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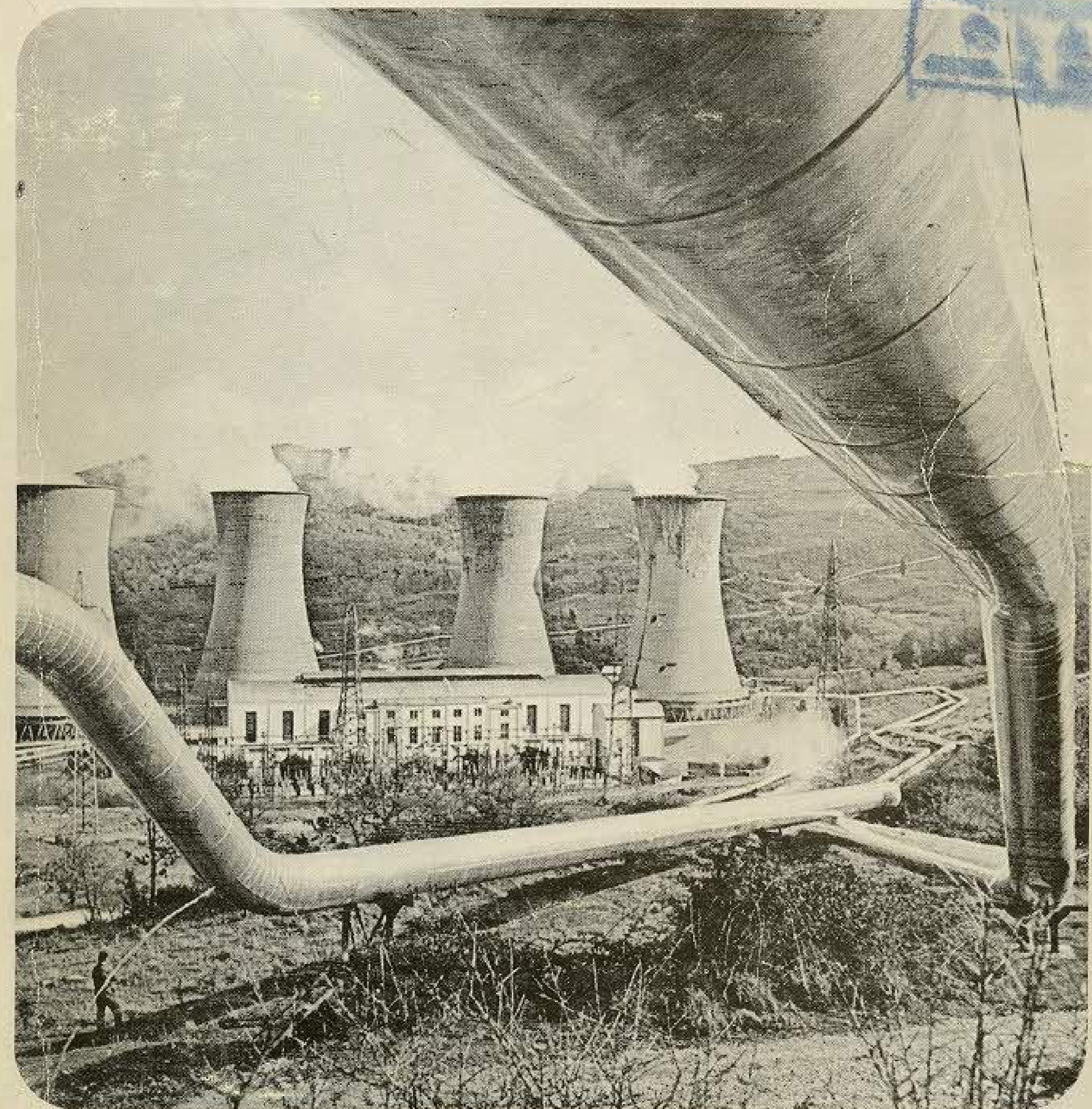

# AMERICA LATINA Y LA GEOTERMIA

# general review of international electrical interconnections

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## 1.0 PRINCIPLES FOR THE COORDINATED OPERATION OF ELECTRICAL SYSTEMS

### 1.1 Objectives of coordination

When two or more companies responsible for electrical power services, in the same country, or in two or more countries, decide to coordinate the operation of their electrical systems, they try to attain the following main objectives:

– Reducing as much as possible the cost of their services.

– Optimizing the reliability of the power fed to the interconnected system.

The projects to establish interconnected electrical systems are aimed at the following technical *and economic objectives:*

- *Reducing the need for generating capacity, by taking advantage of loads of neighbouring systems.*

- *Reducing the need for stand-by generating capacity taking advantage of the lower probability of simultaneous breakdowns of the generating units, and by harmonizing maintenance schedules.*

- *Increasing the energy actually available, through the rational exploitation of hydrologically different neighbouring basins, and through the harmonized utilization of hydraulic and thermal power plants, following appropriate patterns of operation.*

- *Reducing the costs of operation through the economic exchange that results from substituting low cost energy generated by one system for the higher cost energy generated by the other.*

  *Effecting overall savings by installing larger generating units and higher capacity power plants.*

  *Securing more uniform frequency characteristics, less frequency fluctuations during perturbations, and better voltage characteristics.*

- *Providing mutual assistance in case of emergency.*

*1.2 Economic factors*

*From the economic point of view, it is justified to coordinate the operation of electrical system if the reduction in costs of the services rendered offsets the incremental costs entailed. If this is not the case, such coordination is not economically warranted unless other reasons might prevail.*

*The incremental costs entailed in the coordinated operation of two or more electrical systems are due to:*

- *Investment in stations and lines for the interconnection.*

- *Investment to strengthen the system between the points of interconnection and the load centres.*

- *Investment in control systems needed to regulate the interconnection.*

- *Higher losses in the interconnected system, although under certain conditions a reduction of losses could take place.*

- *Increase in the cost of dispatching, accounting and administration.*

*The tangible economic benefits resulting from coordinated operations of two or more electrical systems consist of a reduction in investment and operating costs of generating plants. Depending on the case, reduction of investment and operational costs can be obtained as a result of the following factors:*

- *Installation of lower power generating capacity as a result of the lower reserve capacity required for the interconnected system taken as a whole, and for each company in particular when two or more systems are interconnected, the probability that both will suffer a power deficit at the same time is very reduced. The fact that the electrical systems are interconnected implies that the same reliability in the services can be obtained with a lower reserve capacity.*

- *Installation of lower power generating capacity, as a result of differences in the load on each system. If two or more systems have different daily or annual load curves, the excess power capacity in one system can be used to supply others which are overloaded, rather than installing additional capacity in the latter.*

- *Overall savings as a result of the installation of larger size generating units, and of larger capacity power plants. When two or more systems are interconnected, larger size generators and power plants can be installed, providing a more economical division of generating resources between them, which probably would not be obtained if each system worked independently.*

- *Saving in the supply of energy through the coordinated operation of energy resources. When two or more electrical systems are interconnected, uneconomic use of water from the reservoirs in hydroelectric power plants can be avoided by management of the different regimes of the basins, i.e. the economic interchange based on the harmonized use of the lower cost generating resources.*

*1.3 Plans for coordination*

*From the moment two or more companies agree to coordinate their systems, a plan has to be defined to serve as a basis for their coordina-*

*tion.*

*Coordination plans usually adopted for the operation of electrical systems are as follows:*

- *Coordination between companies is limited to and adequate for the particular circumstances of each case.*

- *Coordination between companies is effected as though the set of interconnected systems were one single system.*

*1.3.1 Technical classification of interconnected electrical systems.*

*From the above, interconnected electrical systems can be divided into two basic, types, classed progressively according to level of coordination. In the United States of America they are known as "Interconnected Systems, "IS" and "Power Pools, PP".*

*The ISs include a large number of companies, and cover wide areas. Acording to the level of coordination adopted, they can be classed as follows:*

*Interconnected systems in which a coordinating body meets once or twice a year, limiting itself to forecasting power requirements and global consumption. The data thus obtained serves the companies to plan the expansion of their energy resources, the purchasing of energy, and the possible economic interchanges.*

*Interconnected systems in which the coordinating body advised by specialised technical committees, established combined operating norms which are periodically revised following the results of the actual operation. The coordinating body holds no power of enforcement. The norms adopted are accepted and followed voluntarily by the companies. It has no executive functions. Operations are carried out independently in each system by the respective specific body.*

*The method of control by multiple areas is used in the operation of these systems. That is, each company adjusts its own generating resources in order to absorb the load variations which occur in its system. The energy flow between interconnected electrical systems is programmed and controlled accordingly.*

*In these systems, the Load Dispatching Office of each company prepares a preliminary daily load program, including an hour by hour forecast, the turning reserves and excedents of each central, toghether with the incremental or decremental generating costs. Then the respective operation supervisors hold a telephone conference during which those costs are compared, to arrive at daily agreements by which certain companies forego either generating blocks or turning reserves for others available at lower cost. When a load program for the interconnection, which details the hourly load to be observed the following day, is agreed upon, each office then revises its own program.*

*It should be noted that the telephone conference does not present a problem since the economic distribution of the load differs very little from one day to another, and only gradually during the year, which means a small variation in the daily agreeements, unless an emergency occurs or new generating units go into service.*

*The loads on the interconnection lines, following the established hourly program, are maintained by automatic load and frequency control equipment, which generally operates according to the "tie line bias" principle. Each system absorbs its own load variations and even assists neighbouring systems temporarily, up to the limits agreed.*

*The PPs cover a small number of companies working in limited areas, which are associated more closely in order to benefit from common energy resources, and in some cases for joint expansion and financing of main generating and transmitting installations. The PPs can also be divided into two classes according to the level of coordination, as indicated below:*

- *Interconnected systems in which the controlling body keeps a permanent office which effects long and mid-range planning of operations, and, in some cases, planning for expansion of the main generating and transmitting installations of the member companies.*

  *However, the operation is directed individually by the Dispatching Offices of the companies, but the controlling body holds powers of enforcement, established in a legally binding document, by which the companies are obliged to follow the planning.*

- *Interconnected systems, the coordinating bodies of which, in addition to the functions described above, are also in charge* *of the daily operation of main generating and transmitting installations, through an independent Dispatching Office. The operation of local installations are left to the Dispatching Offices of the individual companies.*

*In these systems, the different companies are considered as one as far as daily operations are concerned. Thus, a common controlling body supervises the operation of the main production and transmission installations as a whole, and keeps a record of energy savings, distributing the latter equitably between parties, in such a way that load variations, wherever they may occur, are absorbed by the interconnected electrical systems as a whole.*

### 1.4 Technical problems

*In order for two or more systems to work in coordination, some technical problems concerning interconnection must be appropriately analysed and resolved. They are the following:*

- *Voltage control*
- *Repartition of load interconnected lines in parallel*
- *Protection system*
- *Static and transient stability*
- *Load and frequency control*
- *Communication system*
- *Long extra-high tension interconnection lines.*

### 1.5 Basic technical content of interconnection contracts

*The intercompany contracts for energy and power interchange (either within the same country or between different countries) should contain a series of clauses which define the responsability of the contracting parties. Generally speaking, energy and power interchange contracts contain the following techni- clauses, referring to:*

- *Organization of coordination activities*
- *Movement of reactive loads at points of interconnection*
- *Unintentional energy and power exchanges*
- *Protection at points of interconnection*
- *Communication between Load Dispatching offices*
- *Programming the energy to be supplied or received*
- *Stocking energy in third party reservoirs*
- *Substitution of hydraulic for thermal energy*
- *Suplementary and emergency supplies*
- *Interruption and reduction of supplies*
- *Power reserve*
- *Voltage and frequency variations*
- *Measurement systems*
- *Invoicing criteria*
- *Energy transfer through third party systems*
- *Accidents and "acts of God" (force majeure)*
- *Arbitration in case of disagreement*

