policy for economic growth. In reality there would be little value in drawing up a programme to expand energy supplies without basing it upon a hypothesis of the available aggregate resources for all activities of a given country.

In addition to some hypothesis concerning the over-all growth of the economy, every energy programme presupposes an approximate knowledge of the structure of the demand for energy, both as a consumer service and as a production factor, and must take account of probable modifications in that structure, determined by its own development. This initial general plan should be completed by another which pays due regard, firstly, to the probable geographic location of the productive activity and of the population, as well as the latter's distribution into urban and rural groups. Secondly, a reference must be made to the location of alternative sources of energy which may exist in the area, provided these are of major importance from the point of view of their possible economic use.

A study of energy in a national or regional economy is thus bound up with much wider problems. It is nevertheless essential to begin from the bottom and work upwards, because a general study of economic development demands a prior knowledge of the potentialities of the region and of the conditions in which the system is operating, particularly as regards the infra-structure. The aim of this report is to contribute towards a preliminary statement of the possibilities of developing energy in Latin America, an indispensable condition for the establishment of an effective development programme for the economies of the region.

Broadly speaking, although at times in a very provisional form, the report attempts to cover the following points:

1. A diagnosis of the present situation based on an analysis of the behaviour of the energy sector during the last few five-year periods, or wherever possible over the last quarter-century. One of the main aims of this diagnosis is to focus attention upon the deficit which exists in the energy supply and upon the inadequate use of energy in different activities, and to stress the consequences from various points of view, such as: a) a reduction in the rate of growth, b) the degree of prosperity compatible with

the level of income, c) insufficient use of productive capacity and d) the rise in production costs.

2. With the experience of the recent past in mind, and in view of the need to combat under-consumption and the low efficiency achieved in the utilization of energy, as revealed by the diagnosis - with the help of certain assumptions as to future development [4/] and the trend of relations between the latter and the energy sector, as well as within that sector itself - an attempt has been made to prepare a few preliminary projections of the energy demand for a number of countries and for the whole region over a relatively short period (ten years). These projections - presented here for strictly illustrative purposes - take into account the possibilities of substitution between the different sources, the relative independence of the demand for electricity and for certain liquid fuels, etc.

3. Once the potential demand is known, the possible sources of supply should be studied. The available sources of energy are known to be to some extent a reflection of the possibility of their own use, because their expansion demands substantial investment which is not always justified if their immediate use is not in sight. An assessment of the sources on the basis of past experience is thus of limited scope; nevertheless, knowledge gained from this experience may suffice to indicate the lines of an exploratory policy aimed at developing new sources or at enlarging known supplies. A better utilization of these sources of energy is also pertinent as regards extraction, processing and transport as well as the final use for the production of goods and services. Greater efficiency at any of these stages is equivalent to raising available energy reserves in the same proportion as the efficiency is increased.

4. On the basis of demand forecasts and of an analysis of the potential of internal sources, it remains to be seen how the demand can be met through a combination of greater domestic production and imports. While the first is derived, mainly, from the type and wealth of national energy reserves, the second depends upon the anticipated capacity to import. The way in which

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4/ In this case and elsewhere in the text, reference is made to hypotheses, the methodology of which is explained in document E/CN.12/363, Analyses and Projections of Economic Development. I. Introduction to the Technique of Programming.

/the three

the three variable factors - demand, imports and the potentialities of domestic sources - may be combined to arrive at the most important point, namely production policy, is a problem which must be resolved in each specific case and always provisionally, and must consequently remain a matter of permanent study. It should not be forgotten that there is always more than one possible solution for the problem of the domestic energy supply and that this will be difficult to attain without a certain degree of arbitrariness. The advantage of a study of this nature is that it enables alternative solutions to be advanced, while changes can be made to the initial decisions without wasting more time or resources.

5. Once the targets for domestic productions have been defined, and once imports compatible with forecasts of the capacity to import, as well as the percentage of the latter which can be used for fuels have been established, the next step is to evaluate the resources required for investment in this sector. The results of this assessment must then be compared with the aggregate investment resources for economic activities as a whole. From this analysis a calculation must be made of the share of investment to be met with foreign exchange. Finally, these results provide a means of studying the alternative methods of financing capital investment.

The first point is of particular interest as a method of checking the changes which would have to be introduced in the channelling of investment. For example, if the projections show the need for a substantial increase in the rate of the net investment which is currently being made in the energy sector, an idea will be obtained of the effort which must be made to modify the composition of the investment. The second point refers to the share of foreign exchange in aggregate investment and raises the question of substituting materials and equipment of domestic origin for similar imports, or of replacing services from abroad with those paid for in national currency, a problem which requires the framework of an over-all programme for its adequate solution.

Finally, the methods of financing investment must be studied in close connexion with the costs of the services and with price policy. The basic problems in an over-all development programme are the rate of saving and the magnitude of the available external resources. But in special programmes

- such as energy for example- the significance lies with the specific problems of the origin of the resources to be used for investment, and the contribution of international credit institutions is a subject which is often raised.

Price and taxation policies both serve to absorb investment resources and to influence the structure and the level of demand. Any measure affecting the relative costs of the various forms of energy must be considered from this two-fold aspect. Moreover, such costs almost always have indirect repercussions upon the balance of payments.

The points summarized above suggest the scope and the limitations of this report. It should be considered as a preliminary exploration in the complex field of the connecting links between the problem of energy and the broader question of over-all economic development. The problems presented here clearly show the need to continue with more detailed research and to integrate even further the study of the varied and complicated aspects of energy with the analysis of those other questions which, in the many different sectors of economic activity, arise for the Latin American countries at their present stages of development.

/CHAPTER II

CHAPTER II

RECENT DEVELOPMENT OF ENERGY CONSUMPTION

1. Relative position of the region

The shortage of energy is among the major obstacles hampering economic development in Latin America. The relative under-consumption of energy is one of the expressions of economic under-development and is reflected in the fact that the total per capita consumption is less than one-third of that of the countries of the world as a whole. Differences are also observed, albeit not so great, in the consumption of energy per unit of gross product. The exclusion of the United States from the aggregate world figure somewhat improves the relationship, which, however, continues to be greatly unfavourable to Latin America. It is nevertheless worth noting that the region's position in energy consumption is superior to that of other under-developed areas.

The significant fact, however, is not so much the relative under-consumption 5/ - a phenomenon which is widespread and, as mentioned above, is linked to general economic under-development - as the rates of growth. These were relatively intense during recent periods for commercial energy and satisfactory for the total consumption, which rose between 1937 and 1952 from 43.7 to 77.1 million tons of petroleum equivalent. 6/ The annual per capita rate of increase was 1.62 per cent. During the same period the generation of electricity rose from 11.3 to 32.1 million kWh, representing an annual per capita growth of 5.0 per cent.

Comparatively speaking, the consumption of energy in Latin America, during the period under consideration, shows an appreciable improvement. It should not be forgotten, however, that comparisons of this nature with certain other regions are adversely affected by the direct and indirect

5/ In addition, in order to measure under-consumption it is necessary to select the levels of comparison and to define the quantum of consumption considered adequate. (See below in this chapter.)

6/ At the stage of gross energy consumption. (See chapter V.)

/influence of

influence of the war on their consumption of energy. However, it may be shown that *per capita* energy consumption increased in Latin America at a rate very similar to that of the United States, thus maintaining the gap in consumption which prevailed in pre-war days. With due regard to the intense rate of development which took place in the United States in recent years, this indication is still favourable to Latin America.

Simple numerical comparison, in addition, often embraces profound differences in processes. Thus, for example, passage from an agricultural economy to one of a more diversified industrial type implies increases in the consumption of energy per unit of production, but this becomes stationary and later begins to diminish when, at a higher level of economic development, technological advances allow a saving of energy greater than the increase resulting from the expansion of production. Nevertheless, it is significant that, taking figures for the year 1952, the *per capita* energy consumption in kilogrammes of petroleum equivalent was approximately 6,000 in the United States, 2,500 in Western Europe and 500 in Latin America. *Per capita* electricity production in the same year amounted to 2,900, 1,000 and 200 kWh respectively.

The rates of increase mentioned above refer to aggregate consumption and therefore include both commercial and more primitive forms of energy. But, in reality, the statistics dealing with the latter are insufficient and exclude animate forms of energy from the calculation, 7/ which are difficult, if not impossible, to express quantitatively. Their replacement by commercial forms may be inferred indirectly, but since this phenomenon appears with variable, though generally high, intensity, the increased consumption of these commercial forms must be relatively greater in Latin America.

7/ The replacement of animate energy is largely imposed by development itself, which induces mechanization, but it may also reflect special situations caused by exchange policy or other factors. It may result in a more rational utilization of the factors as a whole, with a more economic use of land formerly devoted to the upkeep of animals, although this optimum result is not always achieved. It will be seen how problems of this nature, if they are to be viewed in proper perspective, presuppose an over-all analysis of the development process.

/Table 1

Table 1

LATIN AMERICA: AGGREGATE ENERGY CONSUMPTION, 1929, 1937 AND 1952

Year	Petroleum	Coal	Hydro-electricity	Vegetable fuels	Total	Electricity
	(Millions of tons of petroleum equivalent)					(Millions of kWh)
1929	9.3	6.1	1.6	-	-	8,230
1937	11.7	6.2	2.4	23.3	43.7	11,292
1952	38.[illegible]	5.8	7.3	25.3	77.1	32,062

Source: Economic Commission for Latin America, Energy Division.

This may partly be corroborated when it is observed that the consumption of commercial forms of energy has grown in Latin America since pre-war days twice as intensely as aggregate consumption. The annual rates of growth were 6.4 and 3.8 per cent respectively. On a *per capita* basis the rates are 4.1 and 1.62 per cent. In relation to aggregate consumption commercial energy represented 47 per cent in 1937 and 67 per cent in 1952.

Between 1929 and 1952, the gross consumption of commercial energy grew at an annual rate of 4.9 per cent, representing an annual cumulative *per capita* rate of 2.8 per cent.

It is interesting to note that the difference in relative growth and the intensity of the substitution process appear greater in that group of countries 8/ which still show a low consumption of energy, both as an aggregate and on a *per capita* basis. In this group, the consumption of commercial fuels rose between 1937 and 1952 at a rate of 8.3 per cent, while the total consumption of fuels increased by 3.6 per cent.

The figures given in this report take no account of the degree of efficiency in the utilization of energy, which varies from one economy to another or between different development stages. The growth of the gross product may be coupled with variations in the useful consumption of energy, depending upon whether efficiency in the use of energy is static, increasing or diminishing.

8/ For countries in this group, see table 3 group III.

/In the

In the foregoing paragraphs, reference has been made to inequalities in the total consumption of energy as between Latin America and the more developed countries. The same phenomenon is found in industrial activities, since these are still mainly light industries in Latin America and their mechanization is low.

In Latin America's industry it is easy to see that mechanical and electrical power, as well as the use of fuels and electric energy, are much lower than in the United States and to a smaller extent below those of Europe; consequently production per worker or per man-hour is also low. The various coefficients vary between one-fourth and one-half.

It is clear from the preceding discussion that, despite the existence of a considerable difference between energy consumption in Latin America and in more industrialized countries, there are encouraging signs that in recent periods the rate in the former has been increasing. Rates of growth during these years, as well as the product-elasticities for the consumption of energy and electricity, are valuable starting points for preparing projections of future supply needs, which are studied in chapter III. Thus an analysis of the trend of net energy consumption per unit of product in certain Latin American countries shows that, as a general rule and with slight variations of short duration, the tendency is to maintain a constant ratio, which is around unity. (See charts I, II and III.) An exception may be quoted in the case of Chile in the decade from 1923 to 1932, which was marked by basic changes in the structure of the system - there was a significant reduction in the relative importance of the export sector, characterized by a high consumption of energy per unit of product - and the case of Colombia in recent years, where there has been a strong downward tendency. With the above exceptions, the greater efficiency apparently achieved through equipment which is technologically more modern is being offset by the greater consumption of new forms of energy and by the reduced efficiency of worn-out equipment still in operation.

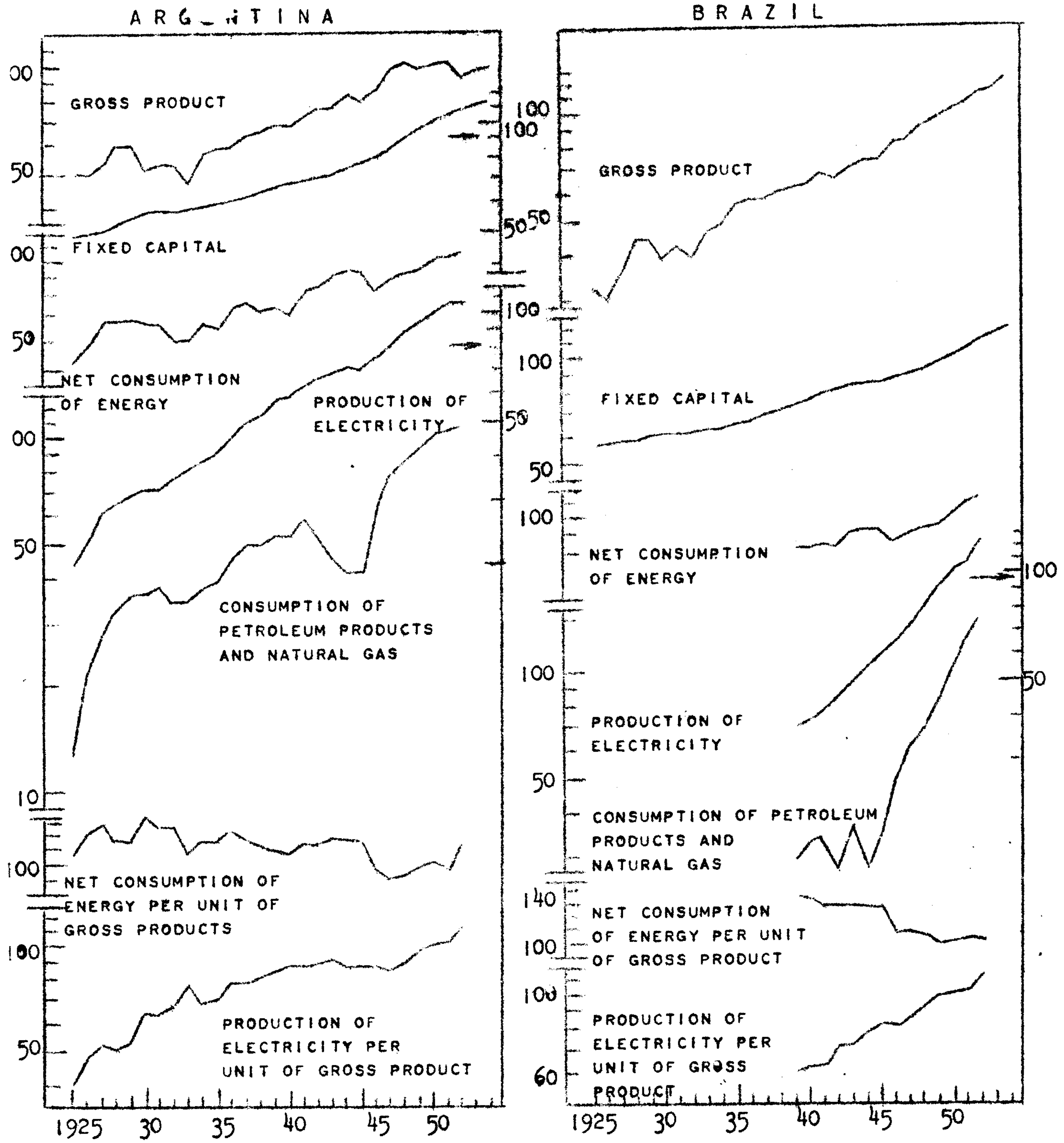
/Chart I

CHART I

VARIATIONS IN THE GROSS PRODUCT, FIXED CAPITAL, ENERGY CONSUMPTION AND THEIR INTERRELATION

INDICES 1950 = 100

(SEMI-LOGARITHMIC SCALE)



