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REPORT OF THE LATIN AMERICAN ELECTRIC POWER SEMINAR  
(Mexico City, 31 July to 12 August 1961)



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## I N T R O D U C T I O N

1. This report summarizes the activities of the Latin American Electric Power Seminar, held in Mexico City from July 31 to 12 August, 1961, under the joint auspices of the Economic Commission for Latin America (ECLA), the Bureau of Technical Assistance Operations (B.T.O) and the Resources and Transport Economics Branch of the United Nations, with the collaboration of the Government of the United Mexican States which had duly extended the invitation and offered its hospitality to the Seminar.

2. The origin of the Seminar is to be found in resolution 99 (VI), adopted at ECLA's sixth session (Bogotá, Colombia, August-September 1955), which recommended that the secretariat continue the research work covered in a report, presented to the Commission, on the situation of energy in Latin America,<sup>1/</sup> and also "carry out research on the efficiency with which energy resources are being used, convening for the purpose study groups on the subject whenever advisable". Since then the secretariat has completed studies on electric power and water resources in specific countries and some of them have already been published.<sup>2/</sup> The work undertaken and the results obtained have emphasized the need for a thorough study of the problems of the electric power industry in relation to the economic development of Latin America and for convening a meeting at which experts from Latin America and other parts of the world could exchange their views.

Although consideration has been given to convening this meeting ever since ECLA's seventh session (La Paz, Bolivia, March-April 1957),

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1/ See the final version of this report in Energy in Latin America (E/CN.12/384/Rev.1), United Nations Publication, Sales No. : 1957, II.G.2.

2/ See, for example, Los recursos hidráulicos y su aprovechamiento en América Latina: I. Chile (E/CN.12/504/Add.1), II. Venezuela (E/CN.12/595), and the chapters relating to energy in various country studies that are included in the series Analyses and Projections of Economic Development.

on which occasion it was included in the Commission's Programme of Work, it was not until the eighth session (Panama, May, 1959) that preparations for it could be given the requisite priority. In 1960-61, this work was one of the top priorities in the secretariat's Programme of Work.

3. The Ministry of Industry and Commerce of Mexico played the leading role at the initial stage of organizing the Seminar and supplying the facilities necessary for holding it. The actual work of organization in cooperation with ECLA was the responsibility of the Comisión Federal de Electricidad, at whose head office the meetings were held.

4. The present report is divided into two parts, Part I indicates the attendance and membership of the Seminar and the manner in which it organized its work, and includes the agenda. Part II presents an outline of the activities of the Seminar. In the general introduction to this part, the importance of the electric power industry in Latin America's economic development is stressed and analysed. The conclusions reached at the Seminar and the recommendations which, in the opinion of the participating experts, call for action by the Governments and competent bodies of the Latin American countries and by the United Nations are set forth at the end of each section of this part of the report.

Part I

ORGANIZATION OF THE SEMINAR

I: Membership, attendance and organization of work

1. Opening and closing meetings

5. The opening meeting was held in the Auditorium of the Comisión Federal de Electricidad building in Mexico City, on 31 July 1961. His Excellency Manuel Tello, Minister of Foreign Affairs, representing the President of Mexico, formally declared the Seminar open. Addresses were delivered at the opening meeting by Mr. Adolfo Dorfman, Director of the Energy and Water Resources Programme of the Economic Commission for Latin America and Director of the Seminar, on behalf of the United Nations; Mr. Manuel Moreno Torres, Director-General of the Comisión Federal de Electricidad of Mexico; and Mr. Raúl Saez Saez (Chile), on behalf of the participating experts. (The texts of these three addresses are contained in annex I of this report.)

6. At the final plenary meeting the Seminar heard the Rapporteur, Mr. Raúl Saez Saez, and took cognizance of, and adopted, the provisional report on its work, authorizing the secretariat to prepare it in its final form and incorporate whatever changes were necessary to make it as complete as possible.

7. On 12 August 1961, at the closing meeting, also held in the Auditorium of the Comisión Federal de Electricidad building, the following participants took the floor: Mr. Moreno Torres, Mr. Dorfman, Mr. Krymm, Mr. Lyra, Mr. Salinas.

2. Membership and attendance

8. The Seminar was attended by 113 experts from the following Latin American countries: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Mexico, Panama, Peru, Surinam and Venezuela. Fifty one experts from the following countries also participated: Canada, Federal Republic of Germany, France, Japan,

/Portugal, Union

Portugal, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland and United States of America.

9. In addition to the United Nations agencies sponsoring the Seminar, the following international organizations were represented: the International Labour Organization (ILO), International Bank for Reconstruction and Development (IBRD), International Atomic Energy Agency (IAEA), Economic Commission for Europe (ECE), Inter-American Development Bank (IDB), Union International des Producteurs et Distributeurs d'Energie (UNIFEDE), the Centre for Latin American Monetary Studies (CEMLA) and the Inter-American Council of Commerce and Production (IACCP).

10. Various special consultants, who cooperated with the ECLA secretariat in Argentina, Bolivia, Brazil, Chile, Costa Rica, Cuba, Ecuador, Mexico and Uruguay, likewise took part in the preparation and some of them also in the discussions and work of the Seminar.

11. Various electricity institutions and enterprises of Brazil, Chile, and, in particular, Mexico, among the Latin American countries, and Canada, and the United States, among others, sent a total of 79 observers to the Seminar.

12. Annex III of this report contains the complete list of the aforesaid participants, international organizations, consultants and observers. Also included therein are the names of authors and institutions, which, although they did not take part in the discussions, contributed papers to the Seminar.

### 3. Organization of work

#### (a) Officers

13. Mr. Manuel Moreno Torres, Director-General of the Comisión Federal de Electricidad of Mexico, was elected Chairman, and Mr. Mario Lopes Leao (Brazil) and Elías Quiroz Salazar (Costa Rica) were elected Vice-Chairmen. Mr. Raúl Saez Saez (Chile) was elected Rapporteur of the session.

/14. The secretariat

14. The secretariat of the Seminar was as follows:

Director

Adolfo Dorfman, Director of the Energy and Water Resources Programme  
(ECLA)

Technical Advisers

Eduardo García (ECLA)

Carlos Plaza (ECLA)

Alejandro Vegh Villegas (ECLA)

Special Consultants

J. Agrest

Renato Salazar

Salvador San Martín

Administrative and Conference Officer

Rosa Doren (ECLA)

Editorial Section

Francisco Giner de los Ríos, Chief Editor (ECLA)

Colin Campbell, English Editor (ECLA)

Press and Information Office

Luis Moreno Verdin, Deputy Director, United Nations Information Centre

Jorge H. N. Ciancaglini (United Nations Information Centre)

15. In order to coordinate the work of the Seminar with that of the secretariat in accordance with the arrangements agreed on beforehand, the Comisión Federal de Electricidad appointed Mr. Enrique Vilar to collaborate in the various aspects of organization. He was ably assisted by Mr. Salvador Martínez Mancera and Mr. Enrique González Moreno. In addition, the Comisión Federal assigned Mario Bunt Ramírez, Juan Eibenschutz Hartman, Tomás Endo Sano, Evaristo Lira Zamudio, Gregorio Merino Oramas, Roberto Ontiveros Aguilar, Carlos A. Treviño de la Peña, and Fernando Vázquez Torres to the secretariat to act as technical aides in the Committees.

/(b) Committees

(b) Committees

16. Eight committees were set up to study items 2 to 9 of the agenda, item 1: "Electric power development in Latin America and its main problems" having been discussed at two plenary meetings. The committees were constituted as follows:

Committee I (Evaluation of demand and its bearing on economic development)

Chairman: Rafael Urrutia (Puerto Rico)

Rapporteur: Salvador San Martín (Special Consultant from Argentina)

Committee II (Capital requirements and methods of financing)

Chairman: Flavio Lyra (Brazil)

Rapporteur: Alejandro Vegh Villegas (Special Consultant from Uruguay)

Committee III (Economic criteria for selecting possible alternatives in the development of electric systems)

Chairman: J. Formoso Ferrer (Mexico)

Rapporteur: Rafael Herrera Palacios (Chile)

Committee IV (Hydroelectric resources, their measurement and utilization)

Chairman: Enrique R. Lima (El Salvador)

Rapporteur: Fernando Hiriart (Mexico)

Committee V (Nuclear power and its possibilities in Latin America)

Chairman: Ricardo Zuloaga (Venezuela)

Rapporteur: Rurik Krymm (IAEA)

Committee VI (Economic utilizations of fuels)

Chairman: Mario O. Fleites Díaz (Cuba)

Rapporteur: J. Agrest (Special Consultant from Argentina)

Committee VII (Electric equipment industry in Latin America)

Chairman: Roberto Jorge Calegari (Argentina)

Rapporteur: Renato Salazar (Special Consultant from Chile)

/Committee VIII

Committee VIII (Legal and institutional problems of the electricity industry in Latin America)

Chairman: Augusto Martinelli Tizón (Perú)

Rapporteur: Guillermo Rodríguez Cárdenas (Colombia)

II. AGENDA

17. The Seminar adopted the following agenda<sup>3/</sup> for its working meetings:
1. Electric power development in Latin America and its main problems
  2. Evaluation of demand and its bearing on economic development
  3. Capital requirements and methods of financing
  4. Economic criteria for selecting possible alternatives in the development of electric systems
  5. Hydroelectric resources, their measurement and utilization
  6. Nuclear power and its possibilities in Latin America
  7. Economic utilization of fuels
  8. Electric equipment industry in Latin America
  9. Legal and institutional problems of the electricity industry in Latin America
18. The various items on the agenda were discussed in the order required by the progress of the work, and the following number of meetings was allotted for the discussion of each item in the plenary and committee meetings:

<u>Item</u>	<u>Body</u>	<u>Number of meetings</u>
1	Plenary	2
2	Committee I	4
3	" II	5
4	" III	6
5	" IV	5
6	" V	5
7	" VI	3
8	" VII	3
9	" VIII	1

<sup>3/</sup> This same agenda, together with the documents presented for discussion of each item, may be consulted in annex II of this report.

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## Part II

### ACCOUNT OF PROCEEDINGS AND CONCLUSIONS

#### AND RECOMMENDATIONS

#### INTRODUCTION

19. The economy of the entire world is expanding. The rapid rate of growth characterizing the developed areas, unless it is surpassed by that of the countries in process of development, will make "the rich richer and the poor poorer", in the relative sense of the expression.

20. Latin America, with various levels of living in the different countries of the area, constitutes, as a whole, an under-developed continent. In order to better its lot, a considerable internal effort is necessary, to which, it is hoped, the economically more prosperous countries and the international development organizations will contribute.

21. The development of sources of energy is a vital part of this effort. It is not, of course, the only important factor. To quote the Organization for European Economic Cooperation, "water and raw materials, the training of human resources, means of transport, soil fertility and differences in climate, also play an important role, but, in the final analysis, the possibility of having a sufficient amount of energy available is a sine qua non of all development".<sup>4/</sup>

22. On the other hand, it is an unquestionable fact that industrialization is an inevitable process for a country that has reached a certain stage in its economic development. In all areas of the world, the level of living tends to rise as agriculture diminishes in importance as an occupational factor.

23. The industrial sector is precisely the goods-producing activity that can absorb the largest part of the agricultural population which may become redundant because of increased agricultural productivity. However, if the industrialization process is to be expedited and steered towards the desired targets, it is necessary to have larger amounts and

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<sup>4/</sup> See OEEC, L'Europe face a ses besoins croissants en energie.

better forms of power. Here is where electricity has its vital and universally recognized part to play.

24. Electricity does not represent an essential element in the cost of manufactured products. But, just as water may cost little or nothing in agriculture and is nevertheless essential for its survival, so is electricity a catalyst capable of accelerating general development, and especially industrial development, to such great velocity that, in time, the enormous lag of the under-developed areas can be made up.

25. So far as Latin America, in particular, is concerned, the work carried out for many years by ECLA and the numerous documents submitted for consideration to the present Seminar reflect the tremendous job to be done. By 1970 it will be necessary to supply three times the present-day demand for electricity, which will call for a capital outlay of some 13,000 million dollars, or about 10 per cent of the total investment resource for that period.

26. The topics discussed in the Seminar, which, in their essentials, covered the aspects of electric power development within the general context of the economy, and which dealt with such essential items as the programming and financing of electricity systems, questions of a legal and institutional character, etc., will undoubtedly be extremely valuable contributions to the solution of those problems in the countries of Latin America. Likewise, the points that emerge from the conclusions and the implementation of the participants' recommendations will constitute effective tools of progress.

## I

### ELECTRIC POWER DEVELOPMENT IN LATIN AMERICA AND ITS MAIN PROBLEMS

27. This topic was visualized as a kind of general introduction to the other items on the agenda which would have to be dealt with later in the various committees. Consequently, it was discussed directly in the plenary meetings with all the participants in the Seminar in attendance.

/The discussion

The discussion was more in the nature of a general exposition than a systematic consideration of the various aspects examined during the meetings.

28. The substance of this section of the report is therefore not set out so systematically as in the sections dealing with the other agenda items. Here, unlike the other sections, the presentation and discussion of the topic have been combined, and the conclusions and recommendations are therefore a reflection of the opinions expressed at the plenary meetings and in the committees. Some of the general problems connected with item 1 of the agenda were dealt with more thoroughly in the committees.

1. Presentation and discussion of the topic

29. In numerous documents submitted for the consideration of the Seminar, it is acknowledged that the consumption of electricity as an item of final demand, or when used as a productive factor in industry or commerce, constitutes a basic element in the productive machinery and in the consumption pattern of modern society.

30. The development of electric power in Latin America in the fifteen years following the Second World War has been insufficient, not only in absolute terms with respect to other more developed areas of the world, but also in relative terms if its rate of expansion is compared with the economic requirements of the region. Several of the participants bore out this assertion citing, in the course of the discussion, various examples of the development of the supply of electricity in their respective countries.

31. Therefore, the electric sector, far from constituting an incentive for expediting economic development, has - for various reasons which were analysed in the plenary meetings and in greater detail in the discussions of the various committees of the Seminar - often acted as a brake on this process owing to the inadequacy, in quantity and quality alike, of the electric supply.

32. As a consequence of this, the relative gap in the production and consumption of electricity, which has separated Latin America from world averages and, particularly, from the averages in the more developed countries has widened.

33. The participants agreed that, during the next decade, the Latin American countries should, first and foremost, make up the existing deficit in this sector, and, in addition, programme expansion in keeping with the development requirements of the over-all economic system.

34. This would mean stepping up electric power production from the 62,000 million KWH recorded in 1959 to some 200,000 million by the end of the decade, i.e. almost tripling installed capacity - from 16 million to 46 million kilowatts in that period.

35. Such expansion is essential not only because of the growing demand for electricity which accompanies the process of economic development, but also because of the simple passage of time, since electric power development also has its own dynamic which is closely linked to innovations and technological advances.

36. Financial requirements and the adequate channelling of capital towards the electricity sector constituted one of the most important points brought out at the plenary meetings.

37. In this connexion it was pointed out that that had been one of the most serious problems which the electricity industry had had to face in the past. To a great extent, the problem arose from inadequate tariff regulations which still persisted in various countries of the region, with the same unfavourable consequences for the electricity service. In order to appreciate the seriousness of this situation, suffice it to recall that the share of the electric power sector in total gross investment is of the order of 4 to 5 times its direct contribution to income. This happens, in the first place, because the sector should grow, on the average, at a speed twice that of the gross product and, secondly, because its capital density is also double the average in the economic system.

/38. Hence, electric

38. Hence, electric power expansion in the area will require, in the next ten years, a gross investment estimated at some 13,000 million dollars, representing between 7 and 9 per cent of total investment. This relative share is substantially larger than that of the past decade, when, generally speaking, it did not rise above 5 per cent, and closely approximates the orders of magnitude of the respective sectoral coefficient in the European countries and in the United States.

39. Besides the allotment and channelling of resources, it is evident that electric power expansion requires an adequate institutional and legal framework. It also raises technical problems of great importance, connected with the selection, programming and operation of generating plants and interconnected systems, aspects of concern to all the participants in the Seminar, particularly in Committees I, II, III, IV and VIII.<sup>5/</sup>

40. With regard to those problems, many of the participants referred, in the plenary meetings, to the influence which the ownership of an enterprise had on the criteria applied in solving them. The reasons were explained which had prompted Mexico to embark on nationalization, and the various aspects which the separate or coordinated coexistence of public utility and privately- or Government-owned electric power services assumed in different countries of Latin America were brought out.

41. The importance of the contribution of privately-owned enterprises, which generate approximately 40 per cent of the total in Latin America and distribute an even higher percentage, was also pointed out. The participants agreed that, in that field, the circumstances were very varied in the different countries of the area, and that, with respect to the ownership of the electricity service, there was no single criterion.

42. Besides the gradual interconnexion of systems on a national scale, the possibility of international interconnexion was stressed. Apart from the economic advantages deriving from a variety of generation and consumption conditions, from economies of scale and from the reduction

<sup>5/</sup> See especially the account of proceedings relating to items 2, 3, 4, 5 and 9 of the agenda.

of reserve margins, that type of interconnexion would also exert a favourable influence on the integration of the Latin American economies and on international cooperation inside and outside the area, as had happened, for example, on the European continent. In that connexion, the lucky coincidence was emphasized at the first plenary meeting that the Seminar was being opened almost simultaneously with the meetings of the Latin American Free-Trade Association at Montevideo, and of the Inter-American Economic and Social Council at Punta del Este.

43. The programming for electrification should be carried out in close coordination with over-all economic programming, not only because of the importance of the electric power sector in the economic system, but also because of its leading role in absorbing savings generated in that system. Thus, for example, in choosing alternatives within the sector, the real opportunity cost of the resources used and the fact that any over-investment in electricity meant smaller possible investments in the economic infrastructure could not be overlooked.<sup>6/</sup>

44. In the course of the general statements, it was pointed out that one of the problems which hampered electrification was precisely the lack of a public awareness of the importance of that service, of its influence on economic progress and of the constantly increasing magnitude of its investments. The lack of public awareness was encouraged by the tendency to consider the service rendered as a social question without giving the economic aspect its proper due.

45. However, considering electricity's important role as an element of civilization and development, chiefly in rural areas and small provincial communities where more than half of the people of Latin America live, it was stressed that public supply of electricity for use chiefly for lighting, wireless sets and small-scale mechanization of some forms of labour was of social significance, albeit to a lesser extent than for other essential services such as public health, education, etc.

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<sup>6/</sup> This topic in particular, was dealt with at length in Committees I and II.

The action taken in that field by CFE and ENDESA, State-owned enterprises in Mexico and Chile respectively, on the basis of local organizations often of the co-operative type, in which those who benefit from the service provided a large share of the financing required for the expansion of the service, were considered useful examples for similar action in other Latin American countries.

46. As in the case of all economic goods, in the production of electric power, the supply and demand curves were functions of the price. The entire problem of electric power development was summed up in the determination of sales tariffs. The level and structure of rates would have an important impact on current and future demand, but would also determine the profitability of the enterprise providing the service, its capacity for financing its expansion to a greater or lesser degree from its own resources or for attracting fresh capital which would contribute to that expansion.

47. The variety of available sources of generation for the electric sector both facilitated and complicated the work of programming. It facilitated it to the extent that it allowed great flexibility in the use of the primary power resources at its disposal, but it complicated it by the complexity of the necessary studies and of the statistics required to arrive at the optimum solutions with a certain degree of approximation.

48. Even though the preceding points formed part of the discussion in Committees I, II, IV and V, it should be mentioned here that particular emphasis was laid, during the general debate, on the fact that the lack of information on basic resources and on the history of electric supply were serious obstacles to the properly programmed development of the service. Therefore it was considered, from the methodological aspect - and in order to continue in the future with the exchange of experiences in electric power development that had begun at the Seminar - that the

/standardization of

standardization of terminology and of the respective statistical bases, as well as the use of a common language which would enable a comparative analysis to be made of industrial efficiencies of great use to all entrepreneurs in the service, should be urged.

## 2. Conclusions and recommendations

49. The following conclusions may be drawn from the discussion of item 1 during the plenary meetings and from the background information contributed later in various committees of the Seminar which dealt with specific aspects of the same topic:

- (a) In spite of the basic importance of an adequate electric power supply to furthering economic development, there is still no public awareness of the magnitude of the problem and of the various factors affecting it;
- (b) This lack of public awareness is illustrated, among other ways, by the difficulty of finding internal means of financing for the investments required, and by the inadequate rates system in force in numerous areas of Latin America;
- (c) The progress of electric power supply calls for efficient and modern regulations which take into account the new conditions created by the economic and technical progress of the countries and the growing magnitude and extension of the service;
- (d) As regards public or private ownership of electric services, the appropriate policy depends exclusively on local circumstances in each country or region.

50. Finally, considering the points of view presented at the plenary meetings and in some committee meetings, the Seminar recommended:

- (a) That the ECLA secretariat, together with other international bodies, cooperate with the Latin American countries in studying the programming of their power sectors, within over-all plans or programmes of economic and social development, by constituting advisory groups on power and electricity development;

/(b) That the



- (b) That the ECLA secretariat, when circumstances so require, convene further meetings such as the present Seminar, or meetings of groups of Latin American experts on specific problems of the electric power industry, with a view to discussing and suggesting adequate ways and means of solving those problems.

## II

### EVALUATION OF DEMAND AND ITS BEARING ON ECONOMIC DEVELOPMENT

#### 1. Presentation of the topic

51. The demand for electricity is variable and dependent to a high degree on general economic development. But, at the same time, the form and rate of variation in demand affect directly and immediately the programming of electric systems and their investment requirements. This fundamental observation shows that the topic assigned to Committee I for discussion is closely related to many of the other items on the agenda of the Seminar, particularly items 3 and 4 referring to financing and the economic criteria for selecting possible alternatives in the development of systems. Therefore, the presentation and discussion of this topic should include some reference to aspects common to subjects discussed in other committees.

#### (a) Co-ordination of electric power programming with the programming of general economic development

52. While the power sector's contribution to the gross national product is small, experience in Latin America - also borne out in the European countries and in the United States - shows that its investment requirements amount to between ten and fifteen per cent of the national totals and that electricity accounts for two-thirds of that quota.

53. Experience also shows that the demand for electricity<sup>7/</sup> has its own dynamic that overcomes transitory economic setbacks which, in

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<sup>7/</sup> In this report the demand for electricity implies the load demand and the power demand which may vary in different ways if there is a change in the load factor.

/addition, it

addition, it feels to a lesser degree. But this does not mean that it is not deeply rooted in the national economic structure and particularly in the sectors which make most use of it.

54. Hence, forecasts of the future demand for electricity should be made in close co-ordination with the agencies concerned with national economic planning and in the light of a careful study of the economic indices and of the economic development and investment programmes of the region to be served. The supply of that form of electricity must be adequate and timely in order to avoid bottlenecks in the sectors which depend on it. On the other hand, an unduly large expansion substantially exceeding the absorption capacity of the economic system must be avoided. It should be borne in mind that, in order to use electricity, it is necessary to invest in equipment and other items whose added value is several times greater than the investment made in the electric supply systems. Thus the current economic situation and its future alternatives and possibilities will dictate many of the steps or decisions to be taken by the electricity programmer, which should fit into the system of priorities established for the economy as a whole.

55. The electricity programmer does not have to be a planner of the economic system as a whole, but he does have to take into account such limiting factors as the balance-of-payments situation and the shortage of available resources in order to determine the optimum concentration of capital in the electric development plan. That shortage enters into the calculations via the interest rate, or rather the "opportunity cost" of the capital used. Therefore, it is important to have some idea of the order of magnitude of this parameter in order to avoid the mistakes so often made in that connexion.

56. In one of the papers presented (ST/ECLA/CONF.7/L.2.1) and in the discussion of the methods of comparative analysis among various generating sources, it is pointed out that, while the rate of interest estimated as the most appropriate for France is 7 per cent and for the United States 5.5 per cent<sup>8/</sup> a similar estimate for Chile gives a figure between 10 and 12 per cent.

<sup>8/</sup> "Opportunity cost" in the study of some federal projects.

57. This is a point of supreme importance among the topics dealt with at the Seminar, and it could lead to the formulation of recommendations of use to State planning bodies in establishing priorities.

58. Even while bearing in mind as much as possible the connexion between demand for electricity and the pace and structure of the process of economic development and the interdependence of power supply and demand, it is obvious that there will always exist - to a greater or lesser degree according to circumstances - a margin of uncertainty with respect to the validity of the results.

59. Thus, the programming of projects to meet that future demand should be an example of what has been called in modern economic theory, the problem of making decisions under conditions of uncertainty and/or incomplete information.

60. The criteria for solving problems of this type are based fundamentally on an analysis of the probability of distribution of possible errors and the cost of those errors. In the particular case of electric power, both factors lead to the recommendation that the programmer should be relatively generous in estimating the capacity required to meet future demand. Experience shows that, generally speaking, the mistake of under-estimation has been much more common than that of over-estimation, and is also much more costly as far as the over-all economy is concerned.

(b) Methods of projecting demand

61. The specific topic of methods of projecting demand for electricity is analysed in a series of documents presented to the Seminar.<sup>9/</sup>

62. The methods of forecasting demand have been divided in the document submitted by the ECLA secretariat into three main groups: (i) simple extrapolation; (ii) correlation with macroeconomic variables; and (iii) survey.

<sup>9/</sup> Mention should be made, inter alia, of documents ST/ECLA/CONF.7/L.1.10, prepared by the ECLA secretariat, and ST/ECLA/CONF.7/L.1.07, by the Energy Division of the Economic Commission for Europe. With regard to the problems of electric power development in the United States, see also documents ST/ECLA/CONF.7/L.1.12, 1.13 and 1.15; and documents ST/ECLA/CONF.7/L.1.17, 1.18, 1.19 and 1.20 concerning the methodology for projecting demand in Chile and Mexico. As regards the documents considered in connexion with this item of the agenda, see annex II of this report.

63. The methods of simple extrapolation are all those procedures whereby a given curve, with time as an independent variable and electric power demand and consumption as dependent variables, is adjusted to the data of past experience. The problem consists in choosing, in the first place, the functional form in which the adjustment curve will be determined, and, in the second place, the time interval - and in particular, the initial moment - for which the data of past experience will be used.

64. It is common knowledge that the functional form most frequently used in practice is the simple exponential with a single parameter, i.e. with a constant rate of annual growth.

65. A possible refinement in the extrapolation methods is the introduction of interval instead of point predictions. Thus, a higher probable limit and a lower probable limit of electricity demand for a specific margin of safety are established at each value of the time variable.

66. Under such conditions it is possible to determine, besides the curve of mean values given by the consumption trend, the probable maximum and minimum levels of this consumption, and to compare these extremes with the plans for expanding generating capacities.

67. The results obtained by the extrapolation methods will be adjusted to future reality to the extent that the new conditions approximate those that characterized the base period for the extrapolation made. If the demand for electricity has been reduced in the recent past by restrictions on supply or by stagnation in the process of economic development or both together - and this is a common case in Latin America - extrapolation of the historical trend will be valid only when the adjustments corresponding to the probable conditions that will obtain in the future can be introduced.

68. The same thing occurs if there are reasons for believing that the pace of electrification in the consumer sectors will differ substantially in the future from that of the past or if a structural change takes place in the economy.

69. The methods of correlation with macroeconomic variables include those in which electricity demand is determined in the form of a

/secondary forecast,

secondary forecast, i.e. by studying its relationship with given variables - for example, the gross product, industrial production, disposable personal income, rate of urbanization, etc. - and by formulating forecasts concerning its probable development. Hence these variables come to play the role of independent or determinant variables.

70. Increases in the consumption and demand of the industrial sector are produced by the superimposed action of three different causes: (i) the increase in over-all industrial production; (ii) the process of electrification in each of the sectors or branches of industry; and (iii) modification of the industrial structure, i.e. of the relative importance of the sectors constituting a country's industrial assets.

71. The analyses and projections of demand in the domestic sector, that is, electric power considered as a final consumer good, offer fewer difficulties than industrial demand thanks to its greater statistical homogeneity. In the absence of supply restrictions, the increase in consumption in this sector will bear a close relationship to the number of construction licenses, the population's level and distribution of income, the sale of electric equipment for the home, etc. within the area served by the respective electric system.

72. Finally, the third group of methods of classification, the survey methods, include those procedures of direct consultation with the industrial enterprises - at least with the largest ones - and a sampling of the probable trends of domestic consumers. Direct consultation greatly increases the validity of the projections of industrial demand, since it is well known that statistical methods that use regression analysis - as those of the two first groups generally do - are suitable only when dealing with numerous and homogeneous groups, and this is far from being the case in the industrial sector where a small and heterogeneous nucleus of enterprises accounts for a preponderant percentage of the total production of the sector.<sup>10/</sup>

73. It seems obvious that there is no inconsistency among the different methods. On the contrary, they are complementary, as the

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<sup>10/</sup> See in this connexion, inter alia, document ST/ECLA/CONF.7/L.1.15, in which this type of direct and survey methods is specially analysed.

faults attributable to some differ from those affecting others. Therefore, it is desirable to recommend their simultaneous and combined use. The applicability of these methods of estimating demand to the specific conditions obtaining in each Latin American country will depend upon the present economic structure of the country concerned, the structural changes to be effected, the present supply of electric power, etc. It should also be pointed out that a distinction should be made in these estimates between requirements for energy - measured in kWh - and for power - measured in kW. Each of these parameters establishes its own values and requirements which can be translated into separate estimates of the maximum capacity needed.

(c) Experience in projecting demand in Latin America

74. Faced with the need to guide the decisions for investment, the Latin American bodies and enterprises responsible for supplying electricity have followed separate courses dictated by the specific circumstances applying to each case. But those courses generally fall within one of the main types of demand projection mentioned or within combinations thereof.

75. The projections correlated with macroeconomic variables used in national plans about 1955 have been too optimistic in most cases owing to the relative stagnation in Latin America during the last five years.

76. The economic structure has imparted specific characteristics to the projection. In countries where industrial consumption is a preponderant part of electricity consumption - in Chile and Peru, for instance, it constitutes three quarters - this sector has been the subject of special study. In projecting demand in Argentina and Brazil, planned changes in the industrial structure of these countries have also been considered.

77. The predominance of the industrial sector is usually the result of export activities - copper in Chile, sugar in Cuba - subject to their own dynamics that are dependent upon external factors. Generally speaking, the electricity needs of those activities, by their very nature, have not weighed heavily on local public services.

78. It is noteworthy that demand for electric power has been so heavy that, rather than forecasting its expansion, it has often been necessary to limit it to the possibilities of supply.

79. For many years, one important obstacle to the adequate expansion of electricity supply has been precisely the lack of serious studies on the present situation, which also includes plans for future action. The situation has recently improved considerably and there are only a few countries that do not have that type of study available. But a distinction must be made between those studies which at the same time constitute plans for action by decision of the respective Governments or enterprises, and those other which are only information studies. In the absence of a decision, it is obvious that a programme, no matter how carefully studied and prepared, is only an expression of the author's opinions.

80. Even in those cases in which the Government has decided to adopt a specific programme for action, it has been frequently observed in the case of Latin America, that the results obtained are very far removed from those anticipated and from the policy drawn up in the plan, either owing to a lack of resources for financing the projects planned, or to the lack of co-ordination with private enterprises which also take part in serving the public, or finally, to the lack of an institutional structure in the electricity sector consistent with the execution of the programme adopted.

81. It is quite usual, for example, for plans to include estimates with respect to the expansion of the installed capacity of private enterprises, when in fact the expansion is subject to certain prior requirements: rate adjustments, changes in the legislation regulating those services, or provisions for attracting national or foreign capitals. These requirements are not always fulfilled as anticipated implicitly or explicitly in the plan.