## 2.0 INTERNATIONAL ELECTRICAL INTERCONNECTIONS

*Some mention should be made to the vast world-wide experience concerning international electrical interconnections, the concept and development of which could be useful in Latin America, which moved recently into this field.*

*In order to systematize the treatment of this subject, the following geographical areas will be considered:*

1) *Western Europe*
2) *Eastern Europe*
3) *North America*
4) *Central America*
5) *South America*

### 2.1 Concept and evolution of electrical interconnections in Western Europe

*The following stages can be noted:*

#### 2.1.1 From the beginning of electricity (end of 19th Century) to 1914

*On 28 August, 1891, during the International Electrotechnical Exhibition at Frankfurt-am-Main, Oskar von Miller transmitted electrical energy, at a relatively high voltage for the period, from Lauffen-Necker to the Exhibition grounds, a distance of 175 Km, with an energy loss of 24o/o. This demonstration showed that consumers did not have to be situated in the area where energy was produced and opened the way for the provision of energy to remote industries and lighting of distant cities.*

*From now on, it was only a question of finding an area relatively equidistant and fairly close to electrical energy consumer centres, from where the demand could be met. In other words, a central area, from which originated the name "electricity central".*

*During this period, electrification was predominantly local, at most regional, covering small areas within each country. However, not even the different electrified regions within the same country were interconnected, basically because of the different technical features of the sys-*

*tems (frequency, voltage, continous or alternating current, etc).*

*2.1.2 1918 – 1939*

*At this time, the European countries started an intense process of national electrification, caused by the large scale development of heavy industry and as a result of the integration of their electrical systems. During this period, because of the difficulties of importing combustibles, hydroelectric resources were developed to a maximum. In addition, the electrical companies within a country (the case of Italy, Switzerland, France, Germany, Belgium, Holland, etc.) cooperated in their planning either voluntarily or because of laws, decrees or regulations imposed by their respective governments.*

*In particular, the following can be noted:*

- *Intense electrification at national level*
- *Maximum benefit derived from hydroelectric resources*
- *Creation of legislation concerning electricity*
- *National coordination of activities of the different concessionary electrical companies.*

*In the field of international electrical interconnections, the results were not of relevance.*

*Apart from the major interconnections between Germany and the Alpine countries, the rest were either minor interconnections between border towns, or joint construction of hydroelectric stations as a result of international agreements.*

*The national legislation in effect was totally inadequate and hindered, rather than helped, the process of international electrical interconnections. The administrative requirements governing the import or export of electrical energy from one country to another constituted a deterrent. The magnitude of these difficulties rendered impossible emergency or seasonal electrical interchange, which was carried out only between border towns, and even then on a limited scale.*

*2.1.3 1945 – 1970*

*During the Second World War, the electrical systems of participating European countries were destroyed.*

*Between 1946 and 1950, the European countries adopted measures to mitigate: 1) the damages suffered by the systems; 2) the scarcity of combustibles; 3) the droughts which affected Europe and which diminished the availability of hydraulic power.*

*To relieve these conditions, which affected all the West European countries to a greater or lesser extent, an effort was made during the reconstruction of the electrical systems to achieve their technical harmonization, with a view to their eventual international interconnection.*

*In 1947, the International Union of Producers and Distributors of Electrical Energy (UNIPEDE) (established on 1st. January, 1925), created a Committee for the Study of International Electrical Interconnections, the objective of which was to collaborate with the countries in the field of coordinated operation of interconnected systems. Since the independent producers constituted a large group, their generating capacity was substantial, and they had established on their side the International Federation of Producers of Electricity for Own Consumption (FIPACE).*

*In order to combine their efforts, UNIPEDE and FIPACE established the International Confederation of Associations of Electrical Energy Producers (CILPE), which incorporated only those two associations. Neither UNIPEDE nor FIPACE are governmental organizations.*

*During this period, regular meetings were held in Europe by the Western countries and the United Kingdom. They met approximately every three months, in a forum called Public Utilities Panel (PANEL), where they exchanged information on the coordinated operation of electrical systems, as well as on public electrical services.*

*The PANEL meetings were very important: they established the need to build 220KV transmission lines, and to reinforce the lower voltage lines. From them emerged the Regional International Committees, with representatives from two or three countries, the purpose of which was to carry out studies aimed at international interconnection of the electrical systems, and at promoting the exchange of electrical energy.*

*It should be pointed out that existence of central agencies for the production and transmission of electrical energy, such as EDF in France, CPTE in Belgium, and SEP in Holland, rendered the work or PANEL easier.*

*In 1947, PANEL was dissolved, when its objectives were taken over by the Electrical Energy Committee of the European Economic Commission (EEC) of the United Nations.*

*The Organization for European Economic Cooperation (OEEC), was established 16 April, 1948, and was entrusted primarily with the distribution of assistance provided under the Marshall Plan. The following countries participated in it: Austria, Belgium, Denmark, Iceland, Ireland, Italy, Luxembourg, Norway, Portugal, Spain, Sweden, Sneitzerland, Turkey and the United Kingdom, in addition to the U.S.A. and Canada.*

*In 1949, the "Tecaid" mission sent by the OEEC to the U.S.A. recommended the establishment of associations for the coordination of production and transmission of electrical energy. This recommendation gave rise, in 1951, to the creation of the Association for the Coordination of Production and Transmission of Electrical Energy (UCPTE), incorporating Austria, Belgium, Federal Republic of Germany, France, Holland, Italy, Luxembourg, and Switzerland.*

*The Association was a logical consequence of the action of the member states as to electrification both at national and international levels.*

*The report of Tecaid pointed out the existence of national borders and of currency exchange restrictions which hampered the free interchange of electrical energy between the coun- interchange of electrical energy between the tries. Thus, the UCPTE requested OEEC to study the matter in order to have the governments allow the supply of electrical energy from abroad, and provide the necessary foreign currency for payment.*

*Following studies undertaken with the participation of the Electrical Energy Committee of the OEEC, the UCPTE, and the European Committee on Exchanges and Payments, the OEEC decided in 1953 to authorize the occasional import-export of energy and the allotment of the necessary foreign currency for payment by the importer.*

*In 1959, the authorization was extended to seasonal exchanges. Only long-term exchanges required prior authorization.*

*In addition to the UCPTE, other regional associations were formed, such as UFIPTE, NOREL, SUDEL, with the participation of the following countries:*

*UFIPTE (France, Portugal, Spain), established in 1962;*

*NORDEL (Denmark, Federal Republic of Germany, Finland, Iceland, Norway, and Sweden);*
*SUDEL (Austria, Italy and Yugoslavia)*

*Information on the above will be given futher on.*

*The integration of the systems under the Association for the Coordination of Production and Transmission of Electricity constitutes the Electrical Network of Western Europe.*

*2.1.4 1970 on*

*This period starts approximately at the end of the Sixties. During this stage, full integration of the European Electrical systems is sought, between, on one hande, the West European system, referred to above, comprising the integrated systems of the UCPTE and the regional associations; and on the other, the East European system, which comprises the electrical systems of the Council for Mutual Economic Assistance (COMECON), that is, Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland, Rumania and the Soviet Union.*

*The huge electrical system thus formed is denominated International Electrical System (SEI). Today, the two huge electrical systems (Western and Eastern), which do not work in parallel, are interconnected at some points through Austria (interconnected with Czechoslovaquia and Hungary), and through the Federal Republic of Germany (interconnected with Czechoslovakia).*

*The last stage of the international electrical interconnection in Europe, now under implementation, aims at the operation of the two huge systems in parallel.*

*2.1.5 Considerations and comments on the international electrical interconnections in Western Europe.*

*It seems appropriate to make some considerations on the above.*

*The international interconnections in Western and Eastern Europe are due to the joint action of the electrical companies and the international organizations for cooperation (such as UCPTE, OEEC, and COMECON), which have harmonized their technical and administrative activities, in order to favour, promote and stimulate, within limits the international exchange of electrical energy.*

*It is important to point out that this has been achieved in Western Europe without the signature of any multilateral treaty, and without the establishment of any international organization to centralize the exchanges of electrical energy.*

*That is, from the legal point of view, the rela-*

*tions between the parties involved are not based on multinational treaties, but on bilateral agreements, and above all, on the associations created by the producing companies, which are supported by the states.*

*Another interesting aspect is that supplies, operations, etc. are dealt with on a technical level, by those responsible for the integrated systems.*

*2.1.5.1 Types of contract*

*The international exchanges of electrical energy in Western Europe are regulated by different types of contract covering the following situations:*

- *Long-term contracts, when the objective is the regular export of energy from one country to another.*
- *Interchange contracts: 1) seasonal and daily, to profit from different hydraulic patterns or from different load curves; and 2) to coordinate the production of hydro-thermal systems.*
- *Occasional exchange contracts, covering use by one country of excess energy produced by another*
- *Emergency interchange contracts, covering the possible failure of a system*
- *Local distribution contracts, for border areas*
- *Interchange or allotment of production contracts, covering the case of power stations in border areas, shared by two countries.*

*It should be reiterated that all types of authorization or custom tariffs have been abolished in Western Europe for occasional and seasonal transfer of energy; only the long-term contracts require this sort of authorization.*

*2.1.5.2 Some intergovernmental and non-governmental organizations in the field of electrical energy.*

*European intergovernmental and non-governmental organizations that have been and are active in the field of electrical energy, and that have been mentioned previously, are briefly described below. The intergovernmental bodies appeared after 1945, and the non-governmental, in the Twenties.*

*The European Economic Commission (EEC) of the United Nations (U.N.) was established in December 1946, and started its work in May 1947, after its sanction in April of the same year by the Economic and Social Council of the U.N.*

*The aim of the Commission is to maintain and intensify the economic relations between the European countries among themselves and with the rest of the world.*

*In the 10th meeting of the EEC, the Electrical Energy Committee was established, with the purpose of studying all matters related to electrical energy in Western and Eastern Europe It replaced the Public utilities Panel (PANEL), established in 1945.*

*The Committee deals with matters concerning electrical energy and it is authorized to produce studies that include recommendations on the improvement of the coordinated utilization of their resources. However, the Committee can not undertake any steps concerning a country without its prior agreement.*

*The Committee receives advice from several permanent technical working groups, such as the one that dealt with hydraulic resources. This latter group produced in 1953 a study on hydroelectrical potential in Europe. The study triggered the establishment of international companies with the purpose of appraising the hydroelectric resources of those countries with large unexploited potential, and of looking into the possibilities of their exporting energy to other countries, etc.*

*Two companies were formed: YOUGELEX–PORT and INTERALPEN. In a way, they failed because of financial difficulties, over-ambitious objectives, non-profitable operations caused by high transmission losses and considerable investment, and also because of the explicit reluctance of the purchasing countries to depend on foreign sources of electricity for long periods of time.*

*The Organization for European Economic Cooperation (OEEC) and the Organization for Economic Cooperation and Devlopement (OECD). The OEEC was created in April 1948, and its main objective was the distribution of assistance under the Marshall Plan.*

*Governed by a Council, an Executive Committe, and a Secretariat, the OEEC established three committees to deal with the energy sector: one for coal, one for petroleum, and one for electricity. At the end of 1956, the Council of the Organization established the Consultative Commission on Energy, and the Committee on Energy.*

The functions of the Commission were to study the general problems of the sector, and its activities had an influence on the four other Committees mentioned above.

Upon creation of the European Common Market and the European Free Trade Association, the OEEC amended its statutes, and the OECD was established from it in December 1960. The latter started its work in September 1961 and its membership includes the OEEC countries plus Canada and the U.S.A.

The OECD, as its predecessor the OEEC, is not a regional organization as it includes Canada and the U.S.A. among its members.

At present, the OECD does not deal in any with electrical energy.

The European Nuclear Energy Agency (ENEA or AEEN). The OEEC established this agency in November 1957. Its objective is the explotation of nuclear energy by the Eurpean countries

ENEA has brought about cooperation of the member countries in technical, economical and political aspects in the field of nuclear energy.