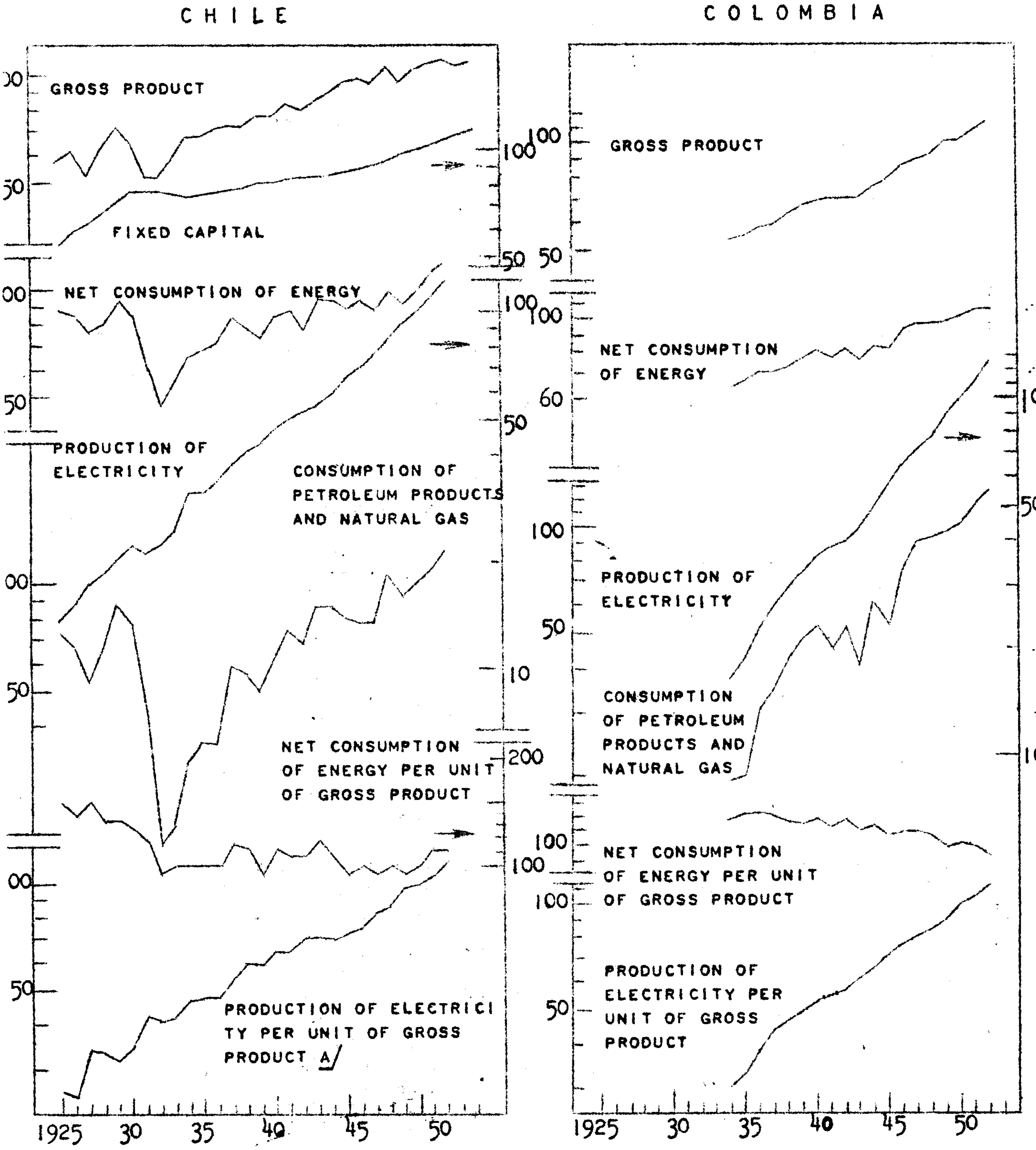
/Chart II

CHART II

VARIATIONS IN THE GROSS PRODUCT, FIXED CAPITAL, ENERGY CONSUMPTION AND THEIR INTERRELATION

INDICES 1950 = 100

(SEMI-LOGARITHMIC SCALE)



A/ EXCLUDING ELECTRICITY GENERATED PRIVATELY BY THE LARGE EXPORT MINING COMPANIES

/Chart III

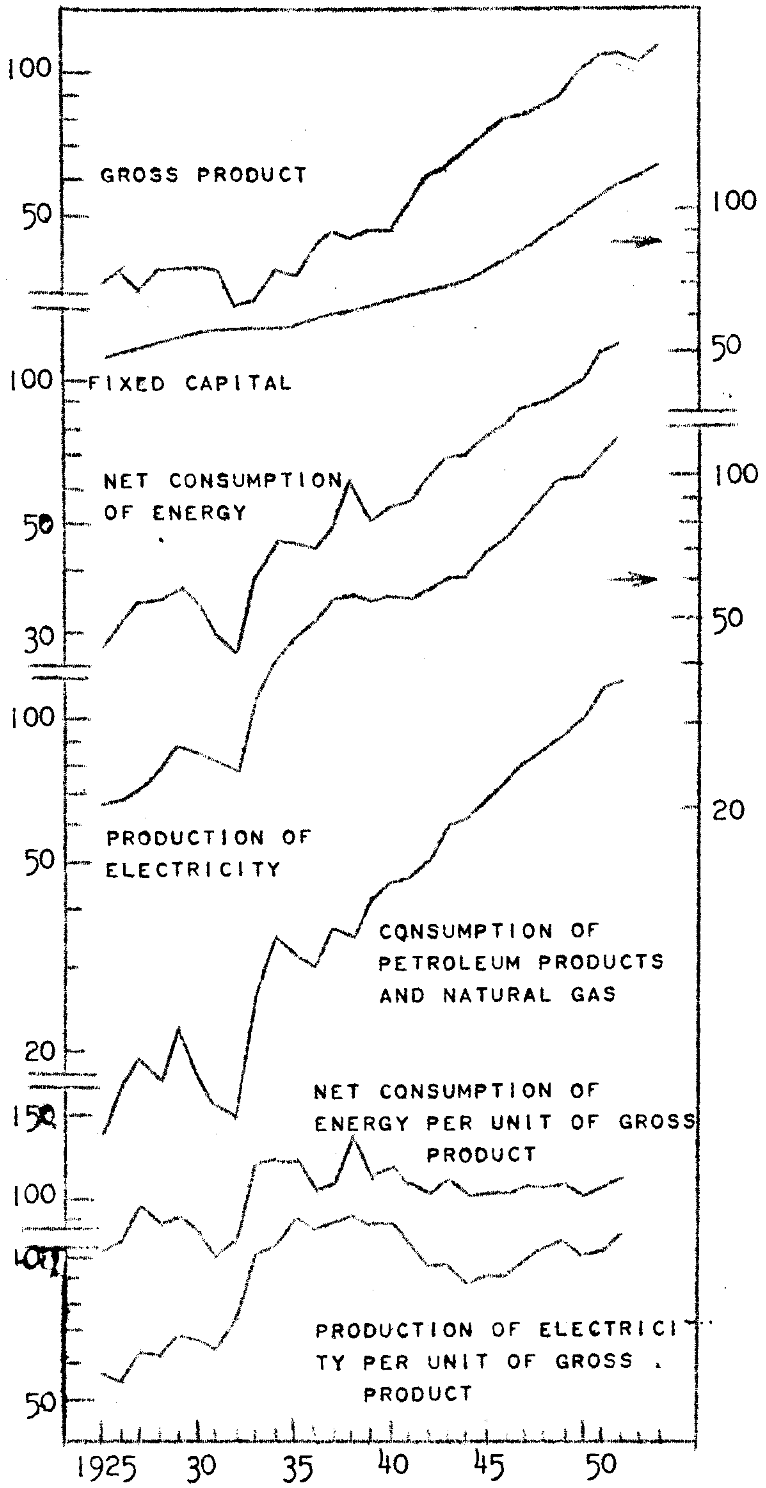
CHART III

VARIATION IN THE GROSS PRODUCT, FIXED CAPITAL, ENERGY CONSUMPTION AND RESULTANT RELATION

INDICES 1950 = 100

(SEMI-LOGARITHMIC SCALE)

MEXICO



/Consequently,

Consequently, there is no indication among the Latin American countries of the tendency typical of the industrialized countries and clearly displayed in the United States, where the energy input per unit of product increased up to the First World War and has been regularly decreasing at an approximate rate of 1.6 annually in the ensuing decades. The decrease reflects the progressive increase in efficiency of energy utilization rendered possible by technical progress, of which full advantage is not taken in Latin America.

Interesting conclusions may also be drawn from a study of the relations between *per capita* energy and electricity consumption and the *per capita* product.

High correlations are found for the countries analysed in the case of electricity with variable elasticities according to the countries. 9/ For net energy consumption the elasticity is around unity for all countries studied.

To ascertain the relations becoming established between energy consumption in various forms and the gross product, the relevant data were also studied for some fifty countries within and without Latin America, taking the average for the years 1949 to 1951. (See charts IV and V.)

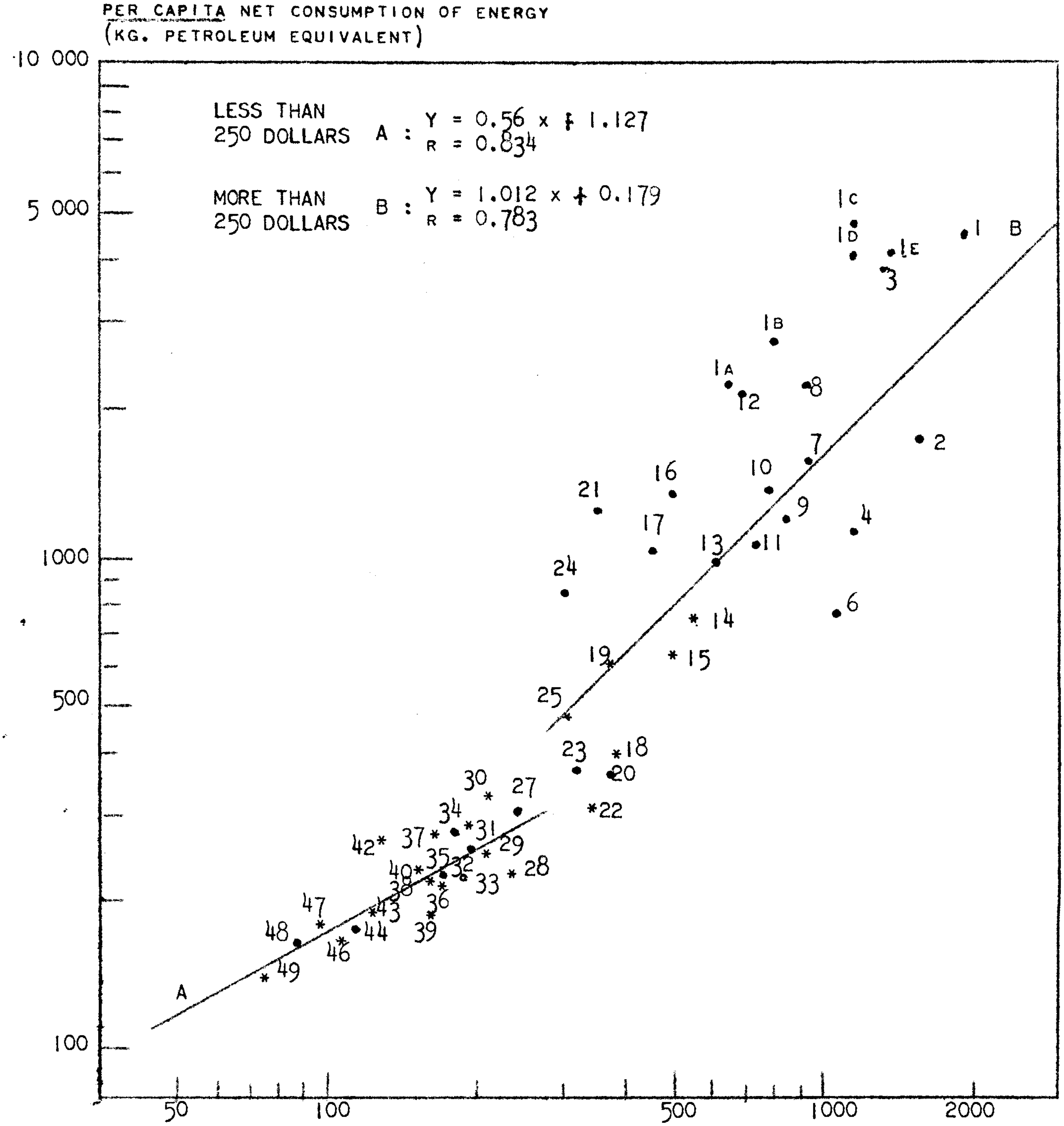
The following conclusions were drawn:

a) The unit-consumption of energy is linked with the *per capita* product and the structure of the economy. There is a satisfactory correlation between energy and electricity consumption *per capita* and the gross *per capita* product; it is a correlation which becomes even better if the active population only is considered, instead of the total population. For *per capita* energy consumption, in particular, the regression line seems to be a curve. To simplify in the present study two straight lines were calculated instead: one below and the other above 250 dollars *per capita*. It can be seen that the product-elasticity for countries with low *per capita* product is much lower than for the other group (see chart IV).

9/ Argentina, 2.28; Brazil, 2.77; Chile, 3.76; Colombia, 3.75; Mexico, 1.61 (United States 2.60).

/Chart IV

CHART IV
CORRELATION BETWEEN PER CAPITA NET CONSUMPTION OF ENERGY AND *PER CAPITA* GROSS PRODUCT
AVERAGE 1949 - 51
(LOGARITHMIC SCALE)



NOTE : FOR THE ORDER OF THE COUNTRIES SEE SEPARATE LIST.
THE COUNTRIES NUMBERED 5, 26, 41, 45, 50, 51, 52 AND 1A, 1B, 1C, 1D, 1E, ARE EXCLUDED FROM THE CALCULATION OF THE CORRELATION
* LATIN AMERICAN COUNTRIES

/ORDER OF

ORDER OF COUNTRIES CHARTS IV AND V

1	United States	27	Yugoslavia
2	Australia	28	Costa Rica
3	Canada	29	Colombia
4	New Zealand	30	Mexico
5	Israel	31	Brazil
6	Switzerland	32	Turkey
7	Sweden	33	Greece
8	United Kingdom	34	Portugal
9	Denmark	35	Egypt
10	Norway	36	Guatemala
11	France	37	Dominican Republic
12	Belgium and Luxemburg	38	Honduras
13	Netherlands	39	Nicaragua
14	Venezuela	40	El Salvador
15	Argentina	41	Japan
16	Western Germany	42	Peru
17	Ireland	43	Ecuador
18	Uruguay	44	Ceylon
19	Cuba	45	Southern Rhodesia
20	Spain	46	Bolivia
21	Finland	47	Paraguay
22	Panama	48	Thailand
23	Italy	49	Haiti
24	Austria	50	India
25	Chile	51	Northern Rhodesia
26	Union of South Africa	52	Belgian Congo

1A	United	States	(1889/98
1B	"	"	(1902)
1C	"	"	(1918)
1D	"	"	(1930)
1E	"	"	(1940)

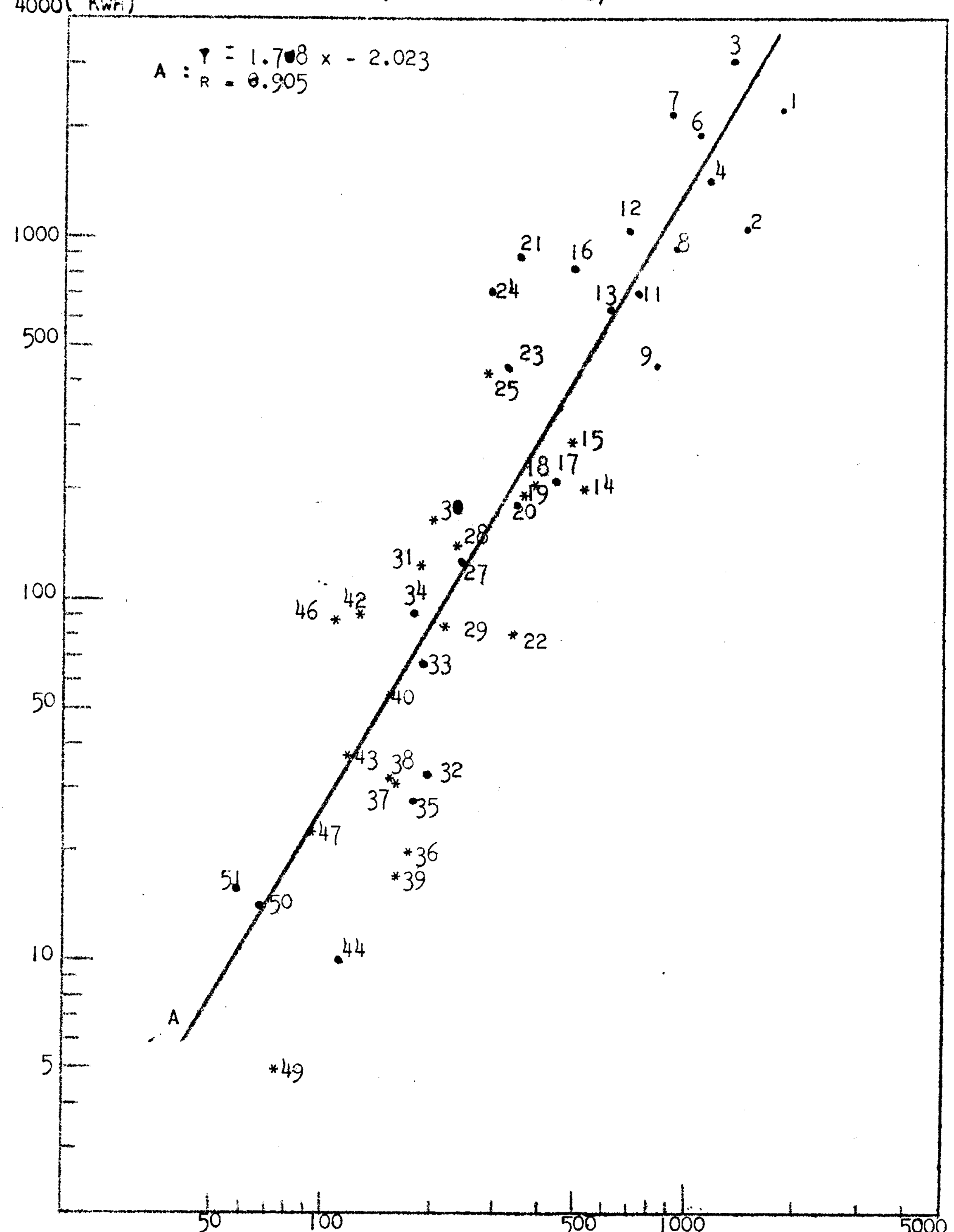
/Chart V

CHART V

CORRELATION BETWEEN PER CAPITA CONSUMPTION OF ELECTRICITY AND PER CAPITA GROSS PRODUCT

AVERAGE 1949 - 51

(LOGARITHMIC SCALE)



NOTE : FOR THE ORDER OF THE COUNTRIES SEE SEPARATE LIST.
THE COUNTRIES NUMBERED 5, 10, 26, 41, 45, 48, 52 ARE EXCLUDED FROM THE CALCULATION OF THE CORRELATION
* LATIN AMERICAN COUNTRIES

/b) At

b) At one and the same level of <u>per capita</u> product there are strong variations in <u>per capita</u> energy consumption under the influence of a great number of factors, such as economic structure, income distribution, and so forth, none of which by itself is decisive. The most important, however, is the composition of the product and in particular the proportion of industrial output to the total.

c) Notwithstanding the correlations found, considerable disparities are observed, which are greater in regard to electricity than to total energy. Such irregularities are linked with the energy consumption per unit of gross product, which varies widely from country to country. The Latin American countries with the lowest unit consumption of total energy are Panama, Uruguay and Argentina, with a little less than 1 kg. of petroleum equivalent for each dollar of gross product, at 1950 prices. Peru reaches a value of 2.0 and Chile, Cuba and Mexico of 1.50. For electricity, the unit consumption varies from 0.07 kWh per dollar of gross product at 1950 prices for Haiti to 1.40 for Chile.

d) Consumption per unit of product by countries of low and relatively low gross product (up to 250 dollars approximately) is more uniform than in those with higher product. The reason is that, so far as total energy consumption is concerned, differences of economic structure carry more weight in countries with high income levels than in those where income is low.

e) On the basis of the relation between over-all energy and electricity consumption and the gross product, and of comparisons between the relative situation in the different countries, projections of future needs may be made with reasonable accuracy.