82. This point is most important, because the relative share of private enterprise in providing electricity services, although it has been decreasing, is still important. In fact, at the end of

1960, it amounted to two-fifths of installed generating capacity. The role of private enterprise in the distribution of electric power to the consumer, and its consequent responsibility in the modernization and expansion of the respective networks, is much greater still than in the case of generation, since many State enterprises are mainly generating concerns and sell large amounts of power en bloc to concessionaires who finally deliver it to the consumer, especially in the large urban areas.

83. This creates a problem with respect to the programming of investments in the sector, since those corresponding to the distribution networks do not always proceed at a pace in keeping with those made in generating plants and transmission lines.

84. All of those aspects emphasize the need for the electric power programme to be not only rational but also sufficiently realistic to make its execution a probability. Hence, it is important that the Seminar has subjected the experience of various countries and enterprises to critical analysis in order to formulate the relevant recommendations.<sup>11/</sup>

## 2. Discussion of the topic

85. As was pointed out earlier, there is a close relationship between the problem of the trend of demand and other topics of the Seminar. Consequently, during the discussion, certain aspects, which, according to the agenda, fell within the purview of other Committees, were dealt with at some length. In order to present the discussions and conclusions in an orderly manner, those points considered as belonging more logically to another topic will be taken up in the discussions of the corresponding committee, even when already partially discussed in Committee I.

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<sup>11/</sup> See below, paragraphs 122-123.



(a) Co-ordination of electric power programming with the programming of general economic development

86. Notwithstanding the fact that differences of opinion arose among some participants with respect to the priority of the electricity sector, considered in relation to other economic sectors depending on the particular stage of development of each country, it was generally agreed that the supply of electric power and the programming of its development constituted a fundamental "problem" common to all Latin American countries. Owing to its special characteristics, electricity was not only an indispensable factor, but also a factor determining the nature and intensity of industrial as well as general development.

87. In that connexion, the case of Argentina was mentioned as an example, since that country currently faced problems of investment in the transport sector far greater than the capital requirements estimated for electric power. In other words, the priority, in the Government's opinion, had been transferred from the electric power to the transport sector. Nevertheless, within the possible technical and economic solutions to the transport problem, the ultimate choice depended on the availability or non-availability of electric power.

88. That interdependence between the electricity sector and the other sectors of the economy was naturally much more apparent in the case of economies which had been planned in their entirety, as in Cuba, where future demand for electric power was established as a result of the levels of economic development set for each sector.

89. That specific example, as well as the comments of other participants, served to underline the inter-relationship existing between increasing the supply of electric power at a given rate and the consequent expansion of the economy as a whole and the rise in the level of living. Nevertheless, because of the constant shortage of power in most of the industrialized areas of Latin America, no valid conclusions could be drawn as regards the speed of growth in the electric power sector and that in the other sectors of the economy.

/90. Since

90. Since there was insufficient capital for the development of the Latin American economies, and in view of the importance of investment in the electric power sector, a new and very close relationship emerged with the rest of the economy, which tended to increase as a result of the higher rate of growth of that sector in face of the rate of growth of the economy as a whole. Many experts took part in the discussion on the criteria to be used for measuring the more effective alternative use of capital (optimum intensity), dealing with the problem of "opportunity cost" in detail, a subject which will be taken up later under item 3 of the agenda (Committee II).

91. In connexion with the relationship between electricity and other economic sectors, the discussion entered into the interesting aspect of the influence of an anticipated and abundant supply of electric power as a factor for promoting the development of a given zone. Many experts referred to the points of view adopted in each case by private enterprises providing electricity services through concessions and by public electric utilities. The private enterprise, by its very nature, could often respond only to possible present or future demand, whereas the public enterprise could develop electricity projects in regions where supply anticipated consumption as a factor of development promotion. Naturally, that ability of the public enterprise was more important when the Government had additional sums available for promotion investment, without neglecting the other sectors of the economy as a whole.

92. The capital invested by the United States Government in developing the Tennessee Valley was cited as an example of the last-mentioned type of investment. That precedent indicated the course to be followed for the promotion of regional development. While in many respects it was not comparable with the circumstances prevailing in the countries of Latin America, it nevertheless provided interesting lessons that could be adapted to less developed economies. The TVA had been set up not just to ensure the adequate utilization of hydroelectric resources, but primarily to control catastrophic floods in the river, to protect the cultivated banks, to make navigation safe, to establish agricultural services, to conserve the soil, for purpose of reforestation, etc.

/As regards

As regards electricity, the TVA provided power to the Federal and State Government agencies (almost 50 per cent of the total generated), to the industries established in the region, and to 153 municipalities, co-operatives and private systems responsible for distribution in the area.

93. The participants felt that the TVA was not exclusively an example of development adjusted to an abundant supply of cheap electricity, because it was evident that its promotion had come about as a result of several factors together and not just of the supply of electric power, although that was basic. When the same conditions applying to the TVA were repeated in any other given area, the technicians of that organization believed that electricity programming could proceed at whatever speed had been previously established as a target. The TVA technicians believed that wherever conditions were similar to those in that area electricity development could, within certain limits, achieve the annual rates of growth set as a target. Many participants felt that that would require a number of favourable factors such as a brisk market in the domestic sector deriving from a high level of income and habits of well-being conveniently promoted, the existence of economically usable mineral and agricultural resources, and the possibility of substantial capital investment in industrial enterprises. However, those familiar with the history of TVA since its earliest days pointed out that its initial income had been low, that capital had not been readily obtainable and that there had been a general feeling that there would not be an adequate market for the energy it would produce.

94. Most of the participants in the Seminar felt that it did not seem possible, without first applying a few special restrictions, to transfer the TVA experience to other areas, particularly to Latin America, where the supply of electricity did not seem by itself to be a sufficient condition for the development of a given region, if the region lacked other attributes favourable to its promotion. The localizing effect of electricity, as a simple factor, was not very self-evident unless, in addition to an abundant and cheap supply of electric power,

/adequate transport

adequate transport facilities and other services were provided, and, moreover, there existed a local population with income levels sufficient to pay for large amounts of electricity. There were numerous examples which served to illustrate that circumstance, among them the SIMCA enterprise at Bello Horizonte, Brazil, where the plentiful supply of electric power plus the provision of land and facilities for investment capital had not sufficed to attract industry which required, in addition, other much more important conditions for its establishment.

95. That and other cases cited emphasized the danger of using electric power inorganically to promote certain areas, because marked distortions might occur in the regional or national economy. That would happen if, for example, the electric power of El Chocón - an Argentine project under study - were to be offered, at unduly low prices, to work the Sierra Grande iron-ore deposits, since that would encourage electro-siderurgical techniques possibly less economic for the country than the conventional reduction processes or the more recent processes using natural gas.

96. Uruguay offered another example. The supply of electricity at low prices in the interior of the country, through unification of the rates system in such a manner that the great centres of population were practically subsidizing the rest of the country, had led to the desired industrial decentralization since the existence of low electricity rates alone had not offered sufficient incentive for industrial localization. The same thing had happened in Argentina with the operation of the Electric Power Compensatory Fund (Fondo Compensador de Energía Eléctrica).

97. Development similar to that of TVA, but without its abundant capital resources, being carried out in Iran, might not have the effect of incentive expected of it.

98. In support of the general concept of the inadequacy of large amounts of electric power at low prices as the principal means of promoting regional or sectoral development, the fact was stressed that,

/generally speaking,

generally speaking, the share of electricity in the final costs of finished products was not a substantial one.

99. In countries where the insufficiency of electric power was very marked, the promotion of new areas by means of vast supplies of electricity provided for that purpose seem pointless, unless those other areas were catered for, where unsatisfied potential consumption already existed which could offer a quicker return on investment. An exception might be those new areas with resources which could and should be developed for the country's benefit.

100. Bearing in mind that the opening-up of new areas basically demanded not only investment in the generation of electric power, but also large investment for the promotion of consumption (approximate ratio: 1 to 12), the Seminar considered that the Latin American countries suffering from extreme shortages of capital should be very careful about such projects and give priority, for the time being, to those where demand already existed or might be created without much effort over the short term.

101. Some of the participants cited successful cases of small-scale promotion in certain areas which had produced interesting and satisfactory results, for example, some irrigation projects in Mexico.

(j) Methods of projecting demand

102. A good projection of demand in the case of the less-developed countries was of fundamental importance because it had a considerable effect on investments vis-à-vis the marked insufficiency of capital resources which was a chronic characteristic of their economies. A wrong decision might divert financial efforts which could have been put to better use in other sectors or other projects.

103. Latin American experience seemed to indicate that, generally speaking, the cases in which the estimates had proved insufficient in the face of a demand stimulated by structural transformations of the respective economies, especially those consequent upon events

outside Latin America, such as the Second World War, had been much more common. Shortages in the supply of electric power had occasioned and were still occasioning extraordinary losses in the economy, especially with respect to the production of goods and services in general.

104. The cases in which the forecast of demand had led to the execution of oversized projects were relatively few in the Latin American region and were not, in the main, attributable to mistakes in calculation but to unjustified improvisations. During the discussion, it was possible to single out only one or two cases in which the demand foreseen did not materialize in the time established because of real mistakes in programming.

105. But the fact that the examples of oversizing were few did not mean that the problem ceased to exist in the many electric power plants of the Latin American countries. Hence it seemed vital to meet all the requirements for making a reasonably reliable forecast. However, it was generally agreed that the programmer should adopt a cautiously optimistic outlook, since the mistake of oversizing projects as a result of overestimating future demand would, in any event, be much less harmful economically than a false step in the opposite direction. In the case of an unforeseen energy surplus, it was advisable to opt for the replacement of other sources of power by hydro-electricity, whenever that was feasible without affecting the economy as a whole. In particular, the temporary replacement of thermal sources using petroleum or its derivatives, or natural or liquid gas by electric heating processes as an alternative resource, might prove an adequate solution to the problem of hydro-electric surpluses. The use of differential rates to encourage use of electricity in the troughs of the load curve was undoubtedly an effective supplementary device.

106. In analysing existing technical methods for projecting demand, the participants made it clear that the philosophy favouring demand forecasting varied radically according to the nature of the body making the forecast and depending on whether or not the national economy

/responded to

responded to total planning. When the body carrying out the forecast was a private enterprise, the restrictions deriving from the profit-seeking character of the concern called for a careful and conservative attitude on the part of the calculator, for a relatively small error in the amount of investment might jeopardize the enterprise's financial position. Adequate compensatory regulations might reconcile the minimum yields of enterprises with the national interest. That course had been adopted by several countries of Latin America, including Argentina, Brazil and Chile, which had enacted legislation under which it was possible to co-ordinate private and public enterprise effectively within the general context of the electric power policy established by government agencies with the general interest in mind.

107. When a country's general economy was regulated by strict planning, in which not only the electricity project itself but also consumption was forecast and the corresponding supplementary investments made, the estimate of demand could not have the same significance as in countries with a free economy.

108. It was likewise noted that forecasts could not be limited to an evaluation of power but that power demand should be estimated as accurately as possible, since the investments yet to be made were related essentially to the power to be installed. A prior study of the historical behaviour of the various consumptions and their respective load factors was basic to any method that might be used in the projection of demand.

109. The participants also felt that the rate policy which might be adopted in the future would directly influence the projection of demand, given the great flexibility of certain consumptions which, in the face of favourable price incentives, could either quickly increase the power required or - even more probably - improve the load factor.

110. Finally, as regards the various theoretical methods discussed, it was generally agreed that the combined use of all of them should be encouraged, but that, because of the general lack of economic information and of reliable input-output ratios, the methods of

macroeconomic correlations could not be used to any extent, although sectoral correlations are desirable and should be encouraged.

111. It was considered that the projection of demand based on detailed market research could constitute an adequate method, if an efficient organization were available to make the survey. The experience of the Edison Electric Institute of the United States in market research enabled comparisons to be made with other methods and favourable conclusions to be reached as regards the survey. But that experience could not be applied in regions or countries lacking organizations capable of carrying out the detailed research among consumers which that method presupposed. So far as possible, the Latin American countries should organize themselves in order to apply that method as a supplement to other methods and in order to make realistic forecasts. Account should particularly be taken of consumption by large industrial consumers of electricity since their volume of consumption is usually preponderant and is concentrated in a few, readily identifiable, industrial establishments.

(c) Experience in projecting demand in Latin America

112. Most of the methods currently in use were basically of the type known as extrapolation over time, applied throughout the sector, or by groups of consumers. As regards that method, attention was drawn to the fundamental need for having complete statistics in order to make a methodical study of historical experience, both in each separate sector of consumption and in respect of the general behaviour of consumption and the incidence of disruptive factors. Such detailed statistics for sufficiently long periods were generally not available, or, at best, available only for specific areas of a country or rather for certain service areas. The lack of general standards for compiling those statistics was the main reason why they were usually derived from the experience of private and, more recently, public electric utilities. Some countries had had sufficient information on electricity consumption trends and on the development of other sectors of the economy. In those cases, the difficulty of forecasting was greatly reduced.



113. It was also pointed out in the discussions that the trend of consumption in Latin America had been greatly influenced by various factors, some of them the outcome of events outside the region. The difficulties of obtaining supplies of equipment, because of the Second World War slowed down the expansion of electric power and imposed restrictions on consumption that strongly affected load curves. The sector's failure to attract capital, aggravated in some cases by institutional disputes, had also been a factor limiting the supply of power.

114. Consequently, in most of the countries under consideration it was impossible to determine whether the rate of growth registered in the last few years would have been the same had there not been restrictions, which still continued in effect, alongside a very substantial unsatisfied demand.

115. All those observations, the product of the experience of the Latin American countries, led to the conclusion that the method of extrapolation in time should be used with extreme circumspection and only after all the distortion factors had been corrected. Everything pointed to the fact that, even after the establishment of a historic rate of growth of demand, demand could not be simply projected into the future in a constant manner. During the period of forecasting, too, it was necessary to make corrections in the same way as for the historic period considered. Those corrections led to consideration of the impact that the general facts of the economic dynamism of a country would have on demand. The consideration of structural economic changes was basic, and for that purpose plans for the establishment of new industries, which implied a very heavy demand in relation to current requirements, must be kept in mind. The common case in Latin America would undoubtedly be that of industrialization increasing at an accelerated pace. Since that picture was not generally reflected in the statistics of historic consumption, the simple projection of the historic rate might lead to mistakes of under-estimation involving serious consequences.

116. Another problem was that of determining the period which the forecast should cover. It was stressed that the evolutionary process in Latin America was so complex, varied and rapid that a very long-term forecast might lead to serious mistakes in its appraisal. Hence the wise course would be to adopt relatively short periods for the forecast, such as the generally used period of ten years. But that would clearly complicate decisions on hydroelectric projects - with a useful life of up to 50 years or more - in view of the high degree of uncertainty as to the behaviour of demand beyond the period under consideration, particularly since future expansion of installations required considerable advance investment.

117. It was also pointed out that the analysis of the historic behaviour of demand should be made by sectors of consumption - possibly divided into industrial, commercial, domestic and public or governmental sectors - and by geographic areas with different economic characteristics.

118. The desperate plight of most Latin American countries in the matter of electric power supply called for the adoption of simplified methods owing to the short-time available for taking decisions. Almost all the participants who spoke on the subject pointed out that, even if all the necessary time were available, the use of any of the methods described or all of them together, was no substitute for a personal approach to the problem and the intuition of the experienced programmer, which was basic in determining the course to be followed. As already pointed out in that respect, experience indicated that in only a very few cases had serious mistakes due to overestimation of demand been made.

119. Lastly, some participants analysed the evaluation of electric power demand in virgin areas, where no consumption statistics were available simply because electricity had never been supplied. Attention was drawn to the desirability, in such cases, of using the survey method with respect to the population of the area, for the purpose of ascertaining what systems they used for lighting, pumping water, and preserving food. The survey should also cover their income levels and

/the possibilities

the possibilities of developing the area concerned. That procedure, while fraught with uncertainty, was nonetheless better than embarking on the projects guided only by simple and confused assumptions divorced from reality. The survey should be supplemented by a comparison of its results with those from economically and socially similar areas which already had a certain known degree of electrification.

120. It was agreed that all those problems and methods of projection had something in common: statistical information was a basic condition. During the discussion it was suggested that it was necessary to promote, through ECLA, the standardization of electricity statistics and their systematic compilation in all countries of Latin America, since that would furnish the information required for the drafting of plans and the study of the problems involved.

121. It was further stated that that standardization work would necessitate the adoption of a uniform terminology for the purpose of correctly interpreting statistical data. Both suggestions - relating to the standardization of statistics and to technical terminology - were strongly supported by all those participating in the discussion.

### 3. Conclusions and recommendations

122. The following conclusions may be drawn from the papers presented for the consideration of the Seminar in connexion with the topic under consideration and from the relevant discussions:

- (a) The increase in the demand for electric power is closely linked to over-all economic development, not only constituting an essential factor thereof but also determining its nature and intensity;
- (b) The importance of the timely supply of electric power, as well as the considerable time required to put the basic supply installations into operation and the magnitude of the capital required, necessitate a most accurate forecast of probable demand for periods of not less than eight years;

/(c) For

- (e) For the above reasons, it is believed that electric development programmes should not be modified because of situations arising from short-term economic circumstances;
- (d) It is believed that an over-estimation of demand leads to economic consequences far less unfavourable than those brought about by an equivalent case of under-estimation.

123. The foregoing considerations prompt the Seminar to make the following recommendations:

- (a) Projections of demand should be made using the various existing methods for which reliable data are available. Special attention should be paid to known structural changes and economic development programmes;
- (b) In forecasts based on the extrapolation of historic data the factors which may have altered the real value of the growth of the sector should be particularly borne in mind, as well as the rate policies which may be adopted and which may act as an incentive or as a brake on the use of electricity;
- (c) Projection criteria should be optimistic, but should allow for revision during relatively short periods (two years);
- (d) The ECLA secretariat should be requested to organize a study group for the purpose of proposing to the Latin American countries the use of a standard system of electric power consumption statistics and of a common terminology in all aspects of the electricity economy, in order to allow a constant interchange of information to take place.

### III

#### CAPITAL REQUIREMENTS AND METHODS OF FINANCING

##### 1. Presentation of the topic

124. As was already pointed out<sup>12/</sup> in the presentation of item 2, item 3 of the agenda is closely related to it and also to item 4. Thus, part of the discussion reviewed in this section of the report bears on debates on the afore-mentioned item 2, in the same way as some of the matters dealt with here will be developed in the section covering item 4.<sup>13/</sup>

125. It is, therefore, impossible - or at least irrational - to deal separately with the problems relating to the financing of electrification, the establishment of sales tariffs and general policy on power.

126. It is obvious that the problems of financing electric power are also closely connected with decisions of economic policy which presuppose value judgements. The decision to nationalize the electricity sector, to integrate it into a single State monopoly, to leave the service to national and/or foreign private enterprise, and the intermediate solution of co-existing State and private enterprises, are all points which cannot and should not be decided on the basis of purely economic considerations. This is not the place to enter into a discussion of this matter. It would be pointless to do so, since the opinions one way or another are well rooted and new factors are unlikely to be forthcoming. But it is interesting, on the other hand, to point out the importance of duly recognizing the economic and financial effect of a political decision on this problem.

127. For example, if the State directly or indirectly replaces private enterprise in providing an electricity service, it should bear in mind, in so doing, that it closes off a source of financing for the expansion of this sector and, consequently, should be careful to provide alternative sources so that this transfer of responsibility is not reflected in a lower level of power supply.

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<sup>12/</sup> See above, paragraph 51.

<sup>13/</sup> See below, paragraphs 213 et seq.

(a) Capital requirements: relative participation of financing sources; importance of self-financing

128. In presenting topic I<sup>14/</sup> the broad lines of this problem were stressed. The demand for electric power in Latin America by 1970 has been estimated at 200,000 million kWh, i.e. more than three times the figure for 1959, the last year of the statistical series taken as a basis for these forecasts.

129. In order to meet this demand, the electric power industry should increase its installed capacity from 16 million to 46 million kW, which seems feasible if the Latin American countries manage to fulfil satisfactorily the programmes adopted or under way.

130. An expansion of such magnitude in installed capacity and the corresponding increase in distribution systems will demand an investment calculated - on the basis of programme estimates which have been adjusted - in some cases - at the equivalent of some 13,000 million dollars, of which about two-fifths represent expenditure which will have to be made outside the area. As is to be expected, this proportion will depend not only on the relative pre-eminence of hydro-electric over thermal projects but also on the development of the electric capital goods industry in the region. This last-mentioned aspect will be given special attention elsewhere in this report.<sup>15/</sup>

131. The average magnitude and dispersion of the unit costs for various types of plan and their variation according to its scale have been specifically analysed in document ST/ECLA/CONF.7/L.1.51, submitted to the Seminar by the secretariat. The cost of several hydro-electric plants built and studied in Chile has been analysed in another paper (ST/ECLA/CONF.7/L.1.46) in relation to the natural features and size of the works.

132. The available sources of financing for electric power expansion may be classified, in general terms, as follows:

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<sup>14/</sup> See above, paragraphs 29-48.

<sup>15/</sup> See below, paragraphs 447-484.

- (i) contribution of new capital in the form of securities of private origin;
- (ii) contribution of capital or subsidies by the State;
- (iii) issuance of long-term forms of security and the obtention of internal or external credit;
- (iv) self-financing (ploughing back profits, amortizations, reserves).

133. Although the margin of flexibility is theoretically a wide one, in practice both the institutional and the legal framework in which the electric power enterprise operates as well as the conditions prevailing in capital markets - and, in many cases, the characteristics of the projects too - seriously limit the field of choice as regards means of financing.

134. Two parameters of special importance in the financial theory of the electric power enterprise are, firstly, the relationship between the enterprise's real capital and the amount of the long-term forms of security, and, secondly, the relationship between this real capital - measured also by the net assets immobilized at a given moment - and the value of the capital stock.

135. From the point of view of the financial load of the enterprise, servicing the long-term forms of security - including interest and amortization - is generally less expensive than the level of dividends it is necessary to maintain if the stock is to continue to appeal to the private investor in the capital market sufficiently for him to continue to buy it and thus finance part of the expansion. There are also other advantages deriving from the fiscal system, since income or profit taxes are levied on these dividends but not, generally speaking, on the servicing of the debt.

136. The electricity enterprise should weigh these advantages against the disadvantage of the inflexibility of the form of security, which must be serviced permanently whatever the level of profits or state of liquidity of the enterprise involved. The contrary is true of the enterprise's own capital; in this case the dividend may be equated each year to the enterprise's financial position, or a dividend policy may be adopted which represents an average situation estimated for a specific period of time and which can be maintained without any appreciable change

137. The fact that the electric power industry is not subjected to the cyclical variations in demand that characterize other industries means that the proportion of the debt with respect to its total servicing may be quite high.

138. This is what happens in the United States and in some European countries. As regards the latter, reference may be made to a paper submitted to the Economic Commission for Europe (ST/ECLA/CONF.7/L.1.32). On the other hand, the situation in Latin America is different owing to the primitive state of the capital markets and to the unfavourable effect that inflation in the real yield of fixed-interest securities has on original purchase values.

139. It should be noted - and this is one of the many points in which the financing of electrification is closely related to the institutional and legal framework in which the industry operates - that the capital structure of the enterprise is especially important with respect to the various legal devices used to determine rates (see document ST/ECLA/CONF.7/L.1.50).

140. Self-financing of electric power expansion by ploughing back net profits depends fundamentally on three factors: (i) the level of profitability of the rates in relation to the total costs of operation; (ii) the impact of taxation on these profits; (iii) the policy followed with respect to the distribution of dividends.

141. Generally speaking, electric power legislation lays down maximum legal profits on the total investment or the capital stock of an enterprise. The incentives to increase self-financing must therefore come from a rise in this legal ceiling, or from tax measures such as those which exempt from income tax that part of the profits which is intended for re-investment, or, finally, from a sacrifice on the part of the stockholders who are forced to save by a reduction of the percentage of profits distributed. It may be assumed that the last measure will be compensated later by an increase in the value of the stock on the capital market by means of the servicing of the reserves so accumulated.

142. But funds derived from net profits are not the only contribution to self-financing. There is also an expensive effect on production capacity brought about by the automatic reinvestment of accumulated funds through depreciation reserves. This effect - which can be readily observed if a

/linear depreciation



linear depreciation method is used - increases even further if a more realistic method is applied: that of depreciation charges diminishing over time.

143. In accordance with the estimates contained in the documents on the subject of financing submitted to the Seminar by the Economic Commission for Latin America and the Economic Commission for Europe<sup>16/</sup> self-financing on the basis of the reinvestment of depreciation charges may account for between one-third and one half of the net capacity expansion requirements. This is, therefore, a factor of importance in electric power development.

144. But, in any event, as pointed out in the study Regulation of electric power in Latin America, prepared by the Harvard University Law School, electricity rates are the focal point on which all problems of the industry converge: regulation policy, demand for service and financing. These are the end result of the regulation policy, and the cause of the capacity or incapacity to finance expansion with one's own resources, or to attract voluntary savings.

145. The fixing of electricity rates is an essential aspect of electric power policy. The development of electricity cannot be adequately planned unless this development is integrated in an organic programme of the entire power sector so that optimum utilization of the available resources may be ensured.

146. Hence, it is essential that the countries of Latin America, following the example of those in Europe, should adopt and co-ordinate their power policies in order to allow this sector also to reap the benefits of the regional economic integration which will be carried out under the Montevideo Treaty and the various instruments through which the Central American countries are achieving their own regional economic integration.

147. The adoption of a rational price policy in the power sector is all the more important the higher the substitution price elasticities and the use of all types of fuel in the production of electric power. Extreme care should be exercised not to distort the price structure in such a manner that it prompts irrational decisions with respect, for example, to the substitution of fuel oil for coal or to a more intensive use of natural gas or of nuclear fuels.

16/ See ST/ECLA/CONF.7/L.1.30 and L.1.32, respectively

148. The picture presented by Latin America in this connexion shows considerable room for improvement and this was discussed in the Seminar under item 7 of the agenda.<sup>17/</sup> There are great distortions in the price structure of the electric power sector owing to inadequate regulatory legislation, to discrimination in taxation as among the various forms of power, to multiple exchange systems which, by subsidizing imports of fuel, seriously jeopardize the use of national fuels, to State financial contributions whose real cost to the economy is not properly recognized in the sales price of electric power, and to many other factors too numerous to mention here.

(b) The opportunity cost

149. When topic II (Evaluation of demand and its bearing on economic development) was considered, the essential aspects of optimum capital intensity were mentioned.<sup>18/</sup> Reference was made to the concept of the "opportunity cost" of a given investment, which was defined as the maximum yield which, from the point of view of the over-all economy, these resources would produce in other investments in which they could be applied inside or outside the sector under consideration.

150. The lack of sufficient capital to deal simultaneously with all the problems of the area - transport, insufficient housing, lack of proper communications, industrial development, etc. - renders it necessary to have devices for guiding economic decisions, the opportunity cost being one of the possible means for comparing the results of the investments in various production sectors and, especially, for alternative projects within the electricity sector itself.

(c) Inflation and the financing of electricity; specific electrification taxes; forms of security; compulsory savings procedures

151. In document ST/ECLA/CONF.7/L.1.30 a special chapter is devoted to analysing the impact of inflation on electric power development. It is impossible to ignore the powerful influence which this phenomenon has had on electric power financing in Latin America during the fifteen years following the Second World War.

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<sup>17/</sup> See below, paragraph 447-484.

<sup>18/</sup> See above, paragraph 90.

152. For a detailed analysis of some extremely interesting particular cases, the aforementioned study made by the Harvard University Law School should be consulted.<sup>19/</sup>

153. The phenomenon of inflation radically affects the financing of the electric power sector (i) through its tariff regulative mechanisms; (ii) through its influence on the relative attraction and competitive position of the securities of electricity enterprises in the capital market.

154. With respect to the former, it is obvious that, to the same extent that regulatory legislation ignores the inflationary phenomenon and its influence on the direct or indirect costs of electric power production, the real price of power resulting from the application of legal machinery will be reduced. In general terms, it may be said that electric power legislation in Latin America has been more realistic with respect to variations in operational costs than with regard to investment costs. Thus, the automatic adjustment clauses responding to variations in the prices of fuels or labour have generally preceded the regulations authorizing a revaluation of assets in relation to tax effects and to the fixing of rates.

155. As stated in document ST/ECLA/CONF.7/L.2.1, rate regulations which establish the yield on investment according to its original or historic cost - in such a way that the repayment of capital in real terms may be penalized on periods of monetary devaluation - not only affect the financial aspect of electric power development, but also distort the process of choosing between alternatives and encourage the investor to prefer the project requiring less capital investment, i.e. generally speaking, the thermal power plant.

156. With regard to the investor is reduced interest in securities with a relatively invariable nominal rate of interest in inflationary situations, attention should be drawn to the recent introduction of forms of security with a "gold clause", i.e. those in which automatic mechanisms come into play in an attempt to maintain the real yield of the original investment. France in Europe and Mexico in Latin America offer interesting examples of

<sup>19/</sup> See above, paragraph 144.

/these innovations.

these innovations. The efforts of the Nacional Financiera in Mexico to diversify and broaden the range of forms of security in such a way as to perfect the channeling of resources derived from personal savings into productive investment are particularly noteworthy.

157. Document ST/ECLA/CONF.7/L.1.30 mentions some examples of specific electrification taxes and forced savings procedures now applied in various Latin American countries, the practical application of which - with its advantages and disadvantages - is studied.

(d) Role of the international financing institutions; the problem of import substitution in respect of capital goods; credit for equipment suppliers

158. In the recently mentioned document submitted to the Seminar by the ECLA secretariat, the role which the international financing institutions have played is analysed, as well as their probable role in the future. It has already been stated that about two-fifths of the 13,000 million dollars which will be required for investment in the electric power sector up to 1970 are for expenditure on capital goods produced outside Latin America. Therefore, it is important that these institutions should be in a position to provide, to the largest possible extent, the financing of this part of the investment. But this is not enough. It is necessary, as has been underlined in document ST/ECLA/CONF.L.1.36, to create other machinery for financing, either on the part of the same agencies or of new ones, which will eliminate the unfavourable impact, from the financial point of view, of import substitution in respect of capital goods for the electric power industry and which derives from the fact that these institutions do not usually authorize the use of credits for purchases in local currency.

159. The above-mentioned institutions should also promote the establishment of rational electric power expansion programmes. In this connexion, it is believed that the recent entry of the Inter-American Development Bank into the group of international financing agencies, and its close co-operation with ECLA and the OAS, will constitute one more factor ensuring that the programming and financing of electric power development in Latin America will maintain a more direct relationship in the future than they have in the past.

160. This is not the place to deal in detail with the technical possibilities of substitution in respect of capital goods imported from outside the area, since this topic will be taken up later in this report.<sup>20/</sup>

## 2. Discussion of the topic

### (a) Capital requirements: relative participation of financing sources; importance of self-financing

161. The electricity industry consumed a great deal of capital. In the United Kingdom, for example, the output-capital ratio was 1:4, in the United States 1:4.5 and in Latin America 1:5, being lower in mainly hydro-electric systems and still lower in nuclear systems.

162. Capital charges were therefore important in the cost of electric power, since with an output-capital ratio equal to 1:5 and a coefficient of 12 per cent for interest and amortization, it meant that 60 cents of each dollar of power sold should go towards servicing capital invested in electric plant.

163. It was pointed out that one way of saving capital was for systems to be as large as possible, as that reduced the necessary reserve capacity and introduced economies of scale in the expansion of capacity.