The International Association of Producers and Distributors of Electrical Energy (UNIPEDE) It was established on 1 January 1925. It is a professional association of producers who study those matters which could promote their industry.

UNIPEDE constitutes a direct liaison between producers in the different member countries, who meet to exchange their experiences and points view on problems of international scope or of interest to the majority.

Its technical action is carried out through study committees. In particular, the Committee on Large Networks and International Electrical Interconnections has contributed significantly to the development of exchanges of electrical energy between the West European countries.

The International Federation of Industrial Producers of Electricity for Autoconsumption (FIPACE). It was established in 1954, and it is a professional association of independent producers.

The International Liaison Conference between Producers of Electrical Energy (CILPE) has two members: UNIPEDE and FIPACE.

The Association for the Coordination of Production and Transmission of Electricity (UCPTE). It is an international non-governmental organization. Its creation was brought about at the end of December 1950 following an initiative of the Council of the OEEC, based on a proposal of its Committee on Electricity.

It is very important to note that this Association and those of a regional character that stemmed from it (UFIPTE, NORDEL, and SUDEL), are associations between representatives of companies, rather than government organizations with legal status as such.

They aim at a better utilization of the energy production and transmission facilities both in existence or being planned in the member countries.

The activity of UCPTE is oriented towards the intensification of electrical energy exchanges between its members. Within this framework, the regional associations already mentioned are agents for the implementation of its objectives.

UCPTE groups eight West European countries: Austria, Belgium, Federal Republic of Germany France, Holland, Italy, Luxemburg and Switzerland.

The other three regional associations (UFIPTE, NORDEL and SUDEL), cooperate closely with UCPTE and group the electrical systems of other countries, although in each association there is always a country that belongs to UCPTE.

UFIPTE (Franco-Iberic Association for the Coodination of Production and Transmission of Electricity), groups the electrical systems of France (member of UCPTE), Portugal and Spain. It started its activities in 1962.

NORDEL was established in 1963 and at present groups the electrical systems of the Federal Republic of Germany (member of UCPTE), Denmark, Finland, Inceland, Norway and Sweden. (In 1965 the interconnection via underwater cable between Denmark and Sweden made possible the linking of NORDEL and UCPTE networks.)

SUDEL was established in 1964 and it incorporates the electrical systems of Austria (member of UCPTE), Italy (member of UCPTE), and Yugoslavia.

The tasks of these associations (UCPTE, FIPTE, NORDEL and SUDEL) are essentially as follows:

1) Inform the producers of electrical energy on possibilities as to generation and transmission.

2) Study the improvements that could ena-

*ble exploitation in parallel of all the interconnected systems.*

3) *Promote the administrative measures that could favour the international interchange of electrical energy.*

4) *Promote and establishe bilateral contacts between countries for the interchange of electrical energy. The interested parties negotiate the regulations that would govern the interchanges.*

*The fundamental role played by UCPTE between 1951 and 1961 in the total liberation of occasional and seasonal exchanges of electrical energy has already been dealt with. Its negotiations with the OEEC and the European Committee for Interchanges and Payments, were crowned with success.*

*It is important to point out that UCPTE is not fully developed as an institution, but has played a very important role concerning the international interconnections and interchanges of electrical energy.*

*Finally, its should be noted that all the electrical systems between the UCPTE and affiliates work in parallel to make possible the export-import transactions under long-term contracts, as well as those of short-term, occasional and seasonal nature.*

## 2.2 *Concept and evolution of electrical interconnections in Eastern Europe*

*The Council for Mutual Economic Assitance (COMECON) is an international body of regional character which centralizes economic cooperation between socialist countries.*

*It was created in January 1947, but its activities began two years later. The member countries are: Bulgaria, Cuba, Czechoslovakia, Democratic Republic of Germany, Hungary, Mongolia, Poland, Rumania, and the Soviet Union. Headquarters of the General Secretariat are in Moscow.*

*In June 1962, two COMECON bodies were reorganized to reinforce their authority: the Executive Council and the Office for Coordination of Economic Planning.*

*A large number Permanent Commissions were created by the executive Council to promote the development of relations between member countries and to stimulate multilateral technical economic, and scientific cooperation in the different economic sectors.*

*In 1958, on the occasion of the 10th Session of COMECON, the Permanent Commission for Electrical Energy was created. It succeeded the Commission for Electrical Energy Interchange and Exploitation of the Hydraulic Energy of the River Danube.*

*The aim of the Commission is to facilitate the development of electrical interconnections between member countries. All the member countries are represented in the Commission by technical specialists.*

*The seat of the Commission is in Moscow. It is advised by working groups which are created according to need.*

*The Commission can make recommendations directly to the Member States, without the intervention of higher bodies, and can formulate multilateral projects and recommend them directly to member countries for their approval.*

*It appears that the Member States are bound by the recommendations adopted from the moment when verbal agreement is reached at the meeting. The Executive Comittee has authority to enforce the recommendations.*

*The Commission works according to Five-Year Plans, and presents an annual report on its activities to the Conference of Representatives, a permanent body which directs the work of the COMECON during the periods between sessions of the Council, which is the highest body.*

*The interconnected electrical system of East European countries is called the International Electrical System (SEI), and incorporates the coordinated operations in parallel of the systems in Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Rumania and the Soviet Union.*

*The operations are coordinated by a central office, with Headquarters in Prague. There are some interesting cases which are worth further comment.*

*The East German system is interconnected to the Czech and Polish systems by 220KV lines. The interconnections between the three countries constitute a true triangular operation. In fact, Czechoslovakia exports to East Germany, the latter to Poland, and Poland to Czechoslovakia. Payments between the three countries are affected quarterly.*

*The Soviet Union and Hungary are interconnected by 220 and 400KV lines. Hungary uses these lines to import electrical energy under long-term contracts.*

*Among the West European countries, Austria has a special position, since it is interconnected to Czechoslovakia and Hungary. Austria supplies Czechoslovakia with energy in summer, and receives energy in winter.*

*The Austrian and Czech systems operate in parallel with the UCPTE and IES systems respectively; however, the former cannot operate in parallel between themselves.*

*West Germany is also interconnected to Czechoslovakia. Possibly, when the UCPTE (West Europe) and the SEI (East Europe) systems are interconnected, the points of inteconnection would be at the border between Austria and Czechoslovakia.*

*Austria, in addition, is interconnected with Yugoslavia under the three folowing types of contract:*

1) *Yugoslavia receives industrial products in exchange for electrical energy exported to Austria.*

2) *Austria exports electrical energy to Yugoslavia in summer, and imports in winter.*

3) *The two countries interchange energy against payment of the imbalances.*

## 2.3 *Concept and evolution of electrical interconnections in North America*

### *2.3.1 The United States of America*

*77o/o of the demand in the United States is met by private companies supplying electricity as a public service, and the rest by organizations and cooperatives financed by the Government.*

*Independent producers generated approximately 11o/o of the total amount of electricity consumed in the U.S.A.*

*There are approximately 400 electrical companies which constitute separate entities, working in coordination to operate in the most economical and efficient way possible. The Edison Electrical Institute was formed to favour such cooperation.*

*It is a commercial association created in 1933, in the interest of the community, to promote the progress of electrical energy production, transmission and distribution. The Institute acts through Working Committees composed of representatives of the member companies. At present there are 80 Committees and Working Groups in activity.*

*As elsewhere in the world, electricity in the United States appeared first in the desely populated areas where demand was met by small plants owned by different companies.*

*Due to economic reasons, these small plants were substituted by others of larger capacity, and in turn the different companies started to interconnect their systems, this being the origin of huge electrical companies which at present meet the demand of the whole country. A certain number of companies participate in these interconnected systems, which have different levels of integration.*

*They designed and constructed their plants and transmission lines according to a program which optimizes the system as a whole in all its aspects.*

*These groups were formed mainly due to several technological factors, in particular because of the possibility of relying on huge generating unites in large capacity plants. In fact there are very few companies which can justify and absorb the cost of installation of the large plants needed to benefit from large-scale generation.*

*Another reason was the increase in the voltage of electrical transmission lines which allow the transportation of large blocks of energy over long distances.*

*Another technological factor which permited the increase, perhaps exagerated (as shown by the power failure on the East Coast a few years ago) in the size of the groups, was the use of advanced computers needed by the joint load dispatching offices to obtain maximum savings.*

*The existence of a joint load dispatching office, which results in the most economical distribution, does not imply dependence as to planning and construction of stations, but only as to their operation.*

*It is important to note the complete absence of a contractual framework and the fact that agreements are reached by unanimity. As up to now, all members have respected their duties and obligations; a legal instrument has not been considered necessary to define rights, obligations and sanctions.*

*That is, the arrangement is de fact and not de jure, since the association of companies is voluntary. Each company has a different financial structure. They work together for their mutual benefit, without losing identity and sovereingnity in the area they serve.*

*Each company voluntarily offers its generating* *and transmission facilities to a general program which optimizes the combined capacity of the group for the production of electrical energy.*

*The group is directed by an Operations Committee, incorporating representatives of the companies, and a Coordinating Group that advises the Committee, which either reaches a decision through unanimous vote, or rejects the proposal.*

*Questions concerning the transmission of energy across the State borders within the U.S.A., are under the jurisdiction of the Federal Commission of Electricity (FCE). The electrical companies issue contracts to their customers. When foreign customers request services that require international electrical interconnections and authorization from the FCE is necessary, and the electrical company is bound to the foreign customer by contracts similar to those used with national customers.*

*The contracts are of private nature. For example, if an American electrical cooperative sells energy to a foreign electrical company, the latter must become a member of the cooperative, and the fact that it is on the other side of a border has no legal implications.*

*2.3.2 Electrical interconnections between Mexico and the U.S.A.*

*There are thirteen electrical interconnections between the U.S.A. and Mexico, including the electrical interconnection at Falcon. All of them represent net sales from the U.S. to Mexico with the exception of the Falcon plant where the nil balance system is used.*

*Three international rivers run between Mexico and the U.S.: The Grande, the Colorado and the Tijuana. The first two are border rivers, and the last one crosses the two countries successively. The use of water from these rivers was regulated by the two Water Treaties of 3 February 1944. One of them regulates the use of the Rio Grande waters between Ciudad Juarez and Fort Quitman in Texas; the other regulates the use of the rest of the Rio Grande waters, and those of the Colorado and the Tijuana Rivers.*

*The legal antecedents of the treaties can be found in the International Border Convention of 1 May 1899, and the Treaty of 1906.*

*The international Falcon Dam on the Rio Grande was finished in 1953 and is the first construction of international nature undertaken by two governments.*

*Its cost was pro-rated according to the water storage capacity alloted to each country, but the cost of construction, operation and maintenance of the electrical plants was shared equally between the two countries. The electrical energy produced is distributed in the same way. The two plants are identical, and at the beginning they operated in parallel, but later, due to the different consumption patterns in each country, an independent operation was preferred.*

*Each country generates its electricity independently, according to its needs, if and when the energy does not exceed a fixed average (65,000 Kwh).*

*The interconnection is in fact maintained for compensations or emergencies and operates on a nil balance system.*

*The Amistad Dam in the Rio Bravo is situated 20 Km up river from Acuña-Coahuila, Mexico, and Del Rio, Texas, and was planned to operate with the Falcon Dam. It produces 323 x $10^6$ Kwh anually, equally divided between the two countries.*

*2.3.3 Electrical interconnections between Canada and the U.S.A.*

*The most important electrical interconnections between Canada and the U.S. are situated on the Saint Lawrence and Columbia rivers.*

*The Robert Moses/Rober H. Saunder hydroelectric plant is on the St. Lawrence. It has an installed capacity of 1,824 MW and generates anually some 6,500 GWh for each country.*

*The costs of construction, operation and maintenance were divided equally between the two countries, with the exception of the costs for the sixteen turbines and an equal number of generators on each side.*