2. <u>Consumption characteristics in accordance with types of economy</u>

It should not be overlooked that the statistics of energy consumption comprise two elements with highly diverse characteristics: energy as a consumer service, utilized by the population, and energy incorporated in the productive process. Available data permit of only summary analyses, based on this distinction. But there is every indication that the demand for energy for direct or indirect consumption is greatly influenced by the development

/of urbanization

of urbanization (the urban consumption of electricity per town-dweller in important centres is many times greater than consumption in less-urbanized regions). This phenomenon is especially intense in some areas, such as Sao Paulo, Rio de Janeiro, or Greater Buenos Aires. Nevertheless, in the majority of Latin American countries, mining and transforming industries absorb a greatly increased share of the total consumption of electricity (between a half and two-thirds). Consumption per employed person is also much higher there in comparison with urban (total minus industrial) consumption (between 7 and 12 times in countries like Argentina, Brazil, Chile and Mexico).

It is clear from the foregoing that at the stage of development which, by and large, has been reached by Latin American countries today, the rate of increase in the demand for energy is particularly high. The growth of the population in many countries, which in earlier times was absorbed by extensive agricultural activities, is now being absorbed by industrial activities and their connected services, and becoming concentrated in urban centres, thus raising the unit and total consumption of the latter. This new form of development calls for intensification of investment per person employed, and as a result of heavy demands for social capital, it brings in its train a reduction in the average productivity of capital. In such cases it is important that the supply of energy, as a factor in production and urban consumption, should grow faster than the product. The need for meeting the growing demand, together with building capacity in advance of future expansions of the country's requirements, is reflected in a reduction in the economic productivity of energy. 10/

The amount of energy which a given economy absorbs to generate one unit of product is not correlated solely with its degree of development, but depends also on the characteristics of the latter. An economy which enjoys exceptional land and climatic resources (Group I), provided that it succeeds in fully using those resources by expanding its foreign trade, may achieve a very high product per unit of energy consumption as a production factor

10/ Such productivity is the reciprocal of the energy consumption per unit of product.

/(see table

(see table 2). On the other hand, an economy which is rich in mineral or forest resources, of which it makes intensive use by means of foreign trade, will need large amounts of energy to develop its production (Group II).

Thus it is the conjunction of the natural resources of the region which, by determining the best conditions for development, also determines the intensity of the growth of the energy demand as a function of the increase in the gross product.

Table 2 provides a few examples of countries with different types of development.

Table 2

NET ENERGY CONSUMPTION PER UNIT OF PRODUCT, 1951

Countries	kg. of petroleum equivalent per dollar at 1950 prices
I.	
Argentina	1.11
Australia	1.15
New Zealand	0.97
II.	
Canada	2.88
Chile	1.62
Finland	3.56
Peru	2.10
III.	
Brazil	1.47
Colombia	1.19
Mexico	1.54
IV.	
United Kingdom	2.43
United States	2.42
Western Germany	2.72

Source: Economic Commission for Latin America, Energy Division.

/Groups I and II

Groups I and II are cases of development with a differing degree of advancement, on the basis of ample use of abundant natural resources. These are all economies which depend or formerly depended to a high degree on foreign trade: in the one case exporters of agricultural products, and in the other of forest and mining products. This is why the unit-consumption is low in the first and high in the second group of countries. 11/ The third group represents under-developed economies in which foreign trade plays a relatively less important part although, from this point of view, countries of this group may frequently be interchangeable with those of group I. Finally, the fourth group includes highly industrialized economies, where as a consequence, independently of the diversity of their resources, the input of energy per unit of product is always very high.

It will readily be understood that if the development of a country in Group I takes place together with a reduction in the export coefficient, it is most probable that the unit-consumption of energy will increase. The opposite would be expected in countries of the type of Group II. In this second case, the fall in unit-consumption might first take place over a given period, owing to the relative reduction in the importance of the extractive activities, and would then be succeeded by a stage of upswing resulting from industrialization. In the countries of the third group, regardless of the type of their exports, it is most probable that development together with a reduction in the export-coefficient will be reflected in a rise in the unit-consumption of energy, on account of their greater industrialization. It is therefore clear that both the stage and the form of the development process basically influence the demand for energy. An adequate projection of this development presupposes a full knowledge of the conditions under which general economic development is proceeding and of the structural readjustment which may occur in the stage to which the projections refer.

11/ It is well known that energy consumption per unit of product is much higher in mining and forest exploitation than in agricultural tasks. In reality, by taking account of animate energy and of solar energy absorbed in photosynthesis in the case of agriculture, the differences may well be only apparent. This, however, is not the case if the commonly used forms of inanimate energy alone are considered, since these are the only kinds of energy lending themselves to comparisons, as they can be reduced to common terms.

/3. Analyses

3. Analyses by countries

The remarks in the preceding section enable the problem of energy in relation to economic development to be stated in its most general terms. For a more profound study it is essential to consider the national economies separately.

Study of each country should include the fullest possible assessment of the consumption of all sources of energy, specifying in every case the share of imports and detailing the form in which the energy is being utilized. Such a study has been started in regard to those Latin American countries for which the most ample information is available, and will constitute the point of departure for an adequate statement of the energy problem in each particular case.

Table 3 gives data concerning gross energy consumption in a number of countries of the region during three significant years of the last quarter-century. From the standpoint of this relative consumption and degree of dependence on imports, the countries may be grouped as follows:

I. Relatively high consumption
   a) Self-sufficient: Mexico and Venezuela
   b) Partly relying on imports: Argentina, Brazil and Chile
   c) Largely dependent on imports: Cuba and Uruguay

II. Moderate consumption
   a) Self-sufficient: Colombia and Peru

III. Low consumption
   a) Self-sufficient: Bolivia and Ecuador
   b) Largely dependent on imports: the remainder

Table 4 shows gross energy and electricity consumption per capita and per unit of product in Latin American countries. The data on consumption "excluding large-scale exports" indicate the influence on unit and per capita consumption of certain extractive or capital intensive industries connected with foreign trade. 12/ In Venezuela, for instance, per capita consumption falls to half if energy consumed by the petroleum export industry be omitted.

12/ Metals in Chile, Bolivia, Peru and Mexico; petroleum in Venezuela and Colombia; sugar in Cuba.

/Table 3

Table 3
LATIN AMERICA: EVOLUTION OF PER CAPITA GROSS CONSUMPTION OF ENERGY, 1929, 1937 AND 1952

Countries	Years	Population (Thousands)	Refined petroleum products and natural gas	Coal and coke	Hydro-electricity	Vegetable fuels	Total gross consumption of energy	Electricity production (kWh)	Coefficient of electrification a/
			(Kilogrammes of petroleum equivalent b/)						
Argentina	1929	11,600	254	176	-	-	-	140	-
	1937	13,500	303	152	3	198	655	191	0.303
	1952	18,000	493	68	3	161	725	306	0.513
Brazil	1929	32,900	23	47	23	-	-	61	-
	1937	38,700	25	37	26	284	373	68	0.193
	1952	54,500	110	25	71	194	400	184	0.537
Chile	1929	4,228	263	232	47	-	-	216	-
	1937	4,777	156	265	66	176	663	325	0.630
	1952	5,960	260	276	136	141	814	550	0.879
Colombia	1929	7,279	33	11	5	-	-	21	-
	1937	8,531	44	30	9	205	288	35	0.136
	1952	11,847	113	49	31	139	333	122	0.431
Mexico	1929	16,200	114	38	29	-	-	77	-
	1937	18,700	160	36	41	55	292	134	0.577
	1952	27,200	358	27	45	46	475	203	0.521
Group II c/	1929	14,002	138	60	5	-	-	78	-
	1937	16,549	126	33	7	192	358	77	0.222
	1952	22,366	422	11	31	195	659	223	0.378
Group III d/	1929	14,232	33	2	5	-	-	19	-
	1937	16,387	29	1	6	170	206	28	0.141
	1952	22,692	75	0.4	11	166	252	57	0.236
Latin America	1929	100,441	93	61	16	-	-	72	-
	1937	117,144	100	53	21	199	373	96	0.275
	1952	162,565	238	36	45	156	474	197	0.487

Source: Economic Commission for Latin America, based on national statistics and the United Nations Statistical Paper, J-1.

a/ Total consumption of electricity in kWh divided by total consumption of net utilizable energy obtained from fuels used for purposes other than the generation of electricity in kilogrammes of petroleum equivalent.
b/ Heat value of petroleum = 10,700 calories/kilogrammes.
c/ Cuba, Peru, Uruguay and Venezuela.
d/ Bolivia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Panama and Paraguay.

/Table 4

Table 4

LATIN AMERICA: CHARACTERISTICS OF GROSS ENERGY CONSUMPTION IN 1952, WITH RELATION TO INCOME LEVELS

Country	On a *per capita* basis			Per unit of production (dollars) a/		Relation of imports to consumption
	Gross product (dollars) a/	Gross consumption (petr. equiv. in kg.)	Electricity output (kWh)	Gross consumption (petr. equiv. in kg.)	Electricity output (kWh)	(percentage)
Argentina	442	725	306	1.64	0.692	57.0
Bolivia	100	236	108	2.36	1.080	14.4
Brazil	207	400	184	1.93	0.889	31.0
Colombia	224	333	122	1.49	0.545	8.4
Costa Rica	221	368	212	1.67	0.959	42.5
Cuba	404	779	261	1.93	0.646	45.6
Dominican Republic	169	330	49	1.95	0.290	25.7
Chile	319	814	554	2.55	1.737	31.9
Ecuador	130	250	53	1.92	0.408	2.1
El Salvador	166	284	47	1.71	0.283	23.8
Guatemala	174	231	33	1.33	0.190	32.7
Haiti	114	162	6	1.42	0.052	8.3
Honduras	152	259	40	1.70	0.263	43.1
Mexico	219	475	203	2.17	0.927	3.1
Nicaragua	152	231	43	1.52	0.383	34.5
Panama	361	426	152	1.18	0.421	67.0
Paraguay	76	220	26	2.89	0.342	9.7
Peru	138	361	119	2.62	0.862	1.2
Uruguay	391	576	304	1.47	0.777	72.1
Venezuela	625	1,067	320	1.71	0.512	1.0
<u>Excluding large-scale exports</u>						
Chile	298	687	321	2.30	1.077	..
Cuba	300	411	174	1.37	0.580	..
Peru	115	-	64	-	0.557	..
Venezuela	417	528	154	1.27	0.369	..

<u>Source</u>: Economic Commission for Latin America, Energy Division.

a/ At 1950 prices.

/Wide differences

Wide differences exist within each country between separate economic sectors or geographical consumption areas: e.g. industry and mining have much greater energy and electricity consumption coefficients, both *per capita* and in relation to the value of production, than have other sectors.

Thus in recent years energy consumption per unit of product in industry was, in Argentina, double that of the economy as a whole, while in Chile it was even higher. Similar proportions apply to electricity consumption. Total energy consumption per person in industry was two to three times higher than in the economy in general. These ratios rise to five and ten in the case of electricity.

The disparity in electricity consumption between zones in the same country (more important urban industrial centres and the rest) becomes clear from the following figures. In Argentina the *per capita* consumption in Greater Buenos Aires is 560 kWh and in the remainder of the country 100 kWh; in Brazil the Rio-Sao Paulo area has 790 and the remainder 60; in Chile the figures are 300 for the Central Zone and 140 elsewhere; in Colombia, consumption is 400 kWh in Bogota, Cali, Barranquilla and Medellin, while in the rest of the country it is less than 30; in Ecuador, Quito and Guayaquil show 120 and the remaining areas 25; in Peru, Lima and Callao have 240 and the rest 15; in Uruguay, Montevideo has 560 and remaining districts 70; and in Mexico the most important cities have 500 and the remainder 70.

Although the rates of increase in gross product and energy consumption show a high degree of correlation, there have been considerable variations in the growth rates *per capita* energy consumption as between different countries. For this many factors were responsible, and they were not always the same factors. (See charts I to III.)

For example, in Argentina the relationship between the growth rates of the product and of energy consumption remained very close to unity over the whole period between 1925 and 1952. Had the supply of energy been more elastic, that relationship would probably have shown an upward trend, thus covering the deficit in energy consumption - a deficit clearly reflected in the low level of *per capita* energy consumption in relation to the *per capita* income. Since it is to be expected that with a sufficient expansion of the energy supply the deficit will in future be wholly or partially absorbed, the

/consumption of

consumption of energy may perhaps then tend to increase more strongly than the product. The intervention of other factors is not thereby excluded, in particular a more rational utilization of the available energy. A systematic campaign to this effect might arrest the tendency mentioned earlier, which could also be reduced through direct or indirect control of energy consumption by the population. The latter method may already have been operative in the past.

In Chile, during a period terminating in 1932, there was a marked trend towards a reduction in energy consumption per unit of product. Most probably this reflected the lowered share in the gross product of large-scale mining for export. From 1933 to 1952 the ratio was more stable, (with fluctuations of around 12 per cent) owing to the fact that the export sector succeeded in maintaining its relative position, largely due to a substantial improvement in export prices. Depending upon whether prospects for Chilean mineral exports are promising or otherwise, it may be assumed that there is not, or is, a tendency for the ratio to fall. In any event, apart from large-scale mining for export, it is most likely that consumption will tend to grow in proportion to the product, or even more strongly, owing to increased industrialization and agricultural mechanization.

Available data for Brazil (1939-52) and Colombia (1934-52) indicate a downward tendency in the energy/product ratio; it was less marked in the case of Brazil, and became stronger in Colombia from 1947-52. In all probability this phenomenon reflects improved terms of trade, resulting from a high relative increase in coffee prices, observed during the whole post-war period, and other factors which made possible a broad expansion in productive capacity as well as the rate of utilization. When the gross product thus increases, other factors remaining constant, the average productivity of capital improves and the ratio energy consumption/unit of product becomes less, because the increase in energy consumption resulting from industrial diversification does not succeed in offsetting the disproportionate rise in the product. In view of the preponderance of coffee in the Colombian economy, it is understandable that in that country the ratio will show a stronger tendency to fall. The prospects for coffee prices being unfavourable, it must be expected that the tendency shown by both

/countries will

countries will be reversed, i.e. there will be an increase in energy consumption per unit of product. This trend will be strengthened if the intense rate of industrial growth and urbanization latterly characterizing these countries persists.

In Mexico the energy/product ratio was growing with important fluctuations, over the period 1925-38. (See chart III). This may well not be a true reflection of the facts, and may well to a great extent depend on the circumstance that, for lack of data, the consumption of vegetable fuels was taken as constant throughout those years. It also may be connected with the petroleum boom. At any rate after 1939 the tendency is practically horizontal.

Consideration similar to the foregoing were borne in mind when projecting the energy supply needs of Latin America.

4. Petroleum and electricity

Liquid fuels and electric energy should now be examined. It is common knowledge that modern technology tends towards the preferential use of these two forms of energy. The progressive increase in the use of internal combustion engines, especially for transport, has endowed petroleum products with a growing predominance over other fuels. Also, their greater calorific power per unit of weight, and such technical advantages as ease of conditioning and greater efficiency in combustion, have made their use more economical and convenient. The case of electricity is still clearer, since this is an advanced form of energy utilization which is one of the most important advances of modern technique. Not only has it enabled much greater use to be made of renewable sources such as hydro-power, but it has also made possible a vast number of new uses for energy in the productive process, as well as in the community as a whole. On these grounds the trend is towards an ever-increasing use of energy in the form of electricity, both hydro and thermal.