164. With reference to capital accumulation, it was emphasized that there were essentially two forms of savings: voluntary and compulsory. The latter referred to savings through taxes on the consumer or through the non-distribution of profits of private or State enterprises. The problem of assigning those resources by sectors and in accordance with a scale of priorities then arose.

165. Some of the experts pointed out that the relative share of self-financing in the electric enterprise - whether State or private - should be at least 50 per cent, and emphasized that that figure was reached in the United Kingdom. Self-financing should play a larger

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<sup>20/</sup> See below, paragraphs 458-527.

part in Latin America owing to the difficulty of obtaining money in the capital markets of the region and the stringency of Government treasuries on which so many demands were placed by other sectors competing for those resources.

166. Some participants also pointed out that promises of State contributions to electricity programmes were often not fulfilled in practice, which caused serious delays and losses in the execution of plans depending on those funds.

167. It was agreed that the level of self-financing should be related to the rate of expansion of demand. For example, if a system, which was capable of 50 per cent self-financing, increased by 8 per cent per year, it could not undertake self-financing in the same proportion if it increased by 15 or 20 per cent, unless excessively high consumer rates were in force, which distorted the price structure of the power sector. In this connexion, attention was drawn to the fact that during the next decade demand was expected to grow at annual rates of more than 10 per cent.

168. It was further pointed out that that level of self-financing - for reasons of tax fairness, so to speak - should be related to the degree to which the system expanded to supply new consumers, or to enlarge or improve the services for existing consumers. The greater the emphasis placed on the last-mentioned aspect, the greater the justification for obtaining a contribution towards future expansion from the cost of current services.

169. With respect to the current rate level - analysed in secretariat document ST/ECLA/CONF.7/L.1.51 - reference was made to considerable spread in the distribution of average sales prices by countries. Thus, of the fifteen countries studied in the document (in 1959), the average prices had been 2 cents or less per kWh in eight countries, between 2 and 4 cents in four countries, and over 4 cents in four others. For purposes of comparison, all those values were determined according to rates equal to the purchase power parity of the respective currencies as calculated by ECLA.

170. The average rate weighted for 1959 had been 2.3 cents per kWh. It had been estimated that in order to add 27.5 million kW to public services in the next ten years and to replace 3.5 million kW, it would be necessary to invest 12,000 million dollars, of which 60 per cent would be in local currency. Taking into consideration the fact that consumption by public services in 1959 had been about 40,500 million kWh and that 150,000 million kWh were estimated for the end of the period, every rise of one thousandth of a dollar in the average price per kWh would increase the gross revenue of the electricity sector, on a yearly average during the period, by about 100 million dollars. In other words, in order to self-finance the cost of expansion entirely in local currency - taking into consideration what was already financed with revenue from the electric services - the average level of rates would have to be raised from 2.3 to 2.9 cents, an increase of 25 per cent.

171. The representative of the International Bank said he was gratified at having heard various participants speak of a self-financing level of 40 to 60 per cent of the total cost of expansion of the electric sector. He emphasized the need to be realistic in fixing rate levels; the most expensive electric power was that which was not produced. That view was supported by the Argentine and Chilean representatives who described their costly experience of restrictions on electric supply, with a loss of value added in manufacturing representing many times the value of an electric plant that had not been built because the enterprise providing the service had not had the necessary funds.

172. In Latin America there were usually three sources for financing electric power expansion: State contributions, foreign credit and self-financing (sometimes called "residue for development"). There were other sources but they were unimportant and could be included in the three groups mentioned.

173. State contributions were limited not only by government revenue but also by competitive demands for funds for other essential sectors: roads, railways, schools, hospitals, internal and external security, etc.

174. Foreign credit was naturally restricted by the financial capacity of the respective institutions. Generally speaking, that form of financing could not represent more than 50 per cent of the amount of the electricity project.

175. Hence, it was necessary to fix sales rates for electric power with those factors in mind and on the basis of a financial plan of the enterprise for the near future which maintained a balance, so far as possible, between income and expenditure throughout the period under consideration.

176. The following were cited as specific examples of the relative share of self-financing: in Uruguay, the UTE was self-financed to the extent of 50 to 60 per cent; in Costa Rica, the ICE provided for a self-financing level of approximately 50 per cent; in Chile, ENDESA was currently financing expansion as follows: 40 per cent with the residue for development, 30 per cent with credit from international financing agencies, and 30 per cent with new contributions from the Government. It planned to raise its self-financing to 60 per cent and thus to reduce the Government's contribution to 10 per cent of requirements.

(b) Opportunity cost

177. The Seminar thoroughly discussed the problem of the use of opportunity costs with reference to decisions within the electric sector, and particularly, to the choice of alternatives in additions to installed capacity and of labour replacement. On the basis of the definition of opportunity cost, already explained in the presentation of the topic,<sup>21/</sup> it was concluded that it had an effect on two types of decisions: the prior decision above the level - if so it might be called - of the electric sector; and the decision referring to different alternatives within the sector, with which the Seminar was particularly concerned.

178. There was general agreement on the fact that opportunity cost was of little use where certain types of decisions were concerned, as it was not possible to compute quantitatively the potential return on investment in hospitals, schools or roads. On the other hand, most of the participants

<sup>21/</sup> See above, paragraph 149.



felt that it should be kept in mind for decisions involving a comparison with other productive investments and, more particularly, for internal resolutions of the sector.

179. It was pointed out that it was not only important to bear in mind the current opportunity cost but also its possible future variation during the life of the investments being analysed. For example, in the case of ENDESA in Chile, the nominal cost of the money received by the State had increased from 5 to 8 per cent, a change which in some way reflected a possible change in the opportunity cost of the capital.

180. Another example cited was that of Electricité de France, where an initial optimistic forecast of an opportunity cost of 4 per cent was made and where that estimate had now risen to around 7 per cent.

181. In the case of Latin America, there seemed to be no reason to suppose that the cost of money, which was to some extent an index of the scarcity of capital resources, would decrease over the medium term of 10 or 15 years.

182. With reference to methods of comparison, it was generally agreed that the so-called "present value method" should be considered the most recommendable. That method computed the initial investment values plus an amount equivalent to the present value of future annual costs. The equivalence was calculated on the basis of a rate of conversion to present worth which was precisely the opportunity cost mentioned earlier. A more detailed discussion of the subject was held in Committee III (topic IV).

183. It was also observed that distortion between the opportunity cost of capital and the nominal interest of money for the electric enterprises - especially when the enterprise was State-owned and received direct contributions from the national treasury - was but another example of what the theoreticians of economic development had pointed out as differences between the market price of production factors and their intrinsic values. Thus, for example, social and wage legislation and the power of trade unions made the wage level higher, as a rule, than the opportunity cost of labour. In the case of foreign exchange, the Latin American Governments' insistence on maintaining the relative stability

/of their

of their currencies in the free financial market, even in the face of extreme inflationary processes at home, resulted in an over-valuation of their currencies which distorted the real price of imports. Both factors made the replacement of national labour by imported capital goods seem more economically worthwhile than it really was. That contributed to unemployment in the region.

184. It was recalled that a study by the International Bank - published in January 1957 - dealt precisely with the rate of interest to be used for making comparisons between thermal and hydroelectric alternatives. That publication stated that an analysis of various Government hydro projects showed that the average interest on money had been 4.5 per cent, compared with a 15 to 20 per cent return on investments in other sectors of the economy.

185. As some participants pointed out, it was usually unnecessary - nor would it be possible - to know the exact value of opportunity cost, and that it was sufficient to have an idea of its order of magnitude so as to compare it with the return on the difference in capital between the two alternatives.

186. With reference to the order of magnitude, it was agreed that it would vary greatly from country to country. In France it would be about 7 per cent; in the United States between 5 and 6 per cent; in Chile - and possibly in Argentina and Uruguay as well - between 10 and 12 per cent (at the present time). On the other hand, it might possibly be rather less in some Central American countries and in Puerto Rico, which had relatively easy access to larger financial markets.

187. It was also stated that, even though the interest rate on International Bank loans for electricity projects had increased from 4 per cent in the first few years to the current rate of 6 per cent, it was still well below the opportunity cost in most Latin American countries. On the other hand, and even for those who objected to using the opportunity cost, as the Bank's loans constituted only a percentage - almost never more than 50 per cent of the total cost of a project - it would be logical to take a weighted average of the rate at which the Bank made loans and the rate prevailing in the local capital markets, according to the relative share of those sources of financing.

188. The advocates of the use of the opportunity cost to calculate electric power investment alternatives recognized that, in some cases, the use of the interest rate prevalent in the capital market was a good enough approximation for practical purposes. It was emphasized, however, that that was not so if the rate of interest was taken as that at which the Government made loans to its enterprises, since that rate was usually extremely low.

189. Stress was laid on the importance of taking into account a sufficient number of alternatives for making comparisons and of not singling out a specific project in order to justify it. In other words, programming should first determine the requirements of demand and then the most economical way of satisfying it within the limitations imposed by available resources. As was the case with countries of limited means, the Latin American countries could least allow themselves the luxury of mistakes which implied a drain on those resources.

190. There was a brief discussion on whether to add the costs of investment in production and fuel transport to the thermal alternative when comparing it with the hydroelectric. That was the practice, for example, in the Soviet Union. It was pointed out that that was not necessary so long as the present value of the thermal alternative took into account the fact that the price of fuel included a potential return equal to the opportunity cost on the investment in production plant and transport.

191. Several participants said that limited funds and the urgent need to make up substantial deficits in supply sometimes imposed the choice of solutions that were not the most economical in the long run. That was the reason, for example, why the criterion of minimum investment in the selection of an expansion programme for the sector was imposed upon the foreign consultants in the Argentine electric study.

192. With respect to the method used in the USSR to recover differential capital in ten years which also aspired to optimum capital intensity, it was pointed out that it was equivalent to taking a rate of interest that could be calculated in each case. Thus, for a hydro/thermal investment

cost ratio of 1.5 and for depreciation periods of 50 and 30 years, respectively, the recovery of differential capital in 10 years was equivalent to a rate of about 10.5 per cent.

193. Other criteria suggested for determining opportunity cost were the potential return on investments similar in risk to electricity, the return laid down in electric power legislation - that value should be a limit below that cost - etc.

(c) Inflation and the financing of electricity; specific electrification taxes; forms of security; compulsory savings procedures

194. The havoc wrought in electric power financing by inflation, and the unsuitable legislation in many countries for undoing the damage, was unanimously deplored. The case of Brazil was singled out, as a country in which rates were still fixed on the basis of the historical cost of investment in spite of the marked devaluation of the currency. That represented a corresponding reduction in the real revenue from the rates.

195. Several countries had amended their legislation in order to deal with the problem and the recent laws of Argentina and Chile were mentioned in that connexion. In the former country, it had been established that the revenue from rates must include 10 per cent of the value of the assets measured in terms of replacement cost (3 per cent depreciation and 7 per cent net profit). The adjustments were annual. In Chile, a level of gross profit was established of 10 per cent of the value of net immobilized assets, plus a technical depreciation of not less than 2.5 per cent of the original values periodically revalued according to current price levels.

196. The representatives of private enterprises indicated that excessively low rates not only made the self-financing of expansion scarce or excluded it entirely, but at the same time also reduced the possibilities of attracting new capital from the private market.

197. With respect to the supply of capital for the electricity sector, some participants remarked that savings in Latin America were not that low. The coefficient of investment fluctuated around 15 per cent as a regional average and, in some cases, was as high as 20 per cent or even higher. It was not so much the shortage of resources as their poor

/distribution that

distribution that checked the rate of development in the Latin American countries; hence, the importance of channeling savings into the basic sectors which had been neglected, as was the case with the electric sector.

198. Various suggestions were made in that respect concerning forms of security with the gold clause - for example, with regard to the price of the kWh, as in France - or on mechanisms for compulsory contributions, such as the obligation to buy bonds or stock in the enterprise in order to have a service connexion, in proportion to the importance of this service in terms of the capacity demanded.

199. The role of governmental investment banks was also discussed. As regards Brazil, it was observed that the Banco Nacional do Desenvolvimento Econômico had at its disposal, among the resources available for the electric power sector, funds provided under the United States-Brazil agreement on the purchase of agricultural surpluses, in accordance with Act No. 480, and resources from the Electrification Fund. The last-mentioned item was covered in part by revenue from the electrification tax, which, in Brazil, was a tax levied on a certain number of monetary units per kWh. That had the disadvantage that the real value of the tax revenue was reduced by inflation. On the other hand, an ad valorem tax was unjust in the sense that it placed a greater burden in absolute terms, on consumers in zones where generation was expensive. A compromise solution might be an ad valorem tax, but with an absolute ceiling.

200. Most of the participants were opposed to specific taxes on electricity for the financing of electric power development and showed their preference for a realistic tariff, the State or its representatives being at liberty to control or supervise the use of surplus resources derived from the revenue from rates.

201. As regards the legal machinery for regulating the electric service, the possibility was suggested of establishing incentive standards for improving productivity. A scale was indicated, as a possible example, in which the maximum authorized profit to the enterprise increased with an improvement in certain productivity indices, particularly that of fuel consumption in thermal plants.

202. With regard to the topic of taxes on electricity as a means of producing greater resources for the general expenditure of the public sector, the participants agreed that the abolition of all taxation was to be recommended owing to its negative impact on financing and to the distorting effects on prices in the electric power sector. It was considered that the sales price of electric power should be as low as possible, so long as it was consistent with the aforementioned financing aspects.

203. Emphasis was also placed on the fact that for the purpose of international comparisons of production costs and the sales prices of electric energy, that part of the tariff that corresponded to taxes should be accurately established.

204. With respect to taxation in the capital-exporting countries, the desirability of their establishing tax incentives to promote exports, wherever compatible with the principles of tax justice and of the redistribution of income in these countries, was discussed.

(d) The role of international financial institutions: the problem of import substitution in respect of capital goods: credit for equipment suppliers

205. Some figures were mentioned in the Seminar concerning the relative participation of international financial institutions in investment in Latin America and particularly in the electricity sector. In the period 1950-60, the loans authorized for electricity by the Export-Import Bank of the United States amounted to 5 per cent of its total loans to Latin America, which had been some 2,500 million dollars during that period. International Bank loans for electrification had amounted to 50 per cent of its total loans to Latin America (1,000 million dollars, in the period mentioned). Consequently, the total contribution to the electric power sector in the form of credits had been some 650 million dollars.

206. Also during 1950-60 the total amount authorized for long-term loans by the United States Government and international financial agencies to Latin America had been 4,700 million dollars, while the net

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influx of long-term private capital - including reinvested profits - to the area had been 7,500 million dollars.

207. Considering that the gross product of Latin America was some 70,000 million dollars, and estimating that the net investment necessary to maintain a fairly adequate rate of economic development was some 15 per cent, then the annual contribution of external capital - governmental, international and private - was around 10 per cent of investment needs.

208. The Inter-American Development Bank had recently taken its place among the international financial agencies. Its representative at the Seminar emphasized the need for a careful study of loan applications in respect of electricity projects, from the technical as well as the economic and financial points of view, and also the importance of having a rational and organic electricity development plan. In view of the Bank's current financial possibilities, its efforts would be largely concentrated on providing or financing technical assistance to countries requiring it.

209. Several participants raised the problem of the financing by these agencies of equipment purchases in local markets. In the absence of such financing growing import substitution would aggravate the financial difficulties of electric power expansion. The International Bank representative said that his organization was considering the question carefully, particularly the cases of Mexico and Brazil, where foreign purchases might be reduced to as little as 20 per cent of the total investment. It was evident, then, that if the Bank limited itself to financing the foreign part, it would be reducing its share in electric power development. In Mexico, authorization had already been given for the use of part of the Bank's credit for domestic purchases. Without denying the validity of these observations, he felt that the need was evident for developing the electric capital goods industry in a rational manner so that the economicity of import substitution was a closely observed principle. Hence, the local production cost of equipment should not exceed by more than a certain percentage the cost of similar imported equipment.

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210. In the matter of credit for equipment suppliers, some participants pointed out the dangers arising out of the excessively short terms which might weaken the financial stability of the electric enterprise. Others said that, in view of the limited resources of the International Bank and other agencies, it was essential to resort, at least in some degree, to such credit. The conditions under which that credit was granted had improved, owing to growing competition, and repayment periods of 10 years or more were being allowed.

### 3. Conclusions and recommendations

211. The following conclusions emerged from the work considered by the Seminar in the discussion of this topic and from the results of its deliberations:

- (a) It is highly important to adopt an adequate rate of interest for use in the calculations, on which the choice of investment alternatives in the electric sector is to be based, in such a manner that the rate reflects, as accurately as possible, the scarcity of capital resources in the country in question;
- (b) It is essential to fix reasonable and realistic rates with machinery that neutralizes the impact of inflation and in such a way that the electricity enterprise can cover its real costs and self-finance its expansion in a proportion consistent with the speed of this expansion and with the pace at which the electric service is extended to new consumers;
- (c) Once the financial situation of the electricity enterprise is stabilized at a reasonable level, it is necessary to select and establish machinery to attract private savings into the electric power sector, in the case of both State-owned and privately-owned enterprises.

212. In the light of the discussion held on the topic of capital requirements and methods of financing, the Seminar makes the following recommendations:

/(a) That



- (a) That the ECLA secretariat centralize and co-ordinate the studies carried out in some countries on methods of deciding between alternative investments, with the object of improving and adjusting them so far as possible, and with a view to the adoption of a methodology for general use and, in addition, bringing them to the attention of the countries and enterprises interested in such studies;
- (b) That Governments study and adopt financial policies for electric power development which are integrated in national economic and investment policy, and that they consider the best use, in each case, of the various sources of available resources;
- (c) That the ECLA secretariat convene, at the earliest opportunity, a meeting of experts to study the problems of electricity rates, so that the respective analyses and conclusions may serve as a basis for the adoption of adequate policies by Latin American electricity enterprises;
- (d) That Governments adopt an adequate taxation policy in order to avoid overcharging for electric consumption and distortions in the price structure of the power sector. The abolition of specific taxes on electricity consumption is particularly recommended;
- (e) That international financial agencies study the problem of financing the purchase of locally-produced capital goods for electric projects, especially in those countries that have advanced considerably as regards import substitution in respect of these goods.



IV

ECONOMIC CRITERIA FOR SELECTING POSSIBLE ALTERNATIVES  
IN THE DEVELOPMENT OF ELECTRIC POWER SYSTEMS

1. Presentation of the topic

213. Many of the innumerable aspects, which the problem of the development of electric power systems presents, have been covered in the extensive documentation received on this subject by the Seminar. In the following paragraphs, which concentrate on the substance of one of the main documents (ST/ECLA/CONF.7/L.2.1.), special emphasis is laid on economic criteria.

(a) Special factors which influence the economic criteria

214. The main objective of the economic analysis of the potential yield, in general, is to determine the maximum benefit that may be derived from the adequate use of available resources: human, natural and financial. In the case of electric power systems, the difficulty in determining this maximum benefit resides in the fact that the installations have to be planned well in advance and produce their benefit for long periods of time (30 to 65 years).

215. There are many outside factors which influence the amount and the manner of determining these benefits. Among these the following may be singled out:

- (i) ownership of the electricity enterprise
- (ii) potential return and economic cost of the money;
- (iii) other considerations which influence the decision criteria.

216. With respect to the first factor, if the enterprise is privately owned, the entrepreneur generally considers only the income and expenditure which appear on his balance sheets and tries to ensure that his direct profits are the highest possible. On the other hand, a publicly-owned enterprise has to consider, besides the direct profits derived from its investment, the indirect and social effects, in respect of inputs as well as of the goods and services produced (see document ST/ECLA/CONF.7/L.2.22).

217. With respect to the second factor, it must be pointed out that the cost of money directly influences any comparison of alternatives. For a private enterprise it will be the price at which it can obtain money on

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the capital market. For a public enterprise it will not be so easy to pinpoint this cost, especially if the allotment of money must be made by comparing the investment for electricity with other public investments which generally produce only indirect benefits that are difficult to quantify.<sup>22/</sup>

218. Among other considerations which influence the decision criteria, the following may be mentioned:

- (i) the scarcity of financial resources which imposes the choice of solutions involving less capital intensity;
- (ii) the urgency of the supply, which carries considerable weight as regards the choice in cases of electricity rationing, since it forces a decision in favour of solutions which, while not necessarily the most desirable, must be chosen because they require less construction time
- (iii) the economy of foreign exchange or the existence of financing for certain types of projects but not for others.

219. As an example of other considerations which influence decisions, it should be pointed out that, in document ST/ECLA/CONF.7/L.2.29, an economic comparison is made between the utilization of Salto Grande on the river Uruguay (international Argentine-Uruguayan project) and an equivalent thermal power plant to serve the Argentine seaboard. The consulting firms do not recommend the hydro-electric solution, because it would require an investment of 100 million dollars more than that required by the thermal plant. Nevertheless, in the above mentioned paper, emphasis is laid on the point that, in making the comparison, the following considerations among others, should be taken into account:

- (i) the benefits which accrue to navigation from the Salto Grande project;
- (ii) the foreign exchange input in respect of each solution;
- (iii) the inclusion of the investment required for the production of fuels among the capital requirements deriving from the thermal plant solution.

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<sup>22/</sup> Extensive discussions on this subject were held in Committees I and II.

(b) Priority criteria

220. Electric power development plans are faced from the outset, in Latin America, with three fundamental limitations - insufficiency of basic information, scarcity of technicians and tight financial resources - which make it necessary to establish priorities for their execution. The priority criteria will be related to the amount of basic information available, the possible use of the power, etc.

(c) Choice of the type and size of plant for an electric power system

221. Very elaborate comparative methods of analysing alternatives can be applied only when the information used reaches a degree of approximation equivalent to that which these methods seek to achieve.

222. Since sound basic information for analysing various solutions is frequently lacking in the Latin American countries, preference should be given to simple quantitative comparisons accompanied by qualitative appreciations in the choice of the most desirable hydro-electric solution. This solution may then be compared in detail with the possible steam thermo-electric or diesel alternatives.

223. The technicians available should concentrate on drafting the chosen project as completely and expertly as possible, rather than on a detailed discussion of various alternative power plants. But, when the electric system reaches a certain size, the comparison is made not with the object of opting for a given plant, but rather for a combination of projects to be executed within the programme period (usually 10 years). For a large system, sudden extensions of the installations are not very feasible, technically speaking, and turn out to be uneconomic. The addition of new capacity thus becomes a continuous process.

224. The advantages of having a programme for a relatively long period of time, besides avoiding decisions having to be taken under the pressure of the lack of power, enables basic information to be compiled in an orderly manner and reduces the risk of a decision being taken on projects which might be detrimental to the over-all utilization of a river or basin because of a too narrowly localized study.

225. Hence, it is necessary to study what happens with the programme over a certain length of time. The classic industrial method is to represent the investment by an annual amount calculated by the usual formulae, which take into account the number of years required to pay back the capital at a fixed interest rate. When the annual operating costs and revenue are known, the difference between the two gives the net income, which should then be compared with the yearly amount required to pay back the capital, in order to see if there is an additional profit or a deficit. In this way the result may be determined for any year within the period chosen for comparison. This method - sometimes called "equivalent standard annual cost" - is criticized because it implies that the annual payment made for an outdated installation is the same as originally made for it when it was new.

226. Today preference is given to the concept of "present value", which consists in the reduction of any amount, income or expenditure for the year  $n$ , to the present, chosen as the time origin, dividing this amount by  $(1+i)^n$ . This is equivalent to replacing the expenditure or income of the year  $n$  by a capital which, at an interest rate  $i$  at the present moment, may produce the same amount in the year  $n$ . Thus, the investment, expenditure and future income are represented by equivalent capitals at the "present" moment, the combination of which will enable an appreciation to be made of the project over the entire comparison period chosen. Naturally, the "rate of conversion to present worth" will correspond to the opportunity cost fixed for the money.

227. With respect to the future prices factor, it is estimated that it should be used with its present values, since it is in practice impossible to make forecasts based on their trend, except in special cases. If the rate of conversion to present work is high, the periods of comparison need to not generally exceed 15 years, since events after that will be of relatively little importance.

228. When a comparison among various hydro-electric solutions is desired, the "value coefficient" system is proposed as an example. This consists of a comparison, within the period chosen for the study, of the benefits

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derived from a hydro-electric plant with those of an equivalent thermal plant used for reference. The benefits are measured by determining the present value of investments, income and expenditure throughout the entire period for both plants. The difference between income and disbursements (investments and expenses) for one plant gives the profits, which are then compared with those of the other. If the hydro-electric plant is better than the thermal plant, the gains are relative. The "value coefficient" will be higher the larger the gains in relation to the investment.

229. Among other procedures considered in the Seminar, mention should be made of the one used in the USSR, which bears a certain similarity to the value coefficient and is known as "repayment time of the extra capital invested", and finally, another type of approach to the same problem, based on the analysis of the power production cost during the various hours of the year, a method frequently used for determining rate systems (see document ST/ECLA/CONF.7/L.1.47 in this connexion).

230. Once the various plants have been compared, successive calculations may be made in order to draw up the most suitable programme for the next 5 or 10 years. But, when the system is a large one and implies the choice of a great number of plants within the period comprised by the programme (easily 50 in a European system), more systematic procedures should be resorted to. Linear programming is used, one obligation in the equation system being to ensure a minimum "total present outlay" and to fulfil the combinations of maximum demand and consumption previously described, as well as any other conditions which may be demanded of the programme: the maintenance of a certain proportion of thermal power or a given consumption of foreign exchange, etc.

231. The unknown factors in this system of equations are the characteristics which will determine the plants, and it is accepted that all the conditions may be expressed as their linear equalities or inequalities. Once the solutions for the unknown factors are known, the plants with the highest "value coefficient" for satisfying them will be sought. The procedure requires some adjustments before a final answer is reached.

232. In most of the systems of Latin America, it will suffice for the present to proceed by trial-and-error methods, owing to the small number of plants to be covered in the programming.

233. In another of the documents submitted to the Seminar (ST/ECLA/CONF.7/L.2.4.), the importance of evaluating indigenous primary power resources is underlined, in order to prepare economic studies that are not only mutually comparable but also comparable in relation to those which may be imported. This will constitute a basis for defining the electric power development policy of a region or country. In the case of fuels, research should also cover the probable price of delivery during a period similar to that of the economic life of an electric power plant, and the method of transporting or dispatching the power (fuels or electricity).

234. On the other hand, document ST/ECLA/CONF.7/L.2.6 analyses the advantages derived from the combined operation of hydro and thermal plants in supplying a system, and a method of utilizing the sector of a river in the most effective manner for the economy of a country is described.

235. In support of the above-mentioned method, which refers directly to the choice of reservoir size and the capacity to be installed in a river sector, there is the simplifying consideration that the different variants depend in most cases only on two basic parameters, which are the mean daily guaranteed flow and the relation between the safe hydroelectric capacity of the system and its maximum demand.

236. Document ST/ECLA/CONF.7/L.2.10, working from the premise that the most economical project for adding to a system is that which enables it to provide the consumers with power at a lower cost than could be supplied by any other complementary source during several years, describes in detail the steps which should be systematically taken in the economic analysis of a hydro-electric project in order to increase the generating capacity of a system.



237. Document ST/ECLA/CONF.7/L.1.35 recognizes that the problems involved are quite delicate when an attempt is made to find a general theoretical method for sizing hydroelectric plants, and that it is clearly impossible to make a separate study of the equipment standards and rate scales. For the operation of systems drawing on hydro and thermal sources, the balance of the marginal costs between both types of plants is a generally valid criterion.

238. Two other papers submitted to the Seminar (ST/ECLA/CONF.7/L.3.1 and L.3.2) outline the characteristics demanded of a hydro-electric project that is well prepared and economically sound according to the usual procedures of the Corps of Engineers and of the United States Federal Power Commission were reviewed. It is pointed out that a project produces maximum benefits when the scale of utilization of a use reaches the point where the benefits added by the last increase are equal to its cost.

239. In order to evaluate over-all storage requirements in a hydro-electric system a method has been outlined in document ST/ECLA/CONF.7/L.3.3, which emphasizes that, in determining the characteristics of a new plant, the economic and power needs of the whole system of which it will form a part must be borne in mind.

240. With respect to the calculation of fuel consumption in electric power plants, document ST/ECLA/CONF.7/L.2.30 emphasizes the need to know the consumption for a given year. The plant under examination should have the most economic position on the load diagram.

241. Current trends in the design and use of gas and steam turbines are examined in documents ST/ECLA/CONF.7/L.2.31 and L.2.13, respectively. These documents indicate the advantages, in each case, of their use in specific fields of action and their future development prospects.

242. Document ST/ECLA/CONF.7/L.2.18 examines some factors which, while not peculiar to Latin America, may - because of the magnitude they assume in the region - exercise a decisive influence on certain aspects

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of electric power plants. The importance of the choice of transmission and distribution tensions to the economy of electricity supply is analysed in document ST/ECLA/CONF.7/L.2.16, which offers some guidance for the selection and effective scaling of voltages.

(d) The combined use of thermal and hydro resources and the position with respect to nuclear energy

243. The combination of thermal and hydro-electric resources produces the most favourable operating conditions.

244. The operation of an electric system must ensure the most economical service possible. In a combined system, using thermal and hydro-electric plants, joint operation is complex. Optimum utilization of the resource implies recourse to seasonal storage and the use of the latter as well as of hourly ponds for the principal load modulation. The available power of the run-of-the-river plants will be used in the base of the load curves.

245. The thermal plants will be above or below the reservoir plants in the load curve according to the proportion of the latter and the type of hydrologic year in question. On the basis of these principles, the situation in some Latin American countries has been examined.

246. Several documents were submitted to the Seminar for the discussion of this important aspect<sup>23/</sup> and all of them point out the advantages to be derived from the combination of thermal and hydro-electric power in the development of a system. They also emphasize that hydro-electricity and thermal electricity are not mutually exclusive.

247. The Economic Commission for Europe supplied the Seminar with information on the relationship between hydro-electric and thermo-electric production in Europe in document ST/ECLA/CONF.7/L.2.25.

248. Other documents (ST/ECLA/CONF.7/L.2.19, L.2.21 and L.4.3) also outline the advantages of the combined operation of hydro and thermal plants and refer to the current technical and economic situation of the electro-nuclear plants and to their role in the load curve of a system.

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<sup>23/</sup> See in particular documents ST/ECLA/CONF.7/L.2.6, L.2.8, L.2.9, L.2.10 and L.2.22.

249. In the matter of the position of nuclear energy as regards the aspect examined here, it should be pointed out that electro-nuclear plants - even the very large ones - involve a high cost per kW installed, and their fuel, while costing considerably less per kW than conventional fuels, still represents a very high figure. Under these conditions nuclear plants should work as base units.

250. At the present time, countries install electro-nuclear centres for three main reasons:

- (i) scarcity of other methods of generation;
- (ii) need to acquire the technique necessary for manufacturing nuclear equipment;
- (iii) possibility of gaining experience for future commercial development.

251. The conditions justifying the commercial installation of this type of plant in Latin America are apparently to be found only in a very few cases.

(e) The interconnexion of systems and its advantages

252. The interconnexion of systems has developed gradually and at the rate at which they have come into contact by virtue of their own growth. The most obvious advantage of joint operation is in the use of the existing "diversity" in load diagrams and the generating conditions of the systems. Also, interconnexion facilitates the use of substantial power resources that can be transmitted only by electric means (hydro-power) or where transport by other means is uneconomical (e.g. coal of low heating capacity).