*The aim of the undertaking was to generate electrical energy taking advantage of the fact that the national companies responsible for construction were interconnected and formed part of the group which supplies the East Coast of the U.S.*

*Joint Canada–U.S. projects on the Columbia River.*

*Before the agreement for joint exploitation of the Columbia River, the U.S. had constructed hydroelectric plants without reservoirs on the river, for a total installed power of 10 x $10^6$ KW. However, when the flow of the river diminished, they could not generate at maximum capacity.*

*On the other hand, the irregularity of the flow caused the loss of large volumes for generation, and the consequent loss of energy.*

*The objective of the Columbia River Treaty was to generate low cost energy and to control the floods produced by the swelling of the river. The Treaty also dealt with the transmission of energy which remained the responsibility of the U.S. The U.S. also retained the right to build storage dams to control the swelling, to generate power and possibly divert the flow during certain periods.*

*The Treaty is valid for 60 years. Canada, on its side, agreed to cede its rights to the Province of British Columbia. The latter assumed all the obligations which were previously the responsability of Canada.*

*British Columbia did not use the energy to which it was entitled (originally belonging to Canada), but sold its rights to the U.S. in order to obtain funds to finance the Canadian part of the project.*

*The project was very complex to carry out because of geographical and geological reasons. Each country is responsible for the operation of the project, but work must be coordinated to keep its unity.*

*To reach an agreement, the negotiations took into account the benefits for each party. The main guideline was equal profits.*

2.4 *International electrical interconnections in South America: Present and future*

*Generalities*

*Before going into details, it would seem appropriate to cast a rapid glance over the South American situation in order to understand better development and future trends.*

*The subcontinent presents some particular geodemographic aspects. It can be said that is basically perimetral or coastal, since most of the population, cities, industries and commerce are situated in a strip parallel to the coast. The rest of the subcontinent it composed of large areas, mostly uninhabited, covered by huge forests.*

*In addition, the Andes mountains, stretching from the Straights of Magellan to Venezuela, represent another exceptional feature.*

*The economic development of the South American countries has taken place within this sociogeographic framework, and electrification was equally effected by it.*

*Since the beginning of the century until approximately 1950, electrification was localised and urban, given that the areas of large human and economic concentration, such as cities, offered profitable markets. From that period on, the countries began, in general, to take advantage of their extensive hydroelectrical resources, and of electrical interconnections between the different regions, which were developed to a greater or lesser extent.*

*This process continues today, and it can be said with assurance that is first priority in all the South American countries.*

*The internal electric interconnections of the different systems in each country, were also "perimetral" or "coastal", because of the general characteristics of the subcontinent, already mentioned. However, certain internal systems, relatively isolated from the coast, achieved a high level of development (such as the systems of Cuyo and Cordoba in Argentina, La Paz in Bolivia, Asunción in Paraguay, and those of Cali, Bogota and Medellin in Colombia).*

*The process of interconnection between the different national electrical systems in the South American countries, always with a large city as a load centre, began approximately in the Sixties.*

*This process continues today and will carry on during the next fifteen years.*

*To put it more graphically, in general the countries are like so many electrical archipelagos, and are trying to lay bridges between the islands, i.e. to interconnect them electrically.*

*For these reasons, the border towns have remained merginated from the interconnection processes and their needs are met by isolated diesel generators or small electrical systems.*

*The CIER *, created in 1964, has undertaken a very important and extensive work in the electrical subsector, which is basically interesting in two aspects. The first was to promote the internal interconnection of isolated national systems of member countries, and the second, to stimulate international interconnections between countries.*

*Present international electrical interconnections between CIER countries ***

*These two objectives, among many others in favour of the electrical subsector, were purdued with calm, caution and firmness.*

*These occurred in two large areas of South America almost simultaneously and with similar features, in 1965: in the Southern Cone, between Brasil and Uruguay, and in the North between Colombia and Venezuela. In the future international electrical interconnection will be increased in the Southern Cone, perhaps because of the existence of large rivers with immense hydroelectric possibilities and a more favourable geography than that of the northern area.*

*Reference will be made below, case by case, to present and future interconnections between the member countries of the CIER.*

*2.4.1 Brazil – Uruguay*

*As already mentioned, international electrical interconnections were established at four border points between the two countries in 1965. These were local interconnections between contiguous Brazilian and Uruguayan towns, situated along the border (Artigas - Quaria, Rivera - Livramento, Rio Branco - Jaguarao, Chuy - Xui).*

*In principle these interconnections were independent from each other and were not interconnected to the main electrical systems of either country.*

*The four interconnections, which were not important undertakings, required an agreement for electrical energy interchange.*

*During the negotiations, Uruguay was represented by the General Administration for State Power Plants and Telephones (UTE) (now, State Power Plants and Electrical Transmission) and Brazil was represented by the State Company for Electrical Energy (CEEE) of the Brazilian state of Rio Grande do Sul. As a result of this agreement, and another signed later (which will be mentioned further on), the diesel generators ceased to operate and were kept in reserve and for load compensation.*

*A further agreement was signed between UTE and the thermoelectric plant at Alegrete (Termoale, a subsidiary of Electrobras), which allowed the supply of electrical energy to the Uruguayan town of Artigas and Rivera, which remain incorporated in the system of the plant mentioned above, until the national Uruguayan interconnected system reaches them. Termoale assures a capacity of 2 MW for town of Artigas and 3 MW for Rivera as support and substitution (depending on the time of the day) for the diesel plants existing in those towns.*

*A uniform price was established for energy, which is transferred only in one direction, from Brazil to Uruguay.*

*The Rio Branco - Jaguarao interconnection only effects occasional energy interchanges. The Cuy - Xui interconnection effects interchanges which are slightly favourable to Uruguay.*

*The interchange between Brazil and Uruguay, originally undertaken between the CEEE and the UTE for the four border points mentioned, was then substituted, as was explained, for a supply from the Brazilian plant of Termoale to the Uruguayan towns of Artigas and Rivera, leaving the two other points of interconnection (Rio Branco - Jaguarao and Chuy - Xui) linked, in case of emergency.*

*The following interchanges have been effected:*

*cuadro No. 1*

ENERGY IN GWH

| YEAR | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 |
|---|---|---|---|---|---|---|---|---|
| FROM BRAZIL | 1.6 | 2.6 | 16.1 | 20.8 | 25.4 | 25.9 | 23.7 | 19.7 |
| FROM URUGUAY | 2.1 | 0.9 | 0 | 0 | 0 | 0 | 0.7 | 0.4 |

*The power transmitted is limited to 10 MW.*

*It is important to note the economic conditions of the contract. A price was fixed in US dollars per KWh of energy sold, payable in the currency of the selling country, within a certain period and upon presentation of a monthly invoice. If the payment was not effected within the period, the supplier country could suspend the service. There is a clause concerning the interest rates on delayed payments.*

** CIER, Commission for Regional Electrical Integration. A nongovernmental international association which links the public, private and state electrical companies of Argentina, Bolivia, Colombia, Chile, Ecuador, Paraguay, Peru, Uruguay and Venezuela. The companies choose a CIER National Committee in each country, which represents them internationally, and which must be recognized by each government, at the level that each one considers pertinent.*

*** Guyana and Surinam do not belong to the CIER.*

2.4.2 Colombia – Venezuela

This international interconnection started in 1965 and underwent a series of modifications over the years.

Originally there was an agreement between the Northern Electrical Power Station of Santander in Colombia, and the Company for Electrical Development (CADAFE) in Venezuela. Later, the Colombian company was replaced by the Colombian Institute for Electrical Energy (ICEL). The first company mentioned, which serves the department of Santander, meets the demands of the capital of the province, the city of Cúcuta. On their side, CADAFE meets the needs of the Venezuelan state of Tachira. The interconnection was made through three lines with the following technical characteristics:

- 13.8 KV, 60H, with a transmitting capacity of 12 MW
- 34.5 KV, 60H, with a transmitting capacity of 12 MW
- 115 KV, 60H, with a transmitting capacity of 30 MW.

Each country constructed the interconnection lines in its own territory. Their lenght, from one end to the other, does not exceed 30 Km.

The agreement reached was of the "nil balance" type, and the quarterly differences cannot exceed 2 GW in favour of either party.

The three lines interconnect the Venezuelan plant of La Fria, with a capacity of 40 MW, to the Colombian plant of Tibu, with 18 MW, and that of Rio Zulia, with 15 MW.

The interconnection is controlled by a Joint Permanent Commission, and expansion is being considered for the time when Venezuela will construct and operate the important hydroelectric power plant of Rio Uribantes. Probably the interconnection under study will operate at 220 KV.

cuadro No. 2

ENERGY IN GWH

| YEAR | 1974 | 1975 | 1976 |
|---|---|---|---|
| FROM COLOMBIA | 7.8 | 1.4 | 0.5 |
| FROM VENEZUELA | 9.5 | 1 | 1.4 |

The maximum power from Colombia is 2 MW, from Venezuela, 20 MW.

As can be seen, the aim of this agreement is to achieve nil balance. If not, the excess KWh are paid by the receiving country in local currency (equivalent to the amount calculated in US dollars), within a certain established delay. within a certain established delay.

2.4.3 Argentina – Paraguay

The Paraguayan plant at Acaray, on the river of the same name, an affluent of the Parana River, was the first power plant to be constructed under the concept of integration. It has a capacity of 90 MW, which will shortly be expanded to 180 MW. Its economic justification stems from its interconnection with Argentina and Brazil, to which it sells energy.

The interconnection with Argentina takes place in the Province of Misiones and services are furnished to the Electrical Company of Misiones S.A. (EMSA) to meet the demand of the provincial capital, Posadas, and neighbouring localities.

EMSA, for Argentina, and the National Electricity Administration (ANDE) for Paraguay, agreed on the interconnection on the basis that the ANDE would meet the demand from the areas of Misiones mentioned, and EMSA would keep in reserve a diesel generator in Posadas for cases of emergency.

As a result of the interconnection, a 132 KV transmission line was constructed from the Acaray Plant to the town of Carlos A. Lopez (Paraguay), which is separated from the town of El Dorado in Argentina by the Parana River. Each company constructed the line in its own country, and the crossing of the Parana River was considered a joint undertaking. The agreement foresees a second crossing of the Parana from Posadas to the city if Encarnacion in Paraguay, so that this city will be supplied with 3 MW through the binational energy line from Acaray.

The agreement is effective for ten years and began in 1971. In addition it fixes the power guaranteed by the Acaray hydroelectrical plant to EMSA, which varies between 17 and MW.

ANDE invoices its electricity sales monthly on the basis of two parameters: power and energy. The agreement cover daily and montly load factors with maximum limits and power factors with montly, daily and hourly averages.