But it would be incorrect to assert that the coefficient of electrification 13/ is proportionate to the degree of development. The fact that a country possesses abundant and easily harnessed hydro resources may

13/ Obtained by dividing total electricity consumption in kWh by the consumption of fuels used for other purposes, in kg. of petroleum equivalent.

/result in

result in a high coefficient. This phenomenon can readily be confirmed in Latin America. Thus, by comparing data for 1952, in regard to Argentina and Brazil, it is seen that the gross total energy consumption *per capita* in the former country was 725 kilogrammes of petroleum equivalent and in Brazil hardly 400. Nevertheless, the coefficient of electrification was 0.537 in Brazil and 0.513 in Argentina.

However, it is everywhere observed that this coefficient tends to rise with economic development. Thus for all Latin America it rose from 0.275 in 1937 to 0.487 in 1952, in other words it is not far from double the figure before the Second World War. This is a trend which may be noted in respect of each economy, in proportion to its combination of resources and current stage of development. The growth of certain industries such as chemicals and electro-metallurgy implies relatively greater pressure on energy supply in the form of electricity; the same applies to mechanization and automatization in general, as well as to the process of urban development.

As regards petroleum products, the dynamics of the demand for these may be seen to have points of similarity with that for electricity. For Latin America as a whole, the proportion of petroleum to all sources of energy rose from 25 to 50 per cent between 1937 and 1952. Even in countries like Brazil, which 1952 produced practically no petroleum, its share increased sharply (see table 6). But it should not be imagined that the great increase in petroleum consumption in all the Latin American countries has merely resulted from the progress of technology. The problem of relative prices plays a fundamental part. In those countries where petroleum is imported, and its price depends much more on exchange policy than on domestic cost structure, there has frequently been a great relative fall in the prices of liquid fuels owing both to technical progress and to the use of preferential exchange rates for such products. In other cases a considerable influence is also wielded by electricity tariffs and coal prices, especially in countries which produce the latter mineral and consequently tend to stimulate use of domestic production.

/Table 5

Table 5

LATIN AMERICA: PER CAPITA GROSS CONSUMPTION OF ENERGY

(Annual cumulative rates of growth)

	Years	Gross total energy	Refined Petroleum products and natural gas	Electricity production
Argentina	1929/37	..	2.2	4.0
	1937/52	0.68	3.3	3.2
	1929/52	..	3.0	3.5
Brazil	1929/37	..	1.0	1.4
	1937/52	0.53	10.4	6.9
	1929/52	..	9.3	4.9
Chile	1929/37	..	- 6.3	5.2
	1937/52	1.9	3.5	3.6
	1929/52	..	..	4.2
Colombia	1929/37	..	3.7	7.0
	1937/52	1.0	6.5	8.7
	1929/52	..	5.5	8.0
Mexico	1929/37	..	4.3	7.2
	1937/52	3.3	5.5	2.9
	1929/52	..	5.1	4.3
Group II[a/]	1929/37	..	- 1.1	- 0.2
	1937/52	4.2	8.4	7.3
	1929/52	..	5.0	4.7
Group III[b/]	1929/37	..	- 1.6	4.9
	1937/52	1.4	6.9	4.9
	1929/52	..	3.7	4.9
LATIN AMERICA	1929/37	..	0.9	3.7
	1937/52	1.6	6.0	5.0
	1929/52	..	4.2	4.6

Source: Economic Commission for Latin America, based on national statistics and the United Nations, Statistical Paper, J-1.

a/ See footnote c/ to table 3.

b/ See footnote d/ to table 3.

/Table 6

Table 6

LATIN AMERICA: EVOLUTION OF MINERAL FUEL AND HYDRO-ELECTRIC CONSUMPTION, 1929, 1937 AND 1952

(As a percentage of gross commercial consumption of energy) a/

		Petroleum	Coal	Hydro-electricity
Argentina	1929	59.1	40.9	-
	1937	66.1	33.2	0.7
	1952	87.4	12.0	0.6
Brazil	1929	24.9	50.7	24.4
	1937	28.6	42.2	29.2
	1952	53.4	12.2	34.4
Chile	1929	48.5	42.9	8.6
	1937	32.1	54.4	13.5
	1952	38.6	41.1	20.3
Colombia	1929	66.1	22.8	11.1
	1937	52.8	36.4	10.8
	1952	58.4	25.5	16.1
Mexico	1929	63.0	20.9	16.1
	1937	67.4	15.2	17.4
	1952	83.3	6.3	10.4
Group II b/	1929	67.1	29.2	3.7
	1937	75.7	19.8	4.5
	1952	90.9	2.4	6.7
Group III c/	1929	84.1	4.1	11.8
	1937	81.0	1.5	17.5
	1952	86.7	0.4	12.9
Total Latin America	1929	54.5	35.9	9.6
	1937	57.5	30.6	11.9
	1952	74.4	11.2	14.4

Source: Economic Commission for Latin America, Energy Division.

a/ Excluding fuelwood and other vegetable fuels.

b/ See footnote c/ to table 3.

c/ See footnote d/ to table 3.

/The evolution

The evolution of the demand for petroleum should therefore be regarded as an autononous sector of the general energy demand, insofar as it consists of an autonomous sector (gasoline) and another sector with a high substitution intensity (medium and heavy products). In the latter case the picture is complicated by the intervention of numerous factors. Although there are grounds for asserting as a general principle that the share of petroleum, and in some cases that of natural gas, is tending to increase, the intensity of this relative growth will need to be studied in each individual case. In none of them would there be reason to assume that the recorded trend is fixed and immutable.

Over the whole period 1929-52, the annual growth rate of the per capita consumption of petroleum products (including natural gas) in Latin America was 4.17 per cent and that of electricity 4.57. Dividing this period into two stages, in the first (1929-37) the production of electricity grew more quickly than petroleum consumption (3.65 per cent annually as against 0.92). In the second stage the trend was reversed: electricity grew at 5 and petroleum at 6 per cent. This phenomenon is no doubt closely linked with the development of foreign trade in the two periods. Since petroleum is the source of energy most dependent on the capacity for external payments for the importer countries the collapse of that capacity in the 'thirties, in most Latin American Republics, must have had a more direct effect. The great upsurge of the demand for petroleum in the following period partly reflects progress in making up the ground lost during the 'thirties.

5. The deficit in energy consumption

One of the problems demanding immediate analysis is that of assessing a possible deficit in energy consumption. Various aspects present themselves and confusion may easily arise. The notion of a deficit is, by its very nature, relative, and presupposes the acceptance of a yard-stick by which to measure it. If under-consumption is defined in relation to the level of per capita income, a glance at charts IV and V will show that some Latin American countries are in a position below, while others are above, the general trend. It might thus be reasonably affirmed that those countries with consumption lower than corresponds to their income level, such as Argentina, are subject to under-consumption. Conversely, those

/countries in

countries in the opposite situation, e.g. Chile, would have a consumption surplus. But this is only a preliminary indication with almost no practical value, since it omits any reference to the structure of production and the conjunction of resources. In this sense, as has already been seen, Argentina and Chile are in fact examples of two very different situations unaffected by the notion of under-consumption.

But if an analysis by sectors is undertaken, the idea of a deficit gains greater significance. In some countries, for instance, approximate estimates exist of the outstanding demand for electricity for industrial purposes. In such cases a distinction must be drawn between demand with a view to enlargement of productive capacity and demand with a view to better utilization of capacity already installed. From both aspects there is a deficit, though its implications are different. The absence of any guarantee that future supply will expand is sufficient to hamper the development of many industries. In some parts of Latin America this type of deficit has been accentuated in recent years and in others a direct deficit has developed, forcing certain industries into under-utilization of installed capacity. Many enterprises in Sao Paulo and Buenos Aires, for example, had to introduce very irregular timetables and cut down daily hours of work because of electricity shortages, while rationing was very widespread in almost all countries and still continues in some.

In other cases the deficit in energy consumption is a mere corollary of the deficit in some other sector. A typical example is the shortage of means of transport, although it is not commonly observed that the primary factor determining this situation is the inelasticity of energy supply.

Reference should finally be made to the possible existence of a deficit in the use of energy for direct consumption purposes. In such a case the demand for energy is mainly a reflection of the income available for consumption. When there is rationing of consumption or an outstanding demand, the deficit is explicit. In other cases it may tend to express itself in some indirect way.

/The demand

The demand for consumer goods or services is elastic not only in relation to average consumer income but also to relative prices. In actual fact, electric energy consumption by urban populations for non-industrial purposes is high in some Latin American countries in proportion to the average income level of the particular population. This is one aspect of the general phenomenon of the rapid assimilation of advanced forms of consumption which is noted among higher and even middle income groups in the under-developed countries, and it may be reflected in part in an artificial cheapening of electric energy brought about by factors such as as inflation. In some of these cases the increase in energy consumption is a consequence of economic development, to which it subsequently becomes a deterrent.

/CHAPTER III

CHAPTER III

PROJECTION OF THE NEEDS IN 1965

Having examined the historic evolution of energy, the characteristics of its use, the substitution which took place between types of fuels and those other factors which determine the nature of energy consumption in the course of economic development, the following questions logically arise:

a) Given an arbitrary rate of growth for the product, what should be the aggregate energy supply to achieve this rate?

b) What will be its composition by principal sources, allowing for the development of the economy and substitution between the various sources?

c) How will the demand be met by the contribution of domestic output and imports?

d) What levels will be reached by the capacities to generate electricity and to refine petroleum?

e) What will be the aggregate requirements for investment and foreign exchange and how will they be calculated?

1. Aggregate demand for fuels and electricity

Any estimate of the future demand for energy must be based on a knowledge of the possible rate of growth of the *per capita* gross product during the period under consideration. In the absence of complete national studies for programming or forecasting economic development, this calculation could not be made. Instead, the possibilities were examined of a greater energy supply in the next decade (1955-65), based upon an arbitrary rate of growth in the *per capita* gross product of 2.5 per cent annually. The size of the supply thus reached is purely illustrative and merely expresses the energy which would be necessary to attain the hypothetical rate of 2.5 per cent. Both for the whole region and for some individual countries and selected groups of countries in Latin America, this rate of growth has been used without in any way implying that it represents a real forecast of national economic development.

At once follows the problem of estimating the energy supply in the aggregate and by the individual sectors of the economy. This preliminary report only deals with the aggregate estimates for the following reasons:

a) The information on energy consumption by sectors of economic activity (industry, mining, agriculture, transport and residential use) is at present very scanty and incomplete, so that it was only possible in a few isolated cases to make this type of calculation;

b) Detailed data on economic growth by sectors is lacking;

c) Strictly speaking, this type of calculation can only be made as part of a general effort for national programming.

In any case, since the concern here is only that of establishing the size of the supply requirements, for Latin America as a whole and by countries, and not of a detailed and itemized calculation, the aggregate method is perfectly acceptable. (See table 7.) Moreover, it should be borne in mind that, wherever possible, outstanding future consumption of energy has been included (the establishment, for example, of heavy industries with a large energy consumption such as iron and steel plants).

/Table 7

Table 7

LATIN AMERICA: PROJECTION OF NET AGGREGATE ENERGY CONSUMPTION IN 1965

Country	Total net energy consumption a/	Net energy consumption per unit of gross product b/	Percentage annual variation	Net energy consumption per unit of gross product b/ c/	Total net energy consumption a/	Per capita net energy consumption d/	
	1952	1952		1965	1965	1952	196
Argentina	10,185	1,282	0.5	1,324	17,890	566	778
Brazil	16,528	1,468	-	1,475	31,100	303	424
Chile	3,212	1,687	- 0.5	1,642	4,800	539	652
Colombia	2,972	1,121	-	1,188	6,200	251	394
Mexico	9,696	1,630	0.5	1,692	19,141	356	483
Sub-group I	42,593	1,433	-	1,464	79,131	362	498
Sub-group II	11,578	1,483	-	1,483	19,230	518	658
Sub-group III	4,623	1,497	- 1.0	1,314	7,733	204	249
Latin America	58,794	1,448	-	1,455	106,094	362	484

Source: Economic Commission for Latin America, Energy Division.

a/ Thousand of tons of petroleum equivalent.

b/ Tons of petroleum equivalent required to produce one million dollars at 1950 prices of the gross product.

c/ The net energy consumption per unit of product in 1965 is obtained by applying the percentage annual variation to the unit consumption in 1952 corresponding to the countries on the line of central trend and not to the actual figure for 1952 which is indicated in the table.

d/ Kilogrammes of petroleum equivalent.

/The projections

The projections of the supply needs of aggregate energy and of electricity for 1965 have been computed on the basis of detailed analyses of five countries (Argentina, Brazil, Chile, Colombia and Mexico) and a general survey of the remainder, in two combined sub-groups[14/] (see tables 8 and 9). In calculating these projections, the following factors have been taken into account:

a) The historic product-elasticity i) of the per capita consumption of all energy, and ii) the per capita output of electricity;

b) Trends of energy consumption and of electricity output, per unit of the gross product;

c) Historic trend of aggregate energy consumption and of electricity output, excluding variation in the gross product;

d) Relative position of the countries as compared with the rest of the world.

It was felt that by pooling these four concepts and attaching relative significance to them, more prudent and authentic results are obtained than by considering each of them separately. The use of historic trends and elasticities alone, for instance, would cause the anomalies of past growth - such as shortages or surplus - to be prolonged, instead of being corrected. The elasticity, the comparison with other countries and the application of the coefficients thus obtained, enable approximate estimates to be made of the present deficits and the projections for 1965 to be corrected.

The calculation for aggregate energy consumption was made first, because it is an element closely linked with economic development in general, while its composition is a subsequent problem in the distribution of the total. The calculation of electricity output, however, may be made separately but in a similar manner to that of aggregate energy, by following specific basic relations and trends. This was the method used here, without overlooking the fact that in this case, more than in any other form of energy, strictly economic causes are modified by decisions of energy policy.

14/ Despite this grouping, the outstanding characteristics of each individual country and its influence upon the whole have been borne in mind.

/Table 8

Table 8
LATIN AMERICA: PROJECTION OF GROSS ENERGY CONSUMPTION IN 1965

	Argentine	Brazil	Chile	Colombia	Mexico	Group II a/	Group III b/	Total Latin America
Refined petroleum products and natural gas								
Total consumption, 1965 c/	19,130	21,380	2,892	4,095	20,524	18,635	5,055	91,791
Annual rate of growth, 1952-65 d/	6.1	10.3	4.9	9.0	5.9	5.4	8.7	6.9
Per capita consumption, 1965 e/	832	292	393	260	528	641	163	420
Annual rate of growth, 1952-65 d/	4.1	7.8	3.2	6.6	3.0	3.2	6.2	4.5
Import-consumption ratio, 1952 d/	57.2	98.4	99.7	25.4	9.0	31.4	79.0	46.8
Import-consumption ratio, 1965 d/	29.8	43.2	57.3	0	0	28.2	76.7	28.0
	47.7	76.3						38.6
Coal and coke								
Total consumption, 1965 c/	1,475	2,720	2,082	2,090	1,337	520	10	10,234
Annual rate of growth, 1952-65 d/	1.5	5.4	1.8	10.3	4.7	5.9	0	4.5
Import-consumption ratio, 1952 d/	92.9	47.0	7.2	4.3	3.5	36.7	100.0	35.2
Import-consumption ratio, 1965 d/	42.0	33.8	8.7	0	0	23.0	100.0	18.1
Hydro-electricity f/								
Total production, 1965 c/	960	9,770	1,570	1,600	2,617	1,335	628	18,480
Annual rate of growth, 1952-65 d/	23.5	7.4	5.2	11.9	6.1	4.7	2.2	7.5
Vegetable fuels								
Total consumption, 1965 c/	2,560	10,400	765	1,130	1,200	4,620	3,760	24,435
Annual rate of growth, 1952-65 d/	-0.9	-0.1	-0.7	-2.9	-0.3	0.4	0	-0.3
Gross consumption of total energy								
Total consumption, 1965 c/	24,085	44.200	7,309	8,911	25,678	25,110	9,453	144,940
Annual rate of growth, 1952-65 d/	4.8	5.6	3.2	6.5	5.4	4.2	3.6	5.0
Per capita consumption, 1965 e/	1,047	603	1,000	566	650	860	304	661
Annual rate of growth, 1952-65 d/	2.9	3.2	1.6	4.2	2.4	1.9	1.1	2.6

Source: Economic Commission for Latin Amerie, Energy Division.

a/ See footnote c/ to table 3
b/ See footnote d/ to table 3
c/ Thousands of tons of petroleum equivalent
d/ Percentage.
e/ Kilograms of petroleum equivalent

f/ To convert hidroelectricity into petroleum equivalent, the following rates were adopted: 1952: 4,500 cal/Kwh; 1965: 3,500 cal/Kwh except for Brazil (4,100) and Chile (4,000). Annual rates of growth appearing here are diff-

Table 9

Table 9

LATIN AMERICA: PROJECTION OF ELECTRICITY PRODUCTION IN 1965

	Argentine	Brazil	Chile	Colombia	Mexico	Group II a/	Group III b/	Total Latin America
Thermo-electricity								
Total production, 1965 c/	11,060	4,500	2,000	1,550	6,000	7,860	1,460	31,430
Annual rate of growth, 1952-65 d/	5.7	13.6	2.9	8.2	4.4	6.8	6.0	6.7
Percentage of total, 1952 d/	97.3	8.6	41.7	38.8	47.6	66.8	53.3	46.1
Percentage of total, 1965 d/	79.0	15.0	32.3	24.0	50.0	67.6	43.2	41.4
Hydro-electricity								
Total production, 1965 c/	2,940	25,500	4,200	4,900	8,000	4,070	1,920	51,530
Annual rate of growth, 1952-65 d/	25.8	8.2	6.2	14.1	8.2	7.1	9.3	8.9
Percentage of total, 1952 d/	2.7	91.4	58.3	61.2	52.4	33.2	46.7	53.6
Percentage of total, 1965 d/	21.0	85.0	67.7	76.0	50.0	32.4	56.8	58.6
Total electricity								
Total production, 1965 c/	14,000	30,000	6,200	6.450	14,000	11,930	3,380	85,960
Annual rate of growth, 1952-65 d/	7.5	8.8	5.0	12.2	7.4	6.9	7.7	7.8
Per capita production, 1952 e/	306	184	554	122	203	223	57	196
Per capita production, 1965 e/	609	409	843	410	354	408	109	392
Annual rate of growth, 1952-65 d/	5.4	6.4	3.3	9.8	4.4	4.8	5.1	5.5
Coefficient of electrification								
1952 f/	0.513	0.537	0.879	0.431	0.522	0.277	0.236	0.485
1965 f/	0.703	0.853	1.205	0.723	0.655	0.551	0.383	0.729

Source: Economic Commission for Latin America, Energy Division.

a/ See footnote c/ to table 3
b/ See footnote d/ to table 3
c/ Millions of Kwh
d/ Percentage
e/ Kwh
f/ Kwh/kg of petroleum

/Projections of

Projections of over-all energy consumption and of electricity output for 1965 are given in tables 8 and 9. It will be seen from them that aggregate energy consumption in Latin America could reach 144.9 million tons of petroleum equivalent by 1965, providing a per capita consumption of 661 kg. of petroleum and 2.0 kg. for each dollar (at 1950 prices) of the gross product. Per capita consumption represents a rise of 39 per cent in relation to 1952, or an annual increment of 2.6 per cent. Electricity output would increase to 86 thousand million kWh, with an annual rate of 7.8 per cent, representing 5.5 per cent on a per capita basis. Hydro-electric energy might grow at a more rapid rate than thermic electricity. These figures are not exaggerated and are compatible with both historic trends and the future requirements of Latin America.