253. Apart from the foregoing, the advantages of interconnexion are many and may be enumerated thus:

- (i) it enables better use to be made of installations because of the time differences in load diagrams;
- (ii) it increases operational efficiency because a greater number of generating sources are available;
- (iii) it reduces total reserve capacity;
- (iv) it introduces technical improvements arising from the need to adopt the standards of the most efficient interconnected systems;
- (v) it facilitates the joint development of resources on a larger scale, more completely and in the most efficient order.
- (vi) it fosters a spirit of cooperation.

254. Interconnexion raises technical organizational, economic and communication problems which have to be solved among the interconnected systems. Its joint operation is generally regulated in the same way as that of a single large system and the plants have to operate in such a way that they all have the same incremental cost.

255. Various documents of the Seminar (ST/ECLA/CONF.7/L.2.22, L.2.8, and L.2.21) enumerate the advantages derived from the interconnexion of systems. The last two mentioned review the experience of the TVA in the United States and the Guanajuato-Michoacan-Chapala system in Mexico, respectively.

256. The Economic Commission for Europe and the UNIPEDE Study Committee<sup>24/</sup> have examined the results obtained by the European countries in the interconnexion of their electric systems, emphasizing such important aspects as the objectives sought, the development of interconnexions at the national and international level, the development of power transfers, the technical conditions required for the interconnexion of systems and the conditions necessary for its organization, the combined operation of various national systems, etc.

257. The possible co-ordination of electrification programmes in Central America is studied in the first part of document ST/ECLA/CONF.7/L.2.2, which analyses three international projects in general terms; (i) the interconnexion of the electric systems of Honduras (ENEE) and El Salvador (CEL), which is promoting the development of the Yojoa-Rio Lindo area in Honduras; (ii) the supplying of the northwest zone of Guatemala (Puerto Barrios, Puerto Matías de Galvez and other neighbouring localities) in a few more years, by the extension of the future central transmission system from San Pedro Sula in Honduras; (iii) the eventual interconnexion of Nicaragua with the electric systems of Honduras and El Salvador, which will enable firm power from Nicaragua (the Tuma-Viejo-Matagalpa) system and the thermal plant of Managua) to be transferred to Honduras and El Salvador. During the rainy season, El Salvador will return the surplus power from its plants (without reservoirs) on the Rio Lempa to the common interconnected system.

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<sup>24/</sup> See ST/ECLA/CONF.7/L.2.25 and L.2.11, respectively.

(f) Electric development in areas at present with little or no service

258. Under this item of the agenda it was considered advisable to analyse two special problems: (i) that of isolated areas with no electric service which should have their own generating sources; (ii) that of the large regions where it is decided to offer a supply of power in advance as a means of promoting economic development

259. For the isolated areas, a comparison with other isolated areas with electricity services and similar social and economic characteristics was indicated as the best way of determining demand. These areas should be developed in accordance with uniform technical standards in the country and should be given the necessary assistance during installation and subsequent operation. The possibilities of future interconnexion should always be borne in mind and, by the same token, the small hydro plants may be integrated in the larger systems with satisfactory economic results.

260. In the case of extensive rural areas where it is desired to establish means of transport and other services and, at the same time, to provide an electricity supply in advance in order to encourage new economic activities and raise the level of living, it is advisable to use an existing system by extending its lines of transmission. This consumption represents only a small percentage of the system's previous supply and therefore have no immediate influence on the economy of the enterprise. The state should act in the place of private capital in the likely event that the latter is not interested in solving such problems by hypothetical direct yield of investments in these initial stages of development.

261. The problem posed by the low population density and small per capita income of the rural population of Mexico for rural electrification is taken up in document ST/ECLA/CONF.7/L.2.24. This paper proposes some criteria for fixing regional priorities based on the length of transmission lines and on the ways of carrying out electrification in these areas. It also deals with the case of isolated plants but with a view to subsequent integration.

262. Document ST/ECLA/CONF.7/L.2.12 outlines market research designed to establish the demand for electricity in the rural areas of the island

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of Trinidad and presents an empirical method of estimating the direct economic advisability of expanding a system as applied to the southern half of the island.

263. The experience of rural electrification in Chile, through the joint efforts of the State enterprise (ENDESA) and consumers' cooperatives is examined and analysed in the other paper submitted to the Seminar (ST/ECLA/CONF.7/L.2.33).

264. Lastly, a brief description and analysis of rural electricity systems in the United States is given in document ST/ECLA/CONF.7/L.2.5.

## 2. Discussion of the topic

(a) Special factors affecting economic criteria in electricity

(b) Criteria of priority

265. In opening the discussion, it was pointed out that some external factors had considerable significance for the examination of alternative solutions with respect to the development of an electricity system i.e., the ownership of the enterprises, the profitability and cost of money, rates, etc. There were also other incidental considerations that determined the criteria on which the choice was made, such as shortage of funds, the urgent need for a solution, saving of foreign exchange, etc.

266. With reference to the ownership of enterprises, it was pointed out - as already stated in the presentation of the topic - that when an enterprise was privately owned it acted, operated and developed legitimately on the basis of the profits shown on its balance-sheet, although indirect benefits were also taken into consideration but to lesser extent. When a public enterprise, on the other hand, had to take decisions it regarded indirect benefits as being of great importance and perhaps sufficient in themselves to justify the solution chosen. The example of the Valle del Cauca (Colombia) was cited, where there were hydraulic plants and a thermal plant with a capacity of 20,000 kW and an annual consumption of about 20,000 tons of coal. In the next four years it was hoped to raise total installed capacity to 180,000 kW, of which 60,000 would be thermal and would need a supply of some 200,000 tons of coal yearly. It was stressed

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that, in the example given, the public enterprise took into account the fact that light coal consumption in the thermal plant would be a basis for the investment of fresh capital in the corresponding mine. Apart from enabling the mine to be worked more efficiently, such investment would also produce an exportable surplus of high - grade coal, thereby acting as a strong stimulus for the economy of the area.

267. Another illustration referred to the need for providing an electricity supply for the population of a port situated in an area of scanty hydro-electric resources, and with a coal mine inland but with no satisfactory means of communication between the two. The choice of a power plant fed by coal instead of undoubtedly petroleum would promote the construction or improvement of communications with the mine to the consequent benefit of the area. Such a consideration would carry weight for a public enterprise when it had to make its final decision.

268. The advantages to be derived from a multi-purpose hydraulic project were of particular interest to enterprises operating on public capital and had an appreciable influence on their decisions. The Chocón-Cerros Colorados project in Argentina was cited, in which flood control was of fundamental importance. The catastrophic results of the 1899 flood were recalled, and it was pointed out that a similar inundation at the present time would cause much greater damage, since agricultural production in the area was worth 2,000 million Argentine pesos annually and fruit exports more than 15 million dollars. A preliminary distribution of costs among the different objectives of the project allocated to flood control a sum approximately equivalent to 60 million dollars which meant that the hydro-electric project in question would be greatly benefited.

269. There were numerous publicly-financed enterprises in Latin America which paid due regard, in their decisions on hydro-electric works, to the benefits that the community would reap from the simultaneous execution of irrigation works. Reference was made to ENDESA in Chile, which took part in the construction of a dam on the river Maule designed to help irrigate the area. For the future harnessing of hydro-electric resources, it also built an intake tunnel for the waters of Lake Laja on financially unfavourable

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terms, but with a view to the substantial contribution it would make thereby to the future irrigation of 200,000 hectares of agricultural land.

270. It was pointed out that the topographical, hydrological and geological research promoted by a hydro-electric project favoured other uses of water. Similarly, works undertaken in close association with a hydro plant affected other aspects of the national economy and social well-being, such as roads, schools, medical services, etc. At a given time, the construction of a hydro plant might also help other problems to be solved through the employment of a number of unemployed workers or the large-scale use of cement produced by a plant already in existence. The indirect benefits to be obtained from a hydro-electric solution might tip the scales in its favour as against other alternatives that did not offer the same advantages.

271. Those and similar considerations affected the decisions taken by a public enterprise to a greater extent than those taken by a private enterprise. Nevertheless, examples were given of Latin American countries in which privately-owned enterprises took decisions with due regard to the importance of indirect benefits, as exemplified by the construction of two thermal plants to make use of light coal production, thus stimulating the corresponding mining activities, although the ideal fuel would have been petroleum.

272. Another example of the part played by external factors was the construction of the tidal-energy plant of La Rance. It was a fairly small plant that took advantage of exceptional tidal conditions (13.5m) at a spot where the water was fairly shallow. Twenty-four groups of 10 mW each of the so-called "bulb" type would be installed there to generate 500 million kWh yearly.

273. The justification for La Rance was influenced to a great extent by the test that Electricité de France had to make for another project of a similar nature but on a much larger scale: the harnessing of tidal energy at the Chaussé islands. The plant would be very important for France's electricity economy, since in about fifteen years' time the hydro-electric resources of the country would be fully harnessed. It was planned to install 1,000 "bulb" units of 10 mW each, similar to those in La Rance, and the whole barrier would be some 20 kilometres long.

/274. Other



274. Other considerations discussed, which exerted a more direct influence on the choice of a steam or hydraulic plant, concerned the vulnerability of the operations. The complexity of the equipment in thermal plants made it necessary to have better trained personnel and resulted in higher operating costs. Reference was made in that respect to experience acquired in servicing the greater Buenos Aires power plants.

275. With regard to hydro plants, mention was made of the vulnerability of long high-tension cables exposed to bad weather conditions.

276. It was pointed out that, in Latin America, the decision to adopt a certain solution was often taken because electricity supply crises had to be resolved without delay. Furthermore, in various cases in which hydro-electric solutions were considered, the choice fell on the solution with the best background data and basic information immediately available, another factor that constitutes a criterion of priority.

(c) Selection of types and sizes of plant for an electricity system

277. At the beginning of the discussion on this point, the methods most commonly used for comparing alternatives were briefly reviewed, and stress was laid on the fact that no director of an electricity company should rely on a single equation when making his choice of plant, but that he would also be wrong to discount the value of the different mathematical methods evolved for the purpose. It was mentioned in that respect that a model had been devised for an important project, that considered nearly 250 parameters and reached a decision with the aid of electronic computers, often giving replies that proved surprisingly good in practice.

278. It was considered that the method of present worth explained in ST/ECLA/CONF.7/L.2.1 was becoming increasingly widely used to determine the most advantageous solution, not for a given moment but for the whole period under consideration. On the whole, that method was greatly preferable to the classic system of annual equivalent standard cost, or any other methods commonly used, and it was generally agreed that it was a good instrument for investigating alternative solutions.

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279. With a view to establishing a comparative scale of values for the different hydro-electric solutions, various methods of classification had been developed. Attention was particularly drawn to the so-called coefficient of worth method, whereby any hydro plant could be compared with an equivalent thermal plant capable of supplying the same service. The greater present worth (difference between the capital representing the income minus the investment and capital representing the expenditure) of the hydro-electric than of the thermal plant constituted the gains of the country, and the greater the ratio of gains to investment the higher the coefficient of worth.

280. It was pointed out that if the coefficient of worth were applied blindly in countries moderately endowed with hydro-electric resources, nothing but hydraulic plants would be built for a number of years. It was also indicated that other criteria existed that would justify the construction of thermal plants. Stress was then laid on the vital importance of thermal plants for reinforcing hydro-electric works designed to harness flows of relatively short duration.

281. When the electric power development plan for Peru was being formulated it was noted that there was little point in using a thermal plant as a yardstick for comparison with alternative hydro-electric projects when the analysis related to electricity supplies in isolated parts of the country, where there were serious communication problems that made the price of fuels vary sharply from one part to another. A study was made of possible ways of adapting the method of present worth so that it could be applied to countries such as those in the area.

282. The importance of the time factor for methods of comparing alternatives was recognized, together with its influence on such aspects as future operating costs and the amount and price of the power sold.

283. It was generally thought preferable to adopt current prices for fuels and kWh when applying the methods of comparison, instead of introducing fresh elements of doubt through unreliable estimates. It was also pointed out that the system of present worth enabled highly

/trained technical

trained technical staff requirements the complexity of the installations and, to a certain extent, their vulnerability - mentioned as one of the conditions affecting choice - to be duly taken into account as cost factors.

284. With regard to future costs and prices, it was pointed out, however, that a careful search should be made for possible distortions that could be eliminated in very little time by putting those same costs and prices on a different level. To take as an example nuclear energy, which was going through a rapid technological evolution, one way of projecting the method of present worth would be to place the problem between the two limits corresponding respectively to a pessimistic projection based on established data and to an optimistic projection based on probable technical developments during the period of comparison.

285. It was stated that the USSR also used the method of comparing alternative hydro-electric proposals with a thermal model and determining the so-called "repayment time" of the extra capital investment in the hydro station (see ST/ECLA/CONF.7/L.2.1, page 60).

286. It was emphasized that very complex methods of comparison could be applied only when the information used had the same degree of accuracy as that which it was hoped to attain by those methods.

287. It was pointed out that while there was no great problem with respect to drawing up the estimates for the generating plants, there was some difficulty in calculating the investment required for the production of fossil fuels: coal mines, oil wells, railways, etc.

288. In all the methods of comparison examined the useful life attributable to each part of the generating plant was also an important factor.

289. It was emphasized that whatever the method of comparison used, a generally sound approach would take into account, when a final decision was being reached, the fact that fossil fuels were exhaustible and water resources were not.

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290. Similarly, it was stated that a generally sound approach would include supplementing mathematical methods of comparison by analysing the advantages of combining the use of thermal and hydro plants in the same system, especially from the standpoint of the reliability of the service.

291. All the methods of comparison described would make it possible to choose between various types of power plant or installation in solving a specific problem. They would also make it possible to make a list of various draft projects in order of value, for use when the time came to draw up broader programmes that might involve the decision to undertake a large number of constructions within a given period, seven to ten years, for example, considered a reasonable period for predominantly hydro-electric systems.

292. In smaller systems the programming was carried out practically at the same time as the work of comparing the various alternatives, on the basis of simplified calculations. That was generally the case in Latin America. However, when the system was a large one, a choice must be made between alternative programmes, and the method of comparison must be more systematic.

293. Two alternative expansion programmes for an electricity system for a given period might be differentiated on the following grounds:

- (i) They comprised different groups of installations.
- (ii) Although they contained the same group of thermal or hydraulic installations, there were differences in the dimensions of the essential elements of one or more of the hydraulic installations.
- (iii) Although the group of installations and the features of the installations were the same, the order in which their construction was to be undertaken was not.

294. In addition, in order to obtain an idea of the economic value of each programme, the most exact determination possible must be made of the optimum method of using the generating units so as to meet demand throughout the period under consideration. In other words, the new installations planned, plus the existing capacity, must be distributed on the local diagram envisaged.

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295. The detailed analysis of that problem was obviously a lengthy and complicated undertaking. Theoretically speaking, there were thousands or tens of thousands of feasible alternative programmes. It should be recalled that in many cases hydro-electric stations affected one another, especially when they were part of a series of installations using the waters of the same basin.

296. Methods such as the coefficient of worth, provided that their limitations were clearly understood and they were used only to obtain some form of ranking of the possible hydro-electric alternatives, would make it possible to reduce the number of alternative programmes to something more in line with the limits imposed by the time and the human and financial resources available for studying the question of the best programme to choose.

297. An important and difficult point in selecting alternatives for the expansion of an electricity system related to the flow duration level for which a hydro-electric plant was to be designed, and also to the reliability of transmission to consumer centres and of inter-connexion between generating plants. Apart from the question of the trustworthiness of the hydrologic history of the basin concerned, from the standpoint of the period covered and the quality of the measurements made, it was obvious that the choice of a high safety margin would have the effect of tilting the scales in favour of thermal plants.

298. As pointed out in document ST/ECLA/CONF.7/L.2.1 (page 47), in practice the same power station designed for different flow duration levels was the equivalent of a group of alternative stations, and should be so regarded for the purpose of selecting the best programme.

299. Once the constituent elements for each of the alternative programmes had been selected, all the mathematical techniques of operational research could be applied. If the programmes were very complex, it would of course be necessary to resort to the indispensable aid of electronic computers, which could deal easily with the number of operations called for.

(d) The combined use of thermal and hydro resources and the position with respect to nuclear energy

300. Although the consideration of the choice between thermal and hydro plants involved some idea of competition between the two forms, the correct approach should be to regard them as two methods that were to a high degree complementary. It was pointed out that that had become obvious in recent years, ever since the era when the aim had been systems consisting as far as possible of hydro plants, with a stated minimum of thermal power which, because it was available at all times, could make up for any hydrologic shortages. The more recent trend had been to elevate the role of thermal power to that of providing a substantial share of the load diagram, thus permitting a better use of the available hydraulic potential. In other words, the result had been a marked decrease in the flow duration levels for which those plants had been designed.

301. A description was given of the work done in that field in France where an analytical method described in document ST/ECLA/CONF.7/L.2.6 had been developed to determine the optimum combination of a water resource with a thermal plant. That criterion had been used in the plan recently drawn up for Venezuela, and the result had been an increase in the ratio of thermal to hydro plants.

302. With respect to the placing of the various types of thermal and hydro plants on the load diagram, it was stated that modern thermal units could be adapted to provide the load on any part of it, either at the base, with a group of high fuel-efficiency turboalternators, or at the peak, with the modern gas turbine with speedy entry into operation. The first type should be used only when there was a shortage of run-of-river plants, which were of course the most economical for providing the base load.

303. Programming of the combined use of various types of plants for the future must take account of their tendency to be displaced towards the top of the load diagram as their efficiency was exceeded by other

/more modern

more modern units, an effect that could be accurately measured by the present worth method. Hydro plants were essentially dependent on hydrologic conditions, a factor which was beyond human control, whereas a thermal plant, sufficiently supplemented by a supply of fuel, communications and storage facilities, could operate entirely at will, although the kWh produced generally cost more than in a hydro plant.

304. There was a discussion of the position of nuclear plants in the already wide range of types of plants that could be used to meet the needs of a load diagram, and what that development might mean for Latin America. Although such plants were technically speaking thermal plants, from the standpoint of economic yield they were more on a footing with hydro plants, since they were distinguished by a high initial investment and a low direct operating cost. Consequently it was natural to use them for supplying a high load factor (of the order of 80-85 per cent). To some extent that gave them an initial advantage in comparison with other plants which needed to be more adapted to variations in the load. But it must be recognized that the uncertainty that still prevailed as to its future development meant that the amortization periods allowed were probably too short, which tended to offset the above-mentioned advantage.

305. Reasons of economic size indicated that for Latin America plans should be in terms of units of some 200 MW. Because of the high load factor at which such plants operated, they could be used only in systems with a maximum demand of over a million kW. Such systems were found in only a few places, such as the Rio de Janeiro - Sao Paulo region, Greater Buenos Aires, and Mexico City. Another suitable area would be where there was an industrial concentration with special features, such as in the north of Chile. With respect to all such proposed sitings there were indications by participants that preliminary studies had excluded them from plans for the immediate future, in most cases because of the heavy burden they would impose on already scarce capital resources, and the uncertainty that still prevailed as to the future course of development. In that connexion reference was made to the debates in Committee V.

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306. It was also generally agreed that as far as smaller reactors of an experimental type were concerned, there were many more places where their installation might be advisable. An account was given of the experience of Puerto Rico, which in 1962 would begin operating a nuclear plant of 15.5 MW. Three basic factors had led to the decision to install that plant: (i) there were no local fuels on the island and its water resources were already being fully exploited; (ii) it would provide a training ground for both local and foreign staff; (iii) it constituted a further link in the chain of experiments sponsored by the United States Government.

307. There was also much discussion of the economic criteria that governed the selection of such plants for inclusion in a system. The representative of the International Atomic Energy Agency (IAEA) said that nuclear power could already be regarded as truly competitive economically with other types of power, and that its costs could be fairly accurately estimated before the plants concerned were constructed.

308. It might be possible in the future to use more refined programming techniques to evaluate the possibilities of such plants, but in the mean time such evaluation must continue to be made in a relatively simple manner. In particular, when the question was one of adding nuclear units that would constitute only a small part of the capacity of the whole system, use was made of such methods of comparison as annual cost, present worth, etc. The present worth method was the most suitable in a situation where the initial investment was high. At present it was about twice as high as for a conventional thermal plant, but it was expected that in the near future the ratio would be reduced to 1.3 or 1.5 to 1.0.

309. With respect to fuel cost, there was a declining trend, which had recently been officially recognized by the United States Government as regards its own plants, although technology in that field was in a very fluid state (see topic VII). Direct costs per kWh ranged from 0.012 dollar cents for a Canadian plant to nearly 0.3 for other cases (costs referred to plants of the order of 200 MW). The amortization periods

/used were



used were 15 years for the reactor, 40 for the heavy water and 25 for the conventional electromechanical parts.

310. In summing up those considerations, it was agreed that there was no single or preferred method of comparing nuclear and conventional thermal plants. The best course was to make a careful study of the greatest possible variety of alternatives and to reach a decision in the light of all the factors that had a direct or indirect bearing.

(e) Interconnexion of systems and its advantages

311. The advantages deriving from interconnected systems were reviewed. They included the following: complementarity of different sources of electric energy; complementarity of load curves with different characteristics (diversity); reduction of installed capacity by the raising of load and plant factors, etc. To sum up, all the advantages of interconnexion were epitomized in the statement that it lowered the cost of power.

312. Interconnexion in Europe had demonstrated the many advantages attendant upon the parallel operation of major systems. It had reduced the amount of reserve capacity that each country or company needed to install, and had made it possible to use high-power equipment whose performance was more economic and efficient. It had also permitted more efficient utilization of water in hydro-electric storage plants, and had cut down the amount of steam consumed in thermal plants.

313. With respect to new power stations, construction en bloc had increased; the construction programmes of various countries were combined, and it was also possible to co-ordinate their maintenance programmes, an extremely important factor, especially in the case of thermal plants. Systematic advantage was also taken of seasonal differences and hourly variations in consumption.

314. In connexion with the desirability of long-distance transmission, it had to be borne in mind that the economic transmission distance was short. The problem should be carefully studied in Latin America, where

/the cost

the cost of transmission was proportionally high, and it might be justifiable to carry electricity over longer distances than would be economic in Europe and the United States.

315. In Chile, the hydro-electric plants in the central zone were based on ice, and were therefore short of water in winter and fed with snow melt in summer, when the load was less. Interconnexion enabled them to be operated on a basis of complementarity with more southerly power stations based partly on ice and partly on rainfall and plants in the far south, where rainwater was available all the year round.

316. In that interconnected system the thermo-electric plants worked only in winter, and in summer were under repair, advantage being taken of the considerable increase in the output of hydro-electricity. In the future, thanks to the interconnexion in question, it would be possible to use a flow duration of about 50 per cent as firm capacity. The length of the interconnexion lines was, at present, 1,500 kilometres. The drawback of the combination of systems was that the scale of problems altered. For example, serious breakdowns in Santiago, the capital, might plunge a large part of the country into darkness. The same problem had arisen in a much more serious form in the European interconnected system.

317. Consequently, such interconnexions had necessitated technical advances, that would enable the affected area to be isolated, through the installation of better protection systems. That was one of the advantages of interconnexion, for it compelled the establishment of higher standards, and the various component parts were improved.

318. A description was given of the situation in the centre and south of Brazil, where 80 per cent of the country's installed capacity was concentrated in five States. In 1959, pursuant to a suggestion from the International Bank for Reconstruction and Development, a joint study of the development of that area had been undertaken, in which all the public and private companies had co-operated through an ad hoc working group. A projection of demand up to 1970 had been formulated, and a

/study had

study had been made of each of the 60 to 70 hydro-electric plants which it was proposed should serve that demand, on the basis of the most unfavourable hypothesis in respect of hydrological conditions deducible from the available statistics for a period of 30 years. The study had revealed a shortage of capacity in some parts of the area and a surplus in others. By means of interconnexion, it had been possible to reduce the projected installed capacity from 3.6 million kW to 3 million kW, i.e. by 20 per cent. That was a very good example of what could be achieved through the programming of an integrated system.

319. The problems of standardization of frequencies sometimes raised by interconnexion in Latin America were also fully discussed. The desirability of standardization was unquestionable, for even if the cost of conversion remained high, it was much more burdensome for national economies to have to keep on producing equipment and appliances for both frequencies and effecting minor installations at each of the frequencies adopted.

320. In the case of a 100 MW load in Brazil, the frequency was changed at one-tenth of the estimated cost. Both the Government and the companies concerned had established contact with the suppliers of equipment in order to expedite and facilitate the change. The residential districts paid the cost of transforming appliances as a form of co-operation designed to avert the need for higher electricity tariffs.

321. The change of frequency was currently being carried out in Rio de Janeiro at a cost equivalent to 80 million dollars. The plan was for the electricity company to make the necessary changes in the power stations; industrial consumers would do their part on the basis of loans. It was estimated that by January 1964 the change of current would be completed. In the future it would be possible to install industries only in certain areas where the frequency was 60 cycles, and the expansion of the 50-cycle area would be prohibited.

/322. In Venezuela,

322. In Venezuela, too, interconnexion raised a serious problem, as the aim was to transmit the power that would be generated on a large scale in the south-east zone to the centre of the country, where a different frequency prevailed.

323. Lastly, emphasis was laid on the importance of international hydro-electric projects and of interconnexions between various countries. Agreements for such purposes were usually the outcome of the uneven distribution of sources of energy over the different countries concerned. A case in point was that of Yugoslavia, which had a potential 63 billion kWh annually, of which only 5 per cent had been developed. On the other hand, Italy and Bavaria had harnessed all their hydro-electric reserves and, moreover, possessed no coal; consequently, Italy and the Federal Republic of Germany wished to co-operate in the construction of hydro-electric plants in Yugoslavia, which would pay for themselves through consumption. The idea was to construct several plants and a transmission line of 380 kW, at a cost of 400 million dollars. During the initial phase, 5,000 million kWh would be exported annually.

324. There were some interesting cases in Latin America to which it was essential that more thorough study should be devoted. Among the projects already carried out, mention might be made of the Falcon Dam on the Rio Bravo, between Mexico and the United States. The dam in question was a multiple-use project, for irrigation, flood control and generation of power.

(f) Development of electricity in areas served inadequately or not at all

325. Although that point was raised in Committee III and was considered in the presentation of the topic,<sup>25/</sup> it was felt that some of the most interesting problems connected with the projection of demand and electrification media in such cases had already been discussed in broad outline under other items on the agenda.

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<sup>25/</sup> See paragraphs 258-264 above.

### 3. Conclusions and recommendations

326. From the papers presented on this topic and the relevant discussions the following conclusions may be drawn:

- (a) The choice between alternative possibilities for investment in electricity systems is strongly influenced by factors extrinsic to the electricity sector itself, such as the available supplies of capital and of foreign exchange, the need to meet emergencies and the indirect advantages of specific solutions;
- (b) Methods of evaluating the various alternatives for purposes of comparison must take into account the useful life of installations. The system most to be recommended seems to be the so-called "present worth" method;
- (c) In many instances, the lack of basic data (hydrological and geological statistics, etc.) and of technical specialists frequently precludes the use of the most suitable instruments of comparison, and necessitates recourse to simplifications and approximations in the selection of investment alternatives;
- (d) It has become evident in practice that if hydro and thermal power are not used as mutually exclusive alternatives, but on a complementary basis, the additional benefits resulting are considerable;
- (e) Given the economic situation of the countries of the region, only in exceptional cases does it seem recommendable for electronuclear plants to be installed within the next few years, apart from small ones primarily for experimental and training purposes;
- (f) The expansion of the region's electricity service and the complementarity of hydrological régimes and load diagrams are making the interconnexion of systems increasingly desirable since it leads to considerable savings on intalled capacity and operational costs;

/(g) Standardization

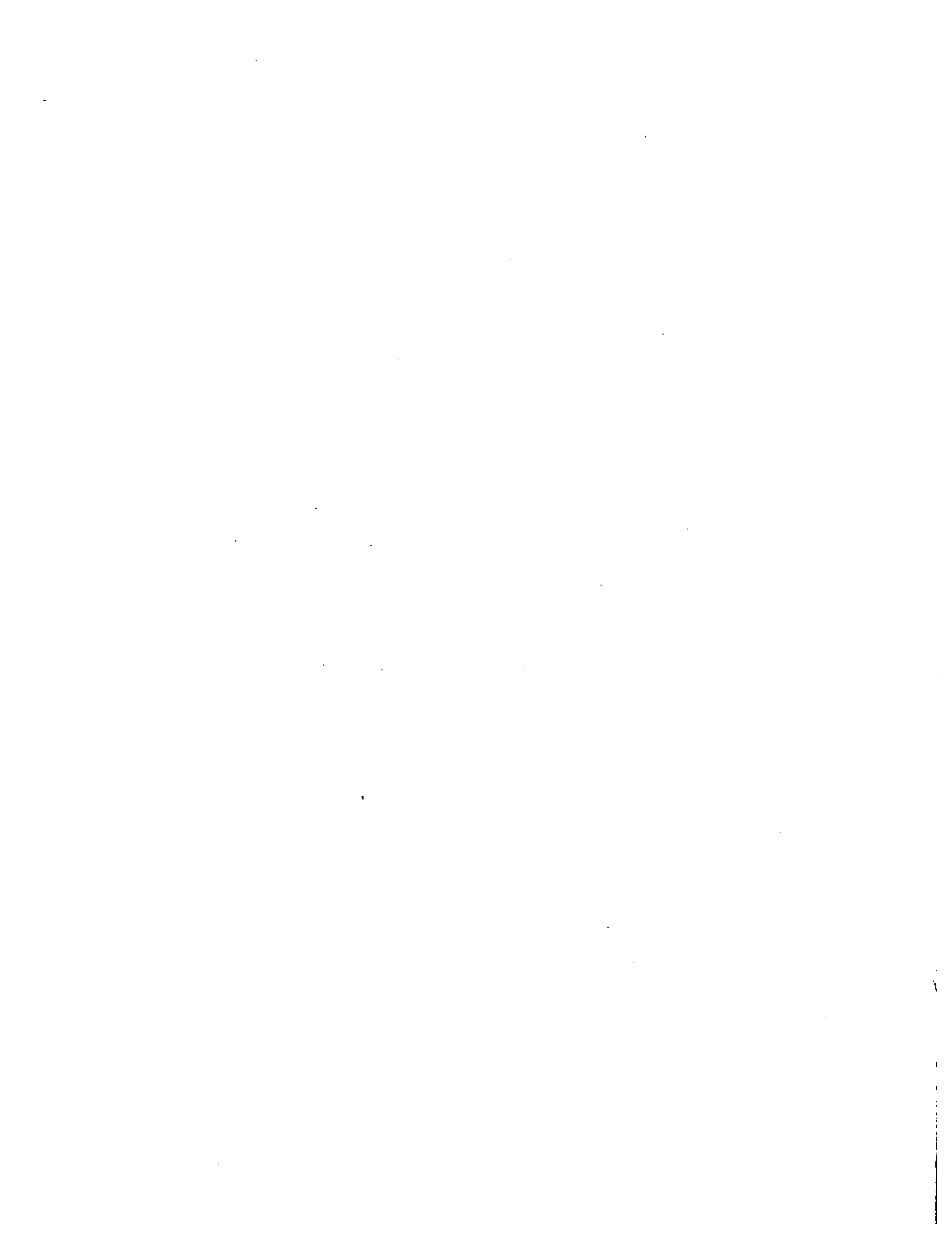
- (g) Standardization of frequencies should be aimed at for the sake of the more efficient development of electricity systems as well as of the industries manufacturing equipment for the transformation, distribution and use of electricity;
- (h) The provision of electricity in rural areas with a low consumption density has a high social value. Every country should seek the most economic means of meeting supply requirements of this kind to the best of its ability.