The agreement foresees interruptions by ANDE *of a certain number of hours per year, as well as the fines applicable to ANDE in case the interruptions not due to force majeure exceed the agreed number of hours.*

*The supply of energy is limited to 3,220 hours per year for each yearly unit of power garanteed, with provisions for the compensation due in case secondary, tertiary, or even quaternary power is supplied.*

*The agreement envisages the signature of a second one, before the expiration of the first (ten years), given that the expansion of the Acaray power plant is under way.*

*The supply of energy from the Acaray hydroelectric plant is of real significance for the province of Misiones.*

*The price established in the agreement is a funtion of two parameters: the agreed amount of power guaranteed in KW, and the montly consumption in KWh.*

*It also establishes the possibility of having secondary power, for which a price is given. That power is in excess of the amount guaranteed, and the consumer can occasionally have access to it, provided the supplier is in a position to deliver it.*

*This secondary power results in secondary energy.*

*The contract foresees also the possible supply of tertiary energy, that is the energy drawn within the power contractually guaranteed, during a number of hours, in excess of the agreed annual figure, but within the maximum yearly number of hours established.*

*The payments to ANDE are to be effected monthly, in freely convertible US dollars, adjustable in case of devaluation of the US currency. If payment if not effected in 45 days, ANDE can interrupt the service, which does nor relieve EMSA from the penalties applicable, and payment of interest on the overdue balances.*

*If ANDE does not meet the deliveries as stipulated in the contract, it is liable to fines from EMSA, except in the case of force majeure.*

*The contract also contains clauses on payment for reactive power beyond certain limits.*

*2.4.4 Brazil – Paraguay*

*As established previously, the construction of the Acaray hydroelectrical plant implied its interconnection with the system belonging to the Paraense Electrical Company (COPEL), which is responsible for the electric services in the Brazilian state of Paraná.*

*To that effect, a 132 KV line was built (Acaray-Foz de Iguaçu, Brazil), but it was necessary to install a 50/60 Hz frequency converter, because Paraguay is on 50 Hz, while Brazil is on 60 Hz.*

*As was the case with Argentina, each country built the portion of the line within its territory. The guaranteed power was established at 23 MW, with a maximum of 30 MVA, and a yearly total of 3,220 hours of utilization. Maximum values were determined for COPEL's load factor, both daily and montly, as well as limits for the reactive power, and for the number of interruptions during the period of calidity of the contract, set at ten years.*

*On the other hand, COPEL would take maximum annual energy of 74.244 GWh. Through a supplementary agreement, the possibility of duplicating the power supplied was envisaged (as was the case with the ANDE – EMSA agreement), when the Acaray hydroelectrical plant would be expanded. The details as to load factors and prices follow the pattern of the ANDE – EMSA agreement, without being identical.*

*The interchanges effected by ANDE with EMSA and COPEL are as follows:*

*Cuadro No. 3*

ENERGY IN GWA

| | YEAR | 1973 | 1974 | 1975 | 1976 |
|---|---|---|---|---|---|
| ANDE–ENSA | POWER MW | 17 | 19 | 21 | 23 |
| | ENERGY GWH | 66 | 95 | 121 | 130 |
| ANDE–COPEL | POWER MW | 16 | 23 | 23 | 23 |
| | ENERGY GWH | 9 | 60 | 74 | 74 |

*2.4.5 Colombia – Ecuador*

*There is a small interconnection between the town of Ipiales (Colombia) and Tulcán (Ecuador).*

*Ipiales is served by the Nariño Electrical Power Plant, and Tulcán by the Tulcán Electrical Company. The agreement was signed by the Colombian Institute of Electrical Energy (ICEL), and the Ecuadorian Institute of Electrical Energy (INECEL), and envisages nil monthly balances, although a price is fixed for energy, in case this does not occur.*

A 13.3 KV, 60 Hz line, conncects the two towns; in the future, it will be able to operate at 33 KV.

The agreement does not include clauses on guaranteed power, and therefore the power supplied depends on the possibilites of the parties. Its duration is two years, with automatic yearly extensions.

The whole interconnection line was built by ICEL, and INECEL will pay its share over a five year period.

2.4.6 Argentina – Uruguay

The Uruguay town and port of Salto, on the Uruguay River, was until recently not incorporated into the country's Western System.

As a result of this, and because of breakdowns in its diesel power plant, the electrical supply of Salto underwent very critical periods.

To relieve this situation temporarily until the interconnection with the Western System, the town was interconnected with Concordia (Argentina), which faces Salto on the other side of the river.

The agreement was negotiated for Argentina by the Electrical Cooperative of Concordia, and for Uruguay by the General Administration of the State Power Plants and Telephones (UTE).

The agreement was based on mutual complementarity, while recognizing that during the first years there would be a flow from Concordia to Salto.

Both companies decided to construct a 22.8 KV line bridging the Uruguay River. The voltage can be brought to 138/150 KV, that is, the interconnection tension of each town with their respective systems in each country.

Financing and construction of the line was shared equally by the two parties.

Argentina agreed to guarantee a supply of 1 MW, with the possible non-guaranteed supply of an addition 2 MW, Monthly payments are stipulated, and UTE undertakes to draw 36 Wh per year, up to the time Salto is interconnected to the Western System.

This interconnection has since been made, and at present there is no flow of energy through the Concordia – Salto line, except during emergencies. However, its future utilization is under consideration.

The interchanges have been:

| Year | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|
| GWh | 1.1 | 7.7 | 7.9 | 10 | 7.4 | 0 |

2.4.7 Argentina – Chile

There is an interconnection in the South, between the towns of Rio Turbio (Argentina) and Puerto Natales (Chile).

Chile receives energy from the thermal power station of Fiscal Coal Deposits (YCF), in Argentina, through a 33 KV line, which operates at 13.2 KV.

The agreement was signed by the Chilean National Electrical Company (ENDESA) and YCF. The latter undertakes basically to supply electrical energy to Puerto Natales during the three daily peak hours.

ENDESA, on its side, undertakes to purchase a minimum of 1.5 GWh per year. Each country built the necessary installations on its own territory.

The agreement was put into effect in 1970, for a period of five years, with automatic yearly extensions. It is still in force.

The power required by Chile during the peak load periods has oscillated between 450 and 600 KW between 1971 and 1974. The energy purchased by ENDECA reached 2.5 GWh in 1975, with the power under 1 MW.

The financial provisions established different prices for supply within guaranteed power limits at different hours. The tarif is binomial: a fixed monthly sum for guaranteed power, plus the price of energy in US dollars per KWh supplied.

2.4.8 Argentina – Bolivia

The agreement between the Argentinian State Company, Water and Electrical Energy (AYEE) and the Provincial Commission for Development and Public Works of the town of Villazón, in the Departament of Tarija, Bolivia, consists of the interchange of energy between the power stations of Quiaca (Argentina) and Villazón (Bolivia).

The terms of the agreement are:

AYEE guarantees 40 KW during hours of daylight, and a nonguaranteed 250 KW during hours of darkness. The Villazón Commission guarantees Quiaca 250 KW during the night.

*The transmission line operates at 13.2 KV and 50 Hz, the frequency common to both countries.*

*The agreement is valid for five years, renewable prior agreement of the parties. The energy interchange has been of little significance.*

*2.4.9 Bolivia – Brazil*

*There is a minor interconnection between the border towns of Corumba, Brazil and Puerto Busch, Bolicia. The first town supplies energy to the second.*

*Future international electrical interconnections between the CIER countries.*

*The projects under study, or realization are very important. All of them are in the River Plate Basin.*

*Reference to them is made in the following:*

*2.4.10 Argentina – Uruguay*

*The Salto Grande Hydroelectric Power Station, on the Uruguay River, the border between the two countries, is under construction.*

*The installed power, shared equally by the two countries, will be 1,890 MW, and includes excess capacity.*

*The Salto Grande Joint Commission has responsability for the construction and commissioning of the power station. Later, the station will be under the Administrative Commission of the Uruguay River, which will deal with matters of common interest concerning the river.*

*The lines of the interconnected system in both countries will operate at 500 KV. The civil engineering work is well advanced, and the first generating unit will be in operation during 1980.*

*The initial capital contributions were very uneven: Argentina took care of a high percentage of the total investment required. Because of this, the Uruguayan share of power and energy during the first years of operation will be one sixth, thus permitting Argentina to recuperate its larger initial investment.*

*Later on, Uruguay will increase its share up to its entitlement of 50o/o by 1995/1996.*

*Summing up, under the agreement, both countries eventually contribute equivalent amounts: but initially one of them (Argentina), invests more capital than the other (Uruguay), which later on repays the difference along several years. At the end of 1995, both countries will have contributed equally.*

*Interconnection of the Greater Buenos Aires and the Argentinian Litoral Electrical System with the Uruguayan interconnected system.*

*In 1947, an agreement for the interconnection of the two systems was signed by the two governments. The objective was to secure the backing of the Uruguayan system by the Argentinian, until the Salto Grande Hydroelectric Power Station starts operations. The interconnection was effected between the towns of Paysandu (Uruguay), and Concepcion del Uruguay (Argentina), both on the Uruguay River.*

*The interconnection will be effected through a 138/150 KV line, which will be in operation next year.*

*The agreement envisages the provision by Argentina of thermal support to the Uruguayan interconnected system by 1978, up to 100 MW.*

*2.4.11 Argentina – Brazil*

*Water and Electrical Energy (AYEE), an Argentinian State Company, and ELECTROBRAS of Brazil, signed, in 1972, an agreement to study the exploitation of the Uruguay River which serves as a border between the two countries.*

*The study indicated a number of sites which offer good possibilities for hydroelectric generation. They are: San Pedro, 745 MW; Garabi, 1,825 MW; Roncador, or Panambi, 2,700 MW.*

*At present, a preliminary project for the Garabi site is being prepared. It offers the lowest estimated cost per KW of installed power.*

*As a whole, the sites mentioned above could furnish approximately 20.000 GWh of energy per year. Actual work could start, as things go at present, in about five years time.*

*2.4.12 Argentina – Paraguay*

*These two countries have undertaken the study of an approximately 2,000 MW hydroelectric power station situated where the Yacireta-Apipe Islands lie in the Parana River, which is a border between the two countries.*

*Consideration is also being given to another large capacity power station in the same river. Construction work on this project, known as "Corpus", and on the previously mentioned one, could be started in less than ten years.*

2.4.13 Argentina – Chile

The National Electrical Company (ENDESA) in Chile and the Argentinian State Company Water and Electrical Energy (AYEE), have been studying for the last four years, the possible interconnection between the central system in Chile and the Cuyano system in Argentina (San Juan and Mendoza Provinces). To that effect, they formed in 1972 the Commission for the Chilean - Argentinian Interconnection (CIECHA), which has furthered the studies needed to realize the interconnection.

The interchanges as power, as foreseen, would be in the order of 150 MW, and presumably the transmission line would operate at 220 KV

2.4.14 Argentina – Bolivia – Paraguay

The hydroelectric explotation of the Pilcomayo River, which has its sources in Bolivia and then becomes a border between Argentina and Paraguay, is being studied at present.

Nothing concrete has emerged yet from the very general considerations made so far.

2.4.15 Brazil – Paraguay

After reaching pertinent agreements, the governments of both countries began construction in 1955 on the Itaipu Hydroelectric Plant, the largest in the world, with an installed capacity of 12,600 MW.

The project is being undertaken by a binational body, "Itaipu", which incorporates the Paraguayan National Electricity Administration (ANDE) and the Brazilian ELECTROBRAS (Brazilian Electrical Power Plants). The project would be operative in 1983, but work has been delayed and the original budget has been largely exceeded as a result of the 1973 economic crisis and world inflation.

Transmission of energy in Paraguay is planned on 400 KV lines, and in Brazil on 500 KV lines. Each country will be responsible for construction of the respective lines.

2.4.16 Brazil – Uruguay

Both countries created, some years ago, the Joint Comission for the Lake Merin Basin, which they share. The studies have been multidisciplinary, basically related to development of agriculture, irrigation, industry, flood control, etc. From these studies came the possibility of constructing a 32 MW hydroelectric plant in an irrigation dam situated on the River Yaguaron, affluent of Lake Merin, which, in addition, is the international boundary between the two countries.

This plant, Paso del Centurion, will be interconnected in Brazil with the Rio Grande do Sul State electrical system, and in Uruguay with the district capitals of Melo and Treinta y Tres, at present fed by diesel generators.

The extension of the Uruguayan transmission line from Paso del Centurion to the interconnected hydroelectric plants on the Rio Negro. has been considered. However, nothing has yet been defined, given the technical difficulties to be overcome.

As the South Brazilian system will shortly be interconnected with the Northern system, this would give an interconnected system the whole length of the Atlantic Coast (bearing in mind the Argentinian – Uruguayan interconnections previously mentioned). It would run from the extreme north east of Brazil to Argentina, passing through Uruguay, and, in the future, through Uruguay, and, in the future, through Paraguay.

However, it should be recognized that some of the junctions will have to be reinforced for the whole system to operate.