It should be noted that during development the efficiency in the use of energy increases because modern equipment replaces or is added to out-of-date equipment. Higher efficiency is also obtained from improved technological research, from planning and from supervision of industrial and transport operations. Such effects are implicit in the rates of growth adopted for the projections.

2. Composition of future consumption

To estimate the composition of consumption by sources of energy in 1965, the following bases have been used:

a) There will always be a certain consumption of mineral coal, coke, vegetable fuels and hydro-electricity, depending on the possibilities of national output and the imperative economic need to save foreign exchange used for import. Coke, moreover, will depend on the volume of consumption for which no substitute can be found, for technical reasons;

b) The remainder of the demand will be absorbed by petroleum and natural gas derivatives, given the strong trend for substitution of this type of energy.

It has been assumed that vegetable fuels will, in general, maintain their level or suffer a gradual decrease (around one per cent annually), tempered by the growing use of sugar-cane bagasse in countries which produce it and often by that of charcoal. Consumption of mineral coal will not vary substantially, or will increase according to specific demands in its sector,

/which is

which is relatively small. For some countries - particularly Brazil, Chile and Colombia - the consumption of domestic coal in generating thermo-electricity has been assumed. Hydro-electric energy responds to forecasts for its output which vary from one country to another.

In this way the two principal elements of aggregate energy are separated; that which will be utilized as electricity, whether thermal or hydraulic; and that which is consumed as fuel. The relation between the two parts sets the pattern for the electrification of Latin America and is measured by what may be termed the coefficient of electrification.15/ It is expected that by 1965 this coefficient will reach a value of 0.729, varying greatly between different countries and depending on various factors, the paramount among them being the hydraulic potential utilized and the problems raised by fuel imports. The resulting coefficients of electrification were compared with the present situation in countries outside the region, with which an additional adjustment of the values was made.

The coefficients of electrification obtained for 1965 are high in relation to those of 1949-51. But, since the whole world's output of electricity increases more rapidly than total energy consumption, it is clear that the Latin American countries, as well as those elsewhere, will raise their coefficient of electrification for 1965.

When the composition of the future demand by sources of energy is examined, the problem of substitution, among others, naturally appears. The present position of consumption is not similar to the past and very probably will not remain constant during the next ten years. The variations will be dependent upon a series of factors, some arising from the energy sector itself, others from particular demands of the economy, and others still from financial or foreign exchange considerations.

For this reason, the accepted composition can only be regarded as an alternative, perhaps even a plausible one, but not necessarily the most suitable for the economy. To arrive at such a solution more detailed studies would have been required, which are outside the scope of this report.

15/ See chapter II.

/3. Substitution

3. Substitution possibilities

It is known that, in general, substitution between different forms of energy depends upon a series of factors which may be classified principally as technological and of prices. A combination of both will determine the elasticity of substitution which will be reflected by the shifts from one form of energy to another, at a more or less rapid rate.

In theory, the substitution possibilities between the different forms of energy are very considerable, but in practice concrete conditions impose more rigid frontiers upon them in each case. These possibilities must be borne in mind, and have been taken into account wherever possible in this report, when determining the final composition 16/ of the supply projection for a future date.

Substitution mainly takes place between heavy fuels, such as coal, heavy oils and some medium oils, fuelwood and in many cases electricity. The increase in the coefficient of electrification in Latin America, to which reference was made above, expresses numerically the phenomenon of the substitution of fuels by electricity. The scarce statistical data and technical information on the use of fuelwood in the region makes it extremely difficult in this report to account for its participation. A study of the substitution between the different forms of energy is thus limited to commercial fuels and electric energy. This circumstance undoubtedly makes a calculation of possible future substitution more hazardous, but with better data the required revision can be made at a later date.

An examination of the characteristics of substitution between the principal separate commercial forms of energy in Latin America, enables it to be said that for most, the short-term trend has been largely for coal and fuel oil to be inter-changeable, but over the longer term, fuel oil,

16/ It should be recalled that substitution generally appears in most of the practical applications (transport, generation of electricity, industries, residential use) where the use by types of energy is indifferent, characterizing a substantial economic elasticity of substitution. However, there also exist situations of preferential use, where the advantage of one form over others may be appreciable or exceptional, in which case the high economic elasticities of substitution may be modified by variable technical elasticities.

/and even

and even more so, natural gas, tend to displace coal. Substitution takes place at a different rate according to the type of usage and depends essentially upon national or regional conditions, as well as upon relative prices and degree of scarcity or availability.

Thus, in Argentina, refined petroleum products, which in 1935 amounted to 40 per cent of the consumption of heavy fuels, declined during the war (1943) to about 35 per cent, returning later to become an even greater factor in consumption and to constitute 71 per cent in 1952. In contrast, coal in 1952 stood at only 12 per cent of the consumption, after reaching 30 per cent in 1935. It may also be noted how fuelwood occupied an important position during war periods when mineral fuels were in short supply.

A similar situation occurred in Brazil. Before the middle of the 'forties coal contributed more than petroleum to the market for heavy commercial products, but later the shift from coal to petroleum is evident and by 1952 petroleum comprised 70 per cent of the total. Fuelwood weighs heavily in the aggregate, generally in years of shortage.

In Chile, coal has always represented a larger share in the consumption of heavy fuels than petroleum, even so a tendency towards substitution is apparent and petroleum from 25 per cent in 1935 had risen to 40 per cent in 1952.

In Latin America as a whole, coal has dropped from one-third of the commercial consumption of energy to one-sixth, while refined petroleum products already absorbed three-quarters of that consumption at the end of the period.

A comparison of the composition of the petroleum sector shows that while European countries use an increasingly greater share of heavy petroleum products, in Latin America light oils are expanding at a faster rate.[17/] This situation in the region apparently reflects the greater relative influence of light road transport than of heavy transport and industrialization.

17/ The light oils comprise petrol and kerosene, while the heavy oils consist of fuel, gas and diesel oils. The first group shows the absolute predominance of petrol and represents the specific consumption of cars and aeroplanes. The second group combines all the products which compete with coal and fuelwood. The lack of detailed statistics often prevents a distinction between medium and heavy oils, a distinction which would have been most useful because the rate of evolution of each sub-group is different.

/The proportion

The proportion of petrol in aggregate energy consumption in Latin America is about 15 per cent, not very different from the position in the United States but three times that of the share of Europe. In terms of per capita petrol consumption, however, Latin America shows roughly the same figure as for Europe (75 litres annually) and about 7 per cent of that in the United States.

Whenever technical factors do not oblige a definite choice to be made for one form of energy, the price will be the decisive factor. The establishment and maintenance of a relative price structure between energy and the general level on the one hand, and in particular between the various forms of energy on the other, in the final analysis decide the extent and share of consumption of each form of energy.

Herein lies the great importance of a careful study of all the factors, whether technical, financial or relating to prices, which affect a decision of the volume of consumption of each form of energy. As stated elsewhere in this report, an over-all and simultaneous examination of these factors can only be conceived as the result of an integrated policy of co-ordination in the energy and economic spheres.

A certain amount of material has been collected on the relative prices of the various forms of energy and their variation among themselves and in relation to the general price level in some Latin American countries for certain years. An analysis of this data suggests the following conclusions:

a) For equal final energy content, electricity is cheaper than the other forms. This is a phenomenon common to other parts of the world and is especially evident in many European countries. The relative advantage in the use of electricity has been increasing during the last quarter of a century, although it is unlikely that this trend will continue at the same pace in the future. Furthermore, electricity for industrial use, apart from exceptional cases, is cheaper than its residential use. Consequently, apart from examples where electricity cannot be replaced, motive power for example, the price incentive seems to be the special inducement for its preferential use in industry.

/b) Broadly speaking

b) Broadly speaking, fuel oil is cheaper than other fuels, while fuelwood is the most expensive among them all, except in very exceptional cases where it is produced far from any other source of supply. The use of coal, in similar circumstances, can also be justified on an economic basis, but for the final consumer it is almost always more expensive than fuel oil. In both cases the cost of transporting coal and fuelwood play the decisive part.

c) Without doubt, the future price evolution of the different sources of energy and their relative variations depend upon a series of inter-related circumstances which are difficult to foresee. Some of them are of a technical nature, others are concerned with the establishment of prices and rates, while others depend upon decisions of over-all economic policy.[18/]

18/ It is possible that the unit price of electric energy might increase more than in the immediate past. It is also conceivable that the price of some fuels might decrease because their production became geared to other basic operations of industrialization. Finally, the wider use of natural gas, already being developed in some countries of Latin America, principally Argentina and Mexico, may allow it to compete very actively with other fuels as a result of lower prices.

CHAPTER IV

A SURVEY OF ENERGY RESOURCES

1. A concept of energy reserves

An estimate once made of the demand for the various types of fuels and for hydro-electric energy, the possibility of meeting these requirements from domestic production must be investigated.

In response to this need, a survey of what is known about Latin America's energy resources was undertaken.

It should be noted at the outset that the concept of energy reserves is eminently dynamic, and prone to vary with the passage of time. The determination of energy availabilities not only calls for investment which can be justified only when the need is imperative, but is also affected by technical and economic factors which are undergoing a constant process of evolution. The concept of a reserve is dependent upon existing knowledge of the natural resources of the several countries, and upon technological developments concerning prospecting, exploitation and mining, transport, processing and refining of fuels, development of sites for hydro-electric plants, and generation and long-distance transmission of electricity. At the same time, such a concept is partly governed by economic factors relating to the cost of the various operations, as also by the final relative prices of the different kinds of energy per thermal or electrical unit. And, finally, it is also influenced by the stage of economic development reached by the country, and by the volume, structure and characteristics of the energy demand, which will determine whether there is sufficient justification for incurring the outlay involved in identifying and locating such sources of energy as could be exploited on a scale compatible with economic costs.

At present, knowledge of Latin America's reserves of mineral fuels and hydro-electric resources is very fragmentary and erratic; but it will presumably gain in comprehensiveness, thoroughness and precision as each country's need to make full use of its energy resources becomes more and more pressing.

/The foregoing

The foregoing considerations combine to suggest that the energy reserves shown in the tables accompanying the present report represent a somewhat conservative estimate, which will undoubtedly be exceeded as prospecting for petroleum and natural gas expands, and as the determination of hydro-electric potential becomes more accurate. Furthermore, the increasing needs of economic development will give an impulse to such studies and render them indispensable.

Neither does the concept of reserves remain static with respect to the requirements of domestic consumption. Reserves may be abundant or limited, adequate or inadequate, according to the demands of the national economy. If the annual consumption of such reserves is very low, even an extremely modest potential will suffice to maintain a country's economic activity over a long period of years.

For this reason, it has been considered necessary to draw up tables assessing the volume of available energy reserves in relation to possible consumption. (See tables 10 and 11.) Clearly, final and definite figures cannot be established, since demand expands as population increases and the process of industrialization is accelerated. However, by taking as a basis the projections of consumption for 1965, it was possible to express this capacity in very approximate terms, within the limitations imposed by the unreliability of existing knowledge of reserves and future demand. The forms chosen are, in one case, the number of years in which requirements could be met, and, in the other, a qualitative indication of potential, always providing that demand were to develop in accordance with the assumed rates of per capita consumption. The situation may be seen to differ widely from one country to another; and it should be pointed out that changes easily take place, for the worse or for the better according to whether real consumption exceeds or falls below the projection made, or whether knowledge of available reserves does or does not increase. It is more than probable that the statistics given constitute a sizeable under-estimate of Latin America's future energy capacity.

/ Table 10.

Table 10

LATIN AMERICA: ADEQUACY OR INADEQUACY OF NATURAL RESOURCES OF ENERGY TO MEET THE DEMAND PROJECTED UNTIL 1965

	Commercial fuels a/ b/				Hydro-electricity c/		
	Technico-Economic		Potential				
Country	Petroleum and natural gas	Coal	Petroleum and natural gas	Coal	Economic	Technical	Potential
I. Countries with abundant fuels and hudro-electricity:							
Venezuela	xxx	x	xxx	xx	x	x	xx
Colombia	xx	xx	xx	xxx	x	-	xx
Mexico	xx	x	xx	x	-	-	x
Brazil	-	x	x? d/	x	x	x	xx
II. Countries with adequate fuels and hudr-electricity:							
Perú	x?	x	?	x	x	xx	xxx
Bolivia	x	-	xx?	-	x	xx	xx
Ecuador	-	-	x?	- e/	x	x	xx
Chile	-	x	-	xx f/	x	xx	xx
Argentina	-?	-	x?	x f/	x	x	x
III. Countries with a shortage of fuels and abundant (or adequate) hydro-electr.:							
Uruguay	-	-	-	-	x	x	x
El Salvador	-	-	-	-	x	x	x
Costa Rica	-	-	-	-	x	x	x
Guatemala	-	-	-	-	x	x	x
Nicaragua	-	-	-	-	x	x	x
IV. Countries with a shortage of both fuels and hydro-electricity:							
Paraguay	-	-	-	-	-	x	x
Honduras	-	-	-	-	-	x	x
Cuba	-	-	x?	-	-	-	-
Dominican Republic	-	-	-	-	-	-	?
Panama	-	-	-	-	-	x	x
Haiti	-	-	-	- e/	-	-	-

Source: Economic Commission for Latin America, Energy Division.

Key to symbols:

xxx ... Very abundant
xx ... Abundant
x ... Adequate
\- ... Inadequate (either an absolute dearth, or what may be considered a shortage, in view of the demand over the next decade)
? ... Doubtful or unknown

The combination

The combination of two symbols indicates that the situation might change in the near future as a result either of the intensive prospection which is now being carried on, or of the prospects for expanding exploitation. It should be noted that the position of countries as regards their capacity to absorb the demand for energy may change radically with the possible development of nuclear fission and other non-conventional sources of energy.

a/ Technico-economic resources are those which can be utilized on a competitive basis, given the state of the energy market at present, or within the next decade.

Potential resources are those whose economic exploitation is not considered feasible over the short term.

b/ Most of the Latin American countries possess forested areas which, if well managed, might well satisfy their fuelwood requirements for the next 50 years. Exceptions are Cuba, El Salvador, Haiti, Mexico, Nicaragua, Panama and Uruguay.

c/ Economic hydraulic resources are those which can be advantageously exploited at the present moment, given the structure of prices (investment and competitive fuel costs) and of demand and in view of balance-of-payment problems.

Technical hydraulic resources are those which can be exploited with technique as it is at present, or what it would foreseeably be during the next decade (developments in construction, generation and transmission). However, either the cost of their exploitation would be prohibitive at the present time, or demand in the area inadequate to justify the investment required.

Potential hydraulic resources are those of which little is known as to real capacity, hydrological conditions, works required, etc., and which are located too far from possible consumer centres.

No claim is made that a rigid classification of this type has been established, since this would be possible only on the basis of very comprehensive field studies. The grouping of hydroelectric resources is more an indication than an enumeration.

d/ Also possesses sizeable shale oil deposits which have not yet been worked.

e/ Possesses a certain quantity of brown coal.

f/ Possesses large deposits of brown coal (lignites and peat), which do not have great economic significance at the present time.