327. The foregoing considerations led the Seminar to formulate the following recommendations:

- (a) Investment alternatives should be studied in relation to the systems of which the projects concerned will form a part, and, as far as possible, under national electrification plans which take into due account the position of electricity in the energy sector and the over-all situation as regards economic development;
- (b) Electricity planning should take into consideration all the factors affecting decisions, both those of a technical nature and proper to the sector, and those extrinsic to it and deriving from the socio-economic situation of the areas to be served;
- (c) Every endeavour should be made to apply analytical methods of evaluating investment alternatives, whereby all the determinants are reduced to cost factors. The possibilities of the "present worth" method are recommended for study;
- (d) In addition to the need to ascertain and measure the hydro-electric potential of the Latin American countries, coefficients measuring its relative value should be worked out, to facilitate decisions as to its utilization;
- (e) Study should be given to the possibilities of carrying the benefits of interconnexion beyond national frontiers, when circumstances so permit, especially in relation to hydro-electric projects of international scope;

/(f) It is

- (f) It is recommended that the ECLA Secretariat be requested to form a study group to work on the idea of publishing a review containing technical, economic, statistical and general information on electricity supply problems in the region, as a first step towards the effective co-ordination of this activity in Latin America. The publication in question would be financed with voluntary contributions from all the enterprises producing electricity in Latin America, the amount of which might be proportional in each case to the company's annual output of kWh;
- (g) It is recommended that the ECLA Secretariat be requested to study the methods and systems of co-ordination applied by the Economic Commission for Europe in the electricity sector, for the purpose of considering and recommending their introduction in Latin America with the co-operation of the countries that have reached the most advanced stage of development in this field.





V

HYDRO-ELECTRIC RESOURCES, THEIR MEASUREMENT AND UTILIZATION

1. Presentation of the Topic

328. Electricity can be produced from all known energy resources, whether primary (coal or hydrocarbons) or secondary, such as nuclear fuels, blast-furnace gas and many others. Among these resources, hydro-electricity - which does not depend on the consumption of matter but only on use of the continuity of the weather cycles of evaporation and precipitation - will constitute indefinitely a limited but inexhaustible source of power for humanity. These conditions and the growing demand for power following improvements in levels of living make it imperative to study water resources with increasing care and to investigate their supply and optimum use, as in the case of the other sources.

329. This study is even more urgent and necessary in view of the fact that the supply of water in many parts of the world and in various areas of Latin America is the most important factor limiting development. The use of water for drinking and hygiene in the communities, for irrigation and industry and for navigation and transport take priority in most cases over its alternative use for the generation of electric power. But, in many cases, hydro-electricity does not exclude the other uses of water and even combines with and facilitates the other applications in so-called "multiple-use" projects.

330. In view of the objectives of the Seminar, the topic, as presented here, is restricted mainly to hydro-electric power but it must be borne in mind at all times that the Survey of water resources may be applied to a large extent to all other uses of water.

(a) The need for making over-all evaluations of hydro-electric potentials

331. Until recently estimates of hydro-electric potentials - even in the more developed countries - has been carried out in a very incomplete manner and has lacked the uniformity of methodology and of technical and economic language necessary for reporting on the findings of the corresponding research.

/332. The specialized

332. The specialized agencies of the United Nations and, in addition, the Economic Commissions for Europe and for Asia and the Far East in particular, have clarified many concepts, and to some extent, established a methodology for the uniform evaluation of water potentials worthy of consideration and adoption by the Latin American countries as well.

333. Existing estimates of hydro-electric resources in the area (see document ST/ECLA/CONF.7/L.3.0 prepared by the secretariat) lack uniformity precisely as regards the criteria and procedures used and are also insufficient in coverage. Nevertheless, it is possible to form from them some idea of the magnitude of water potentials in most of the countries, and it may be stated that they constitute a safe and economic basis for development as a source of power.

334. As hydrological and hydrometeorological statistics are the basis of all studies on water, the establishment of the respective networks of measurement stations in the first necessary step, to be taken many years in advance, for the rational utilization of water in a country or region.

335. Analysis of the means available for surveying water resources in Latin America shows, in general terms, an unsatisfactory level. But, in various countries, there are sufficient background data for carrying out - or at least starting - an over-all evaluation of the hydro-electric potential which would yield reliable quantitative information on its availability and geographic distribution.

336. The economic importance of water resources would by itself justify the need to know their size and characteristics in each area of a given country. But, in addition, the contribution of water to the supply of commercial power throughout the world has increased during the last two decades, not only in absolute terms but also relatively, as it rose from 6.6 per cent in 1937 to 8.7 in 1959.

337. Whereas in Latin America, this contribution has fluctuated around 14 per cent, in Western Europe it climbed from 7.6 to 13.7 per cent and in the United States from 4.1 to 5.8 per cent in the period 1937-59. Taking Australia, Canada, Japan, New Zealand and the Union of South Africa as a group, the share of water resources is approximately 29 per cent of commercial power.

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338. On the other hand, in relation to electricity production alone, the share of water as a power source has dropped from 42.7 to 31.8 per cent in the world as a whole (1937-59), as a result of the more rapid development of thermal electricity. Only in Latin America and Eastern Europe has the share of hydro-electricity in electricity production been growing for the last two decades. In 1959, it reached the levels of 52 and 17 per cent respectively. The highest figure was again recorded in the group comprising Australia, Canada, Japan, New Zealand and the Union of South Africa, where it amounted to almost 70 per cent in 1959.

339. In spite of the preceding figures, the utilization of Latin America's water potential may be considered to have hardly begun. While the world average for hydro-electric production in 1959 was 4,950 kWh per square kilometre, 20,500 in Europe, and 20,300 in the United States, in Latin America it was only 1,630 kWh/km<sup>2</sup>, despite the fact that the region's available water potential per surface unit seems to be considerably above the world average.

340. While the measurement of water potentials is always an arduous task, it may be said that the relevant surveys and studies are broadening their scope by going from theoretical to technical and then to economic potentials.<sup>26/</sup> Besides the hydrological and topographical information to which theoretical potentials are limited, technical potentials require information on geological structure - including data on soil mechanics - and, to some degree, cost analyses. Economic potentials also call for specific research in each case into the use of water resources most desirable for community use.

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<sup>26/</sup> The "theoretical potential" of a basin is defined as that which considers the capacity and power of the natural water resources of the basin while ignoring the possibilities of practical utilization and with a 100 per cent yield. On the other hand, the "technical (or feasible) potential" refers to the power and energy of all possible existing project or projects that could be executed using normal techniques. Finally, the "economic potential" is the potential economically desirable for development and which does not pose insoluble conflicts with other uses of water having greater priority.

341. Since it is a widespread practice in Latin America not to evaluate potentials as a whole but to limit them to sites considered economically usable, it is advisable to point out that this procedure - even if a uniform criterion is applied - raises specific difficulties. Of course the personal factors that enter into the general concept leave upon evaluation their own mark in determining the possibilities of each project. In addition, the conditions that justify the economic character of a project a few years hence - ten or fifteen, for example - include many imponderables: supply and prices of other competitive sources of electric power; characteristics of the consumption diagram to be satisfied (as a result not only of increased demand, but also of the type and economic characteristics of the plants constructed in the same system prior to the development studied); complementarity or conflicts with other uses of water and criteria for distributing investments made in multiple-purpose projects; development of techniques and construction costs, etc.

342. To sum up, in countries in process of development such as those of Latin America, more rapid simplifying criteria are needed to make evaluations on a broad basis for planning purposes. It is desirable that those evaluations should be made as quickly as possible and in conformity with the material possibilities of each country.

(b) Suggested concepts and methods of evaluation

343. The theoretical surface run-off potential method supposes that the area under study is divided into small tributary basins (sub-basins), for which statistics are available on run-offs over a period of twenty years or more, or which if they cover only some twelve to fifteen years or more, can be extended, by covariation, by using rainfall, after an adequate correlation has been checked.<sup>27/</sup>

344. Assuming total utilization and 100 per cent output, the theoretical surface potential in millions of kWh per year is given by the formula:

$$P_s = \frac{V \times H}{367}$$

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<sup>27/</sup> The figures mentioned are considered as minimum. Generally speaking periods of no less than 30 years are recommended. (In this connexion, see documents ST/ECLA/CONF.7/L.3.6 and L.3.8)

/in which

in which  $\underline{V}$  is the volume of annual run-off in millions of cubic metres exclusively from the rainfall in the sub-basin considered, and  $\underline{H}$  is the mean elevation of the sub-basin above sea level, in metres.

345. By adding these values together, the potential of a whole region or country is obtained. When the potential of each basin is divided by the respective area in square kilometres, the specific value of its potential in  $\text{kWh/k}^2$  is obtained. This expression enables equipotential curves to be traced on the map of the area or country being studied.

346. Land-locked lakes, in which underground seepage and evaporation are equal to tributary flows, deserve special consideration. It was recommended that the total theoretical surface potential should be reported at sea level, with a specific and separate indication of the potential that should be subtracted for the gradient between the surfaces of the land-locked lakes and the sea.

347. In the case of the gross linear potential, each river or watercourse is divided into sectors bounded by the confluence points of consecutive tributaries. In each sector the corresponding potential is calculated using the formula:  $P_L = 9.8 \times Q_m \times H$ , in which  $P_L$  is the mean capacity in kW,  $Q_m$  is the average of the flows at each end of the sector in cubic metres per second and  $H$  is the difference in metres between the water levels at both extremes. The gross linear potential of a basin, country or region is obtained by addition.

348. This potential is represented graphically by tracing on a map, along the rivers, lines of different width, proportional in each sector to the potential per unit of length (kW/km). This evaluation has the advantage over the foregoing, of accurately locating the points at which each potential is to be found.

349. In general evaluations for planning purposes only, the alternative to the direct determination of the feasible potential - by the preparation of specific preliminary projects - is its estimation from the theoretical potentials expressed as a fraction of them, on the basis of similarity with thoroughly-studied river basins or systems displaying similar geographical or physical characteristics, in the manner described below.

/350. The experience

350. The experience of developed countries in different areas of the world indicates, in general terms, that the relationship between present-day feasible and economic potentials and theoretical potentials falls within a relatively narrow range of values. In several European countries the feasible potential would seem to be between 20 and 25 per cent of the theoretical surface run-off, with a few exceptions of a local character that vary between wider limits.

351. The ratio of the current economic potential to gross surface run-off in eight European countries, was 0.17 to 0.20.<sup>28/</sup> On the other hand, the findings of other studies<sup>29/</sup> seem to indicate that the ratio of the current economic potential to the gross linear potential is approximately 0.33 to 0.40.

352. While these coefficients cannot, of course, be applied to Latin America unless a careful numerical investigation is made beforehand, they give some idea of the lower limits of these ratios.

353. The main interest for countries in process of development, as regards determining their theoretical potentials, lies in the fact that, with relatively simple hydrological and geomorphological research, their economically usable hydro-electric potential can be approximately estimated in a short time.

354. However, one factor that has a considerable influence on the part of the potential that can be developed economically, in a river, in relation to the respective theoretical potential, is the irregularity of its flow. Detailed studies, for the purpose of specific projects, make use of known flow duration curves. If the ordinates of these curves are expressed in terms of moduli, taking the average flow as 100, valuable comparisons may be made between the characteristics of various rivers.

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<sup>28/</sup> See Economic Commission for Europe, "Hydroelectric potential in Europe and its gross, technical and economic limits" (E/ECE/EP/131).

<sup>29/</sup> See ECAFE, "Methods of assessment of hydroelectric potentials" (I/NR/sub.1/HPWP/1) with quotations from "Power Resources of Yugoslavia", Belgrade, 1956, and "Determination of hydroelectric potential in the USSR" (EP/Working Paper/52-56).

355. In general planning studies, however, it is practical to have an indicator to facilitate preparation of maps in order to show the territorial distribution of the irregular river run-off during a given hydrological year. The Economic Commission for Europe recommends the following:

$$C_{ri} = \frac{V_i}{W_i}$$

in which  $C_{ri}$  is the coefficient (indicator),  $V_i$  is the capacity of the reservoir required for total control of that year's run-off, and  $W_i$  is the volume of run-off during the year.

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356. The repeated underestimation of hydro-electric resources in the United States is attributed to the absence in that country of these concepts of evaluation on a national scale at the theoretical, feasible and economic levels.

(c) Facilities for examining hydro-electric resources in Latin America

357. The numerical information compiled by the secretariat (document ST/ECLA/CONF.7/L.3.0) for the purpose of studying the present situation with respect to statistics and the facilities available for examination in the matter of hydrology and hydrometeorology should be considered only as a first approximation to the analysis of such an important regional problem. Owing to the fact that the sources of information are inadequate, it cannot be said that the numerical data supplied to the Seminar are free from error.

358. The supply of measuring equipment is notoriously poor in Latin America. Only ten countries have an average lower than 1,000 square kilometres per pluviometer.<sup>30/</sup> Densely populated countries whose economy is linked with agriculture are the ones which have the best supply of pluviometric equipment, some of them boasting less than 300 km<sup>2</sup> per rain gauge. Conversely, there are countries in which this average is higher than 5,000 km<sup>2</sup>.

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<sup>30/</sup> The area which a rain gauge can representatively cover is very variable. Nevertheless, an area of 100 to 1,000 km<sup>2</sup> is, on the average, adequate for many purposes in various regions. There are smaller areas per station in mountainous regions, where the rainfall distribution is more irregular than in the lowlands.

/359. The proportion

359. The proportion of rain recorders in the pluviometric networks in some countries reaches the figure of more than 20 per cent and shows a tendency to increase.

360. In fluviometry, where the required number of stations is in direct relation to the number of confluences of main water-courses, comparisons are often made, often through similarity with the rainfall measurements referred to above, between the territorial surface averages corresponding to each of them. Only two countries record averages lower than 1,000 km<sup>2</sup> per station, there being only eight which exceed 5,000 km<sup>2</sup> and four which have an average of over 10,000 km<sup>2</sup> per fluviometer.<sup>31/</sup>

361. There are three countries with more than 100 evaporation-measuring stations. The distribution of pluviometers and fluviometers is, of course, very irregular in each country, as is apparent from an analysis of the more thoroughly studied basins and sub-basins.

362. In pluviometry, relatively long measurements are frequent, because many instruments were installed long ago by private institutions for purposes closely connected with their main activities (railways, agricultural and cattle enterprises, airlines, mines, etc.).

363. In pluviometry and fluviometry, the index of coverage is defined as the product of two factors: the number of observation stations per 10,000 km<sup>2</sup> of territory examined and the average age (in years) of the relevant records.

364. With the values corresponding to these indices by zones, maps have been drawn up covering all of Latin America. In examining these maps, it must be remembered that there are arid and even unexplored areas. That explains the absence or low density of observation stations in these areas. A comparison with countries in other continents using these indices shows that Latin America as a whole has a very limited knowledge of its water resources.

365. In almost all the countries there are public, semi-public and private agencies dealing with hydrological, including hydrometeorological observations, and, in some cases, with the corresponding research. Unfortunately, an appreciable part of the work done is not utilized precisely because of the lack of uniformity and co-ordination among these agencies and because their observations are not usually published.

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<sup>31/</sup> In more developed countries, averages between 500 and 2,000 km<sup>2</sup> of basin per measuring station are frequent.



366. With the relatively small additional cost that the work of co-ordination done in several countries outside the region entails, it would be possible for many Latin American countries substantially to increase their output, at present limited owing to the dispersion of work, some of which is even unknown.

367. In most countries, there are meteorological publications covering part of the hydrometeorological observations, but with respect to fluviometry, there are only six countries which publish their material, but without including, as a general rule, all the measuring stations.

368. In another document (ST/ECLA/CONF.7/L.3.8), referring to experience in Mexico, the great irregularity of the river flows in tropical zones is stressed, citing the Necaxa area as an example. The dry periods from 1913 to 1923 and from 1945 to 1951 showed variations as high as 40 per cent in relation to those recorded for the years 1925 to 1937 and 1951 to 1958.<sup>32/</sup>

369. For the planning and projecting of multiple-purpose projects in the Colorado river basin (United States) the Bureau of Reclamation has statistical series which have been compiled over the last sixty years. Nevertheless, the Bureau always proceeds with caution, for fear that the observation period may not furnish the complete data required for a perfect design (see document ST/ECLA/CONF.7/L.3.6).

370. With regard to the more economic use of water resources and the research which should be undertaken for this purpose, several documents were submitted to the Seminar for its consideration (see ST/ECLA/CONF.7/L.3.1 and L.3.2) which deal with such important subjects as the scale of utilization, analysis of justification, the adjustment of the values of hydro-electric in relation to thermal capacity and power, the relationship between profits and costs, etc., in the United States and other countries.

371. Water development in North-West Mexico for various purposes is another of the specific cases brought to the Seminar's attention. Document ST/ECLA/CONF.7/L.2.3 carefully analyses the favourable consequences

<sup>32/</sup> This refers to the average for each period and not to variations from one year to the next.

/that would

that would have resulted for the projecting and execution of the works carried out there, if the basic information (topographical, hydrological and geological) now available had been to hand at the right time and if they had been planned as a co-ordinated whole with a view to their use as a multiple-purpose scheme.

372. The advantages of multiple-purpose water development and the co-ordination work which the Ministry of Water Resources of Mexico is carrying out in this respect are set forth in another of the papers submitted (ST/ECLA/CONF.7/L.3.13) in which the studies made on the river Tampoñ and the Pujal reservoir are used as examples. Document ST/ECLA/CONF.7/L.3.12 refers to the development of the Mezquital Valley in Mexico and to their multiple-purpose utilization of its water resources.

373. An evaluation made by the United States Geological Survey on the basis of very general data assesses the capacity of Latin America as a whole at 520 million kW out of almost 2,270 million kW estimated for the entire world, i.e. nearly 23 per cent. According to this estimate, the region should have a water potential equivalent to the combined potentials of the United States and of Europe (including the entire USSR).

374. Per unit of area, Latin America should have 25 kW/km<sup>2</sup>, an average much higher than the world average (16.7 kW/km<sup>2</sup>) and one of the highest regional averages.

375. According to information compiled on estimates of potential made in each of the Latin American countries, the following observations may be made:

- (i) There are countries which have not undertaken research in this field;
- (ii) In various countries data from various sources differ widely and their classification is difficult due to the lack of information on the criteria and methods used;
- (iii) Frequently data are limited to a few known basins within each country;
- (iv) The most widely used concept is that of the economic potential.

/376. The total

376. The total of each Latin American country's estimate of its economic potential amounts to little more than 150 million kW, over 70 per cent thereof being concentrated in four countries - Brazil, Chile, Colombia and Venezuela. The general average per surface unit is higher than 7.5 kW/km<sup>2</sup>. In this respect, El Salvador and Colombia have more than 35 kW/km<sup>2</sup>, Costa Rica and Chile coming next with approximately 30 kW/km<sup>2</sup>.

377. There is no evidence to show whether maps or extensive regional research have been undertaken in Latin America in connexion with the irregularity of river flows. In the studies of the joint ECLA/BTAO/WMO group on the water resources of Chile and Venezuela<sup>33/</sup>, the coefficient of irregularity within the hydrologic year, previously recommended, has been estimated for a relatively small number of rivers.

378. Latin America had 6.2 million kW of installed hydro-electric capacity in 1948, that is, only 1.2 per cent of the potential resources estimated for the mean flow, while the world average, in Western Europe and the United States, amounted to 6.2, 45.1 and 35.3 per cent of the corresponding estimates made on the same bases.

379. As regards known economic potentials, regional average utilization is 4.1 per cent. Uruguay, Mexico and Brazil appear to be the countries which have reached a higher level of utilization in proportion to their possibilities (1958), with percentages between 10.7 and 9.5. Nevertheless, there are basins very close to urban centres which are already well developed. For example, in Uruguay, the Rio Negro in 1960 was using 45 per cent of its potential, and the Rio Grande de Tárcoles in Costa Rica almost 40 per cent.

380. Approximately 60 per cent of the capacity installed in the public service hydro-electric plants in Latin America in 1958 was of the type which has regulating reservoirs accounting for more or less 64 per cent of hydro-electric generation. The capacity of the reservoirs was estimated at approximately 36 per cent of hydro-electric generation for the same year.

381. This type of plant is spreading in almost all the Latin American countries. There is a simultaneous trend towards using them more extensively for generating power during peak hours, in systems fed by thermal and hydro-electric plants of different characteristics.

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<sup>33/</sup> See E/CN.12/501/Add.1 and E/CN.12/593, respectively. /382. At the

382. At the same time, the tendency to carry out all water projects in the interest of the maximum public benefit and with a view to the optimum use of water is becoming more and more widespread. The possibilities of irrigation, drinking water, flood control, navigation, etc. are examined simultaneously with electricity production, as a financial and economic basis for the whole plan. Good examples of this policy are to be found in Argentina, Brazil, Chile, Colombia, Mexico and Uruguay.

383. Thirteen countries, concerning whose electric development plans information is available, propose to install a combined total of 7.8 million kW of hydro-electricity in the period 1958-65, which represents a high cumulative annual rate (13.6 per cent). Likewise, six countries, for which estimates are available up to 1970, intend to install a total of 11.1 million kW of hydro-electricity in the period 1958-70 (19.4 per cent annual growth). Both estimates clearly show the magnitude of hydro-electric development in Latin America in the coming years. The greatest absolute increases up to 1965 would apparently be registered by Brazil and Mexico, followed by Colombia, Peru, Chile and Argentina.

384. In document ST/ECLA/CONF.7/L.3.7, which analyses the probable development of hydro-electricity in Mexico, the figure for economic installation is set at only 6.5 million kW. It is also anticipated that the immediate increase in the share of hydro-electricity, according to existing plans will tend to decline after 1970 because the best resources will be already in use. On the other hand, it is expected that, by the year 2000, practically all Mexico's hydro-electric potential will have been utilized.

## 2. Discussion of the topic

### (a) The need for making over-all evaluations of hydro-electric potentials

385. Following the presentation of some general considerations: the growing demand for electric power is confronting Latin America; the renewable nature of hydroelectric resources in contrast to the exhaustible nature of fossil fuels; the circumstance that, in the production of hydro-electricity water is not consumed, and that, when a multiple-purpose project is being developed, it can be coordinated, thereby even facilitating the use of this element for other purposes, etc; it was generally agreed that the hydro-electric resources of the area should be utilized consistently with

/growing power

growing power requirement, and to the extent that the economic interest of the countries made that advisable.

386. It was likewise recognized that, in each country an inventory of water resources had to be made and their characteristics had to be known before the most suitable use of the water could be planned or an effective general power policy, outlined especially with respect to electricity.

387. After several participants had confirmed that the evaluations so far made in Latin America were partial and not governed by uniform criteria or methods, was a unanimous expression of opinion in favour of the desirability of making over-all evaluations of the potential of the entire area, using uniform criteria, methods and terminology and taking advantage of the experience of more developed countries.

(b) Suggested concepts and methods of evaluation

388. After clarifying, as was done in presenting topic<sup>34/</sup> the concept of the measurement of hydroelectric potentials at different levels - theoretical, technical and economic - the importance of the first and of the last was specially emphasized.

389. It was acknowledged that the usefulness of the "theoretical potential" concept for a basin or country resided in its merit as a maximum and fixed although, in practice, unattainable value in relation to which the gradual progress of utilization of the resource could be measured and the future capacity for economic production estimated.

(i) Methods for the evaluation of hydroelectric potentials

390. The two methods for evaluating the theoretical potentials suggested in the presentation of the topic and in secretariat document ST/ECLA/CONF.7/L.3.0 were examined, the first bearing on the potential per surface unit of the basins, and the second, on the length of the river-beds. In view of their efficacy and of the fact that the basic data required for their application were simple, they were considered recommendable for adoption in the Latin American countries on the ground that they represented an effective step towards the standardization of the evaluations of hydroelectric potentials in the region.

34/ See above, paragraphs 343-356.

/391. In contrast

391. In contrast with the theoretical potentials, no standard systematic method was recommended for the evaluation of economic potentials, in view of the difficulties involved in fixing them and of the short time available for their discussion. It was only suggested that they should be estimated using the other methods.

392. With reference to multiple-purpose uses and to relative priorities in the use of water, several criteria used in different countries were examined. It was noted that drinking water and irrigation services were generally acknowledged to have a high priority: in the Tennessee Valley the main objective was flood control, and frequently water was lost for electric generation purposes because of that. A similar situation was to be found in the western United States, in the projects of the Bureau of Reclamation, where irrigation was also a high priority. In the Sonora and Sinaloa (Mexico) schemes, electric power generation took second place to irrigation.

393. Cognizant of the fact that in some countries the order of priority of those uses was established by law, most participants felt that the most recommendable criterion would be to reap the maximum benefits for the community, from all the joint uses made of water within an economic framework. The opponents of that view underlined the need to lay down very strict priorities for its various uses.

394. Some cases were mentioned, such as that of the Villa Victoria (Mexico) dam, where a concession for drinking water was refused because it was proved that it was more economic to use the water for power production and to satisfy domestic needs from another source. Likewise the case of Sao Paulo (Brazil), was mentioned where by 1980  $42^{m}3$ /sec would be required for drinking water services. That supply would be taken, in ever-increasing proportions, from the River Rieté and thus diverted from power production, since there was no other convenient source available.

395. Several criteria were discussed for the distribution of the total cost of a multiple-purpose project among its various uses. For example, in Mexico the maximum cost was assigned to power production until it was equal to that of thermal generation in a nearby alternative plant. Among other criteria, that of "justifiable alternative costs" was analysed,

/based not

based not only on the actual amount of the over-all works, but also on the probable amount if they had been built separately for the same purpose. Likewise, the criterion known as "distribution of costs of residual benefits" was examined, according to which the distribution was made by taking into consideration the benefits derived from each of the uses.

396. Although unanimity was not reached, both criteria were considered to be among the most effective for resolving the aforementioned problem.

(ii) Essential basic information

397. Since the determination of potentials and the pattern of hydro-electric uses was based on a knowledge of river flows and of gradients it was suggested that, so far as possible, that knowledge should be sought by the most simple, uniform and economic methods compatible with the accuracy required for the purposes intended.

398. On examining the minimum period of hydrological and hydrometeorological observations which could be considered adequate for the preparation of a project, it was proposed that the minimum should be equal to the hydrological cycle of the region under study, a cycle which, in many areas, was considered to last from 25 to 30 years. Nevertheless, the discussion led to the conclusion that the period had not been definitely established in any country. Among other examples, the case of Mexico City was cited. In spite of having 100 years of rainfall records, no definite hydrologic cycle had been determined.

399. In view of the reality - inevitable in many cases - of having to execute water schemes on the basis of insufficient information, the opinion was expressed that in such circumstances available data should be used as judiciously as possible, through the adoption of safety margins reflecting the magnitude of the risk and the importance of the project.

400. In studying the usual methods of extrapolating hydrological data in order to determine maximum floods for the purpose of designing the relevant engineering works, some participants expressed the opinion that the usual statistical procedures did not reflect the influence of cyclones in tropical zones. That was illustrated by the example of the cyclone "Janette" (1955) that caused a discharge from the Necaxa reservoir equal to the maximum forecast for the overflow works.

401. The Seminar did not have sufficient basic information to elucidate this question. However, some participants maintained that the statistical methods of extrapolation should include the influence of cyclones, whenever the basic statistics were insufficient, and also any observations made when other similar weather phenomena had occurred.

402. The Seminar was also informed of a procedure used in Brazil, which gave a larger number of direct observations, combined the data obtained simultaneously at various stations of the same basin and considered them as hydrological phenomena completely independent of each other,

403. From the statements of various participants it was concluded that the commonest method employed at present to determine floods in the design of discharge works was the one which combined "most unfavourable weather conditions" with the unit hydrograph.

404. In regard to the extension of statistics by covariation with other longer series, it was felt that it was impossible to define minimum acceptable values for the pertinent correlation coefficients. That was a problem that was conditioned by a multitude of factors difficult to quantify, and decisions in each specific case depended on the planner's good judgement.

405. The Seminar was also informed of the procedure being developed by the Department of Water and Electric Power of the State of Sao Paulo in Brazil for estimating the flow of a river during critical low water periods and the results obtained from the method when it was first applied in practice.

406. Bearing in mind that the detailed study of irregularity of river flow was carried out according to traditional procedures, among which was the duration-of-flow curve, the Seminar took note of the coefficient suggested in document ST/ECLA/CONF.7/L.3.0, intended for the preparation of maps showing the territorial distribution of run-off irregularity. The advantages of that coefficient as an auxiliary element in general studies was acknowledged, and its use in Latin America was recommended.

/407. The Seminar



407. The Seminar agreed that it was impossible to set general standards for averages of territorial surfaces by pluviometric or fluviometric station in order to determine the measurements necessary for a basin, because the circumstances governing their number and distribution were very varied. Among the examples offered for discussion was the Catemaco Basin (Mexico) with its poor distribution of pluviometers even though their number was large in relation to the surface of the basin. It was remarked, moreover, that the mean values of territorial surface by station should be considered as simple indices which would give a general idea of the degree of scarcity of pluviometers and fluviometers in a given country or region.

408. With regard to the quality of the data required to make an over-all evaluation of theoretical potentials, the conclusion was reached that use should be made of the best available background material - maps, hydrological and meteorological statistics - in order to make a preliminary and immediate estimate of those resources, an estimate that would become gradually more precise as more and better information came to hand. Maps with a scale of 1:250,000 or larger, with level lines every 200 meters, or less, had been considered acceptable for estimates of theoretical surface potentials.

(c) Facilities for examining water resources in Latin America

409. The information furnished to the Seminar clearly showed the scarcity of data and the lack of uniformity in the methods employed to ascertain the water resources of each country. It was emphasized that the work done, frequently with the co-operation of numerous organizations, was used only to a limited extent because the observations were not coordinated and centralized. There were even cases where the central authorities were unaware of the existence of private stations that had been operating for years and which possessed valuable information.

410. In view of those and other shortcomings in existing research methods, with the intention of encouraging the wider use of those methods and for the purpose of ascertaining on what bases hydrological, hydrometeorological and cartographic services should be enlarged and improved, it was  
/considered necessary

considered necessary that each country should take an inventory of the bodies making observations, of existing statistics, and of the maps with level lines on different scales with details, in each case, of the territorial surfaces covered.

411. It was also deemed necessary to coordinate the work of the various bodies making hydrological and hydrometeorological observations, as well as any efforts to collect and publish that information and to make it more readily available to interested persons and organizations.

412. In conclusion, the Seminar stressed the desirability of an international exchange of information on evaluations of hydroelectric potentials and suggested that data and experience might be centralized in ECLA, for the purpose of its national and regional studies and publications.

### 3. Conclusions and recommendations

413. The following main conclusions have been drawn from the documents presented to the Seminar on this topic, and from the corresponding discussions:

- (a) It is essential for each country to have an over-all evaluation of its hydro-electric potential with uniform criteria and methodology; this is an indispensable preliminary to planning the optimum utilization of both water resources and other sources of energy;
- (b) The concept of over-all evaluation of theoretical hydro-electric potentials and the methods suggested for determining them are considered advisable and commendable at the stage of development and research of natural resources prevailing in the countries of Latin America;
- (c) It is necessary, in each country, to improve co-ordination of the work of the various bodies responsible for hydrological and hydrometeorological observations, the preparation, centralization and publication of the findings, and the gradual expansion of the network of hydrological and hydrometeorological stations, the purpose of all this being to attain a more thorough knowledge of water resources, an initial step for their utilization.