2.4.17 Intergovernmental and non-governmental organizations in the field of electrical energy.

It is appropriate to mention the South American organization which have played a relevant role in the field of electrical interconnections.

It can be said that the seed of electrical integration was planted on the occasion of the first Latin America Seminar on Electricity, organized by ECLA and held in Mexico in 1961 This was the first major continental meeting of specialists and managers in the Latin American electrical susbsector.

From then on, certain directors of the electrical subsector began working out a plan of integration, which could be effected trhough a technical - professional association.

In 1964, this idea was taken further and promoted by the directors of the Uruguayan electrical sector, who invited their counterparts in Argentina, Bolivia, Brazil, Chile and Paraguay to meet in Montevideo to consider the possibility of forming an association to accomplish the objective of integration.

In July 1964, the First Regional Electrical Integration Congress was held in Montevideo, from which emerged the Regional Electrical Integration Commission, CIER, the statutes of *which were approved in Viña del Mar in February 1965.*

*In its first years, the CIER undertook steps to incorporate the rest of the Latin American countries into the organization. This resulted, towards the end of 1968, in Colombia, Ecuador, Peru and Venezuela joining the CIER, which, together with the six founder countries, represent the present group of ten countries which compose the organization.*

*CIER groups all the public, private and state electrical companies of those ten countries. In each country, the companies elect a National Committee, which represents them internationally. The statutes of CIER require that the respective governments recognize the existence of the National Committees.*

*CIER is a non-governmental international association, which does not act on behalf of the governments, but its existence and proceedings are known and followed with interest because the members of the National Committees are, in their large majority, State officials.. The maximum authority is a Central Committee incorporating up to three representatives of each National Committee. It meets usually once a year. The General Secretariat, with headquarters in Montevideo, carries out the annual or bi-annual programs.*

*Those programs are accomplished by the General Secretariat and its dependent technical sub-committees. The technical sub-committees incorporate specialists from all the National Committees, and its work is coordinated by a technical coordinador, who depends from the General Secretariat. Up to now, the techical work of the CIER has been of relevance. The technical subcommittees are:*

1) *Energy Resources*
2) *Electrical Systems*
3) *Operation and Maintenance of Electrical Systems*
4) *Construction of Electrical Systems*
5) *Legal Matters*
6) *Management*
7) *Distribution of Electrical Energy*
8) *Industrial*
9) *Electrical Planning*

*These subcommittees which have worked for years in a methodical and systematic way, have produced a series of reports of great technical value, which gather direct and up-to date experience from each company in each country.*

*The CIER did not take part directly in the negotiations which resulted in the South American electrical interconnections mentioned previously. However, being a forum of ideas, contacts and exchange of experience, undoubtedly it influenced indirectly the success of those projects, especially since its statutory aims include the promotion of those activities leading to the interconnection of the systems.*

*It can be said that many ideas on possible international interconnections germinated within the CIER, through informal contacts between representatives of the different National Committees. Many of these ideas have born fruit.*

*These ideas, put before the governments, have given rise to the formation of binational commission which officially implemented them.*

*Thus, the CIER has been the only organization in the Latin American subcontinent created by the countries on their own initiative, to work on electrical integration.*

*Its functions have been multiple and cover those fields where the exchange of information and experience is important.*

*If the South American institutional framework is compared with that of Western Europe, it can be seen that due to the lack of bodies in Latin American such as the International Conference of Large Networks (CIGRE), CIER created the Electrical Systems Subcommittee; and in the absence of an association such as the West European UCPTE, the CIER bridged the gap with its subcommittees for Operation and Maintenance, and for Legal Matters. The Energy Resources Subcommittee is a South American equivalent, as far as responsibilities are concerned, to the World Energy Conference and so on.*

*The CIER achieved the desired objectives through the wide range of functions it assumed, in order to attain certain integrational objective moreover, it filled the institutional lacunae which accounted for the lack of information and of channels to transmit experience.*

*Today, with the existence of OLADE and SELA, which are governmental organizations, it would be appropriate to harmonize and coordinate tasks, especially those concerning energy, a field in which OLADE has been assigned specific responsibilities by the govenments.*

*OLADE has proposed this coordination to the CIER, referring particularly to the programs it had prepared in relation to technical cooperation between countries, training of personnel, and global energy planning, which were sent to the CIER for their consideration and comment.*

*The coodination of tasks with the CIER, is, in the opinion of OLADE, very desirable, given the benefit it implies for the countries incorporated in both bodies.*

*In its first meeting held in Lima in October 1975, the CIER Subcommittee for Legal Matters recommended its National Committees to include certain basic clauses in the contracts for international electrical interconnections. These are:*

- *Definition of the contracting parties;*
- *Object of the agreement;*
- *Administration of the agreement and division of responsibility as to administration;*
- *Definition of the documentation (existing or to be produced, which forms part of the agreement, definition of terms, technical and operating regulations, etc.);*
- *Duration (initiation, length of commitments, cancellation, extensions, renewals, modifications, etc.);*
- *Reciprocity or differential conditions between the parties;*
- *Definition of the installations and ancilliary work for the aims of the agreement; criteria for distributing costs of the above between the parties, olbigations of the parties concerning construction, financing operation, maintenance;*
- *Distribution of responsibilities between the parties and with respect to third parties concerning construction, financing, operation, maintenance;*
- *Distribution of responsibilities between the parties and with respect to third parties, stemming from construction work, installations, and actions on the part of personnel;*
- *Definition of the site of connection and technical references;*
- *Definition of measurement systems, and technical references;*
- *Definition of measurements systems, and obligations of the parties;*
- *Definition of the conditions of supply, reception and utilization;*
- *Interruptions of the service. Rights and responsibilities of the parties;*
- *Measures in case of non-fulfilment of obligations; (execution of work, maintenance, adjustment of measuring instruments, delay in payments, etc.);*
- *Provisions for compensation of damages arising from breach of contract;*
- *Clauses for revision in case of modification of economic circumstances;*
- *Definition of obligation concerning taxes and fiscal contributions;*
- *Definition of possibilities for expanding or reducing the utilization of the interconnection by the parties;*
- *Definition of methods to resolve differences between the parties;*
- *Definition of the need for ratification by public authorities, legislative sanctions, etc., as the case may be.*

*Finally, a diagram is given which schematizes the national and international electrical interconnection systems in the South American region.*

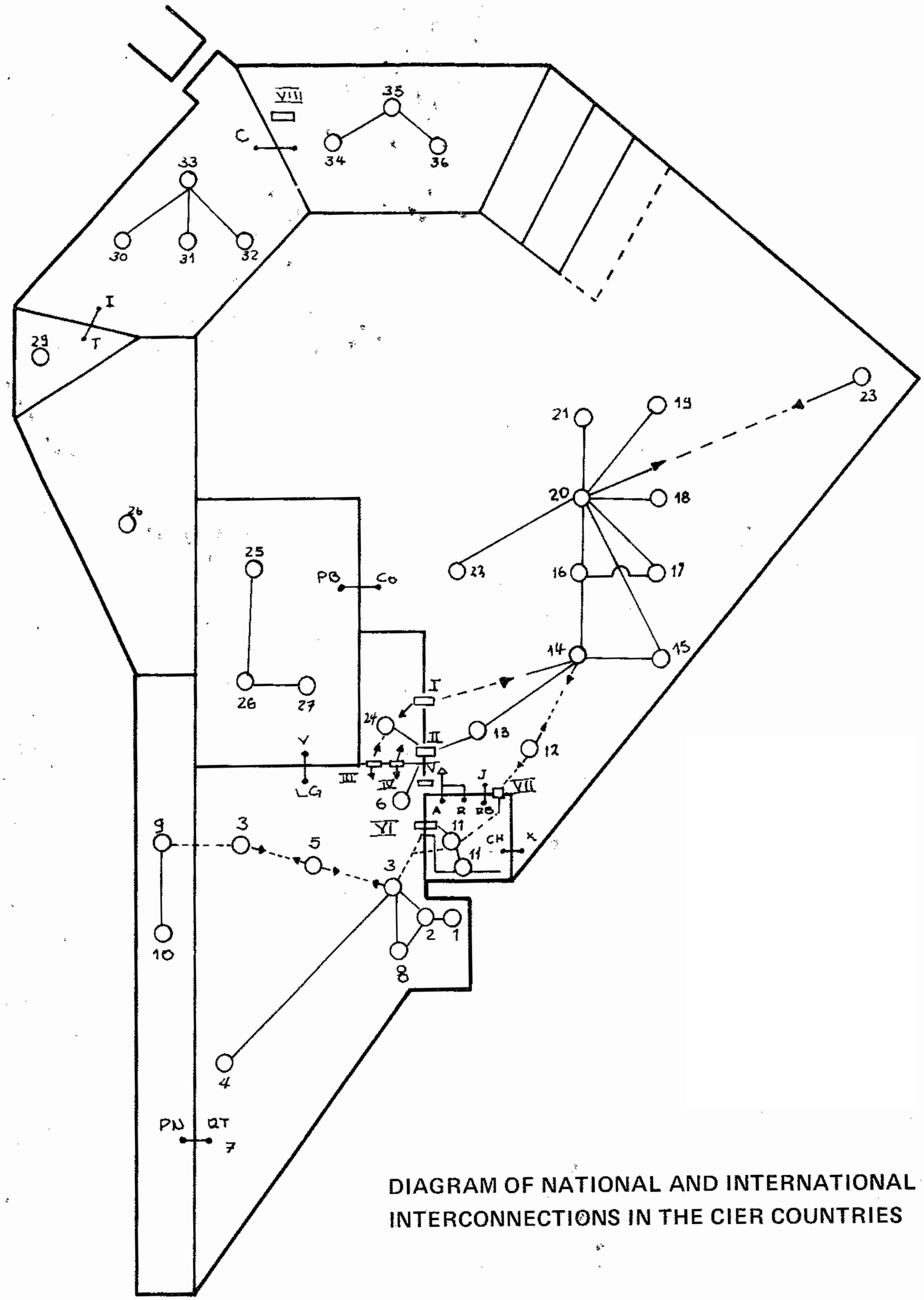



DIAGRAM OF NATIONAL AND INTERNATIONAL INTERCONNECTIONS IN THE CIER COUNTRIES

## NOMENCLATURE

SYSTEM OF:

*In Artentina*

| | | |
|---|---|---|
| 1. | CIAE | Italo-Argentinian Electrical Company Inc (p) |
| 2. | SEGBA | Electrical Services of Greater Buenos Aires (S) |
| 3. | AYE | State Water and Electrical Energy Comapny (S) |
| 4. | HIDRONOR | Norpatagonica S.A. (S) |
| 5. | EPEC | Cordoba Province Energy Company (S) |
| 6. | EMSA | Misiones Electrical Company (S) |
| 7. | YCF | Fiscal Coal Deposits (S) |
| 8. | DEBA | Energy Management of the Province of Buenos Aires |

*In Chile*

| | | |
|---|---|---|
| 9. | ENDESA | State National Electrical Company (S) |
| 10. | CHILECTRA | Chilean Electrical Company (S) |

*In Uruguay*

| | | |
|---|---|---|
| 11. | UTE | Electrical Power Plants and Transmissions (S) |

*In Brazil*

| | | |
|---|---|---|
| 12. | CEEE | State Electrical Energy Company<br>State of Rio Grande do Sul (S) |
| 13. | COPEL | Parana Electrical Energy Company<br>State of Parana (S) |
| 14. | CESP | Sao Paulo Electrical Plants<br>State of Sao Paulo (S) |
| 15. | CPFL | Sao Paulo Light and Power Company<br>State of Sao Paulo |
| 16. | LIGHT SP | Electrical Services<br>State of Sao Paulo |
| 17. | LIGHT RJ | Electrical Services<br>State of Rio de Janeiro |
| 18. | CELF | Fluminense Electrical Power Plants<br>State of Rio de Janeiro (S) |
| 19. | CBEE | Brazilian Electrical Energy Company (S) |
| 20. | FURNAS | FURNAS Electrical Power Plants State of Minas Gerais (S) |
| 21. | CEMIG | Minas Gerais Electrical Power Plants<br>State of Minas Gerais (S) |
| 22. | CELG | Goias Electrical Power Plants<br>State of Goias |
| 23. | CHESF | Sao Francisco Hydroelectric Company<br>(7 States in the North-east of Brazil) |