Table 11

LATIN AMERICA: POTENTIAL ENERGY RESOURCES AT PRESENT KNOWN

(Years of duration)

	Fuels a/ Calculated to maintain an annual consumption equivalent to: 1950-55	1965 c/	Hydroelectricity Until full utilization of the resources from 1954 b/
Latin America	200	111	30
Argentina d/	23	13	50
Brazil e/	34	18	25
Chile f/	225	156	22
Colombia	2,020	1.000	32
Mexico	114	62	20

Source: Economic Commission for Latin America, Energy Division.

a/ Excluding vegetable fuels. The approximate condition in 1954-55 has been taken of proven resources of coal and petroleum, assuming that one-third cannot be recovered.

b/ It has been assumed that the installed hydro-electric capacity doubles each 8 years, a reasonable period, but which obviously varies in terms of different factors, among them the possible replacement of fuels and hydroelectricity which had to be divided to draw up the table. In addition, the number of years calculated is influenced by the under-estimation of hydraulic resources existing in Latin America.

c/ Projected consumption (see chapter III).

d/ Excluding peat and asphalt, with which the duration might double.

e/ Excluding shale oil; with their inclusion the duration should be multiplied by 50.

f/ Excluding peat and coal deposits in the Magallanes zone which are both little known.

2. Energy resources

2. Energy resources

Latin America as a whole is rich in petroleum deposits and in hydro-electric and forest resources, although its proven reserves of coal are small, and knowledge of its possible natural gas availability is very scanty as yet. However, a table has been prepared to show that the sources of energy are very unevenly distributed throughout the various countries (see table 10). This disparity becomes even more striking when instead of total reserves of each country its per capita reserves are taken (both in tons of petroleum equivalent).

Despite the wealth of certain sources of energy, the fact is that the volume of reserves provided by all Latin America's sources of energy surveyed to date is approximately only one-fifth of the world per capita average, largely because its full potential has not been discovered. The region possesses only 3 per cent of the world's installed capacity for the generation of electricity, and 7 per cent of its petroleum refining capacity. About 7 per cent of known hydro-electric potential is exploited in Latin America, whereas in the world as a whole the corresponding figure stands at 17 per cent.

It should also be recalled that Latin America, as a group of countries, is an economic abstraction, and to assess the real extent to which it is under-endowed with resources, a more thorough study of the features peculiar to each country must be carried out. Thus, the very unequal distribution of energy reserves among the countries of the region still further accentuates the relative deficiency noted above.

These resources are unevenly divided not only among the countries themselves, but also within each one. This latter circumstance is particularly important where sources must necessarily be exploited in situ and where their radius of influence is limited for technical and economic reasons, as in the case of hydro-electric potential.

While some countries own substantial natural sources of energy within their territories, others are virtually devoid of resources of this kind. For instance, Venezuela possesses more than three-fourths of the proven reserves of petroleum, Colombia over half those of coal, and Brazil more than one-fourth of the hydro-electric resources of the region. Of Latin America's aggregate energy reserves, including shale oil, more than three-quarters belong to Brazil.

/ Considerable differences

Considerable differences also exist with regard to technical resources for conversion of energy, although, comparatively speaking, these are more evenly distributed. Venezuela commands almost one-third of Latin America's total petroleum refining capacity, Mexico coming second with one-sixth. Brazil, Mexico and Argentina, in that order, possess in each case between one-fourth and one-fifth of the aggregate capacity for the generation of electricity. The extent to which the various sources are utilized also differs considerably from one country to another, leaving wide margins for improvement as a general rule. Numerous cases may be cited of substantial and conveniently situated resources which are only very recently beginning to be exploited or studied.

Even so, Latin America as a whole possesses abundant, though not excessiv reserves of petroleum, considerable hydro-electric potential and vast forest areas, but, broadly speaking, there is an apparent shortage of coal deposits.

Knowledge of the location and potential wealth of their energy reserves is rather incomplete in almost all the countries of the region, especially as regards natural gas, mineral coal and hydro-electric energy. Petroleum resources are more fully ascertained, although their real possibilities are still far from having been completely assessed, since this industry's method of operation does not call for the immediate determination of all the reserves existing in a deposit, but rather for their gradual discovery.

The deficiencies described assume their most serious form in the case of hydro-electric resources; most of the countries in the region are unaware of their real heritage in this connexion. The ascertaining of hydro-electric potential is the longest, slowest and perhaps the most costly of all the tasks involved in prospecting for energy, as it has to be carried out over a very wide area and necessitates observation and the keeping of records over a long period of years. Needless to say, as requirements are intensified, wider, more thorough and more accurate knowledge will become an imperative necessity in this field. Thus it may be hoped that hydraulic resources will be exploited in accordance with the possibilities implicit in each case, both from the point of view of energy and multiple water resource utilization.

/ Chile has a

Chile has a reasonably accurate notion of its real hydro-electric potential, and Uruguay has carried out a survey of its most important resources. Brazil possesses a very advanced catalogue of the hydro-electric resources that could be exploited in the more highly developed areas of the country, and in Argentina rapid progress is being made with a similar inventory. But it much more frequently happens that knowledge of this kind, whether for countries or for entire river basins, is definitely rudimentary and inadequate. A table has been drawn up to show how the hydro-electric energy exploited in each country relates to the hydro-electric resources estimated to date. (See table 12.) This estimate takes into account the potential on the basis of the minimum flow, both with developed and undeveloped sites. In this latter case, only the natural conditions of possible locations are taken into account, and these can be considerably modified by hydro-electric works, such as reservoirs, diverting of water-courses, etc.

It is interesting to note that these resources do not always belong exclusively to one given country, but in many cases are the common property of two or more Republics, in which case their development depends upon the agreement reached on the subject by the governments concerned. Various cases deserving of study exist both in South and in Central America.

Besides the traditional sources of energy, some Latin American countries have at their disposal other specific energy resources which might be exploited on a fairly large scale. Examples of this are provided by oil shale in Brazil, the geothermic sources in Chile and Mexico, and the Patagonian tides in Argentina.

If such sources are to mean a real contribution to the energy system of some of the countries of the region, certain prerequisites must be fulfilled. These sometimes comprise the solving of particular technical problems which still prevent such resources from being used on any considerable scale. In other cases present costs are prohibitive, so that more economical techniques must be developed for their utilization.

The exploitation of nuclear energy for industrial purposes is undoubtedly feasible, since the most serious technical problems have been eliminated, and from the economic point of view it seems that costs have already been brought down to competitive levels. It is reasonable to

/Table 12

Table 12

LATIN AMERICA: PROPORTION OF HYDRAULIC POTENTIAL USED, 1954 a/

Countries	Present estimate potential	Hydraulic installed capacity	Percentage used
	(thousands of kW)		
Argentina	6,500	80	1.2
Bolivia	3,680	73	2.0
Brazil	16,200	1,791	11.0
Chile	6,600	424	6.4
Colombia	4,020	258	6.4
Ecuador	970	25	2.6
Mexico	6,030	863	14.3
Paraguay	3,150	-	-
Peru	5,800	220	3.8
Uruguay	1,000	128	12.8
Venezuela	3,200	70	2.2
Central America b/	5,200	52 c/	1.0 c/

Source: Economic Commission for Latin America, Energy Division

a/ The hydraulic potential of Cuba, Dominican Republic and Haiti is not available.

b/ Includes Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama.

c/ Provisional estimates.

assume that they

assume that they will continue to fall as nuclear installations on a commercial scale increase and greater experience is acquired. The contribution of nuclear sources to the energy system may attain very important proportions, both in the generation of electricity and for purposes of heating and motor power, although no sensational superseding of the traditional sources can be expected within the next few years.

Tables have been prepared which offer in outline an approximate reply to the question as to how far energy resources can meet the volume of future demand. (See again tables 10 and 11.) It may be noted that except in a few special cases like those of Venezuela and Colombia, and some other countries with respect to specific types of energy, the satisfaction of this demand will call for an organic and sustained effort on the part of all the countries of the area, aimed at the discovery of additional sources in the immediate future.

/ CHAPTER V

CHAPTER V

THE BALANCE OF ENERGY AND ITS UTILIZATION

When studying a country's energy consumption over a given period, it is customary to draw up energy balance-sheets. These consist of the sum total of energy in its different forms (thermal, electric, mechanical), so that a general aggregate is reached which represents, at the various levels of its utilization, the total of all energy consumed by the economy, expressed in a common unit.

The common unit adopted in this report is a ton of "normal" crude petroleum with a calorific equivalent of 10.7 million calories, to which other fuels and hydro-electric energy are reduced by conversion based on their respective thermal equivalents, in order to arrive at the aggregate energy used; these components expressed in equivalent tons of petroleum are added together. The figures must, however, be taken at a level where the state of processing, or the degree to which the different forms of energy are utilized, exactly correspond. 19/

In assessing these totals serious difficulties are encountered. The different physico-chemical and technological characteristics of the forms of energy, the spheres in which they are used, their efficiency and the technical processes through which they pass - both in their preparation and their use - are all handicaps making it difficult to present a single composite figure, based on such heterogeneous components, without giving a false picture of the relative importance of the latter or introducing factors which alter the economic significance of their composition.

19/ The major difficulty of including in a single figure all the forms of energy at present used lies in electricity, since it is the least suitable for reduction to a common unit. The solution selected as the most appropriate is that of computing hydro-electric energy at the stage of gross energy, in terms of the calories which would have been necessary to generate it thermally and which to some degree it replaces. At the stage of net energy, all electricity (thermo and hydro) has been considered as having a theoretical thermal equivalent of 860 cal/kWh, at the same time deducting the fuels actually used for thermal generation from the total.

/1. Stages

1. Stages of utilization

Since it is clear that there is no one stage which alone represents the complex process of the use of energy, it was decided that these difficulties could be avoided, or at least reduced, if that process were studied at various points from the stage of a natural resource up to final utilization.

Three stages were therefore chosen, both for their importance as a means of interpreting the process and for their economic significance. These three stages are: i) gross energy; ii) net energy (or useful energy); iii) energy used (or effective energy).

i) Gross energy is that which is contained in the sum total of all sources of energy before they have been incorporated in the economy (potential thermal energy);

ii) Net energy expresses potential energy in a form suitable for utilization and in the places where it is to be used;

iii) Energy used is the mechanical work, heating or light into which part of the net energy is transformed for absorption in a process.[20]

Each one of these levels has its value. Gross energy represents potential theoretical energy and as such measures national production needs and in part import requirements. Net energy will measure the real demand at the consumption points. Energy used expresses the final use.

Net energy is thus seen to represent the stage of intermediate use; and it is the only one which - if specific consumption by the energy sector itself be excluded - genuinely measures the energy available to the economy and is subsequently reflected in the production of goods or execution of services. It is also the stage which, in the absence of complete and reliable figures on the quantity of energy actually utilized, comes closest to values representative of end consumption. This is the reason why it is the concept most widely employed in the present report. It should, however,

20/ Some examples will help to clarify the differences between stages ii) and iii). The fuel consumed by railway locomotives represents net energy, while the ton/kilometres covered by the train - and expressed in calories - are energy used. In a blast furnace, the net energy is fuel burnt, while energy used is that part of the heat which is absorbed by the materials and equipment.

/be emphasized

be emphasized that the three stages must be jointly considered in order to arrive at conclusions on aggregate energy consumption and its characteristics.

The breakdown of energy consumption at stage iii) will be a measure of the degree of technical advancement and of the economic structure. 21/

By presenting energy balance-sheets based on the foregoing concepts and sequence, it is possible to express in clear and coherent form the majority of the technical and economic factors affecting energy utilization. Accounting by this method is also important because it permits:

a) an interpretation of the process by which energy fulfills its functions in the economy; and

b) a definition of operation involving a major expenditure of energy, in which efficiency is abnormally low by comparison with the use made of similar functions in other countries.

An analysis of this kind is, of course, particularly interesting when the figures for the efficiency at each stage exactly correspond to the country's situation. This position can arise only as a result of direct studies in this shpere, particularly in industry and transport.

2. Losses and efficiency

The passage from one stage to the next is marked by intrinsic consumption and losses of energy. Some of these are an inherent feature of the process, while others can be avoided. Nevertheless, they all tend to diminish as technology advances and depend both upon the structure of production and consumption and upon the characteristics of the equipment used. Thus, between stages i) and ii) losses occur due to the extraction, preparation, transformation, processing and conversion of energy from its sources to the consumption centres. Between ii) and iii) the efficiency that affects the final consumption of energy, in the form of work or

21/ It should be remembered that, strictly speaking, the sole stage at which equivalence between the different forms of energy can properly be said to exist is stage iii), or energy used. Only when this point has been reached, when an economically useful function has been fulfilled and when energy as such has disappeared and become incorporated in final operations or products, do all the differences between such forms, as regards their characteristics and efficiency, become blurred and indistinguishable.
Calculation at this stage, however, requires a fairly exact knowledge of the efficiency afforded by the various fuels and by electricity in the course of their utilization in the principal economic processes. By and large the efficiency has not been measured in Latin America and informatio about them is extremely vague even in many industrial countries.

/industrial heat

industrial heat, transport, residential heating, etc., must be considered. Losses between stages ii) and iii) are considerably greater than those which take place between i) and ii).

Broadly speaking, energy losses are fairly considerable in all parts of the world, but in the Latin American countries they reach greater dimensions than the world averages. Table 13 gives an idea of the magnitude of such losses. The efficiency achieved at the passage from one stage to another is consequently low, being on an over-all average not less than 50 per cent, in Latin America, below those of countries at a more advanced technological level. 22/ This fact is explained by the heterogeneous nature of the equipment used, much of which consists of antiquated machinery, as mentioned in Chapter I.

It should be emphasized that individual consumers may not be particularly anxious to save energy, from the financial standpoint, since the incidence of the cost of energy upon production costs is low, usually about 5 per cent. 23/ Governments, however, are supremely interested in the efficient use of energy, since it enables them without great effort to save from 10 to 20 per cent of current consumption, with consequent advantages which often include a considerable saving of foreign exchange.

The over-all average efficiency - expressed as a ratio of iii) : i) - is not very indicative. Its mere size is insufficient to permit the characteristics of the energy-economy peculiar to the system to be defined and to interpret them correctly the components must be known and the efficiency recorded within each of the main sectors. The efficiency is found to vary considerably in accordance with the type of activity, process, equipment utilized, etc. 24/

22/ The size of the problem is clear when it is stated that, with a very similar composition of consumption, the efficiency of the use of energy in Argentina is at least 60 per cent lower than that of the United States.

23/ Admittedly this figure is much greater in certain intensive activities of energy, such as metallurgy, electro-chemistry, etc.

24/ Thus, since the residential use of fuels generally takes place with a final efficiency which is higher than that of the remaining activities, the relative predominance of this type of consumption would improve the over-all efficiency of the system, while concealing the fact - if such were the case - of the small or deficient use of energy by industry.

/Table 13

Table 13

APPROXIMATE EFFICIENCY OF DIFFERENT FORMS OF ENERGY, BY UTILIZATIONS (STAGES i - iii), IN THE GROUP OF LATIN AMERICAN COUNTRIES WITH MORE ADVANCED TECHNIQUES, 1950

Form of energy	Efficiency in passage from gross energy to net energy (i-ii)					Efficiency in passage from net energy to energy used (i-iii)		Over-all efficiency (i - iii)
	Extraction	Preparation and conversion	Generation of electricity	Trans-port	Over-all efficiency			
Hydro-electricity:	100	100	93	85	79	Residential heat	100	79
						Mechanical work	90	71
						Industrial heat	80	63
						Transport	15	11.8
						Lighting	10	7.9
Commercial fuels: a/	96	92	-	97	85.6	Residential heat	50	43.8
						Industrial heat	25	21.9
						Transport	4b/	3.4
Thermo-electricity:	96	92	16 - 18.5	92	15	Residential heat	100	15
						Mechanical work	90	13.5
						Industrial heat	80	12
						Transport	15c/	2.3
						Lighting	10	1.5
Fuelwood and other vegetable fuels: d/	90	75	-	90	60.8	Residential heat	50	30.3
						Industrial heat	20	12.2
						Transport	3	1.8

Source: Economic Commission for Latin America, Energy Division.
a/ Refined petroleum productos, mineral coal and gas, but excluding the generation of electricity.
b/ Including diesel-electric, though very scarce in Latin America.
c/ Excluding diesel-electric.
d/ Including charcoal.

/Between the

Between the stages of gross energy and net energy, the system suffers considerable losses, resulting from the extraction, refining, conversion and transport of fuels and the generation and transmission of electricity. Such losses are variable, depending upon the breakdown of consumption by sources and they increase proportionately to the secondary or derived energy employed. Calculations for Latin America indicate that between 25 to 30 per cent of the gross energy consumption is used in the afore-mentioned operations. The principal losses result from the generation of electricity by thermal means, from the carbonization of fuelwood and from the extraction of mineral coal.

In Latin America, not more than 15 per cent - and often less - of the aggregate energy designed to generate electricity becomes available to consumers in the form of electric current, whereas the same ratio in countries which are technically and economically well developed generally exceeds an average of 21 to 22 per cent. It is thus an expensive operation from the point of view of heat utilization, as well as from that of physical and financial resources.