/414. In view

414. In view of the foregoing considerations and of the discussions held, the Seminar deems it necessary to make the following recommendations:

- (a) It is recommended that urgent attention be given to the concepts and methods suggested by the Seminar for the evaluation of hydro-electric potentials by basins, covering national territories so far as possible;
- (b) It is recommended that a national organization be established in each country to take charge of research into and evaluations and inventories of water resources on the basis of standard methods and concepts, and that it centralize and co-ordinate existing information and initiate new research wherever necessary and, for that purpose, promote the improvement of hydrological and hydrometeorological systems.
- (c) It is recommended that the United Nations actively continue its cooperation with the Governments of Latin America through the ECLA/BTAO/WMO group in studying water resources and their present and future utilization, and that they include, if so requested by the respective Governments, a co-ordinated and uniform analysis of background information on international water resources, with a view to their joint and full utilization, availing themselves, where necessary, of Joint International Commissions;
- (d) It is recommended that the ECLA secretariat centralize the information on the evaluation of hydro-electric potentials submitted by the various Governments with a view to its publication in due course, and that, continuing its initiative of regulating and intensifying the study of Latin American water resources and planning their utilization in the area, it duly convene special meetings, in order to promote the optimum and rational use of water on an ever-growing scale.



VI

NUCLEAR POWER AND ITS POSSIBILITIES IN LATIN AMERICA

1. Presentation of the topic

(a) Types of nuclear reactors for power production. Cost of investment and of nuclear fuels

(i) Types of reactors

415. The nuclear reactors in operation, under construction or in process of investigation can be divided into three categories.

Category 1: Power reactors sufficiently developed for industrial use

416. This group comprises heterogeneous uranium-graphite reactors cooled by pressurized water (boiling and non-boiling). A number of industrial nuclear power stations using reactors of these types are operating in countries with advanced nuclear energy industries and are being built or planned in many other countries. Their technology incorporates the wide experience gained in the use of water and gases as coolants accumulated in conventional power engineering practice. Their technical equipment is produced on an industrial scale. They are less complex to service and maintain than reactors of other types.

Category 2: Technically promising power reactors, experience on the industrial use of which will be available shortly

417. This group comprises organic moderated and cooled and heavy water power reactors. These reactors are technically and economically promising for industrial use. However, work on them is at a semi-experimental, semi-industrial stage and has not yet advanced far enough to yield concrete conclusions regarding prospects for their use in less developed countries. No experience on their industrial use is yet available. But a number of nuclear power stations embodying reactors of these types are under construction, and the necessary technical and operational experience will therefore be obtained shortly.

/Category 3:

Category 3: Reactors which cannot, now or in the immediate future, be recommended for industrial use in less developed countries

418. They include aqueous homogeneous, liquid-fuel, liquid-metal coolant, pebble-bed and fast neutron reactors. They have been grouped together here because of their technical complexity and the lack of data on their operation.

419. Fast reactors occupy a special position owing to the excellent prospects they offer in the long-term planning of atomic power development. However, owing to inadequate operational experience, technical difficulties, and the high cost of their fuel charge, they must be excluded from the list of types which can be used during the initial stage of atomic power engineering in less developed areas. They become attractive when enough plutonium has been accumulated in thermal reactors to make possible a large-scale regeneration of nuclear fuel and fuller utilization of natural supplies of nuclear raw materials.

(ii) Investment costs

420. If the main components of a present nuclear power station are considered separately, it appears that, unless comparable steam temperature and pressure conditions are achieved, the cost of turbogenerators and auxiliary power equipment must of course be higher for nuclear plants than for conventional plants of similar sizes. Building and civil works with special concrete shielding and containment structures cost substantially more for a nuclear power plant than for corresponding conventional installations; the heat transfer system and the reactor part of a nuclear power plant will cost more than the conventional steam generating equipment. It can therefore hardly be expected that the capital cost of a nuclear power plant could fall below that of a conventional station.

421. The estimates for large nuclear plants to be built in the next five years indicate that the cost per KW installed will exceed that of conventional stations of similar size by a factor of 1.5 or more, except perhaps for direct cycle reactors.

/(iii) Fuel costs

(iii) Fuel costs

422. With regard to uranium prices, the trend towards lower levels, which had been evident for several years in quotations of  $U_3O_8$  in concentrates, has now been repercutated in the new United States schedule for enriched uranium with reduction, ranging from 40 per cent for natural uranium to 20 per cent for highly enriched ore.

423. In a recent United States study, it was found that the prices for enriched uranium were free of any element of subsidy and attention was drawn to the fact that the present capacity of the United States diffusion plants alone appears sufficient to meet the requirements of inventory and burn-up of a 40 000 MWe capacity. Consequently, there appeared to be no grounds for increases in the cost of natural or enriched uranium in the near and medium term future.

424. With regard to natural-uranium systems, although the mining of ores and production of concentrates are relatively simple processes, they involve considerable investment. Similarly the production of uranium metal of nuclear purity in small amounts is quite feasible, but the fabrication of fuel elements for use at high temperature is a very difficult undertaking. The unit investment cost of a processing plant for irradiated fuel elements increases substantially for smaller throughputs, and a plant of this kind would hardly be economic unless a very substantial nuclear power programme were contemplated on a national or regional basis. Finally, the cost of an enrichment plant running into several hundred million dollars clearly rules out this type of development for any country taking its initial steps towards the utilization of nuclear power.

(b) Operating and maintenance costs

425. As yet there is still insufficient information on the operating and maintenance cost of a nuclear power station used solely for the production of electricity, although estimates have been made by analogy with conventional stations or by inspection of nuclear station designs. For example, it is still uncertain what staff is required.

/426. Reductions

426. Reductions in operating staff, increased automation and lower repair bills are a likely expectation and, together with greater experience in safety requirements, will all contribute to lower operating and maintenance costs. Considering, however, that this item represents less than 10 per cent of the total nuclear power costs, even a 20 per cent saving in operating and maintenance costs would imply only a two per cent over-all saving.

(c) The International Atomic Energy Agency

427. The cooperation extended by the International Atomic Energy Agency to member countries can be summarized as follows:

- (i) Dissemination of technical and cost information;
- (ii) Methodological studies of generation costs determination;
- (iii) Specific case studies of nuclear power prospects for individual countries;
- (iv) Assistance in training.

(d) Nuclear power prospects in Latin America

428. In the light of the present cost characteristics of nuclear power reactors characterized by sharply increasing unit investment cost for sizes below the 100 - 150 MW range, it was recognized that power reactors could only be considered for

- (i) large inter-connected systems of 1 000 MW capacity or more in which relatively large thermal plants are required for base load duty;
- (ii) somewhat smaller systems serving industrial complexes situated in areas devoid of hydro resources and dependent upon fossil fuel with high transport costs.

429. The Sao Paulo - Rio de Janeiro region in Brazil and the Buenos Aires seaboard area in Argentina appear to fall in the first category, while the northern zone of Chile belongs to the second group.



2. Discussion of the topic

(a) Types of nuclear reactors for energy production. Costs of investment and of nuclear fuels

(i) Types of reactors

430. The Committee began by reviewing power reactor systems from the standpoint of a country considering its first nuclear power plant.

431. It was felt that the reactors in categories 1 and 2 were basically similar in their technical and economic aspects. Consequently, when exploring the technical possibilities of using a nuclear reactor in an under-developed country, careful consideration ought to be given to both categories.

432. On the other hand, before the economic superiority of the reactors in category 3 over those in categories 1 and 2 could be established, a considerable financial outlay had to be made in experiments and tests on an industrial scale.

(ii) Investment costs for power reactors

433. For the coming years, there was a promise of a reduction in the costs of the items referred to in the paragraphs of the presentation. Conservative containment structures which represented a substantial part of the civil works at present considered necessary might progressively be reduced or entirely eliminated. Simpler pumps and more conventional piping materials would bring down some of the coolant circuit costs, while structural materials in the reactor proper should become cheaper through improvements in manufacturing methods. Higher power densities should also bring a significant reduction in the cost of the reactor's initial fuel charge.

434. No general answer could be given to the question of whether the figure of 1.5 indicated as cost relation between a conventional power station and a large nuclear plant would be different for less-developed countries. The lower wages for unskilled labour would make for lower construction costs, but the higher salaries of foreign technicians required

/for construction

for construction and start-up would substantially offset that advantage. The possible lower prices of some of the domestically produced materials would have to be balanced against the transport charges for the main plant components and the cost of the larger stock of spare parts that would be required. The degree of industrialization of the country would condition possible further savings, but the general conclusion would seem to be that nuclear power plant construction costs in a less-developed country were not likely to be lower than in the country of manufacture. To a large extent those considerations also applied to conventional thermal stations, where experience showed that costs were generally higher than in the countries from which the equipment had been imported.

(iii) Fuel costs

435. The Seminar recognized that the promise of nuclear power lay essentially in its low fuel costs. In that connexion, the promising present picture was expected to improve further.

(b) Operating and maintenance costs

436. The Seminar noted also the constant improvement in the amount of heat extracted per weight unit of fuel before it had to be reprocessed and the expected persistence of that trend in most reactor systems.

437. In addition it was felt that the present trend towards lower fabrication costs which represented a substantial part of total fuel costs was due to continue. Mass production of fuel elements and the end of rapid amortization of semi-experimental facilities for their fabrication heralded further savings in this field.

438. The Seminar consequently concluded that fuel costs which for a large power reactor would, at present, range between 1.2 and 3 mills per KWH depending on the system selected, were likely to drop further over the next decade and would in any case not rise from their present levels.

439. The problems of accurately estimating nuclear power costs were considered in some detail. While the question of the economics of a nuclear power plant within a system was left to Committee III, the problem

/of accurately

of accurately allocating nuclear fuel expenditures was debated and the suitability of the "present worth" method emphasized whenever complex fuel cycles occurred or variations of technical and economic parameters over the life of the reactor could be accurately anticipated.

(c) The International Atomic Energy Agency. Problems of disseminating information

440. The participants were informed in detail of the possibilities of cooperation which might be afforded by the International Atomic Energy Agency.

441. The Seminar felt that the extreme rapidity of changes in the technical and cost characteristics of reactor systems made it especially necessary to keep a constant check on the latest developments in the power reactor field.

(d) Nuclear energy prospects in Latin America

442. The Seminar had neither the time nor the intention of proceeding to make a detailed analysis of the different possibilities in Latin America.

443. In the case of Brazil, the present status of the Mambucaba project was not described to the Seminar and it appeared therefore difficult to pursue the problem further. In the case of Argentina, while all technical conditions appeared to be fulfilled for the consideration of a nuclear power reactor in the Buenos Aires area, with a present power demand of 1,300 MW due to grow to 3,000 MW by 1970, the economic comparison would hinge on the value to be attached to fuel oil or natural gas which, considering the present development plans of the country, would appear to be in surplus from 1964 onwards.

444. Finally, the case of the northern area of Chile appeared to offer an interesting possibility for a relatively small (50MW) reactor. Provided inter-connexion was achieved between the plants serving the copper mines, the refineries and the neighbouring cities there would appear to be a good economic case even on the basis of the preliminary computations which were based on prices for enriched uranium prior to the recent decrease. A further technical and economic inquiry to ascertain the possibility of

/allocating to

allocating to a single reactor more than 25 per cent of the total capacity of the area and to consider the foreign exchange costs of both solutions as well as to take other national factors, such as the use of domestic coal, into account would be desirable before a clearer judgement could be formed.

### 3. Conclusions and recommendations

445. The following conclusions may be drawn from the discussion of this topic:

- (a) That, at the present moment, nuclear power offers few immediate prospects of industrial application in most of Latin America, except for a few special cases;
- (b) That it might be of interest to consider the possibility of installing a small reactor as a regional centre for training personnel for many countries of the region.

446. The Seminar also made the following recommendations:

- (a) Utilize, whenever convenient, the services of the International Atomic Energy Agency in respect of technical assistance in training, general studies of nuclear fuel costs, methodological studies and special missions to investigate nuclear energy;
- (b) Keep up to date the most recent information on nuclear reactors, paying special attention to those aspects in which the situation changes very quickly, namely, the cost of fuels in general, and the cost of small and medium units in particular;
- (c) Calculate the cost of nuclear generation on the basis of the present and anticipated costs of nuclear fuel for the purpose of establishing a scale of values, within which it may be expected that the real costs will remain during the useful life of the plant, and, in addition, employ methods of estimation which duly take into consideration future variations in the operating and cost parameters.

## VII

### ECONOMIC UTILIZATION OF FUELS

#### 1. Presentation of the topic

447. The economic implications of transforming the latent energy in fuels into electricity and the utilization of such energy for industrial processes, heating, transport, etc., have not yet been properly understood. A great deal of attention is often given to technical aspects, while no economic evaluation is made of the investment and operating costs that correspond to each level of efficiency.

448. This subject is of outstanding importance for the economy of thermo-electric plants and its study indicates that there are good prospects of improving the combined use of heat and electricity. There is an extremely wide range of fuels that could be used in a number of very different processes. In order to determine the most effective way of using these fuels, the optimal uses will have to be established in each case as well as the conditions in which they are attainable. In document ST/ECLA/CONF. 7/L.5.1 a detailed analysis is made of numerous examples of this kind for different industries and circumstances.

449. Special attention should be paid to the various non-conventional ways in which thermal energy might be generated economically, due consideration being given to derived uses, such as:

- (i) Residual fuels of little or no commercial value;
- (ii) Waste heat from industrial ovens;
- (iii) The waste energy left over from direct production of low pressure steam or hot air required by thermoelectric processes;
- (iv) The production of cold by means of the steam condensed in the turbines or the exhaust gas from them.

450. The generation of electricity cannot and should not be considered as being isolated from energy as a whole. Electricity generation for public utilities and industry should be closely linked to the use of heat at different levels.

/451. This is

451. This is the only way in which it will be possible to determine in each case what types of fuel should be used to generate the electricity and heat required and how and in what proportions they should be used. The resulting information will provide valuable guide-lines for deciding on the use to be made of available resources.
452. Reference has already been made in other Committees of this Seminar to the way in which economic policy decisions are distorted by the irrationality and instability of prices for the different forms of energy.
453. The use of combination cycles for the generation of electricity and heat in public power stations shows that interest is taken in the discovery of solutions that would enable the available fuels to be used more efficiently.
454. The production of cold by the absorption method, in its different manifestations, offers great possibilities of putting to good use the latent heat in steam, which is otherwise lost in the circulating water in the condensers or in the cooling jacket water.
455. It should be pointed out that the back-pressure and condensing turbine with centre intake is only one of the most widely-used mechanisms for the rationalization of energy generation, but many other practical and economic solutions also exist whose prospects have widened in the last few years with the development of gas and hot air turbines.
456. The valuation of the electric energy that the industry is able to deliver to the public utility network presents serious problems, and sufficiently equitable types of agreement that would lead to a more intensive development of this possibility have not yet been worked out.
457. It is very important that energy should not be used at higher thermal levels than those strictly required by the nature of the heating process, a rule which is frequently disregarded to the consequent serious squandering of resources.
458. Sufficient experience has been acquired in various European countries and even in the Latin American countries themselves with respect to the different forms and methods used for these problems to be solved. It is evident, however, that there is a need for communication among experts

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so that the fruits of this experience could be put to better use, as well as for national regulations and collaboration between technical experts and enterprises. A rational and co-operative approach to the whole complex of problems would be highly beneficial, both economically and financially.

2. Discussion of the topic

(a) Economic impact of power rationalization

459. The economic advantages offered by power rationalization were considered and it was agreed in the Seminar that rationalization involved the coordination of the efforts of all the sectors concerned, in order to satisfy their power needs with a minimum consumption of fuels and financial outlay.

460. In order to extract the maximum benefit, the need to co-ordinate the utilization of fuels in the electric power and industrial sectors to the full was pointed out.

461. In view of the existing discrepancies with respect to a common unit for expressing electric and thermal power, it was suggested that a standard criterion should be adopted by converting electricity into mechanical work measurable in kilo Joules (kJ). The various concepts of output were examined in order to clarify their different meanings in the case of conversion into electricity, on the one hand, and into industrial heat, on the other.

462. Taking into account the capacity of the electric plants and of demand for the next few years, the indiscriminate utilization of the solutions applied in the more developed countries was not considered desirable, since the lower specific consumption, in itself, did not assure the maximum economicity or the rational basis of a solution. In that connexion, it was pointed out that the power of many of the plants to be built within the next few years in Latin America, would require capacities of some 30-60 MW. In order to achieve that it was not in general economically desirable to proceed to more advanced thermal conditions.

/(b) Economic

(b) Economic comparison of electricity generation in public power-plants with the combined production of steam.

463. The important economies arising from the second alternative with respect to the first, were shown in concrete examples, pointing out that savings in fuel as high as 20 to 35 per cent and in the annual costs of operation from 12 to 24 per cent, might be achieved according to the hours of operation and the interest rates adopted for the comparison.

464. It was considered that for a better appreciation of the relative advantages, the total annual costs of each solution should be compared by using methods such as the present value system.

465. Factors such as amortization, interest rates, fuel prices and hours of use incorporated as constants in the estimate were variables, especially if the periods of comparison were long. In that connexion, a very useful formula was considered to be one which allowed the determination of payback periods of additional investments in relation to the savings produced in fuel.

466. It was pointed out that the payback periods adopted in general by an industrial power-plant, rarely exceeded five years and often were not more than two or three years, compared with the much longer periods adopted by public power-plants. Such rapid amortization distorts a sound comparison and might produce solutions which would not be economical for the community.

(c) Power linkage: development and possibilities

467. If the use of a back-pressure turbine for generating electricity and heat was the solution most commonly adopted so far, that was only one of many possible solutions.

468. It was pointed out that in order to choose the most suitable solution, it was important to know the electric power and industrial heat load curves within each industry over the proposed period of use. A fact to be borne in mind for that calculation was the relative decrease of steam consumption and the relative increase of the need for electric power caused by the evolution of the industrial processes.

/469. Several



469. Several cases of linkage at various levels were examined and it was concluded that the savings which could be effected were so substantial as to constitute an additional source of funds for increasing the capacity of public power-plants, which would clearly be of benefit to other consumer sectors.

470. Linkage within a public power plant itself was also shown to be a way of improving the use of gas fuels in cycles with combined gas and steam turbines. That would reduce unit investment cost by 4 or 5 per cent and, at the same time, increase specific consumption by 7 per cent. Resources were thus made available equivalent to an addition of 6 to 11 per cent to installed capacity if the saving was capitalized over a five year period.

471. A method not yet used in Latin America was the expansion of natural gas before its combustion. Europe could already offer a number of interesting examples of that method. It was also pointed out that the production of cold simultaneously with the generation of electricity with low level heat was a good solution for some of Latin America's specific requirements.

472. Throughout the discussion, reference was repeatedly made to the need for criteria and methodology for evaluating the qualities of fuels in relation to their best specific use. For that purpose, more was needed than data on calorific power and market price.

473. Similarly, it was pointed out that insufficient attention had been paid to methods for improving the use of industrial fuel residues, in spite of the fact that they constituted an important source of funds in Latin America.

474. With respect to the relationship between the characteristics of various thermal mechanisms and the processes of industrial production, the participants discussed a number of practical cases and called attention to the need to bring them into line with the characteristics of the industries themselves with a view to achieving greater operating efficiency.

(d) Factors of rationalization

475. Also discussed were the methods followed by such enterprises as TVA in their interconnexions, based on mutual benefits and corresponding savings of power. Reference was made to topics dealt with more extensively in Committee III and valuable experiences relating to the parallel operation of public and industrial electric systems were presented.

476. The discussion of these points included the lack of adequate training of sufficient technical personnel as an obstacle in the installation of more efficient equipment.

477. With respect to external factors, the conditions of availability and prices of fuel in the different countries were discussed. The importance of rates in the selection of alternatives and the possibility of reviewing certain industrial rates, based on the principle of rational use of power, were pointed out.

(e) Methods of allocating the cost of electric power and industrial heat.

478. The influence which the methods used to allocate the cost of the power under consideration might have on the nature of the solutions to be adopted was examined. The methods used were found to exert a powerful influence. The generation of electricity combined with industrial heat might or might not be encouraged, depending on the method resorted to. Artificial results might also be produced, particularly if the process required a great deal of steam.

479. The exergetic method was recommended as the most equitable for evaluating electric power as well as industrial heat in simultaneous generation or for deciding upon the design of a new plant.

(f) Means of promoting and organizing the rational use of energy

480. The advantages to be derived from the adoption of uniform standards and terminology in the area, as well as a more active exchange of experiences and publications, were discussed. To that end, it was suggested that each country should set up an agency responsible for the co-ordinated promotion of the rational use of energy.

481. The fact was emphasized that every sector of the economy, whether public or private, producer or consumer, should take part in the task of rationalization. Reference was made to some cases, such as that of Argentina, where an agency for that purpose had been set up and had provided valuable experience.

482. Similar European and American agencies might be requested to co-operate in that work, which might be undertaken under ECLA's auspices with financial assistance from the United Nations organs concerned.

### 3. Conclusions and recommendations

483. The following conclusions might be drawn from the discussion of this topic in the Seminar:

- (a) The need to rationalize the use of fuels and to increase its efficiency is obvious.
- (b) Close co-ordination between public and self-generating electricity plants can result in substantial savings.
- (c) Important fuel savings can often be obtained in industry through small-scale investments, recoverable over short periods.
- (d) The compilation of uniform statistics throughout Latin America, with respect to both primary and derived energy, including intermediate and final use, is desirable.

484. The foregoing considerations and the results of its discussions prompted the Seminar to make the following recommendations:

- (a) More emphasis should be placed on the dissemination of technical and economic data and experiences on rational and efficient use of energy, as well as on the standardization of nomenclature and basic concepts. Each country should investigate the possibility of setting up agencies for that purpose.
- (b) ECLA should be requested, providing several countries express interest in these questions, to convene a special meeting for the purpose of exchanging views on the organization of this type of work on a Latin American scale, possibly through an internationally-financed regional agency.



VIII

ELECTRICAL EQUIPMENT INDUSTRY IN LATIN AMERICA

1. Presentation of the topic

485. It was not possible to obtain the minimum necessary antecedents to establish in authentic form the present status of the industry engaged in the manufacture of generating, transmission and distribution of electric power equipment in Latin America. The extensive questionnaires which were sent well in advance to the countries to be used as examples of this situation - Argentina, Brazil, Chile and Mexico - did not produce the expected results in time to be included by the consultants in document ST/ECLA/CONF.7/L.6.1.

486. Apparently the various industries - some of them small or average sized - do not have the necessary personnel or information to provide, by means of questionnaires, the extensive data required of them. Also, a certain amount of suspicion exists in Latin America, due to the tight competition resulting from a limited market, and there is some concern lest the data provided might be used in unethical competition.

487. The very incomplete results achieved are an excellent object lesson for future action in this field which, it is felt, must be taken. It is essential that such studies should be made by experts sent to the various countries to interview the executives of each industry personally in order to investigate and acquire the data requested in the questionnaires. The effectiveness of this method is underlined by the example of Mexico, where it has been adopted with very encouraging results.

(a) Importance of local manufacture of electrical equipment

488. From the studies presented to the Seminar, there is an obvious desire to analyse, as quantitatively as possible, the importance of the value of electrical equipment in the total amount of investment necessary for the realization of an electrification programme of a Latin American

/country. In

country. In other sections of this report, the antecedents related to the total investment required and possible sources of financing have been analysed. There still remains to be studied what part of these investments are a product of the utilization of manpower, materials or national services. A country in the initial stages of industrial development must import a large part of what it needs for electrification thus depriving itself of one of the important factors of the over-all benefit to be derived therefrom. It must therefore confront the problem of the external supply of the elements required for the production and use of electricity. (See document ST/ECLA/CONF.7/L.6.1.)

489. This topic refers specifically to the requirements of equipment and material for the generation, transmission and distribution of electricity but not for its use. However, it should be emphasized that the initial expense in the acquisition of capital and consumer goods for the use of electricity is much greater than the investment of capital for its generation and distribution (the ratio being 6 to 1). It is therefore essential to consider the problem deriving from the manufacture of appliances and equipment necessary for the use of electric power.

490. Total investment requirements must first be ascertained and then that part of the requirements representing goods manufactured locally or likely to be manufactured in the future. In this respect, it should be pointed out that the figures in document ST/ECLA/CONF.7/L.6.3 indicate that total per capita investment will have to be as high as 55 dollars by 1965 and 64 dollars by 1970.

491. In document ST/ECLA/CONF.7/L.6.1 there is an estimate - in what is referred to as average cost - of 62.5 dollars for thermal generation and 71.5 dollars for hydro-electric generation figures which are fairly in line with the estimates appearing in the document mentioned in the previous paragraph.

492. Document ST/ECLA/CONF.7/L.1.11 assumes a required investment of 407 dollars per installed kW which, at the per capita rate of 0.1 kW, results in a per capita figure of 40.7 dollars. The discrepancy between these and the previous figures is chiefly due to the distribution sector, which is usually under-estimated in Latin American electricity expansion plans. The part of the total investment to be spent within the country and what the part relating to imported equipment, material and services may vary considerably. It depends upon the country's degree of industrial development, the type of installations to be effected, etc.

493. Analysis of the many specific cases in Latin America, based on similar projects in several countries, shows (document ST/ECLA/CONF.7/L.6.1) that incidence is highest in some instances of thermal generation and distribution, in which the foreign exchange share may be as much as 80 per cent of the total investment. It is lowest (only 20 per cent) for some cases of hydro-electric generation.

494. The foregoing is readily explained by the fact that, within the progressive development of the capital goods industries, the first to develop were those related to construction, thus providing a domestic supply of materials used in the civil engineering works of the hydro-electric projects. These same projects usually require transmission lines using structural materials and conductors manufactured in industries established after those manufacturing construction materials.

495. Combining all the factors - annual growth of installations, foreign currency share, etc. - a very general annual per capita figure for total requirements would be up to 3 dollars, which would be needed today to purchase abroad the material required for carrying out an electrification plan in a Latin American country where average conditions prevail. Based on the present population of Latin America, the investment required would amount to about 550 million dollars a year. This is obviously a large sum which, over the years, will increase at the same rate as that of the demand for electricity.

(b) Prospects

496. The action to be taken in dealing with this problem will depend on a variety of circumstances. Naturally, the path chosen by Brazil, as outlined in document ST/ECLA/CONF.7/L.6.2, should not be followed by a country with a population only one-tenth or one-twentieth the size of the Brazilian population, or where the chief activity is agriculture rather than industry or mining.

497. Moreover, current conditions do not necessarily reflect what might happen upon entry into full force of the provisions deriving from the agreements of the Latin American Free-Trade Area under which countries where conditions for the economic production of equipment are more favourable can export to areas where such conditions do not prevail.

498. From the survey made in the countries already mentioned, it may be deduced that their national industries are better prepared for the local manufacture of the following items in the order in which they are listed:

- (i) materials mainly required for civil engineering works;
- (ii) structural materials, mainly for transmission lines;
- (iii) electric conductors of different types;
- (iv) distribution transformers;
- (v) other equipment for distribution systems;
- (vi) light iron work in general;
- (vii) control boards and switchboards with some of their component parts;
- (viii) heavy electrical equipment in general.

499. Some countries have extensively developed the manufacture of diesel motors and generators. However, these have been deliberately omitted from the above list because it is believed that their importance as an industry related to the generation of electricity, will diminish as interconnected systems progressively eliminate isolated plants in which diesel equipment is used.



500. Another characteristic observed in the survey, applicable particularly to Chile and possibly to other countries of the area, is the existence of many small industries which compete with one another in supplying a relatively reduced market.

501. In the countries analysed it is also noted that the facilities of other industries to act as sub-suppliers of some specialized items are scarcely used.

502. Chile's experience with respect to the manufacture of distribution transformers is very encouraging as it has drastically reduced costs through the following basic measures:

- (i) standardizing and simplifying designs so as to adapt them to the limitations of domestic industry;
- (ii) making ample use of the facilities of the sub-suppliers so that factories for the manufacture of transformers are essentially assembly plants, manufacturing only basic parts.

503. The above notes lead to the conclusion that a much broader industrial survey is needed than the one already undertaken, a survey not confined to the electric industry alone but extended to all well-established industries capable of producing the elements needed for the electric industry.

504. The development of heavy industry such as that planned by Brazil, with the technological assistance of the industrial enterprise of developed countries is being justified more and more in other countries in line with the exponential growth of demand. A similar situation already exists in Argentina and Mexico where the manufacture of equipment has progressed appreciably.

505. It is hoped that the effect of the provisions deriving from the agreements of the Latin American Free-Trade Area will enable each country, depending upon the conditions extant, to specialize in such fields as the supply of raw materials, local labour, etc. All this would contribute to a larger volume of production and, consequently, to a reduction in costs.

## 2. Discussion of the topic

### (a) Importance of local manufacture of electric material

506. The figures given in the different papers presented to the Seminar and relating to the investments required for electrification were analysed first. The differences in estimates of investment in dollars per capita between documents ST/ECLA/CONF.7/L.6.1 and ST/ECLA/CONF.7/L.6.2, on the one hand, and ST/ECLA/CONF.7/L.1.11, on the other, were attributed mainly to the estimates made to evaluate the investments in distribution. The costs estimated in the last-mentioned paper were based on national development plans and the characteristics of existing installations, which were generally overloaded and corresponded to equipment acquired abroad, which was usually less expensive. On the other hand, the estimates in the first two papers presupposed a distribution system well supplied with domestically manufactured equipment.

507. In general, it was considered that the annual per capita investment figure of 3 dollars was a first over-all approximation still subject to correction by the ratio between the per capita power actually installed and the assumption of 0.1 kW used in determining the above figure. Naturally, some countries of the area were in a position to make more specific direct studies of their own particular case.

### (b) Prospects

508. The question was raised of the desirability of an industrial policy protecting local industry which, while allowing it to develop would at the same time maintain the incentive of foreign competition for its continued improvement. In that connexion, it was felt that an attempt should be made to manufacture the elements needed for electrification to the greatest possible extent compatible with the industrial development of the country since that would lead to savings in foreign exchange, less dependence upon the foreign market, increased technical capacity of personnel, technological improvement of the domestic industry and greater facility in standardizing and obtaining spare parts.

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509. In any case, the participants agreed that there was a considerable demand for equipment capable of being produced locally in the different Latin American countries, and that demand would already exceed production capacity were it not for various negative factors outlined below.

510. It was explained that foreign manufacturers could offer deferred payment facilities of up to 10 years at a 6 or 7 per cent annual rate of interest; domestic industries, on the other hand, were unable to find banks prepared to participate in financing of that type.

511. In that connexion, an institution purchasing equipment might be faced with two possible situations. In one case, international credit facilities, usually more generous than, and thus preferable to, those offered by the suppliers, would be available. In the other case, international credit facilities would not be available and recourse would have to be had to the facilities offered by the supplier.

512. After discussing the problem with the representative of the Inter-American Development Bank and with the various participants, the Seminar considered three possible remedies:

- (a) Enterprises should request the international credit agencies to include in their loans financing for the purchase of domestic materials and equipment. It was proposed that the agencies concerned should grant the enterprises a credit consisting of two parts: one for purchases abroad and the other for local purchases. Enterprises would thus be encouraged to make full use of local currency credit and would not be able to transfer local currency credit to foreign currency credit, since the latter would be lost if not used.<sup>35/</sup>

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<sup>35/</sup> The subject was also widely discussed in Committee III.

- (b) The establishment of a national fund or medium-term domestic credit should be secured for the purchase of capital goods needed for the development of the domestic electric industry or for the export of such goods to other countries.
- (c) The creation should be proposed of a common fund among the countries comprising each of the two areas of Latin American free trade for the export of capital goods on credit within the countries in each of the two areas. That would be an organization similar to those already set up in Europe.