*In Paraguay*

| | | |
|---|---|---|
| 24. | ANDE | National Electrical Administration (S) |

*In Bolivia*

| | | |
|---|---|---|
| 25. | CBEESA | Bolivian Electrical Company (P) |
| 26. | ENDE | National Electrical Company (S) |
| 27. | ELFEC | Cochabamba Electrical Light and Power (S) |

*In Peru*

| | | |
|---|---|---|
| 28. | ELECTROPERU | Peruvian Electricity (S) |

*In Ecuador*

| | | |
|---|---|---|
| 29. | INECEL | Ecuadorian Institute of Electrification (S) |

*In Colombia*

| | | |
|---|---|---|
| 30. | EEEB | Bogota Electrical Energy Company (S) |
| 31. | CHEC | (S) |
| 32. | EEPP | Medellin Public Companies (S) |
| 33. | CVC | Valle del Cauca Autonomous Regional Corporation (S) |

*In Venezuela*

| | | |
|---|---|---|
| 34. | CADAFE | Electrical Administration and Development Company (S) |
| 35. | EDELGA | Caroni Electricity (S) |
| 36. | ELECAR | Caracas Electrical Company (P) |

HYDROELECTRIC POWER PLANTS OF:

| | |
|---|---|
| I | Itaipu |
| II | Acaray |
| III | Yacireta-Apipe |
| IV | Corpus |
| V | Garabi |
| VI | Salto Grande |
| VII | Paso del Centurion |
| VIII | Uribantes |

INTERCONNECTED CITIES:

| | |
|---|---|
| A | Artigas |
| R | Rivera |
| RB | Rio Branco |

| | |
|---|---|
| *J* | *Jaguarao* |
| *CH* | *Chuy* |
| *X* | *Xui* |
| *PN* | *Puerto Natales* |
| *RT* | *Rio Turbio* |
| *V* | *Villazón* |
| *LQ* | *La Quiaca* |
| *PB* | *Puerto Busch* |
| *CO* | *Corumbá* |
| *T* | *Tulcán* |
| *I* | *Ipiales* |
| *C* | *Cúcuta* |

*INTERCONNECTED SYSTEMS*

*SYSTEMS IN THE PROCESS OF INTERCONNECTION*

*2.5 Concept and evolution of interconnection in Central America and Panama (Central American Isthmus)*

*Generalities*

*Studies carried out 1972 by ECLA estimated the average practical capacity * in the region to be 156 Terawatts-hour. Assuming a continual utilization of the power plants, this would be equivalent to 17,800 MW.*

*Guatemala and Honduras have a practical capacity of about 4,00 MW; El Salvador 734 MW; Nicaragua, 2,285 MW; Costa Rica, 3,500 MW; and Panama, 3,122 MW.*

*In 1975, the installed capacity of the hydroelectric power stations was approximately 650 MW, out of a total 1,500 MW, 95o/o of which are state-owned. In the same year the total energy generated in the Central American Isthmus was approximately 5,000 GWh, with a hydroelectric share amounting to slightly more than 50o/o.*

*In spite of its importance, hydroelectricity represented approximately 2o/o of the available energy.*

*El Salvador is the country that has exploited its resources to the largest extent (7o/o); and Honduras and Guatemala, to the least.*

*Cuadro No. 5*

EXPLOTATION OF HYDROELECTRIC RESOURCES - 1975

| | Practical energy available GWh | Total energy generated GWh | Hydroelectric energy GWh |
|---|---|---|---|
| Central American Isthmus | 156,630 | 1.477 | 632 |
| Guatemala | 35,970 | 227 | 103 |
| El Salvador | 6,430 | 245 | 108 |
| Honduras | 34,930 | 148 | 69 |
| Nicaragua | 20,020 | 217 | 100 |
| Costa Rica | 30,900 | 375 | 237 |
| Panama (including Canal Zone) | 27,380 | 275 | 15 |

*The integration of the national electrical systems in the Isthmus gained momentum in 1960. The first high voltage lines were installed at the time, as a result of the construction of hydroelectric power stations far from centres of consumption. Panama and El Salvador adopted 115 KV for their transission lines; the other countries adopted 138 KV; at present, they are operating in the 200 KV range.*

*ECLA foresees the additional hydroelectric power, indicated below, for the period 1973 - 1985.*

ADDITIONS OF HYDROELECTRIC POWER IN M.W, TO THE GENERATING SYSTEMS BETWEEN 1974–1985

| | TOTAL | HYDROELECTRIC |
|---|---|---|
| Central American Isthmus | 2.877 | 2.027 |
| Guatemala | 442 | 310 |
| El Salvador | 452 | 270 |
| Honduras | 254 | 190 |
| Nicaragua | 365 | 200 |
| Costa Rica | 574 | 502 |
| Panamá | 790 | 555 |

*Close to 95o/o of the installed power in the public utility systems of the six countries in the Central American Isthmus, corresponds to interconnected systems that generate 95o/o of the electrical energy consumed in the region.*

*At the present, the organisms for the electrification of the region are trying to extend the national and international interconnections. By the end of 1980, the smallest system will be that of Honduras (200 MW), and the biggest, that of Panama (665 MW).*

*The international electrical interconnections between the systems in the six countries are being considered since 1960 because of the very favourable prospects offered by some of the countries.*

*Such is the case of Costa Rica, which could*

---

* *Calculated on the basis of available flow and the average difference in level for each basin, using the equation $E_p - QH/1835$. $E_p$ is the practical energy available in GWh; Q is the annual volumetric flow in $10^6$ $m^3$; and H is the average difference in level of the basin, in m.*

*have an excedent of 1,500 GWh of hydroelectric power between 1975 and 1985, and of Nicaragua, which does not have petroleum, and will have to generate 10,000 GWh thermal.*

*Cost estimate prepared by ECLA and the countries mentioned for a 128 KV international interconnecting line with a capactiy of 5 MW, between Rivas in Nicaragua and Canas in Costa Rica, indicate that the returns would high (annual savings of combustable in excess of 1 x $10^6$ US dollars, against an investment of 5 x $10^6$ US dollars).*

*If the countries in the Isthmus would plan their electrical systems in a coordinated way, they could profit from the savings. If, in addition, such coordination were made on the basis of the hydraulic resources not yet exploited, the region would reduce substantially its dependence on petroleum, the importation of which causes a heavy drain of foreign currency.*

*These criteria stimulated the project of interconnection between Nicaragua and Honduras on the basis of the El Cajón Hydroelectric Power Station on the Humuya River in Honduras (340 MW and 1,315 GWh per year). The study indicates that before commercial operation of El Cajón, Nicaragua would sell thermal energy to Honduras to prevent the latter from installing a steam power plant which would be needed in case of independent development of its electrical system.*

*Guatemala and El Salvador offer good possiblilities for the coordinated development of their systems. The expansion programs envisage joint reserves between 104 MW in 1975, and 356 MW in 1981. These figures amount to 25 and 45o/o respectively of the maximum combined demand.*

*If both countries would agree to share their reserves, the total could be significantly reduced, with a corresponding saving in foreign currency.*

*Coordinated planning of the Costa Rican and Nicaraguan systems on the basis of the Arenal Hydroelectric Power Station, mentioned previously, offer good possibilities. It would allow the supply of hydroelectric energy from Costa Rica to Nicaragua, where it would replace thermal energy.*

*The energy crisis of 1973 brought about a revision of the programs for expansion for the period 1975 – 1985 in all countries.*

*Between 1975 and 1985, the countries of the region would spend almost 2,000 million dollars in combustible for generating plants. Nicaragua, Panama and Guatemala would be most affected since a large percentage of their generation is thermal. Costa Rica would be the least affected.*

*The revision of the programs gave rise to several alternatives, aimed at reducing the dependence on petroleum, avoiding expenditure in foreign currency and increasing the share of hydraulic resources in the generation of electricity.*

*The Guatemala program for installation of electrical power plants will not be modified, because work continues on the 230 MW Chixoy Hydroelectric Power Station, the operation of which is scheduled for 1981. A 132 MW steam power plant was screpped; in its place, a 25 MW gas turbine and a 50 MW thermal plant will be installed in 1978. Between 1979 and 1981, 80 MW (30 – 50 MW) will be added, drawing geothermal energy from the fields of Moyuta and Zunil.*

*El Salvador hopes to install 5 x 30 MW on the basis of geothermal energy between 1976 and 1984. It has abandoned the project for two 66 MW thermal plants originally included in their plans. They are accelerating the construction of the Cerron Grande Hydroelectric Power Plant, as well as the studies of the La Pintada plant, a total addition of 380 GWh by 1981. Cerron Grande's capacity was raised to 700 GWh originally foreseen. By 1984, the 80 MW Guayabo Hydroelectric Plant would be in operation; and by 1985, another plant at Zapotillo or Paso del Oso, thus adding 140 MW, 210 GWh.*

*Honduras, on its side, modified its programs, giving more importance to hydroelectric power and abandoning the project for a 40 MW steam power plant, originally foreseen for 1981 The new program includes the following three alternatives:*

*In all of them the first stage would be the Rio Lindo Hydroelectric Power Station (40 MW and 248 GWh per year) in 1978.*

*The first alternative assumes that the El Cajón Hydroelectric Plant (492 MW, 1315 GWh) would operate in 1982; and that between 1977 and 1981, 490 GWh (thermal power) would be bought from Nicaragua.*

*The second and third alternatives assume that Naranjito Hydroelectric Plant (120 MW, 407 GWh) would be in operation in 1980. In the second alternative the Remolino Hydroelectric Plant (120 MW, 427 GWh) would be in operation in 1983, while the third alternative considers the possibility that the El Cajon Hydro-*

*electric Power Station will be functioning in 1984.*

*Since that interconnection between Honduras and Nicaragua was put into operation on 12 October 1976, any change in the plans of one country will affect those of the other. Thus, both countries are considering jointly their respective electrification plans. Nicaragua has already abandoned plans for thermal plants, and considers the possibility of bringing forward hydroelectric projects that would permit installing a generating capacity of 220 MW, 880 GWh, before 1983. Therefore, and assuming that Honduras develops the first of the three alternatives, Nicaragua could import 2260 GWh (hydroelectric) from Honduras, between the years 1982 and 1985.*

*In the case of Costa Rica the changes involve expansion in 1976 of the Cachi Hydroelectric project (32MW, 162 GWh) and advancing by two years the third unit at the Arenal Hydroelectric Power Plant, which would then have a capacity of 3 x 45 MW by 1977, with a total annual generation of 311 GWh. The 90 MW, 458 GWh Angostura Hydroelectric Power Station would be started in 1985. As to Panama the program has not been changed significantly, The construction of El Bayano Hydroelectric Power Plant continues.*

*The Hydroelectric Plan (including geothermal energy) of the Isthmus for 1975 - 1985, which covers the installation of 2,027 MW will require approximately US dollars 1,000 million, and will bring about a savings of US dollars 500 million in fuel imports.*

*Finally, it is worth mentioning the action promoted by ECLA in the six countries of the Central American Isthmus, and the instruments adopted.*

*The Central American Subcommittee on Electrification and Hydraulic Resources of the Committee for Economic Cooperation in the Central American Isthmus, pointed out, on the occasion of its third meeting in Tegucigalpa in 1966, the need to promote the integration and interconnection of the electrical systems in the area.*

*To further this aim, the Subcommittee created the Regional Group for Electrical Interconnection (GRIE) which met for the first time in Tegucigalpa in 1968.*