It is in this activity, then, that the most attractive prospects exist for diminishing the losses which the energy system suffers between stages i) and ii).

The backward condition of almost all the Latin American countries in the matter of energy arises both from the age of the generating equipment - with its consequently greater consumption of calorific energy per unit of electricity - and from the greater consumption of the plants themselves, as well as from losses in the distribution network. Characteristic features of consumption, including small-load and diversity factors and the lack of hydro-thermal interconnexion, are also responsible for this situation. By taking suitable steps to remedy all these deficiencies, it is possible to obtain very marked improvements in the efficiency of the electricity system, which in many countries have become worse during recent periods.

The collection of fuelwood and its conversion into charcoal is generally subject, in Latin America, to very low efficiency, owing to the out-of-date processes which are still popular and to the lack of integration in the operations. In view of the high proportion of fuelwood and its derivatives

/to the

to the total consumption of almost all the countries of the region, such losses have a very pronounced effect upon the total.

Losses in coal mining are also very high, owing to the uneconomical methods frequently adopted and to the absence of organization in the industry.

As regards the extraction, transport and refining of petroleum, these are operations which in Latin America show an efficiency similar to that of more advanced countries.

Once they have been adequately "prepared" to make them available for use, the various forms of energy proceed to fulfill their functions in many economic activities connected with production, transport and consumption. It is at these stages that the greatest losses arise, and it is here that there are the best prospects of effecting considerable savings. While the losses between the stages of gross and net energy stand at about 25 per cent, those which take place at this point represent more than double that proportion.

The figures given in the present report are provisional, but it is considered that they represent an acceptable approximation of the Latin American situation. Table 13 shows, step by step, each of the operations mentioned. The final efficiency summarizes the combined average effect of all the fuels used in the different operations. (See table 14).

A combination of the efficiency of each activity with the share taken by the latter in aggregate energy consumption indicates the characteristics governing the use of energy by the various countries. The principal sectors are: industry, transport and residential use. 25/

25/ It is well known that increased industrial diversification tends to raise the importance of the power, blast furnace and damp-heat sectors, and to reduce the importance of dry heat which, to a very large extent, is intended for the manufacture of building materials and other industries which satisfy basic needs. These effects may be observed from a study of the energy balance-sheets at the stage of the energy used in several Latin American countries.

/Table 14

Table 14

AVERAGE ENERGY EFFICIENCY BETWEEN STAGES ii AND iii IN THE VARIOUS ECONOMIC SECTORS OF THREE GROUPS OF COUNTRIES

	Industrial countries	Latin America: Countries with more advanced techniques	Latin America: Countries with less advanced techniques
Generation of electricity	25	19	15 a/
Stationary mechanical work	90	90	80 b/
Industrial heat:			
Metallurgical furnaces	35	25-30 c/	15-20 d/
Other types of dry heat	30	22-28	15-20
Wet heat	30	20-25	15-20
Residencial use:			
Heating e/	60	50-55	30-35 f/
Lighting	15	10	10 g/
Transport:			
Railways	3.6	2.9	2.0
Motor vehicles	5.0	5.0 h/	4 i/

Source: Economic Commission for Latin America, Energy Division.

a/ Efficiency under generating conditions similar to those prevailing in the rest of Latin America. The average is not lower becasue of the diesel plants existing in these countries which work with higher efficiency.

b/ For this group of countries, it has been assumed that electric motors are not utilized under optimum conditions, which would give 90 per cent efficiency.

c/ The efficiency has been reduced because of the incidence of small-scale industries, whose efficiency is lower than that of manufacturing industry with higher techniques.

d/ The absence of heavy industry is responsible for the lower value of this coefficient.

e/ Includes heating, cooking and hot-water supply. The variation among countries is very great.

f/ The poor quality of the fuels, combined with the current housing conditions, necessitates a greater expenditure of calories to obtain a given rise in room temperature.

g/ Kerosene or carbide lamps - although inferior to electricity for lighting purposes - give a relatively good thermic efficiency.

h/ The same efficiency has been assumed as for industrialized countries, owing to the fact that the number of out-of-date models is compensated by the longer distances travelled by motor vehicles with one passenger only and by the great traffic congestion.

i/ Very poor roads, together with other factors, are responsible for lower efficiency.

/The apparent

The apparent approximate efficiency of aggregate industrial activity in the technologically advanced countries of Latin America is about 25 per cent. This figure may be improved by taking action directed at various aspects, such as: introducing technical improvements in the use of fuels, or adapting that form of utilization which gives the best efficiency at each utilization. The efficiency in the final use of electricity is, as a general rule, adequate, since the operations here take place in accordance with universally accepted practices. Nevertheless, a margin remains which is capable of improvement by means of the modernization of the electrical installations and the more rational use of direct drive.

But the use of industrial heat- save in exceptional cases such as integrated iron and steel industries, metallurgy for export and isolated large-scale establishments in a number of industries - involves heavy losses and lends itself to the introduction of much higher utilization than at present.

It is perhaps in the transport sector that the greatest losses arise in use. This is due to the exceedingly low energy efficiency in such operations, averaging not more than 3.5 per cent in Latin America. Rail transport in particular shows much scope for very considerable improvement, since the efficiency in Latin America is only half or one-third of that obtained in more developed countries.

The fact that these figures are so low results basically from the inadequate state of the locomotive equipment and the fuels used for traction. There is no doubt, however, that a rationalization of railway transport would lead to pronounced improvements in efficiency and therefore to a saving of fuels. Since a quarter and even more of the aggregate energy in many Latin American countries is intended for transport purposes, the result represents very high losses for the economy. It is obvious that for rail transport, more than for any other economic activity, the necessity of the best possible utilization of available capital goods must always be borne in mind. The solutions adopted must fulfill the requirements of the maximum economy of energy together with the lowest additional investment.

Although the residential sector uses energy with comparatively satisfactory efficiency, the introduction of certain technical methods (applie to the rationalization of building, the choice of fuels and central heating) would all result in considerable economies.

/Chapter VI

CHAPTER VI

PROJECTION OF DOMESTIC PRODUCTION

Once the demand for the different types of fuel and hydro-electric energy has been estimated, and the existing resources of energy in Latin America have been examined, the problem arises of projecting production in 1965.

Any future estimates at this point are complicated by the fact that, particularly in the case of petroleum, many countries have embarked upon far-reaching plans for developing production, the targets for which bear no relation to past experience. Recent discoveries in some cases, or increases in the extraction rates of hydrocarbons in others, appear to suggest further expansion, but nothing definitive can be stated. Still more doubtful is a forecast for the production of natural gas, or for certain promising new sources of energy such as the oil shale deposits in Brazil.

Lastly, there is always the possibility that, before the ten-year period set for the demand projections in this report has expired, some nuclear energy plants may have been established in Latin America. If this occurs, it will considerably lessen the pressure of demand for other fuels, in particular petroleum.

1. Projection of production

In estimating the possible contribution of national production, the plans already suggested or in the process of being realized in some countries were analysed, as well as their possibilities, according to the nature of the resource in question, and their consistency. Consideration was also given to demand requirements with little elasticity for substitution, especially in the face of an urgent need to economise foreign exchange or to safeguard the supply in the event of an international emergency. For example, prospective iron and steel industries will require the prospection and use of coking coals in the area where they are established. The growing demand for petroleum derivatives impels countries to redouble their efforts to increase

/output and

output and lessen imports of a product which weighs heavily in the balance of payments. On the same principle, the development of hydro-electric resources is receiving a considerable stimulus, and almost all the countries are planning to use this form of energy more intensively.

The increase in national production of energy for domestic consumption (excluding exportable surpluses) which is anticipated for 1965 for Latin America as a whole, on the basis of arbitrary assumptions of development set forth in this study, is very great. According to these estimates, total output of energy would be approximately 86,000 million kWh, representing accumulative annual rate of increase of 7.8 per cent. Hydro-electric energy would expand more rapidly (8.9 per cent annually), representing almost 60 per cent of the aggregate in 1965. The production of petroleum for domestic consumption would also rise at a rate of 10.7 per cent, exceeding 65 million tons at the end of the period, while that of coal would surpass 12 million tons, with a yearly rate of 5.7 per cent.

/Table 15

Table 15

LATIN AMERICA: PROJECTIONS OF PETROLEUM PRODUCTION, 1954-65
(Millions of tons annually) a/

	Real Production	Production for domestic consumption		
	1954	1954	1965	Difference b/ 1954/65
Argentina	4.23	4.23	12.14 c/	7.91
Bolivia	0.22	0.22	0.52	0.30
Brazil	0.13	0.13	12.82 c/	12.69
Chile	0.23	0.23	1.30	1.07
Colombia	5.66	1.32	1.30	-
Cuba	-	-	1.00	1.00
Ecuador	0.41	0.30	0.72	0.31
Mexico	11.98	8.65	19.5	7.52
Peru	2.29	1.51	3.24	0.95
Venezuela	98.00	4.90	9.8	-
Total	123.15	21.49	65.34	31.75

Source: Economic Commission for Latin America, Energy Division.

a/ To calculate the daily productive capacity in barrels, 1 million tons annually has been considered the equivalent of 19,000 barrels daily. This assumes an average density of crude at 0.9.

b/ The additional production is the result of subtracting the real productin in 1954 from the projected output in 1965 and corresponds to the share of which the financing has been estimated in this report. In examples such as Colombia and Venezuela, where present output will exceed domestic requirements in 1965, no additional capacity was considered necessary. This is equivalent to assuming that supplies for the domestic demand will be financed from the export industry, and, given the size of the examples, is not significant.

c/ A more moderate production alternative in 1965 has been assumed for these two countries, which would be: Argentina, 8.5 million tons; and Brazil, 6 million tons (see the revelant section of the text).

/Only Venezuela

Only Venezuela and Colombia, and possibly Bolivia, would have important exportable surpluses of locally-produced petroleum. In some countries, such as Ecuador, Peru and Mexico, the extraction of crude would barely meet the projected demand, while in others it would have to be supplemented by imports (Argentina, Brazil, Chile). In general, these projections have taken into account previous yields from such resources, since, for the most part, expansion of known supply zones is contemplated. On the other hand, when forecasts were based on new areas, as was the case to some extent in Argentina and wholly in Brazil and Cuba, the estimate had to be deduced from general considerations. For the first two countries, recourse was had to an indirect method, taking as the point of departure certain hypotheses of maximum imports of fuels, compatible with the countries' capacity for external payment.

In the case of Argentina, for example, it was assumed that imports of petroleum and coal in 1965 would be maintained at the average level reached in 1948/49 - 1953 (6 million tons), a figure which seems reasonable bearing in mind the characteristics of the period and the expansion of foreign trade predicted. Thus, it appeared that it would be necessary to reach a domestic output of 12 million tons of petroleum in 1965, which would mean a 10 per cent annual rate of increase. This is fairly high in comparison with past trends, and could only be achieved through heavy investment in the development of new oilfields. There is another less ambitious alternative, according to which output would grow at an annual rate of 6.5 per cent, affording at the end of the period an annual production of 8.5 million tons. (See table 15.)

In the case of Brazil a similar procedure was followed. The first step was to determine a volume of fuel imports which would represent 18 per cent of the over-all imports estimated for 1965, a proportion which is slightly larger than that prevailing in recent years, but which is considered acceptable.[26/] In this way the figure of 12.8 million tons was arrived at

26/ Analyses and Projections of Economic Development, II. The Economic Development of Brazil, document No. E/CN.12/364.

/for the

for the domestic output of petroleum needed to complement the above imports. Despite the favourable conditions prevailing in vast zones in the Amazon area, and its probable potentiality, official statements as to the physical and financial possibilities available seem to indicate that it is doubtful whether work on such a large scale could be undertaken. Hence it was deemed advisable to consider, as an alternative, a domestic output of only 6 million tons in 1965. (See table 15.)

In the case of Peru, domestic supply will be met from the probable output of the present oilfields. Should the Sechura field, which at present is being actively investigated, produce positive results, this would invigorate exports without materially altering the present hypothesis. There might be exportable surpluses in Bolivia should extraction continue to increase at the rapid rate now prevailing.

2. Installed capacity required

From the calculation of the annual demand for the different fuels and for electric energy, together with the share expected from national production, an estimate was made as to the size of the installations necessary to meet these requirements. That is to say, operating capacities were calculated for power stations, oil-wells, coal mines, petroleum refineries, transport and distribution of over-all requirements. For a prompt and adequate servicing of demand, its seasonal and regional distribution would have to be taken into consideration. However, the scope of this study does not allow a projection of needs in such detail, as it has been carried out merely on a national scale and in annual totals; thus the size of installations can be only approximately estimated. For this purpose, use has been made of coefficients reflecting domestic averages for the different elements that enter into the calculations. These coefficients have been adopted on the grounds of the actual experience of the different countries and of the changes that may be envisaged as a result of new rates of economic growth, or of the new levels reached in the supply of energy.

a) Electricity. The probable consumption of electricity in 1965 was taken as a point of reference, and by adding the unavoidable losses in transmission and distribution and the energy used by the plants themselves,

/the aggregate

the aggregate energy which would have to be generated in that year was deduced. This estimate of generation and the pattern and characteristics of consumption - above all, the load factor[27] - make it possible to determine the minimum number of installations needed to satisfy the estimated consumption. By adding to the foregoing a reserve capacity[28], the total capacity which should be installed by 1965 was calculated, and thereafter distributed between hydro- and thermo-electric energy, according to the availability of hydraulic resources, and servicing requirements.

A table was drawn up to show total installed capacity divided between the requirements for hydro- and thermo-electric energy in 1965. Current installed capacity for 1954 is also given, making it possible to determine what additional equipment for the generation of energy must be installed in the intervening period. (See table 16.)

Strictly speaking, for the additional capacity in the period under review there should be a marginal allowance to cover inevitable and possibly extensive replacements of worn-out plant. As it is extremely difficult to determine such requirements from available information, this figure has been omitted, although in many cases it may reach 25 per cent of the 1954 installed capacity, or more.

It should be remarked that in the hypothesis of growth adopted for the gross national product, which assumes an annual increase of 2.5 per cent, total capacity is more than doubled in the period, rising from 9.9 to 21.7 million kW (7.4 per cent annually). This implies a substantial building

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27/ It is assumed that through the natural diversification of consumption resulting from a greater development of electrification, and through the efforts made towards this goal, almost all countries will be able to achieve a load factor of 55 per cent at the end of the ten years, based on the current figure of approximately 50 per cent.

28/ For this reserve capacity, which has generally been lacking in nearly all the great consumer centres of Latin America in recent years, slowing down industrial and urban expansion, a provisional estimate of 20 per cent has been adopted.

programme. Some countries, for example, Brazil and Colombia, would manage to treble their installed capacity. In the interim, the proportion of hydro-electric plants varies from 44 to 57 per cent, thus pointing the way to a better utilization of this renewable resource. 29/

Table 16

LATIN AMERICA: REQUIREMENTS FOR ELECTRIC GENERATING CAPACITY, 1954-65
(Thousands of KW)

	Installed 1954			Projected 1965			Addition 1965		
	Hydro	Thermal	Total	Hydro	Thermal	Total	Hydro	Thermal	Total
Argentina	80	1,805	1,885	740	2,740	3,480	660	935	1,595
Brazil	2,136	642	2,778	6,050	1,300	7,350	3,914	658	4,572
Chile	424	404	828	1,005	1,605	1,610	1,581	201	782
Colombia	260	220	480	1,200	410	1,610	940	190	1,130
Mexico	845	1,005	1,850	1,900	1,600	3,500	1,055	595	1,650
Total	3,745	4,076	7,821	10,895	6,655	17,550	7,150	2,579	9,729
Group II a/	426	1,148	1,574	980	2,200	3,180	554	1,052	1,606
Group III b/	195	314	509	490	440	930	295	126	421
Grand Total	7,366	5,538	9.904	12,365	9,295	21,660	7,999	3,757	11,756

Source: Economic Commission for Latin America, Energy Division.

a/ See footnote c/ to table 3.

b/ See footnote d/ to table 3.

It must be remembered that the problem of estimated generated capacity is allied to that of transporting eletric energy over greater or lesser distances, according to circumstances, to the consumer centres, which is

29/ The use of hydro-electric energy means a saving of coal and heavy oils in the following percentages of such fuels: 1937 - Brazil 51, Chile 16 and Mexico 25; 1952 - Brazil 85, Chile 30 and Mexico 16.

/followed by

followed by that of rural and urban distribution to the end consumer. A separate estimate of this additional equipment has not been made, although its cost is known to be in proportion to generating capacity and to the different types of transmission which have been taken into account in view of the varying geographical location of hydro-electric resources. This latter point has been considered in the calculation of the unit-coefficient of capital.

b) Petroleum and coal. It is simple to calculate the installed production capacity per day required to obtain the projected annual volumes of petroleum, since operations are as a rule carried out in a uniform and continuous manner. (See table 15.) In the case of the refineries, possible irregularities in the work during the year are forecast, and the structure of demand for refined products has been analysed so as to ascertain the type of plants that would be needed.

Another table gives the installed refining capacity needed for 1965, as well as requirements additional to those installations which are now in operation. (See table 17.)

While national output of petroleum would be trebled in 1965, increasing by 10.7 per cent annually refining capacity would be doubled, rising by 6.9 per cent annually. These rates of growth, although they reveal substantial efforts at expansion, are not very high in the aggregate compared with those experienced by the industry in recent years. In the case of refining capacity it was assumed that such development would take place only in those countries producing crude (with the exception of Uruguay), and in some countries not enough crude to satisfy domestic demand would be refined locally (75 per cent of requirements in Brazil and Chile).