513. Those formulas would enable domestic industry to be placed on an equal footing with foreign suppliers. The funds suggested in points (b) and (c) above could be financed by means of credit made available by an international agency.

514. In addition to that negative factor - lack of financing - three other difficulties were analysed, the most important being the rates of taxation imposed on national industry and the high freight charges for exports from one Latin American country to another.

515. It was proposed, in that connexion, to place on record the fact that the high rates of taxation on domestic production - in Mexico, for example, they amounted to a 20 to 25 per cent surcharge over cost - impeded the development of local industry in the face of foreign competition. When the agreements of the Latin American Free-Trade Area entered fully into force the negative effect which the present high freight charges had on exchange of products within the countries of Latin America would be felt. The force of those two factors should be diminished by a future development policy on the part of governments.

516. An exchange of views was held on the advantages to be derived by the Latin American countries from the gradual adoption of a joint plan for standardization of equipment for the purpose of lowering domestic production costs through an increase in the volume of similar equipment. Such standardization would take into account the characteristics of demand in the Latin American market and the procedures and limitations of the national industry attempting to obtain simple designs which would promote the use of local raw materials and the training of skilled

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labour. That did not mean that quality standards should be lowered.

The present standards required by enterprises would be maintained.

517. In discussing the advantages and drawbacks of nationalization of the electric power generating industry in Latin America, it was pointed out that State agencies could better study the problems of local manufacture of equipment, since they would analyse them from a national instead of a strictly commercial and immediate point of view. Promotion of the development of the electric material industries was a specific instance in which State enterprises would achieve highly favourable results. It was therefore felt that it remained for those enterprises to establish criteria for the selection of purchases which would favour - even at greater expense - the purchase of domestic equipment, through a volume of purchases which would warrant financing expansion of the industry. All those measures would tend to stabilize production of domestic equipment. In that connexion, the desirability of the establishment of long-term purchasing programmes by enterprises was stressed.

518. The Seminar considered that in order to embark upon a policy aimed at development of the electric equipment and materials industry in Latin America, the most complete register possible of all the industrial facilities now available in those countries, and knowledge of their future plans, were essential.

519. The compiling of data through questionnaires - as had been done in preparing the present Seminar, was insufficient. The Seminar felt that each country should have a group of experts responsible for collecting the data through interviews and other direct methods. Once the national or regional group was set up, it should keep the information required by the register up to date.

520. In view of the considerable expense involved, the representative of the Inter-American Development Bank pointed out that if a fully-documented plan on establishing such a register were submitted, the Bank might favourably consider financing it.

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521. The Seminar believed that preparation of a plan of that kind should be entrusted to an international agency such as ECLA and, in any case, should be co-ordinated with other agencies working on problems similar to those discussed at the Seminar, in order to avoid duplication or obstruction of the work to be done.

522. It was essential that the national expert committees should include representatives of electric power enterprises and of manufacturers. With the committees working simultaneously in the different countries, the register could be established in a short time. However, the committees should be set up on a permanent basis in order to keep the information which would be published regularly, up to date.

523. Should such a register be available, a primary objective would be the formulation of an intelligent policy of co-ordinating the development of the industry in Latin America, aimed at avoiding duplication of installations or competition harmful to that development. A second objective would be to provide both industrialists and power enterprises with guidance on the policy to apply with respect to increased production of and demand for those materials.

524. It would also be useful to governments in establishing a policy on production of raw materials, use of manpower, etc.

525. Finally, it should be pointed out that for the benefit of the participants concerned with the topic, some experts from Argentina, Brazil, Chile and Mexico described present conditions and future plans in their respective countries with respect to the industry engaged in the manufacture of materials and equipment for the generation, transmission and distribution of electric power.

### 3. Conclusions and recommendations

526. The following conclusions were drawn from the documents submitted to the Seminar in connexion with this topic and from the discussions at the meetings:

/(a) In

- (a) In view of the sizable share of capital goods payable in foreign currency within the total investment required for electrification in Latin America, it is essential to develop domestic industries manufacturing electric equipment and materials, consistent with the economic conditions and means of each country;
- (b) There is an urgent need for a general register of the industry producing materials and equipment for the generation, transmission and distribution of electric power, and of all related industries, to serve as a basis for the rational planning of the development of these industries in Latin America;
- (c) At the present time there is not stable demand for domestically-manufactured electric equipment, an indispensable requisite for the development of the industry;
- (d) Domestic suppliers of electric equipment are in an unfavourable position as compared to foreign suppliers owing to the lack of long-term credit;
- (e) Implementation of the Latin American Free-Trade Area agreements provides an opportunity for specialization and expansion of specific sectors in the manufacture of electric equipment and materials in Latin America.

527. The Seminar makes the following recommendations in accordance with the above conclusions and the results of the discussions on this topic:

- (a) That a general register of the industry manufacturing electric materials and of supplementary industries should be established by experts in each country who would keep up to date the information required for periodic publication, and that efforts should be made to have the study financed by the Inter-American Development Bank. In these studies of an international character, duplication of work by different agencies should be avoided;
- (b) That the above study should be supplemented by a thorough investigation of the manufacture of appliances and equipment for the use of electricity;

/(c) That

- (c) That electricity firms should present to the manufacturers their plans for the purchase of electrical equipment sufficiently in advance to enable them to plan the development of their industries;
- (d) That encouragement should be given to international and national financing for the purchase of domestically-manufactured equipment in each country and for its possible export within Latin America.



IX

LEGAL AND INSTITUTIONAL PROBLEMS OF THE  
ELECTRIC INDUSTRY IN LATIN AMERICA

528. The discussion of this point on the agenda was held in a relatively small group of participants. This led to a livelier discussion than would have been possible in committees with a larger attendance. For this reason the systematic approach to the other topics in the Seminar was dispensed with and the most interesting points of this topic were discussed directly. It is also noteworthy that the legal aspects of some of these points - legislation governing the electric sector, regulation of tariffs, mechanisms of automatic compensatory adjustments, effects of inflation, instruments for channeling private investment toward electric financing - are discussed elsewhere in this report<sup>36/</sup> and it would therefore have been pointless to repeat them.

1. Presentation and discussion of the topic

529. With reference to the problem of ownership of electric enterprises, the Seminar agreed that each country would have to deal with it individually and that it did not call for analysis on a general basis or the formulation of recommendations.

530. As a point of information - and bearing in mind the novelty of the experience and its possible application to other countries as a means of co-existence and co-ordination between the public sector and private enterprise in the field of electricity - some experiences of joint ownership in Brazil were recalled, particularly the establishment of the Central Elétrica de Furnas, S.A., which is building the hydroelectric power plant of the same name with an installed capacity of 1.2 million kW. The company was formed by the Federal Government, the States of Minas Gerais and São Paulo,<sup>37/</sup> and two private enterprises.

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<sup>36/</sup> See above, particularly paragraphs 124 et seq.

<sup>37/</sup> Through Centrais Elétricas de Minas Gerais (CEMIG) and an autonomous agency called the Departamento de Aguas y Energía Eléctrica.

with a majority of foreign capital. The voting stock was fully owned by the Federal and State governments and by the organizations of the public sector, while the participation of the private enterprises was in the form of preferred stock, although they were also members of the company's Board of Directors.

531. With respect to Brazil, reference was also made to the recent law establishing ELETROBRAS, a federally-owned corporation, which would have three main functions: (i) the production of electric power in less developed areas; (ii) the creation of subsidiary companies intended to acquire autonomy of operation; (iii) participation in existing electric enterprises through ownership of shares in and the granting of loans to those enterprises. The company will take over the administration of the National Electrification Fund, which has so far been the responsibility of the National Bank for Economic Development.

532. Another jointly-owned company financed by public and private capital is SEGBA in Argentina. However, unlike the Brazilian enterprise mentioned above, private enterprise has supplied most of the capital and is not limited to non-voting stock.

533. Costa Rica was also mentioned as a case where government and private enterprise had established a harmonious relationship. Both were subject to control by an agency in charge of regulating electric development and fixing rates.

534. With respect to the regulation of electric energy and the machinery for fixing rates, discussion centred on the effect of cost inflation on the real level of these rates, both with regard to the effects of the legal system itself<sup>38/</sup> and the inertia of the regulating body. In connexion with the latter, it was pointed out that the time transpiring between the actual rise in the electric enterprise's costs and the regulating body's decision to grant the respective rate increase, had tended to cause financial disequilibrium which might well have a major impact.

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<sup>38/</sup> For example, where the historic cost is used to determine the "investment base" on which the coefficient of profitability is based.

535. Various cases of legislation in Latin America were examined with respect to the degree of automaticity of compensatory mechanisms and the periodicity of the readjustments. Some participants pointed out the incompatibility which sometimes arose between the high quality of the mechanism of compensatory adjustments - measured by its degree of automaticity - and the efficiency of the productive process. If the entrepreneur is absolutely certain that the rates will always cover his costs and provide him with the margin of profit fixed by law, there will not be much inducement for him to improve efficiency or to resist the unwarranted salary increases requested by the unions. This tends to create privileged sectors of workers who are paid more than the average in other branches of the economy, the result being that labour constitutes a disproportionate percentage of the total cost of the kWh.

536. Under the topic of rate-fixing, the possibility was examined of establishing legal machinery which would serve as incentives for increasing productivity in the sector. For example, in a predominantly thermal generating system, the entrepreneur's profit margin might be established as a function of the specific consumption of fuel per generated kWh in such a way that the former increases when the latter diminishes within certain margins pre-established for both. It was recalled that this system has been tried in some cases in the United States.

537. With respect to the problems of hydro-electric use and inter-connexions of international systems, there was agreement on the importance of closer contact between the electric enterprises and agencies in the various countries and on the desirability of taking advantage of the experience gained in Europe and United States. The need was also emphasized of establishing realistic criteria for financing international projects, particularly when they were jointly carried out by countries of widely varying economic capacity which were therefore not in the same position as far as paying for the investment and absorbing the power produced were concerned.

538. Mention was also made of the desirability of co-ordinating energy and electricity policies as an instrument of international co-operation leading to greater economic integration and, consequently, to better use of the available resources in the region.

539. The Seminar examined the legal problems relating to the relationship between enterprises supplying electric service, on the one hand, and the central and state governments and the municipalities, on the other, as well as the question of jurisdictional disputes, particularly with respect to the fixing of rates. Electricity legislation in Latin America was found to vary considerably. In Brazil, for example, the Federal Government has jurisdiction over the whole country for purposes of rate-fixing. In Argentina, on the other hand, only the local authorities can fix rates. This has created problems not only for the private enterprises which have the franchise to provide electric service but also for Agua y Energía Eléctrica, the State agency, itself. It was pointed out that Argentina proposes to amend its legislation so as to give the Federal Government full jurisdiction over the country. Under the Argentine Constitution the amendment will have to be made through a "ley de adhesión" (adherence act), which is an act adopted by the Executive and the National Congress and to which the adherence of the provinces is left to the discretion of the provincial authorities.

540. With respect to administrative and institutional arrangements for the electricity sector, the discussion centred on the advantages and drawbacks of centralizing those functions in a single agency. Administrative bureaucratization was compared with the savings to be effected from integral planning and interconnexion of systems. An intermediate formula was suggested which would maintain competition between more than one operating unit - which would have autonomy with respect to day-to-day decisions - while centralizing substantive decisions in the matter of investments, financing and the economy of the electricity sector.

541. Taking into account the results produced by its discussions, the Seminar made the following recommendations:

## 2. Recommendations

- (a) Governments should study the possibility of including in their legal machinery for regulating the electricity sector, standards which will provide an incentive to higher productivity;
- (b) The ECLA secretariat study the legal, economic and financial problems involved in hydro-electric projects and the inter-connexion of international systems in Latin America, and the possibility of applying, where suitable, the results of European experience;
- (c) Governments and the electricity enterprises should maintain a permanent exchange of information on their legal and institutional regimes relating to electricity regulation;
- (d) An international mechanism should be established for co-ordinating the power policies of the Latin American countries, in order to ensure the optimum use of available resources;
- (e) Bearing in mind the fact that it was not possible at the Seminar to complete the discussion on the topic of the institutional and administrative aspects of electric power development, ECLA should include this item in the agenda of a future meeting of experts on this subject at which ideas are exchanged.



Annex I

OPENING ADDRESSES

1

ADDRESS DELIVERED BY MR. ADOLFO DORFMAN, DIRECTOR  
OF THE ECLA ENERGY AND WATER RESOURCES PROGRAMME  
AND DIRECTOR OF THE SEMINAR

It is a signal honour for me to represent the United Nations at this opening meeting of the Latin American Electric Power Seminar and to extend my sincere thanks, on behalf of the organization to which I belong, to the Minister of Foreign Affairs, Mr. Manuel Tello, for his kind words. The Executive Secretary of the Economic Commission for Latin America, Mr. Raúl Prebisch, has instructed me to convey the following message to you:

"On the occasion of the opening of the Electric Power Seminar, I have the honour to express, on behalf of the ECLA secretariat, my gratitude for the warm welcome extended by the Mexican Government and to offer my heartfelt wishes for the successful outcome of this important meeting. The results of your discussions will clarify the ways and means required, in the matter of planning and international co-operation, to deal with energy problems which constitute a fundamental obstacle to the economic development of Latin America. I deeply regret that the obligations connected with the forthcoming conference at Punta del Este prevent me from fulfilling my earnest desire to participate in the work of the Seminar."

As we begin our work today, I wish to offer another token of gratitude on behalf of the United Nations. From the very outset, when the idea of holding the Seminar in this country and of providing the necessary facilities for it was first suggested, His Excellency the Minister of Industry and Trade, Mr. Raúl Salinas Lozano, and his closest collaborators, have played a very decisive role - for which the secretariat is deeply grateful. The arrangements were then placed in the hands of the Comisión Federal de Electricidad, which very enthusiastically undertook to carry out the necessary work. We

/owe thanks

owe thanks to its Director-General, Mr. Manuel Moreno Torres, and his efficient team not just for the magnificent hospitality which they have extended to us as "hosts", as we say in the South, but also for their fullest and most intelligent collaboration in all our work. Suffice it to say that, without their unflagging support and efforts, this Seminar could not have been held.

I would also like to express my gratitude to the officials of the Nacional Financiera, S.A. and other enterprises and institutions interested in electricity for their generous contribution and support.

Finally, I wish to extend a most cordial welcome on behalf of the secretariat and to express our gratification at seeing, present in this forum, representatives of such high technical calibre that I am convinced that our labours will fulfil all the hopes we have placed in them.

I need hardly recall that a fundamental task lies before you: that of submitting the most urgent problems encountered in the field of electricity to investigation and analysis. Their solution is basic, for it will remove the obstacles which now hamper optimum development, and this sector of the economy will thus be able to make a maximum and timely contribution to the development of our countries and towards improving the well-being of their inhabitants.

There is not the slightest doubt that, if we had to point out some of the essential factors which determine the possibilities, characteristics and pace of economic development in each country, we would find that electric power occupies a prominent place. Without plentiful electric power which can be sold at prices remunerative both for the producer and the consumer, it is impossible to establish or maintain large-scale, modern and technified industries capable of more economic production and of offering good working conditions; there can be no possibility of developing and establishing activities of a higher level in this field; there can be no organized urban living and there will be a shortage of personal /comforts. Unless



comforts. Unless extensive use is made of "mechanical and electric slaves", as represented by mechanization and electrification, it would be futile for man to attempt to fulfil his dreams of well-being or to develop his personality to the full at all levels of human society.

Hence, electricity is irrevocably and intimately integrated in economic and social life, determining and channeling it in various ways, although it is also an outcome of it. Just what are these forms, these multiple and complex relationships existing between electricity and the other aspects of economic and social life? What should be done to ascertain more accurately the characteristics of this phenomenon, and, consequently, to forecast more efficaciously its evolution and to adopt the necessary measures so that electric power development may be adjusted to these desiderata? It would be a very important advance if some useful guidance were to be provided by this Seminar, not only for those who concentrate on studying these aspects of programming, so necessary in modern activities, but also for those others who endeavour to determine and carry out the necessary measures.

Precisely because electricity is an essential factor in economic and social development, the coefficients which measure or indicate the magnitude of its consumption are very significant. You are all aware that this consumption is very small in Latin America, both in total and per capita terms. The figure is less than 400 kWh per capita in 1961, that is, several times smaller than normal consumption in Europe and much less than in the United States. The difference in stages of development is, of course, reflected in the corresponding consumption levels. But, even taking these differences into consideration, the inhabitants of Latin America could aspire to a better supply of this form of power, as shown by numerous facts which reveal the existing deficit.

A more thorough analysis shows that this coefficient is not only low, but also that its distribution is highly irregular. And this is true as between the various consumer sectors - residential, industrial and others - and, more particularly, as between the various Latin American countries, and even within each one as between the various geographical zones or regions, not to speak of urban and rural areas. In most cases, the inhabitants of our vast rural areas have no electricity at all or, at best, a very precarious supply.

Since the effects of this situation are only too well known, suffice it to recall the irreparable damage that the loss of industrial production caused by lack of electric power represents for the economies of our respective countries, either because new factories cannot be set up or because the existing ones are unable to mobilize their full output capacity, not to speak of the serious inconveniences to private and urban living caused by black-outs, rationing and shortcomings in this service.

What are the causes? To what should this low rate of consumption be attributed? That is precisely one of the cardinal points which we wish to have investigated in this Seminar because, once we have a better knowledge of the causes of this phenomenon, we can surely hope to correct these faults and steer electric development along the most suitable course.

We might find, among other causes, the lack of adequate programming or financing, problems of organization and operation, and the inadequate or inefficient use of resources. Historical experience provides a good base, a point of departure from which we may undertake this task; but these very factors we have just mentioned will also have to be considered in the light of future electric power requirements in order to establish the criteria to be recommended for action. These requirements are closely linked to the characteristics and pace of future economic and social development.

/Consumption will,

Consumption will, of course, depend on the type of industries to be installed within the period under consideration and on their scale of operation; on the process of urbanization and on the degree of electrification in rural districts. To express this in another way; since electric power development is both a cause and effect of a country's economic development, it will depend on the nature of this development. Thus, electric power development does not take place in a vacuum, and it is highly desirable to establish the functional relationship between electricity and other aspects of the economic and social life of a country in order to plan its organic growth in a more rational and efficient manner.

The importance of this type of consideration becomes even clearer if it is borne in mind that electric power consumption in Latin America will increase threefold in the next ten years and will reach a figure of some 200,000 million kWh in the last year of this period, which will necessitate a proportionately slightly smaller increase in the installed capacity of generating plant.

The task of installing an output of more than 30 million kWh in ten years, with the consequent studies, plans, selection and construction of plants, interconnections, etc., presupposes a series of interlinked operations which require careful analysis. And, obviously, the manner in which a sum equivalent to more than 12,000 million dollars - more than two-thirds of which will be in national currency of the respective countries and the remainder in foreign exchange - is to be obtained, deserves very careful consideration.

What factors are involved in determining the conditions required to make this vigorous development possible? How can the best and most efficient use be made of physical and financial resources? Which are the elements which should be analysed and determined in order to use them as a basis for reaching effective decisions in the matter of electric power development policy? How are all these factors to be interpreted and combined so that sound measures can be adopted and the

/necessary policy

necessary policy forged into a coherent whole? What are the legal and institutional forms which should be worked out in order to ensure that the policy of expanding the electricity sector is integrated rationally with over-all power policy and the general programming of economic development?

These are the points which, in my opinion, are strategic and essential, and regarding which our discussions here could prove most beneficial and useful for those officials who must make these decisions in the public and private sectors alike.

Let us take a closer look at the main elements which make up the basis for this policy in the power field and see how we may attempt to discuss them jointly here. In the first place, there is the matter of the magnitude and characteristics of demand. If we remember that this is an inseparable part of the economic process, how can it be estimated for the future, and what criteria and procedures are to be used?

Next comes the problem of the energy resources available to generate the necessary power. The combination of hydraulic, thermal, nuclear and other sources should be accurately evaluated, in absolute and relative terms, from the physical and technical and economic points of view, and in this connexion it will be useful to examine the standards, definitions and methods which you may suggest in order to achieve this objective. In view of the tremendous importance of water resources, particularly in Latin America, we hope to establish bases for the evaluation of water potentials, taking into account not only their use for the generation of hydro-electric power, but also their multiple utilization in various essential aspects of economic development, such as drinking water, irrigation, flood control, navigation, etc.

In this context, it might be well to remember that our present knowledge of this highly important resource is very inadequate in Latin America. In fact, only an average of four per cent of the

/evaluated potential

evaluated potential is being utilized, and in Mexico, ten per cent. It is almost certain that the figure of a potential 150 million kW, which is economically usable and which Latin America is supposed to have at present, may reach much higher levels when the resources are better known. The above-mentioned percentages of utilization would then be much lower, which only goes to emphasize the insufficient use made of it.

With respect to atomic energy, we are fortunate in having documents prepared by the International Atomic Energy Agency, and the representatives of this organization attending the Seminar will, no doubt, contribute valuable opinions on the conditions required for these plants to be economic and regarding when this may be possible in the various countries or regions of Latin America.

In order to have an optimum combination of hydraulic, thermal, etc. electric plants with the most heterogeneous characteristics that satisfies demand under the conditions that this imposes, it will be necessary to lay down the bases for determining what criteria should be applied in selecting these plants and their manner of operation within this system during a certain period of time. This is one of the crucial problems of our Seminar, and the great interest it has aroused among the participants is evidenced by the large number of papers received on this particular subject. We hope to be able to devote as many meetings as may be necessary to the analysis of this problem until we can establish the desirable economic criteria in accordance with the varied conditions in which our various countries are developing.

Once these systems have been chosen, there arises the problem of their investment costs and the ways and means of financing them. As may be expected, we shall find that these costs fluctuate within wide margins and on a varying scale according to the nature of the plants - hydraulic, steam, diesel, nuclear, etc. - or their type and characteristics: run-of-the-river or reservoir, and in the latter

/case, the

case, the extent of regulation, and engineering difficulties. The complexity of their construction, its scale and size, as well as the efficiency in organizing the work, etc., are further factors. Therefore we shall also find wide margins of variation in the respective proportions of national currency or foreign exchange required. The studies made by the secretariat and the papers presented to the Seminar give us reason to believe that the discussions on the different kinds of investment costs must produce useful results which will help to guide countries in this connexion.

Once the necessary investment figures have been established, the different ways and means normally used to ensure financing will also be discussed. We already stated, on the basis of an almost threefold increase in installed capacity by 1970, that, in order to meet these needs, a sum equivalent to more than 12,000 million dollars would be required. This amount would represent up to 8 - 9 per cent of the total gross capital formation of the Latin American countries on the average for the whole period, and even larger amounts and proportions for some of them in specific years.

The magnitude of this figure gives us pause for reflexion, since it is indicative of the sustained and persistent effort which will be required to prevent plans and projects from remaining on paper as a mere expression of very real and justifiable aspirations, partly unattainable because of the lack of an adequate financing plan.

How can these resources be obtained, both as regards the portion in national currency and that in foreign exchange? And how can this be achieved without affecting monetary stability, unleashing inflation or creating difficulties or pressures on the balance of payments? Here we come to another critical matter. Just as this is clear to us, so must it be apparent to everyone that this is a key problem and that many meetings should be devoted to discussing it during the next two weeks.

/Undoubtedly the

Undoubtedly the electricity enterprise itself - whether publicly or privately owned - is one source of capital which comes from the amortization and reserve funds and from the ploughing-back of profits. Its volume will depend, among other things, on electric power legislation and on the margins between costs and income from sales, i.e., tariffs, that are left over. In the first case, those investment costs to which we have already referred affect it, as do fuels and labour. Therefore, we are also interested on this occasion in studying ways and means of economizing fuels in the generation of power, through improved technical and economic efficiency in their utilization.

Many elements are involved in the fixing of rates, among which may be mentioned the criteria established concerning capital yields - and the definition and determination of capital -, the need for increasing electrification and the elements of economic and social advancement. Some of these operate in the opposite direction, and it would be necessary to arrive at an even balance which does not affect the functioning of the principal convergent or resultant factors. This topic is so broad in scope that it goes beyond the limit set for this Seminar. For this reason we do not intend to discuss it here specifically and in detail.

However, experience teaches that capital accruing from operations in the electricity sector itself cannot be the only - nor even the major - source of financing in this field. This is not the case in the more developed countries, and possibly and more logically it could not aspire to be so in those countries which, like ours, must increase their electric capacity at such a fast rate that it would exceed every reasonable possibility of domestic financing.

Another source could be capital furnished from outside the electricity sector itself, through public and private capital. Another way would be loans or credit, or the floating of debenture bonds on private or public capital markets, either domestic or international.

A calm and careful analysis should be made of the contribution that these various sources of financing could make to the capital formation of the electricity industry in Latin America, taking into consideration the

/scale of

scale of the requirements, their structure - as regards the proportions of national funds, foreign currency and instalments - over-all economic or financial policies and, in general, a great number of basic factors. The careful and intelligent management of this whole aspect can result in great advantages for national treasuries.

A dispassionate, informed and scientific consideration of all these points at this Seminar will undoubtedly help very substantially to clarify and define the problems and to present them in such a way as to facilitate constructive solutions.

In proceeding thus, consideration should be given to all factors of any importance that bear on the problem. Among these is the fact that the heavy electrical machinery and equipment industry is growing and becoming increasingly diversified at a lively pace in our countries, and is contributing in ever greater measure, to the satisfaction of the electrical industry's needs. If, in addition, this growth is visualized in the light of the instruments of the possible common market and of the vast demand of future electric development, it may constitute an interesting topic for discussion.

In conclusion, we feel that the experts attending this Seminar may consider it useful to discuss those questions that bear on the institutional organization of the industry, without losing sight of the variety of national experiences and the marked tendency towards the greater and more active participation of governments in the field of electricity. What types of institution are to be recommended, and when and under what circumstances? How are the functions of planning, coordination, regulation, execution and operation to be divided? What bodies should be suggested in accordance with existing conditions and what functional structure could they have?

You have received a large amount of documents prepared by United Nations bodies and by some of the experts participating in the Seminar. By selecting some outstanding problems or aspects in the field of electricity, we have attempted to offer you the basic material necessary for your discussions.

/In my



In my opinion, we cannot aspire to definitive conclusions and recommendations, formulae or categorical answers. In some cases this is not possible, for a single and invariable solution simply does not exist. It is subject to many varied characteristics and circumstances that condition its adoption. In other cases, sufficient agreement has not yet been reached among the experts in the field, and there are opinions that are equally valid and legitimate but which visualize very divergent solutions. In still others the nature of the problems needs to be clarified, or more thorough economic and statistical research has to be carried out before an answer is ventured. But, in any event, a fundamental discussion of the problems and the search for ideas or norms for their solution are of great practical value, even though the discussion only produces possible alternatives.

Therein lies what we hope to achieve in this Seminar: a contribution to the analysis and clarification of the problems; the formulation of conclusions that will serve as a guide; and the raising of fundamental questions that must be studied; in a nutshell, to enable studious or responsible executives in the field of electricity in the Latin American countries to advance further towards the solution of those problems, thus helping to strengthen our economies and to lay the foundations for the fulfilment of the noble aspirations contained in the United Nations Charter, Article 55 of which recommends the promotion of "higher standards of living, full employment, and conditions of economic and social progress and development".

Latin America is passing through one of the most grave and decisive moments in its economic history. Many of our countries are confronted with far-reaching structural changes in their economies, and possibly, their ways of life in the social field as well as in some institutional aspects. We are all agreed that electrification is called upon to play a leading role in ensuring that those changes are consolidated in keeping with the patterns most suitable for each country. It will be for Governments to decide upon numerous essential aspects connected with planning or programming, the organization of the electricity industry at its different levels, the relevant legislation, the sources and forms of financing, and rates.

/In short

In short, it is incumbent on the Governments to define and lay down the bases and guide-lines of their economic and financial policies in the matter of electricity.

I am fully confident that valuable ideas will emerge from the discussions in this Seminar and that, in the light of its results, Governments will be able to set new courses and choose new alternatives for the decisions that lie in their hands. If, as I expect, our efforts are crowned with success, we will have fully discharged our obligations, and the work of the Seminar will represent a fruitful contribution to the solution of one of the most fundamental problems of the economic development of Latin America.

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ADDRESS DELIVERED BY MR. MANUEL MORENO TORRES, DIRECTOR-GENERAL  
OF THE COMISION FEDERAL DE ELECTRICIDAD OF MEXICO

The Comisión Federal de Electricidad, a Mexican Government agency contributing to the goal of national electrification, extends a hearty welcome to the Latin American Electric Power Seminar, which is to deal with the problems connected with the development of electrification and its trends in the Latin American countries, - all in the interest of progress.

Most of the problems that will be reviewed at this conference, convened by the Economic Commission for Latin America, the Bureau of Technical Assistance Operations and the Resources and Transport Economics Branch of the United Nations are common to all the Latin American countries. This is mainly attributable to their inadequate economic capacity to carry out over-all electric development, as well as to topographical obstacles and, of course, their social problems, cultural levels and state of development. But, faced with these problems, the people and Government of each and every one of these countries share the same enthusiasm as well as the same concern and hopes for social, cultural and economic betterment.

/Mexico is

Mexico is contributing to this Seminar the experience accumulated by its electric power industry over a period of 80 years, but more particularly the achievements of the Revolutionary Governments since 1937, when the Comisión Federal de Electricidad was founded.

For many long years, Mexico delayed the development of its electrification for various reasons, among which the most weighty was the multiplicity of concessionary enterprises. Although these enterprises were properly divided into two economic units, the areas of national territory assigned to them under their concession were such that vast stretches of the country had no power supply, and the diversity of means of production and of administrative bodies resulted in high costs.

The concern of the Revolutionary Governments of Mexico to put into practice their ideals of social justice more and more each day encouraged the State to intervene in the production of power as the basis of national progress. In the course of time it managed to enter the complicated field of the electricity industry through the Comisión Federal de Electricidad, founded for the purpose of organizing and directing a national non-profit-making system for the generation, transmission and distribution of electric power, and of achieving the greatest yield at the lowest cost for the good of the community. It had sufficient support to formulate a social welfare policy, eliminating the defects of earlier times in which Mexico's situation encouraged the flourishing of eminently profit-seeking enterprises. Pursuing this policy, it nationalized the electricity industry. Thus, with the introduction of constitutional reform, the State was given the exclusive right to generate, transform and supply electric power as a public service. This was an affirmation of the nation's inalienable right to use its national resources in the way that the public interest dictated.

Thanks to the efforts of Mexico's workers and technicians, the Comisión Federal de Electricidad has become a vigorous national agency, efficiently carrying out the work assigned to it in each Government programme. With zeal and application the technicians and workers of this institution and those employed in the recently acquired systems are helping to expedite /electrification. Their

electrification. Their goal is to consolidate a single system which would lead to a greater output of electricity, in order gradually to satisfy the growing demand for power at minimum cost to the consumer.

Through the Comisión Federal de Electricidad, Mexico will be proud to show you its achievements, in the matter of electrification - a factor in our country's progress and one of the most cherished ideals of the Mexican Revolution. On its behalf, I now extend to you a most cordial invitation to visit some of the installations of this institution, especially the hydro-electric plants, planned and constructed entirely by Mexican workers and technicians, as it has been the fundamental concern of our Governments to use first and foremost our own technical and human resources in the development of the industry.

Without boasting, we are proud to declare that Mexico's own sons - workers and technicians throughout the industry - have carried out the electrification of the country.

We hope that most, if not all, the participants and observers at this meeting will visit the installations of the Comisión Federal de Electricidad, which are comparable in many cases in design and execution to the best in other countries and which embody strenuous effort and the loftiest patriotism.