*On that occasion, it decided that it was necessary to undertake a study on the possibilities of electrical integration in the region, and to establish the guidelines for a Regional Agreement which would regulate the legal aspects of electrical energy interchange between the countries.*

*Following the first meeting, the ECLA regional office in Mexico undertook studies which compared various alternatives for interconnection between pairs of countries in the area, and carried out more detailed studies of the feasibility of the interconnection between Costa Rica and Honduras, and between Guatemala and El Salvador. Two meetings of the Working Group were held on the Nicaragua and Costa Rica electrical interconnection, and an interconnection agreement was signed between Honduras and Nicaragua (which was put into operation on 12 October 1976).*

*Steps were taken on the possibility of an interconnection between Guatemala on one hand, and El Salvador and Honduras on the other.*

*Faced with the 1973 energy crisis, ECLA promoted in 1974 the revision and updating of the interconnection studies in order to lessen the effects of the crisis by adopting measures such as a more rational and intense use of hydroelectric resources.*
*The execution of this study was approved during the meeting of the Isthmus countries on Energy and Petroleum held in Guatemala in February 1975.*

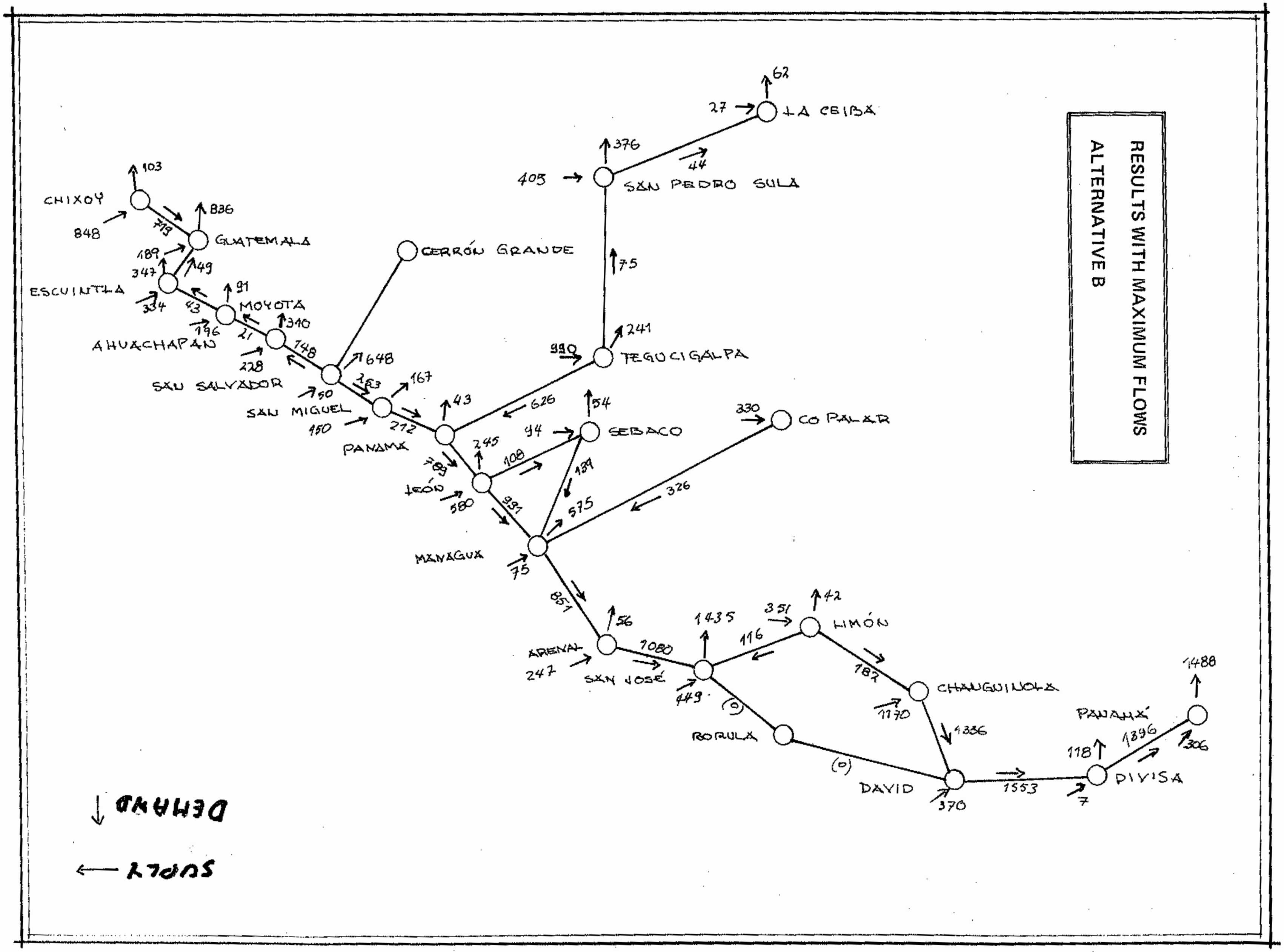
*During the meeting of the GRIE held in San José, Costa Rica in 1975, the terms of reference elaborated by ECLA were approved and it was agreed to undertake the study using the most modern methodology for electrical system planning (SIPSE), drawn up for the Mexican Federal Electricity Commission (CFE), by Electricité de France (EDF). It was also agreed to apply this study to the optimization of national electricity plans.*

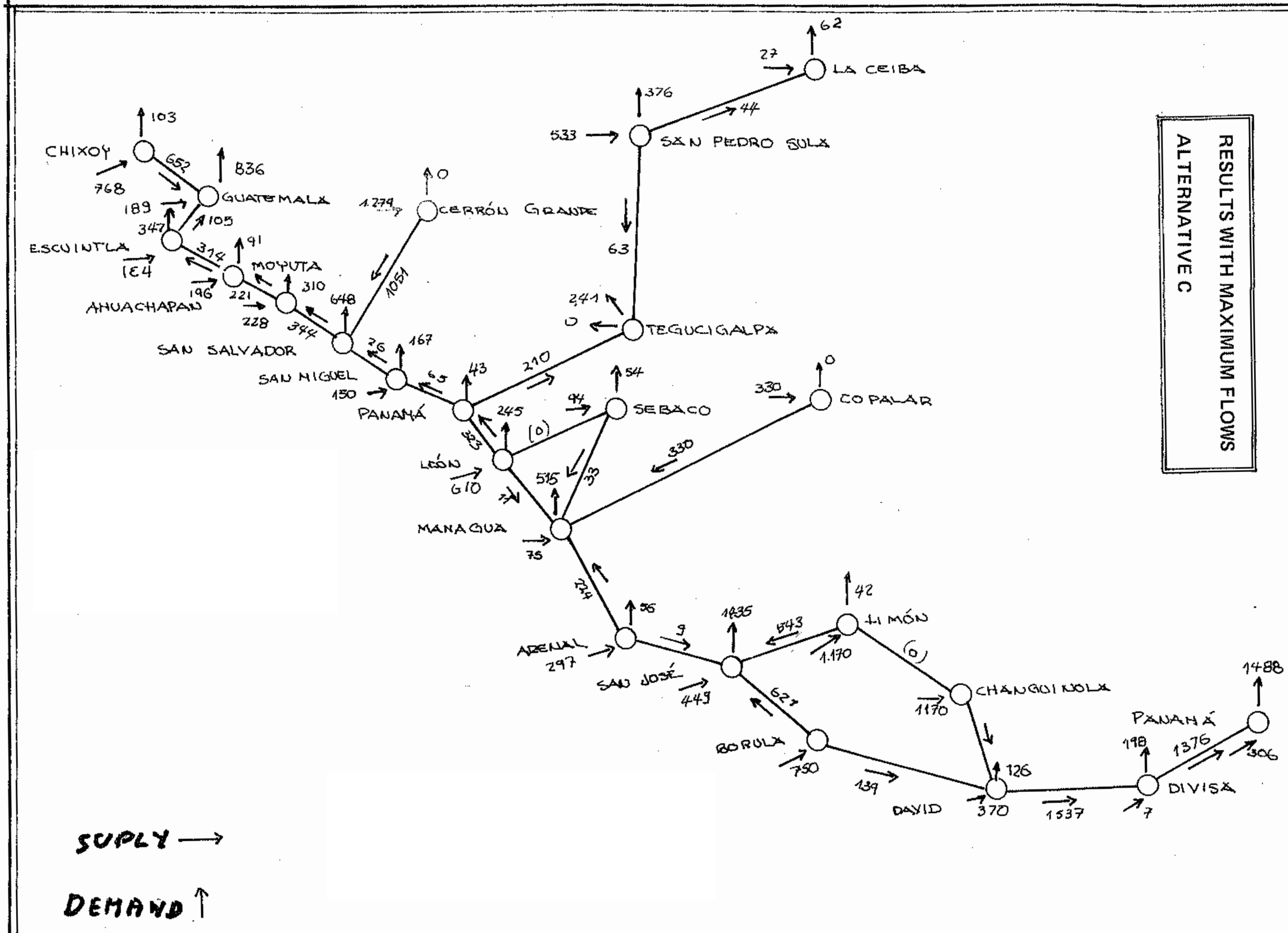
*The third meeting of GRIE was held in Mexico in May 1976 and ECLA presented for consideration three very interesting reports:*

- *The method for integral planning of electrical power systems prepared by the CFE.*
- *Estimating procedures of investments for hydroelectric projects, for various capacity alternatives.*
- *Progress of the study on electrical interconnection in Central American Isthmus-National systems.*

*Conclusions*

*According to ECLA's preliminary estimates, the up-dated total cost of the program to add lines and substations for the interconnection*


RESULTS WITH MAXIMUM FLOWS
ALTERNATIVE B
CHIXOY
GUATEMALA
ESCUINTLA
MOYOTA
AHUACHAPAN
SAN SALVADOR
SAN MIGUEL
CERRÓN GRANDE
PANAMA
LEÓN
MANAGUA
SAN PEDRO SULA
LA CEIBA
TEGUCIGALPA
SEBACO
COPALAR
ARENAL
SAN JOSÉ
LIMÓN
CHANGUINOLA
RORULA
DAVID
DIVISA
PANAMÁ
DEMAND
SUPPLY




RESULTS WITH MAXIMUM FLOWS
ALTERNATIVE C

*of the electrical system in the Isthmus, would amount to US dollars 214 million for alternative B – interconnection with integrated supply and US dollars 229 million for alternative C – independent supply. The cost of independent development of the systems would be US dollars 145 million in actual value. Thus, the cost due to the interconnection of transmmission systems would be US dollars 69 million for alternative C, in excess of independent development.*

*It should be noted that cost difference between alternatives is due principally to changes in priority for the addition of hydroelectric stations. (For instance, the Gopalar – Managua line would be installed within alternative C in 1984, while it would be installed in 1990 under alternative B.)*

*Naturally, these results depend on a series of elements which are not well-defined at present (demand, hydroelectric development programs, energy transfers, etc.). However, it is considered that the main object of the study has been reached by testing an acceptable methodology to determine the characteristics, and estimate an order of magnitude, for the cost of an additional network which would be required by the electrical interconnection between the countries of the Central American Isthmus (Source: CCE/SC. 5/GRIE/IV/7)*

*Diagrama No. 7 y 8*

*2.6 Concept and evolution of international interconnections in the Caribbean Region.*

*Before concluding, a reference should be made to the insular countries of this area.*

*Apart from the cases where countries share the same island, as with Haiti and Dominican Republic, the possibility of international interconnections are for the moment rather remote, given that they would have to be made by underwater cable. This type of interconnection is very costly and requires special technology. The systems to be interconnected would have to be of high installed power in order to be economical (e.g. Great Britain and France across the Staights of Dover, NORDEL and UCPTE across the Straights of Copenhagen, etc). which presumably would be difficult to justify in the near future.*