/Table 17

Table 17

LATIN AMERICA: REQUIREMENTS FOR PETROLEUM REFINING CAPACITY
(Installed capacity in thousands of barrels of petroleum/day)a/

	Existing 1954	Total 1965 b/	Addition 1965
Argentina	208.0 c/	385	177
Bolivia	11.3	11	-
Brazil	109.8 d/	368	258
Chile	21.1 e/	34	13
Colombia	38.0	90	52
Cuba	6.1	99	93
Ecuador	5.7	18	12
Mexico	256.5	414	157
Peru	46.9	69	22
Uruguay	28.0	40	12
Grand total	732.4	1,528	796

Source: Economic Commission for Latin America, Energy Division.

a/ Crude processing capacity equivalent to 1 million tons annually, requires a daily refining capacity of 21,200 barrels. This figure was calculated by establishing an average gravity of 0.9 for crude petroleum and by ensuring a 90 per cent utilization factor for the refinery. (This last presupposes a working year of only 330 days.)

b/ Assuming total domestic refining of consumer needs and excluding the consumption of important export activities, except in Brazil and in Chile, three-quarters.

c/ Includes the Presidente Perón refinery which entered operation in early 1955.

d/ Includes the Cubatao refinery which entered operation in April 1955.

e/ Includes the Conoón refinery which entered operation in early 1955.

f/ Excluding Venezuela.

/The marketing

The marketing of finished products, whether of local origin or imported, calls for investment in dockyard warehouses, distribution centres, service selling-stations, etc., which have been scaled in line with over-all consumption.

As coal plays a lesser part in aggregate future investment, a detailed estimate in relation to other types of energy was not made. Estimated production in tons per annum was taken as a point of departure, and it was assumed that all the installations in the various aspects of the industry were proportionate, when determining this annual productive capacity. This increases from 7 million tons a year to 12.8, within the period; in other words, by 83 per cent (5.7 per cent annually). As can be seen, such expansion is also comparable with that projected for petroleum and electricity, and will allow this industry to develop normally within the framework of the energy market.

CHAPTER VII

THE INVESTMENT AND FOREIGN EXCHANGE REQUIRED FOR ENERGY

Once the approximate size of the installations which will be required to meet the need for energy in Latin America over the next decade has been determined, a calculation can be made of the capital and foreign exchange requirements it will involve within the investment budget and the balance of payments of the countries concerned.

With the sole aim of providing an idea of the size of the figures involved, an approximate estimate was made, in which all installations were divided, for each type and energy sector, into groups of similar types and characteristics and, insofar as possible, by geographic location. Costs could thus be estimated by a comparison with typical examples of installations recently carried out, or planned, in the region, the accuracy of which had been checked with many other examples within the region and elsewhere.

1. Unit costs

These unit costs represent average situations which, although similar, vary substantially according to the country, region, size of the project, specific characteristics, etc. However, despite these wide disparities, it is possible to establish that the difference in costs for large groups of installations and equipment on a national scale is fairly narrow. The validity of the figures rests upon this average statistical behaviour.

These calculations similarly include the share of investment which must be spent abroad, for which comparative and suitably adjusted examples have also been used.

In the case of electricity, cost per installed kW, including transmission and distribution, worked out to an average according to the country of between 480 and 560 dollars (at 1954 prices) for hydraulic plants and of 425 to 475 dollars for thermic plants. The margins of variation between individual cases are naturally very broad and depend - among other factors - upon the size, type and complexity of hydraulic works, transmission networks, planned expansion in the future, characteristics of the plants and the type of fuel, etc. The variations are less in thermic plants, but are still relatively large.

/In adopting standards

In adopting standards of unit cost, averages reached on the basis of organic plans were consulted, such as those carried out in Argentina, Chile, Colombia, Ecuador, etc. in which are included a variety of plants and services linked with planning, inter-connexions, frequency unification, etc., thus resulting in suitably weighted averages.

For petroleum, the unit costs of the plants required to obtain a given extractive capacity vary considerably according to conditions of the resources. Consequently, projections in this sphere are subject to much uncertainty. Fairly high coefficients were adopted, which allow a wide range of possibilities to be covered. They represent from 2,900 - 3,000 dollars per barrel/day of production capacity (including the cost of transporting crude) in countries with relatively rich deposits that have been worked for a long time, such as Colombia and Mexico; to 3,600 dollars under average conditions, in countries such as Bolivia, Cuba, Ecuador and Peru; and as high as 3,800 and 4,100 dollars in little-known or more distant areas, such as Brazil and Chile. These values were also checked with experience in the United States, where the coefficient stood at 2,800 dollars in 1950.

Refining can be more accurately estimated, and the installation cost to refine one barrel/day of crude resulted between 1,000 and 1,200 dollars according to the size of the refinery and diversity of products. Some recent instances in the region appear to be slightly below this figure, although this is because they correspond - on the whole - to a more simple type of installation.

By adding the transport of refined products (300-400 dollars) and marketing of finished products (1,100 dollars), the unit cost for the over-all development of the industry represents between 5,600 and 6,800 dollars per barrel/day capacity, according to the country.

Coal has installation costs which vary a great deal. However, because there are only a few countries which are developing coal mines in the region and the information is indefinite, a single representative value of 20 dollars a ton was calculated. This value, although it excludes regional differences, provides a sufficient approximation since the total figures for Latin America are in any case relatively low.

/2. Aggregate investment

2. Aggregate investment

Having established the unit cost of the different installations for production and distribution of energy, the aggregate investment until 1965 was calculated by multiplying the unit cost by the previously calculated capacities. (See chapter VI.)

These figures are shown in table 18. They express the annual average investment needed for the whole of Latin America during the period 1954-65, in millions of dollars at 1954 prices, to satisfy the needs for energy arising out of development proceeding at an arbitrary annual rate of 2.5 per cent during this period.[30/] Of the 1,046 million dollars which are required for such investment every year, 54 per cent represents electricity, over 44 per cent petroleum and close to 2 per cent coal. Of the total, 57 per cent would have to be spent abroad.

If, instead of the preceding assumption, the question had been raised as to the required investment total to cause growth in the given economy at a rate of 1 and 4 per cent respectively, the totals would be 600 million dollars and 1,655 millions annually. The proportions mentioned above would change; the share of petroleum would diminish for the 4 per cent growth rate assumed and it would increase for the 1 per cent hypothesis.

The percentage of the total to be spent abroad represents, as noted, an appraisal of what national production and techniques cannot supply. This is very variable and the values only express a general average. An example may be given of a large transmission line. In Brazil it was recently estimated that for a 60 thousand kW project, the power line could be entirely financed in the country mainly on the basis of domestic aluminium and steel. In smaller countries, El Salvador for instance, where no such output is available, only 25 per cent of such an installation could be financed in local currency.

30/ See chapter III.

/Table 18

Table 18

LATIN AMERICA: INVESTMENT OF CAPITAL FOR THE SUPPLY OF TOTAL ENERGY 1954-65

(Millions of 1954 dollars)

	Electricity		Petroleum		Coal		Energy sector as a whole	
	Total	Abroad	Total	Abroad	Total	Abroad	Total	Abroad
Argentina	777	470	1,089 a/	708	26	13	1,892	1,191
Brazil	2,175	1,099	1,736 a/	1,042	20	10	3,931	2,061
Chile	352	141	119	84	40	20	511	245
Colombia	565	287	125	88	30	15	720	390
Mexico	825	454	974	585	14	7	1,813	1,046
Sub-total	4,694	2,361	4,043	2,507	130	65	8,867	4,93
Group II a/	775	475	456	319	6	3	1,237	79
" III b/	223	122	135	94	-	-	358	21
Totals	5,692	2,954	4,634	2,920	136	68	10,462	5,94

a/ With the more modest assumption for domestic output of oil the figures for total investments and foreign exchange requirements would be, respectively for Argentina 1,626 and 1,018 millions and for Brazil 3,335 and 1,703 milli This would lower the gran total for the whole of the energy sector to 9,60 millions of which 5,411 millions would be in foreign exchange; but it woul on the other hand, imply higher imports of fuel (see text).

b/ See footnote c/ to table 3.

c/ See footnote d/ to table 3.

NOTES: The investments required for the replacement of worn-out equipment are not included. It is assumed that the figures for the projected period will be the same as 1954 productive capacity. Investments are also excluded, which, at the end of the period will be essential for the preparation of post-1965 programmes, but on the other hand they do not take into account the projects under way at the present time.

/3. Energy in the

3. Energy in the national capital outlay

To estimate the share of total national investment which might be required for energy, the gross annual investment expected during the period must be known. For a rate of growth such as that assumed, this investment would represent approximately 17 per cent of the gross product. In other words, some 8.700 million dollars (at 1954 prices) would be needed at the beginning of the period and around 13.900 millions at its close. The energy sector, with its average quota of 1.046 million dollars annually would thus absorb from 12 to 7.5 per cent of the total capital available, respectively.

If petroleum output in Argentina and Brazil were to conform to the other assumption referred to in Chapter VI, the energy investment needs for the whole of Latin America would decline to 945 millions annually, corresponding to 10.5 per cent and to 6.6 per cent respectively of the investment needs for the region, within this period.

It remains to analyse whether these percentages represent efforts compatible with the possibilities and traditions of the countries in the region. Historical data on this point is available only for Chile and Mexico. In these countries, during the period 1940-52, energy absorbed percentages of the gross annual investment which varied in the case of Chile from 6 per cent at the beginning of the period to 11 per cent at the end; and from 5.5 to 14 per cent in the case of Mexico. The high figures during the later years include expenditure on electrification plans and on the development of State petroleum concerns. It may be said they constitute situations comparable to those anticipated for the future i the hypothesis assumed here, which would demand from 17.0 to 11.4 per cent in the case of Chile, and from 15.3 to 8.8 per cent in that of Mexico, at the beginning and end of the next decade respectively.

No assumptions are made of the sources for financing the capital needs in the energy supply of the region, because this largely dependent upon many factors which are difficult to forecast and the analysis of which is outside the scope of this report. Nevertheless, it may be of value to show that international credit institutions have actively co-operated in financing electrification projects in Latin America. Such loans have been granted both to official concerns as well as to private enterprise with a government guarantee.

/Table 19

Table 19

LATIN AMERICA: PROPORTION OF ANNUAL GROSS INVESTMENT IN ENERGY TO NATIONAL GROSS ANNUAL INVESTMENT

	National gross annual investment			Gross investment in energy			
	Millions of 1954 dollars			Millions of 1954 dollars per annum	Percentage in national gross annual investment		
	1955	1960	1965		1955	1960	1965
Argentina a/	1,897	2,353	2,912	189	10.0	8.0	6.5
Brazil a/	2,196	2,776	3,509	393	17.9	14.2	11.2
Chile	300	367	446	51	17.0	13.9	11.4
Colombia	694	874	1,108	72	10.4	8.2	6.5
Mexico	1,186	1,550	2,047	181	15.3	11.7	8.8
Others	2,457	3,170	3,900	160	6.5	5.0	4.1
Latin America	8,730	11,090	13,922	1,046	12.0	9.4	7.5

a/ Considering the other alternative assumption for the production of petroleum, the overall annual investments would be 163 millions instead of 189 for Argentina and 351 instead of 393 millions for Brazil. This would bring the total for Latin America to 960 millions per annum (see table 18). This figure would represent 11.0 per cent, 8.7 per cent and 6.9 per cent of the gross annual investments for 1955, 1960 and 1965 respectively.

/ Up to the

Up to the beginning of 1955 such institutions have loans authorized for a total of 424 million dollars for the development of electric energy in the region, of which 53 per cent was granted to State enterprises.[31] The total loans were composed as follows:

a) International Bank for Reconstruction and Development

	Millions of dollars
to State enterprises	172.53
to private companies	117.39
Total	289.92

This total, consisting of loans since 1948, represents 63 per cent of the aggregate credit extended to Latin America and 57 per cent of all loans for electric energy made by the Bank.

b) Export-Import Bank

	Millions of dollars
to State enterprises	55.84
to private companies	78.41
Total	134.25

The first of these loans was granted in 1939. The total represents some 8.3 per cent of all credit extended to Latin America.

For distribution of over-all investments in electricity on a national scale the example of Mexico may be given. In the period 1939 to 1950 the investments of the four major utility companies, whose joint output represents more than 90 per cent of the national total, were financed in the following way;

31/ The contribution of State enterprises at present represents 15 per cent of the generating capacity for electricity in the region. In the over-all total of capacity installed between 1946 and 1953, the share of public bodies represents 35 per cent and that of foreign public utility companies 27 per cent. The reminder mainly consists of private mining and industrial companies owned locally or by foreign interests.

/Government contributions

		Percentage
Domestic financing:	private	14
	public	57
	private	6
Foreign financing:	public	23
		100

4. Energy in the foreign exchange budget

From the preceding sections it would appear that the capital requirements for energy investment are compatible with the resources which the countries can and should devote to their energy supply. But it is quite clear that for some of the countries the invetment would be higher than the capital devoted to energy in the recent past.

It is also of interest to note how far such energy requirements will weigh in the foreign exchange budgets of these countries. Such needs comprise the equipment and services required for the national energy system which cannot be obtained locally, and the fuels which must be imported to cover deficits in domestic output. For this purpose the capacity to import for the whole of Latin America and for some selected countries has been projected until 1965.

With the assumptions of table 18, fuel imports would reach 941 million dollars (at 1954 prices) at the end of the period and would represent 9.4 per cent of the foreign exchange availability accruing from exports. The 594 million dollars representing the purchases abroad required by investment are equivalent to another 5.9 per cent.

In the assumption of lower domestic output of petroleum for Argentina and Brazil, the imports of fuels for Latin America as a whole would increase to 1,268 million dollars, corresponding to close on 13 per cent of the total.

It is difficult to compare these figures with past records because data are lacking. As an example, percentages which fuels have represented in the imports of some countries may be cited. They have of course varied substantially according to the availability of natural resources and have been maximum in those countries which have been affected by the shortage of national output in relation to the growing demand.

/The principal

The principal countries concerned are Argentina, Brazil, Chile, Cuba and Uruguay. In Argentina, fuels represented 15 per cent of the total of all imports in 1950-51, 21 per cent in 1952 and 24 per cent in 1953. In the case of Brazil, the proportion varied around 10 per cent in 1946-52, but reached 16.5 per cent in 1953. Both Chile and Uruguay have shown a proportion of some 10 per cent during recent years, while Cuba's, from an average of 5 per cent during the immediate post-war years, had risen to more than 9 per cent in 1952.

These percentages are the highest for the region as a whole. Some other countries, such as those of Central America, of the Caribbean area and Paraguay, which must import almost all their requirements of commercial fuels, have devoted only 3 to 6 or 7 per cent of their foreign exchange to this purpose and perhaps slightly more during the last few years.

It can thus be appreciated that the Latin American average for fuel imports in 1965 is relatively high and includes some individual cases where the situation may be more serious.

For Brazil, for example, assuming that petroleum output would reach only 6 million tons (see chapter VI), the imports of fuels would absorb 28 per cent of the national total, posing a serious balance of payments problem.

Colombia is a representative example where the abundance of natural resources meets all energy requirements and purchases abroad for the energy sector only represent equipment needs, so that only 6.4 per cent of the payments capacity in 1965 - estimated at 610 million dollars - would be required for investment in electric power, petroleum and coal industries.

Reliable figures for the equipment purchased for the energy sector in the past could not be obtained, although a basis for their approximate estimation at from 4 to 6 per cent is available for countries such as Argentina, Brazil, Chile and Mexico during the last ten or fifteen years. Figures projected for 1965 thus seem to conform to this pattern.

To ease the balance of payments of the strong pressure which is exercised by the current needs for fuel imports, it would be necessary - without endangering the projected rate of development - to raise national energy output. The assumptions given of national output in this report are based on an actual knowledge of the available resources and, unless they are much greater, or can be developed more rapidly than had been expected,

/it will be

it will be difficult to increase the contribution of national energy to a level well above that which was estimated.

Doubtless special efforts might in some cases permit a more intensive use of the national sources of energy, but in other cases such possibilities are physically limited by an absence or shortage of resources, or even by the high cost of exploiting.

Since the principal deficit of energy is found in petroleum, the imports of this fuel will seriously drain available foreign exchange. In countries where there are good prospects for petroleum activities, more active prospection - accompanied by the corresponding investment to exploit the reserves to be drilled - may help to cover the deficit. 32/ Finally, as stated earlier, it is quite possible that towards the end of the period under consideration some nuclear energy plants may be installed in the region, but it cannot be ignored that, for the moment, the unit-cost is high and that such plants could only supply requirements for electricity.

Other methods for decreasing foreign exchange expenditure consist of raising the national output of some capital goods which must now be imported and in reducing technical services from abroad. Both depend upon the industrial development of each country and upon the future structural changes which would justify the production of a number of elements indispensable for carrying out the projects.

32/ It is as well to note that the critical situations mentioned above may improve considerably in countries which have natural gas deposits, ready for exploitation and at economic distances from consumption centres. To market natural gas requires far smaller investments than petroleum, since almost no refining is required, and it could meet some of the needs. In the previous calculations, this possibility was considered with caution, because the scanty knowledge of natural gas reserves in the region at present does not allow disproportionate projects to be made.