On behalf of the workers and technicians of the Comisión Federal de Electricidad, in extending our hospitality to you, I wish you a pleasant stay in our country and hope that our experience and achievements, carried out in accordance with our economic possibilities, will be of benefit to you, as we, in turn, are sure that we will glean a great deal of useful information from your experience. I beg you to convey Mexico's most cordial greetings to your countries, with our fervent hopes for the progress and well-being of your peoples.

ADDRESS DELIVERED BY MR. RAUL SAEZ SAEZ, REPRESENTATIVE OF  
EMPRESA NACIONAL DE ELECTRICIDAD DE CHILE, ON BEHALF  
OF THE PARTICIPANTS

Someone has said, with reference to living creatures, "that the technique of the species is invariable. Animal thought, instinct, is closely linked to the immediate here and now; it knows neither the past nor the future. Hence, it knows neither experience nor anxiety."

On the other hand, "the technique of man's life is conscious, voluntary, variable, personal and inventive. He learns and improves. Man is the creator of his tactics for living. This is his grandeur and his misfortune."

We are part of this human techniques. If it were not too pretentious, I should venture to say that our work in the field of power strikes at the very roots of this technique, since present-day thinkers and interpreters of history accept the fact that man has been able to progress only in direct relation to the amount of external power he has had the cleverness and ability to use and which has thus relieved him of the basic necessity of dedicating his efforts exclusively to securing his means of livelihood.

The progress of mankind may be described in terms of the bigger and better forms of power it has learned to use. It took man a million years to discover the first industrial application of heat in the manufacture of bricks for living quarters. It took him 10,000 years to convert this heat into motive power in the first steam engines. One hundred years later, he put electricity, doubtless the most versatile form of using power resources, to practical use. In ten years he has managed to harness atomic energy

Faced with this increasing acceleration, our responsibility is clear and well-defined. Of all forms of power, electricity has the greatest rate of growth, the most varied applications and the most basic social function since it conditions all aspects of modern life. Some years ago the California Institute of Technology estimated that, by the year 2050, the increase in the total consumption of electricity would be 25 times greater than the level attained in 1950, and that by the date mentioned,

/more than

more than 60 per cent of power consumption would be in the form of electricity.

Therefore, as members of Government agencies responsible for promoting and regulating the development of electricity services and as executives of enterprises undertaking and operating power systems in the countries of Latin America, I wish to stress that our responsibility is great and serious.

We know from the studies carried out in our own countries and from ECLA's joint analyses and reports just how deficient the supply of electric power is in our continent at present and the magnitude of the effort that must be made.

It is precisely the very importance of this subject that justifies the present Seminar. We urgently need to get to know one another; to explain our problems and exchange experiences; to enrich our knowledge and to do the things that others have done under similar conditions or at more advanced stages.

You know the agenda for this conference. It covers the essential aspects of the development of electric power in our countries with all the implicit economic, financial, legal and institutional problems. I should like to dwell for a minute on the importance which the programming of the electricity sector will have in our discussions as an essential part of the power sector and as the consequence of, or rather, the condition for the general economic development of our countries.

The power problem is by its very nature one of those which economists call structural problems. It should therefore not depend so much on the short-term economic situation nor should it be subject to a policy of alternatives in keeping with the circumstances of the moment. Investments in power are substantial and take many years to begin yielding the benefits expected of them, from the outset to the time of their full-scale utilization. It is therefore absolutely necessary for the power sector to develop in accordance with clearly-defined and continuous policies in order to ensure that its programmes materialize as foreseen. The foregoing remarks are particularly relevant to the electricity sector which,

/besides its

besides its exponential and explosive growth, involves the progressive integration of its installations into increasingly complex systems, which can be achieved without difficulty and excessive cost only if uniform techniques, principles and policies are applied.

It is for this reason that I would like to appeal at this conference for a completely frank discussion of our experiences on this subject so that we may all benefit from the obstacles encountered, the successes and failures - often learning more worthwhile lessons from failures than from positive results. I also believe that uniformity of language and technique might prove decidedly beneficial for future exchanges of opinion.

It is a favourable omen that our discussions, which begin today, will be held concurrently with other extremely important meetings in another country of this continent. I refer to the Montevideo conference on the free-trade area and especially to the meeting of Ministers of Financial Affairs at Punta del Este, where it is expected that new forms of relationship between the countries of America will be discussed, which will lead to more effective solutions for the economic and social development of our countries.

We all know that the main topic for discussion at the Punta del Este meeting is the programming of development and the practical tools to be forged for achieving this. If constructive solutions are reached, the responsibility of those on whom the supply of electric power depends in the Latin American countries will be further increased because of the heavier demand which the accelerated development of our economies will place on the electricity sector.

But, as I was saying, the fact that the Mexico and Uruguay conferences are being held simultaneously seems to me to be a favourable omen, since, as Europeans well remember, the first and best evidence of integration, complementarity and joint development in the European countries was the co-ordinated work of the electric power  
/enterprises of

enterprises of the continent, the exchange of experiences, the standardization of methods and the progressive interconnexion of their electricity systems.

I am convinced that this, the first opportunity we have had of meeting together, might well be the beginning of further and continuous contacts which, in the future, will be reflected in a mutually beneficial acquaintanceship with our peoples, experiences and problems. Perhaps the great merit of meetings such as this is that we come to them not to defend our positions, but to listen, to talk and to learn.

Because I am certain of the importance that this meeting may have, I should like to express my sincerest appreciation to the sponsors of this Seminar and to those responsible for its organization. I refer to the Bureau of Technical Assistance Operations and the Resources and Transport Economics Branch of the United Nations, but very especially to the Economic Commission for Latin America and to those with ECLA who have done the heavy work of co-ordinating the studies and preparing the basic reports. I must also thank all those public and private bodies outside Latin America which have contributed documents and sent participants who will enrich the discussions of this Seminar with their experience. In expressing thanks to those who have helped to arrange this meetings, while I am not the designated spokesman for those who share this debt of gratitude, I am sure that I am interpreting the feelings of all.

But I do not wish to conclude without placing on record, on behalf of those of us who come from outside Mexico -- and I purposely do not use the word "foreigners" because I do not feel that I am one -- our appreciation to the Government of the United Mexican States which has sponsored this meetings, and to the Comisión Federal de Electricidad, which constitutes an example for our continent of what can be done in the fields which will be discussed here, and which has so graciously offered to be our host.



## Annex II

### AGENDA AND LIST OF DOCUMENTS

#### 1. ELECTRIC POWER DEVELOPMENT IN LATIN AMERICA AND ITS MAIN PROBLEMS

Documents:

- ST/ECLA/CONF.7/L.1.01          The electric power industry in Latin America  
- present status and recent development  
(secretariat)
- 1.01/Add.1      Statistical annexes
- 1.02            Trinidad's power system (Kenneth W. Finch,  
Trinidad and Tobago Electricity Commission,  
Federation of the West Indies)
- 1.03            Electric power in Brazil (A energia elétrica  
no Brasil) (Carlos Berenhauser Jr., Cia.  
Hidro Elétrica de Sao Francisco, Brazil)
- 1.04            A survey of electric power development  
in the ECAFE region (Economic Commission  
for Asia and the Far East)
- 1.05            The case of Chile - Statement made at a  
preparatory meeting held in September  
1959 at United Nations Headquarters  
in New York (by Raúl Sáez, Empresa  
Nacional de Electricidad S.A. (ENDESA),  
Chile)
- 1.06            Central America and the problems of  
electrification - Statement made at a  
preparatory meeting held in September  
1959 at United Nations Headquarters in  
New York (by Jorge M. Dengo, former  
General Manager of the Instituto  
Costarricense de Electricidad, Costa Rica)

/1.08    The

- ST/ECLA/CONF.7/L.1.08 The public corporation: and adequate instrument for the supply of electric power (Rafael V. Urrutia and Victor M. Cataldo, Autoridad de las Fuentes Fluviales, Puerto Rico)
- 1.09 Some criteria applicable to the economic planning of electricity projects (Guillermo A. Maza, Agua y Energía Eléctrica, Argentina)
- 1.01a Electric power in Uruguay (Ramón Oxman, Instituto de Teoría y Política Económicas, Uruguay)
- 1.01b Electric public utilities in Argentina and the State water and electric power enterprise (Carlos A. Volpi, Agua y Energía Eléctrica (ENDE), Argentina)
- 1.01c How the Comisión Federal de Electricidad of Mexico projects and constructs (Carlos Tercero E., Raúl J. Marsal and Raymundo Rieman of the Technical Advisory Service of the Comisión Federal de Electricidad, Mexico)
- 1.02a Electric power supply as a factor in the promotion of the regional economic development in Mexico (Emilio Rodríguez Mata, Banco de México, S.A., Mexico).
- 1.03a Survey of the status and development of the electric power industry in the USSR (N.M. Chuprakov, Ministry of Power Plant Construction, USSR)
- 1.04a Works programme 1961-1970 of the Comisión Federal de Electricidad of Mexico (Pablo Tapie, Mario Bunt R. and Jorge Young of the Comisión Federal de Electricidad, Mexico)

/1.05a Nationalization

- ST/ECLA/CONF.7/L.1.05a Nationalization of the electricity industry in Mexico (Comisión Federal de Electricidad, Mexico)
- 1.06a State electrification boards (Arguemedes Catalán Guevara, Salvador Almanza Nieto, Enrique Ontiveros Aguilar, Salvador Saenz Nieves and Mario Bunt, Comisión Federal de Electricidad, Mexico)
- 1.07a Status of the electric utility industry in the United States of America (Philip A. Fleger, Edison Electric Institute, United States)
- 1.08a Outstanding aspects of the development of electrification in Costa Rica (Instituto Costarricense de Electricidad, Costa Rica)

See also documents ST/ECLA/CONF.7/L.2.2, 2.4 and 3.7

## 2. EVALUATION OF DEMAND AND ITS BEARING ON ECONOMIC DEVELOPMENT

### Documents

- ST/ECLA/CONF.7/L.1.10. Methodology for forecasting electric power demand (secretariat)
- 1.11 Expansion of the electricity sector in Latin America and its capital requirements for 1960-70 (secretariat)
- 1.07 Methods of forecasting future electric power requirements (Energy Division, United Nations Economic Commission for Europe)
- 1.12 Forecasting future electric power requirements (American Public Power Association, United States)

- ST/ECLA/CONF.7/L.1.13 The historical relationship between energy consumption and gross national product in the United States  
(Sam H. Schurr, Resources for the Future, Inc., United States)
- 1.14 The technical and economic criteria to be applied in preparing an electricity production programme  
(Union Internationale des Producteurs et Distributeurs d'Energie (UNIPEDE))
- 1.15 Problems of load forecasting and the generating capacity to meet these loads  
(Arthur S. Griswold and F. Douglas Campbell, The Detroit Edison Company, United States)
- 1.16 Statistics, the fundamental basis for planning the electrification of under-developed countries  
(José G. Treviño Siller, Empresas Eléctricas NAFINSA, Mexico)
- 1.17 Planned electrification in the under-developed countries of Latin America  
(Rolfo Ortega Mata, NAFINSA, Mexico)
- 1.18 Forecasting the demand for and consumption of electric power in Chile  
(Edmundo Bordeu P., Empresa Nacional de Electricidad, S.A. (ENDESA), Chile)
- 1.19 Methodology for projecting the demand for electricity  
(U. Alberto Trujillo E., Department of Economic Research, Nacional Financiera, S.A., Mexico)

/1.20 Methods

- ST/ECLA/CONF.7/L.1.20 Methods of estimating future electric power requirements (Luis F. de Anda and Bruno Romero H., Comisión Federal de Electricidad, Mexico)
- 1.21 Methods used by the Empresa Nacional de Electricidad S.A. (ENDESA) in selecting alternatives for the supply of electric power in the interconnected system in the central zone of Chile (Renato E. Salazar and Carlos Croxatto, Empresa Nacional de Electricidad S.A. (ENDESA), Chile)

See also documents ST/ECLA/CONF.7/L.1.02b and 1.33

### 3. CAPITAL REQUIREMENTS AND METHODS OF FINANCING

#### Documents

- ST/ECLA/CONF.7/L.1.30 Financial requirements, sources of funds and investment priorities (secretariat)
- 1.31 Comparative study of electric power costs in Central America and Panama, 1959. (Eugenio Salazar, Inter-American Development Bank, special ECLA consultant for this study)
- 1.32 Electric power costs and the functions of electricity undertakings (Energy Division, ECE)
- 1.32/Add.1 Ibid Annex. Financing of new electric power projects
- 1.33 Some aspects of the appraisal of electric power projects in less developed countries (Alfred E. Matter, International Bank for Reconstruction and Development)

- ST/ECLA/CONF.7/L.1.34 The economic criteria to be applied in selecting investments ((Union Internationale des Producteurs et Distributeurs d'Energie (UNIFEDE))
- 1.35 Rates and methods for selecting hydro-electric equipment ((M. Bouvard, Société Grenobloise d'Etudes et d'Applications Hydrauliques (SOGREAH), France))
- 1.36 Financing of electric power expansion in the State of Minas Gerais (Mario Penna Bhering, Centrais Elétricas Minas Gerais, Brazil)
- 1.37 Operational and institutional problems of electric power development (Sir Josiah Eccles, C.B.E., The Electricity Council, United Kingdom of Great Britain and Northern Ireland)
- 1.38 Electric tariffs and regional development (James E. Watson, Tennessee Valley Authority, United States)
- 1.39 The policy, methods and experience of the Electricity Administration and Development Company (CADAFE) of Venezuela in regard to rates (Luis E. Galavis, C.A. de Administración y Fomento Eléctrico (CADAFE), Venezuela)
- 1.40 Methods of determining original cost (Gordon F. Heim, Federal Power Commission, United States)
- 1.41 Rates policies and their influence on electrification (Jorge Mandas Chacón, Henry McGhie Boyd and Antonio Fernández Ramírez, Servicio Nacional de Electricidad, Costa Rica)

- ST/ECLA/CONF.7/L.1.42 Financing the United States Columbia River power system (Earl D. Ostrander, Bonneville Power Administration, United States)
- 1.43 Rates and their influence on electric power financing in Argentina (Salvador San Martín, Argentina, special ECLA consultant for this study)
- 1.44 Determining cost per kilowatt-hour. Suggestions for the operation of an electricity service using State enterprises (Carlos A. Volpi, Agua y Energía Eléctrica, Argentina)
- 1.45 Considerations on costs and electricity rates in Mexico (Gregorio Covarrubias de Labra, Colegio de Ingenieros Mecánicos y Electricistas, Mexico)
- 1.46 Effects of size and other characteristics of a hydro-electric plant on the cost of projects ((Alberto Bennett, Luis Court, Raúl Arteaga and Rodolfo Bennowitz, Empresa Nacional de Electricidad S.A. (ENDESA), Chile))
- 1.47 Hourly cost of electricity supply in an inter-connected system ((Efraín Friedmann and Raúl Schkolnik, Empresa Nacional de Electricidad S.A. (ENDESA), Chile))
- 1.48 Electric power supply at predetermined hours; its influence on the operation of generating plants, and general considerations on the rates applicable to this type of service (Héctor Balandrano, Mexico)

- ST/ECLA/CONF.7/L.1.49      Economicity in electric power production  
  ((Hugo R. Giavi, Manuel Mendiola and  
  Manuel Arestivo, Administración General  
  de Usinas Eléctricas y los Teléfonos del  
  Estado (UTE), Uruguay))
- 1.50      Choosing a plan for financing power or  
  other public services in under-developed  
  countries (Jean Valley, Belgium)
- 1.51      Prices and costs in the electric energy  
  industry in Latin America ((Economic  
  Commission for Latin America (ECLA),  
  Energy and Water Resources Programme))
- 1.52      Aspects of the present and future tariff  
  organization in Mexico (Enrique Viler,  
  Consultant, Comisión Federal de Electricidad,  
  Mexico)
- 1.53      Capital requirements of the electric  
  utility industry in Latin America  
  (Marvin L. Fink, Inter-American  
  Council of Commerce and Production)
- 1.54      Determination of production costs in  
  Costa Rica (Instituto Costarricense de  
  Electricidad, Costa Rica)

See also document ST/ECLA/CONF.7/2.1

#### 4. ECONOMIC CRITERIA FOR SELECTING POSSIBLE ALTERNATIVES IN THE DEVELOPMENT OF ELECTRIC SYSTEMS

##### Documents:

- ST/ECLA/CONF.7/L.2.1      Economic criteria for the selection and  
  development of power stations and  
  electricity systems ((Raúl Sáez, Empresa  
  Nacional de Electricidad S.A. (ENDESA)  
  Chile, special ECLA consultant for  
  this study))

/2.2 Co-ordination



- ST/ECLA/CONF.7/L.2.2 Co-ordination of electrification programmes in Central America, Special analysis for Honduras and El Salvador (Eugenio Salazar, Inter-American Development Bank, special ECLA consultant for this study)
- 2.3 Planning a system. Study based on the development of the Sonora-Sinaloa system (Glicerio González, Department of Planning and Studies, Comisión Federal de Electricidad, Mexico)
- 2.4 Basic problems in electric power development (Sir Josiah Eccles, C.B.E., The Electricity Council, United Kingdom of Great Britain and Northern Ireland)
- 2.5 Characteristics, design, construction and operation of rural electric systems in the United States (John H. Rixse Jr., Rural Electrification Administration, Department of Agriculture, United States)
- 2.6 Economic aspects of combining thermal and hydroelectric plants ((Marcel Mary, Electricité de France and Société Française d'Etudes et de Réalisations d'Equipement Electriques S.A. (SOFRELEC), France))
- 2.7 Methods for the evaluation of hydro-electric potential (Energy Division, United Nations Economic Commission for Europe)
- 2.8 Economical use of hydro power, steam power and system interconnections (Ross N. Brudenell and Jack H. Gilbreath, Tennessee Valley Authority, United States)

/2.9 Combining

ST/ECLA/CONF.7/L.2.9

- Combining hydro and thermal capacity results in maximum economic benefits (John F. Pett, American and Foreign Power Company Inc., United States)
- 2.10 Evaluation of a potential hydro-electric project as an addition to an existing power system (Léo A. Penna, Cia. Auxiliar de Empresas Elétricas Brasileiras, Brazil)
- 2.11 Economic and technical aspects of the inter-connexion of electric power systems (Union Internationale des Producteurs et Distributeurs d'Energie (UNIPEDE))
- 2.12 A commercial approach to rural electrification (Kenneth W. Finch, Trinidad and Tobago Electricity Commission, Federation of the West Indies)
- 2.13 Steam power station design criteria (S. Kriese, Allgemeine Elektrizitätsgesellschaft AEG, Federal Republic of Germany)
- 2.14 The role of operations research in the analysis of complex management problems in a large electric utility (William Shelton, The Hydro-electric Power Commission of Ontario, Canada)
- 2.15 Problems of load dispatching in inter-connected systems (W. Henning, H. Bauer and H. Stössinger, Siemens-Schuckertwerke A.G., Federal Republic of Germany)
- 2.16 Economic considerations governing the choice of voltage for power supply systems (F. Wienken, H. Dorsch and W. Bückner, Siemens-Schuckertwerke A.G., Federal Republic of Germany)
- 2.17 Aspects governing the selection of generating plant (K. Weinlich, Siemens-Schuckertwerke, A.G., Federal Republic of Germany)

/2.18 Considerations

- ST/ECLA/CONF.7/L.2.18 Considerations governing the selection and design of waterwheel generators with special reference to the conditions obtaining in Latin America (Siegfried Rois and Hans Troger, Siemens-Schuckertwerke A.G., Federal Republic of Germany)
- 2.19 The co-ordination of hydro and thermal production of electricity: the situation in Italy and the experiences of the Edison Group (Societa Edison, Italy)
- 2.20 Companhia Hidro Elétrica do Sao Francisco (Antonio José Alves de Souza, Cia. Hidro Elétrica do Sao Francisco, Brazil)
- 2.21 Some problems arising from the development of power stations and electricity systems (Arturo Rodríguez Ulloa, Nacional Financiera, Mexico)
- 2.22 Problems of plant and system development (Yvon de Guise, Quebec Hydro-electric Commission, Canada)
- 2.23 The technical and economic criteria to be applied in preparing an electricity distribution programme (Union Internationale des Producteurs et Distributeurs d'Energie (UNIPEDE) )
- 2.24 Basic problems involved in developing electric power in Mexico, by regions (Antonio González Rivera, Colegio de Ingenieros Mecánicos y Electricistas, Mexico)
- 2.25 Experience acquired in Europe in the integration and co-ordinated operation of national electric power transmission networks (Energy Division, United Nations Economic Commission for Europe)

- ST/ECLA/CONF.7/L.2.26 Economic considerations in the planning and design of storage systems (H. Bauer and K. Theilsiefje, Siemens-Schuckertwerke A.G., Federal Republic of Germany)
- 2.27 Management improvement in electric public utilities (Merrill J. Collett, Collett and Clapp, Puerto Rico)
- 2.28 The need for co-ordination between management improvement and technical development in electric power (Merrill J. Collett, Collett and Clapp, Puerto Rico)
- 2.29 Economic comparison of hydraulic or thermal solutions for electric power supply (Raul A. Ondarts, Argentina)
- 2.30 Fuel consumption estimates for comparison of projects (Hugo R. Giavi and Siegmund Antmann, Administración General de Usinas Eléctricas y los Teléfonos del Estado (UTE), Uruguay)
- 2.31 Power production with gas turbines and steam turbines (Hugo R. Giavi, Administración General de Usinas Eléctricas y los Teléfonos del Estado (UTE) Uruguay)
- 2.32 Rural electrification in Chile by means of electric power supply co-operatives (Gustavo Cuevas G., Empresa Nacional de Electricidad S.A. (ENDESA), Chile)
- 2.33 Some economic considerations in the design, commissioning and operation of power stations containing large generating units (H.B. Johnson, Merz and McLellan and Associated Electrical Industries Export Ltd., United Kingdom)

See also documents ST/ECLA/CONF.7/L.1.35, 1.47, 3.8 and 4.3

5. HYDRO-ELECTRIC RESOURCES, THEIR MEASUREMENT AND UTILIZATION

Documents:

- ST/ECLA/CONF.7/L.3.0 Hydro-electric resources in Latin America; their measurement and utilization (secretariat)
- 3.1 General criteria for selecting hydro-electric generating plant size at multiple-purpose projects (Arnold B. Taylor, Corps of Engineers, United States)
- 3.2 Economic analysis of proposed hydro-electric projects (Frank L. Weaver, Federal Power Commission, United States)
- 3.3 Aspects of the technical and economic definition of the most suitable storage capacity for a hydro-electric power system (José Cruz Morais and Jorge Azevedo Cirpiano, Repartidor Nacional de Cargas, Portugal)
- 3.4 Use of hydraulic models for hydro-electric projects in Chile (Alberto Bennett and Horacio Mery, Empresa Nacional de Electricidad S.A. (ENDESA), Chile, with the collaboration of Roberto Muñoz of the University of Chile)
- 3.5 Energy resources evaluation (Bruce N. Netschert, Resources for the Future, Inc., United States)
- 3.6 Collection and uses of hydrological and hydro-meteorological data for system operation and planning (Bureau of Reclamation, Department of the Interior, United States)

/3.7 Probable

- ST/ECLA/CONF.7/L.3.7 Probable development of electric power of hydraulic origin in Mexico (Bruno Devecchi, Cfa. Mexicana de Luz y Fuerza Motriz, S.A. and Comisión Nacional de Energía Nuclear, Mexico)
- 3.8 Collection and use of hydrological and hydro-meteorological data for system planning and operation (Corrado V. Schlaepfer, Cfa. Mexicana de Luz y Fuerza Motriz S.A., Mexico)
- 3.9 Utilization of axial groups for equipping low heads (H. Amblard, Etablissements Neyrpic, France)
- 3.10 Activities of the World Meteorological Organization (WMO) in the development of hydro-meteorology in Latin America (World Meteorological Organization)
- 3.11 Possibilities of generating electric power in the Lerma-Chapala-Santiago basin (Lerma-Chapala-Santiago Commission of the Water Resources Department, Mexico)
- 3.12 Energy resources of the upper basin of the River Pánuco and industrialization of the Mezquital Valley (Pablo Bistrain, College of Mechanical and Electrical Engineers of Mexico, Mexico)
- 3.13 Evaluation of surface water resources (Ministry of Water Resources, Hydrology Department, Mexico)

See also documents ST/ECLA/CONF.7/L.1.46, 2.4, 2.7 and 2.25

## 6. NUCLEAR POWER AND ITS POSSIBILITIES IN LATIN AMERICA

### Documents

- ST/ECLA/CONF.7/L.4.1 Nuclear power costs and their trends with special reference to less developed countries (International Atomic Energy Agency)

- ST/ECLA/CONF.7/L.4.2 Note on the activities of the International Atomic Energy Agency (International Atomic Energy Agency)
- 4.3 Criteria for the addition of nuclear power stations to existing electricity systems (Carlos Vélez, Cía. Mexicana de Luz y Fuerza Motriz, S.A. and Comisión Nacional de Energía Nuclear, Mexico)
- 4.4 Observations on atomic power in Latin America (Michael Deutch, United States of America)

## 7. ECONOMIC UTILIZATION OF FUELS

### Documents

- ST/ECLA/CONF.7/L.5.1 Rational and economic utilization of fuels (J. Agrest, Argentina, special ECLA consultant for this study)
- 5.2 Economy of combustion processes (F.D. Wilson, The Babcock & Wilcox Co., United States)
- 5.3 Some types of thermal electric power plant and their application to conditions in Latin America (J.M. Saunders, The English Electric Co. Ltd., United Kingdom of Great Britain and Northern Ireland)
- 5.4 Industrial utilization of exhaust gases from gas turbines (Eduardo de Maria y Campos, Brown Boveri Mexicana, S.A., Mexico)
- 5.5. More power at less cost (H.M. Lowenstein, Combustion Engineering, Inc., United States)

See also documents ST/ECLA/CONF.7/L.2.13 and 2.17

## 8. ELECTRIC EQUIPMENT INDUSTRY IN LATIN AMERICA

### Documents

- ST/ECLA/CONF.7/L.6.1 Electrical equipment industry in Latin America  
(Renato Salazar and Carlos Peralta, Empresa Nacional de Electricidad S.A. (ENDESA), Chile, special EICA consultants for this study)
- 6.2 Present status of the electrical manufacturing industry in Brazil (Carlos Berenhauser Jr., Cia. Hidro Eléctrica do São Francisco, Brazil)
- 6.3 The demand for equipment for the Mexican electric power industry (Octavio Garduño Díaz Chávez, Department of Industrial Research, Banco de México, S.A., Mexico)

## 9. LEGAL AND INSTITUTIONAL PROBLEMS OF THE ELECTRICITY INDUSTRY IN LATIN AMERICA

### Documents

- ST/ECLA/CONF.7/L.7.1 Legal and institutional aspects of the electricity industry in Latin America  
(Rafael de Pina Vara, Instituto de Derecho Comparado de México, Mexico, special ECLA consultant for this study)
- 7.1/Add.1 Ibid Annex
- 7.2 State monopoly and private co-operation in the electric energy services in Brazil  
(Miguel Reale, Cia. Brasileira Administradora de Servicios Eléctricos (COBAST), Brazil)

See also document ST/ECLA/CONF.7/L.1.41

Note: The Seminar also received information documents on a number of topics related to items of the agenda which were submitted by a few Latin American electricity organs (Departamento de Aguas e Energia Elétrica, Secretaria da Viação e Obras Públicas, São Paulo, Brazil; Corporación Autónoma Regional del Cauca, Colombia; Instituto Costarricense de Electricidad, Costa Rica; Serviço Nacional de Electricidad, Costa Rica; Junta Nacional de Planificación, Cuba); the Canadian, Spanish and Yugoslav national committees of the World Power Conference, the State Power Board, Sweden, and a few United States Government agencies such as the Bonneville Power Administration, the Bureau of Reclamation and the Rural Electrification Administration.



Annex III

LIST OF PARTICIPANTS AND OBSERVERS AND PERSONS  
AND BODIES WHICH SUBMITTED PAPERS TO  
THE SEMINAR a/

1. Latin American countries

ARGENTINA

\* Raúl A. Ondarts

Empresa de Agua y Energía Eléctrica (ENDE)

R Roberto Jorge Calegari, Director

\* Guillermo A. Mazza

\* Carlos A. Volpi

Italconsult Argentina

Carlos Robertson Lavalle

NEYRPIC Argentina

J. Richterich

BOLIVIA

Corporación Boliviana de Fomento

Bernardo Abela R., Chief, Energy Division

BRAZIL

Centrais Elétricas de Minas Gerais, S.A.

Antonio Carlos Bastos, Manager

\* Mario Penna Bhering

Central Elétrica de Furnas, S.A.

Flavio H. Lyra, Managing Vice-President

Luis Carlos Barreto

Mario Lopes Leao, Director

Comissão Estadual Energia Elétrica - State of Rio de Janeiro

Armando José de Oliveira Ferraz, Managing Director

Ronaldo Arthur Cruz Fabricio, Technical Director

Companhia Auxiliar de Empresas Elétricas Brasileiras

Jorge Magalhaes Gondim

\* Leo A. Penna

a/ An asterisk (\*) alongside a name means that the person or body concerned submitted papers but did not attend the Seminar, and in some cases, did not send representatives. The inclusion of a name under a specific country does not necessarily mean that the person concerned is a national of that country since he might be an expert working outside his own country. When members of delegations are not listed alphabetically the sequence followed is the order of seniority in which they were accredited.

Companhia Brasileira Administradora de Serviços Técnicos  
COBAST

Mitchell William Sharp, Vice-President

\* Companhia Hidro Elétrica de São Francisco

\* Carlos Berenhauser Jr.

\* Antonio José Alves de Souza

Water and Electricity Department, São Paulo

Alfredo Bandini

Ministerio Das Minas e Energia

Flavio H. Lyra

Rio Light, S. A.

Caio Tacito, Chief, Legal Department

São Paulo Light, S. A.

Miguel Reale, Legal Counsel

Usinas Elétricas do Paranapanema S. A. y Companhia  
Hidroelétrica de Rio Pardo

Mario Lopes Leao, President

Observers

Gastao C. Cruz, Sales Manager of General Electric, S. A.

CHILE

Compañía Chilena de Electricidad y Asociación de Empresas  
de Servicio Público

Rafael Herrera Palacios, Operations Manager

Department of Electricity and Gas Services

Ministry of the Interior

Lautaro Echiburú Concha

Empresa Nacional de Electricidad, S. A. (ENDESA)

Raúl Sáez Sáez, General Manager

Renato E. Salazar, Works Manager

\* Raúl Arteaga

\* Alberto Bennett

\* Rodolfo Bennewitz

/Edmundo Bordeu P.

- \* Edmundo Bordeu P.
- \* Luis Court
- \* Carlos Croxatto
- \* Gustavo Cuevas
- \* Efraín Friedmann
- \* Horacio Mery
- \* Carlos Peralta
- \* Raúl Schkolnik

Observers

Aurelio Fernández García Huidobro, Minister Counsellor to the  
Embassy of Chile in Mexico

COLOMBIA

Corporación Autónoma Regional del Cauca

Nicolás A. M. Zawadowski, Electric Power Planning Engineer

Instituto de Aprovechamiento de Aguas y Fomento Eléctrico

Guillermo Rodríguez Cárdenas, Assistant Manager

COSTA RICA

Compañía Nacional de Fuerza y Luz, S. A.

Claudio Alpizar Vargas, Operations Manager

Instituto Costarricense de Electricidad

Elías Quiros Salazar, Chairman of the Board of Directors

Oscar Rohmoser Volio, Director

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